diversity

MDPI

Article

A New Species and a New Record of Byssoid Arthoniaceae (Lichenized Ascomycota) from Southern China

Lulu Zhang *, Junxia Xue and Linlin Liu

Institute of Environment and Ecology, Shandong Normal University, Jinan 250014, China; 2021021173@stu.sdnu.edu.cn (J.X.); 2020021114@stu.sdnu.edu.cn (L.L.)
* Correspondence: 612038@sdnu.edu.cn

Abstract: This paper illustrates two species in the lichen-forming family Arthoniaceae from southern China, including a new species of *Herpothallon*, *H. fibrosum* L.L. Liu & Lu L. Zhang and a new record of *Cryptothecia*, *C. striata* G. Thor for China. *Herpothallon fibrosum* has fluffy, cylindrical pseudoisidia, like a bundle of fiber, and psoromic acid and confluentic acid are present. Furthermore, the new record of *Cryptothecia striata* has been identified by morphological, anatomical, chemical, and molecular studies. The systematic position of the two species was clarified by the molecular sequence data from the small subunit of the mitochondrial ribosomal DNA (mtSSU). Detailed taxonomic descriptions, chemical characters, comparisons, and discussion of the characteristics of similar species are provided for the two species; the relationship between *Cryptothecia* and *Herpothallon* is also discussed here.

Keywords: byssoid thalli; *Cryptothecia*; *Herpothallon*; molecular phylogeny

Citation: Zhang, L.; Xue, J.; Liu, L. A New Species and a New Record of Byssoid Arthoniaceae (Lichenized Ascomycota) from Southern China. *Diversity* **2024**, *16*, 287. https://doi.org/10.3390/d16050287

Academic Editor: Michael Wink

Received: 1 April 2024
Revised: 8 May 2024
Accepted: 9 May 2024
Published: 10 May 2024

1. Introduction

The family Arthoniaceae (Arthoniales, Arthoniomycetes, Ascomycota) contains over 700 lichenized species in 20 genera [1], and it is a major component of the lichen flora of many forest types, especially in the tropical and subtropical regions [2,3]. Up to now, 58 species of 11 genera in Arthoniaceae have been reported from China, including five species of *Cryptothecia* and 17 species of *Herpothallon* [4–7].

Morphologically, *Cryptothecia* and *Herpothallon* are closely related. Both have conspicuous byssoid crusts with trentepohlioid photobionts and asci not developing inside true ascomata. And species of *Herpothallon* were, until 2009, included within *Cryptothecia* but have been segregated by Aptroot et al. [8]; the thallus of *Cryptothecia* species is usually more tightly attached to the substrate than that of *Herpothallon*, most described species in *Cryptothecia* are fertile and without soredia and pseudoisidia; the species of *Herpothallon* typically have abundant pseudoisidia or other propagules for vegetative dispersal and are mostly sterile. Only one species, *H. fertile*, is known to produce isolated asci within pseudoisidia and ascospores with straight, not curved septa (as is characteristic for *Cryptothecia*) [8–14]. In addition, pycnidia are developed in some species inside or at the top of pseudoisidia, such as *H. isidiatum* Jagadeesh Ram & G. P. Sinha and *H. tomentosum* L.L. Liu & Lu L. Zhang [6,11]. However, in our research, we frequently encountered sterile crustose lichens that lack distinctive characteristics for accurate taxonomic classification. Adding many sterile species to *Herpothallon* or any other genus simply would make this genus even more of a dustbin. In this case, the genotypic characteristics assume great significance alongside the morphological and chemical traits. Aptroot et al. [15] described these unknown sterile species in the genera that are phylogenetically closest in their recent work. This work offers us valuable guidance in the nomenclature of sterile tropical Arthoniaceae.

In southern China, there are abundant subtropical to tropical evergreen resources. This habitat is favorable for the lichens of Arthoniaceae. Since 2020, we have conducted several investigations on Arthoniaceae in southern China and found that this family exhibits a high level of species richness, especially in the vicinity of flowing water sources, such as streams

and river valleys within forested areas. During our research, a new species of *Herpothallon* and a new record of *Cryptothecia* for China were discovered; we used mitochondrial small subunit (mtSSU) rDNA data to construct a phylogenetic tree to show the position of these two taxa and to support the delimitation of these species in the family Arthoniaceae. Our study found that the ITS sequence, typically considered crucial for distinguishing between lichen species, is essentially identical in *Cryptothecia* and *Herpothallon* and cannot be used as a standard for distinguishing between species within these two genera.

2. Materials and Methods

2.1. Investigation of Lichen Specimens

The specimens studied were collected in Fujian, Guangdong, Guizhou, Yunnan, Zhejiang Provinces, and Guangxi Zhuang Autonomous Region, China, and are preserved in the Lichen Section of the Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). The voucher numbers refer to Table 1.

Table 1. Specimens and sequences used for phylogenetic analyses. Newly generated sequences are in bold. * = outgroup.

Taxon	Locality	GenBank Accession no.	Voucher
Arthonia calcarea	Sweden	KJ850974	Thor 11/6a (UPS)
Arthonia radiata	Sweden	KJ850968	Frisch 10/Se29 (UPS)
Arthothelium orbilliferum	Norway	KY983977	TRH-L-15449
Crypthonia palaeotropica	Uganda	KJ850961	Frisch 11/Ug457 (UPS)
Cryptophaea phaeospora	DR Congo	KX077541	Van den Broeck 5809 (BR)
Cryptothecia sp. 1	Rwanda	EU704053	Ertz 8472 (BR)
Cryptothecia sp. 2	Uganda	KJ850955	Frisch 11/Ug18 (UPS)
Cryptothecia sp. 3	Uganda	KJ850956	Frisch 11/Ug194 (UPS)
***Cryptothecia striata* 1**	**China**	**PP302048**	**20230938 (SDNU)**
***Cryptothecia striata* 2**	**China**	**PP302049**	**20233925 (SDNU)**
Cryptothecia subnidulans 1	Réunion	KJ850952	v.d.Boom 40613 (hd v.d. Boom)
Cryptothecia subnidulans 2	Guyana	KJ850953	Joensson Guyana 6a (UPS)
Herpothallon inopinatum	Mexico	KJ850964	Rudolphi 12 (UPS)
Herpothallon kigeziense	Uganda	KF707644	Frisch 11/Ug26 (UPS)
Herpothallon rubrocinctum	Mexico	KF707643	Rudolphi 5 (UPS)
Herpothallon sp. 1	Uganda	KF707645	Frisch 11/Ug401 (UPS)
Herpothallon sp. 2	Brazil	OR544590	Aptroot40528
Herpothallon echinatum 1	China	OQ676528	20220048 (SDNU)
Herpothallon echinatum 2	China	OQ676540	20211610 (SDNU)
Herpothallon fibrosum 1	**China**	**OQ676530**	**20220088 (SDNU)**
Herpothallon fibrosum 2	**China**	**OQ676541**	**20222323 (SDNU)**
Herpothallon fibrosum 3	**China**	**OQ676536**	**20220374 (SDNU)**
Herpothallon glaucescens	China	OQ676531	20220069 (SDNU)
Herpothallon lilacinum	China	OQ676532	20220090 (SDNU)
Herpothallon tomentosum	China	OQ676538	20220565 (SDNU)
Inoderma nipponicum	Japan	KP870146	Frisch 12Jp227 (TNS)
Leprantha cinereopruinosa	Poland	MG207692	Kukwa 17127 & Lubek (BR)
Myriostigma candidum 1	Gabon	EU704052	Ertz 9260 (BR)
Myriostigma candidum 2	Uganda	KJ850959	Frisch 11/Ug125 (UPS)
Myriostigmaminiatum	Brazil	KP843606	Silva T2A29 (ISE—epitype)
Pachnolepia pruinata	Sweden	KJ850967	Frisch 11/Se34 (UPS)
Snippocia nivea	France	MG207695	Ertz 17437 (BR)
Stirtonia neotropica	Brazil	KP843611	Cáceres & Aptroot 11112 (ISE)
Sporodophoron gossypinum	Japan	KP870154	Frisch 12Jp186 (TNS)
Sporodophoron primorskiense	Russia	KP870157	Ohmura 10509 (TNS)
Tylophoron moderatum	DR Congo	JF830780	Ertz 14504 (BR)
Chiodecton natalense *	Zambia	EU704051	Ertz 6576 (BR)

2.2. Morphological and Chemical Analyses

The morphological and anatomical characters were examined under a stereo microscope (COIC XTL7045B2) and a polarizing microscope (Olympus CX41). The thallus and medulla were tested with K (a 10% aqueous solution of potassium hydroxide), C (a saturated solution of aqueous sodium hypochlorite), P (a saturated solution of p-phenylenediamine in 95% ethyl alcohol), I (a 3% Lugol's iodine) for identification, and H_2SO_4 (a 10% sulfuric acid solution). Polarized light (pol) was used to locate crystals in the sections. The lichen substances were identified using standardized thin-layer chromatography techniques (TLC) with systems B′ and C [16]. In this study, *Lethariella cladonioides* (Nyl.) Krog. containing atranorin and norstictic acid was used as the partition standard sample. Micrographs were taken under an Olympus SZX16 research stereo microscope and a BX61 research microscope with an Olympus DP72 CCD Microscope Digital Camera.

2.3. DNA Extraction, Amplification and Sequencing

Samples for molecular genetic analysis were taken from the clean growing portions of the thallus (e.g., prothallus hyphae, pseudoisidia, pseudoisidioid structure) of specimens, and pigmented or carbonized portions were removed as far as possible. The amount of lichen used depends on the thickness of the thallus; usually, 7 mm^2 was used.

Genomic DNA was extracted using the Sigma-Aldrich REDExtract-N-Amp Plant PCR Kit (St. Louis, MO, USA) following the manufacturer's instructions, except only 30 µL of extraction buffer and 30 µL dilution buffer were used.

The following primers were used for PCR amplification: mrSSU1 and mrSSU3R [17]. The 50 µL PCR mixture consisted of 2 µL DNA, 2 µL of each primer, 25 µL 2 × Taq PCR MasterMix (Taq DNA Polymerase [0.1 unit/µL]; 3 mM $MgCl_2$; 100 mM KCl; 0.5 mM dNTPs; and 20 mM Tris-HCl [pH 8.3]) (Tiangen, Beijing, China) and 19 µL dd H_2O. PCR cycling conditions were 94 °C for 10 min, followed by 34 cycles of 95 °C for 45 s, 50 °C for 45 s, and 72 °C for 90 s, followed by a final extension at 72 °C for 10 min. Sequencing was performed by the company BioSune Biological Technology (Shanghai, China); an ABI 3730 XL sequencer was used to sequence both strands.

2.4. Phylogenetic Analysis

The mtSSU sequences were assembled and edited using SeqMan v.7.0 (DNAstar packages). The assembled sequences were blasted using NCBI Blast (http://www.ncbi.nlm.nih.gov/BLAST/, accessed on 8 February 2024) to preliminarily identify which taxa they belong to and subsequently aligned with MAFFT v7.505 using E-INS-i algorithm and normal alignment mode [18]. The final alignment contained species of *Cryptothecia*, *Herpothallon*, and other genera in the Arthoniaceae. The species *Chiodecton natalense* Nyl. was chosen as the outgroup. In addition to our newly generated sequences, other related sequences were downloaded from GenBank and mostly from Frisch et al. [19] and Thiyagaraja et al. [20] (Table 1).

Phylogenetic relationships were inferred using maximum likelihood (ML) and Bayesian inference (BI). The best substitution models were estimated using ModelFinder v2.2.0 for the subsequent ML and BI analyses [21]. In ML analysis, TVM+F+I+G4 is the best-fit model for mtSSU; in BI analysis, GTR+I+G+F is the best-fit model. The ML analyses were performed by the IQ-TREE v2.2.0 with 1000 replicates as bootstrap analysis [22]. The BI analyses were performed by MrBayes v. 3.2.6 [23], using three Markov chains running for 10 million generations for the concatenated dataset. The trees were sampled every 100 generations, and the first 25% of the trees were discarded as burn-ins. Bootstrap support (BS) $\geq$ 70 and posterior probability (PP) $\geq$ 0.95 were considered significant support values. All of the above analysis software, except SeqManv.7.0, operate within PhyloSuite v1.2.3 [24,25].

The phylogenetic trees generated were visualized with FigTree v. 1.4.2 [26].

3. Results and Discussion

A total of five mtSSU sequences were newly generated from five specimens. We constructed ML and BI topologies based on mtSSU sequences and 32 additional sequences found on GenBank, mostly from Frisch et al. [19] and Thiyagaraja et al. [20]. The phylogenetic trees obtained from ML and BI analyses exhibited consistent topologies; therefore, we present only the ML tree (Figure 1).

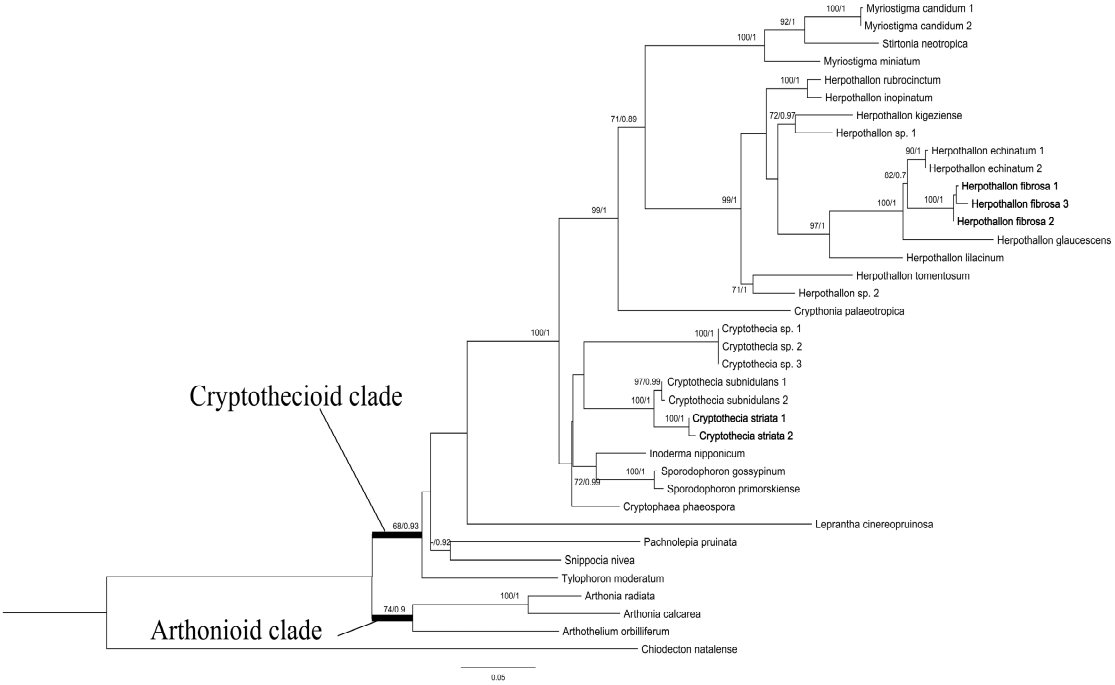

Figure 1. Phylogenetic tree generated from maximum likelihood (ML) analysis based on mtSSU sequences. ML bootstrap values (**left**) and Bayesian posterior probabilities (**right**) are indicated at the nodes. New species and records from China are shown in bold.

The topology of the phylogenetic tree, divided into the Arthonioid and Cryptothecioid clades, was largely congruent with that of earlier studies [19,20]. All species of *Herpothallon* and *Crypthothecia* belong to the Cryptothecioid clade. The newly identified *Herpothallon* specimens formed a single clade, represented by a bootstrap support of 100 and a posterior probability of 1 for the branch (Figure 1). Based on the differences in phylogeny and morphology compared to other species, which are described in detail below, it is classified as a new species named *Herpothallon fibrosum* (refer to Taxonomy below). The new record, *Cryptothecia striata*, is phylogenetically close to *C. subnidulans*, the type of the genus; they all have gray thallus and 1-spored asci, but *C. striata* exhibit radiating ridges on the thallus and contain gyrophoric acid and lecanoric acid as secondary metabolites, which distinguish it from *C. subnidulans* [9,27].

4. Taxonomy

Herpothallon fibrosum L.L. Liu & Lu L. Zhang, sp. nov. (Figure 2).

MycoBank No: 852798.

Diagnosis: This species is easily recognized by the fluffy, cylindrical pseudoisidia like a bunch of wool and the presence of both psoromic and confluentic acids.

Type: China, Guizhou Province: Tongren City, Xu Jia Ba town, Zhang Jia Gou, along the stream. 27°55′33.38″ N, 108°1′59.13″ E, on leaves, alt. 851 m,11 June 2022, L.L. Liu, Y.X. Bi, Z.H. Jiang & D.C. Yan 20220088 (SDNU, Holotype).

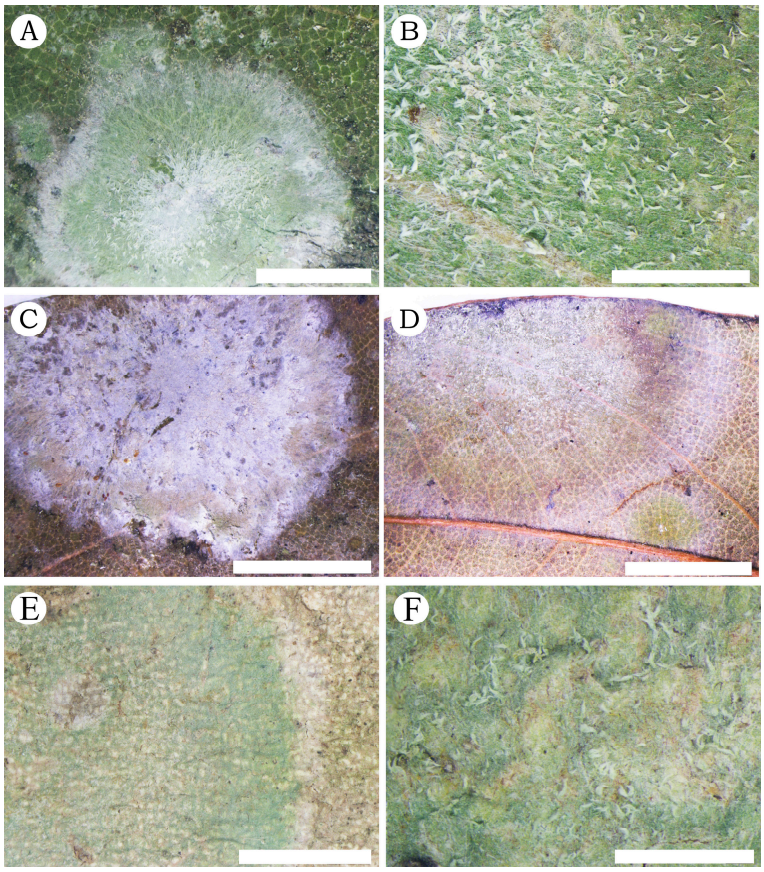

Figure 2. *Herpothallon fibrosum* (**A**,**B**) Thallus and pseudoisidia of fresh foliicolous specimen (20220088); (**C**,**D**) Thallus of foliicolous specimen after storage ((**D**): hypophyllous thallus) (20220088); (**E**,**F**) Thallus and pseudoisidia of fresh corticolous specimen (20220077) Scale bars: 2 mm (**A**); 800 µm (**B**); 3 mm (**C**); 4 mm (**D**); 3 mm (**E**); 500 µm (**F**).

Description: Thallus foliicolous, corticolous or saxicolous, up to 3 cm across, orbicular, sometimes flaking off, loosely to firmly appressed to the substrate, soft, felty to byssoid (sometimes arachnoid), dull, blue–green to greenish grey and greenish white in the inner part, rather thin, in sections up to 50 µm thick, with many calcium oxalate crystals throughout the thallus (insoluble in KOH, forming colorless, needle-shaped crystals in 10% H_2SO_4). Hypothallus whitish, byssoid, composed of 1–3 µm wide hyphae. Prothallus up to 3 mm broad, distinct, whitish, byssoid, composed of interwoven and radiating hyphae. Pseudoisidia are numerous, covered in the center of the thallus, loose, fluffy, cylindrical, like a bundle of fiber, sparsely branched, greenish white to whitish, 0.1–0.45 × 0.02–0.1 mm. Photobiont *trentepohlia*, in short, irregular threads; cells yellowish green, 6–18 × 5–10 µm. Asci and pycnidia were not seen.

Chemistry: Thallus and prothallus K−, C−, P−, UV−, I+ orange–red in the medulla. TLC: psoromic acid (major), confluentic acid (major).

Etymology: The epithet refers to the fluffy, cylindrical pseudoisidia, like a bundle of fiber.

Ecology and distribution: The new species was found growing on leaves of a tree next to a stream in Guizhou, high humidity in the growing environment.

Additional specimen examined: CHINA. Guizhou Province: Tongren City, Xu Jia Ba town, Zhang Jia Gou, along the stream, 851 m elev., 27°55′33.38″ N, 108°1′59.13″ E, on leaves, 11 June 2022, L.L. Liu, Y.X. Bi, Z.H. Jiang & D.C. Yan 20220083 (SDNU); Tongren City, Xu Jia Ba town, Zhang Jia Gou, along the stream, 851 m elev., 27°55′33.38″ N, 108°1′59.13″ E, on barks, 11 June 2022, L.L. Liu, Y.X. Bi, Z.H. Jiang & D.C. Yan 20220051, 20220077, 20220091, 20220092 (SDNU); Fujian Province: Zhangzhou City, Gongya Mountain Forest Park, near

Shenxiandong, 1224 m elev., 24°54′8.6″ N, 117°25′33.76″ E, on bark, 13 July 2022, L.L. Liu, J.X. Xue & L. Wang 20221040, 20221167, 20221216, 20221219, 20221259 (SDNU); Zhangzhou City, Gongya Mountain Forest Park, from Yingkemen to the "Precious Taxus chinensis", 1020 m elev., 24°54′28.05″ N, 117°25′17.83″ E, on the leaves of Pseudosasa orthotropa S.L. Chen et Wen, 13 July 2022, L.L. Liu, J.X. Xue & L. Wang 20221061, 20221062; Longyan City, Dongxiao National Forest Park, 621 m elev., 24°58′8.64″ N, 117°1′11.98″ E, on bark of a tree, 12 July 2022, L.L. Liu, J.X. Xue & L. Wang, 20220659 (SDNU); Xiamen City, Tianzhu Mountain Forest Park, the forest near Haowangjiao, 308 m elev., 24°35′40.26″ N, 117°55′45.74″ E, on bark, 11 July 2022, L.L. Liu, J.X. Xue & L. Wang 20220372, 20220374 (SDNU); Zhejiang Province: Lishui City, Jingning County, Wangdongyang Nature Reserve, 1299 m elev., on bark of tree, 2 December 2020, C.G. Zhao & L.L. Zhang 20222322, 20222323, 20222324, 20222325, 20222326, 20222327 (SDNU); Guangdong Province: Chaozhou City, Raoping County, Xiyan Mountain tea farm, 830 m elev., on bark of tree, 16 July 2022, L.L. Liu, J.X. Xue & L. Wang 20220998, 20221000 (SDNU); Guangxi Zhuang Autonomous Region: Liuzhou City, Rongshui County, Jiuwan Mountain National Nature Reserve, 359 m elev., on bark of tree, 29 December 2020, L. Hu, P.F. Chen & Y.X. Bi, 20200325, 20200329, 20200331 (SDNU); Fangchenggang City, Shiwan Mountain National Nature Reserve, 753 m elev., on leaves of tree, 28 December 2020, L.L. Zhang et.al 20200237 (SDNU); Nanning City, Daming Mountain National Nature Reserve, 1210 m elev., on bark of tree, 30 December 2020, X. Zhang, 20200053 (SDNU); Nanning City, Daming Mountain National Nature Reserve, 1210 m elev., on rock, 30 December 2020, X. Zhang, 20200504 (SDNU).

Notes: *Herpothallon fibrosum* is widely distributed in southern China and is unusual among species of *Herpothallon* in the fluffy, cylindrical pseudoisidia. The foliicolous specimens have thin thalli in sections up to 50 µm thick, usually epiphyllous, partly hypophyllous, and forming a hyphal network incompletely covering the substrate, and during the storage in the herbarium, their thallus turned beige to greyish white. The corticolous and saxicolous specimens have thick thalli in sections up to 200 µm thick.

The chemical composition of this species has not previously been reported for the genus, but the beige to greyish white thallus and similar form of pseudoisidia (20–60 µm diam.) can be seen at *Herpothallon aff. confluenticum* Aptroot & Lücking, it also produces confluentic acid, but without psoromic acid and calcium oxalate crystals, I Lugol's− and delimited by a compact brown prothallus [12]. The compact brown prothallus of *H. aff. confluenticum* mentioned in Bungartz et al. [12], it looks like there is another lichen around its thallus, so we suppose its compact brown prothallus may be caused by another lichen and thalli. *Herpothallon confluenticum* Aptroot & Lücking also contains confluentic acid as major; however, it has a dirty whitish prothallus and a whitish to brownish hypothallus, cylindrical pseudoisidia, partly branched at the tips, up to 0.6 × 0.2 mm [8].

Cryptothecia striata G. Thor, The Bryologist 32: 277 (1991) (Figure 3).

Type: USA. Florida: Sarasota Co. Myakka State Park, ca. 33 km ESE Sarasota, rather dry swamp forest, Thor 2200 (s, holotype; NY, isotype).

Description: Thallus corticolous, rarely saxicolous, up to 1–10.5 cm in diameter, ecorticate, firmly to loosely attached to the substrate, cottony, dull, greenish grey to whitish grey or pale green. Medulla white, with many calcium oxalate crystals (insoluble in KOH, forming colorless, needle-shaped crystals in 10% H_2SO_4). Hyphae 1.5–2 µm wide. Prothallus is usually distinct, thick, whitish byssoid, mainly composed of interwoven hyphae. Isidia not observed, but the thallus has granula isidia-like structures. Photobiont trentepohlioid, single or aggregated into bundles, cells yellowish green, 7–16.5 × 7–10 µm.

Ascigerous areas are generally delimited, whitish, and developing in the thallus center as white dots at first and then soon merging into distinctly radiating striae, rarely not forming striae. Asci hyaline, isolated or weakly aggregated, broadly pyriform to oblong or rarely globose, with a stalk, often covered by hyaline hyphae, 1-spored or very rarely 2-spored, 62–80 × 42–56 µm. Ascospores hyaline, ovoid to oblong, muriform, surrounded by abundant cytoplasm in the asci when mature, 54–80 × 21–42 µm. Pycnidia were not observed.

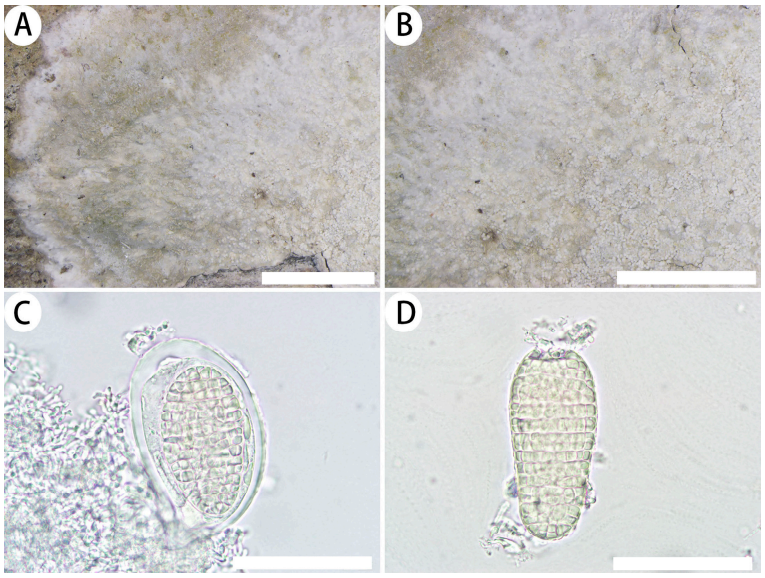

Figure 3. *Cryptothecia striata* (SDNU 20231073). (**A**) Thallus and prothallus. (**B**) Ascigerous areas. (**C**) Ascus. (**D**) Ascospores. Scale bars: 2 mm (**A**,**B**); 50 µm (**C**,**D**).

Chemistry: Thallus C+ red, K–, P–, UV+ pale grey–white; medulla and paraphysoids I+ blue. TLC: gyrophoric acid (major), lecanoric acid, traces of atranorin.

Ecology and distribution: *Cryptothecia striata* has previously been reported in the USA, Georgia, Ecuador, and India et al. [12,27,28] and is new to China. It was found growing on the bark of trees in a humid forest in Yunnan, Guangxi Zhuang Autonomous Region, and Fujian Province.

Additional specimen examined: CHINA. Yunnan Province: Jinghong City, Mengla County, Menglun Town, Xishuangbanna Tropical Botanical Garden, 21°55′35.23″ N, 101°15′15.09″ E, alt. 512 m, on the bark of trees, 4 March 2023, L.L. Liu et al. 20230938 (SDNU); same collection data for preceding, 21°55′43.17″ N, 101°15′39.08″ E, alt. 525 m, on the bark of trees, 5 March 2023, L.L. Liu et al. 20231073 (SDNU); Xishuangbanna Dai Autonomous Prefecture, Jinghong City, Wild Elephant Valley, 22°10′17.90″ N, 100°51′39.06″ E, alt. 732 m, on the bark of trees, 6 March 2023, L.L. Liu et al. 20233925 (SDNU); Guangxi Zhuang Autonomous Region: Nanning City, Shiwan Mountain, 21°53′58.25″ N, 107°54′04.41″ E, alt. 533 m, on the bark of trees, 27 December 2020, Lu L. Zhang et al. 20200189 (SDNU); same collection data for preceding, 21°53′58.04″ N, 107°54′23.54″ E, alt. 341 m, on the bark of trees, 28 December 2020, Lu L. Zhang et al. 20200230 (SDNU); Fujian Province: Nanping City, Jianou City, Fangdao Town, Wanmulin Nature Reserve, 27°3′0.43″ N, 118°8′35.51″ E, alt. 265 m, on the bark of trees, 15 April 2023, J.X. Xue & L. Wang 20231685 (SDNU); same collection data for preceding, 27°2′51.11″ N, 118°8′34.32″ E, alt. 300 m, on the bark of trees, 14 April 2024, Lu L. Zhang et al. 20231311 (SDNU).

Notes: According to Thor, Bungartz, and Mishra et al. [12,27,28], *Cryptothecia striata* is characterized by thallus having granula isidia-like structures and ascigerous areas merging into distinctly radiating striae. The Chinese material closely matches the description in Thor, Bungartz, and Mishra et al. [12,27,28]. *Cryptothecia striata* is similar to *C. punctosorediata* Sparrius in having greenish grey to whitish grey thallus and isidia-like structures, but *C. punctosorediata* has (6–)8-spored asci and smaller ascospores (40–50 × 15–20 µm) [29]. In addition, *Cryptothecia striata* is similar to *C. scripta* G. Thor in having isidia-like structures, 1-spored asci and gyrophoric acid and lecanoric acid as secondary metabolites, but the latter has globose isidia-like structures, shorter asci (30–40 µm), and shorter ascospores (19–27 µm) [9].

Author Contributions: Conceptualization, L.Z.; methodology, J.X. and L.Z.; software, J.X. and L.Z.; validation, L.L.; formal analysis, J.X., L.L. and L.Z.; investigation, L.L., J.X. and L.Z.; data curation, J.X. and L.Z.; writing—original draft preparation, L.L. and L.Z.; writing—review and editing, L.Z. and L.L.; visualization, J.X. and L.L.; supervision, L.Z.; project administration, L.Z.; funding acquisition, L.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the National Natural Science Foundation of China (No. 32170002, 31750001).

Institutional Review Board Statement: Not applicable.

Data Availability Statement: Publicly available datasets were analyzed in this study. This data can be found from here: https://www.ncbi.nlm.nih.gov/ (accessed on 8 February 2024).

Acknowledgments: We would like to express our deep thanks to Y.X. Bi, L. Wang, and L. Hu for their help with field research.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Lücking, R.; Hodkinson, B.P.; Leavitt, S.D. The 2016 classification of lichenized fungi in the Ascomycota and Basidiomycota—Approaching one thousand genera. *Bryologist* **2017**, *119*, 361–416. [CrossRef]
2. Broeck, V.D.; Frisch, A.; Razafindrahaja, T.; Vijver, B.V.; Ertz, D. Phylogenetic position of *Synarthonia* (lichenized Ascomycota, Arthoniaceae), with the description of six new species. *Plant Ecol. Evol.* **2018**, *151*, 327–351. [CrossRef]
3. Frisch, A.; Thor, G. *Crypthonia*, a new genus of byssoid *Arthoniaceae* (lichenised *Ascomycota*). *Mycol. Prog.* **2010**, *9*, 281–303. [CrossRef]
4. Wei, J.C. *The Enumeration of Lichenized Fungi in China*; China Forestry Publishing House: Beijing, China, 2020; pp. 1–7, ISBN 978-75-2190-770-4.
5. Chen, P.F.; Liu, L.L.; Xie, C.M.; Zhang, L.L. Four new species of *Herpothallon* (Arthoniaceae, Arthoniales, Arthoniomycetes, Ascomycota) from China. *Phytotaxa* **2022**, *536*, 83–91. [CrossRef]
6. Liu, L.L.; Zuo, Q.J.; Xue, J.X.; Ren, Z.J.; Zhang, L.L. Three new species of *Herpothallon* (Lichenized Ascomycota) from Southern China. *Phytotaxa* **2023**, *597*, 287–296. [CrossRef]
7. Liu, L.L.; Zuo, Q.J.; Zhang, L.L. Species diversity and floristic elements of the lichen genus *Herpothallon* in China. *Guihaia* **2023**, *43*, 1268–1275. [CrossRef]
8. Aptroot, A.; Thor, G.; Lücking, R.; Elix, J.A.; Chaves, J.L. The lichen genus *Herpothallon* reinstated. *Bibl. Lichenol.* **2009**, *99*, 19–66.
9. Thor, G. The genus *Cryptothecia* in Australia and New Zealand and the circumscription of the genus. *Symb. Bot. Ups.* **1997**, *32*, 267–289. Available online: https://BiotaNZ.landcareresearch.co.nz/references/2b656e1b-9b06-4e85-8e5d-4c2d90a1d017 (accessed on 7 May 2024).
10. Makhija, U.; Patwardhan, P.G. A contribution towards a monograph of the lichen genus *Cryptothecia* (family Arthoniaceae). In *Current Researches in Plant Sciences*; Bishen Singh Mahendra Pal Singh: Dehra Dun, India, 1994; pp. 57–72. [CrossRef]
11. Jagadeesh Ram, T.A.M.; Sinha, P.G.; Singh, K.P. New species and new records of *Cryptothecia* and *Herpothallon* (*Arthoniales*) from India. *Lichenologist* **2009**, *41*, 605–613. [CrossRef]
12. Bungartz, F.; Dutan-Patino, V.L.; Elix, J.A. The lichen genera *Cryptothecia*, *Herpothallon* and *Helminthocarpon* (Arthoniales) in the Galapagos Islands, Ecuador. *Lichenologist* **2013**, *45*, 739–762. [CrossRef]
13. Frisch, A.; Rudolphi, J.; Thor, G. *Herpothallon inopinatum* (*Arthoniaceae*), a new lichen species from Mexico. *Ann. Bot. Fenn.* **2014**, *51*, 63–68. [CrossRef]
14. Jagadeesh Ram, T.A.M.; Sinha, G.P. A world key to *Cryptothecia* and *Myriostigma* (Arthoniaceae), with new species and new records from the Andaman and Nicobar Islands, India. *Phytotaxa* **2016**, *266*, 103–114. [CrossRef]
15. Aptroot, A.; Cáceres, M.E.; Santos, L.A. The taxonomy of sterile Arthoniaceae from Brazil: White crusts on overhanging tropical trees can be named. *Lichenologist* **2024**, *56*, 1–13. [CrossRef]
16. Orange, A.; James, P.W.; White, F.J. *Microchemical Methods for the Identification of Lichens*; British Lichen Society: London, UK, 2001; pp. 1–101. [CrossRef]
17. Zoller, S.; Scheidegger, C.; Sperisen, C. PCR primers for the amplification of mitochondrial small subunit ribosomal DNA of lichen-forming ascomycetes. *Lichenologist* **1999**, *31*, 511–516. [CrossRef]
18. Katoh, K.; Standley, D.M. MAFFT multiple sequence alignment software version 7: Improvements in performance and usability. *Mol. Biol. Evol.* **2013**, *30*, 772–780. [CrossRef]
19. Frisch, A.; Thor, G.; Ertz, D.; Grube, M. The Arthonialean challenge: Restructuring Arthoniaceae. *Taxon* **2014**, *63*, 727–744. [CrossRef]
20. Thiyagaraja, V.; Lücking, R.; Ertz, D.; Wanasinghe, D.N.; Karunarathna, S.C.; Camporesi, E.; Hyde, K.D. Evolution of non-lichenized, saprotrophic species of Arthonia (Ascomycota, Arthoniales) and resurrection of Naevia, with notes on Mycoporum. *Fungal Divers.* **2020**, *3*, 205–224. [CrossRef]

21. Kalyaanamoorthy, S.; Minh, B.Q.; Wong, T.K.F.; von Haeseler, A.; Jermiin, L.S. ModelFinder: Fast model selection for accurate phylogenetic estimates. *Nat. Methods* **2017**, *14*, 587–589. [CrossRef]
22. Nguyen, L.T.; Schmidt, H.A.; von Haeseler, A.; Minh, B.Q. IQ-TREE: A fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. *Mol. Biol. Evol.* **2014**, *32*, 268–274. [CrossRef]
23. Ronquist, F.; Teslenko, M.; van der Mark, P.; Ayres, D.L.; Darling, A.; Höhna, S.; Larget, B.; Liu, L.; Suchard, M.A.; Huelsenbeck, J.P. MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. *Syst. Biol.* **2012**, *61*, 539–542. [CrossRef]
24. Zhang, D.; Gao, F.; Jakovlić, I.; Zou, H.; Zhang, J.; Li, W.X.; Wang, G.T. PhyloSuite: An integrated and scalable desktop platform for streamlined molecular sequence data management and evolutionary phylogenetics studies. *Mol. Ecol. Resour.* **2020**, *20*, 348–355. [CrossRef] [PubMed]
25. Xiang, C.-Y.; Gao, F.; Ivan, J.; Lei, H.; Hu, Y.; Zhang, H.; Zou, H.; Wang, G.; Zhang, D. *Using PhyloSuite for Molecular Phylogeny and Tree-Based Analyses*; IMeta: Chilworth, UK, 2023. [CrossRef]
26. Rambaut, A. FigTree, v. 1.4.0. Institute of Evolutionary Biology, University of Edinburgh. 2012. Available online: http://tree.bio.ed.ac.uk/software/Figtree/ (accessed on 7 May 2024).
27. Thor, G. The Placement of *Chiodecton sanguineum* (syn. *Chiodecton rubrocinctum*), and *Cryptothecia striata* sp. nov. *Bryologist* **1991**, *94*, 278–283. [CrossRef]
28. Mishra, R.; Chand, P.K.; Satapathy, K.B. New Addition of Twenty Lichen Species to the Flora of Odisha: A Report. *Asian J. Biol. Life Sci.* **2021**, *10*, 378–390. [CrossRef]
29. Sparrius, L.B.; Saipunkaew, W. *Cryptothecia punctosorediata*, a new species from Northern Thailand. *Lichenologist* **2005**, *37*, 507–509. [CrossRef]