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Sporocarpic species of arbuscular mycorrhizal fungi (Glomeromycota), with a new report from Brazil

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RESUMO – (Espécies esporocárpicas de fungos micorrízicos arbusculares (Glomeromycota), com uma nova ocorrência para o Brasil). Os fungos micorrízicos arbusculares (FMA) são amplamente distribuídos nos ecossistemas terrestres; entretanto, espécies esporocárpicas são pouco documentadas em investigações sobre FMA. Cinco dessas espécies foram encontradas em remanescentes de Floresta Atlântica e em áreas cultivadas, no nordeste do Brasil: *Glomus glomerulatum, G. sinuosum, G. coremioides, G. fuegianum* e *G. taiwanensis*, sendo o último primeira ocorrência para o Brasil.

Palavras-chave: Glomerales, Glomeraceae, *Glomus*, micorriza arbuscular, diversidade

ABSTRACT – (Sporocarpic species of arbuscular mycorrhizal fungi (Glomeromycota), with a new report from Brazil). The arbuscular mycorrhizal fungi (AMF) are widely distributed in terrestrial ecossystems; however the sporocarpic species are less documented on AMF surveys. Five of these species were found in natural areas of Atlantic Forest and in agricultural ecosystems of Northeast Brazil: *Glomus glomerulatum, G. sinuosum, G. coremioides, G. fuegianum* and *G. taiwanensis*, with the last one being registered for the first time in Brazilian soils.

Key words: Glomerales, Glomeraceae, *Glomus*, arbuscular mycorrhiza, diversity

Introduction

Many arbuscular mycorrhizal fungi (AMF), mostly sporocarpic species, are not well known regarding their distribution. Among the AMF species, the former sporocarpic genus *Sclerocystis* was poorly documented in tropical countries such as Brazil. Almeida & Schenck (1990) transfered most of the *Sclerocystis* species to the genus *Glomus*, maintaining only *S. coremioides*. Wu (1993) did not agree with this proposal, while Redecker *et al*. (2000) based on molecular studies, indicated that *S. coremioides* belongs to a clade that contains *Glomus* species. Today, among the sporocarpic species of AMF, only two belong to the genus *Acaulospora*, all others are included in *Glomus*.

The term sporocarp is used for the arrangement of spores in *Acrasiomycota*, *Myxomycota* and *Endogonales* (Kirk *et al*. 2001). The AMF, initially included among the *Endogonales*, were transferred to *Glomerales* (Morton & Benny 1990) but actually constitute a phylum: *Glomeromycota* (Schubler *et al*. 2001). The term sporocarp for this group of organisms is complex, since that similar structures are refered as "cluster" of spores for some authors, while others mention such structures as "sporocarp". However, as considered by Schenck & Pérez (1990), sporocarp is a structure with spores borne closely together that may be surrounded by peridial hypha. The species earlier included in *Sclerocystis* have a complex arrangement of their sporocarpic structure, while other *Glomus* species have a less complex arrangement of spores. Species such as *Glomus glomerulatum* Sieverding whose spores have two subtending hypha, present a more complex hyphal arrangement, while others such as *Glomus fasciculatum* (Thaxter) Gerd. & Trappe emend. Walker & Koske have only one subtending hypha per spore and a less complex structure. However, other species (*G. aggregatum* (Schenck & Smith) emend. Koske) show characters that are intermediate, between those of *G. glomerulatum* and *G. fasciculatum*, with spores presenting one or two subtending hypha in the same sporocarp. Thus, the term sporocarp used for the AMF include species with spores in clusters and species with more complex structures such as those found in *G. coremioides, G. sinuosum* and *G taiwanensis.* This work describes

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sporocarpic species of AMF registered in some Brazilian soils.

Material and methods

Soil samples were taken from areas cultivated with both *Anacardium occidentale* L. (cashew) and *Manihot sculenta* Cranz. (cassava), in the Municipality of Pacajus (04°10'21"S and 38°27'38"W), Ceará State; and also in areas cultivated with *Passiflora alata* Dryander (sweet passion fruit) in Limoeiro (07°52'29"S and 35°27'01"W), and *Hancornia speciosa* Gomes (mangaba), in Sirinhaém (8°35'30"S and 35°07'00"W), both cities in the State of Pernambuco. In natural ecossystems, soil samples were taken from remnants of Atlantic Forest, in Igarassu (7°50'20"S and 35°00'10"W) and Cabo de Santo Agostinho (8°28'66"S and 35°03'50"W), north and south of the State of Pernambuco, respectively. All samples were taken at ramdom, from 5-20 cm deep. Spores were extracted from soil by wet sieving and sucrose centrifugation (Gerdemann & Nicolson 1963; Jenkins 1964), separated in Petri dishes on a stereomicroscope and mounted in glass slides with PVLG (Schenck & Peréz 1990).

Results

Five species of *Glomus* are described, with references to the geographical distribution in Brazil.

1. ***Glomus glomerulatum*** Sieverding, 1987 (Mycotaxon 29:74).

Fig. 1-2.

Sporocarps subglobose to irregular. Spores globose (50-70 µm) to subglobose, all of them with 2-3 subtending hypha. Wall in a group with two layers, the first laminated, from gold yellow to dark brown and the second membranous, thin (<1.0 µm) and hyaline. Subtending hypha delicate and interwoven inside the sporocarp. Septum viewed only in one of the hypha, in spores presenting large thickness of the wall next to the point of insertion of the subtending hypha, as referred in the original description.

Sporocarps of *G. glomerulatum* are similar to those of *G. fasciculatum*, *G. aggregatum* and *G. microaggregatum* Koske, Gemma & Olexia; however in *G. glomerulatum* all spores present 2-3 subtending hyphae, while in the other species the spores have only one subtending hypha. The spores of *G. glomerulatum* that we observed possessed an external wall, as described by Sieverding (1987).

Material examined: **BRAZIL**. **Pernambuco**: Municipality of Limoeiro, in the rhizosphere of *Passiflora alata*; Ecological Station of Gurjaú, Municipality of Cabo de Santo Agostinho, in Atlantic Forest area. (IX/2000), *Goto* URM 44245.

Distribution and habitat: spores found in natural (Atlantic Forest) and agricultural ecosystems, Brazil, Pernambuco State, and in the Amazonian Forest, Brazil, Pará State (Caproni *et al.* 2003).

2. ***Glomus taiwanensis*** (Wu & Chen) Almeida & Schenck, 1990 (Mycologia 82:711) ex Y.J. Yao, 1995 (Kew Bull. 50:306).

Fig. 3-4.

Sporocarps globose, without peridium, dark brown at the stereomicroscope and red brown at the light microscope. Presence of debris attached to the sporocarp. Spores clavate to cylindrical (84 µm long, 16.8 µm wide at the base and 18.8 µm wide at the apex), brown to slightly red, with the apex darker. Wall in a group, with the external layer thin, hyaline, evanescent and the inner layer laminated, brown. Wall thinner at the base of the spore (3.7 µm) and wider at the apex (20 µm). Spores formed in a radial distribution. Only one subtending hypha per spore. Central plexus approximately 100 µm diam. Sporophores observed in different developmental stages.

This species is similar to *G. clavisporum* (Trappe) Almeida & Schenck in arrangement of the spores inside the sporocarp, in form, as well as in colour. However, *G. clavisporum* presents two spore types: one longer and other wider, with two well defined layers of the same thickness, while *G. taiwanensis* have only one spore type and also presents an evanescent, hyaline layer, easily detached from the laminated wall layer (Wu 1993).

Material examined: **BRAZIL**. **Pernambuco**: Municipality of Igarassu, in remnant of Atlantic Forest, (II/2003), *Melo*, URM 45717.

Distribution and habitat: spores isolated only from Atlantic Forest, Pernambuco State, Brazil.

3. ***Glomus fuegianum*** (Spagazzini) Trappe & Gerd., 1974 (Mycol. Mem. 5:58).

Sporocarps subglobose (273×211 µm), light brown. Peridium scant. Spores subglobose to slightly elongated (97.7-)39.4×37.6(-60.1) µm, brown, in a central plexus of thin, interconnected hypha. Only one subtending hypha per spore. Septum not observed. Wall from 5.4-9.4 µm wide, with two layers; one external, thin,

easily detached from the inner, laminated, brown layer.

Glomus fuegianum has clusters that are much more compact than in *G. australe* (Berkeley) Berch. Besides, the spores of *G. fuegianum* "tend to be elongated, their shape resulting from multual packing in the tight clusters", as mentioned by Berch & Fortin (1983), while those of *G. australe* are globose.

This is the first report, in Brasil, of *G. fuegianum*; sporocarps of this species were observed and described in Poland (Blaszkowski *et al.* 1998) and Australia (McGee & Trappe 2002). The sporocarps observed in Brazilian soils do not show well defined peridium, confirming data from Blaszkowski *et al.* (1998) who mentioned sporocarps of *G. fuegianum* without a peridium.

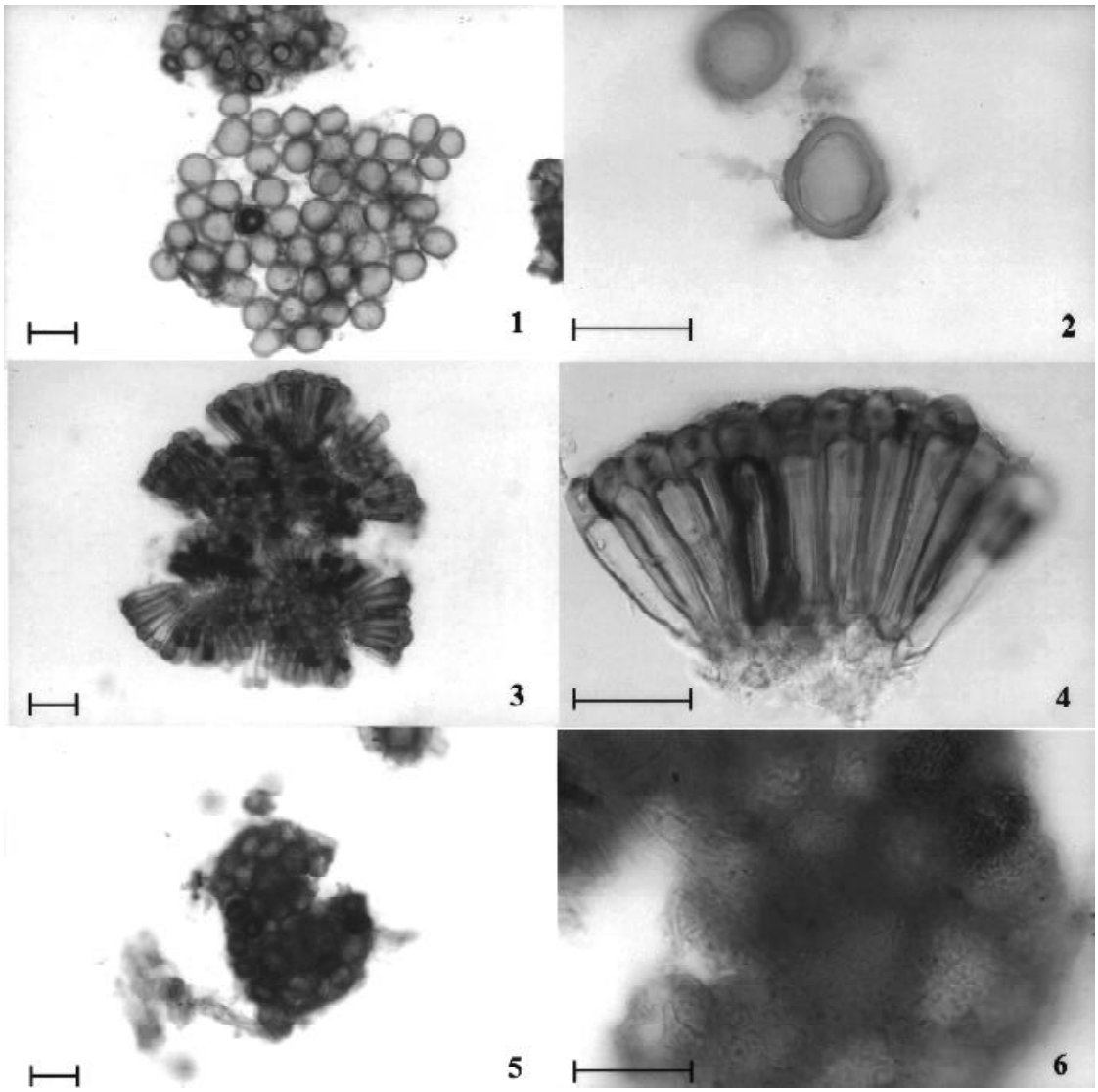
Material examined: **BRAZIL**. **Pernambuco**: Municipality of Sirinhaém, in the rhizosphere of *Hancornia speciosa* (mangaba). (VI/2002), *Costa*, URM 45718.

Distribution and habitat: spores isolated only in areas cultivated with *H. speciosa*, Pernambuco State, Brazil.

4. ***Glomus sinuosum*** (Gerd. & Bakshi) Almeida & Schenck 1990 (Mycologia 82:710).

Fig. 5-6.

Sporocarp globose to subglobose with peridium brown to dark brown (446×330 µm). Subtending hypha with thick wall, interwoven in a sinuose way. Central



Figures 1-6. Spores and sporocarps of species of Glomeromycota. 1-2. *Glomus glomerulatum* Sieverding. General view of a sporocarp and spores with its subtending hypha. 3-4. *Glomus taiwanensis* (Wu & Chen) Almeida & Schenck. General view of a sporocarp and detail of spores. 5-6. *Glomus sinuosum* (Gerd. & Bakshi) Almeida & Schenck. General view of a sporocarp and detail of sinuose hypha from the peridium. Bar: 1, 3 and 5 = 100 µm; 2, 4 and 6 = 50 µm.

plexus around 112 µm diam. Spores elongated (94 µm long), with thin wall (2-3 µm), light brown. Septum easily observed between the spore and its subtending hypha. A hyphal stalk originating the sporocarp, as refered by Wu (1993) was not observed.

At the stereomicroscope *G. sinuosum* is similar to *G. coremioides* but differs in the thickness of the peridium as well as in the hyphal arrangement.

Material examined: **BRAZIL**. **Ceará**: Municipality of Pacajus, in cultivated area. (VII/2003), *Gugel*, URM 44458.

Distribution and habitat: spores isolated from areas cultivated with both *Anacardium occidentale* and *Manihot esculenta*, Town of Pacajús, Ceará State, Brazil. *G. sinuosum* is widely distributed in Brazilian soils, being cited for agrosystems, Atlantic Forest, sand areas, sand dunes, Cerrado, Caatinga and sandbank (Bononi & Trufem 1983; Trufem & Bononi 1985; Trufem *et al*. 1989; Maia & Trufem 1990; Trufem & Viriato 1990; Trufem *et al*. 1994; Trufem 1995; Trufem & Malatinszki 1995; Souza *et al*. 1999; Carrenho & Trufem 2001; Souza *et al*. 2003; Yano-Melo *et al*. 2003).

5. ***Glomus coremioides*** (Berkeley & Broome) Redecker & Morton, 2000 (Mycologia 92:284).

Sporocarps red brown at the light microscope and dark brown at the stereomicroscope, hemispheric to spheric (814-)653×571(-499) µm, with thick peridium (56.4 µm). Spores globose (64 µm) to clavate in the same sporocarp. Spores with only one visible wall layer (5.6-3.7 µm). Wall formed by a laminated brown layer, with the same thickness all around. Septum easily observed in most of the spores. Only one subtending hypha per spore. Central plexus of interwoven hypha (307-)230×230(-192) µm.

At the stereomicroscope, sporocarps of *G. coremioides* are similar to those of *G. sinuosum*; however differ in thickness and in the hyphal arrangement of the peridium. In *G. coremioides* the peridium is thick without a sinuose hyphal structure and the sporocarp is hemispheric, while that of *G. sinuosum* is globose to subglobose.

Material examined: **BRAZIL**. **Pernambuco**: Recife. (VI/2002), *Goto*, URM 44457.

Distribution and habitat: spores isolated as contaminant in pot cultures of *Gigaspora albida* Schenck & Smith, Laboratório de Micorrizas, UFPE, Recife, Pernambuco State, Brazil. *G. coremioides* was cited in agrosystems, Atlantic Forest and sandbank (Maia & Trufem 1990; Trufem 1990; Trufem 1995).

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