Occurrence of fungi on tissues of the peat swamp palm *Licuala longicalycata*

Umpava Pinruan[1], Kevin D. Hyde[2*], Saisamorn Lumyong[1], E.H.C. McKenzie[3] and E.B. Gareth Jones[4]

[1]Department of Microbiology, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand 50200
[2]Centre for Research in Fungal Diversity, Department of Ecology & Biodiversity, The University of Hong Kong, Pokfulam Road, Hong Kong SAR, PR China
[3]Landcare Research, Private Bag 92170, Auckland, New Zealand
[4]National Center for Genetic Engineering and Biotechnology, 113 Thailand Science Park, Paholyothin Road, Khlong 1, Khlong Luang, Pathum Thani, Thailand 12120

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The biodiversity of fungi from decaying palm material of *Licuala longicalycata* was studied following six field collections in May, June, September and November 2001, and February and May 2002. One-hundred and seventy-seven fungal collections were identified to species level, 153 collections to generic level, while 28 collections remained unidentified. A total of 147 species were identified, including 79 ascomycetes in 50 genera (53%), 65 anamorphic taxa in 53 genera (45%) and 3 basidiomycete species in 3 genera (2%). Nine ascomycetes and 5 anamorphic fungi were new to science. The percentage of fungi occurring in different microhabitats were as follows: dry material supported the most fungi with 40%, submerged material had 32%, while the damp material supported the least number of fungi (28%). The percentage occurrence of fungi on different tissues of *L. longicalycata* were: petioles 61%, trunks 24%, and leaves 15%. The most common fungi were *Annulatascus velatisporus*, *Microthyrium* sp., *Phaeoisaria clematidis*, *Massarina bipolaris*, *Phruensis brunneispora*, *Thailiomyces setulis*, and *Solheimia costaspora*. Species diversity on *L. longicalycata* was high, with little overlap with fungal communities on other palms. Factors affecting the colonization of palm material in the peat swamp are discussed.

Key words: biodiversity, palm fungi, peat swamp, tissue recurrence

Introduction

There have been several estimates of global fungal numbers ranging from less than 1 million to more than 9 million (Cannon, 1997; Hyde *et al*., 2007), although 1.5 million is generally considered to be a reasonably accurate

*Corresponding author: kdhyde; e-mail: kdhyde@hkucc.hku.hk

working figure (Hyde *et al.*, 2007). It was estimated that there were approximately 69,000 taxa known in 1990 and that there was an estimated annual rate of 1,700 new species being described (Hawksworth, 1991). Revised estimates of known species are 75,000 (Hawksworth, 2001), or 90,000 (Kirk *et al*., 2001).

There are various reasons for studying fungal diversity. Fungi have an excellent record in producing novel compounds and many of these presently have important medicinal and other uses (Concepcion *et al*., 2001), while the pharmaceutical industry have utilized fungi extensively in their search for new bioactive compounds (Miller, 1990; Fox, 1993; Huang and Kaneko, 1996; Wildman, 1997). According to Taylor (1997), the search for the undescribed fungi or "missing fungi" is important in biodiversity surveys. Tropical forest ecosystems are the most species rich environments (Hyde and Goh, 1997), although they cover less than 10 percent of the world's surface, they may contain 90 percent of the world's species (UNEP-WCMA, 2000). Thai fungal diversity has been poorly studied with *ca* 1.5% of the total known 90,000 worldwide fungal species reported (Hywel-Jones, unpublished), while Jones and Hyde (2004) indicate that 6,000 fungi are documented for Thailand.

Microfungi on palms have been extensively studied in Australia, Brunei, Ecuador, Hong Kong and Thailand (Fröhlich and Hyde, 1994, 1999; Yanna *et al*., 1998, 2001a; Pinnoi *et al*., 2006), indicating a rich fungal diversity and numerous new species (Fröhlich, 1997; Hyde *et al*., 1998; Taylor, 1997; Hyde and Alias, 1999; Fröhlich and Hyde, 2000; Yanna *et al*., 2001b; Hidayat *et al*., 2006). A comprehensive literature review carried out on palm microfungi (Fröhlich, 1997; Hyde *et al*., 1997) between 1994 and 1997, documented approximately 650 ascomycetes, 270 basidiomycetes, and 660 anamorphic fungi (400 hyphomycetes, 260 coelomycetes), all new records for fungi from palm material (Hyde *et al*., 1997). Few studies of palm fungi in peat swamp forests have been undertaken, and this is the primary objective of this investigation.

Material and methods

Decaying *Licuala longicalycata* palm material (Fig. 1) was collected at Sirindhorn Peat Swamp Forest in southern Thailand (06°12'N 101°57'E, elevation is 0-4 metre). The site is situated in an area subject to monsoonal seasonality, climatically with high humidity and high rainfall, nearly year-round (2,560 millimetres on average). The peat water is acidic (pH level about 4.5-6.0) (Anon, 1994, 1996). Six field collections were made in May, June, September and November 2001 and February and May 2002. Samples were

Fig. 1. *Licuala longicalycata* palm in Sirindhorn peat swamp forest showing decaying and living material.

randomly taken from as many different pieces of dead material of the palm and from a variety of sites within the forest. These materials were divided into three parts; leaves, petioles and trunks and from three different microhabitats:

Dry material = decaying palm collected under dry conditions - usually aerial.
Damp material = decaying palm collected under damp conditions - generally on the surface of the soil.
Submerged material = decaying palm totally submerged.

Samples were placed in plastic bags, sealed and labelled with data on collecting condition, palm part, collector and date. Samples were returned to the laboratory and the material incubated in plastic boxes with moist tissues for up to 1 week. The material was examined under a microscope, and fungi isolated into axenic culture using a single spore technique (Choi *et al*., 1999). Fungi were recorded, identified and samples dried down for deposition in the BIOTEC Bangkok Herbarium (BBH). Identification of fungi was based on their morphology and sporulation on agar media.

Formula for calculation of percentage abundance/frequency used in this study include:

Percentage abundance of taxon A:

$$= \frac{\text{Occurrence of taxon A} \times 100}{\text{occurrence of all taxa}}$$

Percentage frequency of occurrence

$$= \frac{\text{total number of collections of particular taxon encountered}}{\text{total number samples examined}} \times 100$$

Results

Frequency of occurrence of fungi on the palm *Licuala longicalycata*

Three-hundred and fifty-eight fungal identifications were made, representing 79 ascomycetes, 65 anamorphic fungi, and 3 basidiomycetes (Table 1, Fig. 2). The ten most common fungi were *Annulatascus velatisporus* (2.8%), *Microthyrium* sp. (2.8%), *Phaeoisaria clematidis* (2.8%), *Massarina bipolaris* (2.5%), *Phruensis brunneispora* (2.5%), *Solheimia costaspora* (2.2%), *Thailiomyces setulis* (2.2%), *Helicoma* sp. 1 (2%), *Nectria* sp. 1 (2%), and *Astrosphaeriella aquatica* (1.7%) (Table 1). However, 66 species (19.8%) were represented by only one collection, including 38 ascomycetes (58%), 27 hyphomycetes (41%) and 1 basidiomycete (1%).

Dry material supported the greatest diversity (40%) (Fig. 2) and the most frequent fungi included: *Solheimia costaspora* (8 records), *Phaeoisaria clematidis* (7 records), *Astrosphaeriella malayensis* (6 records) and *Thailiomyces setulis* (6 records). Submerged material accounted for 32% of the diversity (Fig. 2) with the most common being: *Annulatascus velatisporus* (10 records), *Phruensis brunneispora* (9 records), *Nectria* sp. 1 (7 records), *Candelabrum brocchiatum* (6 records), *Jahnula appendiculata* (6 records), *Massarina bipolaris* (6 records), and *Tubeufia* sp. (6 records). Damp material on the soil surface supported the least number of fungi with 28% (Fig. 2) including: *Microthyrium* sp. (8 records), *Helicoma* sp. 1 (7 records) *Astrosphaeriella aquatica* (6 records), and *Lasiodiplodia* sp. 1 (5 records).

Three tissue types were collected in this study: 1. petioles, 2. trunks, and 3. leaves, and fungi were identified with a percentage occurrence of 61%, 24%, and 15%, respectively (Fig. 2). Petioles supported the greatest number of fungal records and diversity.

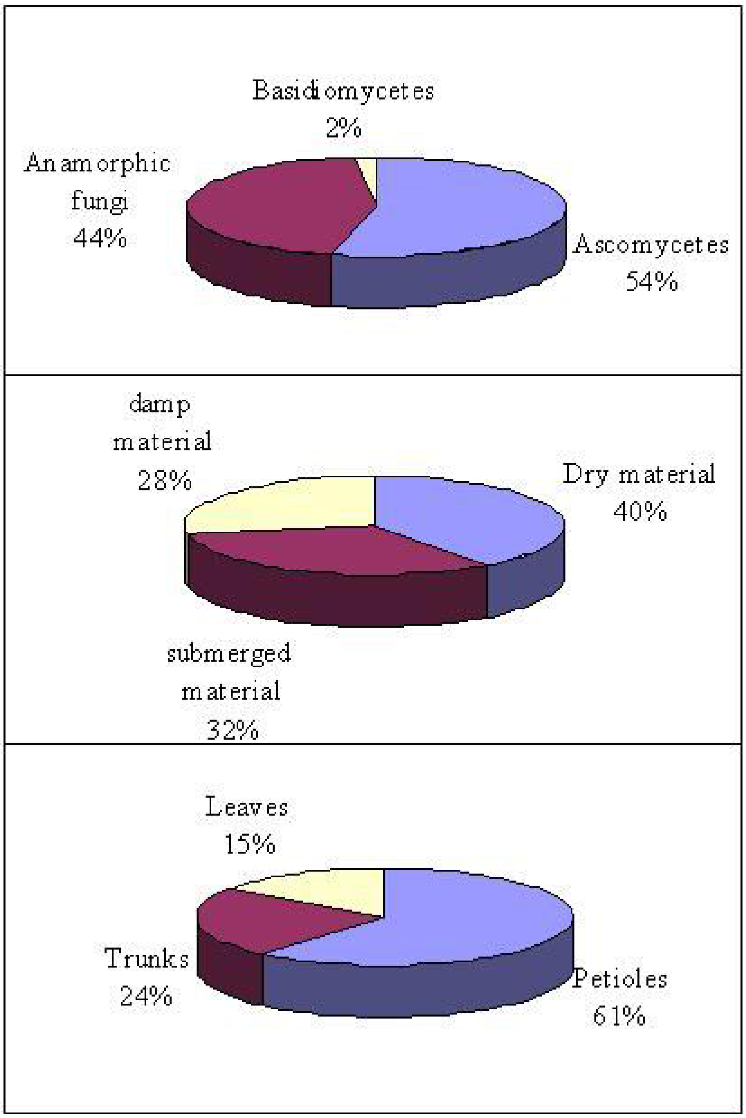

Fig. 2. Percentage of fungal records on *Licuala longicalycata* palm material.

Table 1. Distribution of fungi on _Licuala longicalycata_, in the peat swamp forest, Narathiwat, Thailand.

Fungus	**Percentage occurrence**	**Fungus**	**Percentage occurrence**
_Annulatascus velatisporus_*	2.8	_Dictyochaeta gyrosetula_	0.8
Microthyrium sp.*	2.8	_Gliocladium_ sp.	0.8
_Phaeoisaria clematidis_*	2.8	_Lasiodiplodia_ sp.	0.8
_Massarina bipolaris_*	2.5	_Linocarpon pandani_	0.8
_Phruensis brunneispora_*[#]	2.5	_Linocarpon_ sp.	0.8
Thailiomyces setulis[#]	2.2	_Massarina corticola_	0.8
Solheimia costaspora	2.2	_Oxydothis grisea_	0.8
Helicoma sp. 1	2	_Oxydothis hoehnelii_	0.8
Nectria sp. 1*	2	_Pseudorobillarda sojae_	0.8
Astrosphaeriella aquatica	1.7	_Spadicoides obovatum_	0.8
Astrosphaeriella malayensis	1.7	_Thozetella radicata_*	0.8
_Candelabrum brocchiatum_*	1.7	_Anthostomella palmiria_	0.6
_Jahnula appendiculata_*[#]	1.7	_Arthrinium arundinis_	0.6
Thozetella nivea	1.7	_Arthrobotrys oligospora_	0.6
_Tubeufia claspisphaeria_*	1.7	_Ascominuta lignicola_*	0.6
_Chaetospermum camelliae_*	1.4	_Astrosphaeriella lophiostomopsis_	0.6
_Delortia palmicola_*	1.4	_Astrosphaeriella papillata_	0.6
Lasiodiplodia theobromae	1.4	_Astrosphaeriella fronsicola_	0.6
Petrakiopsis sp.	1.4	_Bactrodesmium_ sp.	0.6
_Submersisphaeria aquatica_*	1.4	_Berkleasmium typhae_*	0.6
_Xylomyces aquaticus_*	1.4	_Canalisporium variable_*	0.6
_Astrosphaeriella angustispora_*	1.1	_Chalara siamense_	0.6
Gonytrichum macrocladum	1.1	_Dictyosporium digitatum_	0.6
Submersisphaeria palmae	1.1	_Flammispora bioteca_*[#]	0.6
Trichoderma harzianum	1.1	_Glomerella_ sp.	0.6
_Wiesneriomyces javanicus_*	1.1	_Guignadia manokwaria_	0.6
_Annulatascus aquaticus_*	0.8	_Helicoma_-like 2	0.6
_Annulatascus palmae_*	0.8	_Helicosporium gigasporum_	0.6
Astrosphaeriella livistonicola	0.8	_Linocarpon elaeidis_	0.6
_Baipadsphaeria spathulospora_*[#]	0.8	_Lophodermium licualae_	0.6
_Cancellidium applanatum_*	0.8	_Massariana_ sp. nov. [#]	0.6
Craspedodidymum licualae[#]	0.8	_Myelosperma tumidum_	0.6
Craspedodidymum microsporum[#]	0.8	_Nawawia fusiformis_	0.6

Table 1 continued. Distribution of fungi on *Licuala longicalycata*, in the peat swamp forest, Narathiwat, Thailand.

Fungus	**Percentage occurrence**	**Fungus**	**Percentage occurrence**
Nectria sp. 2*	0.6	*Koorchaloma bambusae*	0.3
Oxydothis angustispora *	0.6	*Cryptophailoidea manifesta* *	0.3
Oxydothis atypical *[#]	0.6	*Lanceispora amphibia*	0.3
Oxydothis livistonae	0.6	*Linocarpon livistonae*	0.3
Oxydothis licualae	0.6	*Lophiostoma frondisubmersa* *	0.3
Phomatospora berkleyi	0.6	*Lophiostoma*-like	0.3
Sporidesmiella oraniopsis	0.6	*Melanographium palmicola*	0.3
Stachybotrys palmae[#]	0.6	*Monotosporella rhizoidea* *	0.3
Stachybotrys bambusicola	0.6	*Myelosperma tumidum*	0.3
Stilbohypoxylon moelleri	0.6	*Niesslia* sp.	0.3
Acrospeira-like	0.3	*Ophioceras* sp.*	0.3
Arecomyces bruneiensis	0.3	*Orbilia* sp.	0.3
Arecomyces frondicola	0.3	*Oxydothis frondicola* *	0.3
Arecomyces epigeni *	0.3	*Oxydothis oraniopsis*	0.3
Arecophila striatispora	0.3	*Oxydothis livistonica*	0.3
Aspergillus sp.	0.3	*Penicillium* sp.	0.3
Astrocystis rachidis	0.3	*Phaeodothis* sp.*	0.3
Astrocystis sp.	0.3	*Rosellinia corticum* *	0.3
Astrosphaeriella floridana	0.3	*Sarocladium*-like	0.3
Astrosphaeriella sp.1*	0.3	*Spadicoides klotzchii*	0.3
Berkleasmium typhae *	0.3	*Spadicoides* sp. [#]	0.3
Canalisporium caribense	0.3	*Verticillium* sp.*	0.3
Carinispora nypae	0.3	*Zalerion*-like	0.3
Caryospora sp. [#]	0.3	Unidentified anamorphic fungi (8 taxa)	2.7
Chaetosphaeria sp.	0.3	Unidentified ascomycetes (12 taxa)	3.9
Ciliclopodium-like	0.3	Unidentified basidiomycete (3 taxa)	1.7
Craspedodidymum siamense[#]	0.3	**Total records = 358**	
Dactylaria hemibeltranioidea	0.3	**Ascomycetes = 79 species, Basidiomycetes = 3 species, Anamorphic fungi = 65 species**	
Dictyochaeta ramulosetula	0.3	**Total species = 147 species**	
Dictyosporium palmae[#]	0.3	**Fully identified = 93 species, Partially identified = 31 species, Unidentified = 23 species**	
Didymosphaeria bisphaerica *	0.3		
Endocalyx melanoxanthus	0.3		

*Species on submerged palm material
#New species or probable new species

Discussion

Biodiversity of fungi in Sirindhorn peat swamp forest

Estimates of global fungal numbers vary depending on the opinions of the authors (see Bisby and Ainsworth, 1943; Martin, 1951; Pascoe, 1990; Hawksworth, 1991; Cannon, 1997). It is hard to conclude which estimate is the most realistic as all are based on incomplete data. It is however, important to search for the missing fungi in order to provide evidence to conserve genetic resources before species become extinct (Hawksworth, 1991; Hyde and Hawksworth, 1997). These newly discovered fungi may also be important to mankind, e.g. in the pharmaceutical industry, and in documenting the fungi present in different ecosystems.

Peat swamp forests are different in structure from other forests, predominantly because of their waterlogged condition. They also have a high level of acidity and organic materials in the water, a low input of nutrients and lack soil or firm ground for the growth of plants. Sepiah and Lit (2004) studied the diversity of fungi colonizing leaf vegetation in a peat swamp forest in Malaysia and recorded 58 genera and 132 species with the majority being anamorphic fungi. Hankaew (2004) reported that the water within Sirindhorn peat swamp forest, sampled in both the wet and dry seasons, was strongly acidic (pH 2.5-4.7), and with a dissolved oxygen of 2.3-8.7%. Therefore pH and oxygen are low. Diehl (1937) and Bisby and Ainsworth (1943) opinioned that the distribution of fungi was more dependent on the host or substratum than on climate. However, Jørgensen (1983) argued that this is not true for all fungi, and cited as an example the distribution of marine fungi, soil fungi and lichens. Fungal distribution patterns may also reflect past geological events (Pirozynski and Weresub, 1979; Horak, 1983; Jørgensen, 1983; Pirozynski, 1983). Dix and Webster (1995) stressed that the environment, physiological and biological factors may affect the vertical distribution of fungi.

Most of the palms which have previously been studied were from rain forest habitats (Fröhlich and Hyde, 1994, 1999; Yanna *et al*., 1998, 2001a), and Hyde *et al*. (1997) reported the global palm fungi as 1,580 species: Ascomycota 650 species, Basidiomycota 270 species, coelomycetes 260 species, and hyphomycetes 400 species.

In the present study, one-hundred and forty-seven fungi were found to colonize different parts of *L. longicalycata*, indicating a high species richness (Table 2), and with many undescribed taxa.

However, only one fungus, *Delortia palmicola* was found on all palm tissue types, while *Phaeoisaria clematidis* was the only species collected in each microhabitat. There was also some overlap between fungi recorded in each of the three microhabitats and tissue types (Table 3).

Table 2. A synopsis of the taxonomic groups of fungi recorded from *Licuala longicalycata*, and other palms with the relative proportions of species (%).

Host	Ascomycete species	Basidiomycete species	Anamorphic fungi (species)	Total species	References
Archontophoenix alexandrae	91 (60%)	1 (1%)	59 (39%)	151	Taylor, 1997
Licuala longicalycata	79 (54%)	3 (2%)	65 (44%)	147	This study
Trachycarpus fortunei	61 (42 %)	-	83 (58 %)	144	Taylor, 1997
Eleiodoxa conferta	45 (48%)	2 (2%)	47 (50%)	94	Pinnoi *et al*., 2006
Phoenix haceana	28 (32%)	-	59 (68%)	87	Yanna, 2001
Cocos nucifera	44 (57%)	1 (1%)	32 (42%)	77	Taylor, 1997
Oncosperma horridium	26 (38%)	5 (7%)	38 (55%)	69	Yanna, 2001
Salacca affinis	26 (40%)	3 (5%)	36 (55%)	65	Yanna, 2001
Oraniosis appendiculatum	24 (43%)	-	32 (57%)	56	Yanna, 2001
Nypa fruticans	35 (85%)	2 (5%)	4 (10%)	41	Hyde and Alias, 2000
Livistona australis	15 (47%)	-	17 (53%)	32	Yanna, 2001

The ten most common fungi (Table 1) differ significantly from those usually found to be common on terrestrial palms (Fröhlich, 1997; Hyde *et al*., 1997; Taylor, 1997; Yanna *et al*., 2001a, b). Typical fungal genera on tropical palms generally include *Anthostomella*, *Arecomyces*, *Astrosphaeriella*, *Linocarpon*, *Oxydothis* and *Sorokinella*. The only common genus on *Licuala longicalycata* which also commonly occurs on other palms is *Astrosphaeriella*, and there is a marked difference in the percentage occurrence of genera such as *Arecomyces*, *Linocarpon*, and *Oxydothis*. The reason for the differences are unclear, but are unlikely to be due to the effects of biogeography. Taylor (1997) noted variation in the relative abundance and species richness of fungi in different countries e.g. in the New and Old World tropics: *Arecomyces* was better represented in Ecuador than *Oxydothis*, while *Oxydothis* was the most abundant genus recorded in South East Asia and Australia. Fröhlich and Hyde (2000) noted that fungi on palms in the South East Asian countries and Australia were more similar to each other than those on palms in Ecuador. Taylor (1997) noted that the ascomycete assemblages in Hong Kong and Australia were found to be similar despite being in different hemispheres. Hong Kong had the highest diversity and species richness when compared with temperate and tropical Australia, China, Europe, Malaysia, Seychelles, and Sri Lanka (Taylor, 1997). The differences were probably due to the effect of sampling, as collections were made at the optimum collecting times, at several times throughout the wet season and in two consecutive years, while in other countries only one visit took place and collections made at the "whim of weather" (Taylor, 1997).

Table 3. The percentage of overlapping of fungi on different tissue types and habitats.

Different tissues	
Only found on petioles	69.7%
Only found on trunks	8.9%
Only found on leaves	8.9%
Petioles and trunks	5.0%
Petioles and leaves	6.9%
Trunks and leaves	0.3%
Found on all tissues	0.3%
Different microhabitats	
Only found on dry material	44.7%
Only found on damp material	18.9%
Only found on submerged material	20.8%
Dry and damp	7.5%
Dry and submerged	0.3%
Damp and submerged	7.5%
Found all habitats	0.3%

Comparison of fungi on *Licuala longicalycata* with those on terrestrial palms

The number of fungi reported from terrestrial palms ranges from 32 species on *Livistonia australis* to 151 on *Archontophoenix alexandrae* (Table 2). *Licuala longicalycata* (147) therefore supported a wide range of species similar to *A. alexandrae* (151 species) and *Trachycarpus fortunei* (144 species). In all studies, basidiomycetes were poorly represented, and this probably reflects the fact that few basidiomycetes occur on decaying palms, and possibly a bias in the documentation and identification of ascomycetes and anamorphic fungi. Choeyklin *et al*. (2006) report 34 basidiomycetes from palm material collected in Thailand. Ascomycetes were the most abundant on *A. alexandrae* and *L. longicalycata*, while on *T. fortunei* and *Phoenix hanceana*, anamorphic fungi were dominant.

Many factors govern fungal colonization of various substrata: the nature of the host substratum (chemical), minor components of the substratum; lignin/cellulose ratio; nitrogen/carbohydrate ratio. Host plants may contain low to high amounts of compounds that are toxic or inhibit the growth of fungi e.g. phenols, while wood density of a substratum may also influence the ability of fungi to colonise and penetrate the host. Other factors that may play a role in determining fungal colonization and species richness: number of samples collected, parts sampled (often not defined), frequency of collections, dry or wet season, different hosts, and habitats (submerged or aerial), climate, historical biogeography, past and present host distribution, state of the host in the country (planted or natural), and fungal competition for a resource. Despite all these factors *L. longicalycata* supports a rich fungal diversity. This study also highlights the high number of undescribed fungi which can be found on palm fronds in the peat swamp forest.

Fungi on different habitats and parts of *Licuala longicalycata*

Of the 147 species recorded on *L. longicalycata*, there was little evidence of host-specific fungi. Shivas and Hyde (1997) noted that there is a high degree of host-specificity in plant pathogens (parasites) and endophytes, while saprobes are considered the least host-specific fungi. Similarly, Fröhlich and Hyde (2000) reported that the ascomycete genera from decaying palm material, although typical of palm hosts, showed little host-specificity.

The present study showed that different palm tissues and microhabitats of the palm supported distinct fungal communities. Palm petioles were found to support a more diverse fungal community than trunks and leaves. Dry palm material was found to support a greater fungal diversity than damp or submerged material. Possible factors affecting these differences in fungal communities include:

Difference in the structural anatomy of each palm part. The morphology of palms may have some influence on the ability of fungi to colonize them: thin-walled parenchymatous cells in leaves and thick-walled cells in petioles and rachides, are cellulose rich and contain lignin.

Nutrient availability of substratum. Palm trunks and petioles provide a substratum rich in cellulose and lignin, and only fungi with the necessary enzymes can utilize these. These properties favour the ascomycetes, which require a longer period for the development of fruiting structures. Palm leaves favour the more rapidly growing hyphomycetes that are able to utilize starches and sugars, colonize rapidly and dry out when nutrients are exhausted (Table 4).

Table 4. Summary of properties of different palm tissues.

Tissue	Properties
Petioles	1. High nutrient
Trunks	- many vascular bundles
	- many lignified cell walls
	- many sclerenchyma cells
	2. Slow drying out
	3. High moisture reserve
	- contain spongy cell walls
	4. High nutrient reserve
Leaves	1. Low nutrient
	- few vascular bundles
	- few sclerenchyma cells
	2. Rapid drying out
	- thin walled parenchyma cells
	3. Low moisture reserve
	4. Low nutrient reserve

Water content and volume of the substratum. Each palm part varies in volume of the tissue with trunks and petioles having a greater volume than leaves. Because trunks and petioles contain more vascular bundles and associated sclerenchyma, they retain more moisture and dry out more slowly. This enables a more complex fungal community to develop and colonize the substratum. However, as base trunks are submerged in water, it may be that the petioles are more suitable for fungal colonization. Leaves have few vascular bundles and sclerenchyma, the greater part of the leaf is made of thin-walled parenchyma cells, contain less moisture and are subject to more rapid drying out than the petiole and trunks (Table 4).

Microhabitat conditions

Palm parts exposed under different microhabitat conditions also showed differences in fungal populations, with dry material supporting a higher species diversity than damp or submerged samples. A number of factors may account for this:

Acidic water in the peat swamp. The average pH of peat swamp water was 4.2-6.0 (while Hankaew, 2004 reported lower pH values of 2.5- 4.7), and may not be suitable for the production of biodegrative enzymes. This in turn may account for the limited number of fungi on palm material under submerged conditions.

Oxygen availability. Peat swamps are waterlogged, with poor water circulation, often leading to stagnation and lack of oxygenation (dissolved oxygen of 2.3-8.7%, Hankaew, 2004). Such conditions results in slow decomposition of plant and other organic materials because of its nearly airless condition, hence the production of peat. This may limit the growth of the colonizing fungi on submerged material.

Freshwater palm fungi

Fungi that are commonly encountered on submerged wood and other substrata are generally known as freshwater ascomycetes, Ingoldian fungi, freshwater hyphomycetes, or aero-aquatic fungi and there has been considerable research on these organisms and much has been written about them (e.g. Tsui and Hyde, 2003; Cai *et al*., 2005; Fryar *et al*., 2005; Pascoal *et al*., 2005; Van Ryckegem and Verbeken, 2005a, b; Sakayaroj *et al*., 2005; Magyar *et al*., 2005; Gönczöl and Révay, 2006; Vijaykrishna and Hyde, 2006; Vijaykrishna *et al*., 2006). There has also been considerable research on the fungi on Nypa palm (*Nypa fruticans)* resulting in the review of Hyde and Alias (2000). However, few freshwater fungi are known from palm material submerged in freshwater and this study significantly adds to this data (Table 1). The fungi from submerged palm material generally differs from that on terrestrial palm material and palm material submerged in brackish water.

The peat swamp palm *Licuala longicalycata* has been shown to support a rich fungal diversity and this differs significantly from that reported for terrestrial and brackish water palms. One-hundred and forty-seven fungi are documented, which includes 7 new species: *Craspedodidymum licualae*, *C. microsporum*, and *C. siamense* (Pinruan *et al*., 2004a), *Flammispora bioteca* (Pinruan *et al*., 2004d), *Jahnula appendiculata* (Pinruan *et al*., 2002), *Phruensis brunneispora* (Pinruan *et al*., 2004c), and *Stachybotrys palmae* (Pinruan *et al*., 2004b) while others remain to be described (Table 1).

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