

## *Uromyces* rusts on Cucurbitaceae

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The systematic survey aimed to update, annotate and consolidate currently accepted and described species of *Uromyces* rusts on Cucurbitaceae. Ten valid *Uromyces* species were analyzed, amplified and augmented based on literature data, comprising *Uromyces anguriae*, *U. corallocarpi*, *U. guraniae*, *U. neotropicalis*, *U. novissimus*, *U. poliotelis*, *U. ratoides*, *U. ratus*, *U. reynoldsii*, and *U. yakushimensis*. Descriptions and phylogeographic information are provided together with a diagnostic key to species. Their morphology, taxonomy, geobotany, phylogeny, potential molecular tools and trophic associations are also discussed.

Keywords: biotrophs, cucurbits, morphology, neotropics, systematics, Pucciniales, Uredinales.

This paper presents *Uromyces* species occurring on the plant family Cucurbitaceae. *Uromyces novissimus* Speg. (Anamorph: *Uredo novissima* Speg.) was first reported on cucurbits from Argentina, followed decades later by *U. anguriae* H.S. Jacks. & Holw., *U. cajaponiae* Henn., *U. corallocarpi* W.T. Dale, *U. guraniae* Mayor, *U. hellerianus* Arthur, *U. melothriae* Henn., *U. neotropicalis* J.R. Hern. & Aime, *U. pentastratus* Viégas, *U. poliotelis* Syd. & P. Syd., *U. ratoides* Jørst., *U. ratus* H.S. Jacks. & Holw., *U. reynoldsii* Thaung, *U. umiamensis* R. Berndt & P. Baiswar, *U. yakushimensis* Hirats. f. & Katsuki and several other hitherto unidentified *Uromyces* species especially from the Caribbeans.

There were some nomenclatural issues. *U. hellerianus* and *U. pentastratus* were synonymized with *U. novissimus* on account of morphology (Jørstad 1956, Monoson & Rogers 1978) while *U. appelianus* Gassner and *U. cissampelidis* Dietel were likewise synonymized through correction of host identification (Hennen & Figueiredo 1981, Hennen & McCain 1993). *U. cajaponiae* and *U. melothriae* were originally described with teliospores as well as urediniospores (Hennings 1893, 1896). However, subsequent investigations found urediniospores only on the type specimens (Sydow & Sydow 1908, 1910). Both are therefore anamorphs with illegitimate names of teleomorphs. *U. cajaponiae* is

now regarded as anamorph of *Uromyces novissimus* (Carvalho *et al.* 2006, Spegazzini 1925) and *U. melothriae* is recombined to *Uredo melothriae* (Henn.) Berndt.

The objective of the study was to contribute to a better understanding of their morphology, taxonomy and mycogeography. It also aimed to update, annotate, and integrate their diversity and distribution based on literature data in order to generate composite descriptions and diagnostic keys to valid species. The data on hitherto known cucurbitaculous *Uromyces* species are obtained from sources herein cited, containing USDA A.R.S. fungal database (<http://nt.ars-grin.gov/fungaldatabases/fungushost/fungushost.cfm>).

### Taxonomy

***Uromyces anguriae*** H. S. Jacks. & Holw., *Mycologia* 24: 101, 1932. – *Mycologia* 70: 1146, 1148-1149, 1978 (Fig. 5).

Spermogonia and aecia unknown. – Uredinia on lower surfaces of leaves, scattered or aggregated, small, suborbicular, pulverulent, dehiscent, 0.2–1 mm diam, cinnamon brown. – Urediniospores obovoid to ellipsoid, (18) 25–38 × 18–30 µm, cinnamon brown, wall 1.5–2.5 µm thick, pores 2, subequatorial, with minute, sparse echinulations. – T e l i a hypophyllous, scattered or aggregated, compact, suborbicular, 0.2–0.5 mm diam, erumpent, dark brown. – T e l i o s p o r e s subglobose or broadly ellipsoid, (24) 35–43 × (24) 28–38 µm, round below, but also obtuse or acute above, brown, wall 2.5–4 µm thick, bilaminate, apparently smooth, apex umbonate, (6) 7–8 (12) µm long, pore at the cell apex. – P e d i c e l s hyaline, short, deciduous (Jackson 1932, Monoson & Rogers 1978).

Etymology. – This species is named after the host plant (*Anguria warmingiana* Cogn.).

Host plants. – *Anguria warmingiana* Cogn., *Gurania pycnocephala* Harms, *G. pyrrhocephala* Harms, *Wilbrandia verticillata* Cogn.

Distribution. – Brazil.

Material reported. – ***Uromyces anguriae*** H. S. Jacks. & Holw.: BRAZIL, Rio de Janeiro, Paineiras, on leaves of *Anguria warmingiana* Cogn. (Cucurbitaceae), 17 Aug 1921, *leg.* E.W.D. & M.M. Holway, *det.* H.S. Jackson (MIN 1045); BRAZIL, Rio de Janeiro, Petropolis, on leaves of *Anguria warmingiana* Cogn. (Cucurbitaceae), 29 Dec 1921, *leg.* E.W.D. & M.M. Holway, *det.* H.S. Jackson (PUR F3606 holotype, MIN 1432 type, BPI 000719 type, NY 31622 isotype, DAOM 79192 (*Holway* 1432 isotype)).

***Uromyces corallocarpi*** W.T. Dale, *Mycol. Pap.* 59: 9–10, 1955 (Fig. 10.) – *Mycologia* 70: 1144-1148, 1978 (Fig. 3).

Spermogonia and aecia unknown. – Uredinia amphigenous, scattered, round, 0.2–0.6 mm diam, pulverulent, dark cinnamon brown. – Urediniospores globose to obovoid, (22) 30–38 (43) × (23)

30–35 (40)  $\mu\text{m}$ , light brown to brown, wall 1.5–2.5  $\mu\text{m}$  thick, finely verrucose, pores 2, equatorial. – Telia similar to uredinia. – Teliospores ovoid to ellipsoid, (23) 30–38 (43)  $\times$  (23) 30–38 (42)  $\mu\text{m}$ , brown, wall (2.5) 4–7  $\mu\text{m}$  thick, bilaminated, apex rounded or obtuse to umbo, 2.5–5  $\mu\text{m}$  long, finely verrucose rugose, pore at apex. – Pedicel hyaline, delicate, up to 43  $\mu\text{m}$  long (Dale 1955, Monoson & Rogers 1978).

Etymology. – This species is named after the host plant *Corallocarpus emetocatharticus* (Grosourdy) Cogn.

Host plants. – *Corallocarpus emetocatharticus* (Grosourdy) Cogn., Cucurbitaceae species, *Doyerea emetocathartica* Grosourdy.

Distribution. – Mexico, Trinidad and Tobago, West Indies.

Material reported. – *Uromyces corallocarpi* W.T. Dale: BRITISH WEST INDIES, Gasparee Island, on leaves of *Corallocarpus emetocatharticus* (Gros.) Cogn. (Cucurbitaceae), 31 Dec 1945, *leg. et det.* W.T. Dale (TRIN Dale 788 type, BPI 843331 type, PUR F11659 isotype, IMI 32183 holotype).

*Uromyces guraniae* Mayor, Mém. Soc. neuchât. de Sc. Nat. 5: 466, 1913. – Mycologia 25: 492, 1933.

Spermogonia, aecia and uredinia unknown. – Telia hypophyllous, not in spots, scattered or gregarious and slightly coalescing, light brown, round, 1–1.5 mm in diam, soon becoming erumpent, pulverulent. – Teliospores globose or ovoid, rounded at both ends or occasionally little acute at the apex, 16–22  $\times$  15–19  $\mu\text{m}$ , light brown, wall 2–2.5  $\mu\text{m}$  thick, apex up to 7  $\mu\text{m}$  thick and often obscure, smooth, pore at the apex. – Pedicel hyaline, up to 70  $\mu\text{m}$  long, 3–5  $\mu\text{m}$  thick, persistent (Mayor 1913). – Urediniospores are found intermixed in sori with the teliospores, however. A few sori look as if they were uredinia with teliospores developing in them. – Urediniospores broadly ellipsoid or globoid, 19–26  $\times$  15–19  $\mu\text{m}$ , wall yellowish or pale cinnamon brown, 1–1.5  $\mu\text{m}$  thick, moderately echinulate, pores 2, equatorial; not a lepto *Uromyces* (Kern *et al.* 1933).

Etymology. – This species is named after the host plant (*Gurania* sp.).

Host plant. – *Gurania* sp.

Distribution. – Colombia.

Material reported. – *Uromyces guraniae* Mayor: COLOMBIA, Andes Centralis, Antioquia Department, Chemin entero la Bord du Cauca & Valpariso, alt. 900 m, on leaves of *Gurania* sp. (Cucurbitaceae), 26 Sep 1910, *leg. et det.* Eug. Mayor (Mayor 324 = BPI 846404, PDD 8852); COLOMBIA, Andes centrales, dép Antioquia. Cemin entre Filadelfia et Neira, alt. 1700 m, on leaves of *Gurania* sp. (Cucurbitaceae), 1 Oct 1910, *leg. et det.* Eug. Mayor (NEU 319 type?).

*Uromyces neotropicalis* J. R. Hern. & Aime, Sydowia 57(2): 214–216, 2005 (Figs. 15–20).

Spermogonia and aecia unknown. – Uredinia hypophyllous inside chlorotic spots, cinnamon brown, 1–3  $\mu\text{m}$  wide, apara-

physate. – Urediniospores globose, 21.5–29 × 21.5–29 µm, dark cinnamon brown, wall 2.5–3 µm thick, strongly echinulate; pores 2, equatorial. – Teli a similar to uredinia, lighter in color. – Teli ospores globose to oblong, 19–26.5 × 16.5–20 µm, yellowish to cinnamon brown, walls smooth, 1 µm thick, apex smooth, umbonate, (1) 2.5–3 µm thick. – Pedicel hyaline, 10–20 µm long, 5–9 µm wide, persistent (Hernández *et al.* 2005).

Etymology. – This species is named based on its neotropical distribution.

Host plants. – *Cayaponia selysioides* C. Jeffrey, Cucurbitaceae species.

Distribution. – Ecuador, Guyana.

Material reported. – *Uromyces neotropicalis* J. R. Hern. & Aime: GUY-ANA, Pakaraima Mountains, Grandmother's Creek, on leaves of undetermined Cucurbitaceae sp., 4 Jul 2003, *leg. et det.* J.R. Hernández (J.R. Hernández 2003 – 112 = BPI 863950, II–III, holotype).

*Uromyces novissimus* Speg., Fungi Argentini 3: no. 35, 1880. – An. Soc. Cient. Argent. 10: 134, 1880. – Mycologia 70: 1145–47, 1978 (Fig. 2). – *Caldasia* 26 (1): 83, 2004. – *Hoehnea* 33: 326–327, 2006 (Figs. 19–21).

Synonyms. – *Uromyces cissampelidis* Dietel, Bull. Torrey Bot. Club 26: 632, 1899, *U. hellerianus* Arthur, Bull. Torrey Bot. Club 31: 2, 1904, *U. appelianus* Gäsner, Ver. Deutsch. Bot. Ges. 40: 64–68, 1922 (Fig. 3), *U. pentastriatus* Viégas, Bragantia 5: 70, 1945. – Mycologia 70: 1146, 1978 (Fig. 1), *U. umiamensis* R. Berndt & P. Baiswar (= ?teleomorphic *Aecidium momordicae* Juel from Brazil), Mycological Progress 8: 83–86, 2009 (Figs. 1 – 2).

Anamorph. – *Uredo novissima* Speg., Anal. Mus. Nac. Buenos Aires 6: 235, 1898, *Uromyces cajaponiae* Henn., Hedwigia 35 (4): 226, 1896. – Ann. Mycol. 6: 136–137, 1908. – Revista Argent. Bot. 1: 93–145, 1925. – *Hoehnea* 33: 326–327, 2006.

Spermogonia and aecia unknown except when demicyclic. – Uredinia hypophyllous or caulicolous, in spots, scattered, minute, round, 0.2–0.5 mm diam, pulverulent, pale cinnamon brown, causing hypertrophy and tumors up to 20 cm in diam. – Urediniospores globose to pyriform or obovoid, (20) 23–33 (43) × (18) 28–30 (35) µm, cinnamon yellow to light brown, wall 2.5–5 µm thick, echinulate, pores 2, subequatorial. – Pedicels deciduous. – Teli a hypophyllous, red to chestnut brown, similar to uredinia. – Teli ospores globose, ovoid or ovoid elongate to ellipsoid, slightly curved, size variable from 27–34 × 19–23 µm through 28–35 (50) × (20) 25–30 µm to (31) 36 (42) × (23) 26 (29) µm, cinnamon brown, wall smooth to striate verrucose, (2.2) 2.5–3.4 µm, apex broadly umbonate to generally papillate, (5) 8.8–13 µm in length, hyaline, pore at apex. – Pedicels cylindrical, hyaline, deciduous, 30–50 µm long, 6.2–8.5 µm wide near hilum, persistent, 12–92 µm long (Viégas 1945, Monoson & Rogers 1978, Salazar & Buriticá 2004, Hernández *et al.* 2005, Carvalho Júnior *et al.* 2006).

Etymology. – This species is named for being new, novel, recent or rare.

Host plants. – *Abobra tenuifolia* Naudin, *Cayaponia americana* Cogn., *C. attenuata* Cogn., *C. bonariensis* (Mill.) Mart. Crov., *C. citrullifolia* Cogn. ex Griseb, *C. ficifolia* Cogn., *C. latifolia* Cogn., *C. martiana* Cogn., *C. racemosa* Cogn., *C. racemosa* var. *scaberrima* Cogn., *Cayaponia* sp., *C. tayuya* Cogn., Cucurbitaceae, *Cucurbitella cucumifolia* Cogn., *Fevillea cordifolia* L., *Melothria fluminensis* Gardner, *M. guadalupensis* Cogn., *M. pendula* L., *M. scabra* Naudin, *Melothria* sp., *Momordica cochinchinensis* Spreng., *Momordica* sp., *Pittiera longipedunculata* Cogn., *Rytidostylis* sp., *Trianosperma ficifolia* Cogn. (= *Cayaponia ficifolia* Cogn.), *Trianosperma* sp.

Distribution. – Argentina, Barbados, Brazil, Colombia, Costa Rica, Cuba, Ecuador, Grenada, Guatemala, India, Mexico, Panama, Puerto Rico, USA (Florida), Venezuela, Virgin Islands, West Indies.

Material reported. – ***Uromyces novissimus*** Speg.: ARGENTINA, Boca del Riachuelo, São José das Flores, on leaves of *Trianosperma ficifolia* Mart. (= *Cayaponia ficifolia* (Lam.) Cogn.) (Cucurbitaceae), May 1880, leg. et det. C.L. Spegazzini (Spegazzini, s. n., PUR F3605 isotype?, IMI 56164 isotype?, DAOM 54708 (= Speg., Dec. Myc. Arg. 18 [authentic]). ***U. cissampelidis*** Dietel: COLÔMBIA, Santa Marta near Bonda, on leaves of an indeterminate Cucurbitaceae sp., 21 Nov 1898 and 00 Dec 1898, leg. C.F. Baker, det. P. Dietel (*Baker* 83 = BPI 843328 type, NY 46091 type). ***U. hellerianus*** Arthur: PORTO RICO, along Adjunta Road, 5–8 milhas de Ponce, on leaves of *Cayaponia racemosa* (Mill.) Cogn. (Cucurbitaceae), 4 Dec 1902, leg. A.A. Heller, det. J.C. Arthur (*Heller* P.R. 6206 = NY 46198 -NY 46199 isotypes). ***U. appelianus*** Gassner: URUGUAY and BRAZIL, on leaves and stems of *Cayaponia* sp. (Cucurbitaceae), s.d., s.col., s.n. ***U. pentastriatus*** Viégas: BRAZIL, Santa Catarina, Estação Experimental de Trigo, Rio Caçador, on leaves of *Trianosperma* sp. (Cucurbitaceae), 18 May 1941 (*Deslandes*, s.n.). ***U. umiamensis*** R. Berndt & P. Baiswar (demicyclic): INDIA, Meghalaya State, Barapani, Umiam village, on leaves of *Momordica cochinchinensis* Spreng. (Cucurbitaceae), s.d. 2007, leg. P. Baiswar, det. R. Berndt and P. Baiswar (IMI 396239 holotype).

***Uredo novissima*** Speg.: ARGENTINA, Boca del Riachuelo, São José das Flores, on leaves of *Trianosperma ficifolia* Mart. (= *Cayaponia ficifolia* (Lam.) Cogn.) (Cucurbitaceae), a lectotype needs to be selected from the examined materials collected by Spegazzini. ***Uromyces cajaponiae*** Henn.: BRASIL, Santa Catarina: São Francisco, on leaves of *Cayaponia* sp. (Cucurbitaceae), Jan 1885, leg. E. Ule, det. P. Hennings (*Ule* 302 = BPI 002235 type?).

***Uromyces poliotelis*** Syd. & P. Syd., Ann. Mycol. 23 (3–6): 313, 1925. – Mycologia 70: 1146/1148, 1978 (Fig. 4).

Spots almost none of their own or pale, yellow-green, on upper sides of leaves, indeterminate. – Spermogonia present and appearing as small black structures on the lower leaf surface. – Uredinoid aecia on undersides of leaves, scattered or aggregated, minute, soon erumpent, pulverulent, yellow to reddish brown. – Urediniospores globose, subglobose, obovoid, or triangular, (24) 30–40 × (22) 28–38 µm, light brown, wall 1–1.5 (2.5) µm thick, pores 2, equatorial, moderately echinulate. – Telia hypophyllous, scattered, compact, minute, light brown, soon ash-colored due to germination. – Teliospores ovoid, oblong to lanceolate oblong, mostly round at the top, attenuate to-

wards the base, (32) 35–50 × (18) 25–33 µm, very pale brown, wall 1–2.5 µm thick, bilaminate, apex broadly umbonate, smooth, 2–3 µm thick, pore at the cell apex, germinating at once. – Pedicel hyaline, persistent, up to 90 µm long (Sydow 1925, Monoson & Rogers 1978).

**Etymology.** – This species is named probably for its wall condition being smooth.

**Host plants.** – *Anguria* (or *Gurania*) sp.

**Distribution.** – Costa Rica.

**Material reported.** – *Uromyces poliotelis* Syd. & P. Syd.: COSTA RICA, Mt. Poas near Grecia, on leaves of *Anguria* (*Gurania*?) sp. (Cucurbitaceae), 15 Jan 1925, *leg. et det.* H. Sydow (NY 47365 isotype, PUR 64931 isotype?, IMI 56155 isotype?).

***Uromyces ratooides*** Jørst, Ark. Bot. 3 (14): 479, 1956.

*Spermogonia* epiphyllous, up to 160 µm wide; aecia not known. – *Uredinia* amphigenous, surrounding *spermogonia*, in roundish groups, up to about 2.5 mm in width, coalescing, pale cinnamon brown. – *Urediniospores* ellipsoid, obovate or triangular, 26–36 × 23–30 µm, wall cinnamon brown, 1–1.5 µm thick, prominently and sparsely echinulate, pores 2, subequatorial. – *Teliospores* seldom intermixed in *uredinia*, fusiform or ellipsoid, 39–80 × 16–33 µm, wall pale brown, 1–1.5 µm thick, apex enlarged up to 10 µm by means of papilla, smooth. – Pedicel up to 70 µm long (Jørstad 1956).

**Etymology.** – This species is named to indicate close alliance with *U. ratus*.

**Host plant.** – *Cayaponia* sp., Cucurbitaceae.

**Distribution.** – Ecuador, Venezuela.

**Material reported.** – *Uromyces ratooides* Jørst: ECUADOR, on leaves of *Cayaponia* sp.? (Cucurbitaceae), *s.d.*, *leg.* G. Lagerheim, *det.* Ivar Jørstad (S – F35681 (0 + II + III) type/holotype); ECUADOR, Prov. Pichincha, San Jorge, on leaves of a Cucurbitaceae sp., *s.d.*, *leg.* G. Lagerheim, *det.* Ivar Jørstad (S – F35680 (0 + II) paratype?).

***Uromyces ratus*** H. S. Jacks. & Holw., Mycologia 24: 102, 1932. – Mycologia 70: 1146, 1149–1150, 1978 (Fig. 6).

*Spermogonia* amphigenous, punctiform, subepidermal, sparse, dark brown, ellipsoid, 90–105 µm wide. – *Uredinoid* aecia on both sides of leaves, scattered or aggregated, pulverulent, dehiscent, small, 0.3–0.8 mm diam, light brown. – *Urediniospores* obovoid to ellipsoid, frequently triangular, 27–32 × 22–27 or 30–38 × (22) 28–30 µm, light brown, wall 2.0–2.5 µm thick, prominently echinulated, pores 2, equatorial or barely subequatorial. – *Telia* hypophyllous, compact, pulverulent, dehiscent, chestnut brown. – *Teliospores* subglobose to ellipsoid, 27–38 × 24–27 or (24) 30–40 × 28–33 µm, round below and obtuse above, light brown, wall 2.5 µm thick, bilaminate, apex broadly umbonate, smooth, pore very prominent and extending to the central

border of spore. – Pedicels hyaline, twice the spore or shorter or 13–63 µm long, persistent (Jackson 1932, Monson & Rogers 1978).

Etymology. – This species is named for it being uncommon.

Host plants. – *Cayaponia pentaphylla* Cogn., *C. racemosa* Cogn., *C. ternata* Cogn.

Distribution. – Brazil

Material reported. – *Uromyces ratus* H. S. Jacks. & Holw.: BRAZIL, Petropolis, Rio de Janeiro, on leaves of *Cayaponia ternata* Cogn. (Cucurbitaceae), 27 Oct 1921, leg. E.W.D. and M.M. Holway, det. E.W.D. Holway and H.S. Jackson (BPI 844343 type, 844344 type, MIN-1251 type, PUR F3601 holotype?, Holway 1251 isotype).

*Uromyces reynoldsii* Thaug, Australas. Mycol. 28: 43–44, 2009 (Figs. 1–3).

Spermogonia and aecia unknown. – Uredinia and telia amphigenous, mixed, scattered or loosely grouped on slightly chlorotic areas, irregularly oblong or more or less broadly ellipsoid, up to 0.5 mm long, brown to black, becoming erumpent. – Urediniospores (27.5) 30–37.5 (40) × (22.5) 25–30 (35) µm, subglobose to globose or broadly ellipsoid, wall up to 3.5 µm thick, pale yellow, strongly but sparsely echinulate, spines hyaline, 2–2.5 µm high, 4–5 µm apart, germ pores ± 2, obscure, subequatorial to more or less towards the base, pedicel fragile, deciduous, sometimes persistent, and hilum truncate, up to 10 µm wide. – Teliospores (25) 30–40 (47.5) × (20) 25–30 (35) µm, subglobose to broadly ellipsoid, wall 3–5 (7.5) µm thick, smooth, brown, papilla (2.5) 4–7.5 (12.5) × 10–12.5 µm, at the apex, germ pore 1, at apex. – Pedicel 12.5–47.5 × 6–9 µm, attenuate, hyaline (Thaug 2009).

Etymology. – This species is named after Research Botanist Dr. Don R. Reynolds.

Host plants. – *Trichosanthes palmata* Roxb. (= *Trichosanthes bracteata* (Lamb.) Voigt. = *T. pubera* Blume = *T. tricuspidata* Lour.).

Distribution. – Burma

Material examined. – *Uromyces reynoldsii* Thaug: BURMA, Sagaing, on leaves of *Trichosanthes palmata* Roxb. (Cucurbitaceae), 26 Dec 1977, leg. et det. Maung Mya Thaug (LAM (= UC) 220446–II–III–holotypus, PDD 56248–II–III–isotypus); BURMA, Mandalay, on leaves of *Trichosanthes palmata* Roxb. (Cucurbitaceae), 4 Dec 1925, leg. U. Thet Su, det. Maung Mya Thaug (IMI 79768–II–III–paratypus).

*Uromyces yakushimensis* Hirats. f. & Katsuki, J. Jap. Bot. 27 (4): 55, 1952. – Mem. Fac. Agric. Tokyo. Univ. Educ. 1: 53, 1952. – Rep. Tottori Mycol. Inst. 10: 1–98, 1973.

Spermogonia and aecia unknown. – Uredinia not seen. – Urediniospores ellipsoid, obovate or subglobose, 30–36 × 24–30 µm, yellow brown, wall 1–1.5 µm thick, finely echinulate. – Telia am-

phigenous, mostly epiphyllous, scattered or in loose clusters, minute, pulverulent, dark brown or dark. – Teliospores subglobose, ovoid or pyriform, 36–51 × 27–33 μm, chestnut-brown, walls smooth, thick towards the base, apex papillate, subhyaline, up to 7 μm thick. – Pedicel hyaline, short, persistent (Hiratsuka 1952).

**Etymology.** – This species is named after Yakushima prefecture in Japan.

**Host plant.** – *Trichosanthes multiloba* Miq.

**Distribution.** – Japan

**Material reported.** – *Uromyces yakushimensis* Hirats. f. & Katsuki: JAPAN, Kiushu, Prov. Osumi, Yakushima, on leaves of *Trichosanthes multiloba* Miq. (= *T. bracteata* (Lamb.) Voigt = *T. palmata* Roxb.) (Cucurbitaceae), 13 Oct 1949, leg. S. Katsuki, det. N. Hiratsuka (S. Katsuki II + III, s.n.; H- 89070, type!).

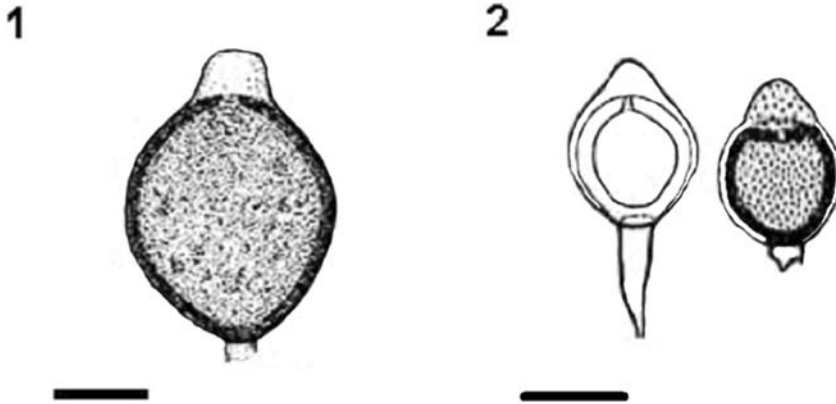
### Key to species

1. Teliospore wall usually smooth ..... 2
- 1\*. Teliospore wall verrucose ..... 5
2. Teliospore apex round/umbonate (Fig. 2.) ..... 3
- 2\*. Teliospore apex acute/papillate (Fig. 1.) ..... 4
3. Teliospore apex 2.5 μm thick, broadly umbonate ..... *U. poliotelis*
- 3\*. Teliospore apex ≤ 3.0 μm thick, umbonate ..... *U. neotropicalis*
- 3<sup>a</sup>. Teliospore apex 6–12 μm thick, umbonate, pore apical *U. anguriae*
- 3<sup>b</sup>. Teliospore apex 6–12 μm thick, broadly umbonate, pore apical to central ..... *U. ratus*
4. Teliospore apex 4–7 μm thick, acute to tapering ..... *U. guraniae*
- 4\*. Teliospore apex ≤ 7 μm thick, teliospore subglobose, ovoid or pyriform ..... *U. yakushimensis*
- 4<sup>a</sup>. Teliospore apex 5–8 (13) μm thick, occasionally striate verrucose ..... *U. novissimus*
- 4<sup>b</sup>. Teliospore apex 10 μm thick, teliospore fusiform to ellipsoid ..... *U. ratoides*
- 4<sup>c</sup>. Teliospore apex ≤ 12.5 μm thick, teliospore subglobose to broadly ellipsoid ..... *U. reynoldsii*
5. Teliospore apex 2.5–5 μm thick, round, verrucose rugose ..... *U. corallocarpi*

### Discussion

This study observes that teliospore and urediniospore morphologies were utilized to characterize teleomorphs (III) and anamorphs (II) respectively or together (II, III) to differentiate taxa based on anamorphs (II) where their teleomorphs (III) are not easily distinguishable per se. Examples of the latter are: *U. hellerianus* vs *U. novissimus* (Arthur 1904), *U. anguriae* vs *U. novissimus* and *U. ratus* vs *U. novissimus* (Jackson 1932, Jørstad 1956, Monoson & Rogers 1978).





**Fig. 1, 2.** – Papillate teliospore (illustration of a papilla after Gassner 1922). Bar = 15  $\mu\text{m}$ . 2. Umbonate teliospore (illustration of an umbo after Dale 1955). Bar = 30  $\mu\text{m}$ .

The morphological characterization is generally subjective since it is largely a matter of interpretation or taste of terminology as, for instance, intergradation or progression of a condition. The teliospore wall condition is interpreted equivocally as corrugation or echinulation in *U. anguriae* and *U. novissimus* (Carvalho *et al.* 2006, Jackson 1932, Monoson & Rogers 1978, Thurston 1940). Similarly, the contour of a teliospore apex can intergrade from papilla (Fig. 1) to umbo (Fig. 2) or vice versa as demonstrated by *U. novissimus* from Colombia (Salazar & Buritica 2004) and Brazil (Carvalho *et al.* 2006).

A close morphological relationship exists where differences were mentioned though without much distinctions between *U. poliotelis* and *U. anguriae/U. ratus* (Jackson 1932, Monoson & Rogers 1978); *U. anguriae* and *U. novissimus* (Jørstad 1956), *U. ratoides* and *U. ratus* (Jørstad 1956); *U. ratus* and *U. novissimus* (Jackson 1932); *U. corallocarpi* and *U. anguriae/U. hellerianus* (Dale 1955); and *U. guraniae* and *U. neotropicalis* (Hernandez *et al.* 2005). In light of host identity and locality, spore morphology and measurement, *U. umiamensis* reported from paleotropic in India on *Momordica* (Berndt & Baiswar 2009) is tentatively disposed here as a synonym of widely distributed and broadly circumscribed *U. novissimus* from neotropic in Brazil despite some insignificant disparities between them. But nevertheless, these morphologic dissimilarities indicate their genetic variability or polymorphism that most likely develops over the years through dynamic trilateral interactions involving *Uromyces* biotrophs, cucurbit substrates and their New World environment.

All in all, cucurbitaculous *Uromyces* species except probably *U. guraniae* and *U. ratoides* fall within the range of spore parameters for *U. novissimus*. Being thus a virtual common denominator and the first recorded *Uromyces* rust on cucurbits, *U. novissimus (sensu lato)* could

readily accommodate *U. ratooides* as well although the latter skews from ellipsoid to fusiform in shape, and thereby stretches much longer in size, of teliospore. On the evidence of close morphological relationships and frequent associations, host range, demographic dominance and geographic distribution, the biotrophic *U. novissimus* could also arguably lay claim to being a “seminal” taxon from which other cucurbitaceous *Uromyces* taxa later originate or emanate and proliferate as diverse species.

These *Uromyces* rusts are autoecious, basically macrocyclic though seldom demicyclic as in *U. umiamensis* and biotrophic. They totaled 10 in all out of which eight occur in the New World on a wide range of some 15 genera, and two in the Old World on one genus while one of the eight appears in both New and Old World on a common genus, *Momordica*, in the host family *Cucurbitaceae*. Their diversity and distribution thus differ with mycogeography, and also display a gamut of fungus-host association patterns from one biotroph on a single host genus to another on several host genera in trophic interaction. Illustrations are: *Uromyces anguriae*, *U. guraniae* and *U. poliotelis* on one host genus *Gurania* (= *Anguria*) and *U. neotropicalis*, *U. ratooides* and *U. ratus* on *Cayaponia* in South America, and *U. novissimus* on eight other cucurbit host genera throughout the New World. *Uromyces reynoldsi* and *U. yakushimensis* appear only on *Trichosanthes* in the Old World (Hiratsuka 1952, 1973; Thaung 2009). *Uredo melothriae* (= *Uromyces melothriae*) was seen on *Melothria* in Africa (Hennings 1893) and *Aecidium* species whose connections with cucurbit *Uromyces* are so far not yet proven, were perceived on *Momordica* cucurbits in Brazil (Saccardo 1899) as *Aecidium momordicae* Juel and in Africa as *A. charantiae* Mayor & Vienn.-Bourg. (Eboh 1981, Mayor & Viennot-bourgin 1951). No host specificity or selectivity was seen, however.

They are evidently and remarkably diversified and distributed more in the neotropics than in the paleotropics on *Cucurbitaceae*. This disparity could be attributed to a difference in the range, variety, and availability in the local flora of the host plants between the two tropics as well as a parallel development of polymorphism in the rust fungus itself in the course of its biotrophic interactions with a wide array of cucurbit host plants.

As far as ascertainable, phylogenetic investigations have not yet been made of these fungi, although molecular techniques are available for studies of *Uromyces* rusts (Braithwaite *et al.* 1991, Pastor-Corrales *et al.* 2004). Hence, whether they are monophyletic or polyphyletic is not clear. Molecular methods can also help provide a more accurate taxonomic placement for them. In general, species differentiation or delimitation could be made using polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP) and sequence analysis of the internal transcribed spacer region (ITS1–5.8S–ITS2) of the ribosomal DNA (rDNA). Interspecific comparisons are available for

information on phylogenetic relationships through sequence analysis of highly conserved rDNA transcription units (18S + 28S) or alternative assays (Thaug 2008). Intraspecific differentiation, group classification, sub-speciation or varieties based on genetic variability should be allowed following the PCR of random amplified polymorphic DNA (RAPD). Sequencing of multi loci based on rDNA-nucleotide sequence or Multi-locus DNA fingerprint [detected as RFLP of mitochondrial DNA (mtDNA)] furnishes an additional, taxonomic tool for both unambiguous characterization and sub-speciation.

Spore shape being more often a useful morphological trait and a reliable indicator of phylogenetic associations (Du *et al.* 2005), frequently unreliable characters of rusts like pedicel, wall color and condition, spore size, and host preference may be considered as secondaries in importance in phylogenetic assays. Consequently, teliospore shape should be the only major parameter or criterion for such investigation.

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