A synopsis of the genus *Berkleasmium* with two new species and new records of *Canalisporium caribense* from *Zingiberaceae* in Thailand

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The genus *Berkleasmium* is reviewed based on the literature and two new species are described from recent collections. A synopsis and key is provided to the 24 accepted species. The new species, *B. nigroapicale* and *B. sutheppuiense* are described from dead pseudostems of *Amomum siamense*, and a morphologically similar fungus, *Canalisporium caribense*, found on the same host species is also reported.

Key words: Hyphomycetes, key, mitosporic fungi, taxonomy.

Introduction

The hyphomycete genus *Berkleasmium* Zobel (Zobel, 1854) was based on *Sporidesmium concinnum* Berk. He named this taxon in honour of Corda illegitimately using the name *B. cordeanum*. The name was corrected to *B. concinnum* by Hughes (1958). Moore (1958) studied similar genera and accepted *Berkleasmium* for sporodochial fungi producing dark coloured dictyospores either on short, simple conidiophores or directly on the hyphae. Moore (1959) accepted ten species in *Berkleasmium* and provided a key to the genus. There are now 24 binomial names in *Berkleasmium* (Table 1).

According to Ellis (1971), *Berkleasmium* comprises sporodochial species characterised by narrow, macronematous conidiophores, which are mostly unbranched and closely packed in a sporodochium. Conidiogenous cells are
Table 1. Synopsis of accepted species of *Berkleasmium*.

<table>
<thead>
<tr>
<th>Species and reference</th>
<th>Sporodochia</th>
<th>Conidiophores</th>
<th>Conidia</th>
<th>Substrata</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>B. ablaense</em> Chouhan and Panwar (Chouhan and Panwar, 1980)</td>
<td>Punctiform, raised, black</td>
<td>22 ± 2.5-4 µm, simple or branched, septate, pale brown, smooth</td>
<td>18-40 × 16-35 µm, subglobose to broadly ellipsoidal, with transverse, longitudinal and oblique septa, olivaceous-brown to dark brown, smooth</td>
<td>Dead twigs</td>
</tr>
<tr>
<td><em>B. concinnum</em> (Berk.) S. Hughes (=<em>B. cordeanum</em> Zobel) (Hughes, 1958; Moore, 1958, 1959; Ellis, 1971)</td>
<td>Punctiform, raised, black, shining</td>
<td>30 ± 2-5 µm, flexuous, unbranched or rarely branched, smooth</td>
<td>60-124 × 24-31 µm, profile regular, muriform, more than 15 cells, broadly cylindrical, cells large and fairly regular, golden brown</td>
<td>Rotten wood</td>
</tr>
<tr>
<td><em>B. conglobatum</em> (Cooke and Ellis) R.T. Moore (Moore, 1958, 1959)</td>
<td>Black</td>
<td>Short, may or may not be separated from conidium by a septum</td>
<td>36.5-99 × 26-47 µm, multicellular, cells small and regular, oval to ovate, without subtending cells, deep fuscous to opaque</td>
<td>Old wood</td>
</tr>
<tr>
<td><em>B. correae</em> H.Y. Yip (Yip, 1988)</td>
<td>Absent</td>
<td>2-5 ± 2-2.5 µm, cylindrical or stopper-shaped, medium brown</td>
<td>26-44 × 16-24 µm, broadly ellipsoidal, with or without protruding hilum, slightly constricted at septa, brown, smooth</td>
<td>Abaxial stellate leaf hairs of <em>Correa lawrenciana</em></td>
</tr>
<tr>
<td><em>B. corticola</em> (P. Karst.) Black R.T. Moore (Moore, 1958, 1959)</td>
<td>Black</td>
<td>Cylindrical, subhyaline to pale brown</td>
<td>26.5-34 × 18.5-26 µm, multicellular, with 1 or 2 subtending cells, absent on some conidia, hyaline; primary portion globose, subglobose, ovate or obovate, deep fuscous</td>
<td>Old birch bark</td>
</tr>
<tr>
<td><em>B. granulosum</em> (Durieu Punctiform and Mont.) R.T. Moore (Moore, 1958, 1959)</td>
<td>Short pedicels which may or may not be separated from the conidium by a septum</td>
<td>29-66 × 16.5-18.5 µm, profile irregular, multicellular, more than 15 cells, subglobose to ovate to irregular cylindrical, composed of heteromorphic cells irregularly ordered, light brown</td>
<td>Old <em>Olea</em> wood</td>
<td></td>
</tr>
<tr>
<td><em>B. longitubulatum</em> Hol.-Jech. (Holobová-Jechová, 1987)</td>
<td>Punctiform, pulvinate, black, shining</td>
<td>48 ± 2-4 µm, with 1-3 bladdery swelling 6-9.5 µm wide</td>
<td>40-48 × 19.5-21 µm, muriform, ellipsoidal, clavate, obovate or pyriform, with a truncate basal scar, golden brown, smooth</td>
<td>Rotten wood</td>
</tr>
</tbody>
</table>
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</thead>
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<tr>
<td>B. leonense M.B. Ellis (Ellis, 1976)</td>
<td>Punciform, pulvinate, black</td>
<td>Up to 25 μm long, 1-3 μm thick, simple or branched, hyaline, smooth</td>
<td>20-27 × 15-17 × 6-8 μm, muriform, broadly elliptical, flattened, smooth</td>
<td>Dead branches of <em>Ficus</em> sp.</td>
</tr>
<tr>
<td>B. lingula R.T. Moore (Moore, 1959)</td>
<td>Dark</td>
<td>Absent</td>
<td>65-89.5 × 18.5-24 μm, multicellular, without subtending cells, cylindrical to slightly obclavate, sometimes somewhat curved, fuscous</td>
<td>Rotten wood</td>
</tr>
<tr>
<td>B. micronesicum Matsush. (Matsushima, 1981)</td>
<td>Pulvinate, dark</td>
<td>Erect, broadly cylindrical, subhyaline to pale brown</td>
<td>30-40 × 13-16 μm, muriform, cylindrical, medium brown</td>
<td>Dead petioles of <em>Cocos nucifera</em></td>
</tr>
<tr>
<td>B. minutissimum (Peck) R.T. Moore (Moore, 1959)</td>
<td>Dark</td>
<td>Absent</td>
<td>11.5-17 × 8.5-11.5 μm, less than 15 cells, subglobose to squarish-subglobose to oval-ellipsoid, often strongly constricted at a prominent medial septum, minutely roughened, pale brown</td>
<td>Dead wood</td>
</tr>
<tr>
<td>B. moriforme (Peck) R.T. Moore (Moore, 1959)</td>
<td>Superficial, black</td>
<td>Cylindrical, subhyaline to pale brown</td>
<td>23.5-26.5 × 18.5-22 μm, muriform, with subtending cells either numerous, tending to be amorphous, or represented by a single, large, hyaline, globose to elliptical vesicle, or sometimes absent</td>
<td>Old decorticated apple wood, dead bark of <em>Vitis vinifera</em></td>
</tr>
<tr>
<td>B. nigroapicale (this paper)</td>
<td>Superficial, granular, black, shiny</td>
<td>Up to 22 μm high, inflated to 6.5-10 μm at the apex, non septate, hyaline to very pale brown</td>
<td>24-27 × 12.5-15 μm, broadly clavate, muriform, constricted at septa, 2 apical rows of cells dark brown, basal rows pale brown</td>
<td>Dead pseudostems of <em>Amomum siamense</em></td>
</tr>
<tr>
<td>B. opacum R.T. Moore (Moore, 1959)</td>
<td>Superficial, black</td>
<td>Absent</td>
<td>52-83 × 31-41.5 μm, verrucose, subglobose to oval-ellipsoid, elongate conidia sometimes strongly constricted, somewhat amorphous, opaque</td>
<td>Dead wood of <em>Juglans cinerea</em>, <em>Quercus</em> sp.</td>
</tr>
</tbody>
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<tr>
<td><em>B. osmaniae</em> P.Rag. Rao and D. Rao (Rao and Rao, 1963)</td>
<td>Superficial, closely packed, black to blackish brown</td>
<td>7.2-7.6 × 3.6-7.2 μm, short, simple, cylindrical or wide at apex, dictyosporous, usually with short stem like, 1-7 septate, cells arranged in 2-3 rows, irregular, oval-clavate to claviform, curved or straight, smooth, with a dome shaped yellowish brown apical cell</td>
<td>18-75 × 3.6-5.4 μm at base, 7.2-10.8 μm</td>
<td>Old dead clumps of grass</td>
</tr>
<tr>
<td><em>B. papillatum</em> P.Rag. Rao and D. Rao (Rao and Rao, 1963)</td>
<td>Irregular, superficial</td>
<td>30-56 × 3-7.5 μm, simple, 1-5 septate, dark blackish to deep brown, gradually becoming paler towards the fertile apical end</td>
<td>20-30 × 12-20 μm, muriform, 5-15 cells arranged in 2-3 rows, attenuated at septa, subhyaline to light brown, papillate at base</td>
<td>Old bamboo thatches</td>
</tr>
<tr>
<td><em>B. parmeliellae</em> Etayo and Diederich (Etayo and Diederich, 1995)</td>
<td>Muculiform, pulvinate, greyish-black</td>
<td>6-9 × 4-5 μm, unbranched, narrow, more or less flexuous, smooth, with a dome shaped yellowish brown apical cell</td>
<td>40-55 × 22-27 μm, muriform, clavate to ellipsoidal, rounded at the ends, brown</td>
<td>Lichen, <em>Parmeliella testacea</em></td>
</tr>
<tr>
<td><em>B. phyllostachydis</em> Matsush. (Matsushima, 1983)</td>
<td>Aggregate</td>
<td>17-25 × 9-13 μm, muriform, ellipsoidal to broadly clavate, medium brown, smooth, basal cells cylindrical, pale to pale brown</td>
<td>15.5-26 × 10.5-15.5 μm, oblong, muriform, 3-4 transverse and 1-4 longitudinal septa, brown, verrucose</td>
<td>Stem of <em>Phyllostachydis</em> sp.</td>
</tr>
<tr>
<td><em>B. sansevieriae</em> Bat., J.L. Bezerra and Cavalc. (Batista et al., 1962)</td>
<td>Epiphyllus, first subepidermal, then superficial, scattered, dark brown</td>
<td>5-13 × 2.6 μm, peripheric, parallel, septate or asperate, subhyaline to olivaceous</td>
<td>35-37 × 22.5-25 μm, muriform, subglobose, dark brown, septa only visible when immature.</td>
<td>Living leaves of <em>Sansevieria</em> sp.</td>
</tr>
<tr>
<td><em>B. sutheppuiense</em> (this paper)</td>
<td>Granular, black, shiny</td>
<td>15-17.5 × 6-6.5 μm, septate, hyaline to very pale brown, smooth</td>
<td></td>
<td>Dead pseudostems of <em>Amomum siamense</em></td>
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<tr>
<td><em>B. talaumae</em> Bat. and Cavalc. (Batista and Cavalcanti, 1964)</td>
<td>Maculiform, hypophyllus, first subepidermal, then superficial, scattered, verrucose, dark brown</td>
<td>Absent</td>
<td>25-51 × 19-28 μm, oblong, dictyosporous</td>
<td>Living leaves of <em>Talauma ovata</em></td>
</tr>
<tr>
<td><em>B. triglochinis</em> (Berk. and Broome) R.T. Moore (Moore, 1959)</td>
<td>Black</td>
<td>4-6 μm long</td>
<td>10-18 × 8-14 μm, tuberculate to more or less scabrid, broadly oval to spherical or pyriform, sometimes slightly constricted at septa, opaque</td>
<td><em>Triglochin palustre</em></td>
</tr>
<tr>
<td><em>B. tropicale</em> Morris (Morris, 1972)</td>
<td>Black</td>
<td>13-16 × 3-4 μm, septate, hyaline</td>
<td>50-57 × 28-34 μm, muriform, flattened, oval, Dead wood with cells in 3 rows, slightly constricted at septa, brown</td>
<td>Dead wood with cells in 3 rows, slightly constricted at septa, brown</td>
</tr>
<tr>
<td><em>B. vogelianum</em> (Syd.) R.T. Moore (Moore, 1959)</td>
<td>Black</td>
<td>A few cells</td>
<td>26.5-39.5 × 13-18.5 μm, less than 15 cells, clavate to subclavate to subglobose, base truncate, moderately constricted at septa, fuscous</td>
<td>Young fallen branches and peduncles of <em>Celtis occidentalis</em></td>
</tr>
</tbody>
</table>
terminally integrated on the conidiophores and are monoblastic, determinate, acrogenous and cylindrical. The conidia are solitary, brown, muriform, clavate or oblong, with rounded ends or irregular, and often have a protruding hilum. Most species are recorded from non-living substrata such as bark or dead wood of various plants (Moore, 1958, 1959; Rao and Rao, 1963; Ellis, 1971, 1976; Morris, 1972; Chouhan and Panwar, 1980; Matsushima, 1981, 1983; Holobová-Jechová, 1987; Yip, 1988). *Berkleasmium correae* H.Y. Yip is also a saprobe, but growing on the abaxial hairs of *Correa lawrenciana*, not invading the underlying leaf tissues. *Berkleasmium sansevieriae* Bat., J.L. Bezera and Cavalc. and *B. talaumae* Bat. and Cavalc. were recorded from living leaves of *Sansevieria* sp. and *Talauma ovata*, respectively (Batista et al., 1962; Batista and Cavalcanti, 1964). *Berkleasmium parmeliellae* has recently been placed into this genus as the first lichenicolous species (Etayo and Diederich, 1995). A synopsis of the 24 accepted species of *Berkleasmium*, which includes the two new species described here is provided in Table 1 and a synoptic diagrammatic representation of all species in provided in Fig. 8.

Nawawi and Kuthubutheen (1989) introduced the genus *Canalisporium* to accommodate *Berkleasmium caribense*, *B. pulchrum* and a new species, *Canalisporium elegans* Nawawi and Kuthub. *Canalisporium* is separated from *Berkleasmium* by its muriform conidia that are complanate with ordered rows of cells, sometimes having darkly pigmented septa. The conidiophores may be macro-, micro- or semi-macronematous (Goh et al., 1998). Recently Goh and Hyde (1999) described *Monodictys melanocephaloides*, a species producing conidia in sporodochioid clumps, superficially resembling colonies of *Berkleasmium*. However, the conidiophores are micronematous, as compared to the macronematous conidiophores of *Berkleasmium*.

During our investigation of saprobic fungi on wild ginger, *Amomum siamense* Craib., we found *Canalisporium caribense* (Hol.-Jech. and Mercado) Nawawi and Kuthub. and two undescribed species of *Berkleasmium*. These are described and illustrated in the present paper. In addition, synopsis of the accepted species in *Berkleasmium* is provided in Table 1, a taxonomic key is given and the new *Berkleasmium* species found on the ginger are described and illustrated.

**Taxonomy**

**Key to accepted species of *Berkleasmium***

1. Associated with algae, lichenicolous, conidia 40-45 × 22-27 μm .............. *B. parmeliellae*
2. Not lichenicolous, conidia other size range .............................................
2. Conidia mostly longer than 60 µm ......................................................... 3
2. Conidia shorter than 60 µm long ......................................................... 6

3. Conidia less than 25 µm wide, 65-89.5 × 18.5-24 µm, cylindrical to slightly oblclavate, fuscous. ................................................................. B. lingula
3. Conidia mostly wider than 25 µm, with other combination of characters 4

4. Conidia profile regular ...................................................................... 5
4. Conidia profile irregular, conidia verrucose, subglobose to oval-ellipsoid, elongate conidia sometimes strongly constricted, opaque, 52-83 × 31-41.5 µm. .................................................. B. opacum

5. Conidia broadly cylindrical, cells large, golden brown, 60-124 × 24-31 µm ... B. concinnum
5. Conidia oval to ovate, cells small, deep fuscous to opaque, 36.5-99 × 26-47 µm ................................................................. B. conglobatum

6. Conidia mostly longer than 28 µm ..................................................... 7
6. Conidia shorter than 28 µm long ......................................................... 17

7. Conidia formed in sporodochia ............................................................ 8
7. Conidia not formed in sporodochia, growing on leaf hairs, conidia 26-44 × 16-24 µm ... B. correae

8. Conidia mostly wider than 10 µm ....................................................... 9
8. Conidia less than 6 µm wide, 18-75 × 3.6-5.4 µm, irregular, oval-clavate to cylindrical, curved or straight ......................................................... B. osmaniae

9. Conidia with more than 15 cells ......................................................... 10
9. Conidia with less than 15 cells ........................................................... 16

10. Conidiophores inflated; conidia 40-48 × 19.5-21 µm, golden brown ... B. inflatum
10. Conidiophores not inflated ................................................................. 11

11. Conidiophores with subtending cells, primary portion globose to subglobose to ovate or obovate, deep fuscous; conidia 26.5-34 × 18.5-26 µm .................................................. B. corticola
11. Conidiophores without subtending cells ............................................. 12

12. Conidia flattened, with cells in three rows, 50-57 × 28-34 µm .............. B. tropicale
12. Conidia not as above ................................................................. 13

13. Conidia cylindrical, 30-40 × 13-16 µm .............................................. B. micronesicum
13. Conidia not cylindrical .................................................................... 14

14. Conidia profile regular, subglobose, very dark brown, 35-37 × 22.5-25 µm, septa only visible when immature ................................................ B. sutheppuiense
14. Conidia profile irregular .................................................................... 15

15. Conidia subglobose to broadly ellipsoidal, with transverse, longitudinal and oblique septa, olivaceous-brown to dark brown, 18-40 × 16-35 µm ... B. abuense
15. Conidia subglobose to oval to irregular cylindrical, light brown, 29-66 × 16.5-18.5 µm ............................................................. B. granulosum
16. Conidiophores cylindrical, consisting of a few cells; conidia clavate to subclavate to subglobose, 26.5-39.5 x 13-18.5 μm ................................................... B. vogelianum
16. Conidiophores absent; conidia oblong, 25-51 x 19-28 μm ......................... B. talauumae

17. Conidia with more than 15 cells ............................................................. 18
17. Conidia with less than 15 cells ............................................................... 23

18. Conidia distinctly verrucose, tuberculate to more or less scabrid .................. 19
18. Conidia not distinctly verrucose ............................................................. 20

19. Conidia verrucose, 15.5-26 x 10.5-15.5 μm .............................................. B. sansevieriae
19. Conidia tuberculate to more or less scabrid, 10-18 x 8-14 μm ................... B. triglochini

20. Conidia flattened, with cells in three rows, 20-27 x 15-17 μm ................... B. leonense
20. Conidia not as above .............................................................................. 21

21. Conidia with subtending cells or in some conidia absent .................................. 22
21. Conidia without subtending cells, 17-25 x 9-13 μm ................................ B. phyllostachydis

22. Conidiophores cylindrical; conidia 23.5-26.5 x 18.5-22 μm ...................... B. moriforme
22. Conidiophores inflated at the apex; conidia 24-27 x 12.5-15 μm .............. B. nigroapicale

23. Conidia with cells arranged in 2-3 rows, papillate at base, 20-30 x 12-20 μm . B. papillatum
23. Conidia with cells not arranged in rows, not papillate at base, 11.5-17 x 8.5-11.5 μm ................. B. minutissimum

**Berkleasmium nigroapicale** Bussaban, S. Lumlung, P. Lumyong, McKenzie and K.D. Hyde, *sp. nov.* (Figs. 1-2, 8M)

*Sporodochia* punctiformis, pulvinata, atra, nitida. *Mycelium* immersum ex hyphis ramosis, septatis, pallide brunnea vel brunnea, laevibus, 1.5-2.5 μm crassis compositum. *Conidiophora* macronemata, eseptata, hyalina vel pallide brunnea, usque ad 22 μm longa, 2.5-5 μm crassa, apice ad 6.5-10 μm inflata. *Conidia* 24-27 x 12.5-15 μm, solitaria, late clavata, muriformia, in septis constricta, laevia; cellulis apicalibus atro-brunneis, cellulis basilaribus pallide brunneis.

*Etymology:* epithet referring to the dark coloured conidial apex.

*Colonies* on natural substratum in the form of sporodochia, granular, black, shiny (Fig. 1). *Mycelium* immersed in the substratum, composed of pale brown to brown, smooth, branched, septate hyphae 1.5-2.5 μm wide. *Conidiophores* up to 22 μm high, 2.5-5 μm diam (inflated to 6.5-10 μm at the apex), macronematous, non-septate, hyaline to pale brown, smooth. *Conidia* 24-27 x 12.5-15 μm, solitary, broadly clavate, muriform, constricted at the septa, the two apical rows of cells are usually dark brown, basal rows pale brown, smooth (Figs. 2, 8M).

*Material examined:* THAILAND, Chiang Mai, Doi Suthep-Pui National Park, on dead pseudostems of *Amomum siamense* (Zingiberaceae), 15 October 2000, B. Bussaban CMUZS2 (PDD 74415, holotype, designated here; *extypes*, living culture in BCC 8220 and HKUCC 7909).
**Known distribution:** Thailand.

This species is similar in appearance to *B. moriforme* (Moore, 1959). In *B. moriforme*, pale coloured basal cells are said to subtend the dark coloured primary portion of the conidium. *Berkleasmium nigroapicis* also has pale coloured basal cells and dark coloured apical cells. However, in *B. nigroapicis* the conidia are 12.5-15 µm wide, whereas in *B. moriforme* the conidia are wider (18.5-22 µm). Furthermore, the conidiophores of *B. nigroapicis* are smaller, and similar to those of *B. inflatum* (Holobová-Jechová, 1987). The conidia of *B. inflatum* are larger (40-48 × 19.5-21 µm) and the conidiophores are longer and septate.

**Berkleasmium sutheppuiense** Bussaban, S. Lumyong, P. Lumyong, McKenzie and K.D. Hyde, **sp. nov.** (Figs. 3-5, 8T)

*Sporodochia* punctiformis, pulvinata, atra, nitida. *Mycelium* immersum ex hyphis ramosis, septatis, pallide brunnea vel brunnea, laevis, 2-2.5 µm crassis compositum. *Conidiophora* macronemata, septata, hyalina vel pallide brunnea, 15-17.5 µm longa, 6-6.5 µm crassa. *Conidia* 35-37 × 22.5-25 µm, solitaria, subglobosa, muriformia, septa obscure, laevia, atro-brunnea.

*Etymology:* epithet referring to the place of origin, Doi Suthep-Pui.

*Colonies* on natural substratum in the form of sporodochia, granular, black, shiny (Fig. 3). *Mycelium* immersed in the substratum, composed of pale brown to brown, smooth, branched, septate hyphae 2-2.5 µm wide. *Conidiophores* 15-17.5 × 6-6.5 µm, macronematous, septate, hyaline to very pale brown, smooth. *Conidia* 35-37 × 22.5-25 µm, solitary, subglobose, muriform, very dark brown, septa only visible when immature, smooth (Figs. 4-5, 8T).


**Known distribution:** Thailand.

This species is similar to *B. abuense* (Chouhan and Panwar, 1980) in that the conidia are subglobose. However, in *B. sutheppuiense* the conidial profiles are regular and the conidia are very dark brown, whereas in *B. abuense* the conidial profiles are irregular and the conidia are olivaceous-brown to dark brown. Furthermore, *B. sutheppuiense* is similar to *B. corticola* (P. Karst.) Moore (1959) in conidial size, shape and colour. While the conidial profile of *B. corticola* is also regular, the conidia usually have one or two subtending cells.

Colonies on natural substratum in the form of sporodochia, granular, black, shining (Fig. 6). Mycelium partly superficial, partly immersed in the substratum, composed of pale brown to brown, smooth, branched, septate hyphae 1.3-2.5 μm wide. Conidiophores up to 10 μm high, 2-4 μm thick, macronematous, hyaline to very pale brown, smooth. Conidia 25-30 μm long, 12.5-20 μm wide, 10-12.5 μm thick, solitary, broadly obclavate to obpyriform in face view, ellipsoid to obclavate in lateral view, septate, with a single longitudinal septum and 4-6 transverse septa, constricted at the septa, dark brown with the pigmentation concentrated around the septa, smooth (Figs. 7, 9).


Known distribution: Brunei, Cuba, Hong Kong, Kenya, Malaysia, Philippines, Thailand, Taiwan, Uganda, Vanuatu.

This species was introduced to accommodate Berkleasmium caribense (Holobová-Jechová and Mercado-Sierra, 1984). Conidia of Canalisporium species are muriform, however, they differ from those of Berkleasmium species in being flattened dorsiventrally, comprising a single layer of two columns of regularly arranged cells, which are supported by a small thin-walled, pale basal cell.

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