

New *Trypetheliaceae* from the Amazon basin in Rondônia (Brazil), the centre of diversity of the genus *Astrothelium*

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Abstract: The following 24 new species of *Trypetheliaceae* are described after three weeks of fieldwork in an area with a radius of 50 km around Porto Velho in Rondônia: *Astrothelium bivelum* with astrothelioid ascomata, 5-septate ascospores with polar gelatinous caps, and a thallus without lichexanthone; *A. curvisporum* with bent, 5-septate ascospores of 115–135 × 29–36 µm with a 17–22 µm thick gelatinous layer; *A. decemseptatum* with pseudostroma that are essentially black and look like breaking through the bark, with anthraquinones mostly on the pseudostromata but also on some parts of the thallus, best seen under UV light as the colour of the pruina is not very strong, and ascospores (7–)9–11-septate, fusiform, 50–65 × 11–17 µm; *A. disjunctum* with black pseudostroma and ascospores 3-septate, (27–)29–33 × (8–)12–14 µm; *A. duplicatum* which is similar to *A. mesoduplex*, but pseudostroma are only yellowish inside and ascospores 45–55 × 11–15 µm; *A. eumultiseptatum* which is similar to *A. eustomum*, but with 9–11-septate ascospores of 65–70 × 15–17 µm; *A. eustomurale* which is also similar to *A. eustomum*, but with submuriform ascospores of 37–45 × 15–19 µm; *A. flavoduplex* which is similar to *A. mesoduplex*, but with ascospores 110–350 × 20–27 µm and the thallus containing lichexanthone; *A. flavomurisporum* with deeply immersed ascomata with muriform ascospores of 165–200 × 28–35 µm, with a distinctly thickened central septum and yellow oil; *A. flavostromatum* which is close to *A. aeneoides* and mainly differs by the bullate thallus and the cream pseudostromata; *A. flavum* which is similar to *A. aeneum*, but differs in the contrast between the linear to reticulate yellow stromata and the unpigmented thallus, and the ascospores of 16–18 × 6–7 µm; *A. mesoduplex* which is similar to *A. flavoduplex*, but with ascospores 90–100 × 20–23 µm and a thallus without lichexanthone; *A. nigrum* with mostly conical black pseudostromata that contrast sharply with the thallus, superficially resembling *Pyrenula infraleucotrypa*; *A. novemseptatum* which is similar to *A. eumultiseptatum*, but without lichexanthone anywhere in the thallus or pseudostroma; *A. ochroleucoides* which is similar to *A. corallinum*, but with lichexanthone on the thallus and pseudostromata; *A. octoseptatum* which is similar to *A. eumultiseptatum*, but with the whole pseudostroma, not just the ostioles, containing lichexanthone, and ascospores somewhat asymmetrical, which is highlighted by the unusual dominant even number of septa (eight) and the asymmetrically placed central septum in the case of uneven septum numbers; *A. quatuorseptatum* which is similar to *A. octoseptatum* Aptroot & M. Cáceres, but without lichexanthone, ascospores somewhat asymmetrical, which is highlighted by the unusual dominant even number of septa (four) and the asymmetrically placed central septum in the case of uneven septum numbers; *A. robustosporum* with solitary ascomata with an eccentric ostiole, and ascospores 11–15-septate, 90–125 × 20–27 µm; *A. solitarium* which is similar to *A. ceratinum* (Fée) Aptroot & Lücking, but with ascospores 33–36 × 10–11 µm; *A. stromatofluorescens* which is close to *A. phlyctaena*, but with lichexanthone only on the pseudostroma, not on the thallus; *A. supraclandestinum* is close to *A. subclandestinum*, but the hamathecium is not interspersed; *A. testudineum* with solitary ascomata with an eccentric ostiole, an interspersed hamathecium, and ascospores 8 per ascus, muriform, 50–65 × 23–27 µm; *A. xanthosuperbum* which is similar to *A. disjunctum*, but with muriform ascospores, 130–160 × 28–35 µm; and *Pseudopyrenula flavoreagens* which is similar to *P. subgregaria*, but with lichexanthone in the thallus. Only a few species were also found elsewhere, such as other areas of Brazil, or in Venezuela, Colombia, Guyana, Panama, Australia and/or Papua New Guinea. Currently, 55 species of *Trypetheliaceae* are known from this spot, including 46 species of *Astrothelium*. The Amazon basin is the centre of diversity for the family, at least for *Astrothelium*, the largest genus in the family.

Key words: Australia, Colombia, Guyana, lichens, Panama, Papua New Guinea, *Pseudopyrenula*, Venezuela

Accepted for publication 29 November 2015

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Introduction

The family *Trypetheliaceae* is most abundant and also generally thought to be species-rich in open forests such as Caatinga vegetation. However, recent collections from expeditions in Venezuela, Guyana, Bolivia and Brazil (especially Rondônia) suggest that it may be most speciose in rainforest, where it grows both on tree trunks and branches. Recently, numerous undescribed species of this family have been found in these countries.

The rainforest in Rondônia is special in that it has a relatively open structure, but contains many large trees. In response, lichens cover most of the bark from the top of the trees to the forest floor, compared with other rainforests where lichens are largely replaced by bryophytes at ground level. The reason is most probably that the soil is extremely nutrient-poor. Until the start of the current research project in 2012, only about twelve lichens had been reported, mostly foliicolous species (Lücking 2008). However, the first results of this survey for lichens in this largely primary forest shows that the region has among the highest epiphytic lichen diversity in the world. There are many so far undescribed species and genera in groups such as *Graphidaceae* (Cáceres *et al.* 2014b), *Arthoniales* (Cáceres *et al.* 2014c) and the pyrenocarps (Aptroot & Cáceres 2013). Surprisingly, there are undescribed species, or some described recently, that are locally abundant e.g. *Pyrenula* spp. (Aptroot *et al.* 2013b).

The high lichen biodiversity is somewhat surprising in the light of the palynological record, which shows that the rainforest in Rondônia at the southern edge of the Amazonian basin is of a geologically recent age and was replaced by savannah in drier or colder periods in the Tertiary and Quaternary, including the ice ages (Hooghiemstra & van der Hammen 1998; Colinvaux *et al.* 2000). The explanation may be that lichens are better dispersers than most other organisms, on which the rapid changes in vegetation may have had a greater effect.

We sampled extensively for *Trypetheliaceae* in Rondônia and made a distinction between primary and secondary forest, and between

species growing on trunks and branches in the primary forest. The primary forest is the most speciose. Quite unexpectedly, the species on the branches are exclusive to that habitat and do not occur on trunks in the same forest or in nearby secondary localities. Below we describe 25 new species of *Trypetheliaceae* found during three weeks of fieldwork in a radius of 50 km from Porto Velho in Rondônia. From the same fieldwork area, 27 previously described species of *Trypetheliaceae* were reported by Aptroot *et al.* (2013a) and Cáceres *et al.* (2014a), to which three species should be added that were at that time not yet taken from synonymy with others, but were already recognized in the material.

The generic concept applied here follows the phylogenetic studies by Nelsen *et al.* (2014). All species are keyed out in Aptroot & Lücking (2016).

Material and Methods

Identification and descriptive work was carried out in Itabaiana, Universidade Federal de Sergipe, using a Leica EZ4 stereomicroscope and a Leica DM500 compound microscope, and also in Soest using an Olympus SZX7 stereomicroscope and an Olympus BX50 compound microscope with interference contrast, connected to a Nikon Coolpix digital camera. Sections were mounted in tap water, in which all measurements were also taken. The chemistry of all specimens was investigated under UV light, and usually spot tests with 10% KOH were carried out. The chemistry of the type specimens was investigated by thin-layer chromatography (TLC) using solvent A (Orange *et al.* 2001).

The New Species

Astrothelium bivelum Aptroot & M. Cáceres sp. nov.

Mycobank No.: MB 815159

Astrothelium with astrothelioid ascomata, 5-septate ascospores with polar gelatinous caps, and thallus without lichexanthone.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. c. 100 m, on tree bark in primary rainforest, 19 November 2012, M. E. S. Cáceres & A. Aptroot 15608 (ISE—holotype; ABL—isotype).

(Figs 1A & 5A)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 3 cm diam.,

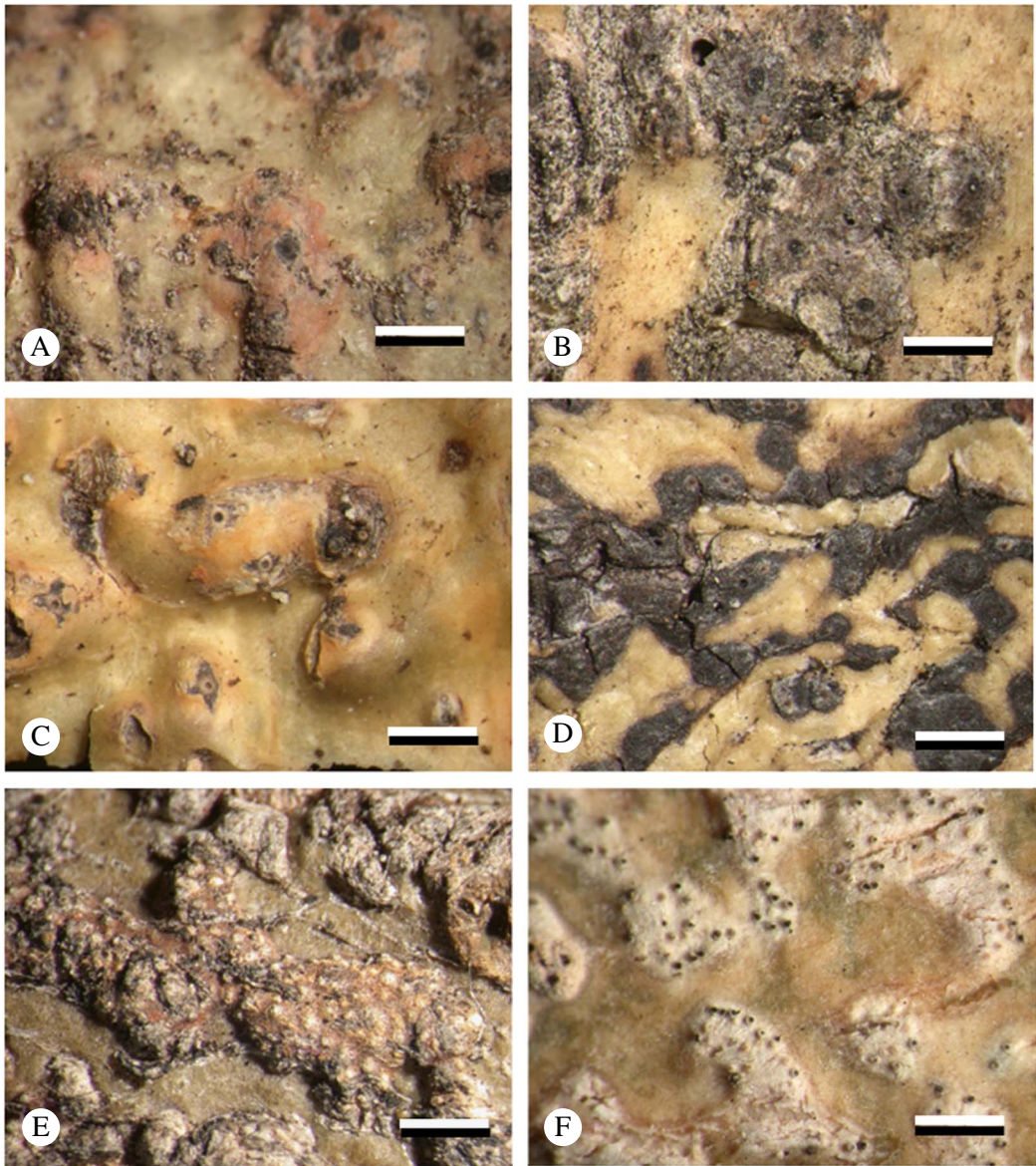


FIG. 1. Habitus of new species of *Trypetheliaceae* (isotypes). A, *Astrothelium bivelum*; B, *A. curvisporum*; C, *A. decemseptatum*; D, *A. disjunctum*; E, *A. duplicatum*; F, *A. eumuliseptatum*. Scales = 1 mm. In colour online.

c. 0.1 mm thick, ochraceous green, surrounded by an irregular and rough c. 0.4 mm wide black prothallus that seems to contain pycnidia, not inducing gall formation of the host bark.

Ascomata pyriform, 0.5–0.7 mm diam., mostly 2–6 aggregated, immersed in pseudostromata

with a surface only slightly different from the thallus, but not corticate, and which are distinctly raised above the thallus, irregular in outline, sides sloping, \leq c. 3 mm diam. and 1 mm high, ochraceous, not containing bark tissue. *Wall* carbonized all around, \leq c. 70 μ m thick. *Ostioles* eccentric, fused,

flat, black, surrounded by a black rim. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 5-septate, fusiform, $55\text{--}65 \times 18\text{--}21 \mu\text{m}$, pointed, lumina diamond-shaped, with two polar gelatinous caps $\leq 6 \mu\text{m}$ thick.

Pycnidia not observed, but prothallus lines seemingly containing old pycnidia.

Chemistry. Thallus surface UV–, thallus medulla K–; pigmented parts of pseudostroma UV+ pink, K–. TLC: besides an unidentified pigment, no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. This is one of the few astrotelioid species with 5-septate ascospores but without lichexanthone. The species is characterized by the polar gelatinous caps, a spectacular character known from few lichens. However, it is a character that may disappear in older material, especially when preservation conditions are suboptimal. Material without polar caps is closest to *A. supraclandestinum* (see below), which differs by the absence of the pinkish pigment.

***Astrothelium curvisporum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815160

Astrothelium with curved, 5-septate ascospores of $115\text{--}135 \times 29\text{--}36 \mu\text{m}$ with a $17\text{--}22 \mu\text{m}$ thick gelatinous layer.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, $8^{\circ}41'10''\text{S}$, $63^{\circ}52'05''\text{W}$, alt. *c.* 100 m, on twig in primary rainforest, 17 November 2012, *M. E. S. Cáceres* & *A. Aptroot* 15556 (ISE—holotype; ABL—isotype).

(Figs 1B & 5B)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas $\leq 5 \text{ cm}$ diam., *c.* 0.2 mm thick, olive-green to olive-brown, medulla whitish, not surrounded by a prothallus, not inducing gall formation of the host bark.

Ascomata globose, 0.8–1.2 mm diam., immersed in groups of 3–15 in pseudostromata with a surface different from the thallus, and distinctly raised above the thallus, irregular in

outline, sides sloping, $\leq c.$ 4 mm diam. and 1 mm high, brown with whitish pruina, inside containing bark tissue. *Wall* dark brown all around, $\leq c.$ 70 μm thick. *Ostioles* apical, not fused, flat, black, often surrounded by a round, flat black disc of *c.* 0.2 mm diam. *Hamathecium* heavily interspersed with hyaline oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 5-septate, fusiform, distinctly curved, $115\text{--}135 \times 29\text{--}36 \mu\text{m}$, ends rounded, lumina diamond-shaped, surrounded by a gelatinous layer $17\text{--}22 \mu\text{m}$ thick.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface UV–. TLC: no secondary substances detected.

Ecology and distribution. On twig in primary forest. Known only from Brazil.

Discussion. This species is characterized by the large, curved, 5-septate ascospores and especially by the very thick gelatinous layer, which is the thickest observed in the whole family. However, it is a character that might disappear in older material, especially when preservation conditions are suboptimal. Material without the gelatinous layer is closest to *A. sipmanii* Aptroot, which has straight ascospores.

***Astrothelium decemseptatum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815161

Astrothelium with pseudostroma that are essentially black and look like they are breaking through the bark, with anthraquinones, mostly on the pseudostromata but also on some parts of the thallus, best seen under UV light as the colour of the pruina is not very strong; ascospores (7–)9–11-septate, fusiform, $50\text{--}65 \times 11\text{--}17 \mu\text{m}$.

Type: Brazil, Rondônia, Sítio Ecológico Buriti on Lago Cujubim NE of Porto Velho, $8^{\circ}35'17''\text{S}$, $63^{\circ}40'40''\text{W}$, alt. *c.* 100 m, on tree bark in disturbed rainforest, 18 November 2012, *M. E. S. Cáceres* & *A. Aptroot* 15484 (ISE—holotype; ABL—isotype).

(Figs 1C & 5C)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas $\leq 7 \text{ cm}$ diam., under 0.1 mm thick, pale yellowish grey, not surrounded by a prothallus, not inducing gall formation of the host bark.

Ascomata pyriform, *c.* 0.6–1.2 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue, surfacing in a blackish, partly orange pruinose pseudostroma that seems to break through the corticated bark. *Wall* carbonized, $\leq c.$ 80 μm thick. *Ostioles* eccentric, fused, flat, tiny black dots surrounded by a whitish zone *c.* 0.1 mm wide. *Hamathecium* interspersed with hyaline oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, (7–)9–11-septate, fusiform, 50–65 \times 11–17 μm , ends rounded, lumina diamond-shaped, surrounded by a 2–4 μm thick gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface partly UV+ pink to orange, partly negative, thallus medulla K–; pseudostroma surface UV+ red, pigmented parts of pseudostroma K+ red. TLC: anthraquinones.

Ecology and distribution. On smooth bark of trees in disturbed forest. Known only from Brazil.

Discussion. This species contains anthraquinones, mostly on the pseudostromata but also on some parts of the thallus. It is best seen under UV light (the colour of the pruina is not very strong). The pseudostroma are essentially black and look like they are breaking through the bark. It is most similar to *A. cinereorosellum* (Krempelh.) Aptroot & Lücking, but this has shorter ascospores and contains lichexanthone in the thallus.

Additional specimen seen. **Brazil:** same as the type, 15488 (ABL, ISE).

***Astrothelium disjunctum* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815162

Astrothelium with black pseudostroma; ascospores 3-septate, (27–)29–33 \times (8–)12–14 μm .

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. *c.* 100 m, on tree bark in park near rainforest, 16 November 2012, M. E. S. Cáceres & A. Aptroot 15161 (ISE—holotype; ABL—istotype).

(Fig. 1D)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 5 cm

diam., *c.* 0.2 mm thick, pale yellowish grey, surrounded by a black prothallus line *c.* 0.3 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.4–0.6 mm diam., immersed in groups of 5–25 in pseudostromata (resembling true stromata) with a black surface different from the thallus, and which are distinctly raised above the thallus and mostly linear in outline and often forming a network. *Wall* dark brown all around, $\leq c.$ 100 μm thick. *Ostioles* apical, not fused, flat, tiny black dots surrounded by a whitish zone *c.* 0.1 mm wide. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, (27–)29–33 \times (8–)12–14 μm , ends rounded, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in park near rainforest. Known only from Brazil.

Discussion. Rather similar to *A. bicolor* (Taylor) Aptroot & Lücking, but with larger ascospores and a black pseudostroma that somewhat resembles a true fungal stroma.

Additional specimens seen. **Brazil:** same as the type, 15203, 15221 (ABL, ISE).

***Astrothelium duplicatum* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815163

Astrothelium similar to *A. mesoduplex*, but pseudostroma only yellowish inside and ascospores 45–55 \times 11–15 μm .

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. *c.* 100 m, on tree bark in park near rainforest, 16 November 2012, M. E. S. Cáceres & A. Aptroot 15165 (ISE—holotype; ABL—istotype).

(Fig. 1E)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 5 cm diam.,

c. 0.1 mm thick, olive-green, surrounded by a black prothallus line *c.* 0.3 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.4–0.6 mm diam., immersed in groups of *c.* 5–50 in pseudostromata. *Pseudostromata* with a surface different from the thallus, *c.* 0.5–1.0 mm raised above the thallus, irregular to linear or reticulate in outline, $\leq c.$ 3 mm wide, pale brown, pale yellow inside. *Wall* dark brown all around, $\leq c.$ 40 μm thick. *Ostioles* apical, not fused, flat to convex, brown. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, muriform, fusiform, 45–55 \times 11–15 μm , ends rounded, lumina angular with many oblique septa, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface UV+ red, medulla K+ blood red. TLC: an anthraquinone, probably parietin.

Ecology and distribution. On twigs of trees in primary forest and on bark in park near rainforest. Known only from Brazil.

Discussion. This is one of a group of probably related new species that mainly occur on branches in rainforest. The habitus is similar in shape, but not in colour, to several other *Astrothelium* species. *Astrothelium flavoduplex* and *A. ochroleucoides* differ, for example, by the presence of lichexanthone, *A. mesoduplex* and *A. flavoduplex* both by the yellow to orange pseudostromata, and all these three species by the longer ascospores.

Additional material seen. **Brazil:** same as the type, but on twig in rainforest, 2012, *M. E. S. Cáceres & A. Aptroot* 11245 (ABL, ISE); *ibid.*, 2012, *M. E. S. Cáceres & A. Aptroot* 15566 (ABL, ISE).

***Astrothelium eumultiseptatum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: 815164

Astrothelium similar to *Astrothelium eustomum* (Mont.) Müll. Arg., but with 9–11-septate ascospores 65–70 \times 15–17 μm .

Type: Brazil, Rondônia, Fazenda São Francisco off BR319, 30 km N of Porto Velho, 8°24'33"S, 63°58'56"W, alt. *c.* 100 m, on tree bark in primary rainforest, 15 March

2012, *M. E. S. Cáceres & A. Aptroot* 11828 (ISE—holotype; ABL—isotype).

(Figs 1F & 5D)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 7 cm diam., under 0.1 mm thick, pale yellowish grey, surrounded by a black prothallus line *c.* 0.3 mm wide, not inducing gall formation of the host bark.

Ascomata pyriform, *c.* 0.6–1.2 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue below pseudostromata with a whitish surface different from the thallus, and which are distinctly raised above the thallus and mostly linear in outline and often forming a network. *Wall* carbonized, $\leq c.$ 80 μm thick. *Ostioles* eccentric, fused, flat, pale brown, white pruinose, surrounded by a whitish zone. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 9–11-septate, fusiform, 65–70 \times 15–17 μm , ends pointed, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia abundant, black, only on the pseudostromata.

Chemistry. Thallus surface UV–, thallus medulla K–; ostiolar region UV+ yellow. TLC: lichexanthone.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. This species is similar to *Astrothelium eustomum* (Mont.) Müll. Arg., but differs by the 9–11-septate rather than 3–5-septate, and much larger, ascospores. The also newly described *A. macrostomum* Aptroot is intermediate, with 5–7-septate ascospores; the following species has submuriform ascospores.

***Astrothelium eustomurale* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815165

Astrothelium similar to *Astrothelium eustomum* (Mont.) Müll. Arg., but with submuriform ascospores 37–45 \times 15–19 μm .

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W,

alt. *c.* 100 m, on tree bark in primary rainforest, 9–12 March 2012, *M. E. S. Cáceres & A. Aptroot* 11547 (ISE—holotype; ABL—istotype).

(Figs 2A & 5E)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 12 cm diam., under 0.1 mm thick, pale yellowish grey, not surrounded by prothallus, not inducing gall formation of the host bark.

Ascomata pyriform, *c.* 0.6–1.2 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue below pseudostromata with a whitish surface different from the thallus, and which are distinctly raised above the thallus and mostly irregular in outline, not forming a network. *Wall* carbonized, $\leq c.$ 80 μ m thick. *Ostioles* eccentric, fused, flat, pale brownish, white pruinose, surrounded by a whitish zone. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, submuriform, fusiform, 37–45 \times 15–19 μ m, ends pointed, lumina diamond-shaped, often surrounded by a gelatinous layer ≤ 10 μ m thick.

Pycnidia abundant, black, only on the pseudostromata.

Chemistry. Thallus surface UV–, thallus medulla K–; ostiolar region UV+ yellow. TLC: lichexanthone.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil; locally common.

Discussion. This species is similar to *Astrothelium eustomum*, but differs in the submuriform rather than 3–5-septate ascospores. The also newly described *A. macrostomum* Aptroot with 5–7-septate ascospores, and the preceding species with 9–11-septate ascospores, are intermediate. This new species is locally common.

Additional specimens seen (all ABL, ISE). **Brazil:** same as the type, 11360, 11361, 11362, 11364, 11402; same locality as the type, 2012, 15615; Fazenda São Francisco off BR319, 30 km N of Porto Velho, alt. *c.* 100 m, on tree bark in primary rainforest, 2012, *Cáceres & Aptroot* 11857, 11940; UNIR Federal University campus SW of city, alt. *c.* 100 m, on tree bark in primary rainforest, 2012, *Cáceres & Aptroot* 11054, 11135.

***Astrothelium flavoduplex* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815167

Astrothelium similar to *A. mesoduplex*, but with ascospores 110–350 \times 20–27 μ m and lichexanthone present in the thallus.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. *c.* 100 m, on twig in primary rainforest, 19 November 2012, *M. E. S. Cáceres & A. Aptroot* 15553 (ISE—holotype; ABL—istotype).

(Figs 2B & 5P)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 8 cm diam., *c.* 0.1 mm thick, olive-green, surrounded by a black prothallus line *c.* 0.3 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.4–0.6 mm diam., immersed in groups of *c.* 7–50 in pseudostromata. *Pseudostromata* with a surface different from the thallus, *c.* 1 mm raised above the thallus, oval to irregular or reticulate in outline, $\leq c.$ 3 mm wide, yellow to orange or brownish, pale yellow inside. *Wall* dark brown all around, $\leq c.$ 40 μ m thick. *Ostioles* apical, not fused, flat to convex, brown. *Hamathecium* not interspersed with oil globules. *Asci* with 4–8 ascospores. *Ascospores* hyaline, muriform with *c.* 22–30 transverse septa, fusiform to clavate, 110–350 \times 20–27 μ m, upper end rounded, lower end pointed, lumina angular with only a few transverse, mostly oblique septa, median septum much thickened at the sides, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV+ yellow, thallus medulla K–; pseudostroma surface and medulla UV+ red, K+ blood red. TLC: an anthraquinone, probably parietin.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. Similar to *A. mesoduplex* but with longer ascospores and lichexanthone. The length of the ascospores is very variable; in general they are longer when the asci are

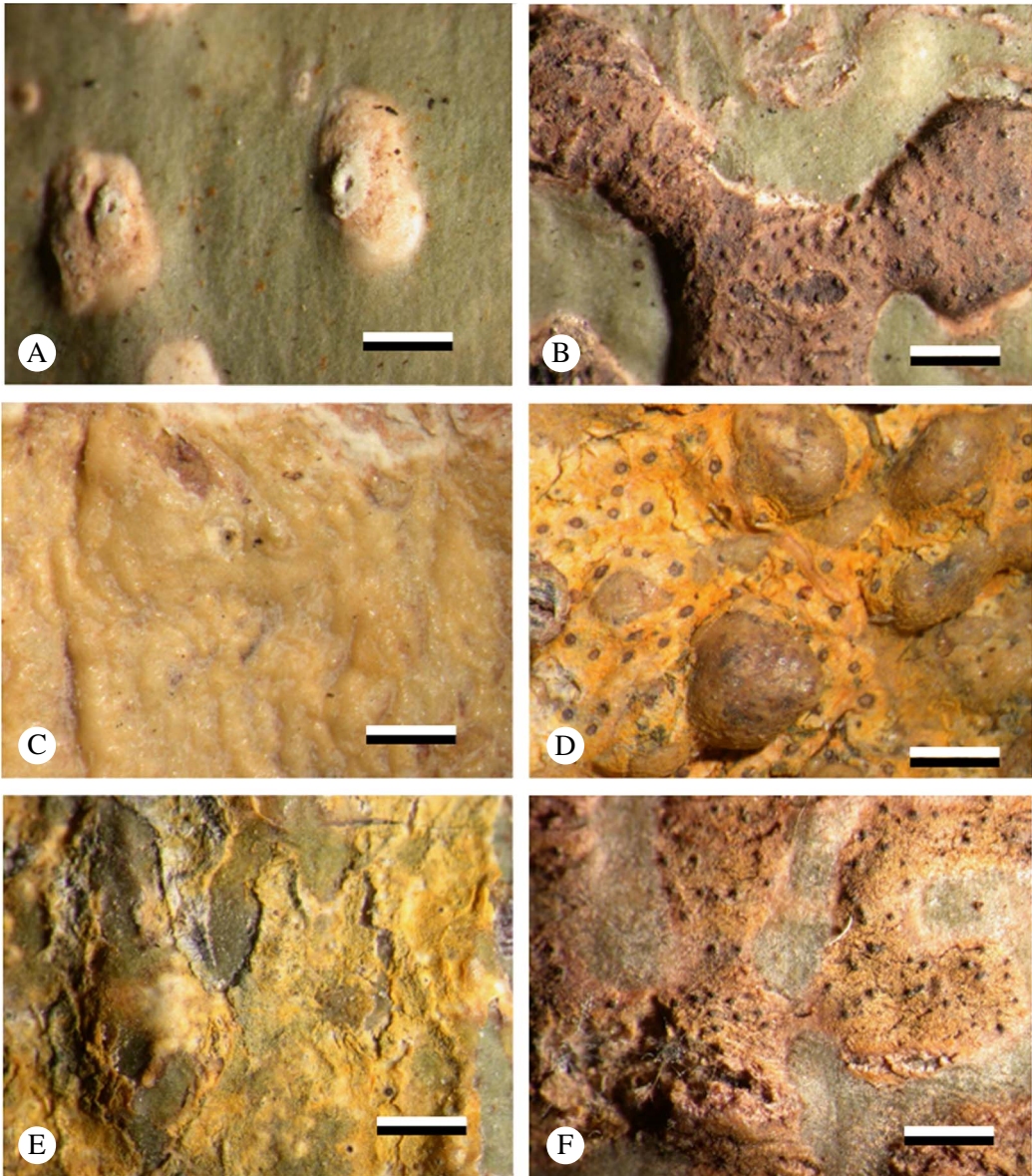


FIG. 2. Habitus of new species of *Trypetheliaceae* (isotypes). A, *Astrothelium eustomurale*; B, *A. flavoduplex*; C, *A. flavomurisporum*; D, *A. flavostromatum*; E, *A. flavum*; F, *A. mesoduplex*. Scales = 1 mm. In colour online.

4-spored, compared with those from 8-spored asci. This new species is widespread and locally common.

Additional material seen. **Brazil:** *Rondônia:* same as the type, M. E. S. Cáceres & A. Aptroot 15570, 15591a; *ibid.*, 2012, M. E. S. Cáceres & A. Aptroot 11251; same locality but in park near rainforest, 2012, M. E. S. Cáceres & A. Aptroot

15184; Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, 8°02'44"S, 63°29'11"W, alt. c. 100 m, on tree bark in primary rainforest, 2012, M. E. S. Cáceres & A. Aptroot 15622, 15704; Fazenda São Francisco off BR319, 30 km N of Porto Velho, 8°24'33"S, 63°58'56"W, alt. c. 100 m, on tree bark in primary rainforest, 2012, M. E. S. Cáceres & A. Aptroot 11836 (all ABL, ISE).—**Guyana:** *Upper Takutu Distr.:*

c. 4 km N of Kuyuwini Landing, along track to Karaudanawa, 1992, *Sipman* 57045 (B).—**Colombia:** Amazonas: Aracuara, opposite Isla Mariñame, alt. 240 m, 1988, *Sipman & Duivenvoorden* 28339 (B).

***Astrothelium flavomurisporum*
Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815168

Astrothelium with deeply immersed ascomata with muriform ascospores 165–200 × 28–35 µm, with a distinctly thickened central septum and yellow oil.

Type: Brazil, Rondônia, Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, 8°02'44"S, 63°29'11"W, alt. c. 100 m, on tree bark in primary rainforest, 20 November 2012, *M. E. S. Cáceres & A. Aptroot* 15697 (ISE—holotype; ABL—isotype).

(Figs 2C & 5F)

Thallus corticate, minutely bullate, somewhat shiny, continuous, covering areas ≤ 7 cm diam., c. 0.2 mm thick, olive-green, not surrounded by a prothallus, not inducing gall formation of the host bark.

Ascomata pyriform, 0.5–0.7 mm diam., 2–5 aggregated, deeply immersed in the bark, visible only from above by the ostioles, without pseudostroma. *Wall* carbonized, ≤ c. 70 µm thick. *Ostioles* eccentric, brown, flat to concave. *Hamathecium* not interspersed. *Ascospores* 8 per ascus, hyaline, muriform, long, ellipsoid, 165–200 × 28–35 µm, not surrounded by a gelatinous layer, lumina with yellow oil, central septum much thickened.

Pycnidia not observed.

Chemistry. Thallus and medulla UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. This species is characterized by the deeply immersed ascomata with muriform ascospores with a distinctly thickened central septum and yellow oil. The species is most similar to *A. cecidiogenum* (Aptroot & Lücking) Aptroot & Lücking, which has hyaline and generally shorter ascospores. Ascospores with yellow oil are otherwise known only from *Pseudopyrenula diluta*.

***Astrothelium flavostromatum* Aptroot
& M. Cáceres sp. nov.**

Mycobank No.: MB 815169

Astrothelium close to *A. aeneoides* Aptroot, mainly differing by the bullate thallus and the cream pseudostromata.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. c. 100 m, on tree bark in park near rainforest, 16 November 2012, *M. E. S. Cáceres & A. Aptroot* 15104 (ISE—holotype; ABL—isotype).

(Figs 2D & 5G)

Thallus corticate, bullate, somewhat shiny, continuous, covering areas ≤ 5 cm diam., c. 0.2 mm thick, olive-green to olive-grey, not surrounded by a prothallus, inducing gall formation of the host bark.

Ascomata globose, 0.6–1.0 mm diam., immersed in groups of 5–25 in pseudostromata with a surface different from the thallus, which are not distinctly raised above the thallus and often even lower, linear to irregular in outline and often forming a network, cream with yellow pruina. *Wall* black all around, ≤ c. 70 µm thick. *Ostioles* apical, not fused, mostly concave, brown, often with a thin blackish rim. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, 23–25 × 9–10 µm, ends rounded, lumina diamond-shaped, surrounded by a gelatinous layer ≤ 5 µm thick.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface UV+ pink to orange, pigmented parts of pseudostroma K+ blood red. TLC: an anthraquinone, probably parietin.

Ecology and distribution. On smooth bark of trees in park near rainforest. Known only from Brazil.

Discussion. This species is closest in key characters to *A. aeneoides*, and mainly differs by the bullate thallus and the cream pseudostromata.

***Astrothelium flavum* Aptroot &
M. Cáceres sp. nov.**

Mycobank No.: MB 815170

Astrothelium similar to *A. aeneum* (Eschw.) Aptroot & Lücking, but differing in the contrast between the linear

to reticulate yellow stromata and the unpigmented thallus, and ascospores $16\text{--}18 \times 6\text{--}7 \mu\text{m}$.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, $8^{\circ}41'10''\text{S}$, $63^{\circ}52'05''\text{W}$, alt. c. 100 m, on tree bark in primary rainforest, 9–12 March 2012, *M. E. S. Cáceres & A. Aptroot* 11410 (ISE—holotype; ABL—isotype).

(Figs 2E & 5H)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas of ≤ 5 cm diam., c. 0.2 mm thick, olive-green to olive-grey, surrounded by a violet-brown prothallus line c. 0.3 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.4–0.7 mm diam., immersed in groups of 5–25 in pseudostromata with a surface different from the thallus, and which are slightly raised above the thallus, irregular to linear or reticulate in outline, $\leq c.$ 3 mm wide, bright yellow, inside with bark tissue. *Wall* dark brown all around, $\leq c.$ 40 μm thick. *Ostioles* apical, not fused, flat to concave, black. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, $16\text{--}18 \times 6\text{--}7 \mu\text{m}$, ends rounded, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface UV+ red, K+ blood red. TLC: an anthraquinone, probably parietin.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. This species is similar to *A. aeneum*, but differs in the contrast between the linear to reticulate yellow stromata and the non-pigmented thalli, and the relatively small ascospores.

***Astrothelium mesoduplex* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815171

Astrothelium similar to *A. flavoduplex*, but ascospores $90\text{--}100 \times 20\text{--}23 \mu\text{m}$ and the thallus is without lichexanthone.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, $8^{\circ}41'10''\text{S}$, $63^{\circ}52'05''\text{W}$, alt. c. 100 m, on twig in primary rainforest, 19 November

2012, *M. E. S. Cáceres & A. Aptroot* 15559 (ISE—holotype; ABL—isotype).

(Fig. 2F)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 8 cm diam., c. 0.1 mm thick, olive-green, surrounded by a black prothallus line c. 0.2 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.4–0.6 mm diam., immersed in groups of c. 3–50 in pseudostromata. *Pseudostromata* with a surface different from the thallus, c. 1 mm raised above the thallus, oval to irregular in outline, $\leq c.$ 3 mm wide, yellow to orange, pale yellow inside. *Wall* dark brown all around, $\leq c.$ 40 μm thick. *Ostioles* apical, not fused, flat to convex, brown. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, muriform with c. 22–30 transverse septa, fusiform to clavate, $90\text{--}100 \times 20\text{--}23 \mu\text{m}$, ends rounded, lumina angular with mostly oblique septa, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface and medulla UV+ red, K+ blood red. TLC: an anthraquinone, probably parietin.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. Similar to *A. flavoduplex* which has longer ascospores and contains lichexanthone. The new species is locally common.

Additional material seen (all ABL, ISE). **Brazil:** same as the type, 15555, 15591o; *ibid.*, 2012, *M. E. S. Cáceres & A. Aptroot* 11253, 11254; Rondônia, Fazenda São Francisco off BR319, 30 km N of Porto Velho, $8^{\circ}24'33''\text{S}$, $63^{\circ}58'56''\text{W}$, alt. c. 100 m, on tree bark in primary rainforest, 2012, *M. E. S. Cáceres & A. Aptroot* 11958.

***Astrothelium nigrum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815174

Astrothelium characterized by the mostly conical black pseudostromata that contrast sharply with the thallus, superficially resembling *Pyrenula infraleuconotrypa* Aptroot & M. Cáceres.

Type: Brazil, Rondônia, Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, $8^{\circ}02'44''\text{S}$, $63^{\circ}29'11''\text{W}$, alt. c. 100 m, on tree bark in primary

rainforest, 20 November 2012, M. E. S. Cáceres & A. Aptroot 15703 (ISE—holotype; ABL—istotype).

(Fig. 3A & B)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 10 cm diam., c. 0.1 mm thick, ochraceous green, surrounded by a black prothallus line c. 0.4 mm wide, inducing gall formation of the host bark in the form of making the bark pieces become slightly concave and thickened along the cracks so that they are almost flaking off.

Ascomata pyriform, 0.2–0.4 mm wide, 0.5–0.7 mm high, mostly 4–16 aggregated, immersed in conical to hemispherical pseudostromata with a black surface which is not corticated; *pseudostromata* distinctly raised above the thallus, regular in outline, sides sloping, $\leq c.$ 2 mm diam. and 0.7 mm high, consisting of carbonized bark tissue. *Wall* carbonized all around, $\leq c.$ 100 μ m thick. *Ostioles* eccentric, fused, flat to convex, black, surrounded by a dull grey pruinose rim. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, 19–21 \times 7–8 μ m, ends rounded, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. Unique in the mostly conical black pseudostromata that contrast sharply with the thallus, superficially giving it the impression of a *Pyrenula* species such as *P. infraleucotrypa*. No other *Trypetheliaceae* is close in appearance.

***Astrothelium novemseptatum* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815175

Astrothelium similar to *A. eumultiseptatum* Aptroot & M. Cáceres, but without lichexanthone anywhere in the thallus or pseudostroma.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. c. 100 m, on tree bark in primary rainforest,

9–12 March 2012, M. E. S. Cáceres & A. Aptroot 11538 (ISE—holotype; ABL—istotype).

(Figs 3C & 5I)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 7 cm diam., c. 0.2 mm thick, pale greenish grey, with or without a black prothallus line c. 0.3 mm wide, inducing infrequent semi-globose galls of the host bark (lower bark locally swollen and erupting through bark).

Ascomata pyriform, c. 0.4–0.7 mm diam., mostly aggregated with 4–10, mostly immersed in the bark tissue below pseudostromata with a whitish surface different from the thallus, and which are distinctly raised above the thallus and mostly oval in outline, and ≤ 3 mm wide and ≤ 6 mm long. *Wall* carbonized, $\leq c.$ 40 μ m thick. *Ostioles* eccentric, fused, flat, pale brown, surrounded by a whitish zone. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 9-septate, fusiform, 49–55 \times 12–17 μ m, ends pointed, lumina diamond-shaped, when fresh surrounded by a gelatinous layer ≤ 8 μ m thick.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known from Brazil, Guyana and Colombia.

Discussion. This species is most similar to *A. eumultiseptatum* (see above), which however has lichexanthone on the ostioles.

Additional specimens seen. **Guyana:** Essequibo River, Gunn's, 1989, *Jansen-Jacobs et al.* 1868 (ABL, L); Potaro-Siparuni Region, Kaieteur Falls National Park, around airstrip, *Sipman* 40456, 1996 (B).—**Colombia:** Amazonas: Araracuara, opposite airstrip, alt. 350 m, 1988, *Sipman & Duivenvoorden* 27867 (B).

***Astrothelium ochroleucoides* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815176

Astrothelium similar to *A. corallinum* Aptroot, but with lichexanthone on the thallus and pseudostromata.

Type: Brazil, Rondônia, Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, 8°02'44"S,

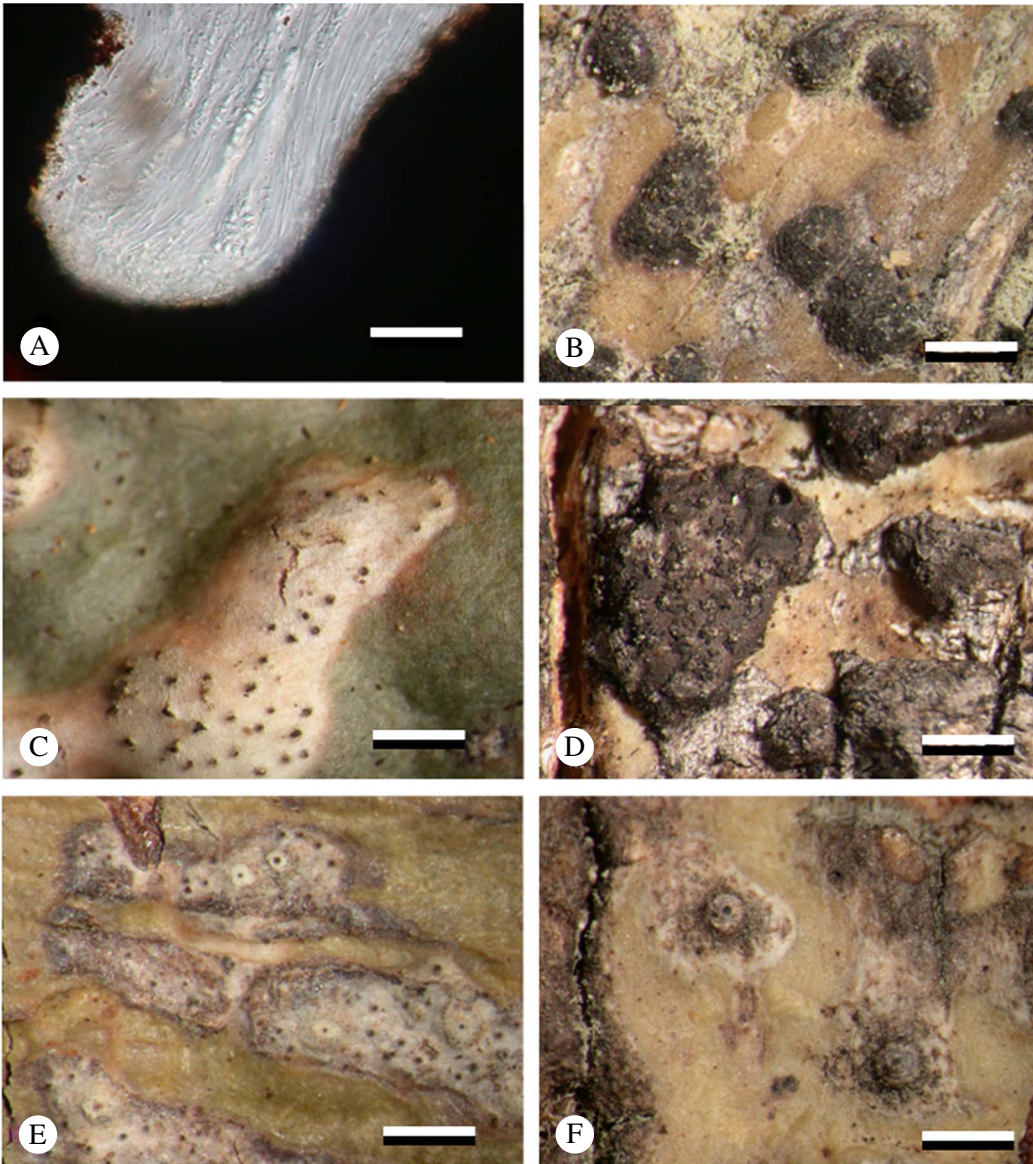


FIG. 3. Habitus (except 3A) of new species of *Trypetheliaceae*, (isotypes). A, *Astrothelium nigrum*, section showing full carbonization; B, *A. nigrum*; C, *A. novemseptatum*; D, *A. ochroleuroides*; E, *A. octoseptatum*; F, *A. quatuorseptatum*. Scales: A = 40 μ m; B–F = 1 mm. In colour online.

63°29'11"W, alt. c. 100 m, on tree bark in primary rain-forest, 20 November 2012, M. E. S. Cáceres & A. Aptroot 15705 (ISE—holotype; ABL—isotype).

(Fig. 3D)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas \leq 8 cm diam.,

c. 0.1 mm thick, olive-green, surrounded by a black prothallus line c. 0.3 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.4–0.6 mm diam., immersed in groups of c. 2–40 in pseudo-stromata. *Pseudostroma* with a surface different from the thallus, c. 0.5–1.0 mm raised

above the thallus, oval to irregular or reticulate in outline, $\leq c.$ 3 mm wide, brownish black, usually partly with whitish cover, partly brownish, partly whitish inside. *Wall* dark brown all around, $\leq c.$ 40 μm thick. *Ostioles* apical, not fused, flat to convex, brown. *Hamathecium* not interspersed with oil globules. *Asci* with 4 ascospores. *Ascospores* hyaline, muriform, fusiform, 80–115 \times 15–24 μm , upper end rounded, lower end pointed, lumina angular with only a few transverse, mostly oblique septa, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV+ yellow, thallus medulla K–; whitish parts of pseudostroma surface UV+ yellow, K–, pseudostroma medulla K–. TLC: lichexanthone in the thallus and on pseudostroma.

Ecology and distribution. On twigs or bark of tree trunks in primary forest, but also in parks and savannahs. Known from Brazil and Guyana where it is locally abundant.

Discussion. This species differs from *A. duplicatum*, *A. flavoduplex* and *A. mesoduplex*, all described above, by the blackish pseudostroma and the absence of anthraquinones. It is most similar to *A. corallinum* Aptroot, which differs by the UV– thallus. These two species grow together in close contact in Guyana. The new species is widespread and locally common.

Additional material seen. **Brazil:** Rondônia: Porto Velho, Parque Natural Municipal de Porto Velho, alt. c. 100 m, on twig in primary rainforest, 2012, Cáceres & Aptroot 15559 (ISE, ABL); same locality but in park near rainforest, 2012, Cáceres & Aptroot 15166, 15169, 15173, 15174, 15176, 15177 (all ISE, ABL). **Mato Grosso:** Jaciara-Sao Vicente, Kalb, 1980 (hb. Kalb).—**Guyana:** East Demarara: Timehri, Dakara Creek, Thompson's farm, 1985, Sipman & Aptroot 18951 & 18051 (ABL, B); along Linden highway, Soesdyke, 1996, Sipman 40261 (B); along Linden highway E of Timehri airport., alt. 10 m, 1985, Sipman & Aptroot 19603 (B, ABL). **Upper Takutu:** Rupununi Savannah, Kusad Mountain, 1992, Sipman 57826 (B); Kuyuwini Landing, 1992, Sipman 57057, 57120, 57121 & 57053 (B). **Potaro-Siparuni Region:** surroundings of Paramakatoi Village, alt. 800 m, 1996, Sipman 41275pp (B).

***Astrothelium octoseptatum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815177

Astrothelium similar to *A. eumultiseptatum* Aptroot & M. Cáceres, but with the whole pseudostroma, not just the ostioles, containing lichexanthone; ascospores somewhat asymmetrical, which is highlighted by the unusual dominant even number of septa (eight) and the asymmetrically placed central septum in the case of uneven septum numbers.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, 8°41'10"S, 63°52'05"W, alt. c. 100 m, on tree bark in primary rainforest, 19 November 2012, M. E. S. Cáceres & A. Aptroot 15614 (ISE—holotype; ABL—isotype).

(Figs 3E & 5J)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 7 cm diam., c. 0.1 mm thick, pale greenish grey, not surrounded by a prothallus, not inducing gall formation of the host bark.

Ascomata pyriform, c. 0.6–0.9 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue below pseudostromata. *Pseudostroma* well delimited, not corticate, brown with a whitish (partly brown when abraded) surface clearly different from the thallus, distinctly c. 0.5 mm raised above the thallus, ≤ 3 mm wide and ≤ 7 mm long, irregular in outline and sometimes forming a network. *Wall* brown, $\leq c.$ 30 μm thick. *Ostioles* eccentric, fused, flat, brown, surrounded by a whitish zone. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, (7–)8(–)septate, fusiform, 40–57 \times 15–19 μm , middle septum (if present) asymmetrical (dividing the ascospore into two unequal parts), ends rounded, lumina diamond-shaped, surrounded by a gelatinous layer ≤ 7 μm thick.

Pycnidia abundant, black, only on the pseudostromata.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface UV+ yellow. TLC: lichexanthone.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. Somewhat similar to *A. eumultiseptatum* (see above), in which only the

ostioles contain lichexanthone. The ascospores of this species are somewhat asymmetrical, which is highlighted by the unusual dominant even number of septa (eight) and the asymmetrically placed central septum in the case of uneven septum numbers.

Additional specimen seen. Brazil: Rondônia: Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, 8°02'44"S, 63°29'11"W, alt. *c.* 100 m, on tree bark in primary rainforest, 2012, *Cáceres & Aptroot* 15831 (ISE, ABL).

***Astrothelium quatuorseptatum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815179

Astrothelium similar to *A. octoseptatum* Aptroot & M. Cáceres, but without lichexanthone; ascospores somewhat asymmetrical, which is highlighted by the unusual dominant even number of septa (four) and the asymmetrically placed central septum in the case of uneven septum numbers.

Type: Brazil, Rondônia, Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, 8°02'44"S, 63°29'11"W, alt. *c.* 100 m, on tree bark in primary rainforest, 20 November 2012, *M. E. S. Cáceres & A. Aptroot* 15717 (ISE—holotype; ABL—istotype).

(Figs 3F & 5K)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 7 cm diam., *c.* 0.1 mm thick, pale greenish grey, surrounded by a prothallus line *c.* 0.1 mm wide, inducing gall formation of the host bark in the form of making the bark pieces become slightly concave and thickened along the cracks so that they are almost flaking off.

Ascomata pyriform, *c.* 0.6–0.8 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue below pseudostromata. *Pseudostroma* well delimited, not corticate, brown, occasionally with a whitish (usually abraded) surface clearly different from the thallus, distinctly *c.* 0.3 mm raised above the thallus, ≤ 2 mm diam., rounded to somewhat irregular in outline. *Wall* brown, $\leq c.$ 30 μ m thick. *Ostioles* eccentric, fused, flat to convex, brown, surrounded by a whitish grey zone. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, (3–)4(–5)-septate, fusiform, 45–55 \times 15–18 μ m, middle septum (if present)

asymmetrical (dividing the ascospore into two unequal parts), ends rounded, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. Similar to *A. octosporum* (see above) in the asymmetrical ascospores, but with only half the number of septa and without lichexanthone.

***Astrothelium robustosporum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815180

Astrothelium with solitary ascomata with an eccentric ostiole, ascospores 11–15-septate, 90–125 \times 20–27 μ m.

Type: Brazil, Rondônia, Estação Ecológica de Cuniã, km 760 on road BR 319 NNE of Porto Velho, 8°02'44"S, 63°29'11"W, alt. *c.* 100 m, on tree bark in primary rainforest, 13 March 2012, *M. E. S. Cáceres & A. Aptroot* 11696 (ISE—holotype; ABL—istotype).

(Figs 4A & 5L)

Thallus corticate, smooth, dull, continuous but locally abraded, covering areas ≤ 10 cm diam., *c.* 0.1 mm thick, pale ochraceous green, not surrounded by a prothallus, not inducing gall formation of the host bark.

Ascomata pyriform (somewhat triangular in horizontal section), 0.6–0.9 mm wide, 0.7–1.1 mm long, solitary, completely immersed in the bark, without visible pseudostromata or swellings. *Wall* carbonized all around, $\leq c.$ 60 μ m thick. *Ostioles* eccentric, simple, flat to convex, black, presenting the only part of the ascoma that is visible from above. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 11–15-septate, fusiform, 90–125 \times 20–27 μ m, pointed, lumina diamond-shaped, surrounded by a gelatinous layer ≤ 10 μ m thick, central septum much thickened at the sides.

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

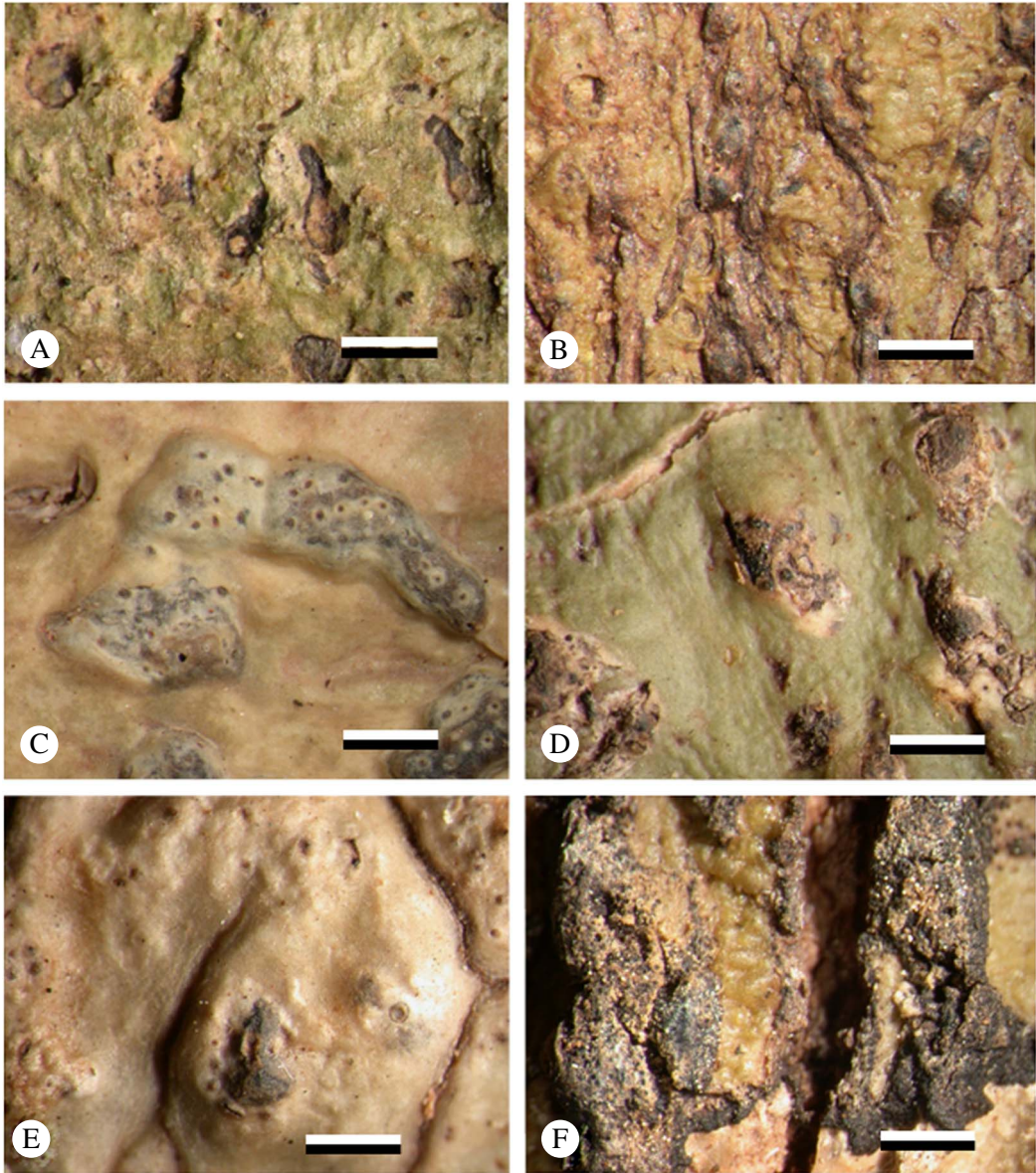


FIG. 4. Habitus of new species of *Trypetheliaceae*, (isotypes). A, *Astrothelium robustosporum*; B, *A. solitarium*; C, *A. stromatofluorescens*; D, *A. supraclandestinum*; E, *A. testudineum*; F, *A. xanthosuperbum*. Scales = 1 mm. In colour online.

Chemistry. Thallus and medulla UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. This species resembles some *Astrothelium* species that were formerly in *Campylothelium* (such as *A. puiggarii* (Müll. Arg.) Aptroot & Lücking) in gross morphology due to the solitary ascomata with eccentric ostiole, but it has large ascospores that are only

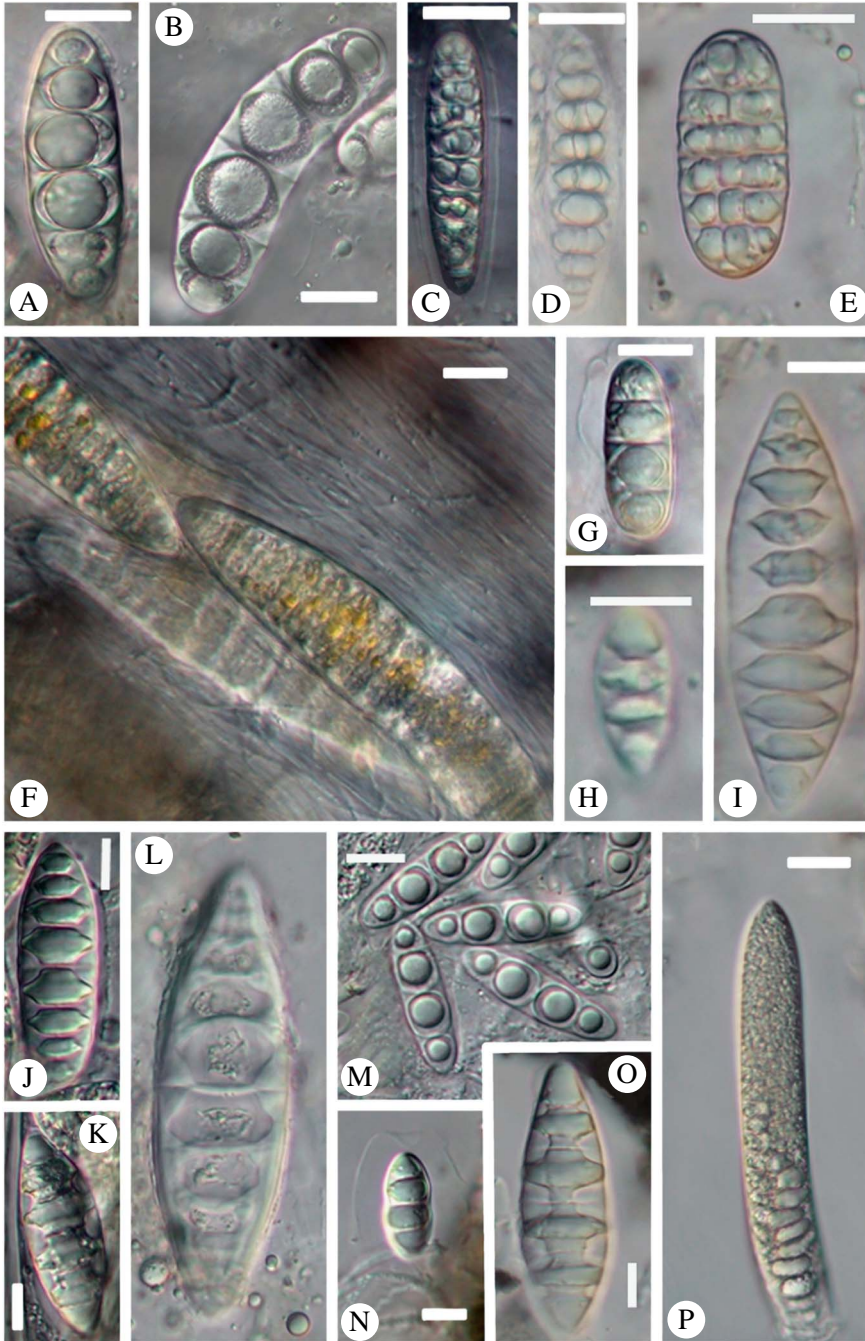


FIG. 5. Ascospores of new species of *Trypetheliaceae*, (isotypes). A, *Astrothelium bivelum*; B, *A. curvisporum*; C, *A. decemseptatum*; D, *A. eumultiseptatum*; E, *A. eustomurale*; F, *A. flavomurisporum*; G, *A. flavostromatum*; H, *A. flavum*; I, *A. novemseptatum*; J, *A. octoseptatum*; K, *A. quatuorseptatum*; L, *A. robustosporum*; M, *A. solitarium*; N, *A. stromatofluorescens*; O, *A. supraclandestinum*; P, *A. flavoduplex*. Scales: A–F & P = 20 μm ; G–O = 10 μm .
In colour online.

transversely septate rather than muriform as in all former *Campylothelium* species. The new species is most similar to *A. basilicum* (Krempelh.) Aptroot & Lücking, which has longer ascospores.

***Astrothelium solitarium* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815181

Astrothelium similar to *A. ceratinum* (Fée) Aptroot & Lücking, but with ascospores $33\text{--}36 \times 10\text{--}11 \mu\text{m}$.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, $8^{\circ}41'10''\text{S}$, $63^{\circ}52'05''\text{W}$, alt. c. 100 m, on tree bark in primary rainforest, 19 November 2012, M. E. S. Cáceres & A. Aptroot 15501 (ISE—holotype; ABL—istotype).

(Figs 4B & 5M)

Thallus corticate, smooth, shiny, continuous, covering areas ≤ 3 cm diam., under 0.1 mm thick, olive-green, surrounded by a dark brown prothallus line c. 0.1 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.3–0.5 mm diam., solitary or in groups of 2–4, erumpent from the bark, black, partly with irregular thallus coverage, not in pseudostromata. *Wall* black all around, \leq c. 30 μm thick. *Ostioles* apical, not fused, flat, dark brown, often surrounded by a pale brown ring. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, $33\text{--}36 \times 10\text{--}11 \mu\text{m}$, ends rounded, lumina diamond-shaped, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus and medulla UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known only from Brazil.

Discussion. This species is most similar to *A. ceratinum*, which has smaller ascospores.

***Astrothelium stromatofluorescens* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815183

Astrothelium close to *A. phlyctaena* (Fée) Aptroot & Lücking, but with lichexanthone only on the pseudostroma, not on the thallus.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, $8^{\circ}41'10''\text{S}$, $63^{\circ}52'05''\text{W}$, alt. c. 100 m, on tree bark in park near rainforest, 16 November 2012, M. E. S. Cáceres & A. Aptroot 15224 (ISE—holotype; ABL—istotype).

(Figs 4C & 5N)

Thallus corticate, smooth, somewhat shiny, continuous, covering areas ≤ 7 cm diam., c. 0.1 mm thick, pale ochraceous green, surrounded by a black prothallus line c. 0.2 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.2–0.5 mm diam., immersed in groups of 7–50 in pseudostromata, not all reaching the surface at one time. *Pseudostromata* well delimited, not corticate, slate grey with a whitish (partly slate grey when abraded) surface clearly different from the thallus, distinctly c. 1 mm raised above the thallus, ≤ 7 mm diam., irregular in outline and sometimes forming a network, inside with carbonized bark tissue. *Wall* black, \leq c. 30 μm thick. *Ostioles* apical, not fused, flat to concave, ferruginous brown, surrounded by a whitish zone. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, $20\text{--}23 \times 7\text{--}9 \mu\text{m}$, ends rounded, lumina diamond-shaped, surrounded by a gelatinous layer $\leq 6 \mu\text{m}$ thick.

Pycnidia not observed.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma surface UV+ yellow. TLC: lichexanthone.

Ecology and distribution. On bark of trees in park near rainforest. Known only from Brazil.

Discussion. This species is close to *A. phlyctaenum*, which has lichexanthone not only on the pseudostroma, but also on the thallus.

***Astrothelium supraclandestinum* Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815185

Astrothelium close to *A. subclandestinum* Leight., but hamathecium not interspersed.

Type: Brazil, Rondônia, Porto Velho, Parque Natural Municipal de Porto Velho, $8^{\circ}41'10''\text{S}$, $63^{\circ}52'05''\text{W}$, alt. c. 100 m, on tree bark in primary rainforest,

9–12 March 2012, *M. E. S. Cáceres & A. Aptroot* 11344 (ISE—holotype; ABL—iso-type).

(Figs 4D & 5O)

Thallus corticate, smooth to somewhat bullate, somewhat shiny, continuous, covering areas ≤ 7 cm diam., *c.* 0.1 mm thick, greenish grey, surrounded by a prothallus line *c.* 0.2 mm wide, infrequently inducing semiglobose galls of the host bark (lower bark locally swollen and erupting through bark).

Ascomata pyriform, *c.* 0.5–0.8 mm diam., mostly 2–5 aggregated, mostly immersed in the bark tissue below pseudostromata. *Pseudostromata* indistinctly delimited, not corticate, ochraceous or concolorous with the thallus, not much raised above the thallus, ≤ 2 mm diam., rounded to somewhat irregular in outline. *Wall* black, $\leq c.$ 60 μ m thick. *Ostioles* eccentric, fused, flat to convex, brown to black. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 5-septate, fusiform, 50–75 \times 14–22 μ m, ends rounded, lumina diamond-shaped, surrounded by a gelatinous layer ≤ 2 μ m thick.

Pycnidia frequent, in the pseudostromata.

Chemistry. Thallus surface UV–, thallus medulla K–; pseudostroma UV–, K–. TLC: no secondary substances detected.

Ecology and distribution. On smooth bark of trees in primary forest. Known from Brazil, Venezuela, Australia and Papua New Guinea.

Discussion. This species is close to *A. subclandestinum*, which has an interspersed hamathecium. It is widespread.

Additional material seen. **Brazil:** same as the type, 11343 (ISE, ABL).—**Venezuela:** Amazonas: Alto Orinoco, Surumoni, 1998, *Hafellner & Komposch* 313–5–48, 313–5–49, 28–21, 17–2 & 3175 (GZU).—**Australia:** Queensland: Millaa Millaa, *Hale* 64166 (ABL, US).—**Papua New Guinea:** Madang: foothills of Finisterre Range, along road Madang–Lae, km 39, 1992, *Aptroot* 33209 (ABL).

***Astrothelium testudineum* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 815186

Astrothelium with solitary ascomata with an eccentric ostiole, interspersed hamathecium, ascospores 8 per ascus, muriform, 50–65 \times 23–27 μ m.

Type: Brazil, Rondônia, Porto Velho, Parque Circuito, 8°43'54"S, 63°54'04"W, alt. *c.* 100 m, on *Hevea brasiliensis* bark in plantation, 8 March 2012, *M. E. S. Cáceres & A. Aptroot* 11448a (ISE—holotype; ABL—iso-type).

(Fig. 4E)

Thallus thickly corticate, smooth, somewhat shiny, continuous, covering areas ≤ 5 cm diam., *c.* 0.2 mm thick, ochraceous, surrounded by a black prothallus line *c.* 0.1 mm wide, not inducing gall formation of the host bark.

Ascomata pyriform, 0.5–0.9 mm diam., mostly 2–6 aggregated, immersed in the thallus, without pseudostroma, but occasionally with paler, lesser corticate areas around the ostioles. *Wall* carbonized all around, $\leq c.$ 70 μ m thick. *Ostioles* eccentric, fused, flat, brown. *Hamathecium* densely interspersed with hyaline oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, densely muriform with many locules in straight rows and partly skewed septa, broadly ellipsoid, 50–65 \times 23–27 μ m, rounded, lumina angular, wall 2 μ m thick.

Pycnidia pale brown, immature but abundant, near the ostioles.

Chemistry. Thallus surface UV–, thallus medulla K–. TLC: no secondary substances detected.

Ecology and distribution. On *Hevea brasiliensis* bark in plantation. Known only from Brazil.

Discussion. This species is similar to some *Astrothelium* species that were described in *Campylothelium*, in the solitary ascomata with eccentric ostioles, but it differs from all other described species by the combination of ascospore size, number of ascospores in the ascus and hamathecium interspersed. It is most similar to *A. leioplacum* (Müll. Arg.) Aptroot & Lücking, which has no hamathecium interspersed and shorter ascospores.

Additional material seen. **Venezuela:** Amazonas: Alto Orinoco, *c.* 15 km SW of La Esmeralda, W bank of Surumoni, on *Goupia glabra*, alt. 110 m, 1997, *Hafellner & Komposch* 909–5–24 (GZU).

***Astrothelium xanthosuperbum*
Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815187

Astrothelium similar to *A. disjunctum* Aptroot & M. Cáceres, but ascospores muriform, 130–160 × 28–35 µm.

Type: Brazil, Rondônia, Sítio Ecológico Buriti on Lago Cujubim NE of Porto Velho, 8°35'17"S, 63°40'40"W, alt. c. 100 m, on tree bark in disturbed rainforest, 18 November 2012, M. E. S. Cáceres & A. Aptroot 15441 (ISE—holotype; ABL—istotype).

(Fig. 4F)

Thallus corticate, smooth, shiny, continuous, covering areas ≤ 3 cm diam., under 0.1 mm thick, olive-green, surrounded by a dark black prothallus line c. 0.3 mm wide, inducing gall formation of the host bark in the form of making the bark pieces become slightly concave and thickened along the cracks so that they are almost flaking off.

Ascomata globose, 0.4–0.7 mm diam., solitary, mostly 2–6 aggregated, immersed in pseudostroma. *Pseudostromata* black, raised above the thallus, irregular in outline or usually in lines, ≤ 2 mm wide and ≤ 7 mm long. *Wall* black all around, ≤ c. 50 µm thick. *Ostioles* apical, not fused, flat, dark brown, often surrounded by a pale brown ring. *Hamathecium* not interspersed with oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, muriform, ellipsoid, 130–160 × 28–35 µm, ends rounded, lumina angular, not surrounded by a gelatinous layer.

Pycnidia young, abundant, in the pseudostroma.

Chemistry. Thallus surface UV+ yellow, thallus medulla K–. TLC: lichexanthone.

Ecology and distribution. On smooth bark of trees in disturbed rainforest. Known only from Brazil.

Discussion. This species looks superficially like *A. disjunctum* (see above), but differs in the large muriform ascospores.

***Pseudopyrenula flavoreagens*
Aptroot & M. Cáceres sp. nov.**

Mycobank No.: MB 815189

Pseudopyrenula similar to *P. subgregaria* Müll. Arg., but with lichexanthone in the thallus.

Type: Brazil, Rondônia, Sítio Ecológico Buriti on Lago Cujubim NE of Porto Velho, 8°35'17"S, 63°40'40"W, alt. c. 100 m, on tree bark in disturbed rainforest, 18 November 2012, M. E. S. Cáceres & A. Aptroot 15443 (ISE—holotype; ABL—istotype).

Thallus not corticate, dull, continuous, covering areas ≤ 2 cm diam., whitish grey, surrounded by a black hypothallus line c. 0.2 mm wide, not inducing gall formation of the host bark.

Ascomata globose, 0.25–0.35 mm diam., single, emergent from the thallus. *Wall* carbonized, ≤ c. 40 µm thick. *Ostioles* apical, not fused, flat, black. *Hamathecium* interspersed with yellow oil globules. *Asci* with 8 ascospores. *Ascospores* hyaline, 3-septate, fusiform, 21–28 × 6–9 µm, ends pointed, lumina diamond-shaped, partly yellow, not surrounded by a gelatinous layer.

Pycnidia not observed.

Chemistry. Thallus UV+ yellow, KOH–. TLC: lichexanthone.

Ecology and distribution. On smooth bark of trees in primary forest, but also in disturbed rainforest. Known from Brazil and Panama.

Discussion. This species differs from *P. subgregaria* by the presence of lichexanthone in the thallus. This new species is widespread.

Additional specimens seen. **Brazil**: Minas Gerais; Catas Altas, Serra do Caraça, Parque Natural de Caraça, near Tanque Grande, on *Araucaria*, alt. 1270 m, 1997, Aptroot 41518 (SP, ABL).—**Panama**: Veraguas: Bahía Honda, Cabrera & Etayo 18518 (ABL, hb. Etayo).

Discussion

Currently, 55 species of *Trypetheliaceae* are known from this small area in Rondônia, including 46 species of *Astrothelium* (out of less than 200 known worldwide). The presence of so many species in such a limited area, in addition to the high numbers of species found in lowland areas of the Guianas, Bolivia, Colombia and Venezuela, suggests that the Amazon basin is the centre of diversity for the family, at least for *Astrothelium*, which in its revised circumscription is the largest genus of the family.

The CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) is thanked for a research grant to MESC (Processo 311706/2012-6). The costs of the collecting expeditions to MESC were financed by CNPq (CNPq-Protax Processo 562330/2010-0 and INCT-Herbário Virtual Processo 563342/2010-2). Elton Bill Souza and Allyne Christina Gomes Silva are thanked for logistical support and for organizing the collecting trips. Leo Spier is thanked for performing thin-layer chromatography.

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