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FULL PAPER

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New geographical distribution and host records of rust fungi from northern Thailand

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Abstract Ten species of rust fungi (*Crossopsora* 2, *Maravalia* 1, *Pileolaria* 1, *Puccinia* 1, *Ravenelia* 1, *Sphaerophragmium* 1, *Uredo* 2, and *Uromyces* 1) are newly recorded together with six new host plants in Thailand.

Key words *Crossopsora · Maravalia · Puccinia · Ravenelia · Sphaerophragmium*

Introduction

Sixty-four species in 17 genera of rust fungi on 66 host species in 27 plant families have been reported for Thailand (Giatgong 1980; Gjaerum 1995; Kakishima et al. 1988; Lohsomboon et al. 1986, 1988, 1992, 1994; Lorsuwan et al. 1984; Ono et al. 1988a,b); however, these numbers are far less than those that are cumulated for the Philippines and Indonesia. Thailand lies in the tropical/subtropical region with high climatic, geographical, and topographical diversity, and these physical diversities have created a multitude of habitats for herbaceous and arborescent plants that have been recorded in Thailand. These conditions indicate that Thailand has been underexplored for rust fungi.

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Recent mycological surveys in the Provinces of Chiang Mai and Mae Hon Son (northern Thailand) in December 2002 and 2003 resulted in more than 150 collections of rust fungi among others. We here report rust species newly recorded in Thailand together with new host species of individual rust species. The specimens have been deposited in the Herbarium of Systematic Mycology, Ibaraki University (IBA), the Mycological Herbarium, the University of Tsukuba (TSH), and Chiang Mai University.

Crossopsora fici Arthur & Cummins, Philipp. J. Sci. 61: 463, 1936.

Fig. 1A,B

Specimens examined: on *Ficus* sp., Doi Chiang Dao Cave, Chiang Mai Prov., 27 Dec. 2002, Y. Ono et al. 02-144 (IBA-9123 = TSH-R22881) and on *F. religiosa* L., Chiang Dao Wildlife Research Station, Chiang Mai Prov., 27 Dec. 2003, Y. Ono et al. 02-147 (IBA-9126 = TSH-R22882); Kasetsart University, Bangkok, 17 Jan. 2000 (TSH-R23275), Chiang Mai University, Chiang Mai Prov., Oct. 2003 (TSH-R23276), and Chiang Mai University, Chiang Mai Prov., Feb. 2004 (TSH-R23277).

Urediniospores subglobose, ellipsoid or obovoid, 18.6–36.0 × 12.8–17.7 μm in size, the wall 1–2 μm thick, echinulate, with 2 equatorial germ pores.

Ficus religiosa is a new host for the fungus. This fungus has previously been reported on *F. variegatus* Bl. in the Philippines (Arthur and Cummins 1936) and on *F. capensis* Thunb. in Uganda (Wakefield and Hansford 1949).

Crossopsora zizyphi (Sydow & Butler) Sydow & P. Sydow, Ann. Mycol. 16: 243. 1918.

Fig. 1C–E

Specimen examined: on *Zizyphus* sp., Queen Sirikit Botanical Garden, Chiang Mai Prov., 24 Dec. 2003, Y. Ono et al. 02-63 (IBA-9040 = TSH-R22883).

Uredinia densely surrounded by basally united paraphyses; paraphyses cylindrical or incurved, 77.9–53.6 × 7.1–11.2 μm in size; urediniospores angularly subglobose or broadly obovoid, 20.0–25.0 × 20.0–22.5 μm in size; the wall

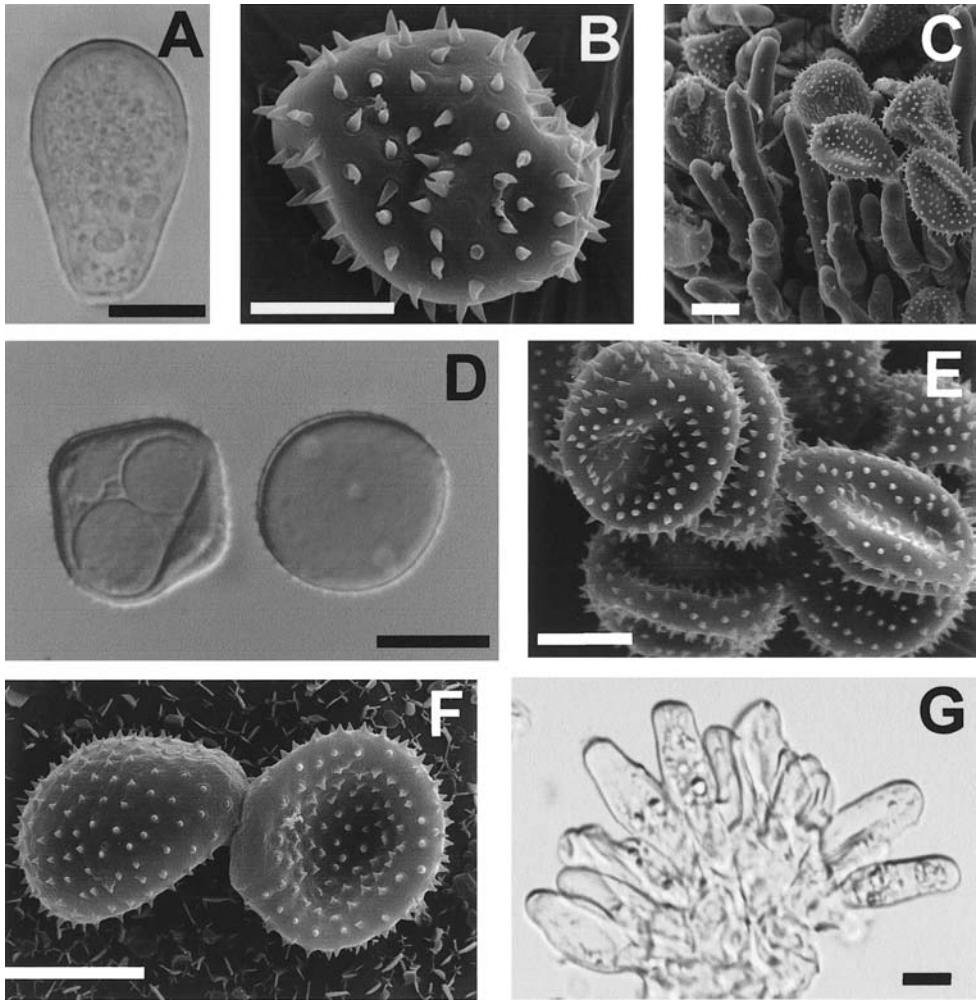

Fig. 1. A,B *Crossopsora fici* (IBA9123). **A** Urediniospore. **B** Surface structure of urediniospore. **C–E** *Crossopsora zizyphi* (IBA9040). **C** Paraphyses and urediniospores. **D** Urediniospores. **E** Surface structure of urediniospores. **F,G** *Maravalia achroa* (IBA9139) **F** Surface structure of urediniospores. **G** Teliospores. *Bars* 10 µm

was ~1 µm thick, echinulate, brown, with 3(–4) equatorial germ pores.

This fungus has been recorded on *Z. oenoplia* in India and Bangladesh (Sydow et al. 1912; Butler and Bisby 1960; Buriticá 1999) and Papua New Guinea (Shaw 1984); on *Z. rugosa* in India (Sydow et al. 1912); and on *Zizyphus* sp. in Vietnam (Buriticá 1999).

Maravalia achroa (Syd. & P. Syd.) Arth. & Cummins, Philipp. J. Sci. 61: 468. 1936.

Fig. 1F,G

Specimen examined: on *Pterocarpus macrocarpus* Kurz., First National Park Protection Unit area, Doi Suthep-Pui National Park, Chiang Mai Prov., 23 Nov. 2003, Y. Ono et al. 03-6, IBA9139 = TSH-R22884.

Sori amphigenous and caulicolous, without peripheral paraphyses; urediniospores subglobose to globose, echinulate, 10.0–15.0 × 10.0–12.5 µm in size; teliospores oblong-ellipsoid, 20.0–37.5 × 10.0–12.5 µm in size; the wall thin, hyaline, smooth; the pedicel persistent, 7.5–13.7 µm long.

Pterocarpus macrocarpus is a new host for the fungus. This fungus has previously been reported on *Dalbergia sissoo* Roxb. in China (Tai 1979; Ono 1984) and Taiwan (Tai 1979; Ono 1984; Hiratsuka and Chen 1991).

Additional two *Maravalia* species are known on *Pterocarpus* species: *M. exigua* Y. Ono in Malawi and *M. pterocarpi* (Thir.) Thir. in the Philippines and India (Ono 1984). The two species differ from *M. achroa* in having cylindrical and often incurved paraphyses around the sori (Ono 1984).

Pileolaria shiraiana (Dietel & P. Sydow) S. Ito, J. Coll. Agr. Hokkaido Imp. Univ. 11: 273. 1922.

Fig. 2A–D

Specimens examined: on *Rhus rhetsoides* Craib., Doi Suthep, Chiang Mai Prov., 23 Nov. 2003, Y. Ono et al. 03-17 (IBA-9150 = TSH-R22885) and on Rt. 1091, Chiang Mai Prov., 26 Nov. 2003, Y. Ono et al. 03-40 (IBA-9173 = TSH-R22886).

Urediniospores mostly subglobose or oval, 35.0–45.0 × 17.5–25 µm in size; the wall 1.5–3.0 µm thick, ornamented with spirally or longitudinally arranged ridges. Teliospores discoid, 30–37.5 × 22.5–32.5 µm in size; the wall thick and blackish brown; the pedicel persistent, 15–20 µm long.

Rhus rhetsoides is a new host for the fungus. This fungus has been reported on *R. chinensis* Mill. in China (Tai 1979); on *R. chinensis* var. *roxburghii* Rehd. in Japan (Hiratsuka et al. 1992); on *R. delavayi* Franch. var. *quinquejuga* Rehd. &

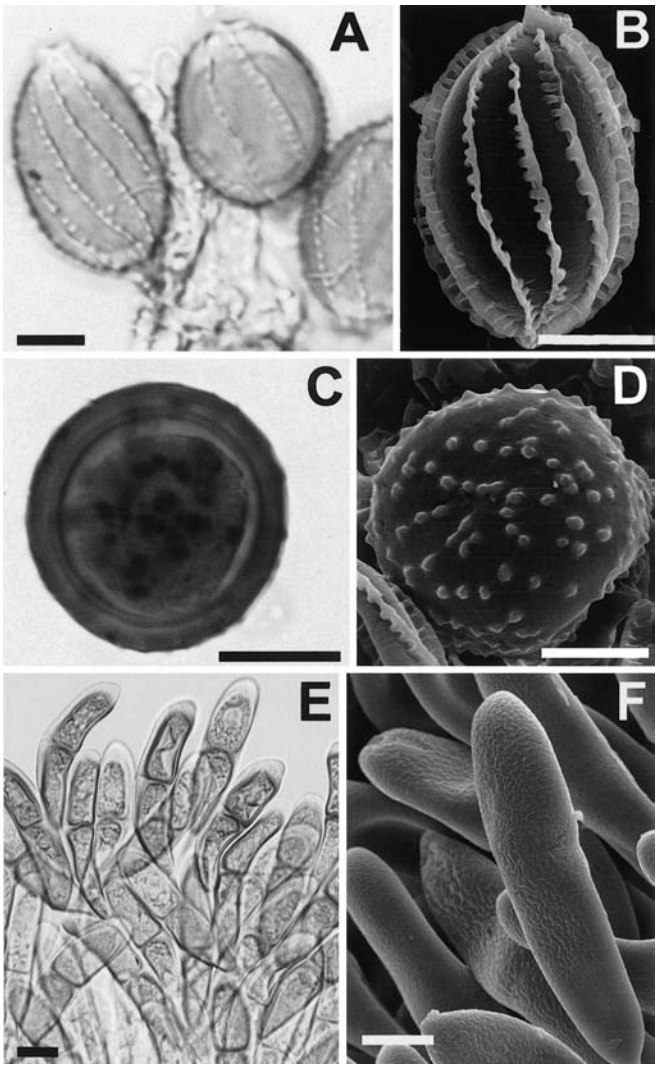

Fig. 2. A–D *Pileolaria shiraiana* (IBA9150). **A** Urediniospores. **B** Surface structure of urediniospore. **C** Teliospore. **D** Surface structure of teliospore. **E,F** *Puccinia cara* (IBA9091). **E** Teliospores. **F** Surface structure of teliospores. *Bars* 10 µm

Wils. in China (Tai 1979); on *R. succedanea* L. in China (Tai 1979), Japan (Hiratsuka et al. 1992), and Taiwan (Hiratsuka and Chen 1991); on *R. sylvestris* Sieb. & Zucc. in China (Tai 1979), Japan (Hiratsuka et al. 1992), and Taiwan (Hiratsuka and Chen 1991); on *R. trichocarpa* Miq. in Japan (Hiratsuka et al. 1992); and on *R. verniciflua* Stocks in China (Tai 1979).

Puccinia cara Cummins, Bull. Torrey Bot. Club 76: 35. 1949.

Fig. 2E,F

Specimens examined: on *Litsea salicifolia* (Roxb. ex Nees) Hook. f., Doi Inthanon, Chiang Mai Prov., 25 Dec. 2002, Y. Ono et al. 02-114 (IBA-9091 = TSH-R22887) and 24 Nov. 2003, Y. Ono et al. 03-19 (IBA-9152 = TSH-R22888).

Teliospores ellipsoid to oblong, rounded at the apex, tapering toward the base, not constricted to slightly constricted at the septum, 52.5–65.0 × 15.0–18.5 µm in size, upper cell 25.0–32.5 µm long and lower cell 27.5–37.5 µm long; the wall light brown to chestnut-brown, 1.5–2.0 µm thick, the apex 2.8–4.3 µm thick.

Litsea salicifolia is a new host for the fungus. This fungus has previously been reported on *Phoebe neurantha* (Hemsl.) Gamble in China (Cummins 1949; Tai 1979; Zhuang 1990, 2003). Cummins (1949) first determined the host of the type specimen as *Benzoin* sp., but Tai (1979) listed the host as *Lindera* sp. Zhuang (1990) reexamined the holotype and identified the host as *P. neurantha*.

Ravenelia japonica Dietel & P. Sydow, Hedwigia 37: 216. 1898.

Fig. 3A,B

Specimens examined: on *Albizia lebbekoides* (DC.) Benth., Queen Sirikit Botanical Garden, Chiang Mai Prov., 24 Dec. 2002, Y. Ono et al. 02-60 (IBA-9037 = TSH-R22889); Doi Inthanon, Chiang Mai Prov., 25 Dec. 2002, Y. Ono et al. 02-125 (IBA-9102 = TSH-R22890); on *A. chinensis* Merr., Doi Inthanon, Chiang Mai Prov., Thailand, 25 Dec. 2002, Y. Ono et al. 02-116 (IBA-9093 = TSH-R22891).

Urediniospores globose or subglobose, 14.6–19.6 × 11.5–16.1 µm in size; the wall 1–2 µm thick, slightly thickened at the apex, echinulate, with 4–5 germ pores. Discoid telial heads consisting of 5–6 teliospore cells across, surface smooth, brown to dark brown, 78.7–93.7 µm diameter in face view, subtended by 8–11 hygroscopic cysts.

Albizia lebbekoides is a new host for the fungus. This fungus has been reported on *A. julibrissin* Durraz. in China (Tai 1979), Japan (Hiratsuka et al. 1992), and Taiwan (Hiratsuka and Chen 1991); on *A. chinensis* (Osb.) Merr. in Himalayas (Nepal) (Ono et al. 1995); on *A. kalkora* (Roxb.) Prain. in China (Tai 1979; Teng 1996); on *A. odoratissima* (L.f.) Benth. in India (Butler and Bisby 1960); and on *A. yunnanensis* Fr. in China (Tai 1979).

Sphaerophragmium clemensiae Sydow in Sydow & Petrak, Ann. Mycol. 29: 161. 1931.

Fig. 3C–G

Specimen examined: on *Albizia lebbek* (L.) Benth., Mae La Noi, Mae Hon Son Prov., 28 Nov. 2003, Y. Ono et al. 03-54 (IBA-9188 = TSH-R22892).

Urediniospores ellipsoid, obovoid or reniform, 25.0–27.5 × 12.5–17.5 µm in size; the wall ~1 µm thick, echinulate, with 3–4 supraequatorial germ pores; teliospores pedicellate, 6–8-celled, subglobose to globose or broadly ellipsoid, 35.0–45.0 × 25.0–37.5 µm in size; the wall cinnamon-brown with projections 7.5–15.0 µm long, tri- or tetra-furcated at the tip; the pedicel 50–90 µm long.

This fungus was once reported on the same host species from Nakhon Sawan Prov. under the name of *S. luzonicum* Yates (Lohsomboon et al. 1988). *Sphaerophragmium luzonicum* has become a synonym of *S. acaciae* (Cooke) Magnus (Lohsomboon et al. 1994), and a specimen (TSH-R7186) cited by Lohsomboon et al. (1988) was listed under *S. acaciae* (Lohsomboon et al. 1994). However, the observations of a new collection and the description of the previous collection (TSH-R7186) show the taxonomic identity of the fungus to *S. clemensiae*. Thus, distribution of *S. acaciae* has not been confirmed in Thailand. This fungus was previ-

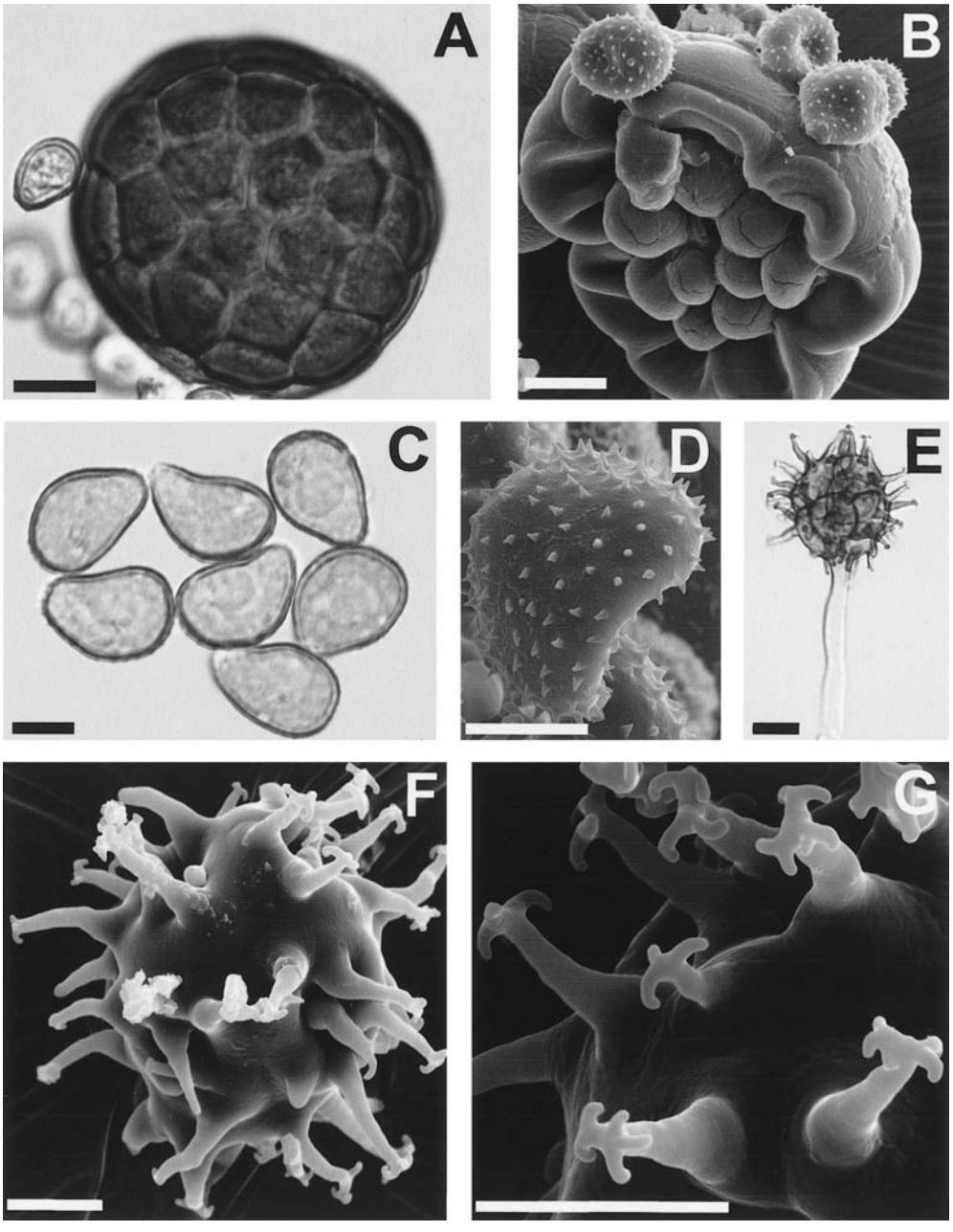

Fig. 3. A,B *Ravenelia japonica* (IBA9037). **A** Teliospore. **B** Surface structure of teliospore and urediniospores attached to the teliospore. **C–G** *Sphaerophragmium clemensiae* (IBA9183). **C** Urediniospores. **D** Surface structure of urediniospore. **E** Teliospore. **F** Surface structure of teliospore. **G** Teliospore projections. *Bars* 10 μm

ously recorded on *Albizia lebbekoides* (DC.) Benth. in the Philippines (Arthur and Cummins 1936; Lohsomboon et al. 1994).

Uredo musae Cummins, Mycologia 33: 151. 1941.

Fig. 4A,B

Specimen examined: on *Musa* sp., Mae-Rim, Chiang Mai Prov., 24 Dec. 2002, Y. Ono et al. 02-84, IBA9062 = TSH-R22893.

Uredinia hypophyllous, minute and mostly linearly arranged, covered by host epidermis and releasing spores through a central aparture. Urediniospores globose, subglobose, or ellipsoid and 20.3–30.5 × 14.2–21.0 μm in size; the wall ~1.0 μm thick, light brown, moderately and evenly echinulate. No germ pores observed.

This fungus was first described from an unidentified banana in Papua New Guinea (Cummins 1941). Another rust fungus, *Uromyces musae* P. Hennings, was described from Congo (Hennings 1907, cited from Mulder and Holliday 1971); however, *Uromyces musae* urediniospores have a thicker (~2.5 μm) wall with finer echinulae than *U. musae* urediniospores. The third species, *Uredo musicola* Yen, was reported on an unidentified *Musa* species from the Philippines (Yen 1974). The urediniospores were said to be larger (25–33 × 17–23 μm) and to have (4–)8(–9) scattered germ pores on the wall (Yen 1974).

This rust fungus is widespread in Oceania (McKenzie and Jackson 1986; Shivas 1987; Gerlach 1988) and Malaysia (Yen 1973); however, no rust outbreak has been reported on cultivated bananas.

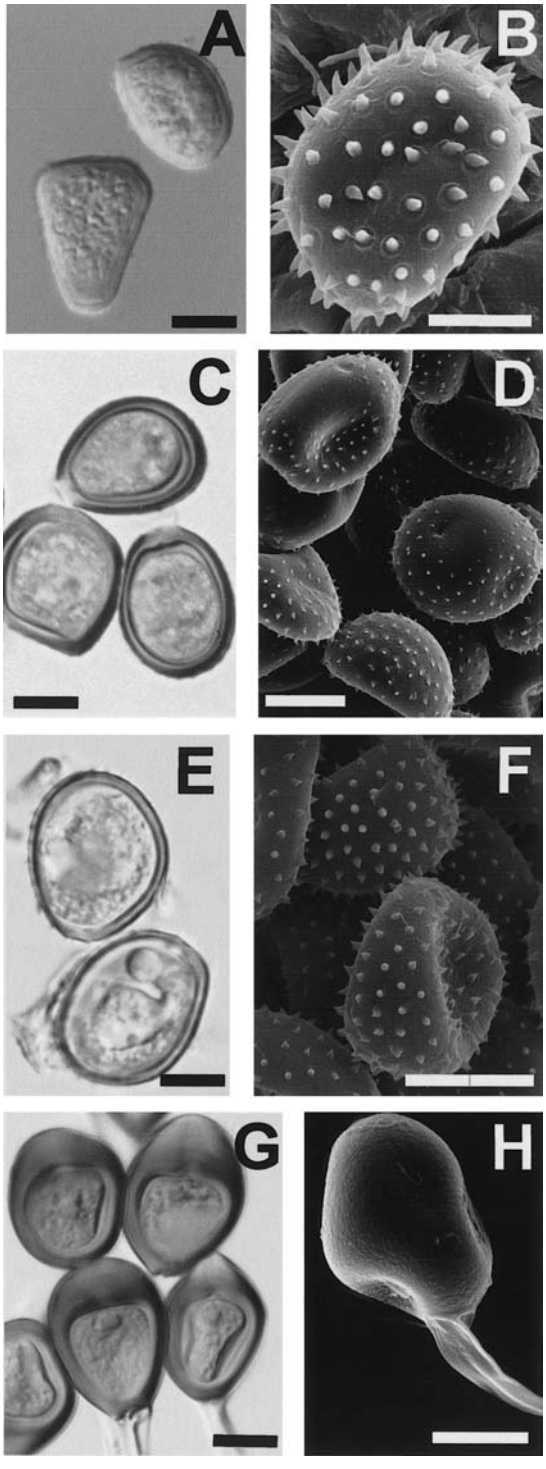

Fig. 4. A,B *Uredo musae* (IBA9062). **A** Urediniospores. **B** Surface structure of urediniospore. **C,D** *Uredo operulinae* (IBA9179). **C** Urediniospores. **D** Surface structure of urediniospores. **E–H** *Uromyces commelinae* (IBA9136). **E** Urediniospores. **F** Surface structure of urediniospores. **G** Teliospores. **H** Surface structure of teliospore. *Bars* 10 μm

Uredo operculinae Sydow & P. Sydow, Philipp. J. Sci. 8: 476. 1913.

Fig. 4C,D

Specimen examined: on *Merremia* sp., Sanpandan Wildlife Sanctuary, Mae Hon Son Prov., 26 Nov. 2003, Y. Ono et al. 03-45, IBA9179 = TSH-R22894.

Urediniospores mostly globose or subglobose, 20.0–25.0 × 16.2–22.5 μm in size; the wall 1.5–2.0 μm thick, echinulate, with 2–3 germ pores.

This fungus has been reported on *O. turpethum* in the Philippines (Sydow and Sydow 1913, 1917; Teodoro 1937) and on *O. aequisepala* (Domin.) R.W. Johnson and *O. brownii* Ooststr. in Australia (Shivas 1989). This fungus should not be confused with *Uredo operculinae* Arthur reported on *O. dissecta* (Jacq.) House in Puerto Rico (Arthur 1917) and Cuba (Arnold 1986; Arthur and Johnston 1917) and on *O. convolvulus* Manso in Brazil (Hennen et al. 1982), which fungus is now *U. laeticolor* Arthur.

Uromyces commelinae M.C. Cooke, Trans. Roy. Soc. Edinburgh 31: 342, 1888.

Fig. 4E–H

Specimen examined: on *Aneilema sinicum* Lindl., First National Park Protection Unit area, Doi Suthep Pui National Park, Chiang Mai Prov., 23 Nov. 2003, Y. Ono et al. 03-3 (IBA-9136 = TSH-R22895).

Urediniospores subglobose to globose, 20.0–27.5 × 17.5–22.5 μm in size; the wall 0.8–1.5 μm thick, echinulate, with 2 equatorial germ pores; teliospores one-celled, 25.0–32.5 × 20.0–23.7 μm in size; the walls smooth, dark brown, 1.2–2.5 μm thick, the apex 7.5–10 μm thick.

Aneilema sinicum is a new host for the fungus. This fungus has previously recorded on *A. keisak* Hassk. in Taiwan (Tai 1979; Hiratsuka and Chen 1991) and on *Aneilema* spp. in China (Tai 1979). In addition to *Aneilema*, this fungus has been reported on *Callisia* in South America, *Commelina* in worldwide distribution, *Cyanotis* in Asia and Africa, *Descantaria* in South America, *Murdannia* in Asia and Africa, *Pollia* in Asia and Oceania, *Tradescantia* in South America, *Tripogandra* in South America, and *Zebrina* in North America.

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