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Authors: Segundo-Neto, Florentino Cazé A., and Wartchow, Felipe

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Research article

The easternmost record of *Cladonia furfuraceoides* (Cladoniaceae) in South America

Florentino Cazé A. Segundo-Neto  and Felipe Wartchow 

Departamento de Sistemática e Ecologia/CCEN, Universidade Federal da Paraíba, João Pessoa, PB, Brazil

Correspondence: Florentino Cazé A. Segundo-Neto (florentinocasn@gmail.com)

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Cladonia furfuraceoides is reported from white sand in a savannoid ‘tabuleiro’ forest in Paraíba, Brazil. Prior to that, it was known only from the Guiana Shield and the Brazilian and Colombian Amazon Basin. The specimens are characterized by the persistent but not abundant primary thallus, and short, mostly simple, ecorticate podetia, melanotic towards the base, without isidioid, reflexed microsquamules, but macrosquamulose, with flattened, submembranous squamules with short-digitate edge.

Keywords: Ascomycota, Lecanoromycetes, Mata Atlântica, symbiosis, taxonomy

Cladonia P.Browne is a relatively well inventoried lichen genus in Brazil. The recent update of the ‘Lista de Espécies da Flora do Brasil’ includes 116 taxa ([Flora e Funga do Brasil 2023](#)). At least 13 species are known from the State of Paraíba ([Ahti et al. 1993](#)): *C. cartilaginea* Müll. Arg., *C. clathrata* Ahti & L.Xavier, *C. furfuracea* Vain., *C. pityrophylla* Nyl., *C. polita* Ahti, *C. polyscypha* Ahti & L.Xavier, *C. rhodoleuca* Vain., *C. rugicaulis* Ahti, *C. salzmännii* Nyl., *C. secundana* Nyl., *C. subminiata* S.Stenroos, *C. subsquamosa* Kremp., *C. substellata* Vain. and *C. verticillaris* (Raddi) Fr. One of these, *C. furfuracea* was originally considered a widespread species, occurring in coastal sandy areas of Brazil and inland, and also in Amazonia and the Guiana Shield ([Ahti 2000](#)). During field trips in the state of Paraíba, specimens resembling *C. furfuracea* were collected. However, upon a closer look this material fits better the description of *C. furfuraceoides* ([Stenroos et al. 2002](#)), a recent segregate, and it is described and discussed here.

Methods

The specimens were collected in an open savanna forest composed mostly of shrub vegetation called ‘tabuleiro’ ([Thomas and Barbosa 2008](#)). For morphological and anatomical analysis, we follow [Yoshimura and Shimada \(1980\)](#) and [Ahti \(2000\)](#). To

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Figure 1. *Cladonia furfuraceoides* Ahti & Sipman (FW 09/2014). Specimens on natural substrate. Scale= 10 mm.

measure the squamules and similar structures, an It-Blue LE-1998 digital caliper was used. Images were taken using a camera and software connected to a stereoscopic microscope. For microscopic analyzes the dried material was rehydrated and mounted in 4% KOH. Herbarium codes follow [Thiers \(2023\)](#).

Cladonia furfuraceoides Ahti & Sipman in [Stenroos et al., Cladistics 18: 243 \(2002\)](#)

Primary thallus persistent but not abundant, thin, consisting of short, foliose squamules 0.5–1.2 mm diam. Podetia (11.8–)14.4–22.2 mm tall and (0.4–)0.7–1.2 mm thick, cylindrical to subulate when young, then capitate or narrowly scyphose, occasionally expanding to 3.1 mm in aged specimens, mostly unbranched, sometimes dichotomously branched mostly near apex, cream, ochraceous buff to browned when fresh, then

gray-cream in dried state, strongly melanotic toward base, in one specimen melanotic over the whole podetium length. Surface esorediate, non-isidioid, but distinctly squamulose; squamules grayish when fresh then gray to pale gray in dried state, anticlinal to podetia surface, flattened, plane to convex, lobate/digitate 0.1–1.0 mm in diam. Podetia wall ecorticate, very infrequently corticate below warts (only one seen), with more or less soft to subcompact arachnoid/interwoven hyphae; conidiomata 0.2–0.3 mm in diam., brownish, pyriform to globose, common near podetia apex; conidia $5.9\text{--}7.9 \times 1.0 \mu\text{m}$, falciform, colorless, embedded in a hyaline gelatinous matrix. Hymenial disks like apothecia, (0.7–)1.1–3.3(–3.8) mm diam., often small, as a single portion or several small ones agglomerated at apex or sometimes arising laterally from the podetia, blunt and somewhat downturned, ochraceous brown to brown, but sometimes yellowish brown to dark brown. Asci immature, 8-spored, up to $50 \times 11 \mu\text{m}$, pale colored, some with ascospores; paraphyses abundant, hyphoid sometimes with capitate apex ([Fig. 1, 2](#)).

Material examined

Brazil, Paraíba, Mamanguape, REBio Guaribas, SEMA II, 12 June 1991, M. A. Sousa & J. V. B. Silva 22309 (JPB 18566); same place, 10 May 2014, F. Wartchow FW 09/2014 (JPB 66977).

Ecology and distribution

The species was collected in the ‘Reserva Biológica Guaribas’, located in Mamanguape, Paraíba. This area corresponds mostly to a savannoid ‘tabuleiro’ forest (sensu [Thomas and Barbosa 2008](#)) with a white sandy soil and relative abundance of graminoid species, shrubs and trees.

Our *C. furfuraceoides* specimens are characterized by a persistent but not abundant primary thallus, short,



Figure 2. *Cladonia furfuraceoides* Ahti & Sipman (FW 09/2014). (A–B) Dried podetia. Scale bars=5 mm. Photos by Jéssica Prata, Laboratório Paulo Young de Invertebrados Marinhos (LIPY).

ecorticate podetia melanotic toward base, mostly simple, occasionally dichotomously branched, without isidioid, reflexed microsquamules, not isidiose nor granulose but macrosquamulose, with flattened, thin, submembranous squamules with short-digitate edge.

Ahti (2000) already supposed that some northern South American putative representatives of *C. furfuracea* did not belong to this taxon. As a solution, he described *C. furfuraceoides* from the Guiana Shield, and the Brazilian and Colombia Amazon (Stenroos et al. 2002), mostly growing on white sand in open scrub savannas. The morphological features are the somewhat similar size, whitish-gray, melanotic base, ecorticate surface, narrow scyphi, and elongate and flat deflexed squamules with incurved tips, that are fragile and easily dehiscent.

In our material, a brown pigment is evident in fresh specimens, the squamules on the podetia are slightly more persistent and are lobate/digitate at the margin, and the scyphi are slightly wider. Regarding the slightly browned podetia of our specimens, which seem different from the ‘hardly browned’ mentioned by Stenroos et al. (2002) and observed in the isotype (Fig. 3A), we have a plausible explanation. According to Buffoni Hall et al. (2002), this phenomenon may be caused due to sun exposure and the consequent increase in metabolic compounds produced by the lichen in an attempt to reduce the penetration of UV radiation. The slightly wider scyphi might be a morphological variation of the species since the two paratypes are fitting more satisfactorily with our material (Fig. 3B–C). Summarizing, the best features to distinguish *C. furfuraceoides* from *C. furfuracea* are



Figure 3. (A–C) Type specimens of *Cladonia furfuraceoides* Ahti & Sipman deposited in the herbarium H. (A) Isotype, (B–C) paratypes. Photos by Saara Velmala, Finnish Museum of Natural History, Univ. of Helsinki.

the flattened podetial squamules instead of isidioid, reflexed microsquamules, and the melanotic instead of non-melanotic podetia (Vainio 1894: 376, Ahti 2000, Stenroos et al. 2002).

The habitat of *C. furfuraceoides* is characterized by Stenroos et al. (2002: 243) as 'on sandy, open places in scrub savanna, being a colonizer of disturbed places in white sand areas and on sandstone tablelands'. The label of the isotype (herbaria H and B) reads 'Premontane sclerophyllous forest & rocky savannas. On rock near falls, abundant' (<https://ww2.bgbm.org/Herbarium/specimen.cfm?Barcode=B600194854>). Clearly, the phytophysionomy of the areas in the Guiana Shield, Amazon and the 'tabuleiro' of the Atlantic Forest shows a considerable similarity.

Phylogenies based upon DNA analyses of the genus *Cladonia* identified *C. itatiaiae* Ahti & Marcelli, *C. mauritiana* Ahti & J.C.David, *C. polyscypha* Ahti & L.Xavier, and *C. subradiata* (Vain.) Sandst. as the most closely related species to *C. furfuraceoides* (Stenroos et al. 2019). All of these taxa differ in the at least partly corticate podetia and, in *C. mauritiana* and *C. subradiata*, they are not melanotic (Ahti 2000, Ahti et al. 2002); *C. itatiaiae* presents an easily disintegrating cortex of granules, phyllidia, and small squamules (Ahti 2000); and *C. polyscypha* contains extremely narrow (0.1–0.2) scyphi in the beginning of the development then opening to 1(–2) mm wide at maturity (Ahti et al. 1993, Ahti 2000).

Also *C. quiririensis* Charnei, Gumbosky & Eliasaro from south Brazil was compared with *C. furfuraceoides* because it shares an evanescent primary thallus and ecorticate podetia with melanotic base and squamulose surface. However, it differs by the sorediate surface of the more ramified podetia (Charnei et al. 2015).

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