



Plant Archives

Journal homepage: <http://www.plantarchives.org>
 DOI Url : <https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.012>

GENUS *TETRACLADIUM* (INGOLDIAN FUNGI) FROM HIMACHAL PRADESH, INDIA

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(Date of Receiving : 02-02-2021; Date of Acceptance : 20-04-2021)

ABSTRACT

The present paper deals with five species of freshwater hyphomycetes, encountered in foam samples collected from Beas, Sutlej and Swan rivers in Himachal Pradesh, viz. *Tetracladium apiense* R.C. Sinclair & Eicker, *Tetracladium breve* A. Roldan, *Tetracladium furcatum* Descals, *Tetracladium marchalianum* De Wild., and *Tetracladium setigerum* (Grove) Ingold. Out of these five species *Tetracladium apiense* and *Tetracladium marchalianum* found in Beas, Sutlej and Swan rivers while the other three species viz. *Tetracladium breve*, *Tetracladium furcatum*, and *Tetracladium setigerum* is found in Beas and Sutlej rivers. The data collected from the three rivers of Himachal Pradesh provide information on the biodiversity and geographical distribution of these fungi from place to place which is also mentioned in the descriptions and illustrations. This data will assist in the compilation of genus *Tetracladium* and all these five species have been reported for the first time in the Himachal Pradesh.

Keywords : Freshwater fungi, Hyphomycetes, mycodegradation, taxonomy

INTRODUCTION

Aquatic fungi are found on submerged decaying leaves, twigs, and foam, in freshwater streams and other aquatic bodies. Since these were first described by Ingold, thus are referred to as the Ingoldian fungi. Because, fungi complete their life cycle on submerged substrate as well as in free flowing well-aerated water, these are also referred to as freshwater, water borne or amphibious hyphomycetes. Aquatic fungi produce a vast quantity of conidia in lotic habitats. The conidia have a different shape like tetra- to polyradiate, sigmoid, multiradiate, branched, helical and spherical. Morphology and development of conidia are the classical tools to understand the taxonomy and identification of fungi. Aquatic hyphomycetes play an important role in decay of organic matter of plant origin. Their capability to break down leaf tissues by degrading plant cell polymers such as cellulose, hemicelluloses, and pectin into their subunits make the leaf litter delectability to stream invertebrates. During the present study, five species of aquatic fungi viz.: *Tetracladium apiense*, *Tetracladium breve*, *Tetracladium furcatum*, *Tetracladium marchalianum*, and *Tetracladium setigerum*, have been collected and described from the Sutlej river in Himachal Pradesh. Review of literature revealed that all these taxa constitute new records for Himachal Pradesh.

MATERIALS AND METHODS

The foam of water samples from the study area was collected in glass vials and brought to the laboratory for

further examination. The samples were mounted in 4% KOH, lactophenol and cotton blue 0.01% in lactophenol (Kirk *et al.*, 2008). They were then examined for macroscopic and microscopic characteristics using a transmission microscope (VRS-2f). Pro MED software was used to take all of the measurements. The specimens were deposited in the Herbarium, Department of Botany, Panjab University, Chandigarh, India (PAN).

RESULTS AND DISCUSSION

Taxonomy

Tetracladium De Wild., *Ann. Soc. Belge Microscop.* 17: 39 (1893)

The genus is characterized by having hyaline, branched and septate hyphae. Conidiophores micro- to semimacronematous, and then mononematous, apical or lateral, simple or sparsely branched. Conidiogenous cells single or paired, integrated and apical (or lateral), polyblastic, sympodial frequently denticulate. Conidia single or grouped, acrogenous, staurosporous, laterally flattened in most species, multiseptate; central axis differentiated into a subclavate stalk and a distal element, a basal extension present in most species; branches pleurogenous and sequential, arranged in two orders and appearing directly below septa; branches of various shapes, ranging from globose to filiform, with basal septa; primary branches appearing on one level or, if on more, then on consecutive

cells of the axis, a secondary branch arising abaxially and from near the middle of one or two parent branches.

***Tetracladium apiense* R.C. Sinclair & Eicker, Trans. Br. mycol. Soc. 76(3): 515 (1981) Fig. 1 (a-c)**

Conidia solitary, hyaline, smooth, with 4 divergent arms, 4 septate, 15-19 μm long, 4.5 μm wide tapering to 2 μm wide, proximal arms tapering to 2-2.5 μm . At the point of divergence of distal arms and just along one arm arise 2-3, 3 celled digitate processes 16-21 μm long, 4-4.5 μm wide, subsequent distal cells arising as lateral outgrowths originating at loci immediately below transverse septae.

Collection Examined: India, Himachal Pradesh, Kullu, Beas river, conidia found in foam sample, 9 January 2016, Punita, PAN (34977); India, Himachal Pradesh, Bilaspur, Sutlej river, conidia found in foam sample, 13 February 2017, Punita, PAN (35018); India, Himachal Pradesh, Una, Swan river, conidia found in foam sample, 25 December 2018, Punita, PAN (35019).

Remarks: The species matches well with the description of *T. apiense* in morphological details. This species has previously been found on submerged leaves in Uttarakhand (Sati *et al.*, 2003), but this is the first time it has been found in Himachal Pradesh (Bilgrami *et al.*, 1991; Jamaluddin *et al.*, 2004 and Borse *et al.*, 2016).

***Tetracladium breve* A. Roldán, in Roldán, Descals & Honrubia, Mycol. Res. 93(4): 455 (1989) Fig. 1 (d-f)**

Conidia staurosporus, laterally compressed, with a central axis and with branches sequential, primary branches on consecutive cells of the axis, diverging in one plane. Detached conidia multiseptate, the axis with distal element subclavate to digitiform, 19-21 μm long, 2 μm wide, 3 septate, scar replaced by a filiform, basal extension up to 7 μm long. At 6-7 μm above the scar three lateral elements are inserted: two of them are opposite, one of which is digitiform, 10-11 \times 2.5 μm , 1 septate; and the other acicular, 17-22 \times 1 μm , 1 septate; the third element is filiform and up to 22 μm long; the digitiform element bears at its middle part an abaxial acicular element 12-14 \times 1.5 μm .

Collection Examined: India, Himachal Pradesh, Kullu, Beas river, conidia found in foam sample, 29 October 2016, Punita, PAN (34978); India, Himachal Pradesh, Bilaspur, Sutlej river, conidia found in foam sample, 13 February 2017, Punita, PAN (35020).

Remarks: In terms of morphological details, the species closely resembles *T. breve*. This species has been reported from submerged leaves in Uttarakhand (Arya and Sati 2010), but it is a new record for Himachal Pradesh (Bilgrami *et al.*, 1991; Jamaluddin *et al.*, 2004 and Borse *et al.*, 2016).

***Tetracladium furcatum* Descals, in Descals & Webster, Trans. Br. mycol. Soc. 80(1): 70 (1983) Fig. 1 (g-i)**

Conidia solitary, staurosporus, spanning, 32-52 μm long and 2.5 μm wide, main body clavate, typically uniseptate, basal scar flat, often with a short caudal extension, 5 branches, in two orders, 3 primary branches, one apical and 2 sub-apical, successive, in more than one plane, apical branch digitate and typically uniseptate, 11-16 \times 2.5 μm , the first

sub-apical branch acutely antorse, mostly digitate, 2 septate, the second primary branch obtusely antorse and pendulous, apiculate, with basal constriction, 0 septate, apiculate, lateral on the digitate branches.

Collection Examined: India, Himachal Pradesh, Kullu, Beas river, conidia found in foam sample, 3 January 2016, Punita, PAN (34979); India, Himachal Pradesh, Bilaspur, Sutlej river, conidia found in foam sample, 13 February 2017, Punita, PAN (35021).

Remarks: The species matches well with the description of *T. furcatum* in morphological details. This species was earlier reported from Uttarakhand (Raviraja *et al.*, 1996), on the submerged roots; however, this is a new record for Himachal Pradesh (Bilgrami *et al.*, 1991; Jamaluddin *et al.*, 2004 and Borse *et al.*, 2016).

***Tetracladium marchalianum* De Wild., Ann. Soc. Belge Microscop. 17: 39 (1893) Fig. 2 (a-c)**

Conidia aleuriospore, has four divergent branches 22-40 μm long, 2-2.5 μm wide, 5 septate and of two more or less spherical knobs, 3-4 μm broad, one situated just above the point from which the four branches diverge, the other a short distance from this point on the upper side of the branches.

Collection Examined: India, Himachal Pradesh, Kullu, Beas river, conidia found in foam sample, 3 January 2016, Punita, PAN (34980); India, Himachal Pradesh, Bilaspur, Sutlej river, conidia found in foam sample, 17 February 2018, Punita, PAN (35022); India, Himachal Pradesh, Una, Swan river, conidia found in foam sample, 24 September 2017, Punita, PAN (35023).

Remarks: The species matches well with the description of *T. marchalianum* in morphological details. This species was earlier reported from Uttarakhand (Mer and Khulbe, 1981); on leaves, Maharashtra (Patil and Kapadnis, 1979); in foam, Karnataka (Chandrashekar *et al.*, 1986, 1990) on leaves, in foam and water, Kerala (Sridhar and Kaveriappa, 1985) Foam and Scum sample; Andhra Pradesh (Manoharachary, 1989); in foam; Madhya Pradesh (Upadhyaya *et al.*, 2012) on leaves and in foam. This species has been the first time recorded from Himachal Pradesh (Bilgrami *et al.*, 1991; Jamaluddin *et al.*, 2004 and Borse *et al.*, 2016).

***Tetracladium setigerum* (Grove) Ingold, Trans. Br. mycol. Soc. 25(4): 371 (1942) [1941] Fig. 2 (d-f)**

= *Tridentaria setigera* Grove, J. Bot., Lond. 50: 16 (1912)

Conidia aleuriospore, with four divergent arms 20-39 μm long and 2.5 μm wide, each tapering from 3 μm near the central region of the conidia to 1 μm near its tip, and of three elongated, parallel, finger-like processes, 4 septate, 13-14 μm long, 4-7 μm wide, two of which are inserted just above the point of divergence of the four arms and the third a short distance along one of the arms.

Collection Examined: India, Himachal Pradesh, Kangra, Beas river, conidia found in foam sample, 14 October 2017, Punita, PAN (34981); India, Himachal Pradesh, Kullu, Sutlej river, conidia found in foam sample, 27 November 2016, Punita, PAN (35024).

Remarks: In terms of morphological details, the species closely resembles *T. setigerum*. This species was earlier

reported from Uttarakhand (Mer and Khulbe, 1981), Maharashtra (Thakur, 1977), on submerged leaves, Karnataka (Subramanian & Bhat 1981) and Andhra Pradesh (Manoharachary 1989) in foam. This species has been the first time recorded from Himachal Pradesh (Bilgrami *et al.*, 1991; Jamaluddin *et al.*, 2004 and Borse *et al.*, 2016).

DISCUSSION

Tetracladium is one of the first described genus of aquatic hyphomycetes (Wildeman, 1893) and *T. marchalianum* as its type species. The genus is characterized by having, branched, septate hyaline hyphae and conidiophores. Conidia produced on the tip of conidiophores, may be solitary or as many as three with finger-like divergent arms. The genus *Tetracladium* (Wildeman, 1893) and its contains 11 valid species (www.indexfungorum.org): *T. apiense* R.C. Sinclair & Eicker, (1981) *T. breve* A. Roldan, (1989) *T. ellipsoideum* M.M. Wang & Xing Z. Liu, (2014) *T. furcatum* Descals, (1983) *T. globosum* M.M. Wang & Xing Z. Liu, (2014) *T. marchalianum* De Wild., (1893) *T. maxilliforme* (Rostr.) Ingold, (1942) *T. nainitalense* Sati &

Arya (2009) *T. palmatum* A. Roldan, (1989) *T. psychrophilum* M.M. Wang & Xing Z. Liu, (2014) *T. setigerum* (Grove) Ingold (1942).

Currently altogether ten valid species of *Tetracladium* are known till to date (March 2021: www.indexfungorum.org;) viz.: *T. apiense*, *T. breve*, *T. ellipsoideum*, *T. furcatum*, *T. globosum*, *T. marchalianum*, *T. nainitalense*, *T. palmatum*, *T. psychrophilum* and *T. setigerum*.

Out of these *Tetracladium maxilliforme* is converted in to *Titaea maxilliformis*. This species was first described by Rostrup under the genus *Titaea* and replaced in the genus *Tetracladium* by Ingold after a thorough discussions. Out of these six species have been recorded from India. These species are *T. apiense*, *T. breve*, *T. furcatum*, *T. marchalianum*, *T. nainitalense* and *T. setigerum*. In present study five species reported and these species constitute a new record for Himachal Pradesh. Synoptic table 1 of all the species of genus *Tetracladium* is also provided.

Table 1 : Synoptic analysis of *Tetracladium* species:

Sr. No.	Species	Arms	Septation	Conidia (µm)	Area	References
1.	<i>T. apiense</i>	3-4	0-5	10-20 × 3.5-4.5	Uttarakhand	Sinclair & Eicker (1981)
2.	<i>T. breve</i>	3	2-3	17-21 × 1.5-2.5	Uttarakhand	Roldan <i>et al.</i> (1989)
3.	<i>T. ellipsoideum</i>	-	1	3-5 × 5-10	China	Wang <i>et al.</i> (2014)
4.	<i>T. furcatum</i>	4-6	1-4	30-53 × 2-3	Uttarakhand	Descals & Webster (1983)
5.	<i>T. globosum</i>	-	1	4-5 × 4-5	China	Wang <i>et al.</i> (2014)
6.	<i>T. marchalianum</i>	4	5	20-40 × 2-3	Uttarakhand, Maharashtra, Kerala, Karnataka, Andhra Pradesh and Madhya Pradesh.	Wildeman (1893)
7.	<i>T. nainitalense</i>	4	2-3	18-25 × 3-4.5	Uttarakhand	Sati <i>et al.</i> (2009)
8.	<i>T. palmatum</i>	3	3-6	22-48 × 3-4.2	Spain	Roldan <i>et al.</i> (1989)
9.	<i>T. psychrophilum</i>	-	-	-	China	Wang <i>et al.</i> (2014)
10.	<i>T. setigerum</i>	4	3	20-40 × 3	Uttarakhand, Maharashtra, Karnataka and Andhra Pradesh.	Ingold (1942)

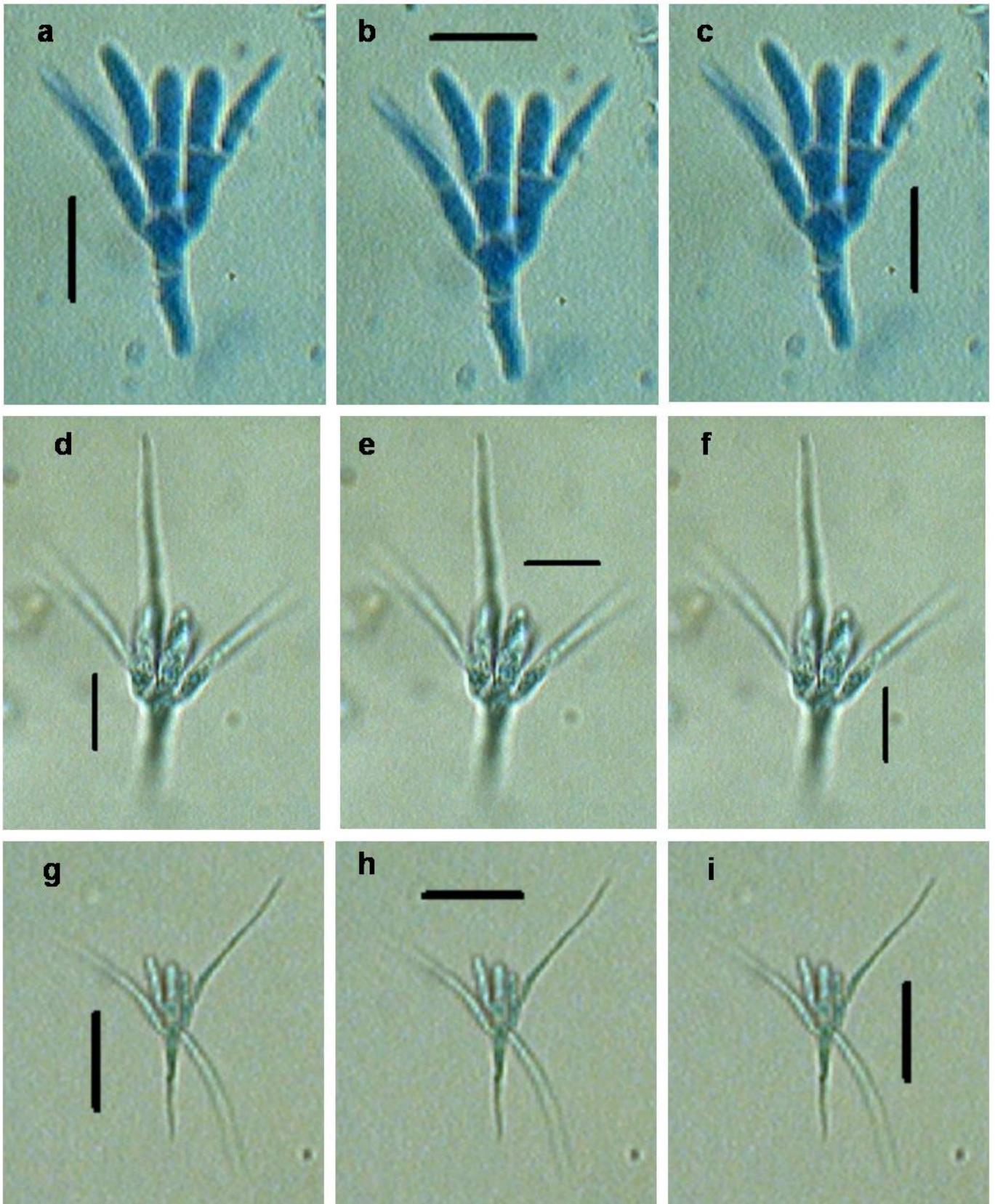


Fig. 1 : (a-c) *Tetracladium apiense* (d-f) *Tetracladium breve* (g-i) *Tetracladium furcatum*
Scale bars a-f = 10 μ m; g-i = 20 μ m.

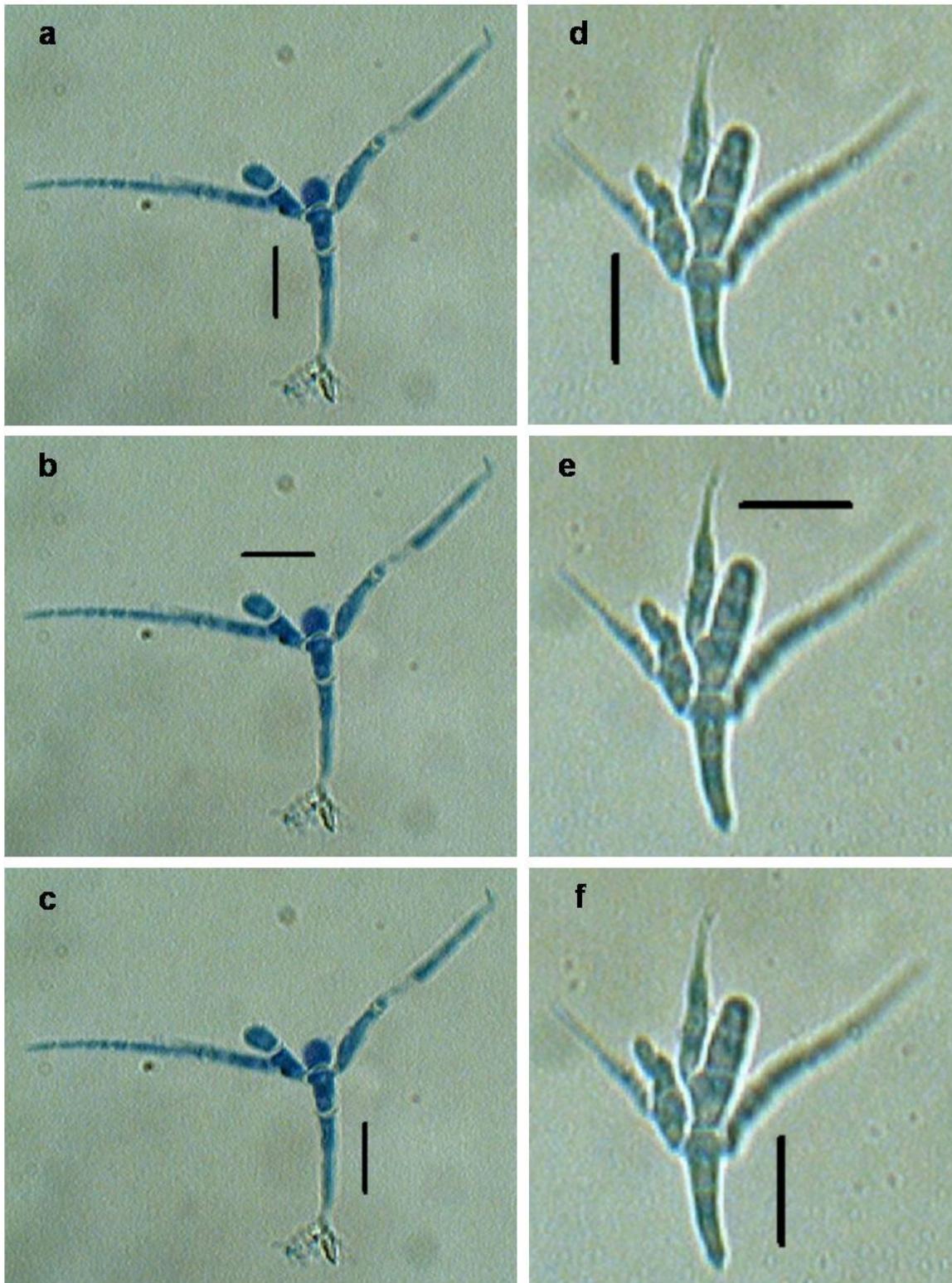


Fig. 2 : (a-c) *Tetracladium marchalianum* (d-f) *Tetracladium setigerum*
 Scale bars a-f = 10 μ m.

Acknowledgements

We are grateful to the Ministry of Environment, Forests and Climate Change (MOEFCC) of the Government of India for the research grant (Vide letter No. 14/257/2013-RE dt.07/09/2015) and to one of us 'P' for the fellowship. We are also thankful to the Chairperson, Department of Botany, Panjab University, for providing laboratory facilities and to the UGC SAP (DRS-III) for infrastructural support.

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