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RESEARCH ARTICLE

Species of *Uromyces* (Pucciniales, Basidiomycota) on Loranthaceae

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ABSTRACT

Two new species of *Uromyces* with reticulated teliospores are compared with nine species of this genus known from Loranthaceae. The new species *Uromyces bahiensis* from Brazil has smaller spores than all known species of *Uromyces* with reticulate teliospores on Loranthaceae. *Uromyces struthanthi* from Panama is characterized by long teliospore pedicels and spinose-echinulate aecidiospores. In addition, new details of ornamentation of aecidiospores and teliospores of known species are presented.
Key words: *Uromyces*, Loranthaceae, new species, Pucciniales.

INTRODUCTION

Pucciniales are the largest order of plant parasitic fungi in the Basidiomycota, including about 9000 species. Nevertheless, numerous unknown species are supposed to exist, especially in the tropics (Shivas & Hyde, 1997). The genus *Puccinia* has the greatest number of species and *Uromyces* is the second largest genus of rust fungi. It includes more than 600 species and despite its high relevance it has not yet been monographed. *Uromyces* spp. differ morphologically from *Puccinia* spp. only by having 1-celled teliospores (Cummins & Hiratsuka, 2003). This characteristic, however, has probably arisen independently several times in Pucciniaceae and alone is not sufficient for recognizing a monophyletic genus (van der Merwe et al., 2007). *Uromyces* species parasitise monocots and dicots throughout the world. More *Uromyces* species have been recorded from the Asteraceae, Euphorbiaceae, Fabaceae, Liliaceae, and Poaceae, than for other host families. Among the plant families that include hosts of *Uromyces* is the family Loranthaceae. It comprises more than 900 species of hemiparasitic shrubs. Most species occur in tropical and subtropical areas of Africa, America, Asia, and Europe, where they live on the stems or branches of their host plants (Vidal-Russell & Nickrent, 2008). Nine species of *Uromyces* are known to have Loranthaceae as host, namely *Uromyces circumscriptus* Neger, *Uromyces euphlebius* Syd. & P. Syd., *Uromyces evastigatus* Cummins, *Uromyces loranthi* H. S. Jacks., *Uromyces nilagiricus* T. S. Ramakr. & K. Ramakr., *Uromyces ornatipes* Arthur, *Uromyces phthirusae* Mayor, *Uromyces socius* Arthur & Holw., and *Uromyces urbanianus* Henn. Here this group of species is re-examined and two novel species of *Uromyces* occurring on this family are described.

MATERIAL AND METHODS

One specimen collected in the province of Chiriquí in Western Panama in 2003 was provided for this study by R. Kirschner and deposited at the Herbario Nacional of the Universidad de Panama (PMA) and at the Botanische Staatssammlung München (M) in Germany. The identification of the host plant for the new species is based on Kuiji (1978) and was compared with specimens available in the National Herbarium in Panama City (PMA). The other specimens cited below were loaned from the herbaria BPI and PUR. *Uromyces nilagiricus* was described from India, but no herbarium specimen could be located. Therefore, only the description published by Ramakrishnan & Ramakrishnan (1950) was used.

Spores and handmade sections of sori were mounted in lactophenol and heated to boiling. They were examined with a Leitz Ortholux II light microscope (LM). Sizes in the species descriptions are based on at least 25 measurements of each structure. For scanning electron microscopy (SEM), air-dried material was mounted directly onto a specimen stub, sputtered with gold for 60 sec, and examined with a Hitachi S 4500 scanning electron microscope. Images were processed with Digital Image System 2.5. The terminology proposed by Cummins & Hiratsuka (2003) was used to describe the life-cycle states.

RESULTS AND DISCUSSION

Ten species, including two new species of *Uromyces* on Loranthaceae are described and illustrated based on an investigation of herbarium material. The main morphological characteristics of these eleven species

are summarized in Table1, including *U. nilagiricus* from India. The known distribution of most *Uromyces* species on Loranthaceae is restricted to Mexico, Central and South America, according to the data currently available. The Loranthaceae are assumed to have evolved on the Gondwana continent before the separation of South America and Africa (Vidal-Russel & Nickrent, 2008). The specific geographical distribution of *Uromyces* species on Loranthaceae might, therefore, be explained by one or few jumps of rust fungi onto species of Loranthaceae from other host families after the separation of South America from Africa.

Uromyces bahiensis Perd.-Sánch., sp. nov. (Figures 1 A-D, 2A, 5 A-B, 6 1-3).

Holotype: BRAZIL, BAHIA: Vitória da Conquista. On living leaves of indet. Loranthaceae, 10 March 1984, *J. F. & M. M. Hennen 84-235* (HOLOTYPE: PUR 89046) [few I, III].

Etymology: Referring to the region of collection in Brazil.

MycoBank # MB805146.

Spermogonia not seen. *Aecidia* hypophyllous, 0.5-0.1 mm diam., subepidermal, erumpent, pulverulent, yellowish. *Peridial cells* (35-) 36-44 (-48) × (20-) 24-32 (-38) µm, rhomboidal or angular, overlapping, outer wall smooth, inner wall verrucose, hyaline or slightly yellowish. *Aecidiospores* (30-) 32-38 (-40) × (21-) 28-33 (-35) µm, catenulate, rhomboidal or angular, verrucose, hyaline or slightly yellowish. *Uredinia* not seen. *Telia* hypophyllous, subepidermal, in small yellowish-brown spots, 0.8-1 mm diam., grouped in areas of 2-2.5 mm diam., flattened to globoid, pulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, oblong-ellipsoidal, (23-) 25-29 (-31) × (15-) 16-18 (-20) µm, wall evenly 2 µm thick, smooth, yellowish to brown, surface reticulate, germ pores not observed. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, short, 5-7 (-8) × 4-6 µm. *Basidia* and *basidiospores* not observed.

On indet. Loranthaceae.

Distribution. Known only from Brazil.

Remarks. The new species *U. bahiensis* is morphologically close to *U. circumscriptus* in aecidiospore size. However, peridial cells are absent in aecidia of *U. circumscriptus*. The new species is characterized by having teliospores which are smaller than those of other known species of *Uromyces* on Loranthaceae which have reticulate teliospores.

Uromyces circumscriptus Neger, Anal. Univ. de Chile, 92: 328. 1895. (Figures 2 B, 5 C-D, 6 4-5).

Type. CHILE. VALDIVIA: 1895. On *Struthanthus complexus* Eichler, *Neger n.n*. [I, III] (PUR F2698).

Spermogonia not seen. *Aecidia* amphigenous, 0.5-1 mm diam., subepidermal, erumpent, pulverulent, grouped in areas of 1.5 mm diam., yellowish. *Peridial cells* not seen. *Aecidiospores* (28-) 31-36 (-42) × (25-) 27-31 (-32) µm, catenulate, rhomboidal or angular, verrucose, hyaline to slightly yellowish. *Uredinia* not seen. *Telia* amphigenous, subepidermal, in small yellowish-brown spots, 0.8-1 mm diam., grouped in areas of 1-3 mm diam., pale brown, subpulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, ellipsoidal, (32-) 36-41 (-43) × (17-) 19-23 (-25) µm, lateral wall 2 µm thick, distal part of the wall 4-7 µm thick, yellowish-cinnamon, rarely hyaline, surface reticulate-striate, germ pores not observed. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, short, 5 (-7) × 5 µm. *Basidia* and *basidiospores* not observed.

On *Loranthus tetrandrus* Ruiz & Pavon, *Loranthus* sp., *Phrygilanthus heterophyllus* Tiegh, *P. verticillatus* (Ruiz & Pav.) Eichler [= *Loranthus verticillatus* Ruiz & Pavon], and *Struthanthus complexus* Eichler (Hennen et al., 1982, 2005; Lindquist, 1982; Mendes et al., 1998; Mujica & Vergara, 1945; Mujica & Oehrens, 1967).

Distribution. Known from Argentina, Brazil, and Chile (Hennen et al., 1982, 2005; Lindquist, 1982; Mendes et al., 1998; Mujica & Vergara, 1945; Mujica & Oehrens, 1967).

Additional specimens examined. ARGENTINA, MENDOZA: Tunuyán, Bella Vista. On *Phrygilanthus verticillatus*, 14 December 1946, *Covas* [I, III] (PUR F11721); MENDOZA, Las Heras, Quebrada del Potrero, 25 March 1956, *A. Ruíz Leal 17.926* [I, III] (PUR F16897); BRAZIL: State unknown, city unknown. On *Strhuthanthus complexus*, 1 January 1896, *Ule 2123* [III] (PUR N3910).

Remarks. *Uromyces circumscriptus* differs from *U. urbanianus* in the surface and size of teliospores and from *U. evastigatus* because teliospores are larger in *U. evastigatus*, and walls of aecidiospores of *U. evastigatus* are thicker at the apex (up to 12 µm). Furthermore, the ornamentation of teliospores of *U. circumscriptus* is reticulate-striate, while it is smooth to finely-densely verrucose in *U. loranthi*, reticulate in *U. bahiensis*, longitudinally striate in *U. euphlebius*, longitudinally rugose-striate in *U. ornatipes*, striate in *U. phthirusae*, longitudinally-striate in *U. socius*, verrucose-striate in *U. urbanianus,* and reticulate-foveate in *U. struthanthi.*

Uromyces euphlebius Syd., Ann. Mycol. 18: 154. 1920. (Figures 3A, 4A, 6 6-7).

Type. MEXICO, JALISCO: On *Phoradendron* sp., *Reiche n.n.* [II, III] (PUR 13782).

Spermogonia and *Aecidia* unknown. *Uredinia* amphigenous, subepidermal, in groups of 2-4 mm diam., cinnamon-brown, pulverulent, ruptured epidermis conspicuous. *Urediniospores* ellipsoidal to oblong-ellipsoidal, (42-) 44-49 (-52) × (21-) 22-25 (-26) µm, wall golden-brown, sparsely echinulate, 2-2.5 µm thick, germ pores 4 equatorial. *Pedicels* persistent or deciduous,

TABLE 1 - Characteristics of aecidiospores, urediniospores, and teliospores of *Uromyces* species on Loranthaceae based on own measurements and observations of specimens, except for *U. nilagiricus*, for which data published by Ramakrishnan & Ramakrishnan (1950) were used.

Species	Aecidiospores size (µm)	Urediniospores size (µm)	Urediniospores germ pores	Teliospores size (µm)	Teliospores ornamentation	Teliospores germ pores
Uromyces bahiensis	(30-) 32-38 (-40) × (21-) 28-33 (-35)	unknown	unknown	(23-) 25-29 (-31) × (15-) 16-18 (-20)	reticulate	not observed
Uromyces circumscriptus	(28-) 31-36 (-42) × (25-) 27-31 (-32)	unknown	unknown	(32-) 36-41 (-43) × (17-) 19-23 (-25)	reticulate-striate	present
Uromyces euphlebius	unknown	(42-) 44-49 (-52) x (21-) 22-25 (-26)	4 equatorial	(41-) 47-52 (-56) × (18-) 20-24 (-26)	longitudinally striate	not observed
Uromyces evastigatus	(30-) 37-43 (-47) × (23-) 28-36 (-40)	unknown	unknown	(40-) 41-48 (-52) × (16-) 20-24 (-25)	reticulate	not observed
Uromyces loranthi	unknown	(30-) 33-40 (-42) × (22-) 23-29 (-38)	4 equatorial	(25-) 26-42 (-45) × (19-) 20-23 (-24)	smooth to finely-densely verrucose	not observed
Uromyces nilagiricus	24-33 × 18-30	unknown	unknown	30-45 × 21-30	smooth	not observed
Uromyces ornatipes	(24-) 26-32 (-35) × 22-26 (-28)	(25-) 26-32 (-33) × (20-) 21-24 (-25)	probably 4 equatorial	(34-) 35-39 (-40) × (23-) 25-28 (-29)	longitudinally rugose-striate	not observed
Uromyces phthirusae	(28-) 29-30 (-32) × (21-) 22-25 (-26)	(30-) 33-40 (-42) × (18-) 20-24 (-27)	4 equatorial	(35-) 38-46 (-53) × (17-) 20-25 (-26)	striate	apical
Uromyces socius	(30-) 32-36 (-38) × (16-) 25-31 (-33)	(40-) 41-52 (-56) × (19-) 22-26 (-27)	4 equatorial	(32-) 34-42 (-47) × (20-) 21-25 (-27)	longitudinally-striate	present
Uromyces struthanthi	(15-) 17-20 (-25) × (10-) 12-17 (-28)	unknown	unknown	(35-) 42-47 (-50) × (20-) 23-26 (-27)	reticulate-foveate	not observed
Uromyces urbanianus	(40-) 42-50 × (20-) 29-40 (-42)	unknown	unknown	(35-) 39-45 (-48) × (20-) 21-24 (-25)	verrucose-striate	not observed

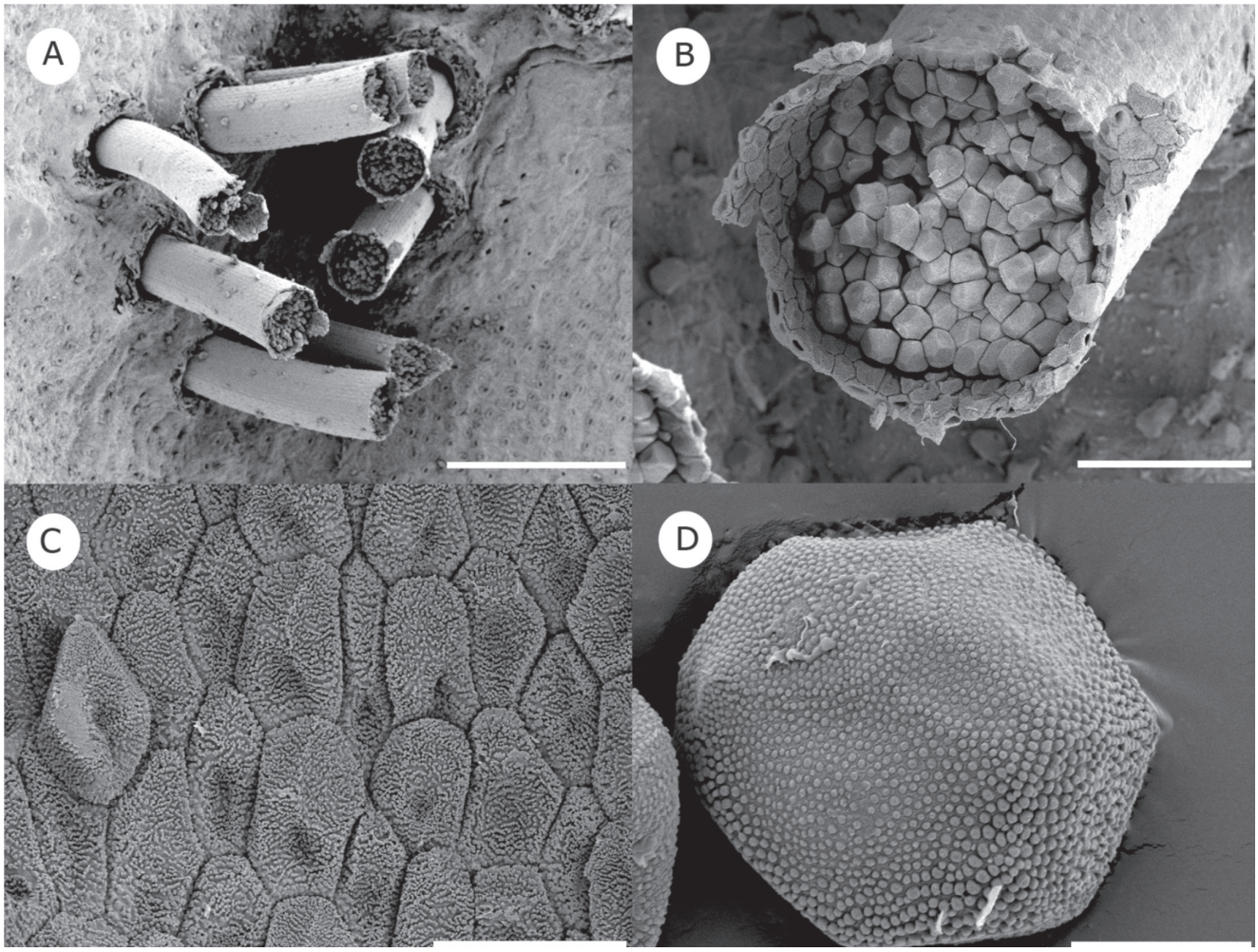

FIGURE 1 - *Uromyces bahiensis*, as seen under SEM. **A**. Aecidia (bar = 50 µm); **B**. Aecidium with peridial cells and aecidiospores (bar = 9 µm); **C**. Peridial cells as seen from the inner side of a peridium (bar = 30 µm); **D**. Mature aecidiospore (bar = 8 µm).

cylindrical, smooth, thin-walled, hyaline, short, 8-18 (-20) × 4-5 µm. *Telia* amphigenous, subepidermal, in small dark chocolate-brown spots, in 1-3 mm diam. groups, subpulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, oblong, (41-) 47-52 (-56) × (18-) 20-24 (-26) µm, lateral wall 2-2.5 µm thick, distal wall 7-10 µm thick, chestnut-brown, longitudinally striate, germ pores not observed. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, 8-10 (-50) × 4-5 (-7) µm. *Basidia* and *basidiospores* not observed.

Neotropical hosts. On *Psittacanthus calyculatus* (DC.) G. Don and *Phoradendron* sp. (Gallegos & Cummins, 1981).

Known only for Mexico (Gallegos & Cummins, 1981).

Additional specimen examined. MEXICO, SANTA MARIA: Cuernavaca, Morelos. On *Psittacanthus calyculatus*, 10 August 1926 *Woronow 2604* [II, III] (PUR 48119).

Remarks. *Uromyces euphlebius* is morphologically close to *U. socius* having a similar urediniospore size and equivalent surface structure of teliospores. However, the teliospores of *U. euphlebius* are longer than those of *U. socius.*

Uromyces evastigatus Cumm., Mycologia 31. 173. 1939. (Figures 2 C, 5 E-F, 6 8-9).

Type. EL SAVADOR, SAN SALVADOR: 650-850 m a.s.l., 30 March 1922, 24 April 1922. On *Phthirusa pyrifolia* (Kunth) Eichler, *P. C. Standley 23106* [I, III] (LECTOTYPE selected here, PUR 34937, ISOLLECTOTYPE [I] BPI 0004660).

Spermogonia unknown. *Aecidia* amphigenous, subepidermal, erumpent, pulverulent, grouped in areas of 1.5 mm diam., yellowish. *Peridial cells* rhomboidal, outer wall smooth, inner wall verrucose, lateral and distal wall *ca.* 2 µm thick. *Aecidiospores* catenulate, oblong to ellipsoidal or globose, (30-) 37-43 (-47) × (23-) 28-36 (-40) µm, minutely verrucose, hyaline, distal wall 5-12 µm thick. *Uredinia* not seen. *Telia* amphigenous, subepidermal, in small chocolate-brown spots, in 1-2 mm diam., groups, pulverulent, ruptured epidermis conspicuous. *Teliospores*

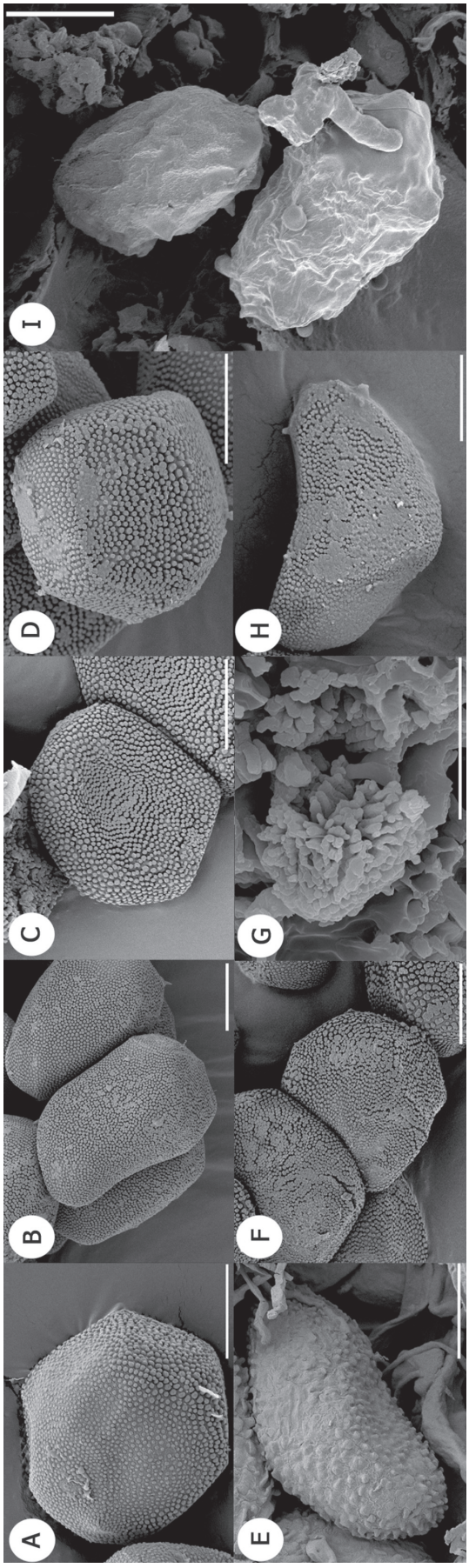

FIGURE 2 - Mature aecidiospores of *Uromyces* spp. on Loranthaceae, as seen under SEM. **A**. *Uromyces bahiensis* (PUR 890426); **B**. *Uromyces circumscriptus* (PUR F16897); **C**. *Uromyces evastigatus* (PUR 34938); **D**. *Uromyces ornatipes* (BPI 0012035); **E**. *Uromyces phthirusae* (PUR F2700); **F**. *Uromyces socius* (PUR N3912); **G**. *Uromyces struthanthi* (Kirschner 1743-B); **H**. *Uromyces urbanianus* (BPI 0019079); **I**. Peridial cells of *Uromyces struthanthi* (Kirschner 1743-B). Bars: **A-H** = 10 µm, **I** = 20 µm.

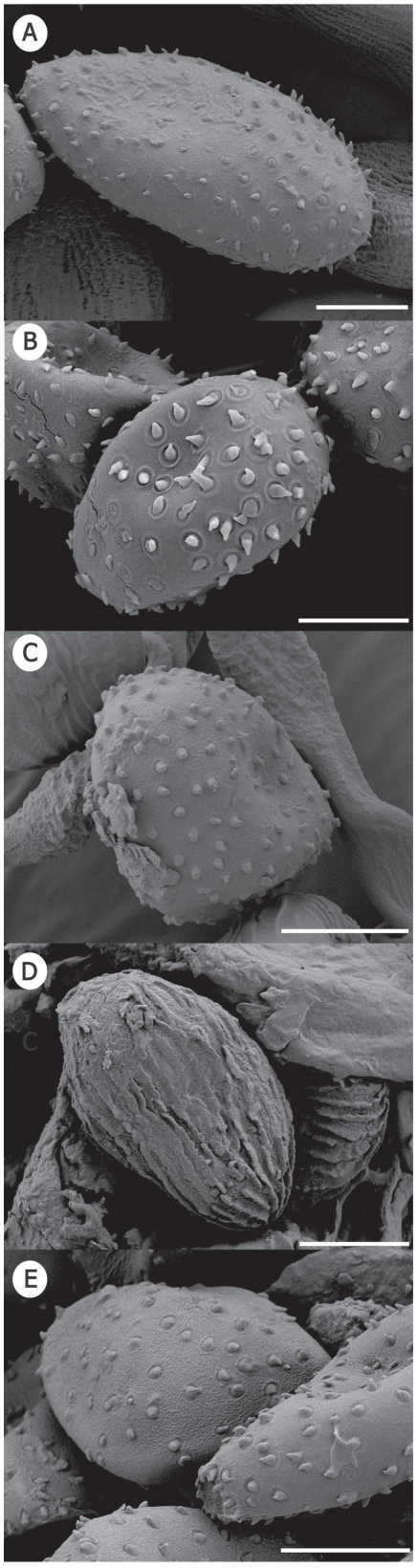

FIGURE 3 - Mature urediniospores of *Uromyces* spp. on Loranthaceae, as seen under SEM. **A**. *Uromyces euphlebius* (PUR 48119); **B**. *Uromyces loranthi* (type PUR F2697); **C**. *Uromyces ornatipes* (PUR 60498); **D**. *Uromyces phthirusae* (PUR F2700); **E**. *Uromyces socius* (PUR 60903). Bars = 10 µm.

1-celled, oblong-ellipsoidal, (40-) 41-48 (-52) × (16-) 20-24 (-25) µm, lateral wall 2-3 µm thick, distal wall 6-9 µm thick, chestnut-brown, reticulate, germ pores not observed. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, 10-47 × 6-7 µm. *Basidia* and *basidiospores* not observed.

On *Phthirusa pyrifolia* (Kunth) Eichler (Cummins & Stevenson, 1956).

Distribution. Known only from El Salvador (Cummins & Stevenson, 1956).

Additional specimen examined. EL SALVADOR, SAN SALVADOR: Tonacatepeque. On *Phthirusa pyrifolia* 30-31 December 1921, *P. C. Standley 19437* [I, III] (PUR 34938); ibid., [I] (BPI 0004659).

Remarks. *Uromyces evastigatus* is morphologically close to *U. urbanianus* having similar sized teliospore. However, the teliospores of *U. evastigatus* are reticulate and have longer pedicels.

Uromyces loranthi Jacks. & Holw., Mycologia 19: 54. 1927. (Figures 3 B, 5 G-H, 6 10-12).

Type. BRAZIL, SABARÁ: Minas On *Loranthus* sp., 2 December 1921, *E.W. D. & M.M. Holway 1358* [II, III] (PUR F2697).

Spermogonia and *aecidia* not seen. *Uredinia* amphigenous, subepidermal, in groups, on small cinnamon-brown spots, 1.5-3 mm diam., pulverulent, ruptured epidermis conspicuous and persistent. *Paraphyses* 40-50 × 5-7 µm, cylindrical, aseptate, smooth, persistent, thin-walled, hyaline to slightly yellowish. *Urediniospores* ellipsoidal or obovoid, (30-) 33-40 (-42) × (22-) 23-29 (-38) µm, light cinnamon-brown, finely and sparsely echinulate, 1-1.5 µm thick, spines abundant, germ pores 4 equatorial. *Pedicels* persistent or deciduous, cylindrical, smooth, thin-walled, hyaline, 10-13 × 3-5 µm. *Telia* amphigenous, mostly abaxial, subepidermal, in small brown spots, 0.8-1 mm diam., in 2-3 mm diam. groups, flattened to globoid, pulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, oblong to ellipsoidal, (25-) 26-42 (-45) × (19-) 20-23 (-24) µm, lateral wall 1.5-2 µm thick, distal wall 6-8 µm thick, yellowish to hyaline, smooth to finely-densely verrucose, germ pores not observed. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, 8-10 (-15) × (3-) 4-5 µm. *Basidia* and *basidiospores* not observed.

On *Loranthus* sp. (Hennen et al., 1982, 2005; Jackson, 1927; Mendes et al., 1998).

Distribution. Known only from Brazil (Hennen et al., 1982, 2005; Jackson, 1927; Mendes et al., 1998).

Remarks. *Uromyces loranthi* differs from *U. euphlebius*, *U. ornatipes*, and *Uromyces socius* by the ornamentation of the teliospores which are not arranged in lines. Additionally, *U. loranthi* differs from *U. circumscriptus*, *U. evastigatus*, and *U. urbanianus* by having smaller teliospores. The paraphyses of *U. loranthi* are reported, described and illustrated here for the first time.

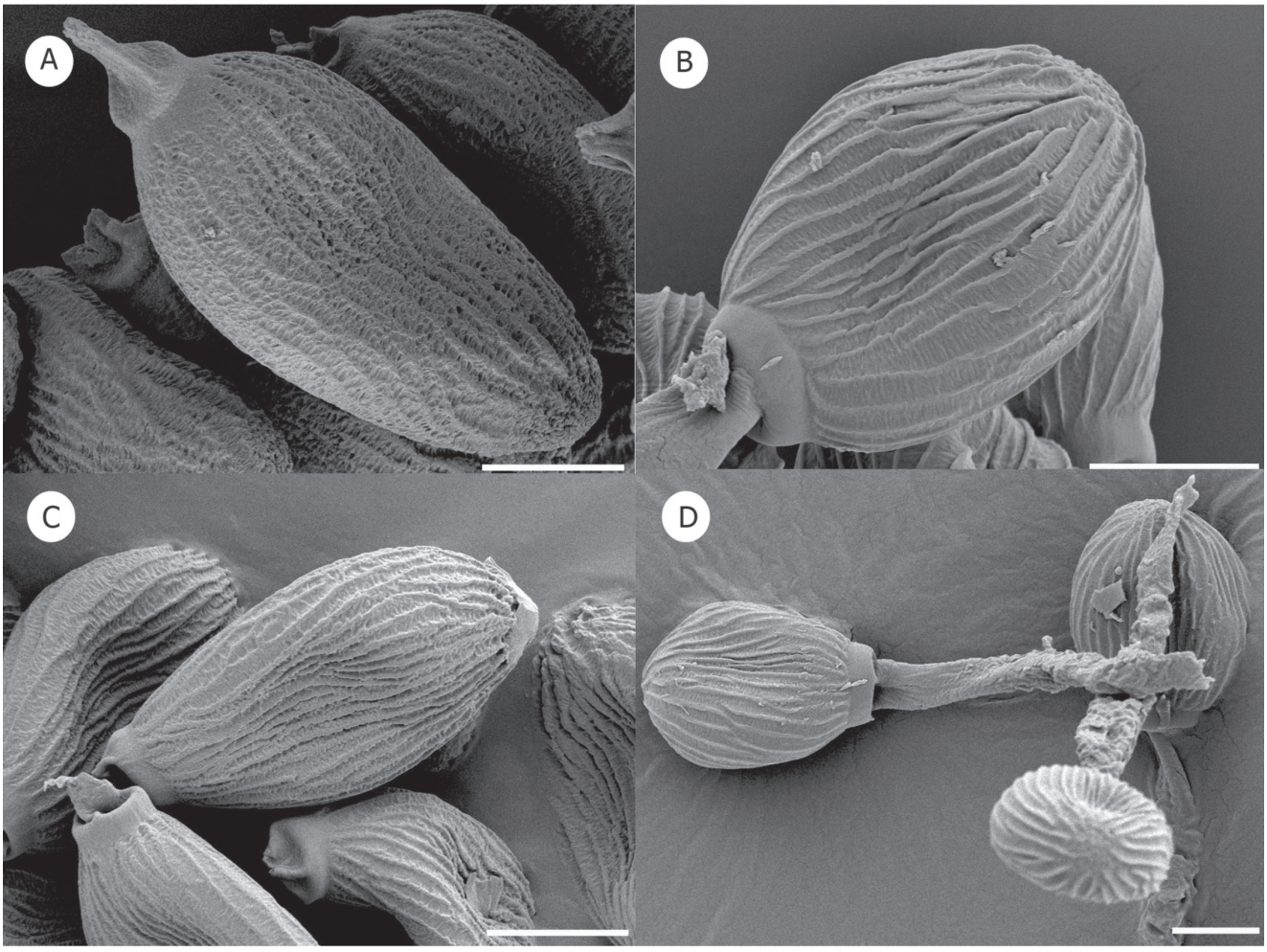

FIGURE 4 - Mature teliospores of *Uromyces* spp. on Loranthaceae, as seen under SEM. **A**. *Uromyces euphlebius* (type PUR 48119); **B**. *Uromyces ornatipes* (PUR 60498); **C**. *Uromyces socius* (PUR 13776); **D**. *Uromyces ornatipes* with details of pedicel (BPI 0012035). Bars = 10 µm.

Uromyces nilagiricus T. S. Ramakr. & K. Ramakr., Proc. Indian Acad. Sci. Sect. B. 32 p. 104. 1950.

Type. INDIA, KOTAGIRI: On *Loranthus* sp., 25 April 1949, parasitic on *Citrus reticulata*, *D. Murudarajan* [I, III] n.v.

As no material is available, the following description is taken from Ramakrishnan & Ramakrishnan (1950).

"Rust spot hypertrophied, up to 7 mm diam. *Pycnidia* amphigenous, subepidermal, oval, 240 x 210 µm. *Aecidia* amphigenous, deeply sunk, cupulate, peridium of one layer of polygonal, colourless, thick-walled, verrucose cells. *Aecidiospores* angular, globose, catenulate, yellowish orange in colour, wall unevenly thickned, highly verrucose, 30 × 25 µm (24-33 µm × 18-30 µm). *Uredinia* wanting. *Telia* amphigenous, chocolate brown, suepidermal, erumpent. Teliospores 1-celled, elliptic to rhomboid, narrow towards the base, 36 × 26 µm (30-45 × 21-30 µm) apex rounded, thickened up to 8 µm, orange brown in colour, wall smooth, pedicellate. *Pedicels* hyaline, up 130 µm long."

On *Loranthus* sp. (Ramakrishnan & Ramakrishnan, 1950).

Distribution. Only known from India (Ramakrishnan & Ramakrishnan, 1950).

Remarks. According to Ramakrishnan & Ramakrishnan (1950) the pycnidia and aecidia occur in swollen concavo-convex areas. The convexity may be oriented towards either surface. The aecidia are projected as short white columns with lacerated and recurved margins. The telia are not on the same spots as aecidia but occur on the same leaf. The wall of the teliospore is completely smooth as seen with the oil immersion objective.

According to Ramakrishnan & Ramakrishnan (1950) *U. nilagiricus* is characterized by long teliospore pedicels and smooth teliospores. Thereby, it apparently differs from all other species of *Uromyces* on Loranthaceae. In order to confirm this species concept, it is necessary to locate and examine the type material or to designate a neotype. To date this is the only species of *Uromyces* on Loranthaceae known outside the Americas.

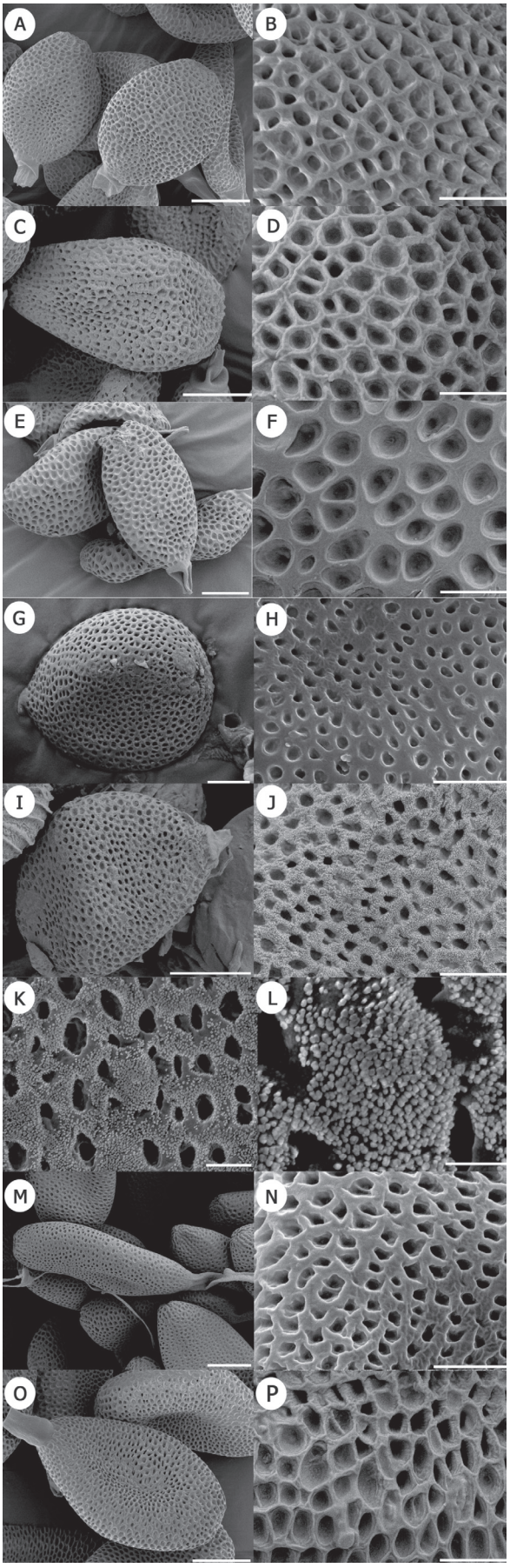

FIGURE 5 - Mature teliospores and ornamentation of *Uromyces* spp. on Loranthaceae, as seen by SEM. **A, B**. *Uromyces bahiensis* (PUR 890426) (Scale bar on the left hand side = 10 µm, on the right hand side = 3 µm); **C, D**. *Uromyces circumscriptus*; **C**. (PUR F11721) (bar = 10 µm); **D**. (PUR N3910) (bar = 3 µm); **E, F**. *Uromyces evastigatus* (PUR 51731) (bar on the left = 10 µm; bar on the right = 3 µm); **G, H**. *Uromyces loranthi* (PUR F2697) (bar on the left = 10 µm, bar on the right = 3 µm); **I, J**. *Uromyces phthirusae* (PUR F2700) (bar on the left = 10 µm, bar on the right = 3 µm); **K, L**. Ornamentation of teliospores of *Uromyces phthirusae* (PUR F2700) (bar on the left = 1 µm, bar on the right = 400 nm); **M, N**. *Uromyces struthanthi* (Kirschner 1743-B) (bar on the left = 10 µm, bar on the right = 3 µm); **O**. *Uromyces urbanianus* (PUR 52982) (bar = 10 µm); **P**. *Uromyces urbanianus* (PUR 64318) (bar = 3 µm).

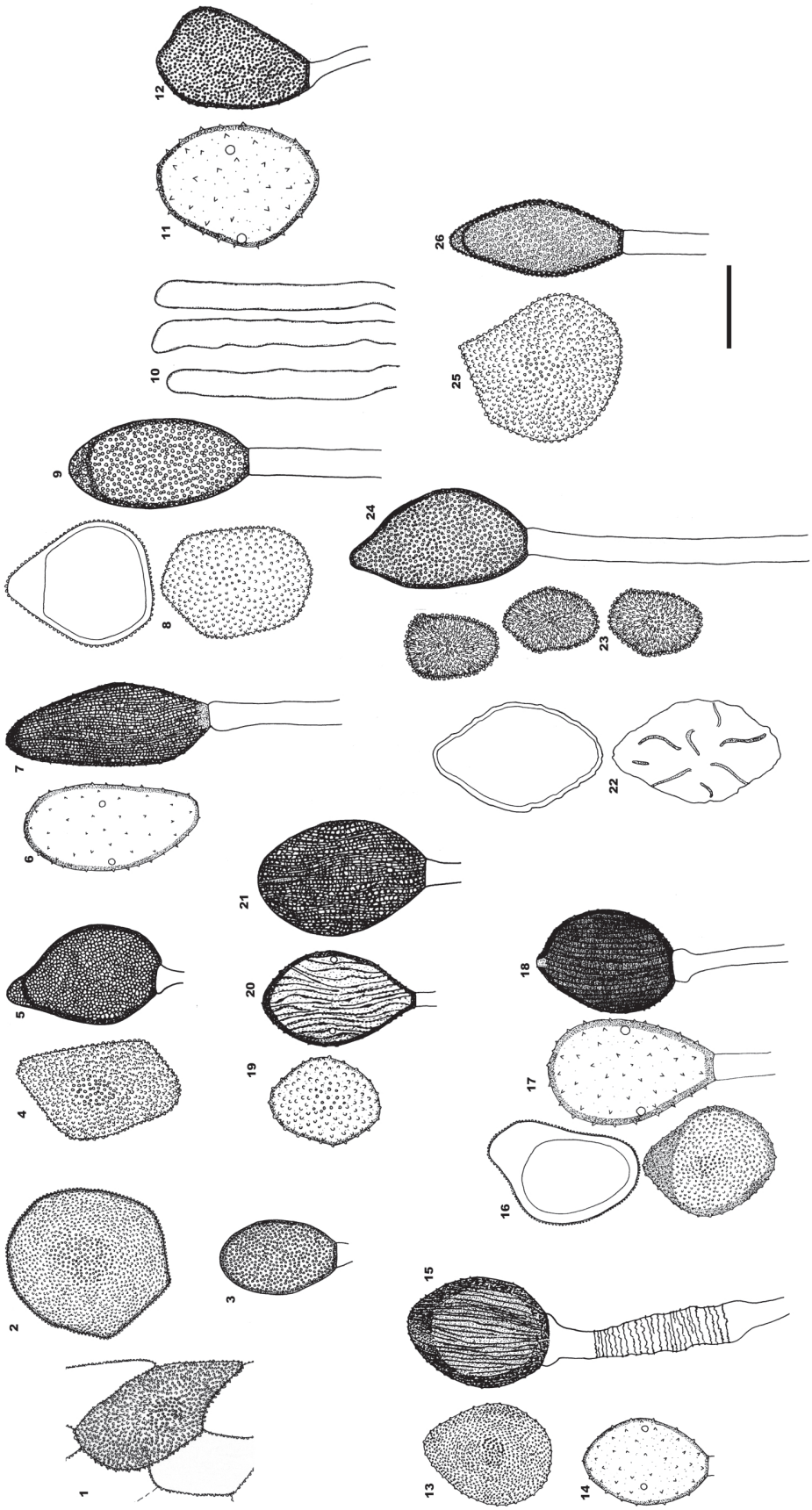

FIGURE 6 - *Uromyces* spp. on Loranthaceae. **1-3**. *Uromyces bahiensis*: 1, Peridial cells; 2, Mature aecidiospore; 3, Mature teliospore; **4-5**. *Uromyces circumscriptus*: 4, Mature aecidiospore; 5, Mature teliospore; **6-7**. *Uromyces euphlebius*: 6, Mature urediniospore; 7, Mature teliospore; **8-9**. *Uromyces evastigatus*: 8, Mature aecidiospores; 9, Mature teliospore; **10-12**. *Uromyces loranthi*: 10, Apice of paraphyses; 11, Mature urediniospore; 12, Mature teliospore; **13-15**. *Uromyces ornatipes*: 13, Mature aecidiospore; 14, Mature urediniospore; 15, Mature teliospore; **16-18**. *Uromyces socius*: 16, Mature aecidiospore; 17, Mature urediniospore; 18, Mature teliospore; **19-21**. *Uromyces phthirusae*: 19, Mature aecidiospores; 20, Mature urediniospore; 21, Mature teliospore. **22-24**. *Uromyces struthanthi*: 22, Peridial cells; 23, Mature aecidiospores; 24, Mature teliospore; **25-26**. *Uromyces urbanianus*: 25, Mature aecidiospore; 26, Mature teliospore. Bar = 20 µm.

Uromyces ornatipes Arth., Bull. Torrey Club 42: 586. 1915. (Figures 2 D, 3 C, 4 B, D, 6 13-15).

Type. MEXICO: Cape San Lucas. On *Phrygilanthus sonorae* (S. Watson) Standl, March 1911, *J.N. Rose 16396* [I, II, III] (LECTOTYPE selected here, PUR 13775; ISOLECTOTYPES [I] (BPI 0012034); [I, III] (BPI 0012035).

Spermogonia not seen. *Aecidia* amphigenous, 0.5-1 mm diam., subepidermal, erumpent, pulverulent, hyaline. *Peridial cells* (25-) 26-32 (-33) × (18-) 19-21 (-23) µm, rhomboidal, overlapping, outer wall smooth, inner wall verrucose. *Aecidiospores* catenulate, angular, globoid or ellipsoidal, (24-) 26-32 (-35) × 22-26 (-28) µm, verrucose, or very inconspicuously verrucose, hyaline. *Uredinia* few, amphigenous, subepidermal, on spots of 1.5-3 mm diam., brown, pulverulent, ruptured epidermis conspicuous. *Urediniospores* ellipsoidal, (25-) 26-32 (-33) × (20-) 21-24 (-25) µm, wall golden-brown, echinulate, 1.5-2.5 µm thick, germ pores indistinct. *Pedicels* deciduous. *Telia* amphigenous, subepidermal, in small yellowish-brown spots, 0.3-0.6 mm diam., blackish to brown, subpulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, ellipsoidal, (34-) 35-39 (-40) × (23-) 25-28 (-29) µm, lateral wall 2-2.5 µm thick, distal wall 5-7 µm thick, dark chocolate brown, often opaque, surface longitudinally rugose-striate, germ pores not observed. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, 60-70 × 7-9 µm, wider (10-14 µm) towards the base which is strongly transversely rugose. *Basidia* and *basidiospores* not observed.

On *Phrygilanthus sonorae* Standl. [= *Loranthus sonorae* (S. Watson) Standl.] (Arthur, 1915; Gallegos & Cummins, 1981).

Distribution. Only known from Mexico (Arthur, 1915; Gallegos & Cummins, 1981).

Additional specimen examined. MEXICO: Baja California. On *Phrygilanthus sonorae*, 14 March 1966, *Lightle & Gill 1-66* [I, II, III] (PUR 60498).

Remarks. *Uromyces ornatipes* differs from all other species of *Uromyces* on Loranthaceae by having pedicels which are smooth to strongly rugose. Furthermore, *U. ornatipes* is the only species with a longitudinally rugose-striate ornamentation of the teliospores.

Uromyces phthirusae Mayor ex Jackson, as "*phtirusae*", Mém. Soc. Neuchât. De Sc. Nat. **5**: 448. 1913. (Figures 2 E, 3 D, 5 I-L, 6 19-21).

Uredo phthirusae (Mayor) Buriticá, in Buriticá & Pardo-Cardona, Revta Acad. Colomb. Cienc. Exact. Fís. Nat. 20: 218. 1996. (Illegitimate name according to Berndt 2002)

Type. COLOMBIA, ANTIOQUIA DEPARTMENT: Cafetal de Camelia, Angelopolis. On *Phthirusa pyrifolia* 1800 m a.s.l., 24 August 1910, *E. Mayor n.n*. [I, II, III] (PUR F2700).

Spermogonia not seen. *Aecidia* amphigenous, 0.5-0.7 mm diam., subepidermal, erumpent, pulverulent, grouped in 1 mm diam., areas of, yellowish. *Peridial cells* not seen. *Aecidiospores* catenulate, angular, (28-) 29-30 (-32) × (21-) 22-25 (-26) µm, verrucose, yellowish. *Uredinia* amphigenous, subepidermal, in groups on cinnamon-brown spots, 1.5-3 mm diam., pulverulent, ruptured epidermis conspicuous and persistent. *Urediniospores* ellipsoidal or obovoid, (30-) 33-40 (-42) × (18-) 20-24 (-27) µm, wall light cinnamon-brown, longitudinally ridged to striate, 1-1.5 µm thick, with 4 equatorial germ pores. *Pedicels* deciduous. *Telia* amphigenous, subepidermal, on small yellowish-brown spots, 0.8-1 mm diam., grouped in areas of 1-3 mm diam., pale brown, pulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, ellipsoidal to oblong-ellipsoidal, (35-) 38-46 (-53) × (17-) 20-25 (-26) µm, lateral wall 3-4 µm thick, distal wall *ca.* 5 µm thick, brown, surface reticulate, with very fine ornamentation and an apical germ pore. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, short, 8-10 × 4-5 µm. *Basidia* and *basidiospores* not observed.

On *Phthirusa pyrifolia* (Kunth) Eichler (Chardon & Toro, 1930; Dennis, 1970; Kern et al., 1933; Pardo Cardona, 1994).

Distribution. Known only in Colombia (Chardon & Toro, 1930; Dennis, 1970; Kern et al., 1933; Pardo Cardona, 1994).

Additional specimen examined. COLOMBIA, ANTIOQUIA DEPARTMENT: Cafetal de Camelia, Angelopolis. On *Phthirusa pyrifolia*, 1800 m a.s.l., 24 August 1910, *E. Mayor n.n.* [III] (BPI 0013083); ibid., [II, III] (BPI 845455).

Remarks. *Uromyces phthirusae* differs from most species of *Uromyces* on Loranthaceae by having sparse verrucose aecidiospores and urediniospores which are longitudinally ridged to striate with four equatorial germ pores. Under SEM, a very fine reticulate ornamentation on the surface of teliospores of *U. phthirusae* was observed. This type of ornamentation is reported here for the first time for teliospores of a species of *Uromyces*. The aecidiospores of *U. phthirusae* are reported, described, and illustrated here for the first time.

Uromyces socius Arth. & Holw., Am. J. Bot. **5**: 437. 1918. (Figures 2 F, 3 E, 4 C, 6 16-18).

Type. GUATEMALA: Antigua. On *Loranthus* sp., 3 March 1916, *Holway 545* [I, II, III] (PUR 13778).

Spermogonia not seen. *Aecidia* amphigenous, 0.5-0.9 mm diam., subepidermal, erumpent, pulverulent, grouped in of 1.5 mm diam. areas, yellowish. *Peridial cells* (35-) 39-46 (-50) × (16-) 18-25 (-30) µm, rhomboidal, yellowish to hyaline, outer wall smooth, inner wall verrucose. *Aecidiospores* catenulate, angular, (30-) 32-36 (-38) × (16-) 25-31 (-33) µm, verrucose, lateral wall 2.5-3

µm thick, distal wall *ca.* 10 µm thick, hyaline to yellowish. *Uredinia* amphigenous, subepidermal, in groups in small cinnamon-brown spots, 1.5-2 mm diam., pulverulent, ruptured epidermis conspicuous. *Urediniospores* ellipsoidal or obovoid, (40-) 41-52 (-56) × (19-) 22-26 (-27) µm, wall light cinnamon-brown, echinulate, 1-2 µm thick, with 4 equatorial germ pores. *Pedicels* persistent, cylindrical, 30-45 × 7-8 µm, smooth, thin-walled, hyaline. *Telia* amphigenous, subepidermal, in small yellowish-brown spots, 0.5-1.5 mm diam., in groups in 1-2 mm diam., areas, pale brown, pulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, ellipsoidal to oblong-ellipsoidal, (32-) 34-42 (-47) × (20-) 21-25 (-27) µm, lateral wall 3 µm thick, distal wall 8-9 µm thick, dark chestnut-brown, surface longitudinally striate, with distal germ pore. *Pedicels* persistent, cylindrical, smooth, thin-walled, hyaline, 10-45 (-65) × 4-8 µm. *Basidia* and *basidiospores* not observed.

On *Struthanthus densiflorus* (Benth.) Standl., *S. haenkeanus* Standl*, S. palmeri* Kuijt*, S. pyrifolius* Blume, *S.* sp., *Loranthus crassipes* Oliv., and *L.* sp. (Arthur, 1918; Carrion & Galvan, 1987; Gallegos & Cummins, 1981).

Distribution. Known from El Salvador, Guatemala and Mexico (Arthur, 1918; Carrion & Galvan, 1987; Gallegos & Cummins, 1981).

Additional specimens examined. EL SALVADOR, SAN SALVADOR: Santa Tecla, Experimental Station. On *Struthanthus* sp., 4 November 1945, *F. L. Wellman 899* [II, III] (PUR 51732); ibid., *F. L. Wellman 900* [II, III] (PUR 517733); MEXICO, SONORA: Guaymas. On *Struthanthus haenkianus*, 22 October 1965, *J.F. Hennen 65-285* [I, III] (PUR 60903); MEXICO, SONORA: Sierra Madre, El Río Bonito about La Nopalera, 10 May 1939, *C. H. Muller 3629* [III] (BPI 0016659); MEXICO, SONORA: Alamos. On *Struthanthus palmeri,* 2 July 1992, *T. R. Van Devender & S. L. Friedman 92-683* [I] (PUR N3912); MEXICO, PUEBLA: On *Loranthus* sp., *C. A. Purpus* [I] (BPI 0016648); GUATEMALA: Huehuetenango. On *Struthanthus densiflorus*, 22 January 1917, *Holway 765* [II, III] (PUR 17381), ibid., [III] (BPI 006651, 0016658); Antigua. On *Loranthus* sp.1 March 1916, *Holway 539* [I, II, III] (PUR 13780), ibid., [I] (BPI 0016650), ibid., [II] (BPI 0016641); Panajachel, Solola, 3 January 1917, *Holway 665* [II, III] (PUR 13779), ibid., [III] (BPI 0016649); Solola. On *Loranthus crassipes*, 1 February 1915, *Holway 169* [I, III] (PUR 13777), ibid., [III] (BPI 006651); San Lucas Toliman, 3 February 1915, *Holway 185* [I, III] (PUR 13776), ibid., [III] (BPI 006652, 0016653); GUATEMALA, ANTIGUA: Sacatépequez. On *Struthantus* sp., 1 March 1916, *E. W. D. Holway 539* [III] (BPI 0016656); EL SALVADOR, LA CEIBA: On *Struthantus pyrifolius*, 10 December 1945, *F.L. Wellman 1143* [II] (BPI 0016660).

Remarks. *Uromyces socius* is morphologically close to *U. euphlebius* by having similar sized urediniospore and similarly ornamented teliospores. However, the teliospores of *U. euphlebius* are longer in contrast to those of *U. socius*.

Uromyces struthanthi Perd.-Sánch., sp. nov. (Figures 2 G, I 5 M-N, 6 22-24).

Type. PANAMA, CHIRIQUÍ PROVINCE: Boquete, Finca Arco Iris. on leaves of *Struthanthus* sp. (Loranthaceae), 1,300 m a.s.l., 7 March 2003, *R. Kirschner 1743 B* [I, III] (holotype PMA, ISOTYPE M-0141257).

Etymology. Named after the host genus, *Struthanthus* (Loranthaceae).

MycoBank # MB805147.

Spermogonia not seen. *Aecidia* hypophyllous, 0.5-1.5 mm diam., subepidermal, erumpent, not pulverulent, yellowish. *Peridial cells* (40-) 42-45 (-48) × (27-) 29-30 (-32) µm, oblong, smooth to roughened, hyaline to yellowish. *Aecidiospores* (15-) 17-20 (-25) × (8-) 10-13 (-15) µm, catenulate, angular, spinose-echinulate, yellowish to hyaline. *Uredinia* not seen. *Telia* hypophyllous, subepidermal, in small yellowish-brown spots, 0.8-1 mm diam., grouped in 2-3 mm diam. areas, flattened to globoid, pulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, oblong-ellipsoidal, (35-) 42-47 (-50) × (20-) 23-26 (-27) µm, lateral wall 2 µm thick, distal wall 8-9 µm thick,, yellowish-brown, reticulate-foveate, germ pores not observed. *Pedicels* persistent, cylindrical, 8-80 (-90) × 4-5 µm, smooth, thin-walled, hyaline. *Basidia* and *basidiospores* not observed.

On *Struthanthus* sp.

Distribution. Known only from Panama.

Remarks. No spermogonia, uredinia, basidia or basidiospores were found in this collection. Telia are abundant. The new species is characterized by having large teliospore pedicels and spinose-echinulate aecidiospores that differentiates it from all other species of *Uromyces* on Loranthaceae.

Uromyces urbanianus P. Henn., Hedwigia 36: 213. 1897. (Figures 2 H, 5 O-P, 6 25-26).

Type. TRINIDAD, ST. ANNS: On *Oryctanthus spicatus*, August 1896, *J. H. Hart n.n.* [III] (PUR F155572).

Spermogonia not seen. *Aecidia* hypophyllous, 0.5-1 mm diam., subepidermal, erumpent, pulverulent, grouped in areas of 1-3 mm diam., yellowish. *Peridial cells* (37-) 38-54 (-72) × (22-) 28-39 (-40) µm, rhomboidal, outer wall smooth, inner wall verrucose, hyaline or slightly yellowish. *Aecidiospores* (40-) 42-50 × (20-) 29-40 (-42) µm, catenulate, angular to globose, verrucose, hyaline. *Uredinia* not seen. *Telia* amphigenous, mostly abaxial, subepidermal, in small brown spots, 0.8-1 mm diam., grouped in 2 mm diam.areas, flattened to globoid, pulverulent, ruptured epidermis conspicuous. *Teliospores* 1-celled, oblong to ellipsoidal, (35-) 39-45 (-48) × (20-) 21-24 (-25) µm, lateral wall 2-4 µm thick, distal wall 5-7 µm thick, yellowish-brown, surface finely-closely verrucose-striate, germ pores not observed. *Pedicels* persistent, cylindrical, smooth,

thin-walled, hyaline, 8-25 (-30) × 5-7 µm. *Basidia* and *basidiospores* not observed.

On *Phoradendron* sp., *Phrygilanthus acutifolius* (Ruiz & Pav.) Eichler, *Psittacanthus calyculatus* (DC.) G. Don, *Psittacanthus americanus* (L.) Mart., *Psittacanthus* sp., *Oryctanthus spicatus* Eichler and *Struthanthus complexus* Eichler. (Buriticá & Pardo Cardona, 1996; Chardon & Toro, 1930; Dennis, 1970; Gallegos & Cummins, 1981; Hennen et al., 1982, 2005; Kern et al., 1933; Lindquist, 1982; Mendes et al., 1998; Pardo Cardona, 1994, 1998; Salazar-Yepes & Buriticá, 2002; Salazar-Yepes et al., 2002).

Distribution. Known from Argentina, Colombia, Guatemala, Honduras, Mexico, and Trinidad (Buriticá & Pardo Cardona, 1996; Chardon & Toro, 1930; Dennis, 1970; Gallegos & Cummins, 1981; Hennen et al., 1982, 2005; Kern et al., 1933; Lindquist, 1982; Mendes et al., 1998; Pardo Cardona, 1994, 1998; Salazar-Yepes & Buriticá 2002; Salazar-Yepes et al., 2002).

Additional specimens examined. ARGENTINA, SALTA: Pampa Grande. On *Phrygilanthus acutifolius*, [III] (PUR F16916); MEXICO: Lepic. On *Psittacanthus americanus*, 18 November 1971, *Cummins 71-491* [III] (PUR 64318); Nayarit. On *Psittacanthus* sp., 14 December 1970, *Cummins 70-271* [III] (PUR 63711); GUATEMALA, BARCENA: On *Psittacanthus* sp., April 1942, *Müller 112* [I, III] (PUR 51132); BRAZIL, RÍO DE JANEIRO: On *Struthanthus complexus* January 1896, *Ule 2123* [III] (PUR F2699); COLOMBIA, EL VALLE: Meléndes, Hacieda Las Palmas. On *Phoradendron* sp., I April 1938, *C. Garces 48* [III] (PUR F 9483); HONDURAS: Escuela Agrícola Panamericana. On *Psittacanthus calyculatus*, 12 January 1951, *Müller 444* [III] (PUR 52982).

Remarks. *Uromyces urbanianus* differs from *U. circumscriptus* by having verrucose-striate teliospores instead of reticulate-striate teliospores as in *U. circumscriptus*. In addition to this, the teliospores of *U. urbanianus* are longer than those of *U. circumscriptus*. *Uromyces urbanianus* is morphologically close to *U. evastigatus* because of similarly sized teliospores. However, teliospores in *U. urbanianus* are finely and densely verrucose instead of reticulate as in *U. evastigatus* and teliospore pedicels are smaller in *U. urbanianus*.

Key to species of *Uromyces* on Loranthaceae

Surface of teliospores longitudinally striate or rugose striate
Pedicels of teliospores with lower part strongly transversely rugose
Teliospores 35-39 µm long……*Uromyces ornatipes*
Pedicels of teliospores completely smooth
Teliospores 47-50 µm long…..……*Uromyces euphlebius*
Teliospores 34-42 µm long……..……..*Uromyces socius*
Surface of teliospores smooth, smooth to finely-densely verrucose, reticulate, finely and densely verrucose, or reticulate-striate. Species with uredinia
Urediniospores echinulate……..*Uromyces loranthi*
Urediniospores longitudinally ridged to striate…*Uromyces phthirusae*
Species without known uredinia
Teliospores mostly less than 40 µm long
Teliospores ellipsoidal, reticulate-striate, 36-41 x 19-23 µm….*Uromyces circumscriptus*
Teliospores oblong-ellipsoidal, reticulate, 25-29 x 16-18 µm…..*Uromyces bahiensis*
Teliospores mostly more than 40 µm long
Teliospores verrucose-striate, 39-45 x 21-24 µm……...*Uromyces urbanianus*
Teliospores reticulate, 41-48 x 20-24 µm……...*Uromyces evastigatus*
Teliospores reticulate-foveate, 42-47 x 23-26 µm…..... *Uromyces struthanthi*
Teliospores smooth, 30-45 x 21-30 µm…...….*Uromyces nilagiricus*

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