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# The forests of Western Ghats, an abode of novel and interesting microfungi*

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**ABSTRACT**

*"Nahi jnaanena sadrusham pavitramahi vidyati"*
*(=Nothing is more purer than knowledge)* - *Lord Shri Krishna in Bhagavad Gita*

I am deeply honoured to have been elected as President of Mycological Society of India. I am equally thankful to Thapar University, Patiala, for organizing the 34th Annual meeting of the Society along with a National Symposium.

## Mycological Society of India

The Mycological Society of India was established in January 1973 in Chennai (formerly Madras), on the sidelines of International Symposium on Taxonomy of Fungi held at Centre for Advanced Studies in Botany, University of Madras. The main architect of the event was Professor C.V. Subramanian. I joined the Botany Department, at a slightly later date in the same year, for my post-M.Sc. Diploma in Mycology and Plant Pathology and subsequently for doctoral studies. I narrowly missed the opportunity of witnessing the birth of the Society. Nevertheless, I have been associated with the Society ever since, in various capacities which I considered as a privilege. The Society has completed 33 years and I am very glad that a large number of young students of mycology are now enrolling as Members.

## Centre for Advanced Studies in Botany, University of Madras

I did my doctoral thesis under the supervision of Professor C.V. Subramanian and, subsequently also worked on a UGC-sponsored project entitled 'Fungus Flora of South India'. My stay at the Centre for Advanced Studies in Botany, University of Madras, for duration of six years was most rewarding. Invaluable guidance from Professor Subramanian and numerous mycological events and interactions that took place those days together provided me not only a foundation on fungal biology but everything that I know today.

## Forests of Western Ghats, southern India (Fig.1)

The Western Ghats, hilly and mountainous terrain on the western side of peninsular India, about 1500 km stretch parallel to the coastline between $8^0$ N to $22^05'$ N and $72^05'$ E to $76^05'$ E, extend from river Tapti southward through the States of Maharastra, Goa, Karnataka, Kerala and Tamil Nadu, up to Kanyakumari. These mountains are 30–80 km away from the sea coast. The escarpment is steep and precipitous along the western side and gently inclined on the east, the highest elevation is at Anamudi in Kerala. Many

short, fast flowing, seasonal streams and perennial rivers originate in the Western Ghats and flow down to the Arabian Sea. The ghats receive south-west monsoon rain from June to September; the downpour is heavy on the western side of the ghat ranging from 200 to 350 cm annually. The mean annual temperature ranges between $26^0$C to $37^0$C, which seldom falls below $16^0$C. The mean annual relative humidity is about 80%. Under these warm and humid conditions, luxuriant forests flourish in the windward western side of the ghats, which include wet-evergreens, sholas, moist-deciduous, dry-deciduous, scrub-jungles and plateau-grasslands. Diverse plant species flourish in the forests of Western Ghats (Pascal, 1989).

Fungi of the Western Ghats have been explored and documented to some extent (Subramanian, 1971; Rao and de Hoog, 1986; Subramanian and Bhat, 1987; Bhat and Kendrick, 1993; Sarbhoy *et al.*, 1986; Sarbhoy *et al.*, 1996; Jamaluddin *et al.*, 2004; Manoharachary *et al.*, 2005; Jacob, 2000; D'Souza, 2002; Nair, 2002; Keshav Prasad, 2003; Jalmi, 2006; Gawas, 2008). Despite the hitherto efforts, vast area of peninsular India still remained unexplored.

## Encounters with micro-fungi

My doctoral studies on Hypocrealean fungi and subsequent project works on floristics of Hyphomycetes demanded extensive field work. In the last three decades, in search of microfungi, I wandered around numerous forests of the Western Ghats (Fig. 1), from Kanyakumari (Tamil Nadu) to Mahabaleshwar (Maharashra) through the States of Kerala, Karnataka

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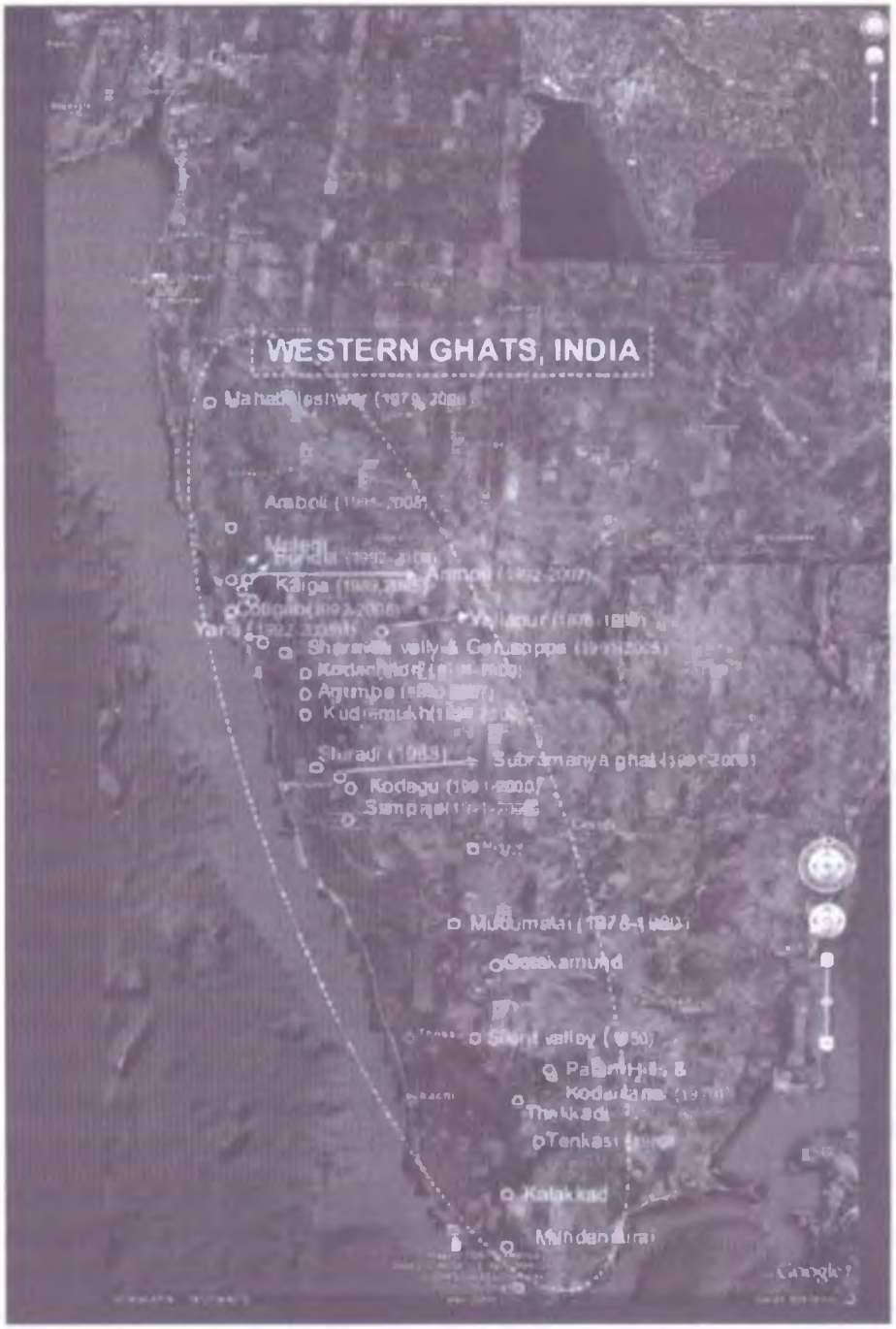


**Fig. 1. Various localities in the forests of Western Ghats, India, visited by the author during 1976-2007**

and Goa, and scanned several types of substrates which included decaying plant litter, freshwater foam, aerial plant parts, internal of fresh leaves and twigs, herbivore dung, dead insects, etc. This enduring search for microfungi provided me some insight on hyphomycete diversity of the region. In this address, I will highlight the excitements derived while encountering some of the new hyphomycetous fungi in the forests of Western Ghats.

## Hyphomycetes from the forests of Western Ghats

It was in the monsoon of 1976, in search of Hypocrealean fungi, I set out on my first field trip into the forests of Western Ghats in Coorg (now Kodagu), located in the State of Karnataka. Moist chamber incubated dead and decaying twigs of *Coffea Arabica* L., gathered from Abby Falls, near Madikeri, under stereoscope exhibited glistening, appendaged, colourless, spherical spores in masses on phialidic conidiophores. This was nothing to do with Hypocrealean fungi; yet, I showed the slides to Professor Subramanian. The mycology laboratory of Centre for Advanced Studies in Botany at Madras University then had total command on conidial fungi, at global level. Professor Subramanian was instant in declaring that the fungus might be an unknown one and I should examine it further. Continued

detailed studies in the next few months, resulted with description of *Bahusutrabeeja dwaya* Subram. et Bhat, a new species in a new genus (Subramanian and Bhat, 1977a). Though Hypocrealean fungi were my focus, in my inner-self, I developed special interest on hyphomycetous fungi. It was my firm conviction then that 'knowledge gaining exercises will surpass everything else'.

A phialidic hyphomycete, *Putagraivam sundaram* Subram. et Bhat (Subramanian and Bhat, 1977b), anamorphic phase of a hypocrealean *Peethambara sundara* Subram. et Bhat (Subramanian and Bhat, 1977c), that I gathered from my native village, Darbhe (Irde) located in the foothills of Western Ghats, Karnataka State, was an accidental discovery. Closely and curiously watching my fungus collecting methods, my father who didn't even have any formal education, brought a head-load of decaying twigs of *Macaranga indica* Wright which had bright-coloured stromatic ascocarps on the surface, from the nearby forests. The ascocarps of *Peethambara sundara*, a new hypocrealean fungus, had accompanying conidial synnemata on the substrate. Single ascospore in culture also produced the synnematous conidial phase. The study ended up in the description of hitherto unknown teleomorph-anamorph connection of the new fungus. *Putagraivam sundaram* is now a synonym of *Didymostilbe sundara* (Seifert, 1985).

My two visits to Silent Valley in Kerala during March-April and December 1980 for collection of fungi were most memorable. Led by the Botanical Survey of India, I was part of a big team set out to study the extent of biodiversity of the region. I collected samples of fungi from all over the forests and streams over a period of 6 weeks. Together with Professor Subramanian, I examined every bit of the samples and documented the fungi (Subramanian, 1992; Subramanian and Bhat, 1987). This was a major fungal biodiversity study of the region. There is no exaggeration if I state that the then proposed plan of construction of a major hydro-electric dam across Kunthi puzza river in Silent Valley was permanently scrapped because of the evidences provided by the high biodiversity of the region, especially the fungi.

As a project staff in the 'Fungus Flora of South India' programme, I collected samples of fungi from different forests of Karnataka, Kerala and Tamilnadu, during May-December 1980. In one of the field trips, near Hassan, Karnataka State, our vehicle was hit by a huge vulture and the van fell into a 20 m deep ditch. Miraculous as it was, we escaped with very minor injuries. Nothing of the sort deterred us from continuing investigations on fungi. I do remember my first visit to Goa (Dudhsagar Falls), during November 1980. We traveled in a train engine to the Falls from Londa railway station and I had an hour-long swim in the pond adjacent to the railway track. I had no idea those days that I would continue my quest on fungi, subsequently from Goa University.

**A brief with fungi of Ethiopia**

During 1981-88, I had worked in Asmara University, Ethiopia (presently Eritrea). Positioned in Asmara, I had a distinct opportunity to survey the highland forests of southern Ethiopia. From fungal diversity study point of view, Ethiopia is equally rich and, undoubtedly, those were some of my very productive mycological study period (Bhat, 1983, 1984, 1985, 1986; Bhat and Sutton, 1984, 1985, 1986; Bhat and Chien, 1990, 1992).

**Return to the Western Ghats**

My interest on hyphomycetes grew steadily and progressively, on return to India. In the subsequent years, while working in Mangalore (1988-89) and Goa Universities (1990-2007), along with my students and colleagues, I surveyed many forests and streams of the Western Ghats and collected fungal samples from everywhere. We trekked long distances; stayed overnights in deep jungles, nearby bus stands and railway platforms. Collection and description of fungi were sheer excitements. Our mycofloristic investigations were was not confined to the forests of Western Ghats alone. We also surveyed the forests of Andaman Islands (Bhat and Kendrick, 1993; D'Souza *et al.*, 2002) and north-eastern highlands of Arunachal Pradesh, Assam and Nagaland in India (Bhat, 2006).

I had invaluable support from Professor K.M. Kaveriappa, Vice Chancellor, Mangalore University, Professors K. Natarajan and B.P.R. Vittal, Centre for Advanced Studies in Botany, University of Madras; Dr B. Sutton, International Mycological Institute, UK; Professor B. Kendrick, University of Waterloo, Canada; and Dr. Kevin D. Hyde, University of Hong Kong (now in Mae Fah Luang University, Thailand), in my mycological journey. They not only accommodated me in their work places for a while but also supplied needful literature on fungi. Major fungal haul came from the wet-evergreen forests of Western Ghats in Silent Valley in Kerala State (Subramanian and Bhat, 1981, 1987-88), Agumbe, Sampaje, Kodachadri hills and Sharavati valley in Karnataka State (Bhat and Kendrick, 1993) and Bondla, Molem and Cotigao in Goa State (Bhat et al., 2009). Not only many new but also numerous common, rare, interesting microfungi were discovered by us. The hitherto described novel fungi from the forests of Western Ghats are listed below, with details on their substrate, locality and time of collection (Table 1).

**Table-1. New hyphomycetes discovered from the forests of Western Ghats:**

| Fungus name | Substrate | Locality | Year of collection | Reference |
|---|---|---|---|---|
| *Acrodictys malabarica* Subram. & Bhat | Dead Bamboo | Silent Valley, Kerala | 1980 | Subramanian and Bhat, 1987 |
| *Anavirga vermiformis* Bhat & Kendrick | Unidentified dead twigs | Kodachadri Hills, Karnataka | 1991 | Bhat and Kendrick, 1993 |
| *Arthrinium mytilomorphum* Bhat et Kendrick | Dead leaves of *Andropogon* sp. | Kodachadri Hills, Karnataka | 1991 | Bhat and Kendrick, 1993 |
| *Aquaphila ramdayalea* Maria & Bhat | Leaves of *Caryota urens* | Cotigao, Goa | 1999 | D'Souza and Bhat, 2001 |
| ***Bahusutrabeeja dwaya*** Subram.& Bhat | Decaying coffee twigs | Abby Falls, Karnataka | 1976 | Subramanian and Bhat, 1977 |
| *B. dubhashii* Bhat | Leaf Litter of *Pandanus fascicularis* | Molem, Goa | 1992 | Bhat, 1994 |
| *B. globosa* Bhat & Kendrick | Unidentified Dead Twig | Kudremukh, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *B. manoharachari* Pratibha & Bhat | Leaves of *Bridelia scandens* | Chorla ghat, Goa | 2004 | Pratibha and Bhat, 2004 |
| *Beltrania circinata* Bhat & Kendrick | Dead leaves of *Terminalia sp.* | Kodachadri Hills, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| ***Benjpalia sundara*** Subram.& Bhat | Dead petiole of *Calamus* sp. | Silent Valley, Kerala | 1980 | Subramanian and Bhat, 1987 |
| ***Bharatheeya goanensis*** D'Souza & Bhat | Unidentified dead Leaves | Morpirla, Goa | 1993 | D'Souza and Bhat, 2002 |
| *B. mucoidea* D'Souza & Bhat | Dry leaves of *Calamus thwaiteii* | Bondla, Goa | 1999 | D'Souza and Bhat, 2002 |
| ***Blastocatena pulneyensis*** Subram. & Bhat | Unidentified decaying twigs | Kodaikanal, Tamil Nadu | 1980 | Subramanian and Bhat, 1987 |
| *Brachysporiellina pulneyusis* Subram.& Bhat | Unidentified dead twig | Kodaikanal, Tamil Nadu | 1981 | Subramanian and Bhat, 1987 |
| *Catenularia kalakadensis* Subram. & Bhat | Unidentified decaying twigs | Kalakad, Tamil Nadu | 1980 | Subramanian and Bhat, 1987 |
| *C. malabarica* Subram. & Bhat | Unidentified dead twig | Silent vally, Kerala | 1980 | Subramanian and Bhat, 1987 |
| ***Ceeveesubramaniomyces litseae*** Pratibha, Hyde & Bhat | On leaves of *Litsea sp.* | Yana, Karnataka | 2005 | Pratibha and Bhat, 2004 |
| *Ceratosporella pulneyensis* Subram. & Bhat | Unidentified dead twig | Kodaikanal, Tamil Nadu | 1980 | Subramanian and Bhat, 1987 |
| *Chalara indica* Pratibha, Gawas, Hyde & Bhat | Live leaves of *Areca catechu* | Kesarval, Goa | 2003 | Pratibha and Bhat, 2005 |
| *Cheiropolyschema ghaticum* Bhat & Kendrick | Dead decaying leaves | Edakumeri, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *Craspedodidymum fimbriatum* Bhat & Kendrick | Unidentified dead twigs | Shiradi ghat, Karnataka | 1988 | Bhat and Kendrick, 1993 |
| *Craspedodidymum hyalosporum* Bhat & Kendrick | Unidentified dead twigs | Edakumeri, Karnataka | 1989 | Bhat and Kendrick, 1993 |

| Fungus name* | Substrate | Locality | Year of collection | Reference |
|---|---|---|---|---|
| *C.pulneyensis* Subram. & Bhat | Unidentified dead twig | Kodaikanal, Tamil Nadu | 1980 | Subramanian and Bhat, 1987 |
| *Cryptophiale apicalis* Bhat & Kendrick | Dead leaves of *Vateria indica* | Shiradi ghat, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *Cryptophiale verrucosa* Bhat & Kendrick | Dead leaves of *Vateria indica* | Sampaje ghat, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *Dendrospora yessemreddyi* Nair & Bhat | Fresh water stream | Bondla, Goa | 1999 | Nair and Bhat, 2002 |
| *Dictyochaeta ciliata* (Onofri & Ramhelli) Bhat & Kendrick | Dead leaves of *Cinnamomum* sp. | Kudremukh, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *Dichotomophthoropsis safeeulaensis* Bhat, Rasheed & Sheeba | Dead leaves of *Oryza sativa*Konaje | Karnataka | 1989 | Sheeba et al., 1989 |
| *Didymobotryum spirillum* D'Souza & Bhat | Dead culm of *Dendrocalamus strictus* | Molem, Goa | 2000 | D'Souza and Bhat, 2002 |
| *Digitoramispora tambdisurlensis* Pratibha, Raghuk & Bhat | Unidentified Dead twig | Tambdi surla, Goa | 2008 | Pratibha et al., 2009 |
| *Dimastigosporium yanense*Yadav & Bhat | Decomposed cattle dung | Yana, Karnataka | 2008 | Yadav and Bhat, 2009 |
| *Diplospora indica* Nair & Bhat | Unidentified submerged litter | Cotigao, Goa | 1999 | Nair and Bhat, 2001 |
| *Echinosphaeria macrospora* Puja, Hyde & Bhat | Endophyte of *Centella asiatica* | Colem, Goa | 2005 | Puja *et al.*, 2006 |
| *E.pteridis* Dharg. & Bhat | Endophyte of Rachis of *Pteris vittata* | Gersoppa, Karnataka | 2007 | Dhargalkar and Bhat, 2009 |
| *Fusichalara goanensis* Bhat & Kendrick | Unidentified dead twig | Cotigao, Goa | 1991 | Bhat and Kendrick, 1993 |
| *Gangliostilbe malabarica* Subram & Bhat | Unidentified dead twig | Silent valley, Kerala | 1980 | Subramanian and Bhat, 1987 |
| *Gliocladium sampajense* Subram & Bhat | Dead bark of *Theobroma Cocoa* | Sampaje, Karnataka | 1979 | Subramanian and Bhat, 1987 |
| *Gonatobotryum bimorphosporum* Jacob & Bhat | Endophyte of *Carrisa carandas* | Taleigao plateau, Goa | 1998 | Jacob and Bhat, 2000 |
| *Helminthosporium belgaumense* Subram. & Bhat | Dead twig of unidentified plant | Upper Anmod, Goa | 1980 | Subramanian and Bhat, 1987 |
| *Hyphopolynema stilboideum* Bhat & Kendrick | Dead leaves of *Syzigium* sp. | Kodachadri hills, Karnataka | 1991 | Bhat and Kendrick, 1993 |
| *Idriella malabarica* Subram. & Bhat | Unidentified leaf litter | Silent Vally, Kerala | 1980 | Subramanian and Bhat, 1987 |
| *Kumanasamuha kalakadensis* Subram. & Bhat | Unidentified dead twig | Kalakad, Tamil Nadu | 1980 | Subramanian and Bhat, 1987 |
| *Kumbhamaya goanensis* Maria & Bhat | Dead leaves of *Flocourtia montana* | Cotigao, Goa | 1999 | Bhat and Kendrick, 1993 |
| *K. jalapriya* Nair & Bhat | Live roots of *Hopea ponga* | Molem, Goa | 2000 | Nair and Bhat, 2002 |
| ***Kumbhamaya indica*** Miriam & Bhat | Endophyte of *Carissa carandas* | Verna plateau, Goa | 1997 | Jacob and Bhat, 2000 |

| Fungus name* | Substrate | Locality | Year of collection | Reference |
|---|---|---|---|---|
| *Micronsporium appediculatum* Miriam & Bhat | On goat dung | Verna, Goa | 1996 | Miriam and Bhat, 1998 |
| ***Natarajania indica*** Pratibha & Bhat | Dead leaf of *Antiaris toxicaria* | Netravali, Goa | 2006 | Pratibha and Bhat, 2005 |
| ***Parahelminthosporium malabaricum*** Subram. & Bhat | Dead Rachis of *Calamus* sp. | Oochipara, Silent vally, Kerala | 1980 | Subramanian and Bhat, 1987 |
| *Phalangispora bharathensis* K.Prasad & Bhat | Leaf litter of *Holigarna arnotiana* | Cotigao, Goa | 1999 | Prasad and Bhat, 2002 |
| *Phialosporostibe setosa* Bhat & Kendrick | On decaying leaves of *Ochlandra sp.* | Kudremukh, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *Pleurothecium magnum* Subram. & Bhat | Unidentified rotten wood | Kodaikanal, Tamil Nadu | 1981 | Subramanian and Bhat, 1987 |
| *P.pulneyense* Subram. & Bhat | Unidentified Dead twig | Kodaikanal, Tamil Nadu | 1980 | Subramanian and Bhat, 1987 |
| *Pircaudiopsis appendiculata* Bhat & Kendrick | Unidentified dead twigs | Kudremukh, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| ***Porosubramaniania malabarica*** Subram. & Bhat | Unidentified Dead twig | Thekkadi, Kerala | 1977 | Subramanian and Bhat, 1987 |
| *Pseudotorula helica* Subram. & Bhat | Unidentified Dead twig | Kodaikanal, Tamil Nadu | 1981 | Subramanian and Bhat, 1987 |
| ***Putagraivam sundaram*** Subram. & Bhat | Dead twigs of *Macaranga indica* | Darbhe (Irde), Karnataka, | | Subramanian and Bhat, 1977 |
| ***Rattania setuifera*** Prabhugaonkar & Bhat, | Endophyte of *Calamus thwaitesii* | Dhoodhsagar, Goa | 2008 | Prabhugaonkar and Bhat, 2009 |
| *Sorocybe indicus* Gawas, Hyde & Bhat | Hanging dead twig | Amboli, Maharashtra | 2003 | Pratibha *et al.*, 2005 |
| *Spegazzinia subramaniinii* Bhat | Hyperparasite on *Helminthosporium velutinum* | Kodachadri hills, Karnataka | 1989 | Bhat, 1994 |
| *Speiropsis rogergoosensis* K.Prasad &t Bhat | Dead leaves of *Artocarpus hirsutus* Lam. | Subramanya, Karnataka | 2001 | Prasad *et al.*, 2002 |
| *Spondylocladiopsis aseptata* Pratibha, Raghuk. & Bhat | Unidentified leaf litter | Calicut, Kerala | 2008 | Pratibha and Bhat, 2009 |
| *Sporidesmina malabarica* Subram & Bhat | Dead petiole of *Curcuma sp.* | Silent Vally, Kerala | 1980 | Subramanian and Bhat, 1987 |
| *Sporidesmiopsis malabarica* Subram & Bhat | Dead petiole of *Curcuma sp.* | Silent Vally, Kerala | 1980 | Subramanian and Bhat, 1987 |
| *S. goanensis* Bhat & Kendrick | Unidentified dead twigs | Kodachadri hills, Karnataka | 1991 | Bhat and Kendrick, 1993 |
| *Sporoschisma uniseptatum* Bhat & Kendrick | Unidentified decaying twig | Morphirla, Goa | 1991 | Bhat and Kendrick, 1993 |
| *Stellomyces kendrickii* K.Prasad & Bhat | Decaying twigs of *Hopea ponga* | Molem, Goa | 2001 | KeshavPrasad and Bhat, 2002 |
| *Tetraploa circinata* Pratibha & Bhat | Dead bamboo twig | Mahabaleshwar, Maharashtra | 2006 | Pratibha and Bhat, 2008 |
| *Trichobotrys ramosa* D'Souza & Bhat | Dead leaves of *Dendrocalamus strictus* | Molem, Goa | 1999 | Maria and Bhat, 2001 |

| Fungus name* | Substrate | Locality | Year of collection | Reference |
|---|---|---|---|---|
| *Trinacrium indica* Soosamma, Lekha, Sreekala & Bhat | Decaying leaf litter of *Coffea arabica* | Somvarpet, Karnataka | 1998 | Soosamma *et al.*, 2001 |
| *Uberispora tropicalis* Bhat & Kendrick | Unidentified dead twigs | Donigalu, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| ***Vamsapriya indica*** Gawas & Bhat | Dead bamboo twig | Yellapur, Karnataka | 2005 | Gawas and Bhat, 2005 |
| *V. mahabaleshwarensis* Pratibha & Bhat | Unidentified dead twig | Mahabaleshwar, Maharashtra | 2006 | Pratibha and Bhat, 2008 |
| ***Vanakripa gigaspora*** Bhat, Kendrick & Nag Raj | Unidentified dead twigs | Molem, Goa | 1991 | Bhat and Kendrick, 1993 |
| *V. parva* Bhat et Kendrick & Nag Raj | Unidentified dead twigs | Cotigao, Goa | 1991 | Bhat and Kendrick, 1993 |
| *Vermiculariopsiella elegans* K.Prasad, D'Souza & Bhat | Leaf litter of *Saraca asoca* | Bondla, Goa | 1999 | Prasad *et al.*, 2003 |
| *V. endophytica* Puja, Shenoy, Hyde & Bhat | Endophyte of *Centella asiatica* | Colem, Goa | 2005 | Puja *et al.*, 2006 |
| *V. indica* K.Prasad, D'Souza & Bhat | Endophyte of *Saraca asoka* | Bondla, Goa | 1999 | Prasad *et al.*, 2003 |
| *V. pteridis* Dharg. & Bhat | Endophyte of rachis of *Pteris vittata* | Gersoppa, Karnataka | 2007 | Dhargalkar and Bhat, 2009 |
| *Vermisporu cauveriana* Rajashekar,,Bhat & Kaveriappa | Dead leaves of *Ficus religiosa* | Srirangapatana, Karnataka | 1991 | Rajashekar *et al.*, 1991 |
| ***Xenoheteroconium bicolor*** Bhat, Kendrick & Nag Raj | Unidentified decaying leaves | Agumbe, Karnataka | 1989 | Bhat and Kendrick, 1993 |
| *Zygosporium tuberculatum* Subram. & Bhat | Unidentified dead twig | Silent Vally, Kerala | 1980 | Subramanian and Bhat, 1987 |

**New genera are in bold*

**Establishment of a fungus culture repository in Goa University**

Professor Subramanian had always advocated culturing and maintenance of fungi in the repositories. I did numerous single-spore isolations of hypocrealean and hyphomycetous fungi, while in Madras, for the Fungus Flora project. Along with my students and colleagues, I continued the exercise in Goa University. While dried herbarium specimens satisfy mandatory taxonomic obligations of description of novel species, culturing and maintaining the fungi in repositories is a potentially optimistic approach of not only slowing down the loss of bioresources from our forests but also a meaningful way of organizing sustainable and utilizable fungal gene banks. We set up an in-house such facility for fungi in the Department of Botany, Goa University, and I had Professor Subramanian to switch on the programme, in 1998.

**Evolution of Hyphomycete taxonomy**

Fries (1821-1832) was considered as the starting point for most fungi. For conidial fungi or Deuteromycotina which embodied the Hyphomycetes and Coelomycetes, Persoon (1801) was taken as the starting point. The International Code of Botanical Nomenclature (ICBN) provides rules and recommendations with regard to application of names at different taxonomic hierarchy in fungi. Presently, St. Louis Code published in 2000 is in use. According to Article 59.1. of the Code, for ascomycete and basidiomycete fungi with asexual and sexual morphs, the name of the holomorph (species with all its morphs), typified by the teleomorph, is the earliest legitimate name to be applied.

In the treatment of Hawksworth et al. (1983), Eumycota included five subdivisions: Mastig omycotina (Chytridiomycetes, Hyphochytriomycetes, Oomycetes), Zygomycotina (Zygomycetes, Trichomycetes), Ascomycotina, Basidiomycotina and Deuteromycotina. Kirk *et al.* (2001) accommodated 'true fungi' in 4 phyla, viz. Chytridiomycota, Zygomycota, Ascomycota and Basidiomycota. The Deuteromycotina is not accepted as a formal taxonomic group as they are polyphyletic (Seifert *et*

*al.*, 2000; Shenoy *et al.*, 2006, 2007). Recently, Hibbett *et al.* (2007) proposed a higher-level phylogenetic classification for fungi based on morphology, molecular biology and phylogenetic relationships which did not treat the sexual and asexual morphs separately.

Notwithstanding what is said above, conidial fungi are rarely encountered in their full form, as holomorph, in nature. Either they exist in their sexual phase (teleomorph) which reproduce by meiospores resulted from sexually differentiated cells as in Ascomycotina or Basidiomycotina or in asexual forms (anamorph) which are propagated by mitospores, as in Deuteromycotina. In nature, sexual and asexual phases of fungi are often separated in space and time; that is, separate entities of anamorphic and teleomorphic fungi exist. More often, an anamorph remains unconnected with a teleomorph, or the latter may be totally absent. Since, the teleomorph holds nomenclatural priority over anamorphic phase and as and when more and more anamorph-teleomorph connections are established, provisions are made in the Code to accommodate conidial fungi with binomials as 'form-genera' and 'form-species', that is 'anamorph-genera' and 'anamorph-species'.

Though all anamorphs are expected to get connected to their teleomorphs, sexual phase of a number of conidial fungi are not yet known. Absence of sexual phase does not imply that the fungus lacks sex. If the fungus is totally asexual, it wouldn't get the advantages of sexual reproduction such as generation of novel genotypes capable of living in changing environments, withstanding the deleterious effects of mutations, escaping from pathogens, etc. It is possible that substrate- and habitat-wise, seasonal and geographic separation of compatible mating types might be limiting the sexual reproduction in fungi (O'Gorman *et al.*, 2008). It is also intriguing that 22% of the reported fungi do not have sexual morphs (Shenoy *et al.*, 2007). This includes many of the industrially important strains and human pathogenic fungi. Though 'anamorphy' will continue to remain as an independent entity in the taxonomy of fungi at least for some time, in the future we will have a single system of classification of fungi based on DNA-sequence data supplemented by other available biological data.

**Future of taxonomy of Hyphomycetes**

Molecular genetic data of fungi provide value addition in taxonomic studies. Advanced methods applied and data generated serve as molecular signatures which on comparison with similar data from other isolate/s facilitate confirmation of relatedness of the two. Sequencing of the ITS, 18S and 28S rRNA gene regions for fungi is employed to distinguish isolates at generic and species level and to study their phylogenetic affinities and relatedness (Hibbett *et al.* 2007). Major drawback in general application of this technology, however, is the high cost of instrumentation, chemicals and lab-wares, especially in the fungi-rich developing countries such as ours.

Nevertheless, there are renewed efforts made to unravel the mysteries associated with refusal of asexual fungi to reproduce sexually. O'Gorman *et al* (2008) studied the mating behaviour and sexuality of genetically variable 12 isolates of an opportunistic human pathogen, *Aspergillus fumigatus*, in a range of media and temperature regimes. In one of these crosses, after 6 months of incubation, they discovered fruiting bodies characteristic of a sexual phase of an aspergillus, *Neosartorya fumigata*. Examination of segregation of five genetic markers in ascospore progeny from different crosses confirmed that meiotic recombination did take place. The discovery of sexual cycle in this species offers not only a useful tool for investigations into classical genetic analyses and studies on genetic basis of pathogenicity and fungicidal resistance in *A. fumigatus* but also opens up avenues to improve the methods of control of aspergillosis. These results propose insights into the potential of sexual reproduction in similar supposedly 'asexual' fungi.

Sex determination in fungi is controlled by a small, specialized region of the genome. Different gene combinations reside at these mating-type (MAT) loci and confer sexual identity. The MAT loci have been characterized for a single monophyletic clade of fungi, the Dikarya (Ascomycota and Basidiomycota), but the ancestral state and evolutionary history of these loci have so far remained a mystery. Applying bioinformatic and genetic mapping tools to identify the sex-determining region in *Phycomyces blakesleeanus* (Zygomycota), which represents an early branch within the fungi, Idnurm *et al.* (2008) found out that each sex allele contains a single gene that encodes for a high mobility group (HMG)-domain, implicating that the HMG-domain proteins are an earlier form of fungal MAT loci.

Eighty years after Alexander Fleming's discovery of penicillin by a strain of *Penicillium notatum*, Hoff et al. (2008) discovered another strain of *Penicillium* with hyper antibacterial activity. Using a heterologous PCR approach, they showed that these strains are of opposite mating types and that both have retained transcriptionally expressed pheromone and pheromone receptor genes required for sexual

reproduction. This discovery gives us a clue why so many of the fungi still remain as asexual.

**Epilogue**

I believe that the basics lie, at least for the present, in the morphological diagnoses of the fungi. Every type or reference taxon needs to be correctly identified morphologically before its sequence forms a reference for comparison with other isolates. Morphology-based identification is a quick, pragmatic and inexpensive method for diagnosis of the fungi. Often, these are found to be phylogenetically natural (Seifert and Gams, 2001). I appeal fellow mycologists, young and elder, to simultaneously venture on morpho- and molecular-based systematics of fungi. This will provide a stable single classification and reliable identification system for fungi.

**REFERENCES:**


BHAT, D.J. 1983. An undescribed species of *Pleiochaeta* from Asmara, Ethiopia. *Trans. Br. mycol. Soc.* **81:** 405-406

BHAT, D.J. 1984. Two new hyphomycetes from Ethiopia. Proc. *Indian Acad. Sci.* **94(b):** 269-272

BHAT, D.J. 1985. Notes on *Pauthramaya Panchanania*. *Trans. Br. mycol. Soc.* **85:** 101-106

BHAT, D.J. 1986. Microfungi of Ethiopia: A Floristic Survey. *Sinet*, **15:** 14-18.

BHAT, D.J. 1994. Two undescribed species of conidial fungi from Western Ghats in southern India. *Indian J. Forestry* **17:** 129-133.

BHAT, D.J. 2006. Hyphomycetous fungal diversity in the north-eastern hill forests of Arunachal Pradesh, Assam and Nagaland. *Kavaka* **34:** 27-48

BHAT, D.J. AND CHIEN, C.Y., 1990. Water-borne Hyphomycetes found in Ethiopia. *Trans. Mycol. Soc. Japan* **31: 147-157.**

BHAT, D.J. AND KENDRICK, B. 1993.Twenty-five new conidial fungi from the Western Ghats and the Andaman Islands (India). *Mycotaxon.* **49(1):19–90.**

BHAT, D.J. AND SUTTON, B.C. 1984. Some phialidic hyphomycetes from Ethiopia. *Trans. Br. mycol. Soc.* **84:** 723-730.

BHAT, D.J. AND SUTTON, B.C. 1985. New and interesting Hyphomycetes from Ethiopia. *Trans. Br. mycol. Soc.* **85:**107-122

BHAT, D.J., PRATIBHA, J., GAWAS, P., SARITA, K.Y. AND SWAPNAJA, D. 2009. Diversity of microfungi in the forests of Western Ghats in Goa and surrounding regions. In: *Plant and Fungal Biodiversity and Bioprospecting*. D.J. Bhat & S. Krishnan (Eds.). Broadway Book Centre, Panaji, Goa. 117-133 pp.

CHIEN, C.-Y. AND BHAT, D.J. 1992. Studies on tropical microfungi: An exercise in Diversity. *Trans. Mycol. Soc. Japan* **33: 135-139.**

DHARGALKAR, S. AND BHAT, D.J. 2009. *Echinosphaeria pteridis* sp. nov. and its *Vermiculariopsiella* anamorph. *Mycotaxon*, **108:** 115-122

D'SOUZA, M. 2002. Studies on Diversity, Ecology and Biology of microfungi associated with a few dicot and monocot plant species of Western Ghats in Goa State, India. *Ph.D. Thesis*. Goa University.

D'SOUZA, M. AND BHAT, D.J. 2001. A new species of *Trichobotrys* from the Western Ghat forests, India. *Mycotaxon* **80:** 104-108

D'SOUZA, M. AND BHAT, D.J. 2002. *Didymobotryum spirillum*, a new synnematous hyphomycete from India. *Mycologia*, **94:** 535-538.

D'SOUZA, M. AND BHAT, D.J. 2002. *Bharatheeya*, a new hyphomycete genus from India. *Mycotaxon* **83:** 397-403.

D'SOUZA, M.A. AND BHAT, D.J. 2007. Diversity and abundance of endophytic fungi in four plant species of Western Ghat forest of Goa, southern India. *Kavaka* **35:** 11-20

D'SOUZA, M., SINGH, S.K. AND BHAT, D.J. 2002. New conidial fungi from Andaman Islands, India. *Mycotaxon*, **82:** 133-143

EICKER, E., SINCLAIR, R. AND BHAT, D.J. 1985. Branching in *Spadicoides*. *Trans. Br. mycol. Soc.* **85: 736-738.**

FRIES, E.M. 1821-1832. *Systema mycologicum, sistens fungorum ordines, genera et species huc usque cognitas*. 3 vol.

GAWAS, P. 2008. Studies on diversity, activity and ecology of microfungi associated with some medicinal plants of Goa region of Western Ghats, India. *Ph.D. Thesis*, Goa University.

GAWAS, P. AND BHAT D.J. 2005. *Vamsapriya indica* gen et sp. nov, a bambusicolous, synnematous fungus from India. *Mycotaxon*, **94:** 149-154.

HAWKSWORTH, D.L., SUTTON, B.C. AND AINSWORTH, G.C. 1983. Ainsworth and Bisby's Dictionary of the Fungi. CAB International, Kew.

HIBBETT, D.S., BINDER, M., BISCHOFF, J.F., BLACKWELL, M., CANNON, P.F., ERIKSSON, O.E., HUHNDORF, S., JAMES, T., KIRK, P.M., LÜCKING, R., LUMBSCH, T., LUTZONI , F., MATHENY, P.B., MCLAUGHLIN, D.J., POWELL, M.J., REDHEAD, S., SCHOCH, C.L., SPATAFORA, J.W., STALPERS, J.A., VILGALYS, R., APRIME, M.C., APTROOT, A., BAUER, R., BEGEROW, D., BENNY, G.L., CASTLEBURY, L.A., CROUS, P.W., DAI, Y.-C., GAMS, W., GEISER, D.M., GRIFFITH, G.W., GUEIDAN, C., HAWKSWORTH, D.L., HESTMARK, G., HOSAKA, K., HUMBER, R.A., HYDE, K.D., IRONSIDE, J.E., KÕLJALG, U., KURTZMAN, C.P., LARSSON, K.-H., LICHTWARDT, R., LONGCORE, J., MIDLIKOWSKA, J., MILLER, A., MONCALVO, J.-M., MOZLEY-STANDRIDGE, S., OBERWINKLER, F., PARMASTO, E., REEB, V., ROGERS, J.D., ROUX, C., RYVARDEN, L., SAMPAIO, J.P., SCHÜßLER, A., SUGIYAMA, J., THORN, R.G., TIBELL, L., UNTEREINER, W.A., WALKER, C., WANG, Z., WEIR, A., WEIß, M., WHITE, M.M., WINKA, K., YAO AND Y.-J., ZHANG, N. 2007. A higher-level phylogenetic

classification of the Fungi. *Mycological Research* **111:** 509-547.

HOFF, B., POGGELER, S. AND KUCK, U. 2008. Eighty years after its discovery, Fleming's *Penicillium* strain discloses the secret of its sex. *Eucaryotic Cell* **7:** 465-470

IDNURM, A., WALTON, F.J., FLOYD, A. AND HEITMAN, J. 2008. Identification of the sex genes in an early diverged fungus. *Nature* **451:** 193-197

JACOB, M. 2000. Studies on Diversity, Ecology and Biology of microfungi associated with *Ficus benghalensis* linn. and *Carissa congesta* Wight. from Goa State, India. *Ph.D. Thesis*. Goa University.

JACOB, M. AND BHAT, D.J. 2000. Two new endophytic conidial fungi from India. *Cryptogam. Mycol.* **21:** 81-88.

JACOB, M. AND BHAT, D.J. 1997. *Microsporum appendiculatum* sp.nov. on goat dung from India. *Kavaka* **25:** 93-94.

JAMALUDDIN, M.G, GOSWAMI AND OJHA, B.M. 2004. *Fungi of India* (1989-2004). Scientific Publishers (India), Jodhpur, 326 pp.

KESHAVAPRASAD, T.S. 2003. Studies on Diversity, Ecology and Biology of microfungi in relation to mosquito developmental stages. *Ph.D. Thesis*. Goa University.

KESHAVAPRASAD, T.S. AND BHAT, D.J. 2002. *Stellomyces kendrickii*, a new hyphomycete from India. *Mycotaxon* **84:** 61-63.

KESHAVAPRASAD, T.S. AND BHAT, D.J. 2002. A new species of *Phalangispora* from India. **82:** 127-131

KESHAVAPRASAD, T.S., ASHA, G. AND BHAT, D.J. 2003. A new species of *Memnoniella* from India. *Mycotaxon* **85:** 341-344.

KESHAVAPRASAD, T.S., ASHWANI KUMAR AND BHAT, D.J. 2004. New records of *Aschersonia* from forests of Western Ghats, India. Indian J. Mycol. Pl. Pathol. April 2004, 34-41.

KIRK, P.M., CANNON, P.F., DAVID, J.C. AND STALPERS, J.A. (EDS). 2001. Ainsworth & Bisby's Dictionary of the Fungi. ninth ed. CABI Publishing, Wallingford.

MANGALA, P.P., HIREMATH, K.G. AND BHAT, D.J. 2006. Pollen and fungal spora of Miramar beach area, Goa. *Indian Journal of Aerobiology* **19:** 37-41.

MANOHARACHARY, C. 2005. Fungal biodiversity: Distribution, conservation and prospecting of fungi from India. *Curr. Sci.* **89:1, 58-71.**

MANOHARACHARY, C., SRIDHAR, K.R., SINGH, R., ADHOLEYA, A., SURYANARAYANAN, T.S., RAWAT, S. AND JOHRI, B.N. 2005. Fungal biodiversity: Distribution, conservation and prospecting of fungi from India. *Curr. Sci.* **85:** 58-71

NAIR, S.K. 2002. Studies on Diversity, Ecology and Biology of Microfungi from freshwater streams of Western Ghats in Goa state, India. *Ph.D. Thesis*. Goa University.

NAIR, S.K. AND BHAT, D.J. 2001. *Diploospora indica*, a new species of Hyphomycetes. *Mycotaxon* **80: 101-104**

NAIR, S.K. AND BHAT, D.J. 2002. *Kumbhamaya jalapriya*, a new endophytic hyphomycete from India. *Mycotaxon* 84: 65-68.

O'GORMAN, C.M., FULLER, H.T. & DYER, P.S. 2008. Discovery of a sexual cycle in the opportunistic fungal pathogen *Aspergillus fumigatus*. *Nature* 457: 471-475

PASCAL, J.P. 1989. Wet Evergreen Forests of the Western Ghats of India: Ecology, Structure, Floristic Composition and Succession. Institut, Francais de Pondichery, India.

PERSOON, C.H. 1801. *Synopsis Fungorum*. 2 vol.

PRABHUGAONKAR, A. AND BHAT, D.J. 2009. *Rattania setulifera*, an undescribed endophytic hyphomycete on rattans from Western Ghats, India. *Mycotaxon 108*: 217–222

JALMI, P. 2006. Stuidies on Folicolous fungi of Goa and neighbouring areas of Maharastra and Karnataka. Ph.D. Thesis. Goa University

PRATIBHA, J. AND BHAT, D.J. 2005. *Natarajania Indica* gen. et sp. nov., a new dematiaceous hyphomycete from the forests of Western Ghats, India. *Kavaka* **33:** 129-133.

PRATIBHA, J. AND BHAT, D.J. 2008. New and unusual hyphomycetes from Mahabaleshwar, India. *Mycotaxon*. **105**: 423-431.

PRATIBHA, J., RAGHUKUMAR, S. AND BHAT, D.J. 2009. New species of *Digitorumispora* and *Spondylocladiopsis* from the forests of Western Ghats, India. *Mycotaxon* **107:** 383-390

PRATIBHA, J., GAWAS, P., SHENOY, B.D., HYDE, K.D. AND BHAT, D.J. 2005. *Chalara indica* sp nov. and *Sorocybe indicus* sp. nov. from India. *Cryptogamie Mycologie*, **26: 123-132.**

PRATIBHA, J., HYDE, K.D. AND BHAT, D.J. 2004. *Ceeveesubramaniomyces*, a new dematiaceous hyphomycete genus from India. *Kavaka* **32:** 21-26.

PUJA, G., SHENOY, B.D., HYDE, K.D. AND BHAT, D.J. 2006. *Echinosphaeria macrospora* sp. nov., teleomorph of *Vermiculariopsiella endophytica* sp. nov. *Cryptogamie Mycologie*. **27:** 1-10.

RAJASHEKAR, S., KAVERIAPPA, K.M. AND BHAT, D.J. 1991. An undescribed species of *Vermispora* from India. *Mycologia* **89: 230-232.**

RAO, V. AND DE HOOG, 1986. New or critical hyphomycetes from India. *Studies in Mycology* **28:** 1-84.

SARBHOY, A.K., AGARWAL, D.K. AND VARSHEY, S.L. 1986. *Fungi of India 1977-81*. Associated publishing company.

SARBHOY, A.K., VASHNEY J.L. AND AGARWAL, D.K. 1996. *Fungi of India 1982- 92*. CBS publishers and distributors: 350pp

SEIFERT, K.A. 1985. A monograph of *Stilbella* and allied Hyphomycetes. *Stud. Mycol.* **27:** 1- 235

SEIFERT, K.A. AND GAMS, W. 2001. The taxonomy of anamorphic fungi. In: *The Mycota* Vol. VII (A). *Systematics and Evolution* (eds. D.J. McLaughlin, E.G. McLaughlin and P.A. Lemke), Springer-Verlag, Berlin. 307-347

SEIFERT, K.A., GAMS, W., CROUS, P.W. AND SAMUELS, G.J. (EDS.) 2000. Molecules, morphology and classification: towards monophyletic genera in the Ascomycetes. *Studies in Mycology* **45:** 1-231.

SHENOY, B.D., JEEWON, R., WU, W.P., BHAT, D.J. AND HYDE, K.D. 2006. Ribosomal and RPB2 DNA sequence analyses suggest that *Sporidesmium* and morphologically similar genera are polyphyletic. *Mycological Research* **110:** 916-928.

SHENOY, B.D., JEEWON, R. AND HYDE, K.D. 2007. Impact of DNA sequence-data on the taxonomy of anamorphic fungi. *Fungal Diversity* **26:** 1-54.

SINCLAIR, R.C., EICKER, A., BHAT, D.J. BRANCHING IN SPADICOIDES. 1985. *Transactions of the British Mycological Society* **85:** 4, 736-738.

SINGH, S.K., BHALLA, K. AND BHAT, D.J. 2002. Four new foliicolous hyphomycetes from Vindhya Hills, India. *J. Mycol. & Pl. Pathol.* 286-289.

SINGH, S.M., GAWAS, P. AND BHAT, D.J. 2006. Psychrophilic fungi from Schirmacher Oasis of East Antarctica. *Current Science*, **90 (10):** 1388-1392.

SOOSAMMA, M., LEKHA, G., SREEKALA, K.N. AND BHAT, D.J. 2001. A new species of *Trinacrium* from submerged leaves from India. *Mycologia* **93: 1200-1202**

SUBRAMANIAN, C.V. 1971. Hyphomycetes. ICAR Publication, New Delhi. 930 pp.

SUBRAMANIAN, C.V. AND BHAT, D.J. 1977a. *Bahusutrabeeja*, a new genus of the Hyphomycetes. *Can. J. Bot.* **55:** 2202-2206

SUBRAMANIAN, C.V. AND BHAT, D.J. 1977b. *Putagraivam*, a new genus of the Hyphomycetes. *Proc. Ind. Acad. Sci.* **87 (B):** 99-104

SUBRAMANIAN, C.V. AND BHAT, D.J. 1977c. *Peethambara*, a new genus of the Hypocreales. *Revue Mycol.* **42: 49-53**

SUBRAMANIAN, C.V. AND BHAT, D.J. 1987-88. Hyphomycetes from South India: Some new Taxa. *Kavaka* **15:** 41-74.

THOMAS, S., AHMAD, R. AND BHAT, D.J. 1990. An Undescribed species of *Dichotomophthoropsis* on rice from India. *Mycologia* **82:** 390-392.

SUBRAMANIAN, C.V. AND BHAT, D.J. 1981. Conidia from Freshwater foam sample from the Western Ghats, southern India. *Kavaka* **9:** 45-62.

YADAV, S. AND BHAT, D.J. 2009. *Dimastigosporium yamense*, a new coprophilous fungus from the forests of Western Ghats in Karnataka State, India. *Mycotaxon* **107: 397–403**

Fig. 1: Extracted from Google Earth™ mapping service