

## **ECTOMYCORRHIZAL FUNGI ASSOCIATED WITH MEMBERS OF THE DIPTEROCARPACEAE IN PENINSULAR MALAYSIA - I**

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*Received March 1994*

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**WATLING, R. & LEE, S. S. 1995. Ectomycorrhizal fungi associated with members of the Dipterocarpaceae in Peninsular Malaysia - I.** Over 50 different agarics, boleti and their relatives, 4 earthballs and a species of *Pisolithus* have been found associated with dipterocarps, in the locality of the Forest Research Institute at Kepong in Peninsular Malaysia. Over half of them are catalogued below with notes of similar species from the Forest Reserve at Pasoh, Negri Sembilan. Tables are provided connecting fungi to suspected hosts; over half have been identified as species whereas the rest have been assigned to specific sections or stirps. Some of the observations have been extended to communities in the hills around Kuala Lumpur. This is the first such list for Peninsular Malaysia.

Key words: Ectomycorrhizal fungi - dipterocarps - Malaysia

**WATLING, R. & LEE, S.S. 1995. Kulat ektomikoriza yang dikaitkan dengan ahli-ahli Dipterocarpaceae di Semenanjung Malaysia. Bahagian I.** Lebih dari 50 pelbagai agarik, boleti dan yang berkaitan dengannya serta 4 earthballs dan 1 spesies *Pisolithus* telah didapati berkaitan dengan dipterokarpa di kawasan Institut Penyelidikan Perhutanan (FRIM) di Kepong, Semenanjung Malaysia. Lebih separuh darinya dikatalogkan di bawah bersama-sama nota spesies yang sama dari Hutan Simpanan Pasoh, Negri Sembilan. Jadual-jadual yang mengaitkan kulat dengan hos yang disyaki diberikan; lebih separuh telah dikenal pasti sebagai spesies dan lebihnya dirujuk kepada bahagian-bahagian tertentu ataupun kumpulan-kumpulan klasifikasi. Beberapa pemerhatian telah dipanjangkan ke komuniti di bukit-bukit di sekitar Kuala Lumpur. Ini merupakan senarai yang pertama seumpama itu untuk Semenanjung Malaysia.

### **Introduction**

Since Singh (1966) first recorded ectomycorrhizal associations between Dipterocarpaceae and Fagaceae in Malaysia, much attention has been directed to this area both in the laboratory and in experimental plots (Lee 1989, 1992). Singh (1966) did not identify any fungal associates and it was another thirteen years before Hong (1979) listed the main genera of agarics associated with selected dipterocarps

in the Arboretum at the Forest Research Institute, Kepong. However, even then although 16 hosts were tabulated and 6 fungal genera listed, only 3 species were identified, viz. *Amanita angustilamellata*, *A. hemibapha* and *A. princeps*.

Whilst conducting a Hands-On Course on the identification of larger fungi in early 1992 at the Forest Research Institute of Malaysia (FRIM), we took advantage of the well documented collection of dipterocarps there not only in the arboretum but also in the rain forest in the vicinity and attempted to associate some of the fungi found there under. Through the painstaking work of A. Taylor, formerly of the University of Aberdeen and Institute of Systematic Botany, University of Munich, it was possible to confirm the suspicion that some of these associates are ectomycorrhizal. A catalogue has therefore been produced and is being added to with records from continuing studies.

The present contribution includes some of the more prominent and widespread taxa collected in the period between 1991 and 1992.

### Materials and methods

The material was collected either in the FRIM grounds at Kepong (1319 ha) near Kuala Lumpur or during short trips to forests near the Awana Golf and Country Club in Pahang, and forests in Sungai Lalang, and Ulu Langat in Selangor, and Pasoh Forest Reserve in Negri Sembilan. Most collections, however, were made in the Bukit Lagong Forest Reserve in the extensive grounds of FRIM.

Collections were documented with sketches and/or photographs and described and dried either in silica gel or in a hot air oven. The material is now housed in the herbarium of the Royal Botanic Garden, Edinburgh with some duplicates at FRIM where previously collected specimens made by the junior author during 1991 are also housed. Some of the latter material have been incorporated into the study.

The methods of collecting were those traditionally employed by serious agaricologists (Henderson *et al.* 1969). Ectomycorrhizas were analysed by digging up roots and basidiomes which were then carefully dissected out with jets of water and fine needles in the laboratory under directional light beams.

It is not known precisely what the constituent flora of the Bukit Lagong Forest Reserve was when taken over for the establishment of the Forest Research Institute, in 1925. Tree composition especially in the upper areas of the hills with a preponderance of non-commercial trees and regrowth of *Eugeissona tristis*, suggests a long history of disturbance. At least some of this disturbance has been caused by aboriginal activity. Some of the woodlands about the laboratory and office complex of the present FRIM have a known history of vegetable and fruit cultivation; in other areas the influences of the former neighbouring tin mining activities are evident.

The forest along the old Gombak-Bentong road between Kuala Lumpur and the road tunnel at the base of the road leading to Genting Highlands consists of disturbed lowland dipterocarp forest with mixtures of *Shorea* spp. and members of many other families including the Caesalpinoid legume, *Intsia palembanica*. The forest along the jungle track of the Awana Golf and Country Club situated

at approximately 1000 m a.s.l. is a remnant lower montane forest community developed on the sides of rather steep ravines and because of this has not been heavily logged.

Collections were also made from lowland forests in the Sungai Lalang and Ulu Langat Forest Reserves, approximately 40 km southeast of Kuala Lumpur. Although both these areas had been selectively logged about 30 to 40 years ago, there are still some fine specimens of dipterocarps including *Shorea leprosula* remaining. The collection site at Ulu Langat has been the site of some mycorrhizal studies in the recent past (Lee 1992).

Pasoh is the site of the FRIM field station and has been the subject of over thirty years of study. It is one of the few remaining untouched lowland dipterocarp forests in the southeast of Peninsular Malaysia. Although the dipterocarps have been the subject of intensive study for many years, the fungi have only recently been considered.

Larger fungi were also provided during the study period by K. Kimura and the Japanese National Institute of Environmental Science (NIES) team of scientists who collected them in the hill forest dominated by *Shorea curtisii* in Semangkok Forest Reserve near Fraser's Hill in Selangor. A few additional records made by the senior author at Fraser's Hill and Templar Park are included for completeness.

The host tree with which the fungus is suspected of being an associate has been taken to be that in which the fungus is found in contact with a major root or between roots or buttresses, or is within the canopy of the tree, and if outside only when no other dipterocarpaceous or other similar arborescent plant is present.

If there is a mixture of trees then the mixture is given in parallel to when the tree can only be named to genus. Those in general associations in dense mixed communities are listed separately but they indicate the range of plants observed. Those species which have been traced to specific trees by the patience and perseverance of A. Taylor are indicated with an asterisk.

The data are arranged alphabetically according to host (Tables 1-4). The key to the sections of *Shorea* follows Symington (1974):

- B = Balau group - *S. glauca*, *S. materialis*, *S. maxwelliana*,  
*S. ochrophloia* and *S. sumatrana*.
- RM = Red meranti group - *S. acuminata*, *S. curtisii*, *S. leprosula*,  
*S. macrantha*, *S. ovalis*, *S. parvifolia* and *S. platyclados*.
- MP = Meranti Pa'ang group - *S. bracteolata* and *S. resinosa*.
- MD = Meranti damar hitam group - not represented.  
*S. macrophylla* belongs to an exclusively Bornean group.

For further details and taxonomic characters, see Ashton (1982).

**Table 1.** Suspected ectomycorrhizal associations at Kepong - planted communities

Mycorrhizal host	Associated fungus
<i>Dipterocarpus baudii</i> Widespread in Malay Peninsula, Burma, Thailand, Sumatra and Indo-China.	Amanitaceae: <i>Amanita fritillaria</i> f. <i>malayensis</i> Russulaceae: <i>Russula virescens</i>
+ <i>D. costulatus</i> Malay Peninsula to Singapore, Sumatra and Borneo.	Russulaceae: <i>Russula virescens</i>
+ <i>D. kerrii</i> Andaman Islands, from Malacca and Pahang northwards in the Malay peninsula, Sumatra, north Borneo, Philippines, even Burma and peninsular Thailand.	Boletaceae: <i>Boletus aureomycelinus</i>
+ <i>D. verrucosus</i> Peninsular Malaysia, Sumatra, Singkep and Borneo.	Russulaceae: <i>Russula virescens</i>
<i>Dipterocarpus</i> spp.	Cortinariaceae: <i>Inocybe fuscospinulosa</i> Russulaceae: <i>Lactarius gerardii</i> , <i>Russula alboareolata</i>
<i>Dryobalanops aromatica</i> Confined to Peninsular Malaysia to eastern parts south of 5°N latitude in Trengganu, Pahang and Johore with small outliers: Sumatra, Borneo, Riau archipelago.	Amanitaceae: <i>Amanita</i> ( <i>Vaginatae</i> ) sp. 6 Corner & Bas (1962) Boletaceae: <i>Boletus cutifractus</i> Cortinariaceae: <i>Inocybe sphaerospora</i> Russulaceae: <i>Lactarius gerardii</i> , <i>R. chloroides</i> var. <i>parvispora</i> , * <i>R. japonica</i> , <i>R. subfoetens</i> , <i>R. virescens</i> 'Gasteromycetes' Sclerodermataceae: * <i>Scloderma sinnamariense</i>
<i>D. aromatica/Shorea macrophylla</i>	Boletaceae: <i>Boletus aureomycelinus</i>
<i>D. oblongifolia</i> Not uncommon in eastern Kelantan, Trengganu, Pahang and Johore and sporadically elsewhere: Sumatra and Borneo.	Boletaceae: <i>Strobilomyces velutipes</i> , <i>Boletus (Tylopilus), maculatus</i> Cortinariaceae: <i>Inocybe sphaerospora</i> Russulaceae: <i>Russula alboareolata</i> , <i>R. cf. castanopsidis</i> , <i>R. chloroides</i> var. <i>parvispora</i> , <i>R. japonica</i> , <i>R. virescens</i> 'Gasteromycetes' Sclerodermataceae: <i>Scloderma verrucosum</i>
Probably <i>Dryobalanops</i> sp. <i>Scorodocarpus borneensis</i> (Olacaceae) close by.	Boletaceae: <i>Rubinoboletus ballouii</i> Cortinariaceae: <i>Astrosporina aequalis</i> Russulaceae: <i>Russula virescens</i> (yellow green form)

Continued

Table 1 (continued)

+ <i>Hopea dryobalanoides</i> Lower areas of Perak, Selangor, Negri Sembilan and Pahang; Sumatra and Borneo.	Russulaceae: <i>Russula</i> cf. <i>castanopsidis</i>
+ <i>H. mengarawan</i> Common in some districts of Pahang but known from eastern Johore, Singapore, Kuala Pilah district of Negri Sembilan; Sumatra and adjacent isles.	Russulaceae: <i>Russula</i> cf. <i>castanopsidis</i>
<i>H. odorata</i> Riparian tree in northern Peninsular Malaysia; Vietnam, Burma, Thailand and Andaman islands. In close proximity to <i>Swietenia macrophylla</i> and <i>Dacrydium elatum</i>	Amanitaceae: <i>Amanita tjibodensis</i> Russulaceae: <i>Lactarius gerardii</i> , <i>Russula cyanoxantha</i> , <i>R.</i> cf. <i>castanopsidis</i> , <i>R. japonica</i> , <i>R. virescens</i>
+ <i>H. sangal</i> Widely distributed from Kedah and Kelantan southwards especially in east; Java and Borneo.	Russulaceae: <i>Russula</i> cf. <i>castanopsidis</i>
<i>Neobalanocarpus heimii</i> Widespread in Peninsular Malaysia except in Perlis and Malacca; south Thailand	Amanitaceae: <i>Amanita</i> cf. <i>alauda</i> , <i>A. ?fritillaria</i> f. <i>malayensis</i> , <i>A. gymnopus</i> , <i>A. princeps</i> , <i>A. sculpta</i> Boletaceae: <i>Boletellus emodensis</i> Russulaceae: * <i>Russula cyanoxantha</i> , <i>R. singaporensis</i> 'Gasteromycetes' Sclerodermataceae: <i>Scleroderma sinnamariense</i>
<i>N. heimii</i> / <i>D. aromatica</i> community	Sclerodermataceae: <i>Scleroderma sinnamariense</i>
<i>N. heimii</i> / <i>Shorea maxwelliana</i> community	Cortinariaceae: <i>Inocybe sphaerospora</i>
+ <i>Parashorea lucida</i> Sumatra and Borneo	Russulaceae: <i>Lactarius gerardii</i>
<i>Shorea bracteolata</i> <i>D. aromatica</i> community On deep well drained soils; Peninsular Malaysia, Borneo and Sumatra.	Boletaceae: * <i>Boletus aureomycelinus</i> , <i>B. cutifractus</i> , <i>Rubinoboletus ballouii</i> Russulaceae: <i>Russula alboareolata</i> , <i>R. cyanoxantha</i>
<i>S. curtisii</i> Widely distributed from Pattani (south Thailand) to Singapore on dry ridges.	See Table 2
<i>S. leprosula</i> Throughout Peninsular Malaysia except Perlis; Sumatra to north Borneo and Peninsular Thailand.	Russulaceae: <i>Russula cyanoxantha</i> , <i>R. virescens</i>

continued

Table 1 (continued)

+ <i>S. macrantha</i> Restricted in distribution even in Perak, east Pahang and Johore; Sarawak.	Russulaceae: <i>Russula</i> cf. <i>castanopsidis</i>
<i>S. macrophylla</i> Borneo.	See: under <i>Dryobalanops aromatica</i>
+ <i>S. materialis</i> Limited to east coasts of Pahang, Johore and possibly Trengganu.	Russulaceae: <i>Russula</i> cf. <i>castanopsidis</i>
<i>S. maxwelliana</i> Throughout Peninsular Malaysia, Borneo. (See also under <i>Neobalanocarpus heimii</i> )	Amanitaceae: <i>Amanita</i> cf. <i>xanthogala</i>
+ <i>S. parvifolia</i> Throughout Peninsular Malaysia, Sumatra, Borneo and adjacent isles.	Russulaceae: <i>Russula violeipes</i>
+ <i>S. platyclados</i> In mountainous areas of Peninsular Malaysia, especially the main range; Sumatra and Borneo.	Russulaceae: <i>Russula</i> cf. <i>castanopsidis</i>
<i>S. stenoptera</i> Borneo.	Amanitaceae: <i>Amanita tjibodensis</i> <i>A. (Vaginatae)</i> sp. 6 Corner & Bas (1962) Russulaceae: <i>Lactarius gerardii</i> , <i>Russula</i> cf. <i>castanopsidis</i> , <i>R.</i> <i>virscens</i>
<i>S. sumatrana</i> Eastern parts of Peninsular Malaysia although known from Pahang; Sumatra.	Amanitaceae: <i>Amanita gymnopus</i> Russulaceae: <i>Lactarius gerardii</i> , <i>Russula alboareolata</i> , * <i>R.</i> <i>singaporensis</i>
<i>Shorea</i> spp. (unidentified)	Amanitaceae: <i>Amanita</i> cf. <i>xanthogala</i> Boletaceae: <i>Rubinoboletus ballouii</i> var. <i>fuscatus</i> Russulaceae: <i>Lactarius gerardii</i> Tricholomataceae: <i>Laccaria</i> <i>vinaceoavellanea</i> 'Gasteromycetes' Sclerodermataceae: <i>Scleroderma</i> <i>dictyosporum</i>
General <i>Shorea</i> / <i>Dryobalanops</i> communities	Amanitaceae: <i>Amanita cinctipes</i> , <i>A.</i> <i>princeps</i> , <i>A. tjibodensis</i> (under <i>Scorodocarpus borneensis</i> - Olacaceae), <i>A. (Vaginatae)</i> sp. 6 Corner & Bas (1962) Boletaceae: <i>Boletus aureomycelinus</i> ( <i>S. macrophylla</i> ), <i>B. pernanus</i> Cortinariaceae: <i>Astrosporina</i> <i>aequalis</i> (= <i>Inocybe</i> ) (with <i>Scorodocarpus borneensis</i> - Olacaceae), <i>I. ?fuscospinulosa</i> ,

continued

Table 1 (continued)

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*I. sphaerospora*, *I. palaeotropica*  
 Paxillaceae: *Phylloporus bellus*  
 (under *Sterculia* - Sterculiaceae)  
 Russulaceae: *Lactarius gerardii*,  
*Russula alboareolata*, *R. cf.*  
*castanopsidis*, *R. delica* var.  
*trachyspora*, *R. fragrantissima*, *R.*  
*virescens*, *R. subfoetens* (under  
*Dyera costulata* - Apocyanaceae  
 Tricholomataceae: *Laccaria*  
*vinaceoavellanea*  
 'Gasteromycetes':  
 Sclerodermataceae: *Scleroderma*  
*sinnamariense* (see note)

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(Symbols used: + individuals in Dipterocarp arboretum, Kepong;  
 \* physical connections made between fungus and host)

Note: Found in *Acacia mangium* (Leguminosae) plantation, Kemasul, Pahang in 1991, and under  
*Cycas*, Botanical Garden, University of Malaya campus, Hadley 4, 23 May 1967.

**Table 2.** Suspected ectomycorrhizal associations - Selangor and Negri Sembilan:  
 wild communities

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- a) Upper dipterocarp/montane oak forest communities - Fraser's Hill
- Probably *S. curtisii*  
 Widely distributed on dry slopes from Singapore north to Pattani (Thailand)  
 Amanitaceae: *Amanita princeps* (amongst palm debris)  
 Boletaceae: *Hiemiella cf. retispora*, *Boletus spinifer*  
 Russulaceae: *Russula singaporensis*  
 General collections: *Boletus nigropurpureus* (= *Tylopilus*)
- b) Lowland communities
- i) Gombak - Lowland dipterocarp forest (many species especially of dipterocarps and also  
 Leguminosae, including *Intsia palembanica* (Caesalpinoideae)  
 Boletaceae: *Boletus destitutus*  
 Cantharellaceae: *Cantharellus ianthinus*
- ii) Sungai Lalang and Ulu Langat - lowland dipterocarp forest
- Amanitaceae: *Amanita demissa*, *A. hemibapha* var. *similis*, *A. tjibodensis*, *A. (Vaginatae)* sp. 6 Corner  
 & Bas  
 Boletaceae: *Boletellus emodensis*  
 Cantharellaceae: *Cantharellus ianthinus*  
 Cortinariaceae: *Inocybe cutifracta*  
 Russulaceae: *Russula alboareolata*, *R. japonica* (under *Shorea acuminata*)  
 'Gasteromycetes' - Sclerodermataceae: *Scleroderma verrucosum*
- iii) Templar Park
- Gomphaceae: *Gomphus* (?) *retisporus*
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**Table 3.** Suspected ectomycorrhizal associations: Pasoh

## a) Arboretum

Host: *Shorea acuminata* (Also see Table 1)Russulaceae: *Russula japonica*'Gasteromycetes' - Sclerodermataceae: *Pisolithus aurantioscaber* Watl. in ed.Host: *Shorea leprosula* (Also in Table 1)Boletaceae: *Pulveroboletus icterinus*Russulaceae: *Lactarius* cf. *hygrophoroides*, *Russula* cf. *castanopsidis*, *R. cyanoxantha*, *R. virescens*Host: *Shorea parvifolia* (Also in Table 1)Cantharellaceae: *Cantharellus ianthinus*Russulaceae: *Lactarius gerardii*'Gasteromycetes' - Sclerodermataceae: *Pisolithus aurantioscaber* Watl. in ed.

## b) General collections

Amanitaceae: *Amanita* ?*demissa*, *A. modesta*Boletaceae: *Boletus peltatus* (under *Schoutenia accrescens* - Tiliaceae), *B. pernanus* (Corner & Watling in ed.) on mossy logs, *Rubinoboletus ballouii*Cantharellaceae: *Cantharellus ianthinus*, *C. lilacinus*Paxillaceae: *Phylloporus bellus*Russulaceae: *Lactarius* cf. *pterosporus*, *L. subplinthogalus*, *L. vellereus*, *Russula alboareolata*, *R. cf. castanopsidis*, *R. crustosa*, *R. cyanoxantha*, *R. singaporensis* (under *Eugenia* - Myrtaceae), *R. virescens*Thelephoraceae: *Sarcodon thwaitsei*'Gasteromycetes' - Sclerodermataceae: *Pisolithus aurantioscaber* Watl. in ed., *Scleroderma echinatum*, *S. sinnamariense**Chamoniixia* nov. sp. (hypogeous Boletales) with *Schoutenia accrescens* - Tiliaceae**Table 4.** A list of all the fungi collected and their herbarium numbers deposited: Wat. in Edinburgh, S-S in FRIM, Kepong

## Amanitaceae

*Amanita* cf. *alauda*

S-S 614

*A. cincipes* Corner & Bas

Wat. 24970

*A. demissa* Corner & Bas

Wat. 24971-3

*A. fritillaria* f. *malayensis* Corner & Bas

S-S 36

*A. gymnopus* Corner & Bas

S-S 612, Wat. 24882

*A. hemibapha* (Berk. & Br.) Sacc.subsp. *similis* (Boed.) Corner & Bas

Record only

*A. modesta* Corner & Bas

Wat. 25010

*A. princeps* Corner & Bas

S-S 613

*A. sculpta* Corner & Bas

S-S 627 illust. only

*A. tjobodensis* Boedijn

Wat. 24878, 24884-5,

S-S 55

*A. cf. xanthogala* Corner & Bas

Wat. 24881

*A. (Vaginatae)* sp. 6 in Corner & Bas, 1962

Wat. 24876-6,

S-S 615, Wat. 24931

## Boletaceae

*Boletus aureomycelinus* Pat & Bak.

S-S 583, 574, 585

*B. cutifRACTUS* Corner

S-S 624

*B. destitutus* Corner

Wat. 24785

continued



Table 4 (continued)

<i>B. nigropurpureus</i> Corner	Record only
<i>B. pellatus</i> Corner & Watl.	Wat. 25151, 24479
<i>B. pernanus</i> Pat. & Baker (= <i>B. nanus</i> Mass. s. Corner)	Wat. 24488-90, 24871, 24386
<i>Boletus (Tylopilus) maculatus</i> Corner	Wat. 24710
<i>Boletus (T.) spinifer</i> Pat. & Bak. (= <i>Boletochaete</i> Singer)	Wat. 24691
<i>Boletellus emodensis</i> (Berk.) Sing.	Wat. 24475, S-S 611
<i>Hiemiella</i> cf. <i>retispora</i> (Pat. & Bak.) Boedijn	Wat. 24478
<i>Pulveroboletus icterinus</i> (Pat. & Bak.) Watl.	Wat. 24620
<i>Rubinoletus ballouii</i> (Peck) Heinem. & Rammeloo	Wat. 24711, 24875, 24693
<i>R. ballouii</i> var. <i>fuscatus</i> (Corner) Heinem. & Rammeloo	Wat. 24694
<i>Strobilomyces velutipes</i> Cke. & Mass.	Wat. 24477, S-S 580
<b>Cantharellaceae</b>	
<i>Cantharellus ianthinus</i> Corner	Wat. 24774-6, 24781
<i>C. lilacinus</i> Clel. & Chel	Wat. 25091
<b>Chamonixiaceae</b>	
<i>Chamonixia</i> Rolland sp.	Wat. 25218-9
<b>Cortinariaceae</b>	
<i>Astrosporina aequalis</i> Horak	Wat. 24593, S-S 51
<i>I. Cutifracta</i> Petch	Wat. 24562
<i>I. fuscospinulosa</i> Corner & Horak	S-S 570
<i>I. sphaerospora</i> Kobayasi	Wat. 24543-8
<i>I. palaeotropicalis</i> Turnbull & Watling <i>in ed.</i>	S-S 575
<b>Gomphaceae</b>	
<i>Gomphus retisporus</i> Corner	Record only
<b>Paxillaceae</b>	
<i>Phylloporus bellus</i> (Mass.) Corner	Wat. 24558, S-S 630
<b>Russulaceae</b>	
<i>Lactarius gerardii</i> Peck	Wat. 24748-9, 24752, 24879, 24751, 24783, 24753, 24750, 25199
<i>L. cf. hygrophoroides</i> Berk. & Curt.	Wat. 24798
<i>L. cf. pterosporus</i> Romagn.	Wat. 24525
<i>L. subplinthogallus</i> Coker	Wat. 24791-2
<i>L. vellereus</i> (Fr.) Fr.	Wat. 24815
<i>Russula alboareolata</i> Hongo	Wat. 24528, 24470-3, 24481
<i>R. cf. castanopsidis</i> Hongo	Wat. 24695-7
<i>R. chloroides</i> var. <i>parvispora</i> Romagn.	Wat. 24533-5
<i>R. crustosa</i> Peck : Zanted.	Wat. 24450-1
<i>R. cyanoxantha</i> (Schaeff.) Fr.	Wat. 24738, 24740, 24682, 24685, 24689, 24736, 24741
<i>R. delica</i> var. <i>trachyspora</i> Romagn.	S-S 601
<i>R. fragrantissima</i> Romagn.	S-S 581
<i>R. japonica</i> Hongo	Wat. 24526

continued

Table 4 (continued)

<i>R. singaporensis</i> Singer	S-S 609, Wat. 24541-2
<i>R. subfoetens</i> Smith	S-S 591, Wat. 24520
<i>R. violeipes</i> Quél.	S-S 578, Wat. 24683-4
<i>R. virescens</i> (Schaeff.) Fr.	Wat. 24449-53, 24531
<b>Sclerodermataceae</b>	
<i>Scleroderma dictyosporum</i> Pat.	Wat. 25191
<i>S. echinatum</i> (Petri) Guzmán	Wat. 24824, 24862
<i>S. sinnamariense</i> Mont.	S-S 618, Wat. 25197, 25188, 24825, 24827, 24844, 24849
<i>S. verrucosum</i> Pers.	Wat. 24826
<i>Pisolithus aurantioscabrosus</i> Watl. <i>nov. prov.</i>	Wat. 24442-3
<b>Thelephoraceae</b>	
<i>Sarcodon thwaitsei</i> (Berk. & Pat.) M. Geest.	Wat. 24712
<b>Tricholomataceae</b>	
<i>Laccaria vinaceoavellanea</i> Hongo	Wat. 24476

## Results

Tables 1 to 4 arrange the records of the fungi found associated with selected angiosperm hosts, all considered to be potential ectomycorrhizal formers.

Many unidentified agarics which are suspected to be ectomycorrhizal have been found and although they can, in some cases, be assigned to a particular higher taxon, have not been added to the list until further critical studies have been completed. Thus *Russula* spp., particularly of the *Foetinae* have been found with *Hopea helferi*, *Shorea glauca*, *S. ochrophloia*, *S. ovalis* and *S. resinosa*; all these particular associations have been studied in the dipterocarp arboretum at Kepong.

## Discussion

Malloch *et al.* (1980) in their summary of the mycorrhizas found in a range of plant communities draw attention to specific rain forests where ectomycorrhizas might be expected, e.g. dipterocarp forests of Southeast Asia, Caesalpinoid miombo of East Central Africa and the Caesalpinoid forest dominants of West Central Africa. However, their statements did little to disperse the generally held views that it was the boreal forests which were the great ectomycorrhizal communities and the tropical forests dominantly endomycorrhizal communities. These ideas have to be modified still further considering that from *Brachystegia* miombo in Zambia at least 100 taxa suspected of being ectomycorrhizal have now been found, from Cameroon 200 taxa and with similar numbers if not more in Zaire reflecting the area's great diversity of angiosperms. In the present study over 100 taxa have been documented with dipterocarps in an intensive one month period of collecting with an additional

25 species based on paintings, some associated with exsiccata, made in the previous twelve months.

It was conversation over 20 years ago with Peter Ashton, who had studied the dipterocarp consortia at Pasoh that first alerted the senior author to the potential richness of ectomycorrhizal fungi in the Malaysian lowland rain forest. This has been confirmed by conversations and correspondence with E.J.H. Corner and an analysis of the fungal species he has described from Southeast Asia (for Corner, 1962 *et subseq.* see Corner 1993).

Amongst the 613 species he listed, 255 are possibly ectomycorrhizal of which 187 are new to science. The same figures appear to apply to the rain forests of the Guinea-Congo domain (Buyck *et al.* 1995). These tropical ectomycorrhizal communities are therefore far richer than previously thought although in number of species the northern fagaceous and conifer forests and the southern myrtaceous and fagaceous (*Nothofagus*) forests are undoubtedly richer. But is this because of the much greater exploration of the temperate fungal floras?

Some of the species found in the tropical rain forests may occur in very great numbers as demonstrated in colonies of *Cantharellus rufopunctatus* in the Korup rain forest of Cameroon and of *Cantharellus* sp. (Watling 1993) at Kepong. What stimulates these enormous fruitings both in temperate and tropical regions is at present unknown.

### Preliminary Conclusion

The same species of *Russula*, *Lactarius*, etc. can be found with a range of dipterocarp species. It would be unwise, however, to make a qualifying statement as yet concerning specificity because of the relatively few collections, about 250, made. Several years study are necessary.

The main genera of ectomycorrhizal agarics and boletes found in Australia, Northern Europe and North America are present in Malaysia. Ectomycorrhizal members of the Cortinariaceae, e.g. *Cortinarius*, *Inocybe*, are extremely important components of the boreal forests and eucalypt communities of the southern hemisphere but are rather sparse in Malaysia. Five species of *Inocybe* were recorded during the present study. Evidence from elsewhere in Peninsular Malaysia suggests that this might be doubled in the future. A possible *Cortinarius* sp. has been found at Kepong.

The flora would appear to have greatest affinities with those documented by the Japanese school (Imazeki, Hongo, etc.); the lowland rain forest having similarities with subtropical parts of Japan, and the more montane forests with the more temperate areas of that country. Thus publications such as Imazeki & Hongo (1957) and Imazeki *et al.* (1988) are of positive use to Malaysian workers. Australian texts will prove to be much less useful because of the many constituents included therein but the floras of the southern states of North America have interesting parallels and works based on these latter areas should be consulted wherever possible. A close watch on publications from Kwangtung Province and Hainan island in China should be kept as there is evidence that there are parallels with