

Original Paper

Funga Capixaba: Ascomycota and lichen-forming fungi

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Abstract

The “Funga Capixaba” have been overlooked for a very long time, leading to a gap in the local mycological knowledge. In order to create a preliminary and updated list of Ascomycetes and lichen-forming fungi from Espírito Santo state, Brazil we reviewed all specimens deposited in the VIES Herbarium and key references of former mycological studies. In our list, we report a total of 528 species belonging to 173 genera and 65 families. 422 are new records for Espírito Santo state, six species, *Mazaediothecium uniseptatum*, *Cratiria chloraceus*, *Lecanora glaucoidea*, *Pyrenula montocensis*, and *P. oleosa*, are new records both for the neotropics and Brazil, and *Lobariella pseudocrenulata* is also new to Brazil. We have increased the number of accepted macrofungi species names from 85 to 528, which makes the Espírito Santo state the 10th highest in terms of known fungal diversity among Brazilian states. An updated and preliminary list of macroscopic Ascomycota including lichen-forming fungi from Espírito Santo, comments, and a brief overview about the local mycology are provided.

Key words: Atlantic forest, diversity, Espírito Santo, lichen, Southeast Brazil.

Resumo

A “Funga Capixaba” foi por muito tempo pouco explorada levando a uma lacuna no conhecimento micológico local. Com o intuito de criar uma lista preliminar e atualizada de Ascomycetes e fungos liquenizados do estado do Espírito Santo, Brasil, nós revisamos todos os espécimes depositados no herbário VIES além de diversas referências sobre estudos micológicos locais. Em nossa lista, reportamos um total de 528 espécies pertencentes a 173 gêneros e 64 famílias. 422 são novos registros para o estado do Espírito Santo, sendo seis espécies *Mazaediothecium uniseptatum*, *Cratiria chloraceus*, *Lecanora glaucoidea*, *Pyrenula montocensis* e *P. oleosa* novos registros tanto para o Brasil como para o Neotrópico e *Lobariella pseudocrenulata* um novo registro para o Brasil. Elevamos o número de nomes de espécies reportadas de 85 para 528, o que faz o Espírito Santo saltar para a 10^a posição em termos de conhecimento da diversidade fúngica entre os estados brasileiros. Fornecemos uma lista atualizada ainda que preliminar de Ascomycetes e fungos liquenizados macroscópicos ocorrentes no Espírito Santo, além de comentários e um panorama sobre a micologia local.

Palavras-chave: Mata Atlântica, diversidade, Espírito Santo, líquen, sudeste brasileiro.

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Introduction

The Espírito Santo state is fully situated inside the Atlantic Forest biome, represented mostly by ombrophilous forest, but also including semideciduous seasonal forest and areas of pioneer formations such as restinga, dunes, and mangroves (Garbin *et al.* 2017) (Fig. 1).

To date, Espírito Santo state was one of the least studied places in Brazil regarding mycology [Maia *et al.* 2015; Flora e Funga do Brasil 2020 (continuously updated)], despite its vast and unique biological diversity.

The first attempt to summarize the fungal diversity from Espírito Santo state was done by Vinha (1988), who published a short list with about 64 species names. Additions to the knowledge of the local Funga were made by Maia & Carvalho Jr. (2010) and Maia *et al.* (2015), who initially reported 45 names, and then raised it to 92 species names, respectively. Nevertheless, recent studies focusing on macrofungi (*e.g.*, Linhares *et al.* 2016; Fraga Jr. *et al.* 2017, 2020; Magnago *et al.* 2018a,b; Simon *et al.* 2020) are beginning to reveal a peculiar and overlooked fungal community, and the area is still poorly known. However, the most recent records in terms of Flora and Funga, made by Flora e Funga do Brasil 2020 (continuously updated), did not make any substantial update, reporting a total of 85 names and 45 genera including micro and macrofungi, from both Ascomycota and Basidiomycota. Data concerning macroscopic Ascomycota and lichen-forming fungi in the same publication are still outdated, representing only 5 families and genera, of which 23 species belong to *Cladonia* Hill *ex* P. Browne, one is *Flabelloporina squamulifera* (Breuss, Lücking & E. Navarro) Sobreira, M. Cáceres & Lücking and few microfungi, as the commonly found *Aspergillus flavus* Link and *Microthyria paraguayensis* (Speg.) Bat., totalizing 26 taxa adding also the basidiolichen *Cora campestris* Dal-Forno, Eliasaro & Spielmann. However, extensive fieldwork made in the last decade and revision of material deposited in the collection of the VIES Herbarium showed a higher number of taxa than previously reported.

This work intends to begin a series of publications focusing on the fungal diversity, mainly of macrofungi, of Espírito Santo state: the *Funga Capixaba*. This time, we report an updated, yet still preliminary, list of macrofungi belonging to non-lichenized Ascomycota and the lichen-forming fungi from Espírito Santo state. This work is based

on a literature review and analyses of Herbarium specimens, and also from collections made in the past few years by the authors, intending to contribute towards the knowledge of regional and Brazilian mycology.

Material and methods

All the fungal specimens belonging to non-lichenized Ascomycota and lichen-forming fungi deposited in VIES Herbarium were reviewed. We also performed field excursions in some local Conservation Units such as ReBio Augusto Ruschi, Estação Biológica Santa Lucia, and Parque Estadual Pedra Azul (Pepaz). Identifications were carried out by specialists from the VIES, ICN, JOI, CGMS, and ISE Herbaria, using standard mycological techniques for taxonomic studies in non-lichenized Ascomycota and lichens. Macroscopic and microscopic analyses were performed under a stereomicroscope (4–40x) and compound microscope (40–1000x) respectively. Chemical tests for lichens such as spot tests (K, C, KC), UV exposure, and in some cases, thin layer chromatography (TLC) were performed (Orange *et al.* 2001). For the systematic treatment, we followed Wijayawardene *et al.* (2020). Specimens collected by Aptroot, A. were stored in CGMS while the specimens collected by Cáceres, M. and Lücking, R. were stored in ISE.

Results and Discussion

A brief history of Mycology in Espírito Santo state

Data about former mycological studies of macrofungi from Espírito Santo state is somewhat difficult to assess. Most of it is probably due to the lack of naturalists exploring the local funga, caused in part by the historical closure of borders during the mining period. Concerning lichenology, Marcelli (1998) presented a brief history of Brazilian lichenology with XIX century naturalists and botanists. The majority of the field excursions took paths outside Espírito Santo state, mainly passing through Rio de Janeiro, Minas Gerais, Bahia, and Amazonas states. However, two prominent naturalists crossed the Espírito Santo state north to south and were mostly likely the first to mention the local funga. The first mention was made by the Prussian prince Maximilian zu Wied-Neuwied at the beginning of XIX century (Phillip 1989): “[...] the city [of Vitória] is built unequally, over pleasant hills, and the river, who

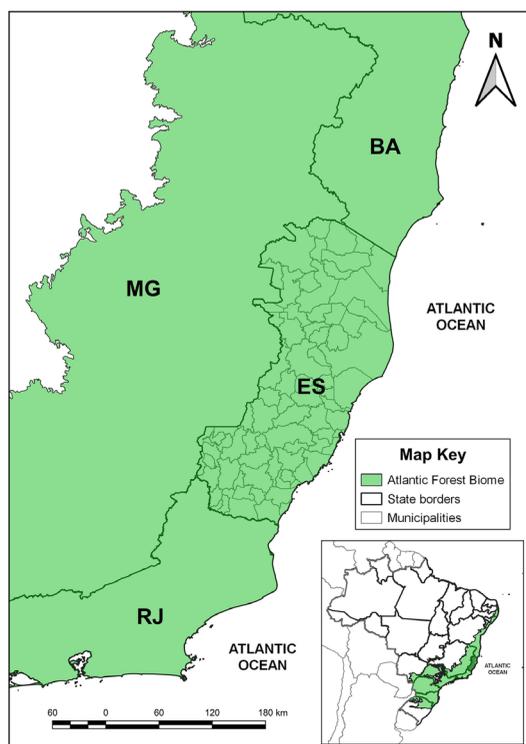


Figure 1 – Geographic Location of Espírito Santo State in Southeastern Brazil, fully situated at the Atlantic Forest.

flows behind it, runs between high slopes, rocky in parts and many places naked or covered by lichens [...]”. Shortly after, the French naturalist Auguste Saint-Hilarie mentions the occurrence of *Lysurus periphragmoides* (Klotzsch) Dring (as *Foetidaria coccinea* Aug. S. Hil.) near Jucutuquara during his visit at the Vila de Vitória (Montagne 1837).

Probably the oldest collections reported in the state, at least of lichen-forming fungi, date from the beginning of the XX century, somewhere near Colatina in 1928 (Redinger 1933) which reports a collection of *Diorygma confluens* Fée, Staiger & Elix, and *Cladonia penicillata* (Vain.) Ahti & Marcelli in 1929 in the mountain region (Ahti 2000). Up to the 1980’s, collections were very scarce, some of them made by Klaus Kalb and Marcelo Marcelli focusing on some Graphidaceae (Frisch 2006; Frisch & Kalb 2006; Staiger 2002; Kalb *et al.* 2004).

In the 1980’s the first autochthonous collections were started by Paulo Cesar Vinha, which produced the very first local list of fungal names (Vinha 1988).

In the 1990s, only a few collections of *Phyllopsora* (Brako 1991) and some of *Cladonia*

(Ahti *et al.* 1993) were reported. Another autochthonous work was made by Santos (1993) who studied the distribution of lichens in a mangrove in Vitória, and almost 10 years later, by Lima (2004) who studied the diversity of lichens in the restinga formation in Parque Estadual Paulo Cesar Vinha. However, both of these studies were not formally published nor were the referred materials deposited in any herbaria. The first decade of the 2000s showed a greater number of collections and records focusing on cyanolichens of granitic inselbergs (*e.g.*, Schultz *et al.* 2001; Büdel *et al.* 2002; Shultz & Aptroot 2008) and foliicolous communities (Lücking 2008) of mountain regions, even describing new species at the time. Besides these examples, all referred materials were deposited in foreign herbaria, and autochthonous mycological work remained held until the 2010s.

Significantly more data concerning the local diversity of Basidiomycota fungi were produced between 2013 and the present (*e.g.*, Magnago *et al.* 2013a,b, 2018a,b; Linhares *et al.* 2016). Further updates on this topic should be published elsewhere.

The most recent efforts of collection regarding macroscopic Ascomycota focused on lichen-forming ones (*e.g.*, Fraga Junior *et al.* 2017, 2020; Simon *et al.* 2020), which still leaves an important gap in the local records concerning the non-lichenized macrofungi.

Diversity of the Funga Capixaba reviewed

We analysed a total of 1,438 specimens in the VIES Herbarium, 300 others in CGMS and about 33 in ISE. Summing previous reports of formal literature, we have reached the count of 528 species belonging to 64 families and 173 genera, of which 422 species are newly recorded to the state (Tab. S1, available on supplementary material <<https://doi.org/10.6084/m9.figshare.23823693.v1>>). Six species, *Mazaediothecium uniseptatum*, *Cratiria chloraceus*, *Lecanora glaucoidea*, *Pyrenula montocensis*, and *P. oleosa* are new records for both the neotropics and Brazil, and *Lobariella pseudocrenulata* is also new to Brazil. Data about invalid names derived from misspelling, missing referred materials, or inaccurate identification were omitted and/or corrected.

Parmeliaceae was the most speciose of lichen-forming fungi (89 species), followed by Graphidaceae (51 species), Cladoniaceae (46

species) and Physciaceae (30 species), whereas members of Xylariales were the most representative of non-lichenized fungi. The corticolous and lignicolous communities were the most reported, both for lichens as well as for non-lichenized fungi, followed by some terricolous species, mainly of the lichenized fungi *Cladonia*.

Reviewing data about collectors in the VIES Herbarium, it was clear that Paulo Cesar Vinha was the local pioneer in terms of collecting macrofungi, and that there was a great gap from 1993 until late 2013, without any collection or deposit in the VIES Herbarium. However, several of his materials needed and still need review and updates.

The collection is still mostly composed of Ascomycota lichen-forming fungi whereas the non-lichenized ascomycetous macrofungi did not turn out to be numerous; even over time very few new collections were added. Xylariaceae and Hypoxylaceae proved to be the most speciose of non-lichenized fungi recorded in the VIES Herbarium, totaling four genera and eight species. We hypothesize that this is most likely due to the ease of collecting and preserving. On the other hand, there are few conspicuous and fleshy apotheciate fungi, leaving some common and fragile Ascomycota out of the list, which represents an interesting niche to explore. Lichenicolous fungi were also found when analysing the material, such as *Arthrorhaphis grisea* growing on *Diploschistes hypoleucus*, *Etayoa trypethelii* on *Trypethelium sp.*, and *Paranectria oropensis*. The foliicolous and saxicolous lichen communities were the least documented in the VIES Herbarium at the time, thus signaling unexplored and rich communities to be revealed that deserve further attention.

Collections made in conservation units, especially in ReBio Augusto Ruschi and Parque Estadual Pedra azul (PEPAZ), showed an impressive diversity, also revealing new species to science, such as the recently described *Carbacanthographis megalospora* (Feuerstein *et al.* 2022). Nonetheless, the mountain region of Espírito Santo state shelters an even higher diversity than is reported here.

Several specimens still need further taxonomic analyses, mainly to be performed by specialists and if possible, done by assessing molecular data. Many of them are probably undescribed species to science. Due to the lack of reliable species keys for some neotropical lichen groups and the lack of resources for thin layer chromatography (TLC), the bulk of the specimens are still in need of further

analyses, and they surely represent an even higher number of records than expected.

It is evident that a lack of local mycologists led to a great gap in terms of recording macrofungi in Espírito Santo state, and the recent efforts to bring to light the hidden fungal diversity are beginning to thrive. In this study, we raise the number of reported Ascomycota and lichen-forming fungi (including Basidiolichens) families from 5 to 64, 5 genera to 173, and 25 species names to 528. We have raised the number of accepted macrofungi species names from 85 to 528, which makes the Espírito Santo state the 10th (raised 16 positions) highest in terms of known fungal diversity. However, data about Basidiomycota macrofungi are still outdated, and further work will also expand the local knowledge of this group. This work filled an old gap in the knowledge of the Brazilian Funga and, despite the large number of new records, we are aware that local fungal diversity is far beyond our reports, and studies in this area must continue in order to understand the local biodiversity. This review was based mainly on materials deposited in one herbarium (VIES) and recent collections, but other collections across the state (MBML, CAP, SAMES), if holding a fungal collection, might bear interesting specimens to add to this list.

Our study revealed several omitted references that might be included in future studies of the diversity of local funga, such as the Flora and Funga Project, and the large number of new records added to the formal scientific literature reinforces the importance to continue studying the local funga.

Since the majority of collections were performed in Conservation Units (CU), local managers and environmental programs could incorporate this data into their strategies and protocols, enhancing numbers and monitoring threatened species lists.

The next steps should be to create artificial keys and illustrated guides for the local funga in order to provide ways for identification which shall be eventually published.

In the light of this brief overview, we strongly recommend: 1- local specialists training; 2- herbarium loans by specialists from other places, referring to local material in literature; 3- formal scientific financing for local mycological research - in basic and applied fields and 4- mycological science popularization via social media, educational projects, citizen science or

analog approaches, in order to disseminate the mycology and allow non-specialists to contribute to the construction of a better understanding of the so far hidden Funga Capixaba.

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Data availability statement

In accordance with Open Science communication practices, the authors inform that all data are available within the manuscript.

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