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Four noteworthy hyphomycetes from indoor environments

De-Wei Li*[1], Guihua Zhao[2], Chin Yang[3], Ariunaa Jalsrai[4] & Brian Kerin[5]

[1] *The Connecticut Agricultural Experiment Station, Valley Laboratory, 153 Cook Hill Road, Windsor, CT 06095, USA*
[2] *Center of Biotechnology R&D, Jiangsu Polytechnic College of Agriculture and Forestry, 3 Changjiang Road, Jurong, Jiangsu 212400, China*
[3] *Prestige EnviroMicrobiology, Inc., 242 Terrace Boulevard Suite B-1, Voorhees, New Jersey 08043, USA*
[4] *EMLab P&K Environmental Laboratories, 1936 Olney Avenue, Cherry Hill, NJ 08003, USA*
[5] *Pacific EHS, 125 - 3001 Wayburne Drive, Burnaby, BC V5G 4W3, Canada*
* Correspondence to: *dewei.li@ct.gov*

Abstract — Four interesting hyphomycetes (*Nalanthamala vermoesenii*, *Parascedosporium putredinis*, *Stachybotrys elegans, Triadelphia australiensis*) have been collected from indoor fungal investigations. Among these fungi, *Triadelphia australiensis* represents a new record for Canada and the USA. *Parascedosporium putredinis* and *Stachybotrys elegans* are reported for the first time from indoor environments.

Key words — anemophilous, microfungi, mold, residence

Introduction

Fungal diversity inside buildings is poorly understood. Although the list of fungi from indoor environments compiled from the databases at commercial laboratories is expanding to include new first records of fungi occurring indoors, no comprehensive list of indoor fungi exists. Recently, four noteworthy hyphomycete species found in indoor environments among samples collected from air and building materials during indoor mold investigations in the USA and Canada were submitted to our laboratories for analysis. We report on these indoor fungi here.

Materials & methods

Fungal isolates were grown on malt extract agar (MEA) at 25°C in the dark. *Parascedosporium putredinis* was also grown on corn meal agar (CMA), dichloran

glycerol agar (DG18), and potato dextrose agar (PDA). If culturing was not successful, tape lifts or a small scalpel were used to get fungal structures directly from the samples for microscopic observation. Conidiophores and conidia were mounted in 85% lactic acid. A staining agent, 0.1% lacto-fuchsin, was used to observe conidiogenous cells and septation of colorless conidia. All microscopic observations were made under Nomarski differential interference contrast optics. Photomicrographs were taken with an Olympus Microfire digital camera (Goleta, CA). Measurements of the fungal structures were statistically analyzed with Microsoft Office Excel 2010 with 95% confidence interval of means. The results were presented as ranges and mean ± standard deviation. Voucher specimens or cultures were deposited to China General Microbiological Culture Collection (CGMCC) and U.S. National Fungus Collections (BPI).

DNA extraction, sequencing, and sequence similarity analysis for *Nalanthamala vermoesenii* and *Parascedosporium putredinis* follow Li et al. (2008).

The partial DNA sequence transcribing the ribosomal spacer region (3' end of the 18S ssu), 5' end of the 28S ribosomal RNA units, and complete sequences for the 5.8S ribosomal RNA and internal transcribed spacers (ITS) 1 and 2) were submitted through the nucleotide MegaBLAST procedure (Zhang et al. 2000) via the NBCI web site (www.ncbi.nlm.nih.gov/blast/) using the non-human, non-mouse database. Sequence similarity searches and comparisons for *Nalanthamala vermoesenii* and *Parascedosporium putredinis* were conducted using MegaBLAST (NCBI).

The partial sequences transcribing the 18S and 28S ribosomal RNA units, and the complete sequences for the 5.8S ribosomal RNA and internal transcribed spacers (ITS) 1 and 2 have been placed in the GenBank database.

Taxonomy

Nalanthamala vermoesenii (Biourge) Schroers, Mycologia 97: 390 (2005) Plate 1

≡ *Penicillium vermoesenii* Biourge, La Cellule 33: 230 (1923)

≡ *Gliocladium vermoesenii* (Biourge) Thom, The Penicillia: 502 (1930)

Colonies 38–55 mm diam at 25°C after 5 d on MEA in the dark. Colony surface fine powdery to dusty, salmon to pink; aerial mycelium sparsely developed. Reverse flesh. Conidiophores dimorphic; penicillate and acremonium-like. Penicillate conidiophores up to 220 µm long, monoverticillate to quaterverticillate, 22–110 µm tall; metulae (6.5–)7.7–14(–19) × (2–)2.5–3.5 (–4) µm (n = 35); phialides cylindrical with a narrowed apex, (8–)10–16(–24) µm long, 1.5–3.5 µm wide at base and in the lower third, and 0.5–1.5 µm wide at the tip (n = 35). Acremonium-like conidiophores, unbranched or occasionally branched; phialides cylindrical or slightly narrowing toward the tip, 9–25(–40) × (1.5–)1.9–2.7(–3) µm, 1–2 µm wide at tip (n = 35). Conidia dimorphic: those on penicillate conidiophores 1-celled, ovoid or ellipsoidal, (3–)3.5–5.5(–7) × (2–)2.1–3.1(–4) µm (n = 30), in long, dry, persistent chains, in masses appearing salmon or pink in color; on acremonium-like conidiophores ellipsoidal or cylindrical (2–)4.8–10.5(–15) × (1.5–)1.7–2.8(–4) µm (n = 30), 1-celled, in liquid drops aggregated at the tip of phialides.

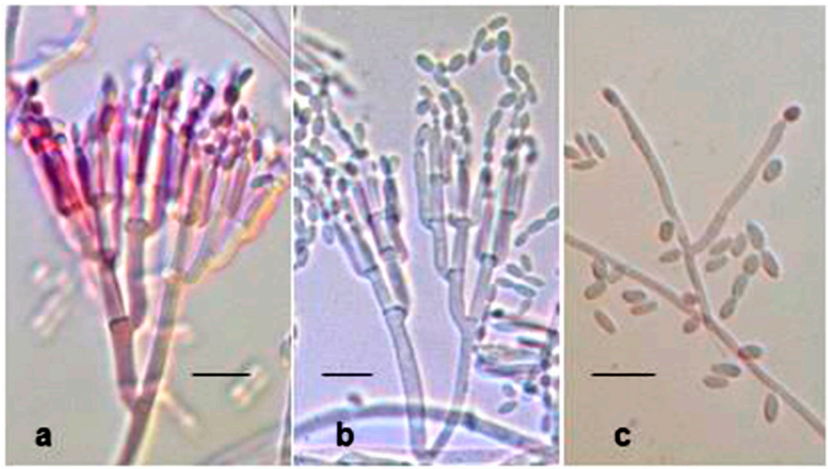


Plate 1. *Nalanthamala vermoesenii* (CGMCC3.15232). a–b. Penicillate conidiophores and conidia; c. *Acremonium*-like conidiophore and conidia. Scale bars = 10 μm.

Teleomorph. Unknown.

Material examined: **U.S.A. California**, Sacramento, in a residence, April 2005, anonymous (CGMCC3.15232; GenBank KC894849).

Distribution: Australia, Belgium, Congo, Czech Republic, Greece, India, Japan, New Zealand, Russia, Spain, South Africa, UK, USA, Uzbekistan. Mainly in warm temperate, Mediterranean, subtropical areas, also on hosts kept in greenhouses of other geographic areas (Subramanian 1956; Spaulding 1961; Carpenter et al. 1962; Holevas et al. 2000; Schroers et al. 2005).

Substrates/hosts: air, indoor environment, soil, on various *Arecaceae* (causing stem rot, pink rot, necrosis and blight), *Citrus medica*, *Psidium guajava* (Schroers et al. 2005).

Note: *Nalanthamala vermoesenii* has been found mainly in indoor environments on the west coast of North America, especially in California. It has also been reported indoors and outdoors from Florida and Hawaii (Raabe et al. 1981; Alfieri. et al. 1984; French 1989) but is not common in other areas of the U.S.A. It is a pathogen on palms, but it is occasionally found from indoor samples (Spaulding 1961). The species is often placed in *Gliocladium* or *Penicillium* due to sharing a similar morphology with those genera. Based on its phylogenetic relationships Schroers et al. (2005) transferred it to *Nalanthamala,* a genus erected by Subramanian (1956), typified by *N. madreeya* Subram., and currently comprising five species. *Nalanthamala vermoesenii* is morphologically similar to *N. psidii* (Sawada & Kuros.) Schroers & M.J. Wingf. on culture media. Its salmon to pink colonies on PDA and 1-celled conidia differentiate

N. vermoesenii from *N. psidii*, which has yellow colored colonies and 1–2 celled conidia (Schroers et al. 2005).

ITS sequence data of *N. vermoesenii* collected from indoor environments have a 100% match with the neotype isolate CBS 110893(= 5 MUCL 9504, Biourge 415, ex-type; GenBank AY554214) and a 95% match with the epitype isolate of *N. psidii* BPI 863661 (GenBank AY864836).

Parascedosporium putredinis (Corda) Lackner & de Hoog, IMA Fungus 2(1): 44 (2011) Plate 2

≡ *Graphium putredinis* (Corda) S. Hughes, Can. J. Bot. 36: 770 (1958)

= *Parascedosporium tectonae* (C. Booth) Gilgado, Gené, Cano & Guarro, Int. J. Syst. Evol. Microbiol. 57: 2176 (2007)

Colonies reaching 34 mm diam on MEA after 14 d at 25°C, velvety, dark gray and slightly raised at center, buff at edge, granulate due to presence of numerous synnemata, reverse pale gray at center; 49 mm diam on PDA, light gray, darker at center, granulate; reaching 53 mm, spreading out in a very thin layer of mycelium, almost transparent on CMA; no growth on DG18.

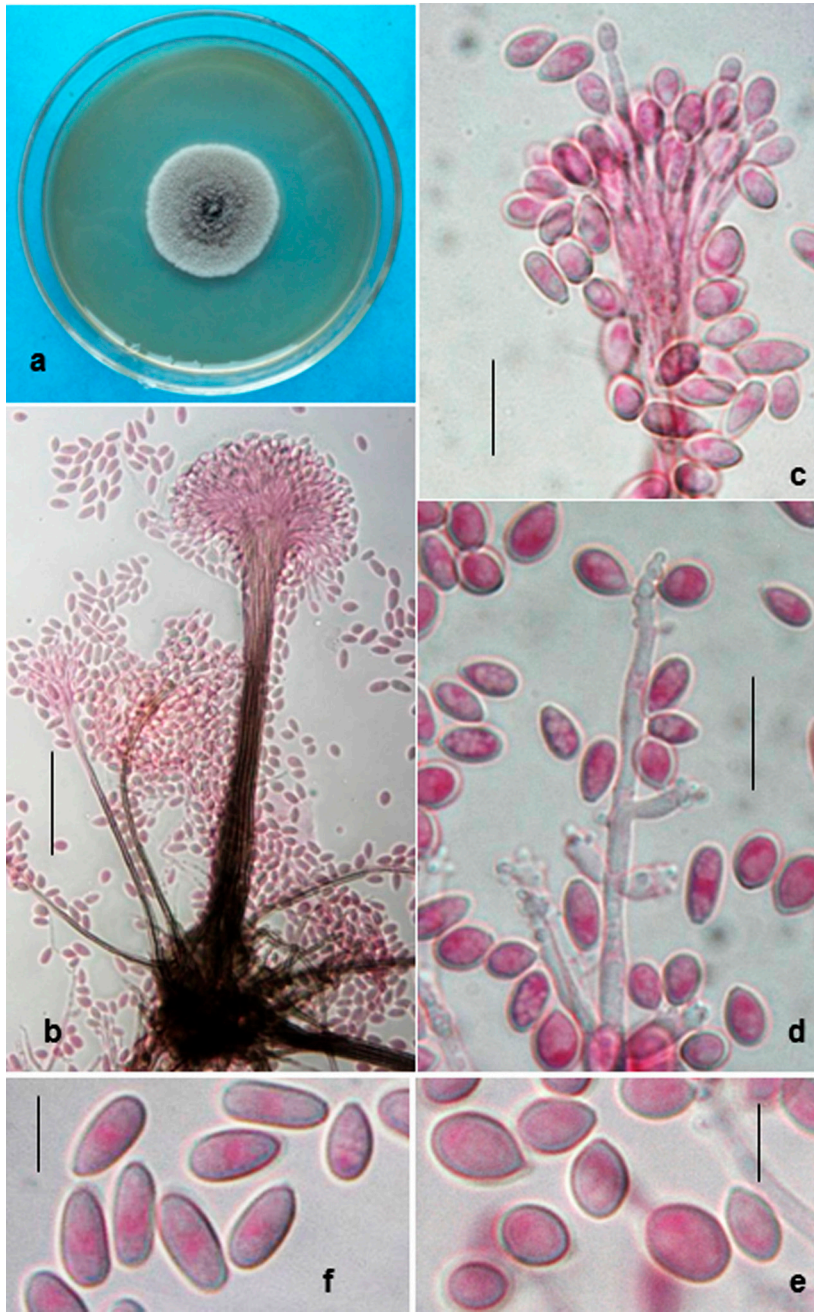
Conidiophores when solitary, simple, undifferentiated, with lateral conidiogenous cells, occasionally reduced to conidiogenous cells, or irregularly branched. Conidiogenous cells cylindrical or ampulliform, 10–25 × 2.0–2.5 µm, colorless, smooth, thin-walled, bearing 2–7 cylindrical denticles ≤1.2 µm long at apical area. Conidia obovoid or ellipsoidal, smooth, thick-walled, (4.3–)4.8–6.4 (–6.9) × (3.3–)3.6–4.4(–4.7) (mean = 5.6 ± 0.8 × 4.0 ± 0.4, n = 25) µm.

Synanamorph: synnemata erect, up to 230 µm in height; stipe to 20 µm in width, dark grey, fanning out at apices and developing conidia in an opaque slimy mass. Conidiogenous cells percurrent, cylindrical, annellidic, lateral or terminal, colorless to subhyaline, smooth-walled, 10–22 × 2.0–2.5 µm. Conidia clavate or subcylindrical, smooth, (5.2–)5.9–7.3 (–7.9) × (2.6–)2.9–3.5(–3.7) (mean = 6.6 ± 0.7 × 3.2 ± 0.3, n = 25) µm. A small number of conidia developing directly from undifferentiated hyphae, lateral, subglobose to obovoid, brown, smooth and thick-walled, usually sessile, 6–7.5 × 5–6 µm.

Material examined: **USA**, **Kentucky**, Lexington, from particleboard under a kitchen sink in a residence, 27 June 2011, Chris Adkins (CGMCC3.15233; GenBank KC894850).

Distribution: Australia, China, Cuba, Czech Republic, Italy, Jamaica, Japan, Malaysia, Madagascar, New Zealand, Nicaragua, Poland, The Netherlands, USA.

Plate 2. *Parascedosporium putredinis* (CGMCC3.15233). a. Colony growing on MEA for 14 days at 25°C; b. Synnemata and conidia; c. Annellidic conidiogenous cells and conidia; d. Denticulate conidiogenous cells and conidia; e. Conidia developed from denticulate conidiogenous cells; f. Conidia developed from annellidic conidiogenous cells. Scale bars: b = 40 µm, c–d = 10 µm, e–f = 5 µm.


a
b
c
d
e
f

Substrates/hosts: *Actinidia deliciosa* (kiwifruit, leaf lesions), *Carex pseudocyperus(Mułenko, Majewski, Ruszkiewicz-Michalska 2008), Chrysalidocarpus lutescens*, *Echium* sp., *Elaeis* sp., *Iris pseudacorus, Pandanus boninensis, Quercus cerris* (living wood), *Schoenoplectus lacustris, Tectona grandis* (seed), *Theobroma cacao*, particle board, air, soil (Booth 1964; Liu 1977; Mercado Sierra et al. 1997; Kobayashi 2007; Mułenko et al. 2008; Zhang et al. 2008; Lackner & de Hoog 2011).

Note: Gilgado et al. (2007) erected *Parascedosporium* as a monotypic genus for *P. tectonae*. Lackner & de Hoog (2011) determined that *P. putredinis* was synonymous, so that the genus remains monotypic.

ITS sequence data of *P. tectonae* collected from indoors in Minnesota has 100% match with isolates from the ex-type of *P. tectonae* (GenBank AM749440), CBS 118694 (as *P. tectonae*; GenBank AM749735), and CMW352 (as *Graphium putredinis*; GenBank HQ335312.1) (Cruywagen et al. 2010). Sequence HQ335312.1 (from a C.T. Rogerson collection from a blackened agaric) is the only previous record of this fungus from the USA (Cruywagen et al. 2010). The 2011 Adkins collection is the first report of this fungus from an indoor environment.

Since this species is synanamorphic, developing both *Graphium* and *Scedosporium* anamorphs, care should be taken to avoid identifying this fungus as two different fungi when both anamorphs are present. This fungus is hydrophilic according to its growth on artificial media.

Stachybotrys elegans (Pidopl.) W. Gams, Compendium of Soil Fungi: 746 (1980)

Plate 3

= *Stachybotrys aurantia* G.L. Barron, Can. J. Bot. 40: 258 (1962)

Colonies on MEA reaching 30 mm diam at 21°C in 12 days; pink to salmon pink with light brown soluble pigment released into medium and conspicuously funiculose (downy) at center and velutinous at edge; radially sulcate on the edge; reverse dirty pink to pinkish brown. Conidiophores differentiated, single, determinate, erect, single, straight or flexuous, unbranched or alternately branched, colorless, smooth or minutely roughened, varying in length, (30–)42–64(–71) × (3.3–)3.5–4.1(–4.5) µm (n = 10), 0–5 septate for unbranched, up to 285 µm in length for alternately branched, tapering toward the apex, slightly enlarged at the apex and the base, terminally bearing a whorl of 2–7 phialides at the apex. Phialides determinate, discrete, subclavate, smooth, colorless, (6.7–)7–8.7(–10.9) × (3.8–)4–4.5(–4.9) µm (n = 20), with conspicuous collarettes. Conidia unicellular, acrogenous, colorless, smooth, ellipsoidal, (4.8–)6.6–8.2(–9.2) × (3.5–)3.9–4.7(–5.5) µm (n = 30), aggregated in slimy masses.

Material examined: **USA**, **New Jersey**, in a residence, 10 March 2008, anonymous (BPI 884211). Additional materials examined are listed in Li (2011).

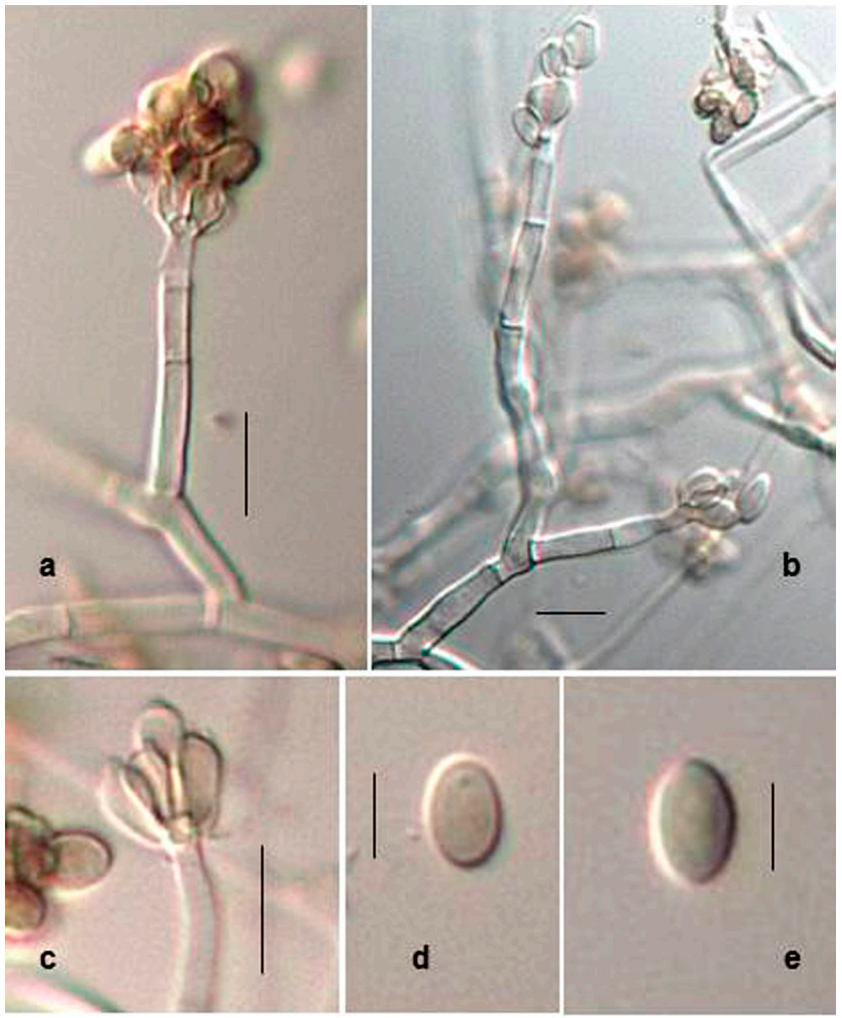


Plate 3. *Stachybotrys elegans* (BPI 884211). a. Conidiophore and conidia; b. Branched conidiophore and conidia; c. Phialides and conidia; d–e. conidium. Scale bars: a–c = 10 µm, d–e = 5 µm.

Distribution: Brazil, Cuba, Canada, China (as *Stachybotrys aurantia*, Wu et al. 2009), Egypt, Georgia, India, Kenya, Malawi, Malaysia, Poland, South Africa, USA, Vietnam.

Substrates/hosts: from soil, plants [*Agropyron repens* (rhizosphere), *Bambusa* sp. (on leaves.), *Betula alleghaniensis* (roots), *Dactylis glomerata*, *Linum usitatissimum*, *Panicum virgatum*, *Phaseolus vulgaris*, *Saccharum officinarum*,

Saccharum spontaneum, *Trifolium alexandrinum*, *Trifolium pratense*], and an isopteran insect.

Note: *Stachybotrys elegans* has been reported from soils and plant debris in North America (Orpurt 1954; Barron 1962; Morgan-Jones 1977; Ghimire et al. 2010). It is here reported for the first time from an indoor environment. Several *Stachybotrys* species (including *Memnoniella*) have previously been reported from indoor environments. Predominant indoor species are *S. chartarum* and *S. echinata* (≡ *M. echinata*), but *S. chlorohalonata*, *S. microspora*, and *S. yunnanensis* have also been reported.

Triadelphia australiensis B. Sutton, Sydowia 41: 339 (1989) Plate 4

[non *Triadelphia australiensis* Joanne E. Taylor et al., nom. illegit.]

Colonies on natural substrate thinly diffuse, sparse, dark brown. Mycelium initially immersed, finally superficial, sparse, of colorless to pale brown, irregularly branched, smooth, septate hyphae 2-3.5 µm wide. Conidiogenous cells integrated, terminal or lateral, holoblastic, monoblastic, colorless to pale brown, thin-walled, smooth, globose to ampulliform, more rarely lageniform, 3–5.5 × 3–4 µm, each with a single, short, unthickened denticle upon which a conidium is formed. Conidia aerogenous, solitary, dry, ellipsoidal, obovoid to broadly obovoid, smooth, thick-walled, 1-septate near the base, thickened, sometimes constricted at the septum, (8.2–)9.1–10.9 (–11.7) × (4.9–)5.6–6.8 (–7.3) (mean = 10 ± 0.9 × 6.2 ± 0.6, n = 30) µm, Q = 1.4–1.9 (mean = 1.6); two cells unequal in size and shape, the apical cell dark brown, thick-walled and the basal cell pale brown, with a small unthickened scar at the base.

Material examined, **CANADA**, **British Columbia**, Nanaimo, from plywood in an ice rink, 2 November 2011, Gordon Wedman (BPI 884210).

Distribution: Australia, Canada, USA.

Substrates/hosts: bark of unknown plant, unknown substrate in a residence, and plywood in an ice rink.

Note: *Triadelphia australiensis* represents a new record for Canada and the USA. It is morphologically very similar to *T. uniseptata* (Berk. & Broome) P.M. Kirk (= *Polyschema bicellulare* Shearer, fide Kirk 1983). The major difference is that *T. australiensis* has smaller conidia (8.5–10 × 4.5–6 µm; Sutton 1989) than *T. uniseptata* (12.5–16 × 6.5–10.5 µm; Kirk 1983). Loose conidia with a similar morphology sometimes found in the air in indoor environments in North America have often been identified as *Endophragmiella*, *Polyschema*, or *Spadicoides* due to lack of conidiophores and the similarity with conidia of *E. uniseptata*, *P. bicellulare*, *S. cordanoides*, and *S. hodgkissii*.

Several attempts to isolate *T. australiensis* from bulk and tape samples failed. The species was found on a tape sample in the USA, but because the sample was

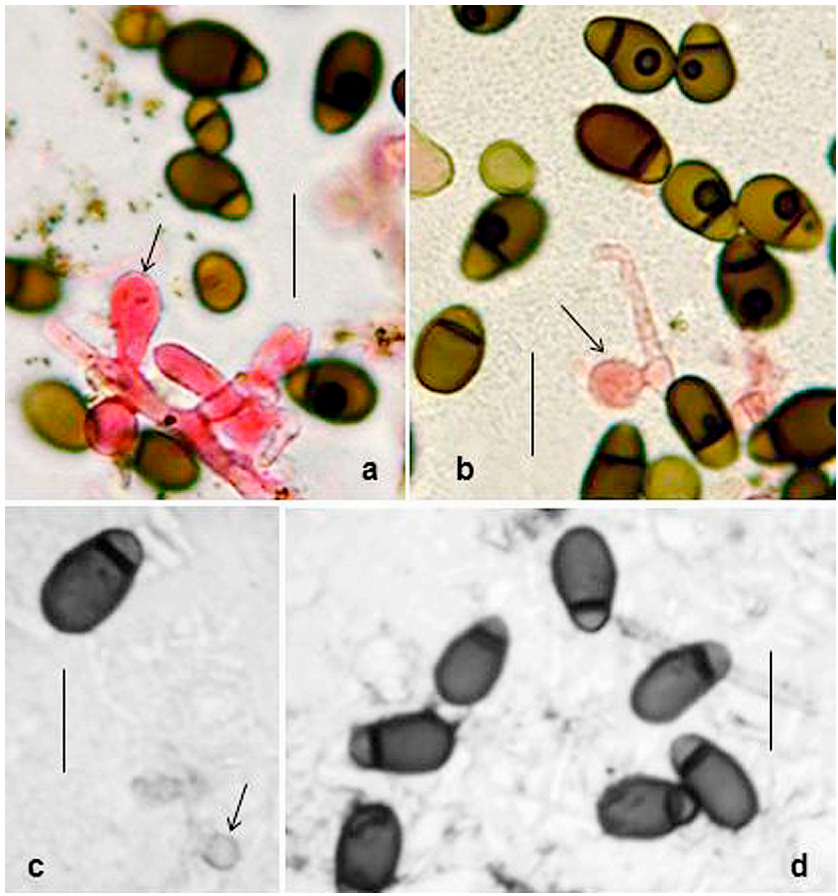


Plate 4. *Triadelphia australiensis* (BPI 884210). a–b. Conidia and conidiogenous cells from a tape sample collected in Canada; c–d. Conidia and conidiogenous cells from a tape sample collected in USA. (Arrows indicate conidiogenous cells.) Scale bars = 10 µm.

consumed during the lab analysis, the excised piece of tape was not retained. Fortunately, although no fungal structures could be found on the tape remnants, photomicrographs were successfully taken from the tape.

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