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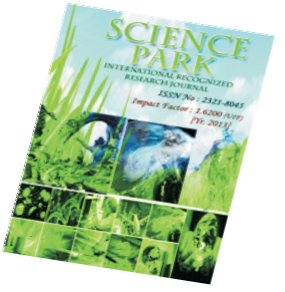
FRESHWATER BASIDIOMYCETES FROM INDIA



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ABSTRACT

The present paper deals with distribution and substratum range of 13 species of freshwater Basidiomycetes (FWA) reported so far from India. They were found as parasites of freshwater plants, saprophytes on woody debris, in water, and leaf litter submerged in freshwater environment. Asexual conidia of some of these fungi were encountered in samples of water, foam, and rainwater draining from intact trees. A checklist of freshwater Basidiomycetes recorded from India is compiled on the basis of present studies in Maharashtra, Gujarat and Madhya Pradesh states of India and published literature. Distribution of 13 species of freshwater Basidiomycetes reported so far from various states of India is provided along with their classification. These include species of the teleomorph / sexual genera viz., *Burrillia, Doassantiopsis, Classicula, Rhamphospora*, and *Sistotrema* and anamorph / asexual genera viz., *Dendrosporomyces, Ingoldiella, Jaculispora, Mrakiella, Naidella, Rhodotorula, and Tricladiomyses*. The checklist includes details of the location and substrata on which they encountered. This data will be useful in the compilation of freshwater fungal diversity of India.

Keywords: freshwater, Basidiomycetes, smut fungi, foam samples

INTRODUCTION

This paper reviews Freshwater Basidiomycetes (FWB) recorded from India. FWA is taxonomically diverse group including both yeasts and filamentous forms. They are few in number and may be a consequence of their evolutionary origin as terrestrial organisms and as symbionts of terrestrial plants (Jones and Fell, 2012; Krings et al., 2012).

Number: They are represented by 115 species in 19 orders (in 50 genera; 41 non yeasts sp. and 74 sp. yeasts) and comprise many yeasts and asexual morphs often associated with glacial waters (Libkind et

al., 2010; Kurtzman et al. 2011; Jones et al., 2014).

Morphology: Morphologically FWB categorized into three groups: a) Yeasts, b) Filamentous fungi, and c) Endophytes. Most of them are known by their asexual states with elaborate conidia including forms that are sigmoid, tetraradiate, extremely branched, and bizarrely shaped.

Identifications: They are identified by the presence of clamp-connections or binucleate cells or sexual stages in culture, a few have been on DNA sequence data. Although a few species of FWB produce fruiting bodies visible to the naked eye, most occur as single cells (yeasts) or as variously branched conidia. (Jones et al., 2014).

Habitats: They have been reported from lakes and streams, brackish water, sewage-contaminated water, glacier melt water, and waste water and found on a variety of substrates, e.g. on culms of Equisetum sp., on submerged decaying leaves or woody debris, in water, parasites of freshwater plants (e.g. smut fungi in the leaves) and asexual states encountered in foam samples (Cooke, 1976; Pore and Sorenson, 1990; de Garcia et al. 2010; Brandao et al., 2011).

Previous research work in India: Research on freshwater smut fungi of India were made by Cunningham (1888), Sydow and Sydow (1912), Mundkur (1940), Mundkur and Thirumalachar (1946), Thirumalachar (1947), Thirumalachar and Mundkur (1951), Mundkur and Thirumalachar (1952), and Gandhe (2011). These workers encountered FWA on leaves of species of the genera *Alisma, Castalia, Nymphae*, and *Potomogeton* sp. Asexual forms were recorded by Ingold and Webster (1973), Subramanian and Bhat (1981), Manoharachary and Rao (1983), Sridhar and Kaveriappa (1990), Sridhar and Kaveriappa (1989a), Sati et al. (2002b), Sati et al. (2003) Rajashekhar and Kaveriappa (2003), Shivaji et al. (2008), Sridhar and Karamchand (2009), and Patil et al. (2011) from various states of India.

Taxonomic account:

1. Burrillia narasimhanii Thirum. & Mundk.
Mycol. Pap., 40: 8 (1951).
Habitat: Parasitic on leaves of Alisma reniforme D. Don.
Distribution in India:- Karnataka: On leaves of Alisma reniforme D. Don. (Thirumalachar and Mundkur, 1951).

2. Dendrosporomyces prolifer Nawawi, J. Webster & R.A. Davey
Trans. Br. Mycol. Soc., 68: 59 (1977a). [Fig. 1]
Habitat: Saprophyte on submerged leaves.
Distribution in India:- Karnataka: On submerged leaves (Sridhar and Kaveriappa, 1989a); *Maharashtra:* Conidia in foam samples (Patil et al., 2011).

3. Doassantiopsis martianoffianus (Thuem.) Dietel
In: Engler & Prantl, *Die Naturl. Pflanznfam*., 1: 21 (1898).
Habitat: Parasitic on leaves of freshwater plants.
Distribution in India:- Kashmir: On floating leaves of *Potamogeton* sp. (Mundkur, 1940); *Karnataka*: Parasitic on leaves of Alisma reniforme G. Don. (*Mundkur and Thirumalachar*, 1946; Thirumalachar, 1947).

4. Doassantiopsis nympaaeae (Syd. & P. Syd.) Thirum.
Mycologia, 39: 604 (1939). [Fig. 3]
Habitat: Parasitic on leaves of *freshwater plants.*
Distribution in India:- Maharashtra: On the leaves of Nymphaea nouchali Burm. (Sydow & Sydow, 1912); parasitic in the petioles and lamina of *Nymphaea nouchali Burm.* (Gandhe, 2011).

5. Ingoldiella fibulata Nawawi
Trans. Br. Mycol. Soc., 61: 525 (1973b).
Habitat: On decaying submerged leaves.
Distribution in India:- Kerala: Conidia in foam (Subramanian and Bhat, 1981).

6. Ingoldiella hamata D.E. Shaw
Trans. Br. Mycol. Soc., 59: 258 (1972).
Habitat: On decaying submerged leaves.
Distribution in India:- Kerala: Conidia in foam samples (Subramanian and Bhat, 1981); *Karnataka:* Conidia in foam samples (Sridhar and Kaveriappa, 1982); On submerged leaves and conidia in foam and water samples (Chandrashekar et al., 1986; Sridhar and Kaveriappa, 1989b); *Tamil Nadu:* Conidia in foam samples (Ingold and Webster, 1973), conidia in foam samples (Subramanian and Bhat, 1981); *Andhra Pradesh*: Conidia in foam samples (Ingold, 1973); Maharashtra: On submerged leaves (Patil, 1998, 2007), conidia in foam samples (Patil, 2003).

7. Jaculispora submersa H.J. Huds. & Ingold
Trans. Br. Mycol. Soc., 43: 475 (1960). [Fig. 2]
Habitat: On decaying submerged leaves.
Distribution in India:- Andhra Pradesh: On submerged leaves (Manoharachary and Rao, 1983); *Uttarakhand:* Conidia in foam samples (Sati et al., 2002); *Karnataka:* Conidia in foam samples (Rajashekhar and Kaveriappa, 2003); *Maharashtra:* Conidia in foam (Borse and Patil, 2015).

8. Naidella fluitans Marvanova & Bandoni
Mycologia, 79: 579 (1987).
Habitat: On decaying submerged leaves.
Distribution in India:- Uttarakhand: On submerged leaves (Sati et al., 2003)

9. Mrakiella aquatica (E.B.G. Jones & Sloof) Margesin & Fell
Intern. J. Syste. & Evol. Microbiol., 58: 2977-2982 (2008).
Habitat: Isolated from freshwater scum and culms of Equisetum sp.
Distribution in India:- Karnataka: Conidia in stem flow and through fall (as *Candida aquatica*, Sridhar and Karamchand, 2009); *Maharashtra*: Conidia in foam samples (as *Vanrija aquatica*, Borse and Patil, 2015).

10. Rhamphospora nymphaeae D.D. Cunn.
Sci. Mem. Medical Officers Army of India, 3: 32 (1888). [Fig. 4]
Habitat: Parasitic on leaves of freshwater plants.
Distribution in India:- West Bengal: On the leaves of *Nymphaea nouchali Burm*. (Cunningham, 1888); *Maharashtra*: On the leaves of *Nymphaea nouchali* Burm. (Gandhe, 2011).

11. Rhodotorula himalayensis Shivaji, Bhadra, R.S. Rao & Pradhan, Extremophiles, 12: 375-381 (2008).
Habitat: Isolated from soils (psychrophilc lake) in Uttaranchal.
Distribution in India:- Uttarakhand: Isolated from the soils of psychrophilc lake from Himalayan Mountains (Shivaji et al., 2008).

12. Titaeella capnophila G. Arnaud ex K. Ando & Tubaki
Bull. Soc. Mycol. Fr., 67: 173-198 (1951).
Habitat: Saprophytic on submerged leaves.
Distribution in India:- Karnataka: Conidia in stem flow and through fall (Sridhar and Karamchand, 2009).

13. Tricladiomyses malaysianum (Nawawi) Nawawi
Bot. J. Linn. Soc., 91: 58 (1985b).
Habitat: Saprophytic on submerged leaves.
Distribution in India:- Karnataka: On submerged leaves (Sridhar and Kaveriappa, 1990), conidia in stem flow and through fall (Sridhar and Karamchand, 2009).

Table- 1. Classification of FWB from India.

Sr. No	Cassification	Sexual morph	Asxual morph	Substratum	Reference
1	Agaricomycotina Exobasidomycetes Diassantiales	***Burrillia narasimhanii*** Thirum. & Mundk.	Not known	Parasitic on leaves of *Alisma reniforme* G. Don.	Thirumalachar and Mundkur, 1951
2	Agaricomycotina Exobasidomycetes Diassantiales	***Rhamphospora nypmhaeae*** D.D. Cunn.	Not known	Leaves of *Caldesia reniformis*, pond water;	Lotz-Winter et al., 2011
3	Ustilaginomycotina Ustilaginomycetes Urocystidales	***Doassantiopsis nymphaeae*** (Syd. & P. Syd.) Thirum.	Not known	Submerged leaves of *Nymphaea nouchali*	Piatek et al., 2008
4	Ustilaginomycotina Ustilaginomycetes Urocystidales	***Doassantiopsis martianoffianus*** (Thuem.) Dietel	Not known	Parasitic on leaves of *Alisma reniforme* G. Don.	Mundkur & Thirumalachar, 1946; Thirumalachar, 1947
5	Pucciniomycotina Classiculomycetes Classiculales	***Classicula fluitans*** Bauer et al.	***Naiadella fluitans*** Marvanova & Bandoni	Submerged leaf litter	Marvanova & Bandoni (1987); Bauer et al., 2003
6	Pucciniomycotina Classiculomycetes Classiculales	Not known	***Jaculispora submersa*** H.J. Hud. & Ingold	Submerged leaf litter	Hudson & Ingold, 1960; Bauer et al., 2003
7	Agaricomycotina Agaricomycetes Cantharellales	***Sistotrema hamatum*** Nawawi & J. Webster	***Ingoldiella hamata*** D.E. Shaw	Submerged decaying leaves, foam	Nawawi & Webster, 1982
8	Agaricomycotina Agaricomycetes Cantharellales	Not known	***Ingoldiella fibulata*** Nawawi	Foam	Nawawi 1973; 1985
9	Basidiomycota *Incertae sedis*	Not known	***Titaeella capnophila*** G. Arnaud ex K. Ando & Tubaki	Rain water from tree, foam	Ando & Tubaki, 1985; Descals (1997)
10	Basidiomycota *Incertae sedis*	Not known	***Dendrosporomyces prolifer*** Nawawi et al.	Submerged decaying leaves, foam	Nawawi et al., 1977a
11	Basidiomycota *Incertae sedis*	Not known	***Tricladiomyses malaysianus*** (Nawawi) Nawawi	Submerged decaying leaves	Nawawi et al., 1977a; Nawawi, 1985
12	Agaricomycotina Tremellomyetes Cryptobasidiales	Not known	***Mrakiella aquatica*** (E.B.G. Jones & Slooff) Margesin & Fell	Foam, *Equisetum* culms	Jones & Slooff, 1966
13	Pucciniomycotina Cystobasidiomycetes Cystobasidiales	Not known	***Rhodotorula himalayensis*** Shivaji et al.	Psychrophilic Lake soil	Shivaji et al., 2008

Table- 2. Substrate range and distribution of FWB from India.

(F-Foam, L- leaf, SF-Stem flow, W-Water, AP-Andhra Pradesh, KA-Karnataka, KE-Kerala, JK-Jammu & Kashmir, MS-Maharashtra, TN-Tamil Nadu, WB-West Bengal, UK-Uttarakhand, UC- Uttaranchal).

Sr No	Name of species	Substrate	Location								
	Basidiomycota	F,L,SF,W	AP	WB	KA	KE	MS	JK	TN	UK	UC
1	*Burrillia narasimhanii* Thirum. & Mundk.	L	-	-	+	-	+	-	-	-	-
2	*Dendrosporomyces prolifer* Nawawi et al.	F, L	-	-	+	-	+	-	-	-	-
3	*Doassansiopsis martianoffianus* (Thuem.) Dietel	L	-	-	+	-	-	+	-	-	-
4	*Doassansiopsis nymphaeae* (Syd. & P. Syd.) Thirum.	L	-	-	-	-	+	-	-	-	-
5	*Ingoldiella hamata* D.E. Shaw	F, L, W	+	-	+	-	+	-	+	-	-
6	*Ingoldiella fibulata* Nawawi		-	-	-	+	-	-	-	-	-
7	*Jaculispora submersa* H.J. Huds. & Ingold	F, L	+	-	+	-	+	-	-	+	-
8	*Mrakiella aquatica* (E.B.G. Jones & Sloof) Margesin & Fell	SF	-	-	+	-	+	-	-	-	-
9	*Naidella fluitans* Marvanova & Bandoni	L	-	-	-	-	-	-	-	+	-
10	*Rhampospora nymphaeae* D.D. Cunn.	L	-	+	-	-	+	-	-	-	-
11	*Rhodotorula himalayensis* Shivaji et al.	W	-	-	-	-	-	-	-	-	+
12	*Titaeella capnophila* G. Arnaud ex K. Ando & Tubaki	SF	-	-	+	-	-	-	-	-	-
13	*Tricladiomyses malaysianum* (Nawawi) Nawawi	L, SF	-	-	+	-	-	-	-	-	-

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Explanation of figs.:

Plate:

Fig. 1. Conidium of *Dendrosporomyces prolifer* (scale bar = 50 µm);

Fig. 2. Conidium of *Jaculispora submersa* (scale bar = 10 µm);

Fig. 3.*Doassansiopsis nymphaeae* (redrawn after Gandhe, 2011), a. Infected petiole of *Nymphae stellata Willd*. (scale bar = 2 µm), b. Infected leaf of *Nymphae stellata Willd.* (scale bar = 1 mm), c. Section of infected leaf passing through the sorus (scale bar = 100 µm), d. Single spore ball (scale bar = 50 µm), e. Smut spores (10 µm);

Fig. 4. *Rhampospora nymphaeae* (redrawn after Gandhe, 2011), a. Infected leaf of *Nymphaea stellata Willd.* (scale bar = 2mm), b. A part of infected leaf (scale bar = 3 mm), c. A section of infected leaf passing through the sorus (scale bar = 50 µm), d. Smut spores (scale bar = 10 µm).