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Diversity of filamentous fungi on coastal woody debris after tsunami on the southeast coast of India

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Five coastal locations on the southeast coast of India severely disturbed after the tsunami on December 26, 2004 were surveyed for the occurrence of filamentous fungi on woody debris by means of short-term (1 month) and long-term (12 months) damp incubation. Short-term incubation revealed 26 mitosporic fungi (8 genera) ranging from 14 to 17 taxa per location with a total frequency of occurrence between 0.4 and 5.6 %. *Aspergillus* taxa were dominant and six of them were common to all locations. Long-term incubation yielded 35 fungi (25 genera) (22 ascomycetes, 1 basidiomycete and 12 mitosporic fungi). The total fungal taxa per location ranged from 25 to 28 with a total frequency of occurrence of 0.8 to 46.8 %. *Corollospora gracilis* was the most dominant ascomycete (46.8 %), while *Cirrenalia tropicalis* and *Dictyosporium pelagicum* dominated among mitosporic fungi (18 %). The total frequency of occurrence of 11 ascomycetes and four mitosporic fungi was above 10 %. Twelve ascomycetes and two mitosporic fungi were common to all locations. The richness of fungi was higher after long-term than short-term incubation. The occurrence of 61 fungal taxa in this study suggests that the tsunami-dumped woody litter on the southeast coast of India might have at least partially originated from the ocean, thus representing a mosaic of fungi existing in seawater and sediments.

Key words: tsunami, Bay of Bengal, southeast coast of India, woody litter, fungal diversity.

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Pět lokalit na jihovýchodním pobřeží Indie postižených tsunami z 26. prosince 2004 bylo studováno s ohledem na výskyt vláknitých hub na zbytcích dřeva. Krátkodobá inkubace (1 měsíc) odhalila 26 druhů z 8 rodů při zastoupení 14–17 druhů na lokalitu. Dominovaly druhy rodu *Aspergillus* a 6 z nich se vyskytovalo na všech lokalitách. Dlouhodobá inkubace (1 rok) odhalila 35 druhů z 25 rodů při zastoupení 25–28 druhů na lokalitu. *Corollospora gracilis* dominovala mezi askomycety (46.8 %), *Cirrenalia tropicalis* a *Dictyosporium pelagicum* (18 %) mezi anamorfami. Výskyt 61 druhů hub naznačuje, že zbytky dřeva vyplavené tsunami alespoň částečně pocházejí ze dna moře a tudíž představují houby žijící v mořské vodě a mořských sedimentech.

INTRODUCTION

Tsunami, a natural catastrophic disaster, caused severe devastation of the southeast coast of India on December 26, 2004 due to a powerful earthquake of a magnitude of 9.3 Mw (9.4 on the Richter scale) at the northwestern Sumatra epicentre (3.32° N, 95.85° E) (Murthy et al. 2006, Mascarenhas and Jayakumar 2008). Impulsive disturbances with vertical displacement of the water column (~100 × 70 × 1.5 km) generated giant waves (tsunami) propagated across the Indian Ocean and exerted impact on the coasts of Indonesia, Thailand, India, Sri Lanka and Somalia (Radhakrishna 2005). The height of the waves attacking the southeast coast of India ranged from 0.7 to 6.5 m and flooding ranged from 31 to 862 m inland with an average inundation of about 247 m (Mascarenhas 2006, Mascarenhas and Jayakumar 2008). Such waves are known to bring deeper nutrient-rich water to the surface with plenty of washed out materials (Levinton 2001).

Fungi in marine ecosystem occupy an important position as they are ubiquitous and involved in the decomposition and mineralisation of organic matter (Kohlmeyer and Kohlmeyer 1979, Hyde 1989, Newell 2001). Marine fungi have been reported from a variety of substrates in marine ecosystems (e.g. woody debris, seaweed, seagrasses, marine fauna, and deep sea sediments) (Jones 1976, Kohlmeyer and Kohlmeyer 1979, Raghukumar et al. 2004, Raghukumar 2008, Das et al. 2009). The purpose of this study was to assess the richness and diversity of filamentous fungi on woody debris accumulated on the beaches of a severely affected stretch of the southeast coast of India after the December 2004 tsunami by means of short-term and long-term damp incubation.

MATERIALS AND METHODS

Five beaches, Palaiyar (11.3° N, 79.8° E), Poombukar (11.2° N, 79.8° E), Karaikkal (10.8° N, 79.8° E), Nagapattinam (10.6° N, 79.8° E), and Velankanni (10.4° N, 79.95° E) in the severely affected region of the Nagapattinam District of Tamil Nadu on the southeast coast of India were selected for survey (Fig. 1). These beaches are characterised by calcareous sandy alluvium. Intertidal woody litter accumulated on the beaches was collected randomly at distances of 0.5–1 km on January 20, 2005 and transported to the laboratory. During sampling, temperature, pH and salinity of the tidal water were assessed. Fifty wood samples with uniform size (1.5–3 × 12–15 cm) per location were incubated (26 ± 2 °C) on a sand-bed moistened with 50 % sterile seawater in airtight polythene bags beneath fluorescent light. Each sample was examined using short-term incubation (2 and 4 weeks) followed by long-term incubation (6 and 12 months). Fungal taxa were separately documented for short-term and long-term incubations. Most of the fungi grown during short-term incubation were cultured on the Czapek-Dox agar medium (Hi-Media Laboratories Pvt. Ltd., Mumbai) for confirmation. The relative frequency of each taxon at each location and at all locations, and the mean relative frequency per taxon were calculated:

Frequency of occurrence (%) = [(number of wood colonised) ÷ (total number of wood samples screened)] × 100.

Mean relative frequency of occurrence/taxon (%) = (total frequency of fungi [%]) ÷ (total taxa on wood samples).

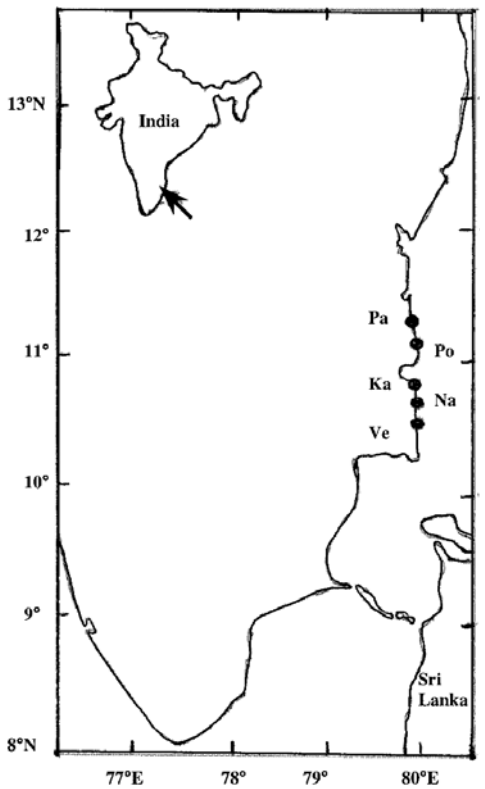

Fig. 1. Sampling locations (beaches) of woody litter collected on the southeast coast of India. Pa: Palaiyar, Po: Poombukar, Ka: Karaikkal, Na: Nagapattinam, Ve: Velankanni.

RESULTS

The mean temperature, pH and salinity of the tidal water at sampling stations ranged from 31 to 35 °C, 7.8 to 8.3 and 33 to 34.5 ‰, respectively.

Short-term incubation of woody litter yielded 26 taxa of mitosporic fungi (8 genera) ranging from 14 (Poombukar) to 17 (Palaiyar and Nagapattinam) (Tab. 1). The mean frequency of occurrence per taxon ranged between 4.3 % (Karaikkal) and 5.5 % (Velankanni). The total frequency of occurrence of fungi ranged between 0.4 % and 5.6 %. *Aspergillus* taxa were most dominant, and six taxa (*A. flavus*, *A. fumigatus*, *A. niger*, *A. ochraceus*, *A. oryzae*, *A. terreus*) were common to all locations.

In the case of long-term incubation, 35 taxa (25 genera) consisting of 22 ascomycetes, 1 basidiomycete, and 12 mitosporic fungi were recorded (Tab. 2). The total number of fungi after long-term incubation ranged between 25

Tab. 1. Frequency of occurrence (%) of fungi after short-term incubation (one month) of woody litter collected from tsunami affected beaches in southeast India. Pa: Palaiyar, Po: Poombukar, Ka: Karaikkal, Na: Nagapattinam, Ve: Velankanni. TFO: total relative frequency of occurrence.

Taxon	Beaches					TFO
	Pa	Po	Ka	Na	Ve	
Mitosporic fungi						
Aspergillus terreus Thom	10	4	4	6	4	5.6
A. flavus Link	8	6	4	6	2	5.2
A. niger Tiegh	6	4	2	4	10	5.2
A. fumigatus Fresen.	4	14	2	2	2	4.8
A. oryzae (Ahlb.) E. Cohn	12	4	2	2	4	4.8
A. nidulans (Eidam) G. Winter	4	4	12	2		4.4
A. ochraceus G. Wilh.	2	14	2	2	2	4.4
A. sulphureus Desm.	4	2	4		12	4.4
Aspergillus sp.			4	16	2	4.4
Drechslera sp.	12		6	2	2	4.4
Aspergillus luchuensis Inui	2	6	4		8	4.0
Cladosporium sp.		2		2	14	3.6
Nigrospora oryzae (Berk. & Broome) Petch	2		4		10	3.2
Aspergillus quercinus (Bainier) Thom & Church	2	2	2	8		2.8
Fusarium sp.		6		4	4	2.8
Penicillium janthinellum Biourge		4		10		2.8
Penicillium sp.	6			6	2	2.8
Penicillium citrinum Sopp			8		4	2.4
Cladosporium britannicum M.B. Ellis			4		6	2.0
Curvularia lunata (Wakker) Boedijn	6		4			2.0
Aspergillus clavatus Desm.				8		1.6
Cladosporium apicale Berk. & Broome	4	4				1.6
Aspergillus funiculosus G. Sm.	4					0.8
A. terricola Marchal & É.J. Marchal				4		0.8
Penicillium frequentans Westling	2					0.4
Alternaria sp.				2		0.4
Total number of taxa	17	14	16	17	16	
Mean relative frequency of occurrence/taxon	5.3	5.4	4.3	5.1	5.5	

Tab. 2. Frequency of occurrence (%) of fungi after long-term incubation (12 months) of woody litter collected from tsunami affected beaches in southeast India. Pa: Palaiyar, Po: Poombukar, Ka: Karaikkal, Na: Nagapattinam, Ve: Velankanni. TFO: total relative frequency of occurrence.

Taxon	Beaches					TFO
	Pa	Po	Ka	Na	Ve	
Ascomycetes						
Corollospora gracilis Nakagiri & Tokura	50	48	40	46	50	46.8
C. angusta Nakagiri & Tokura	24	26	30	20	24	24.8

Taxon	Beaches					TFO
	Pa	Po	Ka	Na	Ve	
Antennospora quadricornuta (Cribb & J. W. Cribb) T. W. Johnson	28	22	4	20	16	18.0
Corollospora pulchella Kohlm., I. Schmidt & N. B. Nair	2	44	4	14	18	16.4
Crinigera maritima Werderm.	16	38	14	4	4	15.2
Savoryella lignicola E. B. G. Jones & R. A. Eaton	18	20	22	6	10	15.2
Saagaromyces ratnagiriensis (S. D. Patil & Borse) K. L. Pang & E. B. G. Jones		24	2	14	34	14.8
Verruculina enalia (Kohlm.) Kohlm. & Volkm.-Kohlm.	16	12	2	18	26	14.8
Savoryella paucispora (Cribb & J. W. Cribb) J. Koch	16	30	6	4	2	11.6
Lulworthia grandispora Meyers	8	4	18	4	20	10.8
Corollospora indica Prasannarai, Ananda & K. R. Sridhar			22		30	10.4
Arenariomyces parvulus Jørg. Koch	16	22	4	2	4	9.6
Julella avicenniae (Borse) K.D. Hyde	12	4		8	16	8.0
Nimbospora effusa Jørg. Koch	4	6	12	8	8	7.6
Kallichroma tethys (Kohlm. & Kohlm.) Kohlm. & Volkm.-Kohlm.	2		8	10	16	7.2
Lophiostoma mangrovei Kohlm. & Vittal	2	2	30			6.8
Arenariomyces majusculus Kohlm. & Volkm.-Kohlm.	2	16	12	2		6.4
Corollospora filiformis Nakagiri		4		16	6	5.2
Lulworthia sp.	6	2	6	2	2	3.6
Aniptodera lignicola K. D. Hyde, W. H. Ho & K. M. Tsui		4		6	6	3.2
Hypoxylon sp.			6	4	2	2.4
Massarina velataspora K. D. Hyde & Borse				4	4	1.6
Basidiomycete						
Halocyphina villosa Kohlm. & E. Kohlm.	2		4	6		2.4
Mitosporic fungi						
Cirrenalia tropicalis Kohlm.	10	30	20	10	20	18.0
Dictyosporium pelagicum (Linder) G. C. Hughes ex E. B. G. Jones	22	32	20	6	10	18.0
Aspergillus sydowii (Bainier & Sartory) Thom & Church	30	24	20			14.8
Cirrenalia macrocephala (Kohlm.) Meyers & R. T. Moore		36	18	8	6	13.6
Cumulospora sp.	6	16		4	12	7.6
Gliocladium virens J. H. Mill., Giddens & A. A. Foster	8	16		4	2	6.0
Aspergillus cervinus Massee		4		12	8	4.8
Cirrenalia pseudomacrocephala Kohlm.	2		4		2	1.6
Monodictys pelagica (T. Johnson) E. B. G. Jones	4			2		1.2
Periconia prolifica Anastasiou		4	2			1.2
Cladosporium algarum Cooke & Massee			2		2	0.8
Zalerion varia Anastasiou	4					0.8
Total number of taxa	25	26	26	28	28	
Mean relative frequency of occurrence/taxon	12.4	18.9	12.8	9.4	12.9	

(Palaiyar) and 28 (Nagapattinam and Velankanni) with a mean frequency of occurrence per taxa ranging from 9.4 % (Nagapattinam) to 18.9 % (Poombukar). Among the ascomycetes, *Corollospora gracilis* was most dominant (46.8 %), while *Cirrenalia tropicalis* and *Dictyosporium pelagicum* dominated among mitosporic fungi (18 %). The total frequency of occurrence of 11 ascomycetes and four mitosporic fungi was above 10 %. Twelve ascomycetes (*Antennospora quadricornuta*, *Arenariomyces parvulus*, *Corollospora gracilis*, *C. angusta*, *C. pulchella*, *Crinigera maritima*, *Lulworthia grandispora*, *Lulworthia* sp., *Nimbospora effusa*, *Savoryella lignicola*, *S. paucispora*, *Verruculina enalia*) and two mitosporic fungi (*Cirrenalia tropicalis* and *Dictyosporium pelagicum*) were common to all locations.

The total number of fungal taxa at different locations was lower after short-term than long-term incubation (Tabs. 1, 2). However, the total number of taxa between locations did not differ much after short-term (14–17) and long-term (25–28) incubation.

DISCUSSION

The present study corresponds with earlier investigations in India on the occurrence of the number of fungal taxa after long-term incubation of woody litter from beaches and mangroves (e.g. Prasannarai and Sridhar 2003, Ananda and Sridhar 2004). Techniques of assessment such as plating (Raghukumar 1996, Dunn and Baker 1983) and damp incubation (Vrijmoed et al. 1982, Prasannarai et al. 1999) of plant litter originating from marine habitats have a major impact on the diversity and richness of colonised fungi. Besides many techniques, duration of incubation and screening intervals of woody debris are important in the evaluation of colonised fungi. For example, marine fungi peaked after 16 weeks, whereas arenicolous fungi after 32 weeks of incubation of mangrove woody litter (Ananda and Sridhar 2004).

Occurrence of typical marine fungi after long-term incubation indicates that the woody litter has been exposed to the marine environment for considerable duration. However, so-called terrestrial mitosporic fungi were also found, especially after short-term incubation. Surprisingly, none of the mitosporic fungi overlapped between short-term and long-term incubation, which makes us suspect that fungi found during short-term incubation might have originated from sea sediments or invaded from terrestrial habitats. It is interesting to note the increased population of *Aspergillus* taxa in waters and sediments of the Chennai coast (Tamil Nadu) during the post-tsunami period (Ramesh et al. 2006). Das et al. (2009) also reported dominance of *Aspergillus* taxa in sediment samples of the continental slope of the Bay of Bengal. Among the dominant *Aspergillus* taxa found in our

study, five taxa (*Aspergillus flavus*, *A. fumigatus*, *A. nidulans*, *A. niger*, *A. terreus*) and *Penicillium citrinum* were considered the major species in sediment samples of the Bay of Bengal (Das et al. 2009). *Aspergillus* taxa are widely distributed along the Indian coast (Gupta and Prabhakaran 1989), in sponges (Varoglu and Crews 2000), and in sediments and marine fauna (Sponga et al. 1999). Recently, Damare et al. (2006) reported an *Aspergillus* taxon from the deep-sea sediments (~5000 m deep) of the Central Indian Basin. Among the filamentous fungi, *Aspergillus* taxa occurred in the highest frequency in coastal marine sediments off Goa of the west coast of India (Arabian Sea) in most of the sampling periods (Cathrine and Raghukumar 2009). Similarly, *Penicillium* sp. has been reported from sediments of Mariana Trench at a depth of about 11.500 m (Takami 1999). The coast of Nagapattinam was severely affected by tsunami and experienced a deposition of slushy greyish brown silt/clay and black sandy soil (Rengalakshmi et al. 2007, Mascarenhas and Jayakumar 2008). These observations reveal the possibilities of woody litter accumulated on the beaches of the southeast cost of India during tsunami being colonized by *Aspergillus* taxa from marine sediments.

In long-term incubation, the frequency of occurrence of *Corollospora gracilis* was consistently high (40–50 %) at all sampling locations. However, a high frequency of occurrence of many marine fungi has been reported on woody litter in earlier studies on the southern Indian coast. For instance, *Torpedospora radiata* was frequent (63.7 %) on woody litter from the Kanyakumari beaches (Tamil Nadu). On the Bambolim beaches (Goa), *Didymosphaeria* sp. and *Halosarpheia retorquens* were frequent, up to 43.3 % and 90 % respectively. Some frequent marine fungi in our study (e.g. *Antennospora quadricornuta*, *Corollospora maritima*, *Dictyosporium pelagicum*) were also frequent on the southwest coast of India (Prasannarai and Sridhar 2001, 2003). Among the fungi recorded after long-term incubation, *Cladosporium algarum*, *Corollospora gracilis*, *C. maritima*, *Halocypina villosa* and *Lulworthia grandispora* were the major taxa in sediments of the continental slope of the Bay of Bengal (Das et al. 2009). *Aspergillus sydowii* was a core-group taxon (14.8 %) in long-term incubated samples also reported from about 420.000 year old deep-sea sediments of the Chagos Trench of the Indian Ocean (Raghukumar et al. 2004).

Gigantic tsunamis uplift nutrients from the deep sea and continental shelf regions along with plant and animal detritus. Such detritus seems to represent a mosaic of microflora of seawater and sediments. The occurrence of 61 fungal taxa after short-term and long-term incubations in our study reconfirms the occurrence of many fungi living in marine sediments on tsunami-dumped woody litter (Raghukumar et al. 2004, Damare et al. 2006, Ramesh et al. 2006, Cathrine and Raghukumar 2009, Das et al. 2009). Our study also suggests that screening woody litter accumulated on beaches by means of short-term and long-term incubations renders a better picture of fungal inhabitants. Fungi sporulating after long-term in-

cubation (ascomycetes and mitosporic fungi) may be involved in lignin processing and mineralisation in marine habitats. Tsunami-dumped woody litter on the southeast coast of India might have originated at least partially from the ocean floor representing a mosaic of fungi living in seawater as well as sediments. A more precise picture of the richness and diversity of fungi on marine-derived woody litter will emerge from adapting molecular techniques.

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REFERENCES

ANANDA K. and SRIDHAR K. R. (2004): Diversity of filamentous fungi on decomposing leaf and woody litter of mangrove forests of southwest coast of India. – Current Science 87: 1431–1437.

CATHRINE S. J. and RAGHUKUMAR C. (2009): Anaerobic denitrification in fungi from coastal marine sediments off Goa, India. – Mycological Research 113: 100–109.

DAMARE S., RAGHUKUMAR C. and RAGHUKUMAR S. (2006): Fungi in deep-sea sediments of the Central Indian Basin. – Deep-Sea Research Part-I 53: 14–27.

DAS S., LYLA P. S. and KHAN S. A. (2009): Filamentous fungal population and species diversity from the continental slope of Bay of Bengal, India. – Acta Oecologica 35: 269–279.

DUNN P. H. and BAKER G. E. (1983): Filamentous fungi of the Psammon habitat at Enewetak Atoll, Marshall Islands. – Mycologia 75: 839–853.

GUPTA R. and PRABHAKARAN N. (1989): Fungi isolated from the EEZ of Indian coast. – In: Mathew K. J. (ed.), Proceedings of the First Workshop on Scientific Results of FORV Sagar Sampada, p. 37–46, Department of Ocean Development, Government of India.

HYDE K. D. (1989): Ecology of tropical marine fungi. – Hydrobiologia 178: 199–208.

JONES E. B. G. (1976): Lignicolous and algicolous fungi. – In: Jones E. B. G. (ed.), Recent Advances in Aquatic Mycology, p. 1–49, Paul Elek Ltd., London.

KOHLMEYER J. and KOHLMEYER E. (1979): Marine mycology – The higher fungi. – Academic Press, New York.

LEVINTON J. S. (2001): Marine biology – Function, biodiversity and ecology. – Oxford University Press, New York.

MASCARENHAS A. (2006): Extreme events, intrinsic landforms and humankind: post-tsunami scenario along Nagore–Velankanni coast, Tamil Nadu, India. – Current Science 90: 1195–1201.

MASCARENHAS A. and JAYAKUMAR S. (2008): An environmental perspective of the post-tsunami scenario along the coast of Tamil Nadu, India: Role of sand dunes and forests. – Journal of Environmental Management 89: 24–34.

MURTHY K. S. R., SUBRAHMANYAM A. S., MURTHY G. P. S., SARMA K. V. L. S., SUBRAHMANYAM V., RAO K. M., RANI P. S., ANURADHA A., ADILAKSHMI B. and DEVI T. S. (2006): Factors guiding tsunami surge at the Nagapattinam-Cuddalore shelf, Tamil Nadu, east coast of India. – Current Science 90: 1535–1538.

NEWELL S. Y. (2001): Fungal biomass and productivity. – In: Paul J. H. (ed.), Methods in microbiology, Volume 30, p. 357–372, Academic Press, London.

PRASANNARAI K. and SRIDHAR K. R. (2001): Diversity and abundance of higher marine fungi on woody substrates along the west coast of India. – Current Science 81: 304–311.

PRASANNARAI K. and SRIDHAR K. R. (2003): Abundance and diversity of marine fungi on intertidal woody litter of the west coast of India on prolonged incubation. – Fungal Diversity 14: 127–141.

PRASANNARAI K., ANANDA K. and SRIDHAR K. R. (1999). Intertidal fungi in Mangalore Harbour, Southern India. – Botanica Marina 42: 117–122.

RADHAKRISHNA B. P. (2005): Devastating tsunami strikes coastline of India. – Journal of the Geological Society of India 65: 129–134.

RAGHUKUMAR S. (1996). Fungi in the marine realm: status, challenges and prospects. – Kavaka 24: 25–34.

RAGHUKUMAR C. (2008): Marine fungal biotechnology: an ecological perspective. – Fungal Diversity 31: 19–35.

RAGHUKUMAR C., RAGHUKUMAR S., SHEELU G., GUPTA S. M., NATH B. N. and RAO B. R. (2004): Buried in time: culturable fungi in a deep-sea sediment core from the Chagos Trench, Indian Ocean. – Deep-Sea Research Part-I 51: 1759–1768.

RAMESH S., JAYAPRAKASHVEL M. and MATHIVANAN N. (2006): Microbial status in seawater and coastal sediments during pre– and post-tsunami periods in the Bay of Bengal, India. – Marine Ecology 27: 198–203.

RENGALAKSHMI R., SENTHILKUMAR R., SELVARASU T. and THAMIZOLI P. (2007): Reclamation and status of tsunami damaged soil in Nagapattinam District, Tamil Nadu. – Current Science 92: 1221–1223.

SPONGA F., CAVALETTI L., LAZZARINI A., BORGHI A., CICILIATO I., LOSI D. and MARINELLI F. (1999): Biodiversity and potentials of marine-derived microorganisms. – Journal of Biotechnology 70: 65–69.

TAKAMI H. (1999): Isolation and characterization of microorganisms from deep-sea mud. – In: Horikoshi K. and Tsujii K. (eds.), Extremophiles in deep-sea environments, p. 3–26, Springer, Tokyo.

VAROGLU M. and CREWS P. (2000): Biosynthetically diverse compounds from a saltwater culture of sponge derived *Aspergillus niger*. – Journal of Natural Products 63: 41–43.

VRIJMOED L. L. P., HODGKISS I. J. and THROWER L. B. (1982): Factors affecting the distribution of lignicolous marine fungi in Hong Kong. – Hydrobiologia 87: 143–160.