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COMPARISON OF MACROFUNGAL DIVERSITY BETWEEN PEAT SWAMP FOREST AND OIL PALM SMALLHOLDING IN PENINSULAR MALAYSIA

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SUMMARY

The North Selangor Peat Swamp Forest is the second largest peat swamp forest ecosystem in Peninsular Malaysia. Changes in land use of peat swamp forest to oil palm agriculture can alter the macrofungal diversity. This study aimed to quantify the macrofungal diversity at three different landscapes; peat swamp forest, monoculture oil palm smallholding and polyculture oil palm smallholding. Five microclimate characteristics were studied, namely, air temperature, humidity, soil pH, soil moisture and wind speed. Substrates availability and vegetation structure such as canopy closure and canopy cover were also measured. A total of 45 plots were established using 9 transect lines in the study area. In January 2016 during rainfall season, a total of 608 macrofungal cluster recorded belongs to 56 families and 81 genera. The number of morphospecies and macrofungal cluster collection were higher ($P \leq 0.001$) at peat swamp forest than smallholding regardless monoculture or polyculture. For peat swamp forest under higher percentage of canopy cover, canopy closure and variety of substrate availability, the macrofungal diversity production increase with humidity and soil moisture but, decreased in air temperature, wind speed and soil pH value. For smallholding, due to lower percentage of canopy cover, canopy closure and also constrain in substrate availability, morphospecies richness and macrofungal abundance decreased with microclimate factor of humidity and soil moisture but increase in air temperature, wind speed and also soil pH value. Therefore, forest land cover contributes to suitable microclimate factors which are important for macrofungal diversity.

Keywords: *Macrofungal, Ecology, Peat swamp forest, Smallholding*

INTRODUCTION

North Selangor Peat Swamp Forest (NSPSF) is the second largest peat swamp forest in Peninsular Malaysia after South-East Peat Swamp Forest in Pahang. It consists of Raja Musa Reserve Forest and Sg. Karang Forest, covers approximately 73,593.03 ha (Rengasamy *et al*., 2013). Since 2008, forest fire occurs extensively and degraded the forest area and reduced 1,231 ha and more of the forest area (Yule & Gomez, 2008).

Currently, oil palm plantations have surrounded at least 60% of the NSPSF perimeter (Azhar *et al*., 2011). Recently, conversion of certain NSPSF area to plantation could change the biodiversity, this includes the fungi community that is important for plantation ecosystem. According to the previous reports, respond on macrofungal diversity information from the tropics is still lacking, especially in agricultural plantation, which creates a large knowledge gaps in fungal diversity knowledge in Malaysia. To date, little is known about the effects of forest conversion to oil palm agriculture on fungal diversity. Therefore, we aimed to quantify the macrofungal diversity based on its morphological characteristics at three different landscapes.

MATERIALS AND METHOD

We conducted macrofungal diversity inventories in three different landscapes; peat swamp forest, monoculture smallholding and polyculture smallholding during wet season in January 2016. We used systematic sampling with random starting point (Morrison *et al.,* 2008). A total of 45 circular plots were established using nine transect lines in the study area. Each transect was established 50 m away from the edge of both peat swamp and oil palm plantation. To avoid overlapping, sampling plots were distanced 50 m apart from each other. The geographical coordinates of the sampling point were mapped using a geographic positioning device (GPS II Plus, Garmin Ltd., Olathe, Kansas).

Within 20 m radius from the point centre, *in*-situ inventory and identification was carried out with the use of keys as guidelines (Kirk *et al*., 2008). The specimens were next photographed and labeled before collection. We focused our sampling on basidiomycetes and ascomycetes with visible sporocarps. Their substrates were also recorded namely, branch with a diameter more than 2.5 cm, twigs with a diameter less than 2.5 cm, fallen leaves, fruit shells (López-Quintero *et al*., 2012), living trees, trunks and soil (Gibertoni *et al*., 2007). At each transect, we recorded the environmental factors, including air temperature, humidity, soil pH, soil moisture and wind speed. We also measured the vegetation characteristics such as canopy cover and closure. These factors may affect the occurrence of macrofungal diversity.

We performed one-way ANOVA to compare the number of family and genus between landscapes. Analysis of similarities (ANOSIM) was conducted to investigate the species compositional difference between landscapes. All of the statistical analysis data were conducted in Genstat version 12 software (VSNI, Hemel, Hempstead, UK).

RESULTS AND DISCUSSION

A total of 608 collections of macrofungal morphospecies clusters, from 81 genera belonging to 56 families were recorded. Our One-way ANOVA Tukey's comparison analysis present a statistical significant difference of morphospecies richness and habitat (F=38.19, P≤0.001). Our results show that morphospecies richness in forest landscape was greater than oil palm plantation smallholdings (Figure 1.a).

Analysis on the collection of macrofungal cluster, also shows a highly significant difference between habitat (F=16.06, P≤0.001). More than half of the total assemblage macrofungal were originated from the NSPSF (Figure 1.b). Result from previous study at Southern Brazil also reported on similar findings where macrofungal diversity in forest land, outnumbered macrofungal diversity in the oil palm smallholding (Paz *et al.*, 2015).

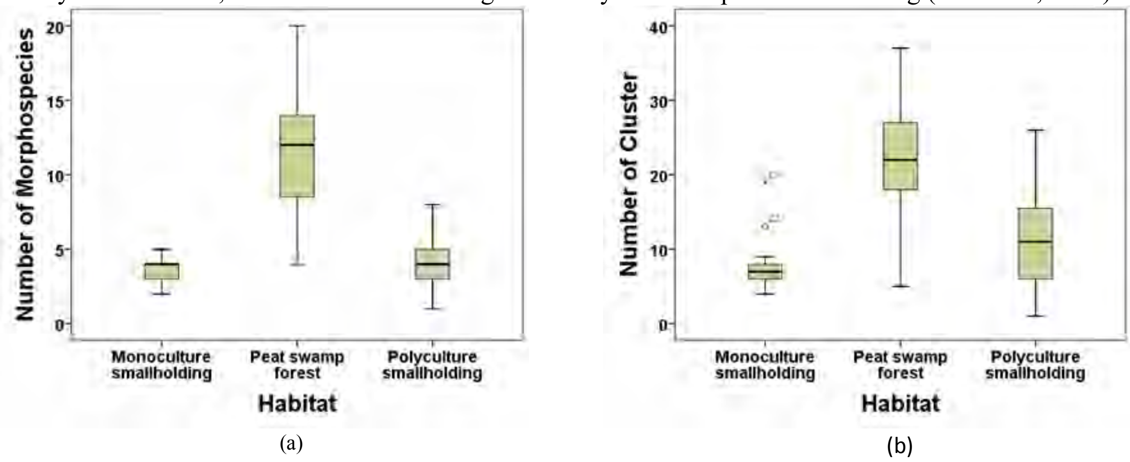
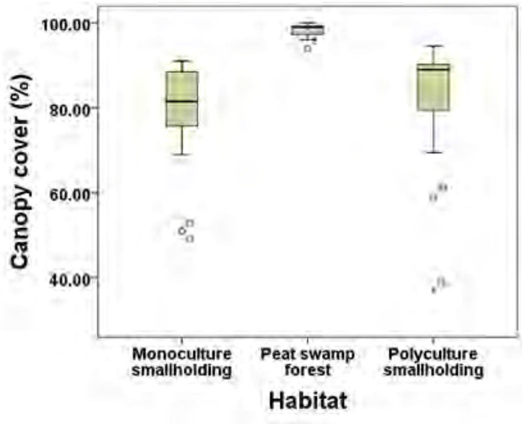


Figure 1: (a) Mean analysis of variance between number of morphospecies richness collection and type of habitat, and. (b) Mean analysis of variance between macrofungal cluster and type of habitat.

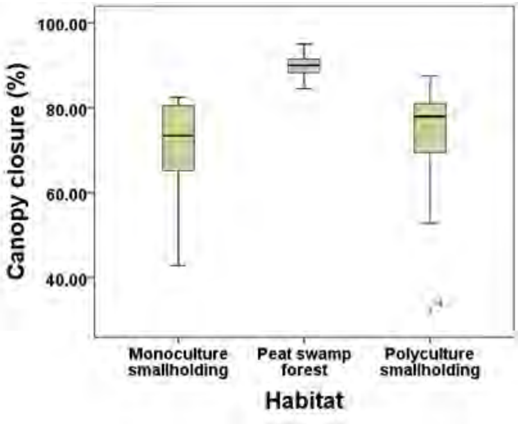
The NSPSF had a denser canopy cover and more intense canopy closure compared to the smallholdings plantation with average of 98.13% (Figure 2.a) and 89.97% (Figure 2.b), respectively where various of tree composition were present inside the peat swamp forest. Due to this reason, various type of substrates such as coarse woody debris are available which explains high assemblage in macrofungal cluster collection at the NSPSF especially saprotrophic fungi of agarics (eg., *Inocybe* sp.) and polyporales (eg., *Trametes* sp.). Due to dense canopy cover also the air temperature of the NSPSF is low (Figure 3.a) and the humidity is high (Figure 3.b). This condition is favorable for the fungi to grow and with a closed canopy the wetter condition of this habitat is retained and resulted in low wind speed (Figure 3.c) but high soil moisture content (Figure 3.d) and is acidic (Figure 3.e) prior to peat swamp nature. Vegetation structure characteristics (eg., canopy cover and canopy closure) determine the distribution and occurrence of macrofungi (Villeneuve *et al*., 1989; Laganá *et al*., 1999; Senn-Irlet & Bieri, 1999; Moreau & Coutecuisse, 2003; Bonet *et al*., 2004; Calado *et al*., 2009). The modification in vegetative structure would change the original condition of microclimatic variables, mainly the temperature and moisture which function to provide suitable environment for the fungi to grow (Belsky *et al*., 1989; Belsky, 1994).

Meanwhile, production of macrofungal communities is found more at polyculture smallholding compared to monoculture smallholding, with 24 and 21 morphospecies for polyculture and monoculture respectively. This could be due to different management practices (Paz *et al*., 2015) and also change in microclimate. Polyculture smallholding comprised of three different crops namely, oil palm, coconut tree and banana, provides denser canopy cover of 81.63 % and higher percentage of canopy closure with 72.50% which result in lower temperature (Figure 3.a), and higher humidity (Figure 3.b) and provide a suitable condition for the fungi to grow. Prior to the vegetative structure, monoculture smallholding, records lowest percentage of canopy cover and canopy closure with 79.73% and 70.67% respectively. Thus, the climate is drier compared to other landscapes.

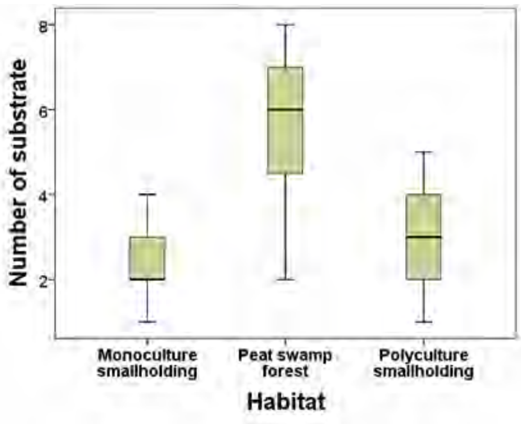
Nevertheless, during our study, we found similar macrofungal morphospecies in the monoculture and polyculture smallholdings. *Schizophyllum commune* and *Ganoderma* sp. were found to be the two most dominant morphospecies found in oil palm smallholdings (Table 1). Some of the fungi were found to be having the ability to adapt to dry condition such as *Schizophyllum commune* (Lodge & Cantrell, 1995) even though the substrate is limited. This is because, fungi are able to adapt to current condition and withstand water stress (Dighton, 2003). Based on the results, it was also found that *Ganoderma* sp. growing on oil palm and coconut trunk was more frequently occurred in polyculture compared to monoculture oil palm and, smallholding. This could be due to the polyculture oil palm management practice. The villagers cut these trees into a few portion and left them to rot at the sites. Wound on the trunk that remains open are vulnerable to microorganism including fungi communities (Hushiarian *et al*., 2013).



(a)

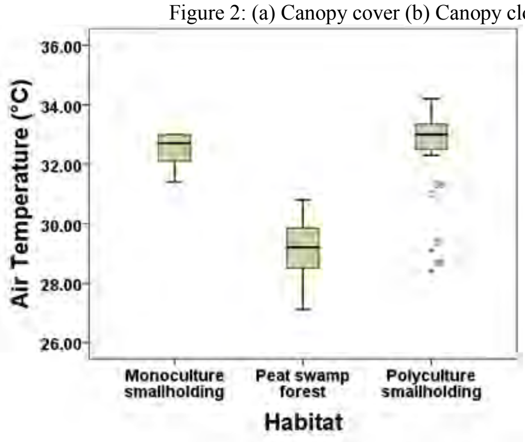


(b)

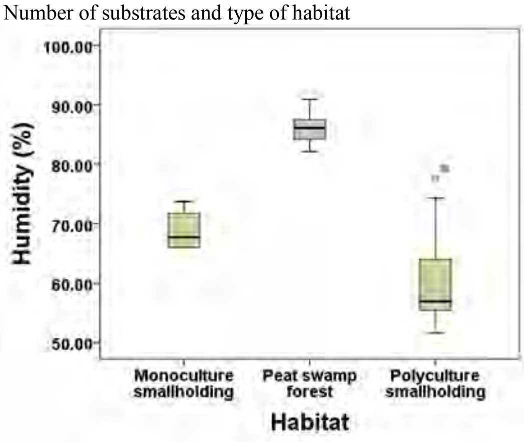


(c)

Figure 2: (a) Canopy cover (b) Canopy closure (c) Number of substrates and type of habitat



(a)



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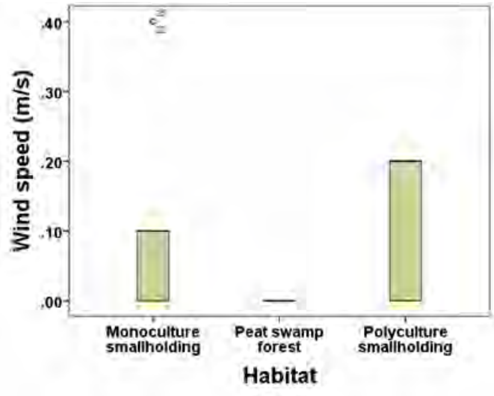
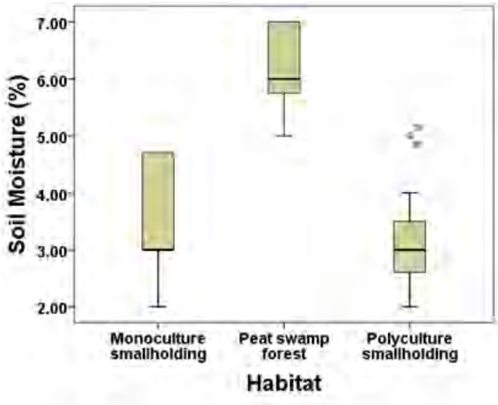
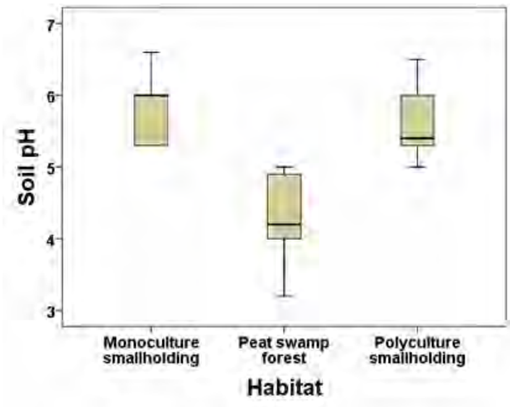


(c)



(d)



(e)

Figure 3: Boxplot on the mean readings of environmental data of. (a) Air temperature, (b) Humidity, (c) Wind speed, (d) Soil moisture, (e) Soil pH and type of habitat

Table 1: Morphospecies dominating all three different habitats

Habitat	Total morphospecies	Morphospecies	Family	Contribution (%)
Peat swamp forest	**61**	*Inocybe* sp.	Inocybaceae	25.11
		Marasmius rotalis	Marasmiaceae	18.20
		Mycena sp. 1	Mycenaceae	11.95
		Marasmiellus sp.	Marasmiaceae	9.40
		Bjerkandera adusta	Meruliaceae	6.72
		Marasmius sp. 1	Marasmiaceae	5.71
		Trametes sp. 3	Polyporaceae	3.36
		Coriolopsis sp. 1	Polyporaceae	2.46
		Tetrapygros nigripes	Marasmiaceae	2.31
		Trametes sp. 2	Polyporaceae	1.33
		Auricularia sp.	Auriculariaceae	1.18
		Trametes sp. 1	Polyporaceae	1.16
		Dichomitus sp.	Polyporaceae	1.14
				90.04%
Monoculture smallholding	**21**	*Schizophyllum commune*	Schizophyllaceae	63.96
		Ganoderma sp. 3	Ganodermataceae	13.95
		Marasmiellus sp.	Marasmiaceae	7.33
		Entoloma sp.	Entolomataceae	2.85
		Mycena sp. 6	Mycenaceae	2.67
				90.75%
Poly-culture smallholding	**24**	*Ganoderma* sp. 3	Ganodermataceae	31.20
		Schizophyllum commune	Schizophyllaceae	28.88
		Entoloma sp.	Entolomataceae	17.77
		Marasmiellus sp.	Marasmiaceae	11.01
		Trametes sp. 1	Polyporaceae	3.84
				92.71%

CONCLUSION

Forested landscape provides suitable microclimate condition for macrofungal diversity growth. Nevertheless, further study is needed especially on biodiversity-friendly agricultural management practice and its influence on macrofungal diversity. This study provides baseline information about macrofungal diversity in both forestry and agricultural landscapes. The information is useful to highlight the conservation value of those landscapes for macrofungi.

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