INOCYBE IN PENINSULAR MALAYSIA

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Nine species of *Inocybe* (Basidiomycotina, Cortinariaceae) are described from Malaysia. *Inocybe aurantiocystidiata* is described as a new species and *I. palaeotropica* is proposed as a new name. *Astrosporina aequalis* is combined in *Inocybe.*

INTRODUCTION

In temperate regions *Inocybe* (Fr.) Fr. is a very common and widespread genus and it is not unusual to gather many species on one collecting trip. It is probably also an ecologically important genus as some members have been proved to form ectomycorrhizas (Ingleby et al., 1990). By contrast, in Peninsular Malaysia, species of *Inocybe* are only occasionally found and even these occurrences are erratic. Chipp (1921) listed only three species from the peninsula: *I. longipes* Massee, *I. umbrina* Massee and *I. violacea* Massee. Of these *I. umbrina* is described below and the other two were rejected from the genus by Horak (1980). A further eight species have been found during the present study.

Horak (1979) made the first analysis of *Inocybe* species (as *Astrosporina*) from Indomalaya and Australasia primarily based on Corner's collections. These collections have also been referred to herein, as have those made by Horak from New Zealand, Papua New Guinea and Borneo (Horak, 1977).

For many years *Inocybe* has been the centre of much discussion. Some authors maintain a single genus, others accept the autonomy of two with the difference based on spore morphology — smooth outline in one and nodulose in the other. Horak is a recent supporter of this separation. *Astrosporina* was the genus created for the nodulose-spored group by Schroeter (1889); it was accepted by Rea (1922) but has been little used since. As remarked by Heim (1931), there is no clear demarcation line between those species with a smooth spore outline and those with a nodulose one and therefore such a classification is considered artificial. However, as a distinguishing character in keys, this separation is quite useful and is still foremost in identifications. It is therefore proposed to follow herein the long tradition adopted by Kuyper (1986), Alessio (1980), Heim (1931) and others, and to maintain a single genus.

In Europe, *Inocybe* forms ectomycorrhizal relationships with many different hosts, some species exhibiting host specificity. If they are suspected of forming such relationships in Peninsular Malaysia, then suitable hosts must be sought. In the collecting sites visited during this study there is an abundance of Dipterocarpaceae. Members of the Fagaceae are also present although to a much lesser degree. Both families are

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known to form ectomycorrhizal relationships with other fungal genera (Redhead, 1980) and are therefore considered to be potential ectomycorrhizal hosts for *Inocybe*.

STUDY SITES AND METHODS

The fungi studied herein were collected from three sites: Selangor (in the grounds of the Forest Research Institute Malaysia (FRIM), Kepong, 3°13′N 101°38′E), Sungai Lallang (a lowland rainforest area, 3°04′N 101°52′E) and Negeri Sembilan (at an outstation of FRIM at Pasoh, 3°00′N 102°20′E). Collections were made by the author, Dr Roy Watling and Dr Lee Su See (FRIM) over a four-year period (1991–94). Most of the specimens dealt with were studied in a fresh condition by the author, but others had already been described and dried by the other collectors. All have been examined both macroscopically and microscopically.

On collecting, the specimens were carefully wrapped in waxed paper and taken back to the laboratory where they were collated and described; the colours of fresh specimens were compared with the *British Fungus Flora Colour Identification Chart* (Henderson et al., 1969). The specimens were then air-dried at 40°C, packaged with a small quantity of silica gel (as a desiccant) and sent back to Edinburgh. Microscopical examinations were carried out using 10% aqueous ammoniacal solution under a ×100 oil-immersion objective. Scanning electron microscopy was carried out using a Zeiss DSM 962.

KEY TO THE MALAYSIAN SPECIES

1a. Basidiospores smooth — 2
1b. Basidiospores nodulose, stellate, verrucose or spiny — 5

2a. Basidiospores globose to subglobose, 5.2–6.1μm — **9. I. sphaerospora**
2b. Basidiospores ovoid, ellipsoid to subphaseoliform — 3

3a. Pileus brown, covered with conspicuous, spiny squamules; basidiospores ovoid, 8.3–8.7 × 5.2μm — **6. I. fuscospinulosa**
(*I. latericia* Horak is similar but differs in its reniform to phaseoliform basidiospores, 9–11.5 × 5–6.5μm)
3b. Pileus lacking squamules, rimose to strongly fibrillose — 4

4a. Pileus reddish to greyish brown; gills distant; basidiospores ellipsoid, 7.9–10.5 × 5.2–6μm — **5. I. cutifracta**
4b. Pileus yellow to ochre; gills crowded; basidiospores ovoid to subphaseoliform, 7–8.3 × 4.8–5.7(–6.5)μm — **8. I. palaeotropica**

5a. Basidiospores ovoid-ellipsoid with distinct, spiny projections, 10.5–11.4(–12.2) × 8.7–10.5μm; pileus scaly over distinct umbo — **3. I. aurantiocystidiata**
5b. Basidiospores nodulose, stellate or verrucose — 6

6a. Basidiospores stellately nodulose, 10.5–12.2 × 10.1–11.8μm; pileus pale brown to fuscous; margin conspicuously rimose — **2. I. asterospora**
6b. Basidiospores less than 9μm in length — 7

7a. Pileus and stipe with violaceous colour; basidiospores nodulose, 7.9–8.3 × 7μm ——— **4. I. corneri**

7b. Basidiome without violaceous colours ——— 8

8a. Pileus and stipe orange to apricot colour; basidiospores nodulose, 7.9–8.3(–8.7) × (5.8–)6.5–7μm ——— **7. I. lutea**
(*I. trechispora* (Berk.) P. Karst. is similar but differs in its duller colours and viscid pileus)

8b. Pileus beige to avellaneous colour; basidiospores with low, less pronounced knobs, 7.9–8.7 × (6.5–)7–7.4(–7.9)μm ——— **1. I. aequalis**

THE SPECIES

1. Inocybe aequalis (Horak) Turnbull & Watling, **comb. nov. Fig. 1A.**
Basionym: *Astrosporina aequalis* Horak in New Zealand J. Bot. 15: 741 (1977).

This species was first described from New Zealand where it was found on soil under *Leptospermum* spp. (Myrtaceae) (Horak, 1977).

Macroscopically it resembles *Inocybe asterospora* Quél. in its beige to avellaneous pileus which is convex to campanulate, rimose-fibrillose and splitting towards the margin. The stipe is concolorous with the pileus, pruinose along the entire length and has a marginate bulb. The gills, which are also concolorous, are adnexed and have a white edge. Microscopically it is easily distinguished by its basidiospores that are ovoid with numerous hemispherical to convex knobs and measure 7.5–10 × 7–8μm, compared with the larger stellate nodulose spores of *I. asterospora* that measure 9–12μm diameter. The basidiospores of the specimens of *I. aequalis* from Malaysia measure 7.9–8.7 × (6.5–)7–7.4(–7.9)μm (Fig. 1A).

In Malaysia, *I. aequalis* has been found growing with members of the Dipterocarpaceae with which it is suspected of forming ectomycorrhizal relationships.

Specimens examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Scorodocarpus borneensis* (Baillon) Becc. (Olacaceae) although associated with *Dryobalanops* sp., 10 iii 1992, *Watling* 24593 (E); ibid., with *Shorea bracteolata* Dyer, 10 iv 1993, *Lee* 846 (KEP)* ; ibid., with *Neobalanocarpus heimii* (King) Ashton, 22 ii 1994, *Watling* 25734 (E).

2. Inocybe asterospora Quél. in Bull. Soc. Bot. France 26: 50 (1880 ['1879']). **Fig. 1B.**
Syn.: *Astrosporina asterospora* (Quél.) Rea, Brit. Basidiomyc.: 210 (1922).

I. asterospora, originally described from France, also occurs in Japan (Imazeki & Hongo, 1971), and in New Zealand where it was found in association with *Leptospermum ericoides* Rich. (Myrtaceae) (Horak, 1977). European collections are identical to those described from the Far East and New Zealand (Horak, 1977).

This species is characterized by its bistre brown pileus which has a conic umbo, becoming conspicuously rimose towards the margin, and the stipe which is com-

* Specimens cited '(KEP)' are under the care of Dr Lee Su See at the Forest Pathology Laboratory (FRIM) until suitable herbarium facilities become available.

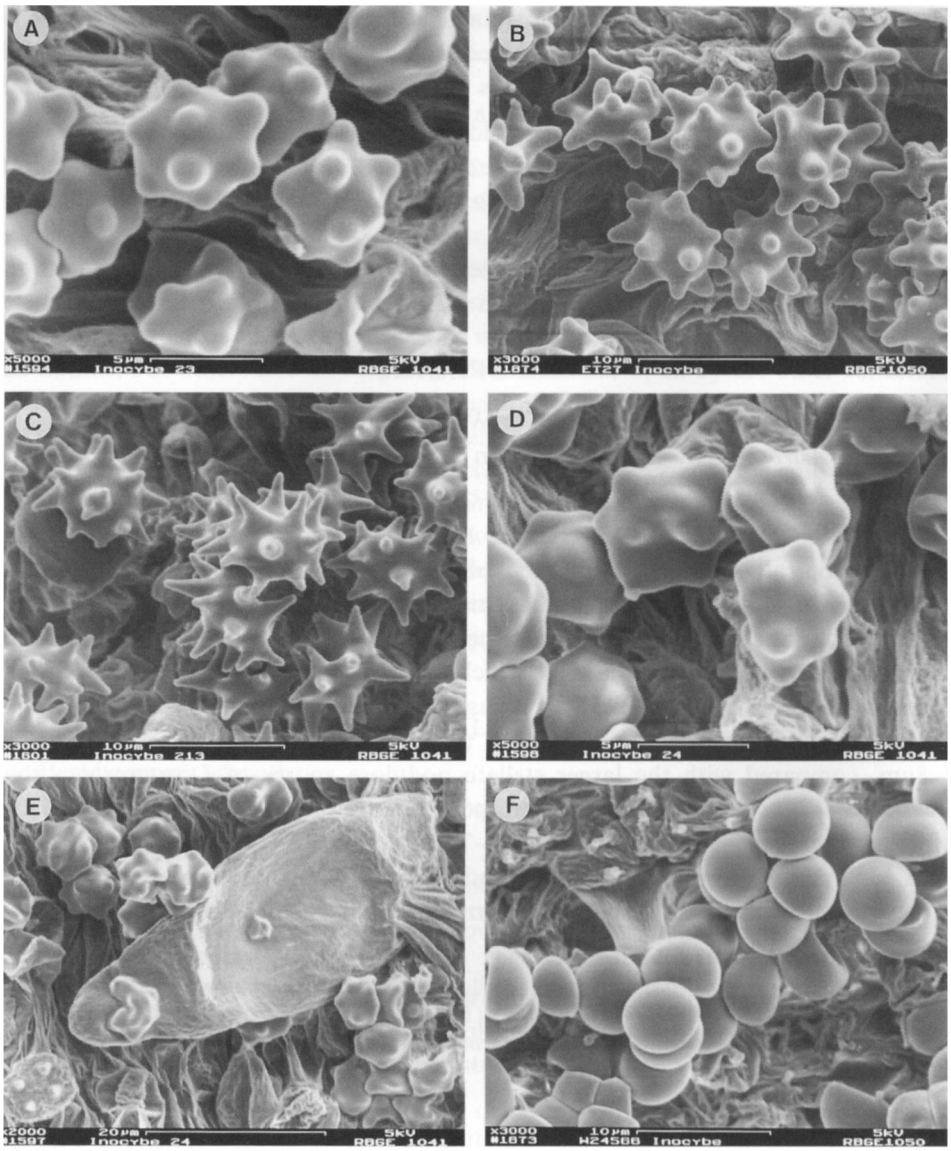

FIG. 1. A, *Inocybe aequalis* (*Watling* 25734); B, *I. asterospora* (*Turnbull* 27); C, *I. aurantiocystidiata* (*Watling* 25737); D & E, *I. lutea* (*Watling* 25735); F, *I. sphaerospora* (*Watling* 24566). A–D & F, basidiospores; E, pleurocystidia.

pletely pruinose and has a marginate bulb. The basidiospores measure 9–12μm diameter and are stellately nodulose in contrast to *I. aequalis* q.v. The basidiospores of the Malaysian collection measure 10.5–12.2 × 10.1–11.8μm (Fig. 1B).

In Malaysia, *I. asterospora* has been found with Dipterocarpaceae.

Specimen examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Shorea sumatrana* (V. Sl.: Foxw.) Sym., 19 iii 1993, *Turnbull* 27 (E).

3. Inocybe aurantiocystidiata Turnbull & Watling, **sp. nov. Fig. 1C.**
Pileus 12mm, conicus obtuse umbonatus siccus, umbrinus, radialiter fibrillosus vel rimosus, ad discum squamulis obscure brunneis ± conlectis. *Stipes* 40 × 3mm, argillaceus sub violaceo-vinaceus tincto. *Lamellae* brunneae ad aciem pallidiores flocculosae. *Caro* avellanea vel vinacea. *Basidia* 4-sporigera. *Sporae* ovoideae-ellipsoideae prominenter nodulato-cristatae, 10.5–11.4(–12.2) × 8.7–10.5μm. *Cystidia* faciei lamellarum tenuiter tunicata, 34.8–48 × 7.6–12 × 3.3–5.5μm, materiae colloidalis clare aurantiae plena.
Holotypus: Malaysia, Negeri Sembilan, Pasoh, 2 iii 1994, *Watling* 25737 (E).

Pileus 12mm, conical with an obtuse umbo, dry, fibrillose becoming radially striate, cigar to date brown with a covering of paler, scurfy, snuff brown scales concentrated over the umbo. *Stipe* 40 × 3mm, clay buff with vinaceous tinge, veil adhering at apex, bulb emarginate. *Lamellae* cigar brown with a paler, snuff brown edge. *Flesh* hazel to vinaceous. *Basidia* 4-spored. *Basidiospores* 10.5–11.4(–12.2) × 8.7–10.5μm, ovoid-ellipsoid with distinct conical projections, some even saddle-shaped. *Pleurocystidia* thin-walled, elongate clavate, seated in the hymenium or even into the subhymenium, hyaline or honey-coloured and filled to some degree with bright, orange-yellow colloidal material, 34.8–48μm long, 7.6–12μm at head tapering to 3.3–5.5μm at the base.

Microscopically this species comes closest to *Astrosporina hydrocybiformis* Corner & Horak which was transferred to *Inocybe* by Garrido (1988). However, *I. aurantiocystidiata* differs in having numerous thin-walled pleurocystidia, which possess strong orange-yellow colloidal inclusions, and in the more ellipsoid basidiospores (Fig. 1C). The presence of pleurocystidia excludes *I. aurantiocystidiata* from subgenus *Leptocybe* Kobayashi (Kobayashi, 1993) where *A. hydrocybiformis* is placed. The two species also differ macroscopically in that *A. hydrocybiformis* lacks the distinctive pileal squamules and has more yellowish tones overall. *I. lasseri* Dennis and *I. lasseroides* Horak show some similarities to *I. aurantiocystidiata* but both have a more bifurcate spore-ornamentation.

Specimens examined. MALAYSIA. Negeri Sembilan: Pasoh, FRIM Field Station, under *Shorea* spp., 17 iii 1992, *Watling* 25436 (E); ibid., under *Shorea* spp., 2 iii 1994, *Watling* 25737 (E).

4. Inocybe corneri (Horak) Garrido in Biblioth. Mycol. 120: 176 (1988).
Syn.: *Astrosporina corneri* Horak in Persoonia 10: 184 (1979).

This species was first found growing on forest soil in Sabah (Horak, 1979). It is characterized by its violaceous to violaceous brown pileus which starts radially fibrillose and becomes rimose. It is convex or plane with an acute umbo. The stipe, which

is pruinose at the apex and fibrillose-tomentose towards the base, starts pale violaceous or lilaceous finally becoming pale yellow.

The colouring and shape of the fruit-body of this species resemble *A. magnifica* Horak, which has been found in Papua New Guinea under *Nothofagus* sp. However, they can be distinguished microscopically by the size and shape of the basidiospores and cheilocystidia. The basidiospores of *I. corneri*, measuring 7–8 × 5.5–6μm, are nodulose with hemispheric knobs, compared with the more nodular, occasionally cruciform, basidiospores of *A. magnifica*. The basidiospores of the Kepong collection measure 7.9–8.3 × 7μm, slightly broader than the type but agreeing in all other aspects.

In Kepong, *I. corneri* has been found associated with a member of the Dipterocarpaceae.

Specimen examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Dryobalanops aromatica* Gaertn., iii 1993, *Lee* 828 (KEP).

5. Inocybe cutifracta Petch in Ann. Roy. Bot. Gard. (Peradeniya) 6: 201 (1917).

This species was first described by Petch from Sri Lanka (Petch, 1917) and has also been reported from Java (van Overeem, 1927), although this identification remains doubtful as no voucher material could be located in Bogor (Horak, 1980).

I. cutifracta is readily recognized by its conico-convex pileus that soon expands leaving the surface rimose and the margin crenate. The pileus is pale yellowish brown with a reddish brown umbo, and the stipe, which is concolorous with the pileus, is densely covered in whitish fibrils. The basidiospores of *I. cutifracta* are smooth, ovoid-ellipsoid, occasionally subphaseoliform and measure 7–11 × 4.5–6μm. The basidiospores of the Malaysian collection measure 7.9–10.5 × 5.2–6μm.

This species is closely allied to the more widespread *I. rimosa* (Bull.: Fr.) Kumm., probably better known under the synonym *I. fastigiata* (Schaeff.: Fr.) Quél. (Kuyper, 1986), but differs in the smaller habit and basidiospores.

Specimen examined. MALAYSIA. Selangor: Sungai Lallang, under mixed dipterocarps, 4 iii 1992, *Watling* 24562 (E).

6. Inocybe fuscospinulosa Corner & Horak in Persoonia 11: 11 (1980).

This species was first described from Java where it was found on soil in forest dominated by species of *Castanopsis* and *Lithocarpus* (Fagaceae) (Horak, 1980). It has also been found in Peradeniya, Sri Lanka (Pegler, 1986).

Macroscopically it is distinguished by the date brown to umber brown pileus that has conspicuous, densely packed spiny squamules.

The basidiospores are smooth, ovoid and measure 6.5–8 × 4–5μm. These are smaller than other members of section *Cervicolores* Kühner & Romagn. ex Singer (reddening flesh on exposure) and this feature, along with the narrow cheilocystidia,

distinguishes it. The basidiospores of the Malaysian collection measure 8.3–8.7 × 5.2μm.

It has been found recently in Malaysia in association with *Dipterocarpus* sp. (Dipterocarpaceae). Both Fagaceae and Dipterocarpaceae are known to form ectomycorrhizal relationships with fungi and this collection may demonstrate the ability of *Inocybe fuscospinulosa* to switch host.

Specimen examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Dipterocarpus* sp., 10 iv 1991, *Lee* 570 (KEP).

7. Inocybe lutea Kobayasi & Hongo in Nagaoa 2: 103 (1952). **Fig. 1D, E.**

This species, first described from Japan (Kobayasi, 1952), is also known from Papua New Guinea where it was growing with species of *Castanopsis* and *Lithocarpus* (Fagaceae) (Horak, 1979).

It is characterized by the dry, orange-yellow pileus which has ochraceous, radially arranged fibrils that are denser at the umbo. The concolorous stipe is pruinose with a bulbous base. In young specimens the margin of the pileus is attached to the stipe by a yellow arachnoid veil. The basidiospores of *I. lutea* are nodulose with conspicuous knobs and measure 5.5–7 × 4.5–5μm.

Specimens found recently in Malaysia have larger basidiospores (7.9–8.3(–8.7) × (5.8–)6.5–7μm), a fact which seems to be in agreement with Horak's specimens from New Guinea (Horak, 1979). The collections agree in all other aspects and have been assigned to this species (Fig. 1D).

Specimens examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Shorea parvifolia* Dyer, 19 iii 1993, *Turnbull* 37 (E); ibid., under *Shorea longisperma* Roxb., 15 iv 1993, *Lee* 866 (KEP); ibid., under mixed dipterocarps, 22 ii 1994, *Watling* 25735 (E).

8. I. palaeotropica Turnbull & Watling, **nom. nov.**
Basionym: *Inocybe umbrina* Massee in Kew Bull. 1914: 74 (1914), non *I. umbrina* Bres., Fungi Tridentini 1: 50, t.55 (1884) [= *Astrosporina umbrina* (Bres.) Rea in Trans. Br. Mycol. Soc. 12: 211 (1927)].
Holotype: Singapore, Havelock Road, 21 x 1913, *Burkill* 250 (K).

This species is well recorded from Indomalaya (Singapore, Malaysia and Sabah) and Australasia (Solomon Is. and Papua New Guinea) (Horak, 1980). It is widespread in these areas where it forms ectomycorrhizal relationships with species of *Lithocarpus* and *Castanopsis* (Fagaceae).

Unfortunately, Massee's epithet (Massee, 1914) has already been used for a European agaric; compounding this is the fact that *I. umbrina* Bres. possesses nodular spores whereas Massee's fungus has spores with a smooth outline. It is necessary therefore to maintain the separation of these two taxa in two distinct subgenera.

I. cutifracta described from Sri Lanka may be considered a possible name for this species, as Horak considers the Javan collection of the fungus as probably

conspecific with *I. umbrina* Massee (Horak, 1980). However, Pegler's analysis of the type of *I. cutifracta* (Pegler, 1986) shows a fungus with capitate cystidia not in keeping with *I. palaeotropica* (*I. umbrina* Massee).

I. palaeotropica is characterized by a fawn to ochre pileus that remains smooth at the umbo but becomes strongly rimose, even splitting, towards the margin. The stem is fibrillose to scurfy, often twisted and lacks a bulbose base. With these characters it strongly resembles *Astrosporina angustifolia* Corner & Horak, although microscopic examination soon separates them as the basidiospores of the latter are nodulose. The specimens found recently in Malaysia have been assigned to *I. palaeotropica* although they have slightly smaller basidiospores (8–10 × 6–7μm in the type description), but agree in all other aspects. A description of the Malaysian collections follows:

Pileus 20–40mm, conico-convex becoming expanded-umbonate; pale yellow or ochre, becoming umber, or ochre brown over the disc with age; rimose fibrillose towards the margin but remaining smooth to innately fibrillose over the umbo. *Stipe* 40–70 × 4–6mm, cylindric, equal, often twisted; white then brownish or concolorous with the pileus; apex with appressed fibrillose remnants of white veil; dry, strongly fibrillose. *Lamellae* adnate, white then cinnamon brown, finally brown. *Basidia* 4-spored. *Basidiospores* smooth, ovoid to subellipsoid, 7–8.3 × 4.8–5.7(–6.5)μm. *Pleurocystidia* none. *Cheilocystidia* clavate to vesiculose, thin-walled, sometimes with yellow-brown encrusting pigment, 20–55 × 10–15μm.

At the Forest Research Institute Malaysia this species has been found with members of the Dipterocarpaceae, again possibly demonstrating host switching.

Specimens examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Dryobalanops aromatica*, 2 ii 1991, *Lee* 575 (KEP); ibid., 25 ii 1993, *Lee* 726 (KEP); ibid., under mixed dipterocarps, 22 ii 1994, *Watling* 25736 (E).

9. Inocybe sphaerospora Kobayasi in Nagaoa 2: 80 (1952). **Fig. 1F.**

This species was first described from Musasi, Japan where it was growing on the ground in woods (Kobayasi, 1952). It is known also from Papua New Guinea and Singapore where it was growing with both Fagaceae and Dipterocarpaceae (Horak, 1980).

Inocybe sphaerospora is characterized macroscopically by the pale ochraceous pileus, which has persistent fibrillose patches of veil along the margin, and its rather stout, concolorous stipe. Microscopically this species is distinct from other members of the genus *Inocybe* by virtue of its globose to subglobose basidiospores, 6–6.5μm diameter. The basidiospore measurements of the specimens from Malaysia fall within the range 5.2–6.1μm.

In Malaysia it was found in association with members of the Dipterocarpaceae. This fungus again demonstrates the possible ability to switch hosts.

Specimens examined. MALAYSIA. Selangor: Kepong, Forest Research Institute Malaysia (FRIM), under *Dryobalanops oblongifolia* Dyer,7 iii 1992, *Watling* 24565 (E); ibid., under *D.*

oblongifolia, 7 iii 1992, *Watling* 24567 (E); 11 iii 1992, *Watling* 24563 (E); 11 iii 1992, *Watling* 24566 (E); ibid., under *D. oblongifolia,* 11 iii 1992, *Watling* 24564 (E); ibid., under *D. aromatica* Gaertn.f., 11 iii 1992, *Watling* 24568 (E); ibid., under *Shorea acuminata* Dyer, 21 iv 1993, *Lee* 875 (KEP).

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