Abundance and diversity of marine fungi on intertidal woody litter of the West Coast of India on prolonged incubation

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Intertidal wood was collected from four coastal locations of the west coast of India during the post-monsoon season over two consecutive years. Samples were assessed for occurrence of filamentous marine fungi at different intervals of incubation in the laboratory (0, 2, 6, 12 and 18 months). Of the 59 taxa identified, 43 were ascomycetes, three basidiomycetes and 13 anamorphic fungi. Six months incubation yielded up to 66% of the total taxa encountered. The taxa found exclusively during specific incubation periods were highest during the 6 or 12 months incubation. Overall, *Torpedospora radiata* was the predominant fungus (11.6-21.5%), while *Aniptodera chesapeakensis, Antennospora quadricornuta, Caryosporella rhizophorae, Corollospora intermedia, C. maritima, Crinigera* sp., *Dictyosporium pelagicum, Didymosphaeria* sp., *Halocyphina villosa, Periconia prolifica* and *Zalerion varium* were frequent (>5%). These fungi attained the highest frequency of occurrence following 12 or 18 months of incubation period. Fungal richness and diversity were highest following six months of incubation. The decrease in the Jaccard's similarity index from two months to 18 months of incubation indicates that additional taxa occur on prolonged incubation. Incubation of intertidal wood of tropical beaches up to 18 months appear to be adequate period for reasonable assessment of marine fungal diversity.

Key words: beaches, diversity, incubation, India, marine fungi, species richness, woody litter,

Introduction

Studies on marine and mangrove fungi of Indian Ocean is quite recent and has been less well explored compared to the Atlantic and Pacific Oceans (e.g. Koch, 1986; Borse, 1988; Zainal and Jones, 1986; Hyde, 1988; Steinke and Jones, 1993). Although Indian sandy beaches, mainland mangroves and some islands have been studied for mangrove and marine fungi, there are few quantitative studies (Borse, 1988; Ravikumar and Vittal, 1996; Prasannarai and

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Sridhar, 1997, 2000-2001, 2001; Sarma and Vittal, 2000, 2001; Sarma *et al*., 2001; Maria and Sridhar, 2002). Recently, Jones (2000) reviewed the factors influencing the diversity of marine fungi and considered the period of incubation of woody substrata as one of the important factors in fungal assessment, while Sarma and Hyde (2001) have reviewed factors affecting the frequency of occurrence of fungi in mangroves. A few studies are available on the impact of incubation of lignocellulosic materials collected from different habitats on the occurrence of fungi (Hyde, 1992; Prasannarai and Sridhar, 1997). Hence, in the present study, intertidal woody litter collected from four locations on the west coast of India over two successive years were assessed for the biodiversity and frequency of occurrence of filamentous marine fungi following incubation over 18 months.

Materials and Methods

Sampling stations

Four sampling stations along the west coast of India were selected for the survey (Fig. 1). The first sampling station Bambolim (Goa) has shallow water and is partly sandy with laterite rocks. Vegetation mainly consists of coconut palms. Plenty of wood was trapped in the crevices of the rocks. The sampling station at Karwar (Karnataka) is a steep sandy shore with sparse vegetation, and a large quantity of driftwood had accumulated at the high-tide region. The third sampling station Kovalam (Kerala), is mainly a vast shallow sandy shore with abundant intertidal driftwood. A coconut plantation exists adjacent to the beach. The sampling site at Kanyakumari (Cape Comorin, Tamil Nadu), at the southern tip of the Indian peninsula comprises mainly steep sandy shores, although some parts are rocky with sparse vegetation. To prevent shore erosion by waves, walls have been built with granite boulders. This site water was contaminated with oil and grease due to the frequent visits of pilgrims to the Vivekananda Rock Memorial, which is situated about 200 m away from the shore. Intertidal wood was rare on the beach, but was found trapped among the granite boulders.

Incubation and observation of intertidal wood

Intertidal wood accumulated at the mid-tide beaches were collected during the month of November (post-monsoon season), 1992 and 1993 were returned to the laboratory. Samples of uniform diam. (about 1.5 cm) were selected, cut into 18 cm lengths and screened for fungal structures within 24-72 hours. One hundred wood samples were assessed from four sampling sites per

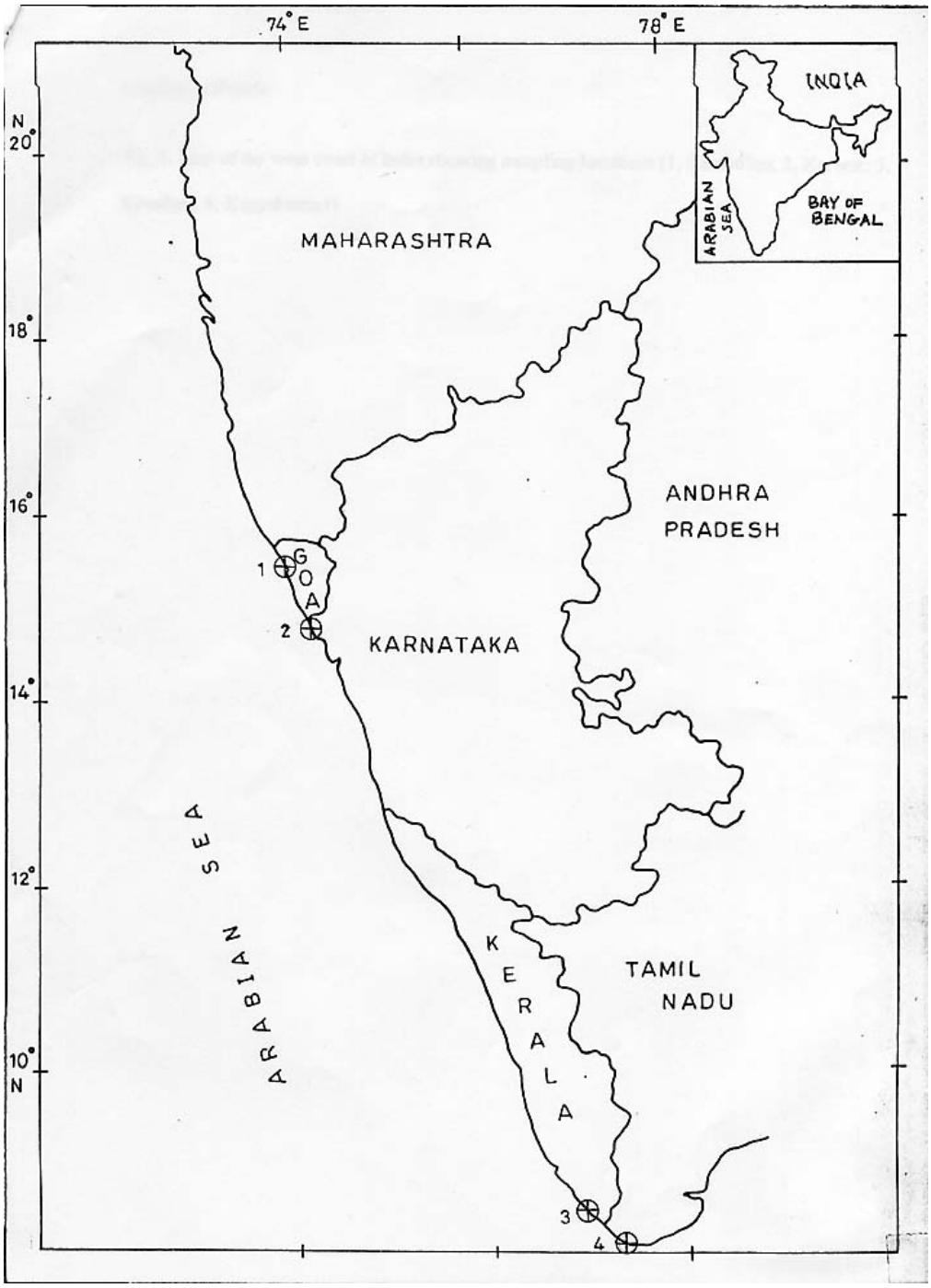

Fig. 1. Map of the west coast of India showing sampling locations **1.** Bambolim, **2.** Karwar, **3.** Kovalam, **4.** Kanyakumari.

Table 1. Occurrence of marine fungi on driftwood collected from four locations (100 wood samples per location) of the west coast of India during November (post-monsoon season) of 1992 and 1993 (n = 4, mean ± SE; range in parenthesis).

	1992	**1993**
Number of driftwood samples examined	100 ± 0	100 ± 0
Percent wood colonized	47.5 ± 4.5 (37-60)	71 ± 6.4 (60-91)
Number of fungal taxa per wood	1.4 ± 0.1 (1.3-1.8)	1.3 ± 0.1 (1.1-1.4)
Total number of fungal taxa per location	20 ± 0.6 (18-21)	13.5 ± 1.2 (11-17)

year. Altogether 800 wood samples were assessed. Each sample was separately incubated beneath fluorescent light (24-32ºC) in airtight polythene bags with sterile sand moistened with sterile seawater (34‰). The sand was re-wetted with sterile distilled water every month. Each sample was examined for fungi periodically at the end of 2, 6, 12 and 18 months of incubation. Fungi were identified using mainly the keys by Kohlmeyer (1984) and Kohlmeyer and Volkmann-Kohlmeyer (1991). Details of analysis are given in Maria and Sridhar (2002).

Results

Occurrence of fungi

Table 1 shows the number of wood samples examined, percentage of wood colonized, the number of fungi per wood sample and the total numbers of fungal taxa recovered during two successive years. On scanning one hundred intertidal wood samples per location, fungal colonization varied between 37 and 91%, the mean number of taxa per sample was 1.1-1.8 and ranged from 11 to 21 per location. Table 2 shows the frequency of occurrence and relative abundance of marine fungi on driftwood at each location over two years. Out of 59 taxa recovered, 43 were ascomycetes, three were basidiomycetes and 13 were anamorphic taxa. No basidiomycetes were recorded from Kanyakumari, while one or two basidiomycetes were found from the other locations. The most frequent (>5%) fungi were *Aniptodera chesapeakensis* (5.6-10.5%), *Antennospora quadricornuta* (6.7-16.3%), *Caryosporella rhizophorae* (0-7.9%), *Corollospora intermedia* (0-14.8%), *Corollospora maritima* (0-18%), *Crinigera* sp. (3.2-10.9%), *Dictyosporium pelagicum* (0-7.4%), *Didymosphaeria* sp. (9.2-10%), *Periconia prolifica* (1.4-12.1%), *Torpedospora radiata* (11.6-21.5%) and *Zalerion varium* (1.1-6.8%).

Table 2. Frequency of occurrence and relative abundance of marine fungi on driftwood at different locations of the west coast of India collected during 1992 and 1993 (in parenthesis) (fungus not recovered in all locations during a particular year has not been represented).

Fungi	Frequency of occurrence (%)[a] Locations[c]				Total frequency occurrence[a] (%)	Relative abundance[b] (%)
	Bam	Kar	Kov	Kan		
Ascomycotina						
Torpedospora radiata Meyers	3.3 (0	8.1 0	34.1 5	5.8 63.7)	11.6 (21.5)	8.1 (17.3)
Antennospora quadricornuta (Cribb & J.W. Cribb) T.W. Johnson	3.3 (0	16.2 24.7	39 1.7	13.5 0)	16.3 (6.7)	11.4 (5.4)
Didymosphaeria sp.	30 (43.3	2.7 0	0 0)	0	10 (9.2)	7 (7.4)
Corollospora maritima Werderm.	(20	12.3	20	19.8)	(18)	(14.5)
Aniptodera chesapeakensis Shearer & M.A. Miller	23.3 (20	2.7 5.5	0 0	9.6 0)	10.5 (5.6)	7.3 (4.5)
Corollospora intermedia I. Schmidt	(3.3	32.9	26.7	0)	(14.8)	(11.9)
Crinigera sp.	0 (6.7	0 37	14.6 0	0 0)	3.2 (10.9)	2.2 (8.8)
Caryosporella rhizophorae Kohlm.	11.7	0	19.5	0	7.9	5.5
Lulworthia sp. 1 (147-235 × 2.5 μm)	0 (0	0 0	0 0	17.3 4.4)	4.7 (1.4)	3.3 (1.1)
Lulworthia sp. 3 (255-295 × 2-2.5 μm)	3.3 (0	0 0	0 0	11.5 3.3)	4.2 (1.1)	2.9 (0.9)
Corollospora colossa Nakagiri & Tokura	0 (0	0 0	2.4 10	1.9 2.2)	1.1 (2.8)	0.7 (2.3)
Corollospora filiformis Nakagiri	(0	1.4	16.7	0)	(3.9)	(3.1)
Corollospora quinqueseptata Nakagiri	(0	2.7	15	0)	(3.9)	(3.1)
Lulworthia sp. 2 (245-372 × 2.5 μm)	8.3 (3.3	0 0	0 0	0 0)	2.6 (0.7)	1.8 (0.6)
Halorosellinia oceanica Whalley, E.B.G. Jones, K.D. Hyde & Laessøe	1.7 (1.7	2.7 0	0 0	0 5.5)	1.1 (2.1)	0.7 (1.7)
Dactylospora haliotrepha (Kohlm. & E. Kohlm.) Hafellner	0 (11.7	0 0	0 0	2.4 0)	0.5 (2.5)	0.4 (2)
Aniptodera longispora K.D. Hyde	3.3 (0	2.7 2.7	2.4 0	0 0)	2.1 (0.7)	1.5 (0.6)
Corollospora angusta Nakagiri & Tokura	(0	4.1	8.3	0)	(2.8)	(2.3)
Lulworthia sp. 4 (274-333 × 2.5 μm)	6.7 (1.7	0 0	0 0	0 0)	2.1 (0.4)	1.5 (0.3)
Carbosphaerella leptosphaerioides I. Schmidt	0	0	0	7.7	2.1	1.5

Table 2 (continued)

Halosarpheia viscosa (I. Schmidt) Shearer & J. Crane	0 (0	2.7 0	0 0	0 4.4)	0.5 (1.4)	0.4 (1.1)
Aniptodera sp. (22.5-25 × 7.5-10 μm)	0	0	7.3	0	1.6	1.1
Antennospora salina (Meyers) Yusoff, E.B.G. Jones & S.T. Moss	1.7	0	2.4	1.9	1.6	1.1
Lineolata rhizophorae (Kohlm. & E. Kohlm.) Kohlm. & Volkm.-Kohlm.	0	2.7	4.9	0	1.6	1.1
Didymosphaeria sp. (16.5-22.5 × 7.5-10 μm)	(0	2.7	0	2.2)	(1.4)	(1.1)
Verruculina enalia (Kohlm.) Kohlm. & Volkm.-Kohlm.	(6.7	0	0	0)	(1.4)	(1.1)
Halosarpheia ratnagiriensis Patil & Borse	(3.3	0	0	0)	(0.7)	(0.6)
**Corollospora* sp. (27.5-32.5 × 6-7.5 μm)	(0	0	5	0)	(1.1)	(0.9)
Halosarpheia marina (Cribb & J.W. Cribb) Kohlm.	0	5.4	0	0	1.1	0.7
**Halosarphaeia* sp.	0	2.7	0	1.9	1.1	0.7
Phaeosphaeria sp. (12.5-17.5 × 6.5-7.5 μm)	0	0	0	3.9	1.1	0.7
Savoryella lignicola E.B.G. Jones & R.A. Eaton	(1.7	1.4	0	0)	(1.1)	(0.6)
Halosarpheia retorquens Shearer & J.L. Crane	0 (90	2.7 1.4	0 0	0 0)	0.5 (0.4)	0.4 (0.3)
Julella avicenniae (Borse) K.D. Hyde	1.7 (1.7	0 0	0 0	0 0)	0.5 (0.4)	0.4 (0.3)
Halosarpheia fibrosa Kohlm. & E. Kohlm.	(3.3	0	0	0)	(0.7)	(0.6)
Savoryella paucispora (Cribb & J.W. Cribb) J. Koch	(3.3	0	0	0)	(0.7)	(0.6)
Ceriosporopsis halima Linder	0	0	2.4	0	0.5	0.4
Kallichroma tethys (Kohlm. & E. Kohlm.) Kohlm. & Volkm.-Kohlm.	1.7	0	0	0	0.5	0.4
Nimbospora bipolaris K.D. Hyde & E.B.G. Jones	0	0	2.4	0	0.5	0.4
Phaeosphaeria spartinicola Leuchtmann	0	0	0	1.9	0.5	0.4
Trematosphaeria striatispora K.D. Hyde	0	0	0	1.9	0.5	0.4
Leptosphaeria pelagica E.B.G. Jones	(1.7	0	0	0)	(0.4)	(0.3)
Lulworthia sp. 5 (492-686 × 2.5 μm)	(1.7	0	0	0)	(0.4)	(0.3)

Basidiomycotina						
Halocyphina villosa Kohlm.	15	2.7	0	0	5.3	3.7
Nia vibrissa R.T. Moore & Meyers	(0	5.5	15	0)	(4.6)	(3.7)
Calathella mangrovei E.B.G. Jones & Agerer	3.3	0	0	0	1.1	0.7
Anamorphic fungi						
Periconia prolifica Anastasiou	3.3	13.5	7.3	25	12.1	8.4
	(0	0	0	4.4)	(1.4)	(1.1)
Zalerion varium Anastasiou	6.7	16.2	4.9	1.9	6.8	4.8
	(3.3	0	0	0)	(1.1)	(0.9)
Dictyosporium pelagicum (Linder) G.C. Hughes	5	27.1 0		2.4	7.4	5.1
Zalerion maritimum (Linder) Anastasiou	0	2.7	7.3	9.6	4.7	3.3
	(0	4.1	0	0)	(1.1)	(0.9)
Trichocladium alopallonellum (Meyers & R.T. Moore) Kohlm. & Volkm.-Kohlm.	8.3	2.7	0	5.8	4.7	3.3
Clavatospora bulbosa (Anast.)	0	2.7	2.4	1.9	1.6	1.1
Nakagiri & Tubaki	(0	0	3.3	1.1)	(1.4)	(0.9)
Periconia sp. (5-12.5 µm)	0	2.7	7.3	0	2.1	1.5
Phoma sp. (5-10 × 2.5 µm)	0	0	7.3	0	1.6	1.1
Deuteromycete sp. 1	0	8.1	0	0	1.6	1.1
Cladosporium algarum Cooke & Massee	0	2.7	0	1.9	1.1	0.7
Trichocladium constrictum I. Schmidt	(0	0	5	0)	(1.1)	(0.9)
Trichocladium achrasporum (Meyers & R.T. Moore) Dixon	0	0	2.4	0	0.5	0.4
Anamorph sp. 2	0	0	2.4	0	0.5	0.4
Percent wood with sporulating fungal taxa[d]	**60**	**55**	**51**	**72**		
Number of fungal taxa per wood[d]	**1.4**	**1.4**	**1.5**	**1.2**		
Total number of taxa[d]	**30**	**30**	**29**	**22**		
Exclusive taxa[d]	**11**	**3**	**8**	**5**		

[a,b]See Materials and Methods for details

[c]Locations: Bam, Bambolim; Kar, Karwar; Kov, Kovalam; Kan, Kanyakumari

[d]Combined for both years 1992 and 1993

[*]Ascospore features resemble the description by Kohlmeyer and Volkmann-Kohlmeyer (1991)

Fungi at different locations

The maximum number of marine fungi (30 species) was recovered from intertidal wood collected at Bambolim. Each year about 60% samples supported between 17 and 20 taxa. The most common taxa include *Didymosphaeria* sp. (30-43.3%), *Aniptodera chesapeakensis* (20-23.3%), *Corollospora maritima* (20%), *Halocyphina villosa* (15%), *Caryosporella rhizophorae* (11.7%) and *Dactylospora heliotrepha* (11.7%). Intertidal wood from Karwar (37-73%) supported 14-21 taxa (30 species). The common taxa were *Crinigera* sp. (37%), *Corollospora intermedia* (32.9%), *Dictyosporium pelagicum* (27.1%), *Antennospora quadricornuta* (16.2-24.7%), *Zalerion varium* (16.2%), *Periconia prolifica* (13.5%) and *Corollospora maritima* (12.3%). Kovalam samples (41-60%) supported 12-21 taxa (total, 29 species) of marine fungi. The most common taxa were *Antennospora quadricornuta* (1.7-39%), *Torpedospora radiata* (5-34.1%), *Corollospora intermedia* (26.7%), *Corollospora maritima* (20%), *Caryosporella rhizophorae* (19.5%), *Corollospora filiformis* (16.7%), *Corollospora quinqueseptata* (15%), *Nia vibrissa* (15%), *Crinigera* sp. (14.6%) and *Corollospora colossa* (2.4-10%). A range of 11-18 taxa was encountered on 52-91% wood samples of Kanyakumari. Common taxa included *Torpedospora radiata* (5.8-63.7%), *Periconia prolifica* (4.4-25%), *Corollospora maritima* (19.8%), *Lulworthia* sp. 1 (4.4-17.3%), *Antennospora quadricornuta* (13.5%) and *Lulworthia* sp. 3 (3.3-11.5%). Since the lowest taxa (3 species) were encountered on freshly collected samples before incubation, the data on the occurrence before incubation was not used to assess similarity indices.

Species diversity and similarity

The diversity indices were highest after a period of six months incubation, which coincided with the occurrence of the highest number of species as well as exclusive taxa (Table 3, 4). Jaccard's index of similarity of fungi was highest between 6 and 12 months incubation (0.62), while it was least between 6 and 18 months (0.4) (Table 5). The decrease in similarity index from two months to 18 months incubation suggests the occurrence of additional taxa on prolonged incubation.

Frequency of occurrence

On examination of driftwood immediately following collection, only two ascomycetes (*Didymosphaeria* sp. and *Halorosellinia oceanica*) from Bambolim

Table 3. Species richness and diversity of marine fungal taxa on intertidal wood incubated at different intervals (combined data for all locations and sampling during 1992 and 1993).

Incubation period (months)	Species richness	Percent species[a]	Diversity Index		Shannon Evenness
			Simpson	Shannon	
0[b]	3	5.1	0.772	1.326	0.683
2	34	57.6	0.940	4.113	0.831
6	39	66.1	0.943	4.420	0.893
12	37	62.7	0.911	4.015	0.854
18	25	42.4	0.862	3.326	0.781

[a]Considering 59 taxa as 100%
[b]Immediately after sampling

and one anamorphic taxon (*Clavatospora bulbosa*) from Kovalam were recorded. The percent frequency of occurrence of 19 and 16 taxa were highest after 6 and 12 months incubation respectively (Table 4). Increase in the frequency of occurrence was seen in many taxa (*Aniptodera chesapeakensis, Antennospora quadricornuta, Corollospora filiformis, Corollospora maritima, Corollospora quinqueseptata, Crinigera* sp., *Dactylella haliotrepha* and *Periconia prolifica*), which also showed the highest frequency of occurrence after 18 months of incubation. Some taxa (*Corollospora angusta, Corollospora intermedia, Dictyosporium pelagicum, Didymosphaeria* sp., *Halosarpheia ratnagiriensis, Halosarpheia retorquens, Halorosellinia oceanica, Lulworthia* sp. 3, *Trichocladium alopallonellum, Torpedospora radiata* and *Zalerion varium*) which were most frequent following 6 or 12 months showed a gradual increase or decrease in frequency of occurrence before or after attaining the peak. The remaining taxa showed a sudden elevation or decline in frequency of occurrence at different incubation periods. Among three basidiomycetes recorded, *Halocyphina villosa* and *Nia vibrissa* attained up to 15% frequency of occurrence on Bambolim and Kovalam wood samples (Table 2). One-way ANOVA revealed a significant difference ($p = 0.04$) in the frequency of occurrence of fungal species in 6, 12 and 18 months of incubation. The extended Tukey's test confirmed the significant difference between 6 and 18 months of incubation (Table 6).

Discussion

Prolonged exposure of driftwood to harsh conditions in the tropics such as direct sunlight, extreme heat and strong winds, result in long periods of desiccation (Sundari *et al*., 1996). Duration of exposure of woody debris to dryness in intertidal zones of the temperate or subtropical beaches might differ from that of the tropical beaches. After six month's incubation of driftwood in

Table 4. Frequency of occurrence of marine fungal taxa on intertidal wood collected from the west coast of India and incubated for different time periods (combined data of all locations and sampling during 1992 and 1993).

Fungi	Frequency of occurrence (%)[a] Incubation (months)				
	0[b]	**2**	**6**	**12**	**18**
Ascomycotina					
Torpedospora radiata	0	7.6	12.5	17.6	4.5
Antennospora quadricornuta	0	2.4	6.5	9.3	11.3
Didymosphaeria sp.	1.6	8.8	9.0	8.6	5.8
Corollospora maritima	0	3.5	2.9	6.6	17.5
Aniptodera chesapeakensis	0	1.5	3.6	6.4	14.8
Corollospora intermedia	0	5	6.3	7.1	3.8
Crinigera sp.	0	1.3	3.1	14.5	32.4
Caryosporella rhizophorae	0	0	4.8	10.8	0
Lulworthia sp. 1 (147-235 × 2.5 μm)	0	0.6	1.2	2.1	0
Lulworthia sp. 3 (255-295 × 2-2.5 μm)	0	2.5	3.4	2.4	0
Corollospora colossa	0	0.6	0	0.4	0.8
Corollospora filiformis	0	2.5	3.8	4.5	7.1
Corollospora quinqueseptata	0	0	0.4	0.4	1.6
Lulworthia sp. 2 (245-372 × 2.5 μm)	0	1.2	0	0	0
Halorosellinia oceanica	0.1	0.7	2.2	5.5	0
Dactylospora haliotrepha	0	0.7	1.3	2.1	2.9
Aniptodera longispora	0	0	3.7	0.3	0.5
Corollospora angusta	0	0.4	2.9	0.3	2.5
Lulworthia sp. 4 (274-333 × 2.5 μm)	0	0.3	0	0	0
Carbosphaerella leptosphaerioides	0	0.5	0.2	0	0
Halosarpheia viscosa	0	0.3	0.5	0.8	0
Aniptodera sp. (22.5-25 × 7.5-10 μm)	0	0	0	0	1.8
Antennospora salina	0	2.5	0	0	1.3
Lineolata rhizophorae	0	1.7	0	1.8	0
Didymosphaeria sp. (16.5-22.5 × 7.5-10 μm)	0	0	0.7	0.3	0
Verruculina enalia	0	0	2	0.8	0
Halosarpheia ratnagiriensis	0	0.2	0.5	0.3	0.3
Corollospora sp. (27.5-32.5 × 6-7.5 μm)	0	1.3	0.8	0	0
Halosarpheia marina	0	0.3	0	0	0
Halosarphaeia sp.	0	0.3	0	0.7	0
Phaeosphaeria sp. (12.5-17.5 × 6.5-7.5 μm)	0	0.8	0	0	0
Savoryella lignicola	0	0	0	0.7	0
Halosarpheia retorquens	0	0.3	0.8	0.8	0.5
Julella avicenniae	0	0.5	0.3	0	0
Halosarpheia fibrosa	0	0.8	0	0	0
Savoryella paucispora	0	0	0.5	0	0
Ceriosporopsis halima	0	0	1.3	0	0
Kallichroma tethys	0	0.2	0	0	0
Nimbospora bipolaris	0	0	0	1.8	0
Phaeosphaeria spartinaecola	0	0	0	0	0.5

Table 4 (continued)

Trematosphaeria striatispora	0	0	0	0	0.5
Leptosphaeria pelagica	0	0	0	0	0.8
Lulworthia sp. 5 (492-686 × 2.5 μm)	0	0	0	0.4	0
Basidiomycotina					
Halocyphina villosa	0	0	2.1	0.4	0
Nia vibrissa	0	0	1.7	3.7	4.2
Calathella mangrovei	0	0	0.3	0	0
Anamorphic fungi					
Periconia prolifica	0	1.1	3.7	7.2	9.8
Zalerion varium	0	0.8	3.3	1.5	1.7
Dictyosporium pelagicum	0	0.7	3.5	2.7	0
Zalerion maritimum	0	0	3.3	0.3	0
Trichocladium alopallonellum	0	0	0.5	2.7	0.5
Clavatospora bulbosa	0.6	1.9	0	0	0.3
Periconia sp. (5-12.5 μm)	0	0	2	0	0
Phoma sp. (5-10 × 2.5 μm)	0	0	0.6	0.7	0
Anamorph sp. 1	0	0.3	0.5	0	0
Cladosporium algarum	0	0	0	1	0
Trichocladium constrictum	0	0	0	0.6	0
Trichocladium achrasporum	0	0	1.3	0	0
Deuteromycete sp. 2	0	0	0.6	0.7	0
Number of taxa	**3**	**34**	**39**	**37**	**25**
Exclusive taxa	**0**	**6**	**6**	**5**	**4**

[a]See Materials and Methods for details
[b]Immediately after sampling

our study, a maximum of 66.1% of the fungal taxa was recorded. Several taxa were encountered only after 12 months of incubation (e.g. *Cladosporium algarum, Leptosphaeria pelagica, Lulworthia* sp. 5, *Nimbospora bipolaris, Savoryella lignicola* and *Trichocladium achrasporum*), while others after 18 months of incubation (e.g. *Aniptodera* sp., *Phaeosphaeria spartinaecola* and

Table 5. Jaccard's similarity indices between fungal communities recovered from intertidal wood during 0 to 18 months of incubation (combined data of all locations and sampling during 1992 and 1993).

Period of incubation (months)	**0 m[a]**	**2 m**	**6 m**	**12 m**	**18 m**
Number of taxa recovered	3	34	39	37	25
Similarity	0 m	0.09	0.05	0.05	0.08
		2 m	0.46	0.47	0.42
			6 m	0.62	0.40
				12 m	0.44

[a]Immediately after sampling

Table 6. Extended Tukey's Test for difference in the frequency of occurrence in six (1), twelve (2) and eighteen (3) months of incubation.

Differences	Critical value	α
$X_1 - X_2 = 1.597$	< 2.73	0.05
$X_1 - X_3 = 3.466$	> 2.73	0.05
$X_2 - X_3 = 1.869$	< 2.73	0.05

Trematosphaeria striatispora). This suggests the need to incubate driftwood of tropical coastal locations for at least six months or more to assess the filamentous fungal diversity. The highest diversity of marine fungi at six months incubation coincided with the highest number of taxon as well as exclusive taxon. However, a consistent decrease of similarity of fungi between two and 18 months of incubation indicates the importance of incubation beyond six months to encompass maximum fungi including rare taxa colonized on the intertidal wood. Unlike tropical beaches, the woody debris of mangrove locations was intermittently inundated (Hyde and Jones, 1989; Hyde, 1992; Hyde and Lee, 1995) hence prolonged incubation to assess fungal colonization is not requisite.

Although the mean percentage colonization was lower for samples collected in 1992 as compared to 1993 (47.5 vs. 71%), the mean number of fungal taxa per wood and (1.4 vs. 1.3) total number of taxa were considerably high (20 vs. 13.5) (see Table 1). A similar trend was also evident in an earlier study (Prasannarai and Sridhar, 1997). Although fungal taxa were lower at Kanyakumari than the other locations (22 vs. 29-30 species), the number of wood samples colonized by fungal taxa were relatively high (72 vs. 51-60%) (see Table 2). Bambolim and Karwar samples yielded the maximum number of taxa (30). At both stations the availability of woody debris was high with less human interference. Thus, the percent colonization and number of isolations of intertidal wood does not reflect on the abundance of species. On two successive years, *Torpedospora radiata* was the most frequent taxon (16.6%) followed by *Antennospora quadricornuta* (11.5%), *Didymosphaeria* sp. (9.6%), *Aniptodera chesapeakensis* (8.1%), *Crinigera* sp. (7.1%), *Periconia prolifica* (6.8%) and *Zalerion maritimum* (4%). The pattern of dominance of these taxa partially resembles that of the other tropical locations: Brunei (Hyde, 1989), Hawaii (Volkmann-Kohlmeyer and Kohlmeyer, 1993), Hong Kong (Vrijmoed *et al*., 1986a, 1986b), India (Borse, 1988; Prasannarai and Sridhar, 1997; Prasannarai *et al*., 1999), Kuwait (Zainal and Jones, 1986), Malaysia (Sundari *et al*., 1996), Seychelles (Hyde and Jones, 1989) and Singapore (Sundari *et al*., 1996). About 50% of the taxon with over 3% frequency of occurrence showed a peak either during 12 or 18 months of incubation. However, among the top six anamorphic taxa (except for *Periconia prolifica*

and *Trichocladium alopallonellum*) *Clavatospora bulbosa, Dictyosporium pelagicum, Zalerion maritimum* and *Zalerion varium* attained a maximum frequency of occurrence during two or six months of incubation.

Increasing trend and maximum frequency occurrence of *Aniptodera chesapeakensis* and *Crinigera maritima* even after 18 months of incubation in the present study corroborates the earlier observations at North Island of St. Mary's Isles (the west coast of India) (Prasannarai and Sridhar, 1997). Increasing trend in the frequency of occurrence was seen in many fungal taxa after 18 months of incubation (e.g. *Aniptodera chesapeakensis, Antennospora quadricornuta, Corollospora filiformis, C. maritima, C. quinqueseptata, Crinigera* sp., *Dactylella heliotrepha* and *Periconia prolifica*) (see Table 4). Thus, these fungi constitute an important "core group" and most successful competitors possibly due to their inhibitory activities against associated fungi. This warrants further study of these fungi for their antagonistic metabolites. In the present study, incubation over 12 months resulted in the degeneration of bark and the wood became soft, probably due to the production of fungal enzymes (Abdel-Raheem and Shearer, 2002).

Although arenicolous fungi normally produce fruit bodies on sand grains and calcareous shells (Kohlmeyer and Kohlmeyer, 1979), they are also known to fruit on woody debris (Grasso *et al*., 1985; Sundari *et al*., 1996; Prasannarai and Sridhar, 1997, 2001). In the present study, one third of the total fungi on wood were arenicolous. Among the *Corollospora* spp., *Corollospora maritima* had highest frequency of occurrence (18%) which corroborates earlier studies in tropics: Seychelles (1.2-13%) (Hyde and Jones, 1989), Malaysia and Singapore (5.8-12.9%) (Sundari *et al*., 1996) and India (12.2%) (Prasannarai and Sridhar, 1997). It is interesting to note that all seven arenicolous fungi recovered from Kovalam samples were frequent (5-26.7%). About 50% of the arenicolous fungi attained maximum frequency of occurrence during 12 or 18 months of incubation.

Hyde (1992) for the first time addressed the impact of incubation period on the occurrence of fungi on woody litter collected from beach, lake, rocky shorelines and mangroves of Brunei. In all these habitats six months of incubation yielded more fungi than 1-2 weeks of incubation. Many fungi showed a higher frequency of occurrence on six months of incubation than 1-2 weeks of incubation. Results of this study corroborate with our findings. Thus, the duration of incubation of tropical beach woody substrata has considerable impact on fungal composition, diversity and similarity. Incubation and repeated screening up to 18 months would result in a reasonable assessment of fungal assemblage, diversity and frequency of occurrence. It could be argued that new fungal species that were not present at collection might grow on samples

following prolonged incubation in unnatural conditions (i.e. moist chambers). Panebianco *et al*. (2002), however, have shown that balsa test blocks pre-innoculated with fungi and exposed in the sea for 2-6 months excluded the sporulation of other fungi following recovery and incubation for up to 8 weeks. The fungal taxa with highest frequency of occurrence during 12 and 18 months incubation period might be ideal candidates to assess their pattern of succession, competition and inhibitory metabolites.

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