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The genus *Canalisporium* (*Savoryellaceae*) from freshwater habitats in Egypt

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During an ongoing study of freshwater fungi colonising decaying submerged wood in Egypt, two species of *Canalisporium*, namely *C. grenadoideum* and *C. jinghongense*, were recorded for the first time in Egypt and Africa. These two species are described and illustrated herein. The conidial morphology of the two species was compared with that of others elsewhere in the world. The asexual morph of *C. grenadoideum* was recorded and described for the first time on natural substrate in the present study. A key to *Canalisporium* species in Egypt is provided.

Key words: asexual, hyphomycetes, lignicolous, muriform, River Nile.

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Bakhit M.S. (2021): Druhy rodu *Canalisporium* (*Savoryellaceae*) ze sladkovodních biotopů v Egyptě. – Czech Mycol. 73(2): 163–171.

Během probíhající studie sladkovodních hub, kolonizujících ponořené dřevo v Egyptě, byly nalezeny dva druhy rodu *Canalisporium*, konkrétně *C. grenadoideum* a *C. jinghongense*; jde o první záznamy o jejich výskytu v Egyptě, jakož i v celé Africe. V článku je podán jejich popis s obrazovým doprovodem. Morfologie konidií z aktuálních sběrů je srovnána s údaji z jiných částí světa. Poprvé z přírodního substrátu je v této studii popsána anamorfa *C. grenadoideum*. Práci doplňuje souhrnný klíč egyptských druhů rodu *Canalisporium*.

INTRODUCTION

Shearer (1993) defined freshwater ascomycetes as fungi which colonise wood and other dead plant material in freshwater habitats. Lignicolous freshwater fungi comprise of meiosporic and mitosporic ascomycetes and are important decomposers of dead plant material in aquatic habitats (Hyde et Goh 1998, 1999, Raja et al. 2018). *Dothideomycetes* and *Sordariomycetes* are the most speciose classes of lignicolous freshwater fungi (Shearer et al. 2014, Cai et al. 2014, Hyde et al. 2020b).

Asexual fungi are generally divided into hyphomycetes, coelomycetes and asexually reproducing yeasts (Seifert et al. 2011: 6) and have been reported from different locations in aquatic habitats (Hu et al. 2013). The genus *Canalisporium* was established by Nawawi et Kuthubutheen (1989). It included *Berkleasmium caribense* Hol.-Jech. et Mercado, *B. pulchrum* Hol.-Jech. et Mercado (Holubová-Jechová et Mercado 1984), and the new species *C. elegans* Nawawi et Kuthub. *Canalisporium* in its asexual morph is a sporodochial hyphomycete, mainly characterised by broadly ellipsoidal, obpyriform to sub-globose and dorsiventrally flattened muriform conidia with a cell lumen connected by narrow canals. Phylogenetic analyses have placed species of *Canalisporium* in *Savoryellales* in *Sordariomycetes*, together with the closest genera, e.g. *Ascotaiwania* Sivan. et H.S. Chang, *Neoascotaiwania* Hern.-Restr., R.F. Castañeda et Guarro, and *Savoryella* E.B.G. Jones et R.A. Eaton (Boonyuen et al. 2011, Dayarathne et al. 2019, Hyde et al. 2020a, Goh et Kuo 2021).

Canalisporium species are common on submerged decaying wood in freshwater habitats (Hyde et Goh 1998, Tsui et al. 2001, Zhang et al. 2014). Réblová et al. (2016) reported that *Canalisporium* includes 12 species. Tibpromma et al. (2018) described two new species of *Canalisporium*, *C. krabiense* Tibpromma et K.D. Hyde, and *C. thailandense* Tibpromma et K.D. Hyde, from Thailand. Two additional new species, *C. dehongense* W. Dong, H. Zhang et K.D. Hyde, and *C. aquaticium* J. Yang et K.D. Hyde, on decaying wood submerged in freshwater streams were introduced from China and Thailand, respectively (Hyde et al. 2019, 2020a). Six new species, *C. macrosporum* Goh et C.H. Kuo, *C. nanhuaense* Goh et C.H. Kuo, *C. parvum* Goh et C.H. Kuo, *C. paulopallidum* Goh et C.H. Kuo, *C. taiwanense* Goh et C.H. Kuo, and *C. waffleum* Goh et C.H. Kuo. were described from Taiwan. In addition, *Canalisporium microsporum* G.Z. Zhao was transferred to *Trimmatostroma canalisporioides* Goh et C.H. Kuo by Goh et Kuo (2021). The genus currently includes twenty-one species. Bakhit (2014) reported three species of *Canalisporium*, namely *C. caribense* (Hol.-Jech. et Mercado) Nawawi et Kuthub., *C. exiguum* Goh et K.D. Hyde and *C. pulchrum* (Hol.-Jech. et Mercado) Nawawi et Kuthub. from freshwater habitats in the Nile Delta region, Egypt.

During a survey of freshwater fungi colonising decaying submerged wood in Egypt, two species, *Canalisporium grenadoideum* Sri-indr., Boonyuen, Sivichai et E.B.G. Jones, and *C. jinghongense* L. Cai, K.D. Hyde et McKenzie were recorded for the first time in Egypt. These two species are described in this article and a key to *Canalisporium* species in Egypt is provided.

Material and methods

Submerged decaying herbaceous and woody samples were collected randomly in the period from November 2018 to February 2020, along a 26 km segment (between 26°32'36.6" N, 31°43'07.0" E and 26°43'30.8" N, 31°35'32.4" E) of the River Nile, in Sohag Governorate, Egypt. Collected samples were placed into clean plastic bags and transported to the laboratory, where they were washed under tap water and then with sterile distilled water. Samples were incubated in appropriate plastic containers lined inside with wet paper towels at room temperature (25–30 °C) and moistened with sterile water. Samples were examined periodically using an Olympus SZ62 stereomicroscope (Olympus Corporation, Tokyo, Japan) during the following weeks for sporulating fungal structures. Micromorphological characteristics were examined with an Olympus BX51 bright field microscope. Photographs of the collections were taken using a Toup Tek XCAM1080PHA (Toup Tek, Zhejiang, China) digital camera. Herbarium specimens are deposited at Sohag University microbial culture collection, Egypt (SUMCC).

Spores of the recorded species did not germinate on potato dextrose agar (PDA; Oxoid, Basingstoke, UK), malt extract agar (MEA; 2 % w/v) or corn meal agar (CMA; Oxoid) media.

Results and discussion

Canalisporium grenadoideum Sri-indrasutdhi, Boonyuen, Sivichai et E.B.G. Jones Fig. 1

Saprobic on submerged decaying wood. Asexual morph: Sporodochia on natural substrate punctiform, scattered, minute, black, 170–210 µm in diameter. Mycelium partly immersed, composed of branched, septate, 1.5–2.5 µm wide, subhyaline to pale brown hyphae. Conidiophores micronematous or semi-macronematous, hyaline, septate, unbranched, smooth and thin-walled. Conidia 20–28 µm long × 16–23 µm wide (mean = 23.4 × 18.9 µm, n = 24), subglobose to oval, brown to dark brown, solitary, acrogenous, holoblastic, thick-walled, muriform, consisting of 4(–5) vertical columns and 4(–5) transverse rows of cells with a single cuneiform to sub-globose, pale brown basal cell and 3–4 apical cells. Number of cells 15 to 19 per conidium, slightly constricted at the septa, cell lumen obscured by heavy pigmentation around the septa, septal pores not visible. Sexual morph: Not observed.

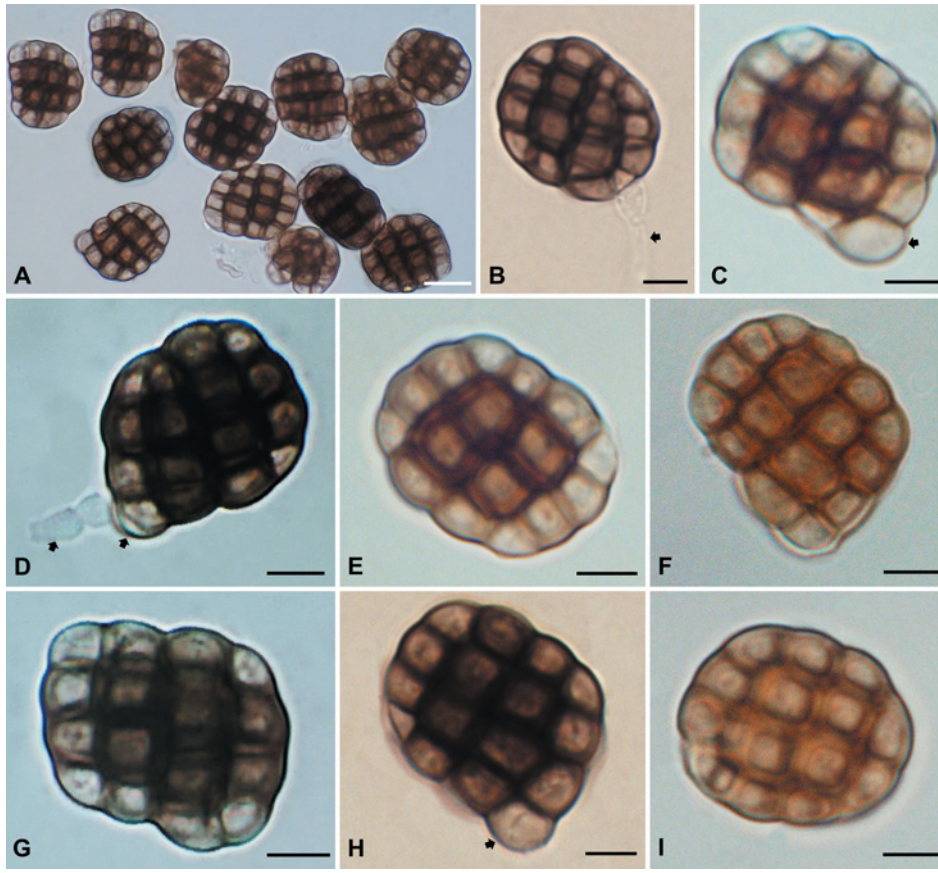

Fig. 1. *Canalisporium grenadoideum* (SUMCC H-19002). **A** – scattered conidia from squashed mounts of sporodochia; **B** – conidium with conidiophore (arrowed); **C–I** – variously shaped conidia with conidiophore (arrowed in D) and basal cells (arrowed in C, D, H). Bars = 10 µm (A), 5 µm (B–I). Photo M.S. Bakhit.

Specimen examined

Egypt. Sohag Governorate, city of El Maragha, River Nile (26°38'49.5" N, 31°37'56.0" E), on decaying submerged dicot wood, 12 April 2019, leg. et det. M.S. Bakhit (SUMCC H-19002).

General distribution. Thailand (Sri-indrasutdhi et al. 2010), Egypt (this study).

Notes. The sexual morph *Ascothailandia grenadoidea* Sri-indr., Boonyuen, Sivichai et E.B.G. Jones, whose ascospores produced asexual *Canalisporium grenadoideum*, was published by Sri-indrasutdhi et al. (2010). This asexual morph has so far only been described from culture. It is characterised by having

Tab. 1. Comparison of conidial morphology of *Canalisporium grenadoideum* and *C. jinghongense* records from various localities.

Species name	Herbarium no.	Country	Length (µm)	Width (µm)	Distinctness of septa	Columns of cells	Rows of cells*	Cell(s) at the apex	Cell(s) at the base	Cells per conidium #	Reference
C. grenadoideum	SS03615	Thailand	22–38	16–28	Slightly	4–5	5–6	3–4	1	17–26	Sri-indrasutdhi et al. 2010
C. grenadoideum	SUMCC H-19002	Egypt	20–28	16–23	Slightly	4(–5)	4(–5)	3–4	1	15–19	This study
C. jinghongense	PDD 74130	China	25–33	20–28	Not or slightly	4–5	3–4(5)	1–4	1(–2)	12–18	Cai et al. 2003
C. *jinghongense*	–	Thailand	25–33	20–28	Not or slightly	3–5	3–4	1–4	1–2	–	Zhang et al. 2014
C. *jinghongense*	NCYU-J8-2	Taiwan	24.5–32	22–31.5	Not or slightly	4–5	3–5	1–4	1	12–19	Goh et Kuo 2021
C. *jinghongense*	NCYU-L5-1	Taiwan	26–38.5	24–35	Not or slightly	4–5	(3)4–5	2–4	1	(14)17–20	Goh et Kuo 2021
C. *jinghongense*	SUMCC H-20006	Egypt	25–38	19–29	Not or slightly	3–5	4–5	1–4	1	12–18	This study

* basal cells(s) excluded but apical cell(s) included; # basal cell(s) included

subglobose to oval, thick-walled, slightly curved conidia with 4–6 columns and 5–6 rows of cells (Sri-indrasutdhi et al. 2010, Goh et Kuo 2021). The conidial dimensions of *C. grenadoideum* observed in this study are within the range given for those obtained from the ex-holotype culture [20–28 × 16–23 µm (this study) vs 22–38 × 16–28 µm (Sri-indrasutdhi et. al. 2010)]. The number of cells varies from 15 to 19 per conidium in the Egyptian collection while it varies from 17 to 26 in the Thailand collection (Tab. 1). This slight difference in conidia may be due to it being an asexual morph of the Thailand collection, which was described from culture, whereas it was identified for the first time on natural substrate in this study.

Canalisporium jinghongense L. Cai, K.D. Hyde et McKenzie Fig. 2

Saprobic on submerged decaying wood. Asexual morph: Sporodochia on natural substrate scattered, punctiform, subglobose, black, glistening, 205–240 µm in diameter. Mycelium immersed, composed of branched, septate, 1.5–2.5 µm wide, hyaline to pale brown hyphae. Conidiophores micronematous or semi-macronematous, hyaline, smooth, septate, unbranched, thin-walled. Conidia 25–38 µm long × 19–29 µm wide × 9–12.5 µm broad (mean = 31.8 × 25.2 × 10.2 µm, n = 32), oval to irregularly subglobose, pale brown to brown, acrogenous, solitary, holoblastic, flattened, muriform, one-cell thick, smooth and thick-walled, constricted at the septa, consisting of 3–5 vertical columns and 4–5 transverse rows of cells with single basal cells and 1–4 apical cells. Number of cells 12 to 18 per conidium. Septa indistinct or slightly pigmented, conidial septal pores clearly visible, columns of vertical septa slightly curved. Sexual morph: Not observed.

Specimen examined

Egypt. Sohag Governorate, city of Sohag, River Nile (26°32'34.3" N, 31°42'42.1" E), on decaying submerged monocot wood, 18 February 2020, leg. et det. M.S. Bakhit (SUMCC H-20006).

General distribution. China (Cai et al. 2003), Taiwan (Zhang et al. 2014), Thailand (Goh et Kuo 2021), Egypt (this study).

Notes. *Canalisporium jinghongense* was described by Cai et al. (2003) from submerged wood in Yunnan, China. This species was characterised by having moderately pigmented conidia, ellipsoidal to irregularly subglobose in surface view with 3–4 slightly curved columns of vertical septa and 2–3(4) rows of transverse septa. *Canalisporium jinghongense* has been recorded from different countries, China, Taiwan and Thailand, on decaying submerged wood in freshwater habitats (Cai et al. 2003, Zhang et al. 2014, Goh et Kuo 2021). Morphological features of the Egyptian record of *C. jinghongense* are very similar to those of other collections (Tab. 1). The thickened septal pores in *C. jinghongense* were clearly visible in the specimen from Egypt.

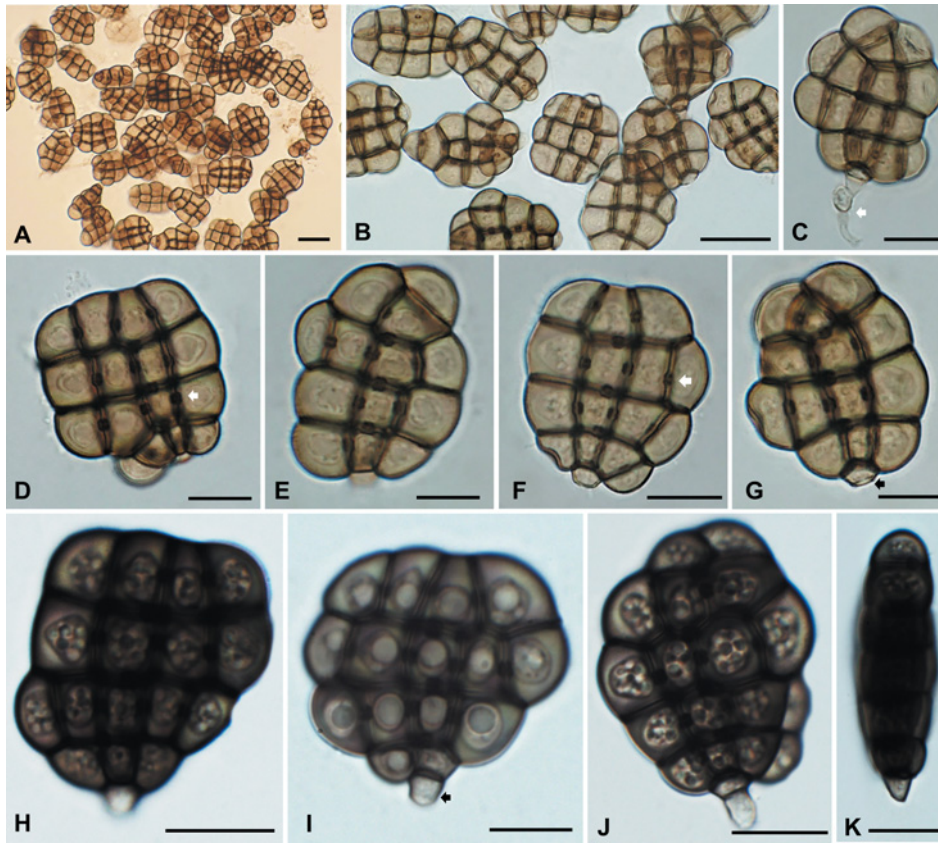

Fig. 2. *Canalisporium jinghongense* (SUMCC H-20006). **A** – scattered conidia from squashed mounts of sporodochia; **B** – variously shaped conidia; **C** – conidium and conidiophore (arrowed); **D–J** – conidia with septal canals (arrowed in D, F) and basal cells (arrowed in G, I); **K** – conidium in lateral view. Bars = 20 µm (A, B), 10 µm (C–K). Photo M.S. Bakhit.

Key to *Canalisporium* species recorded in Egypt

Canalisporium species are mostly found as saprobes on wood and other dead plant material in freshwater habitats and are probably restricted to tropical regions (Goh et al. 1998, Zhang et al. 2014, Goh et Kuo 2021). Four species of *Canalisporium* have been recorded earlier in Africa: *C. caribense* (Egypt, Kenya and Uganda), *C. exiguum* (Egypt), *C. kenyense* Goh, W.H. Ho et K.D. Hyde (Kenya) and *C. pulchrum* (Egypt) (Kirk 1985, Matsushima 1987, Bakhit 2014). To help future identification of Egyptian species of the genus, the following identification key is provided here.

1 Conidia consisting of two columns of cells 2
1' Conidia consisting of three or more columns of cells 3
2 Conidia 12–19 × 10–15 µm, broadly ellipsoidal to obovoid, with 3–5 rows of cells, 4–9 cells per conidium ..... ***C. exiguum***
2' Conidia 28–35 × 17–23 µm, broadly obclavate to obpyriform, with 4–7 rows of cells, 9–15 cells per conidium ..... ***C. caribense***
3 Conidia distinctly prolonged, 35–52 × 20–27 µm, consisting of three columns of cells in 4–6 rows, 2–3 apical cells ..... ***C. pulchrum***
3' Conidia subglobose to widely oval, 20–38 × 16–29 µm, consisting of 3–5 columns of cells in 4–5 rows, 1–4 apical cells 4
4 Conidia 25–38 × 19–29 µm, 3–5 columns and 4–5 rows of cells, 1–4 apical cells, 12–18 cells per conidium, septal pores clearly visible ..... ***C. jinghongense***
4' Conidia 20–28 × 16–23 µm, 4–5 columns and 4–5 rows of cells, 3–4 apical cells, 15–19 cells per conidium, septal pores not visible ..... ***C. grenadoideum***

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