

ORIGINAL ARTICLE

Two new species of rust fungi (Pucciniales) from the Brazilian Amazon: *Aecidium margaritariae* on *Margaritaria* and *Uromyces amapaensis* on *Jatropha*

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ABSTRACT

Two new species of Pucciniales fungi on plants of the Fabid clade are described from samples deposited in the herbarium of Museu Paraense Emílio Goeldi, collected in the state of Amapá, in the Brazilian Amazon. They are *Aecidium margaritariae* found on *Margaritaria nobilis* (Phyllanthaceae), and *Uromyces amapaensis* on *Jatropha gossypifolia* (Euphorbiaceae). The microstructures of the specimens were analyzed using optical and scanning electron microscopy. *Aecidium margaritariae* is characterized by the presence of globose, subglobose to slightly ellipsoid aeciospores with warty walls and smooth areas usually in the basal portion. *Uromyces amapaensis* is distinguished by the presence of uredinia with paraphyses which are thickened and rounded at the tip, and pedicellate and smooth teliospores. Descriptions, illustrations, and taxonomic comments are presented for each species.

KEYWORDS: Basidiomycota, Brazil, Euphorbiaceae, Phyllanthaceae, Pucciniomycetes

Duas novas espécies de ferrugens (Pucciniales) da Amazônia brasileira: *Aecidium margaritariae* sobre *Margaritaria* e *Uromyces amapaensis* sobre *Jatropha*

RESUMO

Duas novas espécies de fungos Pucciniales sobre plantas do clado das fabídeas são descritas a partir de amostras depositadas no herbário do Museu Paraense Emílio Goeldi, coletadas no estado do Amapá, na Amazonia Brasileira. *Aecidium margaritariae* ocorrendo sobre *Margaritaria nobilis* (Phyllanthaceae) e *Uromyces amapaensis* sobre *Jatropha gossypifolia* (Euphorbiaceae). As microestruturas dos espécimes foram analisadas em microscópio óptico e em microscopia eletrônica de varredura. *Aecidium margaritariae* se caracteriza por apresentar eciosporos globosos, subglobosos a levemente elipsoides, parede verrugosa com áreas lisas geralmente na extremidade basal. *Uromyces amapaensis* se diferencia por apresentar uredínios com paráfises engrossadas e arredondadas no ápice e teliosporos pedicelados, lisos. São apresentadas descrições, ilustrações e comentários taxonômicos para cada espécie.

PALAVRAS-CHAVE: Basidiomycota, Brasil, Euphorbiaceae, Phyllanthaceae, Pucciniomycetes

INTRODUCTION

In the fungi order Pucciniales, a very specific relationship between the parasitic fungus species and its host plant is observed. This specificity is a peculiar feature that favors the classic taxonomy of this group of fungi that cause rust in plants. It is used as an aid in the identification of the species, complementing morphological and molecular studies of the different stages of their complex life cycles (Cummins and

Hiratsuka 2003; Aparecido and Passador 2009, 2014; Aime *et al.* 2006, 2018).

About 3,000 species of fungi are reported for the Brazilian Amazon, including those of the order Pucciniales (Basidiomycota), represented by 199 known species causing rust on plants, of which 55 occur in the northern Brazilian state of Amapá (França *et al.* 2010; Carmo *et al.* 2016; Carvalho *et al.* 2018; Furtado *et al.* 2018; Flora do Brasil 2020). According

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to estimates, the Brazilian Amazon harbors about 50,000 botanical species (Cardoso *et al.* 2017), which suggests that many rust species likely remain undiscovered in this biome.

A taxonomic revision of Pucciniales specimens collected on Fabids and deposited in the herbarium of Museu Paraense Emílio Goeldi (Pará, Brazil) revealed the presence of two undescribed species. Here we describe the two new species of Pucciniales, which were found growing on the host species *Jatropha gossypifolia* and *Margaritaria nobilis*, for the Brazilian Amazon in Amapá state.

MATERIAL AND METHODS

The Pucciniales specimens analyzed in this study were collected in the state of Amapá (Brazil) and were deposited in the João Murça Pires Herbarium (MG) of Museu Paraense Emílio Goeldi (MPEG). The identification of the host plants was carried out in collaboration with botanical taxonomists and technicians from the MPEG, following APG IV (2016) and Tropicos (<https://www.tropicos.org/nameSearch>).

The identification of the Pucciniales specimens followed the observation of sori under a Leica EZ4 stereomicroscope to examine the lesions on the plant tissue and the presence of spores, and the preparation of semi-permanent slides of sori, spores and other microstructures in slightly heated drops of lactoglycerol (distilled water + lactic acid + glycerin) to be analyzed using Zeiss Axiolab optical microscopy (Neergaard *et al.* 2000; Aparecido and Passador 2009). Twenty-five spores randomly selected from each specimen were measured. Size variation was expressed by minimum and maximum values. Illustrations of the microstructures were made using an optical microscope attached to a digital camera. For the examination of the surface of fungal structures in scanning electron microscopy (SEM), the methodology of França and Sotão (2009) was adopted. Dry leaf material with rust fungi was hand cut with a razor blade into small pieces of approximately 4 × 4 mm. The samples were mounted onto aluminum stubs with adhesive carbon tape and coated with gold. The images were obtained in a Tescan Mira3 SEM and recorded in digital mode.

Specialized literature with descriptions of species and identification keys was referred to subsidize the identification and description of the new taxa (Cummins and Hiratsuka 2003; Hennen *et al.* 2005; Carvalho Jr and Sotão 2010). The notations for life cycle description followed Salazar-Yepes and Carvalho Jr (2010). The holotypes were deposited at the MG Herbarium and registered in MycoBank (www.mycobank.org). Author names follow the standards of Index Fungorum (www.indexfungorum.org).

RESULTS

Aecidium margaritariae Sotão & Piovezan, sp. nov. (Figure 1)
MycoBank no.: MB 838085

Type: Brazil. Amapá: Mazagão, Mazagão Novo, on *Margaritaria nobilis* L.f. (Phyllanthaceae), 27 July 1995, H.M.P. Sotão *et al.* 95–244, sori I (Holotype: MG 230298).

Diagnosis: *Aecidium margaritariae* can be distinguished from other *Aecidium* species occurring on Phyllanthaceae by the presence of peridial cells with smooth outer walls and warty inner walls, and globose, subglobose to slightly ellipsoid aeciospores with warty walls and smooth areas usually in the basal portion, measuring 27.5–37.5 × 21.5–27.5 µm.

Spermogonia adaxial, subcuticular, gregarious, punctate, brown to black. **Aecia** abaxial, on irregular leaf spots, forming galls, grouped, cup-shaped, with white to pale yellow peridia; peridial cells oblong to ellipsoid, 30–40 × 15–17.5 µm, with smooth outer wall and warty inner wall, 1 µm thick, hyaline; aeciospores catenulate, 27.5–37.5 × 21.5–27.5 µm, globose, subglobose to slightly ellipsoid, wall thin, 0.5–1 µm thick, warty with smooth areas usually in the basal portion, hyaline. **Uredinia and telia** unknown. Life cycle (0/Icv,?,?).

Etymology: the epithet refers to the genus of the host plant, *Margaritaria*, on which the described rust was found.

Known distribution: Brazil

Uromyces amapaensis Sotão & Piovezan, sp. nov. (Figure 2)
MycoBank no.: MB 838086

Type: Brazil. Amapá: Cutias, on *Jatropha gossypifolia* L. (Euphorbiaceae), 05 December 2005, H.M.P. Sotão H2005–02, sori II, III (Holotype: MG 230259).

Diagnosis: *Uromyces amapaensis* is characterized by presenting paraphysate uredinia and telia whose paraphyses have thickened and rounded tips, and pedicellate and smooth teliospores, different from *Uromyces cnidoscolii* Henn. which has no paraphyses in uredinia and telia, and has minutely ornamented teliospores.

Spermogonia and **aecia** not seen. **Uredinia** scattered over the abaxial surface, orangish, subepidermal, pulverulent, grouped; paraphyses clavate, aseptate, 20–36 × 5–13.5 µm, smooth-walled, thickened and rounded at the tip (3–4 µm), light brown; urediniospores broadly globose, subglobose to ellipsoid, pedicellate, 20–30 × 19–20 µm, wall hyaline to light brown, 2–3 µm thick, moderately or densely echinulate, echinulations throughout the spore surface, but slightly irregular, germ pores not seen. **Telia** in uredinia, teliospores pedicellate, ellipsoid, 20–32 × 16–20 µm, lateral wall 1.5–2 µm, thickened at the apex, 3–5 µm, smooth. Life cycle (?/?/IIpe/III).

Etymology: The specific epithet refers to the Brazilian state of Amapá.

Known distribution: Brazil

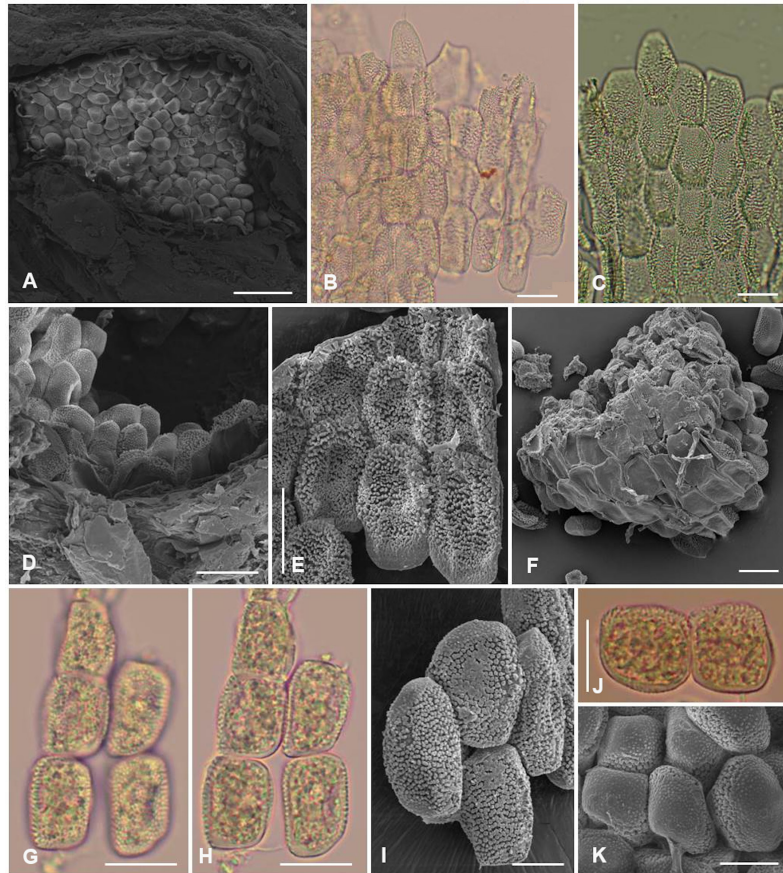


Figure 1. *Aecidium margaritariae* (MG 230298, holotype). A – Superficial view of an aecium (SEM); B – C – Peridial cells; D – Peridial cells on aecium (SEM); E – Inner wall of peridial cells (SEM); F – Outer wall of peridial cells (SEM); G–H – Aeciospores in superficial view (left) and medium focus (right); I – Aeciospores (SEM); J–K – Aeciospores with smooth areas in the basal portion. Scale bars: A = 50 μ m; B–H, J = 20 μ m; I, K = 10 μ m. This figure is in color in the electronic version.

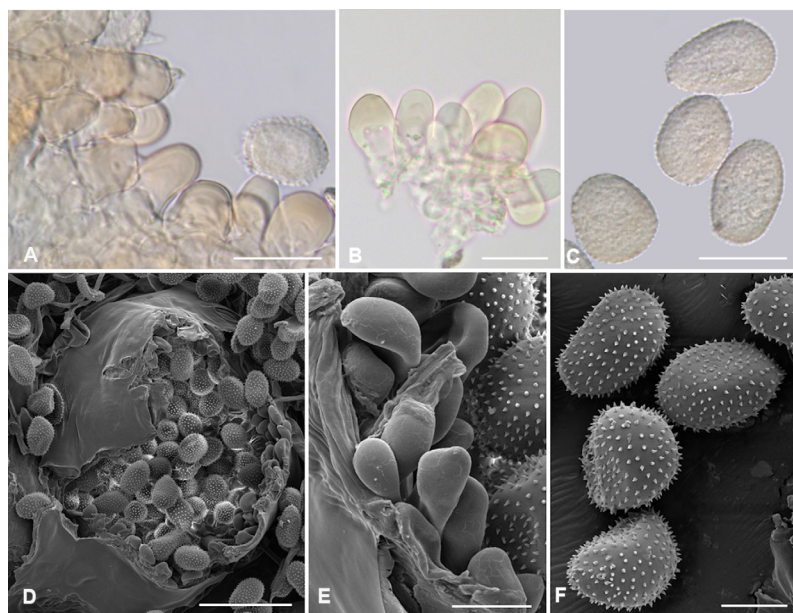


Figure 2. *Uromyces amapaensis* (MG 230259, holotype). A – Paraphyses, urediniospore and teliospores; B – Paraphyses and teliospores; C – Urediniospores in medium focus; D – Superficial view of uredinium with urediniospores, paraphyses and teliospores (SEM); E – Detail of paraphyses and teliospores (SEM); F – Urediniospores (SEM). Scale bars: A = 50 μ m; B–D = 20 μ m; E–F = 10 μ m. This figure is in color in the electronic version.

DISCUSSION

Aecidium margaritariae on *M. nobilis* is the second record of rust on this host genus. The first is *A. entebbense* Cummins, found on *Margaritaria discoidea* (Baill.) G.L. Webster (= *Phyllanthus discoideus* (Baill.) (Cummins 1945). Unlike *A. margaritariae*, in *A. entebbense* the peridial cells are smaller (13–19 × 18–25 µm), oblong to polyhedral, with striate outer walls and warty inner walls, and the aeciospores are smaller (13–18 × 16–23 µm), with apically thickened (3–8 µm) and uniformly warty walls (Cummins 1945).

Another five species of *Aecidium* are known to parasitize other plant genera of Phyllanthaceae: *Aecidium detritum* (*Phyllanthus sellowianus* (Klotzsch) Müll. Arg.), *A. flugeae* (*Flueggea virosa* (Roxb. ex Willd.) Royle, = *F. microcarpa* (Blume) Müll. Arg.), *A. luzoniense* (*Phyllanthus* sp.), *A. phyllanthi* (*Phyllanthus* sp.), *A. phyllanthi-floribundi* (*Phyllanthus floribundus* Müll. Arg.) and *A. phyllanthinum* (*Phyllanthus reticulatus* Poir.) (Hennings 1892, 1900; Sydow *et al.* 1907; Doidge 1927; Viennot-Bourgin 1954; Buriticá *et al.* 2014), with distinct characteristics from those of the new species presented here.

Other rust species registered on Phyllanthaceae have uredinia only, namely, *Uromyces phyllanthi* Henn., *U. phyllanthi-longifolii* Petch, *U. phyllanthi-niruris* M.S. Patil, and *U. phyllanthi-reticulati* Petch (Hennings 1896; Petch 1917, 1922; Patil 1991). Teleomorphic species include *Coleosporium phyllanthinum* Syd. (Sydow 1937), *Masseella capparisi* (Hobson bis ex Cooke) Dietel (Liberato *et al.* 2014), *Masseella narasimhanii* Thirum. (Thirumalachar 1943), *Phakopsora fenestrala* (Arthur) Arthur (Arthur 1917), *P. phyllanthi* Dietel (Dietel 1910), *P. phyllanthi-discoidei* Vienn.-Bourg. (Viennot-Bourgin 1954), *P. purdueae* Buriticá & J.F. Hennen, *P. tijucae* Buriticá & J.F. Hennen, and *P. ulei* (Syd. & P. Syd.) Buriticá & J.F. Hennen (Buriticá 1999).

Uromyces amapaensis represents a new species of rust fungi occurring on *Jatropha*. Five species are known to affect these plants: *Phakopsora arthuriana* Buriticá & J.F. Hennen, *Uromyces agnatus* Arthur, *U. cnidoscoli*, *U. jatrophae* Dietel. & Holw. and *U. oaxanacus* Dietel & Holw. (Monoson & Prose 1983, Hennen *et al.* 2005). *Uromyces amapaensis* is easily differentiated from the other *Uromyces* species mentioned earlier by the presence of a few paraphyses with thickened tips and pedicellate and smooth teliospores.

Berndt (2002) recorded *U. cnidoscoli* on *Jatropha* sp. in Argentina. The Argentinean specimen presented transversely ellipsoidal, grossly warty, dark brown teliospores and pedicels whose apical parts dilated appreciably in aqueous medium. Before that, only the type had been reported from Brazilian collections (Goiás state), in which only teliospores had been observed, however, Berndt (2002) was able to report the presence of spermogonia, aecia and uredinia in the species. Hennings (1895) described *U. cnidoscoli* on *Cnidocolus*

vitifolius (Mill.) Pohl and commented that *Aecidium cnidoscoli* Henn. probably belonged to the life cycle of this species.

Phakopsora arthuriana differs from *U. amapaensis* by presenting subepidermal, non-erumpent telia with 6 to 12 layers of sessile spores, and numerous paraphyses (Hennen *et al.* 2005). The urediniospores of *U. amapaensis* are morphologically similar to those of *P. arthuriana*, but they are pedicellate. The paraphyses are similar in the two species, but in *P. arthuriana* they are numerous and have larger dimensions (20–50 × 9–12 µm vs. 20–36 × 5–13.5 µm in *U. amapaensis*) and the teliospores are smaller (10–27 × 7–13 µm) (Hennen *et al.* 2005).

Monoson and Prose (1983) listed 20 autoecious *Uromyces* species infecting Euphorbiaceae plants in the new world. They presented a key that differentiated them primarily based on the smooth or ornamented walls of the teliospores. Only *Uromyces cisnerioanus* Speg. on *Sapium* sp. has a smooth wall like that of *U. amapaensis*, but it presents as distinctive characteristics teliospores with hyaline outer wall and dark inner wall and thickened apex (5–18 µm), and urediniospores measuring 30–50 × 14–24 µm.

Uromyces amapaensis also presents urediniospores with significant differences in relation to some *Uredo* species that parasitize Euphorbiaceae plants. *Uredo alchorneae* Henn. (*Alchornea* sp.) and *Uredo paulistana* Speg. (*Acalypha* sp.) do not have paraphyses and have slightly angular urediniospores which are smaller than those of *U. amapaensis* (Saccardo and Trotter 1912; Hennen *et al.* 2005). *Uredo saviae* Arthur & J.R. Johnst. (*Savia* sp.) has angularly obovoid urediniospores, usually triangular (Arthur and Johnston 1918). *Uredo valentula* H.S. Jacks & Holw. (*Croton* spp.) has spermogonia, aecia and uredinia in their life cycle, with urediniospores presenting thickened apical wall (3–5.5 µm) and three slightly supraequatorial germ pores (Hennen *et al.* 2005). In turn, *Uredo maceiensis* Henn. (*Maprounea* sp.) presents uredinia with paraphyses thickened at the tip just like *U. amapaensis*, but in *U. maceiensis* the paraphyses are larger (30–50 × 15–16 µm vs. 20–36 × 5–13.5 µm in *U. amapaensis*), the urediniospores are usually ovoid, 4–6 µm thick at the apex, showing three equatorial germ pores (Hennen *et al.* 2005).

Until now, nine species and two varieties of rust fungi have been described on Euphorbiaceae in the Brazilian Amazon, occurring on *Maprounea* Aubl. (*Aecidium maprouneae* var. *maprouneae* Henn., *Aecidium maprouneae* var. *noncrassatum* J.F. Hennen & Sotão, *Chaconia maprouneae* (Viégas) Y. Ono & J.F. Hennen, and *Uredo maceiensis*); *Alchornea* Sw. (*Olivea capituliformis* (Henn.) Arthur and *U. alchorneae*); and *Jatropha* L. (*Phakopsora arthuriana*, *Uromyces cnidoscoli*, and *U. jatrophae*) (Hennen and Sotão 1997; Hennen *et al.* 2005; Carvalho *et al.* 2018).

CONCLUSIONS

This study adds two new species of rust fungi to the Brazilian and Amazonian mycobiota. *Aecidium margaritariae* is the second species of rust fungus found on *Margaritaria nobilis*, while *Uromyces amapaensis* is the fifth species of rust fungi described on *Jatropha gossypifolia*. Our finds increase the known Brazilian mycobiota, highlighting the need to explore new areas in the Amazon region, where fungal diversity remains underestimated.

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