

Fungal Diversity of Pichavaram Mangroves, Southeast Coast of India

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Abstract: This study reports the occurrence of fungi based on a pilot study and a checklist of fungi in Pichavaram mangroves of the southeast coast of India. Damp incubation of wood, root and leaf litter of *Avicennia marina* and *Rhizophora mucronata* yielded 15 fungi. The fungal richness was highest (9 spp.) on woody litter of both plant species and root litter of *R. mucronata*. *Aniptodera chesapeakeensis*, *Halorosellinia oceanica*, *Halosarpheia marina*, *Periconia prolifica* and *Phoma* sp. were dominant (5-6.3%). Woody litter of *A. marina* was highly colonized by *H. marina* (28%), while *R. mucronata* by *Phoma* sp. (24%). The average fungi per sample ranged between 0.3 and 0.8 with a highest on woody litter (0.7-0.8). In Pichavaram mangroves, so far about 10 niches (water, sediment and live/dead plant parts) and 14 mangrove plant species have been surveyed for mycoflora. About 102 fungi consisting of mitosporic fungi (57 spp.), ascomycetes (37 spp.), phycocomycetes (7 spp.) and basidiomycete (1 sp.) have been reported. Woody litter yielded a highest of 36 saprophytic fungi followed by 33 fungi as foliar epiphytes. *Cirrenalia pygmaea* was the most dominant fungus, followed by *H. oceanica*, *P. prolifica*, *Zalerion maritima* and *Z. varia*. The foliar endophyte, *Sporormiella minima* colonized the highest number of mangrove plant species. [Nature and Science. 2009;7(5):67-75]. (ISSN: 1545-0740).

Keywords: Diversity, endophytes, epiphytes, fungi, mangroves, Pichavaram, plant detritus, saprophytes, sediment, water

Introduction

Among the tropical marine ecosystems, mangroves and coral reefs are the major habitats in gross productivity (Qasim & Wafer, 1990). Mangrove forests are spread over 181,000 km² in 112 countries of tropics and sub-tropics (Bunt, 1992; Spalding, 1997). Mangroves through detritus production and decomposition support a variety of planktonic, benthic and fish communities (Robertson *et al.*, 1992; Alongi *et al.*, 1999; Kathiresan & Bingham, 2001). Up to 41% of mangroves exist in South and South East Asia (Spalding, 1997). Indian subcontinent ranks fourth (6,700 km²) after Indonesia, Bangladesh and Malaysia in mangrove vegetation cover (Blasco & Aizpuru, 1997). Mangrove forests in peninsular India mainly distributed in the backwater-estuarine west coast (Arabian Sea) and deltaic east coast (Bay of Bengal) (Natarajan, 1998; Kathiresan, 1999).

The Pichavaram mangroves of east coast of India have been extensively investigated for biodiversity (Kathiresan, 2000; Kumar, 2000; Kathiresan & Bingham, 2001). In 1980, it has been declared as a forest reserve and managed by the Department of Forests, Tamil Nadu (Blasco & Aizpuru, 1997; Kathiresan, 2000). Pichavaram mangroves encompasses 13 mangrove tree species (dominant: *Avicennia marina*, *Rhizophora apiculata* and *R. mucronata*) and 80 mangrove associates (trees, 24 spp.; shrubs, 21 spp.; herbs, 28 spp.; climbers, 7 spp.) (Kathiresan, 2000). According to Kathiresan (2000), the biota reported in Pichavaram mangroves include bacteria (52 spp.), fungi (23 spp.), phytoplankton (82 spp.), zooplankton (95 spp.), seagrasses (3 spp.), seaweeds (22 spp.), meiobenthos (40 spp.), macrobenthos (52 spp.), fishes (177 spp.) and birds (200 spp.). The annual plant litter production by *Rhizophora mucronata*, *R. apiculata* and *Avicennia marina* was up to 624, 1361 and 1456 g/m² respectively and leaf litter constitutes a major proportion (63.2-86.7%) (Muniyandi, 1986). Krishnamoorthy *et al.* (1995) indicated that up to 75% of the green cover and 90% of the forest area of Pichavaram mangroves have been lost due to human interference. Being detritus-driven ecosystem, mangroves are dependent on fungal communities for detritus mineralization and energy transfer to higher trophic levels. The aim of the present study was to investigate fungi associated with dead litter (wood, root and leaf) of two major mangrove plant species (*A. marina* and *R. mucronata*) of Pichavaram mangroves based on a pilot study and to document the mycoflora reported so far. As baseline information, the checklist facilitates comparison of fungal richness in different niches and hosts of Pichavaram mangroves with other mangroves, and to develop future strategies of conservation and exploitation of fungal diversity.

Materials and methods

Pichavaram mangroves situated at the southeast coast of India (11°29' N, 79°46' E) with semidiurnal tides ranging between 0.5 and 1.0 m. Freshwater enters the mangrove ecosystem through the Coleroon River and Khan Saheb Channel, while the neritic water from the Bay of Bengal thorough the Vellar River. Two stations of Pichavaram mangroves (Kidavu and Periyakadavu) have been selected to sample the mangrove detritus. The Kidavu station is situated opposite to the tourist boat jetty, while Periyakadavu at the central region of the Pichavaram mangroves. Dead and partially decomposed wood, root and leaf litter of *Avicennia marina* and *Rhizophora mucronata* accumulated on the floor were sampled during June 2007. The samples were transported to the laboratory in sterile airtight polythene bags. After sorting out the samples, attached debris was removed and 50 samples each of wood, root and leaf litter per plant species were separately incubated (25±2°C) up to six months on sterile sand-bed wetted with 50% sterile seawater in polythene bags. Once in two weeks, the samples were examined for fungal structures and the fungi grown on the substrates were identified based on the descriptions and monographs (Kohlmeyer & Volkmann-Kohlmeyer 1991; Hyde & Sarma 2000). The percent frequency of occurrence of fungi on each substrate and on all substrates were calculated:

Frequency of occurrence (%) = [(Number of samples colonized by fungal taxon) ÷ (Total number samples assessed)] × 100

Results and discussion

Pattern of fungal occurrence on damp incubated wood, root and leaf litter of *A. marina* and *R. mucronata* has been presented in Table 1. A total of 15 species (range, 6-9) of fungi (8 ascomycetes, 6 mitosporic fungi and 1 basidiomycete) was recorded. A highest of nine species was found on woody litter of both plant species and on the root litter of *R. mucronata*. The dominant fungi were: *Aniptodera chesapeakeensis*, *Halorosellinia oceanica*, *Halosarpheia marina*, *Periconia prolifica* and *Phoma* sp. (total frequency, 5-6.3%). The woody litter of *A. marina* was highly colonized by *H. marina* (28%), while woody litter of *R. mucronata* by *Phoma* sp. (24%). The average fungi per sample was highest on woody litter (*A. marina*, 0.8; *R. mucronata*, 0.7) than other substrates (0.3-0.4). This value is lower than other studies on woody litter of the west coast mangroves (mixed wood: 1, Borse, 1988; *Avicennia*, 2.6-2.9; *Rhizophora*, 2-2.4, Maria & Sridhar, 2003). The average fungi per wood may increase by carrying out long-term studies or more number of woody substrates. In addition, the fungal richness on woody litter depends on the difference in wood texture (hard, medium and soft), presence or absence of bark and substratum or host recurrence (Hyde *et al.*, 1998; Maria & Sridhar, 2003).

Table 1. Frequency of occurrence (%) of fungi recovered from dead litter of the Pichavaram mangroves of east coast of India (*, Pneumatophores; **, Prop roots; TFO, Total frequency of occurrence)

Fungus	<i>Avicennia marina</i>			<i>Rhizophora mucronata</i>			TFO (%)
	Wood	Root*	Leaf	Wood	Root**	Leaf	
Ascomycetes							
<i>Halosarpheia marina</i> (Cribb & J.W. Cribb) Kohlm.	28	6	-	-	4	-	6.3
<i>Aniptodera chesapeakeensis</i> Shearer & M.A. Mill.	12	-	-	12	6	-	5.0
<i>Halorosellinia oceanica</i> (S. Schatz) Whalley, E.B.G. Jones, K.D. Hyde & Laessøe	-	2	4	8	4	12	5.0
<i>Littispora abonnis</i> (Kohlm.) J. Campb., J.L. Anderson & Shearer	8	-	-	-	8	-	2.7
<i>Didymosphaeria</i> sp.	-	8	2	6	2	2	1.3
<i>Lindra</i> sp.	2	4	-	2	-	-	1.3
<i>Lulworthia</i> sp. 1 (150 × 2.5 µm)	4	-	-	2	-	-	1.0
<i>Lulworthia</i> sp. 2 (250 × 2.5 µm)	4	2	-	-	-	-	1.0
Basidiomycete							
<i>Halocyphina villosa</i> Kohlm. & E. Kohlm.	-	4	-	2	-	-	1.0
Mitosporic fungi							
<i>Phoma</i> sp.	-	-	4	24	-	8	6.0
<i>Periconia prolifica</i> Anastasiou	-	6	10	4	8	2	5.0
<i>Cladosporium</i> sp.	8	-	-	10	4	4	4.3

<i>Zalerion varia</i> Anastasiou	-	8	2	-	2	10	3.7
<i>Zalerion maritima</i> (Linder) Anastasiou	6	-	8	-	-	4	3.0
<i>Cirrenalia pygmaea</i> Kohlm.	4	-	-	-	6	2	2.0
Total fungi	9	8	6	9	9	8	
Average fungi per sample	0.8	0.4	0.3	0.7	0.4	0.4	

Table 2 shows the list of fungi in Pichavaram mangroves based on literature survey. Ten mangrove niches have been investigated for fungi: water, sediment, live (root, leaf, bark) and dead (wood, root, seedling and leaf litter) plant parts. Up to 14 mangrove hosts have been studied (*Aegiceras*, *Acanthus*, *Arthrocnemum*, *Avicennia* spp., *Bruguiera*, *Ceriops*, *Excoecaria*, *Lumnitzera*, *Rhizophora* spp. *Suaeda*, *Sesuvium* and some unidentified hosts). A total of 102 fungi (range, 3-36 species/niche) encompassing mitosporic fungi (57 spp.), ascomycetes (37 spp.), phycomycetes (7 spp.) and basidiomycete (1 sp.) have been recovered. Dead wood samples yielded the highest of 36 saprophytes (ascomycetes, 24 spp.; mitosporic fungi 11 spp., basidiomycete, 1 sp.) followed by 33 epiphytes on leaves (mitosporic fungi, 26 spp.; phycomycetes, 4 spp.; ascomycetes, 3 spp.), 21 endophytes on bark (ascomycetes, 13 spp.; mitosporic fungi, 8 spp.), 20 saprophytes on root (ascomycetes, 15 spp.; mitosporic fungi 4 spp., basidiomycete, 1 sp.) and 19 saprophytes on leaf litter (mitosporic fungi, 13 spp.; ascomycetes, 6 spp.). *Cirrenalia pygmaea* was found on a maximum of six substrates, followed by *Halorosellinia oceanica* and *Periconia prolifica* on five substrates each, *Zalerion maritima* and *Z. varia* each on four substrates. Foliar endophyte, *Sporormiella minima* was associated with the highest of nine host plant species followed by *Cladosporium cladosporioides* on five hosts.

Table 2. Checklist of fungi recorded from the Pichavaram mangroves of east coast of India (references in parenthesis)

Reference: (1) Salique *et al.* 1985; (2) Venkatesan & Natarajan 1985; (3) Sivakumar & Kathiresan, 1990; (4) Kumaresan & Suryanarayanan 2001; (5) Kumaresan & Suryanarayan 2002; (6) Suryanarayanan & Kumaresan 2000; (7) Suryanarayanan *et al.* 1998; (8) Kumaresan *et al.*, 2002; (9) Ravikumar & Vittal 1996; (10) Nambiar *et al.* 2008; (11) Rajendran & Kathiresan, 2007; (12) Present study

Substrate: Ac, *Aegiceras corniculatum*; Aci, *Acanthus ilicifolius*; Ai, *Arthrocnemum indicum*; Am, *Avicennia marina*; Ao, *Avicennia officinalis*; Bc, *Bruguiera cylindrica*; Cd, *Ceriops decandra*; Ea, *Excoecaria agallocha*; Lr, *Lumnitzera racemosa*; R, *Rhizophora* spp.; Ra, *Rhizophora apiculata*; Rm, *Rhizophora mucronata*; Sm, *Suaeda maritima*; Sp, *Sesuvium portulacastrum*; *, host not defined

Fungus	Water (1)	Sedi-ment (1)	Live part				Dead part			
			Epiphyte		Endophyte		Wood (9,10,12)	Root (9,12)	Seed-ling (9)	Leaf (11,12)
			Root (2)	Leaf (3)	Leaf (4-8)	Bark (8)				
Phycomycetes										
<i>Absidia ramosa</i> (Zopf) Lendn.	-	+	Ao,Rm	-	-	-	-	-	-	-
<i>Cunninghamella elegans</i> Lendn.	-	-	Ao	-	-	-	-	-	-	-
<i>Mucor hiemalis</i> Wehmer	-	+	-	-	-	-	-	-	-	-
<i>M. lumbeus</i> Bonord.	-	+	-	-	-	-	-	-	-	-
<i>M. acemosus</i> Fresen.	+	+	-	*	-	-	-	-	-	-
<i>Rhizopus nigricans</i> Ehrenb.	-	+	Ao,Rm	*	-	-	-	-	-	-
<i>Syncephalastrum racemosum</i> Cohn ex J. Schröt.	-	+	Ao	-	-	-	-	-	-	-
Ascomycetes										
<i>Aigialus grandis</i> Kohlm. & S. Schatz	-	-	-	-	-	R	R	R	-	-
<i>A. mangrovei</i> Borse	-	-	-	-	-	R	R	-	-	-
<i>A. parvus</i> S. Schatz & Kohlm.	-	-	-	-	-	R	R	R	-	-
<i>Aniptodera chesapeakeensis</i> Shearer & M.A. Mill.	-	-	-	-	-	Am, Rm	Rm	-	-	-
<i>Antennospora quadricornuta</i> (Cribb & J.W. Cribb) T.W. Johnson	-	-	-	-	-	-	R	-	-	-
<i>Ascocratera manglicola</i> Kohlm.	-	-	-	-	-	R	R	-	-	-

<i>Astrosphaeriella mangrovis</i> (Kohlm. & Vittal) Aptroot & K.D. Hyde	-	-	-	-	-	R	R	R	-	-
<i>Bathyascus mangrovei</i> Ravik. & Vittal	-	-	-	-	-	-	-	R	-	-
<i>Belizeana tuberculata</i> Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	-	R	-	-	-
<i>Chaetomium globosum</i> Kunze	-	-	-	-	Am,Ra, Rm	-	-	-	-	-
<i>C. olivaceum</i> Cooke & Ellis	-	+	Ao,Rm	-	-	-	-	-	-	-
<i>Dactylospora haliotrepha</i> (Kohlm. & E. Kohlm.) Hafellner	-	-	-	-	-	R	R	R	-	-
<i>Didymella avicenniae</i> S.D. Patil & Borse	-	-	-	-	-	-	-	R	-	-
<i>Emericella nidulans</i> (Eidam) Vuill.	-	-	Ao,Rm	-	-	-	-	-	-	-
<i>Halorosellinia oceanica</i> (S. Schatz) Whalley, E.B.G. Jones, K.D. Hyde & Laessøe	-	-	-	-	-	Rm	Am,Rm,*	Am, Rm	Am, Rm	Am,Rm
<i>Halosphaeria cucullata</i> (Kohlm.) Kohlm.	-	-	-	-	-	-	R	-	-	-
<i>H. fibrosa</i> Kohlm. & E. Kohlm.	-	-	-	-	-	-	-	-	-	Am/Ra
<i>H. marina</i> Cribb & J.W. Cribb Kohlm.	-	-	-	-	-	Am	Am,Rm, R	Am, Rm	-	-
<i>Heleococcum japonense</i> Tubaki	-	-	-	-	-	-	R	-	-	-
<i>Leptosphaeria australiensis</i> (Cribb & Cribb) G.C. Hughes	-	-	-	-	-	R	R	R	-	-
<i>Lineolata rhizophorae</i> (Kohlm. & E. Kohlm.) Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	-	R	-	-	-
<i>Littispora abonnis</i> (Kohlm.) J. Campb., J.L. Anderson & Shearer	-	-	-	-	-	Am	Am,Rm	Rm	-	-
<i>Lulworthia grandispora</i> Meyers	-	-	-	-	-	-	R	R	-	-
<i>Massarina thalassiae</i> Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	-	R	-	-	-
<i>M. velataspora</i> K.D. Hyde & Borse	-	-	-	-	-	-	R	R	-	-
<i>Nais glitra</i> J.L. Crane & Shearer	-	-	-	-	-	R	R	-	-	-
<i>Neptunella longirostris</i> (Cribb & J.W. Cribb) K.L. Pang & E.B.G. Jones	-	-	-	-	-	-	R	R	-	-
<i>Ophiobolus littoralis</i> (P. Crouan & H. Crouan) Sacc.	-	-	-	-	-	-	-	-	-	Am/Ra
<i>Pontoporeia biturbinata</i> (Durieu & Mont.) Kohlm.	-	-	-	-	-	-	-	-	-	Am/Ra
<i>Quintaria lignatilis</i> (Kohlm.) Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	-	R	-	-	-
<i>Savoryella lignicola</i> E.B.G. Jones & R.A. Eaton	-	-	-	-	-	-	*	-	-	-
<i>Spathulospora lanata</i> Kohlm.	-	-	-	-	-	-	-	-	-	Am/Ra
<i>Sporormiella grandispora</i> S.I. Ahmed & Cain ex J.C. Krug	-	-	-	-	-	R	-	-	-	-
<i>S. minima</i> (Auersw.) S.I. Ahmed & Cain	-	-	-	-	Aci,Bc, Cd,Ea,Lr, Ra,Rm, Sm,Sp	-	-	-	-	Am,Ao
<i>Swampomyces armeniacus</i> Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	-	-	R	-	-

<i>Thielavia terricola</i> (J.C. Gilman & E.V. Abbott) C.W. Emmons	-	-	Rm	-	-	-	-	-	-	-
<i>Verruculina enalia</i> (Kohlm.) Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	-	R,*	R	R	-
Basidiomycete										
<i>Halocyphina villosa</i> Kohlm. & E. Kohlm.	-	-	-	-	-	-	Rm,R,*	Am, R	R	-
Mitosporic fungi										
<i>Alternaria alternata</i> (Fr.) Keissl.	-	-	-	*	Aci,Ai, Lr,Ra	-	-	-	-	-
<i>A. alternata</i> (Fr.) Keissl.	-	-	-	-	-	-	-	-	-	Am/Ra
<i>A. tenuissima</i> (Kunze) Wiltshire	-	-	-	*	-	-	-	-	-	-
<i>Aspergillus aureolus</i> Fennell & Raper	-	-	-	-	-	-	-	-	-	Am/Ra
<i>A. brevipes</i> G. Sm.	+	-	-	-	-	-	-	-	-	-
<i>A. candidus</i> Link	-	+	-	-	-	-	-	-	-	Am/Ra
<i>A. chevalieri</i> Thom & Church	-	-	-	-	-	-	-	-	-	Am/Ra
<i>A. flavus</i> Link	-	-	Ao,Rm	*	-	-	-	-	-	Am/Ra
<i>A. fumigatus</i> Fresen.	-	-	Ao,Rm	-	-	-	-	-	-	Am/Ra
<i>A. glaucus</i> (L.) Link	-	-	-	-	Rm	-	-	-	-	Am/Ra
<i>A. nidulans</i> (Eidam) G. Winter	-	+	Ao	-	-	-	-	-	-	-
<i>A. niger</i> Tiegh.	-	-	Ao,Rm	-	Cd,Ea	-	-	-	-	Am/Ra
<i>A. ochraceus</i> G. Wilh.	-	-	-	*	Ra	-	-	-	-	Am/Ra
<i>A. oryzae</i> (Ahlb.) E. Cohn	-	+	-	-	-	-	-	-	-	-
<i>A. terreus</i> Thom	+	+	Ao,Rm	-	-	-	-	-	-	-
<i>A. wentii</i> Wehmer	-	+	-	-	-	-	-	-	-	-
<i>Camarosporium palliatum</i> Kohlm. & E. Kohlm.	-	-	-	-	Ai,Sm	-	-	-	-	-
<i>C. propinquum</i> (Sacc.) Sacc.	-	-	-	-	Ai,Sm	-	-	-	-	-
<i>Chaetomium globosum</i> Kunze	-	-	-	-	Ra	Ra	-	-	-	-
<i>Cirrenalia basiminuta</i> Raghuk. & Zainal	-	-	-	-	-	-	R	-	-	-
<i>C. macrocephala</i> (Kohlm.) Meyers & R.T. Moore	-	-	-	-	-	-	R	-	-	-
<i>C. pygmea</i> Kohlm.	-	-	Rm	-	-	Am	Am,Rm, R,*	Rm, R	Rm	Rm
<i>Cladosporium cladosporioides</i> (Fresen.) G.A. de Vries	-	-	-	-	Am,Ao, Cd,Lr,Ra	-	-	-	-	-
<i>C. oxysporum</i> Berk. & M.A. Curtis	-	-	Ao,Rm	-	-	-	-	-	-	-
<i>Colletotrichum gloeosporioides</i> (Penz.) Penz. & Sacc.	-	-	-	-	Bc	-	-	-	-	-
<i>Curvularia lunata</i> (Wakker) Boedijn	-	-	Ao	-	Ao,Lr,Ra	-	-	-	-	-
<i>C. oryzae</i> Bugnic.	-	+	-	-	-	-	-	-	-	-
<i>C. pallescens</i> Boedijn	-	-	-	-	Am,Lr	-	-	-	-	-
<i>C. tuberculata</i> B.L. Jain	-	-	Ao	-	-	-	-	-	-	-
<i>Dendryphiella salina</i> (G.K. Sutherl.) Pugh & Nicot	-	-	-	-	-	-	*	-	-	-
<i>Drechslera halodes</i> (Drechsler) Subram. & B.L. Jain	-	-	-	-	Lr	-	-	-	-	-
<i>D. hawaiiensis</i> (Bugnic.) Subram. & B.L. Jain	-	-	-	-	Ra	-	-	-	-	-
<i>D. incurvata</i> (C. Bernard) M.B. Ellis	-	-	Ao	-	-	-	-	-	-	-
<i>Epicoccum purpurascens</i> Ehrenb.	-	-	-	-	-	R	R	-	-	-
<i>Fusarium oxysporum</i> E.F. Sm. & Swingle	-	-	Ao,Rm	*	-	-	-	-	-	-

<i>F. solani</i> (Mart.) Sacc.	-	-	Rm	-	-	-	-	-	-	-
<i>Graphium penicillioides</i> Corda	-	-	Rm	-	-	-	-	-	-	-
<i>Humicola fuscoatra</i> Traaen	-	-	Rm	*	-	-	-	-	-	-
<i>Memmoniella echinata</i> (Rivolta) Galloway	-	-	Rm	-	-	-	-	-	-	-
<i>Microdochium oryzae</i> (Hashioka & Yokogi) Samuels & I.C. Hallett	-	-	Rm	-	-	-	-	-	-	-
<i>Monodictys levis</i> (Wiltshire) S. Hughes	-	-	Ao,Rm	-	-	-	-	-	-	-
<i>M. pelagica</i> (T. Johnson) E.B.G. Jones	-	-	-	-	-	R	R	R	-	-
<i>Paecilomyces varioti</i> Bainier	-	-	Rm	-	-	-	-	-	-	-
<i>Penicillium expansum</i> Link	-	-	-	*	-	-	-	-	-	-
<i>P. funiculosum</i> Thom	-	-	Ao,Rm	*	-	-	-	-	-	-
<i>P. nigricans</i> K.M. Zalesky	-	-	Ao	-	-	-	-	-	-	-
<i>Periconia prolifica</i> Anastasiou	-	-	-	-	-	Rm	Am,Rm, R,*	Am, Rm	Am, Rm	Am,Rm
<i>Polystigma rubrum</i> (Pers.) DC.	-	-	Ao	-	-	-	-	-	-	-
<i>Sphaeropsis cylindrospora</i> Desm.	-	-	Ao	-	-	-	-	-	-	-
<i>Trichocladium achrasporum</i> (Meyers & R.T. Moore) M. Dixon	-	-	-	-	-	R	R	-	-	-
<i>T. alopallonellum</i> (Meyers & R.T. Moore) Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	R	R	-	-	-
<i>Trichoderma koningii</i> Oudem.	-	-	Ao	-	-	-	-	-	-	-
<i>T. lignorum</i> (Tode) Harz	-	-	Ao	-	-	-	-	-	-	-
<i>T. pseudokoningii</i> Rifai	-	-	Ao,Rm	-	-	-	-	-	-	-
<i>T. viride</i> Pers.	-	-	Ao,Rm	-	-	-	-	-	-	-
<i>Zalerion maritima</i> (Linder) Anastasiou	-	-	-	-	-	Am	Am	-	Am, Rm	Am,Rm
<i>Z. varia</i> Anastasiou	-	-	-	-	-	-	Am,Rm, R	Am, Rm	Am, Rm	Am,Rm
Phycomycetes	1	6	4	2	-	-	-	-	-	-
Ascomycetes	1	1	3	-	2	13	24	15	2	6
Basidiomycetes	-	-	-	-	-	-	1	1	1	-
Mitosporic fungi	1	6	26	8	13	8	11	4	4	13
Total fungi	3	13	33	10	15	21	36	20	7	19

Figure 1 compares the total fungi, mitosporic fungi and ascomycetes in different mangrove niches: water, sediment, plant surface (epiphytes: root + leaf), tissue interior (endophytes: leaf + bark) and detritus (wood, root, seedling and leaf litter). The highest number of fungi were epiphytic on root + leaf (38 spp.) followed by saprophytes on woody litter (36 spp.), endophytes on bark + leaf (35 spp.), saprophytes on root litter (20 spp.), saprophytes on leaf litter (19 spp.), and sediment inhabitants (13 spp.). Based on the extent of studies carried out, epiphytic, endophytic and saprophytic fungi may be comparable than those recovered from water and sediment. Clearly, epiphytic and endophytic fungi dominated than the saprophytic fungi. Epiphytic and endophytic fungi dominated by mitosporic fungi (30 spp. and 20 spp. respectively). Similarly, mitosporic fungi dominated as saprophytes on leaf litter (13 spp.). Woody litter and root litter showed the dominance of ascomycetes (24 spp. and 15 spp. respectively).

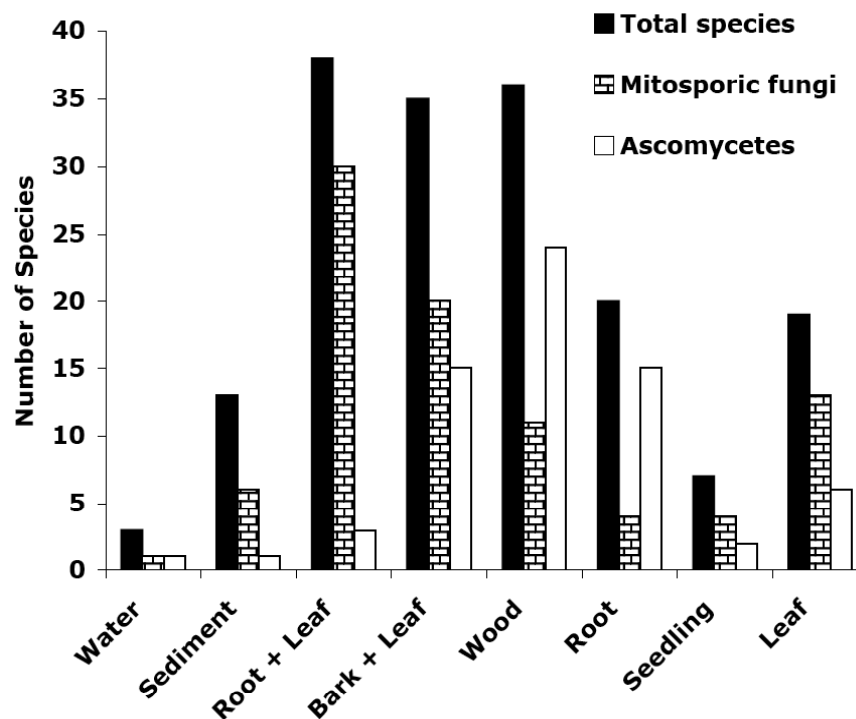


Figure 1. Fungi reported in different niches of Pichavaram mangroves: water, sediment, epiphytes (root + leaf), endophytes (bark + leaf) and saprophytes (wood, root, seedling and leaf)

So far, woody litter of *Avicennia* and *Rhizophora* yielded up to 36 species of fungi in Pichavaram mangroves (Table 2). Fungal richness on woody litter of *Avicennia* and *Rhizophora* was highest (58 spp.) in Udyavara mangrove of the west coast (Maria & Sridhar 2003). Sarma & Vittal (2001) also recovered maximum fungi on woody litter of *Rhizophora* (64 spp.) and *Avicennia* (55 spp.) from the Godavari and Krishna deltas of east coast. The nutritional features and persistent nature of woody litter of *Avicennia* and *Rhizophora* in mangrove habitats might be responsible for yielding rich mycoflora (Maria *et al.*, 2006). Mycological investigations carried out in Pichavaram mangroves are relatively meager compared to biodiversity studies carried out on other flora and fauna (Kathiresan, 2000). As Pichavaram mangroves consists of 37 tree species (mangrove, 13 spp.; mangrove associates, 24 spp.) (Kathiresan, 2000), at least 1,200 fungi might exist based on plant-fungus ratio, 1:33 (Fröhlich & Hyde, 1999). The checklist reveals only 102 fungi, which accounts to about 8% of fungi exist in Pichavaram mangroves. This comparison is also applicable to other Indian mangroves as intense studies have not been carried out. Up to 2006, higher fungi of the Indain mangroves reported were 165 species (ascomycetes, 111 spp.; mitosporic fungi, 53 spp.; basidiomycete, 1 sp.) (Sridhar, 2009). Excluding phycomycetes (7 spp.), higher fungi of Pichavaram mangroves accounts to about 58% of Indian mangrove fungi. However, the checklist of fungi of Pichavaram mangroves presented in Table 2 consists of fungi identified up to species level. There are many reports from Pichavaram mangroves listing only genera of some fungi indicating the necessity of intense study of fungal systematics.

Several mycological investigations of the Indian mangroves have been pursued or intensified after the biodiversity initiative in 1992. There seems to be no studies on the pattern of decomposition of mangrove leaf and woody litter in the east coast (Maria *et al.*, 2006; Ananda *et al.*, 2008). Similarly, endophytic fungal studies carried out are confined to leaves and bark, while roots are not studied (Ananda & Sridhar, 2002). Water and sediments are also not explored intensely for fungal resource. Based on overall biodiversity investigations carried out at the Pichavaram mangroves, this mangrove forest deserves to be considered as a model mangrove of the Peninsular India for comparison with other tropical and subtropical regions. First important step of conservation and sustainable use of biodiversity of Pichavaram mangroves is to elevate the status from forest reserve to a national biodiversity park. The second equally important step would be protection of Pichavaram mangroves from human interference by providing

alternative socioeconomic avenues and resources to the human population currently heavily depending on the Pichavaram mangrove habitats.

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