

Eight new additions to marine macro algal flora of Karnataka coast, India

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भारत के कर्नाटक तट में समुद्री वृहत काई वनस्पतिजात के 8 नवीन संयोजन

एम. पलनीसामी एवं एस. के. यादव

सारांश

भारत के कर्नाटक समुद्र तट पर वर्ष 2017 – 2014 के दौरान व्यापक अन्वेषण किये गये इस दौरान *इंटेरोमोर्फा लिनजा* (एल.) अगर्ध, *एक्रोसिफोनिया ओरियांटेलिस* (जे. अगर्ध) पी. सी. सिल्वा, *किटोमोर्फा एरिया* (डिल्लविन) कुटेज, *किटोमोर्फा क्रासा*, (सी. अगर्ध) कुटेज, *किटोमोर्फा स्पाइरालिस* ओकामुरा, *क्लैडोफोरोप्सिस सुंडानेसिस* रीनबोल्ड, *ब्रायोप्सिस हाइपनोइडिस* जे. वी. लामोर, व *कोडियम द्वारकेंस* बोरीगिसेन नामक 6 कुलों के तहत क्लोरोफाइट्स वर्ग के तहत आठ समुद्री वृहत काई के नये वितरणपरक अभिलेख ज्ञात हुए। इन सभी टैक्सों को सही प्रमाण, संक्षिप्त विवरण के साथ सूचीबद्ध किया गया है।

ABSTRACT

Comprehensive explorations conducted during the years 2014–2017 along the Karnataka coast, India revealed new distributional record of eight marine macro algae belongs to class Chlorophyceae under 6 families namely *Enteromorpha linza* (L.) J. Agardh, *Acrosiphonia orientalis* (J. Agardh) P. C. Silva, *Chaetomorpha aerea* (Dillwyn) Kuetz., *Chaetomorpha crassa* (C. Agardh) Kuetz., *Chaetomorpha spiralis* Okamura, *Cladophoropsis sundanensis* Reinbold, *Bryopsis hypnoides* J.V. Lamour. and *Codium dwarkense* Boergesen. All these taxa are enumerated here with the correct citation, a short description, notes on its occurrence and associated species.

Keywords: Additions, Flora, Karnataka coast, Marine Macro Algae, Chlorophyceae.

INTRODUCTION

The state of Karnataka is well known for its beautiful forests and rich biodiversity. It is also endowed with c. 320 km long coastline, popularly, known as Karavali stretches which particularly spread in three districts *i.e.* Dakshina Kannada, Udupi and Uttara Kannada (map 1).

The coastline is usually rocky, narrow and interrupted at numerous points by various rivers, rivulets, creeks, lagoons, cliffs. Interestingly, the entire coastline is rich in a good number of seaweed vegetation (Plate 1). Works on the seaweed resources of Karnataka are very limited and sporadic (Agadi, 1985, 1986; Untawale & al., 1989; Ambiye & Untawale, 1992; Venkataraman &

Wafar, 2005; Rao & Mantri, 2006; Kaladharan & al., 2011).

The authors conducted botanical explorations in the entire coastline of Karnataka during April, 2014 to March, 2017 and collected more than 108 taxa of marine macro algae (seaweeds), belonging to 54 genera, 31 families and 20 orders. All the collected seaweeds samples are preserved in the form of herbarium specimens at the Madras Herbarium (MH), Botanical Survey of India, Southern Regional Centre, Coimbatore. Interestingly, eight taxa under the class Chlorophyceae (green seaweeds) were recorded which are new to the marine macro algal flora of Karnataka coast. All these taxa are enumerated and described here with the correct citation, description, notes on its occurrence and economic uses.

FAMILY: ULVACEAE

Genus: Enteromorpha Link

Enteromorpha linza (L.) J. Agardh, Algern. Syst. 3: 134. 1883; Untawale & al., List Mar. Alg. India: 8. 1983; P.C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean: 736. 1996; V. Krishnam., Alg. India Neighb. Countr. Chlorophyta 1: 94. 2000; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 151. 2001; Palanisamy & al. in Seaweed Res. Utiln. 35(1&2): 24. 2013; P.S.N. Rao & R.K. Gupta, Algae India 3: 2. 2015. *Ulva linza* L., Sp. Pl. 2: 1163. 1753.

Thallus light-dark green in colour, foliaceous, flattened to slightly tubular, 4-16 cm long, epilithic. Holdfast small, discoid, loosely attached to substratum, sometimes free floating. Stipe tubular, gradually flattened upwards, up to 1 cm long. Fronds simple, flattened, linear to lanceolate, tubular below and gradually flattened upwards, 0.4-1.8 cm wide in middle, margins entire to undulate or proliferated, apex irregular. *Microscopic*: Cells in surface view polygonal to spherical; in cross section usually rectangular, 9-11.8 × 15-18.2 µm wide, sheath 2 µm thick; uninucleate. (Plate 2. a-b)

Occurrence: Monsoon and post-monsoon seasons. Rare.

Distribution: KARNATAKA: Uttara Kannada distr. (Gokarna, Harwada- Tarangamett and Madiyendri) and Dakshina Kannada distr. (Surathkal and Peribail).

Use: This is one of the economically important seaweed. It is used in making seaweed powder, which is used as aqua feed and livestock feed in several countries (Jha & al., 2009).

Specimen examined: Karnataka, Dakshina Kannada district, Peribail, 24.08.2016, Palanisamy & Yadav 135219 (MH); Uttara Kannada district, Gokarna, 31.08.2016, Palanisamy & Yadav 135774 (MH); Surathkal beach, 09.10.2014, Palanisamy & Yadav 131039 (MH).

Notes: According to Algae base, *Enteromorpha linza* is regarded as the synonym of *Ulva linza* based on the molecular study (Hayden & al., 2003; Hayden & Waaland, 2004). They opined that these two genera are paraphyletic in origin and subsequently transferred *Enteromorpha* into *Ulva*. However, in practical, these two genera are well distinct in morphological and anatomical characters. *Enteromorpha* can be recognized by a tubular thallus up to 30 cm long, monostromatic (cells single layer) while in *Ulva* thalli are foliose with upto 2 m length, distromatic (cells two layer). Besides, in most of the Indian literature, these two genera are treated separately. Therefore, *Enteromorpha linza* has been regarded here under *Enteromorpha* genus.

FAMILY: ACROSIPHONIACEAE

Genus: Acrosiphonia J. Agardh

Acrosiphonia orientalis (J. Agardh) P.C. Silva, in P.C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean: 754. 1996; K.S. Sriniv. in Bull. Bot. Surv. India 7: 204. 1965; V. Krishnam. & H.V. Joshi, Checkl. Ind. Mar. Alg.: 36. 1970; P.S.N. Rao & R.K. Gupta, Algae India 3: 4. 2015. *Anadema orientalis* J. Agardh, Ofvers Kongl. Vetensk.-Akad. Forh. 3: 103. 1846.

Thallus dark-muddy green in colour, up to 8 cm long, caespitose, remiform, bushy, growing gregariously, profusely branched, corymbose, lithophilic. Holdfast small, discoid, attached firmly on calcareous bedrocks in intertidal zones. Stipe up to 2 cm long, stalked, tufted, profusely branched. Fronds repeatedly branched, cylindrical, uniseriate, filamentous, 2-5 cm long and up to 1.6 mm in diameter; branching pseudo-dichotomous or trichotomous sometimes alternate, margins entire, apex acute.

Microscopic: Cells in surface view cylindrical or elongated, basal and middle cells 0.8-2.6 mm long, 110-310 µm broad, apical cells 200-980 × 90-250 µm, uniseriately arranged; in cross section cell wall up to 40 µm thick; multinucleate, chloroplast reticulate with numerous pyrenoids. (Plate 2. c)

Occurrence: Usually Monsoon and post - Monsoon seasons. Rare.

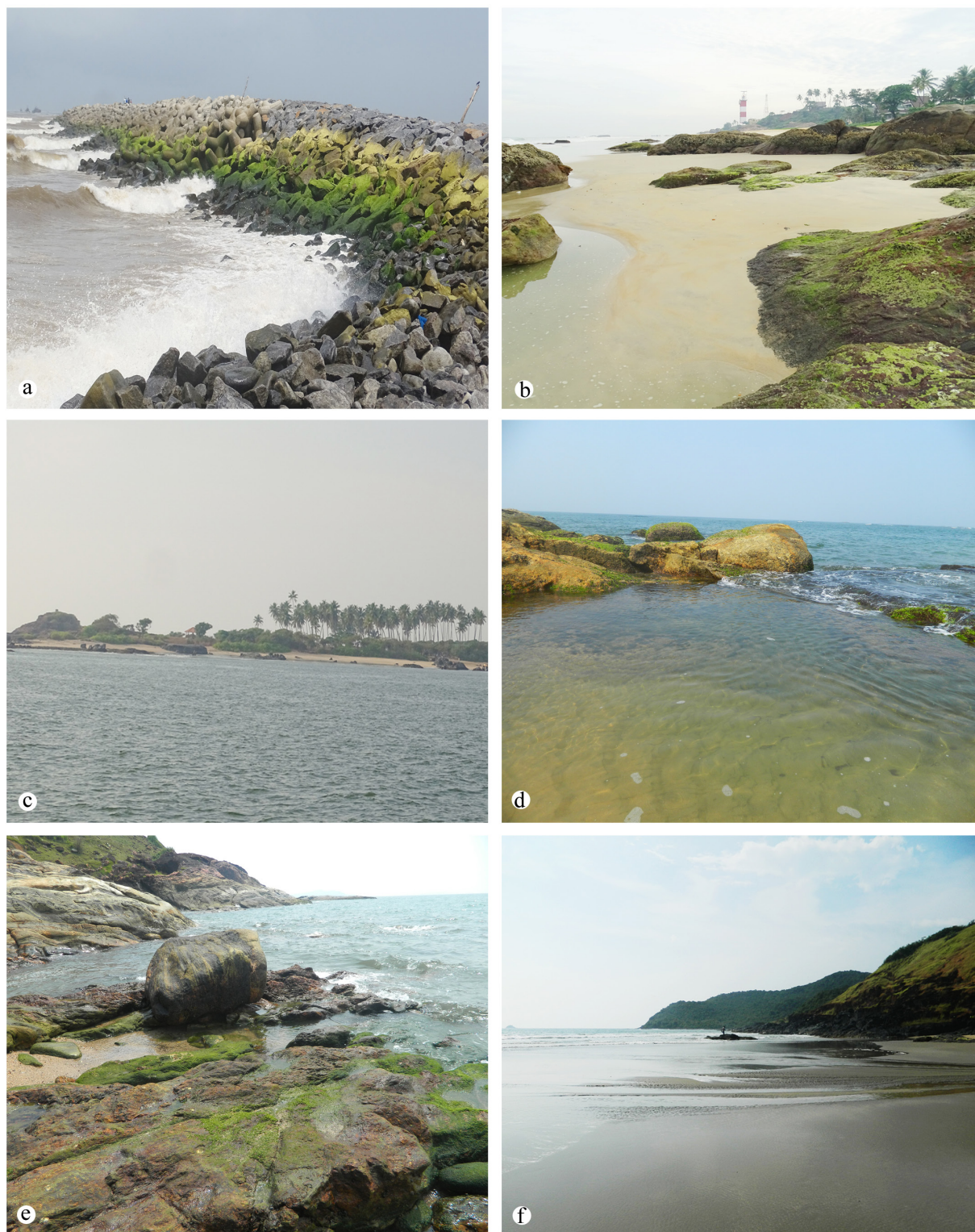


Plate 1. Important seaweed habitats: **a.** Seaweed vegetation on artificially laid stones at Mangalore coast; **b.** Seaweeds growing on exposed rocks at Surathkal coast; **c.** A panoramic view of St. Mary's island, Malpe; **d.** Rocky coast at Gorte; **e.** Rocky coast at Vannali; **f.** A panoramic view of the hills of the Western Ghats facing sea side at Majali coast.

Distribution: KARNATAKA: Udupi distr. (St. Mary's island) and Uttara Kannda distr. (Gorte, Madiyendri, Majali and Mundoli).

Note: It is usually found growing on bedrocks in association with other species of seaweeds.

Use: Manilal & al. (2009) reported that the polysaccharide extracted from this species shows antiviral activity against the shrimp pathogen White Spot Syndrome Virus (WPSV). Thus, it can be utilised as a prophylactic drug in shrimp disease management.

Specimen examined: KARNATAKA: Uttara Kannda distr.: Majali coast, 18.10.2014, *Palanisamy & Yadav* 131223 (MH); Madiyengri, 09.06.2015, *Palanisamy* 132464 (MH); Mundoli coast, 27.11.2016, *Palanisamy & Yadav* 136295 (MH).

FAMILY: CLADOPHORACEAE

1. *Chaetomorpha aerea* (Dillwyn) Kuetz. in Sp. Al., 379. 1849; Untawale & al., List Mar. Alg. India, 9. 1983; Kaliap. & al. in Seaweed Res. Utiln., 14: 106. 1992; P. C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean, 759. 1996; Oza & Zaidi, Rev. Checkl. Ind. mar. alg., 157. 2001. *Conferva aerea* Dillwyn, Brit. Conferv. Fasc., 80. 1806.

Thallus light to bright green in colour, up to 15 (-30) cm long, filamentous, unbranched, epilithic. Holdfast discoid, prominent, firmly attached on rocky substrata. Fronds filamentous, divided into uniseriately arranged nodes and internodes, erect, stiff, gradually tapering towards apex.

Microscopic: Cells cylindrical, basal cell subclavate, basal cell 130-150 µ in diam., other cells 145-350 µ diam. towards apex, cells usually constricted at the internodes.

(Plate 2. d)

Occurrence: During post-monsoon season. Rare.

Distribution: KARNATAKA: Uttara Kannda distr. (Shiroor).

Specimen examined: KARNATAKA: Uttara Kannda distr.: Shiroor coast, 14.10.2014, *Palanisamy & Yadav* 131141 & 131152 (MH).

2. *Chaetomorpha crassa* (C. Agardh) Kuetz., Phycol. Germ. 204. 1845; P.C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean: 762. 1996; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 159. 2001; Yadav & al. in Rajendran & Aravindhan (eds.), Biodiv. Cons.-Asp. Prosp.: 56. 2015; P.S.N. Rao & R.K. Gupta, Algae India, 3: 4. 2015. *Conferva crassa* C. Agardh, Syst. Alg.: 99. 1824.

Thallus dark green in colour, up to 10 cm long, unbranched, coiled, forming loose clumps or entangled, tufted. Holdfast small, discoid, entangled tightly with other seaweeds and waste fishing nets, cloths etc. in the intertidal regions, sometimes free floating. Stipe and fronds undifferentiated, filamentous, divided into nodes and internodes, unbranched, prominently coiled, tapering towards apex.

Microscopic: Cells cylindrical to barrel shaped, slightly swollen in central part and constricted near nodes, 310-600 × 250-400 µm; cell wall 30-95 µm thick; chloroplast reticulately arranged with several pyrenoids.

(Plate 2. e-f)

Occurrence: Monsoon and post-monsoon seasons. Moderate.

Distribution: KARNATAKA: Dakshina Kannada distr. (Surathkal) and Udupi distr. (St. Mary's island) districts.

Notes: This species is usually found growing in entangled stage with the species of *Enteromorpha*, *Chaetomorpha*, *Sargassum* and *Ulva* in intertidal regions and occasionally seen offshore.

Specimen examined: KARNATAKA: Dakshina Kannada distr.: Surathkal, *Palanisamy* 132547, 17.09.2015; Udupi distr.: St. Mary Island, Malpe, *Palanisamy* 134910, 20.02.2016 (MH).

3. *Chaetomorpha spiralis* Okamura in Alg. Jap. Exs. 94: 131. 1903; Untawale & al., List Mar. Alg. India: 9. 1983; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 160. 2001; Pereira & Almeida in Indian J. Mar. Sci. 42 (4): 662. 2014; Yadav & al. in Rajendran & Aravindhan (eds.), Biodiv. Cons.-Asp. Prosp.: 56. 2015; P.S.N. Rao & R.K. Gupta, Algae India 3: 5. 2015.

Thallus usually dark green in colour, becomes light green to white towards apex in mature thallus, usually 2-6 (-10) cm long, filamentous, straight towards base and spirally twisted or coiled upwards, stiff, gregarious, lithophilic. Holdfast small, discoid, loosely attached on rocky substrata in the low intertidal pools. Stipe small with cylindrical cells. Fronds filamentous, unbranched, cylindrical below and moniliform towards apex, loosely entangled, margin entire to undulate; apex usually obtuse.

Microscopic: Basal cells distinctly cylindrical, 480-750 µm long; other cells usually rectangular-squarish, spherical or moniliform in appearance, isodiametric, slightly constricted in nodal regions, 250-710 × 300-430 µm; cell wall 50-90 µm thick; chloroplast elongate, densely arranged; pyrenoids several.

(Plate 3. a-b)

Occurrence: Monsoon and post-monsoon seasons. Moderate.

Distribution: Throughout Karnataka coast.

Specimen examined: KARNATAKA: Udupi distr.: Uchila coast, 10.10.2014, *Palanisamy & Yadav* 131053 (MH); Uttara Kannda distr.: Gorte coast, 14.10.2014, *Palanisamy & Yadav* 131171 (MH); Oyingi beach, 15.10.2014, *Palanisamy & Yadav* 131182 (MH).

FAMILY: SIPHONOCALACEAE

Genus: *Cladophoropsis* Boergesen

Cladophoropsis sundanensis Reinbold in Naova Notarisia 16: 147. 1905; V. Krishnam. & H.V. Joshi, Checkl. Ind. Mar. Alg.: 8. 1970; P.C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean: 793. 1996; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 167. 2001; V. Krishnam., Alg. India Neighb. Countr. Chlorophycota 1: 166. 2000; P.S.N. Rao & R.K. Gupta, Algae India 3: 8. 2015.

Thallus light-medium green in colour, filamentous, forming spongy and moss like small clumps, up to 7 cm across, epilithic. Holdfast rhizoidal, hapteroid, firmly attached on rocky substrata in intertidal regions. Fronds filamentous, irregularly branched; lateral branches mostly unilateral; ultimate branches straight or slightly curved, up to 5 mm long and terminates into round to obtuse apices.

Microscopic: Cells of the main axis cylindrical, elongate, 40-110 (-140) μm in diameter; cell wall conspicuous. (Plate 3. c)

Occurrence: Usually Post-monsoon season. Rare.

Distribution: KARNATAKA: Udupi distr. (St. Mary's island) and Uttara Kannda (Gorte, Tadri and Karwar).

Specimen examined: Karnataka: Uttara Kannda distr.: Gorte coast, 27.11.2016, *Palanisamy & Yadav* 136323 (MH).

FAMILY: BRYOPSIDACEAE

Genus: *Bryopsis* J.V. Lamour.

Bryopsis hypnoides J.V. Lamour. in Nouv. Bull. Sci. Soc. Philom. Paris 1: 333. 1809; Untawale & al., List Mar. Alg. India: 11. 1983; P. C. Silva & al., Cat. Benth. Mar. Alg. Ind. Ocean: 805. 1996; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 170. 2001; Jha & al., Seaweeds Gujarat: 34. 2009; P.S.N. Rao & R.K. Gupta, Algae India 3: 9. 2015.

Thallus light-pale or dark green in colour, tubular, remiform with radially ranged branches, up to 10 cm long, gregarious, siphonous, tufted, epilithic. Holdfast

rhizoidal, firmly attached. Stipe stalked cylindrical, 100-200 μm in diameter. Fronds tubular, cylindrical-terete, main axis up to 250 μm in diameter, progressively tapering towards apex, branches usually naked or with scars in basal portion and dense and radially arranged in middle and apical portion; pinnules almost uniformly cylindrical or linear-lanceolate, facing upwards and gradually or sometimes irregularly becoming shorter, ultimate branches usually terminate into a long and round to acute apex.

Microscopic: Pinnules 300-850 $\times$ 45-140 μm ; cells of the main axis and branches siphonous, usually transparent towards apex, multinucleate, with numerous lecuticular plastids. (Plate 3. d-e)

Occurrence: Usually post - Monsoon season. Rare.

Distribution: Throughout Karnataka coast.

Specimen examined: KARNATAKA: Uttara Kannda distr.: Madiyengri, 26.11.2016, *Palanisamy & Yadav* 136231 (MH).

FAMILY: CODIACEAE

Genus: *Codium* Stackh.

Codium dwarkense Boergesen in J. Indian Bot. Soc. 16: 6, 8, figs. 3-5. 1947; K.S. Sriniv., Phycol. Ind. 2: 32, pl. 32. 1973; Untawale & al., List Mar. Alg. India: 13. 1983; Oza & Zaidi, Rev. Checkl. Ind. Mar. Alg.: 184. 2001; Jha & al., Seaweeds Gujarat: 53. 2009; P.S.N. Rao & R.K. Gupta, Algae India 3: 13. 2015.

Thallus light to yellowish green in colour, occasionally colourless and becomes dark after drying, spongy, and cylindrical, up to 15 cm long, erect, epilithic. Holdfast discoidal, conspicuous, several rhizoidal axes develop from the discoid base, firmly attached on rocky substrata in intertidal zones. Stipe cylindrical, narrow towards base, up to 6 mm in diameter. Fronds almost uniformly cylindrical to slightly terete, elongated, 3.5-6 mm in diameter, regularly dichotomously branched, dichotomies usually at intervals of up to 4 cm long; surface smooth, slightly mucilaginous in nature, often appears as spotted; margins entire; apex simple or dichotomously forked, round to obtuse or slightly acute, light to yellowish coloured.

Microscopic: Utricles cylindrical to clavate, 500-1050 $\times$ 90-200 μm ; utricular wall 1-3 μm thick. (Plate 3. f)

Occurrence: During post-monsoon seasons. Moderate.

Distribution: Throughout Karnataka coast.

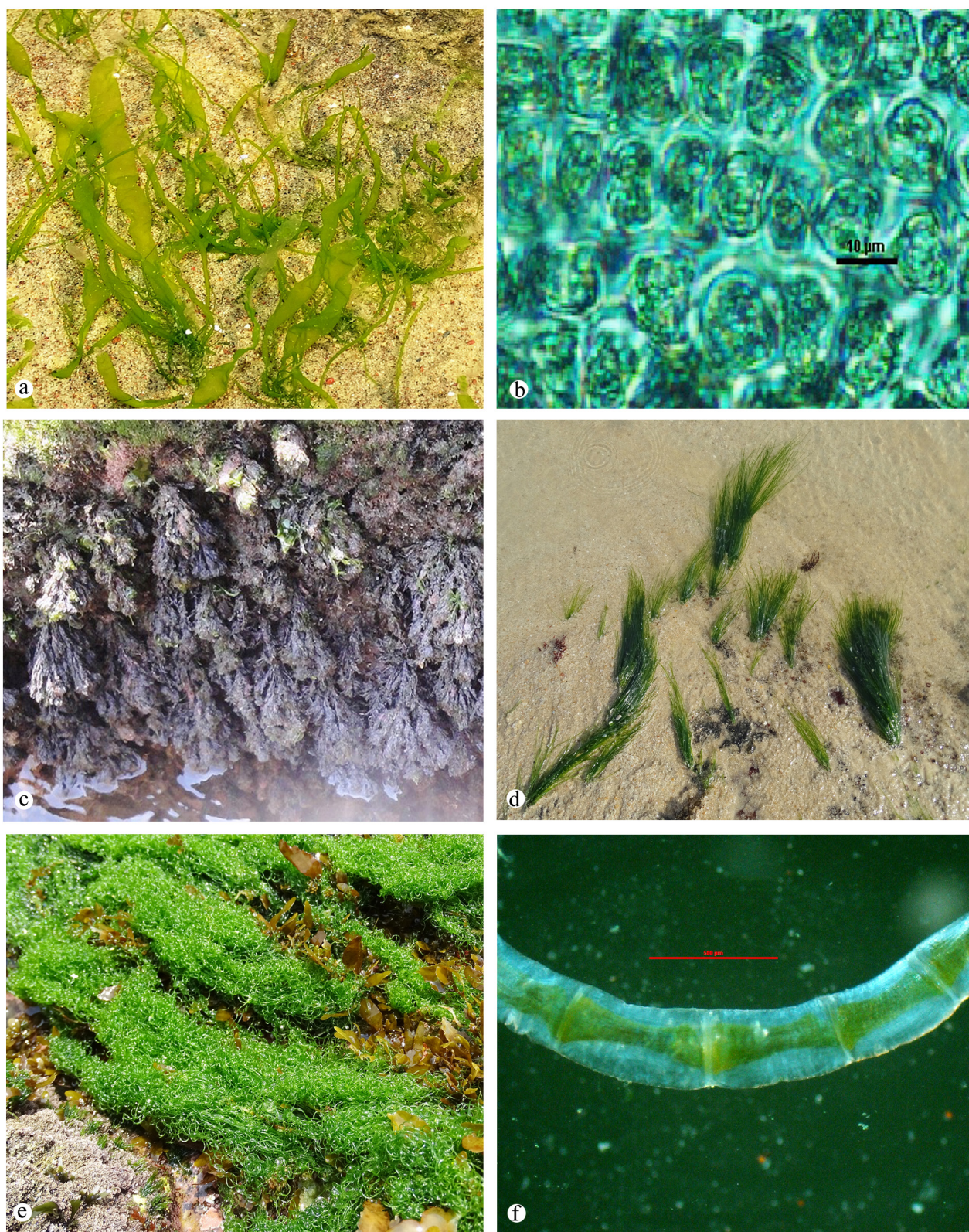


Plate 2. a-b. *Enteromorpha linza* (L.) J. Agardh: habit and surface cells; c. *Acrosiphonia orientalis* (J. Agardh) P.C. Silva: habit; d. *Chaetomorpha aerea* (Dillwyn) Kuetz.: habit; e-f. *Chaetomorpha crassa* (C. Agardh) Kuetz.: habit and filamentous cells.

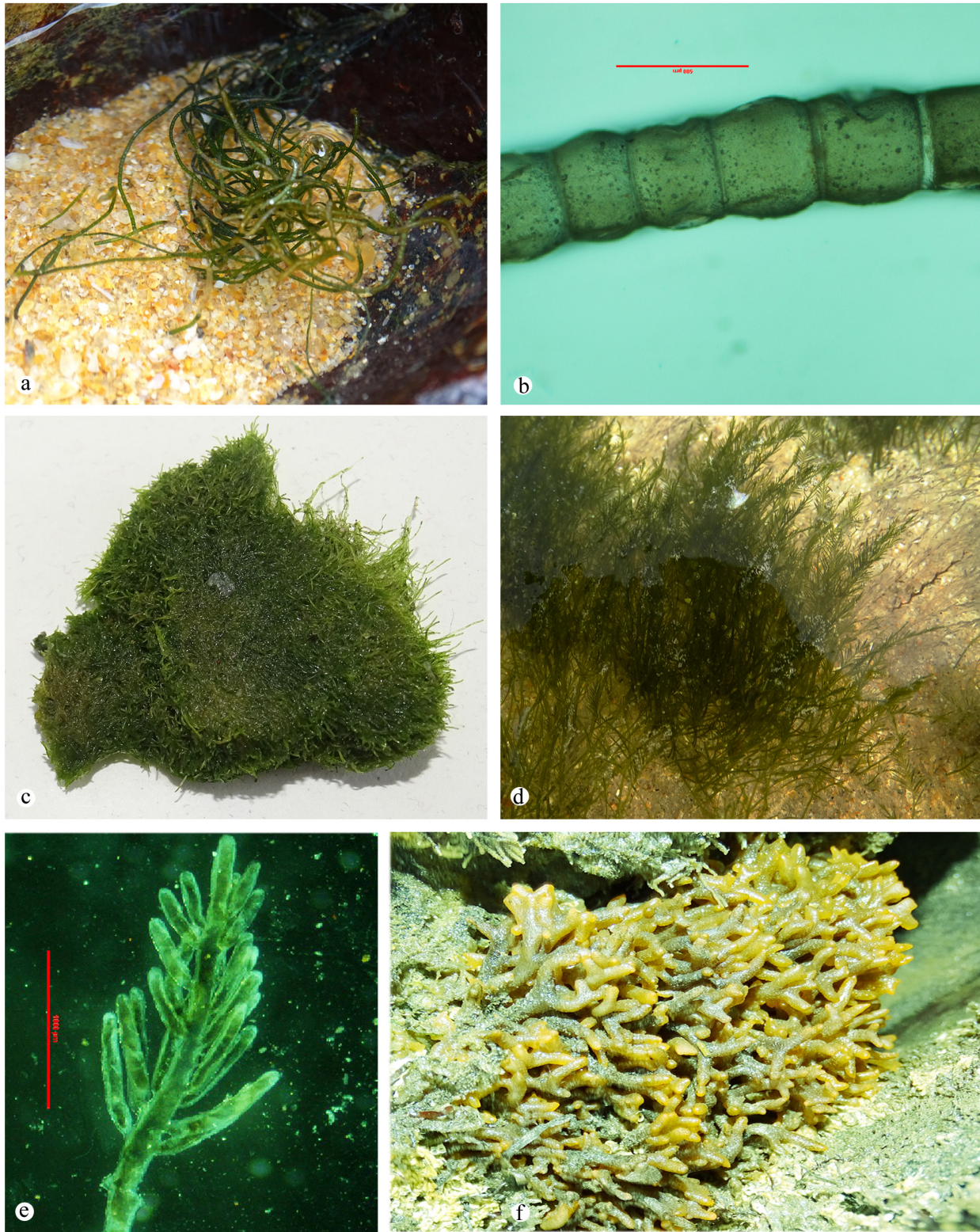
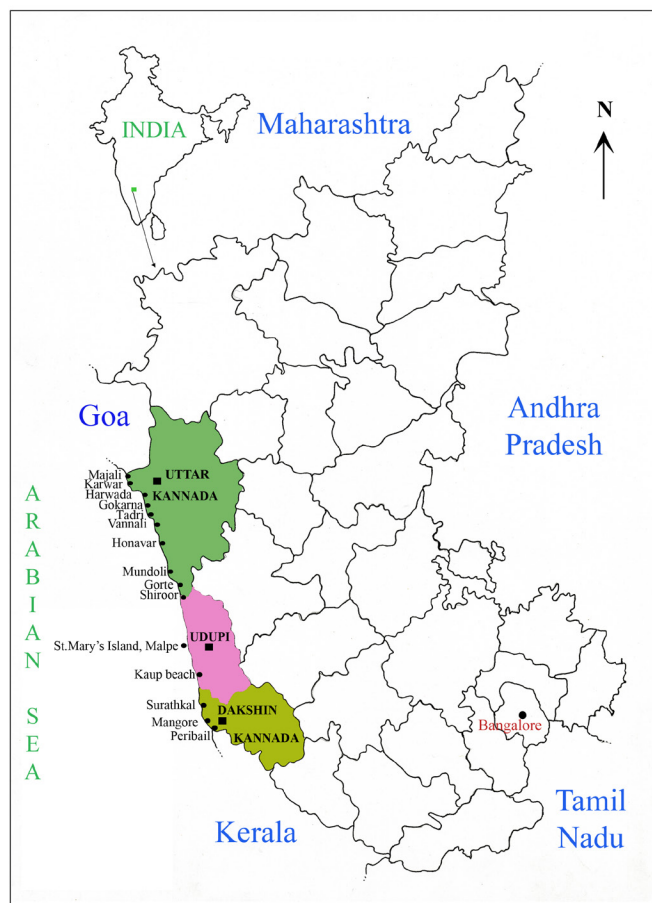


Plate 3. a-b. *Chaetomorpha spiralis* Okamura: habit and filamentous cells; c. *Cladophoropsis sundanensis* Reinbold: habit; d-e. *Bryopsis hypnoides* J.V. Lamour.: habit, fronds apex and surface cells; f. *Codium dwarkense* Boergesen: habit.



Map 1: Map showing important collection localities in Karnataka coast.

Specimen examined: KARNATAKA: Udupi distr.: St. Mary's Island, Malpe, 29.11.2016, *Palanisamy & Yadav* 136385 (MH); Daksina Kannada distr.: New Mangalore port coast, 01.12.2016, *Palanisamy & Yadav* 136455 (MH).

ACKNOWLEDGEMENTS

The authors are thankful to Dr. Paramjit Singh, Director, Botanical Survey of India, Kolkata, Dr. G. V. S. Murthy,

Former Scientist 'G' & Head of Office, Botanical Survey of India, Southern Regional Centre, Coimbatore and Dr. C. Murugan, Scientist 'D' & Head of Office, Botanical Survey of India, Southern Regional Centre, Coimbatore for the facilities and encouragements.

REFERENCES

- AGADI, V. V. 1985. Distribution of marine algae in the littoral zone of the Karnataka coast. In: Krishnamurthy, V. & A. G. Untawale (eds.), *Marine Plants*. Madras. 35–42.
- AGADI, V. V. 1986. Marine algal studies of the central west coast of India. Ph. D. thesis. Karnatak University, Dharwad, India.
- AMBIYE, V AND A. G. UNTAWALE 1992. *Deep water marine algal flora of the submerged banks off west coast of India. Oceanography of the Indian Ocean*. Oxford and IBH, New Delhi. 247–252.
- JHA, B., C. R. K. REDDY, M. K. THAKUR AND M. UMA-MAHESWARA RAO, 2009. *Seaweeds of India: The Diversity and Distribution of Seaweeds in Gujarat Coast*. CSMCRI, Bhavnagar. pp. 215.
- KALADHARAN, P., P. U. ZACHARIA AND K. VIJAYAKUMARAN, 2011. Coastal and marine floral biodiversity along the Karnataka coast. *J. Mar. Biol. Ass. India* 53 (1): 157–159.
- MANILAL, A., S. SUJITH, J. SELVIN, G. S. KIRAN AND C. SHAKIR 2009. *In vivo* Antiviral Activity of Polysaccharide from the Indian Green Alga, *Acrosiphonia orientalis* (J. Agardh): Potential Implication in Shrimp Disease Management. *World J. Fish Mar.Sci.* 1(4): 278–282.
- SUBBA RAO, P. V. AND, V. A. MANTRI 2006. Indian seaweed resources and sustainable utilization: Scenario at the dawn of a new century. *Curr. Sci.* 91: 164–174.
- UNTAWALE, A. G., C. K. R. REDDY AND G. V. DESHMUKHE 1989. Ecology of intertidal benthic algae northern Karnataka coast. *Indian J. Mar. Sci.* 18: 73–81.
- VENKATARAMAN, K. AND M. WAFAR 2005. Coastal and marine biodiversity of India. *Indian J. Mar. Sci.* 43 (1): 57–75.