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Diversity of Saprobic Fungi on *Magnolia garrettii*: Do Collecting Sites and Seasons Affect the Fungal Community?

(Kepelbagaian Kulat Saprob pada *Magnolia garrettii*: Adakah Tapak Pengumpulan dan Musim Mempengaruhi Komuniti Kulat?)

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ABSTRACT

The diversity of saprobic fungi found on woody litter of Magnolia garrettii *collected from Phu Hin Rongkla National Park in Phitsanulok Province, Thailand during the wet and dry seasons, from July 2008 to April 2009, was studied, and the fungal diversity and community was compared with a previous study in Doi Suthep-Pui National Park in Chiang Mai Province. Based on morphological characteristics, 141 taxa were obtained and classified as 40 Ascomycetes, 5 Basidiomycetes, 42 lichens, one unidentified taxon and 53 anamorphic fungi. The number of taxa recovered indicated that Dry season samples supported a more diverse fungal community than samples collected in the wet season, for both collecting sites, although the common genera of fungi obtained during each season were similar. Distinct fungal communities of saprobic fungi collected from each site suggest that site characteristics affect the community composition. Samples from Phu Hin Rongkla National Park provided higher numbers of fungi (especially lichens) than were collected in the previous Doi Suthep-Pui National Park study with few species overlapping in the two sites.*

Keywords: Fungal diversity; lignicolous fungi; magnoliacea; seasonal effect; site specific

ABSTRAK

Kepelbagaian kulat saprob yang terdapat pada sampah berkayu Magnolia garrettii *yang dikumpulkan dari Taman Negara Phu Hin Rongkla di Wilayah Phitsanulok, Thailand semasa musim basah dan kering, dari Julai 2008 hingga April 2009 telah dikaji dan kepelbagaian kulat dan komuniti dibandingkan dengan kajian sebelumnya di Taman Negara Doi Suthep-Pui di Wilayah Chiang Mai. Berdasarkan ciri morfologi, 141 taksonomi telah diperoleh dan dikelaskan sebagai 40 Ascomycetes, 5 Basidiomycetes, 42 liken, satu tidak dikenal pasti dan 53 kulat anamorfik. Bilangan takat yang pulih menunjukkan bahawa sampel musim kering menyokong komuniti kulat yang lebih pelbagai daripada sampel yang dikumpul pada musim hujan, untuk kedua-dua lokasi pengumpulan, walaupun genus kulat umum yang diperoleh pada setiap musim adalah sama. Komuniti kulat yang berbeza daripada kulat saprob yang dikumpulkan dari setiap tapak menunjukkan bahawa ciri tapak mempengaruhi komposisi masyarakat. Sampel dari Taman Negara Phu Hin Rongkla menyediakan lebih banyak kulat (terutama liken) daripada yang dikumpulkan dalam kajian di Taman Negara Doi Suthep-Pui dengan spesies yang agak banyak bertindih di kedua-dua tapak.*

Kata kunci: Kepelbagaian kulat; kesan musim; kulat lignikolus; magnoliacea; tapak khas

INTRODUCTION

Fungi are an important group of organism that have been widely used in several fields and applications for increasing the well-being of mankind (Kodsueb et al. 2018; Ling et al. 2016; Teoh & Don 2013). Over the past decade, studies on the diversity of saprobic fungi in tropical areas have increased. Several novel fungi have been reported from the tropics suggesting that there are still fungi in tropical forests awaiting discovery and analysis (Hawksworth 2002). In Thailand, there have been several studies of microfungi on plants that have discovered many new fungi (Doilom et al. 2017; Kodsueb et al. 2007a, 2007b, 2006; Monkai et al. 2013; Pinnoi et al. 2007, 2006; Seephueak et al. 2011, 2010; Tibpromma et al. 2016).

The woody litter substrate in the forest potentially supports vast fungal diversity in the ecosystem but requires a long period of decomposition for the decay process to be completed (Shearer et al. 1992), thus, may have been subjected to fewer studies or research attention than the leaf litter. Results from previous studies showed that several new and interesting saprobic fungi have been described from plant litter of *Magnoliaceae* (Kodsueb et al. 2007b, 2006; Promputtha et al. 2005, 2004a, 2004b, 2004c, 2003). According to previous studies, it is likely that the woody litter of this plant family may harbor many interesting fungi that await discovery (Kodsueb et al. 2008).

Geographical distribution is believed to be one factor influencing the generation of chemical substances in living plants, especially the medicinal plants, where the same species of plants growing in different sites is believed to harbor different amount of active compound/chemical composition (ElHadj et al. 2010; Khattak & Rahman 2015;

Liu et al. 2018, 2015; Zouari et al. 2012). In the case of saprobic fungi living on plant litter, some studies suggest that geography affects fungal community grown on the same host. For example, distinct fungal communities of saprobic fungi were found on *Pandanus penetrans* leaves collected from different sites in Thailand (Thongkantha et al. 2008). However, Bisby (1943) concluded that saprobic fungi generally have wider distribution than parasitic fungi and the distribution of the host has more influence than the climate.

The occurrence of the same host taxa in different geographical locations supporting similar or different fungal assemblages would have important implications for estimates of fungal diversity and species numbers (Hyde et al. 2007). To investigate this hypothesis, a comparison of the fungal community from samples of the same plant species collected from different sites was considered (Lodge 1997). Apart from the study of Kodsueb et al. (2008), there has been no report comparing communities of saprobic fungi on woody litter of *Magnoliaceae* from different sites.

The purposes of this study, therefore, to investigate the diversity of saprobic fungi on *Magnolia garrettii* (Craib) V.S. Kumar in a study site, and then compare the result with previous work. We studied the fungi on decaying wood of *M. garrettii* to establish whether the saprobic fungi on this host in Phu Hin Rongkla National Park are diverse; whether fungi from the same plant species in different geographical locations differed, or was host specific, and the effect of dry and wet seasons on fungal communities.

Materials and Methods

Study site

Our study was undertaken in an evergreen forest in Phu Hin Rongkla National Park (PHR), Phitsanulok Province, in northern Thailand. This park is covered by mixed deciduous, dry dipterocarp, and evergreen forests. Temperature is generally cool all year round, with an average annual temperature of 26°C (Rattanathirakul & Boonkerd 2003), where sometimes the temperature drops to 0-4°C or less (Thienhirun et al. 2003). More than 1800 mm of annual rainfall has been recorded for PHR National Park. The wet season is from May to October, while the dry season is between November and April. In this study, seven study sites were located in evergreen forest alongside highway number 2331, between KM18 and KM26. The altitude of all collecting sites is 800-1000 m above sea level.

Sample collection and examination

Fallen dead twigs (*ca* 15-25 cm long, 1-2 cm diameter, with bark) of *Magnolia garrettii* were selected for this study. Wet season samples were collected in July 2008 and October 2008 while dry season ones were collected in January 2009 and April 2009. For each collection trip, at least 25 dead wood samples were randomly collected from study sites and returned to the laboratory where they were separately incubated in moistened plastic bags. After five to seven days of incubation, the samples were periodically examined for up to one month, following the methods in Kodsueb et al. (2008), with slight modification. The examined fungi were then recorded, and photographed. Identification was based on the morphological characteristics of the fungi using relevant texts and references (Cai et al. 2006; Carmichael et al. 1980; Doilom et al. 2017; Ellis 1976; 1971; Hanlin 1998; 1990; Hyde et al. 2000; Kiffer & Morelet 1999; Lu & Hyde 2000; Nag Raj 1993; Seifert et al. 2011; Sivanesan 1984; Sutton 1980; Taylor & Hyde 2003; Wu & Zhuang 2005).

The fungal diversity of *M. garrettii* from the PHR site was then evaluated and compared with the results from Kodsueb et al. (2008) where the wood samples had been collected from Doi Suthep-Pui National Park (DSP), Chiang Mai, Thailand.

Statistical analysis

All analyses were done according to the procedures mentioned in Kodsueb et al. (2008). A 3-dimensional correspondence analysis (Anonymous 1995) was performed to examine the differences in fungal communities on *M. garrettii* in PHR and DSP sites. The percentage occurrence of fungi and species diversity indices were calculated. Fungal taxa with a percentage occurrence higher than ten are regarded as dominant species. Shannon indices (H') were used to exhibit species diversity of a community (Shannon & Weaver 1949). A dendogram showing the relative similarities of the fungal assemblages (Magurran 2004) from *M. garrettii* at different seasons and sites was calculated from PC-ORD version 4.0 (McCune & Mefford 1999).

$$\text{Percentage occurrence} = \frac{\text{Number of woods which each fungal taxon was detected}}{\text{Total number of wood samples examined}} \times 100$$

The formula is modified from Sarma and Vittal (2000).

$$\text{Sørensen's similarity index} = 2c/a + b$$

where a is the number of species in PHR site; b is the number of species in DSP site; and c is the number of species in common in both sites.

The formula is modified from Sørensen (1948) and Dice (1945).

Results and Discussion

Fungal taxonomic composition, fungal diversity and colonization of *M. garrettii*-inhabiting fungi collected from PHR National Park

A total of 100 wood samples of *M. garrettii* from PHR site were examined and 141 taxa (Table 1) were identified comprising 40 Ascomycetes (28.4%), 53 anamorphic taxa (37.6%), 42 lichens (29.8%), 5 Basidiomycetes (3.5%) and one unidentified taxon (0.7%). The list of fungal taxa from each collection and their frequency of occurrence are given in Table 2. Number of overlapping taxa between the seasons and sites is shown in Table 3. Species richness, species evenness, the number of fungi per sample, the Shannon-Weiner diversity index (H) and the Simpson diversity index (D) of each collection were calculated and tabulated (Table 4).

Dominant fungi on the woody litter, with over 10% percentage occurrences, are listed in Table 2 (indicated by number of occurrences in bold). Dominant species obtained from PHR site include *Canalisporium* cf. *caribense*, *Canalisporium pulchra*, *Chloridium virescens*, *Corynespora* sp., *Dactylaria* sp., *Dicephalospora rufocornea*, *Ellisembia adscendens, Ellisembia* cf. *brachyphus*, *Ellisembia opaca*, *Gonytrichum* sp., *Graphina* sp. 1, *Graphis tenella*, *Hypoxylon* sp. 3, *Malcomiella* sp., *Monodictys* sp., *Penicillium* sp., *Phaeoisaria clematidis*, *Phillipsia* sp., *Trichoderma viride*, Unidentified, Unidentified lichen sp. 1, Unitunicate ascomycete sp. 5 and *Xylaria polymorpha*. Shannon-Wiener indices of PHR site were high for both wet and dry seasons (Table 4), suggesting great fungal diversity. Fungal diversity is high when compared to other studies on wood worldwide (e.g. submerged wood: Ho et al. 2002; Kane et al. 2002; Maria & Shidhar 2004; Sivichai et al. 2002; Tan et al. 1989; van Ryckegem & Verbeken 2005; terrestrial wood: Allen et al. 2000; Crites & Dale 1998; Huhndorf & Lodge 1997; Kodsueb et al. 2008). In terms of the number of fungi (species richness), samples collected from PHR in dry season had more taxa (130) than samples of PHR in the wet season (114). However, number of overlapping taxa between dry and wet season was high (103 taxa; Table 3), suggesting similar fungal community in both seasons and this is also in accordance with the result from cluster analysis. The reasonable answer leading to this issue still unclear and needs further study.

Comparison of fungal taxonomic composition, fungal diversity and colonization of *M. garrettii*-inhabiting fungi from PHR and DSP National Parks

The combined list of fungal taxa and their frequency of occurrence comparing between PHR (this study) and DSP site (Kodsueb et al. 2008) are given in Table 2. Number of overlapping taxa between the seasons and sites is shown in Table 3. Species richness, species evenness, the number of fungi per sample, the Shannon-Weiner diversity index (H) and the Simpson diversity index (D) of each collection were calculated and shown in Table 4. Genera represented by at least two different species were *Aspergillus*, *Berkleasmium*, *Canalisporium*, *Corynespora*, *Dactylaria*, *Diatrype*, *Diatrypella*, *Dictyochaeta*, *Dictyosporium*, *Ellisembia*, *Eutypa*, *Graphina*, *Graphis*, *Hermatomyces*, *Hypoxylon*, *Ochrolechia*, *Opegrapha*, *Periconia*, *Pertusaria*, *Phaeoisaria*, *Phillipsia*, *Phomopsis*, *Pyrenula*, *Sporidesmium*, *Torula* and *Xylaria*. Species overlapping between different seasons and sites include *Beltraniella* sp., *Berkleasmium nigroapicale*, *Canalisporium* cf. *caribense*, *Dictyosporium manglietiae*, *Ellisembia* cf. *brachyphus*, *Hysterium* sp., *Penicillium* sp., *Phaeoisaria clematidis*, Unitunicate ascomycete sp. 4, Unitunicate ascomycete sp. 5 and *Verticillium* sp. (Table 2).

The number of overlapping species over the two sites and seasons was low to moderate (Table 3). Only three dominant species, *Canalisporium* cf. *caribense*, *Ellisembia opaca* and *Phaeoisaria clematidis*, overlapped between two sites. The difference in the fungal taxonomic composition is the number of lichens where the samples from PHR are much more diverse in lichen species than that from the DSP.

The current study is one of only a few studies of fungi occurring on decaying terrestrial wood in the tropics. It is the first study to address fungal diversity on the same terrestrial wood in different geographical locations in Thailand, although several investigations of saprobic fungi on terrestrial wood in Thailand have been reported (Chatanon 2001; Inderbitzin et al. 2001; Inderbitzin & Berbee 2001; Schumacher 1982; Seephueak et al. 2011; Sihanonth et al. 1998). However, information of terrestrial lignicolous fungi is still poorly understood and requires further study. The studies by Chatanon (2001) and Thienhirun (1997), who investigated Ascomycetes on decaying wood in Thailand, are the most intensive studies on non-selected terrestrial wood, while a study of fungi on

TABLE 1. Number of saprobic fungi obtained from *M. garrettii* woody litter

Study site	Ascomycetes	Anamorphic fungi	Basidiomycetes	Lichens	Unidentified
PHR (this study) [141 taxa]	40 (28.4%)	53 (37.6%)	5 (3.5%)	42 (29.8%)	1 (0.7%)
DSP (Kodsueb et al. 2008) [83 taxa]	25 (30.1%)	56 (67.5%)	-	2 (2.4%)	-
Overall [186 taxa]	50 (26.9%)	88 (47.3%)	5 (2.7%)	42 (22.6%)	1 (0.5%)

The number with % in brackets represent the percentage of taxon group the number in [ ] represents the total number of fungi obtained from each site (PHR = Phu Hin Rongkla National Park, DSP = Doi Suthep-Pui National Park)

TABLE 2. Overall percentage occurrences of fungi found on woody litter of *M. garrettii* collected from two different sites

Taxa	PHR (this study)			DSP (Kodsueb et al. 2008)		
	dry	wet	overall	dry	wet	overall
Acanthodochium		4	2			
Acanthostigma minutum	4	6	5			
Acrodictys deightonii	6	2	4	5		2.5
Amandinea sp.	8		4			
Anthostomella sp.	10	2	6			
Arthopyrenia sp.	8		4			
Ascotaiwania pseudoprolus	4	2	3			
Aspergillus sp. 1	10	4	7			
Aspergillus sp. 2	2	10	6			
Aspergillus sp. 3	2	6	4			
Astrocystis anamorph		4	2			
Bactrodesmium longispora				5		2.5
Beltrania rhombica					5	2.5
Beltraniella sp.	10	6	8	5	15	10
Berkleasmium corticola				5	15	10
Berkleasmium inflatum				40		20
Berkleasmium nigroapicale	10	4	7	10	5	7.5
Berkleasmium sp. 1	12	4	8			
Berkleasmium sp. 2	2	6	4			
Bisporella sp.	2	12	7			
Bitunicate ascomycete sp. 1	12	2	7			
Bitunicate ascomycete sp. 2		8	4	**10**	**15**	**12.5**
Bitunicate ascomycete sp. 3	6	4	5			
Bitunicate ascomycete sp. 4	8		4	15		7.5
Botryosphaeria australis	10	4	7	5		2.5
Canalisporium* cf. *caribense	**12**	**20**	**16**	**10**	**15**	**12.5**
Canalisporium pulchra	**16**	**10**	**13**			
Cercophora sp.	2	8	5			
Chaetomium sp.	2	6	4			
Chapsa sp.	6		3			
Chloridium virescens	**22**	**14**	**18**	10		5
***Corynespora* sp.**	**14**	**8**	**11**	15		7.5
Coryspora cassiicola	6	10	8			
Curvularia sp.				5		2.5
Daldinia sp.	12	8	10			
Dendryphion cubense					10	5
Diaporthe sp. 1					20	10
Diatrype disciformis	4	14	9		5	2.5
Diatrype sp. 1	12	4	8			
Diatrypella sp. 1					5	2.5
Diatrypella sp. 2	8	12	10		10	5
Dicephalospora rufocornea	**18**	**30**	**24**			

continue

(Continued) TABLE 2.

Taxa	PHR (this study)			DSP (Kodsueb et al. 2008)		
	dry	wet	overall	dry	wet	overall
Dictyochaeta simplex					15	7.5
Dictyochaeta ulignicila	6	10	8			
Dictyosporium heptasporum	10	4	7			
Dictyosporium manglietiae	14	4	9	**30**	**10**	**20**
Dictyosporium nigroapice	10	6	8			
Dictyosporium pulchra	4	2	3			
Dictyosporium sp.	8	4	6			
Didymosphaeria sp. 1					10	5
Diheterospora sp.		4	2			
Diplodia sp.				10		5
Dischloridium sp.				5		2.5
Discomycete sp. 1				15		7.5
Discomycete sp. 2				5		2.5
Discomycete sp. 3	2	12	7			
Edmundmasonia-like	6		3			
Edmundmasonia pulchra				**35**		**17.5**
Ellisembia adcendens	**12**	**16**	**14**			
Ellisembia brachyphus				5		2.5
Ellisembia* cf. *brachyphus	**42**	**8**	**25**	5	15	10
Ellisembia opaca	**18**	**6**	**12**	**55**		**27.5**
***Ellisembia* sp. 2**	14	6	10	**30**		**15**
Ellisembia sp. 3	6		3	5		2.5
Eugeniella micrommata	4		2			
Eutypa sp. 1	4		2		15	7.5
Eutypa sp. 2	14		7			
Glyphis sp.	6		3			
***Gonytrichum* sp.**	**10**	**20**	**15**			
Graphina acharii	16		8	20		10
***Graphina* sp. 1**	**36**	**12**	**24**			
Graphina sp. 2	12	4	8			
Graphis asterizans	14	2	8	15		7.5
Graphis elegans	10		5			
Graphis sp. 1	6		3			
Graphis sp. 2	6	2	4			
Graphis sp. 3	10		5			
Graphis sp. 4	18	2	10			
Graphis sp. 5	10	2	6			
Graphis sp. 6	12		6			
Graphis sp. 7	16		8			
Graphis sp. 8	8	2	5			
Graphis sp. 9	6	2	4			
Graphis sp. 10	6		3			
Graphis tenella	**18**	**4**	**11**			

continue

(Continued) TABLE 2.

Taxa	PHR (this study)			DSP (Kodsueb et al. 2008)		
	dry	wet	overall	dry	wet	overall
Gyrostomum sp.	8		4			
Helicosporium griseum				20		10
Hermatomyces sp.	2	10	6			
Hermatomyces tucumanesis	4	4	4			
Hypoxylon fuscum	14	2	8			
Hypoxylon rubiginosum	12	6	9			
Hypoxylon sp. 1	8	2	5			
Hypoxylon sp. 2	10		5	15		7.5
***Hypoxylon* sp. 3**	**26**	**8**	**17**			
Hysterium sp.	8	2	5	5	5	5
Keissleria sp.	4	8	6			
Kostermansinda minima					15	7.5
Lasiodiplodia cf. *theobromae*	12	4	8	5		2.5
Leptosphaeria sp.				5		2.5
Linocarpon-like	6	2	4			
Melanographium palmicolum				5		2.5
Microporus xanthopus	2	6	4			
Monochaetia sp.					10	5
***Monodictys* sp.**	34	10	22		10	5
Monodisma fragilis				5		2.5
Ochrolechia sp.	10		5			
Ochrolechia sp. 2	6		3			
Opegrapha sp. 1	10	2	6			
Opegrapha sp. 2	8	2	5			
Ophioceras sp.					5	2.5
Paecilomyces sp.	6	2	4			
***Penicillium* sp.**	20	6	**13**	5	15	10
Periconia byssoides				5		2.5
Periconia sp. 1	8	2	5		5	2.5
Pertusaria sp. 1	8	2	5			
Pertusaria sp. 2	14	2	8			
Peziza sp.	2	6	4			
Phaeographina sp.	10		5			
Phaeoisaria clematidis	**28**	**16**	**22**	**40**	**15**	**27.5**
Phaeoisaria sp.				10		5
Phialostele sp.		6	3			
Phillipsia hartmannii	2	6	4			
***Phillipsia* sp.**	**14**	**18**	**16**			
Phoma sp.	4	2	3			
Phomopsis sp. 1					5	2.5
Phomopsis sp. 2					5	2.5
Pithomyces chartarum				5		2.5
Pseudospiropes subuliferus				10		5

continue

(Continued) TABLE 2.

Taxa	PHR (this study)			DSP (Kodsueb et al. 2008)		
	dry	wet	overall	dry	wet	overall
Pyrenochaeta sp.				5		2.5
Pyrenula sp. 1	8	2	5			
Pyrenula sp. 2	14	2	8			
Quintaria sp.				5		2.5
Solosympodiella cylindrospora					5	2.5
Sporidesmiella intermedia					5	2.5
Sporidesmium sp. 1				5		2.5
Sporidesmium sp. 2					5	2.5
Sporoschisma saccardoi				5	5	5
Stachybotrys sp.	6	4	5			
Tetraploa biformis				10		5
Torula herbarum	6	2	4	5		2.5
Torula sp.					5	2.5
Trichoderma viride	6	44	25			
Unidentified taxon	4	34	19			
Unidentified basidiomycete sp. 1		6	3			
Unidentified basidiomycete sp. 2		4	2			
Unidentified basidiomycete sp. 3		6	3			
Unidentified basidiomycete sp. 4		4	2			
Unidentified coelomycete sp. 1	6		3			
Unidentified coelomycete sp. 2				5	5	5
Unidentified coelomycete sp. 3				5	5	5
Unidentified coelomycete sp. 4					5	2.5
Unidentified coelomycete sp. 5					5	2.5
Unidentified hyphomycete sp. 1		6	3	5	15	10
Unidentified hyphomycete sp. 2	10	4	7	5		2.5
Unidentified hyphomycete sp. 3	8	2	5	10		5
Unidentified hyphomycete sp. 4	6	4	5	5		2.5
Unidentified hyphomycete sp. 5	14	2	8			
Unidentified hyphomycete sp. 6	6	2	4			
Unidentified hyphomycete sp. 7	4	2	3			
Unidentified hyphomycete sp. 8	6	4	5			
Unidentified lichen sp. 1	**56**	**38**	**47**			
Unidentified lichen sp. 2	6	2	4			
Unidentified lichen sp. 3	10	6	8			

continue

(Continued) TABLE 2.

Taxa	PHR (this study)			DSP (Kodsueb et al. 2008)		
	dry	wet	overall	dry	wet	overall
Unidentified lichen sp. 4	4	2	3			
Unidentified lichen sp. 5	6	2	4			
Unitunicate ascomycete sp. 1	2	10	6			
Unitunicate ascomycete sp. 2	6	2	4	30		15
Unitunicate ascomycete sp. 3	8	2	5			
Unitunicate ascomycete sp. 4	6	2	4	5	5	5
Unitunicate ascomycete sp. 5	**16**	**8**	**12**	5	5	5
Unitunicate ascomycete sp. 6	4		2			
Usnea baileyi		6	3			
***Verticillium* sp.**	12	4	8	**20**	**5**	**12.5**
Xylaria filiformis	4	10	7			
Xylaria polymorpha	**8**	**14**	**11**			
Xylomycesi foliicola		2	1			

Bold indicates percentage occurrence of more than 10%. * One myxomycetes; Stemonitis sp., obtained from PHR sample collected in dry season is excluded in this study (PHR = Phu Hin Rongkla National Park, DSP = Doi Suthep-Pui National Park)

TABLE 3. Overlapping taxa on *M. garrettii* woody litter in wet and dry season from two sites

	DSPD [60]*	DSPW [40]*	PHRD [130]	PHRW [114]
DSPD [60]*	-	17 (0.17)	31 (0.16)	27 (0.16)
DSPW [40]*	-	-	16 (0.09)	17 (0.11)
PHRD [130)]	-	-	-	103 (0.42)
PHRW [114]	-	-	-	-

The number in brackets ( ) represents the similarity index and the number in brackets [ ] represents the total number of fungal taxa obtained from each site/season. DSP = Doi Suthep-Pui National Park, PHR = Phu Hin Rongkla National Park, D = dry season and W = wet season, *data from Kodsueb et al. 2008
overlapping between two sites = 38 species (similarity index = 0.20) overlapping between two seasons on both sites = 11 species (similarity index = 0.06)

TABLE 4. DIVERSITY indices of saprobic fungi recovered from wood of *M. garrettii* during dry and wet seasons from two different sites

Sampling	Fungi per sample	Species richness	Species evenness	Shannon-Wiener indices	Simpson indices
DSPD*	3	60	0.923	3.780	0.9693
DSPW*	2	40	0.964	3.557	0.9681
PHRD	2.6	130	0.951	4.628	0.9875
PHRW	2.3	114	0.922	4.365	0.9817
Average	2.5	86	0.940	4.082	0.9766

*data from Kodsueb et al. 2008

selected terrestrial wood was done on *Magnolia liliifera*, *Magnolia garrettii* and *Michelia bailonii* by Kodsueb et al. (2008) and on para rubber tree (*Hevea brasiliensis*) by Seephueak et al. (2011) and currently on *M. garrettii* in this study.

Samples collected from PHR in dry season had the greatest number of taxa (130), followed by samples of PHR in the wet season (114), samples collected from DSP in the dry season (60) and the wet season (40). The higher number of fungi obtained from the PHR site may be because more wood samples have been collected from PHR than from DSP (100 vs. 40 samples). Differences in geography may also play a part, which was taken into account (Boddy & Watkinson 1995). The dominant or most common fungi of each site (Table 2) were not significantly different from those found to be common on terrestrial wood in previous

studies (Allen et al. 2000; Crites & Dale 1998; Huhndorf & Lodge 1997).

The comparison of fungi obtained from this study with the fungi collected in previous studies showed low similarity in the species level although an overlap of genera on wood is common. For example, *Anthostomella*, *Ascotaiwania*, *Cercophora*, *Diatrype*, *Didymosphaeria*, *Eutypa*, *Hypoxylon*, *Melanochaeta*, and *Xylaria* were found in both the present study and in previous studies (Allen et al. 2000; Chatanon 2001; Crites & Dale 1998; Huhndorf & Lodge 1997; Thienhirun 1997).

FUNGAL COMMUNITIES AND SIMILARITY OF FUNGI ON DIFFERENT SITES AND SEASONS

Three-dimensional correspondence analysis of fungi (Figure 1) obtained from *M. garrettii* showed that there were two distinct fungal communities, corresponding to each of the two sites. For each site, the wet and dry season communities overlapped. The first community represented the fungal community collected from PHR and the second community represented the fungal community collected from DSP. The cluster analysis produced one dendogram, which also divided the fungal communities into two groups (Figure 2). Three-dimensional correspondence and cluster analysis (Figures 1 & 2) indicate that the fungal communities on the woody litter of *M. garrettii* collected from DSP during both the dry and wet seasons were distinct. This is in contrast with the samples from PHR where the fungal community from both seasons clustered together, suggesting similarity in the fungal community. The similarity index of fungi on *M. garrettii* between the two sites, collected in dry and wet seasons, is shown in Table 3. High similarity index between wet and dry seasons of PHR site is in agreement with the result from cluster analysis.

Of the 186 fungal species collected from PHR and DSP, 38 taxa were obtained at both sites, with 20% similarity between the two sites. Only 11 species overlapped both wet and dry seasons from both sites. Dominant taxa restricted to DSP site were *Edmundmasonia pulchra*, while those only found at PHR site were *Canalisporium pulchra*, *Dactylaria* sp., *Dicephalospora rufocornea*, *Ellisembia ascendens*, *Gonytrichum* sp., *Graphina* sp. 1, *Graphis tenella*, *Hypoxylon* sp.3, *Mulcomiella* sp., *Phillipsia* sp., *Trichoderma viride*, Unidentified taxon, Unidentified lichen sp.1 and *Xylaria polymorpha*.

SEASONAL EFFECT ON THE FUNGAL COMMUNITY

The number of taxa recovered from the different seasons indicates that the fungi were more diverse in dry season and this is also indicated by the greater Shannon diversity index (Table 4). A total of 141 taxa were identified from *M. garrettii* wood collected from PHR National Park. One hundred and thirty taxa (38 Ascomycetes, 49 anamorphic fungi, 41 lichens, one Basidiomycetes and one unidentified taxon) were recorded from dry season samples, while 114 taxa (32 Ascomycetes, 51 anamorphic fungi, 25 lichens, 5 Basidiomycetes and one unidentified taxon) were obtained from wet season samples. Fifty-five

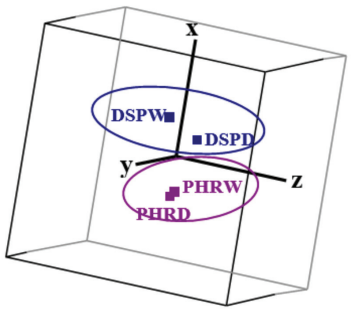

FIGURE 1. Three-dimensional correspondence analysis of fungal taxa occurring on woody litter of *M. garrettii* during the wet and dry seasons collected from two sites (PHR = Phu Hin Rongkla, DSP = Doi Suthep-Pui; data from Kodsueb et al. 2008, W = wet season samples, D = dry season samples)

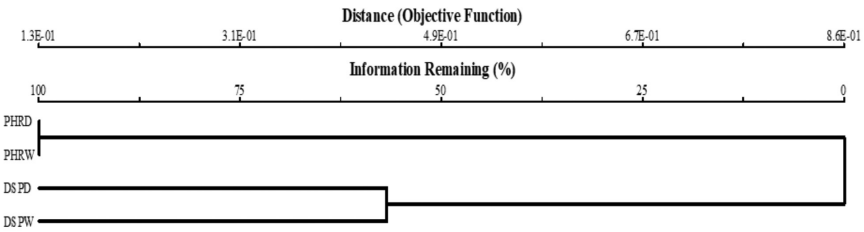

FIGURE 2. Cluster analysis of saprobic fungi on *M. garrettii* woody litter based on Sørensen distance and the group average method (PHR = PhuHinRongkla, DSP = Doi Suthep-Pui, D= dry season samples and W= wet season samples

Ascomycetes, 46 anamorphic fungi, one Basidiomycetes and one unidentified taxon overlapped between the two seasons (Table 2).

Eighty-three taxa identified from *M. garrettii* wood were collected from DSP National Park comprising 25 Ascomycetes, 56 anamorphic fungi and two lichens (Kodsueb et al. 2008, Table 1). Sixty taxa (17 Ascomycetes, 41 anamorphic fungi and two lichens) were recorded from dry season samples, while 40 taxa (11 Ascomycetes, 29 anamorphic fungi) were obtained from wet season samples (Kodsueb et al. 2008). Four Ascomycetes and 13 anamorphic fungi overlapped between the two seasons (Table 2).

One hundred and three species (73.0%) of saprobic fungi obtained from PHR site were found in both wet and dry seasons, although with variation in the frequency of occurrence (Table 2). Only 17 fungal taxa (20.5%) were found in both wet and dry seasons from DSP site.

Several studies have suggested that seasonality is one factor affecting fungal communities (Costa & Gusmao 2015; Kennedy et al. 2006; Nikolcheva & Barlocher 2005), but there is no evidence to clarify the seasonal effects on fungal communities (Kodsueb et al. 2008). Costa and Gusmão (2015) studied saprobic fungi on leaf litter of *Clusia nemorosa* and *Vismia guianensis* in the Atlantic Forest of South America in the wet and dry seasons and concluded that the seasonality was an important factor influencing the distribution of fungal species. Nikolcheva and Barlocher (2005) also concluded that the presence/absence of aquatic hyphomycetes is influenced primarily by season (due to the temperature differences in each season). The effect of seasonality may be more acute in temperate regions where there is usually greater fluctuations in temperature, humidity and rainfall (Thongkantha et al. 2008).

Fungi generally need moisture in order to germinate and grow (Pinnoi et al. 2006), a situation clearly observed in the study on leaf litter fungi in the Atlantic forest, which showed that the wet season yielded more fungi than the dry season (Costa & Gusmao 2015). Interestingly, we found the diversity of fungi on the wood samples was higher in dry season than wet season and this was apparent at both sites. This finding is in agreement with previous studies of Kodsueb et al. (2008) and Seephueak et al. (2011). It is possibly due to lower aeration within the wood during wet season (Rayner & Todd 1979). It is also possible that rapid growth of certain fungal species may suppress other slow-growing ones sharing the same niche.

SITE SPECIFICITY

Lee et al. (2017) reported that species diversity and richness of endophytic fungi colonizing the roots of *Cephalanthera longibracteata* were not significantly different between sites. However, the community structure of the endophytic fungi did significantly differ between sites, suggesting that site characteristics affected the community composition of those endophytic fungi. Generally, saprobic fungi are believed not to be host-specific or host-recurrent (Zhou & Hyde 2001). The similarity index between PHR and DSP sites (Table 3) and the identical results from cluster and 3D-correspondence analyses which divided the fungal communities of saprobic fungi on *M. garrettii* into two different groups, both suggest a dissimilarity of fungal communities between the two sites. The overlapping taxa between the two sites were low, with only 38 out of 186 taxa (Table 3), which suggests the influence of site characteristics. Differences in percentage occurrence of species on the same host at different sites has commonly been noted in studies of fungi in mangroves and is more likely to result from differences in environmental factors than be host related (Alias et al. 1995; Hyde and Lee 1995). The result from this study is in agreement with previous studies (Thongkantha et al. 2008).

The current study confirmed that site characteristics affect the community composition of saprobic fungi of *M. garrettii*. The number of fungi on wood collected at both sites differed significantly, with only 40 samples collected from the DSP site, while 100 wood samples were collected for PHR site. Only two *M. garrettii* trees in the DSP site were sampled, one from each of two collecting sites, while the PHR samples were collected from seven collecting sites, with one or two trees collected from each site. These differences may possibly explain the lower number of fungi obtained from the DSP site. In the case of lichens collected in this study, only two taxa were obtained from the wood samples collected in the DSP site. This might be a result of the lichen being vulnerable to air pollution occurring at the study site; Chiang Mai Province suffered from crisis level air pollution from crop burning during the previous ten dry seasons (Supasri et al. 2018). Differences in time of collection of this comparative study may be raised in question. However, both study sites are located in undisturbed areas of the National Parks. We therefore, believed that microbial faunas were not significantly different.

CONCLUSION

We found that the saprophytic fungal community on wood of *Magnolia garrettii* in PHR was diverse, and the fungal community in wet and dry season was not distinct although we observed higher diversity in dry season. By comparing with previous results from Kodsueb et al. (2008), we also found effects of site and season on the *M. garrettii*-associated fungal communities. None of the Basidiomycetes was common to the two sites and only one species overlapped between the two seasons in PHR. Physical and chemical properties of the trees, microclimate of the growth site, and biological interaction within woody substrate may render changes in the communities of fungi (Holmer & Stenlid 1996; Rayner & Boddy 1988; Renvall 1995). It is therefore important for further investigation to better understand influences of these factors on saprophytic fungal communities.

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