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Ten new species and 34 new country records of *Trypetheliaceae*

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Abstract: Ten new species of *Trypetheliaceae* are described: *Astrothelium bullatothallinum* from Venezuela, which is close to *A. aeneum* but differs by the bullate thallus with a thick cortex, intermixed in a mosaic with the prothallus; *A. cayennense* from French Guiana, which is similar to *A. flavomegaspermum* but with a yellow pigment in the pseudostroma near the ostioles; *A. diaphanocorticatum* from Papua New Guinea, which has a bullate thallus with a thick hyaline cortex and 3-septate ascospores of 25–28 × 10–12 µm; *A. macroeustomum* from French Guiana, with joint lateral ostioles, UV+ yellow ostiolar region and 5-septate ascospores of 50–55 × 12–17 µm; *A. minicecidiogenum* from Costa Rica, with muriform ascospores of 70–90 × 20–25 µm, without pseudostromata, with solitary ascomata, lateral ostioles and an inspersed hamathecium; *A. palaeoexostemmatis* from Thailand, which is similar to *A. exostemmatis* but with larger, I+ blue ascospores; *A. quasimamillanum* from Brazil, with muriform ascospores of 30–33 × 9·5–10·5 µm, without pseudostromata, with solitary ascomata, lateral ostioles and an inspersed hamathecium; *A. studerae* from Brazil, with astrothelioid ascomata, lichexanthone only in the pseudostromata, 3-septate ascospores of 21·5–23·0 × 6·5–7·5 µm; *A. tanianum* from Malaysia, with a bullate thallus, solitary ascomata, covered by the thallus, (9–)11(–15)-septate ascospores, 75–100 × 20–22 µm; and *Pseudopyrenula miniflavida* from Brazil, with a yellow-inspersed hamathecium, the inspersion dissolving in KOH without colour change, and 3-septate ascospores, 15–17 × 5·5–6·5 µm. The unusually thick, hyaline cortical layer of the thallus of *Astrothelium diaphanocorticatum*, through which the individual algal cells are clearly visible, is discussed. Furthermore, 30 species are reported from 34 countries in which they had previously been unrecorded; one (*Astrothelium inspersaeneum*) is from a new continent, Asia.

Key words: *Astrothelium*, Brazil, Costa Rica, French Guiana, Malaysia, Papua New Guinea, *Pseudopyrenula*, Thailand, Venezuela

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Introduction

Trypetheliaceae is an almost entirely tropical, corticolous lichenized family (Aptroot & Lücking 2016). Members of this family were first described by, for example, Zenker (1829) early in the 19th century from pieces of medicinal bark (mainly *Cinchona* for quinine) that had been collected in South American forests. However, until recently only a small number of species was known. At the start of the present century, less than 200 species were known in this family (Aptroot & Lücking 2016).

Aptroot & Lücking (2016) published a revisionary conspectus of the whole family, accepting 418 species, almost a third of which were published simultaneously as new to science (Aptroot & Cáceres 2016; Aptroot *et al.* 2016*a*, *b*; Flakus *et al.* 2016; Luangsuphabool *et al.* 2016; Lücking *et al.* 2016*a*). Since then, 14 additional species have been published in the family by Cáceres & Aptroot (2016, 2017), Diederich *et al.* (2017), Etayo & Aptroot (2017) and Soto Medina *et al.* (2017), bringing the total number of species now accepted in the *Trypetheliaceae* to 432.

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Aptroot *et al.* (2016*c*) predicted the existence of many more species of *Trypetheliaceae* than considered by Aptroot & Lücking (2016). The present paper describes a further ten new species from various parts of the world, collected by the authors. Some were gathered subsequent to the revisionary synopsis. Others date from further back and came to light during a revision of identified specimens in the herbarium of the Botanischer Garten und Botanisches Museum in Berlin (B), using the new monograph (Aptroot & Lücking 2016). This revision also revealed many new country records and one new continental record. The countries of origin of the new species are mostly situated in northern South America. This reflects in part a geographical bias in the collections at B but is also in line with the observation that this area is the centre of diversity for this family (Aptroot & Cáceres 2016).

The generic concept applied here follows the phylogenetic studies by Nelsen *et al.* (2014) and Lücking *et al.* (2016*b*). The characters found to be useful for the delimitation of species include: thallus aspect, thickness, colour, smoothness and gall induction as well as the presence/absence, width and colour of prothallus; ascospore colour, septation, shape, size and number per ascus; hamathecium inspersion and colour of inspersion; presence of lichexanthone and variously coloured anthraquinones in or on ascospores and/or ascomata and/or the hamathecium and/or pseudostromata and/or ostioles. Aptroot & Lücking (2016) provide a more complete treatment and illustration of the characters of these species.

Material and Methods

Identification and descriptive work was carried out in Soest, The Netherlands with an Olympus SZX7 stereomicroscope and an Olympus BX50 compound microscope with interference contrast, connected to a Nikon Coolpix digital camera and, in Berlin, Germany with a Wild M7 stereomicroscope and an Olympus CX41 compound microscope. Sections were mounted in tap water, in which all measurements were also taken.

The chemistry of all specimens was investigated under UV light, and often tested with 10% KOH, generally on sections. The chemistry was further investigated by thin-layer chromatography (TLC) using solvent A (Orange *et al.* 2001).

Taxonomy

Astrothelium bullatothallinum Aptroot & Sipman sp. nov.

MycoBank No.: MB 827202

Astrothelium which is close to *A. aeneum* but differs in having a bullate thallus with thick cortex in a mosaic with a grey prothallus.

Type: Venezuela, Bolivar, Cerro Guaiquinima, along Rio Carapo, alt. 800 m, 11 February 1990, *H. J. M. Sipman* 26957 (B—holotype).

(Fig. 1A–C)

Thallus corticate, smooth, bullate, somewhat shiny, discontinuous in a reticulate pattern, covering areas up to 15 cm diam., *c.* 0·2 mm thick, yellowish orange, with a thick cortex, intermixed with patches of a greyish prothallus, not inducing gall formation in the host bark.

Ascomata globose, 0·3–0·5 mm diam., in groups of 2–15 in lines or in irregular groups, with a brown surface with orange pruina, different from the thallus, distinctly raised above the thallus. *Wall* dark brown all around, up to *c.* 70 µm thick. *Ostioles* apical, not fused, flat to concave, brown. *Hamathecium* not inspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, 20–25 × 6–9 µm, fusiform, ends rounded, IKI−, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus UV−, ascomata UV+ red, yellow pigment on ascomata KOH+ blood red. TLC: an anthraquinone, probably parietin.

Etymology. The name refers to the bullate thallus.

Distribution and ecology. On tree bark in tropical rainforest. So far known only from Venezuela.

Discussion. This species is close to *A. flavostromatum* Aptroot & M. Cáceres

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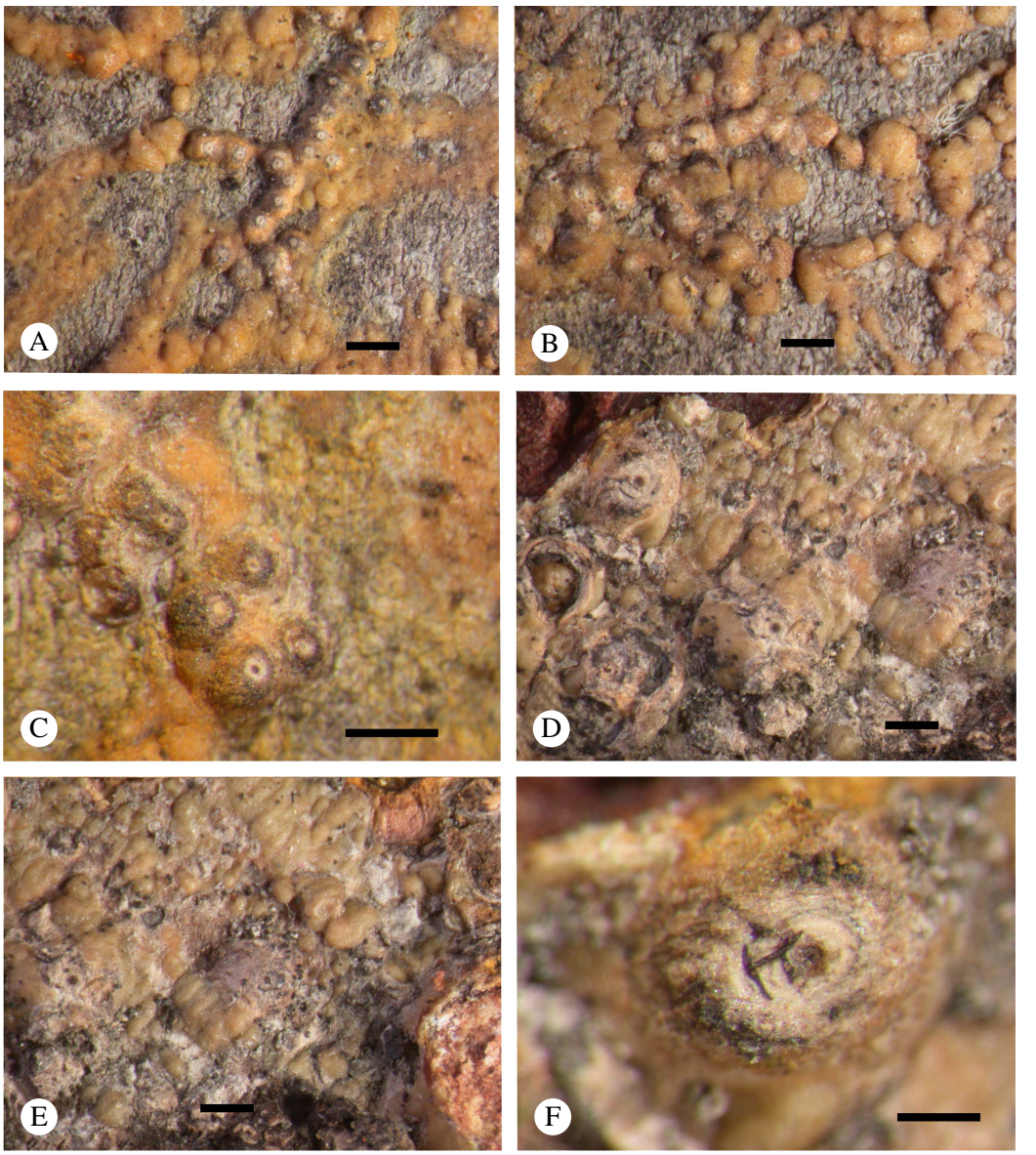

FIG. 1. New *Astrothelium* species, all from holotypes. A–C, *A. bullatothallinum*, habitus; D–F, *A. cayennense*, habitus. Note the two discharged, and now dark, ascospores on the ostiole in Fig. 1F. Scales: A, B, D & E = 1 mm; C & F = 0·5 mm. In colour online.

(Aptroot & Cáceres 2016) and *A. kunzei* (Fée) Aptroot & Lücking (Aptroot & Lücking 2016), which differ by their essentially green thalli without anthraquinones, and also to *A. aeneum* (Eschw.) Aptroot & Lücking (Aptroot & Lücking 2016), which differs mainly by the continuous, non-bullate thallus that is not in a mosaic with a grey prothallus and the ascomata that are not in distinct groups.

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Astrothelium cayennense Aptroot & Sipman sp. nov.

MycoBank No.: MB 827203

Astrothelium similar to *A. flavomegaspermum* but with yellow pigment in the pseudostroma near the ostioles.

Type: French Guiana, Montsinery, *c.* 20 km W of Cayenne, "Risque tout" forest track, alt. 50 m, March 1985, *A. Aptroot* 15125 (B—holotype; ABL—isotype).

(Fig. 1D–F)

Thallus corticate, smooth, shiny, covering areas up to 5 cm diam., *c.* 0·2 mm thick, ochraceous green, not surrounded by prothallus, inducing gall formation in the host bark as numerous *c.* 3–5 mm wide hemispherical warts.

Ascomata pyriform, 0·8–1·3 mm diam., solitary, completely immersed in pseudostromata which are *c.* 1·5–2·5 mm wide, mostly covered by the thallus cortex except for an area around the ostiole *c.* 0·5 mm wide. *Pseudostromata* with dark yellow pigment beneath the cortex, especially near the ostiole. *Wall* carbonized all around, up to *c.* 80 µm thick. *Ostioles* apical, simple, flat, dark brown, surrounded by a non-corticated pale area *c.* 0·4 mm wide. *Hamathecium* inspersed with yellow oil globules. *Asci* with 4 ascospores. *Ascospores* hyaline, muriform, 295–330 × 35–40 µm, ellipsoid, IKI−, without distinctly thickened median septum, not surrounded by a gelatinous layer.

Pycnidia not observed with certainty, although some of the many black dots around the ostioles might represent young pycnidia.

Chemistry. Thallus and ascoma UV−, yellow pigment in pseudostroma KOH+ violet, yellow pigment in hamathecium unchanged in KOH.

Etymology. Named after the collecting locality of the type, Cayenne.

Distribution and ecology. On tree bark in tropical rainforest. So far known only from French Guiana.

Discussion. This species is most similar to *A. flavomegaspermum* Aptroot & Etayo (Etayo & Aptroot 2017) but has a yellow pigment in the pseudostromata near the ostioles. It also resembles *A. meristosporum* (Mont. & Bosch) Aptroot & Lücking by the large perithecia and the large, muriform ascospores, and the type specimen of *A. cayennense* was erroneously considered as a neotropical representative of *A. meristosporum*, a palaeotropical species (Aptroot & Lücking 2016). *Astrothelium cayennense* differs by the absence of lichexanthone in the thallus, the presence of a yellow pigment in the pseudostromata, and the larger ascospores without a thickened median septum or median constriction.

Astrothelium diaphanocorticatum Aptroot & Sipman sp. nov.

MycoBank No.: MB 827205

Astrothelium with a bullate thallus with thick hyaline cortex and 3-septate ascospores, 25–28 × 10–12 µm.

Type: Papua New Guinea, Simbu, Mount Wilhelm, along track from Keglsugl to Pindaunde Valley, alt. 2900 m, 3–8 August 1992, *H. J. M. Sipman* 35615 (B—holotype).

(Fig. 2)

Thallus olive-green to yellowish green, bullate, partly made up of almost spherical globules of *c.* 1 mm diam., with a thick, vitreous cortex where the algal cells can be clearly seen as groups of green dots from above, not surrounded by a prothallus, not inducing gall formation in the bark.

Ascomata globose, 0·7–1·3 mm diam., superficial, solitary or a few fused laterally, dark brown to black, not covered by the thallus, not in pseudostromata or pseudostromata black and not well developed. *Wall* carbonized, up to *c.* 90 µm thick. *Ostioles* apical, black, flat. *Hamathecium* not inspersed. *Asci* with 8 ascospores, *c.* 120–150 × 16–20 µm. *Ascospores* hyaline, 3-septate, 25–28 × 10–12 µm, ellipsoid, IKI−, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, KOH−. TLC: no secondary substances detected.

Etymology. The name refers to the translucent cortex.

Distribution and ecology. On tree bark in montane forest. So far known only from Papua New Guinea.

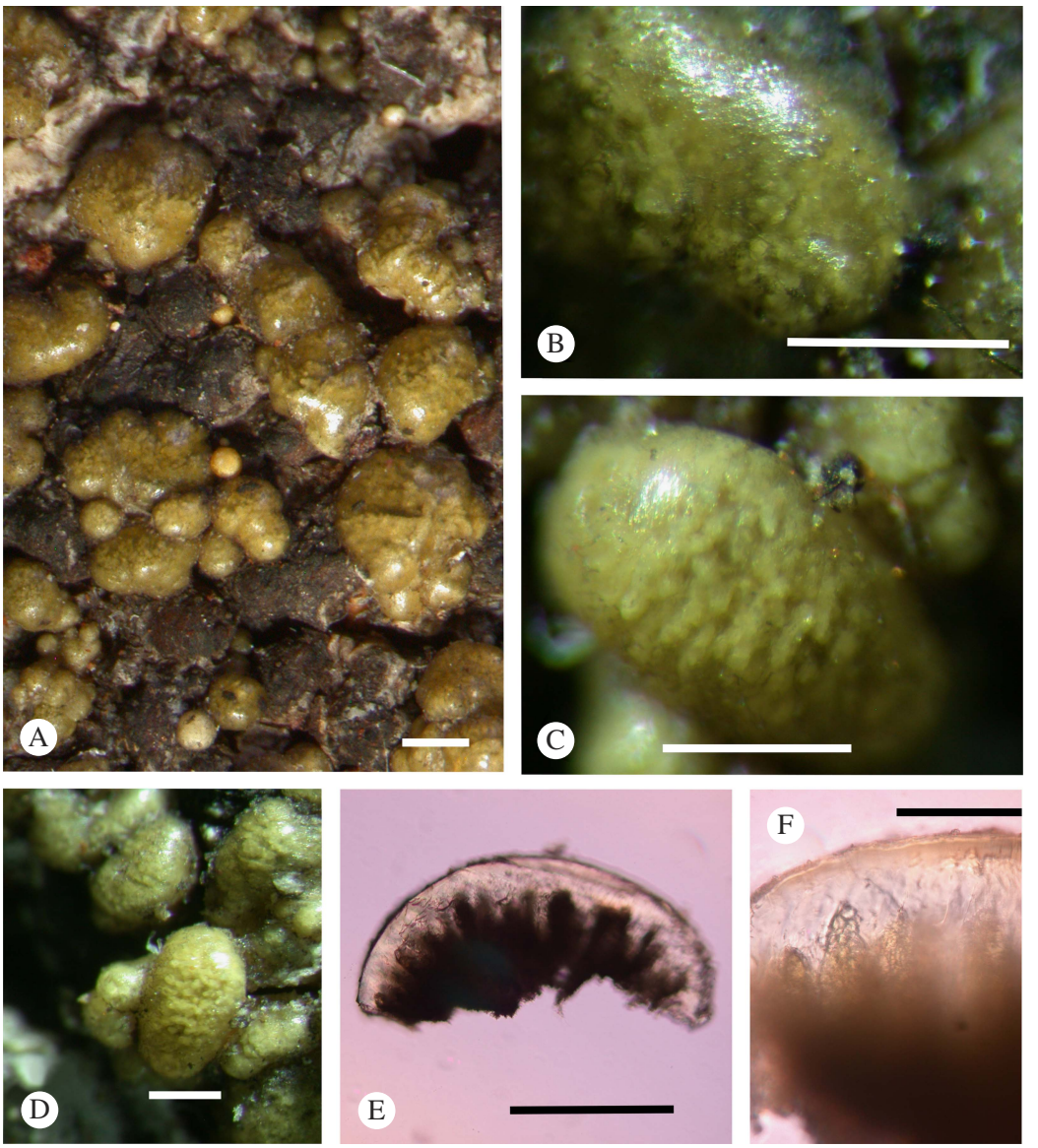

FIG. 2. *Astrothelium diaphanocorticatum*, holotype. A–D, habitus of thallus warts; E & F, sections through a thallus wart. Scales: A = 1 mm; B–D = 0·5 mm; E & F = 0·1 mm. In colour online.

Discussion. Astrothelium diaphanocorticatum is rather unique within the genus in that the thallus consists of almost spherical globules of *c.* 1 mm diam., with a thick hyaline cortex so transparent that the algal cells can be clearly seen under the stereomicroscope as groups of green dots. The unusually thick, vitreous cortical layer is at variance with what is usually found in lichens where the photobionts are sheltered from direct insolation by an opaque fungal cortex. In habitats with higher levels of UV-radiation (see e.g. Bjerke *et al.* 2002), such as high mountains and high latitudes, these lichens tend to contain higher

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concentrations of cortical pigments. *Astrothelium diaphanocorticatum*, however, grows in montane forest in Papua New Guinea at 2900 m altitude, where the photobionts apparently have no need of this protection and they are found under the dense canopy in a usually misty environment. The curved, glassy cortex of the globules may serve to focus the scarce light onto the photobionts. The function of a glassy cortical layer to focus light onto the photobionts of lichens is better known in the so-called window lichens (e.g. Kilias 1984; Timdal 2017).

Somewhat similar, bullate thalli occur in several *Astrothelium* species of very humid habitats, such as *A. bullatum* Flakus & Aptroot, *A. komposchii* Aptroot, *A. megacrypticum* Lücking *et al.*, *A. papillosum* (P. M. McCarthy) Aptroot & Lücking, *A. puiggarii* (Müll. Arg.) Aptroot & Lücking, *A. rimosum* Aptroot, *A. simplex* Aptroot & S. M. Martins and *A. tetrasporum* Aptroot & M. Cáceres. All of these species differ by having much larger, >50 µm long, pluriseptate or muriform ascospores, and a cortex that is not as thick or clear.

Additional specimen examined. **Papua New Guinea:** Morobe, Saruwaged Range, near Honzeukngon Village S of Derim in Timbe Valley, alt. 2500 m, 1987, *A. Aptroot* 18070 (ABL).

Astrothelium macroeustomum Aptroot & Sipman sp. nov.

MycoBank No.: MB 827207

Astrothelium with joint lateral ostioles, a UV+ yellow ostiolar region and 5-septate ascospores of 50–55 × 12–17 µm.

Type: French Guiana, Saül, along piste to Crique Limonade, alt. 300 m, 13 January 1988, *H. J. M. Sipman* 31769 (B—holotype).

(Fig. 3A & B)

Thallus corticate, mostly smooth, somewhat shiny, continuous, covering areas up to 9 cm diam., under 0·1 mm thick, pale ochraceous brown, surrounded by a dark brown prothallus ≤ 0·5 mm wide, not inducing gall formation in the host bark.

Ascomata pyriform, *c.* 0·6–1·0 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue below the thallus. *Wall* carbonized, up to *c.* 80 µm thick. *Ostioles* eccentric, fused, strongly convex, black, surrounded by a yellowish white pruinose ring of 0·3–0·5 mm diam. *Hamathecium* not inspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 5-septate, 50–55 × 12–17 µm, fusiform, ends pointed, IKI− or very pale blue, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, KOH−, ostiole UV+ yellow. TLC: lichexanthone.

Etymology. The name refers to the large ascospores and the resemblance to *A. eustomum* (Mont.) Müll. Arg.

Distribution and ecology. On tree bark in tropical rainforest. So far known only from French Guiana.

Discussion. This is yet another member of the *A. eustomum* group which has whitish, UV+ yellow ostiolar regions strongly contrasting with the thallus. Within this group, *A. macroeustomum* is characterized by large, 5-septate ascospores. Thus, it is closest to *A. eumultiseptatum* Aptroot & M. Cáceres (Aptroot & Cáceres 2016), which differs by having longer (>65 µm) ascospores with more (9–11) septa.

Additional specimen examined. **French Guiana:** same data, *H. J. M. Sipman* 31757 (B).

Astrothelium minicecidiogenum Aptroot & Sipman sp. nov.

MycoBank No.: MB 827209

Astrothelium with muriform ascospores 70–90 × 20–25 µm, without pseudostromata, with solitary ascomata, lateral ostioles and an inspersed hamathecium.

Type: Costa Rica, Alajuela, Volcán Tenorio National Park, surroundings of Pilón Biological Station, alt. 700 m, 16 March 2004, *A. Aptroot* 60498 (INB—holotype).

(Fig.: see Aptroot *et al.* (2008), page 56, Fig. 7C & D)

Thallus corticate, smooth, shiny, bullate, covering areas ≤7 cm diam., *c.* 0·2 mm thick, olive-green, not surrounded by prothallus, not inducing gall formation in the host bark.

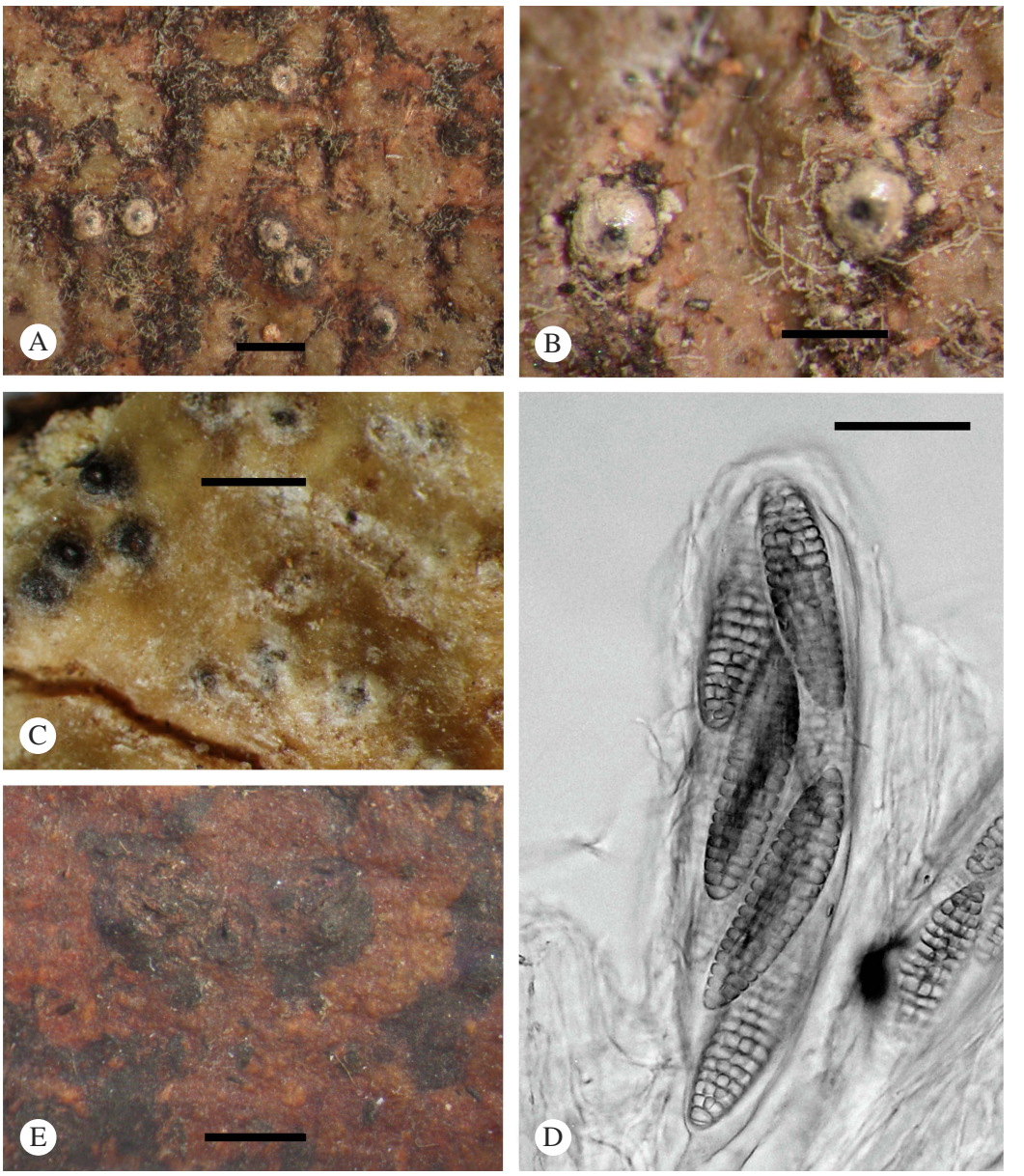

FIG. 3. New *Astrothelium* species, all from holotypes. A & B, *A. macroeustomum*, habitus. C & D, *A. palaeoexostemmatis*; C, habitus; D, ascus, the spores stained blue by IKI. E, *A. quasimamillanum*, habitus. Scales: A & C = 1 mm; B & E = 0·5 mm; D = 50 µm. In colour online.

Ascomata pyriform, 0·7–1·3 mm diam., solitary, fully immersed in the bark, below the thallus cortex, not in pseudostromata. *Wall* carbonized all around, up to *c.* 80 µm thick. *Ostioles* lateral, simple, flat, black. *Hamathecium* inspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline to somewhat ochraceous, muriform,

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70–90 × 20–25 µm, fusiform, IKI−, without a distinctly thickened median septum, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, KOH−. TLC: no secondary substances detected.

Etymology. The name refers to the small ascospores and the resemblance to *A. cecidiogenum* (Aptroot & Lücking) Aptroot & Lücking.

Distribution and ecology. On tree bark in tropical rainforest. So far known only from Costa Rica.

Discussion. This material keys out as *A. puiggarii* in group 8, couplet 5 and is described under that name on page 881 in Aptroot & Lücking (2016). It was described previously in Aptroot *et al*. (2008) on page 53 and the material from Costa Rica was illustrated in Fig. 7C & D on page 56. However, in the original description (Müller 1883) and in some additional material examined from Brazil and French Guiana, *A. puiggarii* has two ascospores per ascus, 170–340 × 30–60 µm. Therefore the 8-spored specimens are described here as a separate species.

Astrothelium palaeoexostemmatis Sipman & Aptroot sp. nov.

MycoBank No.: MB 827211

Astrothelium similar to *A. exostemmatis* but with larger, I+ blue ascospores.

Type: Thailand, Chiang Mai, Doi Suthep, Kings Palace, 18°49'N, 99°53'E, alt. 1550 m, oak/chestnut forest, 19 December 1991, *P. A. Wolseley & B. Aguirre-Hudson* 5771 (B 60 0173986—holotype; BM—isotype).

(Fig. 3C & D)

Thallus corticate, smooth, shiny, covering areas over 5 cm diam., endophloeodic, *c.* 200 µm thick, ochraceous brown (25 years in herbarium), with *c.* 50 µm thick cortex, prothallus unknown (thallus margin not present), not inducing gall formation in the host bark.

Ascomata subspherical, 0·4–0·6 mm diam., simple, solitary, dense and in part contiguous but not forming distinct pseudostromata, covered by the thallus and with only the black ostiole visible, sometimes a larger part of or the complete perithecium is visible as a black spot through the transparent thallus cortex. *Wall* dark brown all around, KOH+ greenish black, *c.* 40 µm thick, the inner 20 µm darkest. *Ostioles* apical, black, surrounded by an area of pale thallus *c.* 0·4 mm wide. *Hamathecium* clear. *Asci* with 8 ascospores, *c.* 300 × 50 µm. *Ascospores* hyaline, muriform, 85–100 × 20–24 µm, composed of *c.* 26 × 4 loculi, ellipsoid, IKI+ blue, with rather thin septa, without a distinctly thickened median septum, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, no pigment visible.

Etymology. The name refers to the occurrence in the Palaeotropics and the similarity with the neotropical species *A. exostemmatis* (Müll. Arg.) Aptroot & Lücking.

Distribution and ecology. On tree bark in montane tropical forest. So far known only from northern Thailand.

Discussion. This species superficially resembles a *Pyrenula* sp. but the hamathecium and ascus structure, and the hyaline ascospores, place it clearly in the *Trypetheliaceae*. It is most similar to *A. exostemmatis* in its immersed, single, simple perithecia and 8 per ascus muriform ascospores without a thickened central septum. However, it has larger, I+ blue ascospores and occurs in the Palaeotropics rather than the Neotropics.

Muriform, I+ blue or violet ascospores are an uncommon feature in *Astrothelium* but Aptroot & Lücking (2016) mention five species: *A. amylosporum* Flakus & Aptroot, *A. auratum* (R. C. Harris) Aptroot & Lücking, *A. bullatum* Flakus & Aptroot, *A. sanguinarium* (Malme) Aptroot & Lücking and *A. sanguineoxanthum* Aptroot with this characteristic. Observations of specimens in the lichen herbarium at B show that *A. subdisjunctum* (Müll. Arg.) Aptroot & Lücking also has I+ blue ascospores. All these species share simple, not astrothelioid or cryptothelioid, perithecia which may be aggregated in pseudostromata or not, and ascospores without a more

strongly thickened median septum. However, *A. auratum*, *A. sanguinarium* and *A. sanguineoxanthum* differ by their orange or red pigmentations; *A. amylosporum* is distinguished by its large perithecia which are not covered by the thallus; *A. bullatum* differs by its bullate thallus and large ascospores; *A. subdisjunctum* generally has 4-spored asci.

Astrothelium quasimamillanum Aptroot & C. Mendonça sp. nov.

MycoBank No.: MB 827213

Astrothelium with muriform ascospores of 30–33 × 9·5–10·5 µm, without pseudostromata, with solitary ascomata, lateral ostioles and an inspersed hamathecium.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal, alt. 100 m, 2015, *C. Mendonça* ISE 23813 (ISE—holotype; ABL—isotype).

(Figs 3E & 4A)

Thallus corticate, smooth, shiny, covering areas ≤7 cm diam., less than *c.* 0·1 mm thick, dark brown, surrounded by a black line denoting the prothallus *c.* 0·4 mm wide, not inducing gall formation in the host bark.

Ascomata pyriform, 0·6–0·9 mm diam., solitary, mostly immersed in the bark, but just discernible as black structures below the thallus cortex, not in pseudostromata. *Wall* carbonized all around, up to *c.* 80 µm thick. *Ostioles* lateral, simple, flat, black. *Hamathecium* inspersed with oil globules. *Asci* with a very wide ocular chamber, of more than half the width of the ascus, with 8 ascospores. *Ascospores* hyaline, muriform, 10–12 × 1–2-septate, 30–33 × 9·5–10·5 µm, ellipsoid, IKI−, without a distinctly thickened median septum, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, KOH−. TLC: no secondary substances detected.

Etymology. The name refers to the superficial resemblance to *Pyrenula mamillana* (Ach.) Trevis.

Distribution and ecology. On tree bark in tropical rainforest. Known only from Brazil at present.

Discussion. This species looks externally very much like a *Pyrenula* of the *mamillana* group but has hyaline ascospores and asci of the *Trypetheliaceae* type with a very wide ocular chamber. It is furthermore characterized by the combination of the following characters: muriform ascospores of 30–33 × 9·5–10·5 µm, lacking a pseudostroma, a lateral ostiole and an inspersed hamathecium. There are no similar species in *Trypetheliaceae*.

Astrothelium studerae Aptroot & M. Cáceres sp. nov.

MycoBank No.: MB 827214

Astrothelium with astrothelioid ascomata, lichexanthone only in the pseudostromata, and 3-septate ascospores of 21·5–23·0 × 6·5–7·5 µm.

Type: Brazil, Alagoas, Quebrangulo, Pedra Talhada private area, alt. 500–700 m, 21–23 October 2017, *M. E. S. Cáceres* & *A. Aptroot* ISE 42813 (ISE—holotype; ABL—isotype).

(Fig. 4B & C)

Thallus olive-green to yellowish green, bullate, surrounded by a black line denoting the prothallus *c.* 0·3 mm wide, not inducing gall formation in the host bark.

Ascomata pyriform, 0·7–1·1 mm diam., 2–5 aggregated with a common ostiole, black, in often somewhat unclear, thallus-like but paler to whitish, slightly raised pseudostromata. *Wall* carbonized, ≤*c.* 70 µm thick. *Ostioles* apical, brown, flat, *c.* 0·1 mm wide, often surrounded by a wide area where the pseudostromatal tissue is abraded and the black ascoma wall exposed. *Hamathecium* inspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, 21·5–23·0 × 6·5–7·5 µm, ellipsoid, IKI−, lumina diamond-shaped, surrounded by a gelatinous layer up to 7 µm thick.

Pycnidia not observed.

Chemistry. Thallus UV−, KOH−, pseudostromata UV+ yellow, KOH−. TLC: lichexanthone.

Etymology. Named in honour of Anita Studer, the protector of the isolated patch of Atlantic rainforest in Alagoas where the new species was collected.

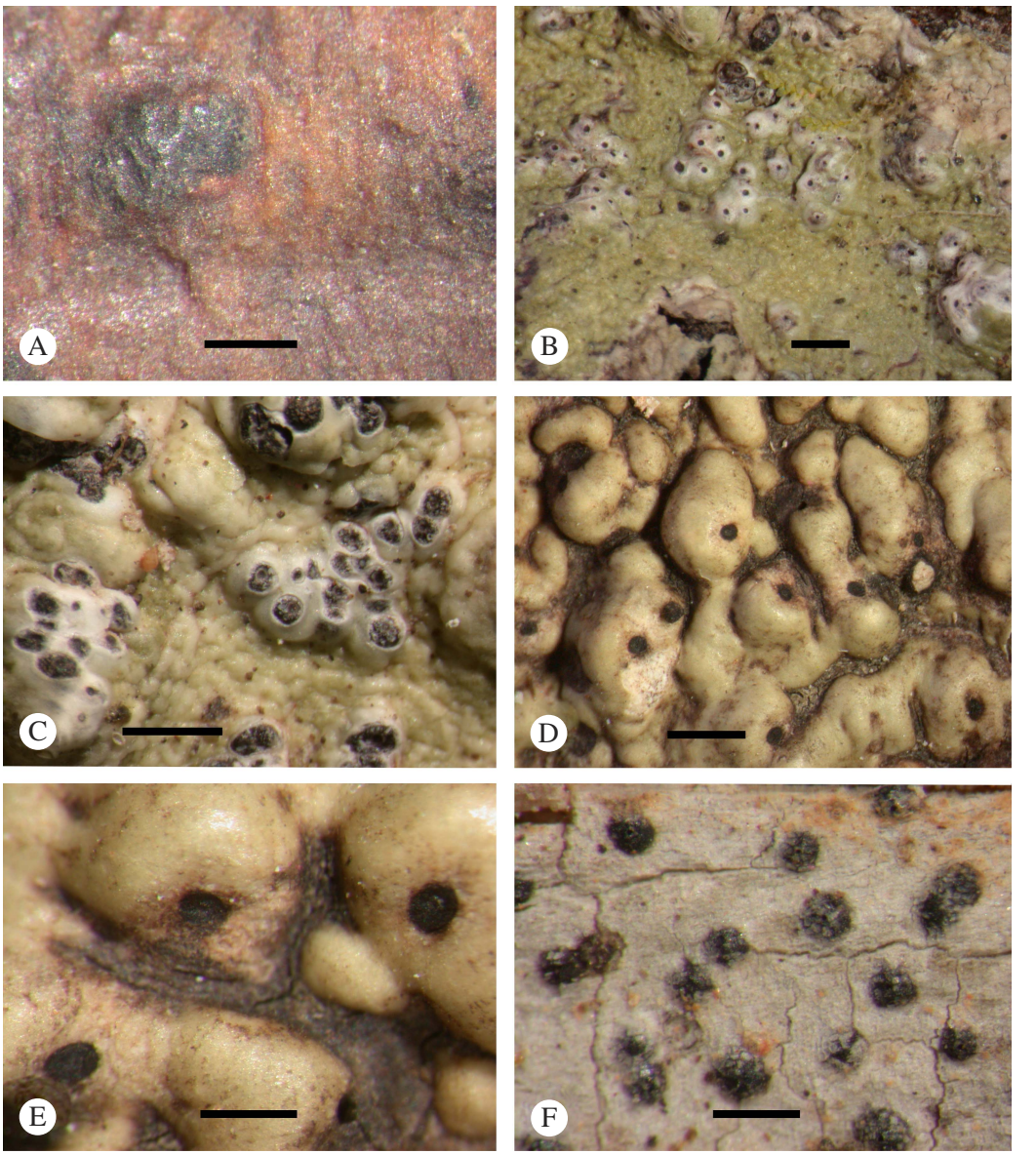

FIG. 4. New species of *Astrothelium* and *Pseudopyrenula*, all from holotypes. A, *A. quasimamillanum*, habitus; B & C, *A. studerae*, habitus; D & E, *A. tanianum*, habitus; F, *P. miniflavida*, habitus. Scales: A, C, E & F = 0·5 mm; B & D = 1 mm. In colour online.

Distribution and ecology. On tree bark in low montane forest. So far known only from Brazil.

Discussion. This species is similar to *A. interjectum* R. C. Harris (Aptroot & Lücking 2016) but differs by the inspersed hamathecium.

Astrothelium tanianum Aptroot & Sipman sp. nov.

MycoBank No.: MB 827215

Astrothelium with a bullate thallus, solitary ascomata, covered by thallus, and (9–)11(–15)-septate ascospores, 75–100 × 20–22 µm.

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Type: Malaysia, Johor, Gunung Pulai Forest Reserve, alt. 150 m, 26 November 2000, *H. J. M. Sipman, B. Tan & Farida* 46414 (B—holotype).

(Fig. 4D & E)

Thallus corticate, bullate, shiny, covering areas of ≤3 cm diam., *c.* 0·2 mm thick, pale olive-green, not surrounded by a prothallus, not inducing gall formation in the host bark.

Ascomata globose, 0·7–1·3 mm diam., solitary, not in pseudostromata, but immersed in thallus verrucae, which can have a rather irregular surface and outline. *Wall* black all around, up to *c.* 60 µm thick. *Ostioles* flat, apical to often somewhat eccentric, 0·1 mm diam., black. *Hamathecium* inspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, (9–)11(–15)-septate, 75–100 × 20–22 µm, fusiform, ends pointed, IKI−, lumina diamond-shaped, surrounded by a 1 µm thick gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, KOH−. TLC: no secondary substances detected.

Etymology. Named in honour of one of the collectors, the late Philippine bryologist Benito Tan.

Distribution and ecology. On tree bark in tropical lowland rainforest. So far known only from Malaysia.

Discussion. This species is characterized by the bullate thallus, which covers the solitary ascomata, and (9–)11(–15)-septate, 75–100 × 20–22 µm ascospores. It resembles species of the *A. annulare* group, such as *A. macrosporum* (Makhija & Patw.) Aptroot & Lücking (Aptroot & Lücking 2016), but lacks the annulus surrounding the ostiole.

Pseudopyrenula miniflavida Aptroot & A. D. Nunes sp. nov.

MycoBank No.: MB 827216

Pseudopyrenula with a yellow inspersed hamathecium, inspersion dissolving in KOH (not changing in colour) and 3-septate ascospores, 15–17 × 5·5–6·5 µm.

Type: Brazil, Sergipe, Quissamãa, Mata do IFS, alt. 50 m, 5 September 2016, *A. D. Nunes* ISE 41583 (ISE—holotype).

(Fig. 4F)

Thallus whitish grey, not corticate.

Ascomata hemispherical, solitary, erumpent, black but often partly white pruinose. *Ostioles* apical. *Hamathecium* inspersed with yellow oil droplets, which dissolve but do not change colour in KOH. *Ascospores* 3-septate, 15–17 × 5·5–6·5 µm.

Pycnidia not observed.

Chemistry. Thallus and ascoma UV−, KOH−, yellow pigment in hamathecium dissolving in KOH. TLC: no secondary substances detected.

Etymology. The name refers to the small ascospores and the yellow oil droplets in the hamathecium.

Distribution and ecology. On tree bark in Atlantic rainforest remnant. So far known only from Brazil.

Discussion. This species is characterized by ascospores of 15–17 × 5·5–6·5 µm and a hamathecium with yellow oil droplets dissolving, but not changing colour, in KOH. It does not closely resemble any known species in *Pseudopyrenula* as it has the smallest ascospores in the genus and an apparently unique pigment in the hamathecium.

New Country Records

For each accepted species in the *Trypetheliaceae*, Aptroot & Lücking (2016) listed the countries from which those species had been reported in the literature, and gave specimen citations from additional countries. Here we report additions to these lists. Some of these are in species groups where the species concept in Aptroot & Lücking (2016) is much narrower than that previously used. In cases where the collective species had already been reported from a country, the record given here is marked with #, signifying that the species has been reported from that country in a much wider sense under a different name. All pertinent material would need to be checked to ascertain if it belongs to the currently accepted species reported herein.

Astrothelium aenascens Aptroot # (previously included within the concept of *A. aeneum* s.l.). **Colombia:** Caqueta, Araracuara, along road to airstrip, 0°36'S, 72°26'W, alt. 300 m, epiphyte on small tree in secondary vegetation and gardens, 1988, *Sipman* 27825 & *Duivenvoorden* (B).

Astrothelium amazonum (R. C. Harris) Aptroot & Lücking. **Ecuador:** Prov. Zamora-Chinchipe, Reserva Biológica San Francisco, 30 km E of Loja on road to Zamora, transect 2, 3°58·3'S, 79°4·7'W, alt. 2000 m, montane tropical rainforest, on bark, 2001, *Nöske & Sipman* 126 (B).

Astrothelium chrysoglyphum (Vain.) Aptroot & Lücking. **Dominica:** Pointe Round, Parish of St. Peter, alt. *c.* 30 m, dry scrub woodland, 1963, *Imshaug* 33485 (B).

Astrothelium degenerans (Vain.) Aptroot & Lücking. **Guyana:** Rupununi Distr., Marudi Mts, *c.* 1 km along trail from NorMan Mines camp to Aishalton, 2° 15'N, 59°10'W, alt. 300–400 m, in disturbed vegetation on lateritic clay, growing on bark of *Jacaranda copaia*, 1982, *Stoffers, Görts-van Rijn, ter Welle & Bonsen* 251e (B).

Astrothelium heterophorum Nyl. **Vanuatu:** Espiritu Santo, logging area near Lavatmas (N of Sara), 48 km NNW of Luganville, 15°7'S, 167°1'E, alt. 300 m, poor lowland forest on *Endospermum medullosum*, *Antiaris toxicaria* & *Pometia pinnata*-dominated flats, upper branches of large felled tree (*Endospermum medullosum*), 1998, *Streimann* 62787 & *Ala* (B).

Astrothelium inspersaeneum E. L. Lima *et al.* # (previously included within the concept of *A. aeneum* s.l.). **Colombia:** Santander, municipality of Charala, corregimiento Virolín, Cañaverales, near finca St. Helena, 6°05'N, 73°12'W, alt. 1900 m, on little trees in pasture fields around farm in mountain valley, 1988, *Sipman* 27555 & *Aguirre* (B).—**Ecuador:** Prov. Zamora-Chinchipe, Cordillera Numbala, Reserva Biologica San Francisco, S of road Loja-Zamora, transecto 1, near Refugio, 3°58'S, 79°04'W, alt. 2450 m, on shrub branches in shrubby forest on mountain ridge, 2003, *Sipman* 51458 (B).—**Malaysia:** State of Sabah, Ranau Distr., Kinabalu Park, S-slope of Mount Kinabalu, surroundings of Headquarters, 6°05'N, 116° 35'E, alt. *c.* 1650 m, tall forest on slope along Kiau View trail, near Ranau highway, from trunk and crown branches of felled tree, 1989, *Sipman* 31459 & *Tan* (B). New to the Asian continent.

Astrothelium leioplacum (Müll. Arg.) Aptroot & Lücking. **Guyana:** Upper Takutu District, *c.* 35 km S of Aishalton, *c.* 4 km N of Kuyuwini Landing, along track to Karaudanawa, *c.* 2°08'N, 59°15'W, alt. *c.* 250 m, epiphyte on scattered shrubs and trees both along the edge of and within small savannah, 1992, *Sipman* 57079 (B).

Astrothelium meiophorum (Nyl.) Aptroot & Lücking # (previously included within the concept of *A. nitidiusculum* s.l.). **Singapore:** Campus of National University of Singapore, around Kent Ridge, 1°18'N, 103°45·5'E, alt. *c.* 50 m, parkland with scattered buildings and roads, on *c.* 20–30 cm diam. trunk of small *Cassia fistula* tree, 2000, *Sipman* 45532 (B), 45538 (B); *ibid.*, Botanic Gardens, 1°18'N, 103°48'E, alt. *c.* 50 m, parkland with scattered trees and shrubs, on *c.* 30 cm diam. tree trunk of *Podocarpus gracilior* (no. 5389, planted 1932), 2000, *Sipman* 45710 (B); *ibid.*, Botanic Gardens, *Plumeria* Garden, 1° 18'N, 103°48'E, alt. *c.* 50 m, parkland with scattered trees and shrubs, on trunks and branches of *Plumeria*, 2000, *Sipman* 45747 (B).

Astrothelium meristosporum (Mont. & Bosch) Aptroot & Lücking. **Vanuatu:** Espiritu Santo, Big Bay-Luganville Road, 26 km NW of Luganville, 15°19'S, 167°01'E, alt. 380 m, regrowth on limestone, *Alphitonia*, *Macaranga*-dominated, on semi-exposed *Macaranga* stem, 1998, *Streimann* 62268 & *Ala* (B).

Astrothelium nicaraguense Lücking *et al.* **Costa Rica:** Puntarenas, near Las Cruzes Garden (district of Coto Brus), *c.* 4 km SSE of San Vito, *c.* 8°43'N, 82°57'W, alt. *c.* 1300 m, premontane rainforest zone, on trunk of isolated tree on exposed hill ridge, 1978, *Sipman* 11962 (B); *ibid.*, Parque Internacional La Amistad (AC Amistad

Pacifico), Cerro Biolley, 30 km NNW of San Vito near Biolley, lower trail from road to Sabanas Esperanza, 9°04'N, 83°03'W, alt. 1300–1400 m, upland savannah zone, disturbed savannah vegetation with abundant shrubs and trees, on bark (lower trunk), 2002, *Sipman* 48111 (B).

Astrothelium nigratum (Müll. Arg.) Aptroot & Lücking # (previously included within the concept of *A. nitidiusculum* s. lat.). **Colombia:** Caqueta, 2·5 km NE of Araracuara, 0°37'S, 72°23'W, alt. 250 m, *c.* 30 m tall, hardly disturbed forest on low terrace of Caquetá River (parcelas de Marcela Torres), on canopy branches of *Brosimum*, 1988, *Sipman* 27907 & *Duivenvoorden* (B).

Astrothelium nigrum Aptroot & M. Cáceres. **Venezuela:** Estado Bolivar, Cerro Guaiquinima, in central part of upper plateau (near camp 4), 5°40'N, 63°34'W, alt. *c.* 950 m, low, mossy forest on rocky slope towards stream, epiphytic, 1990, *Sipman* 26617 (B, VEN).

Astrothelium nitidiusculum (Nyl.) Aptroot & Lücking. **Philippines:** Luzon Island, Prov. Sorsogon, Irosin, alt. *c.* 250 m, on number 14650 (*Gymnartocarpus woodii* Merr.), 1915, *Elmer* 14659 (B).

Astrothelium norisianum Lücking *et al.* **Mexico:** Chiapas, municipality of Ocozocoautla, *c.* 5 km antes del aéropuerto San Juan en la carretera 190, Tuxtla Gutiérrez-México, 16°45·0'N, 93°16·5'W, alt. 1200 m, región Depresion Central, bosque caducifolio bajo seco sobre roca calcárea, epífita, alt. 0–2 m, 1994, *Wolf & Sipman* 2255 (B).—**Costa Rica:** Limón, 40 km S of Limón, Reserva Biológica Hitoy Cerere, near biological station, pasture fields along entrance road, 9°40'N, 83°02'W, alt. 130 m, submontane rainforest zone, on trunk of scattered trees in pastureland, 2004, *Sipman* 51612 (B); *ibid.*, Puntarenas, San Vito de Coto Bruz, Estación Biológico Las Cruzes, 8°47·1'N, 82°57·6'W, alt. *c.* 1200 m, trail to Rio Java, on branches of fallen *Ficus pertusa* on fallen trunk, 2004, *Sipman* 53235 (B).

Astrothelium perspersum Aptroot & Ertz. **Venezuela:** Edo. Merida, Distr. Sucre, finca Los Topos (San Juanito), Chiguará, 8°31·5'N, 71°20'W, alt. *c.* 1200 m, on bark of fence post between meadow and road (former montane mossy forest area), 1996, *Sipman* 38061 & *Morales* (B).

Astrothelium phlyctaena (Fée) Aptroot & Lücking # (previously included within the concept of *Trypethelium ochroleucum* (Eschw.) Nyl. s. lat.). **Venezuela:** Estado Bolivar, Cerro Guaiquinima, in central part of upper plateau, along Rio Carapo (near camp 3-nuevo), 5°49'N, 63°32'W, alt. *c.* 800 m, on trees on rocky slope with low forest in deep clefts and along the river, 1990, *Sipman* 26971 (B).

Astrothelium robustum Müll. Arg. **Mexico:** Chiapas, municipality of La Trinitaria, Parque Nacional Lagunas de Montebello, Paso del Soldado, 16°07·1'N, 91°43·1'W, alt. 1500 m, *Pinus maximinoi* and *Quercus sapotifolia* forest, N exposure , epiphyte, alt. 0–2 m, 1994, *Wolf & Sipman* 2083 (B).—**French Guiana:** Saül, tropical primary forest along piste to Crique Limonade, about halfway, 3°35'N, 53°13'W, alt. *c.* 300 m, on trunk and branches of fallen tree, 1988, *Sipman* 31764 (B).

Astrothelium rufescens (Müll. Arg.) Aptroot & Lücking # (previously included within the concept of *A. nitidiusculum* s. l.). **Costa Rica:** Puntarenas, Fila Cedro (AC Amistad Pacifico), Las Alturas station, 25 km NE of San Vito near Alturas, surroundings of station and trail into forest, 8°57'N, 82°50'W, alt. 1600 m, montane rainforest zone, pasture with group of trees bordering forest, on bark (lower trunk), 2002, *Sipman* 47817a (B).

Astrothelium solitarium Aptroot & M. Cáceres. **Venezuela:** Estado Bolivar, Cerro Guaiquinima, in central part of upper plateau, along Rio Carapo (near camp 4), 5°40'N, 63°34'W, alt. *c.* 1000 m, sandstone flats with boggy *Stegolepis* vegetation and scrub, 1990, *Sipman* 26683 (B, VEN).

Astrothelium straminicolor (Nyl.) Aptroot & Lücking. **Singapore:** SE side of MacRitchie Reservoir, 1°21'N, 103°50'E, alt. *c.* 50 m, secondary forest with primary forest remnants, on tree trunk within reach

of the ground, 2000, *Sipman* 45888 & *Tan* (B).

Astrothelium subdisjunctum (Müll. Arg.) Aptroot & Lücking. **Colombia:** Caqueta, 2·5 km NE of Araracuara, 0°37'S, 72° 23'W, alt. 250 m, *c.* 30 m tall, hardly disturbed forest on low terrace of Caquetá River (parcelas de Marcela Torres), on canopy branches of *Brosimum*, 1988, *Sipman* 27909 & *Duivenvoorden* (B).

Astrothelium subendochryseum Lücking *et al.* **Costa Rica:** Prov. Cartago, SW-slope of Volcán Turrialba, N of Santa Cruz, Fila Bonilla, along Camino El Trazado, 10° 01'N, 83°43'W, alt. 2100 m, pastureland with relic trees of cloud forest, 1985, *Sipman* 20355 (B).

Astrothelium subfuscum Kremp. **Singapore:** Sembawan Park, on N-coast, 1°28'N, 103° 51'E, alt. *c.* 2 m, grassland with scattered trees and shrubs, on tree trunk within reach of the ground, 2000, *Sipman* 46404 & *Tan* (B).

Astrothelium subscoria Flakus & Aptroot # (previously included within the concept of *A. nitidiusculum* s. lat.). **Guyana:** Upper Takutu District, *c.* 45 km S of Aishalton, *c.* 3 km S of Kuyuwini Landing, along trail to Kassikaityu River, 1°55'N, 59°15'W, alt. *c.* 230 m, epiphyte in light scrub with *Clusia* around tiny savannah, 1992, *Sipman* 57022 (B).

Astrothelium vulcanum Aptroot # (previously included within the concept of *Trypethelium ochroleucum* s. lat.). **El Salvador:** Santa Ana, municipality of Metapán, Parque Nacional Montecristo, Hacienda San José Ingenio, Caja de Agua de Metapán, 14°22'N, 89°23'W, alt. *c.* 900 m, on tree in *Pinus-Quercus* forest on lateritic soil on slope, 1993, *Sipman, Berendsohn & Ladino* 37410 (B).

Bathelium madreporiforme (Eschw.) Trevis. **China:** Yunnan Prov., Xishuangbanna, Xishuangbanna Tropical Botanical Garden in Menglun, 21°55·6'N, 101°15·4'E, alt. 550 m, on *Anacardium occidentale* trunks scattered in parkland, 2002, *Sipman* 50476 (B, KUN).

Bathelium nigroporum (Makhija & Patw.) Aptroot & Lücking. **Papua New Guinea:** Madang Prov., S side of Ramu Valley, 8–10 km W of Brahman Mission, 5°44·9'S, 145°19·7'E, alt. 100 m, logging site in lowland forest remnant, 1995, *Sipman* 38820 (B).

Bathelium porinosporum Lücking *et al.* **China:** Yunnan Prov., Xishuangbanna, Xishuangbanna Tropical Botanical Garden in Menglun, 21°55·6'N, 101°15·4'E, alt. 550 m, on trunks scattered in parkland, 2002, *Sipman* 50458 (B, KUN).

Pseudopyrenula flavoreagens Aptroot & M. Cáceres. **French Guiana:** Saül, 2 km S of the village, "sentier lemonade", 3°32'N, 53°12'W, alt. 180–210 m, lowland moist forest, in upper canopy of *Hura crepitans*, 1986, *Montfoort & Ek* 8 (B).

Trypethelium ornatum Müll. Arg. **Bolivia:** Alto Beni, San Antonio, 15° 39·770'S, 67°10·399'W, alt. 410 m, 23 year-old plantation, owned by Angel Flores, on *Theobroma cacao* bark, 1999, *Derakshani* 53 (B).

Updates to Aptroot & Lücking (2016)

Key to *Astrothelium species*

Group 1, couplet 9

Modify option 2: "Ascomata pseudostromatic, grouped in poorly delimited pseudostromata covered by thallus (Aptroot & Lücking 2016; Fig. 12K & L) . . . . . **Astrothelium porosum**"

Add option: "Ascomata pseudostromatic, grouped in prominent pseudostromata that contrast with the thallus (Lücking *et al.* 2016*b*; Fig. 13E) . . . . . **Astrothelium leucosessile**"

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Group 1, couplet 13
Delete first option. . . . . (*Astrothelium leucosessile*)

Group 1, couplet 27
Add option: "Ascomata in pseudostromata, covered with orange pruina; thallus yellow, bullate, with thick cortex, intermixed in mosaic with prothallus . . . . . **Astrothelium bullatothallinum**"

Group 2, couplet 17
Add option: "Thallus bullate, consisting of almost spherical globules, with a thick hyaline cortex. . . . . **Astrothelium diaphanocorticatum**"

Group 2, couplet 31
Add option: "Ascospores (9–)11(–15)-septate, never with longitudinal septa, 20–22 µm broad; thallus bullate, covering the ascomata . . . . . **Astrothelium tanianum**"

Group 3, couplet 15
Add option: "Lichexanthone on ascomata only; ascospores 21·5–23·0 µm long; hamathecium inspersed . . . . . **Astrothelium studerae**"

Group 3, couplet 29
Add option: "Lichexanthone present only in the whitish ostiolar region . . . . . **Astrothelium macroeustomum**"

Group 5, couplet 19
Add option: "Ascoma with pseudostroma with yellow pigment; hamathecium with yellow inspersion; ascospores 4 per ascus, 295–330 × 35–40 µm. . . . . **Astrothelium cayennense**"

Group 5, couplet 21
Reverse order of. . . . . **Astrothelium vezdae** and **Astrothelium chrysoglyphum**

Group 6, couplet 22
Add option: "Ascospores I+ pale blue, *c.* 100 × 20 µm, 8 per ascus; ascomata immersed in the thallus with only black pores visible unless damaged . . . . . **Astrothelium palaeoexostemmatis**"

Group 6, couplet 22
Add option: . . . . . "**Astrothelium subdisjunctum** should also key out here, with ascospores (2–)4 per ascus, I+ violet-blue."

Group 8, couplet 3
Add option: "Ascospores 30–33 × 9·5–10·5 µm; thallus lacking pseudocyphellae . . . . . **Astrothelium quasimamillanum**"

Group 8, couplet 5
Astrothelium puiggarii should be . . . . . **Astrothelium minicecidiogenum**

Group 8, couplet 6
Add option: "Ascospores 170–340 × 30–60 µm, 2 per ascus . . . . **Astrothelium puiggarii**"

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Page 831, Fig. 21: note that Figs 21I and 21J should be reversed.

Astrothelium infuscatulum, description (Aptroot & Lücking 2016, p. 863), add: "Ascospores can reach 50 µm in length".

Astrothelium robustum, description (Aptroot & Lücking 2016, p. 863), add: "Ascospores IKI+ blue".

Key to *Pseudopyrenula* species

Couplet 11.
Add option: "Ascospores 15–17 × 5·5–6·5 µm, yellow oil droplets dissolving in KOH, but not changing in colour. . . . . **Pseudopyrenula miniflavida**"

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References

Aptroot, A. & Cáceres, M. E. S. (2016) New *Trypetheliaceae* from the Amazon basin in Rondônia (Brazil), the centre of diversity of the genus *Astrothelium*. *Lichenologist* **48:** 693–712.

Aptroot, A. & Lücking, R. (2016) A revisionary synopsis of the *Trypetheliaceae* (Ascomycota: *Trypetheliales*). *Lichenologist* **48:** 763–982.

Aptroot, A., Lücking, R., Sipman, H. J. M., Umaña, L. & Chaves, J. L. (2008) Pyrenocarpous lichens with bitunicate asci. A first assessment of the lichen biodiversity inventory in Costa Rica. *Bibliotheca Lichenologica* **98:** 1–162.

Aptroot, A., Ertz, D., Etayo Salazar, J. A., Gueidan, C., Mercado Diaz, J. A., Schumm, F. & Weerakoon, G. (2016*a*) Forty-six new species of *Trypetheliaceae* from the tropics. *Lichenologist* **48:** 609–638.

Aptroot, A., Mendonça, C. O., Andrade, D. S., Silva, J. R., Martins, S. M. A., Gumboski, E., Fraga Júnior, C. V. & Cáceres, M. E. S. (2016*b*) New *Trypetheliaceae* from northern and southern Atlantic rainforests in Brazil. *Lichenologist* **48:** 713–725.

Aptroot, A., Cáceres, M. E. S., Johnston, M. K. & Lücking, R. (2016*c*) How diverse is the lichenized fungal family *Trypetheliaceae* (Ascomycota: Dothideomycetes): a quantitative prediction of global species richness. *Lichenologist* **48:** 983–994.

Bjerke, J. W., Lerfall, K. & Elvebakk, A. (2002) Effects of ultraviolet radiation and PAR on the content of usnic and divaricatic acids in two arctic-alpine lichens. *Photochemical and Photobiological Sciences* **1:** 678–685.

Cáceres, M. E. S. & Aptroot, A. (2016) First inventory of lichens from the Brazilian Amazon in Amapá State. *Bryologist* **119:** 250–265.

Cáceres, M. E. S. & Aptroot, A. (2017) Lichens from the Brazilian Amazon, with special reference to the genus *Astrothelium*. *Bryologist* **120:** 166–182.

Diederich, P., Lücking, R., Aptroot, A., Sipman, H. J. M., Braun, U., Ahti, T. & Ertz, D. (2017) New species and new records of lichens and lichenicolous fungi from the Seychelles. *Herzogia* **30:** 182–236.

Etayo, J. A. & Aptroot, A. (2017) New and interesting lichens from Panama. *Bryologist* **120:** 501–510.

Flakus, A., Kukwa, M. & Aptroot, A. (2016) *Trypetheliaceae* of Bolivia: an updated checklist with the description of twenty-four new species. *Lichenologist* **48:** 661–692.

Kilias, H. (1984) *Catillaria sculpturata* H. Magn. and *C. crystallifera* Kilias, sp. nov.: two "window lichens" with a wide distribution. *Bryologist* **87:** 327–331.

Luangsuphabool, T., Lumbsch, H. T., Aptroot, A., Piapukiew, J. & Sangvichien, E. (2016) Five new species and a new record of *Astrothelium* (*Trypetheliaceae*, Ascomycota) from Thailand. *Lichenologist* **48:** 727–737.

Lücking, R., Nelsen, M. P., Aptroot, A., Benatti, M. N., Binh, N. Q., Gueidan, C., Gutiérrez, M. C., Jungbluth, P., Lumbsch, H. T., Marcelli, M. P., *et al.* (2016*a*) A pot-pourri of new species of *Trypetheliaceae* resulting from molecular phylogenetic studies. *Lichenologist* **48:** 639–660.

Lücking, R., Nelsen, M. P., Aptroot, A., Barillas de Klee, R., Bawingan, P. A., Benatti, M. N., Bungartz, F., Cáceres, M. E. S., Canêz, L. S., Chaves, J.-L., *et al.* (2016*b*) A phylogenetic framework for

reassessing generic concepts and species delimitation in the lichenized family *Trypetheliaceae* (Ascomycota: Dothideomycetes). *Lichenologist* **48:** 739–762.

Müller, J. (1883) Lichenologische Beiträge XVIII. *Flora* **66(16):** 243–249.

Nelsen, M. P., Lücking, R., Aptroot, A., Andrew, C. J., Cáceres, M. E. S., Rivas Plata, E., Gueidan, C., Cañez, L. S., Knight, A., Ludwig, L. R., *et al*. (2014) Elucidating phylogenetic relationships and genus-level classification within the fungal family *Trypetheliaceae* (Dothideomycetes: Ascomycota). *Taxon* **63:** 974–992.

Orange, A., James, P. W. & White, F. J. (2001) *Microchemical Methods for the Identification of Lichens.* London: British Lichen Society.

Soto Medina, E., Aptroot, A. & Lücking, R. (2017) *Aspidothelium silverstonei* and *Astrothelium fuscosporum*, two new corticolous lichen species from Colombia. *Cryptogamie, Mycologie* **38:** 253–258.

Timdal, E. (2017) *Endocarpon crystallinum* found in Crete, a window-lichen new to Europe. *Herzogia* **30:** 309–312.

Zenker, J. C. (1829) Kryptogamische Parasiten auf officinellen Rinden. In *Pharmaceutische Waarenkunde* (E. Schenk, ed.): 109–200. Eisenach: Bärecke.