



A reappraisal of *Microthyriaceae*

HAI-XIA WU¹, QIN TIAN^{2,3}, WEN JING LI^{2,3} & KEVIN D. HYDE^{1,2,3*}

¹ International Fungal Research and Development Centre, Key Laboratory of Resource Insect Cultivation & Utilization State Forestry Administration The Research Institute of Resource Insects, Chinese Academy of Forestry Kunming 650224, PR China
email: aileen2008haixia@gmail.com

² Institute of Excellence in Fungal Research, Mae Fah Luang University Tasud, Muang, Chiang Rai 57100, Thailand

³ School of Science, Mae Fah Luang University Tasud, Muang, Chiang Rai 57100, Thailand

* email: kdhyde3@gmail.com

Abstract

Asterinella, *Cirsosiopsis*, *Phragmaspidium*, *Platypeltella*, *Trichopeltella*, *Trichopeltum* and *Trichothyrimula* are poorly known ascomycete genera, presently included in the family Microthyriaceae. In this paper the type species of each of these genera were examined and the taxa are redescribed and illustrated with photomicrographs. The taxonomic placement of each genus and their familial position is discussed. *Asterinella* and *Platypeltella* has superficial, flattened thyriothecia and superficial hyphae with hyphopodia; the thyriothecia opens by splitting to release the ascospores and these genera should be placed in Asterinaceae. *Cirsosiopsis*, has strongly flattened, discoid or pulvinate to elongate, carbonaceous ascomata and is transferred to Parmulariaceae. *Phragmaspidium* has an upper wall comprising neatly arranged radiating cells; the basal layer is poorly developed and thus the genus should be retained in Microthyriaceae. *Trichopeltella*, *Trichopeltum* and *Trichothyrimula* are foliar epiphytes forming extremely thin, relatively large, brown to black, circular to irregular, or root-like, spreading thalli, which cover the thyriothecia and should be placed in Trichopeltinaceae.

Key words: Asterinaceae, *Asterinella*, Brefeldiaceae, *Cirsosiopsis*, Parmulariaceae, *Phragmaspidium*, *Platypeltella*, *Trichopeltella*, Trichopeltinaceae, *Trichopeltum*, *Trichothyrimula*

Introduction

In a series of papers, Wu *et al.* (2010, 2011a,b,c, 2013, 2014) have partially revised the family Microthyriaceae by examining the generic type species. They were however, not able to locate all generic types and in this paper we report on a further six types that have now been located. The family Microthyriaceae is characterized by superficial, flattened thyriothecia, with cells of the upper wall radiating in a parallel arrangement from the central opening; the opening may or may not be surrounded by setae. Asci are fusiform or obclavate to cylindro-clavate, bitunicate, fissitunicate and ascospores are two-celled, hyaline to brown often with ciliate appendages (Kirk *et al.* 2008, Wu *et al.* 2011a, Hyde *et al.* 2013).

The role of species in the family is not clear as they develop on living leaves, but continue to grow and release ascospores at leaf senescence or during decay. In fact species overwinter on dead leaf litter (Hyde, pers. observ.). It is also not clear if the species are host generalists or host-specific. Appressoria or haustoria have not been reported in many Microthyriaceae genera and studies that have examined whether species can penetrate leaves show that *Xenostomella* species have haustoria (von Arx & Müller, 1975, Müller & von Arx, 1962), but Wu *et al.* (2010) transferred this genus to Asterinaceae. We have successfully isolated several species of Microthyriaceae which suggests that species have saprobic tendencies and may be host generalists (Wu *et al.* 2011a, 2013a). Species of Asterinaceae, on the other hand, which produce appressoria and penetrate host cells, appear to be biotrophic, cannot be isolated and are more likely to be host-specific.

In this study, we have examined the generic types of *Asterinella*, *Cirsosiopsis*, *Phragmaspidium*, *Platypeltella*, *Trichothyrimula*, *Trichopeltella* and *Trichopeltum* and in this paper report on these poorly known genera with morphological descriptions and figures, and discuss taxonomic placements. In future studies, fresh collections are needed and molecular data can be analyzed to obtain a natural classification.

Materials and methods

Type specimens of *Asterinella*, *Cirsosiopsis*, *Macrographa*, *Pachythyrium*, *Phragmaspidium*, *Platypeltella*, *Trichothyridula*, *Trichothyrium*, *Trichopeltella*, *Trichopeltum* were obtained from herbaria S, LPS, W, PDD, MAF, K, ZT, FH, URM. Microscopic study and sectioning performed follow the methods outlined in Wu *et al.* (2011a) and Chomnunti *et al.* (2011) and used Leica MZ16A and KEYENCEVHX-1000 stereomicroscopes, Nikon E800 and 80i compound microscopes and a Leica CM1100 freezing microtome and photographic plates were prepared with Adobe Photoshop CS3 Extended version 10.0 software (Adobe Systems, U.S.A.).

Results

Taxonomy

Microthyriaceae

Taxa of the family Microthyriaceae are foliar epiphytes which are characterized by superficial, flattened thyriothecia, with cells of the upper wall radiating in a parallel arrangement from the central ostiole. The ostiole may or may not be surrounded by setae (Ellis 1976, Wu *et al.* 2011a, Hongsanan *et al.* 2014). Asci are bitunicate, fusiform or obclavate to cylindro-clavate, and ascospores are 2-celled, hyaline to brown often with ciliate appendages (Kirk *et al.* 2008, Wu *et al.* 2011a, Hyde *et al.* 2013). Hyde *et al.* (2013) accepted 13 genera (seven for which the sexual state and six for which the asexual state is known), while Hongsanan *et al.* (2014) add a new genus for which only the sexual state is known. In this paper we also include *Phragmaspidium* in Microthyriaceae.

Phragmaspidium Bat., Publicações Inst. Micol. Recife 260: 109 (1960) MycoBank: MB 4018

Epiphytic on leaves, superficial mycelium lacking. Sexual state: *Thyriothecia* gregarious, circular, or some solitary, brown to black-brown, coriaceous, with prominent and darkened, raised, circular, central ostiole. *Upper wall* comprising neatly arranged radiating cells, basal layer poorly developed. *Hamathecium* comprising asci inclined towards the central ostiole, pseudoparaphyses lacking. *Asci* 8-spored, bitunicate, obclavate to cylindrical, apedicellate, lacking an obvious ocular chamber. *Ascospores* overlapping seriate, fusiform to clavate, with larger region above central septum, smooth-walled. Asexual state: unknown.

Type species:—*Phragmaspidium corruscans* (Rehm 1913: 254) Bat. (1960: 110).

Notes:—*Phragmaspidium* was introduced by Batista (1960) with *P. corruscans* as the type species and placed in Microthyriaceae. *Phragmaspidium manaosense* (Henn. 1904: 377) Bat. (1960: 113) and *P. viniferae* Bat. (1960: 114) have since been added. Wu *et al.* (2011a) followed the description of Rehm (1913) and suggested this genus should be placed in Micropeltidaceae. In this study, we examined the type species of *Phragmaspidium* which lacks a well-developed base, and the upper wall of thyriothecia which comprises cells radiating outwardly in parallel rows from the central raised papillate ostiole. Asci are bitunicate and ascospores are two-celled which are typical of Microthyriaceae. *Phragmaspidium* differs from other genera in Microthyriaceae in fusiform to clavate ascospores.

Phragmaspidium corruscans (Rehm) Bat., Publicações Inst. Micol. Recife 260: 110 (1960) MycoBank: MB 113142 (Fig. 1)

≡ *Micropeltis corruscans* Rehm, Philippine J. Sci. Sect. C Bot. 8: 254, 1913

Epiphytic on the lower surface of leaves, superficial mycelium lacking. Sexual state: *Thyriothecia* 27–61 µm high × 68–124 µm diam, gregarious, circular, or some solitary, slightly raised, brown to black-brown, coriaceous, with prominent and darkened, raised, circular, central ostiole. *Upper wall* comprising neatly arranged radiating cells and at margin occasionally branched, basal layer poorly developed. *Hamathecium* comprising asci inclined towards the central ostiole, pseudoparaphyses not observed or lacking. *Asci* 29–40 × 8–14.5 µm (\bar{x} = 35.3 × 10.5 µm, n = 15), 8-spored, bitunicate, fissitunicate dehiscence not observed, obclavate to cylindrical, apedicellate, lacking an

obvious ocular chamber. *Ascospores* 11–17 × 3–5 μm (\bar{x} = 13.1 × 3.8 μm, n = 20), overlapping 2–3-seriate, fusiform to clavate, with larger region above central septum, not constricted at the septum, 1–4 guttulate, smooth-walled. Asexual state: Unknown.

Material examined:—PHILIPPINES. Laguna Province: Mount Maquiling, near Los Baños, on leaves of *Synedrella nodiflora* (Asteraceae), 7 January 1913, *H. Rehm* (S F8652, holotype).

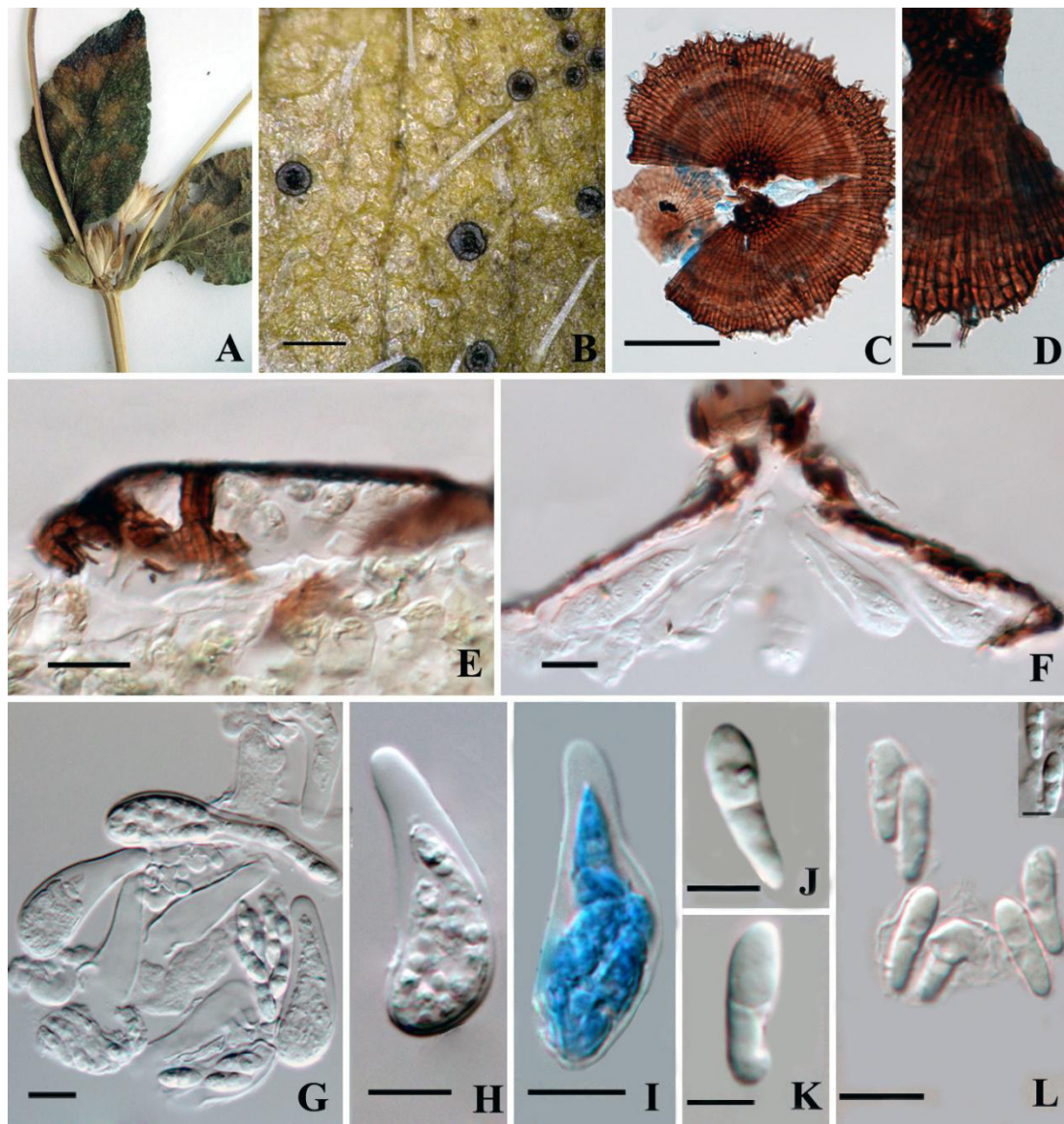


FIGURE 1. *Phragmaspidium corruscans* (holotype). A, B. Appearance of pathogen on host leaf with thyriothechia. C, D. Squash mount of thyriothecium. Note upper wall of radiating cells. E, F. Section of thyriothechia. G–I. Asci. Note I mounted in cotton blue reagent. J–L. Ascospores. Note cells with guttules. Scale bars: B = 200 μm, C = 50 μm, E = 20 μm, D, F–I = 10 μm, J–L = 5 μm.

Genus transferred to Asterinaceae

The family Asterinaceae was introduced by Hansford (1946) and is characterized by superficial, usually hyphopodiate mycelium; with roundish, flattened thyriothechia comprising an upper thin layer of radiating cells and poorly developed base (Hofmann *et al.* 2011). The thyriothechia opening by radiating star-like or longitudinal splits, and asci are generally globose, thick-walled, and bitunicate or fissitunicate. Ascospores are usually brown when mature, mostly conglobose and 1-septate, or occasionally fusiform or cylindrical (Kirk *et al.* 2008, Hyde *et al.* 2013). In this study we include *Asterinella* and *Platypeltella* in Asterinaceae.

Biotrophic on the upper surface of leaves, superficial mycelium present, with hyphopodia. Sexual state: *Thyriothecia* superficial, flattened, coriaceous, opening by splitting or cracking to form a pore. Upper wall comprising rows of cells, radiating from the central opening to the periphery, base poorly developed. Hamathecium of asci and sparse pseudoparaphyses inclined towards the central ostiole. Asci 8-spored, bitunicate, broadly cylindrical, apedicellate. Ascospores overlapping 2–3-seriate, light-brown to hyaline, 2-celled, constricted at the septum, the upper cell larger than the lower cell, ovoid, the upper cell with rough walls, lower cell smooth-walled. Asexual state: Unknown.

Type species:—*Asterinella puiggarii* (Speg. 1881: 99) Theiss (1912: 116).

Notes:—*Asterinella* was introduced by Theissen (1912) with *A. puiggarii* (Speg.) Theiss. as the type species. There are 100 epithets for this genus in Index Fungorum (2014). Müller & von Arx (1962) and Lumbsch & Huhndorf (2010) included *Asterinella* in Microthyriaceae. *Asterinella* has superficial hyphae with hyphopodia and thyriothecia opening by splitting to form a central irregular ostiole and is therefore typical of Asterinaceae. *Asterinella* is very similar to *Maublancia* (Müller & von Arx 1962, Wu *et al.* 2011a), but, they can be distinguished by the hyphopodia. In *Asterinella*, the hyphopodia are mucronate with a short branch of two cells, while hyphopodia in *Maublancia* are capitate with a single cell. Molecular data is needed to establish if these differences support a natural classification of these two genera.

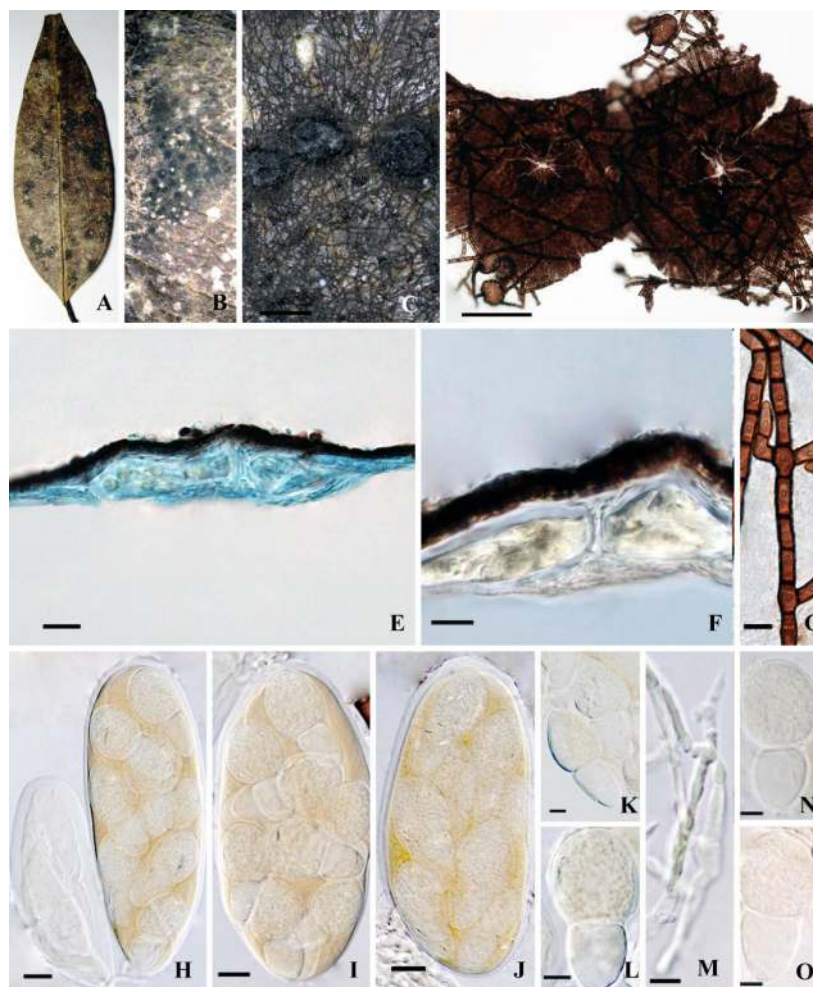


FIGURE 2. *Asterinella puiggarii* (holotype). A. Herbarium material. B, C. Appearance of epiphyte on host leaf with thyriothecia. D. Squash mount of thyriothecium. E, F. Section of thyriothecia. G. Superficial hyphae with hyphopodia. H–J. Asci. K, L, N, O. Ascospores. Note upper cell with rough wall and lower cell with smooth wall. M. Narrow, cellular pseudoparaphyses. Scale bars: C = 200 µm, D = 100 µm, E = 20 µm, F–J, M = 10 µm, K, L, N, O = 5 µm.

Asterinella puiggarii (Speg.) Theiss., Brotéria, sér. bot. 10(2): 116 (1912) MycoBank: MB 119402 (Fig. 2)

≡ *Asterina puiggarii* Speg., Anales Sociedad. científica. argentina 12 (3): 99 [no. 114] (1881)

Biotrophic on the upper surface of leaves appearing as inconspicuous black speckles. Superficial mycelium present with mucronate hyphopodia, covering the thyrriothecia. *Thyrriothecia* 210–327 µm diam × 35–46 µm high, gregarious, superficial, flattened, brown to black, coriaceous, opening by splitting to form a central irregular ostiole. Upper wall comprising rows of cells, radiating from the central opening to the periphery, basal layer poorly developed. *Hamathecium* of asci and sparse pseudoparaphyses inclined towards the central ostiole, pseudoparaphyses filiform. *Asci* 96–118 × 45–54 µm (\bar{x} = 103.7–47.9 µm, n = 15), 8-spored, bitunicate, broadly cylindrical, apedicellate. *Ascospores* 34–38 × 16–19 µm (\bar{x} = 36.5–17.5 µm, n = 20), overlapping 2–3-seriate, light-brown to hyaline, ovoid, 2-celled, constricted at the septum, the upper cell larger than the lower cell, upper cell with rough walls, lower cell smooth-walled.

Material examined:—BRAZIL. São Paulo: Apiahy, on leaf (unknown species), June 1881, *J. Puiggari* (LPS 1377, holotype).

Platypeltella Petr., in Sydow & Petrak, Anns mycol. 27(1/2): 62 (1929) MycoBank: MB 4178.

≡ *Asterinopeltis* Bat. & H. Maia, in Batista et al., Revta Biol., Lisb. 1(3–4): 293 (1958)

Biotrophic on the upper surface of leaves, superficial mycelium present, with lateral, capitate hyphopodia. Sexual state: *Thyrriothecia* superficial, flattened, coriaceous, opening by central cracked region or pore. *Upper wall* comprising rows of cells, radiating from the central opening to the periphery, basal layer poorly developed. Pseudoparaphyses not observed. *Asci* 8-spored, bitunicate, clavate to cylindrical, apedicellate. *Ascospores* uniseriate, hyaline, usually 2-celled, apiosporous, the primary septum forming $\frac{1}{4}$ distance from the apex of the spore, ellipsoidal to elongate-ovoid, smooth-walled. Asexual state: Unknown.

Type species:—*Platypeltella smilacis* Petr.

Notes:—Sydow & Petrak (1929) introduced *Platypeltella* as a monotypic genus represented by *Platypeltella smilacis* Petrak *et al.* (1969) described a second species, *P. angustispora* M.L. Farr & Pollack. A third species *P. irregularis* was also added by Farr (1982). *Platypeltella smilacis* is similar to *P. angustispora* and *P. irregularis* due to its similar morphology. They can however, be distinguished by their hyphopodia size, scutellum structure of thyrriothecia and shape and colour of ascospores. Farr (1982) suggested *Platypeltella* would be more naturally placed in Micropeltidaceae. Our study shows that *Platypeltella* is characterized by superficial mycelium with hyphopodia; roundish, flattened thyrriothecia comprising a thin layer of radiating cells, opening by cracking to form a pore, thick-walled, bitunicate, cylindrical asci and mostly ellipsoidal and 1-septate, or occasionally fusiform or cylindrical ascospores which are usually brown when mature. It is similar to *Paramicrothyrium* in Microthyriaceae due to the similar cylindrical to clavate asci; but they can be distinguished by hyphopodia; in *Paramicrothyrium* hyphopodia are lacking, while *Platypeltella* have hyphopodia. The genus is similar to *Asterinella* in Asterinaceae in having superficial hyphae with intercalary capitate hyphopodia. However, they can be distinguished by their asci and ascospores; in *Asterinella*, the asci are broadly cylindrical and the ascospores are 2-celled and constricted at the septum, while asci in *Platypeltella* are clavate and ascospores are usually 2-celled, the primary septum forming $\frac{1}{4}$ distance from the apex of the spore. The superficial mycelium with hyphopodia in *Platypeltella* is typical of Asterinaceae and thus we tentatively include *Platypeltella* in this family until fresh collections are made and this can be verified with phylogenetic analysis.

Platypeltella smilacis Petr., Anns mycol. 27(1/2): 62 (1929) MycoBank: MB 278312 (Fig. 3)

Biotrophic on the upper surface of leaves, superficial mycelium present, with intercalary capitate hyphopodia, about 15–20 × 14–19 µm. Sexual state: *Thyrriothecia* 140–230 µm diam × 30–55 µm high, gregarious, or in small groups of 6–8, superficial, flattened, rounded, coriaceous, opening by central ostiole. *Upper wall* comprising rows of cells, radiating from the central pore to the periphery, basal layer poorly developed. *Asci* 73–120 × 21–28 µm (\bar{x} = 97.6–26.5 µm, n = 15), 8-spored, bitunicate, fission-tunicate, clavate to cylindrical, apedicellate, apically rounded

with an ocular chamber. *Ascospores* 25.5–30 × 11–13 μm (\bar{x} = 26.7–12.1 μm, n = 20), uniseriate, hyaline, 1–2-septate (rarely 1-celled), constricted at first septum in upper ¼ of spore, ellipsoidal to elongate-ovoid, smooth-walled, upper end broadly rounded, lower end slightly acute. Asexual state: Unknown.

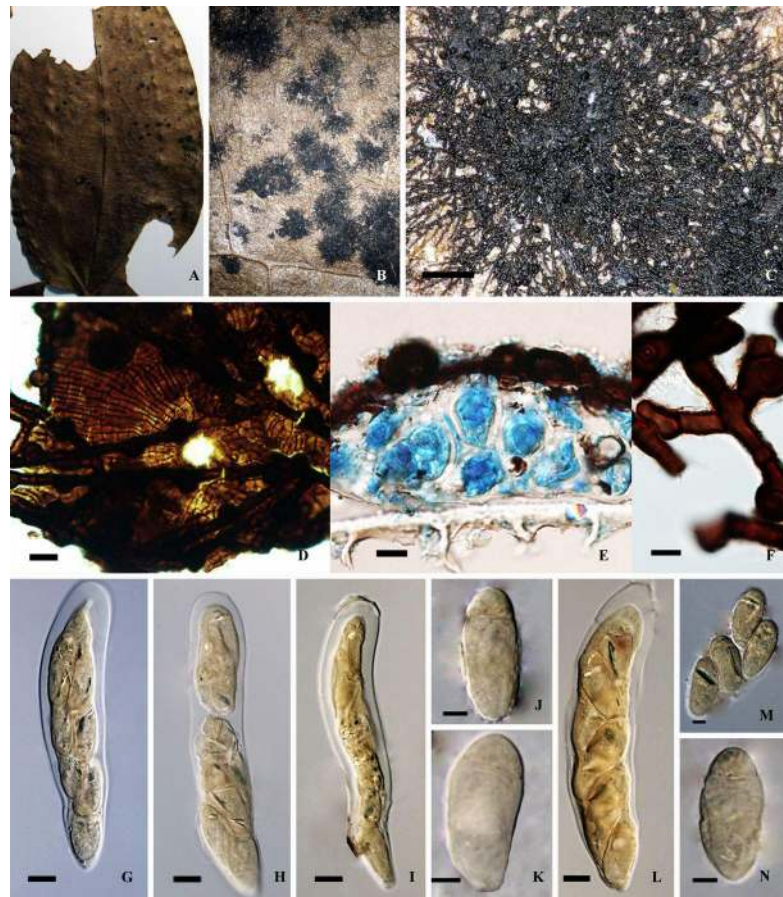


FIGURE 3. *Platypeltella smilacis* (holotype). A–C. Appearance of fungal body on lower surface of leaf. D. Squash mount of thyriothecia. E. Section of thyriothecium. Note the peridium which comprises one layer of cells. F. Superficial hyphae. Note the hyphopodia. G–I, L. Asci, mounted in Melzer’s reagent. J, K, M, N. Ascospores. Note rounded ends, and smooth walls. Scale bars: C = 200 μm, D = 20 μm, E–I, L = 10 μm, J, K, M, N = 5 μm.

Material examined:—COSTA RICA: San Pedro de San Ramon: on *Smilax* sp. (Smilacaceae), 8 January 1927, Petrak (W 257, holotype).

Genera transferred to Trichopeltinaceae (= Brefeldiellaceae)

Müller & von Arx (1962) introduced Brefeldiellaceae which is typified by *Brefeldiella brasiliensis* Speg. (1889: 558), which has a relatively large thallus, extremely thin, superficial, membranous, circular or lobed in outline, composed of radially arranged flattened cells; the thyriothecium is covered by the thallus. (Reynolds & Gilbert 2005, Hyde *et al.* 2013). Trichopeltinaceae is an older name and should be used over Brefeldiellaceae (Hongsanan *et al.* 2014). We refer *Trichopeltella*, *Trichopeltum* and *Trichothyriulina* to Trichopeltinaceae (= Brefeldiellaceae).

Trichopeltella Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1, 119: 458 [66 repr.] (1910) MycoBank: MB 5564

Epiphytes on the upper leaf surface. Thallus, thin, superficial, membranous, lobed or root-like in outline, covering thyriothecia, comprising radially arranged cells Sexual state: *Thyriothecia*, circular, solitary or some gregarious, covered by the thallus, round or elongate in outline, opening by irregular fissures. Asci 8-spored, bitunicate, broadly cylindrical or nearly spherical, apedicellate. Ascospores 1-septate, hyaline, smooth-walled (Reynolds *et al.* 2005). Asexual state: Coelomycetous.

Type species:—*Trichopeltella montana* (Racib. 1909: 378) Höhn (1910: 458).

Notes:—*Trichopeltella* was established by Höhn (1910) as a monotypic genus with *Trichopeltella montana* (Racib.) Höhn. as the type species. In the type species of *Trichopeltella* material is depauperate and lacks asci and ascospores. Höhn (1910) placed this species into Microthyriaceae and this was followed by Lumbsch & Huhndorf (2010). *Trichopeltella* however, has thyriothecia covered by a thallus, which is lobed in outline, composed of a layer of radially arranged flattened cells or irregularly diverging in rows at the margin (Reynolds *et al.* 2005). We therefore place *Trichopeltella* in Trichopeltinaceae (= Brefeldiaceae) as suggested by Hyde *et al.* (2013).

Trichopeltella montana (Racib.) Höhn., Sber. Akad. Wiss. Wien, Math.-naturw. Kl., Abt. 1, 119: 458 [66 repr.] (1910) MycoBank: MB 227170 (Fig. 4)

≡ *Trichopeltis montana* Racib., Bulletin International de l'Academie des Sciences de Cracovie Classe des Sciences Mathematiques et Naturelles 3: 378 (1909)

≡ *Seynesia montana* (Racib.) Sacc. & Trotter, Syll. fung. (Abellini) 22: 524 (1913)

Epiphytes on the upper leaf surface. *Thallus* thin, superficial, lobed or root-like in outline, covering thyriothecia, comprising radially arranged cells. Sexual state: *Thyriothecia* 180–260 µm diam, circular, solitary or some gregarious, dark brown to black, flattened, thin-walled, covered by thallus, ostiole not observed. *Asci* 36–50 × 8–10 µm, 8-spored, bitunicate, fissitunicate, broadly cylindrical, apedicellate. *Ascospores* 11–14 × 3–4 µm, overlapping, hyaline, long ovoid, 1-septate, smooth-walled (Reynolds *et al.* 2005). Asexual state: *Conidiomata* similar to thyriothecia. *Conidia* 9.4–12.3 × 2.9–3.8 µm, formed in chains, fusoid to cylindrical, straight, one-celled, hyaline, smooth-walled.

Material examined:—JAVA. On the leaves of *Vaccinium teysmannianum* (Ericaceae), 1900, M. Raciborski (FH258804, holotype).

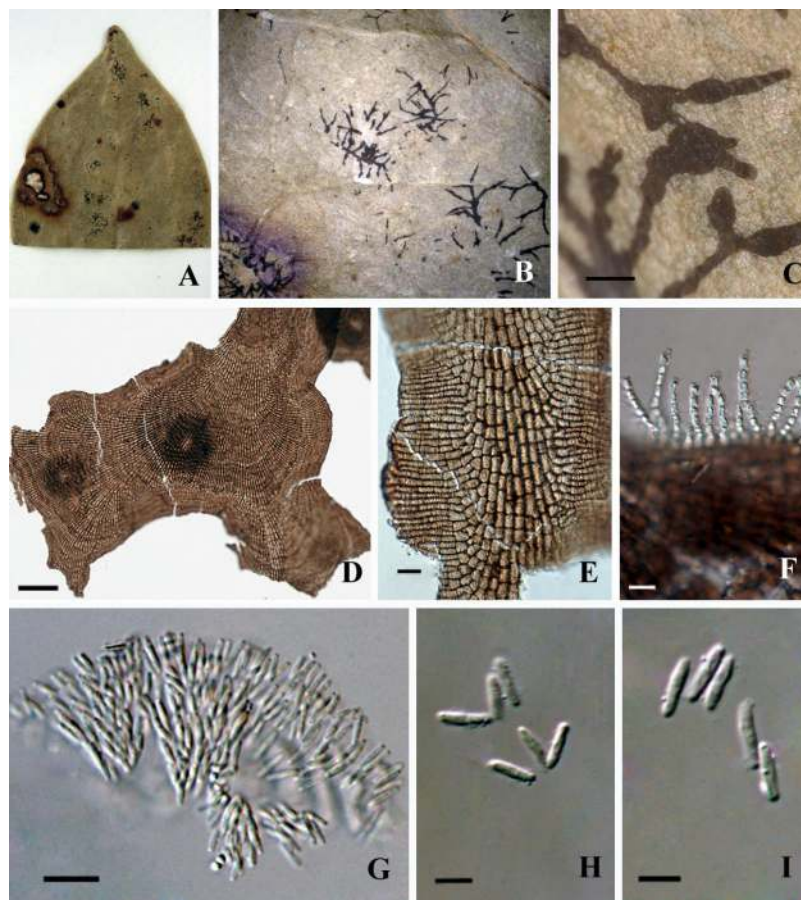


FIGURE 4. *Trichopeltella montana* (holotype). A. Herbarium material. B, C. Close-up of the thyriothecia covered by thallus on upper surface of leaf. D. Squash mount of thyriothecia. E. Part of thallus. G–I. Conidia. Scale bars: C = 200 µm, D = 50 µm, F–I = 10 µm.

Trichopeltum Bat., Cif. & C.A.A. Costa, in Batista et al., *Publicações Inst. Micol. Recife* 90: 20 (1957) MycoBank: MB 5571.

Epiphytes on the upper surface of leaves. *Thallus* thin, superficial, lobed in outline, “root-like” in appearance, growing on the host surface, covering thyriothecia, cells radially arranged. Sexual state: *Thyriothecia*, circular, solitary or some gregarious, dark brown to black, flattened, thin-walled, covered by the thallus, ostiole not observed. *Asci* 8-spored, bitunicate, fissitunicate, saccate, broadly cylindrical, apedicellate. *Ascospores* 2–3-seriate, ovoid to clavate, hyaline, 1-septate, constricted at the septum, upper cell wider and shorter than lower cell, smooth-walled. Asexual state: Unknown.

Type species:—*Trichopeltum hawaiiense* Bat. & C.A.A. Costa. (1957: 21)

Notes:—*Trichopeltum* was established by Batista (1957), with *Trichopeltum hawaiiense* Bat. & C.A.A. Costa. as the type species. There are presently four epithets for *Trichopeltum* in Index Fungorum (2014). Batista *et al.* (1957) placed this genus into Trichopeltinaceae, while Lumbsch & Huhndorf (2010) placed *Trichopeltum* in Microthyriaceae. In *Trichopeltum* the thyriothecia is covered by a thallus, which is superficial, lobed in outline, comprising a single layer radially arranged cells. We place *Trichopeltum* in (= Trichopeltinaceae) Brefeldiellaceae as suggested by Hyde *et al.* (Hongsanant *et al.* 2014).

Trichopeltum is very similar to *Trichopeltella*, and they may be synonyms, but fresh collections are needed to establish this. *Trichopeltum* differs from the similar genus *Brefeldiella*, by its thallus which is lobed or root-like in outline; in *Brefeldiella* the thallus is circular in outline (von Arx *et al.* 1975).

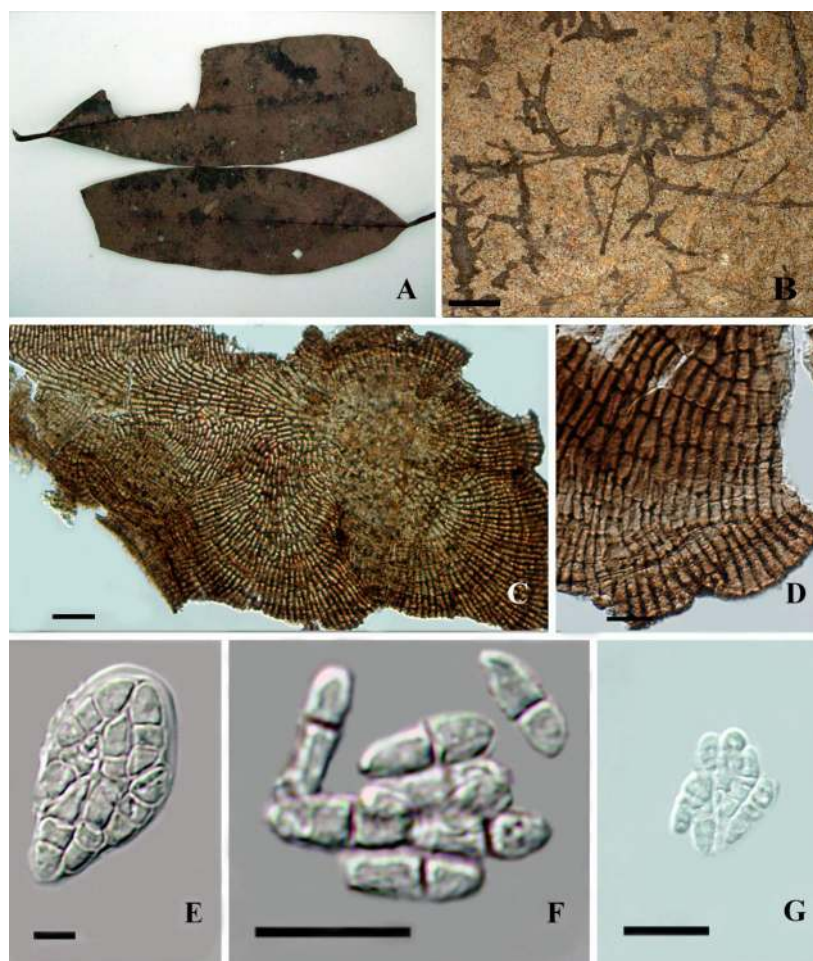


FIGURE 5. *Trichopeltum hawaiiense* (holotype) A. Herbarium material. B. Close up of the thyriothecia covered by thallus on upper surface of leaf. C, D. Squash mount of thyriothecia and close-up of upper wall. E. Ascus. F, G. Ascospores. Scale bars: B = 500 µm, C = 20 µm, D–G = 10 µm.

Trichopeltum hawaiiense Bat. & C.A.A. Costa [as 'hawaiiensis'], in Batista *et al.*, *Publicações Inst. Micol. Recife* 90: 21 (1957) MycoBank: MB 307093 (Fig. 5)

Foliar epiphytes on the upper surface of leaves. Thallus thin, superficial, lobed in outline, covering thyriothecia, cells of thallus radially arranged. Sexual state: *Thyriothecia* 180–240 µm diam, circular, solitary or some gregarious, dark brown to black, flattened, thin-walled, covered by the thallus, ostiole not observed. *Asci* 18–27 × 13–20 µm (\bar{x} = 23.8–16.4 µm, n = 15), 8-spored, bitunicate, fissitunicate, saccate, broadly cylindrical, apedicellate. *Ascospores* 9–13 × 3–4 µm (\bar{x} = 10.4–3.6 µm, n = 20), 2–3-seriate, ovoid, hyaline, 1-septate, constricted at the septum, upper cell wider and smaller than lower cell, smooth-walled.

Material examined:—HAWAII: on the leaves of *Smilax* sp. (Smilacaceae), September 1958, A.C. Batista (URM 14068–14069, holotype).

Trichothyrinula Petr., *Sydowia* 4(1–6): 171 (1950) MycoBank: MB 5595

Epiphytic or *parasitic* on the lower surface of leaves. *Thallus* spreading as regular outgrowths, circular on host surface; covering thyriothecia, cells of thallus radially arranged. Sexual state: *Thyriothecia*, circular, clustered in small groups, dark brown to black, flattened, thin-walled, ostiole not observed. *Hamathecium* scarce, asci parallel, immersed in mucilage, pseudoparaphyses not observed. *Asci* 8-spored, bitunicate, fissitunicate, globose to subglobose, apedicellate. *Ascospores* 2–3-seriate, ovoid to clavate, hyaline, 1-septate, constricted at the septum, upper cell shorter than lower cell, wall with rough ornamentation, becoming brownish with age. Asexual state: Unknown.

Type species:—*Trichothyrinula sydowii* Petr. (1950: 171)

Notes:—*Trichothyrinula* was introduced by Petrak (1950) as a monotypic genus represented by *T. sydowii* Petr. (1950: 171). Müller & von Arx (1962) added a second species, *Trichothyrinula petrakii* Arx (1962: 561) and placed it in the family Trichothyriaceae. Lumbsch & Huhndorf (2010) however, treated *Trichothyrinula* as a member of Microthyriaceae. *Trichothyrinula* has a spreading thallus with regular outgrowths, appears circular on host surface and the cells of thallus are radially arranged. Thyriothecia, covered by a thallus fit well with Trichopeltinaceae. *Trichothyrinula* is most similar to *Brefeldiella*, but differs by its smaller globose to subglobose, apedicellate asci (*Brefeldiella* has cylindrical-clavate, short-pedicellate asci), and rough ornamented spore wall, with spores becoming brownish with age (*Brefeldiella* has smooth-walled and hyaline ascospores) (von Arx *et al.* 1975).

Trichothyrinula sydowii Petr., *Sydowia* 4(1–6): 171 (1950) MycoBank: MB 307129 (Fig. 6)

Epiphytic or *parasitic* on the lower surface of leaves. *Thallus* spreading as regular outgrowths, circular on host surface, about 1–2.5 mm diam; covering thyriothecia, cells of thallus radially arranged. Sexual state: *Thyriothecia* 190–220 µm diam., circular, clustered in groups, dark brown to black, flattened, thin-walled, opening by a fissure or by deliquescence. *Hamathecium* with scarce, parallel asci immersed in mucilage, pseudoparaphyses not observed. *Asci* 24–33 × 13–18 µm (\bar{x} = 28.1 × 17.1 µm, n = 15), 8-spored, bitunicate, fissitunicate, globose to subglobose, apedicellate, apically rounded with a distinct ocular chamber. *Ascospores* 11–13 × 3–5 µm (\bar{x} = 11.9 × 3.5 µm, n = 20), 2–3-seriate, ovoid to clavate, hyaline, 1-septate, constricted at the septum, upper cell shorter than lower cell, with rough ornamentation on spore wall, brownish with age. Asexual state: Unknown.

Material examined:—ECUADOR. Napo-Pastaza Province: Puyo, on *Gurania* sp. (Cucurbitaceae), 9 February 1938, H. Sydow (PDD 54550, isotype).

Genus transferred to Parmulariaceae

The family Parmulariaceae was introduced by Müller & von Arx (1962), and was validated by Barr (1979). Inácio & Cannon (2008) mentioned that this family is polyphyletic and contains a range of ascostromata types, and even thyriothecia, ascus and ascospores forms. The family is characterized by superficial, carbonaceous, strongly flattened, discoid or pulvinate to elongate ascostromata, with single or many locules; opening by irregular disintegration or longitudinal splits. The asexual states are coelomycetous or hyphomycetous (Hyde *et al.* 2013).



FIGURE 6. *Trichothyrimula sydowii* (holotype). A. Herbarium material. B, C. Close-up of the thyriothechia on lower surface of leaf. D. Squash mount of thyriothechia. E–G. Asci, mounted in Melzer's reagent. H–K. Ascospores which are rounded at the ends and smooth-walled. Scale bars: C = 200 μm , E–G = 10 μm , H–K = 5 μm .

Cirsosiopsis Butin & Speer, Sydowia 31(1–6): 10 (1979) [1978] MycoBank: MB 1068

Type species:—*Cirsosiopsis violacescens* Butin & Speer (1978)

Notes:—*Cirsosiopsis* was established as a monotypic genus by Butin & Speer (1978) based on *Cirsosiopsis violacescens* and placed in Microthyriaceae. Subsequently, Lumbsch & Huhndorf (2010) also retained *Cirsosiopsis* in Microthyriaceae. *Cirsosiopsis* is atypical of Microthyriaceae as it has carbonaceous and pulvinate ascostromata (see Fig. 7). No data is available on the asexual state for *C. violacescens* (Butin *et al.* 1978). Thus, we suggest that *Cirsosiopsis* is placed in the family Parmulariaceae.

Cirsosiopsis violacescens Butin & Speer, Sydowia 31(1–6): 10 (1979) [1978] MycoBank: MB 311153 (Fig. 7)

Parasitic on the upper surface of leaves. *Superficial hyphae* absent. Sexual state: *Ascostromata* 170–420 μm diam. \times 197–206 μm high, solitary to gregarious, or some in groups, superficial, carbonaceous, strongly flattened, discoid or pulvinate to elongate, opening by irregular disintegration at the centre. *Hamathecium* with 2–3 μm wide pseudoparaphyses, arranged around, and longer than asci. *Asci* 80–95 \times 27–35 μm (\bar{x} = 90.3 \times 31.4 μm , n = 15), 8-spored, bitunicate, fissitunicate, cylindrical, or globose to subglobose, short pedicellate, with a distinct ocular chamber. *Ascospores* 23–28 \times 12–15 μm (\bar{x} = 25.5 \times 13.4 μm , n = 20), 2–3-seriate, hyaline, ellipsoid to ovate, ends rounded, 1-septate, constricted at the septum, thick-walled with a sheath, with two angular guttules, wall smooth. Asexual state: Unknown.

Material examined:—BRAZIL. Vossoroça: on the leaves of *Araucaria augustifolia* (Araucariaceae), 9 November 1976, Butin & Speer (ZT Myc 4325, holotype).

Discussion

In this paper we re-examine generic types previously associated with Microthyriaceae. Wu *et al.* (2011a) included seven genera in Microthyriaceae. This study suggests that *Phragmaspidium* is correctly placed in this family. Two genera are transferred from Microthyriaceae to Asterinaceae, and three to Trichopeltinaceae based on thallus and cells of thallus consisting of a single layer of somewhat radially arranged cylindrical to cuboid cells. One genus is transferred to Parmulariaceae.

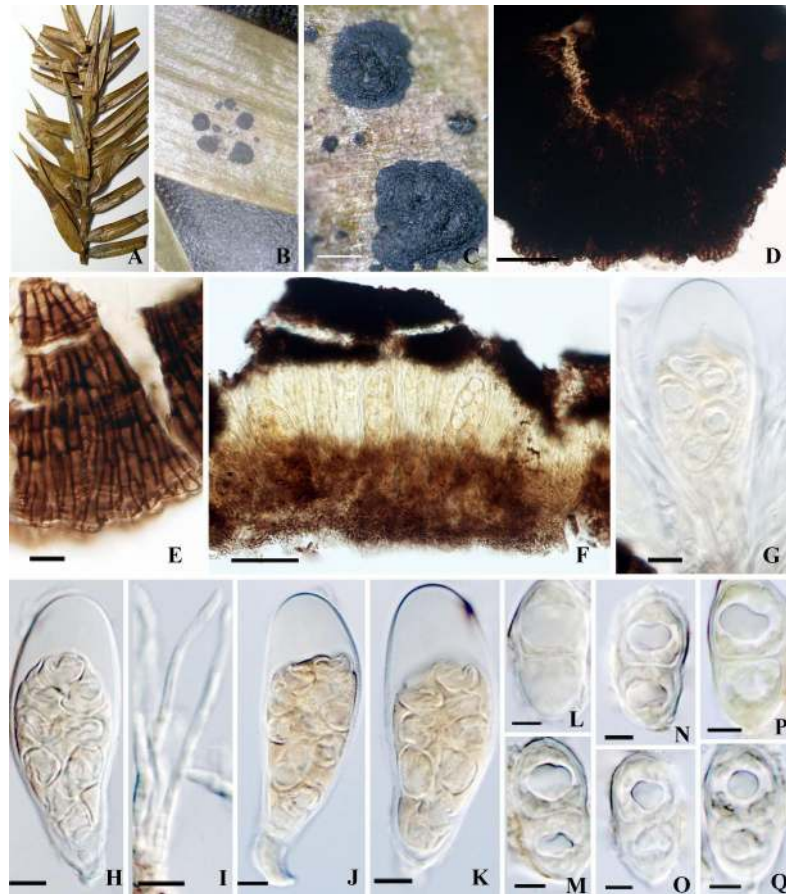


FIGURE 7. *Cirrosiopsis violacescens* (holotype). A–C. Appearance of fungi body on upper surface of leaf. D, E. Squash mounts of ascostromata. F. Section of ascostroma. G, I. Pseudoparaphyses and asci. H, J, K. Asci. L–Q. Ascospores. Note the rounded ends, with a sheath. Scale bars: C = 200 μ m, D, F = 50 μ m, E, G–K = 10 μ m, L–Q = 5 μ m.

Acknowledgments

The National Natural Science Foundation of China (no. 31300019) is thanked for supporting studies on Microthyriaceae. We are grateful to the Grant for Essential Scientific Research of National Non profit Institute (no. riricaf2013004M; no. riricaf2011003z). K.D. Hyde and Qin Tian, Wen Jing Li are grateful to MFLU grant number 56101020032 for supporting studies on Dothideomycetes. The authors also thank Xiaoming Chen, Ying Feng, Chen Hang (The Research Institute of Resource Insects, Chinese Academy of Forestry, China).

References

- Arx, J.A. von & Müller, E. (1975) A re-evaluation of the bitunicate ascomycetes with key to families and genera. *Studies in Mycology* 9: 1–159.
- Barr, M.E. (1979) A classification of Loculoascomycetes. *Mycologia* 71: 935–957.
<http://dx.doi.org/10.2307/3759283>
- Batista, A.C. (1960) Microthyriaceae: conceituação de novos 'taxa'. *Publicações do Instituto de Micologia da Universidade do Recife* 260: 1–132.
- Batista, A.C., Costa, C.A.A. & Ciferri, R. (1957) Orgânogênese e sistemática dos fungos Trichopeltinaceae (Theiss.) emend. Nobis. *Publicações do Instituto de Micologia da Universidade do Recife* 90: 1–24.
- Batista, A.C., Costa, A.A. & Ciferri, R. (1958) Orgânogênese e sistemática dos fungos Trichopeltinaceae (Theiss.) emend. Nobis. *Atti dell'Istituto Botanico della Università e Laboratorio Crittogamico di Pavia* 15: 35–56.
- Butin, H. & Speer, E.O. (1978) Über einige parasitische Ascomyceten auf Nadeln der Brasilianischen Araukarie. *Sydowia* 31(1–6): 9–26.

- Chomnunti, P., Schoch, C.L., Aguirre-Hudson, B., Ko Ko, T.W., Hongsanan, S., Jones, E.B.G., Kodsueb, R., Phookamsak, R., Chukeatirote, E., Bahkali, A.H. & Hyde, K.D. (2011) Capnodiaceae. *Fungal Diversity* 51: 103–134.
<http://dx.doi.org/10.1007/s13225-011-0145-6>
- Ellis, J.P. (1976) British *Microthyrium* species and similar fungi. *Transactions of the British Mycological Society* 67(3): 381–394.
[http://dx.doi.org/10.1016/S0007-1536\(76\)80162-3](http://dx.doi.org/10.1016/S0007-1536(76)80162-3)
- Farr, M.L. (1982) A third species of *Platypteltella* (Microthyriaceae). *Mycotaxon* 15: 448–452.
- Farr, M.L. & Pollack, F.G. (1969) A new species of *Platypteltella* from Mexico. *Mycologia* 61: 191–195.
<http://dx.doi.org/10.2307/3757361>
- Hansford, C.G. (1946) The foliicolous Ascomycetes, their parasites and associated fungi. *Mycological Papers* 15: 1–240.
- Hennings, P. (1904) Fungi Amazonici a cl. Ernesto Ule collecti III. *Hedwigia* 43: 351–400.
- Hofmann, T.A., Kirschner, R. & Piepenbring, M. (2010) Phylogenetic relationships and new records of Asterinaceae (Dothideomycetes) from Panama. *Fungal Diversity* 43(1): 39–53.
<http://dx.doi.org/10.1007/s13225-010-0042-4>
- Höhnelt, F.V. von (1910) Fragmente zur Mykologie: X. Mitteilung (Nr. 468 bis 526). *Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Math.-naturw. Klasse Abt. I*, 119: 393–473.
- Hongsanan, S., Chomnunti, P., Crous, P.W., Chukeatirote, E. & Hyde, K.D. (2014) Introducing *Chaetothyriothecium*, a new genus of Microthyriales. *Phytotaxa* 161 (2): 157–164.
<http://dx.doi.org/10.11646/Phytotaxa.161.2.7>
- Hyde, K.D., Jones, E.G.B., Liu, J.K., Ariyawansa, H.A., Boehm, E., Boonmee, S., Braun, U., Chomnunti, P., Crous, P.W., Dai, D.Q., Diederich, P., Dissanayake, A., Doilom, M., Doveri, F., Hongsanan, S., Jayawardena, R., Lawrey, J.D., Li, Y.M., Liu, Y.X., Lücking, R., Monkai, J., Muggia, L., Nelsen, M.P., Pang, K.L., Phookamsak, R., Senanayake, I.C., Shearer, C.A., Suetrong, S., Tanaka, K., Thambugala, K.M., Wijayawardene, N.N., Wikee, S., Wu, H.X., Zhang, Y., Hudson, B.A., Alias, S.A., Aptroot, A., Bahkali, A.H., Bezerra, J.L., Bhat, J., Jayarama, D., Camporesi, E., Chukeatirote, E., Gueidan, C., Hawksworth, D.L., Hirayama, K., Hoog, S.D., Kang, J.C., Knudsen, K., Li, W.J., Li, X.H., Liu, Z.Y., Mapook, A., McKenzie, E.H.C., Miller, A.N., Mortimer, P. E., Phillips, A.J.L., Raja, H.A., Scheuer, C., Schumm, F., Taylor, J.E., Tian, Q., Tibpromma, S., Wanasinghe, D.N., Wang, Y., Xu, J.C., Yacharoen, S., Yan, J.Y. & Zhang, M. (2013) Families of Dothideomycetes. *Fungal Diversity* 63(1): 1–313.
<http://dx.doi.org/10.1007/s13225-013-0263-4>
- Ignácio, C.A. & Cannon, P.F. (2008) The genera of Parmulariaceae. *CBS Biodiversity Series* 8. CBS Fungal Biodiversity Centre.
- Kirk, P.M., Cannon, P.F., Minter, D.W. & Stalpers, J.A. (2008) *Ainsworth & Bisby's dictionary of the fungi*. 10th edn. CABI, Wallingford, UK.
- Lumbsch, H.T. & Huhndorf, S.M. (2010) Myconet volume 14, part one. Outline of ascomycota—2009, part two. Notes on ascomycete systematics. Nos. 4751–5113. *Fieldiana, Life and Earth Sciences* 1: 1–64.
- Müller, E., & Arx, J.A. von (1962) Die Gattungen der didymosporen Pyrenomyceten. *Beiträge zur Kryptogamenflora der Schweiz* 11(2): 1–922.
- Petrak, F. & Ciferri, R. (1932) Fungi Dominicani. II. *Annales Mycologici* 30(3–4): 149–353.
- Raciborski, M. (1909) Parasitische und epiphytische Pilze Javas. *Bulletin International de l'Academie des Sciences de Cracovie Classe des Sciences Mathematiques et Naturelles* 3: 346–394.
- Rehm, H. (1913) Ascomycetes philippinenses-II. *Philippine Journal of Science Section C Botany* 8: 251–263.
- Reynolds, D.R. & Gilbert, G.S. (2005) Epifoliar fungi from Queensland, Australia. *Australian Systematic Botany* 18: 265–289.
<http://dx.doi.org/10.1071/SB04030>
- Saccardo, P.A. & Trotter, A. (1913) Supplementum Universale, Pars IX. *Sylloge Fungorum* 22: 1–1612.
- Spegazzini, C. (1881) Fungi argentini additis nonnullis brasiliensibus montevidensibusque. Pugillus quartus (Continuacion). *Anales de la Sociedad Científica Argentina* 12(3): 97–117.
- Spegazzini, C. (1889) Fungi Puiggariani. Pugillus 1. *Boletín de la Academia Nacional de Ciencias en Córdoba* 11(4): 381–622.
- Sydow, H. & Petrak, F. (1929) Fungi costaricensis a cl. Prof. Alberto M. Brenes collecti. *Annales Mycologici* 27(1–2): 1–86.
- Theissen, F. (1921) Le genre *Asterinella*. *Brotéria Série Botânica* 10(2): 101–123.
- Wu, H.X. & Hyde, K.D. (2013) Re-appraisal of *Scolecopeltidium*. *Mycotaxon* 125: 1–10.
<http://dx.doi.org/10.5248/125.1>
- Wu, H.X., Li, Y.M., Chen, H. & Hyde, K.D. (2010) Studies on *Microthyriaceae*: some excluded genera. *Mycotaxon* 113: 147–156.
<http://dx.doi.org/10.5248/113.147>
- Wu, H.X., Schoch, C.L., Boonmee, S., Bahkali, A.H., Chomnunti, P. & Hyde, K.D. (2011a) A reappraisal of *Microthyriaceae*. *Fungal Diversity* 51: 189–248.
<http://dx.doi.org/10.1007/s13225-011-0143-8>
- Wu, H.X., Hyde, K.D. & Chen H. (2011b) Studies on *Microthyriaceae*: placement of *Actinomyxa*, *Asteritea*, *Cirsosina*, *Polystomellina* and *Stegothyrium*. *Cryptogamie Mycologie* 32: 3–12.
<http://dx.doi.org/10.7872/crym.v32.iss1.2012.003>
- Wu, H.X., Jaklitsch, W.M., Voglmayr, H. & Hyde, K.D. (2011c) Epitypification, morphology and phylogeny of *Tothia fuscella*. *Mycotaxon* 118: 203–211.
<http://dx.doi.org/10.5248/118.203>
- Wu, H.X., Li, Y.M., Ariyawansa, H.A., Li, W.J., Yang, H. & Hyde, K.D. (2014) A new species of *Microthyrium* from Yunnan, China. *Phytotaxa* 176(1): 213–218.
<http://dx.doi.org/10.11646/phytotaxa.176.1.21>