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Article

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Two new additions to mycoflora (Hyphomycetes) of India

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Abstract

Hyphomycetes are abundant and highly diverse in tropical areas such as India due to its climate and geographical landscape. However, several regions of the country remained unexplored or underexplored and many species remained undiscovered in the country. During mycological forays from the forests of Himachal Pradesh, two hyphomycetous fungi were collected. After detailed analysis of mycological characters like oval to oblong–ellipsoidal, muriform conidia with transverse, longitudinal, and oblique septa rounded or irregular at the ends and often with a protruding hilum, singly on short, unbranched conidiophores or sessile, in sporodochial conidiomata, it was found that these taxa belongs to the genus *Berkleasmium.* The further evaluation of morphological and microscopic characters revealed the identity of these fungi as *B. pandani* and *B. typhae*. Review of literature reveals that both are new records for India. Synoptic table of all the accepted species (both asexual morph and sexual morph) along with checklist of *Berkleasmium* from India is also provided.

Key words – Anamorphic fungi – biodiversity – taxonomy

Introduction

Himachal Pradesh is a state of Indian union situated between 30°22′40″ to 33°12′40″ along North latitudes and 75°45′ 55″ to 79°04′ 20″ along East longitudes. The altitude varies from 350 meters to 6975 meters above mean sea level. Terrestrial fungi play an important role in nutrient cycling and are important part of forest ecosystem of Himalayan region. Most of the studies of fungal diversity in the region are restricted mainly to Agaricomycetes (Prasher & Ashok 2013, Ashok & Prasher 2014a, b, Prasher 2015). There are sporadic reports of hyphomycetes primarily pertaining to the plant pathogenic fungi affecting the crops of this area (Bilgrami et al. 1991, Jamaluddin et al. 2004). India is an active centre of research of fungal biodiversity, with a high proportion of genera and species first described in this country (Subramanian 1971, Bilgrami et al. 1991, Jamaluddin et al. 2004). In spite of this intensive research, new species and records of hyphomycetes are still discovered in India (Kumar & Singh 2018, Kumar et al. 2018, Rajeshkumar et al. 2018, Verma et al. 2019).

The genus *Berkleasmium* was established by Zobel in 1854 with *B. cordaeanum* Zobel as the type species. Hughes (1958) considered *B. cordaeanum* as a synonym of *Sporidesmium concinnum* Berkeley and proposed it as *Berkleasmium concinnum* (Berk.) S. Hughes.

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Asexual morph

There are two main morphological types have been reported by Lu et al. (2018)

1. Forming sporodochia, having short or flexuous conidiophores and producing muriform, ellipsoidal conidia broad-cylindrical, multicellular, with large and fairly regular cells, fuscous, borne on short conidiophores which become obscure with maturity (Moore 1958, Ellis 1971, Lu et al. 2018).

2. Effuse, helicosporous, gregarious, mycelium partly immersed, partly superficial, brown, septate, branched hyphae, with masses of crowded, glistering conidia; conidiophores erect, arising as lateral branches from creeping hyphae, macronematous, mononematous, 0–3-septate, brown, smooth-walled; conidiogenous cells holoblastic, mono- to polyblastic, integrated, sympodial, terminal, cylindrical, truncate at apex, brown, smooth-walled; conidia acrogenous, helicoid, tapering to apex and base, solitary, coiled 1–3 times, with elongated basal cell, rounded at tip, septate, slightly constricted at septa (Lu et al. 2018).

Sexual Morph

Ascomata superficial, seated on a subiculum, scattered, solitary, subglobose to globose, dark brown to black, with ostiole. Ascomata covered by setae. Setae multi-septate, thick-walled, brown to black, straight or slightly curved. Peridium composed of textura angularis. Hamathecium comprising, branched, filiform, septate, pseudoparaphyses. Asci bitunicate, cylindrical, pedicellate, apically with 8 ascospores. Ascospores biseriate, fusiform, hyaline, smooth-walled, tapering towards the ends, slightly curved, guttulate, multi-septate, not constricted at septa (Lu et al. 2017, 2018).

During the survey of saprophytic conidial fungi, two interesting hyphomycetes were collected. Morphological analysis confirmed that these taxa are *Berkleasmium pandani* McKenzie and *B. typhae* Somrithipol & E.B.G. Jones were collected. This is the first report of both taxa from India (Bilgrami et al. 1991, Jamaluddin et al. 2004). Moreover, this communication is in continuation with our earlier reports on hyphomycetes (Prasher & Verma 2014a, b, 2015a, b, c, 2016, Adamčik et al. 2015, Buyck et al. 2017, Verma et al. 2019).

Materials & Methods

Decaying culms, twigs and dead wood and bark were collected and kept in paper bags. Then the specimens were brought to the laboratory. The specimens were mounted in 4 % KOH, lactophenol and cotton blue 0.01 % in lactophenol (Kirk et al. 2008), and were examined for microscopic characters using a Matrix stereo trinocular microscope (VL-Z60) and transmission microscope (VRS-2f) for macroscopic and microscopic characters. All measurements were taken with the help of Pro MED software. The scanning electron microscopic studies were conducted with a JSM-6100 (JEOL Ltd.) microscope. The material was vacuum-dried in an oven for 24 hours, mounted and sputtered with gold for 60 seconds, and photographed. The specimens were deposited in the herbarium of the Department of Botany, Panjab University, Chandigarh, India (PAN)

Results

Berkleasmium pandani McKenzie, Mycotaxon 104: 24 (2008) Figs 1, 2

Index Fungorum: IF511285

Colonies on natural substratum forming black punctiform scattered, pulvinate, shiny or glistening, more or less circular sporodochia. Mycelium mainly immersed in the substratum. Stroma none. Setae and hyphopodia absent. Conidiophores reduced to conidiogenous cell, differentiated, single, aseptate, hyaline, thin–walled, smooth. Conidiogenous cell holoblastic, determinate, 12–20 × 8–19 µm. Conidia solitary, dry, acrogenous, brown, smooth, oval to oblong–ellipsoidal, muriforrn with transverse, longitudinal, and oblique septa, sometimes slightly constricted at the median septa and other septa, 26–35 × 18–22.5 µm. Conidiogenous cell usually remaining attached to base of conidium at maturity.

Material examined – India, Himachal Pradesh, Near Kandaghat (Solan), on bark of *Eucalyptus tereticornis*, 5 April 2014, Rajnish Kumar Verma, PAN (32722).

Remarks – Our collection morphologically resembles with *B. pandani* (McKenzie 2008). The Himalayan collection differs from type in having smaller size of conidiogenous cell i. e 16–26 ×10–19 in type and 12–20 × 8–19 µm in Himalayan collection, but we considered it as same species. This is the first record of *B. pandani* from India.

Berkleasmium typhae Somrithipol & E.B.G. Jones, Fungal diversity 12: 170 (2003). Figs 3, 4

Index Fungorum: IF372008

Colonies on natural substratum forming punctiform, scattered, brown, shiny sporodochia. Mycelium immersed in the substratum. Stroma none. Setae and hyphopodia absent. Conidiogenous cells terminal on the conidiophores, holoblastic 10–14 × 8–10 µm. Conidia solitary, oval to ellipsoidal, muriform, constricted at the septa, often with a dark median septum, pale brown to brown, smooth, 20–29 × 15.5–18.9 µm. Conidiogenous cell sometimes remaining attached to base of conidium at maturity.

Material examined – India, Himachal Pradesh, on the way Kuthera to Morshingi (Bilaspur), on bark of *Eucalyptus* species, 19 January 2013, Rajnish Kumar Verma, PAN (32723).

Remarks – Our new collection morphologically resembles *B. typhae* (Somrithipol & Jones 2003). The species is the first report of *B. typhae* from India (Bilgrami et al. 1991, Jamaluddin et al. 2004).

Discussion

Presently there are 45 accepted species of *Berkleasmium* (Bussaban et al. 2001, Seifert et al. 2011, Whitton et al. 2012, Qu et al. 2013, Hüseyin et al. 2014, Tanney & Miller 2017, Tibpromma et al. 2017, Lu et al. 2018). Among these species, *B. aquaticum* reported as sexual morph while two species (*viz. B. fusiformae* and *B. thailandicum*) are reported with both sexual and asexual morphs. Of the 44 asexual morphs four species namely *B. guangxiense*, *B. latisporum*, *B. longisporum* and *B. thailandicum* are having helicoid conidia rest have dictyoconidia. Table 1 and 2 summarizes synopsis of *Berkleasmium.*

Table 1 Synopsis of *Berkleasmium* species with asexual morph

Species with Dictyoconidia				
Sr. no.	**Species**	**Conidiophores (µm)**	**Conidia (µm)**	**Reference**
1.	***B. ariense***	flexuous, unbranched, 2–5	119–238 × 41–60, solitary, dry or sticky, acrogenous, simple, clavate, ellipsoidal, oblong or irregular, muriform, pale to dark brown or blackish brown, hilum not protruding; conidial base 11–15. Young conidia hyaline or subhyaline, 56 × 17	Tibpromma et al. 2017
2.	***B. atropicale***	–	30–50 × 21–38 broadly elliptical, sometimes ovoid or obovoid	Whitton et al. 2012
3.	***B. atrovirens***	13–16 × 1.5–3.5	Irregularly muriform, 30–37 × 15–17	Zhao & Zhang 2004
4.	***B. concinnum***	30 × 2–5	60–124 × 24–31, muriform	Hughes 1958
5.	***B. conglobatum***	–	36.5–99 × 26–47	Moore 1958

Table 1 Continued.

Sr. no.	Species	Conidiophores (µm)	Conidia (µm)	Reference
6.	***B. correae***	2–5 × 2–2.5	26–44 × 16–24, broadly ellipsoidal	Yip 1988
7.	***B. corticola***	–	26.5–34 × 18.5–26, multicellular, with 1 or 2 subtending cells	Moore 1959
8.	***B. crunisia***	45–47.5 × 10	muriform, oval to ellipsoidal, pale brown, smooth, 35–100 × 17.5–30	Pinnoi et al. 2007
9.	***B. daphniphylli***	–	16.5–28 × 10–13	Zhang et al. 2009
10.	***B. dudkae***	up to 25 long, 1.8–2.3(–2.9) wide	oval to obovoid, smooth, regularly muriform, (13–) 14–17(–17.5) × 12.5–15	Hüseyin et al. 2014
11.	***B. fusiforme***	up to 8 long, 3–5 wide	fusiform, oval to ellipsoidal, 18–29 × 10–14	Qu et al. 2013
12.	***B. granulosum***	–	29–66 × 16.5–18.5, profile irregular, multicellular	Moore 1958
13.	***B. inflatum***	39–80 long, 3–4 wide at base, 7–19 apex	ellipsoidal, 31.5–49 × 16–26	Holubová-Jechová 1987
14.	***B. juglandis***	7–15 × 8–13	20–25 × 14–18	Qu et al. 2013
15.	***B. leonense***	Up to 25 long, 1–3 wide	20–27 × 15–17 × 6–8, muriform, broadly elliptical, flattened, smooth	Ellis 1976
16.	***B. lingual***	–	65–89.5 × 18.5–24 multicellular, without subtending cells, cylindrical to slightly obclavate, sometimes somewhat curved, fuscous	Moore 1959
17.	***B. micronesicum***	–	30–40 × 13–16, muriform, cylindrical	Matsushima 1981
18.	***B. minutissimum***	Absent	11.5–17 × 8.5–11.5, subglobose to squarish–subglobose to oval ellipsoid	Moore 1959
19.	***B. monilicellulare***	13–23 × 4–5.2	27–39 × 20–29, broadly elliptical, pyriform or sometimes almost spherical.	Whitton et al. 2012
20.	***B. moriforme***	–	23.5–26.5 × 18.5–22 , muriform, pale brown subtending cells either numerous, tending to be amorphous	Moore 1959
21.	***B. nigroapicale***	Up to 22 high, inflated to 6.5–10 at the apex	24–27 × 12.5–15 , broadly clavate, muriform	Bussaban et al. 2001
22.	***B. obovoides***	17 long, 6 wide	ellipsoidal to obovoid, regularly muriform, 26–34 × 19–24	Qu et al. 2013

Table 1 Continued.

Sr. no.	Species	Conidiophores (µm)	Conidia (µm)	Reference
23.	***B. opacum***	Absent	52–83 × 31–41.5, verrucose, subglobose to oval–ellipsoid,	Moore 1959
24.	***B. osmaniae***	7.2–7.6 × 3.6–7.2	18–75 × 3.6–5.4 at base, 7.2–10.8 at apex, oval–clavate to cylindrical, curved or straight, Smooth	Rao & Rao 1964
25.	***B. pandani***	Reduced to conidiogenous cell	27–34 × 18–22.5	McKenzie 2008
26.	***B. parmelielfae***	6–9 × 4–5	40–55 × 22–27, muriform, clavate to ellipsoidal, rounded at the ends	Rao & Rao 1964
27.	***B. parmeliellae***	–	40–45 × 22–27	Etayo & Diederich 1995
28.	***B. phyllostachydis***	–	17–25 × 9–13, muriform, ellipsiodal to broadly clavate	Matsushima 1983
29.	***B. pulcharum***	up to 25 long, 2–5 thick	muriform, brown, smooth, 31–41(–46) × 21–28(–32) × 13–16, with (3–) 4–5(–7) transverse and 2 longitudinal thick, dark septa, basal cell conical, hyaline to sub-hyaline, 3–5 × 2.5–5.	Holubová-Jechová & Mercado Sierra1984
30.	***B. sansevieriae***	5–13 × 2.6	15.5–26 × I0.5–15.5, oblong, muriform	Batista et al. 1962
31.	***B. sinense***	–	broadly ellipsoidal to obovoid, brown, paler towards base, 40–52 × 20–32	Taylor & Hyde 2003
32.	***B. sutheppuiense***	15–17.5 × 6–6.5	35–37 × 22.5–25, muriform, subglobose,	Bussaban et al. 2001
33.	***B. taishanense***	Up to 10 long (including conidiogenous cell) 1.5–2 wide with bladder like swelling	Ellipsoidal, clavate, ovovate or pyriform, 22–35 × 15–18.75	Zhao & Zhang 2004
34.	***B. talaumae***	Absent	25–51 × 19–28, oblong,	Batista et al. 1964
35.	***B. tetraploides***	up to 15 long, 3–5 wide	pyriform, smooth, 20–30 × 12–19	Qu et al. 2013
36.	***B. triglochinis***	4–6 long	10–18 × 8–14, tuberculate to more or less scabrid, broadly oval to spherical or pyriform,	Moore 1959
37.	***B. tropicale***	13–16 × 3–4	50–57 × 28–34 , muriform, flattened, oval	Morris 1972

Table 1 Continued.

Sr. no.	Species	Conidiophores (µm)	Conidia (µm)	Reference
38.	***B. typhae***	–	23–28.5 × 15–19.5	Somrithipol & Jones 2003
39.	***B. zhejiangense***	–	oval to ellipsoidal, 38–76 × 19–33	Wongsawas et al. 2009
Species with Helicoid conidia				
1.	***B. guangxiense***	19–37 × 3.5–5, pale brown, macronematous, erect, short, cylindrical, septate, smooth-walled	90–130 (–144) diam. and conidial filament 8–10 wide, 405–725 (-800) long, coiled 2½–3½ times when tightly coiled, basal cell elongated, rounded at tip, multiseptate, up to 62– septate	Lu et. al. 2017, 2018
2.	***B. latisporum***	–	95–120 diam. and conidial filament 12–14.5 wide, 540-760 long, coiled 1½–3½ times when tightly coiled, becoming loosely coiled in the water, basal cell elongated, rounded at the tip, multi-septate, up to 60-septate	Lu et al. 2017, 2018
3.	***B. longisporum***	0–3-septate, 15–40 × 5–7, brown, smooth-walled.	solitary, acrogenous, helicoid, basal cell elongated, rounded at tip, 110–180 diam. and conidial filament 11–15 wide in the broadest, tapering to 4.5–5.5 lm wide near apex and base, 1190–1540 long, 100–122 septate, slightly constricted at septa, coiled 2–3 times, becoming loosely coiled or uncoiled in water, brown, smooth-walled	Lu et al. 2018
4.	***B. thailandicum***	10–24 × 4–6, pale brown, macronematous, erect, short, cylindrical, septate	89-155 diam. and conidial filament 10.5–14 (–15) wide, 630–950 long, coiled 2–3 times when tightly coiled, up to 60-septate	Lu et al. 2017

Table 2 Synopsis of *Berkleasmium* species with sexual morph

Sr. no.	Species	Ascomata (µm)	Setae (µm)	Peridium (µm)	Asci (µm)	Ascospores (µm)	Reference
1.	***B. aquaticum***	235–290 high × 180–225 in diam. subglobose, ellipsoidal-ovate	35–65 long, 3.5–6 wide in the middle, 1-celled	25–34 wide, composed of cells of textura angularis	115–175 × (11–) 12.5–16 (–17.5), 8-spored, bitunicate, cylindrical, short-pedicellate, apically rounded	(45–) 50.5–60 × 4.5–6.5, overlapping 2–3-seriate, fusiform, tapering towards rounded ends, slightly curved, guttulate, 7–septate, not constricted at septa, hyaline, smooth-walled	Lu et al. 2017, 2018
2.	***B. fusiformae***	220–290 high × 240–300, subglobose to globose,	40–55 long, 4–6 wide, 1–3 celled	45–60 thick, composed of several layered cells of textura angularis,	100–140 × 14–19, 8-spored, bitunicate, cylindrical, pedicellate, apically rounded	45–55 × 5–6, biseriate, fusiform, tapering towards rounded ends, slightly curved, guttulate, 6–7-septate, not constricted at septa, hyaline, smooth-walled	Lu et al. 2018
3.	***B. thailandicum***	190–275 high × 175–230 diam., subglobose, ellipsoidal-ovate,	45–85 long, septate, tapering to an acute apex	20–28 wide, composed cells of textura angularis	110–140 × 17–23, 8–spored, bitunicate, cylindrical, short-pedicellate, apically rounded.	95–115 (–128) × 4.5–6.5, fasciculate, broadly filiform, cylindrical to long subfusiform, elongate, rounded at ends, slightly curved, guttulate, 12–13-septate	Lu et al. 2017, 2018

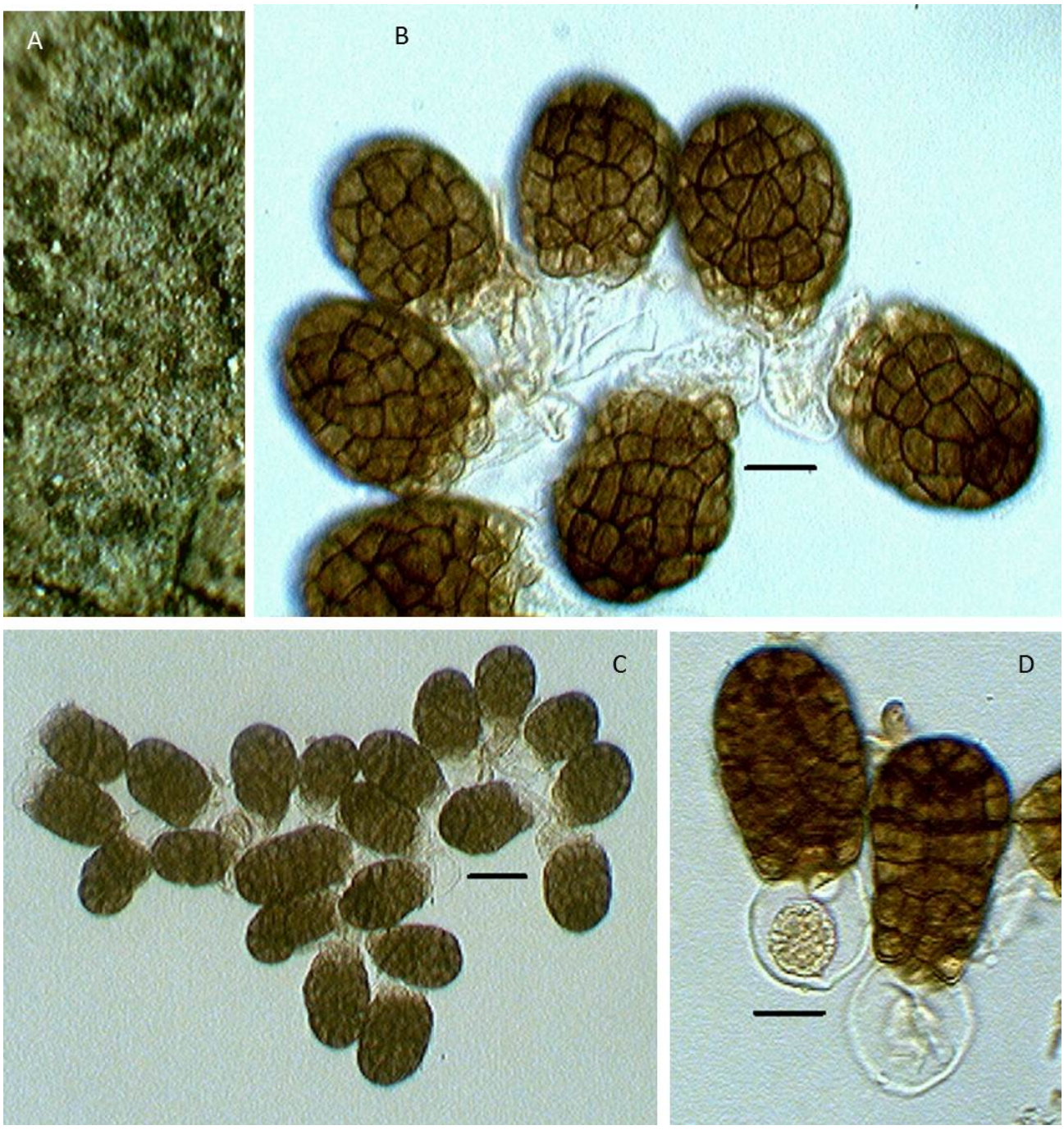

Fig. 1 – *Berkleasmium pandani* A Colonies on natural substratum. B, C Squashed mount of sporodochium. D Conidia with conidiogenous cell. Scale bars: A, D = 10 µm, C = 20 µm.

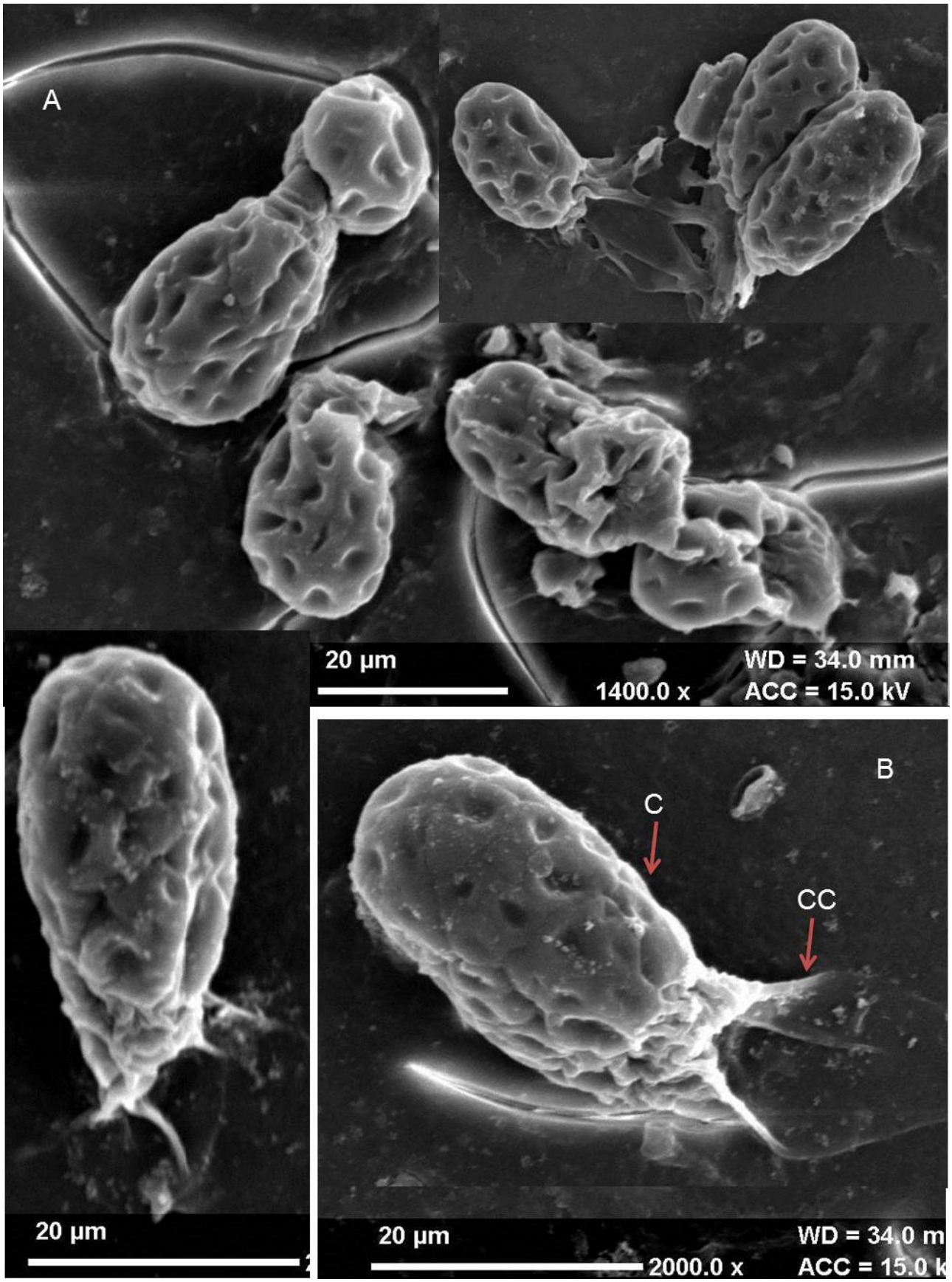

Fig. 2 – *Berkleasmium pandani* (Scanning electron micrograph) A, B Conidia. (CC= Conidiogenous cell, C= Conidium). Scale bar: A, B = 20 µm.

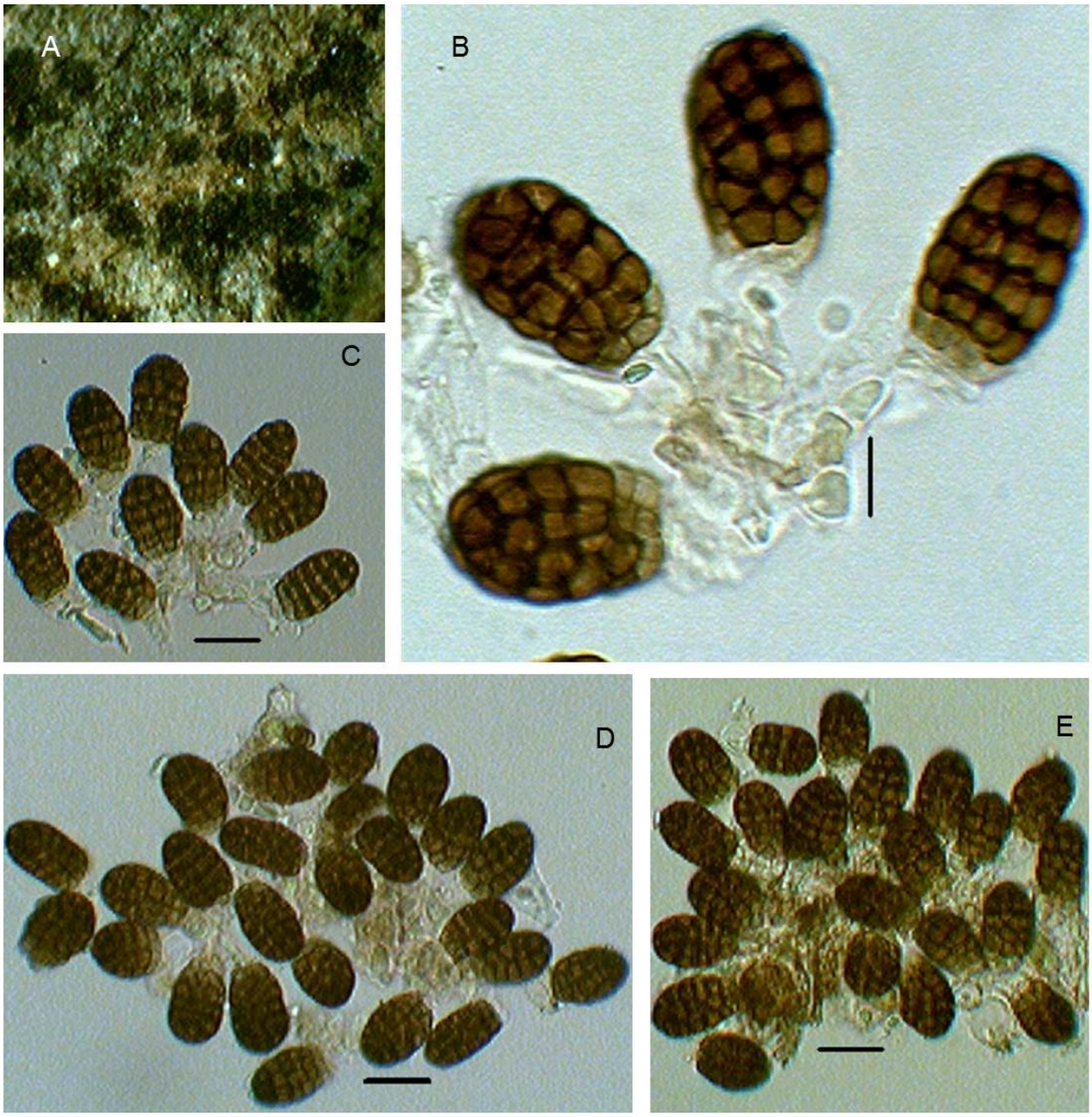

Fig. 3 – *Berkleasmium typhae* A Colonies on natural substratum. B-E Squashed mount of Sporodochium. Scale bars: B= 10 µm, C-E= 20 µm.

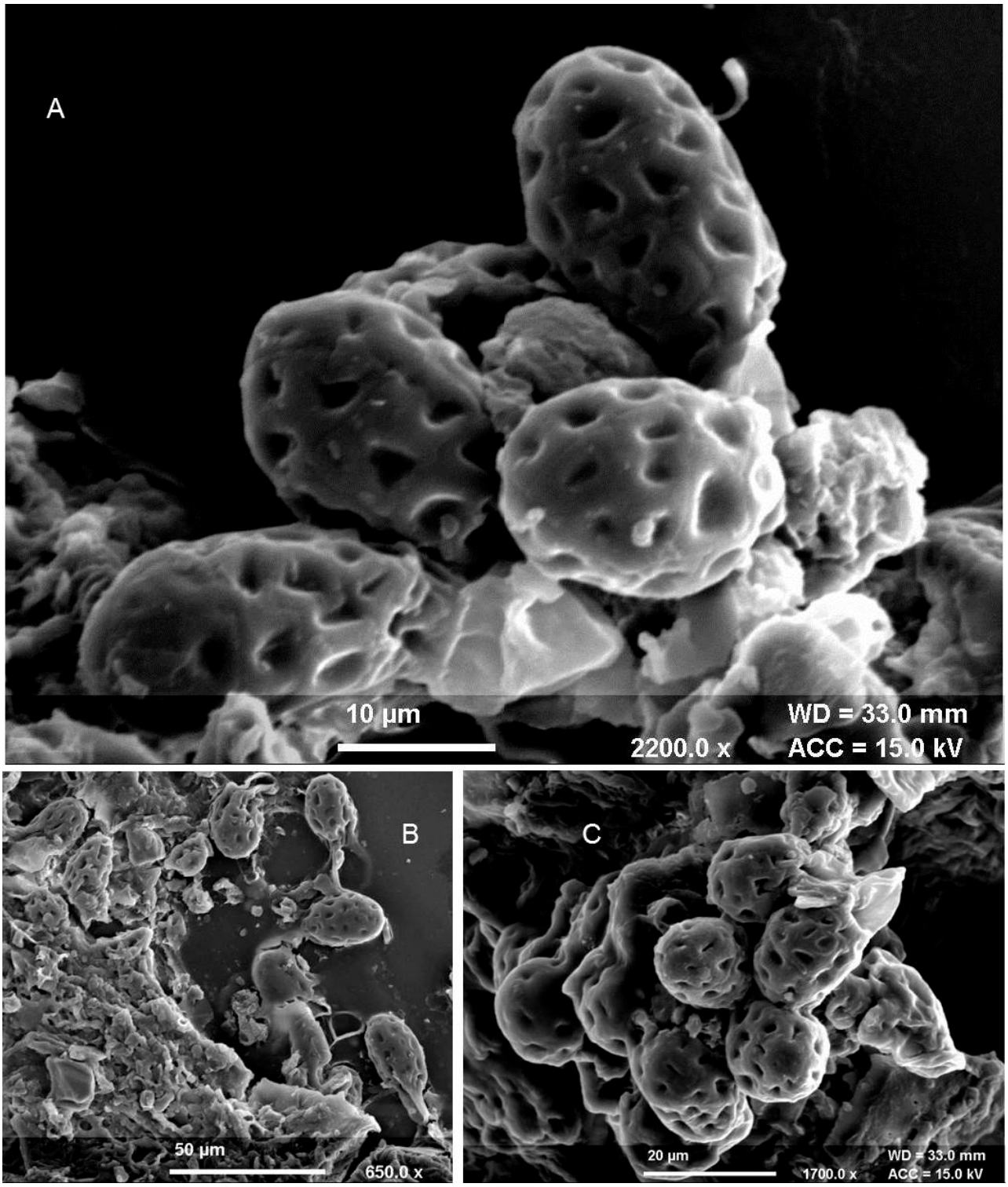

Fig. 4 – *Berkleasmium typhae* (Scanning electron micrograph) A, C Part of sporodochium showing conidia. B Conidia. Scale bars: A= 10 µm, B= 50 µm, C= 20 µm

Checklist of *Berkleasmium* from India.

Berkleasmium ariense Rajeshk. & Marathe, in Tibpromma et al., Fungal Diversity 83: 35 (2017).
Distribution: Maharashtra, Tamhini Village, on unidentified stem litter (Tibpromma et al. 2017)

Berkleasmium conglobatum (Cooke & Ellis) R.T. Moore, Mycologia 50(5): 687 (1959) [1958]
≡ *Sporidesmium conglobatum* Cooke & Ellis, Grevillea 8(no. 45): 11 (1879)
Distribution: On bark of *Syzygium fruiticosum* New Delhi (Chowdhry 1974)

Berkleasmium corticola (P. Karst.) R.T. Moore, Mycologia 51(5): 735 (1961) [1959]

≡ *Sporidesmium corticola* (P. Karst.) Mussat [as 'corticolum'], in Saccardo, Syll. fung. (Abellini) 15: 398 (1901)
≡ *Sporidesmium moriforme* subsp. *corticola* P. Karst., Meddn Soc. Fauna Flora fenn. 14: 99 (1887)
Distribution: On dead bark of *Tectona grandis*, Jabalpur Madhya Pradesh (Sharma 1980), on *Syzygium fruiticosum* Agra Uttar Pradesh (Sharma et al. 1976)
Berkleasmium leonense M.B. Ellis, More Dematiaceous Hyphomycetes (Kew): 69 (1976)
Dead twigs of *Odina wodier*, Moonar, kerala (Rao & Varghese 1979, Varghese & Rao 1979); **Distribution:** unidentified dead wood, Dehradun, Uttrakhand (Begum et al. 1978);
Berkleasmium osmaniae P. Rag. Rao & D. Rao, Mycopath. Mycol. appl. 22: 314 (1964)
Distribution: Dead culms of gramineae, hydrabad Andhra Pradesh (Rao & Rao 1964)

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