Mycoscience 39: 343–346, 1998

Short Communication

Uredo maua, sp. nov., and *Uromyces tairae*: Additions to the rust flora of Hawai'i

Donald E. Gardner[1] and Timothy W. Flynn[2]

[1] Pacific Island Ecosystems Research Center, Biological Resources Division, U. S. Geological Survey, Department of Botany, University of Hawai'i at Manoa, Honolulu, Hawai'i 96822, USA
[2] National Tropical Botanical Garden, Lawa'i, Kaua'i, Hawai'i 96765, USA

Accepted for publication 20 June 1998

***Uredo maua*, on *Xylosma hawaiiense* (Flacourtiaceae), an endemic tree of Hawaiian forests, is newly described as an addition to Hawai'i's native rust flora. *Uredo wakensis*, originally described from Wake Island and reported from other Pacific islands on *Tournefortia argentea* (Boraginaceae), represents the uredinial state of *Uromyces tairae*, described from Okinawa. This rust is newly reported from Hawai'i.**

Key Words——Hawaiian rust fungi; *Tournefortia*; *Uredo wakensis*; *Xylosma*.

Uredo maua The family Flacourtiaceae is represented in Hawai'i by *Xylosma*, a genus of about 100 species that occur in all the tropical regions of the world except Africa. The two Hawaiian species of *Xylosma* are thought to have Indo-Pacific affinities (Fosberg, 1948) but occur as endemic species in Hawai'i. *Xylosma hawaiiense* Seem. is a small tree that is widely distributed but not common, and occurs primarily in mesic forest but also in dry and wet forest habitats at 250–1,220 m elevation on most of the main islands. *Xylosma crenatum* St. John is rare and limited in distribution to particular upper elevation sites on the island of Kaua'i (Wagner et al., 1990).

In recent observations of trees in the South Kona District of the Island of Hawai'i, we found a few leaves of *X. hawaiiense* to be infected with the uredinial state of a rust fungus. No rust has been previously reported on *Xylosma* in Hawai'i.

Uredo maua Gardner & Flynn, sp. nov. Figs. 1, 2

Uredinia hypophylla, dispersa, minuta, 0.2–0.3(–0.5) mm, armeniaca ubi viva, subepidermalia, epidermide rupta prominente. Urediniospora globosa ad late ellipsoidea, 14–17(–20) × 14–22(–24) μm, contento flavo. Paries sine colore, manifeste echinulatus, 2–3 μm crassus. Paraphyses clavata, ad apicem 8–15 μm lata, pariete aeque crasso, circa 2 μm, vel parum crassiore ad apicem. In foliis *Xylosmatis hawaiiensis* parasitus est.

Uredinia hypophyllous, scattered, minute, 0.2–0.3 (–0.5) mm, orange-yellow when fresh, subepidermal, with ruptured epidermis prominent. Urediniospores globoid to broadly ellipsoid, 14–17(–20) × 14–22(–24) μm, with yellow contents. Wall colorless, prominently echinulate, 2–3 μm thick. Paraphyses clavate, 8–15 μm wide at apex, with wall uniformly thick, approximately 2 μm, or slightly thicker at apex.

Habitat: parasitic on leaves of *Xylosma hawaiiense* Seem., in native forest, 1,066–1,097 m elevation, South Kona District, Island of Hawai'i, Hawai'i, USA.

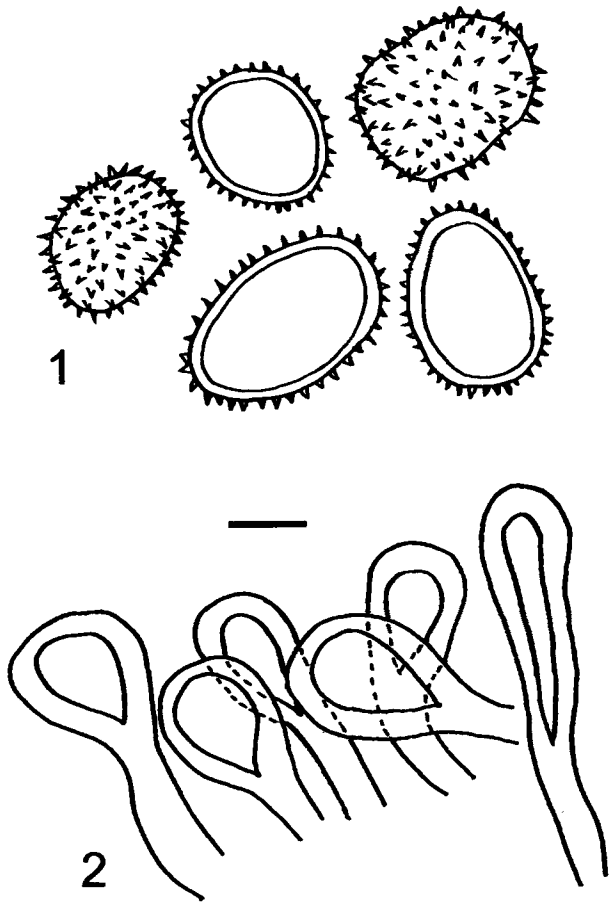
Holotype: Collected by T. Flynn, deposited by D. E. Gardner and T. Flynn in B. P. Bishop Museum Herbarium, Honolulu, Hawai'i, USA (BISH 649010). Isotype: Arthur Herbarium, Purdue University, USA (PUR N-1).

Etymology: "maua" is the common Hawaiian name of *X. hawaiiense*.

Specimens examined: BISH 649010 (holotype), on *Xylosma hawaiiense*, Hawai'i island, Hawai'i, USA, 23 January 1997. PUR N-1 (isotype).

Other than *U. maua*, only one rust, *Uredo recondita* Speg., is known from *Xylosma* (Spegazzini, 1918). This species was reported from Costa Rica on *X. salzmanni* Eichl. in Mart. Rusts recorded on other genera of the Flacourtiaceae include *Phakopsora caseariae* Yadav (Yadav, 1963), on *Casearia tomentosa* Roxb. from India; *U. dovyalidis* Castell. (Castellani, 1942), on *Dovyalis abyssinica* (Clet.) Warb. from Ethiopia and reported also from Kenya (Nattrass, 1961); *U. lindackeriae* Vien.-Bourg. (Viennot-Bourgin, 1958), on *Lindackeria dentata* (Oliv.) Gilg. from Ivory Coast and reported also from Nigeria (Eboh, 1986); and *U. scolopiae* Syd. (Sydow and Sydow, 1914), on *Scolopia crenata* Clos. and *S. oldhami* Hance, described from Taiwan (Hiratsuka and Hashioka, 1934; Hiratsuka, 1943; Sawada, 1961) and reported also from South China on *S. chinensis* Clos. (Hiratsuka, 1942). Morphological comparisons among these species are presented in Table 1.

As indicated above, *U. maua* is distinct from *U. recondita* and rusts on other hosts of the Flacourtiaceae in its geographic isolation from these species. This,



Figs. 1, 2. *Uredo maua*.
1. Urediniospores. 2. Paraphyses. Scale bar = 7.5 μm.

together with its apparent limitation to an endemic host, strongly suggests that *U. maua* evolved with its host rather than having arrived by recent introduction. Morphologically, the smaller urediniospores of *U. maua*, together with its broadly clavate paraphyses, also distinguish this species (Table 1).

In 1925, F. L. Stevens (1925) published the first comprehensive survey of Hawaiian fungi, devoting special attention to certain groups, including the Uredinales. He listed 39 species of rusts, including seven that he considered endemic, and 10 as "probably indigenous." Stevens noted that these numbers were small in comparison with the rust floras of other island localities. He attributed the relative scarcity of rusts in Hawai'i to the remote location of the Islands from any continental land mass, thus minimizing the probability of natural colonization. Additional endemic and indigenous rusts have been found in recent studies (Gardner, 1994), but the numbers remain small in comparison with those of other areas. The occurrence of *U. maua* as an inconspicuous species represented by minute, scattered uredinia is also consistent with Stevens' (Stevens, 1925) description of other endemic species in Hawai'i. He suggested that the apparently weak development of rust fungi on their endemic hosts indicated a phylogenetically recent, and still incomplete, adaptation of the parasite to the host. Thus, while most endemic Hawaiian rusts are of little or no economic significance, they are of considerable scientific interest as examples of evolutionary adaptation for which Hawai'i is well known.

Uredo wakensis A rust fungus on *Tournefortia* (=*Messerschmidia*) *argentea* L. fil. (Boraginaceae) was reported in Hawai'i from the Island of Kaua'i in 1996 (D. Lorence, personal communication). We have since collected the

Table 1. Characteristics of rusts on Flacourtiaceae.

Species	Host	Origin	Urediniospore size (μm)	Wall thickness (μm) and its surface	Paraphysis width (μm)
Uredo maua	*Xylosma hawaiiense*	Hawai'i	14–17(–20) × 14–22(–24)	2–3 echinulate	8–15
U. recondita[a]	*X. salzmanni*	Costa Rica	16–20 × 25–28	thin-walled echinulate	paraphyses not reported
U. dovyalidis[b]	*Dovyalis abyssinica*	Ethiopia, Kenya	14–17 × 21–26	1.6–2.2 verrucose	paraphyses not reported
U. lindakeriae[c]	*Lindackeria dentata*	Ivory Coast, Nigeria	14–19 × 20–25 (IC) 14.4–16.8 × 21.6–28.8(–31.2) (N)	1.3 echinulate	5–8
U. scolopiae[d]	*Scolopia crenata*, *S. oldhami*, *S. chinensis*	Taiwan, South China	16–20 × 20–30	2–3 echinulate	paraphyses not reported
Phakopsora caseariae[e]	*Casearia tomentosa*	India	16–20 × 20–30[f]	thin-walled echinulate	non-paraphysate

a) Spegazzini (1918).
b) Castellani (1942).
c) Viennot-Bourgin (1958).
d) Sydow and Sydow (1914).
e) Yadav (1963).
f) Uredinia encircled by telia.

rust on Oahu (BISH 649053; PUR N-3; PUR N-4). *Tournefortia argentea* is a small coastal tree native to tropical Asia, Madagascar, tropical Australia, and Polynesia. It has become naturalized on islands of the Northwestern Hawaiian chain and on most of the main populated islands (Wagner et al., 1990).

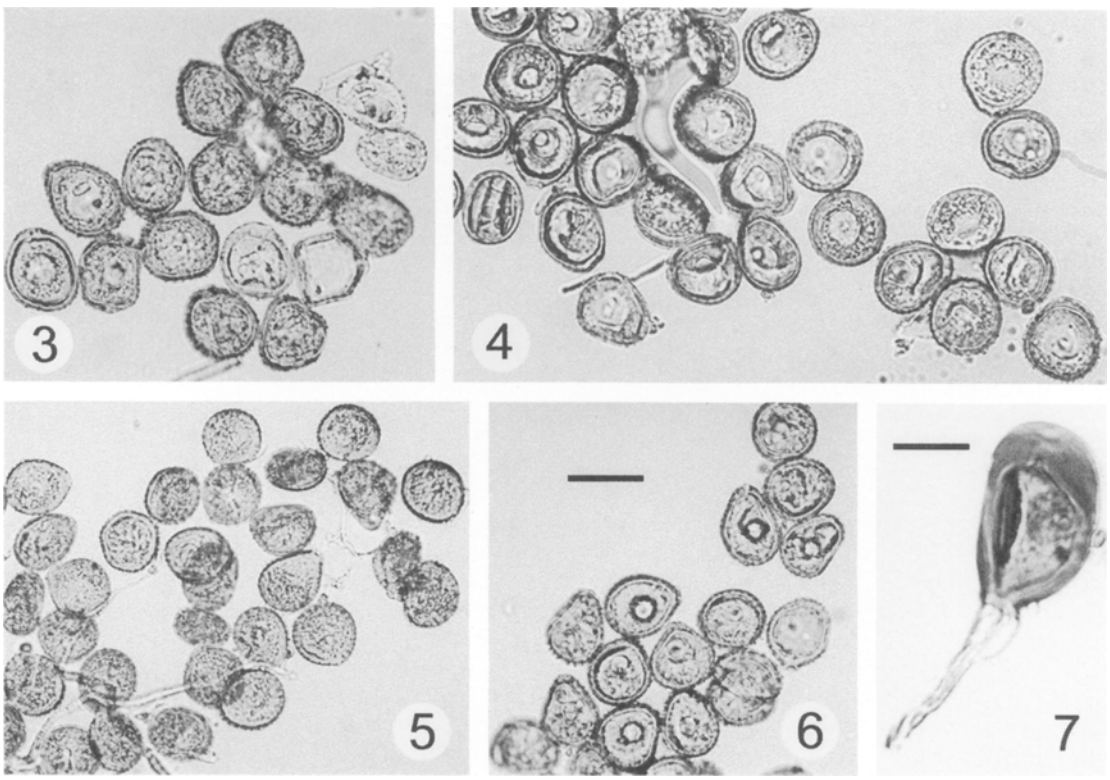
The rust occurs as conspicuous, powdery cinnamon to dark brown uredinia, 0.5–3 mm in diam, on both leaf surfaces. Urediniospores are brown, pyriform, globose or subglobose, moderately thick walled, prominently echinulate, and measure (19–)21–27 × 24–27 μm (Fig. 3). Telia were not present in any of the Hawaiian collections.

A number of rusts have been described on *Tournefortia*: *Uromyces dolichosporus* Diet. & Holw. on *T. velutina*, Mexico (Holway, 1901); *Aecidium tournefortiae* P. Henn. on *T. brachiata* DC., South and Central America (Jackson, 1931); *Puccinia tournefortiae* Jackson & Holway on *T. fuliginosa* H. B. K., Bolivia (Jackson, 1931); *Trichopsora tournefortiae* Lagerh. on *Tournefortia* sp., Ecuador (Jackson, 1931); *Uredo tournefortiae* Jackson & Holway on *T. suaveolens* H. B. K., Ecuador (Jackson, 1931); *U. wakensis* Cumm. on *Tournefortia* sp., Wake Island (Cummins, 1940); and *Uromyces tairae* Hirat. f. on *M. argentea* Johnst., Okinawa (Hiratsuka, 1940).

Based on the published descriptions of the above species, uredinia of the Hawaiian material resembled those of *Uredo wakensis* and *Uromyces tairae*. Therefore, these species were selected for further comparison. Cummins (1940) described *Uredo wakensis* with uredinia amphigenous, pulverulent, cinnamon-brown, densely aggregated, 1–3 mm in diam, urediniospores obovate to globose, 19–23 × 21–26 μm, wall moderately echinulate, 1.5–2 μm thick. Hiratsuka (1940) described *Uromyces tairae* with uredinia amphigenous, round to irregular, pulverulent, chestnut- to dark brown, urediniospores subglobose, obovate to ellipsoid, 17–25 × 22–30 μm, wall echinulate, 1.5–2.4 μm thick. Teliospores also were described as mixed with the urediniospores, subglobose to obovate, apex rounded, 5–10 μm thick, walls smooth, brown, 20–28 × 25–38 μm, pedicel persistent. Hiratsuka noted that telia were not found and only a few teliospores were present in the uredinia examined.

Uromyces tairae Hiratsuka, f., 1940. Figs. 3–7
= *Uredo wakensis* Cummins, 1940.

Specimens examined: PUR F9536, holotype of *Uredo wakensis*, on *Tournefortia* sp., Wake Island, 22 February 1938, A. M. Mito (Fig. 4); PUR F16446, *U. wakensis*, on *Messerschmidia* (= *Tournefortia*) *argentea*, Midway Island, 12 November 1959, E. J. Ford; TSH R1197, isotype of *Uromyces tairae*, on *M.* (= *T.*) *argentea*, Oki-



Figs. 3–7. *Uromyces tairae* (= *Uredo wakensis*) on *Tournefortia* (= *Messerschmidia*) *argentea*.
3. Urediniospores from Hawai'i (BISH 649053). 4. Urediniospores of the holotype of *Uredo wakensis* from Wake Island (PUR F9536). 5. Urediniospores of the isotype of *U. tairae* from Okinawa (TSH-R1197). 6. Urediniospores of *U. tairae* from Vanuatu (PDD 44923). Scale bar for Figs. 3–6 = 22.5 μm. 7. Teliospore from the isotype of *U. tairae* (TSH-R1197). Scale bar = 11 μm.

nawa, Japan, 2 March 1940, Y. Taira (Fig. 5); TSH R1482, *U. tairae*, on *M. (=T.) argentea*, Okinawa, Japan, 12 November 1994; PDD 44923, *U. tairae*, on *M. (=T.) argentea*, Efate, Pango, Vanuatu, 20 November 1983, E. H. C. McKenzie (Fig. 6); PDD 45129, *U. tairae*, on *M. (=T.) argentea*, Errakor Island, Vanuatu, 3 December 1983, E. H. C. McKenzie; PDD 33370, *U. tairae*, on *M. (=T.) argentea*, Tongatapu, Tonga, 6 June 1975, R. A. Fullerton.

Our observations of the above collections agreed in general with the published descriptions, but urediniospores of *Uredo wakensis* were found infrequently that measured somewhat larger (21–26 × 24–29 μm) than the reported range for this species (Cummins, 1940). As Hiratsuka (1940) reported for *U. tairae*, we found infrequent teliospores scattered among the urediniospores of the collections from Okinawa, confirming placement of this species in *Uromyces* (Fig. 7). We did not observe teliospores in collections of *U. tairae* from Vanuatu and Tonga, however. Urediniospores of this material measured 20–27 × 24–31 μm and resembled morphologically those from Okinawa, Wake Island, Midway Island, and Hawai'i. Urediniospores of all collections examined of *Uromyces tairae* and *Uredo wakensis* fell within the size range of 17–27 × 21–31 μm, which closely approximates the size ranges of individual collections.

Based on the above observations, we consider *Uredo wakensis* to represent the anamorphic state of *Uromyces tairae* and conclude that this is the species on *T. argentea* in Hawai'i. In view of the lack of telia and scarcity of teliospores in Hiratsuka's (Hiratsuka, 1940) collections, it is not surprising that telia or teliospores have not been found in other collections of *Uromyces tairae*. This is the first report of a rust on Boraginaceae in Hawai'i (Gardner and Hodges, 1989; Gardner, 1997).

Acknowledgements—We thank Drs. David Lorence for directing our attention to *U. wakensis*; Anthony Swinehart, Arthur Herbarium; Eric McKenzie, Landcare Research, New Zealand; and Makoto Kakishima, University of Tsukuba, Japan, for loan of *Tournefortia* rust specimens. The helpfulness of Drs. Halvor Gjaerum, Plante Forsk, Norway, and Joe Hennen, Botanical Research Institute of Texas, in locating records of Flacourtiaceae rusts, and of Charles Hodges and George Wong for reviewing the manuscript is appreciated. We acknowledge Dr. Karla McDermid for the Latin description.

Literature cited

Castellani, E. 1942. Nuovo giornale botanico Italiano, N. Ser.: Micromiceti dell'Africa Orientale Italiana **49**: 1–31.

Cummins, G. B. 1940. Descriptions of tropical rusts – II. Bull. Torrey Bot. Club **67**: 67–75.

Eboh, D. O. 1986. A taxonomic survey of Nigerian rust fungi: Uredinales Nigerianensis IV. Mycologia **78**: 577–586.

Fosberg, F. R. 1948. Derivation of the flora of the Hawaiian Islands. In: Insects of Hawai'i, vol. 1, (ed. by Zimmerman, E. C.), pp. 107–119. Univ. Hawai'i Press, Honolulu.

Gardner, D. E. 1994. The native rust fungi of Hawaii. Can. J. Bot. **72**: 976–989.

Gardner, D. E. 1997. Additions to the rust fungi of Hawai'i. Pacific Science **51**: 174–182.

Gardner, D. E. and Hodges, C. S., Jr. 1989. The rust fungi (Uredinales) of Hawaii. Pacific Science **43**: 41–55.

Hiratsuka, N. 1940. Materials for a rust-flora of Riukiu Islands. II. Bot. Mag. **54**: 374.

Hiratsuka, N. 1942. Notes on Uredinales collected in South China. J. Jpn. Bot. **18**: 563–572.

Hiratsuka, N. 1943. Uredinales of Formosa. Contributions to the rust-flora of Eastern Asia, IV. Mem. Tottori Agr. Coll. **7**: 1–90.

Hiratsuka, N. and Hashioka, Y. 1934. Uredinales collected in Formosa II. Bot. Mag. **48**: 233–240.

Holway, E. W. D. 1901. Mexican fungi. III. Bot. Gaz. **31**: 326–338.

Jackson, H. S. 1931. The rusts of South America based on the Holway collections-V. Mycologia **23**: 463–503.

Nattrass, R. M. 1961. Host lists of Kenya fungi and bacteria. Mycol. Pap. **81**: 13.

Sawada, K. 1961. List of fungi found in Taiwan (Formosa). In: Papers in commemoration of Dr. Takashi Matsumoto for his thirty years of service as professor of plant pathology. Spec. Publ. No. 10. Coll. Agric., Nat. Taiwan Univ., Taipei, China.

Spegazzini, C. L. 1918. Fungi Costaricenses nonnulli. (Reliquiae Mycologicae Tropicae). Bol. Acad. Nac. Cienc. Córdoba **23**: 541–593.

Stevens, F. L. 1925. Hawaiian fungi. Bernice P. Bishop Mus. Bull., No. 19. Honolulu, Hawaii.

Sydow, H. and Sydow, P. 1914. Beitrag zur Kenntnis der parasitischen Pilze der Insel Formosa **12**: 105–112.

Viennot-Bourgin, G. 1958. Urédinales d'Afrique. Urédinales de Côte-d'Ivoire. Uredineana 5. In: Encycl. Mycol. **31**: 137–248.

Wagner, W. L., Herbst, D. R. and Sohmer, S. H. 1990. Manual of the flowering plants of Hawai'i, vols. 1, 2. Bernice P. Bishop Mus. Spec. Publ. Univ. Hawai'i Press and Bishop Mus. Press, Honolulu.

Yadav, A. S. 1963. Contribution to the knowledge of Uredineae of Bihar, III. Indian Phytopathology **16**: 138–142.