



Standard Paper

The taxonomy of sterile *Arthoniaceae* from Brazil: white crusts on overhanging tropical trees can be named

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Abstract

Twelve new lichen species are described in the family *Arthoniaceae*. All are sterile white crusts growing on overhanging trees (and one on living palm fronds) in ten different states in tropical Brazil. In the tropics, sterile crusts so far have been mostly disregarded. They are all characterized by their chemistry and morphology, often including pseudoisidia or soredia, but their phylogenetic relationships have been investigated with sequencing. The following species are described: *Arthonia farinosorediata*, with shallow soralia and without secondary metabolites; *Crypthonia irregularis*, with irregular isidia, confluent acid and sometimes 2'-*O*-methylperlatolic acid; *Crypthonia pseudisidiata*, with soft pseudoisidia and without secondary metabolites; *Crypthonia stromatica*, with sterile stromata and confluent acid; *Cryptophaea constrictopseudisidiata* with pseudoisidia, lichexanthone and confluent acid; *Cryptophaea lichexanthopseudisidiata* with pseudoisidia and lichexanthone; *Cryptophaea lichexanthosorediata* with soredia, lichexanthone and divaricatic acid; *Cryptothecia lecanorosorediata* with soredia and lecanoric acid; *Glomerulophoron confluentisorediatum* with soredia, confluent and 2'-*O*-methylperlatolic acids; *Herpothallon psorpseudisidiatum* on living palm fronds with a strongly attached thallus, long pseudoisidia and psoromic acid; *Myriostigma minisorediatum* with soredia and 2'-*O*-methylperlatolic acid; *Pachnolepia longipseudisidiata* with long pseudoisidia, and a thallus containing lichexanthone, confluent acid and 2'-*O*-methylperlatolic acid.

Keywords: *Arthonia*; biodiversity; *Crypthonia*; *Cryptophaea*; *Cryptothecia*; *Glomerulophoron*; *Herpothallon*; lichen; *Myriostigma*; *Pachnolepia*; rainforest

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Introduction

The family *Arthoniaceae* is one of the larger families of lichenized fungi, with *c.* 750 species in 20 genera (Lücking *et al.* 2017). It is most diverse in the tropics. Brazil is the country with the highest known lichen diversity, with *c.* 4800 accepted species currently known (A. Aptroot *et al.*, unpublished data). Given the rate in which new species have been found and described in recent years, now that a systematic investigation of all the different states has begun (see e.g. Aptroot & Cáceres 2017), the true number of species must be much higher, at least 10 000.

Sterile crusts are a common element of the lichen flora. They are especially common on overhanging trees, and are often white. In the tropics they have been mostly disregarded, or at least left undescribed; the five most prolific authors (Malme, Müller Argoviensis, Nylander, Vainio and Zahlbruckner) did not generally describe sterile lichens, under the assumption that they were immature. However, it is clear that there exist whole groups of lichens that are never fertile, for instance *Lepraria* Ach. (with *c.* 80 known species) and *Herpothallon* Tobler (with *c.* 50 known species). *Herpothallon* is a mostly sterile genus in the *Arthoniaceae*,

characterized by a byssoid thallus that can be easily removed from the substratum. After carrying out morphological and chemical studies, we reinstated this genus and described many species within it (Aptroot *et al.* 2009). A small number of species have subsequently been shown to have other affinities, in related or less related genera, but mostly the work enabled colleagues to identify at least some of the sterile crusts, and many species have been added to the genus since. We left out the thinner sterile crusts (which are generally annotated as 'cf. *Cryptothecia* sp.') because we were not sure to which genus they belong, and even whether they belong to just one genus. Here we collected a representative set of specimens in ten states all over Brazil, and we describe these below, based on morphological and chemical characters, and assign them to genera based on sequencing. Our purpose is not to describe new genera, which has been abundantly presented in recent *Arthoniales* work (see e.g. Frisch *et al.* 2015; Van den Broeck & Ertz 2016), but to describe species, some of which are probably quite common or at least widespread since we found some of them in locations thousands of kilometres apart. Obviously, some additional species groups might be recognized at genus level in the future. The present work aims to pave the way to naming sterile tropical *Arthoniaceae* in a similar way to our *Herpothallon* paper, and additional species will certainly be described in due course. We describe the new species in the genera that are phylogenetically closest; another option would be to describe them in the already polyphyletic genus *Cryptothecia*. We

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choose not to do this because almost all described species in that genus are fertile and without soredia and pseudoisidia. Adding many sterile species would make the genus even more of a dustbin. We could have described these and many other species much earlier, if we had chosen to publish them in *Cryptothecia*, but we deliberately waited until we had some phylogenetic framework. Here, we describe all new species in the genus that they seem phylogenetically closest to. Most species are described in the hitherto small genera *Crypthonia* and *Cryptophaea*.

In this paper, we describe only species that have been sequenced and cite only specimens that have been sequenced. We collected many more specimens for which sequencing failed or was never attempted. This means that several of the species are described here on the basis of only one specimen. However, the descriptions give mainly diagnostic characters and do not provide a detailed account of just one specimen. This approach has been used frequently in the past and many of the species described have been subsequently re-recorded. For instance in the case of a species which might only be described from one specimen; hundreds of specimens are now known for that species in Brazil or possibly even abroad. This also applies to the few sterile *Arthoniales* that we have so far described, viz. *Cryptothecia isidioxanthina* Aptroot & M. Cáceres, *Dendrographa austrosorediata* Aptroot & Gumboski and *Opegrapha ramisorediata* Aptroot & M. Cáceres; all are now known from several states, and the specimens were easily recognizable from the original descriptions.

Material and Methods

Specimens were observed with an Olympus SZX7 stereomicroscope and photographs were taken with a Nikon Coolpix camera

attached to the dissecting scope. Hand-cut sections of ascomata and thalli were studied in material mounted in water, 5% KOH (K) and/or Lugol's reagent (1% I₂) after pretreatment with KOH (IKI). Chemical spot reactions are abbreviated as K (5% KOH), C (commercial bleach), Pd (paraphenylenediamine) and UV (fluorescence at 366 nm). Thin-layer chromatography (Orange *et al.* 2010) was performed in solvents A and C.

For all specimens, we generated sequences of the mitochondrial small subunit rDNA, following the same methods as applied by Aptroot & Stech (2018). The assembled sequences were blasted using NCBI Blast (<https://blast.ncbi.nlm.nih.gov/Blast.cgi>) and subsequently aligned with available sequences of *Arthoniaceae* using MAFFT v. 7 (Katoh & Standley 2013). The alignments were inspected manually and subjected to maximum likelihood (ML) tree search in RAxML v. 8 (Stamatakis 2014), using the universal GTR-Gamma model and 1000 bootstrap pseudoreplicates. Trees were visualized and edited in FigTree v. 1.4 (<http://tree.bio.ed.ac.uk/software/figtree>).

Results

We only describe species here for which we obtained sequences. Without sequence data, the identification of most of these species may prove difficult since there are relatively few diagnostic characters to make a positive identification. Over time, with more specimen sequences, this may improve.

We sequenced a conservative region and present a cladogram showing our sequences and the most similar sequences found on GenBank, as well as representative sequences of all sequenced genera in the family, mostly from Thiyagaraja *et al.* (2020) (Fig. 1).

Key to sterile tropical species of *Arthoniaceae*, including some other *Arthoniales*

- | | | | |
|------|---|--|---|
| 1 | Thallus easily detached from the substratum, usually with hypothallus of a different colour than the thallus (often blackish) | Crypthonia albida (Fée) Frisch & G. Thor, species of Dichosporidium Pat.,
. Erythrodictyon G. Thor, Heiomasia Nelsen <i>et al.</i> ,
. Herpothallon Tobler and Sagenidiopsis R.W. Rogers & Hafellner | 2 |
| | Thallus not easily detached from the substratum, without hypothallus | | |
| 2(1) | Thallus very thin, pinkish, with soredia | | 3 |
| | Thallus not pinkish, often thicker or byssoid, with or without soredia | | 4 |
| 3(2) | Thallus C–, K+ yellow > red, with norstictic acid | Opegrapha salmonea Ertz & Diederich | |
| | Thallus C+ pink, K–, with gyrophoric acid | Opegrapha ramisorediata Aptroot & M. Cáceres | |
| 4(2) | Thallus UV+ yellow, with lichexanthone | | 5 |
| | Thallus UV–, without lichexanthone | | 9 |
| 5(4) | Thallus with soredia, medulla UV+ white, with divaricatic acid | Cryptophaea lichexanthosorediata Aptroot & M. Cáceres | |
| | Thallus with pseudoisidia | | 6 |
| 6(5) | Medulla without secondary metabolites | | 7 |
| | Medulla with confluent acid, with or without 2'-O-methylperlatolic acid | | 8 |
| 7(6) | Thallus fluffy, corticolous | Cryptophaea lichexanthopseudisidiata Aptroot & M. Cáceres | |
| | Thallus compact, usually saxicolous | Cryptothecia isidioxantha Aptroot & M. Cáceres | |
| 8(6) | Medulla with 2'-O-methylperlatolic acid | Pachnolepia longipseudisidiata Aptroot & M. Cáceres | |
| | Medulla without 2'-O-methylperlatolic acid | Cryptophaea constrictopseudisidiata Aptroot & M. Cáceres | |

- 9(4) Thallus C+ red, with erythrin, lecanoric and/or gyrophoric acid 10
 Thallus C- 12
- 10(9) Thallus with irregular fluffy soralia, containing erythrin and lecanoric acid, usually saxicolous
 **Dendrographa austrosorediata** Aptroot & Gumboski
 Thallus with round soralia, with lecanoric or gyrophoric acid 11
- 11(10) Thallus with punctiform soralia, with gyrophoric acid **Cryptothecia punctosorediata** Sparriss
 Thallus with larger soralia, with lecanoric acid **Cryptothecia lecanorosorediata** Aptroot & M. Cáceres
- 12(9) Thallus with soredia or sterile stromata 13
 Thallus with isidia, pseudoisidia or pustules 16
- 13(12) Thallus with sterile stromata, with confluent acid **Crypthonia stromatica** Aptroot & M. Cáceres
 Thallus with soredia 14
- 14(13) Thallus without secondary substances **Arthonia farinosorediata** Aptroot & M. Cáceres
 Thallus with secondary substances 15
- 15(14) Thallus with small soralia, containing only 2'-O-methylperlatolic acid
 **Myriostigma minisorediatum** Aptroot & M. Cáceres
 Thallus with irregular soredia, containing confluent and 2'-O-methylperlatolic acids
 **Glomerulophoron confluentisorediatum** Aptroot & M. Cáceres
- 16(12) Thallus Pd+ yellow, with psoromic acid **Herpothallon psorpseudisidiatum** Aptroot & M. Cáceres
 Thallus Pd- 17
- 17(16) Thallus with pseudoisidia, without secondary metabolites **Crypthonia pseudisidiata** Aptroot & M. Cáceres
 Thallus with isidia, with confluent acid **Crypthonia irregularis** Aptroot & M. Cáceres

New Species

Arthonia farinosorediata Aptroot, L. A. Santos & M. Cáceres *sp. nov.*

Mycobank No.: MB 849935

Corticolous *Arthonia* with irregular shallow soralia, differing from all previous known species in the genus by the combination of irregular soralia and the absence of secondary substances.

Type: Brazil, Sergipe, Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44'35"S, 37°20'25"W, on bark in transitional forest between Atlantic rainforest and Caatinga, 19 March 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40519—holotype; ABL—istotype). GenBank Accession no: OR544592.

(Fig. 2A & B)

Thallus crustose, continuous, not corticate, dull, creamish, up to 5 cm diam., very thin to immersed, < 0.1 mm thick, not surrounded by a prothallus. *Soredia* numerous, in small, shallow irregular soralia of 0.2–0.6 mm diam., farinose, whitish. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 1 µm wide hyphae without crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C–. TLC: nil.

Etymology. Named for the farinose soredia.

Ecology and distribution. On tree bark in rainforest; known only from Brazil. All other species described so far in the genus are fertile.

Discussion. This species is well characterized by the farinose soredia. It is not related to the core group of *Arthonia*, but to *Arthonia thorianae* Ertz & Sanderson (Ertz *et al.* 2018) and *Cryptothecia austrocoreana* J. J. Woo *et al.* (Woo *et al.* 2017), with which it could be placed in a separate genus.

Crypthonia irregularis Aptroot, L. A. Santos & M. Cáceres *sp. nov.*

Mycobank No.: MB 849936

Corticolous *Crypthonia* with irregular isidia and confluent acid, the combination of which distinguishes it from all known species in the genus.

Type: Brazil, Sergipe, Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44'35"S, 37°20'25"W, on bark in transitional forest between Atlantic rainforest and Caatinga, 17 September 2013, M. E. S. Cáceres & A. Aptroot s. n. (ISE 18281—holotype; ABL—istotype). GenBank Accession no: OR544575.

(Figs 2C–F, 3A)

Thallus crustose, continuous, smooth, corticate, dull, pale olivaceous green, up to 5 cm diam., < 0.1 mm thick, not surrounded by prothallus. *Isidia* irregular, globose to flattened and proliferating, upper surface greenish and corticate; non-corticate and cream-coloured below,

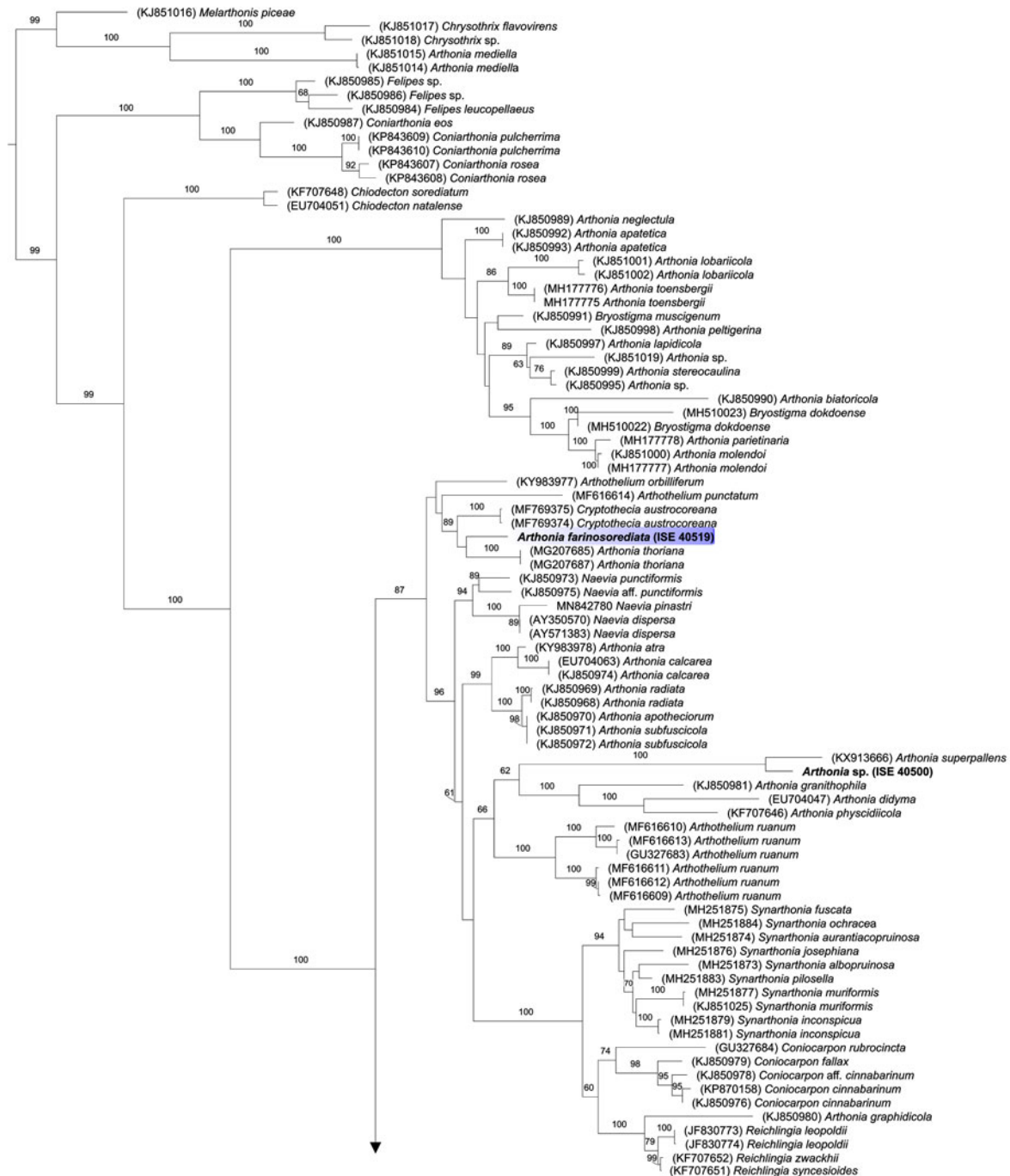


Figure 1. Cladogram of mitochondrial small subunit rDNA in Arthoniaceae. Bootstrap support values are reported adjacent to branches. Sequences downloaded from GenBank are shown in parentheses before the taxon names. New sequences and species are shown in bold. In colour online.

c. 0.1 mm diam. *Photobiont* trentepohlioid. *Medulla* IKI–, containing *c.* 1 µm wide hyphae which are encrusted with small crystals. *Ascomata* and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C–. TLC: confluent acid and sometimes 2'-*O*-methylperlatolic acid.

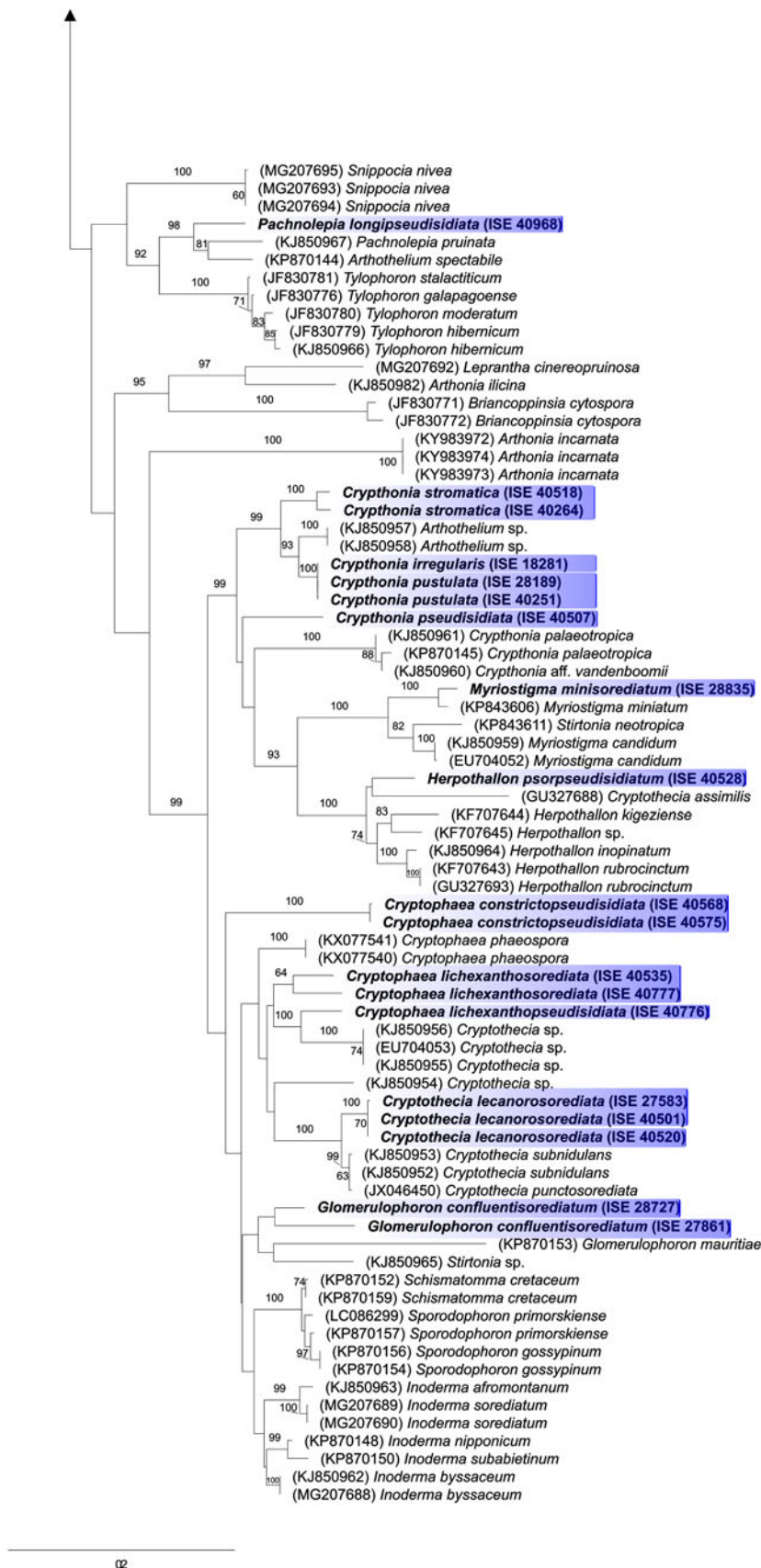
Etymology. Named for the irregular isidia.

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

Discussion. This species is well characterized by the irregular small isidia and the presence of confluent acid. All other species described so far in the genus (Frisch & Thor 2010) are fertile.

Additional material examined. **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, 3–8 vi 2016, *M. E. S. Cáceres* & *A. Aptroot* s. n. (ISE 28189; ABL); GenBank no: OR544573. **Pará:** Dom Eliseu, Vila Nazaré, S Fazenda Pantera, alt. 120 m, 3°53'56"S, 48°05'44"W,

Figure 1. (Continued)



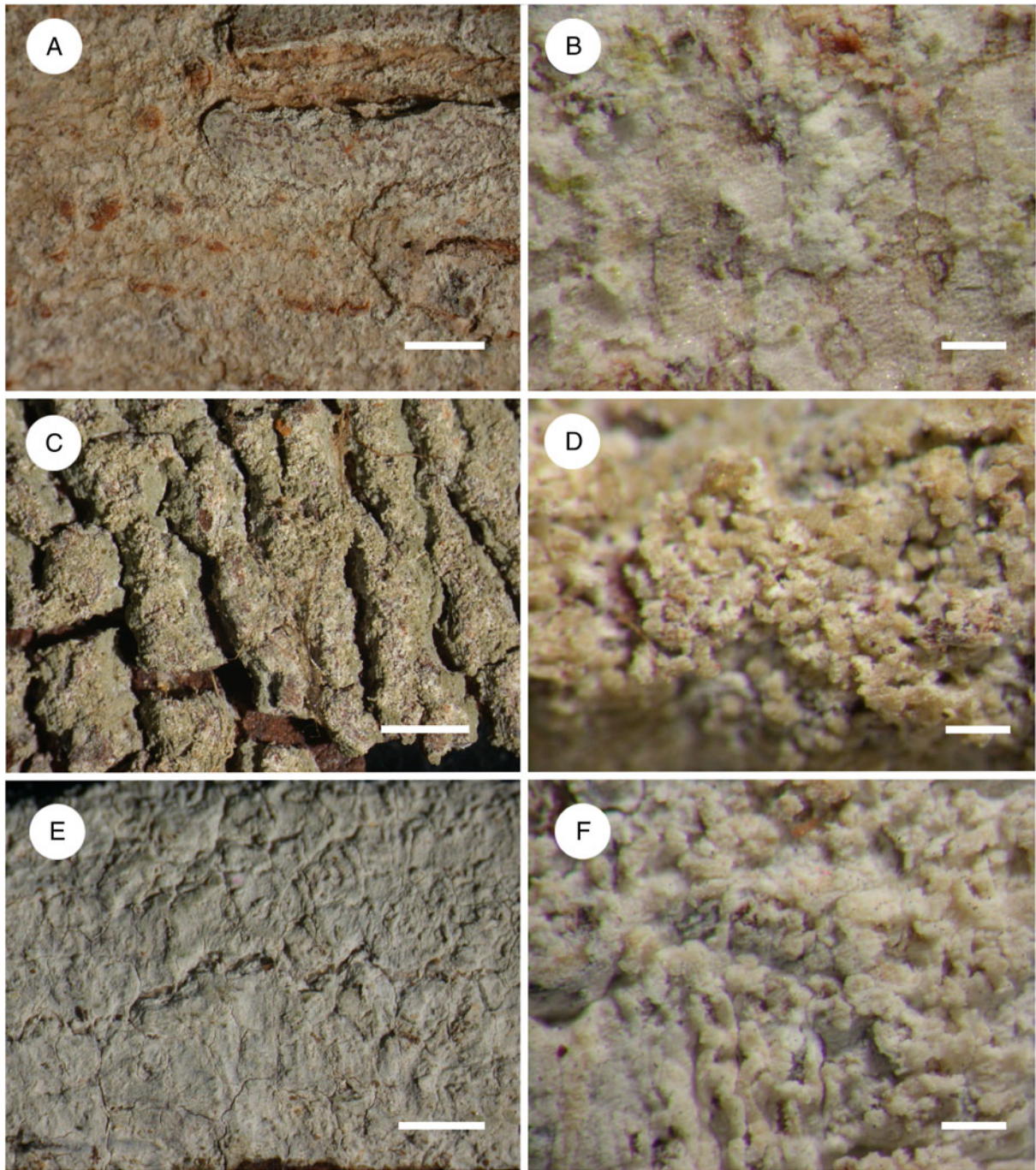


Figure 2. Habitus of new species, taken from isotypes if no collection specified. A & B, *Arthonia farinosorediata*. C–F, *Crypthonia irregularis* (E & F, ISE 40251). Scales: A, C & E = 2 mm; B, D & F = 0.2 mm. In colour online.

on tree bark in primary rainforest, 29 x 2016, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40251; ABL). GenBank No.: OR544574.

Crypthonia pseudisidiata Aptroot, L. A. Santos & M. Cáceres sp. nov.

MycoBank No.: MB 849937

Corticulous *Crypthonia* with soft pseudoisidia, differing from all known species in the genus by the presence of pseudoisidia and the absence of lichen substances.

Type: Brazil, Sergipe, Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44'35"S, 37°20'25"W, on bark in transitional forest between Atlantic rainforest and Caatinga, 19 March 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40507—holotype; ABL—istotype). GenBank Accession no: OR544578.

(Fig. 3B & C)

Thallus crustose, continuous, smooth, pseudocorticate, pure white, up to 6 cm diam., c. 0.1 mm thick, not surrounded by prothallus. *Pseudoisidia* dispersed or in groups, irregular, not very

different from irregular soredia, *c.* 0.05 mm diam., pure white. *Photobiont* trentepohlioid. *Medulla* IKI–, containing *c.* 1 µm wide hyphae without crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C–. TLC: nil.

Etymology. Named for the pseudoisidia.

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

Discussion. This species is well characterized by the soft pseudoisidia. All other species described so far in the genus (Frisch & Thor 2010) are fertile.

***Crypthonia stromatica* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

MycoBank No.: MB 849939

Corticolous *Crypthonia* with sterile stromata and confluent acid, which in addition to the absence of isidia or pseudoisidia, distinguishes it from all known species in the genus.

Type: Brazil, Pará, Dom Eliseu, Vila Nazaré, S Fazenda Pantera, alt. 120 m, 3°53'56"S, 48°05'44"W, on tree bark in primary rainforest, 29 October 2016, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40264—holotype; ABL—isotype). GenBank Accession no: OR544576.

(Fig. 3D–F)

Thallus crustose, more or less continuous, following the surface of the substratum, not corticate, dull, whitish, up to 5 cm diam., < 0.1 mm thick, not surrounded by prothallus. *Stromata* sterile, white, *c.* 0.2 mm diam. *Photobiont* trentepohlioid. *Medulla* IKI–, containing *c.* 1 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C–. TLC: confluent acid.

Etymology. Named for the stromata.

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

Discussion. This species is well characterized by the stromata and the confluent acid. All other species described so far in the genus (Frisch & Thor 2010) are fertile.

Additional material examined. **Brazil:** Sergipe: Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44'35"S, 37°20'25"W, on bark in transitional forest between Atlantic rainforest and Caatinga, 19 March 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40518; ABL); GenBank no: OR544577.

***Cryptophaea constrictopseudisidiata* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

MycoBank No.: MB 849940

Corticolous *Cryptophaea* with pseudoisidia, lichexanthone and confluent acid, the combination of which distinguishes it from all other known species in the genus.

Type: Brazil, Bahia, Chapada Diamantina, Lençóis, Cachoeira do Mosquito, alt. 450 m, 12°23'S, 41°22'40"W, on tree bark in primary Atlantic rainforest, 22 July 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40575—holotype; ABL—isotype). GenBank Accession no: OR544589.

(Fig. 4A–C)

Thallus crustose, continuous, not corticate, dull, bluish white, up to 5 cm diam., < 0.1 mm thick, surrounded by a brown prothallus line *c.* 0.4 mm wide. *Pseudoisidia* numerous, not corticate, single, more or less globose, fluffy, constricted at their base, *c.* 0.1 mm diam. *Photobiont* trentepohlioid. *Medulla* IKI–, containing *c.* 2 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV+ yellow, K–, Pd–, C–. TLC: lichexanthone and confluent acid.

Etymology. Named for the constricted pseudoisidia.

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

Discussion. This species is characterized by the pseudoisidia and the presence of lichexanthone and confluent acid. All other species described so far in the genus (Van den Broeck & Ertz 2016) are fertile. It does not clearly cluster with other species of the same genus and probably merits classification in a separate genus.

Additional material examined. **Brazil:** same as the type, 40568 (ISE; ABL); GenBank no: OR544588.

***Cryptophaea lichexanthopseudisidiata* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

MycoBank No.: MB 849941

Corticolous *Cryptophaea* with pseudoisidia and lichexanthone and an absence of confluent acid, the combination of which distinguishes it from all other species known in the genus.

Type: Brazil, Bahia, Chapada Diamantina, Lençóis, Cachoeira do Mosquito, alt. 450 m, 12°23'S, 41°22'40"W, on tree bark in primary Atlantic rainforest, 22 July 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40776—holotype; ABL—isotype). GenBank Accession no: OR544581.

(Fig. 4D & E)

Thallus crustose, continuous, somewhat verrucose, fluffy, not corticate, dull, whitish, up to 5 cm diam., < 0.1 mm thick, not surrounded by a prothallus. *Pseudoisidia* numerous, not corticate, single, globose, *c.* 0.07 mm diam. *Photobiont* trentepohlioid. *Medulla* IKI–, containing *c.* 1 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

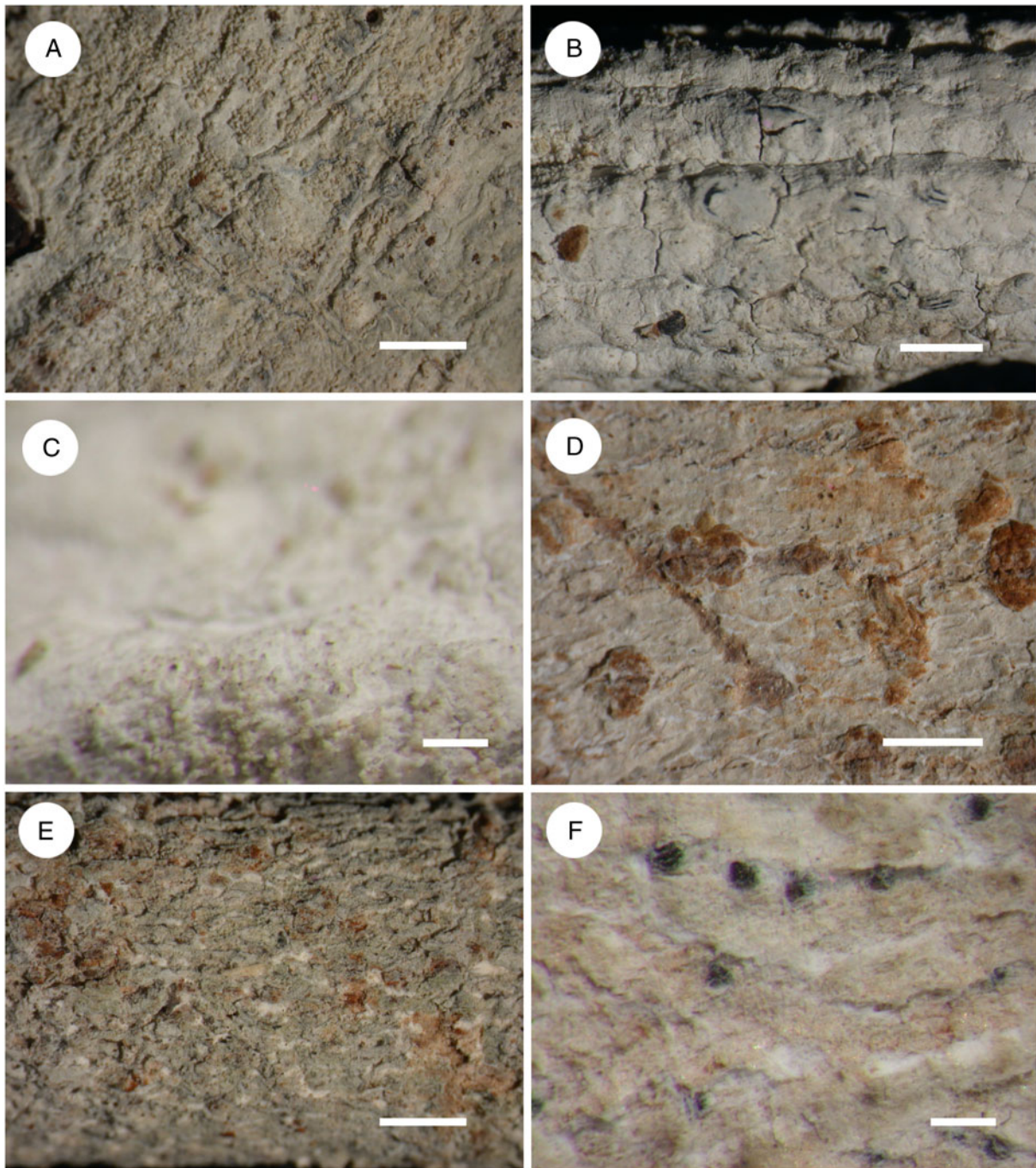


Figure 3. Habitus of new species, taken from isotypes if no collection specified. A, *Cryptothaenia irregularis* (ISE 28189). B & C, *Cryptothaenia pseudisidiatia*. D–F, *Cryptothaenia stromatica* (E, ISE 40518). Scales: A, B, D & E = 2 mm; C & F = 0.2 mm. In colour online.

Chemistry. Thallus UV+ yellow, K–, Pd–, C–. TLC: lichexanthone.

Etymology. Named for the lichexanthone and the pseudoisidia.

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

Discussion. This species is well characterized by the pseudoisidia. All other species described so far in the genus (Van den Broeck & Ertz 2016) are fertile.

***Cryptophaea lichexanthosorediata* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

Mycobank No.: MB 849942

Corticolous *Cryptophaea* with soredia, lichexanthone and divaricatic acid, the combination of which distinguishes it from all other known species in the genus.

Type: Brazil, Bahia, Chapada Diamantina, Lençois, Cachoeira do Mosquito, alt. 450 m, 12°23'S, 41°22'40"W, on tree bark in primary Atlantic rainforest, 22 July 2017, M. E. S. Cáceres & A. Aptroot

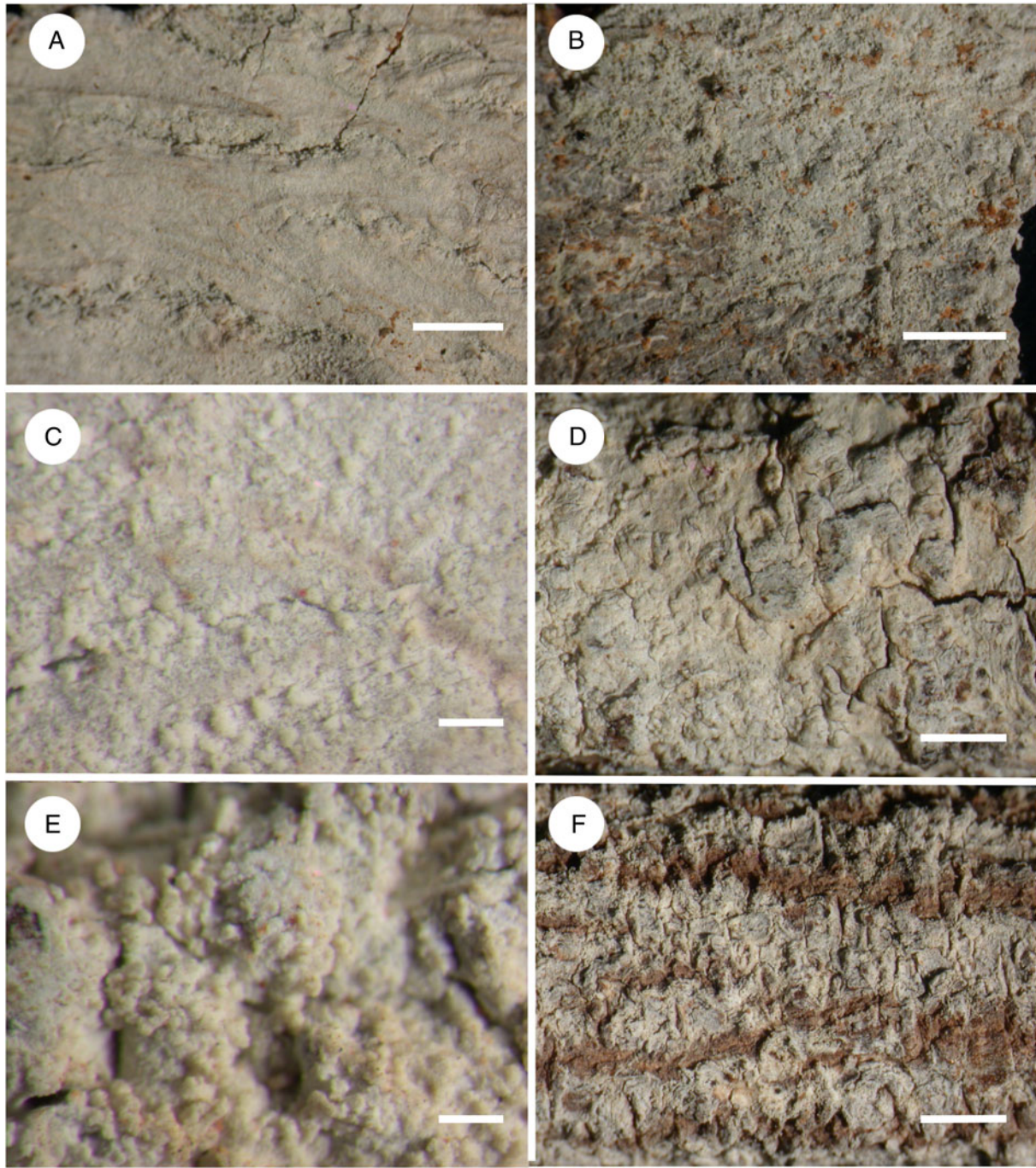


Figure 4. Habitus of new species, taken from isotypes if no collection specified. A–C, *Cryptophaea constrictopseudisidiata* (B, ISE 40568). D & E, *Cryptophaea lichexanthopseudisidiata*. F, *Cryptophaea lichexanthosorediata*. Scales: A, B & F = 2 mm; C & E = 0.2 mm; D = 1 mm. In colour online.

s. n. (ISE 40777—holotype; ABL—isotype). GenBank Accession no: OR544586.

(Figs 4F, 5A & B)

Thallus crustose, continuous, not corticate, dull, whitish, up to 5 cm diam., < 0.1 mm thick, not surrounded by a prothallus. *Soredia* numerous, in irregular soralia, granular, up to c. 0.05 mm diam. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 1 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV+ yellow, K–, Pd–, C–; medulla UV+ white. TLC: lichexanthone and divaricatic acid.

Etymology. Named for the lichexanthone and the soredia.

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

Discussion. This species is well characterized by the soredia and the presence of lichexanthone and divaricatic acid. All other

species described so far in the genus (Van den Broeck & Ertz 2016) are fertile.

Additional material examined. Brazil: same as the type, 40535 (ISE; ABL); GenBank no: OR544580.

***Cryptothecia lecanorosorediata* Aptroot & M. Cáceres sp. nov.**

MycoBank No.: MB 849943

Corticolous *Cryptothecia* with soredia and lecanoric acid, by which it differs from all other species known in the genus.

Type: Brazil, Sergipe, Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44'35"S, 37°20'25"W, on bark in transitional forest between Atlantic rainforest and Caatinga, 19 March 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40501—holotype; ABL—iso-type). GenBank Accession no: OR544584.

(Fig. 5C)

Thallus crustose, continuous, not corticate, dull, whitish, up to 5 cm diam., c. 0.1 mm thick, not surrounded by a prothallus. *Soredia* numerous, in irregular soralia, granular, up to c. 0.03 mm diam., whitish. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 1 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C+ red. TLC: lecanoric acid.

Etymology. Named for the lecanoric acid and the soredia.

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

Discussion. This species is well characterized by its soredia and lecanoric acid. Almost all other species described so far in the genus (Jagadeesh Ram & Sinha 2016) are fertile; the two exceptions are keyed out above and differ in their chemistry and in one case having pseudoisidia instead of soredia.

Additional material examined. Brazil: same as the type, 40520 (ISE; ABL); GenBank no: OR544583. **Amapá:** Mazagão, Reserva extrativista Moracá, along BR 156, alt. 30 m, 0°02'N, 51°45'W, on tree bark in disturbed forest, 21 viii 2015, M. E. S. Cáceres & A. Aptroot (ISE 27583; ABL); GenBank no: OR544582.

***Glomerulophoron confluentisorediatum* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

MycoBank No.: MB 849944

Corticolous *Glomerulophoron* with soredia, confluent and 2'-O-methylperlatolic acids, which in addition to the absence of sporodochia, distinguishes it from the only other species known in this genus.

Type: Brazil, Maranhão, Bananal 20 km S of Imperatriz, alt. 150 m, 5°39'27"S, 46°23'46"W, on *Cecropia* tree bark in garden, 25 October 2016, M. E. S. Cáceres & A. Aptroot s. n. (ISE

28727—holotype; ABL—iso-type). GenBank Accession no: OR544579.

(Fig. 5D–F)

Thallus crustose, continuous, not corticate, dull, whitish, up to 7 cm diam., thin, < 0.1 mm thick, surrounded by a black prothallus line c. 0.2 mm wide. *Soredia* numerous, partly in small, low irregular soralia but eventually on most of the thallus, farinose, whitish. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 1 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C–. TLC: confluent and 2'-O-methylperlatolic acids.

Etymology. Named for the confluent acid and the soredia.

Ecology and distribution. On tree bark in open forests; known only from Brazil.

Discussion. This species is well characterized by the soredia and the presence of confluent and 2'-O-methylperlatolic acids. The other species in the genus (Frisch *et al.* 2015) has sporodochia. The new species is described in this genus because it seems to be the closest relative.

Additional material examined. Brazil: Santa Catarina: São Francisco do Sul, Parque Estadual do Acaraí, alt. 10 m, 26° 20'44"S, 48°33'47"W, on shrub in coastal Restinga forest, 10 xi 2015, M. E. S. Cáceres & A. Aptroot s. n. (ISE 27861; ABL); GenBank no: OR544585.

***Herpothallon psorpseudisidiatum* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

MycoBank No.: MB 849945

Foliicolous *Herpothallon* with strongly attached thallus, long pseudoisidia and psoromic acid, the combination of which distinguish it from all other known species in the genus.

Type: Brazil, Sergipe, Parque Nacional Serra de Itabaiana, alt. 400 m, 10°44'35"S, 37°20'25"W, on living palm fronds in transitional forest between Atlantic rainforest and Caatinga, 19 March 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40528—holotype; ABL—iso-type). GenBank Accession no: OR544590.

(Fig. 6A & B)

Thallus crustose, byssoid, whitish, up to 5 cm diam., < 0.1 mm thick, not surrounded by a prothallus. *Pseudoisidia* globose to elongated, c. 0.1 mm diam., whitish. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 1 µm wide hyphae without crystals.

Ascomata and *pycnidia* not observed.

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

Etymology. Named for the psoromic acid and the pseudoisidia.

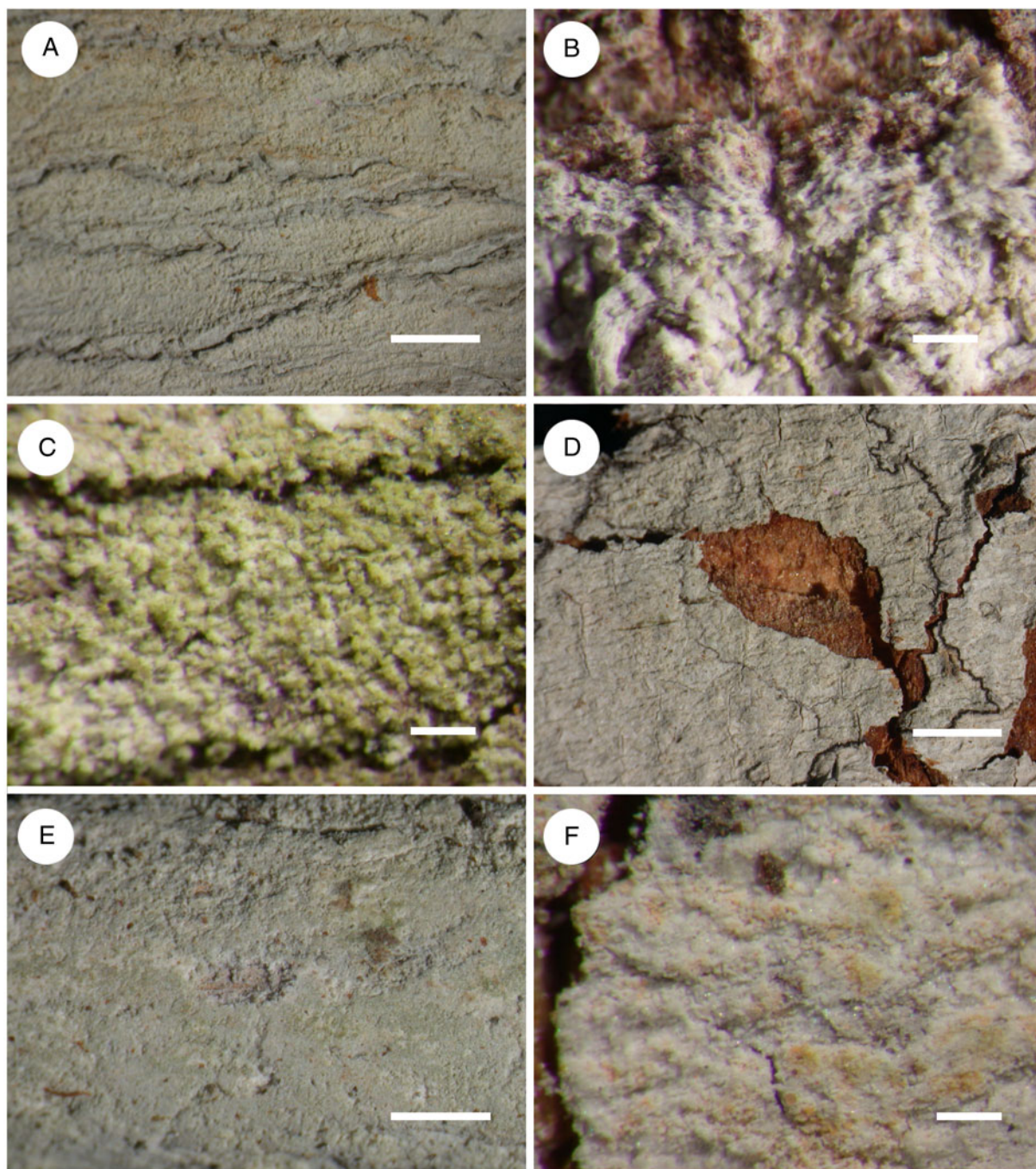


Figure 5. Habitus of new species, taken from isotypes if no collection specified. A & B, *Cryptophaea lichexanthosorediata* (A, ISE 40535). C, *Cryptothecia lecanorosorediata*. D–F, *Glomerulophoron confluentisorediatum* (E, ISE 27861). Scales: A & D = 2 mm; B, C & F = 0.2 mm; E = 1 mm. In colour online.

Ecology and distribution. On living palm leaves in primary rain-forest and on bark in coastal Restinga forest; known only from Brazil.

Discussion. This species is well characterized by the long pseudoisidia and the presence of psoromic acid. All other species described so far in the genus (see Aptroot *et al.* 2009) have a thallus that is easily detached from the substratum.

Additional material examined. **Brazil:** Santa Catarina: São Francisco do Sul, Parque Estadual do Acaraí, alt. 10 m, 26°

20'44"S, 48°33'47"W, on shrub in coastal Restinga forest, 10 xi 2015, M. E. S. Cáceres & A. Aptroot s. n. (ISE 28000; ABL).

***Myriostigma minisorediatum* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

Mycobank No.: MB 849946

Corticolous *Myriostigma* with soredia and 2'-O-methylperlatolic acid, which distinguish it from all other known species in the genus.

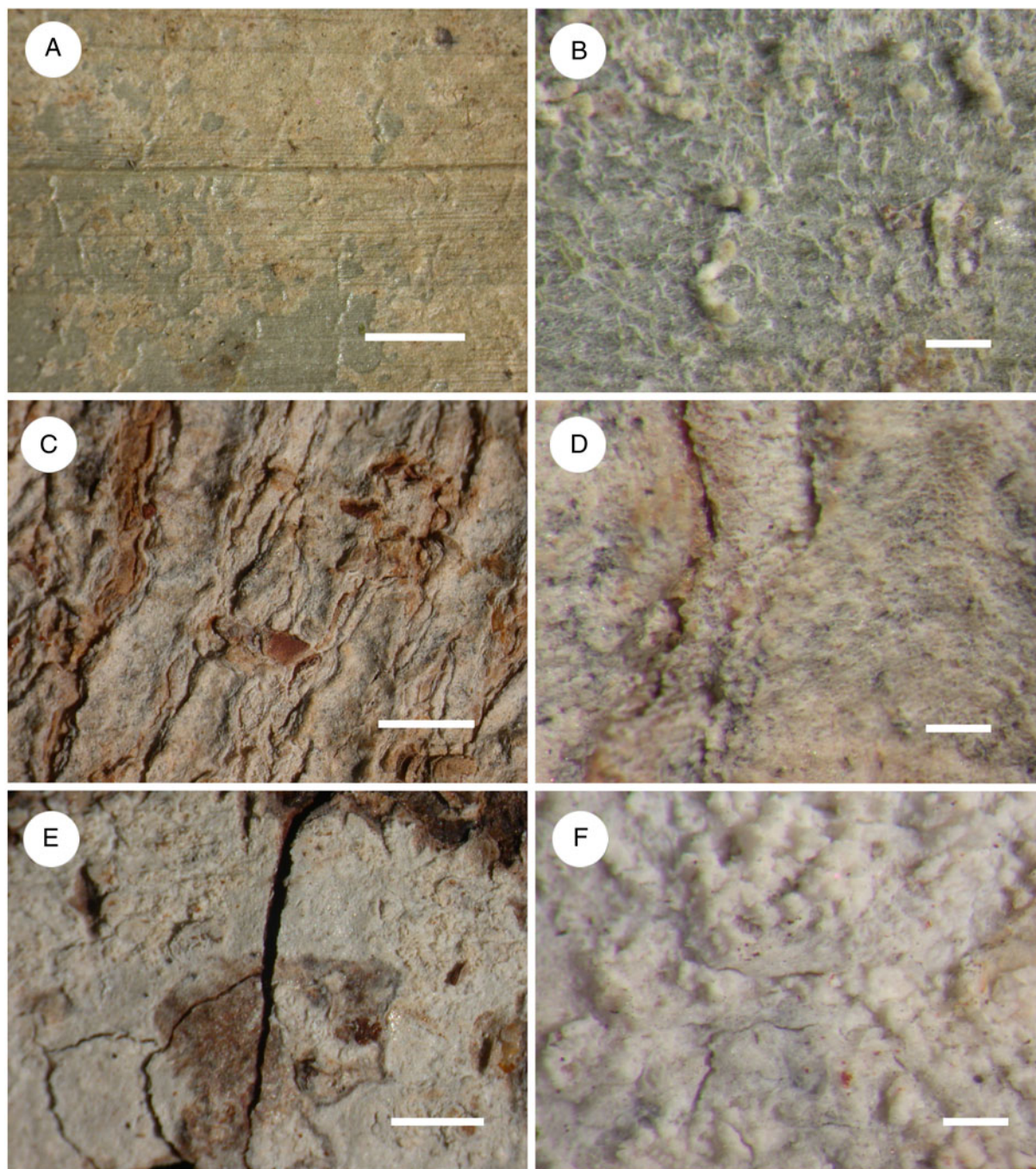


Figure 6. Habitus of new species, taken from isotypes. A & B, *Herpotherallon psorpseudisidiatum*. C & D, *Myriostigma minisorediatum*. E & F, *Pachnolepia longipseu-disidiata*. Scales: A & C = 2 mm; B, D & F = 0.2 mm; E = 1 mm. In colour online.

Type: Brazil, Tocantins, Itaguatins, alt. 150 m, 5°44'48"S, 47°33'46"W, on tree bark in Cerrado forest, 23 October 2016, M. E. S. Cáceres & A. Aptroot (ISE 28835—holotype; ABL—iso-type). GenBank Accession no: OR544587.

(Fig. 6C & D)

Thallus crustose, continuous, smooth, not corticate, whitish, up to 3 cm diam., under 0.1 mm thick, not surrounded by prothallus. *Soredia* not in soralia, dispersed on the thallus, not numerous, c. 0.02 mm diam., whitish. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 1 µm wide hyphae without crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV–, K–, Pd–, C–. TLC: 2'-O-methylperlatolic acid.

Etymology. Named for the small soredia.

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

Discussion. This species is well characterized by the small soredia and the presence of 2'-O-methylperlatolic acid. All other species

described so far in the genus (Jagadeesh Ram & Sinha 2016) are fertile.

***Pachnolepia longipseudisidiata* Aptroot, L. A. Santos & M. Cáceres sp. nov.**

MycoBank No.: MB 849947

Corticolous *Pachnolepia* with long pseudoisidia, and a thallus containing lichexanthone, confluent acid and 2'-*O*-methylperlatolic acid, differing from the only other species known in the genus by the absence of apothecia, the presence of pseudoisidia and the different chemistry.

Type: Brazil, Bahia, Chapada Diamantina, Lençois, Morro do Pai Inácio, alt. 1100 m, 12°27'24"S, 41°28'20"W, on tree bark on table mountain, 23 July 2017, M. E. S. Cáceres & A. Aptroot s. n. (ISE 40968—holotype; ABL—isotype). GenBank Accession no: OR544591.

(Fig. 6E & F)

Thallus crustose, continuous, somewhat verrucose, not corticate, dull, whitish, up to 3 cm diam., < 0.1 mm thick, not surrounded by a prothallus. *Pseudoisidia* numerous, not corticate, in irregular groups, cylindrical to gnarled, not branched, c. 0.1–0.2 mm long, c. 0.05 mm thick. *Photobiont* trentepohlioid. *Medulla* IKI–, containing c. 2 µm wide hyphae which are encrusted with small crystals.

Ascomata and *pycnidia* not observed.

Chemistry. Thallus UV+ yellow, K–, Pd–, C–. TLC: lichexanthone, confluent acid and 2'-*O*-methylperlatolic acids.


Etymology. Named for the long pseudoisidia.

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

Discussion. This species is well characterized by the long pseudoisidia. It is probably only distantly related to the type of the genus, so placement in a new genus in the future is to be expected. The only other species currently accepted in the genus (Frisch *et al.* 2014) is fertile.

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