



Diversity and Distribution of Genus *Trentepohlia* Mart. (Chlorophyta) from North Karnataka, India

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Abstract: Diversity of the subaerial algae genus *Trentepohlia* Mart. was studied in 13 districts of North Karnataka, India. The presence of *Trentepohlia* species was examined in both forest and urban environments. The nine species (*Trentepohlia aurea* (Linnaeus) C Martius, *Trentepohlia odorata* (F. H. Wiggers) Wittrock, *Trentepohlia abietina* (Flotow ex Kützing) Hansgirg, *Trentepohlia rigidula* (J. Müller) Hariot, *Trentepohlia effusa* (Krempelhuber) Hariot, *Trentepohlia annulata* F. Brand, *Trentepohlia thevalliensis* M. V. N. Panikkar and P. Sindhu, *Trentepohlia chapmanii* Rindi and López-Bautista, *Trentepohlia infestans* Rindi and J. López-Bautista) and two varieties (*Trentepohlia abietina* var. *corrugata* (Leighton) Cribb, *Trentepohlia abietina* var. *tenuis* (Zeller) A. B. Cribb) of *Trentepohlia* were recorded from the different regions of North Karnataka. These documented species represent previously unreported taxa. Hence, these are considered as new distributional records from North Karnataka region. The survey of 13 districts conducted in the year 2022 – 2024 concluded that the physical factors like rainfall, temperature, relative humidity and light intensity plays important role in the growth of *Trentepohlia* species. The presence of *Trentepohlia* species was only in 3 districts (Dharwad, Belagavi and Haveri). Shannon diversity index was higher in Belagavi (2.02) followed by Dharwad (1.61) and the lowest diversity in Haveri (1.33) district.

Keywords: Subaerial green algae, *Trentepohlia*, Diversity, Shannon index, North Karnataka.

1. INTRODUCTION

Previously genus *Trentepohlia* Mart. was assumed as *Byssus aurea* L. as in "Species Plantarum" Linnaeus described genus *Trentepohlia* as *Byssus aurea* L. but there is no proof to evident that, "*Byssus aurea*" was based on the concept of "*Byssus capillacea pulverulenta*" and later on, in honour to J. F. Trentepohl who was a German clergyman and botanist, C. F. Philipp von Martius named a particular type of subaerial green algae as *Trentepohlia* in 1817 (Rajapure and Singh, 2025). The subaerial green algae genus *Trentepohlia* Mart. belongs to the Kingdom Plantae, Division Chlorophyta, Class Ulvophyceae, Order Trentepohliales, and Family Trentepohliaceae. It is distributed across tropical, subtropical, and temperate climates (Liu et al., 2012). Species of *Trentepohlia* are easily recognizable on various substrata due to their distinctive orange to red coloration, which results from the accumulation of beta-carotene and hematochrome pigments (Rindi et al., 2008; Kharkongor and Ramanujam, 2015). Hence, these *Trentepohlia* species, although classified as microchlorophytes, exhibit a unique morphological phenotype that sets them apart from other green algae. This

distinctive nature has led to their description as macrochlorophytes, due to their tendency to form, irregular vertical streaks of orange, red, or green colour on various natural and artificial substrata (Kharkongor and Ramanujam, 2015).

The identification of *Trentepohlia* species relies primarily on detailed morphological features. Key diagnostic traits include the shape and size of vegetative cells, the occurrence of characteristic hair-like cells known as setae, patterns of branching in the filamentous thallus, and the position, structure, and morphology of reproductive organs such as sporangia and gametangia (Liu et al., 2012; Saraphol, 2020). Despite these identifiable features, the genus *Trentepohlia* presents significant challenges. One of the major difficulties is high degree of polymorphism as the individuals within the same species can exhibit considerable morphological variability depending on environmental conditions or life cycle stages. This complicates the identification of species (Rindi and Guiry, 2002).

Scientific studies on the genus *Trentepohlia* have largely focused on regions such as Europe, Central America, South America, and some countries where subaerial green algae

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are relatively well-documented. However, tropical regions have proven to be particularly important in algal biodiversity research. Over the past two centuries, the majority of newly described subaerial algal species including those in the genus *Trentepohlia* have originated from tropical zones. This highlights the rich species diversity and ecological importance of these environments (Saraphol, 2020). Conducting the detailed studies on *Trentepohlia* species in tropical, subtropical, and temperate regions is very essential. These investigations provide the foundational taxonomic and ecological data needed to better understand the global distribution, evolutionary adaptations, and potential environmental roles of subaerial green algae. Aim of this study was to elucidate the diversity and some basic aspects of ecology of genus *Trentepohlia* in North Karnataka.

2. MATERIALS AND METHODS

2.1. Collection of *Trentepohlia* Species

Survey and collection of *Trentepohlia* species was obtained by scraping from natural substrata i.e. stem bark of trees and artificial substrata i.e. electric poles, concrete cementing walls of buildings and water tanks and kept in air tight zip lock sterile plastic bags (Satpati and Pal, 2016) from different sampling areas (Belagavi – 15°51'N 74°30' E, Dharwad – 15° 27' 30" N 75° 00' 30" E and Haveri – 14.8° N 75.4°E) of North Karnataka. The parameters like latitude, longitude, temperature, relative humidity and light intensity of sampling sites were estimated by CTH 288 digital temperature, humidity meter and Lutron LX-101A and digital lux meter. The annual rainfall data report was recorded from government website Karnataka State National Disaster Management Centre (KSNDMC). The photographs of the algae along with its habitat have been recorded.

2.2. Identification of *Trentepohlia* Species

The collected algal samples were freeze-dried at -4°C (degree Celsius) and also preserved in 4% formalin in the laboratory (Satpati and Pal, 2016). The species were observed under compound microscope (Olympus OIC), morphometric evaluation by scaling of cell measurements using micrometry (Satpati and Pal, 2019). Identification of *Trentepohlia* species was carried out by using standard monographs, research papers (Cribb, 1970; Rindi and Guiry, 2002; Rindi et al., 2005, 2006 and 2008; Rindi and Lopez-Bautista, 2007; Allali et al., 2013; Satpati and Pal, 2016; Binoy et al., 2019; Saraphol, 2020) and herbarium of one of the species sent to BSI, Howrah for its identification.

2.3. Diversity Index

Diversity of genus *Trentepohlia* was calculated using

Shannon-Weiner diversity index, Eq. 1. (Shannon and Weaver, 1963).

$$H' = -\sum_{i=1}^s p_i \ln p_i \dots \dots \dots (1)$$

Where,

H' - The species diversity index

s - The number of species

p_i – The individuals of one particular species found (n) divided by the total number of individuals found (N)

\ln – Natural log

3. RESULTS AND DISCUSSION

3.1. Effect of Physical Factors on Growth of *Trentepohlia* Species

Physical factors play the major role in the growth of *Trentepohlia* species. Among 13 districts of Karnataka only 3 districts show the diversity of *Trentepohlia* species. The rainfall, temperature, relative humidity and light intensity play crucial role in the growth of *Trentepohlia* species on its different substrata. Dharwad, Belagavi, and Haveri regions have favorable environmental conditions, hence, 9 species and 2 varieties of *Trentepohlia* were observed. In the remaining other 10 districts the *Trentepohlia* species were not observed due to the environmental conditions wherein, the rainfall, relative humidity was comparatively less and temperature, light intensity was comparatively more than Dharwad, Belagavi and Haveri districts. The environmental conditions may be unfavourable for the growth of *Trentepohlia*. In Alnavar forest of Dharwad and 2 sampling sites (Katridaddi and Jamboti) of Belagavi, the *Trentepohlia odorata* and *Trentepohlia rigidula* species were observed throughout the year because of the rich vegetation maintaining 24°C - 27°C temperature, 72% - 84% relative humidity and 4000 - 8000 lux light intensity. But in other districts such as Bidar and Kalaburgi, even though they have sufficient rainfall (838 mm and 813 mm), the other factors like temperature, relative humidity and light intensity were unfavourable for the growth of *Trentepohlia* species.

Earlier studies concluded that genus *Trentepohlia* is widely distributed across a broad range of climatic zones, including tropical, subtropical, and temperate regions (Liu et al., 2012; Satpati and Pal, 2016). This widespread occurrence indicates the genus ecological flexibility and adaptability to colonize diverse habitats. *Trentepohlia* species are frequently found growing on man-made substrates such as concrete surfaces, especially those that are fully exposed to direct sunlight. These exposed environments are often subject to high levels of solar radiation, temperature fluctuations, and limited moisture

availability, making conditions challenging for many organisms to inhabit. However, *Trentepohlia* exhibits remarkable physiological adaptations that enable it to survive and even thrive under such extreme environmental stressors. These adaptations include mechanisms to tolerate desiccation (drying out due to water loss), endure thermal stress (such as high surface temperatures), and maintain metabolic activity under fluctuating light and humidity conditions (Abe et al., 1999).

3.2. Diversity and Distribution of *Trentepohlia* Species

Trentepohlia species were found to be present as orange, red and green patches on both the natural and artificial substrata i.e. stem bark of trees, electric poles, concrete cementing walls of buildings and water tanks. Out

of total 108 sampling sites surveyed from the districts of North Karnataka, 32 sampling sites recorded the presence of *Trentepohlia* species. Hence, total 9 species and 2 varieties of *Trentepohlia* species have been identified (Table 2), collected from various regions of Dharwad, Belagavi and Haveri districts while species were not observed in remaining 10 districts during the survey. *Trentepohlia rigidula* (J. Müller) Hariot and *Trentepohlia odorata* (F. H. Wiggers) Wittrock were the 2 species observed common in all the 3 districts. *Trentepohlia abietina* (Flotow ex Kützing) Hansgirg was common in Belagavi and Haveri regions. *Trentepohlia chapmanii* Rindi and López-Bautista was common in the regions of Dharwad.

Table 1. Physical factors in the sampling sites of different locations

Site location	Rainfall (mm)	Temperature (°C)	Relative humidity (%)	Light intensity (Lux)
Dharwad*	1051	24.3 - 28.6	62 - 84	3500 - 8550
Belagavi*	1194	24 - 28.8	62 - 84	4528 - 11200
Haveri*	1023	25 - 27.5	64 - 84	3900 - 7200
Gadag	399	29 - 34	52 - 57	18020 - 23500
Bidar	838	29.5 - 35	57 - 62	34500 - 48700
Kalburgi	813	27.1 - 30	47 - 49	38000 - 49000
Vijayapura	621	29 - 31	45 - 46	27500 - 48000
Yadgir	736	32 - 36	42 - 45	38000 - 48100
Raichur	637	32 - 36	42 - 45	38000 - 49200
Bagalkot	603	28.2 - 29.3	45 - 47	25400 - 47300
Koppal	598	28 - 34	49 - 52	23200 - 35600
Ballari	662.6	27 - 32	51 - 52	23500 - 38000
Vijayanagara	763.7	29 - 32	49 - 52	24000 - 42000

*Favourable physical factors for the growth of *Trentepohlia* species

Table 2. *Trentepohlia* species in the districts of North Karnataka

<i>Trentepohlia</i> species	Dharwad	Belagavi	Haveri
<i>Trentepohlia aurea</i> (Linnaeus) C Martius	-	+	-
<i>Trentepohlia odorata</i> (F. H. Wiggers) Wittrock	+	+	+
<i>Trentepohlia abietina</i> (Flotow ex Kützing) Hansgirg	-	+	+
<i>Trentepohlia rigidula</i> (J. Müller) Hariot	+	+	+
<i>Trentepohlia effusa</i> (Krempelhuber) Hariot	-	+	-
<i>Trentepohlia annulata</i> , F. Brand	+	-	-
<i>Trentepohlia abietina</i> var. <i>corrugata</i> (Leighton) Cribb	-	+	-
<i>Trentepohlia abietina</i> var. <i>tenuis</i> (Zeller) A. B. Cribb	+	-	-
<i>Trentepohlia thevalliensis</i> M. V. N. Panikkar and P. Sindhu	-	+	-
<i>Trentepohlia chapmanii</i> Rindi and López-Bautista	+	-	+
<i>Trentepohlia infestans</i> Rindi and J. López-Bautista	+	-	-

In Gadag, Bidar, Kalburgi, Vijayapura, Yadgir, Raichur, Bagalkot, Koppal, Ballari, Vijayanagara no species were observed

Keys to *Trentepohlia* species found in surveyed districts of North Karnataka

1. Thallus heterotrichous, distinguished into prostrate and erect filaments.....2
1. Thallus uniseriate.....3
2. Prostrate cells, globular or spherical to barrel shaped, erect cells cylindrical.....2a, 2b, 4, 5, 6, 7
- 2a. Prostrate cells, globular or spherical to barrel shaped, erect cells rectangular and ovoid.....8
- 2b. Prostrate cells entangled into a mass of undifferentiated individual cells.....9
3. Prostrate and erect filaments are undifferentiated3a, 3b
- 3a. Filaments and branched filaments all globular or elliptical with the width of 23.04 μm and length 26.88 μm , each cell separated by septa, presumptive gametangia is spherical 23.04 μm in diameter.....*Trentepohlia rigidula*
- 3b. Branched filaments differentiated into primary long and secondary short filaments, cells cylindrical, width 7.68 – 9.6 μm , length 15.36 – 21.12 μm . apical cell without pectic cap. Sporangia very characteristically borne on lateral, terminal and intercalary position with different size 11.52 – 15.36 μm , 15.36 μm width, 17.28 μm length, 24.96 – 32.64 μm in diameter respectively.....*Trentepohlia thevalliensis*
4. Prostrate cells with width 10 – 13 μm erect cells cylindrical width 7 – 12.5 μm length 15.36 – 23.04 μm , branching densely entangled to produce compact mass, sporangia globular 14.5 – 22 μm in diameter borne on suffultory cell, slightly bent thin or broad.....*Trentepohlia infestans*
5. Prostrate cells of 7 – 13.44 μm in diameter, erect cells 3.84 – 5.76 μm in width and 19.2 – 21.12 μm in length, apical cell pointed with small pectic cap. Sporangia globular 19.2 μm in diameter borne on straight to slightly curved, flask shaped suffultory cell.....*Trentepohlia chapmanii*
6. Prostrate cell subglobose 13.44 – 24.96 μm in diameter, erect cells width of 7.68 – 13.44 μm and length 9.6 – 23.04 μm , apical cell with pectic cap. Stalked to sessile sporangia, globose to subglobose occurring laterally and terminally with a diameter of 10.5 – 11.52 μm , while globular gametangia are lateral, terminal and intercalary 13 – 15.36 μm in diameter.....*Trentepohlia odorata*
7. Presence of horizontal prostrate cells from which erect cells arise vertically, branching present or absent, all cells are similar, bearing apical cell with pectic cap.....7a, 7b, 7c, 7d
- 7a. Branching not observed, cells cylindrical to barrel

- shaped 5.76 – 7.68 μm in width and 15.36 – 16 μm in length, gametangia globular or ovoid 7.68 – 19.2 μm in diameter.....*Trentepohlia abietina*
- 7b. Little or no branching, cells barrel shaped or inflated, rarely cylindrical, width 6 – 9 μm and length 12 – 26 μm , sporangia pedicellate 11 μm in diameter borne on slightly curved, flask shaped suffultory cell, gametangia globular 10 – 15 μm in diameter. Large apical cell with pectic cap.....*Trentepohlia abietina* var. *tenuis*
- 7c. Cells with corrugate appearance, cylindrical or slightly swollen, slightly inflated, 5 – 15 μm width, 14 – 28 μm length, apical cell with pleomorphic pectic cap, gametangia globular 12 – 20 μm in diameter.....*Trentepohlia abietina* var. *corrugata*
- 7d. Profused branching, cells cylindrical, slightly inflated, width 19.2 – 30.72 μm and length 38.4 – 57.6 μm . Apical cell obtuse with blunt tips pectic cap. Gametangia globular to sub globular, slightly ellipsoidal 19.2 – 23.04 μm in diameter.....*Trentepohlia aurea*
8. Prostrate cells spherical 11.52 – 19.2 μm in diameter, erect cells rectangular and ovoid, width of 7.68 μm , length 15.36 – 19.2 μm , apical cell with pectic cap. Sporangia elliptical or flask shaped, 24.5 – 26.88 μm in diameter containing obliquely arranged zoosporangium at the top of the erect axis.....*Trentepohlia annulata*
9. Erect cells arising from the pseudoparenchymatous mass of cylindrical cells, 3.84 – 5.76 μm in width and 19.2 μm in length, sparsely branched, apical cell tapering with pointed end. Reproductive structures sessile, globular, 7.68 – 15.36 μm in diameter.....*Trentepohlia effusa*

Description of Identified *Trentepohlia* species

1. *Trentepohlia rigidula* (J. Müller) Hariot, Queensland (1889)

Thallus uniseriate, The axis is upto 192 – 307.2 μm tall. The cells of filaments are elliptical or globular in shape and ranges 23.04 μm in width and 26.88 μm in length. Filaments are branched profusely. Each cell is separated by septa. The apical cell is oval ranges 19.2 μm in diameter. The presumptive gametangia is spherical in shape ranges 23.04 μm in diameter (Figure 1).

2. *Trentepohlia thevalliensis* M. V. N. Panikkar and P. Sindhu, Thevally, Kerala, India (1993)

The filaments are long bearing 20 – 25 cells. The primary branches are long and secondary branches are small. The cells are cylindrical, 7.68 – 9.6 μm wide and 15.36 – 21.12 μm long. Sporangia sessile, globular, lateral, terminal, or intermediate. The lateral sporangia 11.52 – 15.36 μm in diameter, terminal sporangia 15.36 μm wide and 17.28 μm

long, the intermediate sporangia 24.96 – 32.64 μm in diameter. The apical cells without pectic cap 9.6 μm wide and 24.96 μm long (Figure 2).

3. *Trentepohlia infestans* Rindi and J. López-Bautista, Zone Industrielle, Collery Marengo, French Guiana (2007)
Thallus is heterotrichous, pseudoparenchymatous,

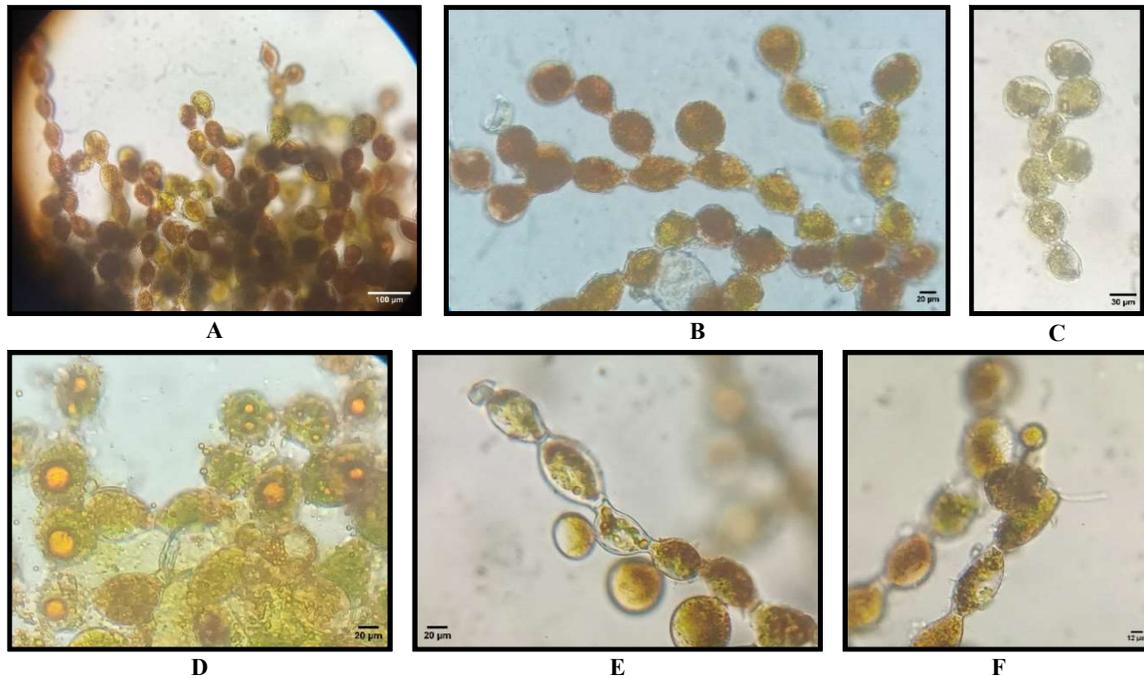


Figure 1. (A – F) Microscopic structures of *Trentepohlia rigidula* (J. Müller) Hariot **A** – Thallus **B** – Branched filaments **C** - Intercalary and Terminal Presumptive Gametangia **D** – Oil globules/lipid droplets **E** – Apical cap **F** – Stalked sporangia

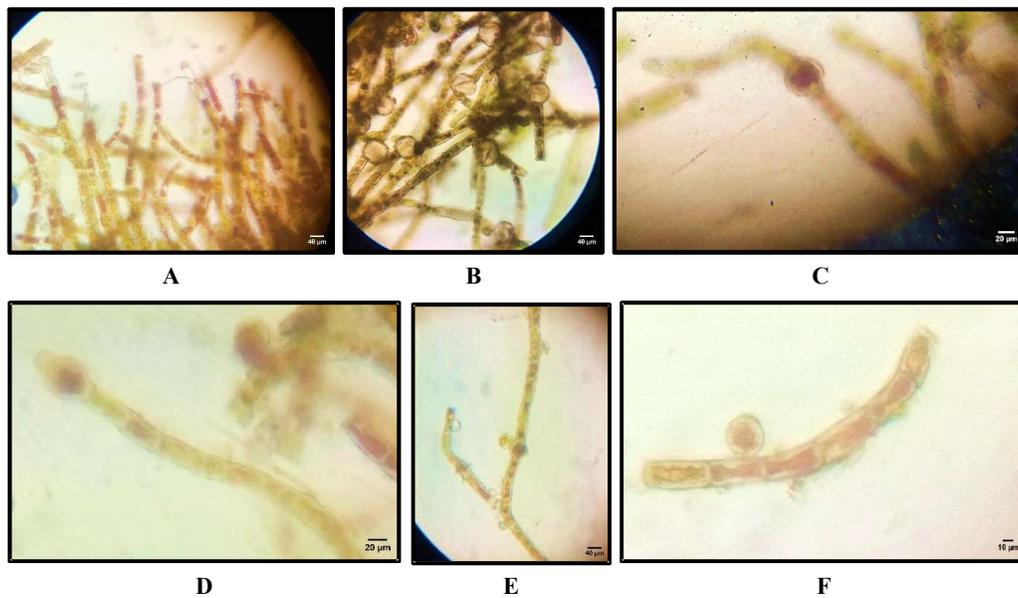


Figure 2. (A - F) Microscopic structures of *Trentepohlia thevalliensis* M. V. N. Panikkar and P. Sindhu **A** – Thallus **B** – Intermediate sessile Sporangia, **C and E**– Intermediate Sporangia **D**– Terminal Sporangia, **F** - Lateral Sporangia

consisting of separation between dense prostrate and erect parts. many individual filaments densely entangled to produce compact mass. The cells of the prostrate part were globular, elliptical, or barrel-shaped, 10–13 μm wide. The erect axes arise from the prostrate part. The cells of erect axes were cylindrical, 7–12.5 μm wide and 15.36–23.04 μm long. Presence of globular sporangia, 14.5 – 22 μm in diameter, borne on suffultory cell. The neck of the suffultory cell was slightly bent and thin as well as broad. Gametangia were not observed (Figure 3).

4. *Trentepohlia chapmanii* Rindi and López-Bautista, Fort Diamant, area of Rémire- Montjoly, French Guiana (2007)

Thallus heterotrichous. Prostrate part spreading, pseudoparenchymatous. Erect filaments arising from the prostrate parts. Cells of the erect filaments are cylindrical,

3.84– 5.76 μm wide and 19.2 – 21.12 μm long. Cells of the prostrate part are globular or elliptical 13.44 – 19.2 μm in diameter. Presence of globular sporangia, 19.2 μm in diameter. The apical cells are pointed and bear a pectic cap. The suffultory cell is straight or slightly curved, flask-shaped 24.96 μm long (Figure 4).

5. *Trentepohlia odorata* (F. H. Wiggers) Wittrock Fionia, Denmark (1880)

Thallus heterotrichous. Cells cylindrical, in erect filament, 9.6 – 23.04 μm long and 7.68 – 13.44 μm wide. The Cells of prostrate filaments are subglobose to ellipsoid 13.44 μm – 24.96 μm in diameter. Presumptive gametangia nearly spherical to elliptic, lateral, terminal, or intercalary 13 - 15.36 μm in diameter. Sporangia, globose to subglobose, lateral/ terminal, sessile and stalked, 10.5 – 11.52 μm

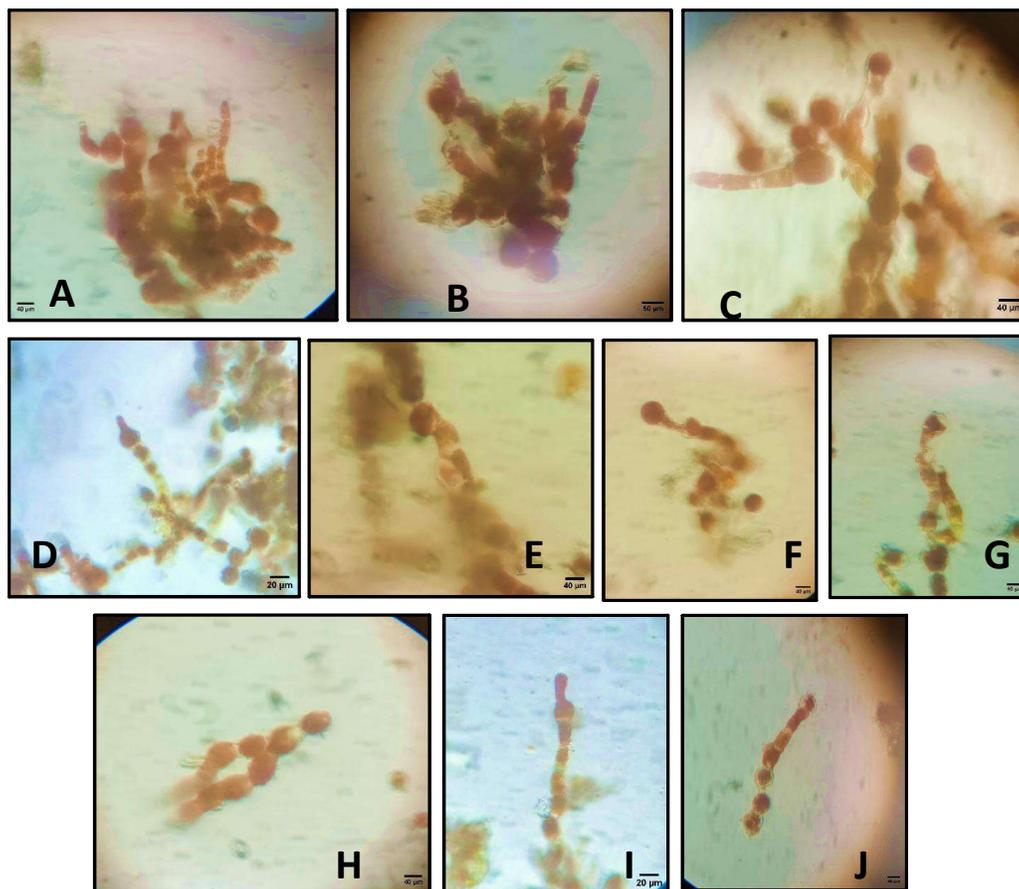


Figure 3. (A - K) Microscopic structures of *Trentepohlia infestans* Rindi and J. López-Bautista
A – Individual cells entangled to form compact mass **B** – Thallus **C** – Sporangia formed on straight suffultory cell **D and I**– Zoosporangium has not yet been divided from the suffultory cell **E** – Sporangia formed on large suffultory cell **F** – Sporangia formed on slightly curved suffultory cell **G** – Sporangia formed on curved suffultory cell **H** – Branching of filaments **J** – Single filament

diameter. The suffultory cell is straight or slightly curved 11.52 μm long. Apical cells with pectic caps 15.36 μm wide and 19.2 μm long (Figure 5).

6. *Trentepohlia abietina* (Flotow ex Kützing) Hansgirg, Hirschberg, Bavaria, Germany (1886)

Thallus heterotrichous, pseudoparenchymatous. The erect axis 126 – 198 μm long. Cells of the erect axes are cylindrical or barrel-shaped 3.84 – 7.68 μm wide and 15.36 – 16 μm long. Cells of the prostrate filaments are elliptical or cylindrical, or barrel-shaped, 5.76 – 7.68 μm wide and 15.36 – 16 μm long. Presumptive gametangia globular or ovoid, 7.68 – 19.2 μm in diameter. Sporangia and Suffultory cells not observed. Apical cell with pectic cap 15.36 – 19.2 μm

long and 7.68 μm wide (Figure 6).

7. *Trentepohlia abietina* var. *tenuis* (Zeller) A. B. Cribb, Elephant Point, Pegu, Burma (1970)

Thallus heterotrichous. Erect axes 200–250 μm tall, with little or no branch, arising from limited prostrate parts. Cells barrel-shaped or inflated, rarely cylindrical, 2–3 times as long as wide (12 – 26 μm long), 6–9 μm wide. Gametangia globular, 10–15 μm in diameter. Sporangia pedicellate, 11 μm in diameter. Suffultory cell slightly curved, flask shaped. Apical cells larger with apical cap (Figure 7).

8. *Trentepohlia abietina* var. *corrugata* (Leighton) Cribb Queensland, Australia (1970)

Thallus heterotrichous. The cells are cylindrical or

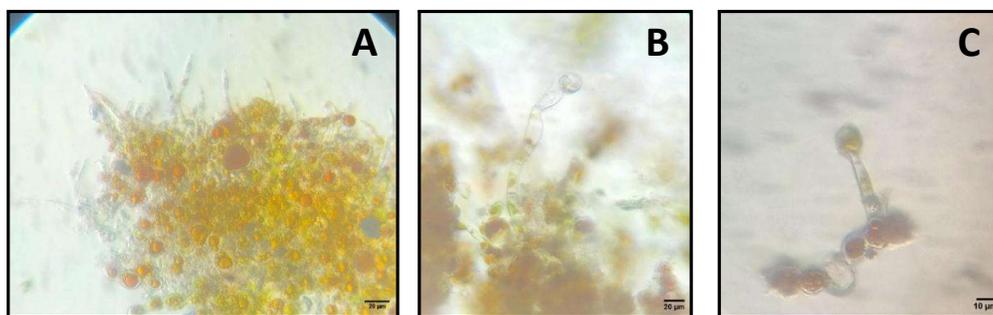


Figure 4. (A - C) Microscopic structures of *Trentepohlia chapmanii* Rindi and López-Bautista A – Thallus with Erect and Prostrate cells B – Sporangia formed on Suffultory Cell C – Terminal Sporangia

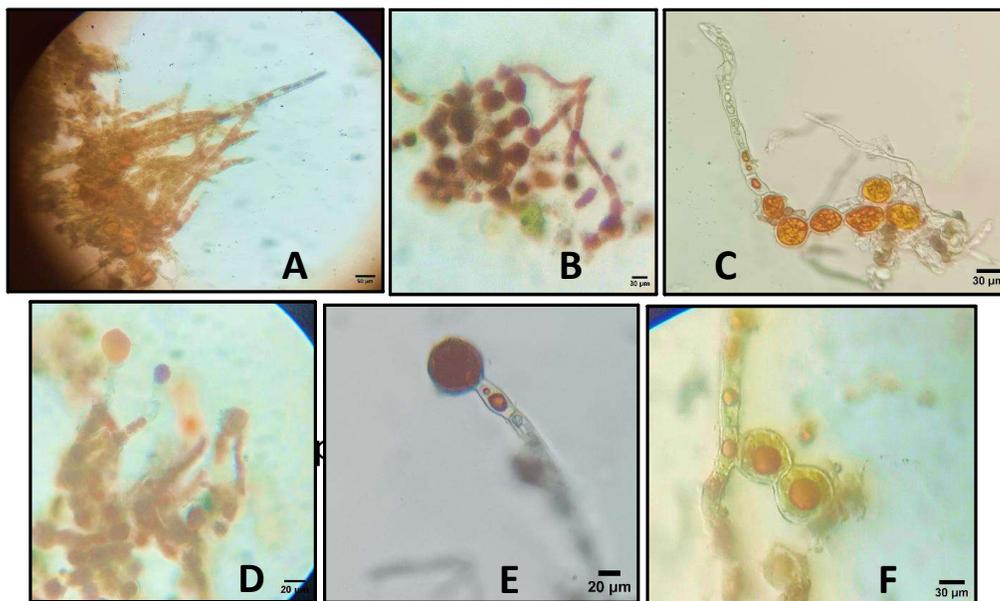


Figure 5. (A - F) Microscopic structures of *Trentepohlia odorata* (F. H. Wiggers) Wittrock A – Thallus with Erect and Prostrate Cells B – Apical cells with pectic caps C – Single Erect Filament Arising from the Prostrate Cells D – Suffultory Cells (SC) E – Terminal Sporangium (S) F - Oil globules/lipid droplets

slightly swollen or slightly inflated, 5–15 µm wide 14–28 µm long as wide. Cells with corrugate appearance. Branching of filaments. Gametangia are present but not abundant, globular, 12–20 µm wide. The zoosporangium is oval, 10–15µm in diameter. Apical cells with irregular caps (Figure 8).

9. *Trentepohlia aurea* (Linnaeus) C Martius, Wales: Caenarvon; Italy (1817)

Thallus heterotrichous, pseudoparenchymatous, 1.11–1.125 mm tall. Filaments are long, straight, slightly curved, more or less branched. Profused branching. The branched

filaments are 390–450 µm long. Cells cylindrical or slightly inflated, 19.2–30.72 µm wide, and 38.4–57.6 µm long. Presumptive gametangia globular, sub globular, slightly ellipsoidal, 19.2–23.04 µm in diameter. The apical cells obtuse with pectic cap and are variable in shape with blunt tips (Figure 9).

10. *Trentepohlia annulata*, F. Brand, Germany (1902)

Thallus is formed by erect axes arising from the prostrate axes. Cells of erect axis are rectangular or ovoid 15.36–19.2 µm long and 7.68 µm wide. The prostrate cells are spherical 11.5–19.2 µm in diameter. Sporangium elliptical or flask-

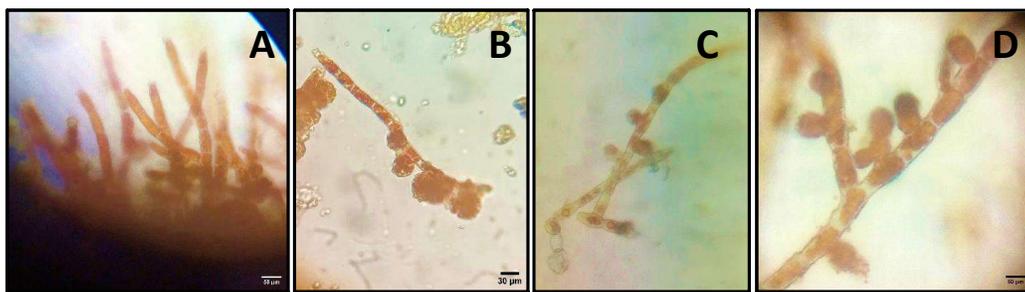


Figure 6. (A - D) Microscopic structures of *Trentepohlia abietina* (Flotow ex Kützing) Hansgirg **A** – Thallus **B** – Apical cells with pectic caps **C** – Single erect filament from the prostrate cells **D** – Branched filaments with presumptive gametangia

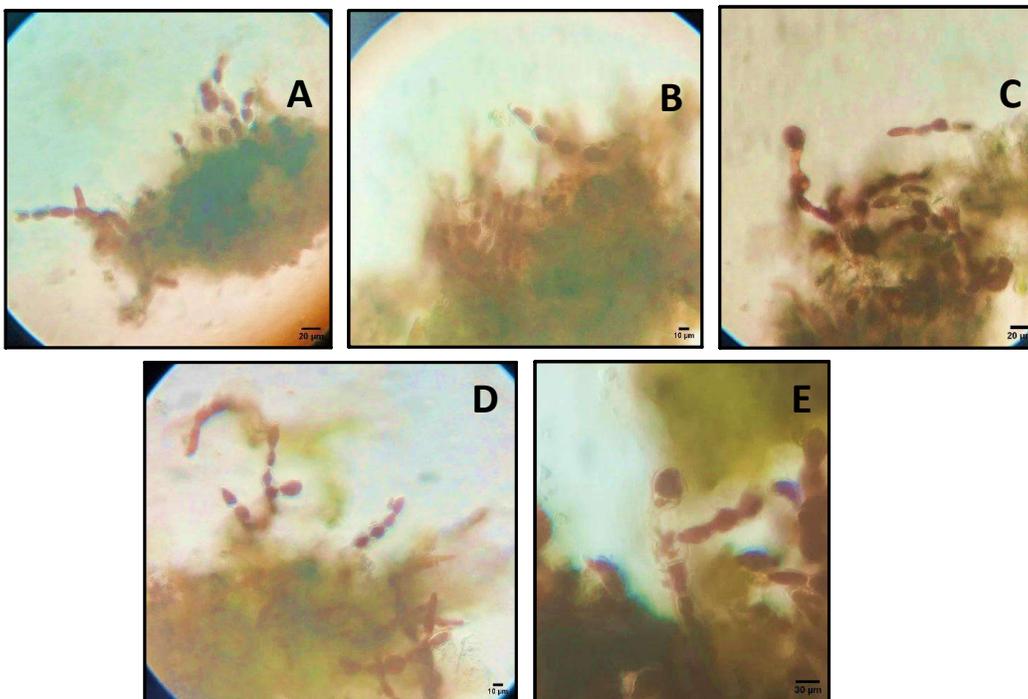


Figure 7. (A - E) Microscopic structures of *Trentepohlia abietina* var. *tenuis* **A** – Thallus **B** – Apical cell with Pectic Cap **C** – Sporangia on slightly bent suffultory cell **D** – Lateral Sporangia **E** – Sporangia on cup shaped Suffultory cell

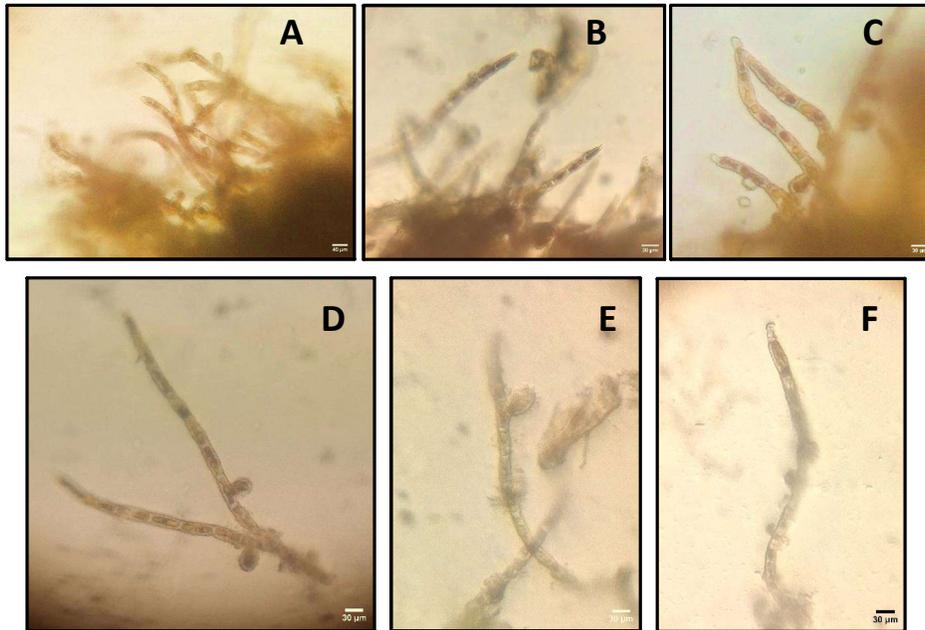


Figure 8. (A - F) Microscopic structures of *Trentepohlia abietina* var. *corrugata* **A** – Thallus **B, C and F** - Apical Cells with Irregular Caps **D** – Branched filaments with Lateral Presumptive Gametangia **E** – Single Filament with Zoosporangia

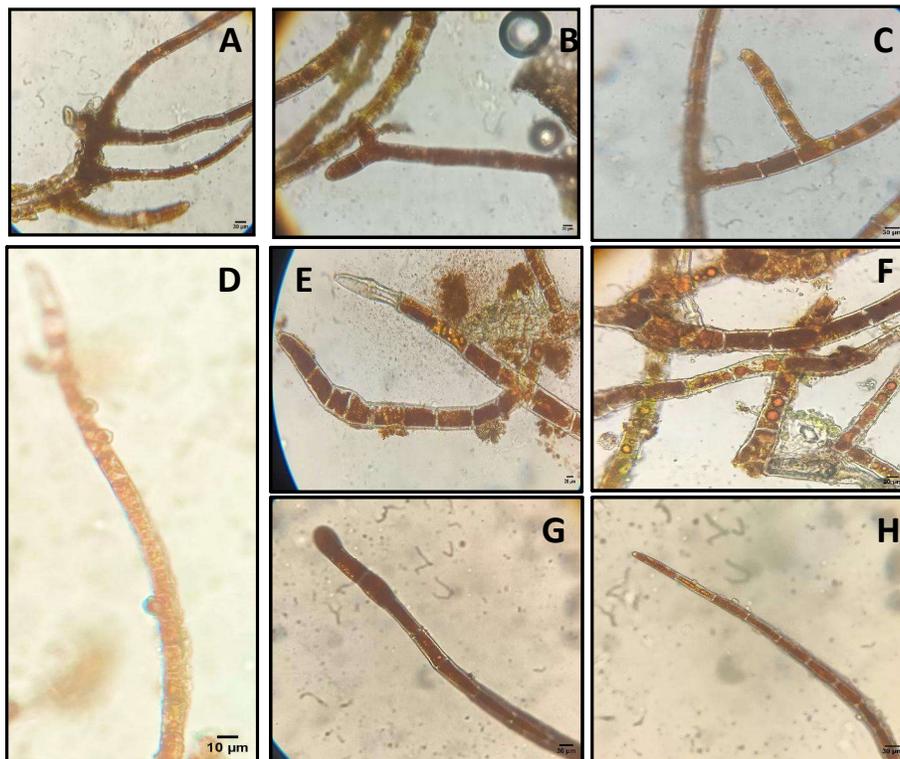


Figure 9. (A - H) Microscopic structures of *Trentepohlia aurea* Martius **A and C** – Profused Branching of Filaments **B** – Erect and Prostrate cells **D** – Presumptive Gametangia on Erect Filament **E** – Cells with rich carotenoid pigments **F** – Oil globules/lipid droplets **G** – Obtuse/ blunt tip **H** – Apical Cell with Pectic Cap

shaped 24.5–26.88 µm in diameter. Oblique arrangement of zoosporangium at the top of erect axes. The apical cell with pectic cap 15.36 µm long and 13.44 µm wide (Figure 10).

11. *Trentepohlia effusa* (Krempelhuber) Hariot, Brazil: Rio de Janeiro State (1890)

Thallus heterotrichous, consists of separation between dense prostrate parts and long sparsely erect parts. Erect axes 115.2 – 230.4 µm tall. Cells of the erect filaments are cylindrical with 3.84 – 5.76 µm wide, 19.2 µm long. Sporangia are sessile, globular 7.68 – 15.36 µm in diameter. Apical cells with tapering/ pointed end (Figure 11).

Guiry and Guiry (2024) observed that genus *Trentepohlia* currently comprises of 53 species and 28 varieties worldwide. India has made a notable contribution to this global diversity, with the documentation of seven species that were first described based on specimens collected within the country and include *Trentepohlia gracilis*, *T. pathanamthittaensis*, *T. angadickalensis*, *T. thevalliensis*, *T. sundarbanensis*, *T. gaviensis*, and *T. keralensis*. These species were described by the Panikkar and Sindhu (1993); Satpati and Pal (2015 and 2019); and Binoy et al. (2019) based on the morphological observations and habitat specificity. In addition to these species, two varieties, *Trentepohlia aurea* Mart. var. *tenuior* and *Trentepohlia monilia* De Wildemann var. *subspherica* were reported from India. These varieties were documented by Bruhl and Biswas (1923) and Krishnamurthy (2000).

Several studies have contributed to the growing understanding of the global diversity and distribution of the genus *Trentepohlia*. In temperate regions, Rindi and Guiry (2002) reported the presence of four *Trentepohlia* species from urban habitats in western Ireland. This finding is significant as it highlights the ability of these algae to colonize artificial substrates in cooler, urban environments, indicating their ecological flexibility and tolerance to anthropogenic conditions.

In tropical South America, Rindi and Lopez-Bautista (2007) documented four *Trentepohlia* species from French Guiana, two of which were newly described and previously unknown to science. Expanding the biogeographical scope further, Rindi et al. (2005) identified five species from the Hawaiian Islands. The presence of multiple *Trentepohlia* species in these islands suggests that the genus has a remarkable dispersal ability and can establish populations in isolated island systems, possibly through airborne spores or anthropogenic vectors. In Central Africa, Allali et al. (2013) conducted an extensive survey in Gabon and recorded eleven species of *Trentepohlia*, the highest species richness

among the studies cited. Gabon's equatorial climate, characterized by high humidity, stable temperatures, and dense forest canopies, likely provides ideal conditions for the growth and diversification of *Trentepohlia* species. More recently, Saraphol (2020) reported eight species from the Chiang Dao Wildlife Sanctuary in Thailand. The findings from this protected area highlight the importance of conservation areas in preserving algal diversity.

In India, the diversity and distribution of *Trentepohlia* species have been documented in various regional studies, reflecting the genus wide ecological range and occurrence in diverse climatic zones. In an early investigation, Panikkar and Sindhu (1993) reported eight species from the state of Kerala, emphasizing the favourable subaerial habitats provided by the humid tropical climate. Subsequently, Krishnamurthy (2000) recorded 14 species from Kolkata, West Bengal, contributing valuable data from an eastern subtropical environment. Tiwari et al. (2011) expanded on the Kerala records by identifying 18 species, the rich algal diversity in this southern coastal region. In contrast, Tamal et al. (2012) documented only a single species from West Bengal, and an additional survey by Satpati and Pal, (2013 and 2015) from the same region increased the known diversity to eight species. From state of Karnataka, Singh and Singh, (2017) recorded four species, providing insights into the genus occurrence in the regions of Karnataka. Binoy et al. (2019) reaffirmed Kerala's significance as a hotspot for *Trentepohlia*, reporting eight species. Collectively, these studies highlight the insufficient yet significant distribution of *Trentepohlia* across different biogeographical zones in India and emphasize the need for continued exploration and systematic documentation.

3.3. Shannon-Wiener Diversity Index

Shannon Weiner diversity index, summarizes that diverseness depends upon both the number of species and their relative individual distribution in the particular areas (Table 3). The total number of different species individuals present in an area is the measure of the total distribution of richness. Though the frequency of collection of samples in Belagavi district was lesser compared to Dharwad, yet Belagavi illustrated higher species diversity than Dharwad. The most abundant species recorded was *Trentepohlia odorata* in Belagavi which is diversified in all the 3 districts. The Dharwad collection was dominated by *Trentepohlia rigidula* with greater diversity. The Belagavi and Dharwad samples had a greater species diversity of 2.02 and 1.61 respectively. The Haveri collection numbered only fewer species with the diversity of 1.31. The reasons for these

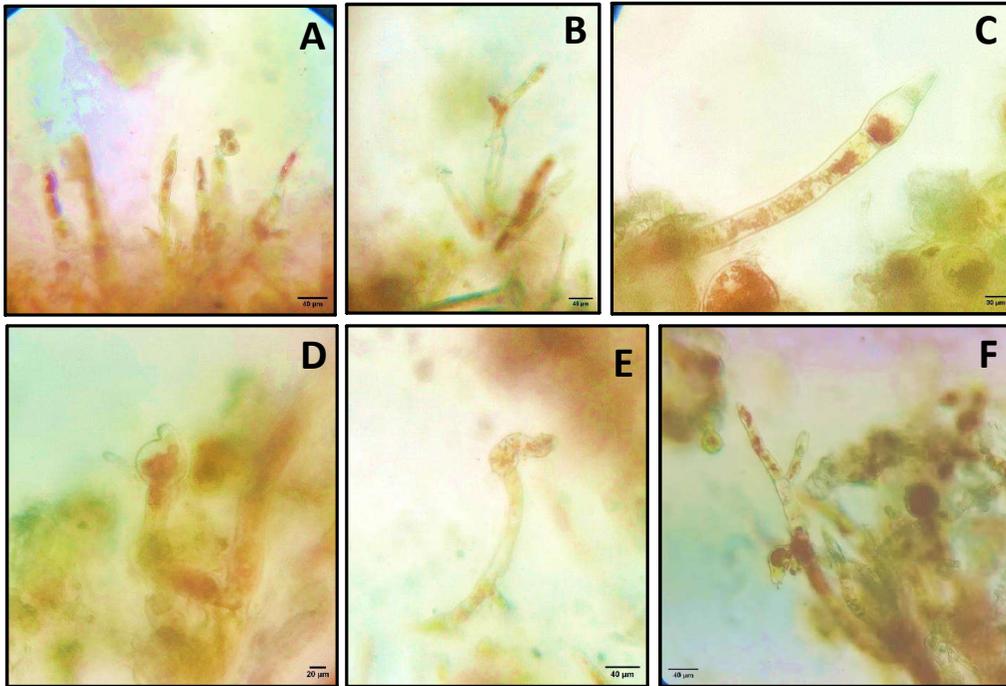


Figure 10. (A - F) Microscopic structures of *Trentepohlia annulata* **A** – Thallus **B** – Branching of Filament **C** – Apical Cell with Pectic Cap **D** –Development of Lateral Zoosporangium **E** – Oblique arrangement of Zoosporangium **F** – Lateral Zoosporangium

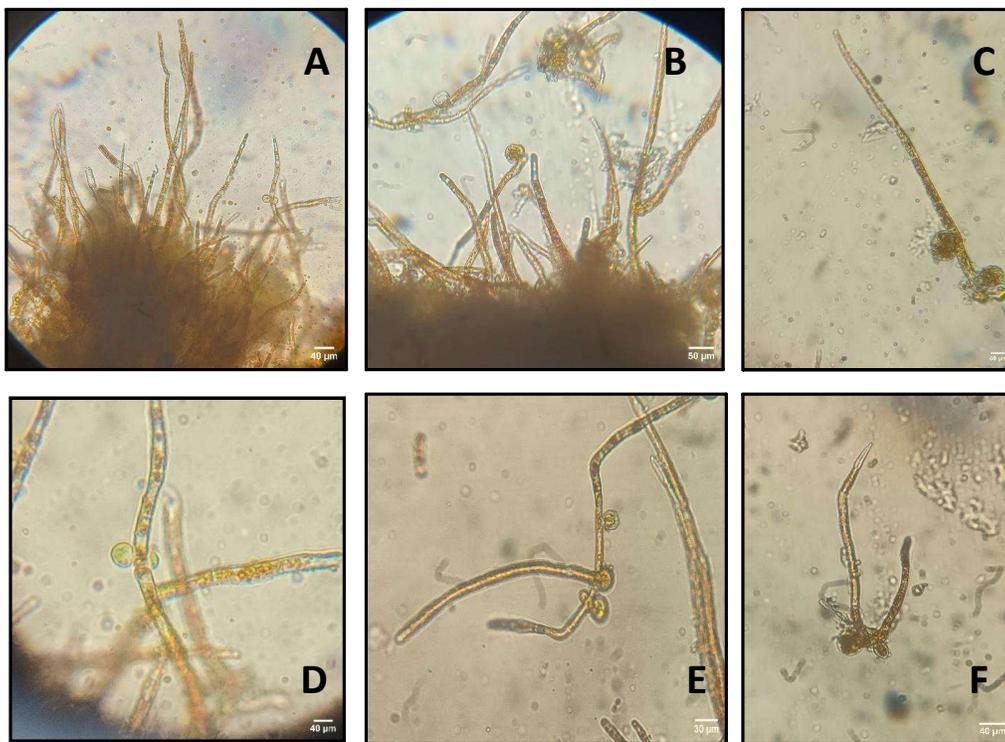


Figure 11. (A - F) Microscopic structures of *Trentepohlia effusa* **A** – Thallus differentiated into Erect and Prostrate parts **B, D and E** – Sessile Sporangia **C** – Single Erect filament with lateral sporangia **F** – Erect filaments arising from Prostrate Part

Table 3. Summary of *Trentepohlia* species surveyed in the sampling sites subjected to Shannon - Weiner diversity index

<i>Trentepohlia</i> species	Dharwad	Belagavi	Haveri
<i>Trentepohlia aurea</i> (Linnaeus) C Martius	0	1	0
<i>Trentepohlia odorata</i> (F. H. Wiggers) Wittrock	1	4	1
<i>Trentepohlia abietina</i> (Flotow ex Kützing) Hansgirg	0	2	2
<i>Trentepohlia rigidula</i> (J. Müller) Hariot	10	3	1
<i>Trentepohlia effusa</i> (Krempelhuber) Hariot	0	1	0
<i>Trentepohlia annulata</i> F. Brand	1	0	0
<i>Trentepohlia abietina</i> var. <i>corrugata</i> (Leighton) Cribb	0	1	0
<i>Trentepohlia abietina</i> var. <i>tenuis</i> (Zeller) A. B. Cribb	1	0	0
<i>Trentepohlia thevalliensis</i> M. V. N. Panikkar and P. Sindhu	0	1	0
<i>Trentepohlia chapmanii</i> Rindi and López-Bautista	1	1	1
<i>Trentepohlia infestans</i> Rindi and J. López-Bautista	1	0	0
Shannon-Weiner Diversity Index	1.61	2.02	1.33

differences could be the variations in the favourable physical conditions of the particular regions for the growth of species.

4. CONCLUSION

The study reveals two characteristic environmental conditions in Karnataka which exhibits a tropical monsoon climate, whereas the northern region of the state generally experiences a subtropical climate characterized by warm to hot summers and mild winters, along with distinct wet and dry seasons. Presence of tropical monsoon climate favouring the growth of *Trentepohlia* species. Since geographically Dharwad and Belagavi comes under the Western Ghat belt, the number of species obtained was more compared to Haveri. The absence of *Trentepohlia* species in other districts was mainly due to low rainfall, low relative humidity, and high temperature and light intensity. All the species documented were previously unreported taxa for this region. These findings constitute new distributional records, indicating a broader biogeographical range than previously known and highlighting the unexplored biodiversity potential of North Karnataka.

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Authors' Contributions

Seema Jagannath Rajapure: Survey, Morphometric evaluation and identification, Data Curation, Original draft preparation, Review and Editing. Doris M. Singh: Conceptualization, Keys Preparation, Supervision

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The authors declare no use of AI tools in the writing process.

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