Fungal diversity of Pichavaram mangroves, Southeast coast of India

Article *in* Nature and Science of Sleep · March 2009

CITATIONS
22

READS
418

1 author:

K. R. Sridhar
Mangalore university
484 PUBLICATIONS **7,839** CITATIONS

SEE PROFILE

Fungal Diversity of Pichavaram Mangroves, Southeast Coast of India

Kandikere R. Sridhar
Microbiology and Biotechnology, Department of Biosciences, Mangalore University,
Mangalagangotri, Mangalore 574 199, Karnataka, India
E-mail: sirikr@yahoo.com

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 chesapeakensis*, *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.), phycomycetes (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 pygmea* 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 habiats in gross productivity (Qasim & Wafer, 1990). Mangrove forests are spread over 181,000 km^2 in 112 countries of tropics and sub-tropics (Bunt, 1992; Spalding, 1997). Mangroves through deritus 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 km^2) 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.), meiobanthos (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/m^2 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 ecsystem, 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 chesapeakensis, Halorosellinia oceanica, Halosarpheia marina, Periconia prolifeica* 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 frequecny of occurrence)

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

Zalerion varia Anastasiou	-	8	2	-	2	10	3.7
Zalerion maritima (Linder) Anastasiou	6	-	8	-	-	4	3.0
Cirrenalia pygmea 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 pygmea* 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)** Suryanaryanan *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										
Absidia ramosa (Zopf) Lendn.	-	+	Ao,Rm	-	-	-	-	-	-	-
Cunninghamella elegans Lendn.	-	-	Ao	-	-	-	-	-	-	-
Mucor hiemalis Wehmer	-	+	-	-	-	-	-	-	-	-
M. lumbeus Bonord.	-	+	-	-	-	-	-	-	-	-
M. acemosus Fresen.	+	+	-	*	-	-	-	-	-	-
Rhizopus nigricans Ehrenb.	-	+	Ao,Rm	*	-	-	-	-	-	-
Syncephalastrum racemosum Cohn ex J. Schröt.	-	+	Ao	-	-	-	-	-	-	-
Ascomycetes										
Aigialus grandis Kohlm. & S. Schatz	-	-	-	-	-	R	R	R	-	-
A. mangrovei Borse	-	-	-	-	-	R	R	-	-	-
A. parvus S. Schatz & Kohlm.	-	-	-	-	-	R	R	R	-	-
Aniptodera chesapeakensis Shearer & M.A. Mill.	-	-	-	-	-	Am, Rm	Rm	-	-	-
Antennospora quadricornuta (Cribb & J.W. Cribb) T.W. Johnson	-	-	-	-	-	-	R	-	-	-
Ascocratera manglicola Kohlm.	-	-	-	-	-	R	R	-	-	-

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

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

F. solani (Mart.) Sacc.	-	-	Rm	-	-	-	-	-	-	-
Graphium penicillioides Corda	-	-	Rm	-	-	-	-	-	-	-
Humicola fuscoatra Traaen	-	-	Rm	*	-	-	-	-	-	-
Memnoniella echinata (Rivolta) Galloway	-	-	Rm	-	-	-	-	-	-	-
Microdochium oryzae (Hashioka & Yokogi) Samuels & I.C. Hallett	-	-	Rm	-	-	-	-	-	-	-
Monodictys levis (Wiltshire) S. Hughes	-	-	Ao,Rm	-	-	-	-	-	-	-
M. pelagica (T. Johnson) E.B.G. Jones	-	-	-	-	-	R	R	R	-	-
Paecilomyces varioti Bainier	-	-	Rm	-	-	-	-	-	-	-
Penicillium expansum Link	-	-	-	*	-	-	-	-	-	-
P. funiculosum Thom	-	-	Ao,Rm	*	-	-	-	-	-	-
P. nigricans K.M. Zalessky	-	-	Ao	-	-	-	-	-	-	-
Periconia prolifica Anastasiou	-	-	-	-	-	Rm	Am,Rm, R,*	Am, Rm	Am, Rm	Am,Rm
Polystigma rubrum (Pers.) DC.	-	-	Ao	-	-	-	-	-	-	-
Sphaeropsis cylindrospora Desm.	-	-	Ao	-	-	-	-	-	-	-
Trichocladium achrasporum (Meyers & R.T. Moore) M. Dixon	-	-	-	-	-	R	R	-	-	-
T. alopallonellum (Meyers & R.T. Moore) Kohlm. & Volkm.-Kohlm.	-	-	-	-	-	R	R	-	-	-
Trichoderma koningii Oudem.	-	-	Ao	-	-	-	-	-	-	-
T. lignorum (Tode) Harz	-	-	Ao	-	-	-	-	-	-	-
T. pseudokoningii Rifai	-	-	Ao,Rm	-	-	-	-	-	-	-
T. viride Pers.	-	-	Ao,Rm	-	-	-	-	-	-	-
Zalerion maritima (Linder) Anastasiou	-	-	-	-	-	Am	Am	-	Am, Rm	Am,Rm
Z. varia 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).

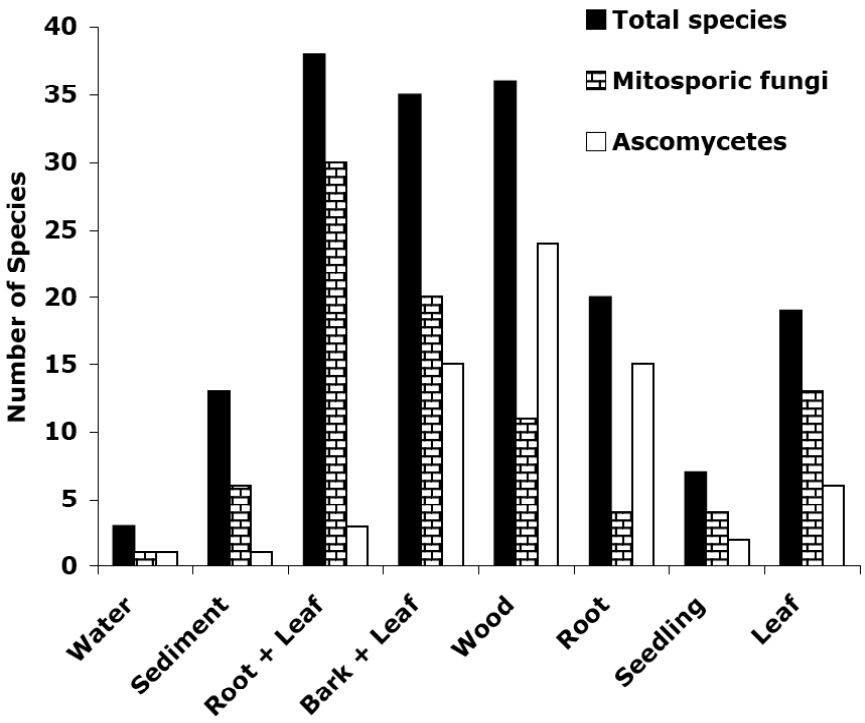

Figure 1. Fungi reported in different niches of Pichavaram mangroves: water, sediment, epiphytes (root + leaf), endophytes (bark + leaf) and saprophytes (wood, root, seedling and leaf)

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 chicklist 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.

References

1. Alongi DM, Tirendi F, Dixon P, Trott LA, Brunskill GJ. Mineralization of organic matter in intertidal sediments of a tropical semi-enclosed delta. Estuarine, Coastal and Shelf Science 1999;48:451-467.
2. Ananda K, Sridhar KR. Diversity of endophytic fungi in the roots of mangrove species on the west coast of India. Canadian Journal of Microbiology 2002;48:871-878.
3. Ananda K, Sridhar KR, Raviraja NS, Baerlocher F. Breakdown of fresh and dried *Rhizophora mucronata* leaves in a mangrove of Southwest India. Wetlands Ecology and Management 2008;16:1-9.
4. Blasco F, Aizpuru M. Classification and evolution of the mangroves of India. Tropical Ecology 1997;38:357-374.
5. Borse BD. Frequency of occurrence of marine fungi from Maharashtra coast, India. Indian Journal of Marine Sciences 1988;17:165-167.
6. Bunt JS. Introduction. In: Robertson AI, Alongi DM, ed. Tropical mangrove ecosystem. American Geophysical Union, Washington DC. 1992: 1-6.
7. Fröhlich J, Hyde, KD. Biodiversity of palm fungi in the tropics: Are global fungal diversity estimates. Biodiversity and Conservation 1999;8:977-1104.
8. Hyde KD, Sarma VV. Pictorial key to higher marine fungi. In: Hyde KD, Pointing SB, ed. Marine Mycology - A Practical Approach. Fungal Diversity Press, Hong Kong. 2000: 205-270.
9. Hyde KD, Jones EBG, Leaãno E, Pointing SB, Poonyth D, Vrijmoed LLP. Role of fungi in marine ecosystems. Biodiversity and Conservation 1998; 7:1147-1161.
10. Kathiresan K. Global biodiversity of mangroves in relation to India. In: Proceedings of UNU International Training Workshop on Methodologies for Assessment of Biodiversity in Estuaries, Mangroves and Coastal Waters. Centre of Advanced Study in Marine Biology, Annamalai University, India. 1999:105-122.
11. Kathiresan K. A review of studies on Pichavaram mangrove, Southern India. Hydrobiologia 2000;430:185-205.
12. Kathiresan K, Bingham BL. Biology of mangroves and mangrove ecosystems. Advances in Marine Biology 2001;40:81-251.
13. Kohlmeyer J, Volkmann-Kohlmeyer B. Illustrated Key to the filamentous higher marine fungi. Botanica Marina 1991;34:1-61.
14. Krishnamoorthy R, Sundaramoorthy S, Mohan D, Gowri DS, Ramchandran S. Status of mangroves along Tamil Nadu coast and their special properties – A remote sensing approach. In: Muralikrishna IV, ed. Remote Sensing and Geographical Information Systems for Environmental Planing. Tata McGraw Hill Publ. Ltd., New Delhi. 1995.
15. Kumar RS. A review of biodiversity studies of soil dwelling organisms in Indian mangroves. Zoos' Print Journal 2000;15:221-227.
16. Kumaresan V, Suryanarayanan TS. Occurrence and distribution of endophytic fungi in a mangrove community. Mycological Research. 2001;105:1388-1391.
17. Kumaresan V, Suryanarayanan TS. Endophyte assemblages in young, mature and senescent leaves of *Rhizophora apiculata*: evidence for the role of endophytes in mangrove litter degradation. Fungal Diversity 2002;9:81-91.
18. Kumaresan V, Suryanarayanan TS, Johnson JA. Ecology of mangrove endophytes. In: Hyde KD, ed. Fungi of Marine Environments. Fungal Diversity Press, Hong Kong. 2002;145-166.
19. Maria GL, Sridhar KR. Diversity of filamentous fungi on woody litter of five mangrove plant species from the southwest coast of India. Fungal Diversity 2003;14:109-126.
20. Maria GL, Sridhar KR, Baerlocher F. Decomposition of dead twigs of *Avicennia officinalis* and *Rhizophora mucronata* in a mangrove in southwest India. Botanica Marina 2006;49:450-455.
21. Muniyandi K. Studies on mangroves of Pichavaram (south-east cost of India). Ph.D. thesis. Annamalai univesity, Parangipettai, India. 1986.
22. Nambiar GR, Ravindran K, Changxing Z, Jaleel CA. A glimpse of lignicolous marine fungi occurring in coastal waterbodies of Tamil Nadu (India). Comptes Rendus Biologies 2008;331:475-480.
23. Natarajan R. The mangroves: a natural, renewable economic resource needs conservation. In: An Anthology of Indian Mangroves. CAS in Marine Biology, ENVIS Centre, Annamalai University, India. 1998;1-6.

24. Qasim SZ, Wafar MVM. Marine resources in the tropics. Resource Management and Optimization 1990;7:141-169.
25. Rajendran N, Kathiresan K. Microbial flora associated with submerged mangrove leaf litter in India. Revista de Biología Tropical 2007;55:293-400.
26. Ravikumar DR, Vittal BPR. Fungal diversity on decomposing biomass of mangrove plant *Rhizophora* in Pichavaram estuary, east coast of India. Indian Journal of Marine Sciences 1996;25:142-144.
27. Robertson AI, Alongi DM, Boto KG. Food chains and carbon fluxes. In: Robertson AI, Alongi DM, ed. Tropical mangrove ecosystems. American Geophysical Union, Washington. 1992:293-329
28. Salique SM, Krishnamurthy K, Palaniappan R. Ecology of fungal population in the Vellar Estuary and Pichavaram mangroves, Southern India. In: Bhosale LJ, ed. The Mangroves. Shivaji University, Kolhapur, India. 1985:153-162.
29. Sarma VV, Vittal BPR. Biodiversity of manglicolous fungi on selected plants in the Godavari and Krishna deltas, east coast of India. Fungal Diversity 2001;6:115-130.
30. Sivakumar A, Kathiresan K. Phylloplane fungi from mangroves. Indian Journal of Microbiology 1990;30:229-231.
31. Spalding MF, Lasco F, Field C. World Mangroves Atlas. Cambridge Samara Publ Co, Cambridge. 1997.
32. Sridhar KR. Mangrove fungi of the Indian Peninsula. In: Sridhar KR, ed. Frontiers in Fungal Ecology, Diversity and Metabolites. IK International Publishing House Pvt Ltd, New Delhi. 2009:28-50.
33. Suryanarayanan TS, Kumaresan V. Endophytic fungi of some halophytes from an estuarine mangrove forest. Mycological Research 2000;104:1465-1467.
34. Suryanarayanan TS, Kumaresan V, Johnson JA. Foilar fungal endophytes from two species of the mangrove *Rhizophora*. Canadian Journal of Microbiology 1998;44:1003-1006.
35. Venkatesan T, Natarajan R. Intertidal mycoflora of Pichavaram mangroves near Porto Novo. In: Bhosale LJ, ed. The Mangroves. Shivaji University, Kolhapur, India. 1985;163-169.

3/27/2009