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## UNIQUE SOUTHEAST ASIAN PEAT SWAMP HABITATS HAVE RELATIVELY FEW DISTINCT PLANT SPECIES

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### SUMMARY

Peat swamp forests of Southeast Asia are often described as having a unique biodiversity. While these watery and nutrient-poor habitats are indeed unique and include a distinct fauna (esp. fish), the peat swamp flora is much less distinct and shares a surprising number of species with other habitats. Out of 1,436 higher plant species found in Southeast Asian swamps (from Thailand to Papua), 1,332 are found in the lowlands (<300m asl). Of the latter, 212 (16.2%) mainly occur in lowland swamps, while 75 species (5.7%) are shared with freshwater swamps on mineral soils and riparian habitats, 49 species (3.7%) are shared with heath forests, 7 species (0.5%) are shared with montane ecosystems, and 86 species (6.5%) are shared with a range of lowland habitats. 116 (8.9%) species occur in lowland swamps only, including freshwater swamps on mineral soils, and 41 of these species (3.1%) are restricted to lowland peat swamps. More than 80% of the peat swamp forest flora is therefore common to a wide range of habitats, while 166 species (12.4%) are opportunistic pioneer or secondary forest species. The largest percentage of the 200+ most common lowland peat swamp species in Southeast Asia occurs on Borneo (97%), followed by Peninsular Malaysia (87%), Sumatra (82%) and Thailand (56%). Due to sea level rise since the last glacial maximum (10-13,000 years BP) the present location of coastal peat swamps is probably at the highest elevation it has been for millennia. This 'landward retreat' of the peat swamp habitat has probably contributed to the relative paucity of unique plant species and an abundance of opportunistic species. Comparison with tropical peatland systems in South America reveals a similar lack of endemic species.

**Keywords:** *peat swamp flora, unique & opportunistic species*

### INTRODUCTION

Peat swamp forests (PSFs) of Southeast Asia are often described as having a unique biodiversity, including endemic tree species and rare and endangered animals (e.g. van der Meer *et al.*, 2008; Yule 2010). These watery and nutrient-poor habitats are indeed unique and include a distinct fauna (esp. fish, Ng *et al.*, 1994, Kottelat & Widjanarti 2005, Kottelat *et al.*, 2006) and the largest remaining populations of species such as false gavia *Tomistoma schlegelii*, Storm's stork *Ciconia stormi*, white-winged wood duck *Asarcornis (Cairina) scutulata*, and Bornean orangutan *Pongo pygmaeus* (Hussen *et al.*, 2009, Yule 2010, Wetlands International 2010). However, botanists have observed that the peat swamp flora is less distinct and appears to share a surprising number of species with other habitats (Anderson 1963, Whitmore 1984). The aim of this study was to assess the degree of floristic distinction of peat swamp forests, and relationships with other habitat types.

### METHODS

Over the past five years a simple (Microsoft Excel) database of PSF plant species has been compiled by the author based on species habitat records in key taxonomic references (Flora Malesiana, Tree Flora of Malaya, Flora of Java), scientific papers and grey literature/reports on peat swamp forests (140+ references in all, available from the first author upon request). Where doubtful, for example due to uncertainty regarding taxonomy or locality, species were excluded. Taxonomy follows the Plant List (2010) Version 1.0 ([www.theplantlist.org/](http://www.theplantlist.org/)). It was assessed if a species occurred in lowland peat swamp habitat by referring to the habitat listed in the key taxonomic references mentioned above, and consulting herbarium records made accessible via the Global Biodiversity Information Facility Version 1.2.6 (<http://data.gbif.org/>), in which all major herbaria with Southeast Asia collections collaborate. Some leniency was required here, and some records list 'swamp' as habitat type, although strictly speaking this could mean freshwater swamps on mineral soils. In such cases the information was not used to add a species to the list, but not used to strike a species from the list. Information on geographic distribution and habitats other than peat

swamps in which a species occurs was also obtained from the aforementioned flora and data sheets of the herbarium collections. Few species are fully confined to one habitat, so a single or a just a few examples of occurrence outside the PSF habitat was regarded as probably too rigorous for excluding a species from the restricted PSF list, and these were therefore retained. Information about whether species were pioneer species or common to secondary forest was obtained from Kostermans (1958), Kessler *et al.* (1995), Kessler (2000), van Eijk *et al.* (2009), Giesen *et al.* (2009), Palangkaraya University (2012) and Giesen (2013). Species most often recorded (i.e. 4 times or more) in peat swamp forest species lists were regarded as ‘common’; many species are only seldom recorded in peat swamp forests, and a cut-off of four records or more was used to identify common species.

## RESULTS

The peat swamp database includes 1,436 plant species found in Southeast Asian swamps, from Thailand and Vietnam to Papua. Of these, 1,332 are lowland swamp species (i.e. <300m asl) and 1,309 are lowland swamp angiosperms, of which 214 (16.2%) mainly occur in lowland swamps (Table 1). Of these 212 species, 116 (8.9%) are found in lowland swamps only including freshwater swamps on mineral soils (75/5.7%) or are restricted to lowland peat swamps (41/3.1%; Table 2); the remainder (96/7.3%) are mainly found in lowland swamps. By far the largest percentage (>80%) of species is found both in peat swamps and a variety of other habitats including many dryland habitats. 405 species are shared with dry lowlands and hill/ridge habitats (300-800m asl), 331 species are shared with a variety of lowland habitats, while 305 species are shared with a range of habitats from dry lowlands to montane habitats (>800m asl). Further, 49 species (3.7%) are shared with heath forests (*kerangas*) only and 7 species (0.5%) are shared with montane/highland ecosystems (i.e. >800m asl) only. [Note that many more species are shared by both peat swamp forests and *kerangas*, and by peat swamp forests and montane habitats, but these are not exclusive to these habitats and are shared among a range of habitats.] A total of 166 lowland swamp species (12.4%) are pioneer species or are characteristic of secondary habitats. The largest percentage of the 200+ most common lowland peat swamp species in Southeast Asia occurs on Borneo (97%), followed by Peninsular Malaysia (87%), Sumatra (82%) and Thailand (56%).

The 41 species restricted to peat swamp forests (Table 2) are generally found on Peninsular Malaysia, Borneo and Sumatra, and 31 species are found in both Indonesia and Malaysia. None of the restricted species are found in Vietnam while only 2 are found in Thailand’s PSFs.

Table 1: Swamp species in Southeast Asia: overlap with other habitats

	Habitat	Number of plant species	% of total
1	All Southeast Asian swamps	1436	
2	Variety of habitats including lowland swamps	1332	
	Of which angiosperms*	1309	100
3	Swamps, plus lowlands (>300m asl) to hills/ridges (300-800m asl)	405	30.9
4	Swamps, plus variety of lowland habitats	331	25.3
5	Swamps, plus variety of lowland to montane habitats	305	23.3
6	Lowland swamps & montane habitat	7	0.5
7	Lowland swamps & heath forest ( <i>kerangas</i> )	49	3.7
8	Predominantly in lowland swamps	212	16.2
	8.a. Only in lowland swamps	116	8.9
	8.a.i: Lowland peat swamps & riparian/mineral soil swamps	75	5.7
	8.a.ii: Restricted to lowland peat swamps	41	3.1
	8.b Mainly in lowland swamps	96	7.3

\* Sum of 3-8 = 1309 species

Table 2: Species restricted to peat swamp forests

#	Scientific name	Family	Status	Brunei	Indonesia	Malaysia	Singapore	Thailand	vietnam
1	<i>Baijania borneensis</i> var. <i>paludicola</i> Duyfjes	Cucurbitaceae	U			+			
2	<i>Calophyllum hosei</i> Ridl. ( <i>C. fragrans</i> )	Calophyllaceae	C		+				
3	<i>Calophyllum lowei</i> Planch. & Triana	Calophyllaceae	R		+				
4	<i>Calophyllum sundaicum</i> P.F. Stevens	Calophyllaceae	R		+				
5	<i>Croton macrocarpus</i> Ridl.	Euphorbiaceae	R			+			
6	<i>Crudia venenosa</i> de Wit	Caesalpiniaceae	R			+			
7	<i>Cryptocarya enervis</i> Hook.f.	Lauraceae	R	+	+	+			
8	<i>Dactylocladus stenostachys</i> Oliv.	Penaeaceae	C	+	+	+			
9	<i>Dichilanthe borneensis</i> Baill.	Rubiaceae	R		+				
10	<i>Diospyros pseudomalabarica</i> Bakh.	Ebenaceae	R		+				
11	<i>Diospyros siamang</i> Bakh.	Ebenaceae	C	+	+	+	+		
12	<i>Dyera polyphylla</i> (Miq.) Steenis ( <i>D. lowii</i> )	Apocynaceae	C	+	+	+			
13	<i>Garcinia apetala</i> Pierre	Clusiaceae	R		+				
14	<i>Ixora pyrantha</i> Bremek.	Rubiaceae	R			+			
15	<i>Knema mamillata</i> W.J. De Wilde	Myristicaceae	R		+				
16	<i>Korthalsia paucijuga</i> Beccari	Arecaceae	U	+	+	+			
17	<i>Lepidaria oviceps</i> Danser	Loranthaceae	R	+	+	+			
18	<i>Lithocarpus andersonii</i> Soepadmo	Fagaceae	U	+	+	+			
19	<i>Litsea crassifolia</i> (Blume) Boerl.	Lauraceae	R		+	+			
20	<i>Litsea grandis</i> var. <i>paludosa</i> (Kosterm.) Ng	Lauraceae	R		+				
21	<i>Lophopetalum sessilifolium</i> Ridl.	Celastraceae	R		+	+			
22	<i>Mesua congestiflora</i> P.F. Stevens	Calophyllaceae	R		+				
23	<i>Palaquium burckii</i> H.J. Lam	Sapotaceae	C		+	+			
24	<i>Palaquium cochleariifolium</i> P. Royen	Sapotaceae	C		+				
25	<i>Pandanus vinaceus</i> B.C. Stone	Pandanaceae	R			+			
26	<i>Parastemon urophyllus</i> (Wall. ex A.DC.) A.DC.	Chrysobalanaceae	C	+	+	+	+		
27	<i>Prunus turfosa</i> Kalkman	Rosaceae	C		+	+			
28	<i>Sandoricum beccarianum</i> Baill.	Meliaceae	C		+	+		+	
29	<i>Shorea hemsleyana</i> (King) King ex Foxw. ssp. <i>hemsleyana</i>	Dipterocarpaceae	C	+	+	+		+	
30	<i>Shorea inaequilateralis</i> Symington	Dipterocarpaceae	C	+		+			
31	<i>Shorea pachyphylla</i> Ridl.	Dipterocarpaceae	C	+	+	+			
32	<i>Shorea platycarpa</i> Heim.	Dipterocarpaceae	C	+	+	+			
33	<i>Shorea teysmanniana</i> Dyer ex Brandis	Dipterocarpaceae	C	+	+	+			
34	<i>Shorea uliginosa</i> Foxw.	Dipterocarpaceae	C	+	+	+			
35	<i>Stemonurus scorpioides</i> Beccari	Stemonuraceae	C	+	+	+	+		
36	<i>Tarenna adpressa</i> (King) Merr.	Rubiaceae	U			+	+		
37	<i>Ternstroemia hosei</i> Ridl.	Pentaphragmaceae	R			+			
38	<i>Tristaniaopsis beccarii</i> (Ridl.) Peter G. Wilson & J.T. Waterh.	Myrtaceae	R			+			
39	<i>Willughbeia grandiflora</i> Dyer ex Hook.f.	Apocynaceae	R	+	+	+			
40	<i>Xanthophyllum ramiflorum</i> Meijden	Polygalaceae	U			+			
41	<i>Xylopiya coriifolia</i> Ridl.	Annonaceae	C		+	+			
	Status: c=common (17); u=uncommon (5); r=rare (19)								
		<b>Totals</b>		<b>16</b>	<b>31</b>	<b>31</b>	<b>4</b>	<b>2</b>	<b>0</b>

## DISCUSSION

Only a relatively small number (41 or 3.1%) of species found in peat swamp forests are found to be restricted to this habitat. This contrasts with findings by Posa *et al* (2011) who report 172 plant species (11% of their total) restricted to peat swamps. Given that total numbers of peat swamp species are similar (1332 in this report versus 1524 for Posa *et al.*, 2011) this difference can only be explained by a different definition of 'restricted'. In the present study, if habitat records were unclear, herbarium records were consulted as these often include habitat descriptions. Regularly, species that are described as 'typical for peat swamps' (e.g. *Camposperma coriaceum*, *Combretocarpus rotundatus*, *Cratoxylum arborescens*, *Eleiodoxa conferta*, *Gonystylus bancanus*, *Ilex cymosa*, *Lophopetalum multinervium*, *Madhuca malayana*, *Syzygium zeylanicum*, *Tetramerista glabra*; Whitmore 1984) were also found to regularly occur in other habitats and are therefore not exclusive to peat swamp forests. However, a total of about 200+ species (a number similar to Posa *et al.*'s restricted species) are typically found in peat swamp

forests and are less commonly found in other habitats – these can be therefore be considered (non-exclusive) peat swamp species. The 17 species restricted to PSFs that are common are either found on Borneo (8 spp.) or on Borneo, Sumatra and Peninsular Malaysia (9 spp.).

Peat swamp forests are rapidly declining and by 2010 only 2.1% and 4.6% was respectively left in a pristine condition in Kalimantan and Sumatra (Miettinen *et al.*, 2010), while a dramatic 70% decline has occurred in key peat swamp forests in Sarawak during 2000-2014 alone (Deltares 2015). Wetlands International (2010) conclude that ‘No example of a hydrologically intact peat dome remains anywhere in Malaysia.’ Given the rate and extent of change, it is to be expected that uncommon (5 spp.) and rare (19 spp.) peat swamp forests plant species restricted to this habitat may be under threat. Three of these rare species are known from 1-2 locations/collections and these are either endangered (*Crudia venenosa*, known from type collection in Sabah only), or are possibly extinct (*Croton macrocarpus* from the now fully converted Telok peat swamp forest in Selangor, Peninsular Malaysia; *Knema mamillata* known from peat swamp forest in South Kalimantan only, where this habitat is fully converted). A number of rare species known only from Sarawak and Peninsular Malaysia can be considered endangered given the state of this habitat, and these include *Garcinia apetala*, *Ixora pyrantha*, *Litsea crassifolia*, *Pandanus vinaceus*, *Tarenna adpressa*, *Ternstroemia hosei* and *Tristaniopsis beccarii*. *Lophopetalum sessilifolium*, which is known from Sarawak and the now disappeared peat swamp forests of Sungai Landak in West Kalimantan further completes the list of endangered species.

Near coastal peat swamps in Southeast Asia are only 5-15,000(-25,000) years old and therefore relatively young (Page *et al.*, 2010; Dommain *et al.*, 2011), but the habitat itself is older as peat formations at 75 m BPL (dating from 13,000 years BP) have been found in the South China Sea off the east coast of Peninsular Malaysia (Voris 2000). Peat swamps of Borneo, Sumatra and Peninsular Malaysia may have remained (relatively) interconnected until about 8-10,000 years BP, when the Sunda shelf was still exposed (Voris, 2000). Due to sea level rise since the last glacial maximum (10-13,000 years BP) the present location of coastal peat swamps is probably at the highest elevation it has been for millennia. According to Hanebuth *et al.* (2011), the development of peat swamps would be especially affected by rates of coastal migration, and the rate of sea level rise would have influenced their degree of development and duration at any specific location. It is hypothesized that this relatively rapid ‘landward retreat’ of the peat swamp habitat may have contributed to the relative paucity of unique plant species and an abundance of opportunistic species able to adapt. 166 lowland peat swamp species (12.4%) are pioneer species or are characteristic of secondary habitats, which compares to 4% for lowland rain forest in Peninsular Malaysia (Putz & Appanah 1987) and 8.7% for similar habitat in eastern Borneo (Slik & Eichhorn 2003).

Interestingly, a recent study of the floristic composition of lowland tropical peatlands in northern Peru shows that these comparable ecosystems, albeit in a very different geographical setting, likely have no endemic tree species (Draper 2016). Instead, the peatlands provide a habitat for many generalist tree species, as well as some specialists from adjacent white sand and floodplain forests. Draper (2016) attributes the paucity of endemics to the dynamic geomorphological setting of these peatlands, although environmental filtering and dispersal limitations may also play a role. As more information becomes available about the vegetation of peatlands across the tropical zone, it will be interesting to make further comparisons and to establish whether any commonalities can be identified in terms of the processes that determine the assembly of peatland plant communities.

## CONCLUSION

Of the 1332 angiosperm plant species found in Southeast Asian peat swamps, only 41 are exclusive to the habitat while about 200+ species are commonly found in this habitat. The vast majority (>80%) of species found in peat swamps are generalists and include a large number (166) of pioneer species and species common in secondary forests.

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