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Diversity of Fungi in Mangrove Forest

Poonpilai Suwanarit[1], Watcharin Sriswadskulmee[1]
Savitree Limtong[1], Wichien Yongmanitchai[1] and Sanit Aksornkoae[2]

ABSTRACT

Soils, water, leaves and twigs were sampled from 5 different areas in mangrove forest at the Ranong Biosphere Reserve during July 2000 and February, April and July 2001. The salinity of water varied among different areas, but pH remained the same in all water samples. The temperature of water was highest in April. The numbers of fungi at surface layer of the soils close to the water were 1.0×10^2-6.3×10^3 CFU/g and of submerged soils were 2.8×10-1.6×10^3 CFU/g. The numbers of fungi in surface water were 1-4×10 CFU/ml and that at 1 meter below water surface were 1-5.6×10 CFU/ml. The numbers of fungi from leaves were 2×10^2-8.3×10^3 CFU/ml whereas those from twigs were 3.0×10^2-2.1×10^4 CFU/g. The numbers of fungi from twigs were higher than those of leaves, soils and water. The numbers of fungi in water were lowest. The fungi were isolated and identified into 16 genera 74 species. Three species, namely *Mucor* sp., *Rhizopus* sp., *Syncephalastum* sp. were in the Phylum Zygomycota; one, namely *Ascotricha guamensis* was in Phylum Ascomycota; seventy, namely *Acremonium* of 5 species, *Aspergillus candidus*, *Aspergillus flavus-oryzae* group of 3 species, *Aspergillus fumigatus*, *Aspergillus niger*, *Aspergillus terreus* group of 3 species, *Aspergillus ustus* group of 2 species, *Aspergillus versicolor*, *Aspergillus* 3 species, *Cladosporium elatum*, *Conidiocarpus* sp., *Curvularia brachyspora*, *Curvularia clavata*, *Curvularia lunata*, *Curvularia harveyi*, *Curvularia pallescens*, *Curvularia trifolii*, *Curvularia tuberculata*, *Fusarium heterosporum*, *Fusarium. sporotrichioides*, *Fusarium* sp., *Humicola* sp., *Monilia* sp., *Paecilomyces carneus*, *Paecilomyces variotii*, *Paecilomyces* sp., *Penicillium atrovenetum*, *Penicillium deleae*, *Penicillium fellutanum*, *Penicillium lanosum*, *Penicillium steckii*, *Pestalotiopsis* 3 species, *Phoma* 2 species, *Trichoderma atroviride*, *Trichoderma aureoviride*, *Trichoderma citrinoviride*, *Trichoderma harzianum*, *Trichoderma konigii*, *Trichoderma longibrachiratum*, *Trichoderma parceramosum*, *Trichoderma viride*, *Trichoderma* 2 species were in class Deuteromycetes. Fifteen were sterile hypha, one species of Basidiomycota and three unidentified. Statistical analysis on biodiversity of fungi was made by Shannon index and Simpson index. The similarity of fungi from the samples was also analyzed by WARD's method, The results showed that, with different seasons, diversity of fungi were highest in the rainy season followed by those of mild season and hot season. Species of fungi in the rainy season were more similar to those of mild season than hot season. Among different sampling sites, diversity of fungi in natural forest was highest. Similarity of species of the fungi were highest in two different areas of one year old mangrove plantation. With different habitats, diversity of fungi was highest in soil, green leaf, yellow leaf and twig. Similarity of species of fungi among habitats was highest in green leaf and yellow leaf.

Key words: biodiversity, mangrove, fungi, Ranong Biosphere Reserve

[1] Department of Microbiology, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.
[2] Department of Silviculture, Faculty of Forestry, Kasetsart University, Bangkok 10900, Thailand.

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INTRODUCTION

Mangrove forest is a tidal salt marshes in tropical and subtropical regions composing of wide variety of shoreline trees and bushes belonging to numerous families (Chapman, 1975). Mangrove plants usually develop in areas that are protected from wave action, such as estuaries, bays, lagoons and on the leeward side of islands and spits. Mangrove forest plays an important role in the production of organic detritus and thus support a large animal community in the mangrove forest (Kohlmeyer and Kolmeyer, 1979).

Diversity of fungi in mangrove forest were investigated. Fungi were isolated from different sampling sites, different periods of time and different habitats. The species diversity and similarity were also analyzed. Fungal isolates were preserved in deep freezing (-80°C) for future study on their application.

MATERIALS AND METHODS

Sampling sites

Samples of soils, water, twigs and difference color leaves of *Rhizophora apicunata* were collected from five different areas in the mangrove forest at the Ranong Biosphere Reserve, Ranong Province. Site 1 represented the existing natural mangrove forest at the mouth of the river, site 2 and 3 represented the mangrove forest plantations of *Rhizophora apicunata*, site 4 was one-year old *Rhizophora apicunata* plantation and site 5 was near the office of the Ranong Biosphere Reserve (Figure 1). Salinity, pH and temperature of water in each site were determined at different water levels by the following methods: salinity by refractometer, pH and temperature by handheld pH meter and thermometer.

Total count of fungi

Soils, water, twigs and leaves from different sites were sampled and total number of fungi were counted by spread plate technique using yeast extract glucose seawater agar as culture medium. All petri dishes were incubated at room temperature (28°C) for two days. All colonies were collected every day until 14 days for some slow grower fungi.

Identification on species of fungi

Morphological characteristics of fungi were determined and identified according to Barnett and Hunter (1998), Domsch and Gams (1993), Ellis (1971), Raper and Fennell (1965), Raper and Thom (1949), Richard (1990) and Von Arx (1981).

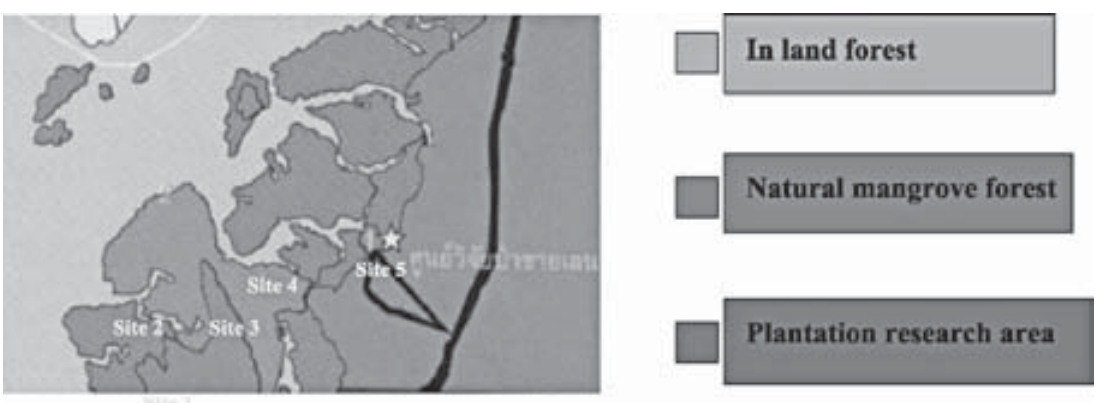

Figure 1 Map showing different sampling sites in mangrove forest at the Ranong Biosphere Reserve. Source: Ranong Biosphere Reserve

Biodiversity analysis

Species richness and species evenness were analyzed using Shannon's diversity index and Simpson's diversity index. Similarity index were also made by using PC-ORD Program, version 4.17

RESULTS AND DISSUSSION

Physical characters of sampling sites

Salinity

Salinity of water at each sampling sites are shown in Table 1. The results showed that the salinity of the water were highest at site 1 which was near the mouth of river and lowest at site 5 which was connected to the fresh water. The salinity of the water in February and April which was the dry season were higher than July which was the rainy season (Table 1).

pH

pH's of water at the sampling sites were around 7 – 8. The pH's at site 5 were lower than the others. The pH's of the water collected in February were higher than the others (Table 2).Generally, the pH of sea water is around 8.The pH's of different sites were different because of different amounts of sea water contaminated into the fresh water.

Temperature

Temperatures of water at different sampling sites during different periods of time were slightly different except the water samples collected in April which was the summer were higher than the others (Table 3).

Numbers of fungi from various samples

Soil

The numbers of fungi from surface soils were $1 \times 10^2 - 6.3 \times 10^3$ CFU/g which were higher than those from submerged soils collected 1 meter under water (Table 4) which were around $2.8 \times 10 - 1.6 \times 10^2$ CFU/g. It could be suggested that oxygen content was the limiting factor for population of fungi since numbers of fungi in submerged soils were lower than surface soils (Durbin 1959). Number of fungi in mangrove

Table 1 Salinity of water at different levels of each sampling sites (ppt).

Month	Site 1		Site 2		Site 3		Site 4		Site 5	
	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
July	24	26	21	21	24	21	15	13	10	10
February	29	29	29	29	28	28	27	28	28	28
April	30	30	25	23	25	25	24	24	20	20
July	25	25	25	20	17	30	27	26	20	17

Sur = Surface water

Sub = Submerge water at 1 meter below water surface

Table 2 The pH of water at different levels of each sampling sites.

Month	Site 1		Site 2		Site 3		Site 4		Site 5	
	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
July	7.65	8.04	7.87	8.04	8.02	8.02	7.66	7.80	7.52	7.57
February	8.14	8.20	8.33	8.15	7.72	8.20	7.86	7.87	7.85	7.80
April	7.55	7.79	7.42	7.62	7.49	7.50	7.08	7.07	6.91	6.87
July	7.60	8.00	7.90	7.85	7.03	8.10	8.04	8.02	7.70	7.18

Sur = Surface water

Sub = Submerge water at 1 meter below water surface

forest were much lower than those in the soils in land because the oxygen was limited and the salinity of the soil was another factor that limited the number of fungi (Table 4).

Water

Numbers of fungi in surface water were 1 – 40 CFU/ml. Numbers of fungi in water collected at 1 meter below surface were 0.3 – 56 CFU/ml (Table 5). The results showed that the numbers of fungi in water were quite low. The total counts did not cover the water mold which require special techniques and media for growth (Poon &Hyde 1998).

Twigs and leaves

The numbers of fungi from twigs and leaves were $10^3 – 10^4$ CFU/g which were higher than the numbers of fungi from soils (Table 6). The result emphasized that fungi in mangrove forest had more activity in twigs and leaves due to the production of cellulose degrading enzyme. (Wongthong, 1998)

Diversity of fungi in mangrove forest

Species diversity

Ninety one isolates were collected from different samples. They were identified into 16 genera and 74 species. Three species, namely *Mucor* sp., *Rhizopus* sp., *Syncephalastum* sp. were

Table 3 The temperatures of water at different levels of each sampling sites (°C).

Month	Site 1		Site 2		Site 3		Site 4		Site 5	
	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
July	29.3	28.0	28.6	27.0	28.3	27.4	28.2	27.1	28.2	26.9
February	28.4	28.0	28.8	28.7	28.4	28.9	30.7	29.9	27.6	28.2
April	30.6	30.7	31.4	31.2	31.2	31.0	31.6	31.1	31.2	30.5
July	27.8	28.4	28.3	28.7	28.0	28.4	28.3	28.3	28.4	28.1

Sur = Surface water

Sub = Submerge water at 1 meter below water surface

Table 4 Numbers of fungi from soils (CFU/g).

Month	Site 1		Site 2		Site 3		Site 4		Site 5	
	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
July	5.9×10^3	-	8.0×10^2	1.4×10^2	1.3×10^2	6.3×10	-	5.5×10^2	1.3×10^3	2.7×10^2
February	6.3×10^3	1.0×10^2	5.6×10^2	6.0×10	1.6×10^3	1.6×10^2	8.3×10^2	2.6×10^2	1.4×10^3	6.0×10
April	3.5×10^3	4.1×10^2	1.0×10^2	6.2×10^2	1.9×10^3	3.9×10^2	-	3.0×10^2	2.1×10^3	3.7×10^2
July	2.0×10^2	2.8×10	3.1×10^2	6.4×10	2.9×10^2	4.7×10	-	1.1×10^2	2.2×10^2	9.0×10

Sur = Soil sample without water flooded at low tide

Sub = Soil sample at 1 meter depth under water at high tide

Table 5 Numbers of fungi from water (CFU/ml).

Month	Site 1		Site 2		Site 3		Site 4		Site 5	
	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
July	4.3	2.3×10	1.8×10	2.4×10	4.3	1.5×10	1.8×10	3.1×10	2.1×10	5.6×10
February	0.3	1.0	4.0×10	1.0×10	4.0	0.6	1.0	1.0	3.0	0.3
April	8.3	5.0	7.0	3.3	3.3	1.0	3.6	4.0	4.0	7.6
July	5.0	1.0	1.0	1.0	1.0	0	1.3	3.0	5.3	1.3

Sur = surface water

Sub = water at 1 meter below surface

in the Phylum Zygomycota; one, namely *Ascotricha guamensis* was in Phylum Ascomycota; seventy, namely *Acremonium* 5 species, *Aspergillus candidus* gr., *Aspergillus flavus-oryzae* gr. of 3 species, *Aspergillus fumigatus* gr., *Aspergillus niger* gr., *Aspergillus terreus* gr. of 3 species., *Aspergillus ustus* gr. of 2 species. *Aspergillus versicolor* gr., *Aspergillus* 3 species, *Cladosporium elatum*, *Conidiocarpus* sp., *Curvularia brachyspora*, *Curvularia clavata*, *Curvularia lunata*, *Curvularia harveyi*, *Curvularia pallescens*, *Curvularia trifolii*, *Curvularia tuberculata*, *Fusarium heterosporum*, *Fusarium sporotrichioides*, *Fusarium* sp., *Humicola* sp., *Monilia* sp., *Paecilomyces carneus*, *Paecilomyces variotii*, *Paecilomyces* sp *Penicillium atrovenetum*, *Penicillium deleae*, *Penicillium fellutanum*, *Penicillium lanosum*, *Penicillium steckii*, *Pestalotiopsis* 3 species, *Phoma* 2 species, *Trichoderma atroviride*, *Trichoderma aureoviride*, *Trichoderma citrinoviride*, *Trichoderma harzianum*, *Trichoderma konigii*, *Trichoderma longibrachiratum*, *Trichoderma parceramosum*, *Trichoderma viride*, *Trichoderma* 2 species and three unidentified were in class Deuteromycetes. Fifteen isolates were sterile hypha, and one species of Basidiomycota.

Statistical analysis on biodiversity of fungi in mangrove forest

Seasons

Biodiversity of fungi collected at different periods of time were analyzed. July was the representative of rainy season. February was the representative of mild season and April was the representative of hot season. Analysis by Shannon's diversity index and Simpson's diversity index showed that the biodiversity of fungi in rainy season was highest, followed by cold and hot season, respectively (Table 7).

In all three seasons, nineteen species of fungi were found, namely, *Rhizopus* sp., *Acremonium* sp.1, *Acremonium* sp.2, *Aspergillus fumigatus*, *A. niger*, *Cladosporium elatum*, *Curvularia brachyspora*, *C. lunata*, *Monilia* sp., *Pestalotiopsis* sp.1, *Pestalotiopsis*. sp.2, *Pestalotiopsis*. sp.3, *Trichoderma atroviride*, *T. aureoviride*, *T. citrinoviride*, *T. harzianum*, *T. parceramosum*, *Trichoderma* sp.1 and *Trichoderma* sp.2. Species of fungi found only in

Table 6 Numbers of fungi in twigs and leaves (CFU/g).

Month		Site 1	Site 2	Site 3	Site 4	Site 5
July	Leaves	5.8×10^3	2.4×10^3	9.7×10^3	7.3×10^2	8.8×10^3
	Twigs	7.3×10^2	5.7×10^3	1.7×10^3	1.3×10^3	5.0×10^3
February	Brown leaves	3.2×10^2	5.3×10^2	2.4×10^3	3.0×10^2	7.0×10^2
	Yellow leaves	8.0×10^2	1.8×10^3	2.3×10^2	1.1×10^3	7.3×10^2
	Green leaves	1.0×10^3	8.0×10^2	8.6×10^2	6.6×10^2	4.0×10^2
	Twigs	8.6×10^3	4.3×10^2	1.3×10^4	1.9×10^3	2.6×10^3
April	Brown leaves	8.3×10^2	4.8×10^3	3.6×10^3	3.6×10^3	6.3×10^3
	Yellow leaves	3.1×10^3	6.7×10^3	8.0×10^3	7.2×10^3	4.1×10^3
	Green leaves	8.3×10^3	6.1×10^3	6.1×10^3	3.9×10^3	1.6×10^3
	Twigs	1.1×10^4	6.5×10^3	6.0×10^2	2.1×10^4	3.0×10^2
July	Brown leaves	4.2×10^3	-	1.9×10^3	-	7.0×10^2
	Yellow leaves	1.1×10^3	2.0×10^2	6.0×10^2	5.3×10^2	4.0×10^2
	Green leaves	3.6×10^3	2.4×10^3	3.1×10^3	2.4×10^3	1.2×10^3
	Twigs	4.8×10^3	1.7×10^4	5.8×10^3	2.0×10^3	5.5×10^3

rainy season were *Ascotricha guamensis*, *Acremonium* sp.3, *Acremonium*. sp.4, *Aspergillus* sp.1, *Aspergillus* sp.2, *Conidiocarpus* sp., *Curvularia clavata*,*Fusarium sporotrichiodes*, *Penicillium fellutanum Trichoderma konigii*, sterlie hypha 1 and sterile hypha 15. Species of fungi found only in mild season were *Syncephalastum* sp., *Aspergillus flavus-oryzae* 1, *Aspergillus* sp.3, *Curvularia tuberculata*, *Paecilomyces variotii*, *Penicillium deleae*, *Phoma* sp.2, sterile hypha 4, sterile hypha 6, sterile hypha 10 and sterile hypha 13. Species of fungi found only in hot season were *Aspergillus candidus*, *A. ustus* 2, *Curvularia trifolii*, sterile hypha 3 and sterile hypha 12 (Table 8).

Table 7 Statistical analysis on biodiversity of fungi in different seasons.

Season	Mean	S.D.	Sum	Minimum	Maximum	S	E	H	D
Rainy	7.068	13.071	523	0.000	78.000	52	0.830	3.294	0.9409
Mild	5.000	9.933	370	0.000	53.000	38	0.823	3.220	0.9339
Hot	4.405	10.027	326	0.000	69.000	42	0.818	3.017	0.9174
Averages	5.491	11.010	406.333	0.000	66.667	44	0.824	3.177	0.9307

S = Richness
E = Evenness
H = Shannon's diversity index
D = Simpson's diversity index

Table 8 Species of fungi found in all seasons and only in each season.

All seasons	Rainy	Mild	Hot
Zygomycetes			
Rhizopus sp.		*Syncephalastum* sp	
Ascomycetes			
	Ascotricha guamensis		
Deuteromycetes			
Acremonium sp. 1	*Acremonium* sp. 3	*Aspergillus flavus–oryzae* gr. 1	*Aspergillus candidus* gr.
Acremonium sp. 2	*Acremonium* sp. 4	*Aspergillus* sp. 3	*Aspergillus ustus* gr. 2
Aspergillus fumigatus gr.	*Aspergillus* sp. 1	*Curvularia tuberculata*	*Curvularia trifolii*
Aspergillus niger gr.	*Aspergillus* sp. 2	*Paecilomyces variotii*	*Sterlie hypha* 3
Cladosporium elatum	*Conidiocarpus* sp	*Penicillium deleae*	*Sterlie hypha* 12
Curvularia brachyspora	*Curvularia clavata*	*Phoma* sp. 2	
Curvularia lunata	*Fusarium sporotrichioides*	*Sterlie hypha*4	
Monilia sp.	*Penicillium fellutanum*	*Sterlie hypha* 6	
Pestalotiopsis sp. 1	*Trichoderma konigii*	*Sterlie hypha* 10	
Pestalotiopsis sp. 2	*Sterlie hypha* 1	*Sterlie hypha* 13	
Trichoderma atroviride	*Sterlie hypha* 15		
Trichoderma aureoviride			
Trichoderma citrinoviride			
Trichoderma harzianum			
Trichoderma parceramosum			
Trichoderma sp. 1			
Trichoderma sp. 2			
Sterlie hypha 5			

Seasons had effect on the species of fungi (Suryanarayanan *et al*., 1998).

The similarity of fungi in different season were also analyzed by WARD's method. The results showed that the species of fungi in rainy season and cold season were more similar than those in the hot season (Figure 2).

Sampling sites

Biodiversity of fungi in each sampling site was analyzed. The results showed that diversity of fungi in sampling sites 1 and 5 which were the natural forests were highest, followed by sites 2 and 3 which were the old forest plantations. The diversity in site 4 which was the one year old forest plantation was the lowest (Table 9).

Twelve species of fungi found in all sampling sites were *Rhizopus* sp., *Acremonium* sp. 1, *Aspergillus niger*, *Aspergillus terreus* gr. 1, *Cladosporium elatum*, *Curvularia brachyspora*, *Monilia* sp., *Pestalotiopsis* sp. 1, *Pestalotiopsis* sp. 2, *Pestalotiopsis* sp. 3., *Trichoderma atroviride* and *Trichoderma viride.* Species of fungi found only at site 1 were *Aspergillu* sp. 1, *Curvularia clavata*, *Curvularia harveyi*, *Fusarium heterosporum*, *Paecilomyces variotii*, *Phoma* sp. 2, *Trichoderma* sp. 1. and sterlie hypha 1. Species of fungi found only at site 2 were *Aspergillus ustus gr.* 1, *Aspergillus* sp. 2, sterile hypha 9 and sterile hypha 13. Species of fungi found only at site 3 were *Curvularia pallescens*, sterile hypha 3 and sterile hypha 11. Species of fungi found only at site 4 was *Ascotricha guamensis*. Species of fungi found only at site 5 were *Aspergillus* sp. 3, *Conidiocarpus* sp., *Penicillium steckii*, *Phoma* sp. 1, sterile hypha 4, sterile hypha 10 and sterile hypha 15 (Table 10). Species of fungi were similar to those reported by Ito & Nakagiri (1997a,b), Wongthong (1998), Ito *et al.* (1999), Mehdi and Siddiqui(1999), and Ito *et al*. (2001).

Similarity of species of fungi at different

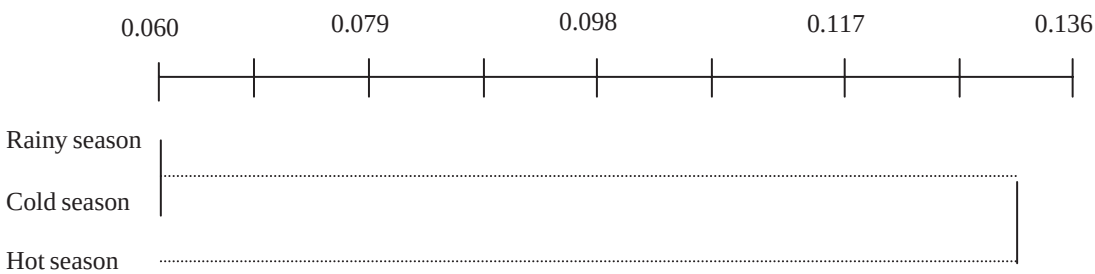

Figure 2 Statistical analysis on similarity of fungi in different seasons.

Table 9 Statistical analysis on biodiversity of fungi in different sites.

Sampling sites	Mean	S.D.	sum	Minimum	Maximum	S	E	H	D
Site 1	8.838	11.828	654	0.000	52.000	49	0.902	3.512	0.9626
Site 2	4.946	8.474	366	0.000	35.000	33	0.897	3.137	0.9474
Site 3	4.919	8.594	364	0.000	35.000	32	0.903	3.156	0.9458
Site 4	3.865	8.400	286	0.000	40.000	24	0.873	2.775	0.9235
Site 5	6.081	8.727	450	0.000	45.000	45	0.910	3.424	0.9590
Averages	5.730	9.204	424	0.000	41.400	36.4	0.897	3.201	0.9477

S = Richness

E = Evenness

H = Shannon ' s diversity index

D = Simpson ' s diversity index

sites were also analyzed. Species of fungi at site 2 were more similar to site 4 since the index was the same value. Specie of fungi at site 1 were similar to those at site 3. Species of fungi at site 5 were different from those at others. Species of fungi at site 5 were more similar to those at site 1 and 3 than those at site 2 and 4 (Figure 3).

Habitats

Biodiversity of fungi in surface water, water at 1 meter below water surface, surface soil, submerge soil, brown leaves, yellow leaves, green leaves and twigs were analyzed. The index value showed that the numbers of fungi in surface soil, green leaves, yellow leaves and twigs were highest.

Table 10 Species of fungi found at all sites and only at each sampling site.

All sites	Site 1	Site 2	Site 3	Site 4	Site 5
Zygomycetes					
Rhizopus sp.					
Ascomycota					
				Ascotricha guamensis	
Deuteromycetes					
Acremonium sp.1	*Aspergillus* sp. 1	*Aspergillus ustus* gr.*1*	*Curvularia pallescens*		*Aspergillus* sp. 3
Aspergillus niger	*Curvularia clavata*	*Aspergillus* sp. 2	*Sterlie hypha* 3		*Conidiocarpus* sp.
Aspergillus terreus gr. 1	*Curvularia harveyi*	Sterlie hypha 9	Sterlie hypha 11		*Penicillium steckii*
Cladosporium elatum	*Fusarium heterosporum*	Sterlie hypha 13			*Phoma* sp. 1
Curvularia brachyspora	*Paecilomyces variotii*				Sterlie hypha 4
Monilia sp.	*Phoma* sp. 2				Sterlie hypha 10
Pestalotiopsis sp. 1	*Trichoderma* sp. 1				Sterlie hypha 15
Pestalotiopsis sp. 2	Sterlie hypha 1				
Pestalotiopsis sp. 3					
Trichoderma atroviride					
Trichoderma viride					

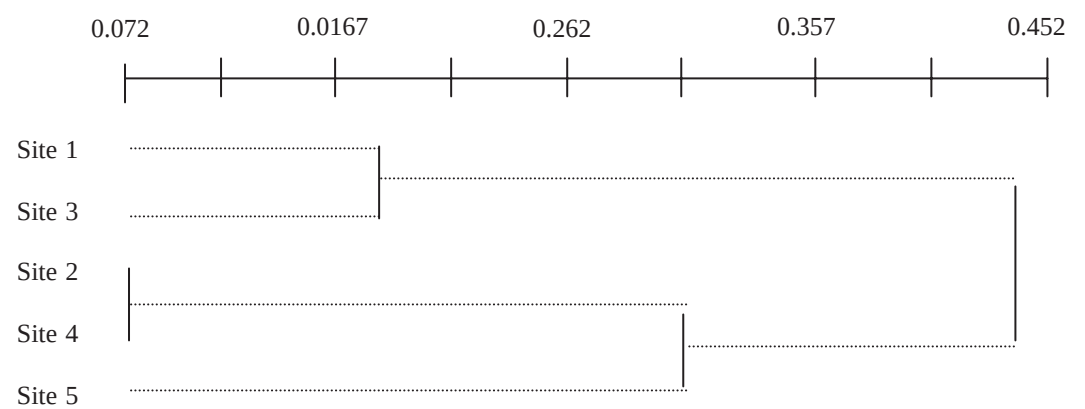

Figure 3 Statistical analysis on similarity of fungi at different sites.

The numbers of fungi in submerged soil and brown leaves were the second highest and from both water samples were lowest (Table 11).

Species of fungi in green leaves were more diverse than brown and yellow leaves. *Acremonium* sp. 1, *Aspergilllus niger*, *Cladosporium elatum*, *Curvularia lunata*, *Monilia* sp. and *Trichoderma viride* were highly distributed in all habitats. *Aspergillus flavus- oryzae* gr. 3, *Aspergillus* sp. 1, *Curvularia pallescens* and Sterile hypha 3 were found only in surface soil and Sterile hypha 12 was found only in submerged soil. *Paecilomyces carneus* and Sterile hypha 11 were found only in water at 1 meter below water surface. *Ascotricha guanensis*, *Aspergillus* sp. 3, *Conidiocarpus* sp., *Fusarium heterosporum*, *Fusarium sporotrichioides*, *Penicillium felutanum*, *Phoma* sp. 2, Sterile hypha 5, Sterile hypha 7 and Sterile hypha 13 were found only in the green leaves. Species of fungi found only in yellow leaves were *Aspergillus versitcolor*, *Curvularia harveyi*, *Curvularia tuberculata*, *Paecilomyces variotii* and Sterile hypha 6. Species of fungi found only in brown leave were *Aspergillus terreus* 2, *Penicillium steckii*, Sterile hypha 9 and Sterile hypha 14. Only 4 species namely *Aspergillus ustus* gr. 2, *Phoma* sp. 1, Sterile hypha 2 and Sterile hypha 15 were found only in twigs (Table 12). Species of fungi were more diverse in green leaves and least diverse in water.

Similarity of species of fungi from different habitats was analyzed. The result showed that yellow leaves had species of fungi closely similar to brown leaves at highest level. The fungi in surface soils and twigs also similar to each other. Species of fungi in green leaves were different from those in soils, twigs, yellow leaves and brown leaves. The species of fungi in water samples were different from those in the other habitats (Figure 4).

CONCLUSIONS

Numbers of fungi in soils, water, leaves and twigs collected from the Ranong Biosphere Reserve were examined. The results showed that numbers of fungi from twigs were higher than those of leaves, soils and water. The numbers of fungi from water were lowest. All different fungal isolates were isolated and identified into 16 genera 74 species. Biodiversity and similarity of fungi were compared among seasons, sampling sites

Table 11 Statistical analysis on biodiversity of fungi in different habitats.

Sample	Mean	S.D.	sum	Minimum	Maximum	S	E	H	D
Surface soil	5.838	8.625	432.000	0.000	32.000	34	0.929	3.303	0.9574
Sub soil	2.716	5.851	201.000	0.000	31.000	21	0.913	2.781	0.9246
Surface water	1.973	5.793	146.000	0.000	35.000	13	0.891	2.285	0.8716
Water 1 meter below	1.986	4.964	147.000	0.000	23.000	15	0.917	2.482	0.9032
Green leave	4.297	6.106	318.000	0.000	27.000	37	0.927	3.372	0.9596
Yellow leave	4.324	6.934	320.000	0.000	25.000	29	0.935	3.149	0.9522
Brown leave	3.203	6.723	237.000	0.000	30.000	22	0.910	2.812	0.9277
Twig	4.378	7.497	324.000	0.000	32.000	31	0.907	3.116	0.9474
Averages	3.590	6.562	265.625	0.000	29.375	25.25	0.916	2.913	0.9305

S = Richness

E = Evenness

H = Shannon ‘ s diversity index

D = Simpson ‘ s diversity index

and habitats. The result showed that biodiversity of fungi were highest in rainy season. Species of fungi in rainy season were more similar to mild season than hot season. Comparison among sampling sites showed that biodiversity of fungi at site 5 which was the natural forest were highest. those at site 2 and site 3 which were one year old mangrove plantations were lowest. Species of fungi in site 2 were more similar to site 3 than the other sites. Species of fungi in site 5 which was near the fresh water were different from the other sites. Biodiversity of fungi from different habitats

Table 12 Species of fungi found in all habitats and only in each habitat.

Habitats		Species of fungi
All habitats		*Acremonium* sp. 1, *Aspergillus niger* gr., *Cladosporium elatum, Curvularia lunata, Monilia* sp., *Trichoderma viride*
Soils	surface	*Aspergillus flavus*–oryzae gr. 3, *Aspergillus* sp. 1, *Curvularia pallescens* Sterlie hypha 3
	submerge	Sterlie hypha 12
Water	surface	
	Submerge	*Paecilomyces carneus,* Sterlie hypha 11
Leaves	green	*Ascotricha guamensis, Aspergillus* sp. 3, *Conidiocarpus* sp., *Fusarium heterosporum, Fusarium sporotrichioides, Penicillium fellutanum, Phoma* sp.2, Sterlie hypha 5, Sterlie hypha 7, Sterlie hypha 13
	yellow	*Aspergillus versicolor* gr. *Curvularia harveyi, Curvularia tuberculata, Paecilomyces variotii,* Sterlie hypha 6
	brown	*Aspergillus terreus* gr. 2, *Penicillium steckii,* Sterlie hypha 9, Sterlie hypha 14
Twigs		*Aspergillus ustus* gr. 2, *Phoma* sp. 1, Sterlie hypha 2, Sterlie hypha 15

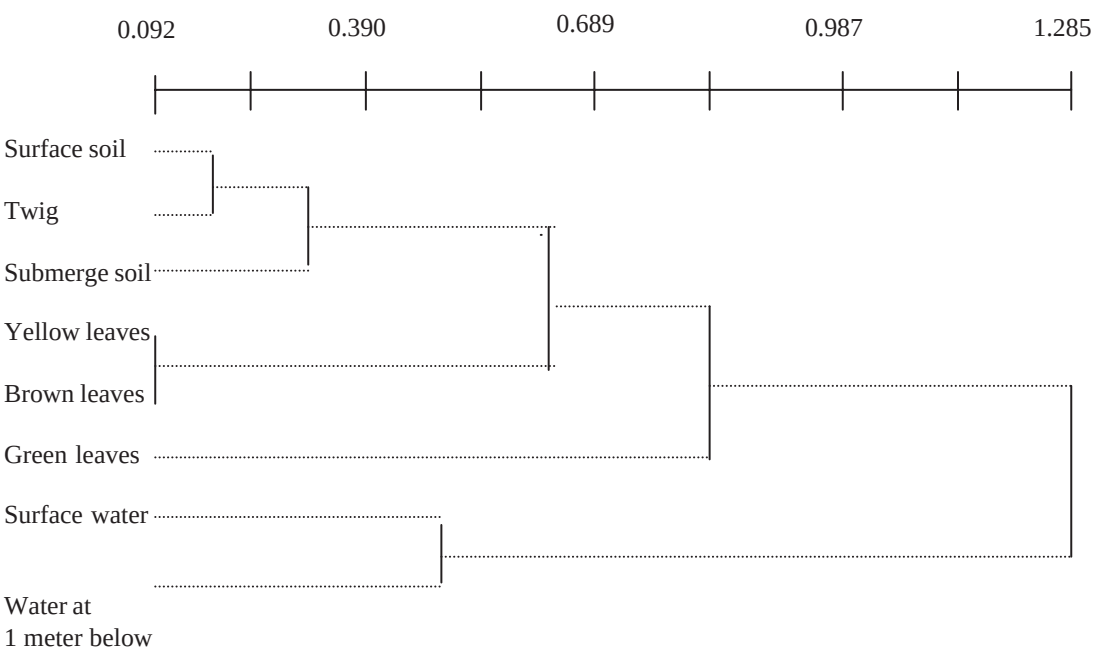

Figure 4 Statistical analysis on similarity of fungi in different habitats.

were also analyzed. The result showed that the biodiversity in soils, green leaves and twigs were higher than water. Similarity of species of fungi were highest in green leaves and yellow leaves.

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