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RESEARCH ARTICLE

Distribution of *Compsopogon caeruleus* (Balbis ex C.Agardh) Montagne (Compsopogonales, Compsopogonophyceae) in West Bengal, India

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ABSTRACT

Compsopogon caeruleus (Balbis ex C. Agardh) Montagne is among the most diverse freshwater red algae, with a widespread distribution across North America, South America, Europe, Africa, Asia, Australasia, and Oceania. Highly adaptable to varied environmental conditions, it thrives in freshwater habitats such as streams, rivers, ponds, and lakes, as well as in brackish ecosystems like lagoons and estuaries. In India, *Compsopogon caeruleus* is widely distributed, with extensive documentation across multiple states. In West Bengal, previous studies have primarily reported its occurrence in the southern Gangetic plains and estuarine regions, while its diversity in the northern districts remains largely unexplored. This article investigates the extensive diversity of *Compsopogon caeruleus* in northern West Bengal, highlighting its ecological significance, agricultural utilization, and global conservation status.

Keywords: *Compsopogon caeruleus, Diversity, Freshwater flora, Red Algae, West Bengal.*

INTRODUCTION

Compsopogon caeruleus (Balbis ex C.Agardh) Montagne, is one of the highly cosmopolitan organisms among the freshwater red algae. This alga has been reported in different aquatic habitats and various environmental conditions. It is found worldwide, with a higher prevalence in tropical and subtropical regions. It can also occasionally be found in northern temperate areas, such as the northern United States, Europe, Japan, and Ukraine (Vis *et al.,* 1992; Rintoul *et al.,* 1999).

Historically, the family Compsopogonaceae comprised eleven species of *Compsopogon* and three species of *Compsopogonopsis*. *Compsopogon* species were distinguished by their rhizoids, which are confined to the thallus base, whereas *Compsopogonopsis* species have rhizoidal outgrowths throughout the plant. Key characteristics for species identification within the genus include the structure of the basal portion of the thallus, the branching pattern, the size of monosporangia, the number of cortical layers, and the size of cortical cells. The thallus is highly branched, saxicolous or epiphytic, filamentous, uniseriate in younger parts, and multiseriate in older parts. A variable number of cortical layers surrounds the axial cell, and the organism reproduces asexually, lacking a sexual life cycle.

However, these thallus characteristics exhibit significant variation between populations and also change with seasons. In a taxonomic revision of the family Compsopogonaceae, Necchi & Dip in 1992,

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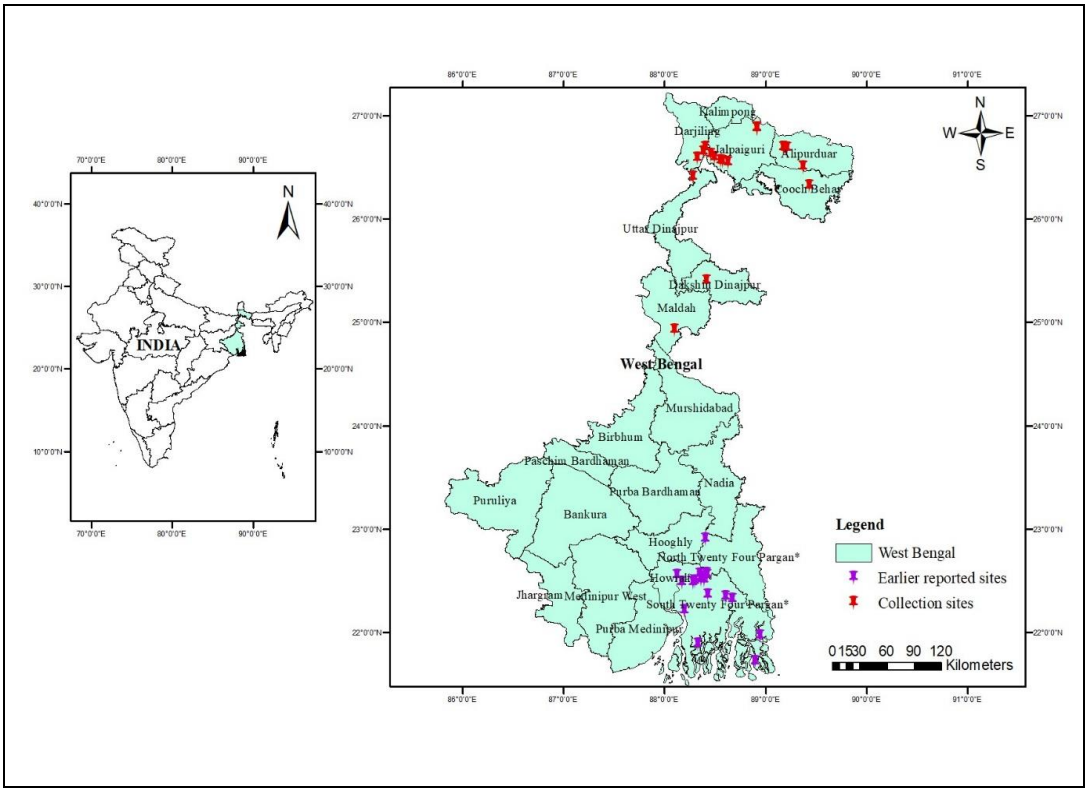
classified all taxa into two clearly defined species: *Compsopogon caeruleus* (lacking rhizoidal filaments in the cortex) and *Compsopogon leptocladus* (possessing such filaments in the cortex). Using multivariate morphometrics and image analysis, Vis *et al.,* (1992) grouped several taxa of Compsopogonaceae into three species: *Compsopogonopsis leptocladus* (Montagne) Krishnamurthy (characterized by rhizoidal cortication throughout the plant), *Compsopogon prolificus* Yadav & Kumano (with U-shaped lateral branches curling around the central axis), and *Compsopogon coeruleus* (Balbis) Montagne (featuring uncurled branches in the axis). Their study also highlighted that microsporangial clusters, the basal system of the thallus, and spine-like branches exhibit significant variability, rendering them unreliable as diagnostic taxonomic characters (Vis *et al.,* 1992). Based on molecular studies by Necchi *et al.,* (2013), all reported species of the *Compsopogon* genus were synonymized under a single species, *Compsopogon caeruleus* (Balbis ex C.Agardh) Montagne. In this article, all the species previously reported from West Bengal and currently collected specimens are considered as *Compsopogon caeruleus* (Balbis ex C.Agardh) Montagne.

MATERIALS AND METHODS

The study was conducted after a detailed review of the literature, which showed no reports of Compsopogonaceae members from northern districts. Hence, the field survey to the northern districts of West Bengal (WB) was carried out in December 2023. All the collected samples were preserved and processed correctly (Elaya Perumal *et al.,* 2015; Elaya Perumal & Sundararaj, 2019, 2020), and the specimens are housed at CAL (Central National Herbarium, Howrah, WB). Slides were prepared using methods described by Elaya Perumal & Sundararaj (2019, 2020). Microphotographic documentation, along with morphological and morphometric analyses, was conducted using a Nikon Advanced Research Microscope (Nikon Eclipse Ni Series: H600L) in conjunction with NIS-Elements software. Organisms were identified based on standard monographs and various research publications, including Elaya Perumal & Sundararaj (2023). The geographic distribution of the *Compsopogon* species in WB was mapped using ArcGIS software (ArcMap desktop version 10.2.2), providing a spatial representation of sampling locations (Map 1).



Map. 1: Geographic map shows the distribution of *Compsopogon caeruleus* in West Bengal based on current study and earlier reports.

RESULTS & DISCUSSIONS

Freshwater red algal samples were collected from 34 locations across West Bengal during an extensive field survey conducted in December, 2023. Of these, 22 samples contained members of the family Compsopogonaceae, 10 samples included Batrachospermaceae, and 2 samples harboured species of Audouinellaceae. These collections were made from seven northern districts: Alipurduar, Cooch Behar, Dakshin Dinajpur, Darjeeling, Jalpaiguri, Malda, and Uttar Dinajpur (Table 1). Previous studies had reported the presence of *Compsopogon caeruleus* (Balbis ex C.Agardh) Montagne primarily in a few southern districts (Ganesan *et al.,* 2018; Elaya Perumal & Palanisamy, 2025); however, the current investigation reveals significant species diversity in northern regions as well (Map. 1). This study effectively expands the known distribution range of *Compsopogon caeruleus*, documenting its presence in seven additional districts of West Bengal, marking the first recorded occurrence of this species in these seven districts. The collected *Compsopogon* specimens exhibited a diverse range of morphological characteristics, consistent with descriptions from previous studies. The thalli varied significantly in size, ranging from microscopic forms to those several meters in height, highlighting the species' remarkable structural plasticity (Necchi *et al.,* 2013).

This study reveals the occurrence of *Compsopogon caeruleus* across a range of physicochemical conditions (Table 2). Atmospheric temperatures recorded at the collection sites ranged from 20.2°C to 28.6°C, while corresponding water temperatures varied between 19.0°C and 26.8°C during the winter season (December 2023). Incident light intensity during sampling spanned 105.34 to 2024 µmol photons m^{-2} s^{-1}. Water physico-chemical parameters, such as pH, were in the range of 6.6 to 8.7, suggesting the species' tolerance to slightly acidic to alkaline conditions. Electrical conductivity fluctuated between 64 and 398 µS/cm, and total dissolved solids (TDS) ranged from 32 to 172 ppm, reflecting moderate mineral content and low to mild levels of pollution. These observations are consistent with earlier findings (Wehr & Sheath, 2003; Liu & Wang, 2004; Liu *et al.,* 2004), which reported the species' affinity for clear, temperate waters with moderate nutrient loads and its resilience to slight anthropogenic disturbances. The current data further support the ecological plasticity of *Compsopogon caeruleus*, indicating its ability to inhabit clear to slightly turbid habitats and persist across a broad spectrum of environmental parameters.

Recent studies have highlighted the potential of red algae as sustainable biofertilizers and plant growth promoters. Polysaccharides and bioactive compounds from red algae play a vital role in enhancing plant growth and resilience. Their multifunctional properties support nutrient uptake, stress tolerance, and sustainable agricultural productivity (Trivedi *et al*., 2023). Biostimulants derived from red algae enhance plant vitality by supplying essential nutrients and bioactive molecules. These natural compounds help plants to withstand abiotic stress through improved physiological and biochemical resilience (Banakar *et al.,* 2022). These findings support the broader use of red algal biomass in promoting plant health and productivity through natural, eco-friendly means. In parallel, *Compsopogon caeruleus*, a freshwater red alga, has shown remarkable ecological tolerance, particularly its ability to thrive in slightly polluted or thermally impacted water bodies (Andrzej & Andrzej, 2022). This resilience makes it a promising candidate for integrated aquaculture-agriculture systems. Its cultivation along with rice plants could serve dual purposes: biomass production for biofertilizer use and phytoremediation of agricultural runoff. The species' adaptability to variable water quality conditions and its capacity to colonize submerged surfaces further enhance its utility in such agroecological models. Together, these insights underscore the untapped potential of red algae in sustainable agriculture, particularly in regions where water quality and soil fertility are limiting factors.

SYSTEMATIC TREATMENT

Compsopogonophyceae G.W.Saunders & Hommersand

Compsopogonales Skuja

Compsopogonaceae F.Schmitz

Compsopogon Montagne

Compsopogon caeruleus (Balbis ex C.Agardh) Montagne, Sciences physiques. Botanique. Cryptogamie. 1:154. 1846; *Conferva caerulea* Balbis ex Agardh, 1824; *Compsopogon aeruginosus* (J.Agardh) Kützing, 1849; *Compsopogon aeruginosus* (J. Agardh) Kützing var. *catenatum* Yadava, &

Table 1. Field Location Data of Collection Sites

S.No.	Field No.	Date	Locality	Geo-coordinates	Habitat	Notes	Collected By
1	CNH-BSI-97703	12.12.2023	Torsa River Bank, Cooch Behar, WB	26.316139, 89.435556	River	Microscopic, Attached on green macroalgae	Dr. U Elaya Perumal
2	CNH-BSI-97709	12.12.2023	Sonapur, Alipurduar District, WB	26.499052, 89.373532	Stream	Microscopic, Attached on green macroalgae	Dr. U Elaya Perumal
3	CNH-BSI-97715	13.12.2023	Madhya Rangali, Alipurduar District, WB	26.681779, 89.216266	River	Fast flowing river with sandy bottom and grass and *Vallisneria* plants	Dr. U Elaya Perumal
4	CNH-BSI-97717	13.12.2023	Madhya Rangali Bazar, Alipurduar District, WB	26.682644, 89.207647	Stream	Slow flowing stream with sandy bottom and submerged stones	Dr. U Elaya Perumal
5	CNH-BSI-97718	13.12.2023	Madhya Rangali Bazar, Alipurduar District, WB	26.684339, 89.199071	River	Moderately flowing river with sandy bottom and submerged stones	Dr. U Elaya Perumal
6	CNH-BSI-97719	13.12.2023	Uttar Sisubari, Alipurduar District, WB	26.686944, 89.187128	Small River	Moderately flowing small river with sandy bottom and submerged stones	Dr. U Elaya Perumal
7	CNH-BSI-97720	13.12.2023	Uttar Sisubari, Alipurduar, WB District	26.689404, 89.179763	Stream	Slow flowing stream with sandy bottom	Dr. U Elaya Perumal
8	CNH-BSI-97721	13.12.2023	Uttar Sisubari, Alipurduar District, WB	26.689812, 89.179731	Stream	slow flowing river with sandy bottom, very less amount of water	Dr. U Elaya Perumal
9	CNH-BSI-97727	14.12.2023	Near Nagarakata Toll Plaza, Jalpaiguri District, WB	26.875417, 88.919833	Stream	Moderately flowing stream with sandy bottom and submerged stones	Dr. U Elaya Perumal
10	CNH-BSI-97728	14.12.2023	Near Nagarakata Toll Plaza, Jalpaiguri District, WB	26.875417, 88.919833	Stream	Moderately flowing stream with sandy bottom and submerged stones	Dr. U Elaya Perumal
11	CNH-BSI-97730	14.12.2023	Near Nagarakata Toll Plaza, Jalpaiguri District, WB	26.874822, 88.918315	Stream	Moderately flowing stream with alluvial bottom	Dr. U Elaya Perumal
12	CNH-BSI-97761	16.12.2023	Jalpaiguri, Nokha ghat, Jalpaiguri District, WB	26.687936, 88.405251	River	Moderately flowing river with sandy and gravel stones as bottom	Dr. U Elaya Perumal
13	CNH-BSI-97763	17.12.2023	Chauli River, Sukani, Jalpaiguri District, WB	26.564279, 88.555898	River	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal
14	CNH-BSI-97765	18.12.2023	NH 27, Bahadur, Jalpaiguri District, WB	26.541577, 88.628056	River	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal
15	CNH-BSI-97766	18.12.2023	Talma River, Jhabera Vita, Jalpaiguri District, WB	26.557071, 88.578075	River	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal

Table1. Continued..

S.No.	Field No.	Date	Locality	Geo-coordinates	Habitat	Notes	Collected By
16	CNH-BSI-97767	18.12.2023	Kartowa Bridge, Balai Gachh, Jalpaiguri District, WB	26.593877, 88.49686	River	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal
17	CNH-BSI-97769	18.12.2023	Sau Bridge, Jugibhita, Jalpaiguri District, WB	26.622727, 88.458043	River	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal
18	CNH-BSI-97770	18.12.2023	Rahamu, Darjeeling District, WB	26.647203, 88.386244	Stream	Moderately flowing stream with gravel stones and sandy bottom	Dr. U Elaya Perumal
19	CNH-BSI-97774	18.12.2023	Kantibhita, Darjeeling District, WB	26.585275, 88.325175	Stream	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal
20	CNH-BSI-97776	18.12.2023	Uttar Bhagalpur, Uttar Dinajpur, WB	26.406195, 88.282779	River	Moderately flowing river with gravel stones and sandy bottom	Dr. U Elaya Perumal
21	CNH-BSI-97781	20.12.2023	Tangaon River, Bansihari, Dakshin Dinajpur District, WB	25.39609, 88.416258	River	Moderately flowing river with sandy bottom and submerged rocks	Dr. U Elaya Perumal
22	CNH-BSI-97785	21.12.2023	Ramchandrapur, Malda district, WB	24.924983, 88.099551	River	Moderately flowing river with sandy bottom and submerged rocks	Dr. U Elaya Perumal

Table 2. Ecological and Physico-chemical parameters of sampling sites

S. No	Field Number	Altitude (m) mean sea level	pH	Water Temperature (°C)	Atmospheric Temperature (°C)	Light Intensity (µmol/s/m²)	Total Dissolved Solids (ppm)	Electrical Conductivity (µS/cm)
1	CNH-BSI-97703	64	7.6	20.1	21	211.6	93	186
2	CNH-BSI-97709	80	8.3	23	24.5	828	98	196
3	CNH-BSI-97715	106	7.6	23	24.5	736	149	236
4	CNH-BSI-97717	105	7.8	25	26	828	108	216
5	CNH-BSI-97718	105	7.6	26	26.8	598	112	224
6	CNH-BSI-97719	110	7.8	26.3	27	736	108	216
7	CNH-BSI-97720	112	7.8	26.6	27	736	172	398
8	CNH-BSI-97721	112	7.8	26.6	27	736	172	398
9	CNH-BSI-97727	182	7	19.6	20.2	105.34	33	66
10	CNH-BSI-97728	182	7	19.6	20.2	105.34	33	66
11	CNH-BSI-97730	176	6.6	22	22.9	110.4	52	104
12	CNH-BSI-97761	133	8.7	26.5	27.8	506	35	70
13	CNH-BSI-97763	111	7.6	21.9	22	529	53	106
14	CNH-BSI-97765	107	8.2	19.3	20	529	53	106
15	CNH-BSI-97766	147	7.6	19	21.5	874	32	64
16	CNH-BSI-97767	115	7.6	22	23	1104	39	78
17	CNH-BSI-97769	120	7.8	23.5	24	1449	33	66
18	CNH-BSI-97770	125	7.4	26.3	27.8	2024	49	98
19	CNH-BSI-97774	120	7.8	28.5	30	1426	40	82
20	CNH-BSI-97776	92	7.8	26.5	28.6	2024	49	100
21	CNH-BSI-97781	53	7.8	26.6	28	2208	69	136
22	CNH-BSI-97785	44	7.8	26.8	28.6	1978	136	276

Pandey, 1980; *Compsopogon chalybeus* Kützing, 1849; *Compsopogon hookeri* Montagne, 1846; *Compsopogon lividus* De Toni, 1897; *Compsopogon indicus* Das, 1963; *Compsopogon iyengarii* Krishnamurthy, 1958; *Composopogon prolificus* Yadava & Kumano, 1985; *Compsopogonopsis japonica* Chihara, 1976; *Compsopogon corinaldii* (Meneghini) Kutzing, 1857; *Compsopogon sparsus* S.L.Xie & Y.J.Ling, 1998.Fig. 1-27.

Vernacular /Common Name: Staghorn algae

The *Compsopogon* specimens exhibited diverse morphological characteristics, occurring either as free-floating or attached to various substrates, including aquatic plants (*Vallisneria* sp.), green algae (*Cladophora* sp., *Pithophora* sp.), submerged rocks, and lifeless materials (dead wood, plastics, cloths, etc.) in streams and rivers. The thallus colouration ranged from blue-green to olivaceous green, with heights varying from 0.1 cm to 120 cm and diameters between 0.1 mm to 2 mm. Basal discs facilitated attachment to the host surface, while the thallus was either distinctly constricted or unconstricted, with apex attenuation varying towards both the tip and base. Branching patterns were highly variable, with branches occurring alternately or irregularly. Some specimens exhibited abundant branching, while others showed minimal branching, with branch angles ranging between 10 °Δ and 90 °Δ. The thallus gradually attenuated towards the tips, though some specimens displayed abrupt constriction at the apex. Axial cells measured between 20.00 to 522.50 µm in height and 60.00 to 550.75 µm in breadth, while apical cells were depressed spherical structures, approximately 12-14 µm in diameter. The thallus was corticated with 1-3 layers of cortical cells, and their size ranged from 10.50 to 65.50 µm in length and 15.00 to 30.50 µm in breadth. These cortical cells divided obconically and formed monosporangia,

Fig. 1-9. Collection locations in Northern districts of West Bengal

1. River near Madhya Rangali gaon, Alipruduar district; 2. Small stream near Nagarakata Toll Plaza, Jalpaiguri District; 3. River, at Sau bridge, Jalpaiguri District; 4.Tangaon River, Bansihari, Dakshin Dinajpur District; 5. *Compsopogon caeruleus* growing on the sandy bottom of the river in Jalpaiguri District; 6. Stream near Madhya Rangali Bazar, Alipruduar District; 7. Big stream near Nagarakata toll plaza, Jalpaiguri district; 8: Mahananda river, Jalpaiguri-Nokha ghat, Jalpaiguri district; 9. Talma River, Talma, Jalpaiguri District

with diameters ranging from 8.50 to 32.80 µm. The liberated monospore adhered to a host, enlarged, and subsequently divided to initiate new thallus growth, establishing attachment on the host.

DISTRIBUTION: India-Arunachal Pradesh, Assam, Bihar, Gujarat, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Maharashtra, Madhya Pradesh, New Delhi, Odisha, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal- North 24 Parganas, South 24 Parganas, Hoogly, Howrah Districts (Ganesan *et al.,* 2018; Elaya Perumal & Palanisamy 2025). **Global** - Austria, Britain, Ireland, Croatia, Czech Republic Czechia, France, Germany, Italy, Malta, Poland, Arkansas, Florida, Louisiana, Mexico, New Mexico, North Carolina, Cuba, Lesser Antilles, Martinique, W. Atlantic, Argentina, Brazil, Paraguay, Algeria, Mauritius, Egypt, Iraq, Bangladesh, India, Khandesh, Indonesia, Malaysia, Thailand, Viet Nam, China, Japan, Taiwan, Australia, New South Wales, New Zealand, Queensland, Australia, Hawaiian Islands, Vanuatu (Elaya Perumal & Palanisamy, 2025).

SPECIMENS EXAMINED: India- West Bengal, Cooch Behar District, Cooch Behar, Torsa River Bank, 12.12.2023, Dr. U Elaya Perumal, CNH-BSI-97703 (CAL); Alipurduar District, Sonapur, Stream, 12.12.2023, Dr. U Elaya Perumal, CNH-BSI-97709 (CAL); Alipurduar

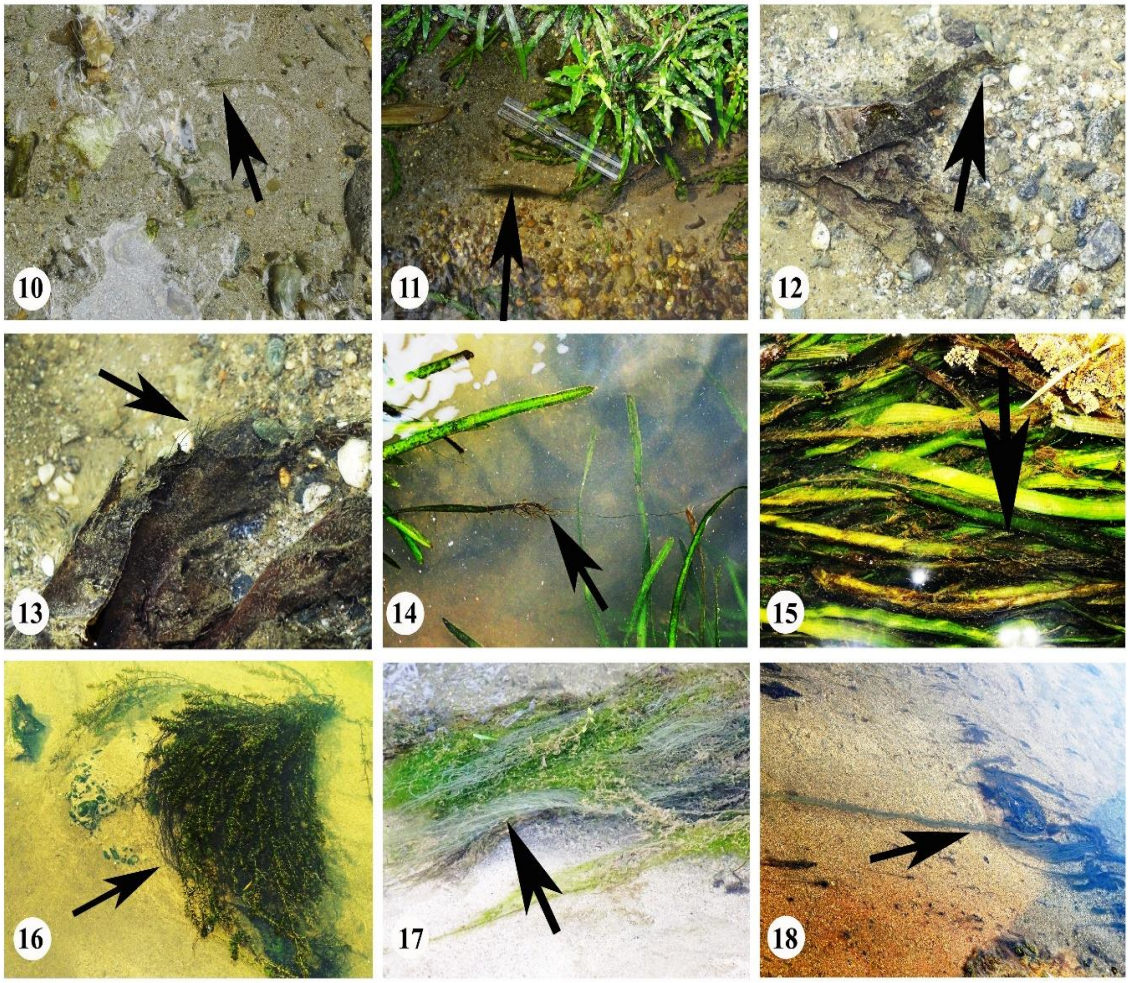


Fig. 10-18, Habitats of *Compsopogon caeruleus* from northern West Bengal

10. *Compsopogon caeruleus* growing on sandy bottom & pebbles of slow-flowing stream; 11,14,15. *Compsopogon caeruleus* growing on *Vallisneria* plant leaves; 12,13. Thallus growing on submerged waste plastic; 16. Thallus growing on *Hydrilla* plant; 17. Thallus growing along with other algae attached to the sandy bottom of the stream; 18. Thallus growing attached to the sandy bottom of river.

District, Madhya Rangali, River Bank, 13.12.2023, Dr. U Elaya Perumal, CNH-BSI-97715 (CAL); Alipurduar District, Madhya Rangali Bazar, stream, 13.12.2023, Dr. U Elaya Perumal, CNH-BSI-097717 (CAL); Alipurduar District, Madhya Rangali Bazar, River, 13.12.2023, Dr. U Elaya Perumal, CNH-BSI-97718 (CAL); Alipurduar District, Uttar Sisubari, river, Dr. U Elaya Perumal, CNH-BSI-97719; Alipurduar District, Uttar Sisubari, stream, 13.12.2023, Dr. U Elaya Perumal, CNH-BSI-97720 (CAL); Alipurduar District, Uttar Sisubari, stream, 13.12.2023, Dr. U Elaya Perumal, CNH-BSI-97721 (CAL); Jalpaiguri District, Near Nagarakata Toll Plaza, Big stream, 14.12.2023, Dr. U Elaya Perumal, CNH-BSI-97727 (CAL); Jalpaiguri District, Near Nagarakata Toll Plaza, small stream, 14.12.2023, Dr. U Elaya Perumal, CNH-BSI-97728 (CAL); Jalpaiguri District, Near Nagarakata Toll Plaza, stream, 14.12.2023, Dr. U Elaya Perumal, CNH-BSI-97730; Jalpaiguri District, Jalpaiguri, Nokha ghat, River, 16.12.2023, Dr. U Elaya Perumal, CNH-BSI-97761 (CAL); Jalpaiguri District, Sukani, Chauli River, 17.12.2023, Dr. U Elaya Perumal, CNH-BSI-97763 (CAL); Jalpaiguri District, Bahadur, stream, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97765 (CAL); Jalpaiguri District, Jhabera Vita, Talma river, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97766 (CAL); Jalpaiguri District, Balai Gachh, Kartowa Bridge, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97767 (CAL); Jalpaiguri District, Jugibhita, Sau Bridge, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97769 (CAL); Darjeeling District, Rahamu,

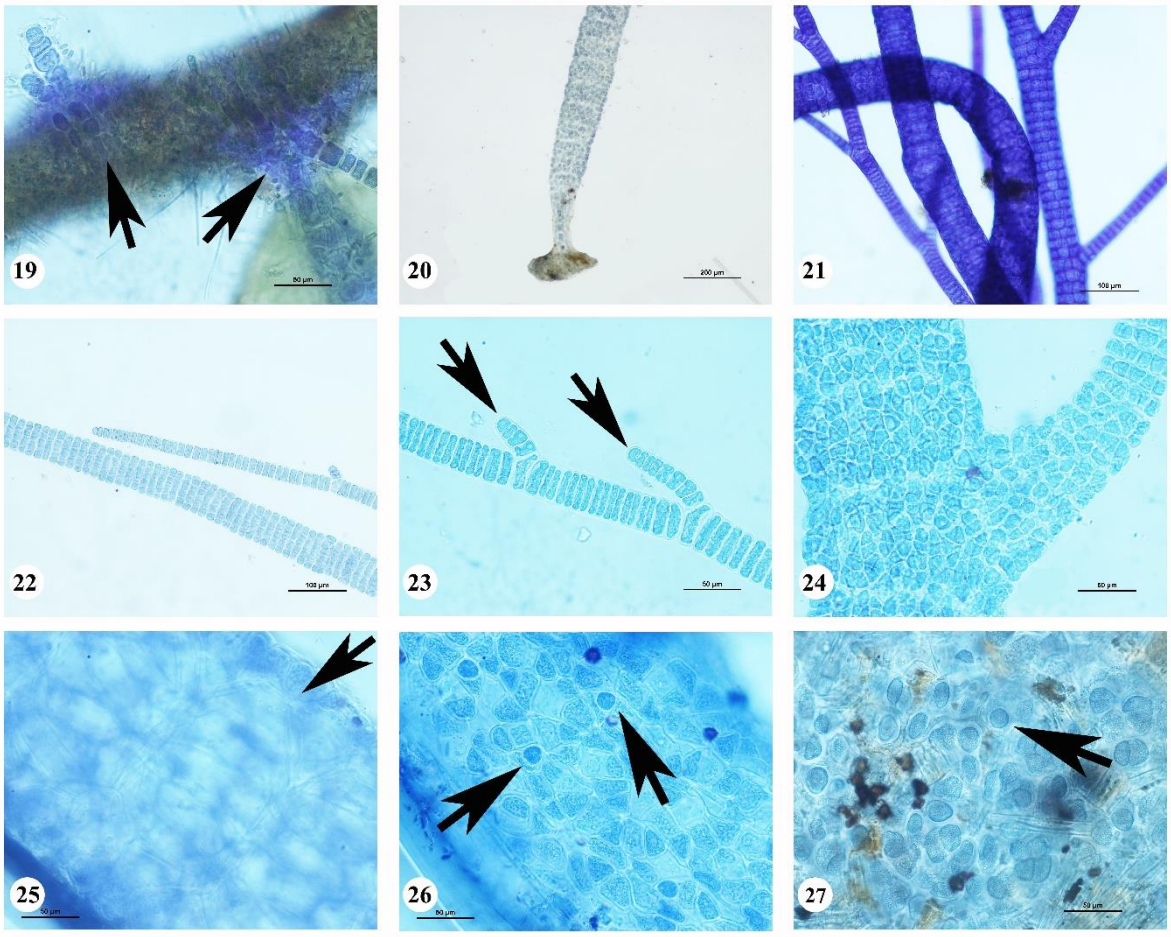


Fig. 19-27, Microscopic images of *Compsopogon caeruleus*

19. Microscopic thallus growing on green algae; 20. Basal disc and axial thallus; 21. Thalli showing branches and axial cells covered with cortical cells; 22. Young thalli part; 23. Apical cells and undivided axial cells; 24. Thalli covered with cortical cells; 25. Thallus focused to show axial cells; 26-27. Thallus focused to show monospore and cortical cells.

Stream, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97770 (CAL); Darjeeling District, Kantibhita, Stream, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97774; Uttar Dinajpur, Uttar Bhagalpur, River, 18.12.2023, Dr. U Elaya Perumal, CNH-BSI-97776 (CAL); Dakshin Dinajpur District, Bansihari, Tangaon River, 20.12.2023, Dr. U Elaya Perumal, CNH-BSI-97781 (CAL); Malda district, Ramchandrapur, River, 21.12.2023, Dr. U Elaya Perumal, CNH-BSI-97785 (CAL).

IUCN CONSERVATION STATUS: Least Concern (LC)

Despite potential threats from increasing anthropogenic activities and habitat degradation, *Compsopogon caeruleus* exhibits a widespread global distribution and remarkable adaptability to extreme (polluted) climatic conditions, where many other red algae struggle to survive. The species is documented across most continents. In India, *Compsopogon caeruleus* is widely distributed, with extensive documentation across multiple states. The corresponding author has critically studied the alga in various states and documented its presence in a few previous publications (Elaya Perumal & Sundararaj, 2023; Elaya Perumal & Palanisamy, 2025). Based on these observations, the authors conclude that the species maintains a substantial population across many studied locations, with only a few sites exhibiting lower population densities. This alga commonly forms dense populations, where mature individuals are frequently abundant, often numbering over 100 within a single subpopulation. However, in a few populations, it is observed at lower densities, with fewer than 50

mature individuals. This alga is commonly found from the monsoon through mid-to-late summer in many locations. In certain areas, however, it appears predominantly in the post-monsoon season. Even though this alga shows adaptability to pollution, it is not found in waters with high pollution (domestic and industrial polluted water bodies). Therefore, increasing anthropogenic pressures and water pollution may pose a growing threat to its long-term persistence. Nonetheless, based on its broad distribution, ecological resilience, and stable populations across multiple regions, this study provisionally assesses *Compsopogon caeruleus* as Least Concern (LC) under IUCN criteria.

CONCLUSION

The present study significantly extends the known distribution of *Compsopogon caeruleus* in West Bengal, revealing its presence in seven additional northern districts. This finding highlights the broader ecological adaptability of the species, suggesting its potential resilience in varied aquatic environments. Furthermore, the observed morphological diversity among collected specimens underscores the species' structural plasticity, aligning with previous taxonomic descriptions. Given that earlier studies primarily reported *Compsopogon caeruleus* in southern districts, these findings contribute valuable new insights into its geographical range and habitat preferences. *Compsopogon caeruleus* is provisionally assessed as Least Concern (LC) in this study, given its widespread distribution and ecological resilience, though localized threats from anthropogenic activities warrant continued monitoring. The authors propose co-cultivating *Compsopogon caeruleus* alongside rice plants, enabling its direct use as a biofertilizer within the same agricultural landscape, thereby enhancing soil fertility and reducing dependence on synthetic inputs.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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