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Additional records of rust fungi (*Pucciniales*) in Peninsular Malaysia and Penang Island

Yoshitaka Ono*, Baharuddin Salleh** and Izumi Okane ***

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Abstract

A total of 62 species in 16 teleomorphic genera and 13 species in 2 anamorphic genera are recorded for Malaysia. Based on the survey in the years from 2002 through 2005, this paper reports 17 rust species in 9 genera previously unknown to Peninsular Malaysia and the Penang Island, i.e., *Coleosporium clerodendri* on *Clerodendrum* sp., *C. merrillii* on *Spathoglottis plicata* (a new host species), *Crossopsora malloti* on *Mallotus* sp., *Melampsora euphorbiae* on *Euphorbia pulcherrima, Milesina philippinensis* on *Nephrolepis* sp., *Neoolivea tectonae* on *Tectona grandis, Phakopsora cingens* on *Glochidion* sp., *Ph. elettariae* on *Alpinia* sp., *Globba pendula* (a new host genus and species), and *Zingiber* sp., *Puccinia absinthii* on *Artemisia* sp., *P. citrina* on *Smilax* sp., *Puccinia dianellae* on *Dianella ensifolia, P. oxalidis* on *Oxalis debilis, P. pelargonii-zonalis* on *Pelargonium* sp., *Ravenelia hobsonii* on *Pongamia pinnata, Uredo cassiae-glaucae* on *Cassia* sp., *Uredo dioscoreae-filiformis* on *Dioscorea* sp., and *Uredo gardeniicola* on *Gardenia jasminoides*. Telial stage of *Uredo musae* was found on *Musa* aff. *acuminata* and is reported for the first time.

Keywords – Fungal diversity・Geographic Distribution・Host range・Southeast Asia・Taxonomy

Introduction

A total of 68 species in 17 teleomorphic genera and 21 species in 2 anamorphic genera have been recorded in the Malay Peninsula, of which 62 species in 16 teleomorphic genera and 13 species in 2 anamorphic genera are in Malaysia, and 15 species in 7 teleomorphic genera and 10 species in 2 anamorphic genera in Singapore (Hennings 1893, 1900a, 1900b; Chipp 1921; Overeem and Overeem 1922; Sydow 1928; Thompson and Johnston 1953; Petrak 1954; Johnston 1960; Laundon 1963; Peterson 1968; Yen 1970; Punithalingam and Jones 1971; Turner 1971; Yen 1973; Williams and Liu 1976; Liu 1977; Singh 1980; Gjaerum 1995; Salleh *et al*. 1995; Old *et al*. 2000; Neo and Tham 2009; Lee *et al*. 2012; du Plessis *et al*. 2017; Ono *et al*. 2020; Khoo

*College of Education, Ibaraki University, Mito, Ibaraki 310-8512, Japan.
**School of Biological Science, Universiti Sains Malaysia, Penang 11800, Malaysia.
***Faculty of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, 305-8572, Japan.

et al. 2022). Nine species in 6 teleomorphic genera and 2 anamorphic species are common between Malaysia and Singapore. As have been stated for the rust fungus diversity in the Korean Peninsula (Ono 2019) and in Thailand (Ono *et al*. 2021, 2022a), we assume that much larger number of rust species would have been discovered based upon existing diversity of vascular plant species in Mainland Southeast Asia and estimated ratio of rust fungi and their vascular plant hosts (cf. Hennen and McCain 1993).

The herbarium specimens collected in the years from 2002 through 2005 in Peninsular Malaysia and the Penang Island, that have been deposited at the Herbarium of Systematic Mycology, the College of Education, Ibaraki University (IBAR), were examined. The same set of the specimens have also been deposited at the School of Biological Sciences, Universiti Sains Malaysia. Individual specimens are listed under each species. Upper case letters, S, A, U, and T, followed by IBAR accession number, denote spermogonial, aecial, uredinial, and/or telial stage, respectively, present on the specimens. Preparations of microscopic slides and observation under a light microscope followed the methods described by Ono *et al*. (2022a, b).

Enumeration of species

(in alphabetical order)

Coleosporium clerodendri Dietel, Bot. Jarhb. 27: 566. 1899 (1900). Fig. 1A–D

On *Clerodendrum* sp. (*Laminaceae*), Kedah, Gunung Jerai, ca. 1200m asl, 17 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U & T; IBAR9020).

Commentary: Only uredinia are found on the specimen. This fungus is widespread in East Asia, but in Southeast Asia, this species had been recorded only in Indonesia on *C. buchananii* (Roxb.) Walp. (= *C. blumeanum* Schauer) and *C. chinense* (Osbeck) Mabb. (= *C. fragrance* Willd.) (Boedijn 1959).

Coleosporium merrillii Henn., Hedwigia 47: 251. 1908. Fig. 1E–I

On *Spathoglottis plicata* Blume (*Orchidaceae*), Pahang, Genting Highland, 350m asl, 21 Nov 2005, Y. Ono (U & T; IBAR9630).

Morphology: Sori produced on small pale yellowish spots and more or less linearly arranged on the leaf veins (Fig 1E). Uredinia subepidermal in origin, soon erumpent, Caeoma-type (Fig. 1F), powdery, and yellowish orange. Urediniospores produced in basipetal succession (Fig. 1F), obovoid, ellipsoid, or oblong-ellipsoid, and 18–28 × 17–22 µm in size (Fig. 1 G); the wall ca. 1.5 µm thick, colorless, and verrucose with smooth portion (Fig. 1G, H). Telia subepidermal in origin, erumpent, pulvinate, waxy, and reddish orange (Fig. 1E). Teliospores ellipsoid or cylindric with apical gelatinous layer, and 50–80 × 15–20 µm in size; the apical gelatinous layer up to 25 µm thick (Fig. 1I).

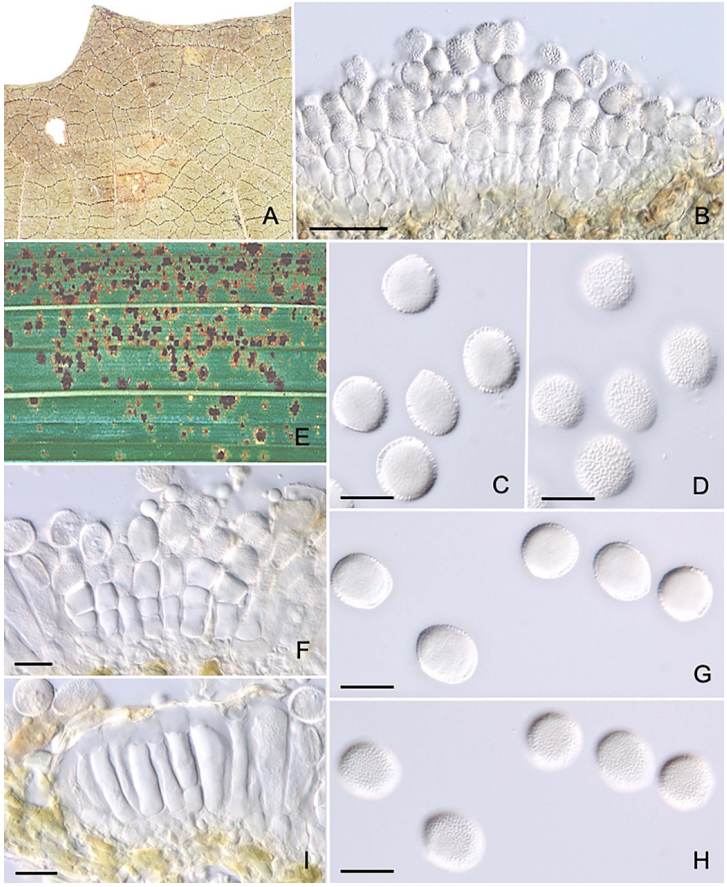

Figure 1. A–D: *Coleosporium clerodendri* on *Clerodendrum* sp. (IBAR9020). E–I: *Coleosporium merrillii* on *Spathoglottis plicata* (IBAR9630). A. Uredinia produced on pale yellow or yellowish brown lesions on the abaxial leaf surface. B. Cross section of uredinium. Urediniospores are produced in basipetal succession from a basal sporogenous cell. C. Urediniospores focused on the transverse plane. D. Urediniospores (the same as C) focused on the upper surface. The wall is verrucose with smooth portion. E. Uredinia (yellowish orange) and telia (reddish orange) produced on the abaxial leaf surface. The sori become dark or blackish brown after maturation. F. Cross section of uredinium. Urediniospores are produced in basipetal succession from a basal sporogenous cell. G. Urediniospores focused on the transverse plane. H. Urediniospores (the same as G) focused on the upper surface. The wall is verrucose with smooth portion. I. Cross section of telium. The teliospores are oblong-ellipsoid to cylindric with apical gelatinous layer. Bars: B 50 µm; C, D, F–I 20 µm.

Commentary: *Spathoglottis plicata* is a new host species for this fungus. This fungus species has been recorded in the Philippines on *Calanthe triplicata* (Willemet) Ames (= *C. furcata* Bateman ex Lindl.) (Arthur and Cummins 1936b); on *Calanthe* sp., *Dendrobium* sp., *Herminium lanceum* (Thunb. ex Sw.) Vuijk. (= *H. angustifolium* (Lindl.) Ridl.), and *Spathoglottis chrysantha* Ames (Teodro 1937); and in Papua New Guinea on an unidentified *Orchidaceae* plant (Shaw 1984).

Crossopsora malloti (Racib.) Cummins, Mycologia 32: 372. 1940. Fig. 2

On *Mallotus* sp. (*Euphorbiaceae*), Pahang, on Rt 59 from Tapah, ca. 300m asl, 3 Dec 2003. Y. Ono (U & T; IBAR9196); Lata Iskandar on Rt 59, 420m asl, 3 Dec 2003. Y. Ono (U & T; IBAR9198).

Morphology: Uredinia scattered or in loose to dense groups on the abaxial leaf surface, subepidermal in origin, soon erumpent, Malupa-type, and densely surrounded by cylindrical, strongly incurved paraphyses arising from basal pseudoparenchya (Fig. 2A). Paraphyses cylindrical, weakly to strongly incurved, dorsally thick-walled, 30–53 µm high, and 5–12 µm wide. Urediniospores singly produced on a pedicel, obovoid, obovoid-ellipsoid or pyriform, and 25–39(–44) × (11–)13–20 µm in size; the wall ca. 1.5 µm thick, pale yellowish brown to cinnamon-brown, and uniformly echinulate; germ pores (2–)3(–4) and scattered on the wall (Fig. 2B, C). Telia filiform, scattered or in small groups, subepidermal in origin, erumpent, and densely surrounded by cylindrical; paraphyses arising from basal pseudoparenchya (Fig. 2D). Teliospores produced in a basipetal succession from a basal sporogenous cell (Fig. 2D). E. Teliospore oblong-ellipsoid to cylindrical and 30–50 × 5–10 µm in size; the wall thin, pale cinnamon-brown, and smooth (Fig. 2E).

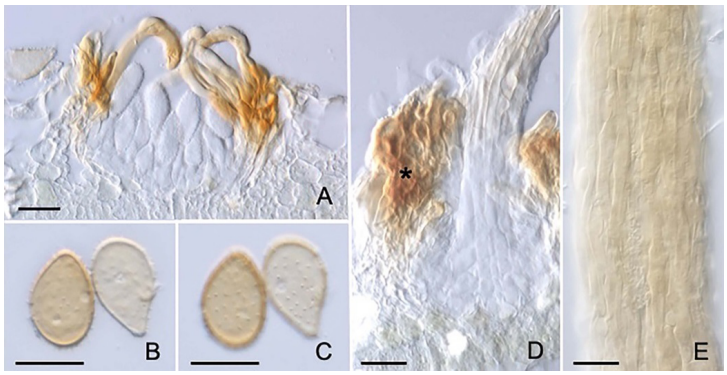

Figure 2. *Crossopsora malloti* on *Mallotus* sp. (IBAR9196). A. Cross section of uredinium. The sorus is densely surrounded by cylindrical, strongly incurved paraphyses arising from basal pseudoparenchya. B. Urediniospores focused on the transverse plane. C. Urediniospores (the same as B) focused on the upper surface. The wall is uniformly and finely echinulate. Two to four, mostly three, germ pores are scattered on the wall. D. Cross section of telium. The sorus is densely surrounded by cylindrical, paraphyses arising from basal pseudoparenchya (asterisk). Teliospores are produced in basipetal succession from a basal sporogenous cell. E. Teliospore column. Individual spores are oblong-ellipsoid to cylindrical. Bars: 20 µm.

Melampsora euphorbiae (Ficinus & C. Schub.) Castagne, Observ. Uréd. 2: 18. 1843. Fig. 3

On *Euphorbia pulcherrima* Willd. ex Klotzsch (*Euphorbiaceae*), Pahang, Cameron Highland, Tanah Rata on Rt 59, ca. 1400m asl, 3 Dec 2003. Y. Ono (U; IBAR9199).

Morphology: Uredinia hypophyllous, scattered or grouped on pale yellowish or brownish spots (Fig. 3A), subepidermal, Uredo-type with abundant hymenial paraphyses, soon erumpent, yellowish orange, and powdery (Fig. 3B). Paraphyses capitate or clavate, 18–24 µm wide, and 50–65 µm high; the wall 3.5–5 µm thick, colorless, and smooth (Fig. 3B). Urediniospores singly produced on a pedicel, subglobose, obovoid-

ellipsoid or ellipsoid, and 18–28 × 16–22 µm in size; the wall uniformly 2–3.5 µm thick, colorless (Fig. 3C), and uniformly and densely echinulate (Fig. 3D). Teliospores not seen.

Commentary: This fungus is common on many *Euphorbia* species and of worldwide distribution. Nonetheless, it has rarely been reported on ornamental poinsettia, *E. pulcherrima*. The previous reports of this rust species on ornamental poinsettias were from Tanzania (Wallace and Wallace 1949), Mauritius (Anonymous 1961; Orieux and Felix 1968), India (Kala and Gaur 1983), and Norway (Gjaerum *et al*. 2007).

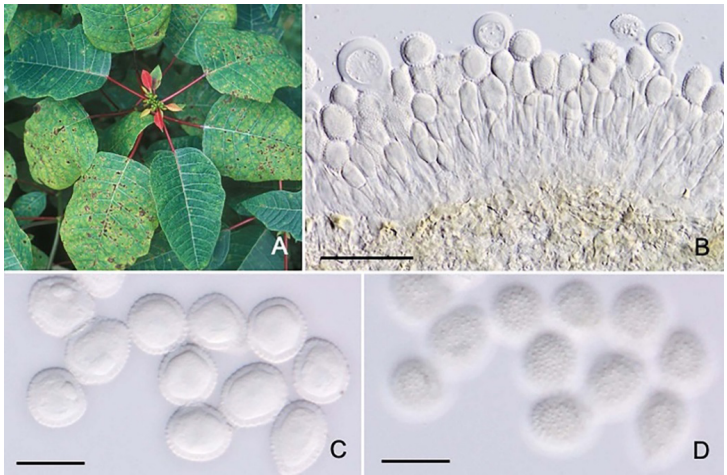

Figure 3. *Melampsora euphorbiae* on *Euphorbia pulcherrima* (IBAR9199). A. Heavily rust-infected poinsettia leaves. B. Cross section of uredinium. The sorus is intermixed with thick-walled capitate or clavate paraphyses. The spores are singly produced on a pedicel. C. Urediniospores focused on the transverse plane. D. Urediniospores (the same as C) focused on the upper surface. The wall is strongly and densely echinulate. Bars: B 50 µm; C, D 20 µm.

Milesina philippinensis Syd., in Sydow and Petrak, Ann. Mycol. 29: 172. 1931. Fig. 4

On *Nephrolepis* sp. (*Oleandraceae*), Pahang, Genting Highland, Tropical Forest Sanctuary, 550m asl, 21 Nov 2005 Y. Ono (U; IBAR9636).

Morphology: Uredinia minute, densely or loosely grouped on the abaxial leaf surface, Milesia-type, pustulate covered by host epidermis and fungal peridium (Fig. 4A), with a few thin-walled cylindrical paraphyses at periphery, rupturing by irregular central aperture. Urediniospores produced on a short pedicel, appearing almost sessile, obovoid, obovoid-ellipsoid or oblong-ellipsoid, and 18–25 × 15–20 µm in size (Fig. 4B); the wall thin, colorless (Fig. 4C), minutely and densely echinulate (Fig. 4D). Teliospores not seen.

Commentary: Sydow and Petrak (1931) described numerous paraphyses, that are thin-walled and mostly clavate and surrounding uredinia. Only a few marginal paraphyses are present in our collection. This fungus has been reported only on *Nephrolepis cordifollia* (L.) C. Presl. from the Philippines (Sydow and Petrak 1931; Teodoro 1937), Taiwan (Hiratsuka and Hashioka 1935; Hsu *et al*. 2002), and Japan (Morimoto 1953; Hiratsuka *et al*. 1955). Telial stage has not been discovered for this fungus.

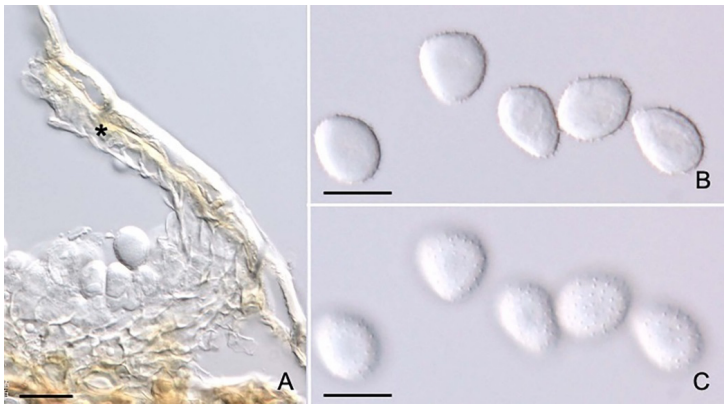

Figure 4. *Milesina philippinensis* on *Nephrolepis* sp. (IBAR9636). A. Cross section of uredinium. The sorus is covered with thin-walled peridium (asterisk). B. Urediniospores focused on the transverse plane. C. Urediniospores (the same as B) focused on the upper surface. The wall is strongly echinulate. Bars: 20 µm.

Neoolivea tectonae (Racib.) Aime & McTaggart, Fungal Systematics and Evolution 7: 40. 2020. Fig. 5

On *Tectona grandis* L. (*Laminaceae*), Penang, Penang Botanical Garden, 18 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U; IBAR9025); Perak, near Pahat, ca. 15 km north of Gerik, on Rt 76, 15 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U; IBAR8993).

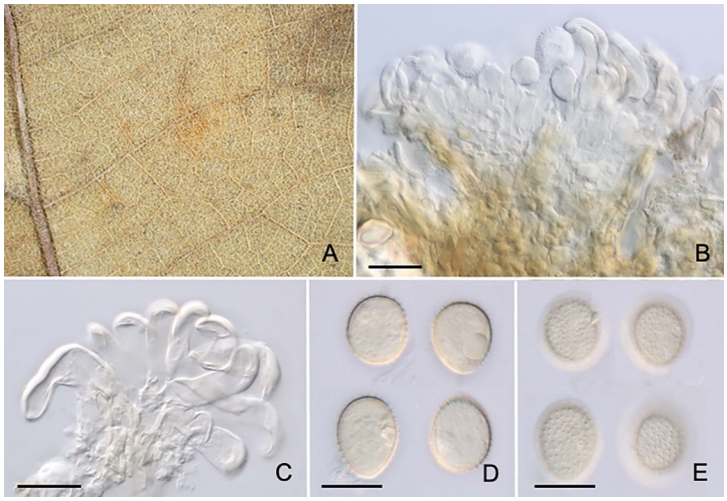

Figure 5. *Neoolivea tectonae* on *Tectona grandis* (IBAR9025). A. Minute uredinia (yellowish powder) densely produced on the abaxial leaf surface. B. Cross section of uredinium. The uredinium is Malupa-type, densely surrounded by cylindrical, incurved paraphyses. C. Dorsally thick-walled paraphyses arising from basal pseudoparenchyma. D. Urediniospores focused on the transverse plane. E. Urediniospores (the same as E) focused on the upper surface. The wall is minutely and densely echinulate. Bars: 20 µm.

Phakopsora cingens (Syd. &P. Syd.) Hirats., Bot. Mag (Tokyo) 50: 2. 1936. Fig. 6A–D

On *Glochidion* sp. (*Phyllanthaceae*), Perlis, Wang Klian, on Rt 15, 16 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U & T; IBAR8999).

Morphology: Sori produced in dense or loose groups on light or dark brownish lesions on the abaxial leaf

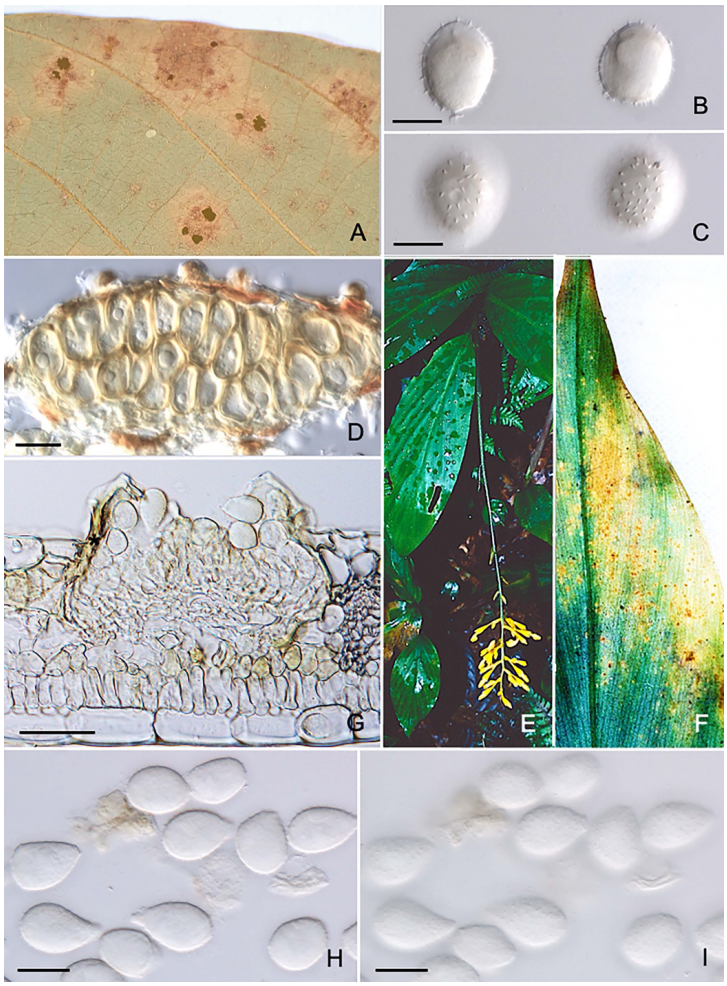

Figure 6. A–D: *Phakopsora cingens* on *Glochidion* sp. (IBAR8999). E–I: *Phakopsora elettariae* on *Globba pendula* (IBAR9642). A. Uredinia (pale brownish pustules) and telia (dark or blackish brown crusts) produced on the abaxial leaf surface. B. Urediniospores focused on the transverse plane. The wall is apically thickened. C. Urediniospores (the same as B) focused on the upper surface. The wall is uniformly and strongly echinulate. Germ pores are distributed on the equatorial zone. D. Cross section of telium. Teliospores are angular-ellipsoid or oblong-ellipsoid, produced in two to four layers. E. Flowering *Globba pendula*. F. Uredinia (brown dots) produced on the abaxial leaf surface. G. Cross section of uredinium. The sorus is covered by thin-walled peridium. H. Urediniospores focused on the transverse plane. I. Urediniospores (the same as H) focused on the upper surface. The wall is uniformly echinulate. Bars: B–D, H, I 20 µm; G 50 µm.

surface (Fig. 6A). Uredinia subepidermal in origin, Milesia-type covered by thin-walled peridium, erumpent, powdery, and light yellowish brown. Urediniospores singly produced on a short pedicel, appearing almost sessile, obovoid, obovoid-ellipsoid, or oblong-ellipsoid, and 29–40 × 23–30 µm in size (Fig. 6B); the wall pale yellowish brown or light cinnamon-brown, 2.5–3.5 µm at side, up to 6 µm thick apically, and completely echinulate; 4 or 6 germ pores distributed on the equatorial zone or scattered (Fig. 6C). Telia subepidermal, 2- to 4-spore layered; individual teliospores angular-subglobose, ellipsoid or oblong, and 22–35 × 12–20 µm in size (Fig. 6D); the wall dark cinnamon-brown or chestnut-brown, 2–2.5 µm thick at side, and up to 4 µm apically.

Phakopsora elettariae (Racib.) Cummins, Mycologia 33:380. 1941. Fig. 6E–I

On *Alpinia* sp. (*Zingiberaceae*), Penang, Penang Botanical Garden, 8 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U; IBAR9024); on *Globba pendula* Roxb. (*Zingiberaceae*), Pahang, Cameron Highlands, Tanah Rata, 1400m asl, 21 Nov 2005 Y. Ono (U; IBAR9642); and on *Zingiber* sp. (*Zingiberaceae*), Pahang, Frazer Hills, ca. 1200m asl, 19 Nov 2005 Y. Ono (U; IBAR9627), Cameron Highlands, Bring Chang, ca. 1500m asl, 23 Nov 2005 Y. Ono (U; IBAR9656).

Morphology—Uredinia minute, densely or loosely grouped on dark brownish lesions along veins or on yellowish, diffused lesions (Fig. 6F) on the abaxial leaf surface, often covering large part of the leaves (Fig. 6F); subepidermal in origin, Milesia-type, covered by thin-walled peridial layers (Fig. 6G), becoming erumpent, powdery, and yellowish. Urediniospores singly produced on a short pedicel, appearing almost sessile, obovoid-ellipsoid or pyriform, and 24–34 × (15–)17–22 µm in size (Fig. 6H); the wall light yellowish brown or almost colorless, ca. 1.5 µm, and uniformly echinulate (Fig. 6I); germ pores obscure and probably 2 distributed on the equatorial zone.

Commentary: *Globba* (Fig. 6E) is a new host genus for this rust fungus. Host genera previously reported include *Alpinia* in Indonesia (Boedijn 1959) and Thailand (Ono *et al*. 2022a), *Amomum* in Papua New Guinea (Shaw 1984), *Curcuma* in Indonesia (Boedijn 1959), *Homstedtia* in Australia (Shivas and Alcorn 1996), *Phaeomeria* in Indonesia (Boedijn 1959), and *Zingiber* in Indonesia (Boedijn 1959; Watson 1971), Thailand (Ono *et al*. 2022a), and Papua New Guinea (Watson 1971).

Puccinia absinthii DC., Encycl. Méth. Bot. 8: 245. 1808. Fig. 7A, B

On *Artemisia* sp. (*Asteraceae*), Penang, Penang Hills, 13 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U; IBAR8986).

Puccinia citrina P. Syd. & Syd., Monogr. Uredin. (Lipsiae) 1: 634. 1903 (1904). Fig. 7C, D

On *Smilax* sp. (*Smilacaceae*), Perak, Banding Island, 14 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum 02-13 (T; IBAR8990).

Puccinia dianellae (Dietel) McTaggart & R.G. Shivas, in Marin-Felix *et al*., Stud. Mycol. 86: 195. 2017. Fig. 7E–H

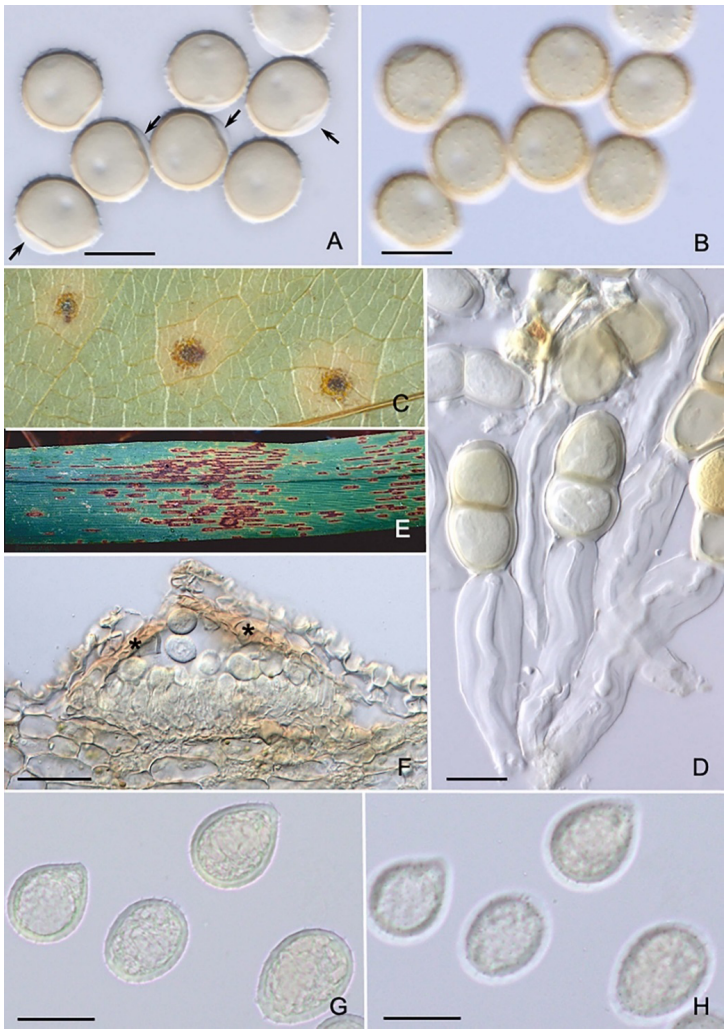

Figure 7. A & B: *Puccinia absinthii* on *Artemisia* sp. (IBAR8986). C & D: *Puccinia citrina* on *Smilax* sp. (IBAR8990). E–H: *Puccinia dianellae* on *Dianella ensifolia* (IBAR9683). A. Urediniospores focused on the transverse plane. Three germ pores are distributed on the equatorial zone. Each germ pore is covered by a transparent cap (arrows). B. Urediniospores (the same as A) focused on the upper surface. The wall is uniformly echinulate. C. Minute telia produced in dense groups on pale yellowish lesions on the abaxial leaf surface. D. Teliospores with a hygroscopic pedicel. The wall appears characteristically pale lemon-yellow. E. Uredinia linearly arranged on purplish brown lesions on the abaxial leaf surface. F. Cross section of uredinium. The sorus is covered by thick-walled peridium (asterisks). G. Urediniospores focused on the transverse plane. H. Urediniospores (the same as G) focused on the upper surface. The wall is uniformly echinulate. Bars: A, B, D, G, H 20 µm; F 50 µm.

On *Dianella ensifolia* (L.) DC. (*Xanthorrhoeaceae*), Pahang, Cameron Highlands, Tanah Rata, ca. 1400m asl, 21 Nov 2005 Y. Ono (U; IBAR9638)

Commentary: Only uredinial stage is known for this fungus. Taxonomic placement of this fungus in the

genus *Puccinia* is determined by a molecular phylogenetic analysis (Marin-Felix *et al*. 2017).

Puccinia oxalidis Dietel & Ellis, in Dietel, Hedwigia 34: 291. 1895. Fig. 8

On *Oxalis debilis* Kunth (*Oxalidaceae*), Pahang, Frazer Hills, 1200m asl, 19 Nov 2005 Y. Ono (U; IBAR9619).

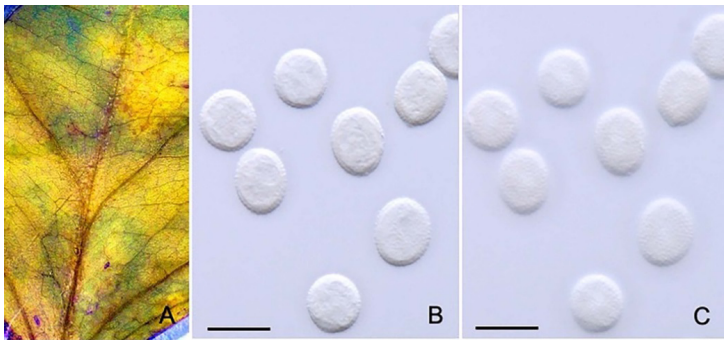

Figure 8 *Puccinia oxalidis* on *Oxalis debilis* (IBAR9619). A. Minute uredinia densely grouped on the abaxial leaf surface. B. Urediniospores focused on the transverse plane. C. Urediniospores (the same as B) focused on the upper surface. The wall is finely echinulate wall. Bars: 20 µm.

Puccinia pelargonii-zonalis Doidge, Bothalia 2: 98, 203. 1927. Fig. 9

On *Pelargonium* sp. (probably *Pelargonium* × *hortorum* L. H. Bailey) (*Geraniaceae*), Pahang, Cameron Highlands, Tanah Rata, on a trail behind Century Pines Resort, 1400m asl, 21 Nov 2005 Y. Ono (U; IBAR9637).

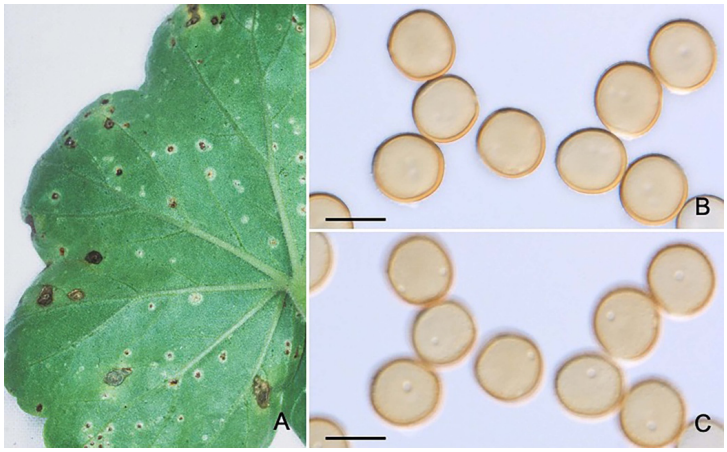

Figure 9. *Puccinia pelargonii-zonalis* on *Pelargonium* sp. (probably *Pelargonium* × *hortorum*) (IBAR9637). A. Uredinia (dark brown spots) produced on whitish, circular lesions on the abaxial leaf surface. B. Urediniospores focused on the transverse plane. C. Urediniospores (the same as B) focused on the upper surface. The wall minutely echinulate. Two or three germ pores are distributed on the equatorial or supraequatorial zone. Bars: 20 µm.

Ravenelia hobsonii Cooke, Journ. Roy. Microscop. Soc. 3: 386. 1880. Fig. 10

On *Pongamia pinnata* (L.) Pierre (*Fabaceae*), Penang, Muka Head, 2 Dec 2003. Y. Ono (U & T; IBAR9194).

Commentary: This fungus is widely distributed in Asia (Cannon 2008; Ono 2023). The autoecious macrocycic life cycle of this fungus was fully described by Ono (2023).

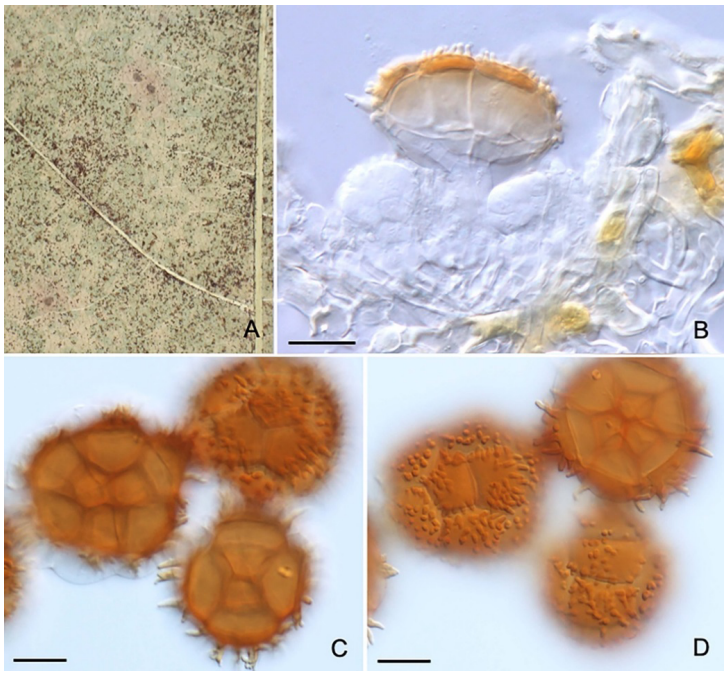

Figure 10 *Ravenelia hobsonii* on *Pongamia pinnata* (IBAR9194). A. Telia (purplish brown dots) produced on the abaxial leaf surface. B. Cross section of telium. C. Teliospores focused on the transverse plane. D. Teliospores (the same as G) focused on the upper surface (left and bottom) and on the lower surface (right top). The wall of central cells is prominently verrucose (left and bottom), and spear-shaped appendages are attached to the marginal cells (right top). Bars: 20 µm.

Uredo cassiae-glaucae Syd. & P. Syd., Ann. Mycol. 1: 331. 1903. Fig. 11

On *Cassia* sp. (*Fabaceae*), Penang, Penang Botanical Garden, 18 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U; IBAR9028).

Morphology: Uredinia produced mostly on leaf veins or scattered on the abaxial surface (Fig. 11A). Uredinia subcuticular in origin, soon erumpent, Uredo-type with no paraphyses or peridium (Fig.11B), dark cinnamon-brown, and powdery. Urediniospores singly produced on a pedicel, subglobose, obovoid or obovoid-ellipsoid, and 17–23 × 12–17 µm in size (Fig. 11C); the wall ca. 1.5 µm thick, light cinnamon-brown, and completely echinulate; six to eight germ pores scattered on the wall (Fig. 11 D).

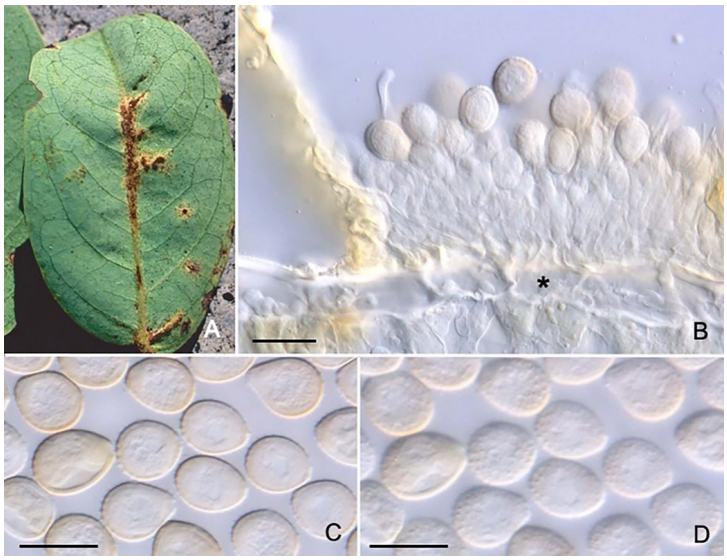

Figure 11. *Uredo cassiae-glaucae* on *Cassia* sp. (IBAR9028). A. Uredinia produced mostly on leaf veins on the abaxial surface. B. Cross section of uredinium. The sorus is produced between the host cuticle and epidermal cells (asterisk). C. Urediniospores focused on the transverse plane. D. Urediniospores focused on the upper surface. The wall is uniformly and densely echinulate. Six to eight germ pores are scattered on the wall. Bars: 20 µm.

Uredo dioscoreae-filiformis Racib., Parasit. Alg. Pilze Java's (Jakarta) 1: 29. 1900. Fig. 12

On *Dioscorea* sp. (*Dioscoreaceae*), Kedah, Gunung Jerai, ca. 1100m asl. 17 Dec 2002. Y. Ono, M. Imazu and J. Engkhaninum (U; IBAR 9018).

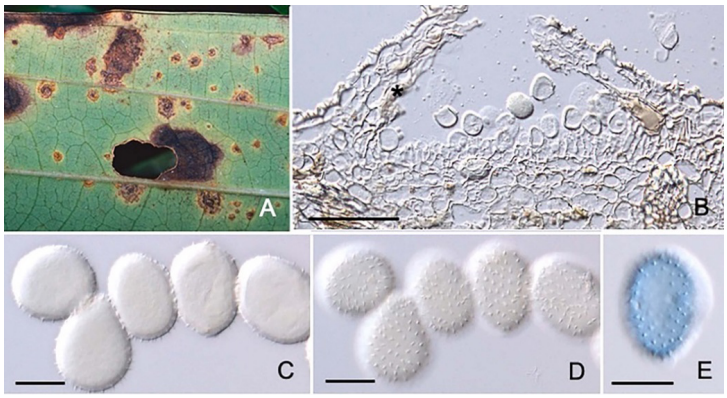

Figure 12. *Uredo dioscoreae-filiformis* on *Dioscorea* sp. (IBAR9018). Uredinia produced in dense groups on yellowish circular lesions on the abaxial leaf surface. B. Cross section of uredinium. The sorus is covered by thin-walled peridium. C. Urediniospores focused on the transverse plane. D. Urediniospores (the same as C) focused on the upper surface. The wall is uniformly and strongly echinulate. E. Equatorial germ pores in urediniospores (stained with aniline-blue). Bars: B 100 µm; D–E 20 µm.

Morphology: Uredinia minute, in dense groups on yellowish circular lesions on the abaxial leaf surface (Fig. 12A). Uredinia subepidermal in origin, Milesia-type, covered by thin-walled peridium and the host epidermis, erumpent through a central aperture (Fig. 12B). Urediniospores singly produced on a short pedicel, subglobose, obovoid or ellipsoid, and 30–40(–45) × 20–28 µm in size; the wall ca. 1.5 µm thick at sides, up to 4.5 µm thick at the apex colorless, and uniformly and strongly echinulate (Fig.12C, D); with four germ pores distributed on the equatorial zone (Fig. 12E).

Commentary: This fungus has been recorded on *D. filiformis* Blume in Indonesia (Bodijn 1959; Ono 1982) and *D. nummularia* Lam. in the Philippines (Arthur and Cummins 1936a; Ono 1982).

Uredo gardeniicola Kakish. & Tak. Kobay. [as *gardenicola*], Mycologia 86: 263. 1994. Fig. 13

On *Gardenia jasminoides* J. Ellis (*Rubiaceae*), Penang, Youth Park near the Botanical Garden, 15 Nov 2005 Y. Ono (U; IBAR9608).

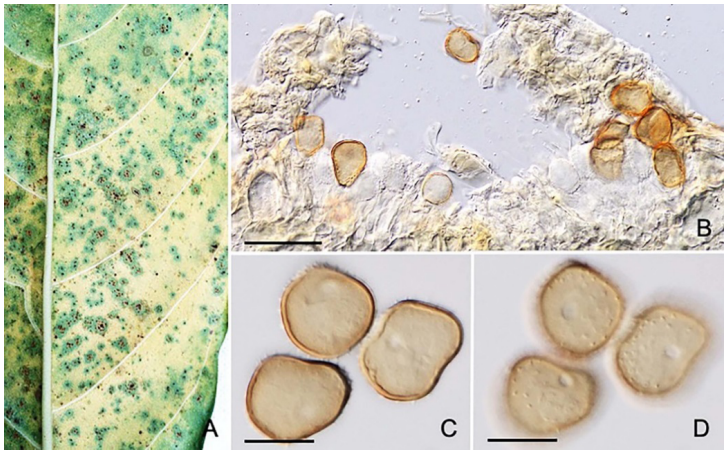

Figure 13. *Uredo gardeniicola* on *Gardenia jasminoides* (IBAR9608). A. Minute uredinia (dark brown spots) scattered or in loose groups on the abaxial leaf surface. B. Cross section of uredinium. C. Urediniospores focused on the transverse plane. D. Urediniospores (the same as C) focused on the upper surface. The wall is uniformly echinulate. Two germ pores are distributed on the subequatorial zone. Bars: 20 µm.

Morphology: Uredinia minute, scattered or in loose groups on the abaxial leaf surface (Fig. 13A); subepidermal in origin, soon erumpent, Uredo-type without peridium or paraphysis (Fig. 13B), and 25–34 × 20–27 µm in size; the wall 1–1.5 µm thick, cinnamon-brown or light chestnut-brown, and uniformly echinulate; two germ pores distributed on subequatorial zone (Fig. 13C, D).

Commentary: This fungus had been known only from the type collection on *G. jasminoides* (reported as *G. angusta* Merr.) from Bogor (west Java) and three additional collections on the same host species from Borobudur (central Java), Cianjur (west Java), and Lampung (Sumatra) (Kakishima and Kobayashi 1994). Kakishima and Kobayashi (1994) were not able to observe urediniospore germ pores in the specimens examined.

Uredo musae Cummins, Mycologia 33, 151. 1941. Fig. 14

On *Musa* aff. *acuminata* Colla (*Musaceae*), Pahang, Genting Highland, 350m asl, 21 Nov 2005. Y. Ono (U & T; IBAR 9628); Tropical Forest Sanctuary, 550m asl, 21 Nov 2005 Y. Ono (U; IBAR 9635); Cameron Highlands, Tanah Rata, on a trail behind Century Pines Resort, alt. 1400m asl, 21 Nov 2005 Y. Ono (U; IBAR9646).

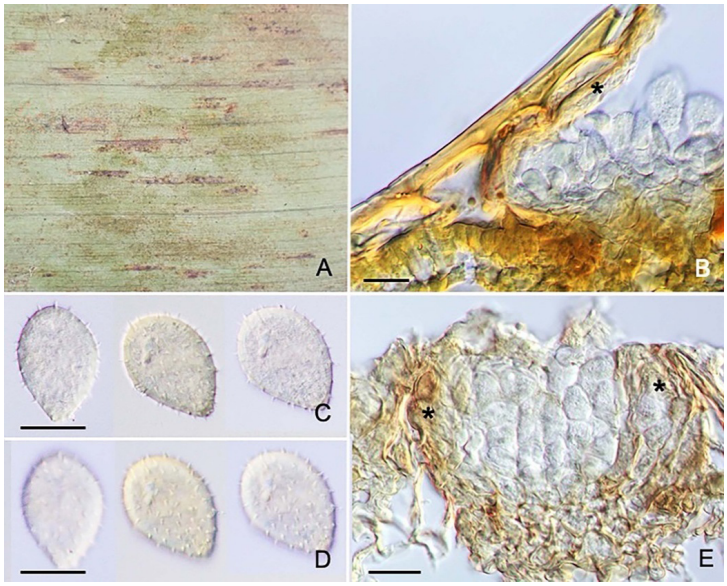

Figure 14. *Uredo musae* on *Musa* aff. *acuminata* (IBAR9628). A. Minute uredinia and telia (dark brown dots) linearly arranged between veins on the abaxial leaf surface. B. Cross section of uredinium. The sorus is covered by thin-walled peridium (asterisk). C. Urediniospores focused on the transverse plane. D. Urediniospores (the same as C) focused on the upper surface, showing completely echinulate wall. E. Cross section of telium. The sorus is surrounded by thin-walled peridial layers (asterisks). Teliospores are produced in basipetal succession.

Morphology: Uredinia and telia linearly arranged between veins on the abaxial leaf surface (Fig. 14A). Uredinia subepidermal in origin, erumpent, Milesia-type, covered by thin-walled peridium, (Fig. 14B), powdery, and pale yellowish brown or almost whitish. Urediniospores singly produced on a short pedicel, obovoid, obovoid-ellipsoid or pyriform, and 29–38 × 20–27 µm in size; the wall ca.1.5 µm thick, pale yellowish brown or almost colorless, and strongly echinulate; no germ pores detected (Fig. 14C, D). Telia subepidermal in origin, surrounded by thin-walled peridial layers (Fig. 14E). Teliospores are produced in basipetal succession, teliospore chains laterally free; individual teliosores angular-subglobose, ellipsoid or oblong, and 12–20 × 8–12 µm in size; the wall thin, colorless, and smooth (Fig. 14E).

Commentary: This fungus has been reported on *M. banksii* F. Muell. (as *M. acuminata* subsp. *banksii* (F. Muell.) N.W. Simmonds) in Samoa (Dingley *et al*. 1981), *Musa* × *paradisiaca* L. (as *Musa* × *sapientum* L.) in Sarawak in Malaysia (Turner 1971, Singh 1980) and in Indonesia (Boedijn 1959), and Musa sp. in Fiji (Dingley *et al*. 1981), Papua New Guinea (Shaw 1984; Cummins 1941), Samoa (McKenzie 1996; Dingley

et al. 1981), and Thailand (Engkhaninun *et al*. 2005). It occurs on *Musa* species, from which hybrid cultivars have derived, and is widely distributed in Southeast Asia, Australasia, and South Pacific. It is potentially dangerous to become an emergent pathogen under certain climatic conditions and cultural practices in banana plantations in these regions.

Only uredinial stage had been known for this fungus. Our morphological study revealed telia intermixed with uredinia in one of three specimens from state of Pahang. The teliospores are single-celled and produced in basipetal succession. The teliospore chains are laterally free, and upper teliospore cells readily fall apart. The developmental morphology of telia and teliospores indicate the taxonomic affinity of this fungus to the genus *Cerotelium* (Ono *et al*. 1992; Ono 2015).

Disclosure

The authors declare no conflict of interests.

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