WALAILAK JOURNAL
http://wjst.wu.ac.th Agricultural Technology and Biological Sciences

Diversity of Macrofungi in Oil Palm (*Elaeis guineensis* Jacq.) Plantation in Southern Thailand

Pornsil SEEPHUEAK[1,*], Chaisit PREECHA[2] and Wuttichai SEEPHUEAK[1]

[1]*Faculty of Agriculture, Rajamangala University of Technology Srivijaya, Thung-Yai, Nakhon Si Thammarat 80240, Thailand*
[2]*Faculty of Agriculture, Rajamangala University of Technology Srivijaya, Thung-Song, Nakhon Si Thammarat 80110, Thailand*

([*]Corresponding author's e-mail: spornsil@gmail.com)

Received: 7 June 2016, Revised: 5 July 2017, Accepted: 17 August 2017

Abstract

The objective of this study was to determine the diversity of macrofungi in oil palm (*Elaeis guineensis* Jacq.) plantation habitats. The diversity of macrofungi was divided into 5 parts; vein, mid-rib and rachis of the oil palm frond litter, other plant litter and on the soil. The study was conducted in Thung Yai District, Nakhon Si Thammarat Province and Huai Yot District, Trang Province, in the southern region of Thailand in 2014 - 2015. In total 111 taxa were identified, comprising 10 ascomycota and 101 basidiomycota. The most abundant species were *Marasmius* (15 species), followed by *Xylaria* (6 species), *Marasmiellus* (5 species) and *Termitomyces* (5 species). Fifty-eight taxa were found on the oil palm rachis litter, 52 taxa from the soil, 19 taxa from the oil palm mid-rib litter, 10 taxa from other plant litter and 4 taxa from the oil palm vein litter.

Keywords: Decomposition, diversity, *Elaeis guineensis* Jacq., macrofungi, oil palm frond

Introduction

The oil palm (*Elaeis guineensis* Jacq.) is a valuable cash crop in tropical areas. Currently, palm oil and its products are a major source of revenue for several countries, notably Indonesia, Malaysia and Thailand; and especially southern Thailand. There are several by-products of oil palm, such as oil palm fronds, palm kernel cake, palm oil mill effluent, and palm press fibres which have great potential to be utilized as a source or as a component in a complete feed for ruminant animals [1]. Moreover, empty fruit bunches were used as a substrate for mushroom cultivation (*Volvariella volvacea*). The oil palm fronds which are cut off during harvesting may also be degraded and colonized by fungi. The majority of the fungi encountered in these plantations are not specifically associated with the oil palm. The oil palm frond litter is a significant process of nutrient cycling in the oil palm plantations, playing a major role in the transfer of energy and nutrients. It is now well established that the decomposition of plantation litter on the soil surface is brought about by variety of microorganisms and insects. Fungi are regarded as efficient decomposers of organic matter, especially plant litter [2]. Many fungi have the ability to degrade a broad range of wood and cellulosic substrates. They originated in the surrounding forests and have adapted to the new environment in the plantation. Several studies of macrofungi in Thailand have been carried out in various habitats [3-11]. However, there were few macrofungi studies in oil palm plantations. Usually, the common mushrooms found in oil palm plantations are *Fomitopsis* sp., *Perenniporia* sp., *Pycnoporus sanguineus*, *Schizophyllum commune* and *Trametes lactinea* [12-14].

This study focused mainly on mushroom fruiting bodies growing on the vein, mid-rib, and rachis of the oil palm frond, other plant litter and on the soil in the oil palm plantations, southern Thailand. The oil palm plantation management has a negative impact on the plantation, some of the chemicals used in herbicide and fungicide are persistent soil contaminants, whose impact may endure for many years and adversely affect soil conservation and soil microbial communities [15-17]. Studies on species richness and composition of various macrofungi groups in the oil palm plantations are therefore of great interest.

Fruiting bodies samples

The macrofungi samples were collected during 6 different months in 2015; February, April, June, August, October and December. The sporocarp survey, the fruiting bodies that were visible at the oil palm frond litter were examined; vein, mid-rib and rachis on other plant litter and those on the soil were also examined. The specimens were photographed, air-dried and preserved in 95 % ethyl alcohol [8]. All fruiting bodies were deposited in the Herbarium of the Mushroom Museum of the Rajamangala University of Technology Srivijaya. Identification was based on morphological study involving examination under stereo and compound microscopes using relevant text references [4,5,8,18,19].

Sampling design

Sporophore of macrofungi were collected at 2 sites in 15 years-old the oil palm plantations in Nakhon Si Thammarat Province (latitude 8º 32″ N, longitude 99º 57″ E) and Trang Province (latitude 7º 84″ N, longitude 99º 60″ E). The areas have a humid tropical climate. The annual rainfall was between 2076.9 and 2318.4 mm. Three plots were distributed on a grid system of 200×200 m^2. The first collection was made in February which in southern Thailand is the early dry season, and the average daily temperature was between 25.93 and 27.42 ºC, no rainfall. The second collection occurred during April (in the late dry season/early rainy season) in which the average daily temperature ranged from 29.54 - 29.55 ºC and the rainfall was recorded as being between 0.01 - 11.19 mm. The third collection was in June which is in the rainy season and had the temperature range 28.85 - 29.25 ºC and the rainfall was recorded as being between 3.82 - 6.97 mm. The fourth collection was in August which is in the rainy season which the temperature range was 28.00 - 28.52 ºC. The rainfall was recorded as between 5.10 - 6.64 mm. The fifth collection was in October, the rainfall was recorded as being between 10.33 - 10.55 mm and had the temperature range 27.41 - 28.36 ºC. The final collection was made in December which was the late rainy season when the temperature ranged from 26.72 - 27.54 ºC and the rainfall was recorded as 5.71 - 20.17 mm.

Definition and statistical analyses

Macrofungi on the oil palm frond litter, on other plant litter and on the soil were recorded in each period. The oil palm frond litter was divided into 3 groups: vein; mid-rib and rachis. The number of samples on which a fungal species was found was designated as the occurrence of a fungus and used to calculate the percentage occurrence of a species on litter using the following formula. % occurrence of taxon A = (number of samples on which each fungus was detected/ total number of sample examined) × 100. Macrofungi species diversity at each substrate and during each period was calculated using the Shannon-Wiener index (H) and Simpson's index (D) [20].

The Shannon-Wiener index $H = -\Sigma P_i \ln P_i$, where Pi is the frequency of fungal species i occurring at a specific part and season, and ln is the natural log. Values of H for real communities are often between 1 and 6. Simpson' index $D = 1-\Sigma[n_i/(n_i - 1) / N/ (N - 1)]$, where ni is the number of individuals in the community of species i and N = the total number of species in the community. Values of D range between 0 and 1 [21].

Results and discussion

Macrofungi taxonomic composition

Macrofungi surveys in the oil palm plantation habitats yielded 111 taxa, comprising 28 families and 51 genera were identified. Among them, 101 taxa (90.99 %) belong to basidiomycetes and 10 taxa (9.01 %) to ascomycetes. Fifty-eight species were found on rachis litter, 52 species were found on the soil, 19 species were found on mid-rib litter, 10 species found on other plant litter and 4 species were found on vein litter. The majority of the macrofungi belonged to the *Marasmius* (15 species), followed by the *Xylaria* (6 species), *Marasmiellus* (5 species) and *Termitomyces* (5 species). The most abundant family was the *Marasmiaceae* with 21 species, followed by 14 species of Polyporaceae and 13 species of Agaricaceae (**Table 1**).

The results show that the patterns of mushrooms found had a significant relationship to the surrounding physical conditions. The communities of macrofungi on soil and plant litter in the oil palm plantations seem to be specially structured areas 200×200 m^2 in size along rainfall and edaphic gradients. The results indicated that the macrofungal production in the oil palm plantations varies predictably by space, time and substratum. The oil palm plantation is a major habitat for macrofungi and other living organisms. There is therefore a need for the appropriate designing of management schemes to safeguard remnants of the tropical rainforest. In this study, the number of macrofungi that were found in the oil palm plantations was less in both areas, when compared with fungal organisms in the forest. According to McGuire [22] who studied soil fungi in 3 sites; primary forest, regenerating forest and the oil palm plantations, the results shown that the richness and diversity of fungal communities were distinct across all sites, fungal diversity in the regenerating forest being more similar to the primary forest while fungal diversity in the oil palm plantations was the lowest. Moreover, the oil palm plantations had the lowest number of ectomycorrhizal fungi [22]. In the present study, *Russula alboareolata* and *Laccaria laccata* were the ectomycorrhizal fungi which were detected. The ectomycorrhizal fungal communities were distinct across land use types, and the oil palm plantations had the lowest number of ectomycorrhizal fungal per unit area [23].

The percentage of macrofungi in the oil palm plantations, divided into 3 groups according to their roles and functions in the forest ecosystem were saprobic mushroom (104 species), termite mushroom (5 species) and ectomycorrhiza (2 species). The ecology of organisms is crucial for the optimal use of land resources. With continuous deforestation, monoculture and environmental degradation, which are contributing to the loss of global biodiversity and which in many cases is irreversible, there is a risk of loss of macrofungi diversity and subsequent loss of knowledge of their existence and possible uses [24].

Fungi habitats may be lost, with resulting reduction of fungal species diversity, either by deforestation, or because of commercial forestry management practices, such as the conversion to less mixed or monoculture plantations for example (oil palm plantations), stand felling of a particular age, and the removal of coarse woody debris [25]. Red-list (endangered, vulnerable or rear) species may be particularly sensitive, which often show a preference for large diameter logs in a late decay stage, of which managed forests are largely deficient [26]. The expansion of oil palm plantation and planting activities are the leading cause of deforestation and biodiversity loss [16,17]. According to Wong [27] who reported that ascomycota and basidiomycota tends to decrease in oil palm plantations in Malaysia. However, the effect of plantation activity on fungal biodiversity remains unclear. The resulting impact on community interactions may have implications for the dynamic between pathogens and saprophytes and the consequent natural limitation of plant disease, and even on the subsequent decay rates of litter and hence nutrient cycling [26]. The study established that macrofungi diversity is threatened in the oil palm plantations and there is a need for conservation measures especially for edible and medicinal mushrooms [24] because of their enormous agro-industrial and commercial benefits.

The colonization and dominant macrofungi

The highest number of macrofungi found on rachis litter were 58 taxa comprising 45 species in Nakhon Si Thammarat Province and 18 species in Trang Province. Eight species were found in ascomycetes and 50 species were found in basidiomycetes. Whereas, 19 macrofungi were found on mid-rib litter comprising, 11 species in Nakhon Si Thammarat Province and 12 species in Trang Province. Only 4 species of macrofungi were found on vein litter in Trang Province. All of them were *Marasmius*.

Ten species of fruiting bodies were found on other plant litter comprising 4 species found in Nakhon Si Thammarat Province and Trang Province. All of them were basidiomycetes. Whereas, 52 species were found on the soil in the oil palm plantations including 30 species found in Nakhon Si

Thammarat Province and 28 species found in Trang Province. Three species were found in ascomycetes and 49 species found in basidiomycetes. Seven species, *Coltricia cinnamomea*, *Laccaria laccata*, *Leucocoprinus bresadola*, *Lepiota* sp.2, *Panaeolus* sp., *Termitomyces indicus* and *Thelephora palmata* were found in both areas (**Tables 1 - 2**).

The common macrofungi found on the oil palm vein, mid-rib and rachis litter, other plant litter and on the soil are shown in **Table 3**. Four species, *Marasmius* sp.1, *M. fulvoferrugineus*, *M. haematocephalus* var. *haematocephalus* and *M. pulcherripes* were the dominant species (over 10 % occurrence) found on the oil palm vein litter. Five species, *Coprinus narcoticus*, *Marasmiellus candidus*, *M. haematocephalus* var. *haematocephalus*, *M. pellicidus* and *Tetrapyrgos nigripes* were dominant species on the oil palm mid-rib litter. One species, *Schizophyllum commune* was the dominant species found on the oil palm rachis litter. Seven species, *Conocybe lactea*, *Coprinus narcoticus*, *Crinipellis stipitaria*, *Lycoperdon pusillum*, *Marasmius* sp.1, *Parasola kuehneri* and *Marasmius pulcherripes* were the dominant species found on other plant litter. Four species, *Agaricus trisulphuratus*, *Conocybe lactea, Marasmius micrater* and *Thelephora palmata* were the dominant species found on the soil. Various major macrofungi were found in the oil palm habitats. Forty-one taxa were found at the oil palm plantation in Trang Province, including 24 Polyporales, 10 Agaricales, 3 Hymenochaetales, one Boletales, Corticiales, Phallales and Thelephorales [13]. While, nearly 50 macrofungi have been recorded from Peninsula Malaysia, Indonesia such as *Ganoderma boninense*, *Pleurotus djamor*, *Pycnoporus sanguineus*, *Gymnopilus dilepis* and *Schizophyllum commune* [14].

The study of macrofungi by direct examination of vein litter, mid-rib litter and rachis litter, other plant litter and on the soil to check for the presence of fruiting bodies is a traditional method of surveying basidiomycetes and ascomycetes activity. The majority of litter decaying fungi studied have been concerned with basidiomycetes on a substrate in an early stage of decomposition in the rainy season [9,10,24,28,29]. Whereas, ascomycetes are particularly associated with an intermediate decomposition stage [30]. Host, litter species, physical properties, chemical properties and microclimate govern the basic fungal community dynamics, as does the history of the substratum [31]. Fungi may gain access either through wounds into tissues following microbial or stress damage or via lenticels of leaf scars.

The richness and abundance of fungi on litter depend on many factors. Decomposition of plant litter gradually releases sources of nutrients [32]. Exposed stumps of felled trees, fallen branches, twigs or timbers may become rapidly colonized by large numbers of individuals of fairly nonselective saprobic types thereby forming numerous smaller decay columns. Community structure and development is affected by the degree of exposure, contact with the surfaces of the other litter, and is influenced by microenvironmental conditions and the arrival mode of individuals. Moreover, exposed surfaces may be colonized by established air-borne spores via *Coriolus*, *Hypoxylon*, *Stereum* and *Xylaria* that were commonly found on the hardwoods. In this study, common species were found on the oil palm fronds such as those of *Marasmiellus*, *Marasmium* and *Xylaria*. Moreover, mode of establishment often produces slower expansion of decay columns compared to that from ground contact, presumably due to more stressful drying regimes [33]. Buried or ground contact litter may be colonized by soil obtained spores and mycelia. Besides, the spatial and temporal combination of extracellular enzymes secreted by a fungus is dependent not only on its evolutionary heritage, but also on the local environmental and biotic conditions [34].

Seasonal effect on the macrofungal community

The patterns of macrofungi in the different seasons were distinct. In Nakhon Si Thammarat Province, the number of fruiting bodies found in the rainy season (August) trended to be higher than the number of fruiting bodies found in other seasons. Forty-four species were found in August, 29 species in October, 16 species in June, in December, 12 species in April and 4 species in February. In addition, looking at the results obtained in Trang Province, the number of fruiting bodies found in the rainy season (August) was higher than in other seasons. The same pattern occurs in Nakhon Si Thammarat Province. Twenty-nine species were found in August, 24 species in June, 21 species in October, 20 species in April, 15 species in December and only one species in February (**Table 4**).

The species diversity in this study was higher in the rainy season compared to the dry season, as there is adequate moisture available during the rainy season because moisture is one of the major factors influencing the fruiting of macrofungi, according to [24,35-40]. The patterns of mushrooms found are significantly correlated with the surrounding physical conditions. In this study, the number of macrofungi was high in the rainy season in both areas. In Trang province, 69 taxa were found in the rainy season and 1 taxa found in dry season. While, in Nakhon Si Thammarat Province, 77 taxa were found in the rainy season and 4 taxa were found in the dry season. *Schizophyllum commune* is the dominant was found in all seasons and both areas.

The mushroom biodiversity in Thailand is rich and poorly unexplored. *Termitomyces* spp. and *Schizophyllum commune* are widely distributed in the country and provide additional source of income for the rural people of Thailand. People in Thailand understand the importance of mushrooms, which are usually found in the rainy season according to [14] who reported that *Termitomyces* is a normal mushroom found in the oil palm plantations in the rainy season in Malaysia.

Table 1 Occurrence (%) of macrofungi on the vein, mid-rib and rachis of the oil palm frond litter, other plant litter and on soil in the oil palm (*E. guineensis*) plantations in Nakhon Si Thammarat and Trang Province.

Taxa	**Location/substrate**								
	Nakhon Si Thammarat				**Trang**				
	Mid-rib	**Rachis**	**Litter**	**Soil**	**Vein**	**Mid-rib**	**Rachis**	**Litter**	**Soil**
Ascomycota									
Cookeina sulcipes		1.32						8.33	
C. tricholoma		2.64						8.33	
Coltricia cinnamomea				3.70					
Galiella rufa				3.70				5.56	
Xylaria sp.1		2.64							
Xylaria sp.2		1.32							
Xylaria sp.3		1.32							
Xylaria sp.4		1.32							
X. brunneovinosa				3.70					
X. hypsipoda		1.32		7.40					
Basidiomycota									
Agaricus sp.									2.27
A. campestris									2.27
A. trisulphuratus									11.36
Bolbitius titubans				3.70					
Campanella tristis	7.69	1.32		3.70		6.25			
Clitopilus apalus				7.40					
Conocybe lactea		2.64						28.56	13.64
Coprinellus micaceus				3.70					
Coprinus fimetarius				7.40					
C. micaceus				3.70					
C. narcoticus	30.76		33.34	7.40			5.56	28.56	
C. plicatilis				7.40					
Crepidotus sp1.		1.32							
Crepidotus sp2.		1.32							
C. citrinus		2.64		7.40					
C. mollis	7.69								
C. variabilis	7.69					6.25			

Taxa	Location/substrate								
	Nakhon Si Thammarat				Trang				
	Mid-rib	Rachis	Litter	Soil	Vein	Mid-rib	Rachis	Litter	Soil
Crinipellis stipitaria			16.67						
C. zonata		2.64							
Cyathus striatus							5.56		2.27
Dacryopinax spathularia		2.64							
Dictyophora multicolor		2.64							
Gymnopilus aeruginosa		1.32		7.40					
G. luteoviridis		3.95					5.56		4.55
Heinemannomyces splendidissima									2.27
Hemimycena dellicatella							2.78		
Hexagonia tenuis		1.32							
Hygrocybe flavescens				3.70					
Laccaria laccata				3.70					2.27
L. Montana		1.32							
Lentinus sp.1		2.64							
L. sajor-caju		1.32							
L. similis		2.64					2.78		
L. squarrosulus		2.64							
Lepiota sp.1									2.27
Lepiota sp.2				3.70					2.27
Leucocoprinus bresadolae				3.70			2.78		2.27
L. cepaestipes		1.32							
Lycogalopsis sp.									2.27
Lycoperdon pusillum								28.57	
Macrolepiota gracilenta		1.32							
M. velosa									2.27
Marasmiellus candidus	7.69	3.95				18.75			
M. corticum		2.64							
M. nigripes		1.32							4.55
M. pseudopellucidus	7.69						5.56		
M. ramealis		1.32					5.56		
Marasmius sp.1			33.34		12.50				
Marasmius sp.2						6.25			
Marasmius sp.3						6.25			
M. androsaceus							2.78		
M. araneocephalus	7.69	1.32							
M. conicopapillatus						6.25	2.78		
M. cremeus						6.25			
M. fulvoferrugineus					37.50		2.78		
M. haematocephalus var. *haematocephalus*	15.38				37.50	6.25			
M. hypochroides		1.32							
M. leveillianus									2.27
M. micrater									11.36
M. olidus									2.27
M. pellcidus						12.50			
M. pulcherripes	7.69				12.50	6.25		28.57	
Micromphale sp.									2.27
Microporus affinis		1.32							

Taxa	**Location/substrate**								
	Nakhon Si Thammarat				**Trang**				
	Mid-rib	**Rachis**	**Litter**	**Soil**	**Vein**	**Mid-rib**	**Rachis**	**Litter**	**Soil**
Mycena sp.1		2.64							
Mycena sp.2		1.32							
Mycena sp.3		2.64		3.70					
M. inclinata	7.69								
Panaeolus sp.				3.70					2.27
P. papilionaceus	7.69								
Parasola kuehneri			33.34						
P. plicatilis				3.70			2.78		
Pholiotina sp.									2.27
Pleurotus sp.1		2.64							
Pleurotus sp.2							2.78		
Podoscypha nitudula									2.27
Polyporus sp.							2.78		
P. arcularius		3.95							
P. tricholoma		1.32							
Psilocybe subaeruginascens									2.27
Psythyrella sp.		1.32							
P. candolleana		5.28					2.78		
P. multissima		1.32		3.70					
Pycnoporus sanguineus		7.92							
Ramariopsis fusiformis				3.70					
Resupinatus trichotis				3.70			2.78		
Russula alboareolata		1.32							
Schizophyllum commune		12.98					16.67		
Scytinopogon angulisporus									2.27
S. pallescens									2.27
Stereopsis radicans									2.27
Termitomyces globulus				3.70					
T. heimii				3.70					
T. indicus				7.40					2.27
T. radicatus									4.55
T. tyleranus				3.70					
Tetrapyrgos nigripes				3.70		12.50			
T. simulans						6.25			
Thelephora palmata				11.11					11.36
Trametes sp.		2.64							
Tremella fuciformis							2.78		
Total	**11**	**45**	**4**	**30**	**4**	**12**	**18**	**7**	**28**

Table 2 Diversity indices of macrofungi on vein, mid-rib and rachis of the oil palm frond litter, other plant litter and on soil in the oil palm plantations.

Substrate	Total (N)	Location					
		Nakhon Si Thammarat			Trang		
		No. of species	Index D	Index H	No. of species	Index D	Index H
Vein litter	4	0	0	0	4	0.8181	1.3862
Mid-rib litter	19	11	0.9310	2.3025	12	0.9375	2.3979
Rachis litter	58	45	0.9850	3.8066	18	0.9692	3.0910
Other plant litter	10	4	0.8181	1.3862	7	0.8571	1.6094
Soil	52	30	0.9677	3.0445	28	0.9750	3.2958

Table 3 Dominant macrofungi found in the oil palm plantations, with over 10 % of occurrence at each substrate.

Substrate	Location	
	Nakhon Si Thammarat	Trang
Vein litter		*Marasmius* sp.1 (12.50)[1] *M. haematocephalus* var. *haematocephalus* (37.50) *M. pulcherripes* (12.50) *M. fulvoferrugineus* (37.50)
Mid-rib litter	*Coprinus narcoticus* (30.76) *Marasmius haematocephalus* var. *haematocephalus* (15.38)	*Marasmius candidus* (18.75) *M. pellcidus* (12.50) *Tetrapyrgos nigripes* (12.50)
Rachis litter	*Schizophyllum commune* (12.98)	*Schizophyllum commune* (16.67)
Other plant litter	*Coprinus narcoticus* (33.34) *Crinipellis stipitaria* (16.67) *Marasmius* sp.1 (33.34) *Parasola kuehneri* (33.34)	*Conocybe lactea* (28.57) *Coprinus narcoticus* (28.57) *Lycoperdon pusillum* (28.57) *Marasmius pulcherripes* (28.57)
Soil	*Thelephora palmata* (11.11)	*Agaricus trisulphuratus* (11.36) *Conocybe lactea* (13.64) *Marasmius micrater* (11.36) *Thelephora palmata* (11.16)

Note: [1] = % occurrence.

Table 4 Diversity indices of macrofungi on vein, mid-rib and rachis of the oil palm frond litter, other plant litter and on the soil in the oil palm plantations during each season.

Location/ Substrate	Season						Total	Index D	Index H
	Feb[1]	Apr[2]	Jun[3]	Aug[4]	Oct[5]	Dec[6]			
Nakhon Si Thammarat									
Vein litter	0	0	0	0	0	0	0	0	0
Mid-rib litter	0	3	1	3	4	2	13	0.9473	2.5649
Rachis litter	3	6	8	30	19	10	76	0.9857	3.6536
Other plant litter	0	1	3	1	0	0	5	0.9444	1.5607
Soil	1	2	4	10	6	4	27	0.9824	3.0710
Total	4	12	16	44	29	16			
Trang									
Vein litter	0	0	1	2	2	2	7	0.9285	1.7328
Mid-rib litter	0	4	5	5	1	1	16	0.9583	2.3933
Rachis litter	1	4	5	12	7	7	36	0.9587	2.9092
Other plant litter	0	1	2	1	3	0	7	0.9047	1.5498
Soil	0	11	11	9	8	5	44	0.9767	3.2562
Total	1	20	24	29	21	15			
No. of species	**4**	**28**	**39**	**64**	**37**	**27**			

Note:[1]February; early dry season, [2]April; late dry season/early rainy season, [3]June; rainy season, [4]August; rainy season, [5]October; rainy season, [6] December; late rainy season.

Conclusions

Sporocarp surveys on oil palm frond, other plant litter and on the soil in oil palm plantations habitat yield 111 macrofungal taxa, consisting of 28 families, with 51 genera identified. Among them 101 taxa (90.99 %) belong to basidiomycetes and 10 taxa (9.01 %) to ascomycetes. Fifty-eight species were found on rachis litter, 52 species were found on the soil, 11 species found on mid-rib litter, 10 species found on other plant litter and 4 species found on vein litter. The majority of the macrofungi belonged to the *Marasmius*, followed by the *Xylaria*, *Marasmiellus* and *Termitomyces*. The macrofungi for the different seasons were diverse. The number of fruiting bodies in the rainy season (August) was higher than other seasons. *Schizophyllum commune* is the dominant species which was found in all seasons.

Acknowledgements

The authors would like to acknowledge the financial support provided by Rajamangala University of Technology Srivijaya.

References

[1] MW Zahari, OA Hassan and JB Liang. Utilization of oil palm frond-based diets for beef and diary production in Malaysia. *J. Anim. Sci.* 2003; **4**, 625-34.

[2] S Shanthi and BPR Vittal. Biodiversity of microfungi associated with litter of *Pavetta indica*. *Mycosphere* 2010; **1**, 23-37.

[3] Kasetsart University Library, Available at: http://www.lib.ku.ac.th/KUCONF/KC4409024.pdf, accessed April 2016.

[4] M Chanopas, W Chanopas, T Jongjitrimol, A Chaingkool and P Sanpote. Survey on macrofungi at Doy Weang La Wildlife, Sanctuary in Mae Hong Son Province. *NU Int. Sci. J.* 2006; **2**, 175-81.

[5] N Sanoamuang. *Wild Mushroom of Thailand: Biodiversity and Utilization*. Universal Graphic and Treading. Bangkok, Thailand, 2010.

[6] P Seephueak. 2012. Fungi Associated with Degradation of Rubber Wood Logs and Leaf Litter. Ph. D. Dissertation. Prince of Songkla University, Thailand.
[7] P Wongchalee and C Pukahute. Diversity of mushroom in dry diterocarp forest at Phuphan National park, Sakon Nakhon province. *Nat. Sci.* 2012; **4**, 1153 - 60.
[8] V Petcharat, K Worapattamasi, N Seehanan and P Seephueak. *Mushroom of Southern Thailand*. Prince of Songkla University, Songkhla, Thailand, 2013.
[9] W Siksirirat, S Sirimungkararat, W Bungatratchata and O Lawinit. Species diversity of macrofungi in plant genetic conservation area of Sirindhorn dam, Ubon Ratchathani Province. *Khon Kaen Agr. J*. 2013; **41**, 513-20.
[10] P Prommanut, W Somprasong and M Thammakajondach. Species diversity of edible mushroom in Mae Sanam Silvicultural research station, Hod district, Chiang Mai Province. *Khon Kaen Agr. J.* 2014; **42**, 339-44.
[11] Y Luo, P Wattanachai and K Soytong. Mushroom and macrofungi collection for screening bioactivity of some species to inhibit coffee anthracnose caused by *Colletotrichum coffeanum. J. Agri. Tech*. 2014; **10**, 845-61.
[12] R Choeyklin. 2009. The Ecology and Lignocellulose Degrading Ability of Basidiomycetes on Selected Bamboo and Palms. Ph. D. Dissertation. Burapha University, Thailand.
[13] U Pinruan, N Rungjindamai, R Choeyklin, S Lumyoung, KD Hyde and EBG Jones. Occurrence and diversity of basidiomycetous endophytes from the oil palm *Elaeis guineensis* in Thailand. *Fungal Divers*. 2010; **41**, 71-88.
[14] R Ture. Macrofungi in oil palm plantation of South East Asia. *Mycologist* 1998; **12**, 10-4.
[15] D Bakewell, R Azmi, FK Yew, FY Ng, Y Basiron and K Sundram. *Biodiversity in Plantation Landscapes: A Practical Resource Guide for Manager and Practitioners in Oil Palm Plantations*. Wild Asia (Malaysia) and the Malaysian Palm Oil Council, Malaysia. 2012.
[16] EB Fitzherbert, MJ Struebig, A Morel, Danielsen F, CA Bruhl, DF Donald and B Phalan. How will oil palm expansion affect biodiversity? *Trends Ecol. Evol*. 2008; **23**, 538-45.
[17] C Petrenko, J Paltseva and S Searle. *Ecological Impacts of Palm Oil Expansion in Indonesia*. Internation Council on Clean Transportation. Washington DC, USA, 2016.
[18] DE Desjardin, TW Flegel and T Boonpratuang. *Basidiomycetes. In*: EGB Jones, M Tanticharoen and KD Hyde (eds.). Thai Fungal Diversity, Biotech Publishing, Thailand, 2004, p. 37-49.
[19] A Chandrasrikul, U Suwanarit, T Morinaga, Y Nishizawa and Y Murakami. *Diversity of Mushroom and Macrofungi in Thailand.* Kasetsart University Publishing, Thailand, 2008.
[20] P Seephueak, S Phongpaichit, KD Hyde and V Petcharat. Diversity of saprobic fungi on decaying branch litter of the rubber tree (*Hevea brasiliensis*). *Mycosphere* 2011; **2**, 307-30.
[21] H Wang, KD Hyde, K Soytong and F Lin. Fungal diversity on fallen leaves of *Ficus* in northern Thailand. *J. Zhejiang Univ. Sci. B* 2008; **9**, 835-41.
[22] KL McGuire, HD Angelo, FQ Brearley, SM Gedallavich, N Babar, N Yang, CM Gillikin, R. Gradoville, C Bateman, BL Turner, P Mansor, JW Leff and N Fierer. Responses of soil fungi to logging and oil palm agriculture in Southeast Asian tropical forests. *Microb. Ecol*. 2014; **69**, 733-47.
[23] JC Frankland. Fungal succession unraveling the unpredictable. *Mycol. Res*. 1998; **102**, 1-15.
[24] EE Andrew, TR Kinge, EM Tabi, N Thiobal and AM Mih. Diversity and distribution of macrofungi (mushrooms) in the Mount Cameroon Region. *J. Ecol. Nat. Environ.* 2013; **5**, 318-34.
[25] B Nordén and H Paltto. Wood-decay fungi in hazel wood: Species richness correlated to stand age and dead wood features. *Biol. Conserv.* 2001; **101**, 1-8.
[26] N Kruys and BG Jonsson. Fine woody debris is important for species richness on logs in managed boreal spruce forests of northern Sweden. *Can. J. Forest. Res.* 1999; **29**, 1295-99.
[27] S Wong, WS King, K Ahmad and SRA Ali. Composition of soil fungi in oil palm plantation, Sungai Asap, Sarawak. Malaysia International Biological Symposium 2012, Available at: https://www.researchgate.net/publication/283664491_Composition_of_Soil_Fungi_in_Oil_Palm_ Plantation_ Sungai_Asap_Sarawak, accessed June 2017.
[28] National Park Service, Available at: https://www.nps.gov/cue/events/spotlight08/Spotlight08_ posters PDFs/MushroomSurveyPoster_Dewsbury.pdf. 2007, accessed April 2016.

[29] Department of National Parks, Available at: http://portal.dnp.go.th/Content/ForestResearchOffice?contentId=752, accessed April 2016.
[30] ADM Rayner and L Bodd. *Fungal Decomposition of Wood Its Biology and Ecology*. John Wiley and Sons, UK, 1988.
[31] IH Chapela, L Boddy and ADM Rayner. Structure and development of fungal communities in beech logs four and a half years after felling. *Microb. Ecol.* 1988; **53**, 59-70.
[32] ME Harmon, J Sexton, BA Caldwell and SE Carpenter. Fungal sporocarp mediated losses of Ca, Fe, K, Mg, Mn, N, P and Zn from conifer log in the early stages of decomposition. *Can. J. For. Res.* 1994; **24**, 1883-93.
[33] J Worrall, S Anagnost and RA Zabel. Comparison of wood decay among diverse lignicolous fungi. *Mycologia* 1997; **89**, 199-219.
[34] DH Griffin. *Fungal Physiology*. Wiley-Liss, New York, 1994.
[35] HV Dijk, NA Onguene and TW Kuyper. Knowledge and utilization of edible mushrooms by local populations of the rain forest of South Cameroon. *Ambio* 2003; **32**, 19-23
[36] MM Apetorgbor, AK Apetorgbor and E Nutakor. *Utilization and Cultivation of Edible Mushroom for Rural Livelihood in Southern Ghana*. 17th Commonwealth Forestry Conference Colombo, Sri Lanka, 2005.
[37] N Brown, S Bhagwat and S Watkinson. Macrofungal diversity in fragmented and disturbed forests of the western ghats of India. *J. Appl. Ecol.* 2006; **43**, 11-7.
[38] J Gbolagade, A Adetolu, O Akpebivie and W Donbebe. Nutritive value of common wild edible mushroom from Southern Nigeria. *Global J. Biotech. Biochem.* 2006; **1**, 16-21.
[39] S Swapna, A Syed and M Krishnappa. Diversity of macrofungi in semi-evergreen and moist deciduous forest of Shimoga District Karnataka, India. *J. Mycol. Plant Pathol*. 2008; **38**, 21-6.
[40] TR Kinge, EA Egbe, EM Tabi, TM Nji and AM Mih. The first checklist of macro fungi of Mount Cameroon. *Mycosphere* 2013; **4**, 694-9.