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FUNGI ASSOCIATED WITH HEART ROT OF *ACACIA MANGIUM* TREES IN PENINSULAR MALAYSIA AND EAST KALIMANTAN

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LEE, S. S. & NORAINI SIKIN, Y. 1999. Fungi associated with heart rot of *Acacia mangium* trees in Peninsular Malaysia and East Kalimantan. Heart rot is a well-known defect in *Acacia mangium* trees grown in Southeast Asia. However, the identification of the fungi associated with the heart rot has been hampered by the absence of fruiting bodies or sporocarps on affected trees. Using a simple technique described in this paper, sporocarps were successfully produced for the identification of the associated heart rot fungi. Mycelial cultures obtained from *A. mangium* trees with heart rot from various locations in Peninsular Malaysia and Kalimantan, Indonesia, were tested. Based on the sporocarps produced, four species of wood decay fungi were successfully identified from the heart rot isolates. These were *Rigidoporus hypobrunneus* (Petch) Corner, *Phellinus noxius* (Corner) Cunn., *Tinctoporellus epimiltinus* (Berk. & Br.) Ryv. and *Oxyporus* cf. *latemarginatus* (Dur. & Mont. *ex* Mont.) Donk. The first three fungi were isolated from both Peninsular Malaysia and Kalimantan while *O.* cf. *latemarginatus* was only obtained from Peninsular Malaysia.

Keywords: Heart rot - fungi - *A. mangium* - Peninsular Malaysia - Kalimantan

LEE, S. S. & NORAINI SIKIN, Y. 1999. Kulat yang berasosiasi dengan reput teras pokok *Acacia mangium* di Semenanjung Malaysia dan Kalimantan Timur. Reput teras diketahui berlaku pada pokok *Acacia mangium* yang ditanam di Asia Tenggara. Bagaimanapun, kulat yang berasosiasi dengan reput teras sukar dikenali kerana jana spora atau sporokarp tidak dapat ditemui pada pokok yang diserang penyakit tersebut. Dengan menggunakan suatu teknik mudah yang dihuraikan dalam artikel ini, sporokarp dapat dihasilkan untuk tujuan mengenal kulat yang berasosiasi dengan reput teras. Kultur miselia yang berasal daripada reput teras *A. mangium* yang dikutip di beberapa tempat di Semenanjung Malaysia dan Kalimantan, Indonesia, telah diuji. Berdasarkan kepada sporokarp yang dihasilkan, empat spesies kulat reput kayu telah dapat dikenal pasti, iaitu *Rigidoporus hypobrunneus* (Petch) Corner, *Phellinus noxius* (Corner) Cunn., *Tinctoporellus epimiltinus* (Berk. & Br.) Ryv. dan *Oxyporus* cf. *latemarginatus* (Dur. & Mont. *ex* Mont.) Donk. Tiga kulat pertama didapati daripada isolat-isolat yang berasal daripada Semenanjung Malaysia dan Kalimantan, sementara kulat yang keempat hanya terdapat daripada isolat yang berasal daripada Semenanjung Malaysia.

Introduction

World-wide, forest plantations are becoming increasingly important sources for the supply of industrial wood. This trend is also evident in Southeast Asia, where countries like Indonesia, Thailand and Vietnam have established substantial areas

of forest plantations, mainly with fast-growing species such as tropical acacias and eucalypts. *Acacia mangium* Willd. is one of the most popular fast-growing tree species for industrial forest plantations and it is estimated that about 600 000 ha have been planted, mainly in China, India, Indonesia, Malaysia, the Philippines, Thailand and Vietnam (Kamis Awang pers. comm.).

Heart rot is a well-known defect of *A. mangium* trees in Malaysia (Gibson 1981, Lee *et al.* 1988, Hashim *et al.* 1991, Mahmud *et al.* 1993, Ito & Nanis 1994, Zakaria *et al.* 1994). Apart from Malaysia, no detailed surveys for heart rot have been carried out elsewhere. The defect is, however, known to be present in plantation trees in Indonesia (unpublished data), India (Mehrotra *et al.* 1996) and Bangladesh (Basak cited in Mehrotra *et al.* 1996). The associated fungi are usually unknown because of the absence of sporocarps (fruiting bodies) which are needed for identification.

Unknown wood decay fungi such as heart rot fungi can sometimes be identified from the morphological and physiological characteristics of the mycelia by comparison with the species codes developed by Nobles (1965) and Stalpers (1978). Using these techniques, Lee and Maziah (1993) identified *Phellinus noxius* as one of the fungi associated with heart rot of seven- and eight-year-old *A. mangium* trees in Peninsular Malaysia. They could not, however, positively identify additional isolates because these often had features or a combination of features not found in the species codes used. Moreover, the codes cover only a limited range of fungi, mainly of temperate species. More recently, using cultural characteristics, Mehrotra and his co-workers (1996) identified *Phellinus pachyphloeus* (Pat.) Pat. and *Trametes palustris* (Berk. *ex* Curt.) Murrill from heart rot of seven- to ten-year-old *A. mangium* trees in West Bengal, India.

This paper describes a simple technique for the production of sporocarps from cultures of heart rot fungi. The fungi associated with heart rot can then be identified by examination of the sporocarps produced and by reference to and comparison with published literature.

Materials and methods

Isolation of fungi

From fruiting bodies

Isolates from cultures of *Ganoderma australe* (Fr.) Pat. (FP104), *Ganoderma chalceum* (Cooke) Steyaert (MA89), *Phellinus lamaensis* (Murrill) Heim (MA20) and *Phellinus noxius* (Corner) Cunn. (MA99) were grown on 2% potato dextrose agar at 28±2 °C in the dark. Isolate FP104 (*G. australe*) was obtained from colleagues in the Wood Mycology Laboratory, Forest Research Institute Malaysia, who isolated the fungus from a sporocarp growing on dead wood. The other three isolates were obtained from T. Hattori of the Forestry and Forest Products Research Institute, Tsukuba, Japan, who made isolates from sporocarps collected from dead trees in Pasoh Forest Reserve, Negri Sembilan, Malaysia.

From heart rot samples

The ten Peninsular Malaysian isolates used for this test (Table 1) originated from billets of *A. mangium* with heart rot obtained from colleagues who were conducting a survey of heart rot in *A. mangium* plantations in Peninsular Malaysia in 1993 (see Lee & Maziah 1993). Another 11 isolates from East Kalimantan were supplied by Charles Hodges, Department of Plant Pathology, North Carolina State University, USA (Table 1). Hodges' isolates were obtained from four-year-old trees which were being thinned and each isolate came from a separate tree.

The pure culture isolates were grown on 0.5% malt extract agar and incubated in the dark at ambient room temperature (28 ± 2 °C). Morphological and physiological characteristics of all the isolates were examined and the species code for each fungus was noted based on the criteria of Stalpers (1978).

Table 1. Fungal isolates obtained from heart rotted wood of *A. mangium* trees from Peninsular Malaysia and East Kalimantan, Indonesia

Fungus isolate number	Source of tree	Age of tree (years)
FP3	Ulu Sedili, Johore, Peninsular Malaysia	8
FP18	Bukit Tarik, Selangor, Peninsular Malaysia	2
FP28	Rawang, Selangor, Peninsular Malaysia	4
FP31	Rawang, Selangor, Peninsular Malaysia	3
FP34	Rawang, Selangor, Peninsular Malaysia	4
FP35	Rawang, Selangor, Peninsular Malaysia	3
FP42	Rawang, Selangor, Peninsular Malaysia	3
FP44	Rawang, Selangor, Peninsular Malaysia	3
FP48	Rawang, Selangor, Peninsular Malaysia	3
FP51	Rawang, Selangor, Peninsular Malaysia	3
FP112	Mauro Bengkal, East Kalimantan	4
FP114	Mauro Bengkal, East Kalimantan	4
FP115	Mauro Bengkal, East Kalimantan	4
FP116	Mauro Bengkal, East Kalimantan	4
FP117	Mauro Bengkal, East Kalimantan	4
FP119	Mauro Bengkal, East Kalimantan	4
FP120	Mauro Bengkal, East Kalimantan	4
FP121	Mauro Bengkal, East Kalimantan	4
FP124	Menamang, East Kalimantan	4
FP130	Menamang, East Kalimantan	4
FP131	Menamang, East Kalimantan	4

Inoculation onto wood blocks

Wood blocks measuring approximately 10 cm long by 5-6 cm in diameter were cut from freshly-collected branches of the rubber tree (*Hevea brasiliensis*). The bark was removed before the blocks were individually placed into autoclavable plastic bags fitted with a PVC ring and cotton wool stopper. Approximately 50 ml of 2% malt extract was poured into each bag so that the wood block contained therein was thoroughly wetted. The bags containing the treated wood blocks were then sterilised in an autoclave for 15 minutes.

Three 1-cm diameter plugs, taken from the edge of one week-old actively growing cultures with a sterilised cork borer were used to inoculate the sterilised wood block in each plastic bag. The plastic bags were then stoppered and incubated in the dark at ambient room temperature (28 ± 2 °C) for about two months to allow good colonisation of the wood blocks by the fungi. At the end of that period, the well colonised blocks were removed from the plastic bags and "planted" to one third of their depth into unsterilised garden soil contained in polybags measuring 160 x 215 mm — one block per bag. The labeled bags were kept in a shadehouse and lightly sprayed with water daily to keep the soil and wood blocks moist. There were three replicates for each fungus. Sporocarps which were produced were collected for identification in the laboratory.

Tests on gallic acid agar and with alcoholic gum guaiac

Mycelia of wood decaying fungi produce a variety of different oxidising enzymes. The presence of these oxidative enzymes can be detected by colour reactions when phenolic compounds in alcoholic solutions are added to the mycelia or fungal growth medium.

The fungi were tested for two colour reactions with gallic acid agar and alcoholic gum guaiac. The reaction of the fungi on gallic acid agar was studied according to the method described in Nobles (1948) while the drop test using alcoholic gum guaiac (0.5g of gum guaiac dissolved in 30 ml of 95% ethyl alcohol) was carried out according to Nobles (1968). Gallic acid is oxidised to a yellowish-brown to medium brown compound in the agar while the brown alcoholic gum guaiac solution is turned blue after 2-3 minutes.

Results

Sporocarps appeared on the exposed wood blocks between two to three weeks after "planting" (Figure 1). These sporocarps were much smaller than those collected from the field, probably because of the limited nutrient supply available from the small wood blocks. The sporocarps together with the cultural characteristics of the mycelial colonies facilitated the identification of the fungi.

Isolates from identified fruiting bodies

Wood blocks inoculated with isolates FP104, MA89, MA20 and MA99 produced sporocarps corresponding to *G. australe, G. chalceum, P. lamaensis* and *P. noxius* respectively. The successful reproduction of the sporocarps confirmed the success of the technique and also showed that no contamination of the wood blocks by other wood decay fungi had occurred during the incubation period both in the laboratory and in the shadehouse.

Figure 1. Sporocarps of *Phellinus noxius* (Corner) Cunn. (isolate MA20) produced on the inoculated rubber wood block after two weeks

Isolates from heart rot samples

Four different fungi were identified from the blocks inoculated with the 21 heart rot isolates (Table 2). These were *Rigidoporus hypobrunneus* (Petch) Corner, *P. noxius, Tinctoporellus epimiltinus* (Berk. & Br.) Ryv. and a fungus closely resembling *Oxyporus latemarginatus* (Dur. & Mont. *ex* Mont.) Donk. The characteristics of these fungi are described below. With the exception of isolate FP3 which was obtained from an eight-year-old tree, all the isolates were obtained from young trees varying between two and four years old.

Rigidoporus hypobrunneus (Petch) Corner

This fungus was most frequently obtained. It was obtained from four Peninsular Malaysian isolates, namely FP18, FP28, FP48 and FP51, and five East Kalimantan isolates, namely FP116, FP121, FP124, FP130 and FP131. Three of the Peninsular Malaysian isolates were obtained from Rawang, Selangor while the fourth was from Bukit Tarik, Selangor (Table 1). Of the East Kalimantan isolates, one (FP116) originated from Mauro Bengkal while the other four were from Menamang (Table 1). The fungus caused a white rot of the wood which became light in weight but hard and bleached cream in colour. In advanced stages the wood became very soft in the cross-section but remained fibrous in the longitudinal section.

Cultural characteristics

The fungus colony was cottony with infrequent pale brown zone lines on the underside. The growth rate was fast, reaching 90 mm diameter within one week. Young colonies were white with powdery-looking aerial mycelium, turning light buff to patchy cream with age. Two types of hyphae were observed: i) simple septate and much branched hyphae of 3–6 µm diameter (Figure 2a), and ii) long, thick-walled fiber hyphae of about 2 µm diameter (Figure 2b). Arthroconidia were observed in the younger parts of the mycelia (Figure 2c) and small crystals were present in the agar. Positive reactions were obtained with gallic acid agar and alcoholic gum guaic.

Species code: 1 5 (6) 13 17 22 24 30 37 50 52 53 54 83 84 89

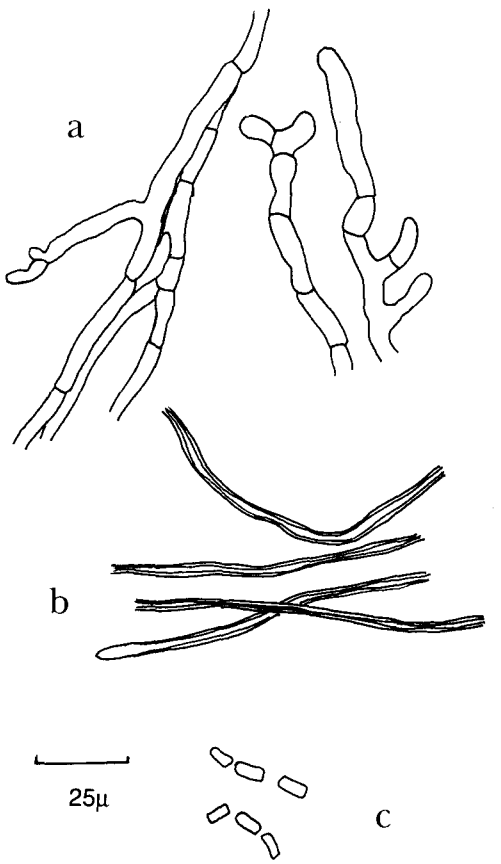

Figure 2. *Rigidoporus hypobrunneus* (Petch) Corner. a) simple septate and much branched hyphae; b) long, thick-walled fibre hyphae; c) arthroconidia

Sporocarp characteristics

Sporocarps first appeared on the wood blocks as small, thin cushion-like, resupinate patches which later became widely effused. The mature sporocarp was leathery, pale ochraceous buff to light pinkish-ochraceous with a whitish-cream coloured margin. The pores were rounded to slightly angular, minute, 4–6 per mm and almost invisible to the naked eye. The context was brown and fibrous with a thin black basal line next to the substrate and completely dominated by yellowish-brown skeletal hyphae. The fungus had a dimitic hyphal system; generative hyphae were hyaline, thin-walled and simple septate, 1.5–4 µm in diameter, and skeletal hyphae were thick-walled, non-septate, pale brownish and 3–7 µm in diameter. Heavily encrusted extrahymenial setae were present in the flesh just above the tubes and in the dissepiments. Despite the absence of spores in the sporocarps, the features of the sporocarps were sufficiently characteristic for the identification of the fungus as *R. hypobrunneus* (Corner 1987).

Phellinus noxius (Corner) Cunn.

The second most frequently occurring fungus was *P. noxius*. Its distinctive features allowed it to be readily identified from three Peninsular Malaysian isolates, namely, FP3 from Ulu Sedili, Johore, FP42 and FP44 from Rawang, Selangor, and five East Kalimantan isolates, namely FP112, FP115, FP117, FP119 and FP120 from Mauro Bengkal. None of the Menamang isolates from East Kalimantan yielded *P. noxius* (Table 2). The fungus caused a pocket rot which was characterised by the formation of distinct ridges of golden brown hyphae demarcating the pockets. This symptom was also observed in the wood samples collected from the field in Peninsular Malaysia which ultimately produced sporocarps of *P. noxius* in this study.

Cultural characteristics

The growth rate of the fungus was relatively fast, attaining 67 mm diameter in one week. In culture, the fungus colonies were crustose with orange-brown, epidermoid patches and ridges formed in between sections of white mycelium. These patches were composed of golden-brown, jigsaw puzzle-like pseudoparenchyma (Figure 3a). Aciculate to lanceolate golden-brown, branched fibre hyphae were evident but no clamped hyphae were observed. The powdery aerial mycelia were golden-brown and dendritic to coral-like microscopically (Figure 3b). The underside of the colony was patchy and reddish-brown. The fungus produced a positive test with gallic acid agar and a slow reaction with alcoholic gum guaiac.

Species code: 1 (6) 7 (12) (13) (18) (19) 21 22 25 28 30 (31) 34 35 38 48 52 53 (54) (55) (61) 64 67 (75) 89

Table 2. Fungi identified from the sporocarps produced

Isolate number	Identity of fungus
FP3	*Phellinus noxius* (Corner) Cunn.
FP18	*Rigidoporus hypobrunneus* (Petch) Corner
FP28	*Rigidoporus hypobrunneus* (Petch) Corner
FP31	*Oxyporus* cf. *latemarginatus* (Dur. & Mont. *ex* Mont.) Donk
FP34	*Oxyporus* cf. *latemarginatus* (Dur. & Mont. *ex* Mont.) Donk
FP35	*Tinctoporellus epimiltinus* (Berk. & Br.) Ryv.
FP42	*Phellinus noxius* (Corner) Cunn.
FP44	*Phellinus noxius* (Corner) Cunn.
FP48	*Rigidoporus hypobrunneus* (Petch) Corner
FP51	*Rigidoporus hypobrunneus* (Petch) Corner
FP112	*Phellinus noxius* (Corner) Cunn.
FP114	*Tinctoporellus epimiltinus* (Berk. & Br.) Ryv.
FP115	*Phellinus noxius* (Corner) Cunn.
FP116	*Rigidoporus hypobrunneus* (Petch) Corner
FP117	*Phellinus noxius* (Corner) Cunn.
FP119	*Phellinus noxius* (Corner) Cunn.
FP120	*Phellinus noxius* (Corner) Cunn.
FP121	*Rigidoporus hypobrunneus* (Petch) Corner
FP124	*Rigidoporus hypobrunneus* (Petch) Corner
FP130	*Rigidoporus hypobrunneus* (Petch) Corner
FP131	*Rigidoporus hypobrunneus* (Petch) Corner

Sporocarp characteristics

Sporocarps were effused to resupinate, crustose, woody and hard. The sporocarps were dark bay to fuscous with small round pores, 6–8 per mm, almost invisible to the naked eye. The tubes were stratified, each layer separated by a 1-mm thick layer of the homogenous dark bay to ferruginous context. The context was paler in colour than the tubes. The fungus had a dimitic hyphal system; generative hyphae in the tubes and context were thin walled, hyaline, pale yellowish, 2–4 µm in diameter while the skeletal hyphae were yellowish-bay, highly agglutinated in the tubes and 3–6 µm wide. No spores were observed.

Tinctoporellus epimiltinus (Berk. & Br.) Ryv.

Sporocarps of *T. epimiltinus* were obtained from two heart rot isolates, namely FP35 from Rawang, Selangor, and FP114 from Mauro Bengkal, East Kalimantan. The rotted wood became spongy, a pale straw colour with reddish-orange lines formed along the edges of the wood block, and easily dented with a fingernail in the longitudinal direction. Dark reddish epidermoid patches of mycelia were also characteristically formed on the surface of the wood blocks.

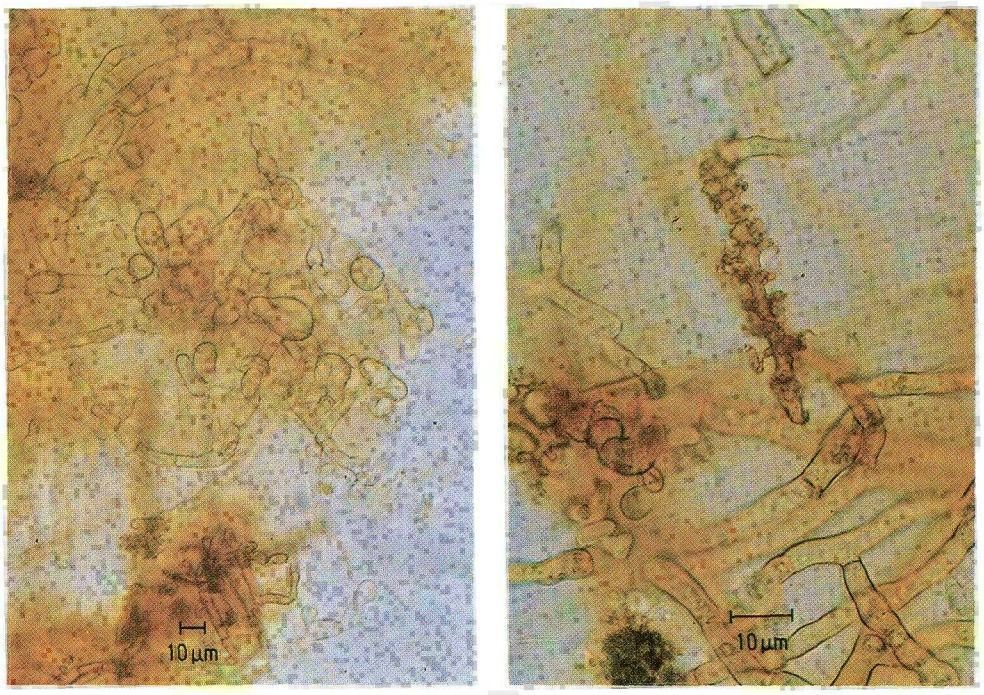

Figure 3. *Phellinus noxius* (Corner) Cunn. a) rounded, golden-brown cells which later form a jigsaw puzzle-like pseudoparenchyma; b) simple septate, golden-brown hyphae and golden-brown, dendritic hyphae

Cultural characteristics

The young colony was white and cottony with raised epidermoid zones coloured reddish-orange becoming reddish-brown with age. The fungus had a relatively fast growth rate, attaining 65 mm diameter in one week. White cottony hyphae radiated out from the centre of the colony forming a fibrillose pattern on the agar. The underside of the colony was cream with orange-brown zone lines. Hyphae were hyaline, light ochre in colour, clamped and 3.5–6 µm in diameter (Figure 4a). Fibre hyphae were thick-walled, hyaline, branched and between 1–2 µm wide (Figure 4b). The epidermoid zones were composed of closely packed, thick-walled, orange coloured, cuticular cells (Figure 4c). Arthrospores were also present (Figure 4d) as were small crystals in the agar. The fungus gave a positive result with gallic acid agar and a slow but positive reaction with alcoholic gum guaiac.

Species code: 1 6 (7) 13 21 25 30 32 34 36 39
46 52 53 54 (55) 64 83 84 89

Sporocarp characteristics

Sporocarps were resupinate, rigid, vinaceous gray with a cream to light clay pink margin. The pores were almost invisible to the naked eye, 4–5 per mm, slightly angular, becoming elongated and splitting on vertical surfaces with the pore edges becoming unclear. The hyphal system was dimitic. Generative hyphae could not be found but skeletal hyphae were thick-walled and 2–4 µm in diameter. There were no cystidia. Although no spores were observed, the cultural and sporocarp characteristics of the fungus match those of *T. epimiltinus* (Ryvarden & Johansen 1980, Rajchenberg 1983).

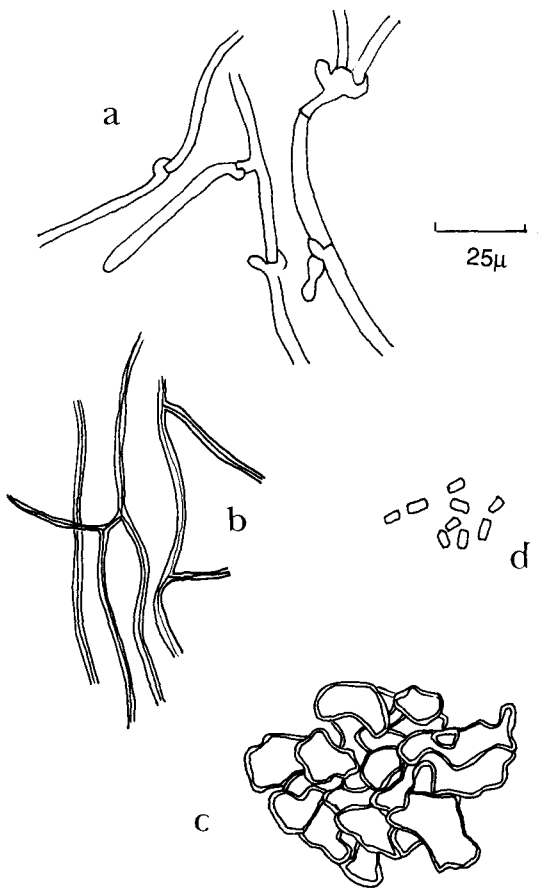

Figure 4. *Tinctoporellus epimiltinus* (Berk. & Br.) Ryv. a) hyaline, clamped hyphae; b) thick-walled, hyaline, branched fibre hyphae; c) closely packed, thick-walled, orange-coloured, cuticular cells of the epidermoid zones; d) arthrospores

Oxyporus cf. latemarginatus (Dur. & Mont. ex Mont.) Donk

Sporocarps of *O.* cf. *latemarginatus* were obtained from two isolates, FP31 and FP34, both from Rawang, Selangor but not from the East Kalimantan isolates. The fungus produced a spongy white rot with the wood becoming pale straw to cream in colour. In advanced stages of decay the wood resembled pressed sugar cane fibre and was soft and light in weight.

Cultural characteristics

The fungus colony was white, initially downy becoming thinly cottony and finally felty. Hyphae were simple septate, generally thin walled but some had slightly thickened cell walls, and some appeared to be slightly encrusted, 1.5–5 µm in diameter. Some hyphae had many short, lateral branches (Figure 5) and small crystals were present in the agar. The growth rate was relatively fast, attaining 67 mm diameter in one week. The fungus did not give a positive reaction with gallic acid agar but reacted positively with alcoholic gum guaiac.

Species code: 1 6 (7) 13 17 21 24 25 30 48 52 53 57 61 83 89

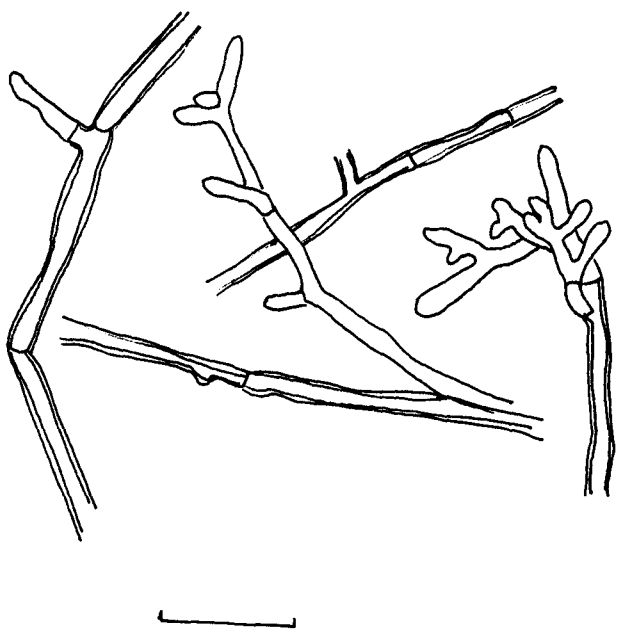

Figure 5. *Oxyporus* cf. *latemarginatus* (Dur. & Mont. *ex* Mont.) Donk. Simple septate, thin walled hyphae, hyphae with many short, lateral branches and hyphae with slightly thickened cell walls

Sporocarp characteristics

The sporocarp was widely effused, thin, cream to white in colour, turning patchy brown and fragile when dry. The pores were irregular and angular, about 1–3 per mm, the dissepiments becoming dentate; the tubes were not stratified. The context was cream coloured and thin. The fungus had a monomitic hyphal system consisting of generative hyphae only which were hyaline, thin walled and simple septate. Thin walled, club shaped cystidia without encrustations were present. Spores were oblong ellipsoid, hyaline, thin walled, smooth, 2.4–5 × 2.4–4 µm. The fungus most closely resembles *O. latemarginatus* except for the smaller spore size (Ryvarden & Johansen 1980).

Discussion

The most frequently occurring fungus, *R. hypobrunneus*, made up 43% of the heart rot isolates examined here. This species was obtained from both the Peninsular Malaysian and East Kalimantan heart rot isolates. This fungus is fairly common on dead wood and bark in the forests of Malesia (Corner 1987) and the closely related *R. vinctus* has been reported from the tropics and warmer parts of the temperate zone (Ryvarden & Johansen 1980). Ivory (1991) reported *R. hypobrunneus* causing root rot of various angiosperm hosts in Fiji, Vanuatu and the Solomon Islands where it was also found associated with root rot of *A. mangium*. However, this is the first report of the association of *R. hypobrunneus* with heart rot of *A. mangium*.

With 38% of the isolates tested producing sporocarps of *P. noxius*, this was the second most frequently occurring fungus. Some species of *Phellinus* are known to cause heart rots, root rots and cankers of live standing trees, and destroy slash and other wood residues (Larsen & Cobb-Poulle 1991). *Phellinus noxius* is a pantropical fungus and is known to be a destructive root pathogen of many tree species (Pegler & Waterston 1968, Bolland 1984, Hodges & Tenorio 1984, Nandris *et al.* 1987, Abe *et al.* 1990, 1995, Kawabe *et al.* 1993 cited in Hattori *et al.* 1996). In Malaysia, *P. noxius* is known to cause brown root rot of *Hevea brasiliensis* (Corner 1932), root diseases of a range of other host trees (Singh 1973) and stem rot in rubber and oil palm (Turner 1981). The fungus is also known to be associated with root rot and mortality of *A. mangium* in Malaysia (Ivory 1991) and Papua New Guinea (Arentz & Simpson 1988). Lee and Maziah (1993) had reported this fungus from heart rot of seven- to eight-year-old *A. mangium* trees in Ulu Sedili, Kemasul and Batu Arang in Malaysia. This is further confirmation of its widespread occurrence in Malaysia.

Tinctoporellus epimiltinus is a pantropical fungus found on angiosperms, often on very hard wood and is believed to occur in all countries of the world with rain forests (Ryvarden 1979, Ryvarden & Johansen 1980). It has been recorded causing wood decay of *A. mangium, Sweitenia macrophylla* and *Myristica* sp. in Fiji, Vanuatu and the Solomon Islands (Ivory 1991). This fungus is known to occur in Malaysia (Ryvarden 1979), and was recently collected from fallen tree trunks in Pasoh Forest Reserve, a lowland tropical rain forest in Peninsular Malaysia (Salmiah

1997). However, this is the first time that this fungus has been reported to be associated with heart rot of trees, and in particular, *A. mangium*, in Peninsular Malaysia.

Oxyporus latemarginatus is a cosmopolitan wood decay fungus of widespread occurrence in the tropics and warmer parts of the temperate zone (Ryvarden & Johansen 1980). It is known to occur on deciduous wood (Stalpers 1978, Ryvarden & Johansen 1980, Zhao & Zhang 1992, Bi *et al.* 1993), but has also been reported on coniferous wood in the United States (Ryvarden & Johansen 1980). The fungus is known to cause a white rot (Zhao & Zhang 1992, Bi *et al.* 1993). Information on the occurrence of this fungus in Malaysia is presently lacking.

Conclusion

Using the simple technique described in this paper, wood decay fungi can be induced to produce sporocarps which are important for identification. Conclusive identification, however, is still dependent on the availability of relevant taxonomic expertise, literature, and comparisons with type specimens or accurately identified herbarium specimens.

The results of this study show that with the exception of *Oxyporus* sp., the same fungi which are associated with heart rot of *A. mangium* in Peninsular Malaysia are also found in East Kalimantan. This, however, does not imply the absence of *Oxyporus* sp. in East Kalimantan as the sample size used in this study was not very large. The occurrence of species common to both the Peninsular Malaysian and East Kalimantan isolates is not unexpected as the fungi found so far are all pantropical fungi, and also because of the proximity of Malaysia and Kalimantan and the similarity in their climate and natural vegetation. It should be noted that not all isolates from Kalimantan and Peninsular Malaysia recovered from heart rot were included in this study. In an earlier study, Lee and Maziah (1993) had reported 24 isolates associated with heart rot of *A. mangium* in Peninsular Malaysia. Therefore there is a high possibility that other species of fungi may be involved in heart rot of *A. mangium*.

All the fungi reported here are common wood decay fungi found growing on dead wood in the Malaysian forests and *A. mangium* plantations. It is unusual that several fungi are involved in heart rot of a single tree species, especially in a small geographical region and at such a young age. However, this is not unexpected considering the high incidence of heart rot (Zakaria *et al.* 1994) and different types of heart rot observed in *A. mangium* (Lee & Maziah 1993) in earlier studies. Lee and Arentz (1997) have suggested that the high incidence of heart rot in *A. mangium* in Peninsular Malaysia may be related to problems of species-site suitability where the lack of a marked dry season impedes wound healing and encourages invasion of the heartwood by a variety of wood decay fungi which are already present in the plantations.

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