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Richness and diversity of filamentous fungi on woody litter of mangroves along the west coast of India

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Randomly sampled decaying mangrove woody litter from ten mangroves along the west coast of India were assessed for the assemblage, species richness and diversity of filamentous fungi. Among 1067 wood samples screened, 94% samples consist of sporulating fungi. A total of 78 species belonging to 45 genera comprising 46 ascomycetes, one basidiomycete and 31 deuteromycetes were recovered. *Halocyphina villosa*, *Lignincola laevis*, *Lulworthia grandispora*, *Periconia prolifica*, *Savoryella paucispora*, *Verruculina enalia* and *Zalerion maritimum* were very frequent (>10%). Except for *H. villosa*, the rest of the fungi were common to all the mangrove locations. The mean number of fungi per wood was 2.1 (range, 1.7–2.5), which is similar or higher than those at several mangroves of the Indian Ocean. Simpson and Shannon indices were highest for the mangroves of Honnavar (Karnataka) and Panaji (Goa) (0.971 and 5.087), which coincided with the highest expected number of species (31–32) among 140 random isolations in these mangroves. Fungal assemblage, richness and diversity of the current study have been compared with other mangroves of the Indian coast and the Indian Ocean.

MANGROVE ecosystems generate a large amount of litter in the form of leaves, branches, twigs, inflorescence and other debris. Depending on the mangrove habitat the litter production ranges from 0.011 (Kenya) to 23.69 t $ha^{-1}y^{-1}$ (Australia)[1,2]. The contribution of mangroves is particularly important in clean tropical waters where nutrient levels are usually low[3]. These organic resources ultimately enrich the coastal ecosystem and in turn the fisheries. Dead woody litter provides hostile habitats for a large number of organisms, including fungi. Among 900 known marine fungi, 358 are recorded from the mangrove ecosystem[4,5]. Out of 54 mangrove tree species and 60 mangrove associate plant species, up to 55 species have been studied for fungi[4]. Studies on mangrove fungi from the Indian Ocean are limited compared to the Atlantic Ocean, Pacific Ocean and South-East Asian region. Although the Indian peninsula possesses about 6700 km^2 of mangroves[6], only a few studies dealt with fungal richness and diversity (Gujarat[7,8], Maharashtra[9], Karnataka[10], Tamil Nadu[11], Andhra Pradesh[12,13]). Except for the study by Borse[9], the rest of them are confined to a few mangrove locations and emphasized on the fungal richness on mangrove host plant species. Due to the lack of studies on different mangrove locations of the Indian coast, the present study aims to understand the assemblage, richness and diversity of filamentous fungi on woody litter of ten mangrove locations of the southwest coast of India.

Mangrove woody litter was sampled from ten mangrove locations covering about 625 km (Figure 1). The mangroves surveyed include, Kerala: Valapatna, Kumble and Talapady; Karnataka: Mulky, Kundapura, Honnavar, Gangavali and Karwar; Goa: Panaji; Maharashtra: Malwan. The dominant plant species in these mangroves include: *Acanthus ilicifolius*, *Avicennia alba*, *A. marina*, *A. officinalis*, *Bruguiera gymnorrhiza*, *Clerodendron* spp., *Cyperus* spp., *Derris triflorum*, *Rhizophora apiculata*, *R. mucronata*, *Sonneratia alba* and *S. caseolaris*.

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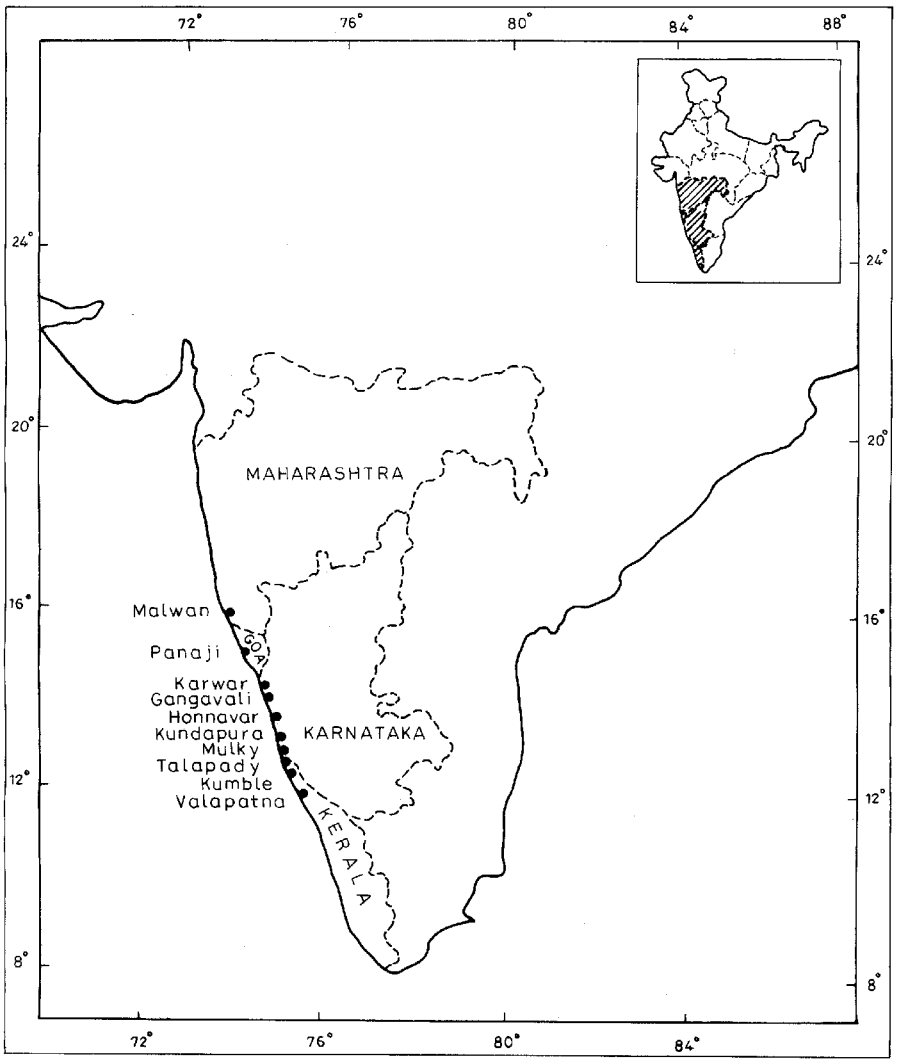

Figure 1. Map showing ten mangrove sampling locations along the west coast of India.

Moderately decomposed, entrapped wet mangrove twigs and branches of more or less uniform size were randomly collected from 0.25 km^2 area of each mangrove location during February to May 2001 (summer). The tidal waters were assessed for temperature and salinity during sampling. Wood samples were transported to the laboratory in sterile polythene bags. Samples of about 2 cm diameter were selected and they were trimmed to 20 cm length. Each wood was screened for the presence of fungal structures within a week of sampling. Later, each wood was incubated (25 ± 2°C) separately in sterile polythene bags containing sterile sand bath wetted with sterile dilute sea water (17‰). The wood samples were screened once a month up to six months to detect the fungi growing on them. The sand bath was re-wetted with sterile distilled water once every two weeks. The fungi grown on the wood were identified by appropriate taxonomic keys[14–16].

At the end of six months, mean number of fungi per wood sample was determined based on the number of wood samples colonized by fungi and total fungal isolations per location, so also the per cent frequency of occurrence of fungi:

$$\text{Mean number of fungi per sample} = \frac{\text{Total number of fungal isolations}}{\text{Number of wood samples with sporulating fungi}}.$$

$$\text{Frequency of occurrence (\%)} = \frac{\text{No. of wood samples colonized by a specific fungus}}{\text{No. of wood samples with sporulating fungi}} \times 100.$$

The diversity of fungi on the woody litter of ten mangroves was assessed based on the diversity indices:

Simpson Index, $D' = \frac{1}{\sum (p_i)^2}$,

and

Shannon Index, $H' = -\Sigma(p_i \ln p_i)$,

where p_i is the proportion of individuals that species i contributes to the total[17].

The Shannon Evenness, J', was expressed by:

$$J' = \frac{H'}{H'_{\max}},$$

where $H'_{\max}$ is the maximum value of diversity for the number of species present[18].

To compare the fungal species richness among the wood samples of each location with unequal number of samples and isolations, rarefaction indices were calculated[19]. The expected number of fungal species, $E(s)$, in a random sample of n isolations taken from a total population of N isolations was estimated using the formula:

$$E(s) = \sum_{i=1}^{s} \left\{ 1 - \left[\binom{N - n_i}{n} \Big/ \binom{N}{n} \right] \right\},$$

where n_i is the number of isolations of the ith species.

Table 1 shows the overall trend of fungal assemblage on woody debris of ten mangrove locations. Among 1067 intertidal wood samples assessed, 93.8% showed fungal colonization. The extent of colonization ranged from 77.6% (Panaji) to 98.1% (Kumble and Kundapura). Mean isolations of fungi per location were 205.4 [range: 142 (Panaji) to 261 (Kumble)]. Number of fungi recovered per wood sample was 2.1 [(range: 1.7 (Panaji) to 2.5 (Kumble)]. Mean number of fungi per location was 30.9 [(range: 26 (Karwar) to 34 (Honnavar and Panaji)]. Altogether 78 fungi (including 7 unknown morphotypes) belonging to 45 genera comprising 46 ascomycetes, one basidiomycete and 31 deuteromycetes were recovered.

Table 1. Details of sampling and occurrence of filamentous fungi on mangrove woody substrates in ten locations of the west coast of India

	Mean ± SD (n = 10)	Range
Water temperature (°C)	32.1 ± 1.4	30–34.5
Water salinity (‰)	28.7 ± 5.3	15.2–33.2
Number of wood samples incubated	106.7 ± 3.4	101–112
Per cent wood colonized	93.8 ± 5.9	77.6–98.1
Total fungal isolations	205.4 ± 31.7	142–261
Number of fungi per wood sample	2.1 ± 0.2	1.7–2.5
Total number of fungi recovered	30.9 ± 2.8	26–34
Ascomycetes	20.5 ± 2.8	16–24
Basidiomycetes	0.9 ± 0.3	0–1
Deuteromycetes	9.5 ± 3.1	4–13

See text for mangrove locations; Sampling period: Summer, 2 February–21 May 2001.

Table 2 indicates the occurrence of fungi in different mangroves, range and total per cent frequency of occurrence of each fungus in mangroves of the west coast of India. Seven fungi were very frequent (>10%): *Lignincola laevis* (17%), *Lulworthia grandispora* (18.4%), *Savoryella paucispora* (11.2%), *Verruculina enalia* (16.5%), *Halocyphina villosa* (13.7%), *Periconia prolifica* (15.4%) and *Zalerion maritimum* (10.1%), and were considered as 'core-group fungi'. Except for *H. villosa*, the rest of the fungi were common to all the mangrove locations. Although *Leptosphaeria australiensis* was common to all mangroves, it was not very frequent (<10%). Six frequent fungi (5–10%) include *Aniptodera indica* (7.2%), *Aniptodera mangrovei* (9.9%), *Halorosellinia oceanica* (5%), *L. australiensis* (7%), *Lignincola longirostris* (5.3%) and *Cirrenalia pygmea* (7.1%). Altogether 19 fungi belonging to the core group (>10%) were confined at least to any one of the mangroves (Table 2). Number of core-group fungi was highest (9) at Kumble and Karwar mangroves and lowest (4) at Honnavar and Panaji (Table 3). Number and mean per cent frequency of occurrence of ascomycetes, basidiomycete and deuteromycetes have been plotted in Figure 2. Among 46 ascomycetes recovered, highest number (24)

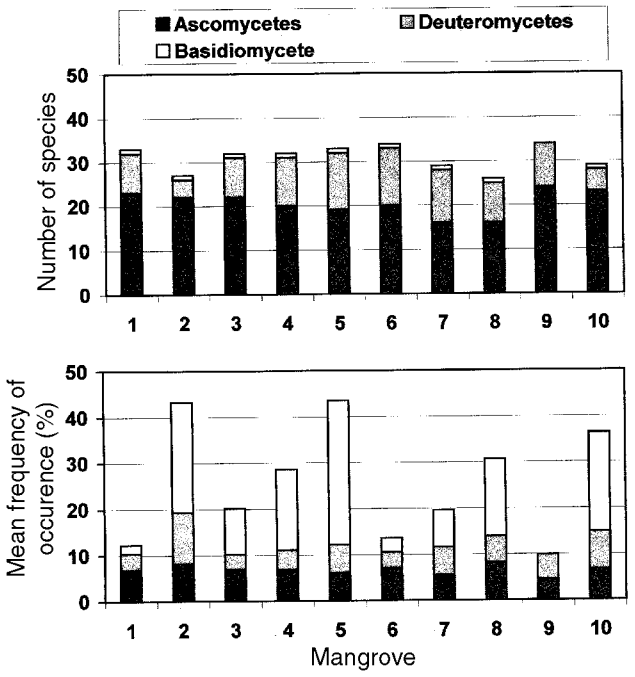

Figure 2. Number of species and mean per cent frequency of occurrence of fungi in different mangroves along the west coast of India (Mangroves: 1, Valapatna; 2, Kumble; 3, Talapady; 4, Mulky; 5, Kundapura; 6, Honnavar; 7, Gangavali; 8, Karwar; 9, Panaji and 10, Malwan).

Table 2. Frequency of occurrence of filamentous fungi on mangrove woody substrates in ten locations of the west coast of India

Fungus	Mangrove location	Range of frequency of occurrence (%)	Total frequency of occurrence (%)
Ascomycotina			
Aigialus parvus Schatz *et* Kohlm.	10	0–0.9	0.1
Aniptodera chesapeakensis Shearer *et* Miller	1–3, 6, 9, 10	0–4.8	2.0
A. indica Ananda *et* Sridhar	2–10	0–12.9	7.2
A. mangrovei Hyde	1–5, 7, 9, 10	0–28	9.9
Aniptodera sp.	1–3, 6, 9	0–3.7	1.4
Ascocratera manglicola Kohlm.	2, 5	0–1	0.2
Ceriosporopsis sundica Koch *et* Jones	6	0–2	0.2
Corollospora maritima Werdermann	1, 2, 7	0–12	1.4
C. pulchella Kohlm., Schmidt *et* Nair	2, 7–10	0–4.9	1.4
Dactylospora haliotrepha (Kohlm. *et* Kohlm.) Hafellner	1, 2, 4–7, 9, 10	0–14	4.7
Didymella avicenniae Patil *et* Borse	5, 10	0–3.1	0.4
Eutypa bathurstensis Hyde *et* Rappaz	1, 5, 9	0–3.7	0.6
Halorosellinia oceanica (Schatz) Whalley, Jones, Hyde *et* Laessøe	1, 4–6, 8, 10	0–26.5	5.0
Halosarpheia abonnis Kohlm.	3	0–1	0.1
H. cincinnatula Shearer *et* Crane	2–4, 6, 8–10	0–13.9	3.4
H. fibrosa Kohlm. *et* Kohlm.	3, 6, 10	0–1.9	0.4
H. marina (Cribb *et* Cribb) Kohlm.	1, 3	0–4	0.6
H. ratnagiriensis Patil *et* Borse	1–5, 8–10	0–7.5	3.0
H. retorquens Shearer *et* Crane	1, 4	0–1	0.2
Hypoxylon sp.	3	0–2	0.2
Kallichroma tethys (Kohlm. *et* Kohlm.) Kohlm. *et* Volkm.-Kohlm.	1, 6, 9	0–1.2	0.3
Lautospora gigantea Hyde *et* Jones	1	0–0.9	0.1
Leptosphaeria australiensis (Cribb *et* Cribb) Hughes	**1–10**	1.9–20.5	7.0
L. pelagica Jones	4, 8	0–3	0.5
****Lignincola laevis*** Höhnk	**1–10**	7.5–36.5	**17.0**
L. longirostris (Cribb *et* Cribb) Kohlm.	1–3, 7, 9	0–37.4	5.3
L. tropica Kohlm.	1, 3, 6	0–2.8	0.6
Lophiostoma mangrovei Kohlm. *et* Vittal	2, 4–7, 9, 10	0–2	1.0
****Lulworthia grandispora*** Meyers	**1–10**	2.8–44.9	**18.4**
L. kniepii Kohlm.	2, 8	0–2	0.3
L. lindroidea Kohlm.	4	0–1	0.1
Lulworthia sp. (350–450 µm)	3–10	0–12	3.2
Massarina velatospora Hyde *et* Borse	4, 9	0–2.4	0.3
Passeriniella mangrovei Maria *et* Sridhar	1	0–1.9	0.2
Rhizophila marina Hyde *et* Jones	3–7, 9	0–8.2	2.3
Savoryella lignicola Jones *et* Eaton	1–3, 5, 6, 8–10	0–10	3.6
S. longispora Jones *et* Hyde	2–4	0–3.9	0.5
****S. paucispora*** (Cribb et Cribb) Koch	**1–10**	1.2–28	**11.2**
Tirispora sp.	1, 3–5, 7–10	0–13	4.8
Torpedospora radiata Meyers	9	0–6	0.5
****Verruculina enalia*** (Kohlm.) Kohlm. *et* Volkm.-Kohlm.	**1–10**	2–31.1	**16.5**
Ascomycete sp. 1	1, 7	0–2.8	0.4
Ascomycete sp. 2	2, 9, 10	0–3.9	0.7
Ascomycete sp. 3	10	0–1.8	0.4
Ascomycete sp. 4	5, 6, 8, 10	0–3	1.2
Ascomycete sp. 5	2	0–2.9	0.3
Basidiomycotina			
**Halocyphina villosa* Kohlm. *et* Kohlm.	1–8, 10	0–31.4	**13.7**
Deuteromycotina			
Alternaria sp.	1, 3, 5	0–1.9	0.4
Aspergillus sp.1	7, 9, 10	0–4.8	0.8

Contd...

Table 2. *Contd...*

Fungus	Mangrove location	Range of frequency of occurrence (%)	Total frequency of occurrence (%)
Aspergillus sp. 2	8, 9	0–8.4	1.0
Camposporium sp.	6	0–1	0.1
Cirrenalia macrocephala (Kohlm.) Meyers *et* Moore	4, 7	0–1	0.2
C. pygmea Kohlm.	4, 5, 7, 10	0–32	7.1
C. tropicalis Kohlm.	3, 5–8	0–3	1.0
Clavataspora bulbosa (Anast.) Nakagiri *et* Tubaki	5, 7–9	0–2.4	0.7
Cytospora rhizophorae Kohlm. *et* Kohlm.	1–3, 9	0–2.8	0.7
Endophragmia sp.	5	0–1	0.1
Fusarium sp.	1, 6	0–3.1	0.4
Monodictys pelagica (Johnson) Jones	9	0–1.2	0.1
M. putredinis (Wallr.) Hughes	6	0–2	0.2
Penicillium sp. 1	3	0–2	0.2
Penicillium sp. 2	6, 9	0–1.2	0.2
****Periconia prolifica*** Anast.	**1–10**	2.9–26.3	**15.4**
Phaeoisaria clematides (Fuckel) Hughes	3, 6	0–7.1	0.8
Phialophora sp.	1	0–1.9	0.2
Phoma sp. 1	4, 5, 7	0–6.9	1.3
Phoma sp. 2	1, 4	0-1.9	0.3
Sporidesmium sp. 1	6	0–2	0.2
Sporidesmium sp. 2	4, 5	0–2.9	0.4
Sporoschima sp.	6	0–2	0.2
Tetraploa aristata Berk. *et* Br.	3	0–1	0.1
Trichocladium achrasporum (Meyers *et* Moore) Dixon	1, 4, 5, 7, 8	0–9.8	2.5
T. alopallonellum (Meyers *et* Moore) Kohlm. *et* Volkm.-Kohlm.	4, 7, 9	0–3.6	0.6
T. linderi Crane *et* Shearer	1, 5, 6	0–1	0.3
****Zalerion maritimum*** (Linder) Anast.	**1–10**	3–32.7	**10.1**
Z. varium Anast.	2–10	0–9.2	4.2
Coelomycete sp. 1	4, 5, 7, 8	0–3	0.7
Coelomycete sp. 2	6, 8	0–1	0.2

Mangrove location: Kerala – 1, Valapatna; 2, Kumble; 3, Talapady; Karnataka – 4, Mulky; 5, Kundapura; 6, Honnavar; 7, Gangavali; 8, Karwar; Goa – 9, Panaji; Maharashtra – 10, Malwan; Fungi recovered in all locations are indicated in bold face; *Core-group fungi: Total frequency of occurrence ≥ 10%.

was found at Panaji, while it was least (16) at Gangavali and Karwar. Among 31 deuteromycetes, the highest number (13) was found at Kundapura and Honnavar, while the least (4) at Kumble. The overall mean per cent frequency of occurrence was highest at Kundapura and least at Panaji.

Table 3 provides the species richness and diversity of fungi at ten mangrove locations. Both Simpson and Shannon indices were highest at two mangroves, i.e. Honnavar and Panaji (0.971 and 5.087 respectively). The highest diversity coincided with the observed species richness (34) as well as expected number of species (31–32) in these mangroves. The Shannon Evenness was least, 0.815 at Honnavar, while it was 0.867 at Panaji. Karwar mangrove showed least Simpson Index (0.962) and Shannon Index (4.700); so also observed least species richness (26). Figure 3 shows the rarefaction curves for ten mangrove locations. It clearly shows that the mangrove Kumble consists of the least expected number of species than other mangroves (19 vs 24–32) out of 140 fungal isolations.

Early investigations on mangrove fungi were confined to the taxonomy and floristics of different regions[20]. After 1980, some studies initiated providing information on fungal frequency of occurrence, zonation, host/substrate specificity and succession/seasonal periodicity[20]. Record of frequency of occurrence of fungi found in mangroves will help establish the most common fungi in a specific geographical area[13]. It is evident that among several species in a community, relatively a few exert major influence by virtue of their size, number or activity[21]. Hence fungi with a frequency of occurrence > 10% are important in the mangrove ecosystem and are considered as 'core-group fungi'.

The frequency of occurrence of fungi depends on the sample size. Based on analysis of a large published data

Table 3. Species richness, diversity and evenness of filamentous fungi recovered from ten mangroves of west coast of India

Mangrove	Species richness			Diversity indices		Shannon Evenness (J')
	Species recovered	$E(s)(140)$*	Core-group fungi**	Simpson (D')	Shannon (H')	
Kerala						
Valapatna	33	30	5	0.970	5.044	0.830
Kumble	27	19	9	0.963	4.755	0.848
Talapady	32	29	6	0.969	5.000	0.832
Karnataka						
Mulky	32	29	7	0.969	5.000	0.873
Kundapura	33	28	5	0.970	5.044	0.843
Honnavar	34	31	4	0.971	5.087	0.815
Gangavali	29	27	5	0.966	4.858	0.825
Karwar	26	25	9	0.962	4.700	0.914
Goa						
Panaji	34	32	4	0.971	5.087	0.867
Maharashtra						
Malwan	29	24	7	0.966	4.858	0.804
Mean ± SD (n = 10)	30.9 ± 2.8	27.4 ± 3.7	6.1 ± 1.9	0.968 ± 0.003	4.943 ± 0.133	0.845 ± 0.031

*Expected number of species: $E(s)(140)$, out of 140 random fungal isolations based on rarefaction index; **Core-group fungi: frequency of occurrence ≥ 10%.

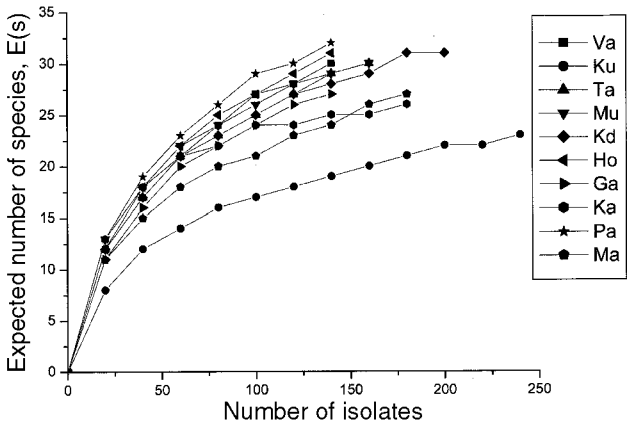

Figure 3. Rarefaction curves of expected number of species of fungi, $E(s)$, from random isolations (Mangroves: Va, Valapatna; Ku, Kumble; Ta, Talapady; Mu, Mulky; Kd, Kundapura; Ho, Honnavar; Ga, Gangavali; Ka, Karwar; Pa, Panaji; and Ma, Malwan).

on mangrove fungi, Sarma and Hyde[20] recommended a sample size between 540 and 1060 for a reasonable assessment of mycoflora of mangroves. In the present study, 1067 wood samples were assessed; possibly this might be the main cause for obtaining diverse mycoflora and additional core-group fungi. However, despite a large number of samples analysed by Ravikumar and Vittal[11] (seedlings of *Rhizophora* spp., 616; prop roots of *Rhizophora* spp., 1658) from Pichavaram mangrove, east coast of India, they found only four core group fungi (Table 4). Sarma and Hyde[20], based on a review of the literature found that *Antennospora quadricornuta*, *Dactylospora haliotrepha*, *Eutypa bathurstensis*, *H. villosa*, *H. oceanica*, *H. marina*, *Kallichroma tethys*, *L. australiensis*, *Lophiostoma mangrovei*, *L. grandispora*, *Rhizophila marina*, *Savoryella longispora* and *V. enalia* are core-group fungi (> 10%) in the mangroves of the Indian Ocean. In the present study also *L. grandispora*, *H. villosa* and *V. enalia* were core-group fungi. Besides these, *L. laevis* (17%), *S. paucispora* (11.2%), *P. prolifica* (15.4%) and *Z. maritimum* (10.1%) were new core-group fungi to the Indian Ocean. So far, from the main coast of India, *Aigialus grandis*, *A. parvus*, *A. indica*, *C. pygmea*, *D. haliotrepha*, *E. bathurstensis*, *Julella avicenniae*, *L. mangrovei*, *R. marina*, *S. lignicola* and *V. enalia* were recorded as core-group fungi (Table 4). The present study added *H. villosa*, *L. grandispora*, *L. laevis*, *P. prolifica*, *S. paucispora* and *Z. maritimum* as additional core-group fungi to the Indian mangroves.

The mean number of fungi per sample is one of the important yardsticks to compare different mangrove locations or substrates. In the present study, the mean number of fungi per wood sample was 2.1 (range 1.7–2.5). This is higher than that of other mangrove locations (e.g. Gujarat, 1; Maharashtra, 1; Karnataka, 1.3; Seychelles, 1.5; Andaman and Nicobar Islands, 1.5; Hong Kong, 1.2–1.7; Mauritius, 1.1–1.4)[22–25] (see Table 4). However, the mean fungi per wood sample in the present study (2.1) is lower than those in Mandai mangrove (2.2)[26] and Malaysian

Table 4. Core-group fungi (frequency of occurrence ≥ 10%) on mangrove woody litter of Indian coast

Mangrove	Nature of sample	Sample size	Core-group fungi (%)	Number of fungi/sample	Reference
West coast (Gujarat)	Wood *Avicennia marina* *Ceriops tagal* *Rhizophora mucronata*	235	*Julella avicenniae* (21.7)	1	8
Pirotan Island (Gujarat)	Mixed wood	150	*Aigialus parvus* (11.3) *J. avicenniae* (13.3)	1	7
West coast (Maharashtra)	Mixed wood	235	Nil	1	9
St. Mary's Island (Karnataka)	Mixed wood	62	*Aniptodera indica* (14.5) *Sovoryella lignicola* (11.3)	1.3	10
West coast (Maharashtra, Goa, Karnataka, Kerala)	Mixed wood	1067	*Lulworthia grandispora* (18.4) *Lignincola laevis* (17) *Verruculina enalia* (16.5) *Periconia prolifica* (15.4) *Halocyphina villosa* (13.7) *Savoryella paucispora* (11.2) *Zalerion maritimum* (10.1)	2.1	Present study
Pichavaram (Tamil Nadu)	Wood *Rhizophora* spp.	103	*Lophiostoma mangrovei* (35.9) *V. enalia* (26.2)	?	11
	Prop roots *Rhizophora* spp.	1658	*V. enalia* (36.3) *L. mangrovei* (12.7)	?	
	Seedlings *Rhizophora* spp.	616	*V. enalia* (23.1) *Aigialus grandis* (12.2) *Cirrenalia pygmea* (12) *L. mangrovei* (10.2)	?	
Krishna (Andhra Pradesh)	Wood *R. apiculata*	?	*V. enalia* (11.6) *Dactylospora haliotrepha* (11.4)	?	31
	Wood *Avicennia* spp.	?	*V. enalia* (22.7) *Eutypa bathurstensis* (22.3)	?	
Godavari (Andhra Pradesh)	Wood *R. apiculata*	?	*V. enalia* (17.1) *C. pygmea* (11.1) *Rhizophila marina* (10.4)	?	31
	Wood *Avicennia* spp.	? ?	*V. enalia* (25.1) *E. bathurstensis* (23.3)	?	

?, not defined.

mangrove (3.3)[27]. The decline in the mean fungi per sample could be due to the dominance of one or two fungi, and they may exert antagonistic effect on the development of other species[28]. Tan *et al.*[29] found some evidence that *A. parvus* and *V. enalia* suppress *L. laevis* in co-culture, while *L. laevis* enhances ascomata formation in association with *V. enalia*. *A. parvus* is known to generate a number of bioactive compounds (e.g. antibiotic: hypothemycin)[30]. Thus, production of such compounds interferes with the assessment of fungal diversity on mangrove substrates. In the present study, relatively low number of fungi was recovered from Karwar (26) and Kumble (27) mangroves. In these mangroves the core-group fungi were higher than other mangroves (9 vs 4–7; Table 4). This supports the concept of interference competition by core-group fungi, which might have resulted in relatively low fungal richness in some mangroves.

Although the number of species recovered was highest at Honnavar and Panaji (34), the mean frequency of occurrence of fungi was lowest in Panaji (9.9%) and slightly high in Honnavar (13.4%; Figure 2). On the contrary, the mangroves with low species richness such as Karwar (26) and Kumble (27) showed elevated mean frequency of occurrence (30.7 and 43.3% respectively). However, in mangrove Kundapura, the high species richness (33) was associated with high mean frequency of occurrence (43.6%). It is interesting to note the exceptionally high frequency of occurrence of *H. villosa* at the mangroves of Kundapura (31.4%), Kumble (24%) and

Malwan (21.5%). Among the mangroves, the expected number of species (out of 140 random isolations) was lowest in Kumble (19) and slightly more in Karwar (25) (Table 3; Figure 3). However, the Simpson Index was relatively high (0.962–0.963), while Shannon Index was relatively low (4.700–4.755). Human interference such as pollution and mangrove clearing activities might be the possible reasons for low species richness and diversity in these mangroves.

Diverse filamentous fungi were recovered on the woody litter of ten mangroves along the southwest coast of India (78 fungi belonging to 45 genera comprising 46 ascomycetes, one basidiomycete and 31 deuteromycetes). Species richness and diversity were highest in Honnavar (Karnataka) and Panaji (Goa) mangroves. Analysis of substantial number of wood samples (1067) added four more core-group fungi (> 10%; *L. laevis*, *P. prolifica*, *S. paucispora* and *Z. maritimum*) to the mangroves of the Indian Ocean. The mean number of fungi per sample (2.1; range, 1.7–2.5) is equal to or higher than those at several mangroves of the Indian Ocean. This reveals a reasonable assessment of mangrove fungal richness and diversity of the west coast of India in the present study.

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Trapped pollen and spores from spider webs of Lucknow environs

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Study of pollen and spores retrieved from the spider webs provides interesting new frontiers to evaluate the aerospora of a region. Such studies carried out for Lucknow environs have yielded a variety of palynomorphs such as pollen grains and fungal spores besides insect body fragments, etc. These studies are of immense significance to understand the aerospora for meaningful comparison with the data on the differential pollen dispersal and deposition in a particular region, generated through other conventional methods, viz. pollen catchers, moss cushions, etc.

VARIOUS techniques to study the aerospora using pollen-catching devices and the study of pollen deposition

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