Fungi on the grasses, *Thysanolaena latifolia* and *Saccharum spontaneum*, in northern Thailand

Bhilabutra W[1], McKenzie EHC [2], Hyde KD[3] and Lumyong S[1*]

[1]Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand.
[2]Landcare Research, Private Bag 92170, Auckland, New Zealand.
[3]School of Science, Mae Fah Luang University, Chiang Rai, Thailand.

Bhilabutra W, McKenzie EHC, Hyde KD, Lumyong S. 2010 – Fungi on the grasses, *Thysanolaena latifolia* and *Saccharum spontaneum*, in northern Thailand. Mycosphere 1(4), 301–314.

Fungi associated with dead leaves and stems of *Thysanolaena latifolia* and *Saccharum spontaneum* were collected and identified at two sites. *T. latifolia* yielded 67 taxa, comprising 24 ascomycetes, 33 hyphomycetes, 9 coelomycetes and 1 myxomycete. The most common genera were *Leptosphaeria*, *Niptera*, *Periconia*, *Septoria*, *Stachybotrys*, *Tetraploa*, and *Verticillium*. *S. spontaneum* yielded 79 taxa comprising 32 ascomycetes, 37 hyphomycetes, and 10 coelomycetes. The most common genera were *Cladosporium*, *Massarina*, *Periconia* and *Tetraploa*. The highest species diversity index was recorded on *S. spontaneum* (H = 6.5), while *T. latifolia* was lower (H = 5.5). The mycota at the two sites differed significantly in species composition. Percentage similarity for *T. latifolia* between the two sites was 50.5% while for *S. spontaneum* it was 52.3 %. A comparison of the fungi occurring on these grasses with those on other monocotyledonous host from tropical regions is presented. *Drumopama moonseti* and *Pycnothyriopsis* sp. were reported as rare species in this study. *Dendrographium thysanolaenae* ined. is considered new to science.

Key words – diversity – graminicolous fungi – saprobes – tropical fungi

Article Information
Received 1 October 2010
Accepted 4 November 2010
Published online 12 December 2010
*Corresponding author: Saisamorn Lumyong – e-mail –scboi009@chiangmai.ac.th

Introduction

There is ongoing interest in the biodiversity of fungi in Thailand (e.g., Lumyong et al. 2000, Photita et al. 2001a,b, Promputha et al. 2002, 2004a, Bussaban et al. 2001, 2004, Jones et al. 2004, Pinnoi et al. 2006, Aptroot et al. 2007, Pinruan et al. 2007, Aung et al. 2008, Duong et al. 2008, Kodsueb et al. 2008, Thongkantha et al. 2008, Osono et al. 2009, Fournier et al. 2010). There have been several reports on saprobic fungal diversity on tropical substrates such as bamboo, banana, gingers, grasses, Magnoliaceae and palms (Lumyong et al. 2000, Bussaban et al. 2001, 2003, 2004, Photita et al. 2001a, 2002a, 2003b, Wong & Hyde 2001, Yanna et al. 2002a, Promputtha et al. 2003, 2004a,c, 2005, Jones et al. 2004). The results have shown that many of the saprobic fungi occurring on these hosts are unique to the host family, genus and/or species (Photita et al. 2001a, Wong & Hyde 2001, Hyde et al. 2002a, b, McKenzie et al. 2002, Whitton et al. 2002, 2003, Yanna et al. 2002a,b). Many novel fungi have been reported from these studies (e.g., Photita et al. 2002b, 2003a, Bussaban et al. 2003, Pinnoi et al. 2003a, b, 2004, 2006, 2007, Promputtha et al. 2003, 2004a,b, 2005, Pinruan et al. 2004a,b,c, 2008, Bhilabutra et al. 2006, Kodsueb et al. 2006, 2007a,b). Such studies help to accumulate the number of fungi known

in Thailand and provide data for improving the accuracy when estimating the number of fungi in the world.

Hawksworth (1991) provided a widely accepted estimate of 1.5 million fungal species. This estimate relied heavily on extrapolation from a suggested ratio of six fungi to each vascular plant species (Hawksworth 1991, Fröhlich & Hyde 1999). This ratio is dependent on whether fungi are host specific or whether they occur more frequently on certain hosts (Yanna et al. 2001). Several investigations have provided evidence which suggests that certain fungi are host specific or host recurrent (Zhou & Hyde 2001, McKenzie et al. 2002, Santana et al. 2005), or at least occur frequently on certain hosts (Yanna et al. 2001). Specificity at host family level is undeniable (Cannon 1991, Fröhlich & Hyde 2000). The problem with proving specificity at the host species level is that too few studies have been carried out, especially in the tropics, to confirm that one fungus species is confined to a particular host. Many examples of fungal taxa are recorded as common on a single plant host, family or order (e.g., Francis 1975, Hawksworth & Boise 1985, Gonzales & Rogers 1989, Læssøe & Lodge 1994, Tokumasu et al. 1994, Fröhlich & Hyde 1995, Ju & Rogers 1996, Polishook et al. 1996, Huhndorf & Lodge 1997, Lodge 1997, Hyde & Alias 2000, Bucheli et al. 2001, McKenzie et al. 2002). However, Zhou & Hyde (2001) reported that saprobes are perhaps less host specific when compared to pathogenic and endophytic fungi.

Whether fungi are host specific, are recurrent on certain hosts, or are restricted to certain tissue types, will have considerable impact on biodiversity estimates. We therefore initiated a study to establish: 1) whether the fungi on two grasses in Thailand, *Thysanolaena latifolia* and *Saccharum spontaneum* vary according to tissue types; 2) whether the fungi on *T. latifolia* and *S. sponta-neum* differ significantly between two sites; and 3) whether the fungi occurring on *T. latifo-lia* and *S. spontaneum* are likely to be host or family specific.

Methods

Sample collection

Dead leaves and stems of *Thysanolaena latifolia*, a terrestrial grass, were collected from Doi Suthep-Pui National Park, Thailand. Two sites were chosen: (1) Chiang Mai Zoo region (300 m above sea level) and (2) Phu Phing Ratchaniwat Palace region (1400 m above sea level). Dead leaves and stems of *Saccharum spontaneum*, a riparian grass, were also collected from two sites: (1) Chiang Dao district (500 m above sea level) and (2) Mae Rim district (300 m above sea level). Samples were taken in the dry season (February) and the wet season (September). At each site 50 dead leaves (each about 10 cm wide and 30 cm long) and 50 dead stem samples (each 20 cm long) were randomly collected. Material was returned to the laboratory in zip lock plastic bags. Samples were incubated individually in plastic chambers, with an addition of tissue paper moistened with sterilized water. Samples were examined for the presence of microfungi after one week of incubation and then periodically for up to one month following the methods detailed by Hyde & Goh (1998) and Hyde et al. (1998).

Statistical analysis

A 3-dimensional correspondence analysis (JMP) was performed to examine the differences in fungal communities at different sites (Anonymous 1995). The results of this study are presented in terms of percentage occurrence of fungi. Fungal taxa with a percentage occurrence higher than 2 are regarded as dominant species. These fungal taxa were used to plot changes in the dominant species throughout the experimental period. Shannon indices (H') were used to calculate fungal species diversity on each grass host (Shannon & Weaver 1949).

$$\text{Percentage occurrence} = \frac{\text{number of leaf/stem samples from which fungus was detected}}{\text{total number of leaves or stem samples examined in each site}} \times 100$$

$$\text{Percentage similarity index} = 2c/a+b \times 100$$

a: the number of species in habitat A
b: the number of species in habitat B
c: the number of species in common to habitat A and B

$$\text{Shannon index (H')} = - \Sigma \, Pi \log 2 \, Pi$$

Where;

Pi: is the probability of finding each taxon in a collection.

Results

Numbers of records and percentage occurrence of fungal taxa on *T. latifolia* and *S. spontaneum* at each site are given in Tables 1 and 2. For *T. latifolia*, 67 taxa were identified, comprising 24 ascomycetes, 42 anamorphic taxa (33 hyphomycetes and 9 coelomycetes) and 1 myxomycete. The most common taxa identified in this study were *Periconia* spp. (occurring on 51.7% of samples), *Verticillium* sp. 1 (29.2%), *Niptera exselsior* (29.2%), *Tetraploa aristata* (20.0%), *Stachybotrys* spp. (24.2%), *Septoria* sp. (20.0%), and *Leptosphaeria compositarum* (22.5%). For *S. spontaneum*, 79 taxa were identified, comprising 32 ascomycetes and 47 anamorphic taxa (37 hyphomycetes and 10 coelomycetes). The most common taxa were *Periconia* spp. (occurring on 19.6 % of samples), *Tetraploa aristata* (9.6%), *Massarina* spp. (6.6%), *Cladosporium cladosporioides* (4.2%), and *Halosphaeria hamata* (3.8%).

Three-dimensional correspondence analysis was performed to visualize the effect of tissue type and site on the colonization by fungi. For *T. latifolia* (Fig. 1), the first three principal axes accounted for 100% of the variability in the data matrix. X-axis clearly separated the two tissue type (leaves and stems), while Z-axis separated the two sites, indicating that there are tissue preferences and site differences for fungi on this plant. The result of the analysis also showed that the sites are effected to fungal communities rather than the tissue types. This is indicated by the cluster distances of the samples from the same site than samples from different tissue types. Percentage similarity index between fungi on leaves and stems in *T. latifolia* were 56.6% and 61.1%, respectively. Similar three-dimensional correspondence analysis was performed for *S. spotaneum* (Fig. 2). Variability between sites was similar in leaves and stems, as expressed by the similar distances between the points representing leaves and stems from the two sites. Percentage similarity index between fungi on leaves and stems in *S. spontaneum* were 46.2% and 56.5%, respectively.

The highest species diversity was recorded on *S. spontaneum* (Shanon diversity index, H = 6.5 average), while for *T. latifolia* it was lower (H = 5.5 average) (Table 3). Further statistical analyses of species richness, species evenness, number of fungi per sample, and Simpson's diversity index of each collection were calculated (Table 3).

Discussion

Fungal taxonomic composition

Generic concepts for loculoascomycetes are presently in a state of flux (Zhang et al. 2008, 2009a,b, Schoch et al. 2009, Suetrong et al. 2009) and we thus use a wide understanding of each genus (e.g., *Botryosphaeria*, *Massarina*, *Phaeosphaeria*) until taxa can be sequenced to establish their natural phylogenetic affinities. We have also used wide species concepts for some speciose anamorphic genera (e.g., *Colletotrichum*, *Pestalotiopsis*, *Phoma*, *Verticillium*). These require sequence data for exact determination (Aveskamp et al. 2008, Crouch & Beirn 2009, Cai et al. 2009, Hyde et al. 2009, Tejesvi et al. 2009) and such methodology was not possible in this study.

The fungi were dominated by anamorphic taxa, and perhaps there were undescribed species in genera such as *Chaetophoma*, *Colletotrichum*, *Fusarium*, *Periconia*, *Pestalotiopsis*, *Phoma*, *Phomopsis*, *Pyricularia* and *Verticillium*. The Shanon diversity index for both grasses was higher than those found by Wong & Hyde (2001), indicating the high species diversity on these grasses.

The common fungi found on both *T. latifolia* and *S. spontaneum* were *Colletotrichum*, *Fusarium*, *Massarina*, *Nipteria*, *Phoma*, *Phomopsis*, *Septoria* and *Tetraploa*, genera also found commonly on other terrestrial grasses by Wong & Hyde (2001). The most common fungal genera recorded on various monocotyledonous substrates, especially from Thailand and nearby tropical regions, are summarized in Table 4.

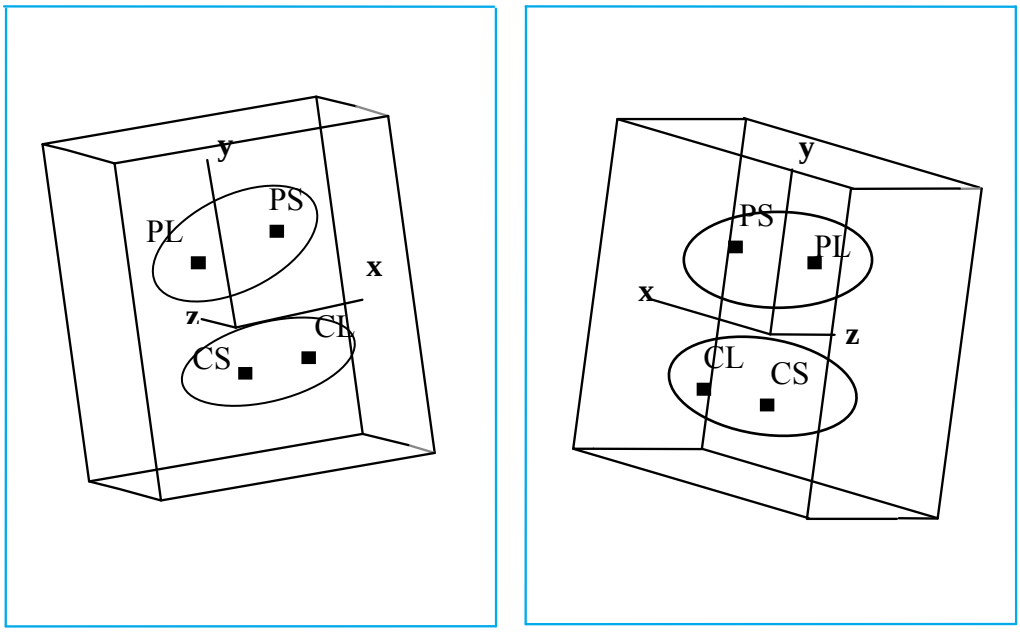
Table 1 Percentage occurrence of fungal taxa on *Thysanoleana latifolia* at two sites in Thailand.

Taxa	Chiang Mai Zoo		Phu Phing Palace		Overall % occurrence
	Leaves	Stems	Leaves	Stems	
Ascomycetes					
Annulatascus triseptatus	3.3				0.8
Anthostomella punctulata		23.3		26.7	12.5
Astrosphaeriella sp.		3.3	3.3	6.7	3.3
Apiospora camptospora			3.3		0.8
Arecophila sp.	3.3	3.3			1.7
Chaetosphaeria lentomita		3.3		3.3	1.7
Didymella sp. #			3.3	3.3	1.7
Gaeumannomyces graminis		10.0		10.0	5.0
Glonium sp.					
Leptosphaeria compositarum	6.7	33.3	10.0	10.0	22.5
Lophaeostoma macrostomum				3.3	0.8
Lophiosphaera sp.#		6.7			1.7
Lophiostoma sp.		3.3			0.8
Magnaporthe salvinii	3.3				0.8
Massarina chamaecyparidi			3.3	6.7	2.5
Massarina papulosa		6.7			1.7
Massarina phragmiticola				3.3	0.8
Niptera excelsior	6.7	50	6.6	53.3	29.2
Ophiobolus leptosporus	6.7	30	6.7	40	19.7
Oxydothis sp.#		3.3			0.8
Phaeosphaeria sp.			3.3		0.8
Pleospora penicillus			3.3		0.8
Terriera sp.		3.3	3.3	6.7	3.3
Xylaria sp.	3.3	10.0	3.3	13.3	7.5
Anamorphic fungi					
Coelomycetes					
Chaetophoma sp.#		3.3			0.8
Colletotrichum sp.	13.3	16.7	10.0	20.0	15.0
Pestalotiopsis versicolor	6.7		3.3		2.5
Pestalotiopsis sp.			3.3	3.3	1.7
Phoma sp. 1			3.3		1.7
Phoma sp. 2		3.3			0.8
Phomopsis sp.		6.7			1.7
Pycnothyriopsis sp.*	3.3				0.8
Septoria sp.	10.0	23.3	10.0	36.7	20.0
Hyphomycetes					
Acremonium kiliense		3.3			0.8
Acremonium masseei	6.7	26.7	10.0	23.3	15.8
Alternaria alternata	3.3	3.3			1.7
Arthrinium sp.	6.7	10.0	6.7	3.3	6.7
Cladosporium cladosporioides	10.0	23.3	3.3	26.7	15.8
Curvularia lunata		3.3			0.8
Dactylaria dimorphospora			3.3	3.3	1.7
Dactylaria triseptata	3.3				0.8
Dactylaria sp.		3.3		3.3	1.7
Dactylella ellipsospora	3.3				0.8
Dendrographium thysanolaenae *		3.3			0.8
Dictyochaeta simplex		10.0			5.0
*Drumopama monoseta**		6.7			1.7
Fusarium oxysporum	13.3	16.7	13.3	20.0	15.8
Memnoniella subsimplex	3.3	13.3		20.0	9.2
Nigrospora oryzae	3.3				0.8
Periconia byssoides	33.3	9.9	26.6	13.3	20.8

Table 1 (Continued) Percentage occurrence of fungal taxa on *Thysanoleana latifolia* at two sites in Thailand.

Taxa	Chiang Mai Zoo		Phu Phing Palace		Overall % occurrence
	Leaves	Stems	Leaves	Stems	
Periconia cookei	40.0	6.7			11.7
Periconia digitata	6.7				1.7
Periconia echinochloae	3.3	13.3	23.3	16.7	14.2
Periconia macrospinosa	3.3	9.9			3.3
Phaeoisaria clematidis		3.3			0.8
Pleurophragmium simplex			6.7		1.7
Pseudocercospora sp.		3.3			0.8
Pyricularia sp.#				3.3	0.8
Spegazzinia deightonii	3.3	6.7			2.5
Sporidesmium cookei	9.9				2.5
Stachybotrys echinata	6.7	33.3	9.9	40.0	22.5
Stachybotrys parvispora		6.7			1.7
Stachylidium bicolor				6.7	1.7
Stilbella sp.	13.3		16.7		7.5
Tetraploa aristata	56.7	20.0	10.0	26.7	20.0
Verticillium sp.	36.7	30.0	23.3	26.7	29.2
Myxomycetes					
Dictydium cancellatum			3.3		0.8
Total no. taxa = 67	**31**	**42**	**29**	**30**	

*Known only from *Thysanoleana* sp.
#Unidentified species, possibly known only from *Thysanoleana* sp.



a **b**

Figs 1 – Three-dimensional correspondence ordination of taxa and fungal communities recorded from leaves (L) and stems (S) of *Thysanoleana latifolia* from Phu Phing Ratchaniwat Palace (P) and Chiang Mai Zoo (C) **a.** Diagram oriented at x- and y- axes **b.** Diagram oriented at y- and z- axes.

Do fungi on *T. latifolia* and *S. spontaneum* vary according to tissue types?

Different fungal communities were found on leaves and stems of the two woody grasses, with higher species diversity on stems. Several fungi showed a preference for stems of *T. latifolia* including the ascomycetes, *Anthostomella punctulata*, *Leptosphaeria compositarum*, *Niptera exselsior* and *Ophiobolus leptosporus*, and the anamorphic fungi, *Acremonium masseei*,

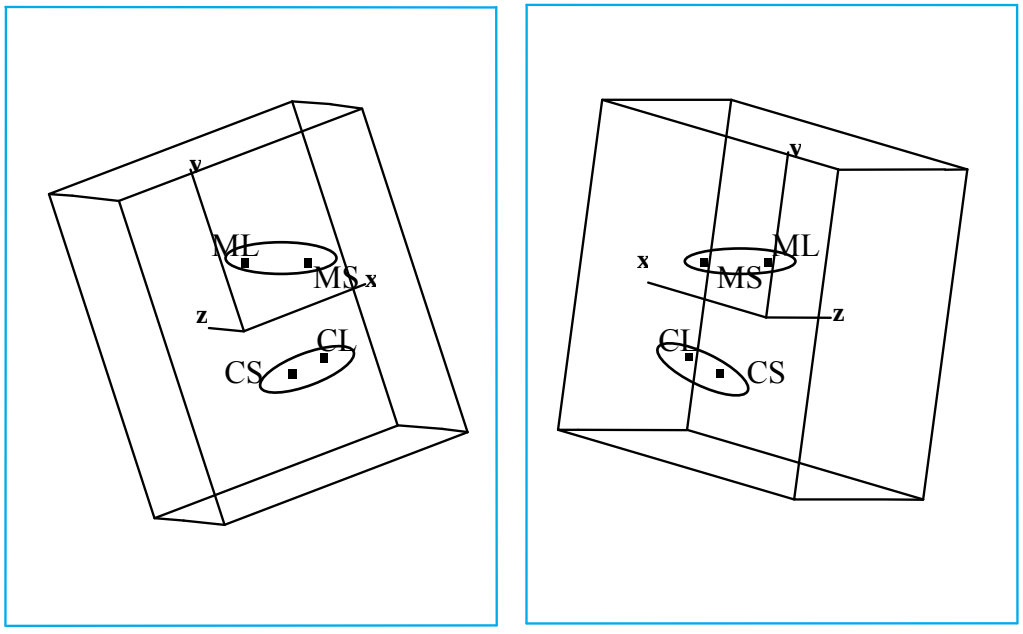
Table 2 Number of records and percentage occurrence of fungal taxa on *Saccharum spontaneum* at two sites in Thailand.

Taxa	Chiang Dao district		Mae Rim district		Overall % occurrence
	Leaves	Stems	Leaves	Stems	
Ascomyce					
Annulatascus sp. 1				1	0.2
Apiospora montagnei			1		0.2
Arecophila sp. 1		1		4	1
Arecophila sp. 2		1			0.2
Arecophila sp. 5 (CMUGS2033) #		3			0.6
Ascomycetes 1 (CMUGS2028)#		1			0.2
Ascomycetes 2 (CMUGS2041)#		2			0.4
Botryosphaeria festucae		5		1	1.2
Didymella glacialis	7	2	1	1	2.2
Didymosphaeria conoidea	1	2		2	1
Gaeumannomyces graminis		5		3	1.6
Gibberella zeae		1			0.2
Halosphaeria hamata	11	2	5	1	3.8
Lewia infectoria		1			0.2
Linocarpon sp. 1		3			0.6
Lophiostoma arundinis	10	2			2.4
Lophiostoma sp.				2	0.4
Massarina arundinacea	14	2	8	1	5
Massarina fluviatilis	1				0.2
Massarina sp. 1		2			0.4
Massarina sp. 2		3			0.6
Massarina sp. 3				1	0.2
Massarina sp. 4 (CMUGS2011)#		1			0.2
Mycosphaerella lineolata		7		6	2.6
Nectria graminicola		1		1	0.4
Ophiobolus leptosporus		1			0.2
Oxydothis sp. 1		2		1	0.6
Paraphaeosphaeria sp.		1			0.2
Phaeosphaeria eustoma	2	2		1	1
Phaeosphaeria pontiformis	1	2			0.6
Phomatospora berkeleyi		3	1	1	1
Stictis sp.#		11			2.2
Coelomycetes					
Coelomycete		2			0.4
Colletotrichum sp. 1	10	3	2	5	4
Microsphaeropsis sp.		7			1.4
Phaeoseptoria sp.		1			0.2
Phialophorophoma sp.			1		0.2
Phoma sp. 1		5		3	1.6
Phoma sp. 2	1	14		5	4
Phomatospora sp.		4			0.8
Phomopsis sp.		5		4	1.8
Septoria sp. 1#	1				0.2
Hyphomycetes					
Acremonium masseei		2			0.4
Acrodictys sacchari		1			0.2
Arthrinium phaeospermum	2	7		4	2.6
Arthrinium saccharicola		1			0.2
Bactrodesmium atrum		3			0.6
Bipolaris stenospila	1				0.2
Cercospora longipes	2				0.2
Cladosporium cladosporioides	9	4	7	1	4.2
Curvularia brachyspora		1			0.2
Curvularia geniculata	1	3		2	1.2
Deightoniella papuana			2		0.4

Table 2 (Continued) Number of records and percentage occurrence of fungal taxa on *Saccharum spontaneum* at two sites in Thailand.

Taxa	Chiang Dao district		Mae Rim district		Overall % occurrence
	Leaves	Stems	Leaves	Stems	
Dictyoarthrinium sacchari			1		0.2
Dictyosporium oblongum	3	1		1	1
Dictyosporium sp. 1#		2			0.4
Fusarium sp. 1	1				0.2
Lacellina graminicola		2			0.4
Myrothecium cinctum.		2			0.4
Myrothecium indicum	11	6	7	3	5.4
Myrothecium sp. 1#		1			0.2
Nigrospora sacchari			3		0.6
Passalora koepkei	5				1
Periconia digitata	3	12	1	7	4.6
Periconia echinochloae	10	8	5	8	6.2
Periconia minutissima	1	5	2	7	3
Periconia sacchari	2		2		0.8
Periconia state *Didymosphaeria igniari*			2		0.4
Periconia sp. 1	11				2.2
Periconia sp. 2	3		9		2.4
Phialophora sp. 1		1			0.2
Pithomyces graminicola		1			0.2
Pithomyces sacchari				1	0.2
Pteroconium state *Apiospora camptospora*	1				0.2
Solheimia sp. 1	1		1		0.4
Spegazzinia deightonii.	2				0.4
Spegazzinia tessarthra	2				0.4
Tetraploa aristata	17	11	12	8	9.6
Thielaviopsis state *Ceratocystis moniliformis*			1	7	1.6
Total no. taxa = 79	**31**	**55**	**21**	**30**	

#Unidentified species, possibly known only from *Saccharum spontaneum*.



a **b**

Fig 2 – Three-dimensional correspondence ordination of taxa and fungal communities recorded from leaves (L) and stems (S) of *Saccharum spontaneum* from Mae Rim district (M) and Chiang Dao district (C). **a.** Diagram oriented at x- and y- axes. **b.** Diagram oriented at y- and z- axes.

Table 3 Diversity indices of saprobic fungi recovered from *Thysanolaena latifolia* and *Saccharum spontaneum* during dry and wet seasons.

Host/season	Fungi/sample	Shannon-Wiener indices	Simpson indices	Species evenness	Species richness
T. latifolia dry	2.9	5.6	0.9477	0.921	30
T. latifolia wet	2.7	5.4	0.9637	0.964	43
S. spontaneum dry	3.3	6.6	0.9822	0.969	31
S. spontaneum wet	3.5	6.4	0.9764	0.962	55
Average	3.1	6	0.9675	0.954	39.75

Table 4 Most common fungal genera recorded on various monocotyledonous substrates from tropical regions (updated post Wong & Hyde 2001).

Bamboo[a]	Banana[b]	Gingers[c]	Grasses[d]	Grasses[e]	Palms[f]	Pandanaceae[g]
Acremonium	*Anthostomella*	*Acremonium* ***	*Colletotrichum***	*Acremonium*[#,]**	*Annulatascus***	*Acremonium*
Acrodictys	*Canalisporium*	*Aspergillus***	*Diaporthe***	*Anthostomella*	*Astrosphaeriella***	*Aspergillus*
Anthostomella	*Chaetomium*	*Canalisporium****	*Didymosphaeria*	*Cladosporium***	*Cancellidium*	*Botryodiplodia*
Apiospora	*Cladosporium*	*Chloridium****	*Fusarium*	*Colletotrichum*[#,]**	*Didymobotryum*	*Canalisporium*
Arecophila	*Deightoniella*	*Cladosporium* ***	*Linocarpon****	*Fusarium*[#]	*Gaeumannomyces*	*Ellisembia*
Astrosphaeriella	*Memnoniella*	*Colletotrichum****	*Macrospora*	*Gaeumannomyces*[#]	*Helicoma*	*Microthyrium*
Chaetomium	*Mycosphaerella*	*Curvularia****	*Massarina****	*Leptosphaeria*	*Jahnula***	*Nectria*
Cladosporium	*Periconia*	*Dactylaria****	*Nigrospora*	*Massarina***	*Lophiostoma*	*Oxydothis*
Corynespora	*Periconiella*	*Dactylella* ***	*Niptera*	*Niptera*	*Massarina*	*Penicillium*
Curvularia	*Pseudobotrytis*	*Dictyoarthrinium****	*Paraphaeosphaeria*	*Ophiobolus*	*Microthyrium***	*Phaeosphaeria*
Ellisembia	*Pyriculariopsis*	*Fusarium* ***	*Petrakia*	*Phaeoisaria***	*Morenoina*	*Phoma*
*Gliomastix***	*Stachybotrys*	*Paecilomyces* ***	*Phaeoisaria***	*Periconia*[#,] **	*Nectria*	*Phomatospora*
Hypoxylon	*Stachylidium*	*Phaeosphaeria*	*Phaeosphaeria*	*Phoma***	*Nemania*	*Stachybotrys*
Massarina	*Torula*	*Phomopsis* ***	*Phoma***	*Phomopsis*[#,] **	*Phaeoisaria***	*Trichoderma*
Phaeoisaria	*Verticillium*	*Phyllosticta****	*Phomopsis***	*Septoria***	*Phruensis*	*Zygosporium*
Podosporium	*Zygosporium*	*Verticillium* ***	*Phragmitensis*	*Stachybotrys*[#]	*Solheimia*	
Trichocladium			*Pleospora*	*Terriera*	*Submersisphaeria***	
			Septoria	*Tetraploa***	*Thailiomyces*	
			*Sporidesmium***	*Verticillium*	*Xylomyces***	
			Tetraploa	*Xylaria*		

***Common genera on three or more hosts., **Common genera on two hosts, # = Fungi also record as endophyte in grass (Bhilabutra et al., in press).
a = Hyde et al. (2001), b = Photita et al. (2001a, 2003b), c = Bussaban et al. (2004), d = Wong and Hyde (2001), e = this study, f = Pinnoi et al. (2006), Pinruan et al. (2007), g = Thongkantha et al. (2008)

Cladosporium cladosporioides, *Memnoniella subsimplex*, *Septoria* sp. and *Stachybotrys echinata*. On *S. spontaneum*, the difference is largely due to species such as *Halosphaeria hamata*, *Lophiostoma arundinis*, and *Massarina arundinacea* showing a preference for leaves, while on *T. latifolia*, *Periconia byssoides* and *P. cookei* were more common on leaves. Different fungal communities on different tissue types has also been shown with other grasses and sedges (Wong & Hyde 2001) and other monocotyledonous hosts, e.g., palms (Yanna et al. 2001), banana (Photita et al. 2001a) and gingers (Bussaban et al. 2002, 2004). The less common fungal species may also show tissue specificity, e.g., *Gaeumannomyces graminis* and *Phomopsis* sp., were found only on some parts of the stems of both grasses, especially in the thickest regions. *Pestalotiopsis versicolor* was found only on some parts of leaves of *T. latifolia* while *Periconia* sp. 1 and *Periconia* sp. 2 were found only on some parts of leaves of *S. spontaneum*.

Do fungi on *T. latifolia* and *S. spontaneum* differ significantly between sites?

Of the 67 species identified from *T. latifolia*, 23 species were identified from both sites, and the percentage similarity between the two sites was 50.5%. For *S. spontaneum*, 79 species were found, 30 species were identified from both sites, and the percentage similarity between the two sites was 52.3%. Taxa restricted to Chiang Mai Zoo region site, and with a high percentage of occurrence were four hyphomycetes, *Periconia cookei*, *P. macrospinosa*, *Spegazzinia deightonii* and *Sporidesmium cookei*, while those only found at Phu Ping Ratchaniwat Palace region site were *Dactylaria dimorphospora*, *Didymella* sp., *Massarina chamaecyparissi*, *Pestalotiopsis* sp., *Pleurophragmium simplex*, and *Stachylidium bicolor*. Taylor (1997) also found very few overlapping fungi when she examined fungi on a single species of palm, *Archontophoenix alexandrae* in Hong Kong, north Queensland and Malaysia. However, with *A. alexandrae*, the differences in fungal communities may be the result of removal of the host from its natural habitat to other geographic locations. Differences in frequency of occurrence of fungal taxa on the same host at different sites were noted for some grasses in Hong Kong (Wong & Hyde 2001). This is more likely to result from differences in environmental factors than to be host related (Alias et al. 1995, Hyde & Lee 1995, Wong & Hyde 2001). Wong & Hyde (2001) reported that *Anthostomella*, *Diaporthe*, *Linocarpon*, *Massarina*, *Oxydothis* and *Stictis* are common ascomycete genera on monocotyledonous hosts. All of these, except *Diaporthe*, were found in the present study. Wong & Hyde (2001) reported ten common anamorphic fungal genera on grasses and sedges. Of these, nine genera *Colletotrichum*, *Fusarium*, *Nigrospora*, *Phaeoisaria*, *Phoma*, *Phomopsis*, *Septoria*, *Sporidesmium* and *Tetraploa* were also collected on *T. latifolia* or *S. spontaneum*; the one exception was *Petrakia*.

The results suggest that the species common to *T. latifolia* and *S. spontaneum* in Thailand may be widespread, although their abundance differs between sites. Some of the fungi (e.g., *Dendrographium thysanolaenae*, *Drumopama monoseta*, *Pycnothyriopsis* sp., *Arecophila* sp. 5, *Stictis* sp. 1 and *Septoria* sp. 1 recorded in this study are rare species and it is unknown whether they are specific to *T. latifolia* or to *S. spontaneum*. It is important to clarify if these rare species are ubiquitous taxa or specific to grasses such as *T. latifolia* or *S. spontaneum* before we can really understand global species numbers.

Are fungi occurring on *T. latifolia* and *S. spontaneum* likely to be host/family specific?

Of the 67 species recorded in this study *Dendrographium thysanolaenae*, *Drumopama monoseta* and *Pycnothyriopsis* sp. 1, are know only from *T. latifolia* (Table 1), although several other species, not identified to species level, may also be specific to *T. latifolia*. Many fungi from *S. spontaneum*, which were not determined to species, are presented in Table 2. Some, such as *Periconia* spp. and *Tetraploa aristata* are probably ubiquitous as they have been recorded from numerous other hosts (Ellis 1971).

Wong & Hyde (2001) studied six grasses and one sedge in Hong Kong and reported that some fungi showed explicit host-exclusivity or specificity, and occurred with frequencies around 50% on only one host during all of the sample periods. These included *Niptera*

excelsior on *Thysanolaena maxima*; *Ceratosporella* sp., *Linocarpon augustatum*, *Massarina purpurascens*, *Phaeoisaria clematidis* and *Stachybotrys kampalensis* on *Miscanthus floridulus*; and *Paraphaeosphaeria schoenoplecti* and *Septoria*-like sp. on *Schoenoplectus litoralis*. Wong & Hyde (2001) hypothesized that these fungi may be host-specific endophytes that later become saprobes, or that they may be host-exclusive saprobes that are responding to differences in physical structure or nutrient levels of the potential hosts.

Although conclusions from our study must be treated with caution, it is apparent that several fungi have, to date, only been found associated with the grasses *T. latifolia* and *S. spontaneum*. However, we cannot be sure that these fungi are host-specific. The data also shows that some fungi occur predominantly on stems, while others occur more commonly on leaves. The recurrence of fungi on certain tissue types has also been shown with palms (Yanna et al. 2001) and other grasses and sedges (Wong & Hyde 2001). This indicates another parameter that should be taken into account when estimating fungal diversity.

Acknowledgements

Funds for this research were provided by the Royal Golden Jubilee Ph.D. Program under The Thailand Research fund (Grant No. 4. B. CM/45/D1). Dr Ho Wai Hong (Wellcome) is thanked for comment and helpful identification of mitosporic fungi. Helen Leung is thanked for help with technical assistance. Nakarin Suwanarach and Jaturong Kumla are thanked for helping preparing manuscript.

References

Alias SA, Kuthubutheen AJ, Jones EBG. 1995 – Frequency of occurrence of fungi on wood in Malaysian mangrove. Hydrobiologia 295, 97–105.

Anonymous. 1995 – JMP® Statistics and Graphics Guide. Version 3.1 of JMP, SAS Institute Inc., Cary, NC.

Aptroot A, Saipunkaew W, Sipman HJM, Sparrius LB, Wolseley PA. 2007 – New lichens from Thailand, mainly microlichens from Chiang Mai. Fungal Diversity 24, 75–134.

Aung OM, Soytong K, Hyde KD, 2008 – Diversity of entomopathogenic fungi in rainforests of Chiang Mai Province, Thailand. Fungal Diversity 30, 15–22.

Aveskamp MM, Gruyter J, Crous PW. 2008 – Biology and recent developments in the systematics of *Phoma*, a complex genus of major quarantine significance. Fungal Diversity 31, 1–18.

Bhilabutra W, Lumyong S, Jeewon R, McKenzie EHC, Hyde KD. 2006 – *Neolinocarpon penniseti* sp. nov. on the grass *Pennisetum purpureum* (Poaceae). Cryptogamie Mycologie 27, 305–310.

Bucheli E, Gautschi B, Shykoff JA. 2001 – Differences in population structure of the anther smut fungus *Microbotryum violaceum* on two closely related host species, *Silene latifolia* and *S. dioica*. Molecular Ecology 10, 285–294.

Bussaban B, Lumyong P, McKenzie EHC, Hyde KD, Lumyong S. 2002 – Index of fungi described from the Zingiberaceae. Mycotaxon 83, 165–182.

Bussaban B, Lumyong P, McKenzie EHC, Hyde KD, Lumyong S. 2004 – Fungi on Zingiberaceae (ginger). In: Thai fungal diversity (eds. EBG Jones and T Tanticharoen). BIOTEC, Thailand. 189–195.

Bussaban B, Lumyong S, Lumyong P, Hyde KD, McKenzie EHC. 2003 – Three new species of *Pyricularia* are isolated as zingiberaceous endophytes from Thailand. Mycologia 95, 521–526.

Bussaban B, Lumyong S, Lumyong P, McKenzie EHC, Hyde KD. 2001 – Endophytic fungi from *Amonum siamense*. Canadian Journal of Microbiology 47, 1–6.

Cai L, Hyde KD, Taylor PWJ, Weir B, Waller J, Abang MM, Zhang JZ, Yang YL, Phoulivong S, Liu ZY, Prihastuti H, Shivas RG, McKenzie EHC, Johnston PR. 2009 – A polyphasic approach for studying *Colletotrichum*. Fungal Diversity 39, 183–204.

Cannon PF. 1991 – A revision of *Phyllachora* and some similar genera on the host family Leguminosae. Mycological Papers 163, 1–302.

Crouch JA, Beirn LA. 2009 – Anthracnose of cereals and grasses. Fungal Diversity 39, 19–44.

Duong LM, McKenzie EHC, Lumyong S, Hyde KD. 2008 – Fungal succession on senescent leaves of *Castanopsis diversifolia* in Doi Suthep-Pui National Park, Thailand. Fungal Diversity 30, 23–36.

Ellis MB. 1971 Dematiaceous Hyphomycetes. CAB International, Kew.

Fournier J, Stadler M, Hyde KD, Duong ML. 2010 – The new genus *Rostrohypoxylon* and two new *Annulohypoxylon* species from Northern Thailand. Fungal Diversity 40, 23–36.

Francis SM. 1975. *Anthostomella* Sacc. (Part I). Mycological Papers 139, 1–97.

FrÖhlich J, Hyde KD. 1995 – Fungi from palms XIX. *Caudatispora palmicola* gen. et sp. nov. from Ecuador. Sydowia 47, 38–43.

FrÖhlich J, Hyde KD. 1999 – Biodiversity of palm fungi in the tropics: are global fungal diversity estimates realistic? Biodiversity and Conservation 8, 977–1004.

FrÖhlich J, Hyde KD. 2000 – Palm Microfungi. Fungal Diversity Press, Hong Kong SAR.

Gonzales SMF, Rogers JD. 1989 — A preliminary account of *Xylaria* of Mexico. Mycotaxon 34, 283–374.

Hawksworth DL. 1991 – The fungal dimension of biodiversity: magnitude, significance, and conservation. Mycological Research 95, 641–655.

Hawksworth DL, Bolse JR. 1985 – Some additional species of *Astrosphaeriella*, with a key to the members of the genus. Sydowia 38, 114–124.

Huhndorf SM, Lodge DJ. 1997 – Host specificity among wood-inhabiting pyrenomycetes (fungi, ascomycetes) in a wet tropical forest in Puerto Rico. Tropical Ecology 38, 307–315.

Hyde KD, Alias SA 2000 – Biodiversity and distribution of fungi associated with decomposing *Nypa fruticans*. Biodiversity and Conservation 9, 393–402.

Hyde KD, Cai L, Cannon PF, Crouch JA, Crous PW, Damm U, Goodwin PH, Chen H, Johnston PR, Jones EBG, Lil ZY, McKenzie EHC, Moriwani J, Noireung P, Pennycook SR, Pfenning LH, Prihastuti H, Sato T, Shivas RG, Taylor PWJ, Tan YP, Weir BS, Yang YL, Zhang JZ. 2009 – *Colletotrichum* – names in current use. Fungal Diversity 39, 147–182.

Hyde KD, Goh TK. 1998 – Fungi on submerged wood in Lake Barrine, north Queenland, Australia. Mycological Research 102, 739–749.

Hyde KD, Goh TK, Steinke TD. 1998 – Fungi on submerged wood in the Palmeit River, Durban, South Africa. South Africa Journal of Botany 64, 151–162.

Hyde KD, Lee SY. 1995 – Ecology of mangrove fungi and their role in nutrient cycling. What gaps occur in our knowledge? Hydrobiologia 295, 107–118.

Hyde KD, Zhou DQ, Dalisay TE. 2002a – Bambusicolous fungi: a review. Fungal Diversity 9, 1–14.

Hyde KD, Zhou DQ, McKenzie EHC, Ho WH, Dalisay TE 2002b – Vertical distribution of saprobic fungi on bamboo culms. Fungal Diversity 11, 109–118.

Jones EBG, Tanticharoen M, Hyde KD. 2004 – Thai Fungal Diversity. BIOTEC, Thailand.

Ju YM, Rogers JD. 1996 – A Revision of the Genus *Hypoxylon*. USA, APS Press.

Kodsueb R, Lumyong S, Ho WH., Hyde KD, McKenzie EHC, Jeewon R. 2007a – Morphological and molecular characterization of *Aquaticheirospora* and phylogenetics of Massarinaceae (Pleosporales). Botanical Journal of the Linnean Society 155, 283–296.

Kodsueb R, Lumyong S, Hyde KD, Lumyong P, McKenzie EHC. 2006 – *Acrodictys micheliae* and *Dictyosporium manglietiae*, two new anamorphic fungi from woody litter of Magnoliaceae in northern Thailand. Cryptogamie Mycologie 27, 111–119.

Kodsueb R, McKenzie EHC, Ho WH, Hyde KD, Lumyong P, Lumyong S. 2007b – New anamorphic fungi from decaying woody litter of *Michelia baillonii* (Magnoliaceae) in northern Thailand. Cryptogamie Mycologie 28, 237– 245.

Kodsueb R, McKenzie EHC, Lumyong S, Hyde KD. 2008 – Diversity of saprobic fungi on Magnoliaceae. Fungal Diversity 30, 37–53.

Læssøe T, Lodge DJ. 1994 – Three host-specific *Xylaria* species. Mycologica 86, 436–446.

Lodge DJ. 1997 – Factors related to diversity of decomposer fungi in tropical forests. Biodiversity and Conservation 6, 681–688.

Lumyong S, Thongantha S, Lumyong P, Tomita F. 2000 – Endophytic fungi from 13 bamboo species in Thailand. Biotechnology for Sustainable Utilization of Biological Resources in the Tropics 14, 96–101.

McKenzie EHC, Whitton SR, Hyde KD. 2002 – The Pandanaceae: does it have a diverse and unique fungal biota? In: Tropical Mycology 2, Micromycota (eds. R Watling, JC Franklin, AM Ainsworth, S Isaac and CH Robinson). CAB International, Wallingford. 51–61.

Osono T, Ishii Y, Takeda H, Seramethakun T, Khamyong S, To-Anun C, Hirose D, Tokumasu S, Kakishima M. 2009 – Fungal succession and lignin decomposition on *Shorea obtusa* leaves in a tropical seasonal forest in northern Thailand. Fungal Diversity 36, 101–119.

Photita W, Lumyong P, McKenzie EHC, Hyde KD, Lumyong S. 2002b – A new *Dictyosporium* species from *Musa acuminata* in Thailand. Mycotaxon 82, 415–419.

Photita W, Lumyong P, McKenzie EHC, Hyde KD, Lumyong S. 2003a – *Memnoniella* and *Stachybotrys* species from *Musa acuminata*. Cryptogamie Mycologie 24, 147–152.

Photita W, Lumyong P, McKenzie EHC, Hyde KD, Lumyong S. 2003b – Saprobic fungi on dead wild banana. Mycotaxon 80, 345–356.

Photita W, Lumyong S, Lumyong P, Hyde KD. 2001a – Fungi on *Musa acuminata* in Hong Kong. Fungal Diversity 6, 99–106.

Photita W, Lumyong S, Lumyong P, Hyde KD. 2001b – Endophytic fungi of wild banana (*Musa acuminata*) at Doi Suthep Pui National Park, Thailand. Mycological Research 105, 1508–1513.

Photita W, Lumyong S, Lumyong P, Hyde KD, McKenzie EHC. 2002a – Index of fungi described from Musaceae. Mycotaxon 81, 491–503.

Pinnoi A, Jeewon R, Sakayaroj J, Hyde KD, Jones EBG. 2007 – *Berkleasmium crunisia* sp. nov. and its phylogenetic affinities to the Pleosporales based on 18S and 28S rDNA sequence analyses. Mycologia 99, 378–384.

Pinnoi A, Jones EBG, McKenzie EHC, Hyde KD. 2003a – Aquatic fungi from peat swamp palms: *Unisetosphaeria penguinoides* gen. et sp. nov., and three new *Dactylaria* species. Mycoscience 44, 377–382.

Pinnoi A, Lumyong S, Hyde KD, Jones EBG. 2006 – Biodiversity of fungi on the palm *Eleiodoxa conferta* in Sirindhorn peat swamp forest, Narathiwat, Thailand. Fungal Diversity 22, 205–218.

Pinnoi A, McKenzie EHC, Jones EBG, Hyde KD. 2003b – Palm fungi from Thailand: *Custingophora undulatistipes* sp. nov. and *Vanakripa minutiellipsoidea* sp. nov. Nova Hedwigia 77, 213–219.

Pinnoi A, Pinruan U, Hyde KD, McKenzie EHC, Lumyong S. 2004 – *Submersisphaeria palmae* sp. nov. with a key to species and notes on *Helicoubisia*. Sydowia 56, 72–78.

Pinruan U, Hyde KD, Lumyong S, McKenzie EHC, Jones EBG. 2007 – Occurrence of fungi on tissues of the peat swamp palm *Licuala longicalycata*. Fungal Diversity 25, 157–173.

Pinruan U, Lumyong S, McKenzie EHC, Jones EBG, Hyde KD. 2004a – Three new species of *Craspedodidymum* from palm in Thailand. Mycoscience 45, 177–180.

Pinruan U, McKenzie EHC, Jones EBG, Hyde KD. 2004b – Two new species of *Stachybotrys*, and a key to the genus. Fungal Diversity 17, 145–157.

Pinruan U, Sakayaroj J, Hyde KD, Jones EBG. 2008 – *Thailandiomyces bisetulosus* gen. et sp. nov. (Diaporthales, Sordariomycetidae, Sordariomycetes) and its anamorph *Craspedodidymum*, is described based on nuclear SSU and LSU rDNA sequences. Fungal Diversity 29, 89–98.

Pinruan U, Sakayaroj J, Jones EBG, Hyde KD. 2004c – Aquatic fungi from peat swamp palms: *Phruensis brunniespora* gen. et sp. nov. and its hyphomycete anamorph.

Canadian Journal of Botany 96, 1161–1181.

Polishook JD, Bills GF, Lodge DJ. 1996 – Microfungi from decaying leaves of two rain forest trees in Puerto Rico. Indian Journal of Microbiology 17, 284–294.

Promputtha I, Hyde KD, Lumyong P, McKenzie EHC, Lumyong S. 2003 – *Dokmaia monthadangii* gen. et sp. nov. a synnematous anamorphic fungus on *Manglietia garrettii*. Sydowia 55, 99–103.

Promputtha I, Hyde KD, Lumyong P, McKenzie EHC, Lumyong S. 2004a – Fungi on *Magnolia liliifera*: *Cheiromyces magnoliae* sp. nov. from dead branches. Nova Hedwigia 80, 527–532.

Promputha I, Lumyong S, Lumyong P, McKenzie EHC, Hyde KD. 2002 – Fungal succession on senescent leaves of *Manglietia garrettii* in Doi Suthep Pui National Park, northern Thailand. Fungal Diversity 10, 89–100.

Promputha I, Lumyong S, Lumyong P, McKenzie EHC, Hyde KD. 2004b – A new species of *Pseudohalonectria* from Thailand. Cryptogamie Mycologie 25, 43–47.

Promputha I, Lumyong S, Lumyong P, McKenzie EHC, Hyde KD. 2004c – Fungal saprobes on dead leaves of *Magnolia liliifera* (Magnoliaceae) in Thailand. Cryptogamie Mycologie 25, 315–321.

Promputha I, Lumyong S, Lumyong P, McKenzie EHC, Hyde KD. 2005 – A new species of *Anthostomella* on *Magnolia liliifera* from northern Thailand. Mycotaxon 91, 413–418.

Santana ME, Lodge DJ, Lebow P. 2005 – Relationship of host recurrence in fungi to rates of tropical leaf decomposition. Pedobiologia 49, 549–564.

Schoch CL, Crous PW, Groenewald JZ, Boehm EWA, Burgess TI, de Gruyter J, de Hoog GS, Dixon LJ, Grube M, Gueidan C, Harada Y, Hatakeyama S, Hirayama K, Hosoya T, Huhndorf SM, Hyde KD, Jones EBG, Kohlmeyer J, Kruys Å, Li YM, Lücking R, Lumbsch HT, Marvanová L, Mbatchou JS, Mcvay AH, Miller AN, Mugambi GK, Muggia L, Nelsen MP, Nelson P, Owensby CA, Phillips AJL, Phongpaichit S, Pointing SB, Pujade-Renaud V, Raja HA, Rivas Plata E, Robbertse B, Ruibal C, Sakayaroj J, Sano T, Selbmann L, Shearer CA, Shirouzu T, Slippers B, Suetrong S, Tanaka K, Volkmann-Kohlmeyer B, Wingfield MJ, Wood AR, Woudenberg JHC, Yonezawa H, Zhang Y, Spatafora JW. 2009 – A class-wide phylogenetic assessment of *Dothideomycetes*. Studies in Mycology 64, 1–15.

Shannon CE, Weaver W. 1949 – The Mathematical Theory of Communication. University of Illinois Press, Urbana.

Suetrong S, Schoch CL, Spatofora JW, Kohlmeyer J, Volkmann-Kohlmeyer B, Sakayaroj J, Phongpaichit S, Tanaka K, Hirayama K, Jones EBG. 2009 – Molecular systematics of the marine Dothideomycetes. Studies in Mycology 64, 155–173.

Taylor J. 1997 – Biodiversity and distribution of microfungi on palms. Ph.D. Thesis. The University of Hong Kong.

Tejesvi MV, Tamhankar SA, Kini KR, Rao VS, Prakash HS. 2009 – Phylogenetic analysis of endophytic *Pestalotiopsis* species from ethnopharmaceutically important medicinal trees. Fungal Diversity 38, 167–183.

Thongkantha S, Lumyong S, McKenzie EHC, Hyde KD. 2008 – Fungal saprobes and pathogens occurring on tissues of *Dracaena lourieri* and *Pandanus* spp. in Thailand. Fungal Diversity 30, 149–169.

Tokumasu S, Aoki T, Oberwinkler F. 1994 – Fungal successions on pine needles in Germany. Mycoscience 35, 29–37.

Whitton SR, McKenzie EHC, Hyde KD. 2002 – Microfungi on the *Pandanaceae*: two new species of *Camposporium*, and a key to the genus. Fungal Diversity 11, 177–187.

Whitton SR, McKenzie EHC, Hyde KD. 2003 – Microfungi on the *Pandanaceae*: *Zygosporium*, a review of the genus and two new species. Fungal Diversity 12, 207–222.

Wong KM, Hyde KD. 2001 – Diversity of fungi on six species of *Gramineae* (Roman) and one species of Cyperaceae

in Hong Kong. Mycological Research 105, 1485–1491.

Yanna, Ho WH, Hyde. KD 2001 – Occurrence of fungi on tissue of *Livistona chinensis*. Fungal Diversity 6, 167–180.

Yanna, Ho WH, Hyde KD. 2002a – Fungal succession on fronds of *Phoenix hanceana* in Hong Kong. Fungal Diversity 10, 185–211.

Yanna, Ho WH, Hyde KD. 2002b – New saprobic fungi on palm fronds from north Queensland, Australia. Australian Systematic Botany 15, 755–764.

Zhang Y, Fournier J, Pointing SB, Hyde KD. 2008 – Are *Melanomma pulvis-pyrius* and *Trematosphaeria pertusa* congeneric? Fungal Diversity 33, 47–60.

Zhang Y, Schoch CL, Fournier J, Crous PW, De Gruyter J, Woudenberg JHC, Hirayama K, Tanaka K, Pointing SB, Spatafora JW, Hyde KD. 2009b – Multi-locus phylogeny of Pleosporales: a taxonomic, ecological and evolutionary re-evaluation. Studies in Mycology 64, 85–102.

Zhang Y, Wang HK, Fournier J, Crous PW, Jeewon R, Pointing SB, Hyde KD. 2009a – Towards a phylogenetic clarification of *Lophiostoma*/*Massarina* and morphologically similar genera in the Pleosporales. Fungal Diversity 38, 225–251.

Zhou DQ, Hyde KD. 2001 – Host-specificity, host-exclusively and host-recurrence in saprobic fungi. Mycological Research 105, 1449–1457.