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Neosergipea, a new name for the lichen fungus *Sergipea*, with an updated phylogeny and notes on the genus *Dichosporidium* (lichenized Ascomycota: *Arthoniales*: *Roccellaceae*)

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Abstract: The new name *Neosergipea* M. Cáceres, Ertz & Aptroot is introduced to replace *Sergipea* M. Cáceres, Ertz & Aptroot, which is a later homonym of *Sergipea* Regali, Uesugui & Santos, a genus of fossil pollen. Using the small subunit of the mitochondrial rDNA cistron, we present an updated phylogeny of the *Enterographa* clade in *Roccellaceae* which includes the genera *Dichosporidium*, *Enterographa*, *Erythrodecton*, *Mazosia*, and *Neosergipea*. While in a previous analysis the relationship between *Neosergipea* and *Dichosporidium* was unresolved, our results suggest *Neosergipea* to be an unsupported sister to *Dichosporidium* s. lat. The latter potentially represents two distinct genera, differing in ascospore type.

Key words: Brazil, *Fossilworks*, Lower Cretaceous, *Paleobiology Database*, Sergipe

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Introduction

The name *Sergipea* M. Cáceres *et al*. was recently established for a novel lineage of lichenized fungi in the *Arthoniales*, related to the genera *Dichosporidium*, *Enterographa*, and *Erythrodecton* (Aptroot *et al*. 2013). The name is derived from the state of Sergipe in north-eastern Brazil, where the new genus was discovered.

While working on a database of neotropical crustose lichens, we found that the name *Sergipea* M. Cáceres *et al*. is a later homonym of *Sergipea* Regali *et al*., a genus of fossil pollen (see Discussion) described from the late Lower Cretaceous (Late Aptian to Early Albian; *c*. 113–109 mya) of north-eastern Brazil (Regali *et al*. 1974). *Sergipea sensu* Regali *et al*. (1974) was originally established for two species, *S. naviformis* Regali *et al*. and *S. variverrucata* Regali *et al*., the first designated as generic type; four additional species, *S. agadirensis* Bettar & Meon, *S. crassiverrucara* Regali, *S. simplex* Regali, and *S. tenuiverrucata* Regali, were described later (Regali 1987, 1989; Bettar & Meon 2006). The genus was subsequently used in a variety of stratigraphic studies of north-eastern Brazil, with a stratigraphic zone even being named after one of the species (Carvalho 2004; Heimhofer & Hochuli 2010; Arai *et al*. 2013).

Since the original publication of *Sergipea sensu* Regali *et al*. (1974) is entirely in Portuguese, without any Latin diagnosis, one might assume the name is invalid. However, according to the *International Code of Nomenclature for Algae, Fungi, and Plants* (Melbourne Code; McNeill *et al*. 2012), ICN Art. 39.1 "… does not apply to names of fossil-taxa …", and hence a "… validating description or diagnosis … in any language is acceptable for them prior to 1996." In addition, the protologue designated a generic

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type, required for valid publication of a genus name on or after 1 January 1958 (ICN Art. 40.1), and included two figures of the type species, thus also fulfilling the requirement for validity of including an illustration or figure when published on or after 1 January 1912 (ICN Art. 43.2).

As a consequence, the name *Sergipea* Regali *et al.* is valid and legitimate and the name *Sergipea* M. Cáceres *et al.* is a later homonym and illegitimate, requiring the introduction of a replacement name. We also took the opportunity to provide an updated phylogenetic analysis using available sequence data of the small subunit of the mitochondrial rDNA cistron (mtSSU).

Materials and Methods

Pertinent literature searches were carried out in Google Scholar (https://scholar.google.de) and on the pages of some of the journals of the original publications, such as the *Boletim Técnico da Petrobras* (http://vdpf.petrobras.com.br/vdpf/index.jsp), as well as the *Paleobiology Database*, *Fossilworks*, and the *Paleobotany Database* (see Discussion).

For the phylogenetic analysis, we downloaded 18 available sequences from Genbank for 11 species in the clade containing *Enterographa* and allied genera (here named the *Enterographa* clade), namely *Dichosporidium boschianum* (Mont.) G. Thor (1 sequence), *D. brunnthaleri* (Zahlbr.) G. Thor (1), *D. nigrocinctum* (Ehrenb.) G. Thor (2), *Enterographa crassa* (DC.) Fée (4), *E. hutchinsiae* (Leight.) A. Massal. (3), *E. zonata* (Körb.) Källsten ex Torrente & Egea (2), *Erythrodecton granulatum* (Mont.) G. Thor (1), *Mazosia bambusae* (Vain.) R. Sant. (1), *M.* aff. *melanophthalma* (Müll. Arg.) R. Sant. (2 different species; 2), and *Neosergipea aurata* (1). Based on previously published phylogenies (Ertz & Tehler 2011; Aptroot *et al.* 2013; Frisch *et al.* 2014; Ertz *et al.* 2015), the clade including *Chiodecton natalense* Nyl. (2 sequences) and *C. sorediatum* G. Thor (1) was used as outgroup (see Fig. 1 for GenBank accession numbers). Only taxa for which the mtSSU sequence was available were used as this was the sole locus which had been sequenced for *Neosergipea aurata*, and consequently our analysis was performed on this locus.

The 21 sequences were automatically aligned using MAFFT 7.244 (Katoh *et al.* 2009). After manual inspection and adjustment of obvious alignment errors, retaining the complete alignment of 825 bases, they were subjected to a maximum likelihood tree search using RAxML 8.20 (Stamatakis 2014), with the universal GTR-Gamma model and 500 non-parametric bootstrap pseudoreplicates. Trees were visualized in FigTree v1.4.2 (Rambaut 2014) and further edited in Adobe Photoshop CS2 and Microsoft PowerPoint 2013.

Results

Nomenclatural novelties

Neosergipea M. Cáceres, Ertz & Aptroot nom. nov.

MycoBank No.: MB816075

Sergipea M. Cáceres *et al.* in Aptroot *et al.*, *Lichenologist* **45:** 629 (2013); type: *Sergipea aurata* M. Cáceres *et al.* (holotype).

Neosergipea aurata (M. Cáceres, Ertz & Aptroot) Lücking, M. Gut. & Moncada comb. nov.

MycoBank No: MB816076

Sergipea aurata M. Cáceres *et al.* in Aptroot *et al.*, *Lichenologist* **45:** 629 (2013); type: Brazil, Sergipe, Areia Branca, Fonte da Bicam, 2012, *Cáceres & Jesus* 12539 (ISE!—holotype).

Phylogenetic analysis

In our updated analysis, including for the first time all available mtSSU sequence data for this clade, *Mazosia* comes out as supported sister to a clade including the remaining species, in which *Enterographa* is supported sister to a clade including *Erythrodecton*, *Neosergipea*, and *Dichosporidium* (Fig. 1). The relationships between the three latter genera are resolved, albeit without support, with *Erythrodecton* basal in the clade and *Neosergipea* sister to *Dichosporidium*. The three sequenced species of *Dichosporidium* appear in two clades, both forming long branches (compared to the shared stem branch), suggesting that this genus might include two distinct entities (genera or subgenera), one with *D. nigrocinctum* and the other with *D. boschianum* and *D. brunnthaleri*.

Discussion

The discovery that the name *Sergipea* M. Cáceres *et al.* represents a later homonym is somewhat surprising, given that there has not been much activity in describing new plant, fungal and algal taxa in this area of north-eastern Brazil. Unfortunately, the earlier name *Sergipea* Regali *et al.*, although

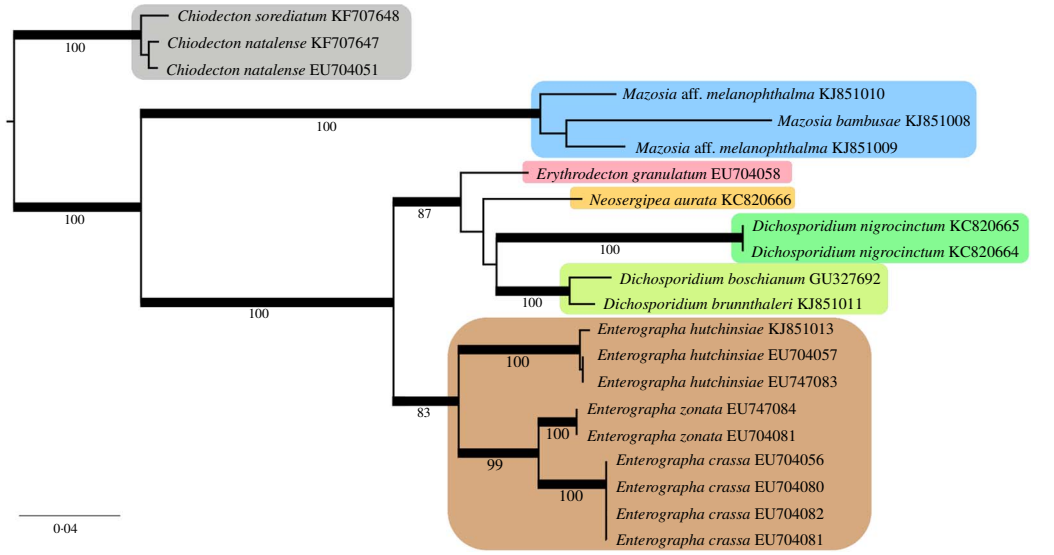

FIG. 1. Maximum likelihood phylogenetic tree of the *Enterographa* clade using the small subunit mitochondrial rDNA sequences in RAxML 8.20. GenBank accession numbers are indicated for each OTU (Operational Taxonomic Unit) and bootstrap support values >70 are given below thickened branches. *Chiodecton natalense* and *C. sorediatum* used as outgroups. In colour online.

governed by the same Code (McNeill *et al.* 2012), does not appear in databases of plant names, and the only available sources are the *Paleobiology Database* (https://paleobiodb.org) and its recent successor, *Fossilworks* (http://fossilworks.org (Behrensmeyer & Turner 2013)), as well as the *Paleobotany Database*, maintained by the Borissiak Paleontological Institute of the Russian Academy of Sciences in Moscow (http://paleobotany.ru). However, while the latter is incomplete and does not include all names published in *Sergipea sensu* Regali *et al.* (1974), the first two contain factual and linking errors. Thus the author for the species *Sergipea agadirensis* is given as Deaf *et al.* (2014) in both the *Paleobiology Database* and *Fossilworks* (accessed 19 January 2016; Fig. 2), whereas it should correctly be Bettar & Meon (2006); Deaf *et al.* (2014) do not mention the genus *Sergipea*. Also, links to supposed literature references do not work correctly. As a consequence, obtaining original information about the publication of *Sergipea sensu* Regali *et al.* (1974) and its included species was not straightforward.

It is further unclear whether the fossil pollen described under the name *Sergipea* in fact represents pollen or dinoflagellate cysts (both governed under the Code); the name is treated as either in several recent publications, without clarification (Carvalho 2004; Fensome & Williams 2004; Heimhofer & Hochuli 2010; Arai *et al.* 2013). Also, a marine fossil mollusc was described from Brazil by Maury (1925) with the name *Sergipia* but elsewhere in the same work misspelled as *Sergipea* (http://www.gbif.org/species/4592627); while this name is not governed by the Code, it might cause additional confusion.

Instead of providing a replacement name for *Sergipea* M. Cáceres *et al.*, a conservation proposal would be an alternative, although this would have very little chance of success since the name *Sergipea sensu* Regali *et al.* (1974) has received ample consideration after its publication, whereas *Sergipea sensu* Aptroot *et al.* (2013) is recent and has not been used except in its original publication. The fact that the names represent organisms in different kingdoms would in itself not prevent a successful proposal; some similar

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FIG. 2. Entry for *Sergipea agadirensis* in the *Fossilworks* database (accessed 19 January 2016), with incorrect taxon author.

examples of conserved later homonyms between fungi and plants already exist in the Code.

Our updated phylogeny confirms that *Neosergipea* is firmly settled within the *Enterographa* clade and clusters with other genera that mostly feature pseudostromatic ascomata, including *Enterographa crassa*, whereas the basal sister clade, *Mazosia*, has ascomata resembling apothecia, with a peculiar, three-layered margin (Santesson 1952; Lücking 2008). However, the single locus used here (mtSSU) is apparently not sufficient to provide support within the subclade containing the genera *Dichosporidium*, *Erythrodecton*, and *Neosergipea* (see also Aptroot *et al.* 2013), and additional loci such as the nuclear large subunit rDNA and the *RPB2* gene (Ertz & Tehler 2011; Frisch *et al.* 2014; Ertz *et al.* 2015) are needed to establish sister group relationships in this lineage. Using the latter two loci, Ertz *et al.* (2015) found an overall similar topology for this clade with good support throughout, including for the sister group relationship of *Enterographa* with *Dichosporidium* plus *Erythrodecton*; however, *Neosergipea* was not included owing to the lack of sequences for these two loci.

The separation of *Dichosporidium* into two supported clades on comparatively long branches, where the basal branch leading to these species is short and unsupported, was not previously recognized owing to smaller taxon sampling in this genus (Aptroot *et al.* 2013; Frisch *et al.* 2014); however, the recent study using the nuclear large subunit rDNA and the *RPB2* gene found a similar topology (Ertz *et al.* 2015). A possible separation into two entities (genera or subgenera) seems to be supported by the fact that *Dichosporidium nigrocinctum* produces biclavate ascospores, whereas in *D. boschianum* and *D. brunnthaleri* they are hooked; also the associated photobionts have a different morphology (Thor 1990). Chemically these species are similar, all containing protocetraric acid as the major compound (Thor 1990). If this genus is split up in the future, the name *Dichosporidium* should be retained for the *D. nigrocinctum* clade since the type, *D. glomeratum* (Pat.) Pat., is a synonym of *D. nigrocinctum* (Thor 1990).

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