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Additions to the knowledge of Ganodermataceae in brazilian Cerrado

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Additions to the knowledge of Ganodermataceae in Brazilian Cerrado

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ABSTRACT - (Additions to the knowledge of Ganodermataceae in Brazilian Cerrado) - As a cosmopolitan family, Ganodermataceae has as distinctive characteristic the presence of double-walled basidiospore: the inner wall thick and ornamented, and the outer wall smooth. Even with the increasing interest in this family, the species are still poorly known in different regions of the Brazilian territory, such as in the central Brazil. This study presents new distribution remarks of Ganodermataceae species in different sites of the biome Cerrado, in the Midwest region. We found 23 specimens from five species which are distributed into three genera, *Amauroderma*, *Foraminispora* and *Ganoderma*. From those species, one is a new record for the Cerrado (*A. exile*), four are new for the State of Goiás *A. exile*, *F. rugosa*, *G. multiplicatum* and *G. stipitatum* and one for the Distrito Federal (*G. stipitatum*). *Amauroderma aurantiacum* is rediscovered in Goiás after 88 years. This study contributes to improving the knowledge regarding the geographic distribution of these taxa in Brazil. **Keywords:** *Amauroderma*, *Brazilian savanna*, *Foraminispora*, *Ganoderma*, *geographic distribution*

RESUMO - (Adições ao conhecimento de Ganodermataceae no Cerrado brasileiro). Cosmopolita, a família Ganodermataceae tem como característica distintiva a presença de basidiósporos de parede dupla, sendo a interna espessa e ornamentada e a externa lisa. Mesmo com o crescente interesse pela família, as espécies ainda permanecem muito pouco conhecidas em diferentes localidades do território brasileiro, como é o caso do Brasil central. Este trabalho relata novas ocorrências de espécies de Ganodermataceae em diferentes localidades do bioma Cerrado, na região Centro-Oeste. Os espécimes estudados somam 23 exemplares de cinco espécies, distribuídas em três gêneros, *Amauroderma*, *Foraminispora* e *Ganoderma*. Dessas, uma é novo registro para o Cerrado (*A. exile*), quatro são novas para o estado de Goiás *A. exile*, *F. rugosa*, *G. multiplicatum* e *G. stipitatum* e uma para o Distrito Federal (*G. stipitatum*). *Amauroderma aurantiacum* é novamente registrada para o estado de Goiás após 88 anos. Este trabalho contribui para ampliar o conhecimento da distribuição geográfica das espécies no Brasil. **Palavras-chave:** *Amauroderma*, *distribuição geográfica*, *Foraminispora*, *Ganoderma*, *savanna brasileira*

Introduction

Proposed in 1948, the family Ganodermataceae (Donk) Donk has approximately 220 species described, distributed into seven genera (*Amauroderma* Murrill, *Foraminispora* Robledo, Costa-Rezende & Drechsler-Santos, *Furtadoa* Costa-Rezende, Robledo & Drechsler-Santos, *Ganoderma* P. Karst., *Haddowia* Steyaert, *Humphreya* Steyaert and *Tomophagus* Murrill) (Ryvarden 2004, Kirk *et al.* 2008, Costa-Rezende *et al.* 2017). Considered cosmopolitan, the family has as a distinct characteristic the presence of double-walled basidiospores, with the inner wall thick and ornamented and the outer smooth, distinguishing

it from other polyporoid groups. The basidiospore can be found in globular and ellipsoid shapes with pigmentation (Gilbertson & Ryvarden 1986, Ryvarden 2004, Cannon & Kirk 2007). Thus, these characteristics, as well as the hardness of the pileus, are essential for the identification of Ganodermataceae species (Ryvarden 2004, Gugliotta *et al.* 2011).

Group of crucial importance in maintaining the trophic balance, Ganodermataceae species play a key role in nutrient cycling of ecosystems, causing white rot in woody tissues (Ryvarden 2004). The family comprises species of recognized economic and medicinal value, and some sources of bioactive compounds are widely studied for biotechnological

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purposes (Zjawiony 2004, Tseng *et al.* 2008, Wang *et al.* 2016).

Species of this family, except the genus *Haddowia*, are widely distributed in the tropics with records in several Brazilian ecosystems (Gibertoni & Cavalcanti 2003, Ryvarden 2004, Silveira *et al.* 2008, Baltazar & Gibertoni 2009, Campacci & Gugliotta 2009, Drechsler-Santos *et al.* 2009, Gomes-Silva & Gibertoni 2009, Gibertoni & Drechsler-Santos 2010, Gugliotta *et al.* 2010, Gomes-Silva *et al.* 2011, Costa-Rezende *et al.* 2016, Bononi *et al.* 2017). However, knowledge about this family in the Cerrado biome is restricted to records of 17 species, with a predominance of the genera *Amauroderma* and *Ganoderma* (Gibertoni & Drechsler-Santos 2010, Abrahão *et al.* 2012, Maia *et al.* 2015, Costa-Rezende *et al.* 2016, Bononi *et al.* 2017). The present study presents new species occurrences of the family Ganodermataceae for the Brazilian Cerrado and Midwest region.

Material and methods

The specimens studied were collected in Cerrado areas between 2005 and 2018, usually located in conservation units (UC) in the State of Goiás: municipality of Caldas Novas: Parque Estadual da Serra de Caldas Novas (PESCAN) (17°43'56"S to 17°50'55,7"S; 48°40'0"W to 48°42'57,6"W); municipality of Rio Quente (17°47'35"S and 48°47'36"W); municipality of Silvânia: Floresta Nacional de Silvânia (FLONA) (16°38'30,46"S and 48°39'3,11"W); municipality of Goiânia: Bosque Auguste Saint-Hilaire (BASH) (16°36'26,74"S and 49°15'51,69"W); municipality of Anápolis: Reserva Ecológica da Universidade Estadual de Goiás (REC-UEG) (16°23'40"S and 48°57'32"W); urban area (16°20'12"S and 48°56'42"W; 16°19'14"S and 48°55'39"W); municipality of Anápolis (14°11'44"S and 49°20'19"W); municipality of Cavalcante, Kalunga community, Engenho II (13°34'56"S and 47°28'16"W) and Distrito Federal: municipality of Brasília (15°46'48"S and 47°55'45"W) (figure 1).

The Cerrado is considered the second largest biome in South America and is located in the Central Plateau of Brazil. Its area covers the States of Goiás, Tocantins, Bahia, Mato Grosso, Mato Grosso do Sul, Maranhão, Piauí, São Paulo, Minas Gerais, Distrito Federal, Rondônia and Paraná. This biome is characterized by physiognomies that encompass savanna and grassland forest formations, with a mixed presence of trees, shrubs and undergrowth vegetation,

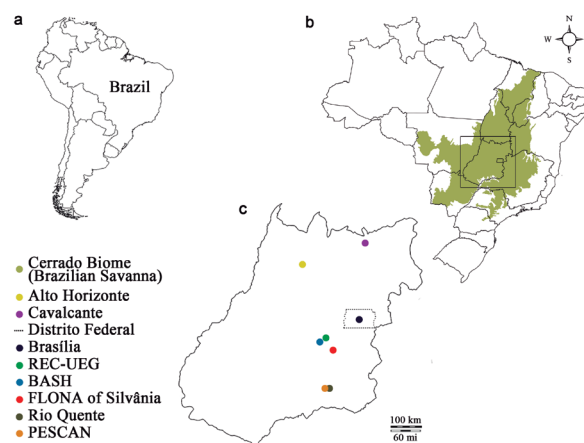


Figure 1. Location of the study area. a. location of Brazil in South America. b. In green, the distribution area of the Cerrado biome in the Brazilian territory. c. Detail of the States of Goiás and the Distrito Federal, with the location of the municipalities and the conservation units where the collections were made.

with a rainy tropical climate with hot summer and dry winter (Ribeiro & Walter 1998, Klink & Machado 2005).

The taxonomic identification of the collected specimens was based on macro and micromorphological characters, considering the methodologies adopted by Teixeira (1995) and Ryvarden (2004). The specimens were deposited in the Herbarium of the Universidade Estadual de Goiás (HUEG).

Results and Discussion

We found 25 specimens, which are distributed into three genera and five species. From those, one is a new record for the Cerrado (*Amauroderma exile* (Berk.) Torrend 1920), are new for the State of Goiás *Foraminispora rugosa* (Berk.) Costa-Rezende, Drechsler-Santos & Robledo 2017, *Ganoderma multiplicatum* (Mont.) Pat. 1889 and *G. stipitatum* (Murrill) Murrill 1908], one for the Distrito Federal (*G. stipitatum*) and *A. aurantiacum* (Torrend) Gibertoni & Bernicchia 2008 is recorded again for the State of Goiás (type locality) 88 years after its publication.

Amauroderma aurantiacum (Torrend) Gibertoni & Bernicchia, Mycotaxon 104: 322 (2008).
= *Amauroderma macrosporum* J.S. Furtado, Revis. Revision of the genus *Amauroderma* (Polyporaceae); Studies based on microstructures of the basidiocarp: 203 (1968).

Figure 2

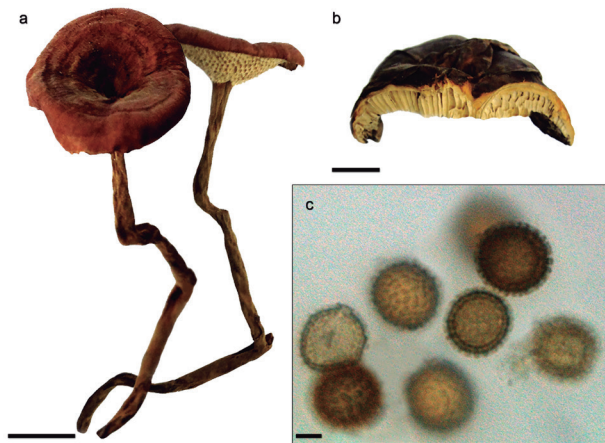


Figure 2. *Amauroderma aurantiacum*. a. Basidiome with an emphasis in the reddish color, long stipe with poroid hymenial surface, scale = 1 cm. b. Pileus and hymenial surface in detail, scale = 1 cm. c. Basidiospores, scale = 5 μ m.

Description: see Gibertoni *et al.* (2008), Gomes-Silva *et al.* (2015).

Substrate: leaf litter.

Distribution: Brazil and Venezuela (Ryvarden 2004). In Brazil there are records in the States of Goiás, Mato Grosso, Rondônia and São Paulo (Bononi *et al.* 1981, Gibertoni *et al.* 2004, 2007, 2008, Gugliotta *et al.* 2011, Gomes-Silva *et al.* 2015, Costa-Rezende *et al.* 2016).

Material examined: BRAZIL. Goiás: Caldas Novas, Parque Estadual da Serra de Caldas Novas (PESCAN), 17-III-2007, Xavier-Santos, S. (2117) (HUEG9927); *ibid.*, 23-I-2008, Xavier-Santos, S. (2387) (HUEG9928); *ibid.*, 24-I-2008, Xavier-Santos, S. (2481) (HUEG9929); *ibid.*, 1-V-2008, Xavier-Santos, S. (2579) (HUEG9932); *ibid.*, 24-I-2008, Xavier-Santos, S. (2418) (HUEG9933); *ibid.*, 17-XII-2013, Xavier-Santos, S. (5803) (HUEG10552); *ibid.*, 17-XII-2013, Xavier-Santos, S. (6099) (HUEG10555); *ibid.*, 1-V-2008, Xavier-Santos, S. (2540) (HUEG9934); Rio Quente: 28-III-2009, Xavier-Santos, S. (3733) (HUEG9930); *ibid.*, 23-I-2008, Xavier-Santos, S. (2324) (HUEG9931); *ibid.*, 29-III-2009, Xavier-Santos, S. (3707) (HUEG10650); *ibid.*, collected in 28-III-2009, Xavier-Santos, S. (3580) (HUEG10560); *ibid.*, 24-I-2008, Xavier-Santos, S. (2484) (HUEG10634); *ibid.*, 28-III-2009, Xavier-Santos, S. (3593) (HUEG10597); Cavalcante, Kalunga community, Engenho II: 20-III-2018, Xavier-Santos, S. (6353) (HUEG11877); *ibid.*, 20-III-2018, Xavier-Santos, S. (6354) (HUEG11878).

Notes: species representative in terms of sampling and showing resistance to changes in seasonality with sampling in dry and rainy seasons in the studied areas. The holotype is reported for the State of Goiás in 1932 (Gibertoni *et al.* 2008). In this case, the species is recorded again for the State of Goiás after 88 years. Among the available descriptions for the species hyphal system, Furtado (1968) and Ryvarden (2004), expose arguments. The first considers the system as a trimitic, composed of generative hyphae with clamp connections; branched thick-walled connective hyphae and arboriform skeletal hyphae. The second considers the system as dimitic, composed of generative hyphae with clamp connections and arboriform skeletal hyphae. In the present study, trimitic hyphal system was adopted. In the field, the species is very similar to *A. calcigenum* (Berk.) Torrend, distinguished by the presence of ellipsoid basidiospores. Among the distinctive characters, the reddish color of basidiome and globose basidiospores, yellowish with dense reticles-shaped ornamentation is highlighted.

Amauroderma exile (Berk.) Torrend, Brotéria, ser. bot. 18: 142 (1920).

≡ *Polyporus exilis* Berk., Hooker's J. Bot. Kew Gard. Misc. 8: 173 (1856).

Figure 3

Description: see Ryvarden (2004).

Substrate: leaf litter.

Distribution: Brazil, Colombia, Honduras and Venezuela (Furtado 1981, Ryvarden 2004). In Brazil there are records for the species in the States of Amapá, Amazonas, Bahia, Mato Grosso, Pará, Pernambuco,



Figure 3. *Amauroderma exile*. a and b. Basidiome with long stipe and hymenial (a) and abhymenial surfaces (b), scale = 1 cm. c. Hymenial surface in detail, scale = 1 mm. d. basidiospores, scale = 5 μ m.

Rio de Janeiro, Rio Grande do Sul, Rondônia and São Paulo (Gomes-Silva *et al.* 2015, Maia *et al.* 2015).

Material examined: BRAZIL. GOIÁS: Caldas Novas, 23-XI-2008, Xavier-Santos, S. (3317) (HUEG9935).

Notes: the species when fresh, has a typical bright reddish-brown color that characterizes it. According to Gomes-Silva *et al.* (2015) the species resembles *A. elegantissimum* Ryvarden & Iturr. differing in the morphology of the basidiospore, since *A. elegantissimum* has globose, not ornamented basidiospores, with 7-10 μm . This is a new record for the Cerrado and for the State of Goiás.

Foraminispora rugosa (Berk.) Costa-Rezende, Drechsler-Santos & Robledo, in Costa-Rezende, Robledo, Góes-Neto, Reck, Crespo & Drechsler-Santos, Persoonia 39: 262 (2017).
 \equiv *Ganoderma sprucei* Pat., Bull. Soc. mycol. Fr. 10(2): 75 (1894).

Figure 4

Description: see Decock & Herrera-Figueroa (2006).

Substrate: dead wood.

Distribution: Brazil, Belize, Brazil, Colombia, Costa Rica, Cuba, French Guiana, Jamaica, Puerto Rico and Venezuela (Ryvarden 2004, Decock & Herrera-Figueroa 2006, Campacci & Gugliotta 2009). In Brazil there are records for the species in the States of Amazonas, Bahia, Mato Grosso, Minas Gerais, Pará, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Sul, Santa Catarina, São Paulo and Sergipe (Ryvarden 2004, Gibertoni *et al.* 2004, 2007, Gugliotta *et al.* 2011, Drechsler-Santos *et al.* 2013, Maia *et al.* 2015, Costa-Rezende *et al.* 2016).

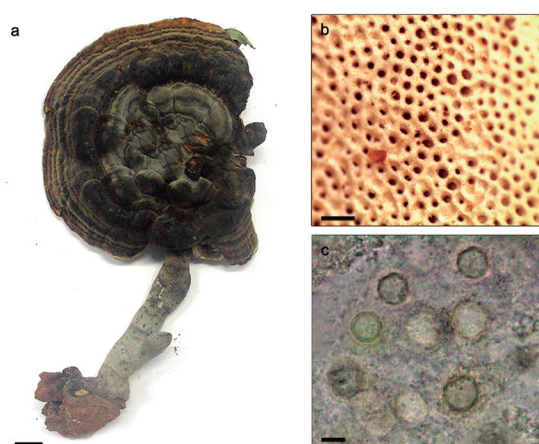


Figure 4. *Foraminispora rugosa*. a. Basidiome, scale = 1 cm. b. Hymenial surface in detail, scale = 0.5 mm. c. Basidiospores, scale = 5 μm .

Material examined: Brazil. GOIÁS: Goiânia, Bosque Auguste Saint-Hilaire, 20-I-2014, Naves L.R. 93 (HUEG9716).

Notes: the species is characterized for its central to the lateral stipe, context cream to light brown and 5-6 pores per mm. Still, it can be distinguished from the other species of the genus by a slightly tomentous abhymenial surface. It is easily confused with *A. schomburgkii* (Mont. & Berk.) Torrend, differing because of the lack of blackened pileal surface (Gugliotta *et al.* 2011, Campos-Santana & Loguercio-Leite 2013). This is a new record for the State of Goiás.

Ganoderma multiplicatum (Mont.) Pat., Bull. Soc. mycol. Fr. 5 (2,3): 74 (1889).

\equiv *Polyporus multiplicatus* Mont., Annls Sci. Nat., Bot., ser. 41: 128 (1854).

Figure 5

Description: see Ryvarden (2004).

Substrate: dead wood.

Distribution: Angola, Argentina, Brazil, China, Colombia, Egypt, French Guiana, India, Indonesia, Ivory Coast, New Guinea, Seychelles, Sierra Leone, Venezuela, Zaire and Zambia (Steyaert 1980, Gottlieb & Wright 1999, Ryvarden 2000, Baltazar & Gibertoni 2009, Gomes-Silva & Gibertoni 2009, Bhosle *et al.* 2010, Gomes-Silva *et al.* 2011, Bolaños *et al.* 2016). In Brazil there are records for the species in the States of Alagoas, Amazonas, Mato Grosso do Sul, Pará, Rio de Janeiro, Rondônia, Roraima, Santa Catarina, São Paulo and Sergipe (Steyaert 1980, Capelari & Maziero 1988, Loguercio-Leite *et al.* 2005, Drechsler-Santos *et al.* 2008, Martins-Júnior *et al.* 2011, Gomes-Silva *et al.* 2011, Gugliotta *et al.* 2011, Quevedo *et al.* 2012, Torres-Torres *et al.* 2012, Maia *et al.* 2015).

Material examined: BRAZIL. GOIÁS: Anápolis, Universidade Estadual de Goiás, Reserva Ecológica of the Universidade Estadual de Goiás (REC-UEG), 22-V-2009, Xavier-Santos, S. (3772) (HUEG11881).

Notes: the species is characterized by the sessile basidiome, lacquer layer, reddish color, and 6-8 pores per mm. *A. multiplicatum* is morphologically similar to *G. orbiforme* (Fr.) Ryvarden, however, differences can be observed through the analysis of microscopic characters, and *G. orbiforme* has larger basidiospores (8.8-10.4 \times 6.4 -7.2 μm) and cuticle cells with more developed protuberances (Gugliotta *et al.* 2011). This is a new record for the State of Goiás.

Ganoderma stipitatum (Murrill) Murrill, N. Amer. Fl. (New York) 9 (2): 122 (1908).

\equiv *Fomes stipitatus* Murrill, Bull. Torrey bot. Club 30(4): 229 (1903).

Figure 6

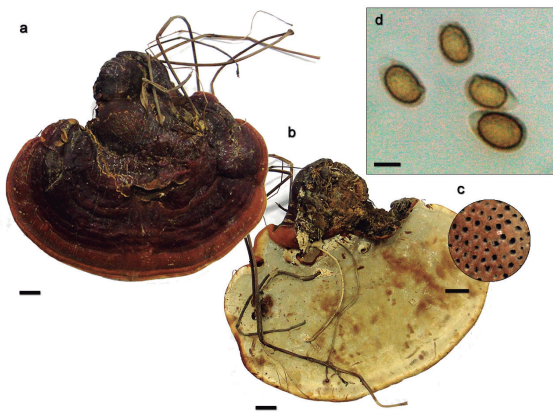


Figure 5. *Ganoderma multiplicatum*. a and b. Basidiome, hymenial (a) and abhymenial surfaces (b), scale = 1 cm. c. Hymenial surface in detail, scale = 0.5 mm. d. Basidiospores, scale = 5 µm.

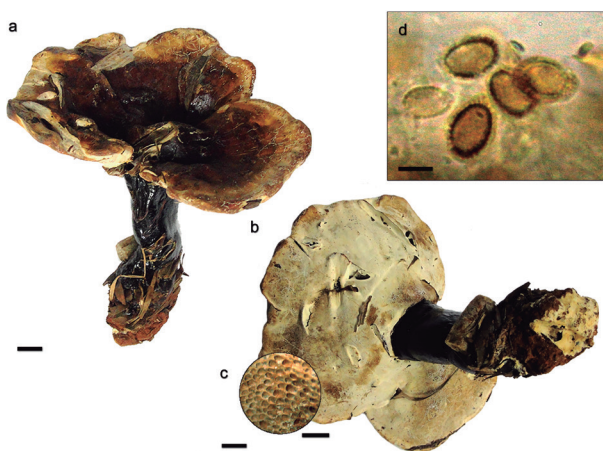


Figure 6. *Ganoderma stipitatum*. a and b. Basidiome, hymenial (a) and abhymenial surfaces (b), scale = 1 cm. c. Hymenial surface in detail, scale = 1 mm. d. Basidiospores, scale = 5 µm.

Description: see Ryvarden (2004).

Substrate: living trees.

Distribution: Bolivia, Brazil, Costa Rica, Nicaragua, Peru, Suriname and Venezuela (Ryvarden 2004, Torres-Torres *et al.* 2012). In Brazil there are records in the States of Acre, Alagoas, Amazonas, Bahia, Mato Grosso do Sul, Paraíba, Paraná, Pernambuco, Rio de Janeiro, Rio Grande do Sul and Rondônia (Steyaert 1980, Capelari & Maziero 1988, Gibertoni *et al.* 2004, 2007, Gomes-Silva *et al.* 2011, Martins-Júnior *et al.* 2011, Torres-Torres *et al.* 2012, Maia *et al.* 2015).

Material examined: BRAZIL. DISTRITO FEDERAL: Brasília, next to the Universidade de Brasília (UNB), 1-XII-2010, Xavier-Santos, S. (4699) (HUEG10726). Goiás: Alto Horizonte, 15-I-2005, Faria-Junior, J. E.Q. (31) (HUEG10771); Anápolis: School São Francisco de Assis, 15-II-2018, Xavier-Santos, S. (6348) (HUEG11875); *ibid* 4-XII-2018, Xavier-Santos, S. (6380) (HUEG11991); Anápolis city, 29-V-2018, Xavier-Santos, S. (6355) (HUEG11876); Avenida São Francisco, 20-XI-2018, Xavier-Santos, S. (6381) (HUEG11992).

Notes: according to Ryvarden (2004), this species has dark resinous bands in the context as a distinguishing characteristic. It is easily confused with *Ganoderma lucidum* (Curtis) P. Karst., because they are macroscopically similar (Martins-Júnior *et al.* 2011), but they differ microscopically by the hyphal system, dimitic in *G. stipitatum* and trimitic in *G. lucidum* and by the basidiospores, ellipsoid to oblong, truncate at apex in *G. stipitatum* and ellipsoid to obovate in *G. lucidum* (Groposo & Loguerio-Leite 2002, Singh *et al.* 2014). This is a new record for the Distrito Federal and for the State of Goiás.

Key to species studied in this work

1. Basidiomata stipitate, with stipe zoned *F. rugosa*
1. Stipitate basidiome, with stipe or substipe without zones
 2. Pilear surface glabrous to laccate; basidiospores with truncate apex
 2. Pilear surface glabrous to tomentous; basidiospores with globose to subglobose apex
 3. Pileus circular to dimidiate, long and irregular stipe, with hymenial surface showing pore angular to circular (6-8 per mm) *G. stipitatum*
 3. Pileus flabelliform to applanate, substipitate, with hymenial surface showing pore angular to circular (5-6 per mm) *G. multiplicatum*
 4. Globose basidiospores (5-7.65-7.6 x 5.3-7.4 µm), with dense reticles-shaped ornamentation *A. aurantiacum*
 4. Globose to subglobose basidiospores (5-7.6 x 5.3-7.4 µm), finely ornamented *A. exile*

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and Fungi), Antônio Sergio Ferreira de Sá (CNPq/IC), Laiza Rosa Rezende Naves (CAPES/Masters) and Elida Lucia da Cunha (FAPEG/Masters). To the reviewers and editors for valuable comments and editorial preparation of the paper.

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