New species of lichenized fungi from Brazil, with a record report of 492 species in a small area of the Amazon Forest

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ABSTRACT. We report a record lichen biodiversity from a small area in the Brazilian Amazon, with 492 identifiable lichen species within nine hectares of protected forest, in the Cristalino Reserve in Mato Grosso, Brazil, collected during one week. This is already an absolute world record, but given our observations while in the field, and the fact that we sampled only a small fraction to the area, we hypothesize that the number of species in this area could be even much higher, well establishing that lichen biodiversity per area in the tropics is higher than elsewhere. Among the species reported, two are new to the southern hemisphere, nine are new to the Neotropics, 30 are first reports for Brazil, and 247 are new to Mato Grosso state. We also describe 40 new lichenized fungi species, mainly from the Amazon, 19 of which are from Cristalino Reserve: Aggregatorygma lichexanthonicum, Allographa pruinodisca, Architrypethelium submuriforme, Astrothelium gyalostiolatum, A. infravulcanum, A. inspersonitidulum, A. parathelioides, A. quintannulare, A. quintosulphureum, A. stromatocinnamomeum, A. xanthosordithecium, Calopla ca cinereosquamosa, Carbancanthographis tetriskersa, Cladonia megafurcata, Coniarthonia echinospora, C. micromuralis, Coniocarpon foliicola, Cresponea pallidosorediata, Cryptothecia demethylconfluentica, C. methylperlatolica, C. parvopsoromica, Fissurina isohypocrellina, Heteroderma apicalis, Lecidella fuliginea, Malmidea densisidiata, M. nigra, Mazosia flavida, Multisporidea conidiophora, Porina albotomentosa, P. muralisidiata, Psorinia cyanea, Ramboldia badia, Saxiobra pruinosa, Sclerophyton perithecioides, Sporopodium soredioplaevescens, Synarthronia xanthonica, Tingiopsidium tropicum, Tylophoron rufescens, and Viridothelium sinuosogelatinosum. Identification keys are given to the Brazilian species of Coniarthonia and Cryptothecia.

KEYWORDS. Lichens, biodiversity, Mato Grosso, Reserva Cristalino, Trypetheliaceae, Arthoniaceae, Argentina.

Lichens are traditionally thought of as being most diverse in arctic-alpine regions, and most abundant in boreal latitudes. However, more than half of the lichen-forming fungal species have been described from the tropics—where diversity seems to be highest. In addition, lichen florals of the various continents share far fewer species than their arctic or boreal parts, increasing the number of tropical species even more. Long lists of lichen species from excursions in alpine regions are regularly published (e.g., Hafellner et al. 2003), but usually refer to much larger areas (in this case 50,000 hectares, with 525 species). Another recently published high species number, just to compare yet another climatic zone, is from Glacier Bay in Arctic Alaska (Spribille et al. 2020). In total, 760 species were identified (or newly described), but this was
from 1,100,000 hectares and the fieldwork was carried out during several months over several years, in over 100 different localities.

Few inventories of the lichens of tropical areas exist, as the taxonomy of many tropical groups has been unresolved until recently. The first reports refer only to foliicolous lichens, of which the taxonomy was studied in more detail in the last century. For instance, 300 species of foliicolous lichens were reported from 100 trees and shrubs in the La Selva reserve in Costa Rica (Lücking 1999). Only in the last decade, after some major contributions to the taxonomy of tropical lichens were published (e.g., Aptroot 2012; Aptroot & Lücking 2016; Lücking et al. 2014, see also under material and methods below), some more or less comprehensive species lists were published. Examples are the list of 350 lichen species that were reported from a one-week collecting trip to a small area in the Chapada dos Guimarães in Mato Grosso (Aptroot & Souza 2021) and the checklist of the lichens of the Reserve Florestal Adolpho Ducke, in Amazonas state in Brazil, which contains 295 species, mostly collected during two trips totaling just over a week of field work (Aptroot et al. 2021a).

Lichens have only been systematically investigated in the Amazon region rather recently (e.g., Aptroot et al. 2021a,b; Cáceres & Aptroot 2017). The Amazon is known to be the richest biodiversity hotspot for many organism groups, but so far, this has not been the case for lichens, although it has been proposed as the center of diversity for one family, Trypetheliaceae Eschw., especially of the genus *Astrothelium* Eschw. (Aptroot et al. 2016b). Arthoniales Henssen species are also very diverse in this region, with many species with unexpected morphology (e.g., Cáceres & Aptroot 2016).

As part of a continuous effort to explore lichenologically relatively unknown regions, we recently investigated the microlichens in three Amazon states. We revisited the Reserva Florestal Adolpho Ducke (Aptroot et al. 2021a) in Amazonas; while we visited for the first time the Reserva extrativista Cazumbá-Iracema (Aptroot et al. 2021b) in Acre and the Reserva Cristalino in Mato Grosso. The Reserva Ducke is roughly equal in size to the Reserva Cristalino, c. 10,000 hectares each.

In 2021, during one week, the first author collected lichens at the Cristalino Reserve in Mato Grosso state (bordering Pará state) in Brazil. This reserve is famous because two illustrated field guides (Lodge & Sourell 2016; Sourell et al. 2018) have been published on the mushrooms from this reserve. These are used widely beyond this region. The area is lowland tropical rain forest at the southern edge of this biome, interspersed with some small granite rock outcrops.

The biodiversity of this reserve is very well documented for a tropical area: 586 bird species are known to occur (Lees et al. 2012), 1000 butterfly species are known from the reserve (Hoyler 2006), about 350 more or less identified non-lichenized fungal species and 500 more which were identified only to genus level, and around 1400 phanerogam plants (Projeto Flora Cristalino 2006).

Here we report the results of our investigations in Cristalino Reserve, and describe 40 species new to science, mostly from this reserve, but also some from other areas.

**Material and Methods**

Specimens were observed with an Olympus SZX7 or SZ40 and pictures were taken with Canon Eos M5, stacking with Genesis GMR-150 on Benro TMS07A with Sunwayfoto XB-2811. Hand-made sections of ascomata and thallus were studied in water, 5% KOH (K) and/or Lugol's reagent (1% I2) after pre-treatment with KOH (IKI). Microscopic photographs were prepared using an Olympus BX50 with Nomarski interference contrast and Nikon Coolpix 995. Chemical spot reactions are abbreviated as K (5% KOH), C (commercial bleach), KC (K followed by C), P (paraphenylenediamine), and UV (fluorescence at 366 nm). Thin-layer chromatography (Orange et al. 2010) was performed in solvent A.

Lücking (2014) for Ocellularia G.Mey.; Lücking (2008) for foliicolous lichens, Lücking et al. (2016b) for Myriotrema Fée; Lücking et al. (2014) for Graphis Adans.; Breuss & Lücking (2015) for Malmidea Kalb, Rivas Plata & Lumbsch; Feuerstein et al. (2014) for Diorygma Eschw.; Kistenich (2019) for Phyllopsora Müll.Arg.; Rivas Plata et al. (2010) and Sipman et al. (2012) for most thelotremoid Graphidaceae Dumort.; Jagadeesh Ram & Sinha (2016) for Cryptothecia Stirt.; Santos et al. (2019) for Neoprotoparmelia Garima Singh, Lumbsch & I.Schmitt; Feuerstein et al. (2022) for Carbancanthographe Staiger & Kalb; and Souza et al. (2022) for Heterodermia Trevis. In addition, several unpublished manuscripts were used, including one containing keys to most described Brazilian fungi and separate draft keys to Fissurina Fée, Phaeographis Müll.Arg., and Porina Müll.Arg. species.

RESULTS

In the area of the private Reserva Cristalino, as many as 473 lichen species were identified (Supplementary Table S1), all collected in one week by the first author alone, on nine hectares of rain forest. There are around 30 km of trails, almost all of it were walked by the first author, and this is where the collecting was largely confined. So, the actual studied area is around nine ha (30 km trail times a three m wide band of observation).

This is an absolute record for number of species reported, not only for a rain forest, but from anywhere on earth for such a small area and time spent. This number is only surpassed by long-time investigations of huge areas. See Aptroot & Souza (2021) for a comparison with other high numbers of lichen species reported from certain areas around the world. It suffices here to say that any number approaching or exceeding 500 was reported from areas at least 100, but usually more than a million times as big as the nine ha investigated here, and that sampling effort invariably was dozens to hundreds of times longer.

Among the species reported, two are new to the Southern Hemisphere, nine are new to the Neotropics, 30 are first reports for Brazil (from where more than 4270 accepted species are already known, Aptroot et al. in prep), and as many as 247 are new to Mato Grosso state (from where so far 891 species were known, see e.g. Aptroot & Souza 2021). Some identifications are not totally certain, usually because material was not fully fertile. On the other hand, several dozens of additional species remained unidentified. Of these, 19 are described from this reserve as new to science below (and 21 are newly described from other recently collected materials), bringing the total of identified species from the reserve up to 492.

Below, we describe some new species from the Cristalino Reserve and other areas, mainly Trypetheliaceae and Arthoniales. Some new species are in unexpected genera that were previously not known from Brazil or not even from the tropics, such as Psorinia Gotth. Schneid., Saxiloba Lücking, B.Moncada & Viñas, and Tingiopsidium Werner. Somewhat to our surprise, our second visit to the Reserve Florestal Adolpho Ducke yielded two additional new species of Trypetheliaceae, including one in the small genus Viridothelium Lücking, M.P.Nelsen & Aptroot, after several new species (including Viridothelium ustulatum Aptroot & M. Cáceres, which is locally very common) had already been described from that reserve by us, and many more reported (Cáceres & Aptroot 2017). This is because during our second visit, we paid special attention to fallen trees and branches, which are often full of Trypetheliaceae which are most abundant just below the canopy.

In the Cristalino Reserve, habitus pictures were made in the field of fresh material of around 275 non-foliicolous species, all of which will be published separately in a rapid field guide (Aptroot et al. 2022b).

TAXONOMY

Aggregatorygma lichexanthonicum Aptroot, sp. nov.

MycoBank MB843586
Corticulous Aggregatorygma with thallus with lichexanthone, ascospores 1/ascus, hyaline, densely muriform, 86–92 × 17–21 μm.

Type: BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 84039 (holotype, CGMS!).

Description. Thallus crustose, continuous, not corticate, rather smooth, dull, almost white, up to 20 cm diam., up to 0.1 mm thick, not surrounded...
Figure 1. Habitus of holotypes. A. Aggregorygma lichexanthonicum, B. Allographa pruinodisca, C. Architrypethelium submuriforme, D. Astrothelium gyalostiolatum, E. A. infravulcanum, F. A. impersonitidulum. Scale = 2 mm, except in E = 0.5 mm. Online pdf in color.
by a prothallus. Photobiont trentepohlioid. Ascomata superficial on the thallus, sessile, with constricted base, initially solitary, soon dividing to become an aggregate of linear, simple or little branched, lirelline within a pseudostroma which is marked lobate in outline. Pseudoostromata 1–4 mm wide, 0.4–0.7 mm high, individual lirellae 0.2–0.4 mm wide, up to 3 mm long, disc pale gray, densely white pruinose, often with splits/cracks between the discs. Pseudoostromatic margin raised above the discs, almost white, 0.4–0.7 mm wide. Epihymenium brownish, with numerous small crystals, probably calcium oxalate. Hamathecium not inspersed. Asci dextrinoid. Ascospores 1/ascus, hyaline, densely muriform, 86–92 \( \times \) 17–21 \( \mu \)m, IKI + violet, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV+ yellow, C–, K–, KC–, P–; disc UV+ bluish white. TLC: lichexanthone.

**Etymology.** Named after the lichexanthone.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This is only the third species in this genus, which was described from Brazil (Cáceres et al. 2014b). The new species markedly differs by the chemistry and ascospore septation; the type species contains two unknown substances and has 3-septate ascospores. However, a second species, with submurriform ascospores, *Aggregatoryga submuriforme* Aptroot (Aptroot & Feuerstein 2020), was recently described, expending the variation of ascospore morphology known from the genus. The new species shares the aggregated part lirellae with the type species. Future studies will be needed to find out if that is (as the name of the genus implies) indeed an important character. DNA sequences are available in the meantime of the first two described species, but from different genes.

*Allographa pruinodisca* Aptroot, *sp. nov.*  
**MycoBank** MB843587

*Corticolous Allographa with striatula-morph lirellae, the pruinose disc and labia top, the non-corticate thallus and ascospores transversely 17–21-septate, 80–90 \( \times \) 9–12 \( \mu \)m, 4/ascus.*

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55'S, 55°55'W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 82317 (holotype, CGMS!).

**Description.** Thallus crustose, continuous, following the surface of the substratum, not corticate, dull, dirty pinkish white, up to 7 cm diam., up to 0.1 mm thick, not surrounded by a prothallus. Photobiont trentepohlioid. Ascomata sessile, solitary, superficial on the thallus, linear, but wavy and often branched, 0.4–0.5 mm wide, up to 4 mm long, c. 0.3 mm high, disc black, almost closed, c. 0.05 mm wide, thinly white pruinose; labia becoming sparingly striate, dull black but thinly pruinose on the top, with basal thalline margin (*striatula*-morph cf. Lücking et al. 2009). Excipulum completely carbonized. Hamathecium not inspersed. Ascospores 4/ascus, hyaline, 17–21-septate, IKI+ violet, 80–90 \( \times \) 9–12 \( \mu \)m, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–. TLC: no secondary metabolites detected.

**Etymology.** Named after the pruinose disc.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This species is well characterized by the *striatula*-morph lirellae, the pruinose disc and labia top, the non-corticate thallus and the large transversely septate ascospores that are arranged 4/ascus. It would key out in the world key of *Graphis* Adans. by Lücking et al. (2009) in group key 17 at couplet 12.

*Architrypethelium submuriforme* Aptroot, *sp. nov.*  
**MycoBank** MB843588

*Corticolous Architrypethelium with ascospores 8/ascus, hyaline, submuriform with 8 main locules and 5–25 smaller locules, 110–127 \( \times \) 22–30 \( \mu \)m.*

**Type:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06'S, 43°29'W, on bark in rain forest, 17–25 May 2021, A. Aptroot 51527 & L.A. dos Santos (holotype, isel!; isotype, CGMS!).

**Description.** Thallus dull, pale ochraceous green, gall-inducing, covering areas of up to 25 cm diam., bullate with mostly ellipsoid thallus patches of up to 1 mm thick intermixed with linear black areas consisting of e.g. empty pycnidia and ostioles
of immersed ascomata, not surrounded by a prothallus. Ascomata globose to pyriform, 0.4–0.7 mm diam., single, mostly immersed in the thallus, not in pseudostromata. Ostioles apical to somewhat eccentric, single, black. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, IKI-negative, submuriiform with 8 main locules and 5–25 smaller locules, 0.4–0.7 mm diam., long-ellipsoid, central septum not thickened, usually slightly bent, not surrounded by a gelatinous sheath. Only postmature pycnidia observed.

Chemistry. Thallus UV–, C–, P–, K–. TLC: no secondary metabolites detected.

Etymology. Named for the submuriiform ascospores.

Ecology and distribution. On tree bark in rain forest; only known from Brazil. Locally common.

Additional specimens examined. BRAZIL. M I NAS GERAIS: same details as the type, A. Aptroot 51868, 51890 & 52289 (paratypes, ise!; CGMS!). PARANÁ: Quatro Barras, Morro do Lóth, on bark in Atlantic rain forest, 17 Dec. 2021, A. Aptroot 84601 (paratype, CGMS!).

Discussion. This is the first species in the genus Architrypethelium Aptroot with submuriiform ascospores. It is somewhat similar to A. lauropaluanum Lücking, M.P.Nelsen & Marcelli, with which it grows together. It is already keyed out in couplet 41a, in the world key by Schumm & Aptroot (2021).

Astrothelium gyalostiolatum Aptroot, sp. nov.

Fig. 1D

MYCOBANK MB843589
Corticolous Astrothelium similar to A. bicolor but differing by the lichexanthone being restricted to only the ostiolar region.

Type: BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 84032 (holotype, CGMS!).

Description. Thallus dull, pale ochraceous, not surrounded by a prothallus. Ascomata globose to pyriform, 0.2–0.4 mm diam., mostly immersed in the thallus, not in pseudostromata. Ostioles apical, single, black. Hamathecium inspersed with hyaline oil globules. Ascospores 8/ascus, hyaline, 3-septate, 14–17 × 5–6 μm, IKI-negative, long-ellipsoid, not surrounded by a gelatinous sheath. Pycnidia not observed.


Etymology. Named for the similarity to Astrothelium vulcanum Aptroot, from which it differs by the smaller (‘infra’) ascospores.

Ecology and distribution. On tree bark in rain forest; only known from Brazil.
Discussion. This species is similar to *A. vulcanum* which has larger ascospores of 20–25 × 6.5–7.5 μm (Aptroot et al. 2016). It is already keyed out in couplet H14b in the world key by Schumm & Aptroot (2021).

Astrothelium inspersonitidulum Aptroot & B.M.C.Barbosa, *sp. nov.*

**Fig. 1F**

MYCOBANK MB843591

*Corticolous Astrothelium similar to A. subscoria but with brown ascomata.*

**Type:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06'S, 43°29'W, on bark in rain forest, 17–25 May 2021, A. Aptroot 51124 & L.A. dos Santos (holotype, ISE; isotype, CGMS).

**Description.** Thallus slightly nitidous, pale olive green, up to 5 cm diam., up to 0.1 mm thick, not surrounded by a prothallus. Ascomata globose, 0.3–0.4 mm diam., brown, erumpent, sides covered by the thallus, not in pseudostromata, single or in loose groups. Ostioles apical, single, black. Hamathecium inspersed with hyaline oil globules. Ascospores 8/ascus, hyaline, 3-septate, 21–24 × 5.5–6.5 μm, IKI-negative, long-ellipsoid, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–. TLC: no secondary metabolites detected.

**Etymology.** Named for the similarity to *Astrothelium nitidulum* Weerakoon & Aptroot, from which it differs by the inspersed hamathecium and the smaller ascospores.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

This species is similar to *A. subscoria* Flakus & Aptroot, which has whitish ascomata instead (Flakus et al. 2016). It would key out in couplet I5a in the world key by Schumm & Aptroot (2021) as: ascomata mostly solitary, brown.

Astrothelium parathelioides Aptroot & B.M.C.Barbosa, *sp. nov.*

**Fig. 2A**

MYCOBANK MB843592

*Corticolous Astrothelium similar to A. medioincrassatum but ascospores 9–13 septate; median septum thickened; ascomata solitary; ostioles lateral.*

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55'S, 55°55'W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 84145 (holotype, CGMS!).

**Description.** Thallus slightly nitidous, pale ochraceous, covering an area of up to 4 cm diam., up to 0.1 mm thick, not surrounded by a prothallus. Ascomata pyriform, 0.5–0.8 mm diam., mostly immersed in the thallus to erumpent, not in pseudostromata. Ostioles lateral, single, black. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, 9–13 septate, 101–124 × 25–30 μm, IKI-negative, long-ellipsoid, central septum conspicuously thickened, not surrounded by a gelatinous sheath. Pycnidia black, erumpent, ingroups dispersed between the ascomata; conidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–. TLC: no secondary metabolites detected.

**Etymology.** Named for the lateral (‘parathelioid’) ascomata.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

This species is similar to *A. medioincrassatum* Aptroot & M.Cáceres (Oliveira Junior et al. 2021) which however has compound ascomata with fused ostioles. It would key out in couplet K33b in the world key by Schumm & Aptroot (2021) as: Ascospores 9–13 septate; median septum thickened; ascomata solitary; ostioles lateral.

Astrothelium quintannulare Aptroot, *sp. nov.*

**Fig. 2B**

MYCOBANK MB843593

*Corticolous Astrothelium similar to A. annulare, but with 5-septate ascospores of 57–61 × 18–22 μm.*

**Type:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06'S, 43°29'W, on bark in rain forest, 17–25 May 2021, A. Aptroot 51906 & L.A. dos Santos (holotype, ISE; isotype, CGMS!).

**Description.** Thallus dull, pale olive green, covering up to 10 cm diam., up to 0.2 mm thick, not surrounded by a prothallus. Ascomata globose, 0.7–1.1 mm diam., mostly immersed in the thallus, not in pseudostromata. Ostioles apical, single, brown, surrounded by a whitish area of c. 0.1 mm diam. Hamathecium not inspersed. Ascospores 8/
Figure 2. Habitus of holotypes. A. Astrothelium parathelioides, B. A. quintannulare, C. A. quintosulphureum, D. A. squamosum, E. A. stromatocinnamomeum, F. A. xanthosordithicum. Scale = 2 mm. Online pdf in color.
ascus, hyaline, 5-septate, 57–61 × 18–22 μm, IKI-negative, long-ellipsoid, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–. TLC: no secondary metabolites detected.

**Etymology.** Named for the similarity to *Astrothelium annulare* (Fée) Aptroot & Lücking, from which it differs by the 5-septate ascospores.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

**Discussion.** This species is similar to *A. annulare*, which has 3-septate ascospores (Aptroot & Lücking 2016). It is already keyed out in couplet I30b in the world key by Schumm & Aptroot (2021).

**Astrothelium quintosulphureum** Aptroot & M.Cáceres, sp. nov.  
**Fig. 2C**  
MYCOBANK MB854594  
*Corticilous Astrothelium with ascomata in pseudostromata, ostioles apical, medulla with yellow pigment; ascospores 5-septate, 45–51 × 11–12.5 μm, lumina diamond-shaped.**

**Type:** BRAZIL. AMAZONAS: Manaus, Reserva Florestal Adolfo Ducke, along trails in vicinity of field station, alt. 50 m, 2°56’S, 59°57’W, on tree bark in primary rain forest, 21 Jun. 2019, M.E.S. Cáceres 50699 & A. Aptroot (holotype, INPA!; isotypes, ABL!, ISE!).

**Description.** Thallus glossy, olivaceous green, smooth and continuous, occupying areas up to 7 cm diam., 0.1–0.2 mm thick, not surrounded by a prothallus. Squamae 0.6–1.7 × 0.5–1.6 mm, lobate, irregularly convex, 0.3–0.6 mm thick, mostly attached with the lower surface. Ascomata pyriform, 0.4–0.8 mm diam., brown, emergent from the bark between the thallus squamae, not in pseudostromata. Ostioles apical, single, black. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, 14–17-septate, 114–127 × 23–26 μm, IKI+ violet, long-ellipsoid, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–; pseudostromata pigment K+ blood red. TLC: an anthraquinone.

**Etymology.** Named for its squamulose thallus.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

**Astrothelium squamosum** Aptroot, sp. nov.  
**Fig. 2D**  
MYCOBANK MB843595  
*Corticilous Astrothelium similar to A. puiggarii, but with ascospores 8/ascus, hyaline, 14–17-septate, 114–127 × 23–26 μm.***

**Type:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06’S, 43°29’W, on bark in rain forest, 17–25 May 2021, A. Aptroot 51260 & L.A. dos Santos (holotype, ISE!; isotype, CGMS!).

**Description.** Thallus consisting of isolated squamae, glossy, covering areas of up to 10 cm diam., olivaceous green, not surrounded by a prothallus. Squamae 0.6–1.7 × 0.5–1.6 mm, lobate, irregularly convex, 0.3–0.6 mm thick, mostly attached with the lower surface. Ascomata pyriform, 0.4–0.8 mm diam., brown, emergent from the bark between the thallus squamae, not in pseudostromata. Ostioles apical, single, black. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, 14–17-septate, 114–127 × 23–26 μm, IKI+ violet, long-ellipsoid, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–; pseudostromata pigment K+ blood red. TLC: no secondary metabolites detected.

**Etymology.** Named for the squamulose thallus.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

**Astrothelium stromatocinnamomeum** Aptroot, sp. nov.  
**Fig. 2E**  
MYCOBANK MB843595  
*Corticilous Astrothelium similar to A. puiggarii, but with ascospores 8/ascus, hyaline, 14–17-septate, 114–127 × 23–26 μm.***
Corticolous Astrothelium similar to A. cinnamomeum, but with pseudostromatata many groups of fused ascomata.

**Type:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06’S, 43°29’W, on bark in rain forest, 17–25 May 2021, A. Aptroot 52080 & L.A. dos Santos (holotype, ISE; isotype, CGMS).

**Description.** Thallus slightly nitidous, ochraceous green, uneven, covering an area of up to 8 cm diam., c. 0.1–0.3 mm thick, not surrounded by a prothallus. Ascomata pyriform, 0.2–0.4 mm diam., immersed in groups of 3–10 in pseudostromatata. Pseudostromata sessile, convex but centrally flattened in larger pseudostromata, orange, rounded to lobate, 1–5 × 1–4 mm, with 4–25 groups of ascomata with joined ostioles. Ostioles eccentric, fused, black. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, 3-septate, 27–30 × 9–11 μm, IKI-negative (dextrinoid), long-ellipsoid, not surrounded by a gelatinous sheath. No pycnidia observed.

**Chemistry.** Thallus UV–, C–, P–, K–; pseudostromata UV+ red. TLC: anthraquinone.

**Etymology.** Named for the similarity to Astrothelium cinnamomeum (Eschw.) Müll.Arg., from which it differs by the many groups of fused ascomata per pseudostromata.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

**Discussion.** This species is similar to A. cinnamomeum, which has pseudostromata with only one group instead of many groups of fused ascomata (Aptroot & Lücking 2016). It is already keyed out in couplet J46b in the world key by Schumm & Aptroot (2021).

**Astrothelium xanthosordithecium** Aptroot, *sp. nov.*

**Fig. 2F**

Corticolous Astrothelium similar to A. sordithecium, the only other Astrothelium species known with brownish hamathecium inspersion, but with lichexanthone.

**Type:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06’S, 43°29’W, on bark in rain forest, 17–25 May 2021, A. Aptroot 51116 & L.A. dos Santos (holotype, ISE; isotype, CGMS).

**Description.** Thallus slightly nitidous, somewhat uneven but following the substratum, olivaceous green, occupying areas of up to 110 cm diam., c. 0.1 mm thick, not surrounded by a prothallus. Ascomata pyriform, 0.3–0.6 mm diam., fused, immersed in pseudostromatata. Pseudostromata usually with one group of fused ascomata, so with one ostiole, sessile, often with constricted base, globose to convex, round to lobate, whitish, 1–3 × 1–3 mm, 0.9–1.4 mm high. Ostioles eccentric, fused, black. Hamathecium inspersed with tiny brownish oil globules. Ascospores 8/ascus, hyaline, 3-septate, 34–37 × 10–12 μm, IKI-negative, long-ellipsoid, not surrounded by a gelatinous sheath. No pycnidia observed.

**Chemistry.** Thallus and pseudostromatata UV+ yellow, C–, P–, K–. TLC: lichexanthone.

**Etymology.** Named for the similarity to Astrothelium sordithecium Lücking, M.P.Nelsen & Marcelli, from which it differs by the presence of lichexanthone in thallus and pseudostromatata.

**Ecology and distribution.** On tree bark in rain forest; only known from Brazil.

**Additional specimen examined.** BRAZIL. MINAS GERAIS: same details as the type, A. Aptroot 51955 & L.A. dos Santos (paratypes: ISE; CGMS).

**Discussion.** This species is similar to Astrothelium sordithecium (Lücking et al. 2016a), which is the only other Astrothelium species known with brownish hamathecium inspersion and with which it grows together, but which has no lichexanthone (Lücking et al. 2016a). It is already keyed out in couplet J14b in the world key by Schumm & Aptroot (2021).

**Caloplaca cinereosquamosa** Aptroot, *sp. nov.*

**Fig. 3A**

Corticolous Caloplaca with appressed gray squamules on a black hypothallus, apothecia with yellow discs, margin raised above the disc, somewhat paler at the inside, gray at the outside, ascospores 7–8 × 5–5.5 μm, septum c. 5 μm thick.
Figure 3. Habitus of holotypes. A. Caloplaca cinereosquamosa, B–C. Cladonia megafurcata, D. Coniarthonia echinospora, E. C. micromuralis, F. Coniocarpon foliicola. Scale = 2 mm, except in B = 2 cm & C = 5 mm. Online pdf in color.
Description. Thallus covering areas of up to 5 cm diam., containing of isolated, single, flattened, corticate, closely appressed squamules on an extended black hypothallus. Squamules gray at the periphery of the thallus, brownish gray in the interior, angular in outline, 0.2–0.4 mm diam., up to 0.1 mm thick, partly bordering each other but mostly surrounded by the black hypothallus. Photobiont chlorococcoid. Apothecia numerous, solitary, superficial on the thallus, round, 0.2–0.4 mm wide, up to 0.2 mm high, disc dark ochraceous yellow, margin raised above the disc, somewhat paler at the inside, gray at the outside, c. 0.05 mm wide. Hymenium c. 50–65 μm high, IKI+ blue. Epihymenium heavily encrusted with yellow crystals. Paraphyses c. 2.5 μm wide, unbranched, upper two cells wider, moniliform. Ascospores 8/ascus, hyaline, 1-septate, polar-diblastic, 7–8 × 5.5–5 μm, septum c. 5 μm thick. Pycnidia not observed.

Chemistry. Thallus UV–, C–, K+ blood red, KC–, P–. TLC: stictic acid, which is a relatively rare substance in the family Graphidaceae but known already in the genus Carbacanthographis (Feuerstein et al. 2022).

Etymology. Named after the gray squamulose thallus.

Ecology and distribution. On granite in rock outcrops between primary rain forest; only known from Brazil.

Discussion. This species is amply characterized by the chloroalba-morph lirellae, the thinly pruinose disc and labia top, and the clavate 3-septate ascospores. It would key out in the world key of Carbacanthographis by Feuerstein et al. (2022) in group key 2 at couplet 1: ascospores small, 3-septate; hamathecium finely inspersed; thallus with stictic acid; lirellae with thinly pruinose disc and labia top. In the world key to Graphis (which also contains cross references to the then-known species of Carbacanthographis) by Lücking et al. (2009) it would key out in group key 19 at couplet 2: ascospores small, 3-septate. It is in habitus very similar to some species of Graphis but differs by the IKI-negative ascospores. Only two other species of Carbacanthographis with consistently 3-septate ascospores are known, viz. C. hertelii Kalb & Staiger, which has an isidiate thallus containing protocetraric acid, and C. alloafzelii (A.W.Archer) A.W.Archer, which contains psoro-
Figure 4. Habitus of holotypes. A. Cresponea pallidosorediata, B. Cryptothecia demethylconfluentica, C. C. methylperlatolica, D. C. parvopsoromica, E. Fissurina isohypocrellina, F. Carbacanthographis tetrinspersa. Scale = 2 mm, except in E = 0.5 mm. Online pdf in color.
mic acid; both species also miss the inspersed hamathecium.

**Cladonia megafurcata** Aptroot, *sp. nov*. Fig. 3B–C

**MYCOBANK:** MB843599

ITS DNA **BARCODING SEQUENCE ACCESSION:** ON178675

Terricolous and saxicolous *Cladonia* similar to *C. furcata*, but the basal branches of non-fertile specimens are much wider and the axils are wide open and partly stellate.

**TYPE:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, 1200–1400 m, 20°06'S, 43°29'W, on soil and granite in campo rupestre, 17–25 May 2021, A. Aptroot 51741 & L.A. dos Santos (holotype, ISE!; isotype, CGMS!).

**Description.** Thallus fruticose, consisting of repeatedly irregularly branched branches, up to 10 cm high, basally 1–2 mm wide, generally wider and up to 3 mm wide at major branching points, apices tapering, hollow, corticate but with open axils and with regular further preformed perforations, dull to slightly nitidous, pale greenish gray mottled with pale greenish brown, apices dark brown. Squamules rather sparse, generally only on the lower half of the thallus, firm, little dissected, more or less rounded, upcurved, 0.4–1.2 mm diam., upper surface pale greenish gray, lower surface white. Stereome only visible in older parts, cartilagineous, waxy; oldest parts only slightly blackening. Photobiont trebouxiioid. Ascomata unknown. Pycnidia at branch tips, black.

**Chemistry.** Thallus UV–, C–, K–, KC–, P+ red. TLC: fumarprotocetraric acid.

**Etymology.** Named after the similarity to *Cladonia furcata* (Huds.) Schrad., from which it differs by the larger dimensions.

**Ecology and distribution.** On soil and granite outcrops in Campo Rupestre (“rupestrian grassland”); so far only confirmed from Brazil, but probably widely distributed in at least South America.

**Discussion.** This species keys out as *Cladonia furcata* in Ahti (2000) in the key to section Ascyphyferae Tornab. at couplet 4. That species is mentioned by Ahti (2000) to be bipolar arctic(-antarctic)-boreal(antiboreal)-temperate, with montane disjunctions, i.e. almost cosmopolitan. The first author has examined thousands of specimens of *C. furcata* from Europe, from almost every country, and seen many thousands of populations in the field in dozens of countries, and the species is in its currently accepted sense variable in morphology (and somewhat in chemistry). The South American specimens reported to be *C. furcata*, or at least the Brazilian specimens examined fall well outside the morphological variation as observed in Europe: The basal branches of non-fertile specimens are much wider than they ever get in Europe, where only fertile specimens become wide, and the axils are wide open and partly stellate, more reminiscent of *C. crispata* (Ach.) Flot. than of *C. furcata*. There is no doubt that these are different species. The status of the material called *C. furcata* in Central and North America (and e.g., Antarctic regions) remains to be investigated in more detail. If found to be different from *C. furcata*, several epithets based on N. American material are available. If it turns out that one of them is conspecific with *C. megafurcata*, so be it; this lies outside the scope of the present work. The purpose of this description here is to provide a name for this species and to debunk the notion that *C. furcata* is an almost cosmopolitan species occurring in Brazil. Phylogenetically, *C. furcata* has repeatedly been shown to be polyphyletic (Stenroos et al. 2018), which fits well with the observation that it encompasses different species.

**Coniarthothina echinospora** Aptroot, *sp. nov*. Fig. 3D

**MYCOBANK:** MB843600

Corticolous *Coniarthothina* with ascospores resting on top of the ascomata. In a mazaedothecium, ornamented with spines and becoming brown.

**TYPE:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 83020 (holotype, CGMS!).

**Description.** Thallus crustose, continuous, not corticate, dull, pale grayish white, occupying areas of up to 25 cm diam., under 0.1 mm thick, surrounded by a c. 0.3 mm wide brown hyphal prothallus. Photobiont trentepohlioid. Ascomata almost punctiform, superficial on the thallus, 0.1–0.3 mm diam., less than 0.1 mm high, disc medium brown, margin not differentiated or paler. Epithecium not differentiated. Hamathecium not inspersed, paraphysoids anastomosing, but unclear. Asci pyriform, 16–20 × 9–12 μm, wall thick above. All structures IKI-
negative (only thallus IKI+ weakly blue). Ascospores 8/ascus, hyaline in the asci but becoming soon brown and remaining on top of the ascomata in a mazaedium, muriform, ellipsoid, 4–5 × 0–1–septate with 7–9 lumina visible in optical view, 11–12.5 × 5.5–6.5 μm, ornamented with many short spines, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–; ascomata UV+ reddish brown. TLC: confluentic acid.

**Etymology.** Named after the spiny ascospores.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This species is unique in that it clearly belongs to the Arthoniaceae because of the thallus and ascoma organization. It is separate lineage from other mazaedium-forming lichens. It comes closest to the genus *Coniarthonia* Grube (Grube 2001, Aptroot et al. 2015). Apart from the ascospores resting on top of the ascomata, it is also characterized by the ascospores being ornamented with spines and becoming brown. Attempts to sequence the type were not successful. As ascospore ornamentation is often an indicative character of phylogenetic relationships, the species may eventually well turn out to belong elsewhere in the phylogenetic relationships, the species may eventually turn out to belong elsewhere in the phylogenetic relationships. As many species have been added since Grube (2001), none of which have been featured in keys, an updated key is presented below to the species of *Coniarthonia* known from Brazil.

**Coniarthonia micromuralis** Aptroot, sp. nov.

**Fig. 3E**

MYCOBANK MB843601

Corticolous *Coniarthonia* with ascospores muriform, 6–7 × 0–2-septate with 12–17 lumina visible in optical view, 16–19 × 5.5–6.5 μm, ends rather pointed.

**Type:** BRAZIL, AMAZONAS: Manaus, Reserva Florestal Adolpho Ducke, along trails in vicinity of field station, alt. 80 m, 2°56'S, 59°57'W, on tree bark in primary rain forest, 21–24 Jun. 2019, M.E.S. Cáceres 50786 & A. Aptroot (holotype, INPA 284707!; isotypes, ABL!, ISE!).

**Description.** Thallus crustose, continuous, not corticate, dull, pale greenish gray, occupying areas of up to 3 cm diam., under 0.1 mm thick, not surrounded by a conspicuous prothallus. Photobiont trentepohlioid. Ascomata almost punctiform, solitary or usually in irregular lines of 5–20, superficial on the thallus, 0.1–0.2 mm diam., c. 0.1 mm high, disc orange, margin not differentiated. Epithectum with orange crystals. Hamathecium not inspersed, paraphysoids anastomosing, but unclear. Asci ovoid, 30–37 × 17–21 μm, wall thick above. All structures IKI-negative (only thallus IKI+ weakly blue). Ascospores 8/ascus, hyaline, muriform, citriform, 6–7 × 0–2-septate with 12–17 lumina visible in optical view, 16–19 × 5.5–6.5 μm, ends rather pointed, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–; orange crystals of apothecia K+ pink, dissolving. No TLC performed (material too small), but the observed K-reaction suggests the presence of haematommone.

**Etymology.** Named after the small muriform ascospores.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This species would key out in the world key by Grube (2001) at couplet 4: Ascospores muriform, 16–19 μm long. Since that paper, several further species have been described or combined into this genus, mainly by Aptroot et al. (2015), but none with muriform ascospores. As many species have been added since Grube (2001), none of which have been featured in keys, an updated key is presented below to the species of *Coniarthonia* known from Brazil.

**KEY TO SPECIES OF CONIARTHONIA IN BRAZIL**

1. Apothecia brown; ascospores becoming brown, ornamented
   ..................................................................................................................
   **C. echinospora** Aptroot
2. Apothecia mustard-yellow, orange, pink or red; ascospores hyaline, not ornamented ................................................................................................................... 2
3. Apothecia mustard-yellow; ascospores 20–28 × 7–11 μm..............
   ..................................................................................................................
   **C. aurata** E.L.Lima, Aptroot & M.Cáceres
4. Apothecia orange, pink or red ................................................................. 3
5. Apothecia orange; ascospores muriform .................................................................................................................................
   ............................................................... **C. micromuralis** Aptroot
6. Apothecia pink or red; ascospores transversely septate ............ 4
7. Apothecia pink, ascospores 13–16 × 3.5–6.5 μm .........................
   ..................................................................................................................
   **C. wilmsiana** (Müll.Arg.) Grube
8. Ascospores 3–7-septate ..................................................................... 6
9. Ascospores 1-septate ...................................................................... 8
10. Ascospores 3–7-septate ................................................................ 7
11. Ascospores 5-septate ...................................................................... 5
12. Ascospores 3–7-septate ................................................................ 4
13. Ascospores 5-septate ...................................................................... 3
14. Ascospores 1-septate ...................................................................... 2
15. Ascospores 3–7-septate ................................................................ 1
16. Ascospores 5-septate ...................................................................... 0
17. Ascospores 1-septate ...................................................................... 1
18. Ascospores 3–7-septate ................................................................ 0
19. Ascospores 5-septate ...................................................................... 9
20. Ascospores 1-septate ...................................................................... 8
21. Ascospores 3–7-septate ................................................................ 7
22. Ascospores 5-septate ...................................................................... 6
23. Ascospores 1-septate ...................................................................... 5
24. Ascospores 3–7-septate ................................................................ 4
25. Ascospores 5-septate ...................................................................... 3
26. Ascospores 1-septate ...................................................................... 2
27. Ascospores 3–7-septate ................................................................ 1
28. Ascospores 5-septate ...................................................................... 0
29. Ascospores 1-septate ...................................................................... 9
30. Ascospores 3–7-septate ................................................................ 8
31. Ascospores 5-septate ...................................................................... 7
32. Ascospores 1-septate ...................................................................... 6
33. Ascospores 3–7-septate ................................................................ 5
34. Ascospores 5-septate ...................................................................... 4
35. Ascospores 1-septate ...................................................................... 3
36. Ascospores 3–7-septate ................................................................ 2
37. Ascospores 5-septate ...................................................................... 1
38. Ascospores 1-septate ...................................................................... 0
Coniocarpus folicola Aptroot, sp. nov.  Fig. 3F

*MycoBank* MB843602

*Foliculicolous Coniocarpus with ascospores 3-septate,* 
*macrocephalic, broadly clavate, 11.5–13 × 5–6 μm.*

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55′S, 55°55′W, on living leaves in primary rain forest, 22–29 Apr. 2021, A. Aptroot 83123 (holotype, CGMS!)

**Description.** Thallus crustose, continuous, not corticate, dull, pale olivaceous brown, covering areas of up to 1.5 cm, under 0.1 mm thick, surrounded by a c. 0.2 mm wide prothallus line. Photobiont trentepohlioid. Ascomata solitary, superficial on the thallus, round to irregular oval, 0.2–0.5 mm diam., 0.1 mm high, disc pink, margin steep but internally not differentiated. Epihymenium with red crystals. Hamathecium not inpesped, IKI+ pale blue, Paraphysoids 1–1.5 μm wide, anastomosing. Ascospores 8/ascus, hyaline, 3-septate, macrocephalic, broadly clavate, 11.5–13 × 5–6 μm, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–; red crystals of apothecia K+ blood red, not dissolving. No TLC performed (material too small), but the observed K-reaction suggests anthraquinones.

**Etymology.** Named after the foliicolous habit.

**Ecology and distribution.** On living leaves in primary rain forest; only known from Argentina.

**Discussion.** Only one sorediate species of the genus *Cresponea* Egea & Torrente is so far known, viz. *C. flavosorediata* Aptroot & M.Cáceres (Cáceres et al. 2014a). It differs by the much larger, irregular soralia. The new species is so far only known from Argentina but was found not far from the Brazilian border.

*Cryptothecia demethylconfluentic* Aptroot, sp. nov.  Fig. 4B

*MycoBank* MB843604

*Corticolous Cryptothecia with ascospores 8/ascus,* 
*muriform, 50–56 × 20–22.5 μm and thallus with demethylconfluentic and confluentic acid.*

**Type:** BRAZIL. SERGIPE: Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44′35″S, 37°20′25″W, on bark in transitional forest to caatinga, 27 Jul. 2013, M.E.S. Cáceres 18063 & A. Aptroot (holotype, ise!; isotypes, abl!, ise!).

**Description.** Thallus crustose, continuous, not corticate, dull, pale ochraceous, covering areas of up to 1.5 cm, under 0.1 mm thick, surrounded by a c. 0.2 mm wide prothallus line. Photobiont trentepohlioid. Ascomata solitary, superficial on the thallus, sessile with constricted base, round, 0.7–1.3 mm diam., c. 0.3 mm high, disc black, mostly with thin golden yellow pruina, margin raised above the disc, black, c. 0.2 mm wide. Excipulum and hypothecium carbonized. Epihymenium brownish. Hamathecium not inspersed, paraphysoids 1–1.5 μm wide, anastomosing. Ascospores 8/ascus, hyaline, 5–7-septate, narrowly clavate, 33–37 × 4.5–5.5 μm, without gelatinous sheath. Pycnidia not observed.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Argentina.

**Discussion.** So far only few species are known in the genus *Coniocarpus* Fée, to which this species clearly belongs. None are foliicolous, and the present species was also not described in another genus in the Arthoniaceae (Lücking 2008).
to 15 cm diam., under 0.1 mm thick, not surrounded by a prothallus, with soredia. Soredia granular, superficial on the thallus, not in soralia. Photobiont trentepohlioid. Ascigerous areas not distinguishable from the thallus. Asci macroscopically invisible, single, immersed in the thallus, globose, c. 100–125 μm diam. Ascospores 8/ascus, hyaline, muriform, ellipsoid, 50–56 × 20–22.5 μm, without gelatinous sheath. Pycnidia not observed.

Chemistry. Thallus UV–, C–, K–, KC–, P–. TLC: demethylconfluentic and confluentic acid.

Etymology. Named after the characteristic secondary metabolite.

Ecology and distribution. On tree bark in primary rain forest; only known from Brazil.

Discussion. This species would key out in the world key by Jagadeesh Ram & Singh (2016) at couplet 60: Thallus with demethylconfluentic and confluentic acid; ascigerous areas raised above the thallus. See also the key to Cryptothecia Stirt. species known from Brazil below.

Cryptothecia methylperlatolatica Aptroot, sp. nov.

Fig. 4C

MycoBank MB843605

Corticolous Cryptothecia with ascospores 8/ascus, hyaline, muriform, broadly ellipsoid, 45–50 × 27–30 μm and thallus with 2′-O-methylperlatolic acid.

Type: BRAZIL. RONDÔNIA: Porto Velho, Parque Natural Municipal, alt. 100 m, 8°41′10″S, 63°52′05″W, on tree in park near rain forest, 16 Nov. 2012, M.E.S. Cáceres 15215 & A. Aptroot (holotype, ISE!; isotype, ABL!).

Description. Thallus crustose, continuous, not corticate, dull, whitish gray, covering areas of up to 25 cm diam., up to 0.1 mm thick, surrounded by a 0.3 mm wide brown, hyphal prothallus, without soredia. Photobiont trentepohlioid. Ascigerous areas whitish, linear, flat, 0.5–6 × 0.3–0.5 mm, somewhat raised from the thallus. Asci macroscopically visible as ochraceous dots, immersed in groups of c. 5–50 in the ascigerous areas, globose, c. 100–125 μm diam. Ascospores 8/ascus, hyaline, muriform, broadly ellipsoid, 45–50 × 27–30 μm, without gelatinous sheath. Pycnidia not observed.

Chemistry. Thallus UV–, C–, K–, KC–, P–. TLC: 2′-O-methylperlatolic acid.

Etymology. Named after the characteristic secondary metabolite and the small ascospores.

Ecology and distribution. On tree bark in primary rain forest; only known from Brazil.

Additional specimens examined. BRAZIL. RONDÔNIA: same details as the type, M.E.S. Cáceres 15217 & A. Aptroot (paratypes, ISE!, ABL!).

Discussion. This species is close to C. albomaculans Jagadeesh Ram & G.P.Sinha, which differs by the heteromerous thallus and flush ascigerous areas. It would key out in the world key by Jagadeesh Ram & Sinha (2016) at couplet 28: thallus with 2′-O-methylperlatolic acid; ascigerous areas raised above the thallus. See also the key to Cryptothecia species known from Brazil below.

Cryptothecia parvporsoromica Aptroot, sp. nov.

MycoBank MB843606

Corticolous Cryptothecia with ascospores 8/ascus, hyaline, muriform, 6–7 × 0–2-septate with 10–13 lumina visible in optical view, broadly clavate, 15–18 × 6.5–7.5 μm and thallus with psoromic acid.

Type: BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55′S, 55°55′W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 82383 (holotype, CGMS!).

Description. Thallus crustose, continuous, not corticate, dull, whitish gray, covering areas of up to 8 cm diam., under 0.1 mm thick, not surrounded by prothallus, without soredia. Photobiont trentepohlioid. Ascigerous areas (no true apothecia are formed because the interascal filaments are not differentiated from thallus hyphae) whitish, irregular to oval, somewhat convex, 0.3–0.8 × 0.3–0.5 mm, somewhat raised from the thallus. Asci macroscopically visible as ochraceous dots, immersed in groups of c. 3–10 in the ascigerous areas, clavate, 38–42 × 18–20.5 μm diam. Ascospores 8/ascus, hyaline, muriform, 6–7 × 0–2-septate with 10–13 lumina visible in optical view, broadly clavate, 15–18 × 6.5–7.5 μm, IKI-negative, without gelatinous sheath. Pycnidia not observed.

Chemistry. Thallus UV–, C–, K–, KC–, P+ yellow. TLC: psoromic acid.

Etymology. Named after the characteristic secondary metabolite and the small ascospores.
Ecology and distribution. On tree bark in primary rain forest; only known from Brazil.

Discussion. This species would key out in the world key by Jagadeesh Ram & Sinha (2016) at couplet 19: ascospores 15–18 × 6.5–7.5 μm; thallus only with psoromic acid. See also the key to Cryptothecia species known from Brazil below.

Key to species of Cryptothecia in Brazil.

Note: this key treats only fertile specimens. Sterile Arthoniaceae specimens are not included. They often belong to other genera; when they are easily removed from the substratum they mostly belong to the genus Herpothallon Tobler (but compare sterile specimens of Cryptothecia Frisch & G.Thor, Dichosporidium Pat. and Sagenidiopsis R.W.Rogers & Hafellner). When firmly attached to the substratum, they may be sterile specimens of Cryptothecia, but more often they are as yet undescribed species in other Arthoniaceae genera, including Nungnuea Sérus., Eb.Fisch. & Killmann.

1. Thallus partly UV yellow, with lichenanthone... 2
2. Thallus partly UV yellow, partly UV+ bluish white, with lichenanthone and 2-O-methylmicrohyllinic acid.......................... 4
3. Thallus and/or ascigerous areas UV yellow, with lichenanthone................................................................. C. duplifluorescens Aptroot & M.F.Souza
4. Thallus partly UV+ yellow, partly UV+ bluish white, with lichenanthone and 2-O-methylmicrohyllinic acid.......................... 4
5. Thallus and/or ascigerous areas UV–, ascospores 55–75 × 32–37 μm....................................................... C. rhizophora Aptroot & M.Cáreres
6. Thallus and/or ascigerous areas UV yellow, ascospores 55–75 × 32–37 μm....................................................... C. rhizophora Aptroot & M.Cáreres
7. Thallus and/or ascigerous areas PD+ yellow, with psoromic acid 5
8. Thallus and/or ascigerous areas PD–, without psoromic acid...... 7
9. Ascigerous areas containing an unidentified secondary metabolite.........
10. Ascigerous areas irregular to oval; ascospores 45–50 × 27–30 μm; with 2'-O-methylperlatolic................. C. methylperlatolica Aptroot
11. Thallus without soralia ................................................................... 12
13. Ascigerous areas irregular or inconspicuous; ascospores 33–43 × 16–23 μm; containing an unidentified secondary metabolite......

Fissurina isohypocrellina Aptroot, sp. nov. Fig. 4E

MycoBank MB843607

Corticolous Fissurina with apothecia with isohypocrellin.

Type: BRAZIL. ACRE: Sena Madureira, Reserva extrativista Cazumbá-Itacema, Comunidade Cuidado, alt. 150 m, 9°07’S, 68°59’W, on bark in rain forest, 9 Apr. 2019, M.E.S. Cáceres 50372 & A. Aptroot (holotype, iset; isotype, abt!)

Description. Thallus crustose, continuous, thinly corticate, slightly shiny pale greenish brown, occupying areas of up to 5 cm, under 0.1 mm thick, not surrounded by a prothallus. Photobiont trentepohlioid. Ascomata immersed in the bark, solitary, linear in outline, often curved, sometimes branched, 0.1–0.2 mm wide, up to 2 mm long, disc wine red, margin raised above the disc, tips carbonized, c. 0.02 mm wide. Excipulum margin fully covered by thallus, existing of a combination of bark cells and lichen that is raised by the hymenium. Ephythymium wine red, K+ a vivid green. Hamathecium not inspersed, IKI-negative. Ascospores immature. Pycnidia not observed.

Chemistry. Thallus UV–, C–, K–, KC–, P–; red pigment K+ green. TLC: isohypocrellin.

Etymology. Named after the isohypocrellin pigment.

Ecology and distribution. On tree bark in primary rain forest; only known from Brazil.

Discussion. Isohypocrellin is a rare, but characteristic, secondary metabolite in lichens. So far, it is known from little over a dozen tropical lichens in the families Graphidaceae, Pyrenulaceae and Theleliaceae. In some species it occurs in the hamathecium, in others in the ostiole or the apothecium disc. This is the first species of Fissurina Fée with the substance. It is described here even though no mature ascospores were found in the material, as it is very characteristic and clearly undescribed. Among the Graphidaceae with isohypocrellin, Phaeographis haematites (Fée) Müll.Arg.
is slightly similar, but this species has a glossy, thickly corticate thallus and much more developed apothecia. There are also species in the genus *Thalloloma* Trevis. with red pigments, and these may show superficial similarities with the new species, but none contain isohypocrellin.

**Heterodermia apicalis** Aptroot & M.F.Souza, sp. nov.  
Fig. 5A–B

**Saxicolous Heteroderma of the H. dactyliza group, similar to H. flavodactyliza, but lower surface with spotted yellow pigment.**

**TYPE:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’00”S, 55°55’00”W, on granite outcrop in primary rain forest, 22–29 Apr. 2021, A. Aptroot 84262 (holotype, CGMS!; isotype, ABL!).

**Description.** Thallus ochraceous gray, loosely adnate, up to 9.0 cm wide, c. 150 μm thick, lower cortex c. 70 μm thick, lower cortex lacking. Lobes with anisotomic ramifications, leaving large inter-spaces, occasionally laterally overlapping, 1.5–2.5 × 0.6–1.2 mm, mostly flat. Soredia, phyllidia, and isidia absent, but ends of secondary lobes often slightly upturned and white, suggesting soralia initials. Medulla white. Lower surface ecorticate, with spots and towards the tips of some lobes larger patches of yellow pigment, with black margins of 0.2 mm wide. Cilia 0.5–1.7 × 0.1–0.2 mm, black, densely squarrosely to irregularly branched, projecting outwards. Apothecia unknown. Pycnidia sparse, brown.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–; pigment K+ blood red. TLC: atranorin, zeorin and another terpenoid (probably 6α,16β-diacetoxyhexahomobane-22-ol), emodin and 5,7-dichloroemodin.

**Etymology.** Named after the aberrant lobe apices.

**Ecology and distribution.** On granite in rock outcrops in primary rain forest; only known from Brazil.

**Discussion.** This is a species of the *Heterodermia dactyliza* group and is similar to *H. flavodactyliza* M.F.Souza & Aptroot, which however has an arachnoid orange pigment that is present on most of the lower surface. It would key out in the key to *Heterodermia* Trevis. species from Brazil by Souza et al. (2022) in key 4 at couplet 1: lower surface with spotted yellow pigment.

**Lecidella fuliginea** Aptroot & L.A.Santos, sp. nov.  
Fig. 5C

**ITS DNA BARCODING SEQUENCE ACCESSION:** ON178677

**Corticolous Lecidella externally similar to Lecidella elaeochroma, but internally it is similar to *L. violaceofuliginea*, including the pigmentation and inspersion, thallus with a xanthone.**

**TYPE:** BRAZIL. MINAS GERAIS: Catas Altas, Santuário do Caraça, alt. 1200–1400 m, 20°06’00”S, 43°29’00”W, on bark in rain forest, 17–25 May 2021, A. Aptroot 52200 & L.A. dos Santos (holotype, ISM!; isotype, CGMS!).

**Description.** Thallus crustose, cracked-areolate into minute areoles, corticate, slightly nitidous, pale greenish, up to 3 cm diam., c. 0.1 mm thick, surrounded by a c. 0.2 mm wide black prothallus line. Photobiont trebouxioid. Ascomata solitary, sessile, not constricted, round to somewhat lobate, 0.2–1.4 mm diam., c. 0.2 mm high, disc purplish brown-black, flat, not pruinose, margin raised above the disc, concolorous, nidiuous, c. 0.05 mm wide. Excipulum brown. Epihymenium gray. Hypothecium red brown. Hamathecium inspersed with hyaline oil droplets, IKI+ blue. Ascospores 8/ascus, hyaline, simple, long ellipsoid, 13–16 × 7–8.5 μm, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV+ pink, C–, K–, KC–, P–; TLC: a xanthone, most probably 4,5-dichloronorlichexanthone.

**Etymology.** The name indicates the dark apothecia but also is meant to reminisce of the similar species *Lecidella violaceofuliginea* (Vain.) Kalb.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This species is externally similar to *Lecidella elaeochroma* (Ach.) M.Choisy, but internally it is similar to *L. violaceofuliginea*, which was described from in the same locality (Vainio 1890). Comparison to toptype material of *L. violaceofuliginea* (ISE 52218 & 52220) shows that it must be related (they share the dens inspersion and violet pigmentation), but a different species, mainly differing by the thallus and apothecium size and
aspect. The type specimen was sequenced and found to cluster inside the genus *Lecidella*.

**Malmidea densisiadiata** Aptroot & Oliveira-Junior, *sp. nov.*

*Fig. 5D*

**MYCOBANK** MB843611

ITS DNA BARCODING SEQUENCE ACCESSION: ON178679

*Corticulcus Malmidea* macroscopically very close to *Malmidea corallophora* but differing by the ascospores of 11–12.5 × 4.5–5.5 μm.

**TYPE:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 82860 (holotype, CGMS!).

**Description.** Thallus crustose, mostly continuous, corticate, dull, pale greenish, covering areas of up to 25 cm, up to 0.1 mm thick, surrounded by a white hyphal prothallus that is also present here and there between thallus parts, e.g. on cracks in the bark, densely covered by isidia. Isidia pale yellowish green, short cylindrical, unbranched, c. 0.2 × 0.1 mm. Medulla of isidia and thallus pale yellow. Photobiont trebouxioid. Ascomata sessile, solitary, constricted at the base, round to lobate, 0.4–1.5 mm wide, up to 0.5 mm high, disc medium brown, flat to slightly convex, margin hardly raised above the disc, whitish, c. 0.1 mm wide, with whitish papillae. Excipulum pale yellow, containing pockets of large hyaline crystals. Epihymenium pale brown. Hypothecium dark brown. Hamathecium not inspersed, IKIþ blue (mostly the ascus tips). Asci *Porpidia*-type. Ascospores 8/ascus, hyaline, simple, ellipsoid, 11–12.5 × 4.5–5.5 μm, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K+ yellow, KC–, P–; yellow medulla K+ reddish. TLC: atranorin and several pigments including chloroemodin.

**Etymology.** Named after the dense layer of isidia.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil. Locally common.

**Additional specimens examined.** BRAZIL. MATO GROSSO: same details as the type, A. Aptroot 84195, 82870 & 83019 (paratypes, CGMS!).

**Discussion.** This species is macroscopically very close to *Malmidea corallophora* Aptroot & Schumm (Schumm & Aptroot 2012), which differs by the much larger ascospores of c. 30 × 15 μm.

**Malmidea nigra** Aptroot & Oliveira-Junior, *sp. nov.*

*Fig. 5E*

**MYCOBANK** MB843612

ITS DNA BARCODING SEQUENCE ACCESSION: ON178678

*Corticulcus Malmidea* with thallus originating as tiny fragments on top of a black hypothallus, green at the margin, but almost black in most of the thallus, ascospores 8/ascus, fusiform to rhomboid, 10–11.5 × 2.5–3.5 μm.

**TYPE:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 83047 (holotype, CGMS!).

**Description.** Thallus crustose, originating as tiny fragments on top of a hypothallus (and is visible in the marginal part of the thallus), soon becoming continuous, not corticate, dull, pale greenish at the margin, almost black in most part of the thallus, covering areas of up to 5 cm, up to 0.1 mm thick, on a c. 0.2 mm thick black hypothallus that also surrounds the thallus as a prothallus. Medulla whitish. Photobiont trebouxioid. Ascomata sessile, solitary, constricted at the base, round to lobate, 0.2–0.8 mm wide, up to 0.3 mm high, disc pale brown, flat to slightly concave, margin raised above the disc, gray, c. 0.1 mm wide. Excipulum hyaline, without crystals. Epihymenium pale brown. Hypothecium dark brown. Hamathecium not inspersed, IKIþ blue (mostly the ascus tips). Asci *Porpidia*-type. Ascospores 8/ascus, hyaline, simple, fusiform to rhomboid, 10–11.5 × 2.5–3.5 μm, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–. TLC: no secondary metabolites detected.

**Etymology.** Named after the black thallus.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This species would key out in the world key to *Malmidea* Kalb, Rivas Plata & Lumbsch (Breuss & Lücking 2015) at couplet 49 (at the end), as: thallus originating as tiny fragments on top of a black hypothallus, green at the margin, but almost black in most of the thallus. The species shows more similarities with species of the genus *Malmidea* than with species of the genus *Phyllop-
sora, which was an alternative hypothesis, mainly because of the rhomboid ascospores. Also, the DNA sequence obtained clustered within the genus Malmidea.

**Mazosia flavida** Aptroot, *sp. nov.*

Fig. 5F

MYCOBANK MB843613

Foliicolous Mazosia with ascospores 9-septate, 46–52 × 3.5–4.5 μm, soon fragmenting, medulla of thallus verrucae and apothecium margin pale yellow.

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on living leaves in primary rain forest, 22–29 Apr. 2021, A. Aptroot 83167 (holotype, CGMS!).

**Description.** Thallus crustose, continuous, corticate, dull, olivaceous green, up to 1 cm diam., less than 0.05 mm thick, not surrounded by a prothallus, with ellipsoid, radially orientated yellowish dots of c. 0.05 × 0.025 mm diam. at c. 0.1 distance from each other. Medulla of the dots pale yellow. Photobiont trentepohlioid. Ascomata solitary, superficial on the thallus, base not constricted, round, 0.3–0.5 mm wide, up to 0.2 mm high, disc dark gray, flat, thinly white pruinose, margin often not raised above the disc, yellowish, c. 0.1 mm wide. Excipulum pale yellow. Hypothecium dark brown. Hamathecium not inspersed, IKI−. Ascospores 8/ascus, hyaline, 9-septate, cylindrical, 46–52 × 3.5–4.5 μm, soon fragmenting, without a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV−, C−, K−, KC−, P−. No TLC performed (material too small); the yellow pigment may well be an emodin derivivate judging from the color and absence of reaction in K.

**Etymology.** Named after the yellow pigment.

**Ecology and distribution.** On living leaves in primary rain forest; only known from Brazil.

**Discussion.** The family Malmideaceae contains one middle-sized genus, *Malmidea* with around 60 known species, and several smaller genera, the most recently described one being the so far monotypic *Multisporidea* Kalb & Aptroot (Kalb & Aptroot 2021). While conidia are unknown or at least inconspicuous in *Malmidea*, they are known from some of the smaller genera, notably *Sprucidea* M.Cáceres, Aptroot & Lücking, which has species with *Penicillium*-like conidiomata (Cáceres et al. 2017a), and *Savoronala* Ertz, Eb.Fisch., Killmann, Razafindr. & Sérus., which has stalked sporodochia (Ertz et al. 2012). The conidiomata found in the new species described here are different from all those found before in Malmideaceae and confirm that a classification of...
Figure 6. Habitus of holotypes. A. Multisporidea conidiophora, B. Porina albotomentosa, C. P. muralisidiata, D. Porinia cyanea, E. Ramboldia badia, F. Saxiloba pruinosa. Scale = 2 mm, except in B = 1 mm & F = 0.5 mm. Online pdf in color.
Malmideaceae with polysporous asci in a separate genus is warranted.

**Porina albotomentosa** Aptroot, *sp. nov.* [Fig. 6B]

*Folicolous Porina with perithecia hemispherical, base constricted, nitidous, red brown, tomentose, ascospores 3-septate, 12–14 × 4–5 μm.*

**Type:** BRAZIL. MATO GROSSO DO SUL: Campo Grande, campus UFMS, alt. 550 m, 20°30′S, 53°37′W, on living leaves in cerrado forest, 20 Nov. 2018, A. Aptroot 78086 (holotype, CGMS!; isotype, ABL!).

**Description.** Thallus slightly nitidous, ochraceous gray, occupying up to 1 cm diam., very thin, not surrounded by a prothallus. Algae trentepohlioid. Perithecia hemispherical, base constricted, nitidous, red brown, 0.2–0.3 mm diam., c. 0.2 mm high, sessile, not covered by the thallus, densely covered by white tomentum. Ostioles apical, single, inapparent. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, 3-septate, 12–14 × 4–5 μm, fusiform, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–. No TLC performed (specimen too small).

**Etymology.** Named for the white tomentum on the ascomata.

**Ecology and distribution.** On living leaves in cerrado forest remnant; only known from Brazil.

**Discussion.** This species would key out in the key to foliicolous neotropical *Porina* Müll.Arg. species by Lücking (2008) at couplet 44 as: ascospores 3-septate; perithecia tomentose. There are only a few *Porina* species known with tomentose perithecia, and none with such small ascospores.

*Porina muralisidiata* Aptroot, *sp. nov.* [Fig. 6C]

*Folicolous Porina with ascospores muriform, 110–132 × 15–18 μm, thallus with gnarled isidia.*

**Type:** BRAZIL. RIO GRANDE DO SUL: Porto Alegre, Ipanema, alt. 0 m, 30°08′S, 51°13′W, on bark on tree along lake, 27 Sep. 2014, M.E.S. Cáceres 22263 & A. Aptroot (holotype, ISE!; paratypes, ISE!, ABL!).

**Description.** Thallus continuous but with irregular surface, slightly nitidous, olivaceous brown, occupying up to 10 cm diam., up to 0.1 mm thick, not surrounded by a prothallus, with isidia. Isidia numerous, simple or branched/aggregated, gnarled, c. 0.1 mm diam. Algae trentepohlioid. Perithecia superficial, globose to hemispherical, base constricted, black, 0.4–0.6 mm diam., c. 0.4 mm high, not covered by the thallus. Wall of perithecia reddish inside. Ostioles apical, single, black, extruding, c. 0.1 mm diam. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, muriform, 110–132 × 15–18 μm, fusiform, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, P–, K–. TLC: no secondary metabolites detected.

**Etymology.** Named for the muriform ascospores and the isidia on the thallus.

**Ecology and distribution.** On bark on roadside trees along a lake; only known from Brazil.

**Additional specimen examined.** BRAZIL. RIO GRANDE DO SUL: same details as the type, M.E.S. Cáceres 22272 & A. Aptroot (paratypes, ISE!, ABL!).

**Discussion.** There are no other *Porina* species known with muriform ascospores and isidia. *Porina* species with muriform ascospores were treated by McCarthy (1995).

*Psorinia cyanea* Aptroot, *sp. nov.* [Fig. 6D]

*Saxicolous Psorinia with thallus with black lines between thallus parts, with terpenoids, and the blue color of the apothecium sections in tap water.*

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55′S, 55°55′W, on granite outcrops in primary rain forest, 22–29 Apr. 2021, A. Aptroot 83087 (holotype, CGMS!).

**Description.** Thallus squamulose, consisting of isolated or aggregated squamules, thinly and indistinctly corticate with rather undifferentiated cortex of c. 15 μm thick, slightly nitidous, pale gray, somewhat mottled, possibly by pseudocyphellae, margins and crevices black, 1–3 mm diam., c. 0.2–0.3 mm thick, usually somewhat lobate, often saddle-shaped, convex, up to 0.4 mm thick, not surrounded by a prothallus. Lower surface yet black, with a c. 15 μm thick cortex, with some folds and irregular hapters. Photobiont chlorococcoid, cells 8–12 μm diam in a c. 40 μm thick band. Ascomata solitary or a few clustered, superficial on the thallus, round, 0.5–1.2 mm wide, c. 0.3 mm high, disc yet

Chemistry. Thallus UV–, C–, K+ yellow, KC–, P–. TLC: atranorin and diffractaic acid.

Etymology. Named after the blue color inside the apothecia.

Ecology and distribution. On granitic rock on rock outcrops in forested areas; only known from Brazil.

Additional specimens examined. BRAZIL. MATO GROSSO: same details as the type, A. Aptroot 84251 (paratype, CGMS!); Chapada dos Guimarães, Pousada do Parque private area, alt. 700 m., 15°26′50″S, 55°49′50″W, on granite outcrop in cerrado, A. Aptroot & M.F. Souza 81858 (paratype, CGMS!).

Discussion. This is the first tropical species in the small genus Psorinia Gotth. Schneider. It differs from the type species (Schneider 1980) mainly by the black rather than whitish lines between thallus parts, the different chemistry, and the blue color of the apothecium section sin tap water. This species was found several times in recent years, and was first thought to belong to Toninia A.Massal. With the gradual and continuous splitting of this genus, it became necessary to evaluate to which split genus it most resembled, and that turned out to be Psorinia. In fact, it shows several similarities with the type species of that genus, especially the mostly thin, not amorphous cortex and the presence of hapters.

Ramboldia badia Aptroot, sp. nov. Fig. 6E

MYCOBANK MB843618
Corticolous Ramboldia morphologically similar to Ramboldia russula, but without red pigment, and thallus with fatty acid.

Type: BRAZIL. MATO GROSSO DO SUL: Campo Grande, campus UFMS, alt. 550 m, 20°30′S, 53°37′W, on bark in park near cerrado forest, 23 Nov. 2021, A. Aptroot 88456 (holotype, CGMS!).

Description. Thallus crustose, continuous but very irregular and three-dimensional, occasionally almost forming squamules, corticate, slightly nitis-
much of a coincidence. The ascus type fits the genus well too.

Saxiloba pruinosa Aptroot, sp. nov. Fig. 6F

**Saxiloba pruinosa Aptroot, sp. nov.**

**Description.** Thallus placodioid but without well-defined lobes or crenations, continuous, corticate, 2–4 mm diam., c. 0.2 mm thick, dull, whitish gray, white pruinose, dotted with elongated spots of c. 0.05 mm without pruina, not surrounded by a prothallus. Photobiont trentepohlioid. Ascomata punctiform, seemingly perithecioid, immersed in groups of 15–35 in pseudostromatata, 0.1–0.15 mm wide, disc black. Pseudostromata almost white, lobate, raised above the thallus but not constricted at the base, 0.6–1.9 mm diam., up to 0.3 mm high. Epihymenium pale brown. Hamathecium not interspersed, IKI+ deep blue. Ascospores 8/ascus, hyaline, 3(–4)-septate, 28–31 μm long, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P+ yellow. TLC: psoromic acid.

**Etymology.** Named after the perithecioid ascomata.

**Ecology and distribution.** On half-exposed granite boulders in primary rain forest; only known from Brazil.

**Additional specimen examined.** BRAZIL. PARA': Vila Nazaré, 80 km N of Dom Eliseu, alt. 120 m, 3°53′56″S, 48°05′44″W, on tree bark in primary rain forest, 29 Oct. 2016, M.E.S. Cáceres 40222 & A. Aptroot (paratype, ABL!, ISE!).

**Discussion.** This species would key out in the world key by Sparrius (2004) at couplet 3: thallus dull, pseudostromatata somewhat glossy; ascospores 28–31 μm long.

Sporopodium soredioflavescens Aptroot, sp. nov. Fig. 7A

**Sporopodium soredioflavescens Aptroot, sp. nov.**

**Description.** Thallus crustose, continuous, not corticate, dull, pale grayish white, covering areas of up to 8 cm, up to 0.1 mm thick, not surrounded by a prothallus. Photobiont trentepohlioid. Ascomata punctiform, seemingly perithecioid, immersed in groups of 15–35 in pseudostromatata, 0.1–0.15 mm wide, disc black. Pseudostromata almost white, lobate, raised above the thallus but not constricted at the base, 0.6–1.9 mm diam., up to 0.3 mm high. Epihymenium pale brown. Hamathecium not interspersed, IKI+ deep blue. Ascospores 8/ascus, hyaline, 3(–4)-septate, clavate, macrocephalic, 28–31 × 7.5–8.5 μm, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P+ yellow. TLC: psoromic acid.

**Etymology.** Named after the perithecioid ascomata.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.
peripheral parts of the thallus, farinose, greenish (darker than the thallus), superficial on the thallus. Photobiont trentepohlioid. Ascomata not observed. Campylidia present, IKI+ blue, 0.2–0.3 mm diam., up to 0.3 mm high, strongly concave; inside deep yellow, outside pale yellow, attached to the thallus with a hyphal white base. Conidia not observed.

**Chemistry.** Thallus UV−, C−, P−, K−. No TLC performed (specimens too small), but the yellow pigment is likely to be a xanthone, as xanthones are

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**Figure 7.** Habitus of holotypes, A. *Sclerophyton perithecioideum*, B. *Sporopodium soredioflavescens*, C. *Synarthonia xanthonica*, D. *Tingiopsidium tropicum*, E. *Tylophoron rufescens*, F. *Viridothelium sinuosogelatinosum*. Scale = 2 mm, except in D & F = 0.5 mm. Online pdf in color.
reported from almost all other species of the genus (Lücking 2008).

**Etymology.** Named for the soredia and the yellow color.

**Ecology and distribution.** On living leaves in primary rain forest; only known from Brazil.

**Discussion.** There are so far no Sporopodium species known with soralia, see e.g. Lücking (2008). The new species is otherwise most similar to S. aeruginascens Lücking & Lumbsch.

**Synarthonia xanthonica** Aptroot, *sp. nov.*  **Fig. 7C**

**MycoBank MB843622**

*Corticolous Synarthonia with thallus UV+ orange, ascomata linear to ink spot-like, UV-negative, ascospores 8/ascus, hyaline, 2-septate, clavate, macrocephalic, 12–13.5 × 4.5–5.5 μm.*

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 82394 (holotype, CGMS!).

**Description.** Thallus crustose, continuous, not corticate, dull, pale ochraceous white, occupying areas of up to 3 cm diam., under 0.1 mm thick, surrounded by a c. 0.2 mm wide dark brown prothallus line. Photobiont trentepohlioid. Ascomata solitary, superficial on the thallus, irregularly linear to ink spot-like branched in outline, 0.3–0.8 mm wide, under 0.05 mm high, disc dark gray, white pruinose, margin not differentiated. Ephydemium pale brown. Hamathecium not inspersed, IKI+ pale blue. Ascospores 8/ascus, hyaline, 2-septate, clavate, macrocephalic, 12–13.5 × 4.5–5.5 μm, IKI-negative, not surrounded by a gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–. TLC: no secondary metabolites found.

**Etymology.** Named after the xanthone.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil.

**Discussion.** This species would key out in the world key by Vanden Broeck et al. (2018) at couplet 19: ascomata without hyaline hairs, UV-negative (only thallus UV+ orange); ascospores 2-septate.

**Tingiopsidium tropicum** Aptroot, *sp. nov.*  **Fig. 7D**

**Tylophoron rufescens** Aptroot, *sp. nov.*  **Fig. 7E**

**Tylophoron rufescens** Aptroot, *sp. nov.*  **Fig. 7E**
Corticolous Tylophoron with thallus UV-negative, C+ red, with gyrophoric and diploschistesic (?) acid, mazaedium with purplish brown pruina, pigment K+ green.

**Type:** BRAZIL. MATO GROSSO: Reserva Cristalino, alt. 250–350 m, 9°55’S, 55°55’W, on tree bark in primary rain forest, 22–29 Apr. 2021, A. Aptroot 84304 (holotype, CGMS!).

**Description.** Thallus crustose, discontinuous, not corticate, dull, almost hyphal and here and there absent, exposing bare bark, whitish, covering areas of up to 5 cm diam., under 0.1 mm thick, not surrounded by a prothallus. Photobiont trentepohlioid. Ascomata solitary, superficial on the thallus, 0.4–0.7 mm wide, up to 0.8 mm high, disc a purplish brown mazaedium, margin whitish gray. Ascospores brown, 1-septate, ellipsoid, 11–14.5 × 5.5–6.5 μm, darker brown around the septum, without gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C+ red, K–, KC+ red, P–. TLC: gyrophoric and diploschistesic (?) acid. Purplish pigment K+ green, most probably isohypoporellin (not detected by TLC).

**Etymology.** Named after the brown pruina.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil. Locally common.

**Additional specimens examined.** BRAZIL. PARANA: Lapa, on sandstone under overhanging cliff, 21 Dec. 2021, A. Aptroot 84562 (paratype, CGMS!).

**Discussion.** This species differs from the currently accepted known species of the genus Tylophoron Nyl., most of which were treated by Tibell (1996), by the purplish pruina on the mazaedium. In the type locality, it grows side-by-side with the most common similar species in the genus, *T. moderatum* Nyl., showing the difference in color.

Viridothelium sinuosogelatinosum Aptroot & M.Cáceres, sp. nov.  

**Type:** BRAZIL. AMAZONAS: Manaus, Reserva Florestal Adolpho Ducke, along trails in vicinity of field station, alt. 50 m, 2°56’S, 59°57’W, on tree bark in primary rain forest, 21 Jun. 2019, M.E.S. Cáceres 50746 & A. Aptroot (holotype, INPA 284667!; isotypes, ABL!, ISE!).

**Description.** Thallus corticate, dull, pale olivaceous brown, not surrounded by a prothallus. Ascomata single, globose to pyriform, 0.4–0.6 mm diam., black, not in pseudostromatata. Ostioles apical or slightly eccentric, single, dark brown with pale central dot, concave, c. 0.2 mm diam. Hamathecium not inspersed. Ascospores 8/ascus, hyaline, 3(–4)-septate, 33–37 × 8–11 μm, IKI-negative, long-ellipsoid, with rectangular lumina, surrounded by an up to 5 μm thick, wavy gelatinous sheath. Pycnidia not observed.

**Chemistry.** Thallus UV–, C–, K–, KC–, P–.

**Etymology.** Named after the wavy gelatinous sheath surrounding the ascospores.

**Ecology and distribution.** On tree bark in primary rain forest; only known from Brazil. Locally common.

**Additional specimens examined.** BRAZIL. AMAZONAS: same details as the type, 21–24 June 2019, M.E.S. Cáceres & A. Aptroot 50676, 50693, 50651, 50746, 50761, 50765 & 50786 (paratypes, all in ABL!, INPA!, ISE!).

**Discussion.** This species is already keyed out in the world key in Schumm & Aptroot (2021) at couplet 311a.

**Discussion**  
Collecting lichens requires experience, knowledge and time. Most historical reports about tropical lichen diversity include relatively few species, unfortunately suggesting that lichen diversity in the tropics is low. During the collecting week in Cristalino, it was registered how many new species were added each day (Fig. 8). During the first day, 73 species were collected. In subsequent days, it first increased, but subsequently leveled off a bit, partly depending on instances where additional different habitats were sampled, e.g. when the first big rock outcrop was visited, and also when an orchard was sampled (which in such places contains the lichens that otherwise grow in the canopies), or
when several recently fallen trees were found and sampled. In the last day, still 62 species were collected for the first time. Many species are here unfortunately described from one known specimen. This is often frowned upon. However, all new species differ clearly from all known described species, at least as far as we could trace. In the past years, many new lichen species were described from tropical areas, already about 500 alone from Brazil. Many were at the time of description only known from this type. Some are still only known from the type, but many have been found subsequently in other locations, including other neotropical countries like Mexico and in a few cases even paleotropical countries (Weerakoon et al. 2016). From a few species that were described on the basis of one specimen, for example *Porina isidioambigua* M.Cáceres, M.W.O.Santos & Aptroot (Cáceres et al. 2013), by now hundreds of specimens have even been collected, and it has been reported in many papers from so far eleven states all over Brazil, as follows: Cáceres et al. 2013 (Sergipe), Aptroot & Cáceres 2013 (Rondônia), Cáceres & Aptroot 2016 (Amapá), Cáceres & Aptroot 2017 (Amazonas), Cáceres et al. 2017b (Ceará), Aptroot & Cáceres 2018 (Bahia), Aptroot et al. 2021b (Acre), Aptroot et al. 2021c (Santa Catarina), Oliveira Junior et al. 2020 (Alagoas), Aptroot et al. 2022a (Mato Grosso do Sul), and the present paper (Mato Grosso). This could be taken as an argument to wait with the description of a species until more material is found, but in practice it would lead to an almost stand-still, with many species in portfolio which would in the end never been described because the authors die or lose access to new material or some other impediment. Many such species which were described in detail in manuscript were never published after all; some names were even applied in herbaria. Well-known examples are the hundreds of herbarium names coined by Groenhart for Indonesian species in the Leyden herbarium and the names in e.g. the genus *Ramalina* Ach. coined by Magnusson in herbaria all over the world. Only occasionally such names are published later on by other researchers who study the specimens and conclude that such species are still undescribed and worth publishing. Depending on what the extent of the previous work was, they are attributed to the original authors, like five recently described new species of *Heterodermia* Trevis. which were published in Souza et al. 2022, or published as original author ex publishing author when no description was found that was made by the original author, like *Polymeridium pyrenastroides* R.C.Harris ex Aptroot (Aptroot & Caceres 2014), or even just the name is taken up, because there were other issues, in cases like *Ramalina sanctae-helenae* Aptroot (Aptroot 2008), a name that Magnusson used for specimens belonging to several different species. Actually, the present paper is an example of how we waited for more material before describing new species: some were already collected in 2012 and singled out as undescribed the same year or the year after but are only described now. In some cases, for instance that of *Ramboldia badia*, we indeed found several additional specimens already, which helped us to evaluate whether a species was indeed new and sometimes to which genus it belongs (if ascospores or asci were not mature in the first specimen for instance). For instance, the holotype of *Ramboldia badia* is the most recently collected well developed specimen, in the hope that it will be sequenced. In other cases, we wanted to wait for DNA results which however not always were generated.

There are papers about how to sample lichens in Brazilian lowland rain forest in a standardized way (Cáceres et al. 2007, 2008). However, first and foremost, the experience of the collector determines the percentage of the species present that is actually found. Lacking experience, one can still get good results by collecting every differently looking thallus on selected trees, as was done by various students, leading to the discovery of many relatively inconspicuous lichens (e.g., Alves et al. 2014; Komposch et al. 2002; Lima et al. 2013; Menezes et al. 2013; Xavier-Leite et al. 2014). In any case, in our experience, this gives a better idea of the lichen biodiversity than collecting only the attractive
lichens, one or two per tree, which is the usual method applied by non-specialists.

So, what is the actual lichen biodiversity of Reserva Cristalino? From the cumulative graph of the number of additional identified species found each day (Fig. 8), it can be seen that the saturation point was not by far reached. As many as 62 species were still added on the last collecting day, even in genera not seen before, such as Crustopatulha Aptroot. When not nine ha, but the whole 11,400 ha would be investigated (which would take an unrealistic 1,300 days equalling 3.5 full years of field days plus additional time to reach places that are far from trails, if they are even reachable at all, so well outside the scope of reality), the number of species (now at least 550 including some still unidentified or undescribed ones) should be much higher. It should also be noted here that some habitats that were expected to occur which usually contain their own specific species composition were not (yet) found during this week. Notably, we did not see spots with a rich flora of pioneer foliicolous lichens (including e.g., species of Calenia Müll.Arg., Gylaldectid Müll.Arg., Lyronoma Bat. & H.Maia, and Microtheliosip Müll.Arg.), or spots with a rich mature foliicolous lichen vegetation. Although we could examine many fallen trees due to a recent storm, there were none lying in damp areas, in the right stage for Gyalideopsis Vezda species, as reported for instance from Costa Rica (Lücking et al. 2006). If such special spots could be found, the number of species found might be expected to increase further.

In any case, this study shows that lichenized fungi are an important component of the biodiversity of tropical rain forests, amounting to at least 500 species (but likely more) in an area where the (admittedly imperfectly) known non-lichenized fungal diversity is around 500, and the (much more completely known) phanerogam diversity is 1,500. The number of bryophytes and algae is below 100 each. This means that a considerable percentage (at least 20%) of the plant/fungal (non-animal) diversity in a rain forest are lichens.

ACKNOWLEDGMENTS
We thank the colleagues at INPA for organizing the second field excursion to Ducke Reserve in Manaus and Jadson J. S. Oliveira for the collecting permit. We also thank Lucas Eduardo Araújo Silva for the permit to collect in the Reserva Cristalino, and Sidnei Dantas for guidance in Reserva Cristalino. André de Meijer guided us two times in Paraná, for which we are very grateful. Angelina Meira Ottoni largely organized our field trip to Acre. Harrie Sipman and Felix Schumm are thanked for performing tlc on some of the new species, and Felix Schumm also for making pictures of some of the new species. Martin Grube and Robert Lücking are thanked for detailed discussions about a few specimens. All materials cited were collected under various permits and are kept in the Brazilian herbaria CGMS and/or ISE. The costs of the collecting expeditions were partly financed by grants from the Conselho Nacional do Pesquisa to MESC (e.g., CNPq-SibiProcesso 563342/2010-2). This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - (CAPES Brasil) - Finance Code 001 who provided a visiting professorship to the first author. The first author warmly thanks the Stichting Hugo de Vries-fonds for travel funds for Cristalino, Caraça and other locations. The collecting trip in Caraça was mainly financed by CNPq. BRBOL-LIQ: Complementando o Brazilian barcode of life com os fungos liquenizados como medida para conservação da biodiversidade.

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Supplementary documents online
Supplementary Table S1. Lichens identified from Cristalino Reserve, with name, area for which it is a new record, substratum and Aptroot number of one collection.

manuscript received December 28, 2021; accepted June 3, 2022.