

[Note]

Three Ecotypes of *Compsopogon coeruleus* (Rhodophyta) from Orissa State, East Coast of India

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Three ecotypes of the freshwater red alga *Compsopogon coeruleus* (Balbis) Montagne were recorded from different freshwater and brackish water habitats of Orissa state in the east coast of India. These three had persistent differences in their branching pattern, e.g. (i) acute angle between main axis and lateral branch, (ii) equal or near to right angle between main axis and lateral branch, and (iii) short spine-like outgrowth instead of a branch in older filaments, besides having differences in the length, breadth and thickness of cortex of the thallus. Morphological observation of these taxa, and the ecological characteristics of the habitat of their occurrence is presented.

Key Words: ecotypes, *Compsopogon coeruleus*, freshwater red alga, morphology

Compsopogon is a freshwater red alga of the family Compsopogonaceae, order Erythropeltiales (Garbary *et al.* 1980) under the sub Class Florideophycidae (Dixon 1973). The organism is widely distributed through out the world, but is most common in tropical and subtropical regions and occasionally extends into north temperate regions such as northern states of North America, Europe, Japan, India, Brazil and Ukraine (Krishnamurthy 1962, Shyam and Sarma 1980, Necchi *et al.* 1990, Vis *et al.* 1992, Rintoul *et al.* 1999, Desikachary *et al.* 1990).

Totally eleven species of *Compsopogon* and three of *Compsopogonopsis* under family Compsopogonaceae have been described. *Compsopogon* is characterized by the rhizoids confined to the thallus base, and *Compsopogonopsis*, with rhizoidal outgrowths throughout the plant (Krishnamurthy 1953). The type of basal portion of the thallus, branching pattern, size of monosporangium, number of cortical layers and size of cortical cells are considered for species recognition within the genus. The thallus is profusely branched, saxicolous or epiphytic, filamentous, uniseriate in younger portions and multiseriate in older portions, axial cell surrounded by variable number of cortical layers, reproduces asexually and lack of sexual life cycle (Fritsch 1945, Bold and Wynne 1978). However all these characters of the thallus show wide variation between populations and also changes with

season (Necchi *et al.* 1990).

Necchi and Dip (1992) in a taxonomic revision of the family Compsopogonaceae has placed all the taxa in two clearly defined species, e.g. *C. coeruleus* (without rhizoidal filament in cortex) and *C. leptocladus* (with such filaments in cortex). Through multivariate morphometrics and image analysis of several taxa of Compsopogonaceae Vis *et al.* (1992) have grouped them into three species, e.g. *Compsopogonopsis leptocladus* (Montagne) Krishnamurthy (presence of rhizoidal cortication throughout the plant); *Compsopogon prolificus* Yadav et Kumano (U shaped lateral branches curl around main axis) and *Compsopogon coeruleus* (Balbis) Montagne (uncurled branches in the axis). They considered that microsporangia clusters, basal system of thallus and spine like branches are inconsistent characters. But all these revisions were based on analysis of formalin preserved materials of representative collections, of which many are unavailable now for further study.

We observed persistent morphological characters in three different taxa of *Compsopogon* in samples from nature as well as in formalin preserved materials collected from four different habitats differing in ecological characteristics for three consecutive years. Hence their occurrence was correlated with their ecological characteristics of the habitats.

Compsopogon samples were collected from two different freshwater bodies, from the channel of an estuary

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Table 1. Date of collection, voucher no and thallus characteristics of the ecotypes of *Compsopogon* measured for identification.

Date of collection	Voucher number/no of samples in parenthesis	Collecting method	Characteristics measured
11.12.2003, 15.01.2004, 20.01.2004, 22.01.2005	B24 (5), B57 (7)	Collected by hand with scalpel and preserved immediately after collection in 4% (v/v) formalin	Thallus color, branching pattern, cell dimension, holdfast structure, lateral branching pattern and its arrangement, out growths on the thallus, structure of monosporangia
10.11.2002, 03.12.2003, 18.12.2004, 16.1.2005	KC44 (3), CL. 56 (5)		
19.12.2003, 18.04.2004, 15.01.2005, 22.03.2005, 06.02.2006	BE 151 (10)		

and from Chilika lagoon in the Orissa state, India. Habitat and the date of collection of each sample was noted and assigned with a voucher number (Table 1). Samples were fixed with 4% formaldehyde on spot. The location of each site was recorded using a Garmin 12 portable GPS receiver. Temperature, pH and conductivity of water of each site was measured using portable thermometer, pH meter (131E, Electronics, India) and conductivity meter (621E, Electronics, India) respectively. Dissolved oxygen content of the water was estimated following Winkler's methods (Adoni 1985). Salinity was measured argentometrically (Barenas 1959) and expressed as ppt (Table-2). Microphotograph of the specimens were taken soon after bringing to the laboratory using a Meiji Trinocular Research microscope fitted with Nikon Coolpix 4500 digital camera. Morphometric analysis was carried out using Erma micrometers. The herbarium and formalin preserved materials were deposited at the Department of Botany, Utkal University for record.

***Composogon coeruleus* (Bablis in C. Agardh) Montagne, Flore d'Algerie 1:154, 1846**

(Figs 1-7)

Thallus bluish green, branched, filamentous, 98-280 μm wide, 2-13 cm long (Figs 1, 2), holdfast conical or hemispherical, young branches have a main axial cell row without forming the cortical cell, acute angle between main axis and lateral branch, tip rounded (Fig. 1), main axis 60-180 μm , old branches corticated, rings numerous (Fig. 2), cells of younger branch barrel shaped, 13.3-16 μm wide, 11.6-16 μm long (Fig. 3), lateral branches arise from barrel shaped, 9-20 μm diameter cells and it is globular in structure (Fig. 4), cortex 2 layered (Fig. 5), inner side of cortex larger than out side cells, cells 11-33 μm wide, 14-43 μm long (Fig. 7), cells polygonal, chromatophores numerous; monosporangia 16.4-22.3 μm in diameter, pigmented (Figs 4-6).

***Compsopogon coeruleus* (Balbis in C. Agardh) Montagne, Flore d'Algerie 1: 154, 1846**

[Syn: *Compsopogon aeruginosus* (J. Agardh) Kützing; Kützing (1849)] (Figs 8-18)

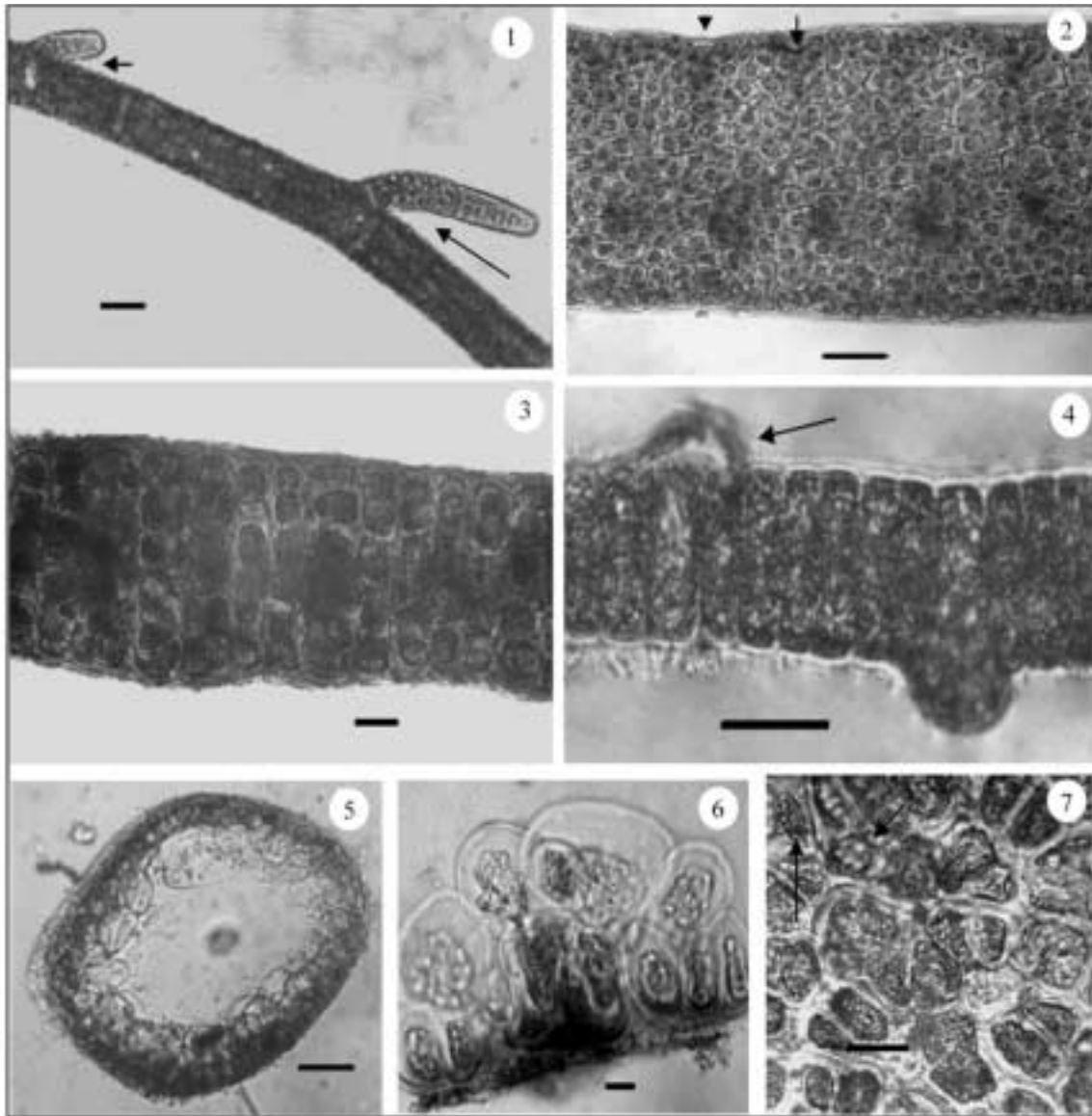
Thallus bluish green or deep green, filamentous, heterotrichous, profusely branched (Figs 8, 12), 220-2800 μm wide, 5-35 cm long, basal holdfast conical, main axis slightly constricted at the base, 218-360 μm wide (Fig. 16) and profusely branched at the apex (Fig. 11), corticated cells arranged in ring like fashion (Fig. 18), lateral branches making acute angle with main axis (Fig. 14), branches attenuated, alternate, 17.8-21.4 μm wide, 56-375 μm long, older branches and main axis multiseriate, constricted with spine-like out growths (Figs 9, 15); uniseriate, long, lateral branches irregularly arise from secondary as well as main axis, 7.6-15.3 μm wide, 30-230 μm long (Figs 10, 11), end rounded (Fig. 12), cells of uniseriate filaments 5.2-11 μm wide, 5.5-15.5 μm long, cortex 2 layered (Fig. 18), outer cells smaller than inner cell, polygonal; 10-20 μm wide, 19-36.6 μm long, chromatophores granulated and numerous; monosporangia pigmented, 10-18.3 μm in diameter (Fig. 17).

***Composogon coeruleus* (Bablis in C. Agardh) Montagne, Flore d'Algerie 1: 154, 1846**

(Figs 19-26)

[Syn: *Compsopogon hookeri* Montagne, Flore d'Algeria 1: 157, 1846]

Thallus greenish grey, profusely branched, filamentous, heterotrichous, holdfast conical or hemispherical, 270-1260 μm wide, 4-21 cm long; main axis cylindrical, multiseriate, corticated, 280-570 μm wide (Figs 19, 22), lateral branches alternate or on one side (Figs 20, 21), lateral branches at right angle to the main axis in older thallus (Fig. 22), young lateral branches tapered towards end, uniseriate (Fig. 23), cells discoid or barrel shaped,

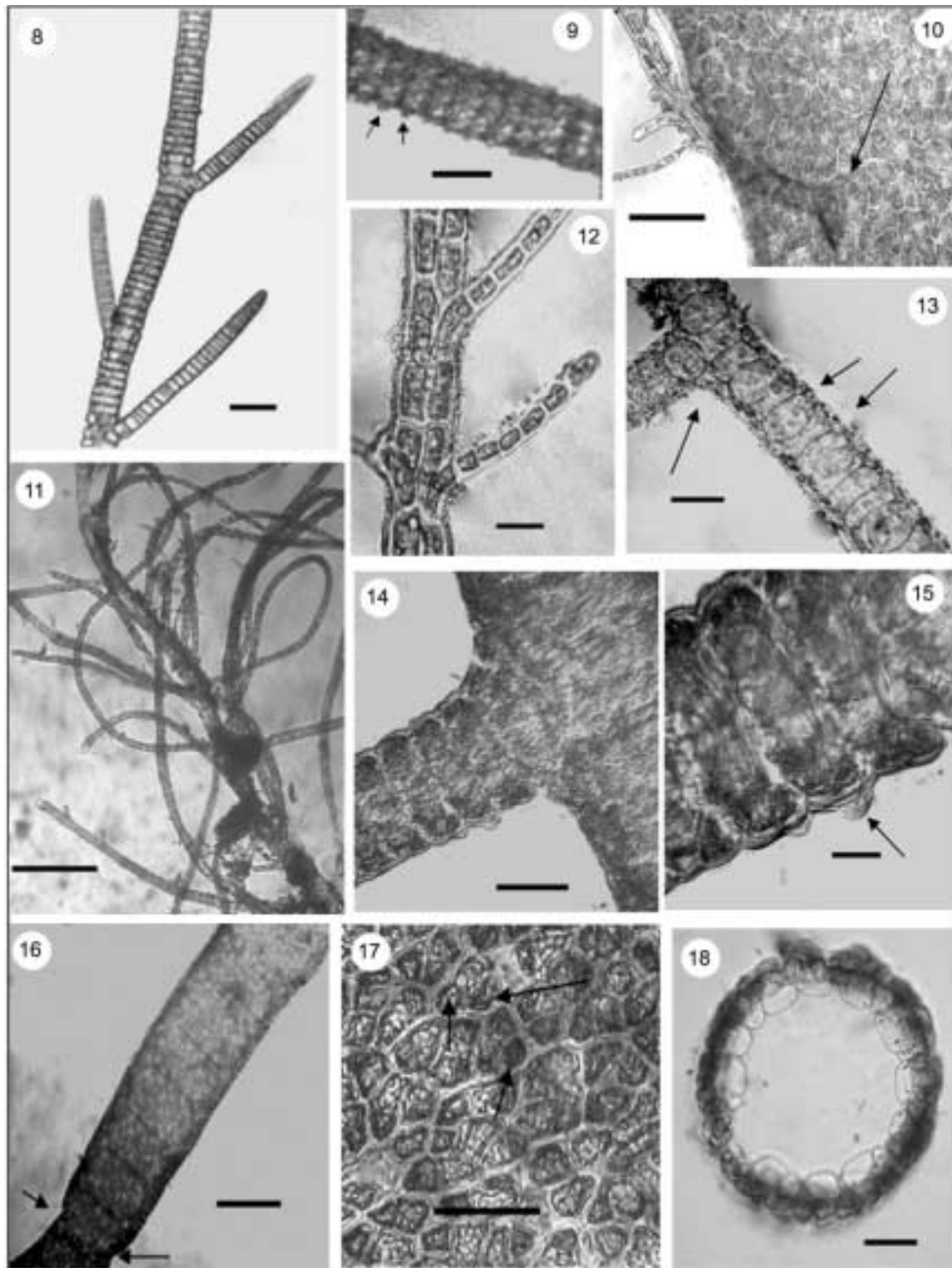


Figs 1-7. *Compsopogon coeruleus*: 1. Branchlet departing from the axis forming acute angle, scale bar = 50 μm ; 2. Corticated old branch showing constricted ring, scale bar = 50 μm ; 3. Barrel shaped cells in the younger portion of the thallus, scale bar = 20 μm ; 4. Thallus with monosporangia, scale bar = 20 μm ; 5. T.S. of thallus showing 3 layer of corticated cells, scale bar = 10 μm ; 6. T.S. of thallus showing cluster of monosporangia, scale bar = 10 μm ; 7. Surface of old branch showing cortical cells and monosporangia, scale bar = 20 μm .

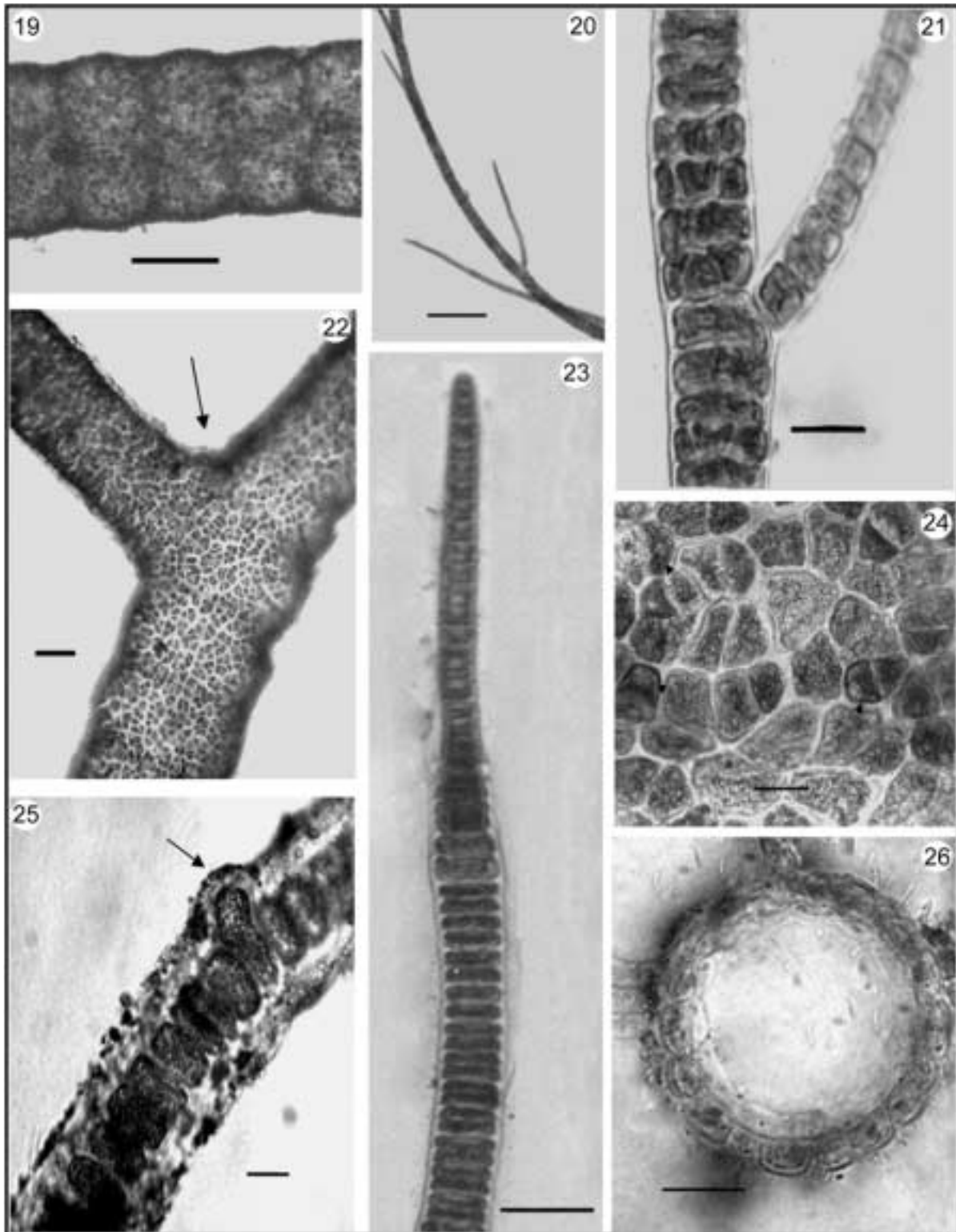
19-24.5 μm wide and 8-17 μm long (Figs 21, 24), cells of older branches polygonal, 10-25 μm wide, 30-40 μm long, cortex 2-3 layered, cells of inner side larger than cells of outer side (Fig. 26); monosporangia ovoid, pigmented (Fig. 25), 8.6-14 μm in diameter.

Compsopogon coeruleus [Syn: *C. aeruginosus*] was reported earlier in freshwater habitats in a river at Gujarat in the western region of India (Patel and Francies 1969), and also in a similar habitat at Bareilly in the northern region (Singh and Pandey 1986). However, we have collected the species from two estuarine habitats (Table 1). This shows that this taxa is not strictly a freshwater

species but also occur in estuarine habitats in the coastal regions. The other ecotype of *C. coeruleus* showed wider distribution in freshwaters of India as has been reported from several localities, e.g. in river water at Dehradun, Allahabad and Bareilly in the northern region (Das 1963, Yadava and Kumano 1985), in a tank of Kolkata in the eastern region (Brühl and Biswas 1923), in the garden ponds of Madras, Bangalore and Trivandrum in the southern region and also in streams at Rajasthan and Gujarat states in the western region of India (Vaidya 1968, Krishnamurthy 1962). *Compsopogon* species were reported earlier from clear water with high oxygen con-



Figs 8-18. Ecotype of *C. coeruleus* [Syn: *Compsopogon aeruginosus*] 8. Young portion of thallus with attenuated lateral branch, scale bar = 50 μm ; 9. Old branch with multiserial and constricted with spine like out growths, scale bar = 200 μm ; 10. Origin of lateral branch from main axis, scale bar = 100 μm ; 11. Tip of branch showing multilateral branches from the lateral axis, scale bar = 200 μm ; 12. Magnified view of uniseriate branches from the lateral axis, scale bar = 20 μm ; 13. Corticated cells arranged in ring like fashion and showing lateral branch at right angle to axis, scale bar = 100 μm ; 14. Older axis showing corticated and multiserial lateral branch, scale bar = 50 μm ; 15. Magnified view of corticated cells and spine like cells of the main axis, scale bar = 10 μm ; 16. Basal portion of thallus showing constricted portion close to holdfast, scale bar = 200 μm ; 17. Surface of old branch showing numerous polygonal corticated cells and monosporangia, scale bar = 50 μm ; 18. T.S. of thallus showing two layers of corticated cells, scale bar = 50 μm .



Figs 19-26. Ecotype of *C. coeruleus* [Syn: *Compsopogon hookeri*]: 19. Main axis with multiseriate corticated thallus, scale bar = 200 μm ; 20. Young portion of thallus showing lateral branch, scale bar = 200 μm ; 21. Young portion of thallus with lateral branch arising from a barrel shaped cell of the main axis, scale bar = 30 μm ; 22. Old thallus showing lateral branch arising at right angle to the main axis, scale bar = 100 μm ; 23. Tip portion of branchlet gradually attenuating towards apex, scale bar = 50 μm ; 24. Surface of old branch showing polygonal corticated cells and pigmented monosporangia, scale bar = 20 μm .; 25. Lateral branchlet initiation, scale bar = 20 μm ; 26. T.S. of thallus showing two layered of corticated cells, scale bar = 50 μm .

Table 2. Location and physico-chemical characteristics of the collection sites.

	<i>C. coeruleus</i>	Ecotype of <i>C. coeruleus</i> [Syn. <i>C. aeruginosus</i>]		Ecotype of <i>C. coeruleus</i> [Syn. <i>C. hookeri</i>]
Location with longitude and latitude	Vanivihar lake, Bhubaneswar (B) 20° 17' 54" N, 85° 50' 38" E	Chilika lagoon (CL) 19° 39' 38" N, 85° 11' 17" E	Kaluni channel (KC) 19° 56' 31" N, 86° 16' 44" E	Shallow pond, Berhampur (BE) 19° 19' 02" N, 84° 48' 50" E
Water temperature (°C)	24-27	20-28	25-27	26-29
pH	7.4-7.5	8.3-9.5	8.1-8.2	6.8-6.85
Conductivity (µS)	379-395	320-350	308-317	95-106
Dissolved oxygen (mg/L)	6.5-6.8	7.2-8.5	8.2-8.5	11.3-11.5
Salinity of water (ppt)	0.18-0.23	12-15	12.2-13.4	0.21-0.29

centration and low nutrient containing freshwater bodies (Sheath and Hambrook 1990). However, this ecotype occurred in a lake receiving sewage water and reported during January each year of study when the water temperature was 24 to 27°C. The third ecotype of *C. coeruleus* [Syn: *C. hookeri*] was reported only once from India in a temporary pool close to Kolkata (Brühl and Biswas 1924). In the present work it was recorded from a pond in the southern part of Orissa state consistently for three consecutive years starting from the winter to early summer season (December to April).

The three ecotypes of *Compsopogon coeruleus* recorded from the eastern region of India, were habitat specific. The ecotype *C. coeruleus* [Syn: *C. aeruginosus*] occurred in the estuarine habitats, whereas *C. coeruleus* and its another ecotype [Syn: *C. hookeri*] were strictly freshwater forms. Further, the later taxa [Syn: *C. hookeri*] occurred in an oligotrophic water body showing higher dissolved oxygen and could withstand a larger temperature range. Thus the present study showed that the three ecotypes of *Compsopogon coeruleus* occurred in a wide range of habitats ranging from estuarine to freshwater at varying conductivity levels, dissolved oxygen and the pH ranging from near neutral to alkaline conditions. They also maintained persistent morphological features while occurring in nature throughout the period of study. Hence, these morphological identities cannot be overlooked while making taxonomic revision of *Compsopogon*.

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REFERENCES

- Adoni A.D. 1985. *Workbook on Limnology*. Pratibha publishers, Sagar, India.
- Barenas H. 1959. *Apparatus and Methods of Oceanography*, Part-I. Chemical. George Allen and Unwin Ltd., London, pp. 341.
- Bold H.C. and Wynne J.M. 1978. *Introduction to the Algae: Structure and Reproduction*. Prentice-Hall Inc., N.Y. USA.
- Brühl P. and Biswas K. 1923. Commentions Algologica III, on a species of *Compsopogon* growing in Bengal. *J. Dept. Sci., Calcutta Univ.* 5: 1-6.
- Brühl P. and Biswas K. 1924. Commentions Algologica IV, *Compsopogon lividus* (Hooker) De Tone. *J. Dept. Sci., Calcutta Univ.* 6: 1-3.
- Das C.R. 1963. The Compsopogonales in India (A systematic account of India representatives of the order). *Proc. Natl. Inst. Sci., India* 29: 239-243.
- Desikachary T.V., Krishnamurthy V. and Balakrishnan M.S. 1990. *Rhodophyta*. Madras Science Foundation, Madras, India.
- Dixon P.S. 1973. *Biology of the Rhodophyta*. Hafner Press, New York.
- Fritsch F.E. 1945. *The Structure and Reproduction of the Algae*. Vol. 2. Cambridge University Press, Cambridge.
- Garbary D.J., Hansen G.I. and Scagel R.F. 1980. A revised classification of the Bangiophyceae (Rhodophyta). *Nova Hedwigia* 33: 145-166.
- Krishnamurthy V. 1953. On the structure and reproduction of *Compsopogon* from Madras. *Phytomorphology* 3: 369-379.
- Krishnamurthy V. 1962. The morphology and taxonomy of the genus *Compsopogon* Montagne. *J. Linnaea Soc. (Botany)* 58: 207-222.
- Kützing F.T. 1849. *Species Algarum*. F.A. Brockhaus, Leipzig.
- Montagne J.F.C. 1846-69. Algae. In: Durieu de Maisonneuve M.C., Montagne J.F.C., Bory de saint-vincent J.B.G.M., Tulasne L.R., Tulasne C. and Leveille J.H. (eds), *Flore d'Algérie Cryptogamie, premiere partie*. Imperiale, Paris, pp. 631.
- Necchi Jr O. and Dip M.R. 1992. The family Compsopogonaceae (Rhodophyta) in Brazil. *Algol. Stud.* 66: 105-118.

- Necchi Jr O., Goes R.M. and Dip M.R. 1990. Phenology of *Compsopogon coeruleus* (Balbis) Montagne (Compsopogonaceae, Rhodophyta) and evaluation of taxonomic characters of the genus. *Jpn. J. Phycol.* **38**: 1-10.
- Patel R.J. and Francis M.A. 1969. Some interesting observations on *Compsopogon aeruginosus* (J.Ag.) Kützing var. *catenatum*. *Phykos* **19**: 15-22.
- Sheath R.G. and Hambrook J.A. 1990. Freshwater ecology. In: Cole K.M. and Sheath R.G. (eds), *Biology of the Red Algae*. Cambridge University Press, Cambridge. pp. 423-453.
- Shyam R. and Sarma Y.S.R.K. 1980. Cultural observations on the morphology, reproduction and cytology of a freshwater red alga *Compsopogon* Mont. from India. *Nova Hedwigia* **32**: 745-765.
- Singh N.B. and Pandey D.C. 1986. A new form of *Compsopogon aeruginosus* (J. Ag.) Kützing. *Phykos* **25**: 84-87.
- Rintoul T.L., Sheath R.G. and Vis M.L. 1999. Systematics and biology of the Compsopogonales (Rhodophyta) with emphasis on the freshwater families in North America. *Phycologia* **38**: 517-527.
- Vaidya B.S. 1968. A note on record of *Compsopogon coeruleus* Mont. from Gujarat. *Curr. Sci.* **37**: 144.
- Vis M.L., Sheath R.G. and Cole K.M. 1992. Systematics of the freshwater red algae family Compsopogonaceae in North America. *Phycologia* **31**: 564-575.
- Yadava R.N. and Kumano S. 1985. *Compsopogon prolificus* sp. nov. (Compsopogonaceae, Rhodophyta) from Allahabad, Uttar Pradesh in India. *Jpn. J. Phycol.* **33**: 13-20.
- Yadava R.N. and Pandey D.C. 1980. Observations on a new variety of *Compsopogon*, *C. aeruginosus* (J. Ag.) Kützing var. *catenaum* var. nov. *Phykos* **19**: 15-22.

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