

Research Article

## Rediscovery of *Westiellopsis interrupta* Kanthamma (Nostocales: Hapalosiphonaceae) from the South West Coast of India and a new addition to the marine cyanobacterial flora

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### ABSTRACT

*Westiellopsis interrupta* Kanthamma 1972 was rediscovered from the mangrove ecosystem of the South West Coast of India after a lapse of 48 years. The taxon was first discovered from the paddy field soils. Its rediscovery is documented by a specimen recently collected from the mangrove ecosystem at Alappuzha, extending its distribution within the Indian subcontinent. Currently, all the valid species of *Westiellopsis* originated from India. None of the species was reported from the marine habitat. Therefore, the occurrence of the species, *W. interrupta* Kanthamma 1972 regarded new addition to the marine cyanobacterial flora. Detailed taxonomic descriptions, distribution, photomicrographs, habitat and ecology of *W. interrupta* are provided for ease of understanding.

**Key words:** *Westiellopsis*, taxonomy, distribution, mangrove ecosystem, Kerala

### INTRODUCTION

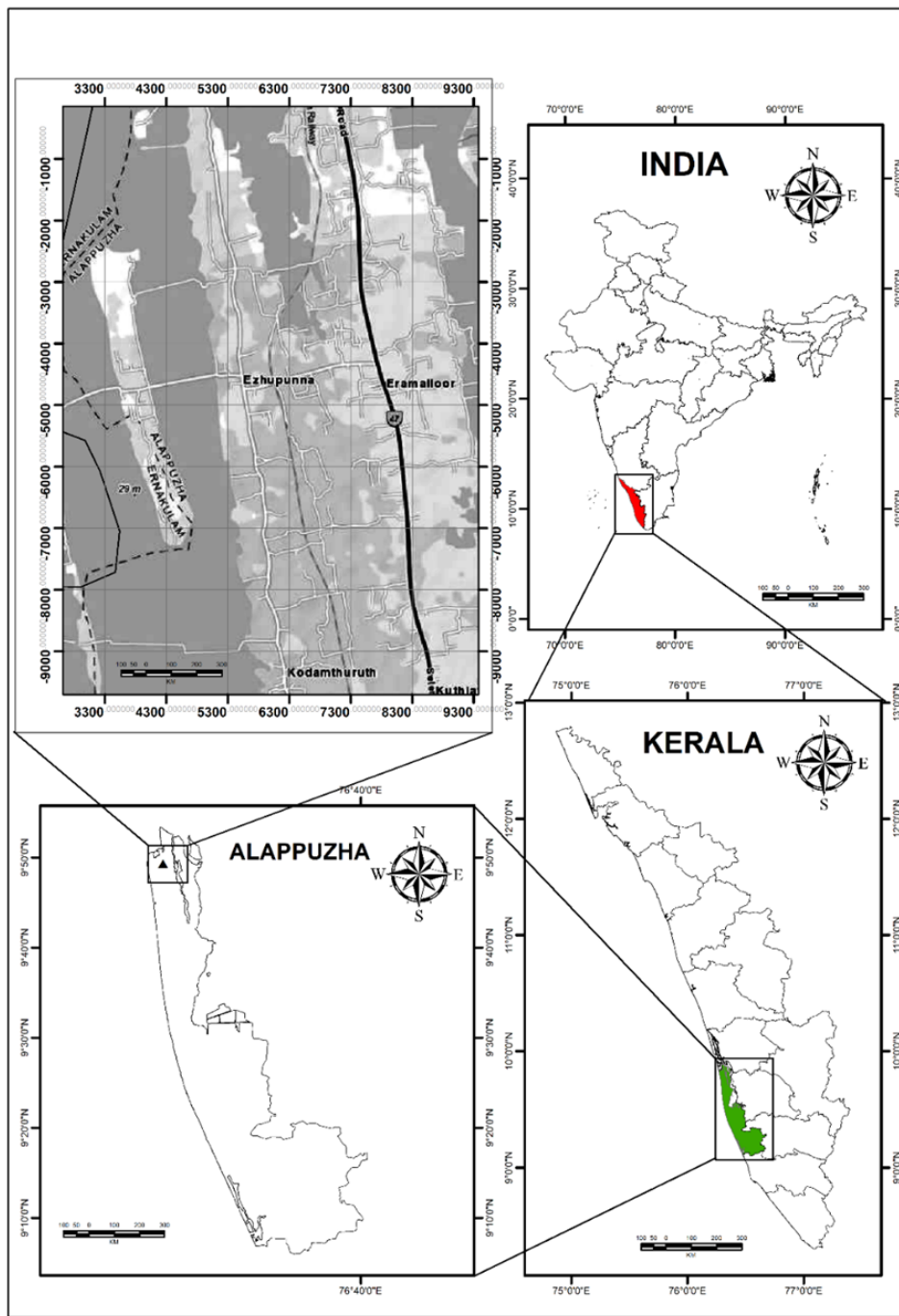
The genus *Westiellopsis* Janet was originally described from the Indian subcontinent as a new member of the family Stigonemataceae of the order Stigonematales (Janet, 1941; Desikachary, 1959; Gugger & Hoffman, 2004). In Komarek (2013), the genus was placed in the family Fischerellaceae of the order Nostocales. According to the recent taxonomic classification proposed by Komarek *et al.* (2014), the true-branching heterocytous cyanobacteria are grouped under the families Hapalosiphonaceae, Stigonemataceae, Symphyonemataceae and Capsosiraceae as per the foundations of polyphasic characterization data combining with the morphological details, ultrastructure and ecological framework. Hapalosiphonaceae is the most widely studied family among the above four families and is stated to be morphologically complex (Singh *et al.*, 2017; Mishra *et al.*, 2020).

According to recently updated databases of cyanobacteria, the family Hapalosiphonaceae consists of 27 genera and 102 species (Guiry & Guiry, 2021; Hauer & Komarek, 2021). The family is characterised by isopolar filaments with the 'T' type true branching, uni or multiserial main filament with uniseriate branches. Morpho-taxonomic characteristics of *Westiellopsis* resemble the other genera such as *Stigonema* (Janet, 1941), *Fischerella*, *Fischerellopsis*, *Hapalosiphon* and *Mastigocladus* which could be easily confused morphologically (Komarek *et al.*, 2014). Recently several new taxa of the family have been published in various states such as *Aetokthonos* (Wilde *et al.*, 2014), *Petalocladus* (Miscoe *et al.* 2016), *Neowestiellopsis* (Kabirnataj *et al.*, 2018) and *Reptodigitus* (Casamatta *et al.*, 2020).

The genus *Westiellopsis* is identified by true branching with two kinds of filaments, the primary prostrate system usually uniseriate to biserial, rarely multiserial trichomes without sheath and erect lateral filaments that are comparatively thin, in addition to reproductive structures that include hormogonia, pseudohormocytes and monocytes (Janet, 1941; Desikachary, 1959; Komarek, 2013). The occurrence of akinetes was observed in certain geographical regions (Agrawal & Sharma, 1994; Gugger & Hoffmann, 2004; Agrawal, 2009) however, Komarek (2013) has identified akinetes, but maybe they are just enlarged cells with thick cell walls. To date, only seven taxonomically accepted species of *Westiellopsis* Janet, (*Westiellopsis prolifica* Janet (Janet, 1941), *Westiellopsis indica* Bourrelly (Bourrelly, 1970), *Westiellopsis interrupta* Kanthamma (Jeeji-Bai, 1972), *Westiellopsis iyengarii* Jeeji-Bai (Jeeji-Bai, 1972), *Westiellopsis mahabalei* Biradar (Biradar, 1977), *Westiellopsis ramosa* Bagchi (Singh *et al.*, 2017) and *Westiellopsis akinetica* Mishra and Singh (Mishra *et al.*, 2020), as well as two infraspecific species (*Westiellopsis iyengarii* f. *allahabadii* M.Gupta & D.C.Pande and *Westiellopsis prolifera* var. *fischerelloides* Bourrelly (Bourrelly 1984) are known to occur (Guiry & Guiry, 2021; Hauer & Komarek, 2021) and their biogeographic distributional data are poorly documented (Saber *et al.*, 2017). However, as per the available works of literature and databases, the distributional pattern has been documented and well-studied.

The species belonging to *Westiellopsis* is mainly restricted to freshwater and terrestrial ecosystems. The species *Westiellopsis prolifica* Janet is widely distributed in tropical and subtropical regions that include:

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**Figure 1.** Location of sampling sites at the Alappuzha mangrove ecosystem

soil (Janet, 1941; Tiwari *et al.*, 2005; Tirkey & Adhikary, 2006; Nayak & Prasanna, 2007; Sethi *et al.*, 2012); freshwater hot springs (Finsinger *et al.*, 2008); the Tigris River in Iraq (Abed *et al.*, 2013); blackish-brown crusts on rocky surfaces inside caves (Pattanaik & Adhikary, 2002) and on building facades and stone monuments (Samad & Adhikary, 2008; Keshari & Adhikary, 2014). The other species of *Westiellopsis* generally occurred from freshwater or terrestrial habitats while the recently evolved species *Westiellopsis akinetica* Mishra and Singh occurred like a dark greenish mat on the soil under the shade of small herbaceous plants (Mishra *et al.*, 2020). *Westiellopsis iyengarii* Jeeji-Bai was recorded as a terrestrial species found distributed at Khandesh, Maharashtra (Jaiswal, 2017). *Westiellopsis indica* Bourrelly and *Westiellopsis mahabalei* Biradar have no distributional records from the time of their original discovery.

## MATERIAL AND METHODS

During the recent cyanobacterial exploration of the mangrove areas of southern Kerala, the authors collected some interesting species of *Westiellopsis* from the Alappuzha mangrove ecosystem of Kerala, India (Figure 1). Photomicrographs of the specimen were taken with the help of a Leica DM 1000 LED compound microscope. The collected specimen was subjected to be compared with the morphological aspects of the allied taxa. After a critical analysis based on the description, and photomicrographs of the live specimen, the collected specimen was turned out to be *Westiellopsis interrupta* Kanthamma 1972. The species identification was confirmed by comparing the collected specimens with the help of relevant taxonomic literature (Jeeji-Bai, 1972; Komarek, 2013; Singh *et al.*, 2017).

The voucher specimens were kept at MES Asmabi College, Kodungallur, Kerala, India (MES 13706).

## RESULTS AND DISCUSSION

*Westiellopsis interrupta* Kanthamma was originally collected and isolated from the paddy field soils of Madras, India in 1972 and it has no distributional records so far. After the original discovery, it was collected from the Ezhupunna mangrove ecosystem at Alappuzha on 17 January 2020. Hence, the present collection after a gap of 48 years from its original collection, is a rediscovery. Differences between *W. interrupta* from allied taxa are given in Table 1. A detailed morpho-taxonomic description, distribution, habitat and ecology are provided with the photomicrographs.

## Taxonomic Treatment

**Order:** Nostocales

**Family:** Hapalosiphonaceae

*Westiellopsis interrupta* Kanthamma in Jeeji-Bai, Desikachary TV. (ed.) Taxonomy and biology of blue-green algae. University of Madras, Madras, 1972, 62-74. Figure 2. A - F.

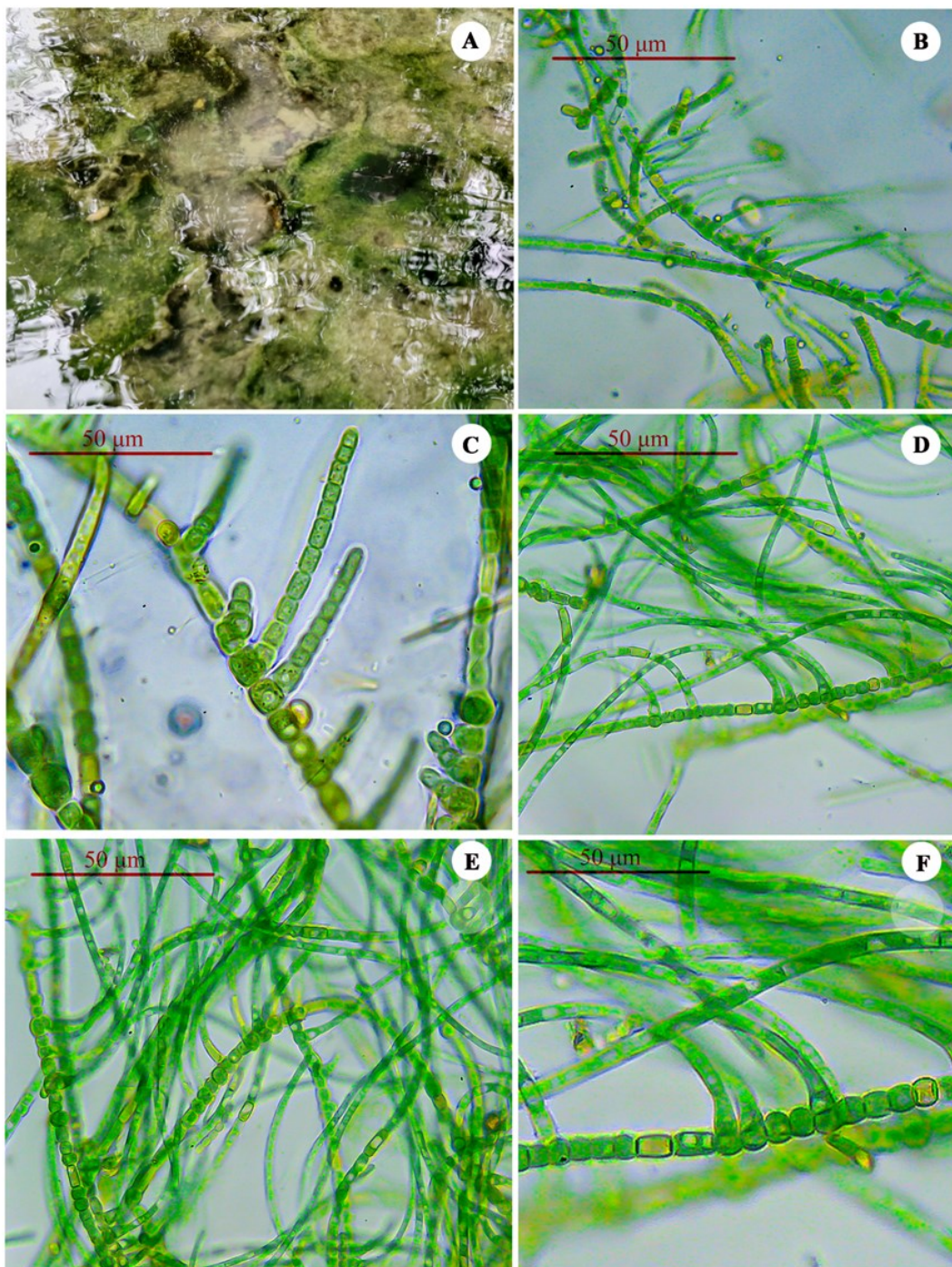
**Reference:** (Jeeji-Bai, 1972; Komarek, 2013)

**Description:** Main filaments torulose, irregularly coiled, mono-seriate, from which grow perpendicularly (unidirectional T-shaped) branches, which are thinner, constricted at the cross walls. Cells in main filaments barrel-shaped, 2.7  $\mu$ m to 7.7  $\mu$ m long, 3.3  $\mu$ m to 6.7  $\mu$ m

**Table 1.** A Comparison of morphological characters used to distinguish *Westiellopsis interrupta* from other closely related taxa

<i>W. interrupta</i>	<i>W. prolifica</i>	<i>W. indica</i>	<i>W. iyengarii</i>	<i>W. ramosa</i>	<i>W. akinetica</i>
Filaments torulous, irregularly coiled, mono- to biseriate and rarely triseriate, slightly constricted at cross-walls; unidirectional T-shaped branching	Filaments torulous, flexuous, mono- to biseriate distinctly constricted at cross walls; unidirectional T-shaped branching	Filaments entangled branches sometimes fasciculated; unidirectional T-shaped branching	Filaments torulous, mono- up to triseriate, unidirectional T-shaped branching	Main filaments neither torulous nor flexuous, monoseriate, clusters of free, untangled, not coalescent together, constricted at cross walls; unidirectional T-shaped branching	Mostly young filament monoseriate, older prostrate filaments may show biseriate condition. Filaments are profusely branched with typical unidirectional/bidirectional T-shaped branching.
Cells barrel-shaped, 2.7- 7.7 $\mu$ m length, 3.3- 6.7 $\mu$ m width.	Cells barrel-shaped to irregular-rounded, $\pm$ 8-12 $\mu$ m in diameter or slightly longer, 6.6-16.2 x 8-12.3 $\mu$ m	Barrel-shaped cells up to almost spherical or slightly elongated, (3.2) 3.6-14.5 (16.6) $\mu$ m wide.	Cells in the main filaments barrel shaped cells, (3.3) 4.9-13.2 (19.8) x 4.2-13.2 (23.1) $\mu$ m	Cells in the main filaments cylindrical to barrel-shaped to irregularly shaped, 5.21-9.21 x 4.03-6.50 $\mu$ m	Vegetative cells adjacent to heterocytes 7.1-9.3 x 3.5-4.7 $\mu$ m width, Oblong and slightly compressed at ends; Vegetative cells away from heterocytes 3.6-7.2 x 3.5-6.1 $\mu$ m, irregular in shape, spherical, elongated.
Elongated cells, oval, long oval up to cylindrical, 3.3 $\mu$ m to 10.8 $\mu$ m long, 2.4 $\mu$ m to 4.2 $\mu$ m broad.	Cells elongated, elongate cylindrical, 8-16.2 x 4-6.1 $\mu$ m	Elongated and narrowed (up to 2-3 (15) x longer than wide, barrel to cylindrical; tapering at branch ends	Cells oval to long cylindrical, 2.5-19.8 (23.1) x 2.8-4.9 (8.2) $\mu$ m	Branch cells rounded or irregularly rounded at the base while proximal cells are more cylindrical with tapering ends, 6.85-9.78 x 2.86-3.65 $\mu$ m	Initial cell of lateral branch emerging from the prostrate main filament, 3.8-5.6 x 3.5-4.8 $\mu$ m; irregular in shape, broad base with pointed cells.
Heterocytes quadrate to oblong to cylindrical, 4.2-12.3 x 3.4-5.2 $\mu$ m; intercalary	Heterocytes oblong-cylindrical, 10.5-22.3 x 5.4-6.1 $\mu$ m	Heterocytes various shaped, 5.8-16.6 x 4-13.2 $\mu$ m	Short quadrate to long cylindrical heterocytes, (3.3) 4.2-23.1 x 4.2-15.6 $\mu$ m; intercalary	Heterocytes cylindrical to barrel-shaped; constrictions at cross-walls, 7.37-11.47 x 3.53-5.06 $\mu$ m; terminal and intercalary	Heterocytes near to the chain of akinetes appear irregularly shaped, 6.2-7.4 $\mu$ m x 2.3-4.1 $\mu$ m, highly granulated and cylindrical with distinct polar granules.
Akinete not observed	Akinete observed	Akinete not observed	Akinete not observed	Akinete not observed	Akinetes range in size from 6.5-7.8 x 3.4- 4.5 $\mu$ m, thick-walled, granulated and larger than cells of the prostrate filament.
Isolated from paddy field soils: India (Madras); Phytoplankton from mangrove ecosystem: India (Kerala)	Cultures from garden soil; India (Madras)	Isolated from soils and rice fields; Egypt, India	Isolated from sandy soils; India (Madras)	Isolated from the lake; India (Jabalpur)	Soil isolate; India (Varanasi)





**Figure 2.** *Westiellopsis interrupta* Kanthamma. **A:** Habitat of cyanobacterial mat occurred as phytoplankton. **B-E:** Unidirectional ‘T’ shaped mono-seriate branches. **F:** Intercalary heterocyst of quadrate to oblong cylindrical cells.

broad, in branches elongate, oval or long oval up to cylindrical cells, 3.3  $\mu\text{m}$  to 10.8  $\mu\text{m}$  long, 2.4  $\mu\text{m}$  to 4.2  $\mu\text{m}$  broad; intercalary cells divide in clusters of wide, short and rounded cells. Heterocytes intercalary, quadrate to oblong cylindrical, 4.2  $\mu\text{m}$  to 12.3  $\mu\text{m}$  long, 3.4  $\mu\text{m}$  to 5.2  $\mu\text{m}$  broad.

**Distribution:** The species is reported for the first time from the mangrove ecosystem of Ezhupunna, Alappuzha district, Kerala, India. Therefore, the occurrence of this species can be considered a rediscovery and also a new addition to the marine cyanobacterial flora of India.

**Habitat and ecology:** Growing as phytoplankton appeared as a dark greenish cyanobacterial mat. Light intensity was found to be 1578 Lux. The pH of the water

was found to be 8.2; the atmospheric temperature was 28.8 $^{\circ}\text{C}$ ; water temperature was 25.8 $^{\circ}\text{C}$ ; electrical conductivity (EC) was 15.8 mS/cm; total dissolved solids (TDS) was 505.23 ppm and salinity was 28.3 ppt.

**Specimen examined:** INDIA: Kerala; Alappuzha, Ezhupunna (9 $^{\circ}$  49' 24.43" N, 76 $^{\circ}$  18' 39.54" E, 17 Jan. 2020); MES 13706.

The genus *Westiellopsis* now includes 7 valid species under the family Hapalosiphonaceae and all the species have been reported in India as freshwater and soil-dwelling forms, but none of these represents the marine environment. Research into mangrove-associated cyanobacterial exploration and documentation is limited in the state of Kerala, India, and our

study underscores the need for more comprehensive biodiversity studies in this area. The study suggests that the species should be subjected to culturing and isolation, thus leading to a search for phylogenetic analysis, physico-chemical parameters of the habitat should be monitored and also the search for potential candidates for several biotechnological, industrial and pharmaceutical applications.

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