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Relationships between terrestrial and freshwater lignicolous fungi

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ABSTRACT

This study investigated the communities of fungi on *Magnolia liliifera* wood in terrestrial and freshwater habitats in northern Thailand. Freshly fallen samples of *M. liliifera* wood were collected from the forest floor, oven dried, and then placed in the stream or adjacent to the stream on the forest floor as baits. The samples were collected and examined after 3 and 6 months of submersion and periodically over 29 months from the forest floor. Thirty-seven species of lignicolous fungi were discovered from 50 bait samples of wood submerged in the stream. Fungi obtained from submerged baits were compared with those found on wood of *M. liliifera* in terrestrial habitats (both naturally terrestrial and terrestrial baits). The fungal communities on wood in freshwater were distinct from those in the terrestrial habitat. Seventeen species of fungi overlapped between freshwater and terrestrial habitats, but only five out of 234 species overlapped between all habitats (freshwater, natural terrestrial and terrestrial bait). *Corynespora cassiicola* (60% frequency of occurrence) was the most common taxon found on natural terrestrial samples, while *Lasiodiplodia theobromae* (43% frequency of occurrence) was the dominant species from terrestrial baits. *Candelabrum brocchiatum* (26%) was the most common species from submerged baits. The common genera of fungi obtained from submerged baits were similar to those reported in other submerged wood studies.

Introduction

Freshwater fungi are any species relying on freshwater for some part of their life cycle, or any species colonizing substrata that are predominantly aquatic or semi-aquatic in nature (Thomas, 1996; Wong et al. 1998). In other words, they are fungi whose habitats may be clearly of an aquatic nature, or that colonize submerged plant parts in freshwater environments (Wong et al. 1998). Freshwater fungi thus are a ubiquitous and diverse group of organisms that colonize substrata found in aquatic or semi-aquatic environments (Luo et al., 2004; Fryar et al., 2005; Pascoal et al., 2005; Sakayaroj

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et al., 2005; Vijaykrishna and Hyde, 2006; Shearer et al., 2007; Hyde et al. 2016). They are taxonomically diverse, and flourish in various ecological niches (Cai et al., 2003; Gönczöl and Révay, 2003; 2004; Fryar et al., 2004a; b; Vijaykrishna and Hyde, 2006; Shearer et al., 2007). According to the above definition, some terrestrial fungi, which release spores that are dispersed in water, are regarded as freshwater fungi (Luo et al., 2004). Shearer (1993), however, mentioned that the presence of spores in water alone may not be an appropriate definition. Moreover, there are several species of fungi (e.g. *Jahnula* species) that only occur in freshwater habitats and only those can be confidently classified as freshwater fungi (Wong et al., 1998). Some ascomycetes categorized as freshwater fungi have also been reported from other habitats e.g. terrestrial and marine habitats. Freshwater ascomycetes can be divided into four groups based on their occurrence: (1) genera that are known only from freshwater habitats; (2) genera found in both freshwater and terrestrial habitats; (3) genera from freshwater and marine habitats; and (4) genera that are found in freshwater, marine and terrestrial habitats (Table 1, Vijaykrishna and Hyde, 2006). Vijaykrishna and Hyde (2006) investigated the origin of freshwater ascomycetes using molecular sequence data, and showed that freshwater ascomycetes (and marine fungi) originated from terrestrial fungi.

The freshwater fungi that grow on submerged wood are known as lignicolous freshwater fungi (Hyde et al., 2016), while those that grow on leaves are known as aquatic leaf-inhabiting hyphomycetes or Ingoldian fungi (Graça et al., 2016). These fungi are generally studied by different methods (Chan et al., 2000; Tsui et al., 2000), with woody lignicolous samples being placed in moist chambers and leaves being placed in aerated bubbles chambers (Graça et al., 2016). The communities on wood and leaves therefore differ, although the few studies where woody litter has been placed in bubble chambers have revealed Ingoldian fungi (Gönczöl and Révay, 1993; Sridhar et al., 2010). Here we use moist chamber incubation so our study is confined to lignicolous freshwater fungi, although we briefly discuss leaf-inhabiting fungi.

Conidial fungi with staurospores, the Ingoldian fungi, are commonly reported from freshwater habitats (Descals and Moralejo, 2001, Gönczöl and Révay, 2006). Ando (1992) introduced the term "terrestrial aquatic hyphomycetes" for the fungi which possess staurospores found in terrestrial habitats (e.g. litter, roots and soils). Some species in this group are listed in Table 2.

Relationships between freshwater and terrestrial lignicolous fungi

There is little information concerning the relationship between freshwater and terrestrial lignicolous fungi. Cai et al. (2006b) studied the fungal communities on bamboo in a freshwater stream and in the riparian region, and found that different fungal communities occur in each habitat, with low overlap of species, and differing dominant species. In Thailand, the relationship between freshwater fungi and terrestrial fungi on palms has been investigated by comparing the occurrence of fungi on the same substratum in different habitats (e.g. Pinnoi et al., 2006; Pinruan et al., 2007; Boonyuen et al., 2014). Pinnoi et al. (2006) studied fungal diversity on different parts of the palm, *Eleidoxa conferta*, including those from terrestrial (dry and damp materials) and submerged habitats. Boonyuen et al. (2014) showed partial overlap in species between the two habitats with submerged samples yielding the most fungal records. Similar work has been reported by Pinruan et al. (2007), who studied the fungal diversity on another palm, *Licuala longicalycata*. However, they found that the dry material supported most fungal diversity. Boonyuen et al. (2014) showed that wood-inhabiting fungi are diverse, however, they differ between studies depending on tree species, geography and the exposure period. They mentioned that freshwater fungi are slow to cause wood decay since they are soft rotters, as compared to white rotters and brown rotters that predominate in wood decay in terrestrial environments (Yuen et al., 2000).

Woody litter may fall into streams and rivers. It is not clear whether the fungi decaying terrestrial forest wood continue to thrive when submerged in water. In this study, we investigated fungi on *Magnolia liliifera* wood from freshwater and terrestrial habitats to see if they are the same or different. This study examined whether fungi on decaying wood on the forest floor are also present on wood submerged in water.

Materials and methods

Study sites

This study was undertaken in an evergreen forest nearby the Medicinal Plant Garden in Doi Suthep-Pui National Park,

Table 1 – Common freshwater ascomycete genera with terrestrial, marine/terrestrial or no counterparts (from Vijaykrishna and Hyde, 2006).

Freshwater only	Freshwater/Terrestrial	Freshwater/Marine	Freshwater/Marine/Terrestrial
Aquaticola	*Annulatascus*	*Aniptodera*	*Anthostomella*
Cataractispora	*Ascotaiwania*	*Halosarpheia*	*Didymella*
Jahnula	*Byssosphaeria*	*Nais*	*Lophiostoma*
Mamillisphaeria	*Cercophora*	*Quintaria*	*Massarina*
Pseudoproboscispora	*Kirschsteiniothelia*	*Savoryella*	*Phomatospora*
Rivulicola	*Ophioceras*		*Saccardoella*
Torrentispora	*Pseudohalonectria*		*Vibrissea*