

**Studies on Diversity and Activity
of Microfungi Associated with
Indigenous Palms of Western
Ghats, India**

**Thesis submitted to
GOA UNIVERSITY**

for the Award of Degree of

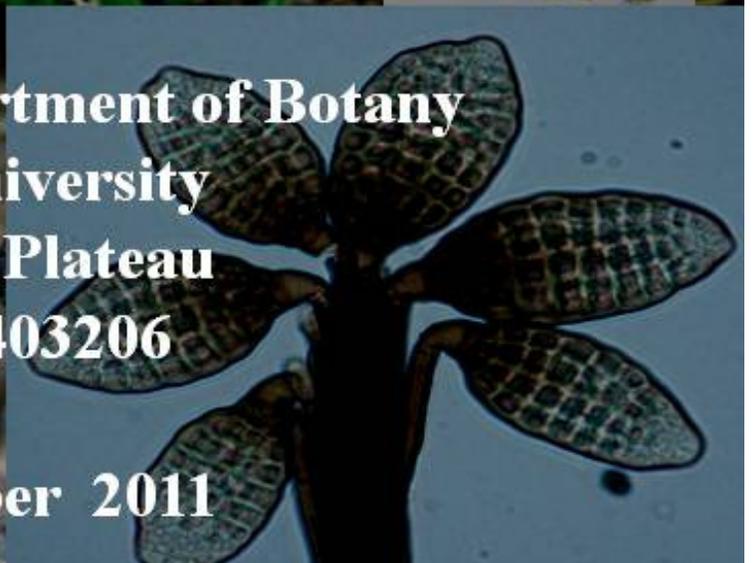
**DOCTOR OF PHILOSOPHY IN
BOTANY**

By

Mr. Ashish Prabhugaonkar, M.Sc.

**UGC-SAP Department of Botany
Goa University
Taligao Plateau
Goa-403206**

December 2011



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DECLARATION

I hereby declare that the Ph.D. thesis entitled “STUDIES ON DIVERSITY AND ACTIVITY OF MICROFUNGI ASSOCIATED WITH INDIGENOUS PALMS OF WESTERN GHATS, INDIA” submitted to Goa University, forms an independent work carried out by me in the Department of Botany, Goa University, under the supervision of Prof. D.J. Bhat, Department of Botany, Goa University and the thesis has not formed previously the basis for the award of any degree, diploma, associateship or any similar titles.

(Ashish V. Prabhugaonkar)

Countersigned by

CERTIFICATE

I certify that thesis entitled “STUDIES ON DIVERSITY AND ACTIVITY OF MICROFUNGI ASSOCIATED WITH INDIGENOUS PALMS OF WESTERN GHATS, INDIA” submitted by Mr. Ashish V. Prabhugaonkar, is a record of research work done by him during the period from 2007-2011 when he worked under my supervision. The thesis has not formed the basis for award of any degree, diploma, associateship or fellowship to Mr. Ashish V. Prabhugaonkar.

I affirm that the thesis submitted by Mr. Ashish V. Prabhugaonkar incorporates the independent research work carried out by him under my supervision.

(Supervisor)

ACKNOWLEDGEMENTS

I owe my gratitude to my guide, Prof. D.J. Bhat, Department of Botany, Goa University, for introducing me towards mycology and giving his entire support and never ending encouragement throughout this study.

I am grateful to Co-guide Prof. M.K. Janarthanam, Department of Botany, Goa University, for perpetual motivation and supervision of the work.

I am thankful to all my teachers, Prof. P.K. Sharma, Prof. B.F. Rodrigues, Dr. Vijaya Kerkar, Dr. S. Krishnan and Dr. N. Kamat, in Department of Botany for their kind support.

I thank Dr. Ganeshan, ATREE, Bangalore, Dr. N.S. Pradeep, TBGRI, Thiruvananthapuram, Dr. P. Paryekar, Goa University, Dr. G. Senthilarasu, ARI, Pune, Dr. T.K. Arun, Calicut University and Sivu, Justin and Rafeeq PhD students at TBGRI, for helping me with sample collections and accompanying me on various field visits in the forests of Western Ghats.

I owe very much to all other staff in the Department of Botany, Goa University, for their assistance in many ways during period of my work. I have great pleasure in acknowledging my seniors Dr. Pratibha and Dr. Puja for their extraordinary help and friends Andy, Bharat, Bhaskar, Cassie, Geeta, Harshal, Indira, James, Jyosna, Jyoti, Priyanka, Sonashia, Ravikiran, Rupali, Sarita, Seema, Sidhesh, Shilpa, Vera, Madam Emilia and many others in Goa University for their invaluable help in many ways.

I thank the Ministry of Environment and Forests (MoEF), New Delhi, for providing me with a research fellowship during the tenure of this work. I am grateful to Department of Botany, Goa University for providing all the facilities.

Lastly and above all, I am indebted to my parents and brother for their encouragement, ceaseless help and constant support.

Ashish V. Prabhugaonkar

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Introduction

'There are countless numbers of fungi, many of them economically important, and many that might jump into prominence for reasons we will know only when they do so. The good earth will continue to hold them if we do not exterminate them. They will continue to draw and demand our attention, especially of those who explore, collect and culture them, and use traditional methods, or even sophisticated techniques, to accord them a name and taxonomic status.'

C.V. Subramanian, *Curr. Sci.* 101: 729-730, 2011

Fungi are unicellular or filamentous microorganisms with absorptive mode of heterotrophic nutrition. They are different from plants in that primary storage product is glycogen instead of starch as in the latter. Further, they have chitin in their cell wall. Fungi are unable to be accommodated in the animal kingdom because, from amoeba to humans, all the animals exhibit ingestive mode of nutrition. Recognizing their unique nature, Whittaker (1969) accommodated 'Fungi' in a separate Kingdom, in par with plants and animals. 'Microfungi' is the colloquial term used to describe the tiny, invisible, microscopic fungi which largely belong to groups such as Chytridiomycota, Zygomycota, Glomeromycota and Ascomycota. Former Deuteromycotina (the conidial fungi – Hyphomycetes and Coelomycetes) are mitosporic phase of either Ascomycota or Basidiomycota and capable of leading an independent asexual life cycle. The conspicuous fruit-body forming mushrooms, puff-balls, polypores, brackets, earth-stars, bird-nests, etc. belonging to Basidiomycota and truffles and morels in Ascomycota are referred as macrofungi.

Based on the number of systematically documented higher plants and their associated fungi in the British Isles, Dr. D.L. Hawksworth, former Director of International Mycological Institute, Kew, UK, in 1991, proposed that there might be 1.5 million species of fungi on the earth's surface (Hawksworth, 1991). Of these, nearly 100000 have so far been described (Hawksworth, 2004). This observation

implied that less than 7% of the world's fungi have so far been documented. Hawksworth (2004) regarded his estimate to be conservative because no allowance was made for the higher ratios of plant-fungal species of the tropical and sub-tropical regions.

By identifying the habitats and habits that are yet to be studied for the presence of fungi, several mycologists lead by Hyde (2004) made efforts to answer the pervading question - 'where are the missing or remaining fungi?' Amongst the most-studied diversity resource-habitats of fungi, angiospermic plants stand tall and apart. Sizable amount of data is now available on host range and plant-associated fungal species diversity. Yet, the fungal diversity in the tropics is still considered as an unexplored and under-explored area of research (Bhat, 2010; Hawksworth, 2004).

Fungal diversity exploration and *ex-situ* conservation

Biodiversity exploration and studies on taxonomy of living organisms are essential components of efforts of documentation of biological resources which aid the humankind in many ways. Organisms, small or big, once isolated and carefully maintained in *ex-situ* repositories, can be used for advantage always.

The fungi can be isolated in artificial culture media and maintained well in culture collections which aid their further utilization. The fungal culture repositories are very useful because they are the (i) source of type cultures/specimen for taxonomy and phylogenetic studies, (ii) authorized custodians of national bio-resources, (iii) potential and ready source of organisms for bioprospecting, (iv) *ex-situ* gene-pool of under- or un-explored biodiversity which might yield molecules of use in human endeavour and (v) source of 'rare and chance-collections' which are otherwise difficult to source again (Gams, 2007).

Substrate-associated fungi

Fungi are present everywhere. Armoured with an array of digestive enzymes, the fungi occur as obligate or facultative pathogens and saprophytes and live on live or dead remains of plants and animals (Kirk et al., 2008). There are mutualistic fungi found in association with algae in lichens and with higher plants in mycorrhizae (Kendrick, 2003).

The substrates and/or habitats that fungi occur include aerial leaves (foliicolous), internal tissues of plants (endophytes), decaying leaves and twigs (litter), herbivore dung (coprophilous), live or dead insects (entomogenous), ponds, lakes, streams and rivers (freshwater aquatics), mangroves (manglicolous), oceans and seas (marine) and animal or humans (mycotics) (Kendrick, 2003).

Palm-associated fungi and its importance:

Palms (F: Arecaceae) are distributed largely in the tropical and subtropical regions around the world (Eiserhardt et al., 2011). These plants are under-explored for fungal biodiversity (Hyde and Fröhlich 2000). Majority of the palms are strictly endemic and distributed in some of the most inaccessible regions of the tropical and subtropical forests. One such noted habitat of palms is the forests of Western Ghats in southern India (Ahmedullah and Nayar, 1987).

Palms constitute an excellent substrate/host for fungal colonization and considered to be one of the large reservoirs of fungi (Hyde and Fröhlich 2000). This is said to be because of high plant productivity in terms of biomass which makes it very favorable for fungal growth (Yanna et al., 2001b). In view of its high lingo-cellulose component, most palm plant parts, viz. stem, frond, dead leaves, dead or moribund spathe, flower and fruits, remain attached to the main plant for long time. Similar to

other groups, the palm-associated fungi also are termed as litter fungi, endophytes, foliicolous fungi and palm pathogens.

The forests of Western Ghats

Western Ghats is a hilly range of mountainous terrains on the western side of peninsular India, about 1600 km, extending parallel to the coastline of Arabian Sea from river Tapti southward through the States of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu up to Kanyakumari (Fig. 2). These mountains are steep and precipitous on the western side and gently sloppy on the east. Many short, fast flowing, seasonal streams and perennial rivers originate in the Western Ghats. Some of these flow westward in Maharashtra, Karnataka and Kerala a short distance to reach the Arabian Sea and several run eastward through the vast plains of Andhra Pradesh, Karnataka and Tamilnadu to reach the Bay of Bengal. The Western Ghats receive south-west monsoon rain from June to September, the downpour being heavy on the western side ranging between 250-400 cm annually. The annual day temperature ranges from 18⁰ to 37⁰C. The mean annual relative humidity is about 80%. Under these warm and humid conditions, luxuriant tropical forests flourish in the windward western side of the Ghats. Notable amongst these are the wet-evergreens, semi-evergreens, sholas, moist deciduous, dry deciduous and scrub jungles (Pascal, 1989). Several distinct endemic plant species have been reported from the region (Ahmedullah and Nayar, 1987). The forests of Western Ghats along with its counterparts in the Sri Lanka are named as one of the 24 biodiversity hotspots of the world (Myers et al., 2000).

Palm plants of the forests of Western Ghats

India has about 50 species of palms, distributed mainly in its two biodiversity hotspots, the forests of Western Ghats in southern India and the forests of eastern Himalayas in the north. The Western Ghats region accommodates about 30 species of indigenous palms (Ahmedullah and Nayar, 1987). Palms are one of the important plant communities. They stand apart for its unique biology, nativity and distribution. A number of them are endemic to the region.

Hitherto known information on fungus flora of palms, around the world, was mostly from commonly occurring palm species such as *Areca catechu*, *Caryota urens*, *Cocos nucifera*, *Borassus flabellifer* and a few species of *Phoenix* (Index Fungorum). The other palm species, those endemics and confined especially to some of the most inaccessible regions of the Western Ghats, remained unexplored till date. For instance, there is no report of fungi from endemic palms such as *Arenga wightii*, *Bentinckia condapanna*, *Corypha umbraculifera*, *Hyphaene dichotoma*, *Pinanga dicksonii*, and some of those restricted species of *Calamus* (USDA online database: Farr and Rossman, 2011).

Hypothesis and approach

Based on available data on mangrove species along the Indian coast, Manoharachary (2005) hypothesized that if the host plant is endemic and restricted in distribution, its fungal component might also have restricted distribution. Such endemic or endangered plants demand special attention from mycological survey point of view. An effort carried out to examine the fungi on selected endemic plant species in Mauritius resulted with over 200 species of saprobic microfungi which included 1 new genus and 38 new species (Dulymamode et al., 2001). About 4500 species of angiosperms are found in the Western Ghats region and of which 1720 (about one

third) are endemic (Ahmedullah and Nayar, 1987). It is presumed that the plant diversity should reflect associative fungal diversity in a given region.

Of the 30 species of palms of the forests of Western Ghats that remained under- and unexplored for fungi, 9 are strictly endemic to the region (Gamble, 1967). Taking this as an issue, it was proposed to explore the diversity of palm-associated fungi of the region. This study was aimed at understanding the fungal diversity associated with indigenous palms of Western Ghats.

Bioactivity of plant-associated microfungi

Cellulose and lignin are the major organic constituents of plant litter. In order to understand the degradation of these components by fungi, activity of cellulase (cellulose degrading enzyme) and laccases (lignin decomposing enzyme complex) are to be measured. Fungi elaborating good cellulase and laccases have also application value in textile dyeing/textile finishing, wine cork-making, teeth-whitening and other similar uses. Both these enzyme complexes are support candidates in the making of biofuels. Cellulases are used in pulp and paper-making. Fungi are also used in the production of various biomolecules including antibiotic principles (Pointing and Hyde, 2003; Aly et al., 2011).

Palms being a ligno-cellulose substrate, these are colonized by a large number of diverse organisms including fungi which together compete in their degradation process. It was thought not only to screen the fungi isolated in culture from palm for cellulases and laccases but also for production of some of the antimicrobial compounds, taking human pathogenic fungi as test organisms. Such investigations have scope for fungal bioprospecting.

Objectives and present work

In the scenario that hitherto knowledge on palm-associative fungi from India is very negligible, present work was taken up with the following objectives:

- Taxonomic documentation of microfungi associated with indigenous palms of Western Ghats.
- Analysis of seasonal variation in the diversity of fungi occurring on some selected palms.
- Maintenance of the isolated fungi in *ex situ* culture collection.
- Determination of some of the biological activity of isolated fungi.

The aforesaid work, carried out from June 2007 to May 2011, is presented in this thesis in four chapters. In Chapter I, as can be seen here, the topic of study is introduced. A detailed review of literature on palm fungi is given in Chapter II. The materials used and methods followed for biodiversity documentation, culturing of fungi, assaying of cellulase and laccase enzyme activity, antimicrobial activity and phylogenetic analysis of some selected isolates are elaborated in Chapter III. The Chapter IV of the thesis deals with results obtained and these are presented in four parts. Part I deals with taxonomic documentation of the fungi isolated from palms; Part II elaborates the study carried out to understand the seasonal variation of fungi on palms; Part III lists the cultures deposited in culture collections; and Part IV showcases the results obtained on screening cultures for cellulase, laccase and antimicrobial activity. The observations made from the study are critically analyzed and discussed in detail towards the end of this chapter. In Chapter V, the entire work is summarized. An exhaustive list of references is given at the end of the thesis. The research papers published during the course of this work are appended to the thesis.

Review of Literature

Fungi are one of the most diverse groups of organisms, in number, similar to insects (Kendrick, 2003). Early estimates of number of fungal species worldwide varied from 100000 (Bisby and Ainsworth, 1943) to approximately the same as the number of vascular plant species, i.e. 250000 to 270000 (Martin, 1951). Subsequent estimate of fungal diversity (Hawksworth, 1991), which banked on molecular phylogeny studies, suggests that the number of species may be an order of magnitude greater than 1.5 million and it was considered as 'conservative' by author himself for four reasons: (i) a modest 270000 figure has been used for the world number of vascular plants; (ii) no separate allowance was made for fungi on the vast numbers of insect species postulated \pm that alone could have raised the figure to 3 M; (iii) the ratios of fungi to plants in various geographic regions did not take into account the scant data of fungi not on plants but occurring within them; and (iv) the ratios of fungi to plant species could be higher in tropical and polar regions than in temperate ones.

The need for more data from the tropics to test the hypothesis was stressed by other authors (Fröhlich and Hyde, 1999). Taking a lead from Hawksworth's observation and realizing the importance of fungal diversity, many researchers tried to look into this problem on a priority basis, especially to find the missing fungi and those growing in some of the difficult habits and habitats (Cannon, 1997; Rossman, 1997; Aptroot and Sipman, 1997; Dreyfuss and Petrini, 1984; Weir and Hammond, 1997; Dulyamamode et al., 2001). Fungi are economically very important with several industrial applications and numerous drugs being continuously discovered from them (Aly et al., 2011).

Studies on diversity and taxonomy of fungi

The number of genera and species is continuously being described, as mycologists continued to explore newer areas and study the collections. Current rate of published description of fungi, new to science, from 1999 to 2009, is an average of 1196 each year, with 1030 species described in 2009 (Hibbett et al., 2011). The pleomorphic nature of fungi has been found adding to the complexity of classification (Shenoy et al., 2007). Diagnosis and classification of fungi based on morphology largely followed the basic biological species concept (Kirk et al., 2008). With discovery of numerous novel fungi and greater insights drawn from the fungal kingdom by adapting newer methods such as gene sequencing and phylogeny analysis, species concept underwent major change in fungal taxonomy and systematics (Hyde et al., 2010).

Morphology-based diagnosis and classification of fungi has been the foundation of taxonomic mycology with several iconic publications coming out time to time, describing all groups of fungi (Subramanian, 1971; Ellis, 1971; Ellis, 1976; Sutton, 1980; Carmichael et al., 1980; Hanlin, 2001; Matsushima, 1975; Nag Raj, 1993; Sivanesan, 1983). The most recent publication 'Genera of Hyphomycetes' by Siefert et al. (2011) brought out by CBS biodiversity series is a classic. It is almost impossible to replace the volumes of classical studies gone into the studies on fungi by molecular phylogenetic approaches, within a short time. Nevertheless, efforts are being made to rectify the confusions arouse from the dual naming system persisting with anamorphic fungi (Hibbett et al., 2007; Shenoy et al., 2007).

Hibbett et al. (2007) proposed a higher-level phylogenetic classification of the fungi based on molecular phylogenetic analyses and inputs from various groups working on fungal taxonomy. A few of the phenomenal changes suggested included

segregation of a subkingdom Dikarya with clade containing Ascomycota and Basidiomycota, reflecting the putative synapomorphy of dikaryotic hyphae. This classification, while retaining Chytridiomycota in a restricted sense, placed Zygomycota among Glomeromycota and several subphyla *incertae sedis* (Hibbett et al., 2007). Application of molecular phylogeny to the study of taxonomy of anamorphic fungi also surfaced problems by bringing to light some of the well-established genera of fungi as indeed polyphyletic and thus making molecular characters as indispensable tool in arriving at a stable systematics (Shenoy et al., 2007). Hyde (2010) tried to answer the question – ‘will bar-coding replace morphological identification’. He concluded that morphological characters have for long served as the basis for fungal taxonomy and the molecular analyses are now aiding in revising the species relationships and higher level systematics. He also agreed that molecular databases and literature are at their infancy in terms of utilization. Though DNA barcode is recently got applauded as a magic formula for species identification, these are yet to confirm the identity of many genera. Hyde (2010) said that several GenBank sequences are wrongly named or contain sequencing errors. It was therefore apparent that, despite advances in molecular studies, there is an urgent need for mycologists to return to the field, recollect species and re-typify taxa with living cultures. Hyde (2010) further added that only after the sequences are obtained for all species and genera and linked properly to named taxa, barcoding will become a successful tool. This exercise calls for a strong base in morphology-based taxonomic work. Realizing the importance of molecular phylogenetic analysis, many of the research papers incorporate molecular phylogenetic data.

Analyzing the ITS and LSU region, Crous et al. (2009) studied the phylogeny and taxonomy of 14 conidial fungi belonging to 10 genera, viz. *Brycekendrickomyces acaciae* Crous & M.J. Wingf., *Chalastospora gossypii* (Jacz.) U. Braun & Crous, *Chalastospora ellipsoidea* Crous & U. Braun, *Chalastospora obclavata* Crous & U. Braun, *Cyphellophora eugeniae* Crous & Alfenas, *Dictyosporium strelitziae* Crous & A.R. Wood, *Edenia gomezpompae* M.C. González, Anaya, Glenn, Saucedo & Hanlin, *Theadonia ligustrina* (Boerema) B. Sutton, *Trochophora fasciculata* (Berk. & M.A. Curtis) Goos, *Verrucisporota daviesiae* (Cooke & Masee) Beilharz & Pascoe, *Verrucisporota grevilleae* Crous & Summerell, *Verrucisporota proteacearum* (D.E. Shaw & Alcorn) D.E. Shaw & Alcorn and *Vonarxia vagans* (Speg.) Aa, *Xenostigmina zilleri* (A. Funk) Crous. In this study, keeping the morphology as basic tool for identification, they applied molecular phylogenetic data to resolve the correct taxonomic identity of the fungi. This study clearly showed the proper path to be followed in future for the taxonomy of hyphomycetous fungi. Thus, the taxonomic mycologists of today not only have the task of searching unexplored habitats for fungi but also need to revise the identity based on newer approaches.

International Botanical Congress 2011 at Melbourne and its implications

In the recently held IBC-2011, the Botanical Code was put into revision, especially the Article 58. The following major decisions were taken.

- Name of the Code changed from International Code of Botanical Nomenclature to *International Code of Nomenclature for Algae, Fungi, and Plants* which reflected the independence of mycology from its traditional grouping under botany.
- Electronic material published online in Portable Document Format (PDF) with an International Standard Serial Number (ISSN) or an International Standard Book

Number (ISBN) will constitute effective publication. This rule will exempt journals from requiring publishing articles in print form. This is aimed to make publication of articles cheaper and also portable.

- The requirement for a Latinized names and diagnosis of new taxa is changed to a requirement for a description or diagnosis either in Latin or English. It simplifies the publication of new species as very few people have expertise in Latin today.
- Effective from 1 January 2013, new names of organisms treated as fungi must, in order to be validly published, include in the protologue (everything associated with a name at its valid publication) the citation of an identifier issued by a recognized repository (such as MycoBank).

Following extensive discussions, The Congress also took steps towards the proposal of ‘One Fungus = One Name’, thus reverting its own decision of the Sydney Congress in 1981 to implement terms anamorph, teleomorph, and holomorph. To address the various aspects of the Code with respect to fungi, including possibility of a separate code for fungi, a Subcommittee on governance of the Code was established and mandated with examination of how the Nomenclature Section being operated (Hawksworth, 2011; Knapp, 2011).

Palm-associated microfungi

Palm plants

Members of the palm family (F: Palmae or conserved alternative name Areaceae) grow in the tropical and subtropical regions of the world which is in general under- and unexplored region for fungal diversity. Palms are ecologically highly sensitive to its biotic and abiotic environment hence they are considered as an ecologically sensitive group (Eiserhardt et al., 2011).

The palm family has approximately 2400 species in 212 genera. The members of Palmae show high degree of endemism (Govaerts and Dransfield, 2005; Eiserhardt et al., 2011). This is said to be the result of its past distribution, continental drift and climatic changes over its evolutionary history (Dransfield and Uhl, 2008). Palms generally have an un-branched trunk or twining stem with a crown of leaves on the top. The large leaves of palm plant remain attached to the stem for long time. Inflorescence of palm plant generally appears in between the leaves and is surrounded by spathe. All parts of palm plant are made of fibrous material and a large quantity of such litter biomass is produced. Due to its fibrous nature, the plant litter has a very good quality of holding water which largely favours fungal growth (Fröhlich, 1997).

Palms such as *Areca catechu* and *Cocos nucifera*, known to be from the Western Ghats region, are widely cultivated for their economic importance. Whereas, other species of palms such as *Borassus flabellifer* and *Caryota urens* are more wildly distributed but occasionally grown for their ornamental value (Cook, 1967). There are 17 species of cane palms belonging to the genus *Calamus* which are rare and considered threatened due to large scale extraction from wild especially for making of cane furniture (Renuka, 1992). Of these, two fairly common canes, viz. *Calamus rotang* and *C. thwaitesii* are included in this study. In all, 9 species of endemic palms of the forests of Western Ghats are included in this study. These included *Arenga wightii*, *Bentinckia condapanna*, *Corypha umbraculifera*, *Hyphaene dichotoma*, *Phoenix acaulis* And *Pinanga dicksonii* (Ahmedullah and Nayar, 1987, Gamble, 1967).

Fungi on Palms:

Palm plants are said to be an excellent substrate/host for fungal colonization (Yanna et al., 2001). This is because of high plant productivity in terms of biomass which is

very favorable for fungal growth. Palms (F: Arecaceae) are mostly distributed in the tropical and subtropical regions of the world (Eiserhardt et al., 2011) and these locations are known as potential sites of unexplored fungal diversity (Bhat, 2010). A number of individual fungi associated with palm hosts have been reported in literature since very early days of fungal floristics (Farr et. al. 2011).

Palms as a substrate of fungal colonization were studied mostly in last two decades, i.e. in the 1990s and 2000s and an account of this is given below. Hyde (1993) described a new genus of the Ascomycete, *Manokwaria notabilis* K. D. Hyde from palm rachides in freshwater swamp, collected from Indonesia. Hyde et al. (1998) described five new species in the genus *Neolinocarpon*, viz. *N. australiense* on dead rattan of *Calamus moti* and *Calamus australis*, from Australia; *N. calamae* on dead petiole of *Calamus conirostris*, Brunei Darussalam; *N. enshiensis* on a dead petiole of *Trachycarpus fortunei* from China; *N. inconspicuus* on a dead rachis of *Archontophoenix alexandrae* from Australia; *N. nonappendiculatus* on a dead petiole of *Archontophoenix alexandrae* from Australia and one new combination in the *N. eutypoides* on a dead rachis of *Archontophoenix alexandrae* from Australia.

Rodrigues (1994), while studying the fungal endophytes of Amazonian palm *Euterpe oleracea*, with samples from 10 palm trees, showed 25 % colonization of leaf tissues by 57 species of endophytic fungi. He observed that the colonization was positively correlated to plant growth stages, site and the inter-effects of both. *Xylaria cubensis* and *Letendraeopsis palmarum* were the most common species encountered during the studies. Significant differences in colonization were observed with respect to growth stages, site and also between tissues such as vein and inter-vein region. Rodrigues and Samuels (1994) in a preliminary study of endophytic fungi of a

tropical palm, *Licuala ramsayi*, isolated 11 fungi, mostly Xylariaceous anamorphs which included a new species, *Idriella licualae*.

Hyde and Sarma (2006) studied the diversity of filamentous fungi associated with mangrove palm, *Nypha fruticans*, from Brunei. A total 46 taxa were recorded which included 33 ascomycetes and 13 anamorphic taxa in 25 genera. The genera *Linocarpon*, *Aniptodera* and *Astrosphaeriella* were found to be the most prevalent species. They also observed more of fungal diversity on the fronds than leaves. It was also observed that submerged plant parts had high fungal diversity followed by intertidal zone with aerial parts having least number of fungi recorded.

Realizing the exceptionally high fungal diversity associated with palms and its importance in understanding the unexplored tropical diversity, Hyde and his students, from the University of Hong Kong, undertook extensive work on palm mycoflora (Fröhlich and Hyde, 1999; Hyde, 1992a, 1992b, 1993a, 1993b, 1996a, 1996b, 1996c; Hyde et al., 2000; Taylor et al., 1997, 2000; Taylor and Hyde 1999, 2000; Fröhlich and Hyde 1995, 1998, 1999; Fröhlich et al., 2000). The volume of work done by his team is reflected in a series of publications titled as 'Fungi from Palms'. One of his students, Taylor et al. (2000) studied the biogeography of microfungi of three palm species. For this, she selected palms with different habitat and ecology, i.e. *Archontophoenix alexandrae*, endemic to tropical rainforests in Australia, *Cocos nucifera*, pan-tropical and *Trachycarpus fortunei* occurring in warm-temperate China. Different assemblages of fungi were found in association with palms of the temperate regions as compared to those in tropical regions. She found that climate played a major role in defining the status of the hosts at a site, i.e. indigenous or introduced, and the degree of disturbance of the habitats within which the palms grew. When sampled in its natural habitat, *Archontophoenix alexandrae* had a distinct palmicolous

mycota, typical of other palms in tropical rainforests. Outside the native habitat, a markedly different mycota was recorded comprising of tropical species more of a plurivorous nature. Results of similar nature were observed with *Cocos nucifera* and *Trachycarpus fortunei*.

An in-depth investigation of palm fungi in different parts of the world showed that the ratio of palm to fungi in Queensland was 1:26 (Hyde et al., 2000) whereas in Australia and Tanzania (Darussalam) it was 1:33 (Fröhlich and Hyde, 1999). In the same study, it was further revealed that the fungal diversity on palms in rainforest of Brunei was 202 species of Ascomycetes of which 95 were new to science (Taylor et al., 2000). Part of this work was accommodated in 2 volumes, viz. 'Genera of Ascomycetes from Palms' (Hyde et al., 2000) and 'Palm Microfungi' (Fröhlich and Hyde 2000). The first volume contains descriptions of 100 genera of ascomycetes, isolated from palms by the authors, with photographic illustrations. Many of these genera are so far known only on palms. The second book on palm microfungi described ascomycetes based on studies done in Australia, Brunei and Hong Kong. In this, many more ascomycete genera are reviewed and more than 50 new species added.

Based on their studies Hyde et al. (2000 and Taylor et al. (2000) posed 2 important questions: (i) 'How many species of fungi can occur on a single host palm?' and (ii) 'What are the implications of this on global estimates of fungal diversity?' They further stated that 33 to 1 would be a more accurate estimated (instead of 5.7 to 1 *sensu* Hawsworth, 1991) ratio of host specific fungi on palm species in the tropics. With this kind of revelations, palm-associated fungi are now called as the 'windows' to unexplored fungal diversity in the tropics.

Taking a lead from this, many palms around the world were studied for associated fungal diversity. Yanna et al. (2001) studied of fungi on palm, *Livistona chinensis*, collected from western part of Hong Kong. Their study yielded 91 species of saprobic fungi. It was observed that leaves of *L. chinensis* were dominated by two species of *Pseudospiropes* during the first month, and subsequently by *Lachnum palmae* and *Zygosporium echinosporum*. Many of the taxa isolated were confined to leaves or petioles thus supporting earlier findings of tissue specificity

Guo et al. (2000) studied the endophytic fungi in fronds of *Livistona chinensis* in Hong Kong and identified them using morphological characters. They consisted of 16 named species and 19 'morpho-species', the latter grouped based on cultural morphology and growth rates. Arrangement of taxa into morpho-species does not reflect species phylogeny, and therefore selected morpho-species were further identified based on ribosomal DNA (rDNA) sequence analysis. The 5.8S gene and flanking internal transcribed spacers (ITS1 and ITS2) regions of rDNA from 19 representative morpho-species were amplified by the polymerase chain reaction and sequenced. Phylogenetic analysis based on 5.8S gene sequences showed that these morphospecies were filamentous Ascomycota, belonging in the Loculoascomycetes and Pyrenomycetes. Further identification was conducted by means of sequence comparison and phylogenetic analysis of both the ITS and 5.8S regions. Results showed that 1 morphospecies belonged to the genus *Diaporthe* and its anamorph *Phomopsis* of the Valsaceae. One was inferred to be *Mycosphaerella* and its anamorph *Cladosporium* of the Mycosphaerellaceae. Seven were placed in the genus *Xylaria* of the Xylariaceae. Three were close to the Clypeosphaeriaceae. Two were closely related to the Pleosporaceae within the Dothideales. The other 5 morphospecies probably are Xylariales.

Wong et al. (2001) studying microfungi from grasses and palms in tropics, described two new species of *Costantinella*, *C. palmicola* sp. nov. from decaying petioles of *Livistona chinensis*, and *C. phragmitis* sp. nov. from decaying culms of *Phragmites australis* from Hong Kong.

Yanna et al. (2001b) identified 91 species of saprobic fungi from decaying leaves and petioles of *Livistona chinensis* from Lung Fu Shan of the western part of Hong Kong. Leaves of *L. chinensis* were dominated by two species of *Pseudospiropes* during the first month, and subsequently by *Lachnum palmae* and *Zygosporium echinosporum*. *Appendicospora hongkongensis* and *Oxydothis elaeicola* dominated on petiole tips, midpetioles and petiole bases of the palm. The frequency of occurrence and the relative abundance of the latter two species increased during the first 4 months. *Astrosphaeriella bakariana* dominated the petiole tips and mid-petioles after 10 months of decay. Fungi with sporadic dominance included *Cocoicola livistonicola* and *Verticillium* cf. *dahliae* on petiole tips, and *Oxydothis obducens* on mid-petioles and petiole bases. A correspondence analysis performed for fungi occurring on different tissue types revealed distinct clusters, corresponding to leaves and petiole parts. The high percentage of fungal taxa confined to the leaves or petiole parts indicated that saprobic palmicolous fungi exhibit tissue specificity.

Wai et al. (2005) described *Endosporoideus pedicellata* gen. et sp. nov. from decaying petioles of *Phoenix hanceana* collected from grassland in Tai Mo Shan, Hong Kong. Pinnoi et al. (2006) studied the biodiversity of fungi on *Eleiodoxa conferta* in Sirindhorn peat swamp forest, Thailand. In this survey, 462 fungal records were made and out of which 251 were identified to species level, 176 to generic level while 35 remained unidentified. It was observed that different parts of *E. conferta* supported different fungi: dry (aerial) material supported 17% of the fungi, damp

(moist and on the surface of the soil) material 34.5%, while submerged wet material had the most fungi (48.5%). The percentage abundances of fungi on different parts of *E. conferta* were as follows: petioles 53%, rachides 30% and leaves 17%. Eight new species and one new genus were described from this palm, while 12 taxa are yet to be described.

Hidayat (2006), in their study of palmicolous fungi in northern Thailand, encountered 3 new species of *Oxydothis*: *O. cyrtostachicola*, *O. inaequalis* and *O. wallichianensis*. Phylogenetic affiliations of the new taxa with members of related ascomycete families within the *Xylariales* were discussed based on morphology and nrDNA sequence data. Their results suggested phylogenetic relationships of *Oxydothis* and its familial placement remain obscure based on the 28S nrDNA sequence analyses. Large sub unit nrDNA (28S) gene sequences did not provide significant phylogenetic information concerning the evolutionary relationships of the xylariaceous fungi. ITS nrDNA sequence analyses, however, indicated that *Oxydothis* is more closely related to members of the *Amphisphaeriaceae* than *Diatrypaceae* or *Xylariaceae*.

Pinruan (2007) studied the fungi on *Licuala longicalycata* by making six field collections in May, June, September, November 2001 and February, May 2002. A total of 177 fungi were identified to species level, 153 collections to generic level, while 28 remained unidentified. Of these, 9 ascomycetes and 5 anamorphic fungi were new to science. Results suggested that the dry material supported most fungi with up to 40%, submerged material 32%, while the damp material supported the least number of fungi (28%). The percentage occurrence of fungi on different tissues of *L. longicalycata* was: petioles 61%, trunks 24%, and leaves 15%. The most common fungi isolated were *Annulataascus velatisporus*, *Microthyrium* sp., *Phaeoisaria*

clematidis, *Massarina bipolaris*, *Phruensis brunneispora*, *Thailiomyces setulis* and *Solheimia costaspora* which was quite a different spectrum from fungi found with other palms.

Study on *Rhopalostylis sapida* and *R. baueri* var. *cheesemaniae* in New Zealand by McKenzie et al. (2004) recorded a total of 147 named species of fungi and 50 species identified only down to genus level distributed in 134 genera. Most of them were saprobes found on dead and fallen leaves, especially on the large leaf sheath. Of these 17 are known only on *R. sapida*, including the corticioid, monotypic genus, *Mycothele*.

Study of Palm-associated microfungi in India

In India, though serious efforts were not made to document the palm-associated fungi exclusively, studies carried out earlier revealed the distinct presence of fungi on palms. Perusal of literature reveals that there are 156 species so far reported from cultivated *Cocos nucifera*. Amongst other palms, 58 species were reported on *Areca catechu*, 43 on *Borassus flabellifer*, 39 on *Calamus* sp., 18 on *Cryota urens*, 10 on *Elaeis guineensis* and 74 on *Phoenix* spp (Pandey et al., 2001; Jamaluddeen et al., 2004). Several of these fungi were described as new to science. The palmicolous fungi so far recorded from India were largely anamorphic Ascomycetes (Hyphomycetes) isolated as litter and endophytic fungi (Ellis, 1971, 1976; Sutton, 1980; Mukerji and Juneja, 1974; Mathur, 1979; Sarbhoy et al., 1996; Verma, 1996; Katumoto and Hosagoudar, 1989; Subramanian and Bhat, 1987).

Bhat and his students in this laboratory studied the fungi occurring on various plants of the forests of Western Ghats and documented a number of fungi including new genera and species which included some fungi on palm too (Bhat, 2010; Bhat et al., 2009). New taxa described on palms were the following: *Parahelminthosporium*

malabaricum (Subramaniam and Bhat, 1987), *Benjpalia sundara* (Subramaniam and Bhat, 1987), *Kostermansinda andamanensis* (Bhat and Kendrick, 1993), *Spegazzinia subramaniani* (Bhat, 1994), *Bharatheeya mucoidea* (D'Souza and Bhat, 2002), *Phialocephala vittalensis* (D'Souza et al., 2002), *Stratiphoromyces raghukumarensis* (D'Souza et al., 2002), *Argopericonia indirae* (D'Souza et al., 2002), *Chalara indica* (Pratibha et. al., 2005), *Rattania setulifera* (Prabhugaonkar and Bhat, 2009) and *Stauriella indica* 2010 (Pratibha et al., 2010). D'Souza (2002) studied cane palm *Calamus thwaitesii* as part of her doctoral thesis and found 23 fungi of which *Bharatheeya* was a new (D'Souza, 2002; D'Souza and Bhat, 2002a). Pratibha et al. (2005) described a new species *Chalara indica* causing leaf spot disease on fresh leaves of *Areca catechu*. All these studies clearly indicated that palm plants in India could be a good repository for known and unknown fungi.

Studies on ecology of fungi on palms in India

A few studies describing the ecological aspects of fungi on palms are available from India. Girivasan and Suryanarayan (2004) studied distribution of endophytes and phylloplane fungi on intact leaves of 12 species of rattans of southern India. In this study, 2400 leaf segments yielded 824 endophyte isolates belonging to 34 species. While 30 species of phylloplane fungi were recorded from same leaves. Several fungal species were found to be common endophytes of different palm hosts. The overlap between endophyte assemblage and phylloplane fungi of each host was however low, suggesting that these two distinct groups of fungi occupy different niches, thereby avoiding competition. D'Souza and Bhat (2007) studied diversity and abundance of endophytic fungi in four plant species in forest of Goa in southern India, one of which was *Calamus thwaitesii* from Bondla wildlife sanctuary. The study showed that post monsoon season was the best season for recovery of endophytes. It

was also observed that each plant species showed certain degree of distinctness in its endophyte composition.

Fungal bioprospecting

Most fungi are readily cultivable in the laboratory conditions. Many of them are known to produce extracellular and intracellular enzymes and big or small molecules. Realizing the possibility of using the fungi for advantage, several have already been exploited. The fungi are expected to play a very important role as alternative sources of food and medicine at scale comparable to green revolution (Ponting and Hyde, 2001). They are currently employed in various fields such as medicine, foods, waste utilization, industrial enzymes, chemicals and materials, bioindication, bioremediation, biocontrol, plant growth regulators, organic manures and teaching and artistic usage (Hawksworth, 2001).

Tropical forests contain numerous possibilities for development of useful products. Less explored fungal diversity from the tropical region holds great hope which can be exploited in the future. Hyde (2001) mentions that the large amount of diversity of fungi on plants such as palms in the tropics tend to exhibit potential for bioprospecting because of high degree of competition, symbiosis and survival needs (Ponting and Hyde, 2001).

Fungi from the forests of Western Ghats were isolated and screened for bioprospecting by many researchers. Sonawane et al. (2011) studied sesquiterpenes extracted from six species of *Phellinus* Quel., against twelve virulent strains of bacteria and fungi. They observed significant broad spectrum anti-bacterial and anti-fungal activity. Raviraja et al. (2006) isolated 15 species of endophytic fungi from eight medicinal plant species which were tested for the production of antimicrobial compounds. Of the 15, eight species of endophytes revealed production of

antimicrobial compounds. Based on experience in screening of fungi from Western Ghats, Suryanarayanan (2009) said that endophytes are a promising source of bioactive compounds.

In the mycology laboratory at Goa University, Jacob (2000) subjected 60 fungal isolates from *Carissa congesta* Wight and *Ficus bengalensis* Linn. to various enzyme assays. Results showed maximum percentage of isolates exhibited protease activity (63.3%) followed by laccase (62.1%), pectinase (52 %), ligninase (48.3 %), amylase (33.3%), xylanase (31%) and least (15%) for cellulase activity. D'Souza (2002) subjected 140 species of litter and endophytic fungi of plants, namely *Saraca asoca*, *Careya arborea*, *Calamus thwaitesii* (Palm) and *Dendrocalamus strictus* to assays for production of amylase, cellulase and pectinase. Result showed 43.57% fungi were positive for amylase, 49.28% were positive for cellulase and 42.85% positive for pectinase activity, 17.14% fungi were positive for all the enzymes. Jalmi (2006) screened 50 foliicolous fungi isolated from various plants for cellulase, pectinase and lipase activity. It was observed that 100% were positive for lipase, 62% were positive for cellulase and 50% were positive for pectinase activity. Gawas (2008) screened 65 fungi isolated from medicinal plants to antimicrobial activity, of these 44(68%) were found to be positive. Out of these six were found to be highly active.

In the present work, major fungal enzymes such as cellulase and laccase and antibacterial and antifungal activity of fungi, isolated from palms were studied. Accordingly, these areas are briefly reviewed below.

Cellulase: Cellulose is a polysaccharide composed of glucose units in long linear chain linked together by β -1,4 glycosidic bonds. It is most abundant organic compound in nature. Cellulase is an enzyme produced by cellulase degrading

organisms such as fungi. This complex enzyme is composed of at least three components, viz. endoglucanase (endo-1,4- β -D-glucanase(E.C. 3.2.1.4)), exoglucanase (1,4- β -D- glucancellulobiohydase (E.C. 3.2.1.91)) and β - glucosidase (E.C. 3.2.1.21). These enzymes cause hydrolyses of cellulose to glucose (Aneja, 2007). Large number of fungi is known to produce cellulose which has applications in commercial food processing, textile industry, detergent manufacturing, pulp and paper industry and of late even in pharmaceutical industry.

Laccase: The fungi producing lignin degrading enzymes are called 'white rot fungi' in a broad sense. Lignin, a hetrogenous polyphenolic polymer, is extremely recalcitrant and mineralized in an obligately aerobic oxidative process, carried out appreciably only by white rot fungi. The degradation of lignin is carried out by one or more of three enzymes called lignin modifying enzymes. The three enzyme comprise of two glycosylated heme containing peroxidase (LiP, E.C. 1.11.1.14) and Mn dependant peroxidase (MnP, E.C. 1.11.1.13) and a copper containing phenoloxidase called Laccase (LCC, E.C. 1.11.1.13) (Ponting, 2001).

Laccases are industrially relevant enzymes. They are widely utilized in paper and textile industry for bleaching purposes. Laccases with other ligninolytic enzymes have been shown to be particularly effective in degradation of recalcitrant organopollutants with structural similarities to lignin. This potential ligninolytic enzyme is now utilized in degradation of many harmful industrial byproducts such as munitions waste, pesticides, polychlorinated biphenyl, polycyclic aromatic hydrocarbons, pulp mill effluent, synthetic dyes, synthetic polymers and wood preservatives (Ponting, 2001).

Antimicrobial compounds: The first antibiotic compound discovered by Alexander Fleming in 1942 was penicillin. He observed that *Penicillium chrysogenum* inhibited the growth of *Staphylococcus aureus*. This drug discovery though accidental drew world's attention towards potential of fungi and many organizations started search of such potential compounds (Sullia, 2002).

For the past 50 years, fungal secondary metabolites have revolutionized medicine, yielding blockbuster drugs and drug leads of enormous therapeutic and agricultural potential (Aly et al., 2011). Over the years fungi have emerged as major source of antimicrobial compounds. Even after advances in combinatorial chemistry as a tool of drug discovery, modern drug discovery has been highly dependent on natural products as source of medicine (Newman and Cragg 2007). With estimated 1.5 million species of fungi on the earth's surface and only 100000 described so far (Hawksworth, 2004) fungi are indeed large group after plants to look for antimicrobial compounds. Several large scale high throughput screening programs are now underway around the world (Ponting and Hyde, 2000). This also required fast-track isolation methods. Initially soil fungi were the choice for fungal biologist as a source of such cultures. Later it was realized that a good culture collection obtained from diverse sources yielded different molecular compounds (Dreyfuss and Chapela 1994). It is widely believed that taxonomic and ecological diversity are likely to result in chemical diversity (Bills, 2006). Role of fungal taxonomist therefore is most important especially to explore, isolate and identify the inconspicuous microorganism from such difficult sources and obtain far more diverse fungal collections (Bhat, 2010; Hyde, 2001). Study of palm fungi from tropics by Frohlich and Hyde (1999) and Hyde et al. (2000) showed that, although time consuming, such efforts resulted

with rare fungi which in turn result with promising bioprospects of bioactive compounds.

Materials and Methods

This thesis embodies results of a detailed investigation carried out to taxonomically document the fungal diversity of indigenous palm plants and understand the seasonal variation in the diversity of palm-associated fungi of the forests of Western Ghats in southern India. The fungi were systematically sampled out from original localities of palms, isolated in pure culture in the laboratory and maintained in a systematic manner in an *ex situ* culture repository, Goa University Fungus Culture Collection. Type cultures of those fungi described as new and part-cultures of all other are being deposited at National Fungal Culture Collection of India (NFCCI), at ARI, Pune and Microbial Type Culture Collection, Institute of Microbial Technology, Chandigarh.

The isolated fungi were screened for the productivity of enzymes such as cellulase and laccase, and tested further for antimicrobial properties. In order to accomplish the set objectives of the study, standard mycological techniques outlined by Booth (1972), Hawksworth (1974), Bhat (2010) and Kirk et al. (2008) were followed. The methods followed and materials used are described below in detail.

Sampling of specimens

1. Collection sites

Regional floras (Cook, 1967; Gamble, 1967) were consulted to locate natural habitats of indigenous palm species in the forests of Western Ghats. Several collecting trips were conducted to these sites in the forests of Goa, Karnataka, Kerala and Tamilnadu and samples of palm plants gathered. Seasonal studies on palm-fungi were restricted to two pre-designated locations in the forests of Goa, viz. Netravali and Dhoodhsagar and these sites were frequented several times at defined intervals, during the study period. The details of field-trips conducted are given in Table 3.

1.1. Collection sites for biodiversity studies in Goa (Fig. 1; Table 3)

For fungal biodiversity documentation studies, samples were gathered from several locations in Goa. The collection sites included the following: Bondla Wildlife Sanctuary, Satre of Mhadai Wildlife Sanctuary, Tambdi Surla of Bhagwan Mahavir National Park, Chorla Ghat, Chandreshwar hills, Morpirla forests and Miramar and Sirdao beaches (Fig. 1). In all, samples of 13 palm species were gathered. Details of the palms sourced from Goa are listed in Table 3.

1.2. Collection sites of seasonal studies in Goa

For seasonal studies, pre-designated two locations (Table 1) were frequented at seasonal intervals (Table 2) for two years (June 2007-May 2009). Site I was about 1 km north of Sawar Waterfalls at Netravali and Site II about 1 km west of Dhoodhsagar Waterfalls. Locations of these two sites are marked in Fig. 1 and details are given below in Table 1 and 2.

Table 1: Collection sites of seasonal studies

<i>Sampling sites</i>	<i>Site 1: Dhoodhsagar Waterfalls, Mollem, Goa</i>	<i>Site 2: Sawar Waterfalls, Netravali, Goa</i>
Location	15 ^o 18' 05.16"N 74 ^o 18' 21.15"E	15 ^o 03' 43.83"N 74 ^o 13' 46.47"E
Topography	Hilly terrain, on the bank of a seasonal stream	Hilly terrain, on the bank of a seasonal stream
Soil type	Well-drained red lateritic	Well-drained red lateritic
Vegetation	Dense; moist deciduous forest	Dense; moist deciduous forest

Table 2: Details of seasonal sampling:

<i>No</i>	<i>Collection</i>	<i>Period</i>	<i>Year</i>
1	Winter sampling	December-January	2007-08
2	Summer sampling	April- May	2008
3	Rainy season sampling	July-August	2008

1.2.1: Analysis of data gathered of seasonal studies:

Diversity indices

A diversity index is a mathematical measure of species diversity in a community. (Krebs, 1989. Hill, 1973). They were calculated using PAST software version 2.01 (Hammer et al., 2001)

Species Richness (S) -. The total number of different organisms present. It does not take into account the proportion and distribution of each species within a zone.

Evenness (E) is a measure of how similar the abundances of different species are. When there are similar proportions of all species then evenness is one, but when the abundances are very dissimilar (some rare and some common species) then the value increases.

Shannon (H) - Shannon index, sometimes referred to as the Shannon-Wiener Index or the Shannon-Weaver Index is the information entropy of the distribution, treating species as symbols and their relative population sizes as the probability. The index values are between 0.0 – 5.0. Results are generally between 1.5 (low species richness and evenness) to 3.5 (high species evenness and richness), and it exceeds 4.5 very rarely. The values above 3.0 indicate that the structure of habitat is stable and balanced; the values under 1.0 indicate less stable habitat structure.

$$H = \sum_{i=1}^s - (P_i * \ln P_i)$$

where:

H = the Shannon diversity index

P_i = fraction of the entire population made up of species i

S = numbers of species encountered

∑ = sum from species 1 to species S

Simpson's Index (1-D) measures the probability that two individuals randomly selected from a sample will belong to different species. This index ranges between 0 and 1, the greater the value, the greater the sample diversity.

$$D = \sum n_i (n_i - 1) / N(N - 1)$$

Where:

D= Diversity index

n_i = Number of individuals belonging to species i.

N= Total number of individuals

Table 3: Details of collection trips conducted in Goa during study period (Fig. 1)

No.	Date	Places visited	Palm specimens collected
1.	07/07/07	Sawar Waterfalls, Netravali	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
2.	20/07/07	Satre, Valpoi	<i>Calamus thwaitesii</i> , <i>Caryota urens</i>
3.	15/08/07	Sawar Waterfalls, Netravali	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
4.	24/08/07	Harmal coast	<i>Phoenix sp.</i> , <i>Caryota urens</i> .
5.	07/09/07	Mashem, Canacona	<i>Caryota urens</i> , <i>Cocos nucifera</i>
6.	03/09/07	Aguada Fort	<i>Caryota urens</i>
7.	16/10/07	Miramar beach, Panaji	<i>Hyphneae dichotoma</i>
8.	28/10/07	Ambe Ghat and Netravali	<i>Calamus thwaitesii</i>
9.	09/11/07	Bondla Wildlife Sanctuary	<i>Calamus thwaitesii</i>
10.	13/01/08	Surla Valley, Valpoi	<i>Calamus thwaitesii</i> , <i>Calamus rotang</i> , <i>Caryota urens</i>
11.	06/01/08	Dhoodhsagar Waterfalls (Seasonal collection)	<i>Arenga wightii</i> , <i>Calamus thwaitesii</i>
12.	30/01/08	Netravali (Seasonal collection)	<i>Arenga wightii</i> , <i>Calamus thwaitesii</i> , <i>Elaeis guineensis</i>
13.	10/03/08	Miramar beach, Panaji	<i>Hyphaene dichotoma</i> , <i>Caryota urens</i> , <i>Cocos nucifera</i>
14.	07/04/08	Mashem, Canacona	<i>Caryota urens</i> , <i>Cocos nucifera</i>
15.	10/05/08	Dhoodhsagar Waterfalls (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
16.	19/05/08	Netravali (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
17.	01/08/08	Mashem	<i>Caryota urens</i>
18.	08/08/08	Netravali (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
19.	21/08/08	Dhoodhsagar Waterfalls (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i> , <i>Caryota urens</i>

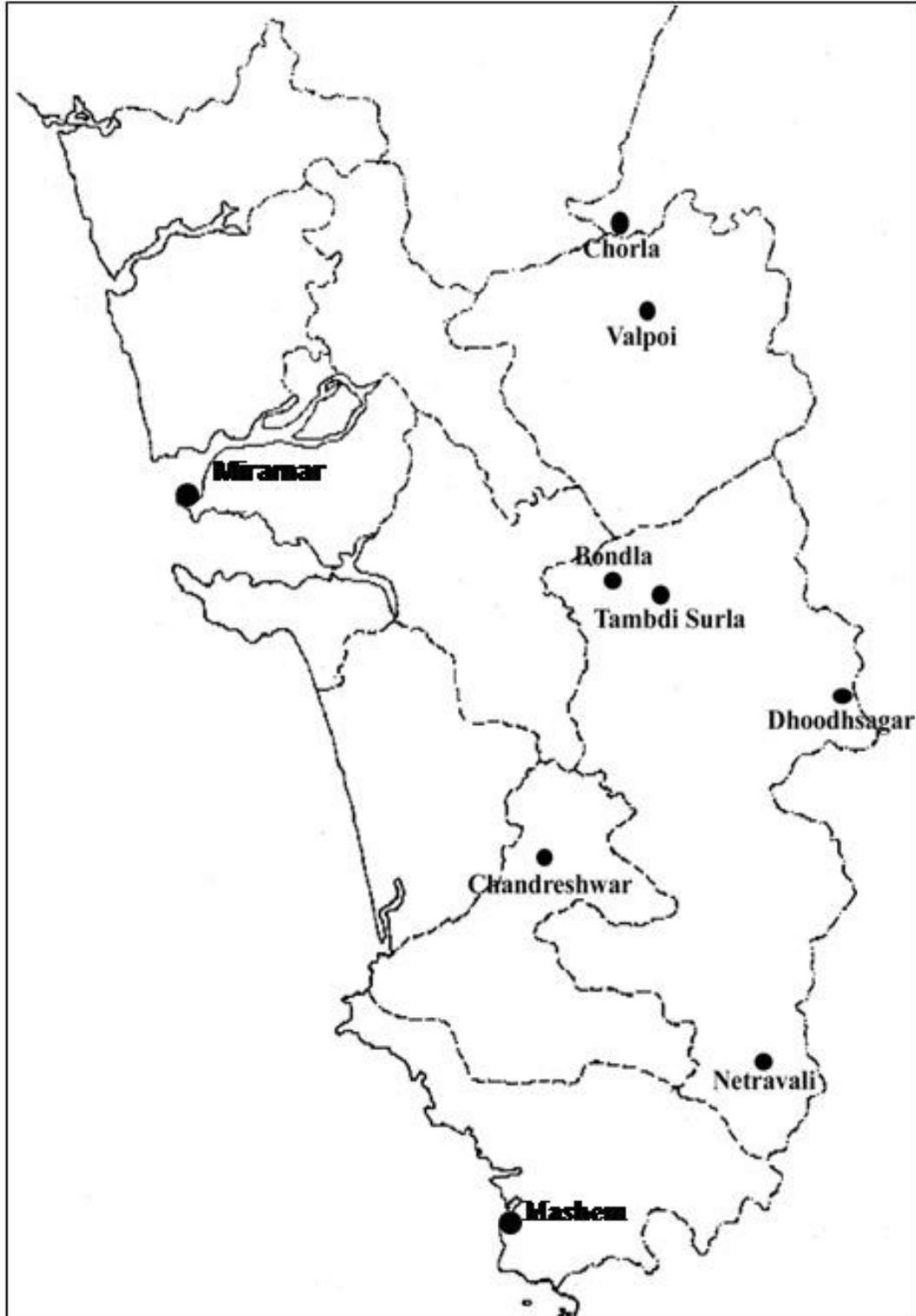
20.	24/08/08	Chorla Ghat	<i>Calamus thwaitesii</i>
21.	09/09/08	Bambolim	<i>Cryota urens</i>
22.	13/09/08	Chorla Ghat	<i>Calamus thwaitesii</i>
23.	05/12/08	Valpoi	<i>Calamus thwaitesii</i>
24.	05/01/09	Netravali (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
25.	17/01/09	Dhoodhsagar (Seasonal Collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
26.	15/04/09	Dhoodhsagar (Seasonal Collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
27.	26/04/09	Netravali (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
28.	28/06/09	Bondla	<i>Calamus thwaitesii</i> , <i>Cryota urens</i>
29.	07/05/09	Valpoi	<i>Areca catechu</i>
30.	25/07/09	Netravali	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
31.	25/07/09	Netravali	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
32.	14/08/09	Paroda	<i>Phoenix acaulis</i>
33.	11/08/09	Netravali (Seasonal collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i> , <i>Cocos nucifera</i>
34.	16/08/09	Dhoodhsagar Waterfalls (Seasonal Collection)	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i>
35.	18/12/09	Mhadai vally, Goa	<i>Calamus</i> sp.
36.	21/06/10	Morpirla, Goa	<i>Cocus nucifera</i>
37.	25/11/10	Dhoodhsagar Waterfall, Goa	<i>Arenga wighatii</i> , <i>Calamus thwaitesii</i>

2. Collection localities along the Western Ghats (Fig. 2; Table 4)

A number of places in the forests of Western Ghats in southern India were visited during the study period for sampling of palm specimens. They are marked in the Fig. 2 and described below based on (Pai, 2005) and some other internet sources.

2.1. Agastyamalai biosphere reserve: This is dense forest, revered as the sacred seat of ancient sage Agastya - the founder of Siddha medicine, located about 70 km East of Thiruvanthapuram, the capital city of Kerara state, is the only site known to have the threatened palm *Bentinckia condapanna*. The palm plant is presently found only on the cliffs of higher mountainous regions in this forest. In the plains the palm leaves

Fig 1: Map of Goa showing places of Collection



are preferentially grazed by wild elephants and bisons. This place was visited in the summer season of 2010.

2.2 Tambraserry: The location is near Calicut in Kerala. This is a small village, 30 km east of Calicut city. The location, in the lower plains of the Western Ghats, has a large stand of the palm *Corypha umbraculifera* which is otherwise said to be a rare palm. This place was visited in the rainy season of 2008.

2.3 Katlekana: The site is located on the way to Jog Falls in Karnataka State from Gersoppa, on the National Highway 206. The place is also well known for its freshwater swamps called 'Myristica swamps' (Bhat and Kaveriappa, 2009). The swamp has a good population of the endemic palm, *Pinanga dicksonii*. This location was visited in the rainy winter 2009.

2.4 Yana: Yana is located 30 km west of the coastal town Kumta in Karnataka State. The place is famous for its granite outcrops and an ancient temple deep inside the forest. The site has a good stand of *Calamus* sp. and a few *Corypha umbraculifera*. This place was visited in the rainy season of 2008.

2.5. Agumbe: This is a mountainous ghat terrain, known to receive highest rainfall in southern India during the monsoon. Samples of several species of *Calamus* and the rare palm *Pinanga dicksonii* were collected from here. This place was visited in the summer season of 2010.

2.6. Palghat: This place is in Palakkad district of Western Ghats lies close to Palghat gap which connects plains of Kerala with that of Tamilnadu. It is also a famous hill station and is known for its paddy fields and palmyra trees. Place is also famous for

its rich flora and fauna. Specimens of *Palmyra* palm that is *Borassus flabellifer* and *Calamus rotang* were collected from this place.

Table 4: Details of collection trips conducted along the Western Ghats (Fig. 2)

No	Date	Places visited	Palm specimens collected
38.	19/08/07	Virajpet, Madikeri, Karnataka	<i>Calamus rotang</i>
39.	24/08/07	Vengurla, Maharashtra	<i>Phoenix</i> sp., <i>Caryota urens</i>
40.	20/11/07	Mangalore, Karnataka	<i>Cocos nucifera</i>
41.	03/12/07	Jog Falls, Katlekan and Gersoppa, Karnataka	<i>Calamus thwaitesii</i> , <i>Arenga wightii</i> , <i>Pinanga dicksonii</i>
42.	03/01/08	Near Pune, Maharastra	<i>Phoenix robusta</i>
43.	29/06/08	Yana forest, Karnataka	<i>Corypha umbraculifera</i> , <i>Calamus</i> sp., <i>Areca catechu</i> , <i>Cocos nucifera</i>
44.	27-30/07/08	Tambraserry, Calicut, Kerala	<i>Corypha umbraculifera</i>
45.	08-25/12/08	Madurai, Tamil Nadu	<i>Borassus flabellifer</i>
46.	31/01/09-03/02/09	Palghat, Kerala	<i>Borassus flabellifer</i> , <i>Calamus rotang</i>
47.	16/11/09	Katlekana, Karnataka	<i>Pinnanga dicksonii</i> , <i>Calamus rotang</i>
48.	26/03/10	Agastimalai hills, Tirunelveli, Tamilnadu	<i>Bentinckia condapanna</i>
49.	19-25/04/10	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i> , <i>Calamus Hook.eri</i>
50.	09/05/10	Agumbe Ghat, Karnataka	<i>Calamus rotang</i> , <i>Pinnanga dicksonii</i>

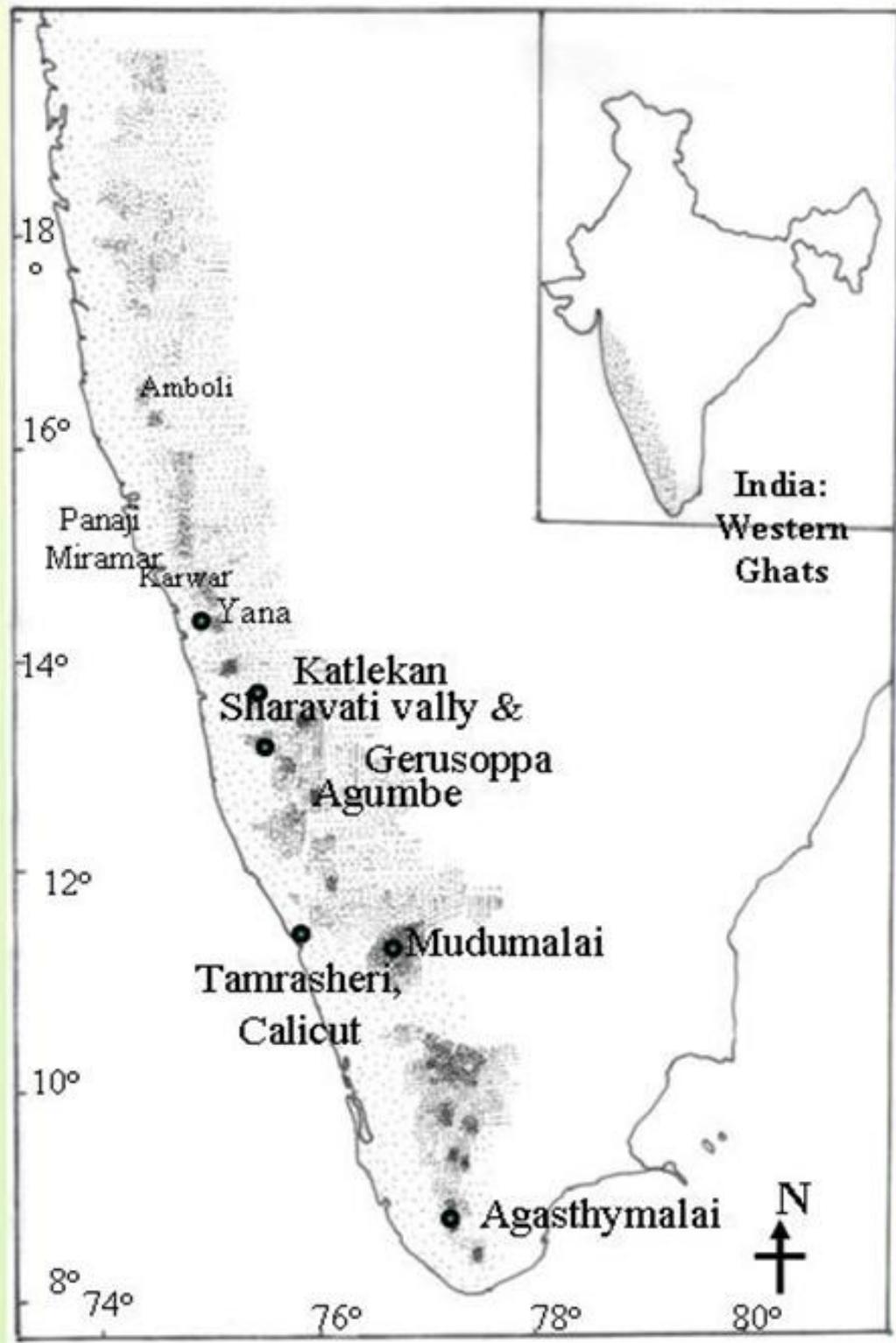
3. Palm plants of the Western Ghats, sampled during the study (Figs. 3-15)

The palm plants of the forests of Western Ghats, studied for associative fungal flora in this thesis, are described below:

(i) *Areca catechu* L. (Fig. 3):- Member of the subfamily *Arecoideae* and believed to be originated from Malaysia or the Philippines, this palm is cultivated for its fruits popularly known as arecanuts. Arecanut trees are under cultivation along the Western Ghats belt since ancient times and presently naturalized in the area (Jones 2001).

(ii) *Arenga wightii* Griff. (Fig. 4):- Member of the subfamily *Coryphoideae*, this endemic palm is mostly found in steep slopes and deep valleys of southern and central Western Ghats with its northern most distribution in Goa. The plant has huge fronds with stunted stem. It is seen in the wet evergreen forests of medium elevation. There

Fig. 2: Map of India showing places of collection in Western Ghats



are reports of local tribes extracting and using starch from the pith of this palm (Johnson, 1998; Manihottam and Francis 2007).

(iii) *Bentinckia condapanna* Berry (**Fig. 5**): Member of the subfamily *Arecoideae*, this highly endemic palm is found on rocky outcrops and steep slopes in Agastyamalai biosphere reserve region of the Western Ghats at an altitude of 1000-1800 msl. This palm is a threatened species because of large-scale harvesting by the locals and degradation of its habitat in its last geographic range (Henderson, 2009).

(iv) *Borassus flabellifer* L. (**Fig. 6**): Member of the subfamily *Borassoideae*, commonly known as Palmyra palm, is widely used for various purposes including for its ornamental value. The plant is native to south-east Asia and Indo-Malaya region where it is found in abundance. The tree grows more than 30m tall and its stem and leaves are used by local inhabitants for construction of houses. Popularly known as toddy, the juice extracted from its flowering stalk is used as an alcoholic beverage (Henderson, 2009).

(v) *Calamus rotang* L. (**Fig. 7**): Member of the subfamily *Calamoideae*, it is also a scandent thorny palm. Widely known as cane or rattan, the stem is used for making furniture. The palm is restricted to the plains along the backwaters and west-coast of southern India (Renuka, 1992).

(vi) *Calamus thwaitesii* Becc. & Hook. (**Fig. 8**): Belonging to the subfamily *Calamoideae*, it is a scandent thorny palm. Known as cane or rattan, it is used for making durable fancy furniture (Renuka, 1992). The palm is widely distributed in the evergreen, semi-evergreen and moist deciduous forests, between 75-900 msl, of the Western Ghats in southern India.

(vii) *Caryota urens* L. (**Fig. 9**): Member of the subfamily *Coryphoideae*, this palm is commonly called as fishtail palm. It is native of Sri Lanka, India and Myanmar. Fairly

common in the Western Ghats, it grows up to 12 m tall and has 4 m long leaves. Wood and leaves are utilized in building houses by the tribals. Sap extracted from the flowering stalk is used to make jaggery and alcoholic beverages (Riffle et al., 2003).

(viii) *Cocos nucifera* L. (**Fig. 10**): Member of the subfamily *Cocoideae* and native of Indo-Malayan region, this coconut palm is cultivated in all tropical and subtropical regions since ancient times. The palm produces up to 20m tall trunk and 3-4 m long leaves. While copra and coconut oil are the major commercial products from the palm, all parts of this palm are utilized in various ways (Chan and Elevitch, 2006)

(ix) *Corypha umbraculifera* L. (**Fig. 11**): Member of the sub-family *Coryphoideae*, this palm is native of India and Shri Lanka. Commonly called as tolpot palm, it grows about 25m tall with up to 3 m broad palmate leaves. The palm flowers once in its lifetime (30-80 y) and produces a terminal inflorescence which is one of the largest inflorescences produced by any plant. The palm is widely cultivated for its ornamental value as well as for its wood and leaves which are used by locals for thatching the houses (Chandran, 1996)

(x) *Elaeis guineensis* Jacq. (**Fig. 12**): Member of the subfamily *Arecoideae*, this palm is native of West Africa. The palm with up to 20 m tall trunk and 3-5 m long numerous leaves is widely cultivated for palm-oil in most tropical countries (Jones, 2001).

(xi) *Hyphaene dichotoma* (White) Furt. (**Fig. 13**): Member of the subfamily *Coryphoideae*, this palm is believed to be native of India and distributed in the costal areas of Gujarat, Maharashtra and Goa. The palm has peculiar dichotomus branching stem and palmate leaves. This palm is threatened due to habitat destruction in its distribution range (Johnson 1998).

Fig. 3-6



Fig. 7-10



Fig. 11-15



(xii) *Phoenix acaulis* Roxb. (**Fig. 14**): Member of the subfamily *Coryphoideae*, this palm is distributed in India and Nepal. With stunted stem, the palm grows mostly in scrub jungles. The palm grows up to 1.5 m tall and has pinnate leaves with armed petiole (Riffle et al., 2003).

(xiii) *Pinanga dicksonii* Blume (**Fig. 15**): Member of the subfamily *Arecoideae*, this palm is native of Andaman Islands and Western Ghats of India. The palm is distributed in central and southern Western Ghats and mostly found in places with abundant water reserves. It is now introduced in cultivation for its ornamental value.

4. Samples and sampling methods in the field:

The study samples gathered at the sites included different plant parts of palms, viz. leaf sheaths, fronds, rachids and lamina, in equal amounts, each time. Fresh leaves were collected for study of the endophytes.

The samples gathered were placed in zip plastic bags and brought to the laboratory. As far as possible and in most cases, the samples were examined or screened for fungal presence, soon after bringing to the laboratory. Wherever delayed, the samples were maintained in a refrigerator until the processing period.

5. Processing of samples in the laboratory:

For fungal biodiversity studies, the samples were subjected to 3 kinds of microscopic examination. First, the samples were examined under a stereoscope as soon as brought to the laboratory. Second, if no fungal presence was visualized, the samples were subjected to microscopy, after incubating in a moist chamber for a few days. Such brief-duration incubation facilitated resident fungal flora to sprout, grow and exhibit. Third, in order to achieve maximum recovery of the fungi living/lived on the

substrate, samples were subjected to particle-plating method. These methods and the fungal isolation procedure are detailed out below.

5.1. Microscopic observation and direct isolation (Fig. 16):

The palm specimen was first examined under a stereoscope to locate the fungi present in the form of fructifications, spore mass or colony form. The fungal material was carefully lifted with a fine-tipped needle and mounted on a clean slide using distilled water or lactophenol as mountant. Excess mountant was removed from the edges of cover-glass using an absorbent tissue paper. The slide mount was later examined under a transmission-light microscope.

5.2. Isolation following moist chamber incubation (Fig. 17):

If no fungal fruit bodies were observed on the substrate, the samples were subjected to moist chamber incubation, so as to enable the fungus to grow and sporulate in a moist, humid environment.

A thin layer of absorbent cotton superimposed by a circular piece of blotting paper was placed in a Petri plate (20 cm diam.) and soaked with distilled water. Excess water was drained off. Four clean microslides were placed on the filter paper. The plates were sterilized at 121⁰C and 15 lbs/cm³ pressure in an autoclave for 20 minutes. Samples were thoroughly washed with tap water and sterile distilled water, placed in the sterilized moist chambers and incubated at room temperature. From third day onwards, the incubated samples were scanned under stereoscope for fungal growth. The sporulating fungal colony was picked up, mounted on a slide with distilled water or lactophenol as mountant and examined under a transmission-light microscope.

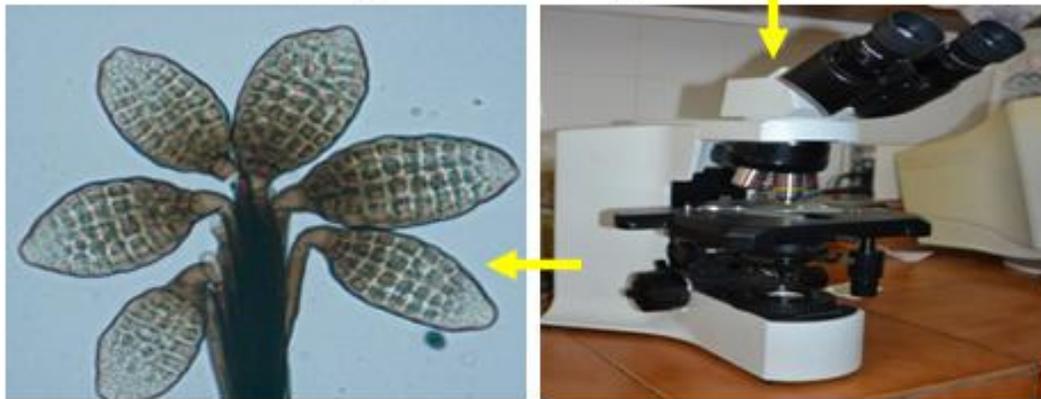
Fig. 16: Direct observation method



Different palm samples collected



specimens observed through the stereo-microscope and picked the fungus

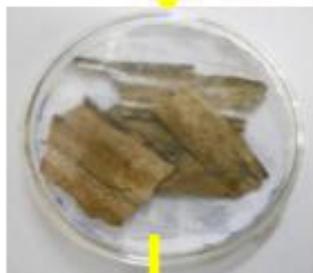


Detailed observation made through compound microscope

Fig. 17: Moist chamber incubation method



Litter samples were thoroughly washed in sterile water



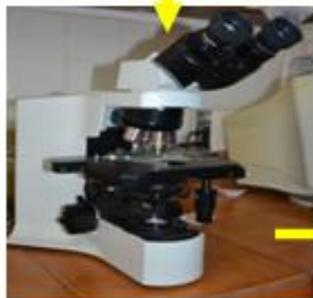
Placed in sterilized moist chamber and incubated at room temperature



Scanned under stereoscope for growth of fungus was observed



Growing fungus was picked up & mounted in lactophenol



Observed under compound microscope



5.2.1. Microscopic observation of slide mounts:

Fungal material, picked up from the palm samples by a flame-sterilized, fine-tipped needle was mounted on a clean slide containing either a drop of distilled water or lactophenol as mountant. For examination of hyaline fungi, cotton blue stain in lactophenol was used. For coloured or pigmented fungi, plain lactophenol was used. The mounted slide was gently warmed over a spirit lamp to eliminate air bubbles trapped under the cover glass. Excess stain, if any, was removed with help of a blotting paper and edges of the cover glass sealed using DPX sealing agent.

The reproductive features, both asexual and sexual, are the diagnostic features for morphology-based identification of fungi. The sporulating structures of anamorphic (asexual) Ascomycota viz. conidiophores, conidiogenous cells and conidia (Hyphomycetes); pycnidia or acervuli, conidiogenous cells and conidia (Coelomycetes) and of teleomorphic (sexual) Ascomycota, viz. ascocarp, asci and ascospores (Ascomycetes) were carefully examined and studied under a compound microscope (Olympus, CH30). Illustration of every fungus with all morphological details was made under different magnifications using a Camera Lucida drawing tube fitted to the light microscope. Photomicrographs were made using an Olympus DP12 digital camera fitted to an Olympus BX41 microscope.

5.2.2. Identification and documentation:

Based on diagnostic morphological features and using standard reference literature, the isolated fungi were identified down to genera and species level. The descriptions of fungi were written in a standard mycological diagnostic format (Hawksworth et al., 1995). Those fungi remained non-sporulating in culture, even after a prolonged duration, were maintained as 'unidentified'.

5.2.3. Preservation of specimens:

The samples were pressed between two dry sheets of blotting papers or newspapers. Well-dried specimens were stored in paper envelopes with a piece of naphthalene pellet which deterred mite or insect invasion in store.

5.2.4. Culturing of palm-associated fungi:

Fungi found sporulating on the sample while bringing from the field was isolated in the laboratory following 'single-spore isolation method', as described below. The particle filtration method also facilitated isolation of pure cultures of fungi.

5.2.4.1. Single spore isolation method (Fig. 18):

Palm samples, direct or after incubation in a moist chamber, were scanned under a stereoscope to locate sporulating fungal colonies. A drop of sterile distilled water was placed on a flame-sterilized slide. Using a sterile fine-tipped needle, sporulating fungal mass was transferred in water mountant and teased apart in order to get free spores. The spore suspension was spread on a 2% MEA plate incorporated with antibiotics. After two days, the developing young colonies were individually transferred into fresh plates.

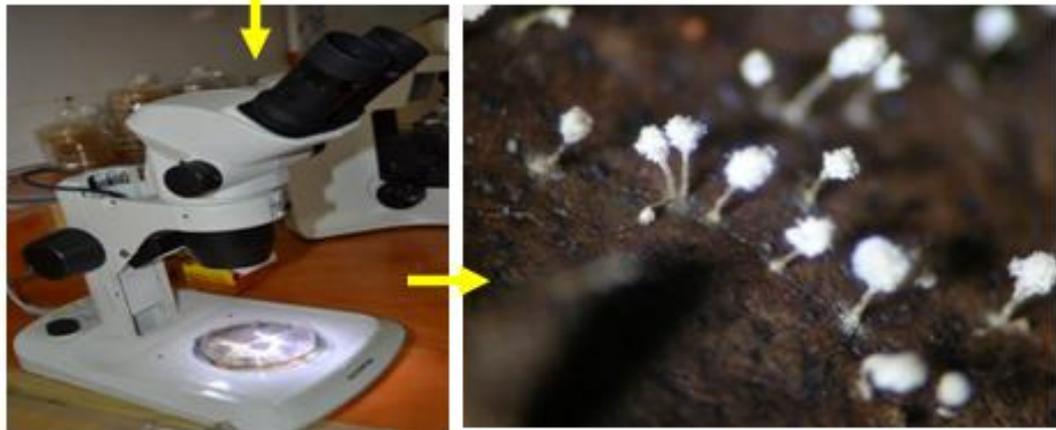
5.2.4.2. Particle-plating method (Fig. 19):

Freshly gathered decaying leaves, fronds, spathes of palm were washed under running tap water followed by repeated wash in sterile distilled water. The materials were ground into fine particles in an electric blender and filtered through three superimposed metal sieves with mesh size of 1000, 250 and 100 μm . The particles trapped in the lower-most sieve, those between 100 and 250 μm size, were repeatedly washed in sterile distilled water and plated on MEA medium incorporated with antibiotics. The colonies appearing from individual particles after two days of

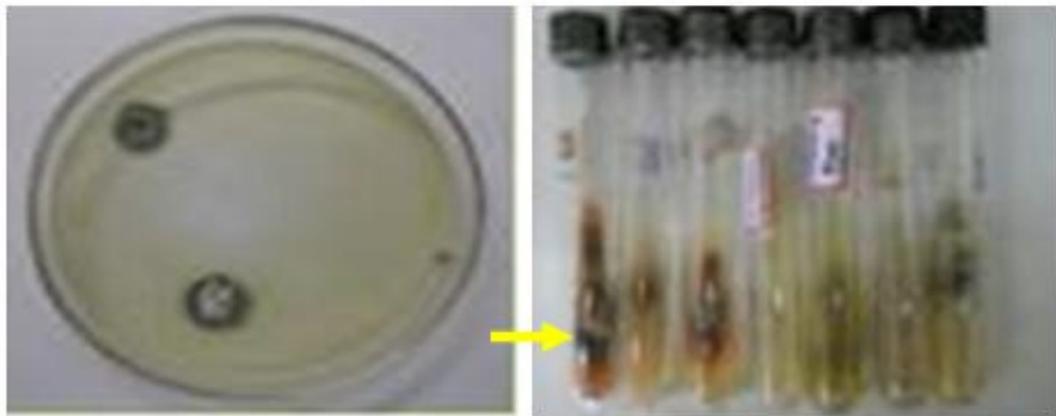
Fig. 18: Single spore isolation method



Different palm samples collected



Samples were scanned under stereomicroscope and picked the fungus using sterile needle



Spores were spread on agar plate and single colonies transferred into slants

Fig. 19: Particle plating technique



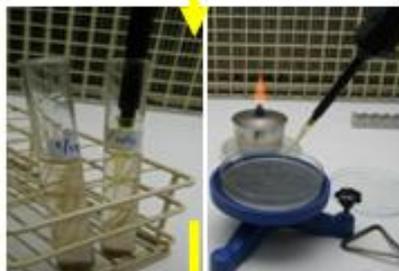
Leaf litter



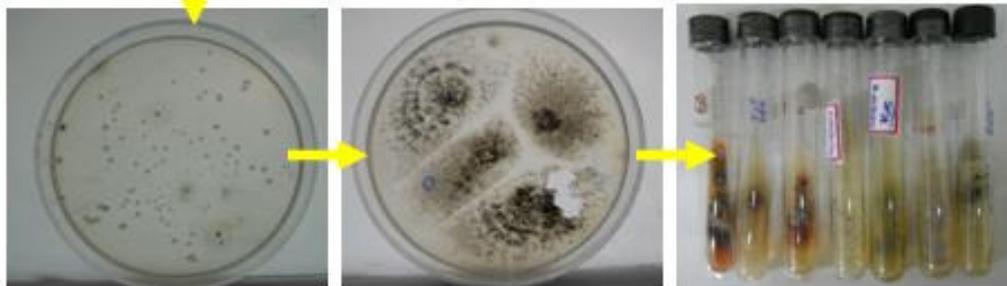
Thoroughly washed in tap water and cut into pieces



Leaf bits ground into particles



Washed in sterile distilled water repeatedly and spread on agar plates



Fungal colonies isolated in sector plates and transferred into slants

incubation were isolated into fresh plates. The method was standardized by Bills and PolisHook. (1994) and perfected by Bhat (2010).

5.2.4.3. Three-step sterilization for isolation of endophytes (Fig. 20):

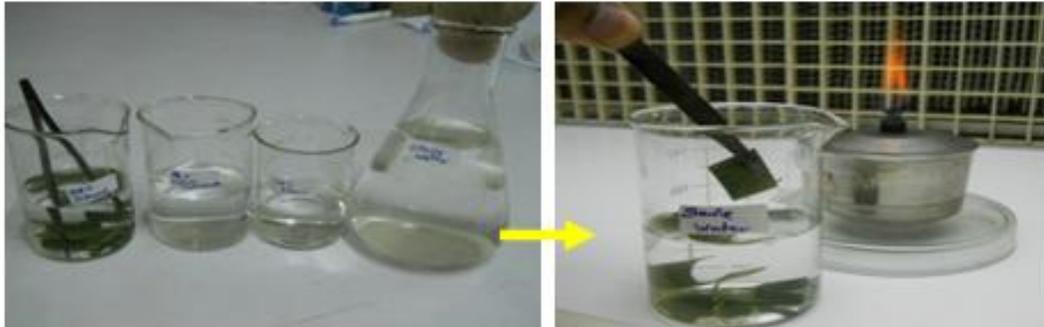
Fresh and disease-free tissue material (leaf or petiole) of palm plant was first thoroughly washed in tap water and sterile distilled water. Subsequent washes were sterilizations in 70% ethanol (0.5 min), 4% sodium hypochloride (1 min) and 70% ethanol (0.5 min). The leaf, stem or petiole was repeatedly washed in sterile distilled water so as to remove any trace of the disinfectants. The tissue was cut into bits (2² mm size) using a sterile blade and plated in 2% MEA containing antibiotics. The colonies emerging out from the cut-edges of the tissues were isolated into fresh MEA plates or slants (Fröhlich, J., 2000).

6. Media used for isolation and maintenance of fungi:

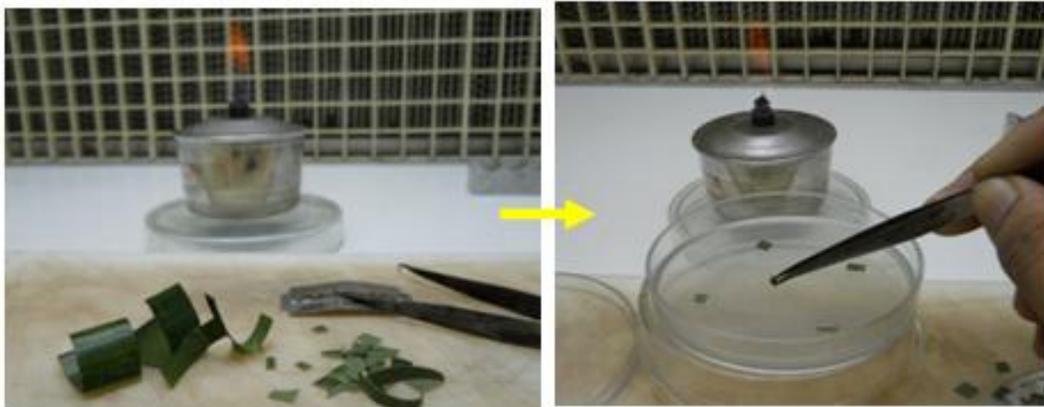
Standard mycological culture media, Malt Extract Agar, Potato Dextrose Agar and Leaf Extract Agar, were used in this study. A mixture of antibiotics, containing bacitracin 0.02 g, neomycin, 0.02 g, penicillin G 0.02 g, streptomycin sulphate 0.02 g and tetracycline 0.02 g, dissolved in 10 ml sterile distilled water and filter sterilized, was added to the 1 L of the medium.

- (i) Malt extract agar (MEA) medium: Dehydrated malt extract (5 g) and agar (20 g) (HiMedia Pvt. Ltd., Mumbai) were dissolved in 1 L distilled water; the pH was adjusted to 5.5 and sterilized in an autoclave at 121⁰C for 20 min under 15 lb/cm³ pressure.
- (ii) Potato dextrose agar (PDA) medium: Potato dextrose agar, 41.0 g (HiMedia Pvt. Ltd., Mumbai), was dissolved in 1 L distilled water. The pH of the medium was adjusted to 5.5 and sterilized in autoclave at 121⁰C for 20 min. at

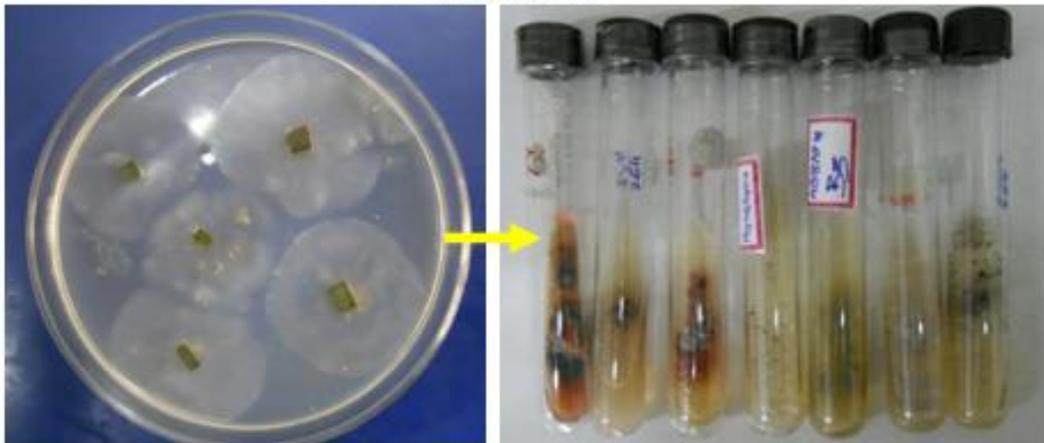
Fig. 20: 3-step sterilization technique



**Fresh uninfected leaves washed in 70% ethanol (1 min.),
4% NaOCl (30 sec.) and 70% ethanol (1 min.)**



**Cut into pieces of 2-5 mm size and plated on agar
medium**



**Fungal colonies isolated in sector plates and
transferred into slants**

15 lb/cm³ pressure.

- (iii) Leaf Extract Agar medium: Leaves of host brought to the laboratory were boiled vigorously in distilled water. Leaf extract was seved through muslin cloth. Disired amount of agar was added and media was sterilized in autoclave at 121⁰C for 20 min. at 15 lb/cm³ pressure.

Isolated fungi were maintained in MEA slants. The cultures were deposited at Goa University Fungus Culture Collection Unit (GUFCC), an in-house repository. The cultures are periodically subcultured and permanently stored here with GUFCC accession numbers.

7. Observation of cultural characters:

Cultural characters of isolated fungi such as colony shape, size, margin, texture and colour were recorded after 7 days of inoculation. Standard colour charts and descriptive terminologies (Hawksworth et al., 1995) were used while describing the colony characters.

8. Enzyme assay:

The isolated fungi were screened for production of 2 enzymes, viz. cellulase and laccase. The test fungus was grown on MEA medium in a Petri plate for 7 days at room temperature (28-32⁰C); colony discs of 6 mm size were cut and used as initial inoculum for enzyme assay.

8.1. Cellulolytic activity:

8.1.1. Qualitative plate assay:

Screening of palm fungi for cellulase was done on CMC agar (0.05% K₂HPO₄, 0.025% MgSO₄, 0.188% CMC sodium salt, 1.5% agar). Six mm disc of growing

fungus was spot inoculated on the CMC agar plate and the plates were incubated at 28⁰C for 10 days. The plates were flooded with 0.1% Congo red for 15 to 20 min and then with 1N NaCl for 15 to 20 min (Hankin & Anagnostakis, 1977). After incubation, CMC Congo red plates were observed for 'zone of clearance' around the colony.

8.1.2. Quantitative assay:

Culture medium: The fungi showing promising cellulose activity were grown in 100 ml conical flasks containing 50 ml of CMC broth medium (Per liter: CMC: 10 g; KH₂PO₄: NaCl: 2 g; MgSO₄.H₂O: 1 g; MnSO₄:0.05 g; FeSO₄.7H₂O : 0.05 g CaCl₂.2H₂O: 2 g; NH₄Cl:2 g; pH 7-7.4) for 7 days in an orbital shaker at 28oC. The cellulase activity was assayed by the DNS method for reducing sugars (Jaradat et al., 2008).

Assay of CM-Cellulase activity: The cellulase activity was measured following the method of Miller (1959). A reaction mixture composed of 1 ml of crude enzyme solution plus 2 ml of 0.5% carboxymethyl cellulose (CMC) in 50 mM phosphate buffer (pH 7.0). The reaction mixture was incubated at 37⁰C in a water bath for 30 min. The reaction was terminated by adding 1 ml of DNS reagent. The color was developed by boiling the mixture for 5 min. Optical densities of samples was measured at 575 nm against a blank containing all the reagents minus the crude enzyme. Result was interpreted in terms of enzyme activity in which one unit (U) of enzyme activity is defined as the amount of enzyme, which liberates 1 μ mol of glucose per minute under the above assay conditions.

8.2. Laccase activity:

8.2.1. Qualitative plate assay: Selection of laccase producing organisms was done on plates containing following composition (g/l): 3.0 peptone, 10.0 glucose, 0.6 KH₂PO₄, 0.001 ZnSO₄, 0.4 K₂HPO₄ 0.0005 FeSO₄, 0.05 MnSO₄, 0.5 MgSO₄, 20.0 agar (pH-6) supplemented with 0.02% guaiacol. Isolated palm fungi were inoculated into these plates and the plates were incubated at 30°C for 7 days. Laccase activity was visualized on plates containing 0.02% guaiacol since laccase catalyzes the oxidative polymerization of guaiacol to form reddish brown zones in the medium (Coll et al., 1993).

8.2.2. Quantitative assay:

Culture medium: Fungal strains showing positive reactions in the plate-test screening were grown in liquid medium containing Malt extract both for 7 days in an orbital shaker incubator at 28°C.

Assay of Laccase activity: The laccase activity was measured based on the oxidation of the substrate 2,2'-azino-bis (3-ethylbenzothiazoline)-6-sulphonic acid (ABTS). The rate of ABTS oxidation was determined spectrophotometrically at 420 nm. The reaction mixture containing 600 µL sodium acetate buffer (0.1 M, pH 5.0 at 27°C), 300 µL ABTS (5 mM), 300 µL culture filtrate (crude enzyme) and 1400 µL distilled water were incubated for 3 min at 30°C. The absorbance was measured immediately in one minute intervals. One unit of laccase activity is defined as activity of an enzyme that catalyzes the conversion of 1 mole of ABTS per minute (Niku-Paavola et al., 1988).

9. Antimicrobial assay:

9.1. Preliminary assay

The disks cut from the 7-day MEA (Malt extract agar) plate cultures of the 60 isolates were screened for their antimicrobial activity against three test organisms spread on specific medium plates.

9.2. Secondary assay with extract preparation

The test fungus was grown in 50 ml Malt Extract broth for 8 days. The fungal mycelia were extracted with methanol overnight and broths extracted with 150 mL of ethyl acetate, a total of 3 times. Both extracts were mixed and evaporated to dryness *in vacuo* by rotary evaporator. The crude extract was then dissolved in 2.5 ml of methanol for assay. On a clean air bench, 50 µl of the extract was placed on a sterile paper using a pipette and allowed to dry. The dry discs were placed centrally on the surface of a pre-seeded plate. The plates were incubated and measured for the inhibition zones. Active cultures were used for further screening.

10. Molecular phylogeny study of selected isolates:

DNA sequencing:- The ITS/ 5.8S rRNA gene from the fungal cultures were amplified by Polymerase Chain Reaction (PCR) using ITS4-ITS5 primer pair (White et al., 1990). This was done by out-sourcing at M/S Royal Life Sciences, Secunderabad, attached with MIDI Labs. The DNA sequencing was done using the above-mentioned primer pair in an Applied Biosystem MicroSeq System.

Phylogenetic analysis:- Sequences obtained from the respective primers were aligned in MEGA version 5.02 (Tamura et al., 2011) and the consensus sequences were deposited in NCBI-GeneBank and accession numbers were obtained. First 100 blast search results in NCBI-GeneBank were considered to select the taxa and most of the

sequences with repetitive names were ignored. Selected sequences were aligned with clustalW incorporated in MEGA 5.02. A dataset based on ITS/5.8S rRNA gene sequence data was prepared using MEGA. Phylogenetic analyses were conducted in MEGA. Phylogenetic relationships were inferred based on Maximum Likelihood method and GTR model incorporated in MEGA to get the tree with the highest log likelihood.

Results

This thesis entitled ‘Studies on Diversity and Activity of Microfungi Associated with Indigenous Palms of Western Ghats, India’ embodies results obtained of four major issues projected in the objectives at the introductory chapter and detailed investigation carried out during the study period. The results are detailed out in the following 4 Parts.

Part I

In this part, taxonomy and diversity of the fungi recovered from 13 indigenous palm plants, viz. *Areca catechu*, *Arenga wightii*, *Bentinckia condapanna*, *Borassus flabellifer*, *Calamus rotang*, *C. thwaitesii*, *Caryota urens*, *Cocos nucifera*, *Corypha umbraculifera*, *Elaeis guineensis*, *Hyphaene dichotoma*, *Phoenix acaulis* and *Pinanga dicksonii*, found growing in the forests of Western Ghats, and worked out during 2007-10, are detailed out. Some of those fungi isolated were found associated with certain diseases on palms and therefore described with details on their symptoms. All the fungi were described based on their morphology. Two morphologically unique isolates were analyzed further for molecular details based on sequence of ITS/ 5.8S region. Blast analysis and alignment of sequences and construction of maximum likelihood tree using software MEGA 5.05 showed the sequences are distinct in Genbank with less than 87% similarity with any of the named sequences in hold and therefore dealt along with descriptions of respective fungi. In addition, a morphology-based taxonomic key to the genus *Pithomyces* is presented with two new taxonomic species.

Part II

This part has details on seasonal variation in the quality and quantity of fungi appeared on two palm plants, viz. *Arenga wightii* and *Calamus thwaitesii*, situated at two different localities, viz. Dudhsagar Falls and Netravali, in 2007-09. Analysis of the data obtained in this exercise was aimed at understanding the ecology between the host plants and the associative fungi. Observations are supplemented with supportive graphs and tables.

Part III

Efforts were made to establish pure cultures of fungi found on 13 palm plants studied, from spores or vegetative mycelia. The isolated fungi were deposited at an in-house facility entitled 'Goa University Fungal Culture Collection' (GUFCC), as an *ex situ* fungal conservation effort. Part-cultures of the isolated fungi are being housed at two nationally recognized repositories, (i) National Fungal Culture Collection (NFCCI) located at Agarkar Research Institute, Pune, and (ii) Microbial Type Culture Collection (MTCC) housed at Institute of Microbial Technology, Chandigarh.

Part IV

The results obtained of screening cultures for cellulase, laccase and antimicrobial activity are detailed out in this part. Of the 60 fungal cultures screened, 40 (67%) exhibited positive for cellulase, 15 (25%) for laccase and 12 (12%) for antimicrobial activity against tested pathogenic microorganisms. Of these, *Dictyoarthrinium quadratum* was found to be positive for all the 3 assays whereas *Dictyosporium elegans* showed maximum laccase activity, i.e. 326 nKat/L.

As detailed out in Chapter III, standard mycological and analytical methods were followed, in this study. For diversity studies, in order to isolate the fungi in pure

culture, direct isolation, isolation following moist chamber incubation, and particle-plating techniques were followed. For seasonal studies of fungal occurrence on two palm plants, sampling and isolation of fungi were done at seasonal intervals (as detailed at Chapter III) for two years. For bioactivity analyses, standard analytical methods were followed.

The results obtained were indeed very interesting. A large number of and diverse fungi were encountered. Adequate care was taken, at all levels of the study, to reconfirm the results obtained. The results are elaborated below, part-wise, under separate headings:

Part 1: Taxonomic diversity of palm fungi

In all, 217 fungi, belonging to 142 genera were recovered from different palm plants. These included Zygomycota (1 species in 1 genus), teleomorphic Ascomycota (17 species in 10 genera), anamorphic Ascomycota and Basidiomycota [Hyphomycetes (193 species in 128 genera) and Coelomycetes (6 species in 4 genera)]

All the fungi isolated during the study are described and illustrated below with information on their cultural characters, morphology based on microscopic observations, taxonomy and the specimens examined. For those fungi remained uncluturable, the specimens were accessioned and deposited at Goa University Botany Herbarium (GUBH) and those recovered in pure culture were maintained at the Goa University Fungus Culture Collection (GUFCC).

Each fungus is fully described and provided with photo-micrographs and/or camera lucida drawings, especially of the conidiophores and conidia in case of anamorphic ascomycota (Hyphomycetes) and ascomata, asci and ascospores in case of teleomorphic Ascomycota. Discriptions of fungi are based on specimens or live cultures which are well preserved at the Goa University Botany Herbarium (GUBH)

and Goa University Fungal Culture Collection (GUFCC). Specimens of new taxon described in this thesis are deposited at the repository of Indian Agricultural Research Institute (IARI), Pusa, New Delhi. Live cultures are deposited at the Microbial Type Culture Collection (MTCC), IMTECH, Chandigarh.

The fungi isolated during the study are listed and described below in alphabetical order.

List of the fungi

A. Hyphomycetes (Anamorphic Ascomycota and Basidiomycota):

1. *Acremonium byssoides*
2. *Acremoniula sarcinellae*
3. *Acroconidiellina arecae*
4. *Acrogenospora sphaerocephala*
5. *Acrostalagmus* sp.
6. *Agaricostilbum palmicola*
7. *Alternaria alternata*
8. *Alternaria* sp.
9. *Alternaria* sp. 2
10. *Alysidium resinae*
11. *Anavirga vermiformis*
12. *Arachnophora fagicola*
13. *Ardhachandra selenoides*
14. *Aspergillus fumigatus*
15. *Aspergillus niger*
16. *Aspergillus nidulans*
17. *Aspergillus oryzae*
18. *Aspergillus terreus*
19. *Aspergillus ustus*
20. *Aureobasidium* sp.
21. *Bactrodesmium longisporum*
22. *Bactrodesmium* sp.
23. *Bahugada sundara*
24. *Bahusandhika indica*
25. *Bahusutrabeija globosa*
26. *Beltrania circinata*
27. *Beltrania concurvispora*
28. *Beltrania rhombica*
29. *Berkleasmium typhae*
30. *Bharatheeya mucoidea*
31. *Bioconiosporium berberidis*
32. *Bisporomyces* sp.
33. *Botryosporium* sp.
34. *Brachydesmiella biseptata*
35. *Brachydesmiella caudata*
36. *Brachysporiella gayana*
37. *Brachysporiella* sp.
38. *Cacumisporium capitulatum*
39. *Candelabrum brocciatum*
40. *Catenularia* sp.
41. *Catenularia* sp.2
42. *Ceratosporella ponapensis*
43. *Ceratosporium* sp.
44. *Chalara indica*
45. *Chalara* sp.
46. *Chloridium reniforme*
47. *Circinotrichum* sp.
48. *Cirrenalia pseudomacrocephala*
49. *Cladosporium cladosporioides*
50. *Cladosporium* sp.
51. *Clonostachys cylindrospora*
52. *Clonostachys pseudosetosa*
53. *Corynespora cassiicola*
54. *Corynespora* sp.
55. *Constantinella clavata*
56. *Constantinella palmicola*
57. *Craspedodidymum* sp.
58. *Cryptophiale udagawae*
59. *Cryptophiale* sp.
60. *Curvularia senegalensis*
61. *Curvularia* sp.
62. *Cylindrocladium quinquesepatum*
63. *Cylindrocladium* sp.
64. *Dactylaria biseptata*
65. *Dactylaria candidula*
66. *Dactylella* sp.
67. *Dictyoarthrinium quadratum*
68. *Dictyochaeta assamica*

69. *Dictyochaeta fertilis*
70. *Dictyochaeta guadalcanalensis*
71. *Dictyosporium elegans*
72. *Dictyosporium* sp.
73. *Didymobotryum rigidum*
74. *Didymostilbe sundara*
75. *Ellisembia adscendens*
76. *Endocalyx melanoxanthus*
77. *Endoconidioma populi*
78. *Endophragmia* sp.
79. *Endophragmiopsis* sp.
80. *Excipularia narsapurensis*
81. *Exserticlava triseptata*
82. *Exserticlava vasiformis*
83. *Fusarium graminearum*
84. *Fusarium* sp.
85. *Gangliostilbe indica*
86. *Gangliostilbe malabarica*
87. *Geniculosporium* sp.
88. *Gliocladium cylindrosporium*
89. *Gliocladium penicillioides*
90. *Gliocladium*
91. *Gliocladiopsis sagariensis*
92. *Gliomastix* sp.
93. *Gonytrichum macrocladum*
94. *Graphiola phoenicis*
95. *Graphium* sp.
96. *Gyrothrix* sp.
97. *Hansfordia pulvinata*
98. *Helicoma* sp. 1
99. *Helicoma* sp. 2
100. *Helicomycetes* sp.1
101. *Helicomycetes* sp. 2
102. *Helicosporium cinereum*
103. *Helminthosporium belgaumense*
104. *Helminthosporium* sp.
105. *Helminthosporium* sp. 2
106. *Hemicorynespora mitrata*
107. *Hemicorynespora* sp.1
108. *Hemicorynespora* sp.2
109. *Hermatomyces tucumanensis*
110. *Idriella fertilis*
111. *Ityorhoptrum verruculosum*
112. *Junewangia sphaerospora*
113. *Kiliophora ubiensis*
114. *Kostermansinda magna*
115. *Megacapitula villosa*
116. *Melanographium citri*
117. *Memnoniella echinata*
118. *Memnoniella levispora* Subram
119. *Monodictys paradoxa* (Corda) S. Hughes
120. *Monodictys* sp.
121. *Monotosporella rhizoidea* Rao & de Hoog
122. *Nalanthamala* sp.
123. *Nigrospora oryzae*
124. *Nodulisporium ochraceum*
125. *Nodulisporium* sp.
126. *Paecilomyces* sp.
127. *Paradictyoarthrinium diffractum*
128. *Paraceratocladium seychellarum*
129. *Parahelminthosporium malabaricum*
130. *Penicillium* sp.
131. *Penicillium* sp. 1
132. *Penicillium* sp.2
133. *Periconia hispidula*
134. *Periconia* sp.
135. *Phaeoisaria clematidis*
136. *Phaeomonilia corticola*
137. *Phialophora cinerescens*
138. *Phialophora richardsiae*
139. *Piricauda cochinchinensis*
140. *Pithomyces africanus*
141. *Pithomyces chartarum*
142. *Pithomyces ellisii*
143. *Pithomyces flavus*
144. *Pithomyces multiappendiculata*
145. *Pithomyces* sp. 1
146. *Pithomyces* New 2
147. *Prathigada* sp.
148. *Pseudoepicoccum cocos*
149. *Pyriculariopsis* sp.
150. *Rattania setulifera*
151. *Scolecobasidium* sp. 1
152. *Sorocybe resiniae*
153. *Spegazzinia parkeri*
154. *Spegazzinia tessarthra*
155. *Spondylocladiopsis aseptata*
156. *Sporidesmiella claviformis*
157. *Sporidesmium ghanaense*
158. *Sporidesmium paradecorosum*
159. *Sporidesmium* sp.
160. *Sporidesmium* sp1.
161. *Sporoschisma mirabile*
162. *Stachybotrys kampalensis*
163. *Stachybotrys nephrospora*
164. *Stigmina palmivora*
165. *Stilbella* sp.

- | | |
|---|--------------------------------------|
| 166. <i>Tetraploa aristata</i> | 180. <i>Verticillium</i> sp. |
| 167. <i>Tetraploa</i> sp. | 181. <i>Virgaria nigra</i> |
| 168. <i>Thozetella tocklaiensis</i> | 182. <i>Volutella gilva</i> |
| 169. <i>Torula herbarum</i> | 183. <i>Wardomyces</i> sp. |
| 170. <i>Trichoderma harzianum</i> | 184. <i>Wiesneriomyces javanicus</i> |
| 171. <i>Trichothecium roseum</i> | 185. <i>Xenosporium africanum</i> |
| 172. <i>Triposporium elegans</i> | 186. <i>Xenosporium boivinii</i> |
| 173. <i>Vanakripa gigaspora</i> | 187. <i>Xenosporium</i> sp. 1. |
| 174. <i>Vanakripa parva</i> | 188. <i>Xenosporium</i> sp.2 |
| 175. <i>Vanakripa</i> sp. 1 | 189. <i>Xenosporium</i> sp. 3 |
| 176. <i>Vermiculariopsiella elegans</i> | 190. <i>Zygosporium masonii</i> |
| 177. <i>Vermiculariopsiella parva</i> | 191. <i>Zygosporium minus</i> |
| 178. <i>Veronaea indica</i> | 192. Unidentified fungus 1 |
| 179. <i>Verticimonosporium diffractum</i> | 193. Unidentified fungus 2 |

B. Coelomycetes

1. *Lasiodiplodia theobromae*
2. *Pestalotiopsis palmarum*
3. *Pestalotiopsis* sp.
4. *Pestalotiopsis* sp. 1
5. *Phoma* sp.
6. *Phomopsis* sp.

C. Ascomycetes

1. *Ascotricha* sp.
2. *Astrosphaeriella* sp.
3. *Caudatispora palmicola*
4. *Ceratocystis paradoxa*
5. *Chaetomium* sp.
6. *Cochliobolus* sp.
7. *Eurotium* sp.
8. *Hypocrea* sp.
9. *Nectria* sp.
10. Unidentified ascomycete 1
11. Unidentified ascomycete 2
12. Unidentified ascomycete 3
13. Unidentified ascomycete 4
14. Unidentified ascomycete 5
15. Unidentified ascomycetes 6
16. Unidentified ascomycetes 7
17. Unidentified ascomycetes 8

D. Zygomycota

1. *Mortierella* sp.

Details of the fungi

A. Hyphomycetes (Anamorphic Ascomycota and Basidiomycota):

Acremonium byssoides W. Gams & T.M. Lim, in Gams, *Trans. Br. mycol. Soc.* 64: 391 (1975)

Colonies effuse, off-white. *Mycelium* superficial, composed of branched, septate, hyaline, smooth, 2-2.5 µm thick hyphae. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, hyaline, smooth, 10-25 x 1.5-2 µm. *Conidiogenous cells* monophialidic, terminal, integrated, hyaline, 8-15 x 1-1.5 µm. *Conidia* formed in slimy heads, ellipsoidal, hyaline, smooth, straight to slightly curved, aseptate, 2-4 x 1.5-2 µm.

Specimen examined: I. Isolated by 3-step sterilization method, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. GUBH-71AP01. II. Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar falls Netravali, Sanguem, Goa, 30/01/08, coll. A. Prabhugaonkar. III. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 242AP21. IV. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 463AP18. V. Isolated by 3-step sterilization method, *Caryota urens* L., Mashem Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar. VI. Isolated by Particle plating method from litter of *Areca catechu* L. Brahmakarmali, Sattari, Goa, 31/01/08, coll. A. Prabhugaonkar, Herb. No. 162AP01.

Acremoniula sarcinellae (Pat. & Har.) G. Arnaud ex Deighton, *Mycol. Pap.* 118: 3 (1969).

Colonies effuse, black, mycelium superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous or semi-macronematous, mononematous, branched or unbranched, straight or flexuous, colourless, smooth 8-16 x 1-4 µm. *Conidiogenous cells* monoblastic, integrated and terminal or discrete, determinate, cylindrical 2-6 X 1-3 µm. *Conidia* solitary, dry, acrogenous, simple, obovoid, pyriform, ellipsoidal or subspherical, truncate at the base, mid to very dark brown, thick-walled, smooth, 0-septate 5-9 x 4-8 µm.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar.

Acroconidiellina arecae (Berk. & Br.) Ellis, 1971. *Mycol. Pap.* 125: 26 (Plate I- 1)

Colonies on leaf spots effuse, dark brown, hairy. *Mycelium* superficial, composed of thin, thin walled, smooth, branched, olivaceous brown, 2-4 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, in dense fascicles, erect, straight, unbranched, septate, thick walled,

verrucose, dark brown to almost black, 60-250 x 5-9 μm . *Conidiogenous cells* monotretic, terminal, integrated, determinate. *Conidia* solitary, simple, acrogenous, dark brown, 3-4 septate, with central cell verrucose and darker than the peripheral cells, 30-75 x 18-22 μm with thickened and darkened hilum.

Specimen examined: On living leaves of *Areca catechu* Linn., Mashem, Cancona, Goa, 15/10/08, coll. A. Prabhugaonkar, Herb. GUBH No. AP25.

***Acrogenospora sphaerocephala* (Berk. & Broome) M.B. Ellis, *Dematiaceous Hyphomycetes* (Kew): 114 (1971) (Plate I- 2; Fig. 21)**

Colonies on natural substrate effuse, hairy, dark brown to black. *Mycelium* partly superficial, partly immersed, composed of light brown, smooth, septate, 2-3 μm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, dark brown at the base, paler towards the apex, smooth, 270-380 x 6-11 μm . *Conidiogenous cells* mono to polyblastic, integrated, terminal, light brown, 20-30 x 6-8 μm . *Conidia* solitary, dry, acroplerogenous, spherical, solitary, dry, dark brown to black, aseptate, smooth, with attached cell at the base, 24-30 μm in diam.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. 171AP01. II. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar. Herb. No. 172AP01.

***Acrostalagmus* sp. (Plate I- 3)**

Colonies on natural substrate effuse, off-white. *Mycelium* partly immersed, partly superficial, composed of branched, septate, hyaline, smooth, 2-2.5 μm thick hyphae. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, branched at the tip, dark brown at the base, brown in the middle, sub-hyaline at the apex, smooth, 250-370 x 5-10 μm . *Conidiogenous cells* monophialidic, verticillate, terminal, discrete, determinate, hyaline, 12-25 x 1.5-2.5 μm . *Conidia* simple, smooth, ellipsoidal, aseptate, hyaline, formed in slimy heads, 4-5 x 1.5-2.5 μm .

Specimen examined: On spathhe litter of *Cocos nucifera* L., Mashem, Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 225AP25.

***Agaricostilbum palmicola* J.E. Wright, *Mycologia* 62(4): 680 (1970) (Plate I- 4; Fig. 22)**

Colonies on substratum affuse, cottony. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* hyaline, septate, macronematous, mononematous,

unbranched, forming synnema with free radiating ends of conidiogenous hyphae, 200-320 x 2-4 µm. *Conidiogenous cells* located on distal end of radiating conidiophores, either terminal producing conidia at the tip or intercalary producing conidia on hump like projection near septa, mono to polyblastic, 8-13 x 2.5-5 µm. *Conidia* solitary, dry, acrogenous, hyaline, circular to oval, aseptate, smooth, pointed at the base, 4-5 x 2.5-3.5 µm.

Specimen examined: I. On litter of *Cocos nucifera* L. Harmal, Pernem, Goa, 08/09/07, coll. A. Prabhugaonkar, Herb. No. 58AP30. II. On dead fronds of *Borassus flabellifer*, near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 84AP22. III. On frond litter of *Phoenix* sp. Dona Paula, Goa, 05/01/07, coll. A. Prabhugaonkar, Herb. No. GUBH 58AP27. IV. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 227AP21.

***Alternaria alternata* (Fr.) Keissl., Beih. bot. Zbl., Abt. 2 29: 434 (1912) (Plate I- 5)**

Colonies on natural substrate effuse, hairy, dark brown. *Mycelium* internal. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, fasciculate, unbranched to rarely branched, straight to flexuous, brown, smooth, 40-200 x 4-6 µm. *Conidiogenous cells* polytretic, integrated, terminal as well as intercalary, sympodial, cicatrized 8-16 x 4-5 µm. *Conidia* catenate, dry, obclavate to ellipsoidal, with a short, cylindrical beak, medium brown, rugulose, muriform, with a single scar at the tip, 20-80 µm long, 8-19 µm wide at the centre, 3-5 µm at the tip.

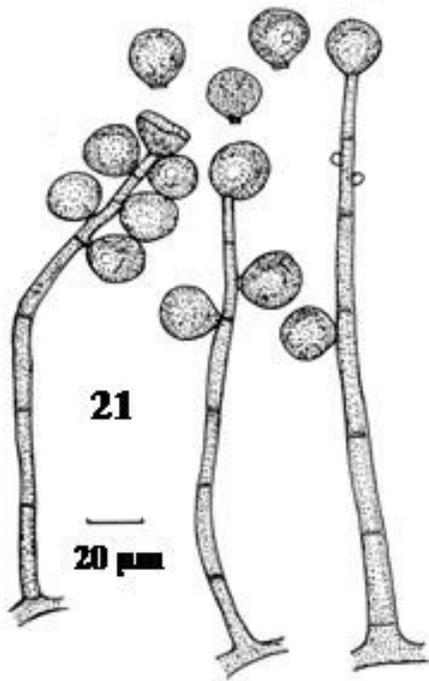
Specimen examined: Isolated by Particle plating method from litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 415AP19.

***Alternaria* sp. (Fig. 23)**

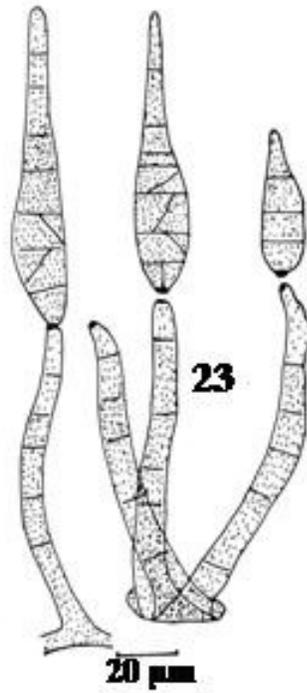
Colonies on natural substrate effuse, hairy, dark brown. *Mycelium* internal. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, fasciculate, unbranched to rarely branched, straight to flexuous, brown, smooth, 7.5-80 x 2.5-5 µm. *Conidiogenous cells* polytretic, integrated, terminal as well as intercalary, sympodial, cicatrized 5-30 x 2-4 µm. *Conidia* catenate, dry, obclavate to ellipsoidal, with a short, cylindrical beak, medium brown, muriform, with a single scar at the tip 7-38 x 5-18 µm, with 2.5-70 µm long beak.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, Herb. No. 23AP01. II. On litter of *Phoenix acaulis* Roxb., Harmal, Pernem, Goa, 24/08/07, coll. A. Prabhugaonkar, Herb. No. 53AP01. III. On spathes of *Cocos nucifera* L. Mashem, Canacona, Goa, 10/11/2007, coll. A. Prabhugaonkar, Herb. No. GUBH- 104AP25. IV. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 197AP01.

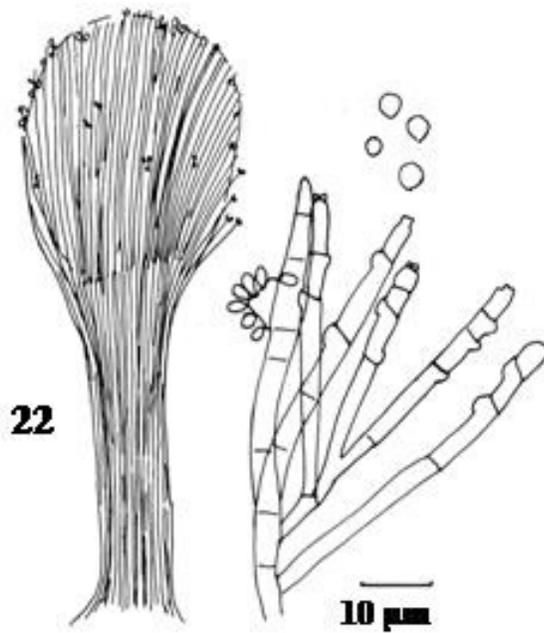
Figs. 21-23



Acrogenospora sphaerocephala



Alternaria sp.



Agaricostilbum palmicola

***Alternaria* sp. 2**

Colonies on natural substrate effuse, hairy, dark brown. *Mycelium* internal. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, straight to flexuous, unbranched, sympodial, brown, smooth, 23-56 x 2-5 µm. *Conidiogenous cells* polytretic, integrated, terminal as well as intercalary, cicatrized, light brown, 6-7 x 2-4 µm. *Conidia* solitary, dry, obclavate, brown, 3-7-septate, often with 1-2 oblique septa, 26-55 µm long, 8-10 µm broad at the centre, 3-4 µm broad at tapering, rounded apex.

Specimen examined: Isolated by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb No. 275AP01.

***Alysidium resinae* (Fr.) M.B. Ellis, *Dematiaceous Hyphomycetes* (Kew): 90 (1971)
(Plate I- 6)**

Colonies on MEA white with black sporulation. *Mycelium* composed of branched, hyaline, smooth, 1.5-2 µm thick hyphae. *Conidiophores* semi-macronematous, mononematous, pale brown, smooth, rarely branched, sometimes with short branches. *Conidiogenous cells* monoblastic, integrated, terminal, intercalary. *Conidia* dry, catenate, smooth, 0-1-septate, acrogenous, simple, ellipsoidal, spherical, oval, limoniform, dark brown, 6-11 x 5-8 µm.

Specimen examined: I. Isolated by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff. Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb No. 297AP20. II. On leaf litter of *Phoenix acaulis* Roxb., Paroda, Quepem, Goa, 14/08/09, coll. A. Prabhugaonkar, Herb. No. GUBH 376AP30.

***Anavirga vermiformis* Bhat & W.B. Kendr., *Mycotaxon* 49: 23 (1993) (Plate I- 7)**

Colonies on natural substrate effuse, brown. *Mycelium* partly immersed partly superficial, composed of smooth pale brown, branched, septate, 3-4 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, integrated, terminal, determinate. *Conidia* dry, smooth, branched, with 2-3 long, divergent arms arising at right angles from successive cells of the main axis; each arm vermiform and flexuous, dark brown, smooth, 35-40 septate, 250-375 x 6.5-8 µm.

Specimen examined: On dead and decaying fronds of *Calamus thwaitesii* Becc. & Hook., 27/12/ 07, coll. A. Prabhugaonkar, Netravali, Sanguem, Goa, Herb. No. GUBH 153AP01.

***Arachnophora fagicola* Hennebert, *Can. J. Bot.* 41: 1166 (1963) (Plate I- 8; Fig. 24)**

Colonies on natural substrate effuse, brown. *Mycelium* partly superficial, composed of dark brown, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and

hyphopodia absent. *Conidiophores* macronematous, mononematous, unbranched, erect, straight to flexuous, brown, smooth, 140-170 x 4-9 µm. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, 6-17 x 3-5 µm. *Conidia* solitary, dry, complex, 25-30 x 16-21 µm, with 2-3-septate, smooth, central body; each of the central cells bears several pale brown, lateral protuberances, which themselves each giving rise to 1-several inwardly curved, hyaline, claw-like processes.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 283AP01.

Ardhachandra selenoides (de Hoog) Subram. & Sudha, *Can. J. Bot.* 56(7): 731 (1978) **(Plate I- 9)**

Colonies on natural substrate effuse, hairy, dark brown. *Mycelium* internal. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophore* macronematous, mononematous, solitary, arising from the hyphae, erect, straight to flexuous, unbranched, septate, smooth, light brown, 30-65 x 2-4 µm. *Conidiogenous cells* polyblastic, terminal, later becoming intercalary, integrated, denticulate, 7-12 x 2-3 µm. *Conidia* solitary, aseptate, smooth, light brown, with pointed ends, 15-19 x 5-8 µm.

Specimen examined: I. Isolated by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar. II. Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar fall, Netravali, Sanguem, Goa, 30/04/08, coll. A. Prabhugaonkar, Herb. No. GUBH 221AP20.

Aspergillus fumigatus Fresen., *Beitr. Mykol.* 3: 81 (1863)

Colonies effuse, brown, showing medium growth. *Mycelium* partly immersed, partly superficial, composed of branched, septate, smooth, 1.5-2 µm diam. *Conidiophores* macronematous, mononematous, unbranched, straight to flexuous, pale to olivaceous brown, aseptate, smooth, up to 280 µm long, 8-19 µm wide, apical region widening to form a vesicle. *Vesicle* sub-globose, pale brown, upper half covered with conidiogenous cells 12-25 µm. *Metulae* absent. *Conidiogenous cells* monophialidic, discrete, determinate, terminal, arising in groups from the vesicle, 5.5-8.5 x 2-3.5 µm, lageniform, arising from vesicle, covering the entire vesicle. *Conidial heads* uniseriate, columnar, yellow to olivaceous brown. *Conidia* catenate, in unbranched, basipetal chains, dry, simple, aseptate, globose, finely verrucose, yellow to olivaceous brown, appearing pale green in mass, 2.5-3.5 µm in diam.

Specimen examined: Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry. Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar.

Plate I:

1. *Acroconidellina arecae*
2. *Acrogenospora sphaerocephala*
3. *Acrostalagmus* sp.
4. *Agaricostilbum palmicola*
5. *Alternaria* sp.
6. *Alysidium resinae*
7. *Anavirga vermiformis*
8. *Arachnophora fagicola*
9. *Ardhachandra selenoides*

Plate I. 1-9



Aspergillus niger Tiegh., *Annls Sci. Nat., Bot.*, sér. 58: 240 (1867)

Colonies effuse, off-white to turning black on sporulation, slow growing. *Mycelium* partly immersed, partly superficial, composed of branched, septate, hyaline, smooth, 2.5-3.5 µm thick hyphae. *Conidiophores* macronematous, mononematous, unbranched, straight to flexuous, sub-hyaline, brown towards the apex, smooth, aseptate, 800 µm to 2 mm long, 14-18 µm wide in the centre widening towards the apex to form a vesicle. *Vesicle* spherical to sub-spherical, hyaline to pale brown, 45-80 µm in diam., completely covered with metulae. *Metulae* pale brown, cylindrical to clavate, 16-28 x 5-6 µm. *Conidiogenous cells* monophialidic, discrete, determinate, terminal, arising in groups from the apex of metulae, 7-11 x 3-3.5 µm. *Conidial heads* biserial, radiating, black. *Conidia* catenate, in unbranched basipetal chains, dry, simple, sub-spherical, verrucose, aseptate, dark brown, 3.5-4.5 µm in diam.

Specimen examined: I. Isolated by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 21/08/08, coll. A. Prabhugaonkar, Herb. No. 301AP01. II. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry. Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 464AP18.

Aspergillus nidulans (Eidam) G. Winter, *Rabenh. Krypt.-Fl.*, Edn 2 (Leipzig) 1.2: 62 (1884) **(Plate II- 10)**

Colonies effuse, brown. *Mycelium* partly immersed, partly superficial, composed of branched, septate, smooth, 2-2.5 µm thick hyphae. *Conidiophores* macronematous, mononematous, unbranched, straight to flexuous, sub-hyaline to pale brown, smooth, aseptate, up to 180 µm long, 5-6 µm wide. *Vesicle* globose to sub-globose, sub-hyaline, 11-15 µm in diam., upper half covered with metulae. *Metulae* clavate, pale brown, 6-8 x 1-1.5 µm. *Conidiogenous cells* monophialidic, discrete, determinate, terminal, arising from the metulae, 8-10 x 1-1.5 µm. *Conidial heads* biserial, radiating, pale brown. *Conidia* catenate, in unbranched basipetal chains, dry, simple, globose, sparsely verruculose, aseptate, hyaline to sub-hyaline, pale green in mass, 3-3.5 µm in diam.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 15/04/09, coll. A. Prabhugaonkar.

Aspergillus oryzae (Ahlb.) E. Cohn, *Jber. schles. Ges. vaterl. Kultur* 61: 226 (1884) [1883]

Colonies on MEA growing rapidly, pale greenish-yellow, olive-yellow or with different shades of green, typically with dull brown shades with age. *Conidial heads* radiate to loosely columnar, pale greenish yellow, later becoming light to dull brown. *Conidiophore* macronematous, mononematous, erect, straight to flexuous, smooth-

walled, hyaline to sub-hyaline, rough walled, upto 4-5 mm long. *Vesicles* subspherical, up to 40-80 µm diam. *Conidiogenous cells* uniseriate. *Metulae* 10-15 x 3-5 µm. *Conidia* spherical, finely rough walled, green, 4.5-8 µm.

Specimen examined: Isolated by particle plating method from litter of *Bentinckia condapanna* Berry. Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar.

Aspergillus terreus Thom, in Thom & Church, *Am. J. Bot.* 5: 85-6 (1918)

Colonies on MEA yellowish-brown to cinnamon-brown, consisting of a dense felt of conidiophores. *Conidial heads* densely columnar. *Conidiophore* macronematous, mononematous, erect, straight to flexuous, smooth-walled, hyaline to sub-hyaline. *Vesicles* subspherical, 10-20 µm diam. *Conidiogenous cells* biserial. *Phialides* borne on metulae, 5-7 x 1.5-2 µm. *Conidia* smooth, striate, spherical to broadly ellipsoidal, hyaline, 1.5-2.5 µm.

Specimen examined: Isolated by Particle plating method from leaf sheathes and rachids litter of *Pinanga dicksonii* Blume, Katilekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar.

Aspergillus ustus (Bainier) Thom & Church, *The Aspergilli*: 152 (1926)

Colonies effuse, pale green to brown. *Mycelium* partly immersed, partly superficial, composed of branched, septate, smooth, 2-2.5 µm thick hyphae. *Conidiophores* macronematous, mononematous, unbranched, straight to flexuous, pale brown to hyaline, smooth, aseptate, up to 400 µm long x 2.5-3 µm wide, ending towards the apex in a vesicle. Vesicle broadly clavate to spherical, pale brown, compactly covered with metulae in the upper half. Metulae broadly clavate, pale brown, 5-6 x 4-4.5 µm. *Conidiogenous cells* monophialidic, discrete, determinate, terminal, arising from the metulae, 5-6 x 2-2.5 µm. *Conidial heads* biserial, radiating, pale green to olivaceous brown. *Conidia* catenate, dry, acrogenous, simple, globose, echinulate, aseptate, sub-hyaline to hyaline, 3-3.5 µm in diam.

Specimen examined: Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry. Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar.

***Aureobasidium* sp.**

Colonies on MEA fast growing, spreading, covered with slimy masses of conidia, brown to greenish brown. Mycelium forming cords of 10-15 µm thickness, smooth, septate, becoming brown and thick-walled. *Conidiogenous cells* on hyaline hyphae, lateral, terminal or intercalary. *Conidia* blastic, produced simultaneously in dense groups, hyaline, smooth, one-celled, variable in shape and size 1-4 x 2-5 µm.

Specimen examined: I. Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar falls, Netravali, Sanguem, Goa, 10/05/08, coll. A. Prabhugaonkar, Herb. No. 201AP20. II. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 472AP18.

Bactrodesmium longisporum M.B. Ellis, *More Dematiaceous Hyphomycetes* (Kew): 68 (1976) **(Plate II- 11)**

Colonies on natural substrate effuse, black. *Sporodochia* erect, scattered, punctiform, dark brown to black. *Conidiophores* fasciculate, simple or branched, light brown, 20-55 x 2-4 µm. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, smooth, light brown. *Conidia* solitary, dry, fusiform, brown, smooth, truncate at the base, pointed at the hyaline tip, multiseptate, 40-90 x 6-8 µm with thin spherical sheath at the apex.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 281AP01.

***Bactrodesmium* sp.** **(Plate II- 12)**

Colonies on natural substrate effuse, black. *Mycelium* immersed. *Stroma* none. Setae and hyphopodia absent. *Conidiophores* micronematous, brown. *Conidiogenous cells* monoblastic, terminal. *Conidia* acrogenous, solitary, dry, smooth, dark brown to black, truncate at base, obovoid, muriform, 50-80 x 30-45 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Goa, 17/09/07, coll. A. Prabhugaonkar, Herb. No. 63AP01.

Bahugada sundara K.A. Reddy & V. Rao, *Curr. Sci.* 53: 544 (1984) **(Plate II- 13)**

Colonies on natural substrate effuse, punctiform, black. *Mycelium* partly immersed partly superficial, composed of branched, septate, smooth, sub-hyaline, 2-3 µm wide hyphae. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, integrated, terminal. *Conidia* solitary, dry, smooth, dark brown with basal hyaline cell, pyriform, 30-44 x 17-20 µm.

Specimen examined: On litter, *Elaeis guineensis* Jacq., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 340AP31.

Bahusandhika indica (Subram.) Subram., *J. Indian bot. Soc.* 35: 469 (1956)

(Plate II- 14: Fig. 25)

Colonies on natural substrate effuse, black, powdery. *Mycelium* partly immersed, partly superficial, composed of smooth, subhyaline, septate, branched, 2-3 µm wide hyphae. *Conidiophores* micronematous, branched, formed on lateral hyphae, 5-8 x 2-2.5 µm. *Conidiogenous cells* monotretic, integrated or discrete, terminal, formed on conidiophores as well as conidia, pale brown, subspherical, light brown 4-6

x 3-4 μm . *Conidia* catenate, in long branched chains, dark brown, verrucose, thick-walled, ellipsoidal, 1-2 septate, 12-17 x 6-8 μm , with 1-2 connecting cells; connecting cells spherical, light brown, 3-4 μm .

Specimen examined: Spatha and floral sheath litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH-87AP25.

***Bahusutrabeija globosa* Bhat & W.B. Kendr., *Mycotaxon* 49: 26 (1993)**

(Plate II- 15)

Colonies on natural substrate effuse, dark brown, velvety. *Mycelium* partly immersed, partly superficial, composed of smooth, subhyaline, septate, branched, 2-2.5 μm wide hyphae. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, smooth, brown, thick-walled, septate, unbranched, sometimes percurrently proliferating, 200-300 x 7-9 μm . *Conidiogenous cells* monophialidic, terminal, integrated, cylindrical, smooth, slightly swollen towards the base, light brown, 20-30 x 8-9 μm , with flared conspicuous collarette. *Conidia* hyaline, thick-walled, globose, 0-septate, 16.5-20 μm in diam., aggregating into a slimy mass at the tip of the phialide, with fine, hyaline, 6-10 μm long setulae.

Specimen examined: Isolated by Particle plating method from litter of *Arenga wightii* Griff. & Hook., Netravali, Sanguem, Goa, 20/10/09, coll. A. Prabhugaonkar, Herb. No. 382AP20.

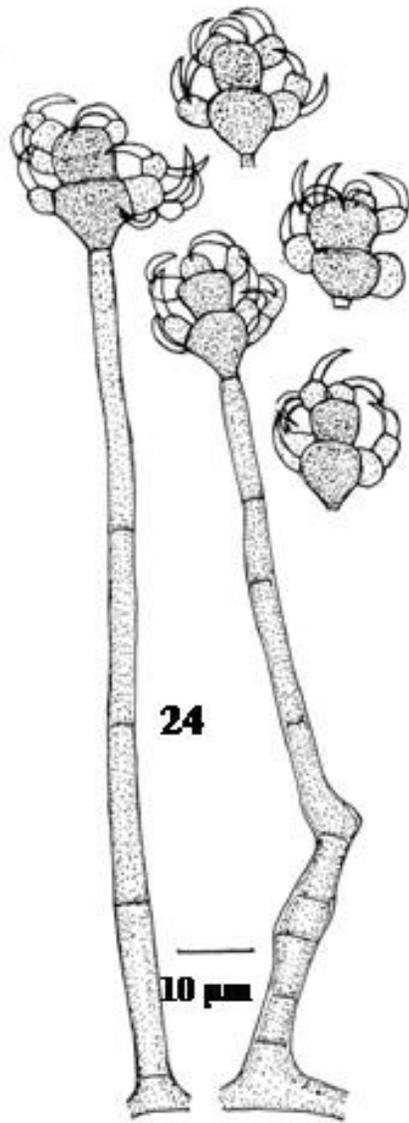
***Beltrania circinata* Bhat & W.B. Kendr., *Mycotaxon* 49: 28 (1993)**

(Plate II- 16)

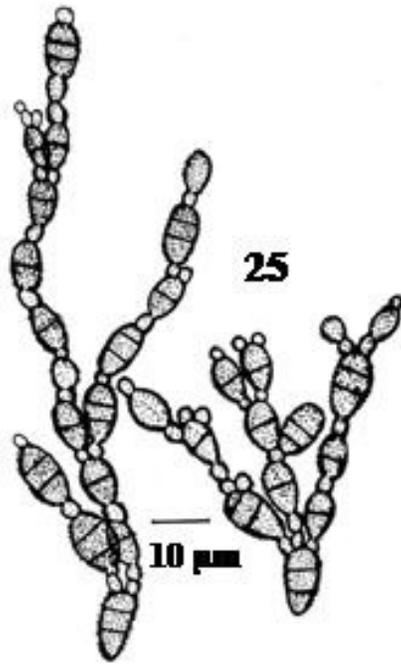
Colonies on natural substrate effuse, brown, hairy. *Mycelium* partly immersed, partly superficial, composed of thin, branched, septate, hyaline, 2-3 μm wide hyphae. *Stroma* none. *Setae* numerous, erect, slightly flexuous at the upper region, unbranched, septate, thick-walled, dark brown, verrucose, 100-250 x 5-8 μm . *Hyphopodia* absent. *Conidiophores* macronematous, mononematous, arising in groups of 3-4, straight to flexuous, unbranched, septate, verrucose, pale brown, 47.5 -100 x 5-8 μm . *Conidiogenous cells* polyblastic, discrete, terminal, integrated, determinate, denticulate, sub-globose, 7-8 μm diam.; denticles cylindrical, pale brown smooth. *Conidia* solitary, dry, smooth, acropleurogenous, dark brown, rhomboidal, biconic, aseptate, with a hyaline transverse band approximately in the middle, 12-18 x 8-14 μm .

Specimen examined: On spathe litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 194AP25.

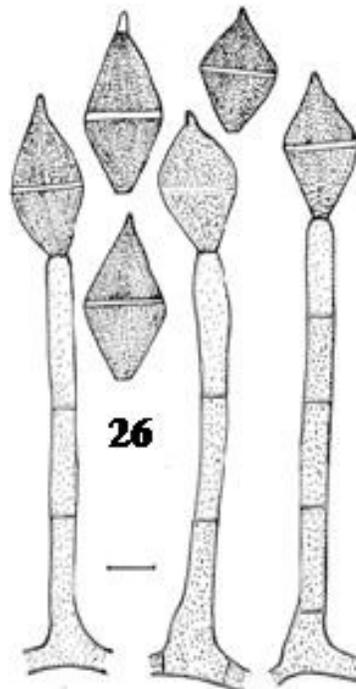
Figs. 24-26



Arachnophora fagicola



Bahusandhika indica



Beltrania concurvispora

Beltrania concurvispora Matsush., *Icon. microfung. Matsush. lect.* (Kobe): 15 (1975)
(Plate II- 17; Fig. 26)

Colonies on natural substrate effuse, brown, hairy. *Seta* absent. *Conidiophores* macronematous, mononematous, solitary, erect, simple, septate, straight to slightly flexuous, smooth, brown, 70-120 x 5-7 µm. *Conidiogenous cells* polyblastic, terminal, integrated, determinate, light brown, 25-34 x 5-7 µm. *Conidia* solitary, brown, rhombic, with a hyaline transverse band approximately in the middle, 30-44 x 15-20 µm.

Specimen examined: On litter, *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 445AP18.

Beltrania rhombica Penz., *Michelia* 2: 474 (1882) (Plate II- 18)

Colonies on natural substrate effuse, brown, hairy. *Mycelium* partly immersed, partly superficial, composed of thin, branched, septate, hyaline, 2-3 µm wide hyphae; *Stroma* none. *Setae* erect, straight to slightly flexuous, unbranched, septate, thick-walled, dark brown, 127-175 x 3-4 µm. *Hyphopodia* absent. *Conidiophores* macronematous, mononematous, solitary, sometimes in group of 2-4, erect, straight to flexuous, unbranched, septate, smooth, pale brown, 35-100 x 3-5 µm. *Conidiogenous cells* polyblastic, terminal, integrated, determinate, denticulate, 8.5-12 x 3-5 µm; denticles cylindrical, smooth, pale brown. *Conidia* solitary, simple, smooth, acropleurogenous, olivaceous brown, rhomboidal, biconic, appendiculate, aseptate, with a hyaline transverse band approximately in the middle, 22-28 x 7-12 µm; appendage hyaline, smooth, 5-6 µm long.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 18/01/08, coll. A. Prabhugaonkar, Herb. No. 27AP01.

Berkleasmiium typhae Somrith. & E.B.G. Jones, *Fungal Diversity* 12: 170 (2003)

(Plate III- 19; Fig. 27)

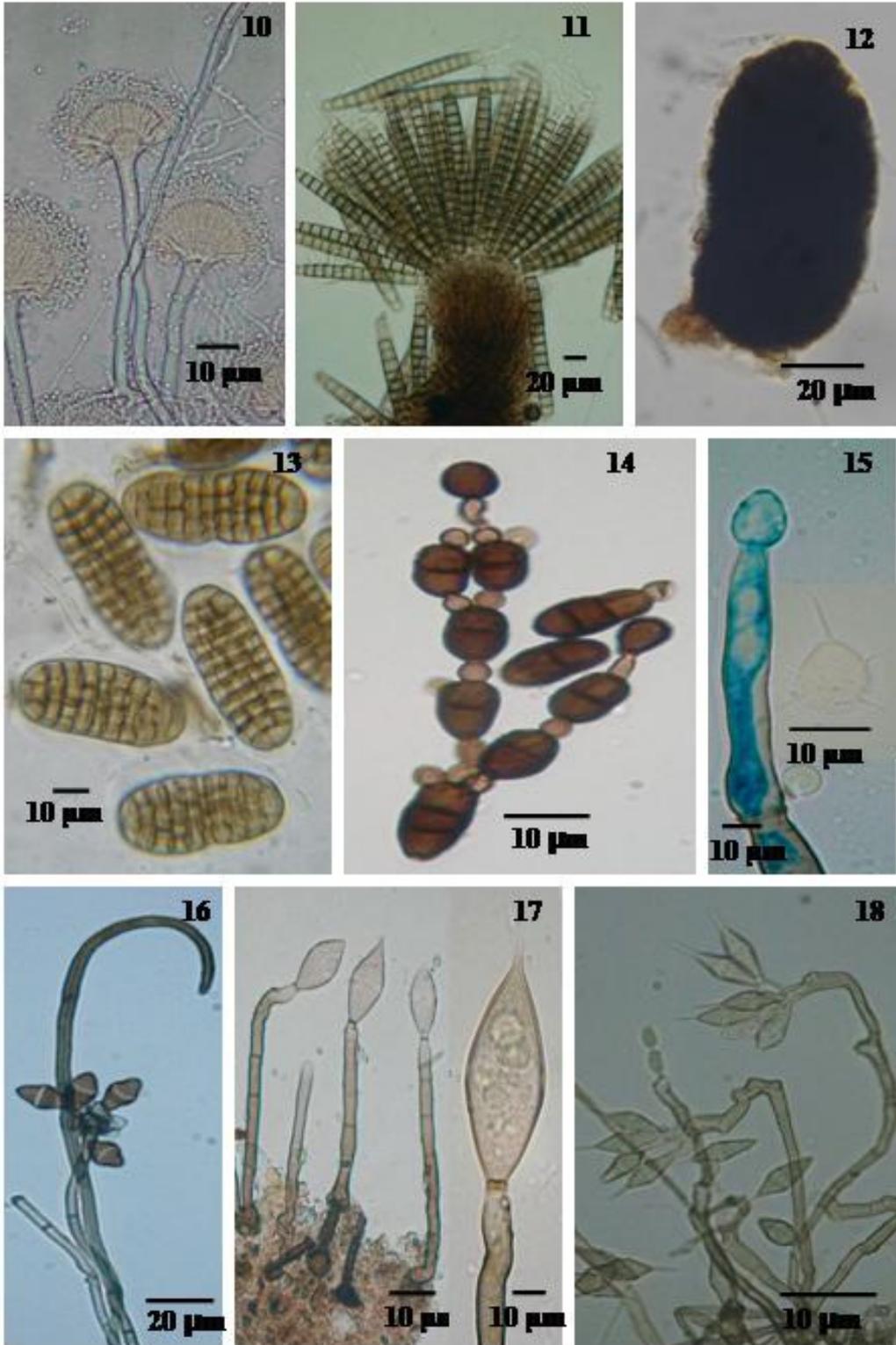
Colonies on natural substrate effuse, black. *Sporodochia*, punctiform, scattered, cushion-shaped, brown, shiny. *Mycelium* immersed in the substratum. *Conidiophores* macronematous, mononematous, fasciculate, hyaline, smooth. *Conidiogenous cells* holoblastic, terminal, clavate, hyaline, 7.5-14 x 4.5-6 µm. *Conidia* solitary, dry, acrogenous, oval to ellipsoidal, muriform, constricted at the septa, brown, smooth, 18-25 x 11-17 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar Herb. No. 285AP01.

Plate II:

10. *Aspergillus nidulans*
11. *Bactrodesmium longisporum*
12. *Bactrodesmium* sp.
13. *Bahugada sundara*
14. *Bahusandhika indica*
15. *Bahusutrabeeja globosa*
16. *Beltrania circinata*
17. *Beltrania concurvispora*
18. *Beltrania rhombica*

Plate II. 10-18



Bharatheeya mucoidea D'Souza & Bhat, *Mycotaxon* 83: 401 (2002)

(Plate III- 20; Fig. 28)

Colonies on MEA effuse, cottony, white, upto 5 cm in dia. in 10 days.

Conidiophores single, macronematous, mononematous, fasciculate, septate, hyaline, light brown, smooth, 250-500 x 4-6 μm . *Conidiogenous cells* monotretic, terminal or intercalary 20-25 x 4-6 μm . *Conidia* solitary, oblong, 2-4 mostly 3 septate, often with a dark median septum, pale brown to brown, smooth, 21-31 x 10-20 μm , with mucus sheath at the tip.

Specimen examined: I. Isolated by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., near Dhoothsagar, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb. No. 335AP01. II. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala 25/04/10, coll. A. Prabhugaonkar, Herb. No. 461AP18.

Bioconiosporium berberidis Narayan & Kamal, *Can. J. Bot.* 64: 201 (1986)

(Plate III- 21)

Colonies on natural substrate effuse, blackish brown. *Mycelium* superficial.

Stroma none. Setae and hyphopodia absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic integrated, terminal. *Conidia* solitary, dry, simple, subspherical, muriform, brown, 100-130 x 85-110 μm .

Specimen examined: Dead leaf sheathes and rachids of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 387AP19.

***Bisporomyces* sp.**

(Plate III- 22)

Colonies on natural substrate effuse, brown. *Mycelium* immersed.

Conidiophores solitary, erect, straight, simple, septate, 100-190 x 4-6 μm . *Conidiogenous cells* monophialidic, terminal, integrated, determinate, light brown, 30-57 x 3-5. *Conidia* simple, smooth, aseptate, hyaline, formed in slimy mass at the tip of conidiogenous cell, 4-5.5 x 3-4 μm .

Specimen examined: I. Isolated by particle plating method, *Arenga wightii* Griff., near Sawar falls, Netravali, Sanguem, Goa, 30/01/08, coll. A. Prabhugaonkar. II. On dead leaf sheath of *Calamus thwaitesii*, Tambdisurla, Sanguem, Goa, 20/07/08, coll. A. Prabhugaonkar, Herb. No. 248AP01.

***Botryosporium* sp.**

Colonies on natural substrate effuse, cottony white. *Mycelium* superficial composed of septate, branched, hyaline, smooth, 2-3 μm wide hyphae. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, branched, subhyaline, 12-16 μm wide at the base with several side branches developed from main stipe. Lateral

branches swollen at the tip, smooth, hyaline, 45-82 μm long, 9-10 μm wide at the broadest part. *Conidiogenous cells* polyblastic, discrete, terminal, smooth, hyaline, denticulate. *Conidia* solitary, dry, ellipsoidal, smooth, hyaline, aseptate, pointed at the base, rounded at the apex, 7-10 x 3-5 μm .

Specimen examined: On litter of *Areca catechu* L. Brahmakarmali, Sattari, Goa, 31/01/08, coll. A. Prabhugaonkar, Herb. No. 162AP01.

***Brachydesmiella biseptata* G. Arnaud, *Bull. trimest. Soc. mycol. Fr.* 69: 287 (1954) [1953] (Plate III- 23)**

Colonies on the natural substrate effuse, black, shining. *Mycelium* partly superficial, partly immersed. Stroma none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, flexuous, unbranched, rarely branched, smooth, 15-40 x 8-10 μm . *Conidiogenous cells* polytretic, integrated, terminal, sympodial, cylindrical, cicatrized, 7-10 x 4-5 μm . *Conidia* solitary, acropleurogenous, simple, smooth, 2-septate, middle cell dark brown to black, end cells hyaline, verrucose, 25-40 x 15-20 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 189AP01.

***Brachydesmiella caudata* V. Rao & de Hoog, *Stud. Mycol.* 28: 5 (1986) (Plate III- 24)**

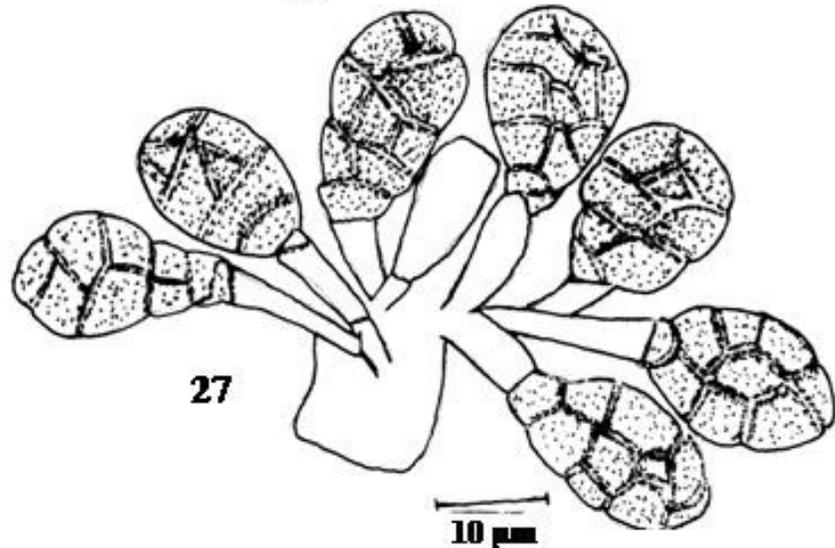
Colonies on the natural substrate effuse, black, shiny. *Mycelium* partly immersed, partly superficial, composed of hyaline, septate, smooth hyphae. *Conidiophores* macronematous, mononematous, solitary, branched, smooth, crawling, pale brown, 18-25 x 3-4 μm . *Conidiogenous cells* polytretic, integrated, terminal, intercalary, light brown 12-16 x 10-13 μm . *Conidia* solitary, simple, dry, 3-celled, 36-62 μm long, 6-8 μm at attachment, basal cell hyaline, cicatised, cylindrical, 4-5 x 5-6 μm ; cenral cell, 20-40 x 14-18 μm ; apical cell hyaline, verrucose towards rhe tip, acicular, 10-16 x 4-5 μm .

Specimen examined: On leaf sheath litter of *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 06/02/08, coll. A. Prabhugaonkar, Herb. No. 164AP01.

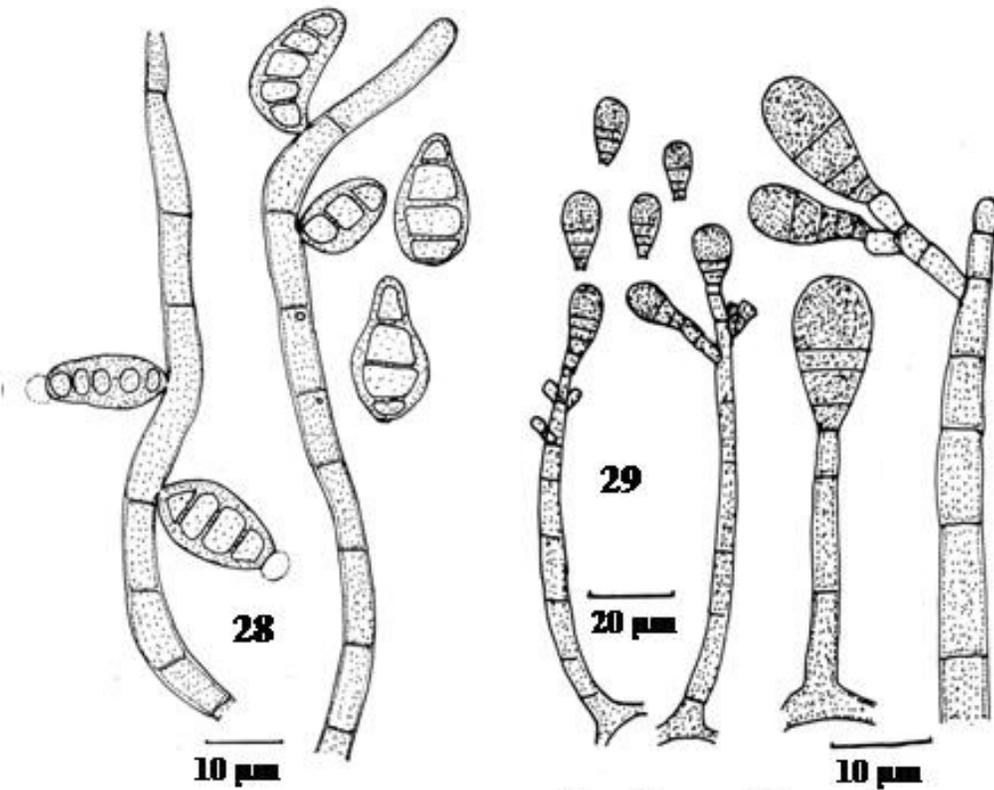
***Brachysporiella gayana* Bat., *Bol. Secr. Agric. (Pernambuco)* 19(1-2): 109 (1952) (Plate III- 25; Fig. 29)**

Colonies on the natural substrate effuse, brown, hairy. *Mycelium* partly immersed, partly superficial. Stroma none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, branched at the apex, dark brown, smooth, 130-160 x 5-7 μm . *Conidiogenous cells*

Figs. 27-29



Berklesmium typhae



Bharatheeya nucoida

Brachysporiella gayana

monoblastic, terminal, 8-20 x 3-8.5 μm . *Conidia* solitary, dry, acrogenous, brown, smooth, simple, 2-3-septate, clavate, truncate at the base, rounded at the apex, 18-25 x 8-15 μm .

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 01/08/07, coll. A. Prabhugaonkar, Herb. No. 31AP01. II. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 284AP01. III. On Dead leaf sheathes and rachids of *Pinanga dicksonii* Blume, Katilekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 385AP19.

***Brachysporiella* sp.**

(Plate III- 26; Fig. 30)

Colonies on the natural substrate effuse, brown, hairy. *Mycelium* partly immersed, partly superficial. Stroma none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, dark brown, smooth, septate, 175-225 x 8-11 μm . *Conidiogenous cells* monoblastic, terminal, 8-11 x 3-4.5 μm . *Conidia* solitary, dry, acrogenous, brown, smooth, simple, 3-septate, clavate, truncate at the base, rounded at the apex, 35-43 x 20-26.5 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 71AP01.

***Cacumisporium capitulatum* (Corda) S. Hughes, *Can. J. Bot.* 36: 743 (1958)**

(Plate III- 27; Fig. 31)

Colonies on the natural substrate effuse, hairy, brown. *Mycelium* immersed. Stroma none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, brown, smooth, percurrent, 55-225 x 2-5.5 μm . *Conidiogenous cells* polyblastic, integrated, terminal, sympodial, cylindrical, denticulate, 15-35 x 2-4 μm . *Conidia* formed in heads, acropleurogenous, simple, 3-septate, light brown, smooth, ellipsoidal, slightly curved, rounded at both the ends, 14-18.5 x 3-4.5 μm .

Specimen examined: On litter, *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 26/03/10, coll. A. Prabhugaonkar, Herb. No. 426AP18.

***Candelabrum brocciatum* Tubaki, *Trans. Mycol. Soc. Japan* 16: 134 (1975)**

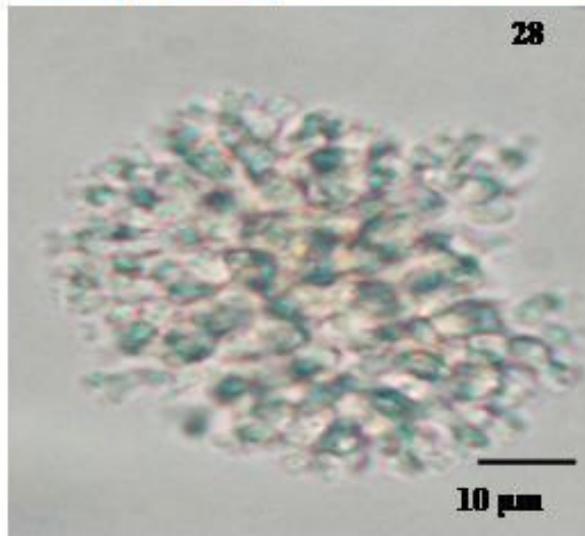
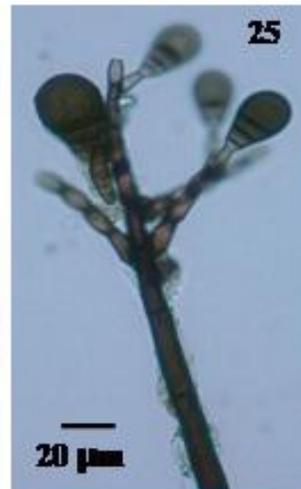
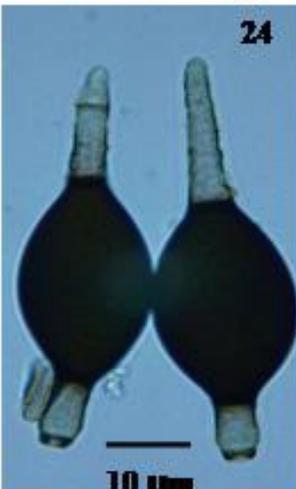
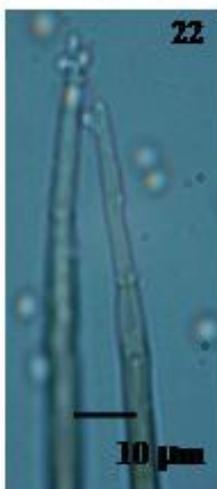
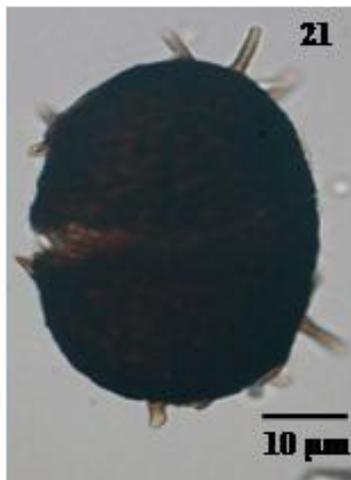
(Plate III- 28)

Colonies on the natural substrate effuse, white. *Mycelium* immersed. Stroma none. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous. *Conidiogenous cells* blastic. *Conidia* formed composed of profuse compact branches, hyaline, smooth, 60-80 x 30-50 μm ; branches septate, hyaline, compact, 3-4 μm broad.

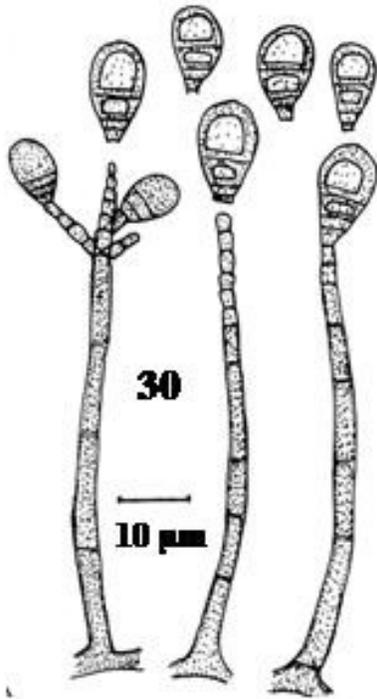
Plate III:

19. *Berkleasmium typhae*
20. *Bharatheeya mucoidea*
21. *Bioconiosporium berberidis*
22. *Bisporomyces* sp.
23. *Brachydesmiella biseptata*
24. *Brachydesmiella caudata*
25. *Brachysporiella gayana*
26. *Brachysporiella* sp.
27. *Cacumisporium capitulatum*
28. *Candelabrum brocchiatum*

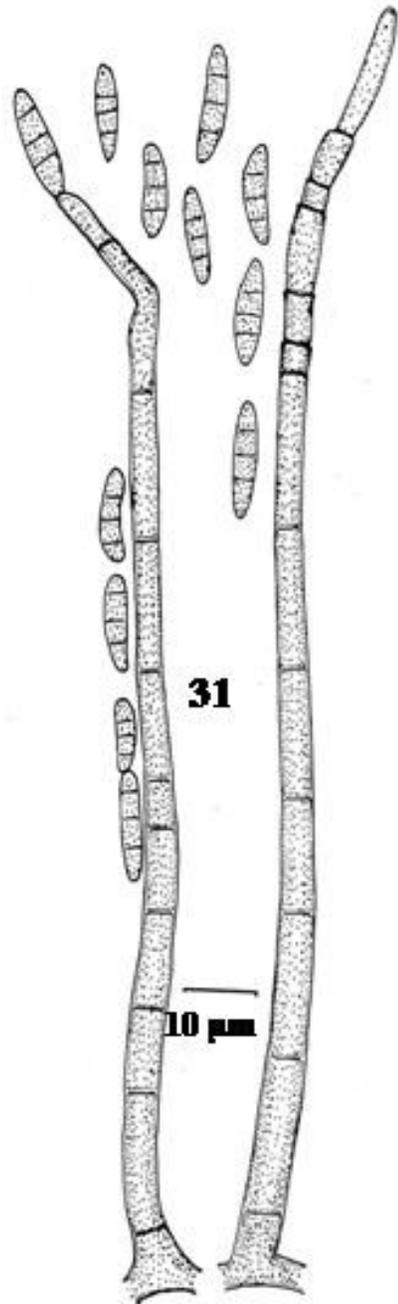
Plate III. 19-28



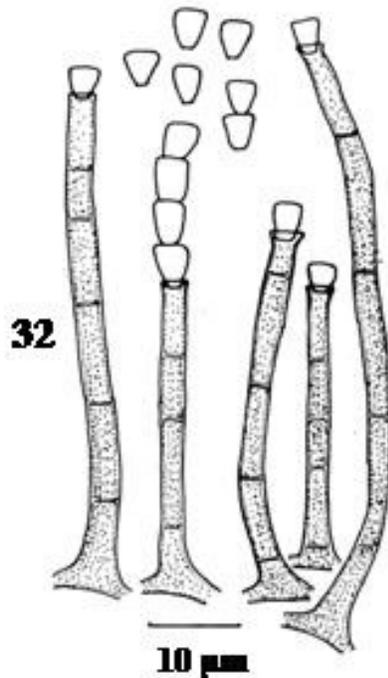
Figs. 30-32



Brachysporiella sp.



Cacumisporium capitulatum



Catenularia sp.

Specimen examined: I. On Spathé litter, *Cocos nucifera* L., Puttur, Karnataka, 20/11/07, coll. D. J. Bhat, Herb. No. GUBH-109AP25. II. On litter of *Arenga wightii* Griff., near Dhoothsagar, Sanguem, Goa, 11/09/09, coll. A. Prabhugaonkar, Heb No. 109AP20. III. On litter of *Elaeis guineensis* Jacq. Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 335AP20.

***Catenularia* sp.**

(Plate IV- 29; Fig. 32)

Colonies on the natural substrate effuse, dark brown, hairy. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, brown, smooth, 65-125 x 3-4.5 µm. *Conidiogenous cells* monophialidic, integrated, terminal, light brown, 8-22 x 3-4.5 µm. *Conidia* endogenous, catenate, simple, cuneiform, hyaline, smooth, aseptate, 5-8 x 4-5 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoothasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 188AP01.

***Catenularia* sp.2**

(Plate IV- 30)

Colonies on the natural substrate effuse, dark brown, hairy. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, brown, smooth, 50-160 x 3.5-5.5 µm. *Conidiogenous cells* monophialidic, integrated, terminal, 20-35 x 3.5-5 µm. *Conidia* endogenous, catenate, simple, cuneiform, hyaline, smooth, aseptate, 7.5-11 x 4-6 µm.

Specimen examined: On dead and decaying fronds of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 17AP24.

***Ceratosporella ponapensis* Matsush., Matsush. Mycol. Mem., no. 2: 3 (1981)**

(Plate IV- 31; Fig. 33)

Colonies on the natural substrate effuse, black. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to slightly flexuous, unbranched, dark brown, smooth, percurrent, 50-115 x 6-8 µm. *Conidiogenous cells* monoblastic, terminal, integrated, indeterminate, 10-20 x 5-7 µm. *Conidia* solitary, acrogenous, branched, dark brown, smooth, 40-50 x 3-6 µm; branches smooth, brown, 6-7-septate, 7-8.5 µm wide.

Specimen examined: On litter, *Cocos nucifera* L., Netravali, Sanguem, Goa, 25/07/09, coll. A. Prabhugaonkar, Herb. No. 362AP20.

***Ceratosporium* sp.**

(Fig. 34)

Colonies on the natural substrate effuse, dark brown. Mycelium immersed. Stroma none. Setae and hyphopodia absent. *Conidiophores* micronematous. *Conidiogenous cells* monoblastic, integrated, terminal, determinate. *Conidia* solitary, branched, dark brown, smooth, with 2-3 divergent, pluriseptate branches, 125-152 x 12-17 μm .

Specimen examined: On Dead leaf sheathes and rachids of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar.

***Chalara indica* Pratibha, K.D. Hyde & Bhat, *Cryptogamie Mycologie*, 26 (2005)**

(Plate IV- 32)

Leaf spots amphigenous, circular to sub-circular, brown, 0.7-2 cm in diam. *Colonies* effuse, brown, composed of immersed mycelium with branched, septate, 2-3 μm wide hyphae. *Conidiophores* fasciculate, mononematous, brown, 1-3-septate, unbranched, smooth, 70-170 x 6-10 μm . *Conidiogenous cells* phialidic, purcurrently regenerating, pale to moderately brown, smooth, 55-70.5 μm long; venter round to subcylindrical, 32.5-40 μm long, 11-16.5 μm wide at the broadest part; collarete cylindrical, 25-32.5 x 8-10 μm . *Conidia* slimy, endogenous, hyaline, cylindrical, smooth, aseptate, rounded at apex, truncate at the base, 20-30 x 5-6.5 μm , developing in basipetal chains.

Specimen examined: On leaf spots of *Areca catachu*, Mashem, Canacona, Goa, 09/05/08, coll. A. Prabhugaonkar, Herb. No. GUBH 68AP26.

***Chalara* sp.**

(Plate IV- 33)

Colonies effuse, brown, composed of superficial mycelium with branched, septate, 2-3 μm wide hyphae. *Conidiophores* variable in shape and size. mononematous or faciculate forming synnematous structures, brown. Individual conidiophores mononematous often branched 2-4 septate 30-100 x 2-4 μm . *Conidiogenous cells* phialidic, terminal, pale to moderately brown, smooth, 20-60 x 2-4 μm . *Conidia* distinctly of two types, dark brown or light brown, dark brown conidia rounded at end, ellipsoidal, dry, solitary 4-6 μm across, Light brown conidia slimy, endogenous, hyaline, cylindrical, smooth, aseptate, rounded at apex, truncate at the base, 2-4 x 2-3 μm , developing in basipetal chains.

Specimen examined: I. On dead wood of *Cocos nucifera* L. St. Cruz, Panaji, Goa, 21/02/11, coll. A. Prabhugaonkar, Herb. No. GUBH- 95AP25, II. On infected rotten trunk, *Cocos nucifera* L., Mashem, Canacona, Goa, 17/10/11, coll. A. Prabhugaonkar, Herb. No. GUBH- 478AP25. III. On fallen nuts of

Areca catechu, Mashem, Canacona, Goa, 17/10/11, coll. A. Prabhugaonkar, Herb. No. GUBH-479AP26.

***Chloridium reniforme* Matsush., *Icon. microfung. Matsush. lect.* (Kobe): 28 (1975)**

(Plate IV- 34)

Colonies on the natural substrate effuse, dark brown. *Mycelium* immersed. *Conidiophores* erect, straight, septate, thick-walled, dark brown below, more or less setiform, 100-180 µm tall, 4-5 µm wide at the base, 2.6-3.2 µm in the upper part and inflated to 3.6-4.4 µm near the tip, but strongly constricted at the hardly visible collarette. *Conidia* arising singly, more or less reniform, 3.5-5.5 x 2.0-3.0 µm, smooth-walled, hyaline, aggregated in a slimy head.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, Herb. No. 208AP26. II. On litter, *Elaeis guineensis* Jacq. Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 345AP31.

***Circinotrichum* sp.**

(Plate IV- 35)

Colonies on natural substrate effuse, black, velvety. *Mycelium* partly superficial, partly immersed. *Stroma* none. *Setae* erect, straight, to flexuous, unbranched, circinate, dark brown to black, verrucose, 70-95 x 3-5 µm. *Hyphopodia* absent. *Conidiophores* micronematous. *Conidiogenous cells* polyblastic, discrete, solitary, percurrent, hyaline, lageniform, 4-6 x 3-5 µm. *Conidia* solitary, dry, arranged, simple, falcate, aseptate, hyaline, smooth, 11-7 x 2-2.5 µm.

Specimen examined: On sphenocarp litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 194AP25.

***Cirrenalia pseudomacrocephala* Kohlm., *Mycologia* 60: 266 (1968)**

(Plate IV- 36; Fig. 35)

Colonies on natural substrate effuse, with shiny black dots of conidia. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* mononematous, micronematous, progressively broader from base, septate, slightly curved, smooth, dark brown, 10-15 x 3-5 µm. *Conidiogenous cells* monoblastic, terminal, 3-6 x 5-8 µm. *Conidia* solitary µm, 2-4, mostly 3 celled, subterminal cell curved 2/3, 4-5 x 4-8 µm. Terminal cells large globose to subglobose 13-25 x 12-25 µm, black

Specimen examined: I. On litter of *Elaeis guineensis* Jacq., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb. No. GUBH-347AP31. II. On litter of *Cocos nucifera* L. Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH- 89AP25. III. On litter of *Elaeis guineensis* Jacq., Tambdi surla, Sanguem, Goa, 15/10/09, coll. A. Prabhugaonkar. IV. On litter of *Arenga wightii*

Griff., near Dhoodhsagar, Sanguem, Goa, 11/09/09, coll. A. Prabhugaonkar. V. On litter of *Elaeis guineensis* Jacq., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 347AP31.

***Cladosporium cladosporioides* (Fresen.) G.A. de Vries, 1952, *Contrib. Knowledge of the Genus Cladosporium Link ex Fries*: 57. (Plate V- 37)**

Colonies on MEA velvety to powdery, olivaceous green, reverse black. *Conidiophores* macronematous, micronematous, erect, straight to flexuous, unbranched, dark brown, smooth, septate, 175-325 x 3-5 µm *Conidiogenous cells* polyblastic, terminal and intercalary, integrated, sympodial, cicatrized, 10-25 x 3-4 µm. *Ramoconidia* smooth, brown, 0-1-septate, 10-22 x 2-4 µm. *Conidia* catenate, in branched chains, dry, acropleurogenous, simple, smooth, aseptate, light brown, 4-6 x 2-3 µm.

Specimen examined: I. Isolated by Particle plating method from litter of *Arenga wightii* Griff., near Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Heb No. 185AP20. II. Isolated by 3-step sterilisation method from fresh leaves of, *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 30/01/08, coll. A. Prabhugaonkar. III. Isolated by Particle plating method from leaf sheathes and rachids litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 393AP19. IV. On litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 444AP18.

***Cladosporium* sp. (Plate V- 38)**

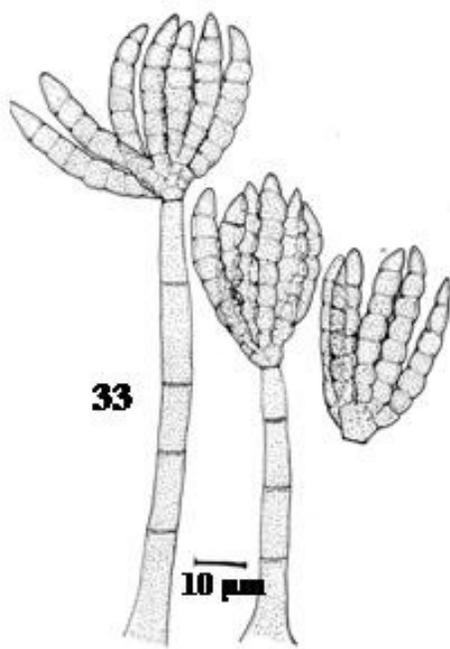
Colonies on MEA velvety to powdery, olivaceous green, reverse black. *Conidiophores* macronematous, micronematous, erect, straight to flexuous, unbranched, dark brown, smooth, septate, 270-560 x 5-7 µm *Conidiogenous cells* polyblastic, terminal and intercalary, integrated, sympodial, cicatrized, 8-10 x 3-4 µm. *Conidia* catenate, in branched chains, dry, acropleurogenous, simple, ellipsoidal, smooth, aseptate, pale brown, 4-7 x 2-3 µm.

Specimen examined: I. On litter, *Caryota urens* L., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 116AP24. II. On litter of *Elaeis guineensis* Jacq. Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 330AP20.

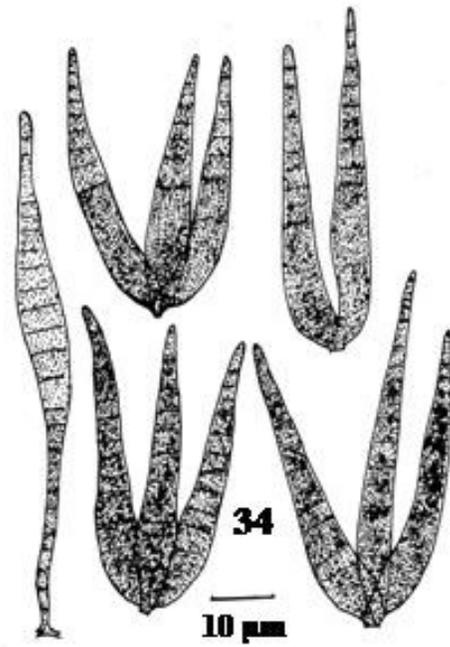
***Clonostachys cylindrospora* G. Arnaud, *Bull. trimest. Soc. mycol. Fr.* 68: 196 (1952) (Plate V- 39)**

Colonies on natural substrate effuse, grey. Mycelium superficial, brown, smooth, thin-walled. *Conidiophores* mononematous, macronematous, erect, straight to flexuous, branched, light brown, smooth, septate, swollen at the nodes, 120-150 x 4-5 µm. *Conidiogenous cells* polyblastic, discrete, light brown, bulging at the apex, 10-15 x 2-4 µm. *Conidia* solitary, aseptate to rarely 1-septate, subhyaline, smooth, 10-14 x 2-4 µm.

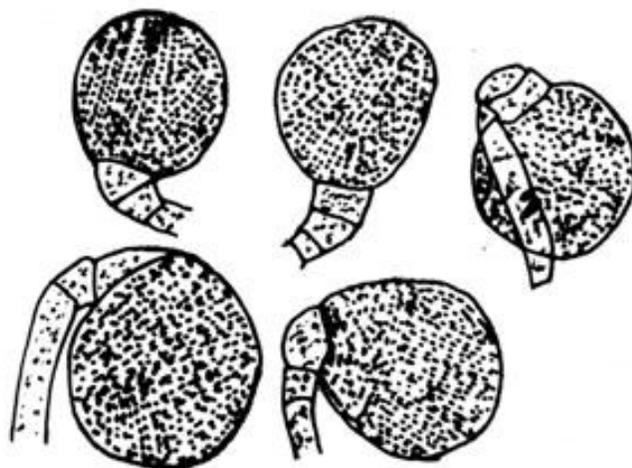
Figs. 33-35



Ceratosporella ponapensis



Ceratosporium sp.



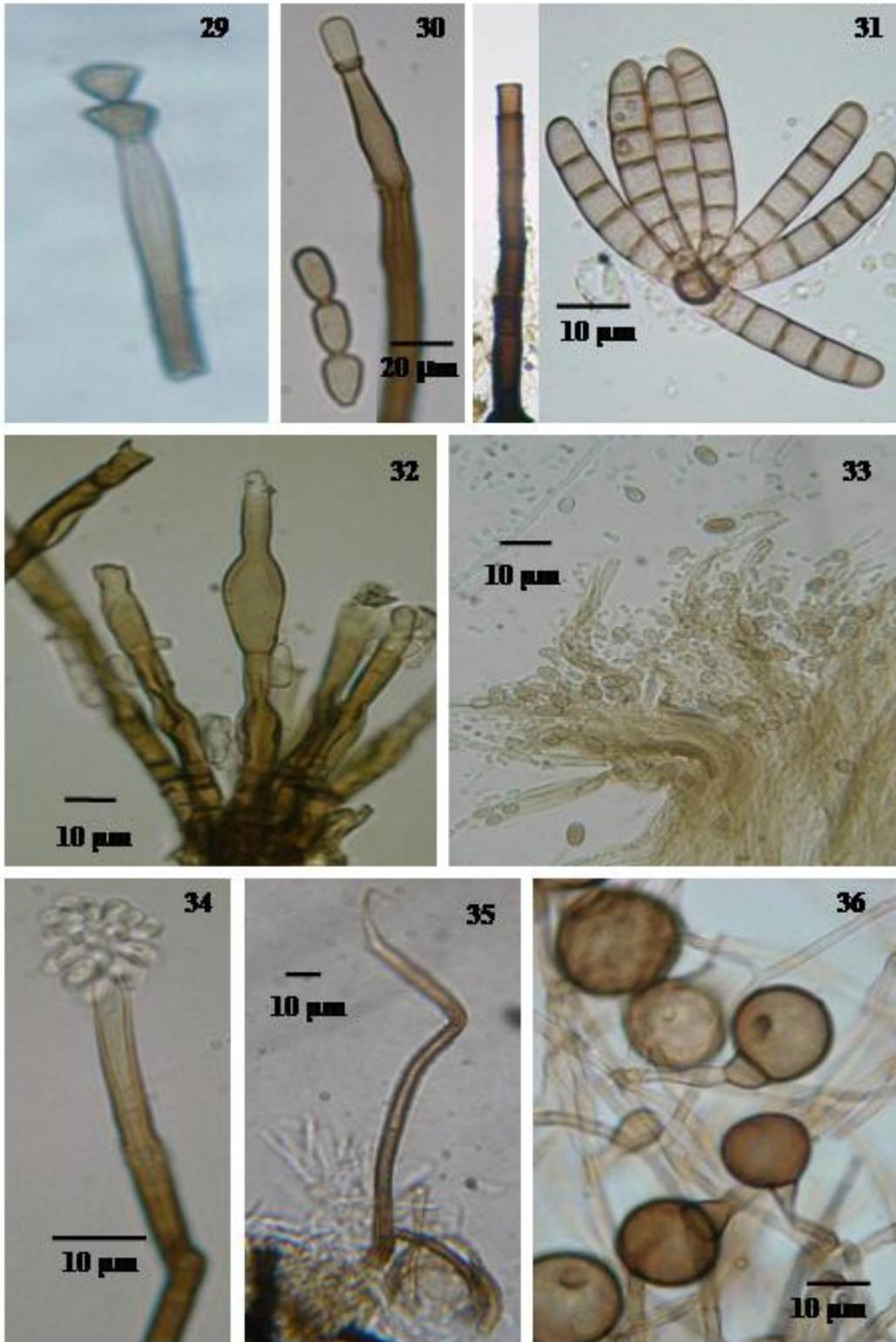
35

Cirrenalia pseudomacrocephala

Plate IV:

29. *Catenularia* sp.
30. *Catenularia* sp. 2
31. *Ceratosporella ponapensis*
32. *Chalara indica*
33. *Chalara* sp.
34. *Chloridium reniforme*
35. *Circinotrichum* sp.
36. *Cirrenalia pseudomacrocephala*

Plate IV. 29-36



Specimen examined: On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08. coll. A. Prabhugaonkar, Herb. No. 227AP21.

***Clonostachys pseudosetosa* (Samuels) Schroers, *Stud. Mycol.* 46: 182 (2001)**

Colonies on natural substrate effuse, grey. Mycelium superficial, brown, smooth, thin-walled. *Conidiophores* mononematous, macronematous, erect, straight to flexuous, branched, light brown, smooth, septate, swollen at the nodes, 75-85 x 3-5 µm. *Conidiogenous cells* polyblastic, discrete, light brown, bulging at the apex, 18-26 x 4-6 µm. *Conidia* solitary, aseptate to rarely 1-septate, subhyaline, smooth, 6-8.5 x 2-4 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 21/08/08, coll. A. Prabhugaonkar, Herb. No. GUBH 107AP01.

***Corynespora cassiicola* (Berk. & M.A. Curtis) C.T. Wei, *Mycol. Pap.* 34: 5 (1950)**

(Plate V- 40)

Colonies on natural substrate effuse, grayish brown, hairy. *Mycelium* partly immersed, partly superficial, composed of light brown, septate, branched, 4-6 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, solitary or in groups, smooth, thick walled, dark brown, septate, unbranched, 200-1200 x 6-12 µm. *Conidiogenous cells* monotretic, terminal, integrated, determinate, pale brown, 9-20 x 4-6 µm. *Conidia* catenate, acrogenous, simple, smooth, thick-walled, pseudoseptate, light brown, obclavate, rounded at the apex, truncate at the base, 25-100 x 6-8 µm.

Specimen examined: I. Isolated by 3-step sterilisation method of fresh leaves, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 251AP21. II. Isolated by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb. No. 298AP20.

***Corynespora* sp.**

(Plate V- 41)

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* partly immersed, partly superficial composed of branched, septate, smooth, light brown, 2-3 µm thick hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight, solitary or in groups, smooth, dark brown, septate, unbranched, 400-650 x 7-10 µm. *Conidiogenous cells* monotretic, terminal, integrated, determinate, pale brown, 62-75 x 7-10 µm. *Conidia* solitary, simple, smooth, thick-walled, 3-7-pseudoseptate, olivaceous brown, acrogenous, obclavate, rounded at the apex, truncate at the base, 55-65 x 5-15 µm.

Specimen examined: I. On leaf spots of *Arenga wightii* Griff., near Dhoodhsagar waterfalls, Sanguem, Goa, 06/02/07, coll. A. Prabhugaonkar, Herb. No. 164AP20.

Costantinella clavata Hol.-Jech., *Eesti NSV Tead. Akad. Toim.*, Biol. seer 29: 135 (1980) **(Plate V- 42)**

Colonies on natural substrate effuse, grey. *Mycelium* superficial, brown, smooth, thin-walled. *Conidiophores* mononematous, macronematous, erect, straight to flexuous, branched, brown, verruculose, septate, 150-280 x 3-5 µm, swollen at the nodes. *Conidiogenous cells* polyblastic, discrete, arranged in whorls on the main axis, olivaceous brown, denticulate, 8-12 x 3-4 µm. *Conidia* solitary, elliptic to subfusiform, aseptate, subhyaline, smooth, 5-6 x 2.5-4 µm.

Specimen examined: I. Isolated by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 297AP20. II. Isolated by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 218AP01.

Costantinella palmicola M.K.M. Wong, Yanna, Goh & K.D. Hyde, *Fungal Diversity* 8: 174 (2001) **(Fig. 36)**

Colonies on natural substrate effuse, pale grayish. *Mycelium* superficial, brown, smooth, thin-walled. *Conidiophores* mononematous, macronematous, straight, erect, branched, light brown, smooth, septate, 125-300 x 2.5-5 µm, swollen at the nodes. *Conidiogenous cells* polyblastic, discrete, arranged in whorls on the main axis, obovoid to ellipsoid, subhyaline, sympodial, denticulate, 7-14 x 3-6 µm. *Conidia* solitary, dry, aseptate, subhyaline, smooth, light brown, rounded at the tip, pointed at the base, 5-12 x 3-5.5 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Malapuzha, near Calicut, Kerala, 30/07/08, coll. A. Prabhugaonkar, Herb. No. GUBH-257AP01.

***Craspedodidymum* sp.** **(Plate V- 43; Fig. 37)**

Colonies on natural substrate effuse, black. *Mycelium* superficial, brown, smooth, thin-walled, 2-3.5 µm wide. *Conidiophores* mononematous, macronematous, straight to flexuous, erect, cylindrical, unbranched, brown, smooth, septate, 175-372 x 5-10 µm. *Conidiogenous cells* monophialidic, integrated, terminal, with large distinct funnel-shaped collarette, 29-34 x 8-13 µm. *Conidia* semi-endogenous, simple, ellipsoidal, dark brown, smooth, 0-septate, 10-15 x 6-9 µm, forming conidial head of 4-6 conidia at the tip of conidiophore.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 21/11/07, coll. A. Prabhugaonkar, Herb. No. 111AP01.

***Cryptophiale udagawae* Piroz. & Ichinoe, in Pirozynski, *Can. J. Bot.* 46: 1126 (1968)
(Plate V- 44)**

Colonies on natural substrate effuse, black. *Stroma* none. Separate setae absent, but upper part of the conidiophores setiform. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, dark brown, smooth, setiform, unbranched, bearing fertile region with rows of phialides in one side, 120-170 x 4-6 µm. *Conidiogenous cells* monophialidic, discrete, determinate, 5-8 x 2-3 µm. *Conidia* aggregated in slimy mass, falcate, smooth, hyaline, aseptate, 15-30 x 1.5-2.5 µm.

Specimen examined: On litter, *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 440AP18.

***Cryptophiale* sp. (Plate VI- 45)**

Colonies on natural substrate effuse, black. *Stroma* none. Separate setae absent, but upper part of the conidiophores setiform. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, brown, smooth, setiform, unbranched, bearing fertile region with rows of phialides from both the sides, 100-120 x 3-5 µm. *Conidiogenous cells* monophialidic, discrete, determinate, 4-6 x 1.5-2.5 µm. *Conidia* aggregated in slimy mass, falcate, smooth, hyaline, aseptate, 12-18 x 1.5-2.5 µm.

Specimen examined: On litter, *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 440AP18.

***Curvularia senegalensis* (Speg.) Subram., *J. Indian bot. Soc.* 35: 467 (1956)
(Plate VI- 46)**

Colonies on MEA spreading, velvety, dark blackish-brown to black. *Mycelium* composed of dark brown, septate, smooth, 2-4 µm wide hyphae. *Conidiophores* branched, straight or flexuose, dark brown, smooth, septate, 110-290 x 3-6 µm. *Conidiogenous cells* polytretic, intergrated, terminal, 15-30 x 3-5 µm. *Conidia* solitary, dry, smooth, dark brown, terminal cells paler, curved, 2-3-septate, 20-30 x 7-15 µm.

Specimen examined: I. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 446AP18.

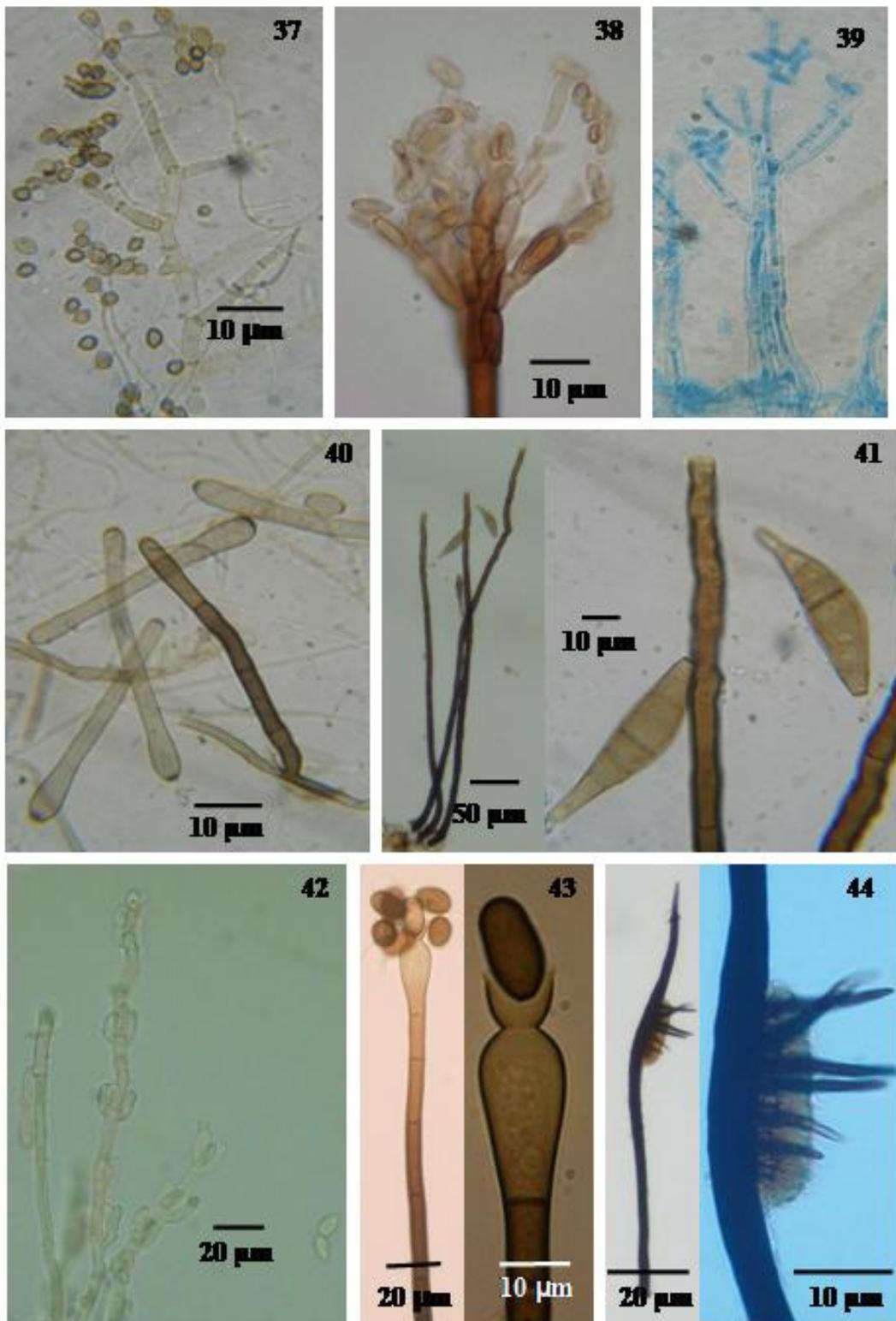
***Curvularia* sp. (Plate VI- 47)**

Fungus Hyphomycete. *Colonies* on MEA spreading, velvety, dark blackish-brown to black. *Conidiophores* simple or branched, straight or flexuose, brownish, smooth-walled, 30-150 x 4-5 µm. *Conidiogenous cells* polytretic, intergrated, terminal

Plate V:

37. *Cladosporium cladosporioides*
38. *Cladosporium* sp.
39. *Clonostachys pseudosetosum*
40. *Corynespora cassicola*
41. *Corynespora* sp.
42. *Costantinella palmicola*
43. *Craspedodidymum* sp.
44. *Cryptophiale udagawae*

Plate V. 37-44



8-20 x 4-5 µm. *Conidia* smooth-walled, dark brown, terminal cells paler, usually curved, mostly 3-septate, often with one oblique septa 10-18 x 5-10 µm.

Specimen examined: Isolated by by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar.

***Cylindrocladium quinqueseptatum* Boedijn & Reitsma, *Reinwardtia* 1: 59 (1950)
(Plate VI- 48)**

Colonies effuse, shiny, offwhite. *Conidiophores* macronematous, mononematous, branched, 200-350 x 2.5-5 µm. *Sterile filament* setiform, septate, smooth, unbranched, hyaline, terminating in a narrowly clavate vesicle, 150-250 x 2-3.5 µm, arising from the apex of conidiophores. *Conidiogenous cells* monophialidic, discrete, hyaline, smooth, 12-18 x 2-3 µm. *Conidia* simple, hyaline, cylindrical, 1-3-septate, 45-65 x 3-5 µm.

Specimen examined: I. On litter of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 25/07/09, coll. A. Prabhugaonkar. Herb. No. 367/AP01. II. Isolated by by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., Katilekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 402AP01.

***Cylindrocladium* sp.**

Colonies effuse, shiny, offwhite. *Conidiophore* macronematous, mononematous, branched, 175-190 x 4-7 µm. *Sterile filament* setiform, septate, smooth, unbranched, hyaline, terminating in a narrowly clavate vesicle, 80-100 x 4-6 µm, arising from the apex of conidiophores. *Conidiogenous cells* monophialidic, discrete, hyaline, smooth, 7-12 x 2-3 µm. *Conidia* simple, hyaline, cylindrical, aseptate, 12-14 x 1.5-2 µm.

Specimen examined: On dead leaf sheath of *Pinnanga dicksonii*, Katilekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 402AP19.

***Dactylaria biseptata* Matsush., *Icon. microfung. Matsush. lect.* (Kobe): 48 (1975)
(Plate VI- 49)**

Colonies on the natural substrate powdery, whitish. *Conidiophores* macronematous, mononematous, erect, hyaline. *Conidiogenous cells* polyblastic, cylindrical, denticulate, 7-12 x 2-5 µm. *Conidia* solitary, dry, smooth, hyaline, fusiform, 1-2-septate, 12-35 x 1.5-2.5 µm.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 176AP01. II. Isolated by Particle plating method from litter of *Arenga wightii* Griff., near Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Heb No. 184AP20.

Dactylaria candidula (Höhn.) G.C. Bhatt & W.B. Kendr., in Stolk & Hennebert, *Can. J. Bot.* 46: 1256 (1968) **(Plate VI- 50)**

Colonies on the natural substrate spreading, powdery, white. *Conidiophores* macronematous, mononematous, erect, smooth, septate, slightly tapering, subhyaline, rarely branched, 85-140 x 3-7 µm. *Conidiogenous cells* polyblastic, cylindrical, terminal and intercalary, denticulate, 20-30 x 3-5 µm; denticles cylindrical. *Conidia* solitary, dry, hyaline, smooth, fusiform, 1-septate, 15-20 x 2-4 µm.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. 176AP01. II. Isolated by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 330AP20.

***Dactylella* sp.** **(Plate VI- 51)**

Colonies on natural substrate effuse, white, hairy. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, solitary, erect, straight to slightly flexuous, unbranched, septate, smooth, thin-walled, hyaline to sub-hyaline, 150-200 x 2-3 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate. *Conidia* solitary, simple, dry, hyaline, 3-4-septate, 35-50 x 12-20 µm.

Specimen examined: On dead and decaying fronds of *Caryota urens* L., Netravali, Sanguem, Goa, 22/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 133AP24.

Dictyoarthrinium quadratum S. Hughes, *Mycol. Pap.* 48: 30 (1952)

(Plate VI- 52; Fig. 38)

Colonies on natural substrate, effuse, with dense tuft of entangled conidiophores, laden with black, dry mass of conidia. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Basal cell* cup shaped, sometimes with short denticles, arising laterally or terminal on mycelia 4-8 X 4-6 µm., *Conidiophores* made of arthric *Conidiogenous cells* with all cells producing single conidia, mononematous, tubular arising from basal cell, flexuous, unbranched, septate with dark black septal bands in between hyaline cells, smooth 40-120 x 3-6 µm, single cell 5-10 x 4-6 µm. *Conidia* born terminally pushed laterally by further growth, solitary, globose to subglobose, multiseptate, dark brown 8-13 µm across.

Specimen examined: On Spathes and floral sheath litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH-81AP25. II. On Spathes and floral sheath litter, *Cocos nucifera* L., Honnavar, Karnataka, Goa, 16/11/09, coll. A. Prabhugaonkar. III. On Spathes and floral sheath litter, *Cocos nucifera* L., near Bambolim beach, Goa, 03/12/07, coll. A. Prabhugaonkar.

Dictyochaeta assamica (Agnihotr.) Aramb., Cabello & Mengasc., *Darwiniana* 28: 297 (1988) [1987] **(Plate VI- 53)**

Colonies on natural substrate, effuse, dark brown. *Mycelium* composed of branched, septate, pale brown, 1-3 μm wide hyphae. *Conidiophore* macronematous, mononematous, erect, straight to slightly flexuous, septate, unbranched, smooth, dark brown, 175-240 x 2.5-7.5 μm . *Conidiogenous cells* monophialidic, terminal, integrated, colarette, light brown, 25-40 x 2.5-5 μm . *Conidia* falcate, aseptata, sub-hyaline, smooth, 10-15 x 2-3 μm , formed in slimy mass at the apex, with 1 setulae at each ends; setulae 3-5 μm long.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 191AP01.

Dictyochaeta fertilis (S. Hughes & W.B. Kendr.) Hol.-Jech., *Folia geobot. phytotax.* 19: 426 (1984) **(Plate VII- 54)**

Colonies on natural substrate, effuse, dark brown. *Mycelium* composed of branched, septate, pale brown, 1.5-3 μm wide hyphae. *Conidiophore* mononematous, macronematous, erect, straight to flexuous, septate, unbranched, smooth, brown, 100-175 x 3-6 μm . *Conidiogenous cells* monophialidic, terminal, integrated, light brown, 25-47 x 3-5 μm . *Conidia* simple, obclavate, smooth, aseptata, sub-hyaline, 16-23 x 3-8 μm , formed in slimy mass at the apex.

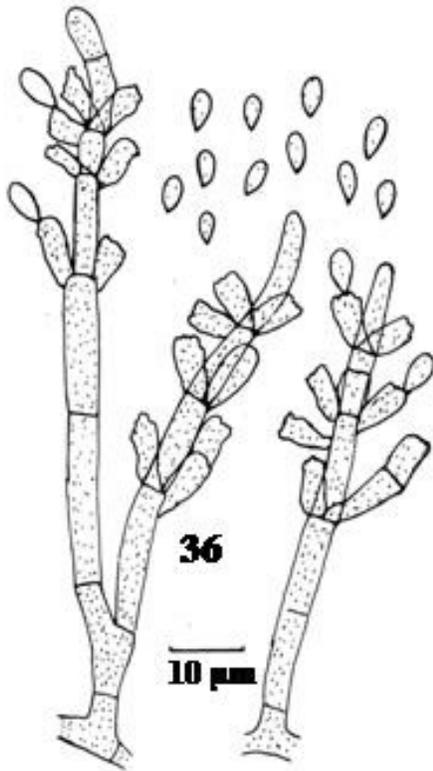
Specimen examined: I. Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb No. 307AP20. II. Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Dhoodhsagar, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 337AP20. III. Dead leaf sheathes and rachids of *Pinanga dicksonii* Blume, Katilekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 391AP19.

Dictyochaeta guadalcanalensis (Matsush.) Kuthub. & Nawawi, *Mycol. Res.* 95: 1220 (1991) **(Plate VII- 55)**

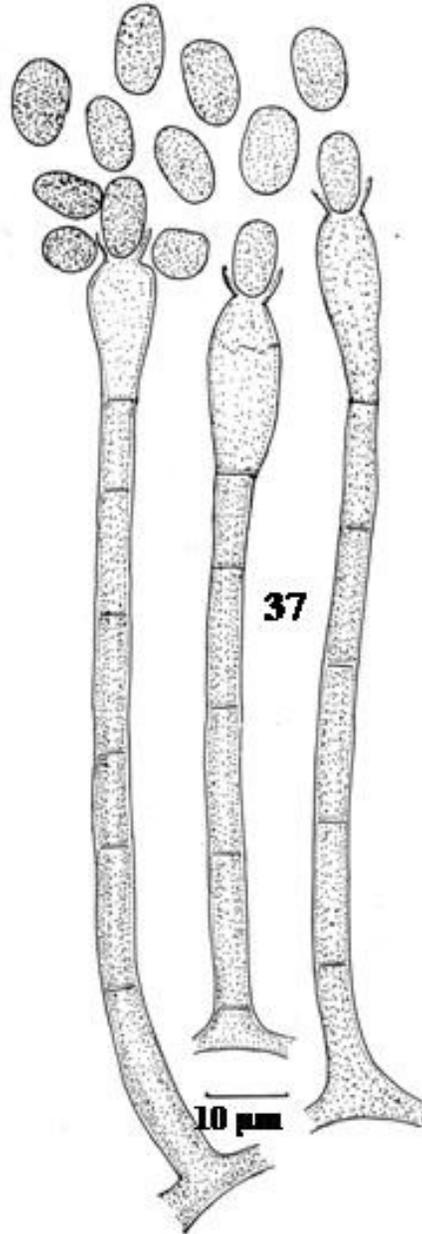
Colonies on natural substrate, effuse, dark brown. *Mycelium* composed of branched, septate, pale brown to brown, 1-3 μm wide hyphae. *Conidiophore* macronematous, mononematous, erect, straight to flexuous, septate, unbranched, 35-100 x 4-7.5 μm . *Conidiogenous cells* polyphialidic, terminal, intercalary, colarette, light brown, 20-34 x 2-5 μm . *Conidia* aseptata, hyaline, truncate at the base, pointed at the tip, 12-18 x 2-4 μm .

Specimen examined: Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Katilekan, near Gersoppa, Uttara Kannada district, Karnataka, 03/12/07, coll. A. Prabhugaonkar, Herb No. 145AP20.

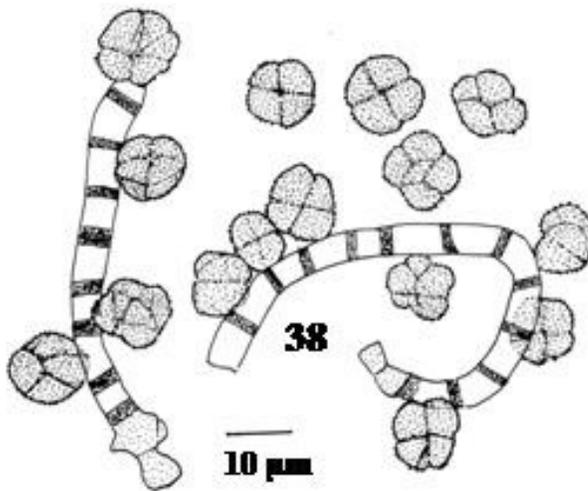
Figs. 36-38



Costantinella palmicola



Craspedodidymum sp.

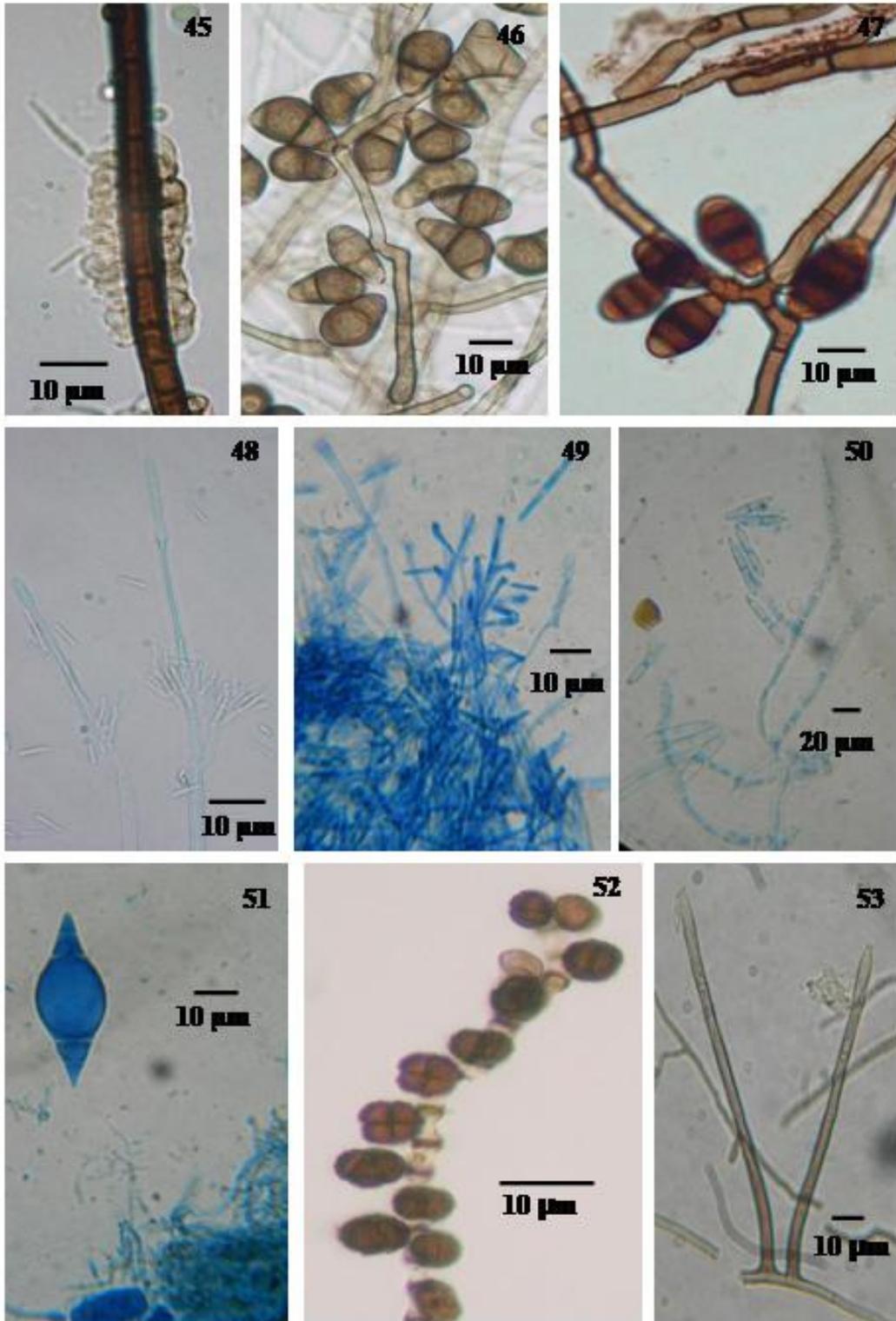


Dictyoarthrinium quadratum

Plate VI:

45. *Cryptophiale* sp.
46. *Curvularia senegalensis*
47. *Curvularia* sp.
48. *Cylindrocladium quinquesepatum*
49. *Dactylaria biseptata*
50. *Dactylaria candidula*
51. *Dactylella* sp.
52. *Dictyoarthrinium quadratum*
53. *Dictyochaeta assamica*

Plate VI. 45-53



***Dictyosporium elegans* Corda, Weitenweber's Beitr. Nat.: 87 (1836) (Plate VII- 56)**

Colonies on natural substrate, effuse, black. Mycelium immersed. Sporodochia disperse, pulvinate. *Conidiophores* micronematous, mononematous, fasciculata, pale brown. *Conidiogenous cells* monoblastic, integrated, terminal, upto 2 µm broad. *Conidia* solitary, dry, branched, brown, smooth, pluriseptate, cheiroid, flattened in one plane, 22-28 x 9-18 µm.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. 170AP01. II. On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 113AP01. III. On litter of *Caryota urens* L., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 116AP24. IV. On dry leaf sheaths of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 13/01/08, coll. A. Prabhugaonkar, Herb. No. GUBH 151AP01. V. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 170AP01. VI. On litter, *Corypha umbraculifera* L., Tambraserry, near Calicut, Kerala, 30/07/08, coll. A. Prabhugaonkar, Herb. No. GUBH-257AP01. VII. On leaf litter of *Phoenix acaulis* Roxb. Paroda, Quepem, Goa, 14/08/09, coll. A. Prabhugaonkar, Herb. No. GUBH 375AP30. VIII. Dead leaf sheaths and rachids of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 386AP19.

***Dictyosporium* sp.**

(Plate VII- 57)

Colonies on natural substrate, effuse, black. Mycelium immersed. Sporodochia disperse, pulvinate. *Conidiophores* micronematous, mononematous, fasciculata, pale brown. *Conidiogenous cells* monoblastic, integrated, terminal. *Conidia* solitary, dry, branched, cheiroid, flattened in one plane, brown, smooth, pluriseptate, 45-75 x 15-25 µm.

Specimen examined: On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 231AP21.

***Didymobotryum rigidum* (Berk. & Broome) Sacc., Syll. fung. (Abellini) 4: 627 (1886)**

(Plate VII- 58; Fig. 39)

Colonies on natural substrate effuse, black, hairy. Mycelium immersed. Stroma absent. Setae and hyphopodia absent. *Conidiophores* macronematous, synnematous, erect, straight or flexuous, 600-1400 x 25-30 µm. *Conidiophores* threads smooth, septate, brown. *Conidiogenous cells* monotretic, integrated, terminal, 5-8.5 x 4-5 µm. *Conidia* catenate, dry, acrogenous, simple, clavate, cylindrical, smooth, rounded at the apex, dark brown, 1-septate, 15-18 x 5-7 µm.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 65AP01.

Didymostilbe sundara (Subram. & Bhat) Seifert, *Stud. Mycol.* 27: 140 (1985)

(Plate VII- 59)

Colonies on natural substrate, effuse, hairy, greyish. *Mycelium* partly immersed, partly superficial, composed of septate, branched, hyphae. Synnemata scattered, unbranched, slender, white to yellow-brown, smooth, 670-730 x 20-100 μm . *Conidiophores* unbranched, septate, smooth, hyaline. *Conidiogenous cells* monophialidic, cylindrical, terminal, 25-38 x 2-3 μm . Conidial mass yellow, hemispherical to globose. *Conidia* solitary, simple, ellipsoidal, smooth, hyaline, 1-2-septate, 15-20 x 3-4 μm .

Specimen examined: I. On Spathe litter, *Cocos nucifera* L., Puttur, Karnataka, 20/11/07, coll. D. J. Bhat, Herb. No. GUBH-124AP26. II. On litter of *Arenga wightii* Griff, Bondla, Satre, Sattari, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. 124AP20. III. On litter, *Corypha umbraculifera* L., Tambraserry, near Calicut, Kerala, 30/07/08, coll. A. Prabhugaonkar, Herb. No. GUBH-257AP01.

Ellisemia adscendens (Berk.) Subram., *Proc. Indian natn Sci. Acad.*, Part B. Biol. Sci. 58: 183 (1992)

(Plate VII- 60; Fig. 40)

Colonies on natural substrate, effuse, hairy. *Mycelium* partly immersed, partly superficial, composed of septate, branched, hyphae. *Conidiophores* mononematous, macronematous, straight or slightly flexuous, mid to dark brown, 20-25 x 4-6 μm . *Conidiogenous cells* monoblastic, terminal, integrated. *Conidia* solitary, dry, smooth, brown, obclavate, elongated, 22-26-pseudoseptate, 60-190 x 6-12 μm .

Specimen examined: On litter, *Elaeis guineensis* Jacq. Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 346AP31.

Endocalyx melanoxanthus (Berk. & Broome) Petch, *Ann. Bot.*, Lond. 22: 390 (1908)
(Plate VII- 61)

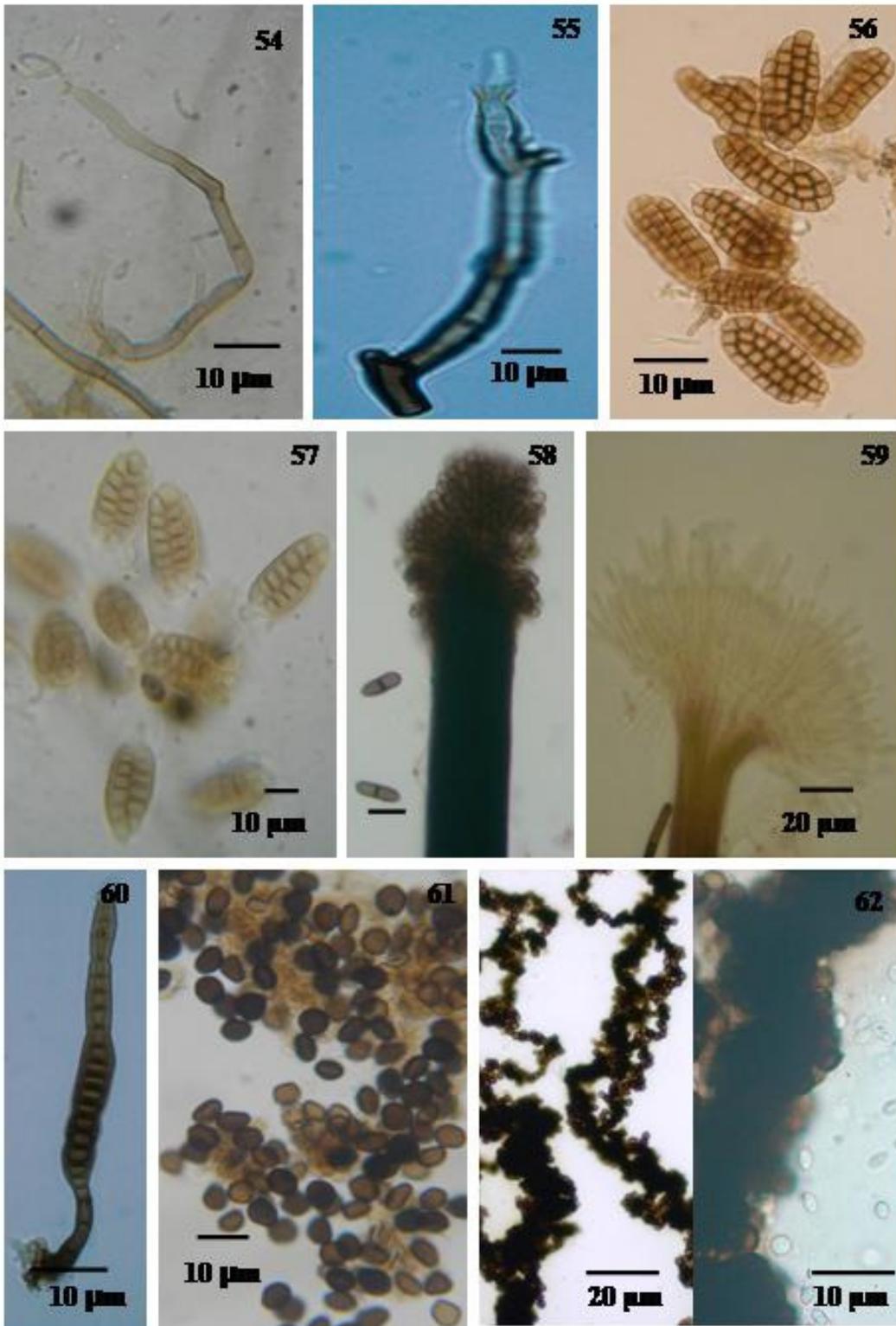
Colonies on natural substrate effuse, black. *Mycelium* immersed. *Stroma* superficial, erect, expanding above into an open, funnel containing black mass of conidia. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, slender, thread-like, flexuous, irregularly branched, light brown, smooth, forming sporodochia. *Conidiogenous cells* monoblastic integrated, terminal. *Conidia* solitary, simple, aseptate, lenticular, elliptical, round in one plane, dark brown, smooth, 6-9 μm , with an elongated germ slit.

Specimen examined: I. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 73AP24. II. On dead decaying spathe, fronds of *Cocos nucifera*, Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar.

Plate VII:

54. *Dictyochaeta fertilis*
55. *Dictyochaeta guadalcanalensis*
56. *Dictyosporium elegans*
57. *Dictyosporium* sp.
58. *Didymobotryum rigidum*
59. *Didymostilbe sundara*
60. *Ellisembia adscendens*
61. *Endocalyx melanoxanthus*
62. *Endoconidioma populi*

Plate VII. 54-62



Endoconidioma populi Tsuneda, Hambl. & Currah, *Mycologia* 96: 1129 (2004)

(Plate VII- 62)

Colonies on MEA greenish brown, slimy, flat. Conidiomata, forming on a black darkly pigmented peridium and a locule filled with conidiogenous cells. *Endoconidia* formed endogenously, hyaline, unicellular, conidiogenous and the peridial cells of the conidioma, 5-8 x 2-3 μm . *Blastic conidia*, mostly two-celled, dark brown, produced holoblastically from pigmented, undifferentiated hyphae, 10-18 μm in diam.

Specimen examined: Isolated by Particle plating method from leaf litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 413AP19.

Endophragmia sp.

(Plate VIII- 63)

Colonies on natural substrate effuse, hairy, dark brown. *Mycelium* partly superficial, partly immersed, composed of light brown, smooth, septate 2-3 μm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous, mononematous, unbranched, brown, smooth. *Conidiogenous cells* monoblastic, integrated, terminal, 4-6 μm broad. *Conidia* solitary, dry, dark brown, transversely and longitudinally septate, smooth, 27-35 x 18-22 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. 177AP01.

Endophragmiopsis sp.

Colonies effuse, black, shortly hairy. *Mycelium* superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, unbranched, straight or flexuous, brown, smooth, 35-40 x 4-8 μm , sometimes terminating in a cup shaped structure. *Conidiogenous cells* monoblastic, integrated, terminal, 23-27 x 4-8 μm . *Conidia* solitary, dry, simple, septate, smooth, basal cells pale brown, apical cells dark brown to black, 15-18 x 7-10 μm .

Specimen examined: I. On litter of *Phoenix acaulis* Roxb., Harmal, Pernem, Goa, 08/09/07, coll. A. Prabhugaonkar, Herb. No. 58AP30. II. On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 15/10/09, coll. A. Prabhugaonkar, Herb. No. 360AP01.

Excipularia narsapurensis Subram., *J. Indian bot. Soc.* 35: 56 (1956)

(Plate VIII- 64)

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* immersed. *Stroma* none. Sporodochia scattered, black, shining with central mass of conidia

supported by a ring of setae. *Setae* dark brown, thick-walled, smooth, septate, unbranched, acutely pointed at the tip, 150-225 x 8-10 µm wide. *Conidiophores* macronematous, erect, straight to flexuous, unbranched, septate, smooth, pale brown, 20-32 x 4-6 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate. *Conidia* solitary, simple, acrogenous, broadly fusiform, dark brown in the middle, peripheral cells hyaline, 5-7-septate, 47-65 x 10-20 µm.

Specimen examined: On Spatha and floral sheath litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 24/10/07, coll. A. Prabhugaonkar.

Exserticlava triseptata (Matsush.) S. Hughes, *N.Z. Jl Bot.* 16: 333 (1978)

(Plate VIII- 65; Fig. 41)

Colonies on natural substrate effuse, dark brown. *Conidiophores* mononematous, macronematous, erect, straight to slightly flexuous, septate, smooth, brown, 295-365 x 6.5-14.5 µm. *Conidiogenous cells* monophialidic, terminal, integrated, light brown, 12-32 x 6-9 µm. *Conidia* ellipsoidal, brown, smooth, 3-pseudoseptate, 25-35 x 15-20 µm.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 64AP01. II. On litter of *Calamus thwaitesii* Becc. & Hook., Ambeghat, Canacona, Goa, 28/10/07, coll. A. Prabhugaonkar, Herb. No. 86AP01. III. On litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 441AP18.

Exserticlava vasiformis (Matsush.) S. Hughes, *N.Z. Jl Bot.* 16: 332 (1978)

(Plate VIII- 66; Fig. 42)

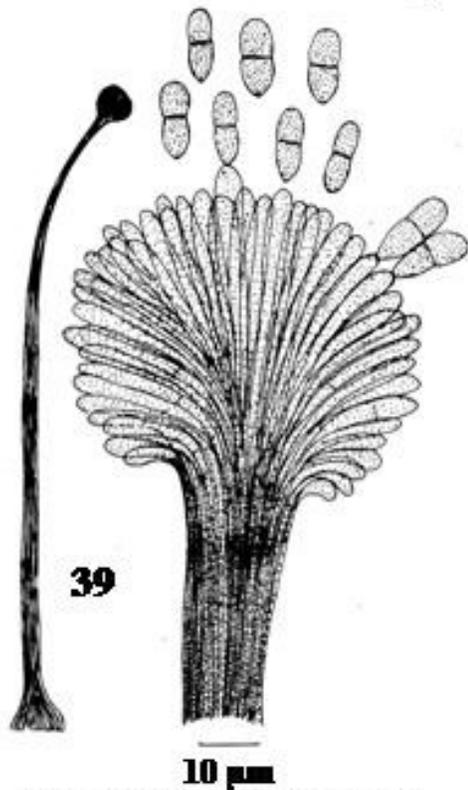
Colonies on natural substrate effusae, brown, shiny. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, erect, straight to slightly flexuous, smooth, dark brown, thick-walled, septate, cylindrical, percurrent, terminating into a hyaline vesicle, 126-270 x 6-11 µm; vesicle 70-85 µm long, 18-20 µm broad at the swollen base, 8-10 µm broad at the rounded tip. *Conidiogenous cells* monophialidic, terminal, integrated, light brown, 14-21 x 8-13 µm. *Conidia* ellipsoidal, brown, smooth, 1-3-pseudoseptate, 23-30 x 14-17 µm.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, Herb. No. 22AP01. II. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar.

Fusarium graminearum Schwabe, *Flora Anhalt* 2: 285 (1839) (Plate VIII- 67)

Colonies on natural substrate effuse, white. *Mycelium* thin, smooth, hyaline, branched, 2-3 µm wide. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, profusely branched,

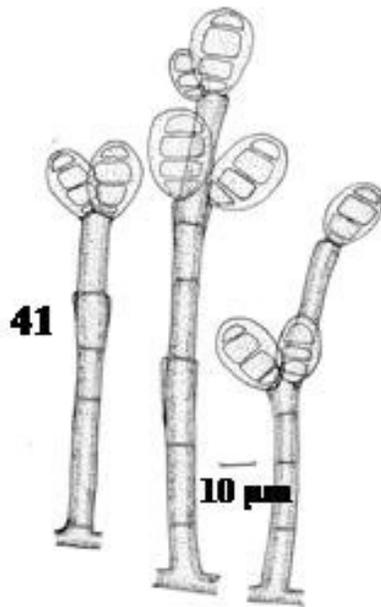
Figs. 39-41



39

10 μm

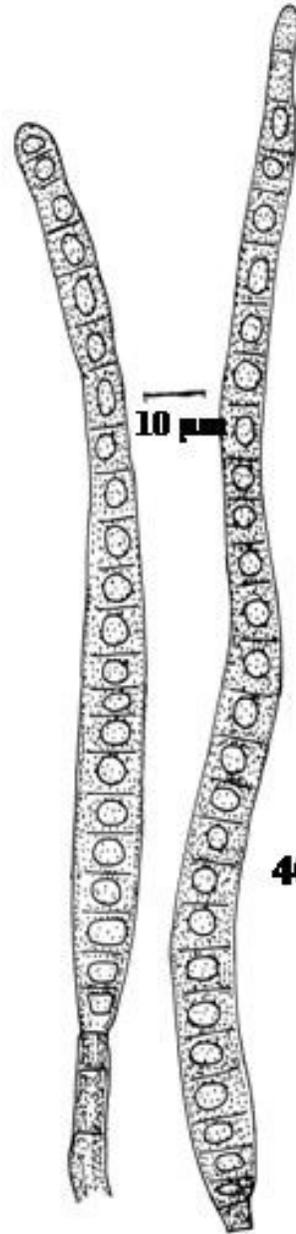
Didymobotryum rigidum



41

10 μm

Exserticlava triseptata



40

Elisembia adscendens

septate, smooth, hyaline, 100-150 x 5-7.5 µm. *Conidiogenous cells* monophialidic, terminal, integrated, 10-17.5 x 2.5-4 µm. *Conidia* solitary, endogenous, simple, fusiform, pointed at both the ends, hyaline, smooth, 3-7-septate, 55-76 x 3-7 µm.

Specimen examined: Isolated by Particle plating method from leaf sheathes, rachids litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 395AP19.

***Fusarium* sp.**

(Plate VIII- 68)

Colonies on MEA fast growing, offwhite. *Mycelium* thin, smooth, hyaline, branched, 2-3 µm wide. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, profusely branched, septate, smooth, hyaline. *Conidiogenous cells* monophialidic, terminal, integrated, 10-15 x 2-4 µm. *Macroconidia* solitary, endogenous, simple, fusiform, pointed at both the ends, hyaline, smooth, septate, 20-25 x 3-5 µm; *microconidia* ellipsoidal, smooth, hyaline, aseptate, 7-15 x 2-4 µm.

Specimen examined: I. Isolated from fresh leaves of *Calamus thwaitesii* by 3-step sterilisation method. Netravali, Sanguem, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 126AP01. II. Isolated by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb No. 295AP20. III. On dead leaf sheath of *Areca catachu*, Mashem, Canacona, Goa, 17/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 313AP26. IV. Isolated by Particle plating method from litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 421AP19.

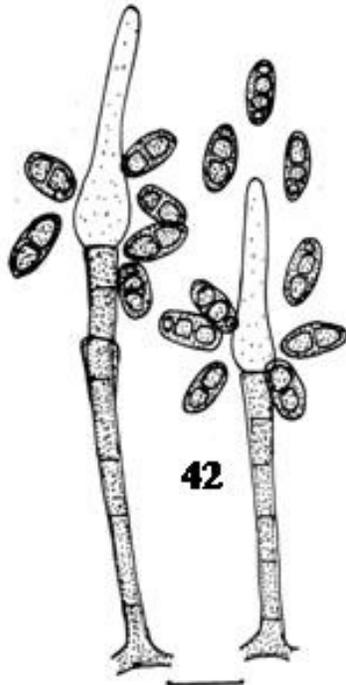
***Gangliostilbe indica* Subram. & Vittal, *Kavaka* 3: 70 (1976) [1975]**

(Plate VIII- 69; Fig. 43)

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* immersed in the host tissue. *Conidiophores* macronematous, synnematous. *Synnema* erect, with the stalk consisting of compact aggregation of parallel hyphae, terminating in dark brown, fertile heads, 300-400 x 20-30 µm. *Conidiophore threads* branched, percurrently proliferating at the tip, smooth, septate, light brown. *Conidiogenous cells* terminal, integrated, determinate, 15-20 x 3-5µm. *Conidia* gangaliar, obovate, 2-3 septate, smooth, light brown, truncate at the base, rounded at the tip, 28-34 x 15-18.5 µm.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 114AP01.

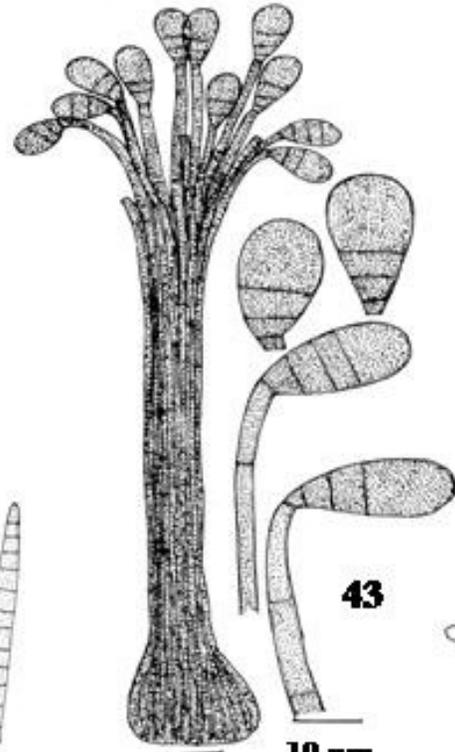
Figs. 42-44



42

10 μ m

Exserticlava vasiformis

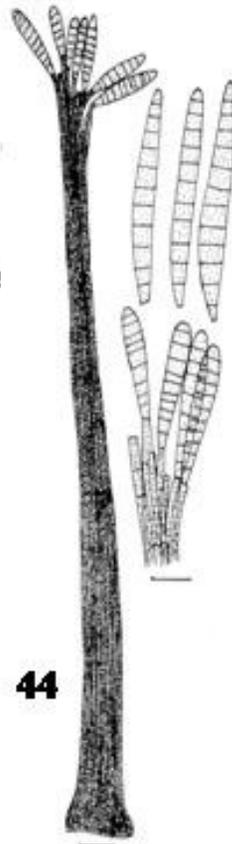


43

20 μ m

10 μ m

Gangliostilbe indica



44

20 μ m

Gangliostilbe malabarica

Gangliostilbe malabarica Subram. & Bhat, *Kavaka* 15(1-2): 54 (1989) [1987]

(Plate VIII- 70; Fig. 44)

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* immersed in the host tissue. *Conidiophores* macronematous, synnematous. *Synnema* erect, with the stalk consisting of compact aggregation of parallel hyphae, terminating in dark brown, fertile heads, 380-570 x 20-40 µm. *Conidiophore threads* branched, percurrently proliferating at the tip, smooth, septate, light brown. *Conidiogenous cells* terminal, integrated, determinate, 7-20 x 3-4 µm. *Conidia* gangaliar, fusiform, multiseptate, smooth, light brown, truncate at the base, rounded at the tip, 25-55 x 4-8 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Malapuzha, near Calicut, Kerala, 30/07/08, coll. A. Prabhugaonkar, Herb. No. GUBH-263AP01.

***Geniculosporium* sp.**

(Plate VIII- 71)

Colonies on natural substrate brown. *Mycelium* partly immersed, partly superficial, composed of hyaline, thin walled, branched, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, fasciculate, erect, straight to slightly flexuous, smooth, branched, septate, light brown, 50-130 x 2-3 µm. *Conidiogenous cells* polyblastic, integrated, terminal and intercalary, sympodial, geniculate, light brown, 30-60 x 2-3 µm. *Conidia* solitary, dry, acropleurogenous, simple, hyaline, smooth, aseptate, 4-6 x 2-3 µm.

Specimen examined: Isolated from fresh leaves of *Arenga wightii* Griff., Kotlekan, near Gersoppa, Uttara Kannada district, Karnataka, 03/12/07, coll. A. Prabhugaonkar, Herb No. 144AP20.

Gliocladium cylindrosporum Matsush., *Icon. microfung. Matsush. lect.* (Kobe): 73 (1975)

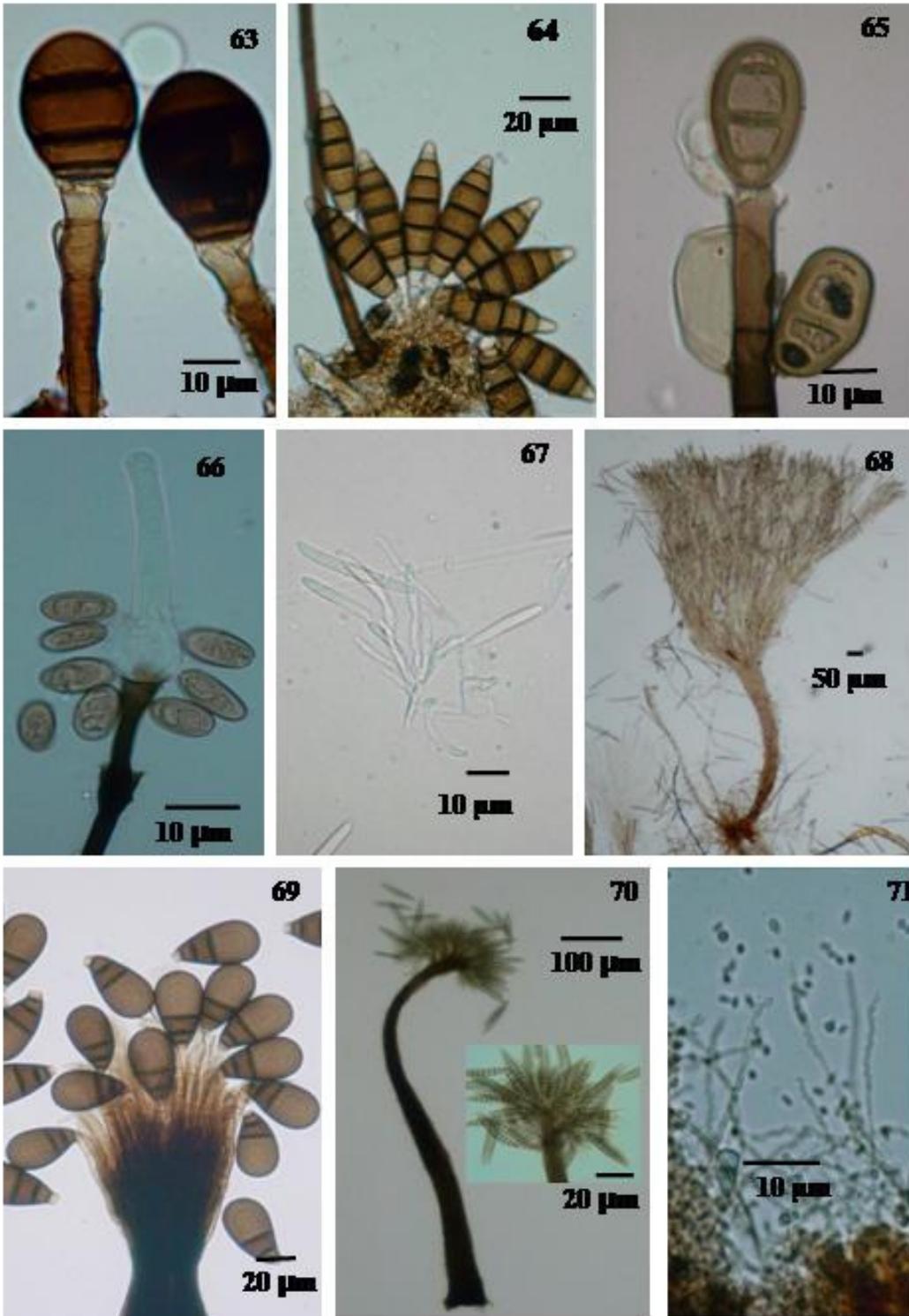
Colonies on MEA fast growing, white with greenish spore mass. *Mycelium* branched, septate, hyaline, smooth, 1.5-2 µm thick. *Conidiophores* macronematous, mononematous, straight to flexuous, profusely branched from the base, penicillately branched at the apex, hyaline, smooth. *Conidiogenous cells* monophialidic, discrete, determinate, terminal, 10-18 x 2.5-4 µm. *Conidia* glioid, simple, smooth, ellipsoidal, aseptate, hyaline, 5-10 x 3-4 µm, rounded at both the ends.

Specimen examined: Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar falls Netravali, Sanguem, Goa, 30/04/08, coll. A. Prabhugaonkar. Hrb. No. GUBH 223AP20.

Plate VIII:

- 63.** *Endophragmia* sp.
- 64.** *Excipularia narsapurensis*
- 65.** *Exserticlava triseptata*
- 66.** *Exserticlava vasiformis*
- 67.** *Fusarium graminearum*
- 68.** *Fusarium* sp.
- 69.** *Gangliostilbe indica*
- 70.** *Gangliostilbe malabarica*
- 71.** *Geniculosporium* sp.

Plate VIII. 63-71



***Gliocladium penicillioides* Corda, *Icon. fung.* (Prague) 4: 31 (1840) (Plate IX- 72)**

Colonies on natural substrate off white. Mycelium branched, septate, hyaline, smooth, 1.5-2 μm thick. *Conidiophores* macronematous, mononematous, straight to flexuous, penicillately branched at the apex, hyaline, smooth, 100-200 x 3-6 μm . *Conidiogenous cells* monophialidic, discrete, determinate, terminal, lageniform, 16-30 x 1.5-2.5 μm . *Conidia* glioid, simple, smooth, obovoid to ellipsoidal, 0-2-pseudoseptate, hyaline, 4-8 x 2-4 μm .

Specimen examined: Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb No. 309AP20.

***Gliocladium roseum* Bainie, Bull. Soc. Mycol. Fr. 23:111 (1907) (Plate IX- 73)**

Colonies on MEA fast growing, white. Mycelium branched, septate, hyaline, smooth, 1.5-2 μm thick. *Conidiophores* macronematous, mononematous, straight to flexuous, branched at the apex, hyaline, smooth, 40-50 x 2-3 μm . *Conidiogenous cells* monophialidic, discrete, determinate, terminal and intercalary, subulate to lageniform, 10-15 x 2-3. μm . *Conidia* glioid, simple, smooth, obovoid to ellipsoidal, aseptate, hyaline, 3-4 x 1-5-2 μm .

Specimen examined: Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 446AP18.

***Gliocladiopsis sagariensis* S.B. Saksena, *Mycologia* 46: 662 (1954)**

Colonies on MEA fast growing, white. *Mycelium* branched, septate, hyaline, smooth, 1.5-2 μm thick. *Conidiophores* macronematous, mononematous, monomorphic, penicillately branched, sub-hyaline to light brown at the base, hyaline at the apex, smooth, 100-150 x 3-7 μm . *Conidiogenous cells* monophialidic, discrete, smooth, hyaline, 20-30 x 2-4 μm . *Conidia* formed in glios mass at the tip, cylindrical, rounded at both ends, straight, 0-1-septate, 10-20 x 1.5-2 μm .

Specimen examined: I. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 240AP21. II. Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb No. 307AP20.

***Gliomastix* sp. (Plate IX- 74)**

Colonies on natural substrate effuse, black. *Mycelium* partly immersed, partly superficial. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, straight to flexuous, unbranched, smooth, dark brown, 30-55 x 2-4 μm . *Conidiogenous cells* monophialidic, integrated, terminal, determinate, 6-15 x 2-3 μm . *Conidia* semi-endogenous, catenate or aggregated in

slimy heads, simple, doliiform, ellipsoidal, dark brown to black, smooth, aseptate, 3-4 x 2-3 μm .

Specimen examined: On litter, *Caryota urens* L., Satre, Sattari, Goa, 13/01/08, coll. A. Prabhugaonkar, Herb. No. 149AP24.

Gonytrichum macrocladum (Sacc.) S. Hughes, *Trans. Br. mycol. Soc.* 34(4): 565 (1952) [1951] **(Plate IX- 75)**

Colonies on MEA slow-growing, dark green. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, dark brown, septate, 185-315 x 2.5-5 μm , terminating sterile setae or sporulating phialide. *Conidigenous cells* monophialidic, subhyaline, discrete, arranged in whorls of 1-6, slender, flask-shaped, pale brown, collarette, 12-18 x 3-5 μm . *Conidia* accumulating in slimy mass, subshperical, , hyaline, smooth, aseptate, 3-4 μm in diam.

Specimen examined: Isolated by Particle plating method of leaf litter of *Calamus thwaitesii* Becc. & Hook., Kotlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 397AP01.

Graphiola phoenicis (Moug.) Poit., *Annl. Sci. Nat., Bot.*, sér. 1 3: 473 (1824)

Colonies on MEA slimy, hyaline, yeast like. On substrate forming upto 4 cm yellow or brown or black raised spots on both sides of the healthy leaf blade. *Conidiomata* dark black cup shaped, scattered evenly on leaf blade, with chains of yellow mass of spores supported by elaters radiating upwards at tip, which are dispersed by wind. Elaters arising from base of conidiomata, composed of cords of septate hyphae. *Conidia* formed from chains of conidigenous cells at the base of conidiomata. *Conidia*, hyaline 0-1 septate, often slightly verruculose 4.5-5.8 x 5.3-6.3 μm , often dispersed in pairs.

Specimen examined: On Fresh leaf blades of *Phoenix* sp. Dona Paula, Goa, 05/01/07, coll. A. Prabhugaonkar, Herb. No. GUBH 157AP29.

***Graphium* sp.**

Colonies on natural substrate effuse, grey, light brown. *Mycelium* immersed. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, synnematous. Synnema brown, 175-500 x 10-12.5 μm . *Conidiophore threads* narrow, straight or flexuous, light brown, smooth. *Conidigenous cells* monoblastic, integrated, 5-10 x 1-2 μm . *Conidia* aggregated in slimy heads, acrogenous, simple, straight, subhyaline, smooth, aseptate, 2-3 x 1.5-2 μm .

Specimen examined: On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 122AP24.

***Gyrothrix* sp.**

Colonies on natural substrate effuse, dark brown to black, velvety. *Mycelium* immersed. *Stroma* none. *Setae* present, repeatedly branched, dark brown, verrucose, 125-200 x 2.5-5 µm. *Hyphopodia* absent. *Conidiophores* micronematous. *Conidiogenous cells* monoblastic, solitary, percurrent, lageniform, subhyaline, 7-10 x 3-5 µm. *Conidia* solitary, dry, simple, acerose, cylindrical, aseptate, hyaline, smooth, 12-16 x 1.5-2 µm.

Specimen examined: On dead leaf lamina of *Borassus flabellifer*, Palghat, Tamilnadu, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 317AP22.

***Hansfordia pulvinata* (Berk. & M.A. Curtis) S. Hughes, *Can. J. Bot.* 36: 771 (1958)**

Colonies on natural substrate effuse, grey, velvety. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-2.5 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, branched, brown at the base, paler towards the apex, smooth, 300-600 x 2-4 µm. *Conidiogenous cells* polyblastic, integrated, terminal, determinate, denticulate, hyaline, smooth, 10-14 x 2-4 µm. *Conidia* solitary, acropleurogenous, spherical, hyaline, smooth, 3-4 µm in diam.

Specimen examined: On leaf litter of *Phoenix acaulis* Roxb., Paroda, Quepem, Goa, 15/05/10, coll. A. Prabhugaonkar, Herb. No. GUBH 336AP30.

***Helicoma* sp. 1**

(Plate IX- 76; Fig. 45)

Colonies on natural substrate effuse, brown. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth, septate, 170-450 x 8-11 µm. *Conidiogenous cells* monoblastic, integrated, terminal, light brown, smooth, 20-32 x 4-7 µm. *Conidia* solitary, smooth, light brown, helicoid, multiseptate, truncate at the base, rounded at the apex, 1 ½ coiled, 80-262 x 10-30 µm.

Specimen examined: On litter, *Cocos nucifera* L. Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH- 91AP25.

***Helicoma* sp. 2**

(Plate IX- 77; Fig. 46)

Colonies on natural substrate effuse, brown. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous,

erect, straight to flexuous, unbranched, brown, smooth, septate, 130-170 x 5-7 µm. *Conidiogenous cells* polyblastic, integrated, terminal, light brown, smooth, 20-24 x 5-7 µm. *Conidia* solitary, smooth, light brown, helicoid, 5-6-septate, truncate at the base, rounded at the apex, 1 ½ coiled, 25-35 x 6-9 µm.

Specimen examined: On dead and decaying fronds of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 16AP24.

***Helicomyces* sp.1**

(Plate IX- 78)

Colonies on natural substrate effuse, grey. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, branched, light brown, smooth, septate, 28-55 x 4-8 µm. *Conidiogenous cells* polyblastic, integrated, terminal, light brown, smooth, denticulate, 12-15 x 4-7 µm. *Conidia* solitary, smooth, hyaline, helicoid, pluriseptate, 115-150 x 3-4 µm.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, Herb. No. 24AP01. II. On litter of *Caryota urens* L. & Hook., Vengurla, Sidhudurg, Maharashtra, 07/09/07, coll. A. Prabhugaonkar, Herb. No. 24AP24. III. On Spatha litter, *Cocos nucifera* L., Puttur, Karnataka, 20/11/07, coll. D. J. Bhat, Herb. No. GUBH-118AP25. IV. On Fronds of *Caryota urens* L., Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. GUBH-118AP24. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 228AP21.

***Helicomyces* sp. 2**

(Plate IX- 79; Fig. 47)

Colonies on natural substrate effuse, grey. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, branched, light brown, smooth, septate, 20-30 x 4-6 µm. *Conidiogenous cells* polyblastic, integrated, terminal, light brown, smooth, denticulate, 15-18 x 4-5 µm. *Conidia* solitary, smooth, hyaline, helicoid, pluriseptate, 200-240 x 3-4.5 µm.

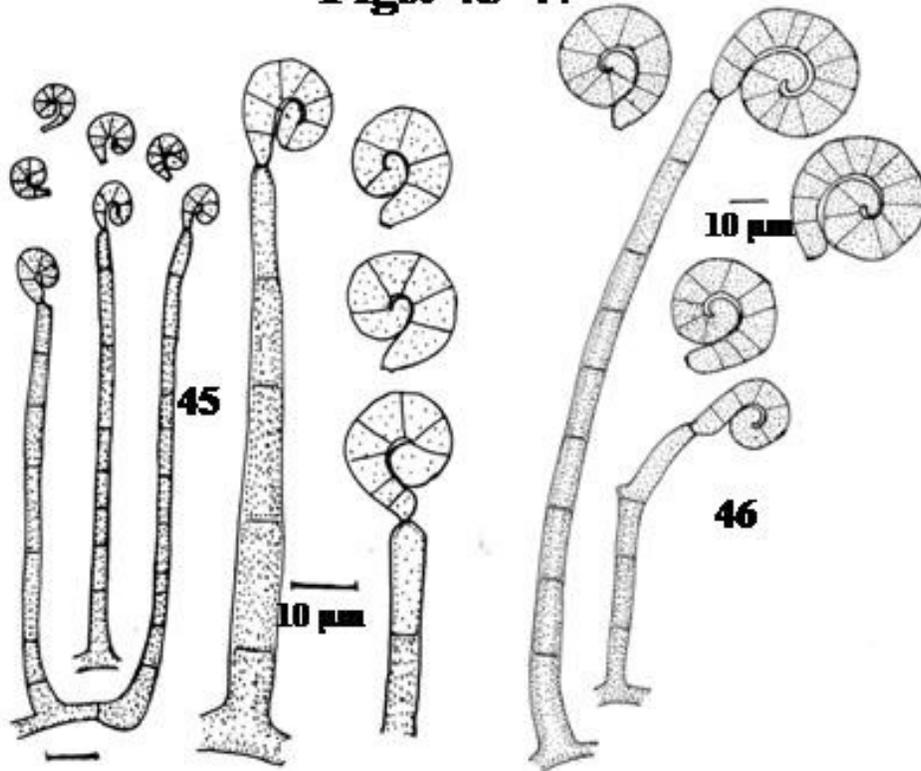
Specimen examined: . On Fronds of *Caryota urens* L., Dhoodhsagar, Sanguem, Goa, 21/09/07, coll. A. Prabhugaonkar, Herb. No. 121AP24

***Helicosporium cinereum* Peck, Saccardo's Syll. fung. IV: 559; XII: 289; XIX: 825(1885)**

(Plate IX- 80)

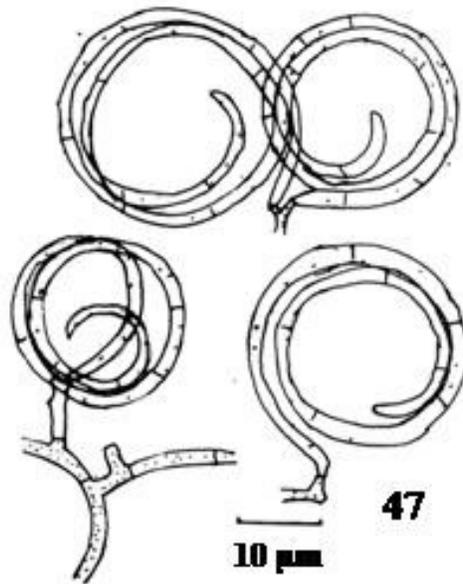
Colonies on natural substrate effuse, cottony, white. *Mycelium* partly immersed, partly superficial, composed of branched, smooth, sub-hyaline, septate, 2-2.5 µm wide hyphae. *Stroma* none. *Hyphopodia* absent. *Conidiophores* macronematous, mononematous, unbranched, erect, straight or flexuous, apex

Figs. 45-47



Helicoma sp. 1

Helicoma sp. 2

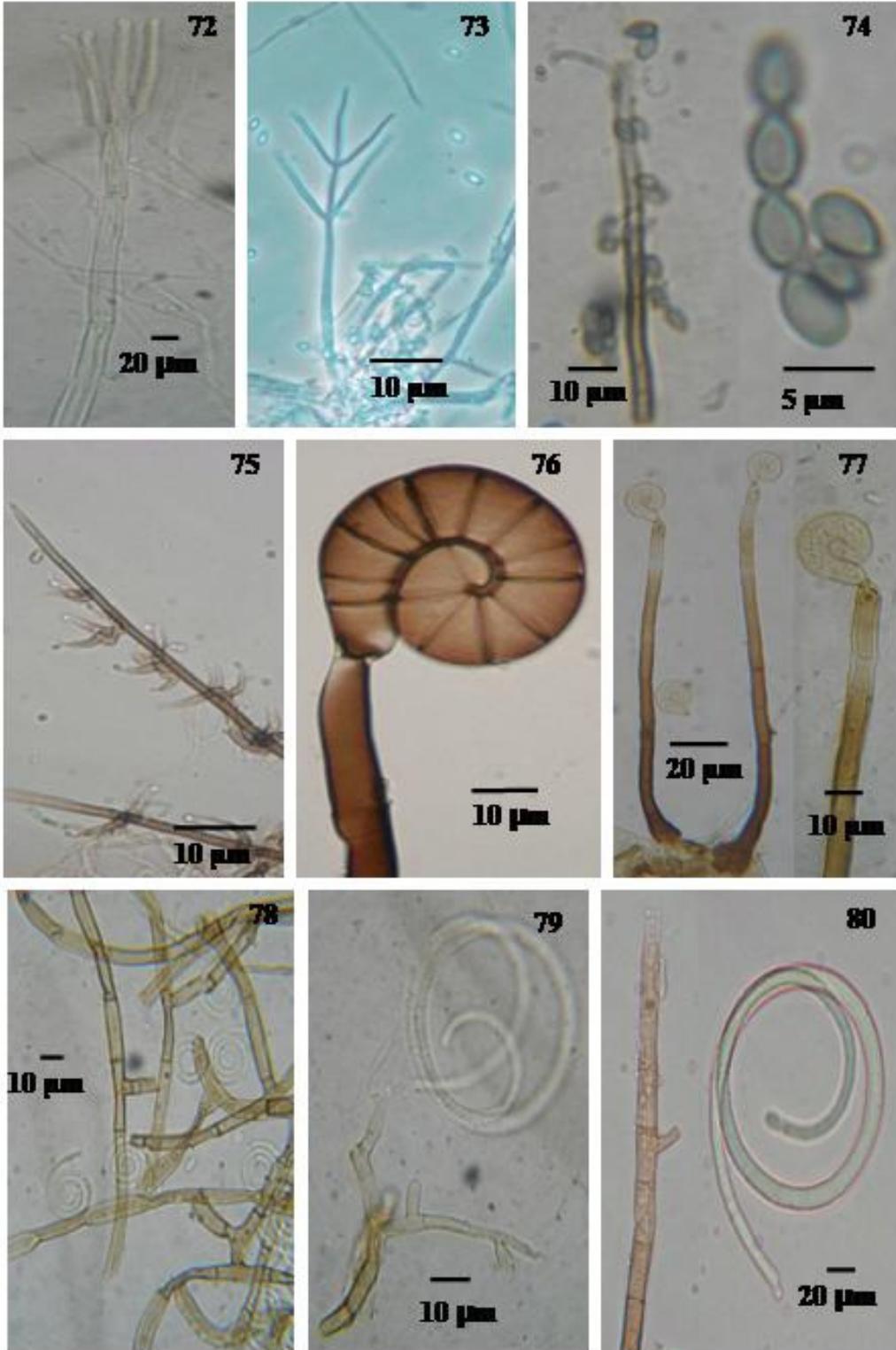


Helicomycetes sp. 2

Plate VIX:

- 72. *Gliocladium penicillioides*
- 73. *Gliocladium roseum*
- 74. *Gliomastix* sp.
- 75. *Gonytrichum macrocladum*
- 76. *Helicoma* sp 1
- 77. *Helicoma* sp. 2
- 78. *Helicomycetes* sp.1
- 79. *Helicomycetes* sp.2
- 80. *Helicosporium cinereum*

Plate IX. 72-80



setiform, 90-130 x 7-10 μm . *Conidiogenous cells* monoblastic, integrated, intercalary, cylindrical, denticulate, 12-15 x 7-10 μm ; denticles cylindrical, narrow. *Conidia* solitary, dry, pleurogenous, simple, helicoid, sub-hyaline, multiseptate, smooth, 150-180 x 5-7 μm .

Specimen examined: On dead leaf sheathes and rachids of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 388AP19.

***Helminthosporium belgaumense* Subram. & Bhat, *Kavaka* 15: 58 (1989) [1987]
(Plate X- 81; Fig. 48)**

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* partly immersed, partly superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth, 140-250 x 6-9 μm . *Conidiogenous cells* polytretic, integrated, terminal and intercalary, cylindrical, smooth, pale brown, 16-19 x 4-5 μm . *Conidia* solitary, dry, sub-spherical, dark brown, truncate at base, roundea at the apex, 1- septate, 10-15 x 6-11 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 279AP01.

***Helminthosporium* sp. (Plate X- 82; Fig. 49)**

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* partly immersed, partly superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth, 165-215 x 4-7 μm . *Conidiogenous cells* polytretic, integrated, terminal and intercalary, cylindrical, smooth, pale brown, 10-22 x 4-5 μm . *Conidia* solitary, dry, acropleurogenous, brown, roundea at the apex, 1- 4-septate, 12-25 x 4-8 μm .

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. 175AP01. II. On litter of *Calamus rotang* Linn., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, A. Herb. No. 21AP02. III. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 79AP24. IV. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 175AP01. V. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 227AP21. VI. Isolated by 3-step sterilisation method of fresh leaves, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 251AP21.

***Helminthosporium* sp. 2**

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* partly immersed, partly superficial. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth, 220-810 x 5-8 µm. *Conidiogenous cells* polytretic, integrated, terminal and intercalary, cylindrical, smooth, light brown, 6-16 x 5-8 µm. *Conidia* solitary, dry, acropleurogenous, brown, rounded at the apex, 3-4-pseudoseptate, 30-42 x 10-12 µm.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 27/07/07, coll. A. Prabhugaonkar, Herb No. 8AP01.

***Hemicorynespora mitrata* (Penz. & Sacc.) M.B. Ellis, *Mycol. Pap.* 131: 21 (1972) (Plate X- 83; Fig. 50)**

Colonies on natural substrate effuse, dark brown to black, sometimes parasitic on other fungi. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3.5 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth, 42-130 x 4-5.5 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate. *Conidia* solitary, dry, smooth, acrogenous, brown to black, 1-3-septate, 23.5-50 x 5-8 µm.

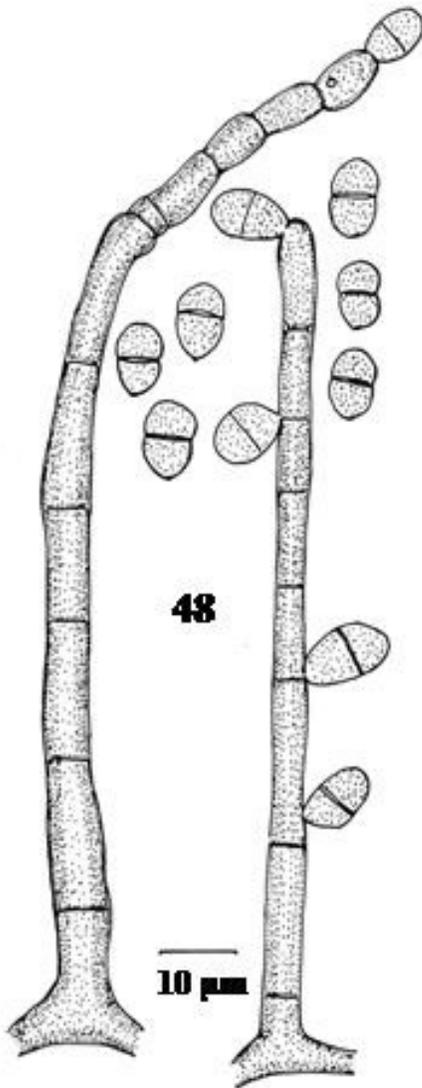
Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 17/08/07, coll. A. Prabhugaonkar, Herb. No. 40AP01.

***Hemicorynespora* sp.1 (Plate X- 84)**

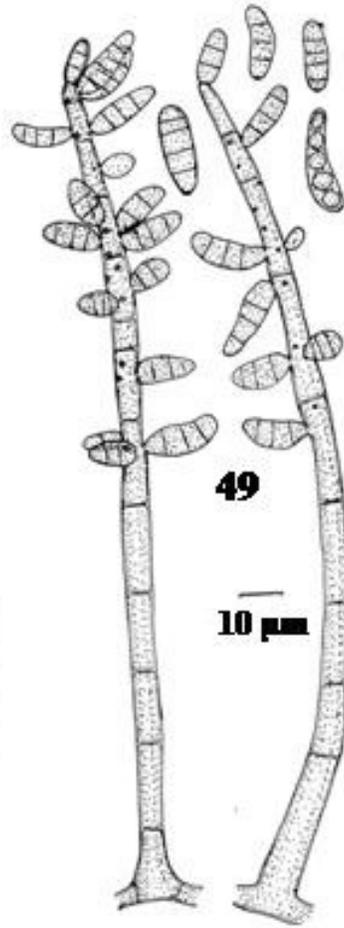
Colonies on natural substrate effuse, dark brown to black. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3.5 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, dark brown, smooth, 75-150 x 5-7.5 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, 15-18 x 5-6 µm. *Conidia* solitary, dry, smooth, acrogenous, dark brown to black, 1-septate, 25-33 µm long, 10-13 µm broad in the centre, 2-3 µm wide at the base and tip.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 17/08/07, coll. A. Prabhugaonkar, Herb. No. 23AP01.

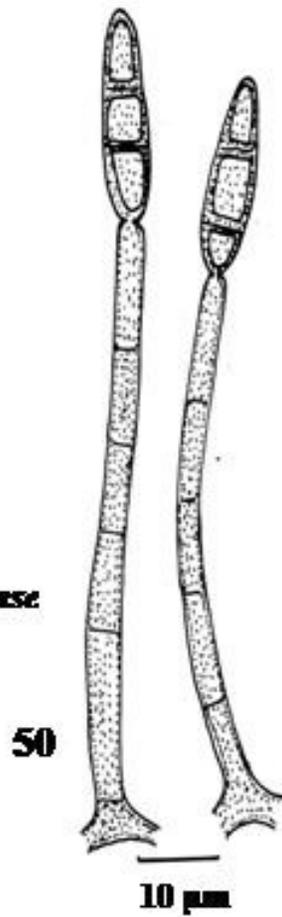
Figs. 48-50



Helminthosporium belgaumense



Helminthosporium sp.



Henicorynespora nitrata

***Hemicorynespora* sp.2**

(Plate X- 85)

Colonies on natural substrate effuse, black. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth, septate, 125-190 x 6-7 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, 20-23 x 6-7 µm. *Conidia* solitary, dry, smooth, acrogenous, brown to black, 1-septate, 25-34 x 10-13 µm.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 17/08/07, coll. A. Prabhugaonkar, Herb. No. 40AP01.

***Hermatomyces tucumanensis* Speg., Anal. Mus. nac. Hist. nat. B. Aires 13: 446 (1911)**

(Plate X- 86; Fig. 51)

Colonies on natural substrate effuse, dark brown to black, velvety. *Mycelium* partly immersed, partly superficial composed of smooth, sub-hyaline, septate, 2-3.5 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* semi-macronematous, mononematous, erect, straight to flexuous, unbranched, brown, smooth. *Conidiogenous cells* monoblastic, terminal, integrated, determinate. *Conidia* solitary acrogenous, spherical, brown to black, with pale peripheral cells surrounding the central dark brown to black cells, 19-25 µm in diam.

Specimen examined: I. On Spatha and floral sheath litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH-88AP25. II. On Fronds of *Caryota urens* L., Dhoothsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. GUBH-88AP24. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/08/07, coll. A. Prabhugaonkar, Herb. No.11AP01.

***Idriella fertilis* (Piroz. & Hodges) Matsush., Icon. microfung. Matsush. lect. (Kobe): 86 (1975)**

(Plate X- 87)

Colonies on natural substrate effuse, light brown. *Mycelium* immersum. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, 40-90 x 2-4 µm. *Conidiogenous cells* polyblastic, integrated, terminal, sympodial, denticulate; denticles short, conical. *Conidia* solitary, dry, acropleurogenous, falcate, smooth, hyaline, aseptate, 14-20 x 2-3 µm.

Specimen examined: Isolated by by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 397AP01.

***Ityorhoptrum verruculosum* (M.B. Ellis) P.M. Krick, -Trans. Br. Mycol. Soc. 86:417 (1986).**

(Plate X- 88; Fig. 52)

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* mononematous, macronematous,

erect, straight to flexuous, unbranched, septate, smooth, dark brown, 180-320 x 4-6.5 μm . *Conidiogenous cells* polyblastic, terminal as well as intercalary, 15-30 x 10-14 μm . *Conidia* solitary, obovoid, truncate at base, rounded at apex, 17-20 x 12-15 μm , 2-celled, upper cell larger, dark brown, verrucose; lower cell light brown, smooth, 5-8 x 4-6 μm .

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. GUBH-169AP01.

***Junewangia sphaerospora* W.A. Baker & Morgan-Jones, *Mycotaxon* 81: 312 (2002)
(Plate X- 89; Fig. 53)**

Colonies on natural substrate effuse, hairy, brown. *Mycelium* partly immersed, partly superficial, composed of branched, smooth, septate, pale brown, 2-4 μm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* mononematous, macronematous, erect, straight to flexuous, unbranched, septate, smooth, dark brown, percurrently proliferating, 44-55 x 3-5.5 μm . *Conidiogenous cells* monoblastic, terminal, indeterminate, light brown, 2.5-5 x 2-3.5 μm . *Conidia* solitary, dry, acrogenous, spherical to subspherical with truncate basal cell, brown, smooth, with numerous oblique septa, 13-17 x 12-15 μm .

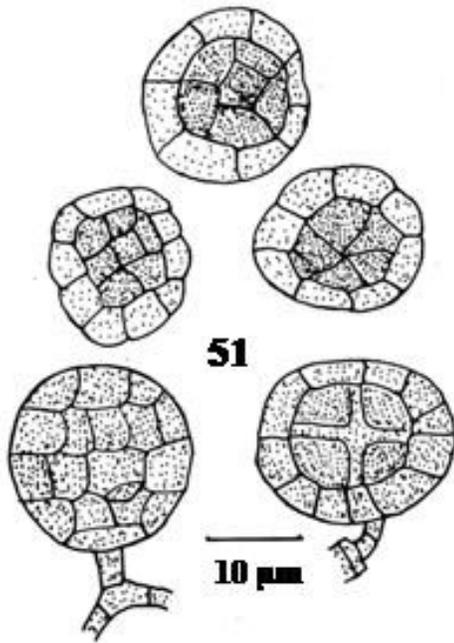
Specimen examined: I. On tendril litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, Herb. No. 30AP01. II. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 23/08/07, coll. A. Prabhugaonkar, Herb. No. 50AP01. III. On sphenocarp of *Cocos nucifera* L. Mashem, Canacona, Goa, 10/11/07, coll. A. Prabhugaonkar, Herb. No. GUBH-102AP25. IV. On sphenocarp, *Cocos nucifera* L. Morpirala, Quepem, Goa, 20/06/10, coll. A. Prabhugaonkar, Herb. No. GUBH- 453AP25.

***Kiliophora ubiensis* (Caneva & Rambelli) Kuthub. & Nawawi, *Mycotaxon* 48: 243 (1993)
(Plate X- 90; Fig. 54)**

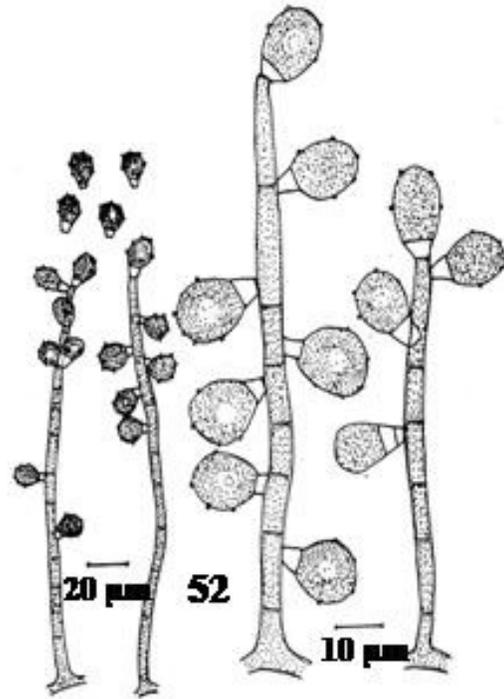
Colonies on natural substrate effuse, dark brown. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* mononematous, macronematous, erect, straight to flexuous, unbranched, septate, smooth, dark brown, setiform, 180-230 x 4.5-7 μm . *Conidiogenous cells* polytretic, discrete, sub-hyaline, globose to subglobose, 4-7 μm , formed in groups of 2-4 on the middle part of the conidiophore. *Conidia* solitary, dry, simple, acropleurogenous, smooth, subhyaline, aseptate, fusiform, 17-22 x 2.5-4 μm , forming denticle like projection at both the ends.

Specimen examined: On litter of *Calamus rotang* Linn., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar.

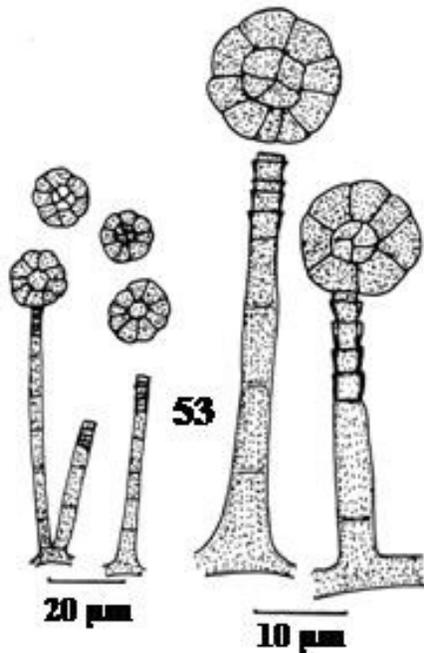
Figs. 51-53



Hermatomyces tucumanensis

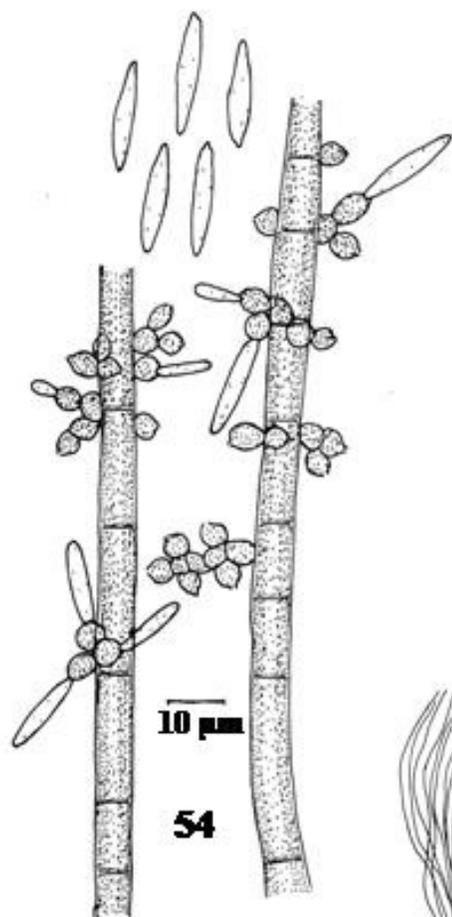


Ityorkoptrum verruculosum

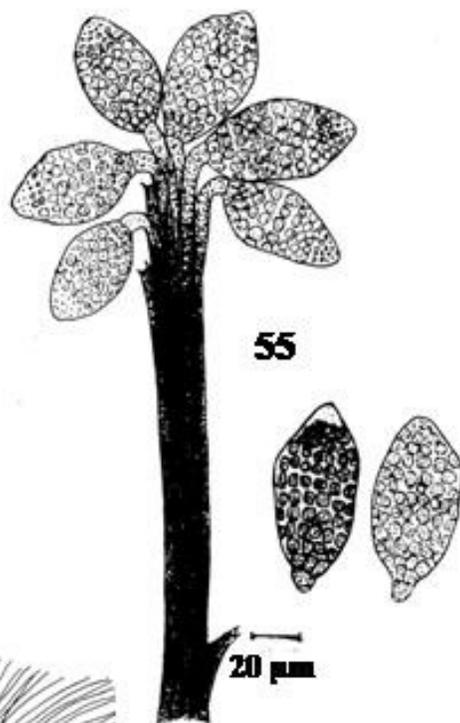


Junewangia sphaerospora

Figs. 54-56



Kiliophora ubiensis



Kostermansinda magna

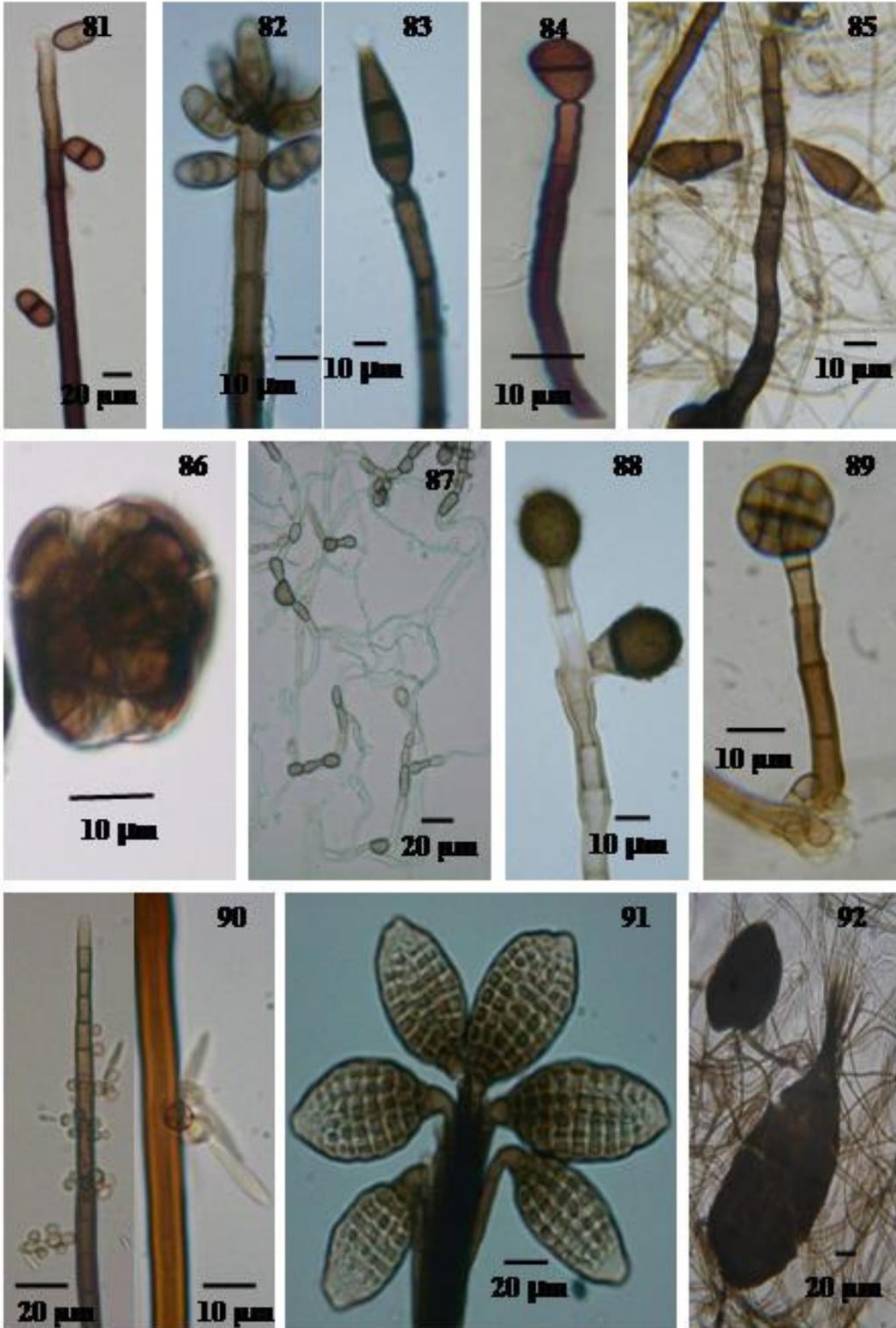


Megacapitula villosa

Plate X:

81. *Helminthosporium belgaumense*
82. *Helminthosporium* sp.
83. *Hemicorynespora mitrata*
84. *Hemicorynespora* sp.1
85. *Hemicorynespora* sp.2
86. *Hermatomyces tucumanensis*
87. *Idriella fertilis*
88. *Ityorhoptrum verruculosum*
89. *Junewangia sphaerospora*
90. *Kiliophora ubiensis*
91. *Kostermansinda magna*
92. *Megacapitula villosa*

Plate X. 81-92



Kostermansinda magna (Boedijn) Rifai, *Reinwardtia* 7: 378 (1968)

(Plate X- 91; Fig. 55)

Colonies on natural substrate effuse, dark brown, hairy. *Mycelium* immersed in the host tissue. *Conidiophores* macronematous, synnematous. Synnema erect, with the stalk consisting of compact aggregation of parallel hyphae, terminating in dark brown, fertile heads, 120-360 x 20-30 μm . *Conidiophore threads* unbranched, straight to flexuous, smooth, brown, swollen at the apex. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, 10-26 x 6-8.5 μm . *Conidia* solitary, dry, acrogenous, smooth, simple, muriform, clavate to broadly ellipsoidal, 45-85 x 30-42 μm , with light brown basal vesicle.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 07/07/07, coll. A. Prabhugaonkar, Herb. No. 2AP01. On leaf sheath litter of *Calamus thwaitesii* Becc. & Hook., Dhoothsagar, Goa, 06/02/08, coll. A. Prabhugaonkar.

Megacapitula villosa J.L. Chen & Tzean, *Mycol. Res.* 97: 347 (1993)

(Plate X- 92; Fig. 56)

Colonies on MEA growing up to 4 cm in 10 days, dark green to brown, cottony, reverse black, forming thick mat of mycelium. *Mycelium* brown, septate, 2–3 μm broad, often verruculose, forming mycelial cords from which conidia arise. *Conidiogenous cells* integrated or terminal on mycelial extensions. *Conidia* holoblastic, rounded when very young then elongating and forming a beak-like structure from which dense hairy appendages arise at maturity, mature conidia ovoid to obclavate, muriform having distinct outer wall which breaks and starts peeling off after mounting, 80–240 μm tall standing erect from mycelial mat, up to 20 to 45 μm broad at base, 60–180 μm broad at centre and 20–40 μm broad at tip from where numerous appendages arise; appendages few to many, grey to brown, smooth, up to 3 μm broad.

Specimen examined: On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, India, 3/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 131AP24; culture no. GUFCC 15515.

Molecular Phylogeny based on ITS/ 5.8S rRNA gene sequence: (Fig. 57) NCBI-GeneBank accession number JN128868

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TGGGGGAGAGAGAAAAAAAAAAAAACGCAGTGACTGCCGCGTCACAACGATCCTCCCCG
AGGAGTCACGCCCGCGGAAGCCTTTGCAGCTACTAGGTAGCAGGGTCCGAACGACTTGAA
AAACAAATCGACCCGCGTGCAAGTCGGCCTGGCGCCGGCGACGCTCTCGAATTGCGGGGA
ACCCCTAAAGCCATCCGCACCCAGCCAGCCGGGGAGAACCCGCTGGCGACGGTAACAGCC
GGATGGATGAGCCGCCCTGGCGGCGAAATGGGCGATCCGCATCGAATCCCCTACAGCCT
CGCGGGGCCATGGGGAACGTTACAGACCTGGCGGGAGCGGGTGGGGCGAACGAGCCCC
GCTCAAGATAAGGTCGGACCCCCGAGAGATCGGGGGAGGTTGGCAGCGTTCCGTAGGTG
AACCTGCGGAAGGATCATTATCGAGGAGCTTCGGCTCCATCGAGATAACACCCTTGCCCTT
ACGAGCACCTATCCGTTTCCCTCGCGGTCATCGGCCGCCAACGGGGACCCCTCAAACGCTT
TGCAATGAGAAGTAAACCGTCTGATACAAAACAAAATTATCACAACCTTCAACGATGGAT
CTCTTGGCTCTGGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAGTGTGAATTGCAG
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AATCCGTGAATCATCGAATCTTTGAACGCACATTGCGCCCTTTGGCATTCCATAGGGCAT
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CCGCGCGGACCCGCCTCAAATGCATTGGCGCGCCGCAATCCGGGCTATGAGCGCAGCA
GAATCGCGCCTCTAACC GG TAGCAGCGCTCCAGCAAGCACCTCTCCACGTTTGACCTC
GGATCAGGCAGGGTTACCCCGCTGAACTTAGACTTCCGGGGGGGGGGGGGGGGGGGG

Chen & Tzean 1993 described *Megacapitula villosa* from fallen, decayed, unidentified petiole in Taiwan. In the present study, the fungus was collected on fronds of palm *Caryota urens* from Goa, India. Blast analysis of sequence of *Megacapitula villosa* showed its much similarity with an unidentified fungal endophyte sequence (GenBank No. EU977274) isolated from an unidentified plant in Peru (Smith et al., 2008). This shows that though the fungus is collected only second time it may have much wider distribution.. ML analysis suggested that *Megacapitula villosa* has a close affinity with the members of the order *Pleosporales*, *Dothideomycetes* (Prabhugaonkar and Bhat 2011).

Melanographium citri (Gonz. Frag. & Cif.) M.B. Ellis, *Mycol. Pap.* 93: 21 (1963)
(Plate XI- 93)

Colonies on natural substrate effuse, black, hairy. *Conidiophores* fasciculate, erect, simple, straight to flexuous, septate, thick-walled, dark brown below, paler towards the apex, 50-200 x 3-5 µm. *Conidiogenous cells* polyblastic, terminal, integrated, sympodial, 26-78 x 4-6 µm. *Conidia* solitary, dry, acropleurogenous, simple, dark brown, smooth, reniform, 12-20 x 10-13 µm.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 277AP01. II. On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 26/04/09, coll. A. Prabhugaonkar, Herb. No. 354AP01.

Memnoniella echinata (Rivolta) Galloway, *Trans. Br. mycol. Soc.* 18(2): 165 (1933)

Colonies on natural substrate effuse, black. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, unbranched, straight to flexuous, sub-hyaline, darker towards the apex, verrucose, 50-115 x 2-4 µm. *Conidiogenous cells* monophialidic, discrete, determinate, clavate, verrucose, sub-hyaline, with a narrow conspicuous collarete, 7-12 x 2-3 µm. *Conidia* dry, catenate, simple, spherical, aseptate, dark brown to black, verrucose, 4-6 µm diam.

Specimen examined: Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar; culture No. GUFCC 15541.

***Memnoniella levispora* Subram., *J. Indian bot. Soc.* **33**: 40 (1954) (Plate XI- 94)**

Colonies on natural substrate effuse, black. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, unbranched, straight to flexuous, sub-hyaline, darker towards the apex, 50-100 x 2-4 µm. *Conidiogenous cells* monophialidic, discrete, determinate, clavate, verrucose, sub-hyaline, with a narrow conspicuous collarette, 10-14 x 3-4 µm. *Conidia* dry, catenate, simple, spherical, aseptate, dark brown to black, smooth, 10-12 µm diam

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 25/07/09, coll. A. Prabhugaonkar, Herb. No. 363AP01.

***Monodictys paradoxa* (Corda) S. Hughes, *Can. J. Bot.* **36**: 786 (1958) (Plate XI- 95)**

Colonies on natural substrate effuse, brown. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, 4-6 x 3-4 µm. *Conidia* solitary, dry, irregular in shape, dark brown to black, smooth, muriform, 30-65 x 20-45 µm.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 115AP01.

***Monodictys* sp. (Plate XI- 96)**

Colonies on natural substrate effuse, black. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous. *Conidiogenous cells* monoblastic. *Conidia* acrogenous, solitary, dry, smooth, dark brown to black, obovoid, muriform, 80-130 x 45-70 µm.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 21/09/07, coll. A. Prabhugaonkar, Herb. No. 63AP01.

***Monotosporella rhizoidea* V. Rao & de Hoog, *Stud. Mycol.* **28**: 6 (1986) (Plate XI- 97; Fig. 58)**

Colonies on the natural substrate effuse, black. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, erect, stiff, dark brown, smooth, thick-walled, unbranched, with rhizoids like structures at the base, septate, proliferates percurrently, 110-150 x 6-7 µm. *Conidiogenous cells* monoblastic, terminal, integrated, often with protruding downward growth from each conidiogenous cell, 7-10 x 2-4 µm. *Conidia* solitary, dry, smooth, turbinate to obovoidal, thick-walled, 2-septate, basal cell brown, terminal cell spherical, black 24-31 x 20-23 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoothasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 177AP01, 287AP01.

***Nalanthamala* sp.**

Colonies on natural substrate brownish orange. *Mycelium* immersed. Conidiophores sporodochial. Sporodochia pale brown. *Conidigenous cells* monophialidic, hyaline, smooth, 9-16 x 2-3 µm. *Conidia* catenate, hyaline, smooth, aseptate, 6-9 x 2.5-4.

Specimen examined: Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar falls Netravali, Sanguem, Goa, 30/04/08, coll. A. Prabhugaonkar, Herb. No. GUBH 222AP20.

***Nigrospora oryzae* (Berk. & Broome) Petch, *J. Indian bot. Soc.* 4: 24 (1924)**

(Plate XI- 98)

Colonies on natural substrate effuse, dark brown to black. *Mycelium* partly immersed, partly superficial, branched, septate, hyaline, 1.5-2 µm thick hyphae. *Conidiophores* micronematous to semi-macronematous, branched, flexuous, pale brown, smooth. *Conidigenous cell* monoblastic, discrete, determinate, sub-globose to globose, hyaline, non-cicatrized, 7-10 x 5-7.5 µm. *Conidia* solitary, dry, acrogenous, spherical, dorsiventrally flattened, smooth, aseptate, dark brown to black, 10-16 µm diam.

Specimen examined: I. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 72AP24. II. Isolated by Particle plating method from leaf litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 405AP19.

***Nodulisporium ochraceum* Preuss [as 'ocheraceum'], *Klotzschii Herb. Viv. Mycol.*: no. 1272 (1849)**

(Plate XI- 99)

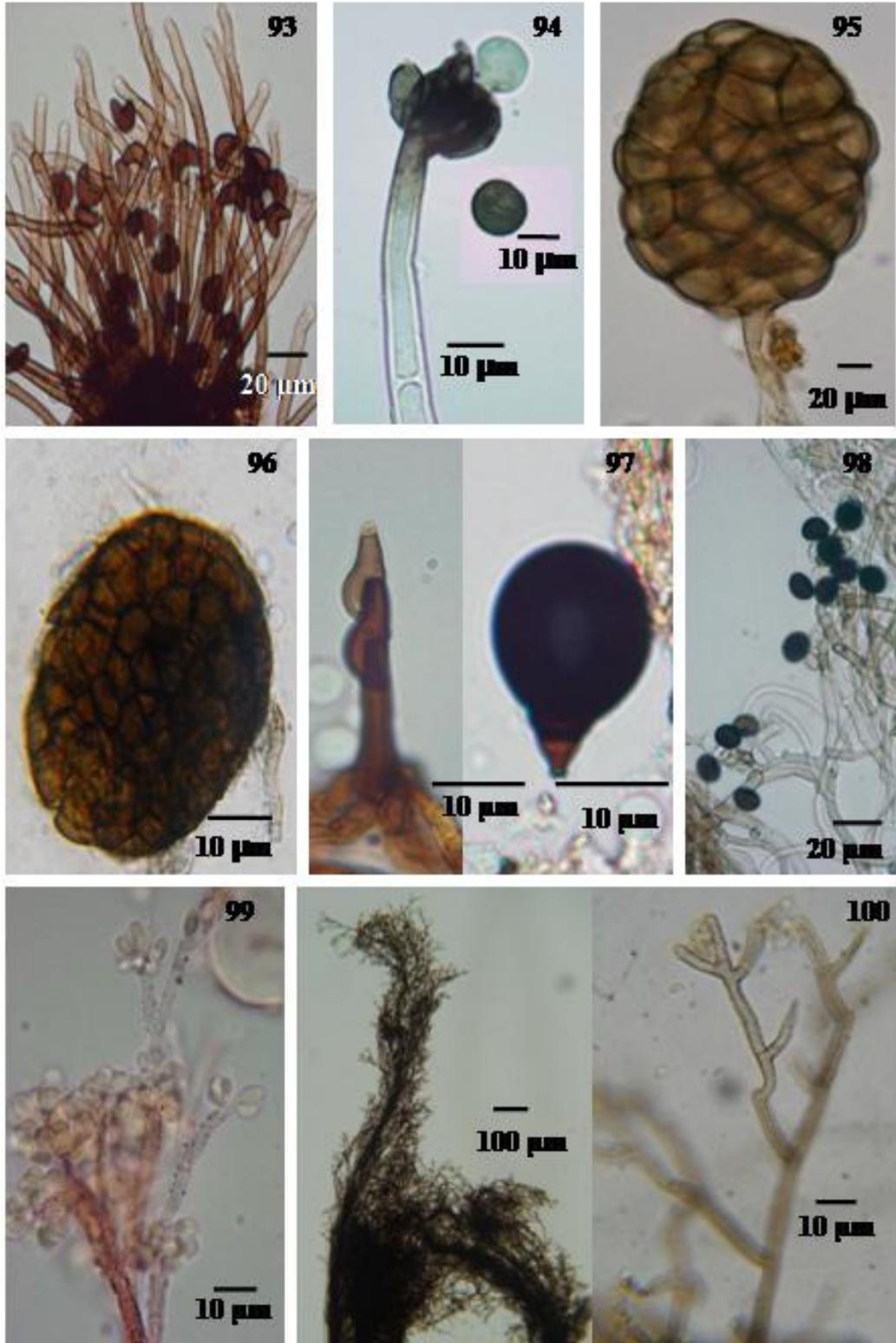
Colonies on MEA effuse, dark brown. *Mycelium* thin, smooth, hyaline, branched, septate, upto 2 µm wide. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, solitary, erect, straight to flexuous, much branched at the tip, septate, verruculose, light brown, 100-300 x 2-4 µm. *Conidigenous cells* polyblastic, terminal, determinate, cylindrical with scars, hyaline to redish brown, swollen at the upper part, ampulliform, 10-30 µm x 2-4 µm. *Conidia* solitary, subspherical, aseptate, hyaline, smooth, 3-5 µm. across.

Specimen examined: I. Isolated by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Dhoothasagar, Goa, 21/08/08, coll. A. Prabhugaonkar. II. On dead leaf lamina of *Borassus flabellifer*, Palghat, Tamilnadu, 03/02/09, coll. A. Prabhugaonkar, Herb. No. GUBH 320AP22.

Plate XI:

93. *Melanographium citri*
94. *Memnoniella levispora*
95. *Monodictys paradoxa*
- 96. *Monodictys* sp.1**
97. *Monotosporella rhizoidea*
98. *Nigrospora oryzae*
99. *Nodulisporium ochraceum*
- 100. *Nodulisporium* sp.**

Plate XI. 93-100



***Nodulisporium* sp.**

(Plate XI- 100)

Colonies on natural substrate effuse, dark brown. *Mycelium* thin, smooth, hyaline, branched, septate, 2-3 μm wide. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, solitary, erect, straight to flexuous, much branched at the tip, septate, smooth, light brown, 100-600 x 3-5 μm . *Conidiogenous cells* polyblastic, terminal, determinate, sub spherical, hyaline, swollen at the upper part, ampulliform, 7-9 μm x 3-4 μm . *Conidia* solitary, subspherical, aseptate, hyaline, smooth, 3-5 μm . across

Specimen examined: I. On dead leaf sheath of *Areca catachu*, Mashem, Canacona, Goa, 17/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 68AP26. II. On litter of *Hyphaene dichotoma* (White) Furt., Miramar, Panaji, Goa, 17/10/07, coll. A. Prabhugaonkar, Herb. No. 68AP23. III. On dead leaf sheath of *Pinnanga dicksonii*, Katlekan, near Gersoppa, Uttar Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 408AP19. IV. On dead leaf sheath of *Calamus thwaitesii*, Tambdisurla, Sanguem, Goa, 20/07/08, coll. A. Prabhugaonkar, Herb. No. 246AP01. V. Isolated by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff. Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 298AP20.

***Paecilomyces* sp.**

Colonies cottony white to greenish white when mature, fast growing. *Hyphae* hyaline, septate, mostly smooth-walled. *Conidiophores* mononematous, flexuous, much branched at tip 10-40 x 2-3 μm . *Conidiogenous cells* phialidic, terminal, cylindrical in whorls at tip of much branched conidiophores, cylindrical, broadest at base, tapering often abruptly into a long distinct neck 10-20 x 1-2 μm . *Conidia* in dry, spherical 3-5 x 2-3 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. 135AP25

***Paradictyoarthrinium diffractum* Matsush., Matsush. Mycol. Mem. 9: 18 (1996)**

(Plate XII- 101; Fig. 59)

Colonies on MEA growing up to 6 cm in 10 days, off-white to brown, becoming dark brown to black after sporulation. *Mycelium* 1-3 μm broad. *Conidiophores* macronematous, rarely micronematous, short, when macronematous showing much varied morphology, unbranched to much branched, uneven, constricted at septa, turning brown to dark brown on maturity, 10-75 x 4-5 μm , part of mature conidiophores often released along with conidia. *Conidiogenous cell* blastic, mostly terminal, 4-10 x 4-5 μm . *Conidia* 2-many unevenly dictyoseptate, circular to irregular, dark brown to black on maturity, 8-33 x 10-30 μm .

Specimen examined: On dead decaying spathe of *Cocos nucifera*, Mashem, Canacona, Goa, 2/01/07, coll. A. Prabhugaonkar, Herb. No. GUBH 136AP25; culture no. GUFCC 15514.

Molecular Phylogeny based on ITS/ 5.8S rRNA gene sequence: (Fig. 57) NCBI-GeneBank accession number JN128869

CGAACAAGGTTCCCGTAGGTGAACCTGCGGAAGGATCATTAGCGATGAAAGCCCCCTTG
AGGGGACACCCCATCACTACCCTTGCCTTTGAGTACCTTCTGTTTCCTCGGCGGGTTCGCC
CGCCAATGGGGACTAATCCCAAACCTCTTTGCAGTAGCAGTGCAGTCTGAAAAAAAAAGTAA
AACTTTTAAAACCTTTCAACAACGGATCTCTTGGTTCTGGCATCGATGAAGAACGCAGCGA
AATGCGATAAGTAGTGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCACAT
TGCGCCCTTTGGTATTCCATAGGGCATGCCTGTTGAGCGTCATTTAAACCCTCAAGCTCA
GCTTGGTGTGGGTGTTTGTCCCGCCTGCCGCGGAGGACTCGCCTCAAAAAGTATTGGCAG
CCGGAACGTTGGCTTTGAGCGCAGCAGAATAGCGCCCCTGGCCTCGTTGTCCGGTTCTCCA
GGAAGCCTGTACCTCCATGTCTTGACCTCGGATCAGGTAGGGATACCCGCTGAACTTAAAG
CATACTA

Paradictyoarthrinium diffractum was described by Matsushima in 1996 from dead plant material collected from a rivulet at Rustenbusrg in South Africa. In the present study, the fungus was collected on dead decaying spathe of *Cocos nucifera* from Goa, India. ML analysis suggested its close affinity with the members of the order *Pleosporales*, *Dothideomycetes*.

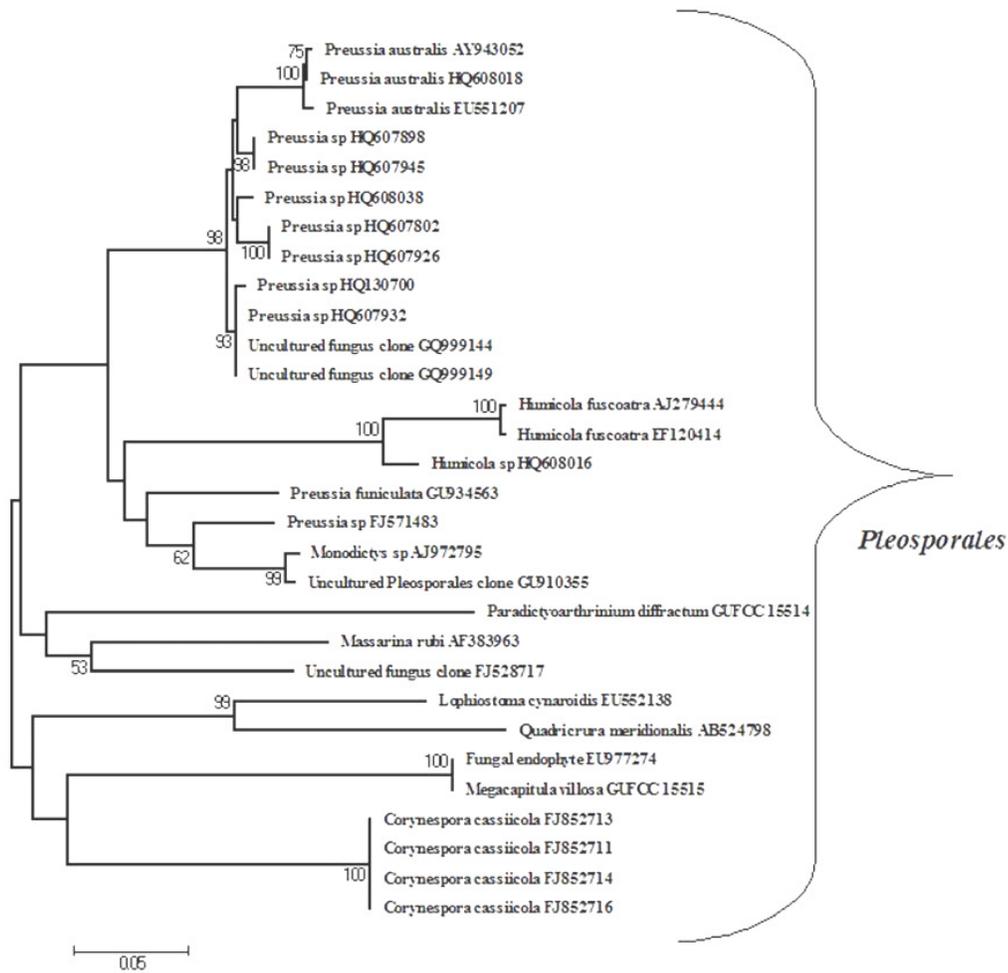


Fig 57. Phylogenetic relationships of *Paradictyoarthrinium diffractum* GUFCC 15514 and *Megacapitula villosa* GUFCC 15515 with closely related members of the *Pleosporales*, *Dothideomycetes*. The tree with the highest log likelihood (-3248.7706) is shown. The percentage of trees in which the associated taxa clustered together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically as follows: When the number of common sites was used; otherwise BIONJ method with MCL distance matrix was used (Tamura et al., 2011). A Discrete Gamma distribution was used to model evolutionary rate differences among site [5 categories (+G, Parameter = 0.4775)]. The rate variation model allowed for some sites to be evolutionarily invariable [(+I), 28.1848% sites]. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 30 nucleotide sequences. There were a total of 589 positions in the final dataset.

***Paraceratocladium seychellarum* Whitton, McKenzie & K.D. Hyde, *Fungal Diversity* 7: 177 (2001) (Plate XII- 102)**

Colonies on the natural substrate hairy, dark brown. *Mycelium* partly immersed partly superficial. Mycelium composed of septate, branched, pale brown, smooth, 1.5-2.5 μm thick hyphae. *Conidiophores* macronematous mononematous, branched, septate, flexuous, dark brown, 150-220 x 2.5-7 μm . *Conidiogenous cells*

monophialidic, discrete, collarete, pale brown, 10-14 x 2-4 μm . *Conidia* in slimy heads, aseptate, globose, hyaline, smooth, 1-2 μm diam.

Specimen examined: On litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 26/03/10, coll. A. Prabhugaonkar, Herb. No. 424AP18.

***Parahelminthosporium malabaricum* Subram. & Bhat, *Kavaka* 15(1-2): 63 (1989) [1987] (Plate XII- 103; Fig. 60)**

Colonies on natural substrate, effuse, dark brown to black. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, frequently caespitose, simple, erect, straight to slightly flexuous, slightly percurrent, septate, smooth, dark brown at base, lighter towards the apex, thick-walled, 250-350 x 7-9 μm . *Conidiogenous cells* polytretic, terminal, becoming intercalary with growth, older ones with circular, dark brown to black scars, 13-20 x 7-8 μm . *Conidia* solitary, dry, acropleurogenous, dark brown to black, smooth, 11-19 x 5-8 μm , with hyaline terminal and basal cell; terminal cell hyaline, smooth, pointed towards the apex, 5-7 x 2-3 μm .

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb. No. 299AP01. II. On leaf litter of *Phoenix acaulis* Roxb., Paroda, Quepem, Goa, 15/05/10, coll. A. Prabhugaonkar, Herb. No. GUBH 450AP30.

***Penicillium* sp. (Plate XII- 104)**

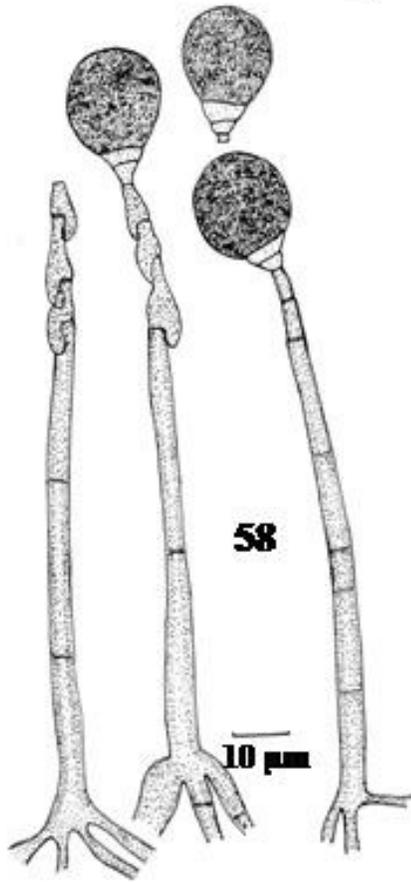
Colonies on MEA effuse, green. *Conidiophores* macronematous, mononematous, branched penicillate at tip, erect, straight to flexuous, hyaline 40-120 x 2.5-4 μm . *Conidiogenous cells* in groups of 3-4, cylindrical with short neck, monophialidic, discrete, determinate, cylindrical, narrowing in to inconspicuous collarete 10-30 x 2-3 μm . *Conidia* slightly verruculose, catenate, dry, simple, globose, smooth, aseptate, 2 μm across.

Specimen examined: Isolated by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 21/08/08, coll. A. Prabhugaonkar.

***Penicillium* sp. 1**

Colonies on MEA effuse, white, paler beneath. *Conidiophores* ter-verticillate, macronematous, mononematous, branched penicillate, erect, straight to flexuous, hyaline 40-100 x 2.5-3 μm , with slightly swollen apex. *Conidiogenous cells* in groups of 3-8, monophialidic, discrete, determinate, cylindrical, narrowing in to inconspicuous collarete, 5-9 x 1.5-2 μm . *Conidia* pale green when in masses catenate, dry, simple, globose, smooth, aseptate, 2-3 μm across.

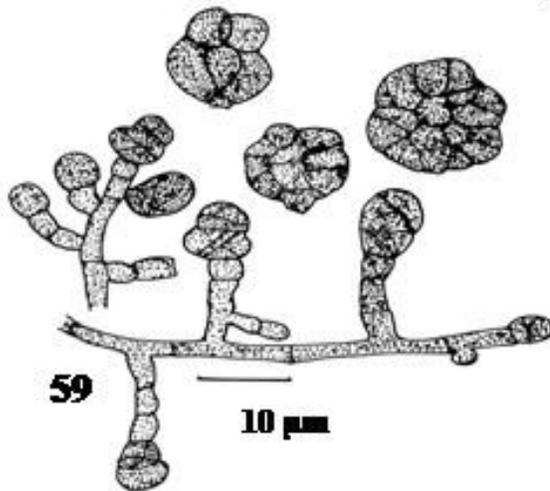
Figs. 58-60



Monotosporella rhizoides



Parahelminthosporium malabaricum



Paradictyoarthrinium diffractum

Specimen examined: Isolated by 3-step sterilisation from fresh leaves of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 406AP19.

***Penicillium* sp.2**

Colonies on MEA effuse, green with yellow green exudates. *Mycelium* partly immersed, partly superficial. *Conidiophores* macronematous, mononematous, penicillate, sub-hyaline, smooth 200-250 x 1.5-4 µm. *Metulae* 7-15 x 3-4 µm in the broadest region. *Conidiogenous cells* monophialidic, discrete, determinate, terminal, flask shaped, with a narrow apex, 7-10 x 2-2.5 µm. *Conidia* catenate, dry, sub-hyaline, simple, sub-globose, smooth, aseptate, 2-3 µm across.

Specimen examined: Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 455AP18.

***Periconia hispidula* (Pers.) E.W. Mason & M.B. Ellis, *Mycol. Pap.* 56: 112 (1953)
(Plate XII- 105)**

Colonies on natural substrate effuse, brown. *Mycelium* immersed. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, sporodochial. Sporodochia 400-500 x 200-275 µm. *Conidiophores* mononematous, brown, smooth, flexuous, terminating setiform apex, 240-280 x 5-6 µm. *Conidiogenous cells* polyblastic, discrete on stipe and branches, intercalary, 30-50 x 6-7 µm. *Conidia* catenate, in branched chains, simple, spherical, dark brown, verruculose, aseptate, 8-11 µm diam.

Specimen examined: On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 237AP21.

***Periconia* sp. (Fig 166)**

Colonies on the natural substrate effuse, dark brown to black, hairy. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, dark brown, smooth, septate, 100-190 x 5-7.5 µm. *Conidiogenous cells* monoblastic, discrete, subhyaline, globose, determinate, 5-7.5 µm diam. *Conidia* catenate, dry, simple, globose, dark brown to black, verruculose, aseptate, 7-10 µm diam.

Specimen examined: Isolated by 3-step sterilisation method from fresh leaves of, *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 17/01/09, coll. A. Prabhugaonkar.

***Phaeoisaria clematidis* (Fuckel) S. Hughes, *Can. J. Bot.* 36: 794 (1958)**

(Plate XII- 106; Fig. 61)

Colonies on natural substrate effuse, black, hairy. *Mycelium* immersed. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, synnematos. Synnema erect, straight to flexuous, dark brown, 420-825 x 15-20 µm. *Conidiophore threads* narrow, branched towards the apex, light brown, smooth, straight or flexuous, splaying out at the apex. *Conidiogenous cells* polyblastic, integrated, sympodial, denticulate, 12-25 x 2-5 µm; denticles cylindrical. *Conidia* solitary, dry, acropleurogenous, simple, ellipsoidal, hyaline, smooth, aseptate, 4-6.5 x 2-4 µm.

Specimen examined: I. On litter of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, Herb. No. 26AP01. II. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 76AP24. III. On litter of *Hyphaene dichotoma* (White) Furt., Miramar, Panaji, Goa, 29/04/08, coll. A. Prabhugaonkar, Herb. No. 200AP23. IV. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 269AP21.

***Phaeomonilia corticola* (R.F. Castañeda) R.F. Castañeda, Saikawa & M. Stadler, in Castañeda Ruíz, Heredia Abarca, Arias, Saikawa, Minter & Stadler, *Mycotaxon* 100: 332 (2007)**
(Plate XII- 107)

Colonies on natural substrate grey, effuse. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, simple, septate, erect, straight to flexuous, smooth, light brown, 80-150 x 9-11 µm. *Conidiogenous cells* polyblastic, terminal, discrete, sub-hyaline, 12-26 x 5-6 µm. *Conidia* catenate, in acropetal branched chains, hyaline, smooth, ovoid, spherical, sub-spherical, 4-8 x 4-6 µm.

Specimen examined: On litter, *Corypha umbraculifera* L., Tambraserry, near Calicut, Kerala, 30/07/08, coll. A. Prabhugaonkar, Herb. No. GUBH-257AP01.

***Phialophora cinerescens* (Wollenw.) J.F.H. Beyma, *Antonie van Leeuwenhoek* 6: 38 (1940)**
(Plate XII- 108)

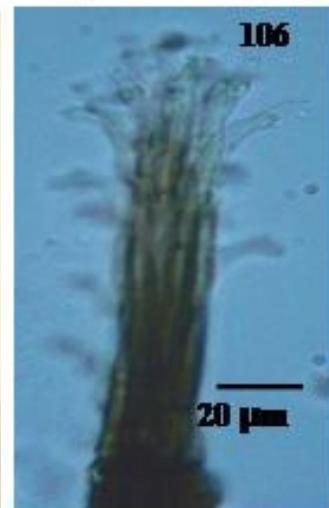
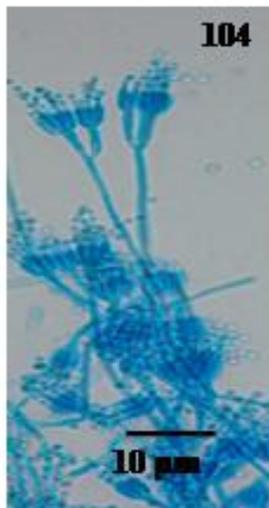
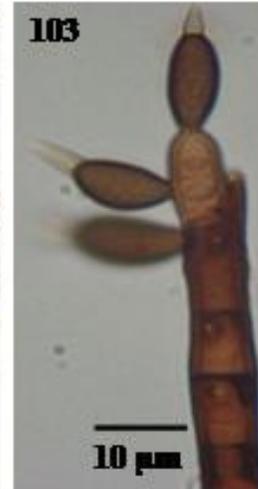
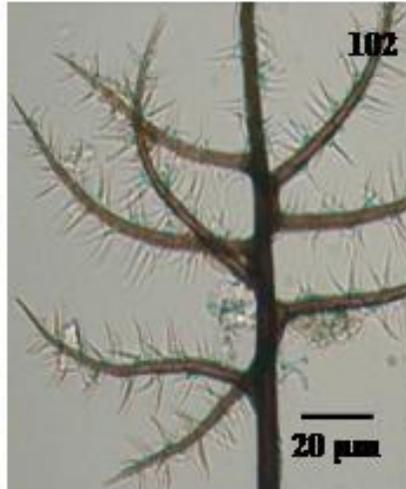
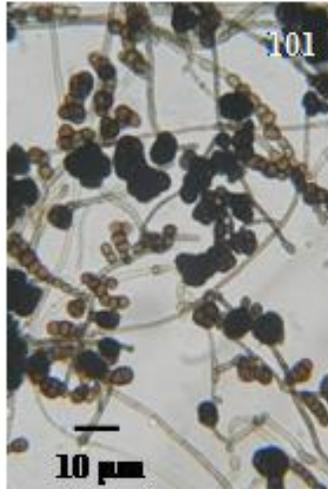
Colonies on the natural substrate effuse, dark brown. *Mycelium* comprising pale brown, smooth, septate, branched, 1.5-3 µm wide hyphae. *Conidiophores* macronematous, mononematous, branched, septate, brown, smooth, 34-50 x 2-3 µm. *Conidiogenous cells* monophialidic, discrete, terminal, with a distinct apical collarette, light brown, smooth 7-16 x 1.5-2 µm. *Conidia* formed in dense slimy heads, simple, hyaline, smooth, spherical, 1.5-2 µm diam.

Specimen examined: On dead leaf sheath of *Calamus thwaitesii*, Tambdisurla, Sanguem, Goa, 20/07/08, coll. A. Prabhugaonkar, Herb. No. 249AP01.

Plate XII:

- 101.** *Penicillium* sp.
102. *Paradictyoarthrinium diffractum*
103. *Paraceratocladium seychellarum*
104. *Parahelminthosporium malabaricum*
105. *Periconia hispidula*
106. *Phaeoisaria clematidis*
107. *Phaeomonilia corticola*
108. *Phialophora cinerescens*
- 109.** *Phialophora richardsiae*

Plate XII. 101-109



Phialophora richardsiae (Nannf.) Conant, *Mycologia* 29(5): 598 (1937)

(Plate XII- 109)

Colonies on natural substrate effuse, dark brown. *Mycelium* comprising light brown, 1.5-3 µm wide hyphae. *Conidiophores* semi-macronematous, mononematous, arising from the aerial mycelium, simple erect, unbranched or branched, smooth, brown, 30-45 x 2-3 µm. *Conidiogenous cells* monophialidic, terminal, light brown, 18-22 x 2-3 µm, with distinct very dark flaring collarettes. *Conidia* aggregated in slimy mass, hyaline, globose, 2-3 µm in diam.

Specimen examined: Isolated by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 398AP01.

Piricauda cochinchensis (Subram.) M.B. Ellis, *More Dematiaceous Hyphomycetes* (Kew): 367 (1976) (Plate XIII- 110)

Colonies on natural substrate effuse, black. *Mycelium* submerged. *Conidiophores* micronematous. *Conidiogenous cells* monotretic, terminal. *Conidia* solitary, dry, obclavate, dark brown, smooth, 45-70 x 35-65 µm, with 3-6 appendages arising from upper half of the conidia; appendages, stiff, straight to flexuous, light brown, smooth, 3-6-septate, rounded at the tip, 25-108 x 4-6.5 µm.

Specimen examined: I. On sphenocarp, *Cocos nucifera* L. Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH- 92AP25. II. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 120AP24.

Pithomyces africanus M.B. Ellis, *Mycol. Pap.* 76: 12 (1960) (Plate XIII- 111)

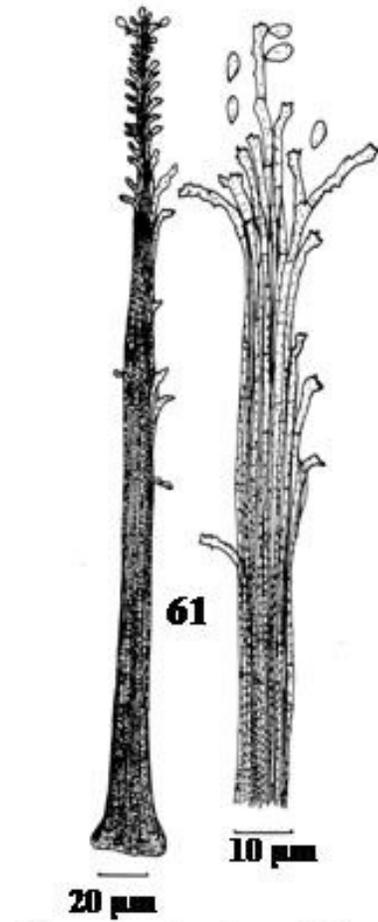
Colonies on natural substrate effuse, black. *Colonies* on MEA circular with undulate margin, cottony grayish brown, dark gray to black from behind, attaining diameter upto 4 cm in 10 days, non sporulating. *Conidiophores* mononematous, micronematous, aseptate. *Conidiogenous cells* terminal or intercalary, monoblastic, denticulate, rhexolytic, light brown, smooth 1.5 - 3.5 x .84-2.5 µm. *Conidia* solitary, dry, 1-celled, dark brown to black, smooth, obovate to oblong, 8 -13 x 5 - 7 µm.

Specimen examined: On dead leaf lamina of *Borassus flabellifer*, near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 183AP22, GUFCC 15505.

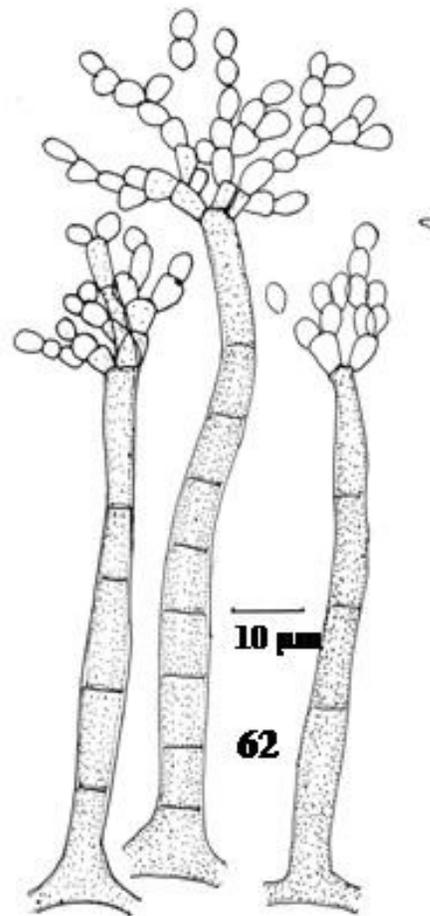
Pithomyces chartarum (Berk. & M.A. Curtis) M.B. Ellis, *Mycol. Pap.* 76: 13 (1960) (Plate XIII- 112; Fig. 63)

Colonies on MEA circular with smooth margin, flat, brown, dark brown from reverse, with aerial sporulating mycelia, attaining diameter upto 6 cm in 10 days. *Conidiophores* mononematous, micronematous, aseptate. *Conidiogenous cells* mono

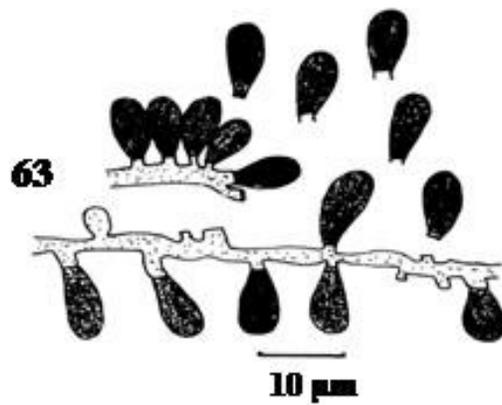
Figs. 61-63



Phaeoisaria clematidis



Phaeomonilia corticola



Pithomyces africanus

or polyblastic, denticulate, rhexolytic, light brown, smooth, 3-10 x 2-5 µm with upto 4 µm broad conidial attachment. *Conidia* solitary, dry, smooth to slightly spinulose, dark brown, obovate to oblong, with mostly 2 longitudinal and one vertical or oblique septa, 16-24 x 7.5-14 µm.

Specimen examined: I. On litter of *Hyphaene dichotoma* (White) Furt., Miramar, Panaji, Goa, 29/04/08, coll. A. Prabhugaonkar, Herb. No. 198AP23. II. Isolated by 3-step sterilization from fresh leaves of *Pinanga dicksonii*, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. 404AP19, GUFCC15506.

Pithomyces ellisii V.G. Rao & Chary, Curr. Sci. 41: 822 (1972)

(Plate XIII- 113; Fig. 64)

Colonies on natural substrate effuse, black. *Colonies* on MEA cottony, brown, dark brown from reverse, margin smooth, attaining diameter upto 6 cm in 10 days. *Conidiophores* mononematous, micronematous, aseptate. *Conidiogenous cells* terminal, monoblastic, denticulate, rhexolytic, light brown, smooth 5-10 X 5-8 µm. *Conidia* solitary, dry, unevenly dictyoseptate, dark brown to black, smooth, obovate to oblong, beaked at the tip, 19-47 x 7-19 µm.

Specimen examined: I. On dead sheathes of *Pinanga dicksonii*, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb No. GUBH 384AP19, GUFCC15507, II. On dry leaf sheathes of *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 13/01/08, coll. A. Prabhugaonkar, Herb. No. GUBH 152AP01.

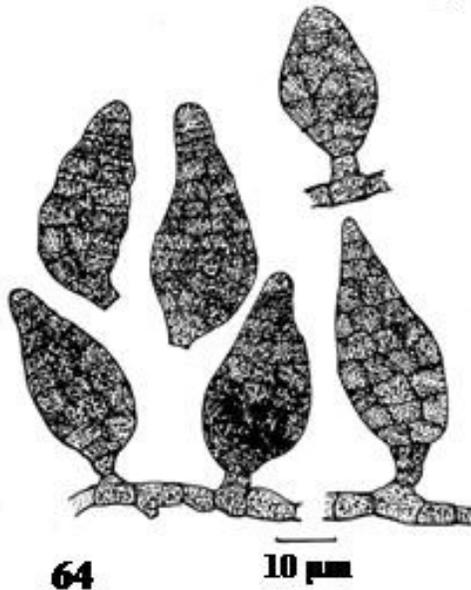
Pithomyces flavus Berk. & Broome J. Linn. Soc. Bot. 14:100 (1873-75)

(Plate XIII- 114; Fig. 65)

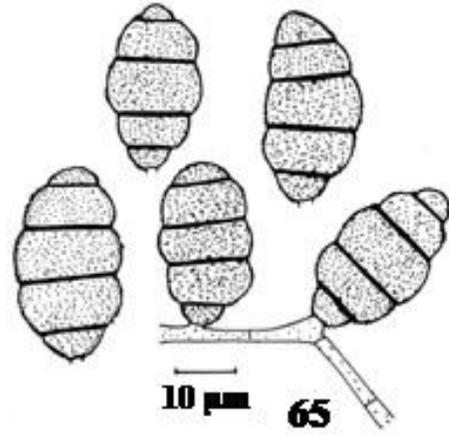
Colonies on natural substrate effuse, cottony with yellow thick mat of aerial mycelium. *Colonies* on MEA circular, cottony at center, flat and spreading outside, dark brown with yellow slightly verruculose mycelia producing the conidia, dark brown on reverse, margin circular, attaining a diameter upto 4 cm in 10 days. *Conidiophores* mononematous, micronematous, aseptate. *Conidiogenous cells* terminal as well as intercalary, mono or polyblastic, denticulate, rhexolytic, light brown, smooth, with upto 3.3 µm broad conidial attachment. *Conidia* solitary, dry, dark brown to black, obovate to oblong, verruculose to spinulose with 3-5 mostly 4 longitudinal dark septa, 24-38 x 14-24 µm.

Specimen examined: I. On dry leaf sheathes of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 22/08/07, coll. A. Prabhugaonkar, Herb. No. GUBH 52AP01, GUFCC15508. II. On litter of *Caryota urens* L., Satre, Sattari, Goa, 13/01/08, coll. A. Prabhugaonkar, Herb. No. 150AP24. III. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08. coll. A. Prabhugaonkar, Herb. No. 238AP21.

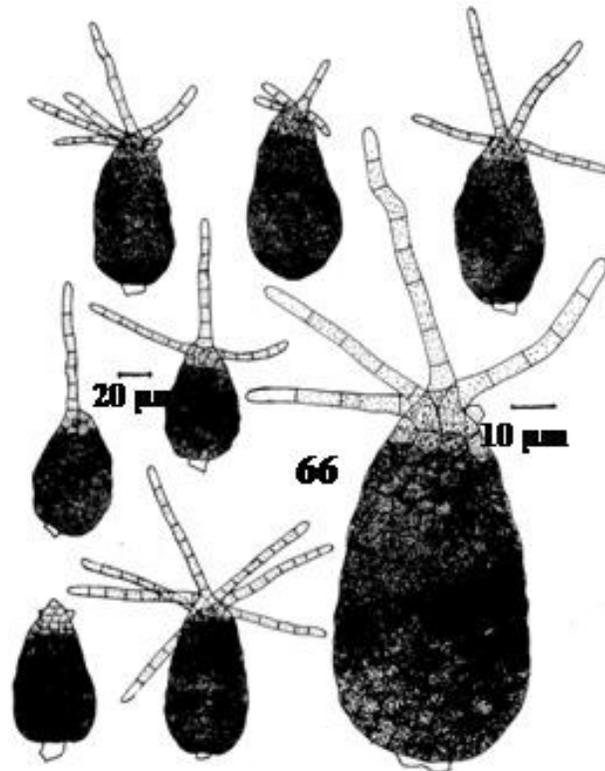
Figs. 64-66



64
Pithomyces ellisii



65
Pithomyces flavus



66
Pithomyces multiappendiculata sp. nov.

***Pithomyces multiappendiculata* Prabhug. & Bhat sp. nov. (Plate XIII- 115; Fig. 66)**

Colonies on natural substrate effuse cottony brown. *Colonies* on MEA circular with entire margin, cottony, brown, dark brown from beneath, upto 3 cm diameter in 10 days. *Conidiophores* mononematous, micronematous, aseptate. *Conidiogenous cells* intercalary or denticulate, monoblastic, rhexolytic, light brown smooth. *Conidia* solitary, dry, 2 celled, dark brown to black, verruculose, obovate 4.5- 11 x 2.5 - 4.5 μm .

Specimen examined: I. On spatha, *Cocos nucifera*. Mashem, Canacona, Goa, 10/11/07, coll. A. Prabhugaonkar, Herb. No.100AP01, GUFCC15502. II. On litter of *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 15/10/09, coll. A. Prabhugaonkar, Herb. No. 358AP01.

***Pithomyces* sp. 1 (Plate XIII- 116)**

Colonies on MEA circular with smooth margin, flat, brown, dark brown from reverse, with aerial sporulating mycelia, attaining diameter upto 3 cm in 10 days. *Conidiophores* mononematous, micronematous, aseptate. *Conidiogenous cells* monoblastic, denticulate, rhexolytic, light brown, smooth. *Conidia* solitary, dry, smooth, dark brown, obovate to oblong, 1- septate, 5-10 x 2.5-4.5 μm .

Specimen examined: On spatha, *Cocos nucifera*, Mashem, Canacona, Goa, 10/11/07, coll. A. Prabhugaonkar, Herb. No. 102AP01, GUFCC15503.

***Pithomyces* sp. 2**

Colonies on natural substrate effuse, light brown, superficial, dry. *Colonies* on MEA circular to irregular, flat, dark brown to black, slow growing, attaining upto 2 cm diam. in 10 days. *Conidiophores* mononematous, micronematous, 2-3 septate, hyaline. *Conidiogenous cells* monoblastic, rhexolytic, hyaline, smooth, 4-11 x 3-13 μm . *Conidia* solitary, dry, unevenly dictyoseptate, sometimes slightly twisted, dark brown to black, smooth, obovate to oblong, rounded at apex, 65-200 x 23-50 μm .

Specimen examined: On dry bark of unidentified palm, near Dhoodhsagar water falls, Goa, 23/12/2010, coll. A. Prabhugaonkar, Herb No. 452AP01, GUFCC15504.

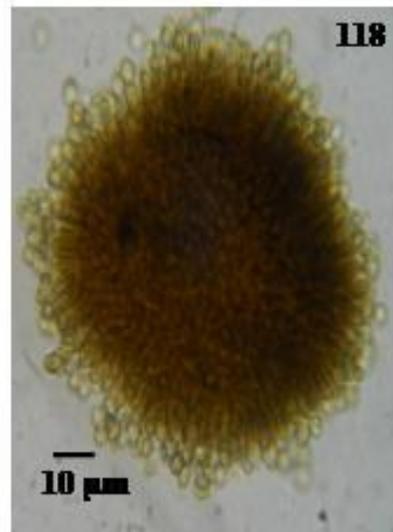
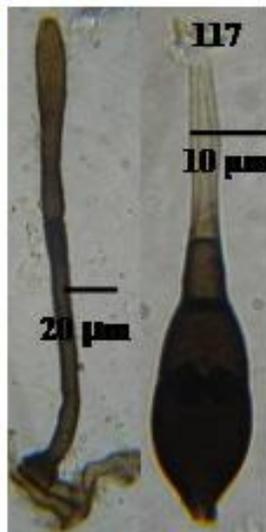
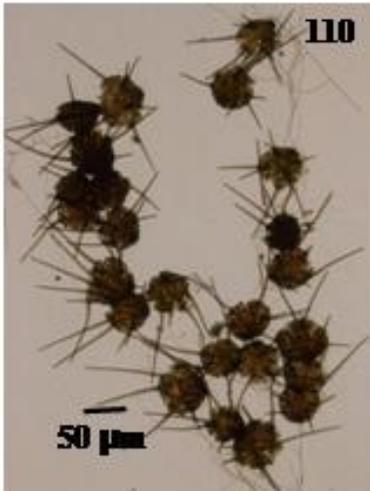
***Pseudoepicoccum cocos* (F. Stevens) M.B. Ellis, *Dematiaceous Hyphomycetes* (Kew): 270 (1971) (Plate XIII- 118)**

Leaf spots brown, with zonate blackened centres and yellow margins, up to 1 cm diam. *Sporodochia* punctiform, dark brown, 90-110 x 50-75 μm diam. *Stroma* superficial, hemispherical, brown, pseudoparenchymatous. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, straight or slightly flexuous,

Plate XIII:

- 110. *Piricauda cochinensis*
- 111.** *Pithomyces africanus*
- 112. *Pithomyces chartarum*
- 113. *Pithomyces ellisii*
- 114. *Pithomyces flavus*
- 115.** *Pithomyces multiappendiculata* sp. nov.
- 116.** *Pithomyces* sp.
- 117.** *Prathigada sundara*
- 118. *Pseudoepicoccum cocos*

Plate XIII. 110-118



unbranched, septate, pale brown, smooth 13-18 x 3-4 μm . *Conidiogenous cells* integrated, terminal, sympodial, cicatrized, 3-5 x 3-4 μm . *Conidia* solitary, dry, aseptate, simple, acropleurogenous, subspherical, pale brown, minutely verruculose, 3-5.5 x 2.5-3 μm .

Specimen examined: On leaf spots of *Cocos nucifera* L., Mashem, Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 193AP25.

***Pyriculariopsis* sp.**

(Plate XIV- 119)

Colonies on the substrate effuse, grey. *Mycelium* immersed. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, unbranched, smooth, thick-walled, dark brown, paler towards the apex, 80-175 x 4-5.5 μm . *Conidiogenous cells* polyblastic, integrated, terminal becoming intercalary, sympodial, denticulate. 20-40 x 4-7 μm . *Conidia* solitary, dry, acropleurogenous, simple, straight to slightly curved, obclavate, rostrate, smooth, mostly 1-5-septate, subhyaline, intermediate, pale brown, 25-55 μm long, 6-10 μm wide at the centre and base, 2-3 μm wide at the tip.

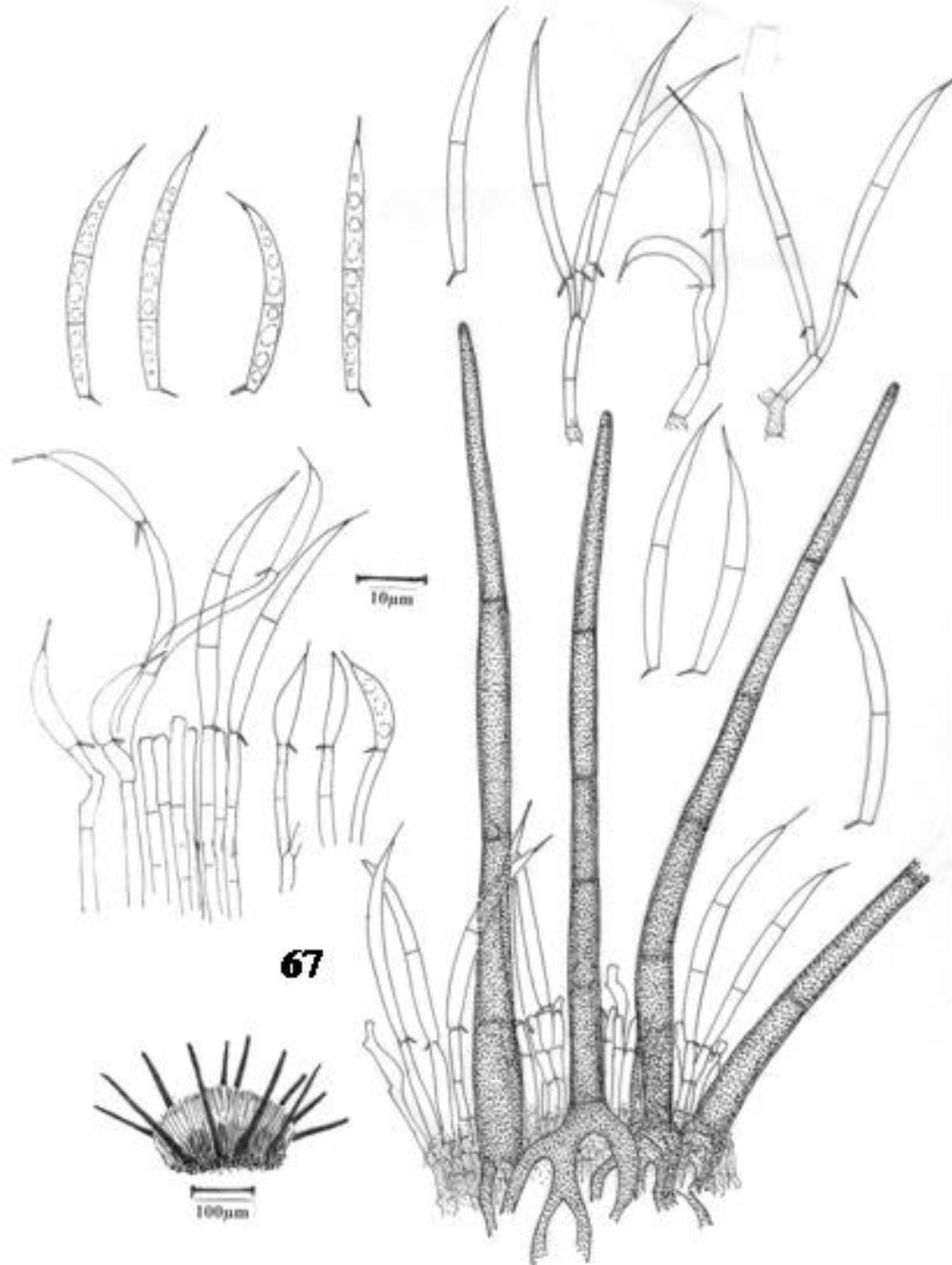
Specimen examined: On litter of *Elaeis guineensis* Jacq., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 341AP31.

***Rattania setulifera* Prabhug. & Bhat, Mycotaxon, 108:220 (209)**

(Plate XIV- 120; Fig. 67)

Colonies on the substrate effuse; on MEA slow growing, effuse, flat, with fringed margin, granular, pale orange, up to 3 cm diam. In 10 days. *Sporodochia* superficial, gregarious, scattered on leaf pieces placed on MEA, dark brown, setose, with dark brown stromatic base, 160-490 x 100-450 μm . *Setae* unbranched, erect, straight to flexuous, rhizoidal at the base, tapering towards apex into an acute tip, smooth, 2-6-septate, unbranched, thick-walled, walls up to 1 μm wide, dark brown, 85-370 μm long, 4-13 μm wide at base, 3-10 μm wide in middle. *Conidiophores* arising from the stroma, branched, hyaline, forming dense clusters, up to 30 μm tall. *Conidiogenous cells* terminal, integrated or discrete, usually monoblastic, sometimes extending sympodially once or twice to produce successive solitary holoblastic conidia, each extension about 4-8 μm long, after secession leaving an inconspicuous, flat secession scar with no evident wall thickening, 3-13 x 1.5-2.5 μm . *Conidia* slimy, solitary, fusiform, truncate at the base, acuminate at the tip, hyaline, smooth, thin-walled, 0-5 (mostly 1-2) septate, 25-50 μm long, 1.5-3.5 μm wide at base and

Fig. 67



middle; setulate at both ends, setula at the base attached to one side, 1–3 µm long, at the apex 2–5 µm long.

Specimen examined: Isolated by by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 21/08/08, coll. A. Prabhugaonkar, Herb. No. HCIO 48776; ex type culture No. GUFCC 15501. II. Isolated by by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 183AP01.

***Scolecobasidium* sp. 1**

Colonies on MEA flat, mycelium thin up to 2 µm wide. *Conidiophores* mononematous, macronematous to micronematous, smooth unbranched, 5-13 x 1-2 µm. *Conidiogenous cells* terminal or intercalary denticulate on main hyphae, polyblastic, denticles upto 3 µm long. *Conidia* solitary, ovate to obovate, rounded at both ends, often 1 septate with constriction at the septa 5-8 x 1-3 µm.

Specimen examined: I. Isolated by Particle plating method from litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 25/07/09, coll. A. Prabhugaonkar, Herb. No. 363AP01. II. Isolated by 3-step sterilization from fresh leaves of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 410AP19.

***Sorocybe resinae* (Fr.) Fr., *Summa veg. Scand.*, Section Post. (Stockholm): 468 (1849)**

Colonies on natural substrate effuse, black, hairy. *Mycelium* immersed. *Conidiophores* macronematous, synnematos. Synnema erect, dark brown to black, 890-910 x 25-65 µm. *Conidiophores* threads pale brown, smooth, branched. *Conidiogenous cells* polyblastic, integrated, terminal, intercalary, denticulate, 6-8 x 3-4 µm. *Conidia* dry, catenate, in branched chains, smooth, aseptate, simple, oval to subspherical, with scars, brown, 4-7 x 3-5 µm.

Specimen examined: On dead leaf lamina of *Borassus flabellifer*, near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 183AP22.

***Spegazzinia parkeri* Sivasith., *Trans. Br. Mycol. Soc.* **62**(2): 427 (1974)**

(Plate XIV- 121; Fig. 68)

Colonies on natural substrate, effuse, dense entangled conidiophores. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Basal cell* cup shaped, arising laterally or terminal on mycelia 4-6 x 3-5 µm. *Conidiophores* of arthric type, tubular 50-90 x 1-2 µm with single terminal conidia. *Conidia* 4-celled with small apendicular projections 12-25 µm.

Specimen examined: On dead decaying spathe and fronds of *Cocos nucifera* L., Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. 82AP25.

***Spiegazzinia tessartha* (Berk. & M.A. Curtis) Sacc., *Syll. Fung.* (Abellini) 4: 758 (1886) (Plate XIV- 122)**

Colonies on natural substrate, effuse, dark brown composed of dense entangled conidiophores arising from cup shaped basal cells. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Basal cell* cup shaped, arising laterally or terminal on mycelia 4-6 x 3-5 µm. *Conidiophores* of arthric type, tubular 50-90 x 1-2 µm with single terminal conidia. *Conidia* 6-8 celled with small apendicular projections 8-20 µm.

Specimen examined: On leaf litter of *Phoenix acaulis* Roxb., Paroda, Quepem, Goa, 14/08/09, coll. A. Prabhugaonkar, Herb. No. GUBH 371AP30.

***Spondylocladiopsis aseptata* Pratibha, Raghuk. & Bhat, *Mycotaxon* 107: 387 (2009)**

Colonies on MEA circular to semi-circular, dark green, flat, reverse black, margin serrated, attaining a diam. of 2 cm in 10 days. *Stroma* none. *Setae* absent, but apex of the conidiophores sterile and setiform. *Hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, smooth, branched at the basal region, brown, with a light brown to sub-hyaline, sterile apex, 45-115 x 2.5-5 µm. *Conidiogenous cells* polyblastic, discrete, borne directly on the conidiophore or on short branches of 1-4 supporting cells, denticulate, light brown, 4.5-8 x 3-6 µm. *Conidia* dry, solitary, smooth, sub-hyaline, 0-septate, cylindrical to fusiform, rounded at both ends, 13.5-23 x 2-4 µm.

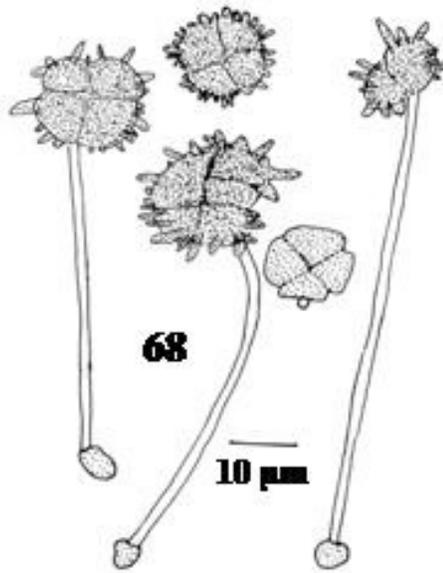
Specimen examined: On litter of *Calamus rotang* Linn., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. GUFCC 15572.

***Sporidesmiella claviformis* P.M. Kirk, *Trans. Br. mycol. Soc.* 79(3): 479 (1982) (Plate XIV- 123; Fig. 69)**

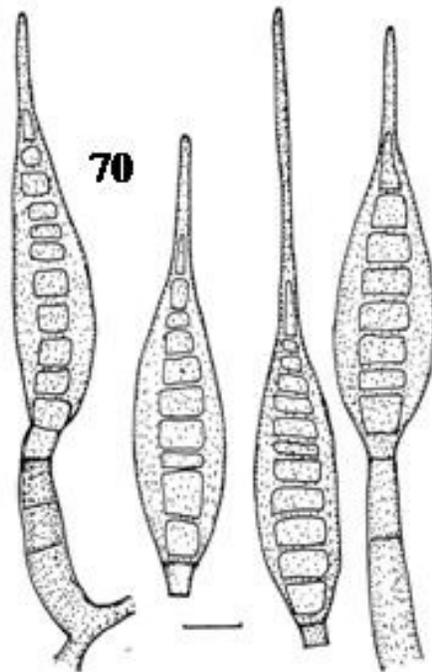
Colonies on natural substrate effuse, light brown. *Mycelium* immersed in the host tissue. *Stroma* none. *Setae* absent and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, smooth, unbranched, brown, with percurrently proliferating annelations, 95-170 x 3-5.5 µm. *Conidiogenous cells* monoblastic, terminal, integrated, light brown, percurrent with 10-19 annelations, 2-4 µm wide. *Conidia* dry, solitary, smooth, light brown, obovate, 0-3-distoseptate, truncate at the base, rounded at the apex, 9-17 µm long, 3-4.5 µm at base, 4-8.5 µm at tip.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 282AP01.

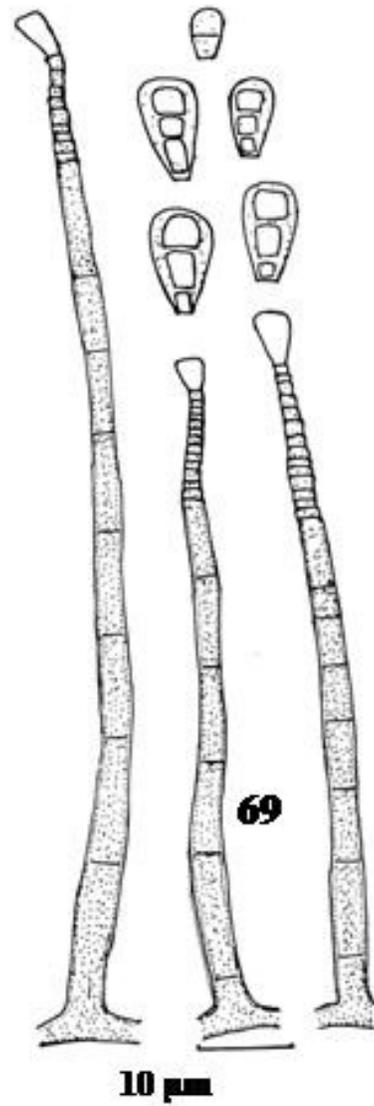
Figs. 68-70



Spogazzinia parkeri



Sporidaesmium sp.



Sporidaesmiella claviformis

***Sporidesmium ghanaense* M.B. Ellis, *Mycol. Pap.* 70: 50 (1958) (Plate XIV- 124)**

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed in the host tissue. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, smooth, unbranched, dark brown, 87-125 × 5-7.5 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, smooth, light brown, 22-25 × 5-8 µm. *Conidia* dry, solitary, smooth, 3-distoseptate, truncate at the base, pointed at the apex, light brown, 45-55 µm long, 10-13 µm broad at the base, 2-3 µm broad at the tip.

Specimen examined: On leaf litter of *Phoenix acaulis* Roxb., Paroda, Quepem, Goa, 14/08/09, coll. A. Prabhugaonkar, Herb. No. GUBH 372AP30.

***Sporidesmium paradecorosum* Dulym., W.P. Wu & Peerally, *Mycoscience* 39(3): 290 (1998) (Plate XIV- 125)**

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed in the host tissue. Stroma none. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, smooth, unbranched, dark brown, 50-60 × 4-6 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, smooth, light brown, 10-13 × 4-5 µm. *Conidia* dry, solitary, smooth, 8-10-distoseptate, truncate at the base, pointed at the apex, light brown, 25-40 × 5-10 µm.

Specimen examined: On litter, *Elaeis guineensis* Jacq. Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 348AP31.

***Sporidesmium* sp. (Plate XIV- 126; Fig. 70)**

Colonies on natural substrate effuse, light brown. *Mycelium* immersed in the host tissue. Stroma none. Setae absent and hyphopodia absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, smooth, light brown, 4-5 × 2-3 µm. *Conidia* dry, solitary, smooth, 10-20-distoseptate, truncate at the base, rounded at the apex, dark brown, 100- 160 × 11-15 µm.

Specimen examined: On litter, *Caryota urens* L. & Hook., Virajpet, Madikeri, Karnataka, 20/09/07, coll. A. Prabhugaonkar, Herb. No. 61AP24.

***Sporidesmium* sp1.**

Colonies on natural substrate effuse, light brown. *Mycelium* immersed in the host tissue. Stroma none. Setae absent and hyphopodia absent. *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, smooth,

unbranched, brown, 40-50 × 6-8 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, smooth, light brown, 12-19 × 4-6 µm. *Conidia* dry, solitary, smooth, 7-12-distoseptate, truncate at the base, pointed at the apex, light brown, 70-120 µm long, 4-6 µm broad at the base, 14-19 µm broad at the centre, tapering to 2-4 µm at the tip.

Specimen examined: I. On litter, *Calamus thwaitesii*, Netravali, Sanguem, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 127AP01. II. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 275AP01.

***Sporidesmium* sp. 2**

(Fig. 71)

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed in the host tissue. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* semi-macronematous, mononematous, erect, straight to flexuous, septate, smooth, unbranched, dark brown, 10-20 × 4-6 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, smooth, light brown. *Conidia* dry, solitary, smooth, distoseptate, truncate at the base, pointed at the apex, light brown, 75-175 × 7-12 µm.

Specimen examined: On litter, *Caryota urens* L. & Hook., Virajpet, Madikeri, Karnataka, 20/09/07, coll. A. Prabhugaonkar, Herb. No. 62AP24.

***Sporoschisma mirabile* Berk. & Broome**, in Berkeley, *Gard. Chron.*, London: 540 (footnote) (1847) **(Plate XIV- 127; Fig. 72)**

Colonies on natural substrate effuse, black, hairy. *Mycelium* immersed. *Stroma* none. *Setae* in groups of 2-3, mixed with conidiophores, capitate, swollen at the apex, smooth, dark brown, 160-310 × 6-9 µm. *Hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, dark brown, smooth, swollen at the base, cylindrical, 240-350 µm long, 23-26 µm wide at the swollen part, 10-12 µm wide at the cylindrical neck. *Conidiogenous cells* monophialidic, integrated, terminal, determinate. *Conidia* endogenous, catenate, simple, smooth, cylindrical, truncate at both the ends, 3-septate, pale brown with darker septa, 32-68 × 10-13 µm.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 19/11/07, coll. A. Prabhugaonkar, Herb. No. 108AP01. II. On dead and decaying fronds of *Caryota urens* L., Bondla, Ponda, Goa, 19/11/07, coll. A. Prabhugaonkar, Herb. No. GUBH 108AP24. III. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 192AP01. IV. On litter, *Arenga wightii* Griff. & Hook., Netravali, Sanguem, Goa, 25/07/09, coll. A. Prabhugaonkar, Herb. No. 361AP20. V. Dead leaf sheathes and rachids of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 389AP19. VI. On litter, *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 442AP18.

***Stachybotrys kampalensis* Hansf., Proc. Linn. Soc. London 155: 45 (1943) [1942-43]
(Plate XIV- 128; Fig. 73)**

Colonies on natural substrate effuse, black, hairy. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, solitary, erect, straight to flexuous, septate, smooth, sub-hyaline, bearing a group of phialides at the apex, 25-60 x 2.5-4.5 µm. *Conidiogenous cells* monophialidic, terminal, discrete, in a group of five, sub-hyaline, smooth, thick-walled, 7-11 x 4-6 µm. *Conidia* solitary, simple, dark brown to black, aseptate, oblong, rounded at both the ends, verrucose, in slimy black heads at the tip of phialide, 6-10.5 x 3-5 µm.

Specimen examined: Isolated by Particle plating method from litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 417AP19.

***Stachybotrys nephrospora* Hansf., Proc. Linn. Soc. London 155: 45 (1943) [1942-43]**

Colonies on MEA white, turning black on maturity with profuse sporulation. *Conidiophores* mononematous, macronematous, smooth, hyaline 80-100 x 2-4 µm. *Conidiogenous phialides* in the group of 3-4 at the tip of conidiophore, 5-10 x 3-6 µm. *Conidia* reniform, black, smooth 8-10 x 4-5 µm.

Specimen examined: On spatha, *Cocos nucifera* L. Mashem, Canacona, Goa, 10/11/07, coll. A. Prabhugaonkar, Herb. No. GUBH- 99AP25.

***Stigmina palmivora* (Sacc.) S. Hughes, Mycol. Pap. 49: 13 (1952)
(Plate XIV- 129; Fig. 74)**

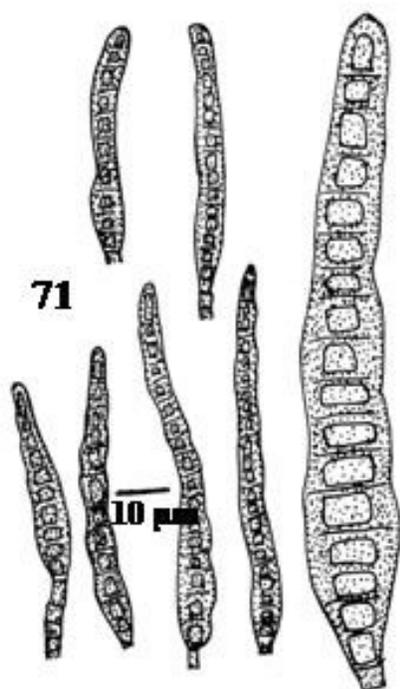
Colonies on natural substrate punctiform, brown. *Mycelium* mostly immersed. *Stroma* superficial, dark brown, pseudoparenchymatous, 42-110 x 30-85 µm. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, sporodochial, unbranched, straight or flexuous, brown, smooth. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, 12-28 x 4.5-7 µm. *Conidia* solitary, dry, acrogenous, simple, clavate to cylindrical, rounded at the apex, truncate at the base, brown, smooth, echinulate, 7-16-septate, 55-90 x 5.5-10.5 µm.

Specimen examined: I. On fresh leaves of *Hyphaene dichotoma* (White) Furt., Miramar, Panaji, Goa, 16/10/07, coll. A. Prabhugaonkar, Herb. No. 66AP23. II. On dead leaf lamina of *Borassus flabellifer*, near Bambolim beach, Goa, 21/07/10, coll. A. Prabhugaonkar.

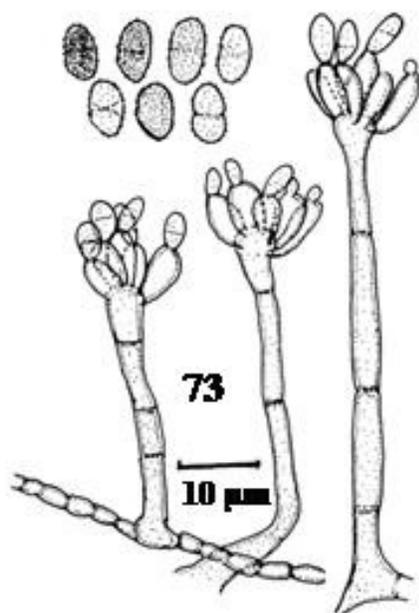
***Stilbella* sp. (Plate XV- 130)**

Colonies on natural substrate effuse, grayish, shiny. *Mycelium* immersed. *Conidiophore* synnematous. *Synnema* erect, dark brown at the base, paler towards the

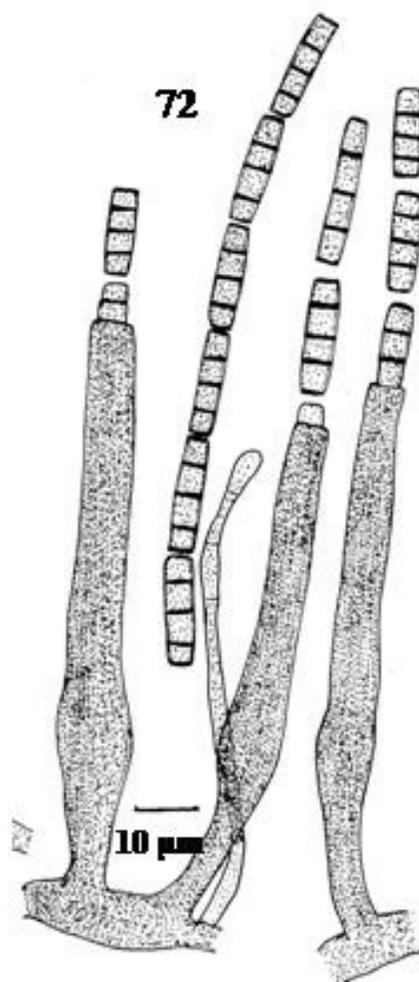
Figs. 71-33



Sporidesmium sp. 2



Stachybotrys kampalensis



Sporoschisma mirabile

apex, 100-230 x 37-45 μm . *Individual thread* septate, smooth, branched, subhyaline. *Conidiogenous cells* monophialides, terminal, determinate. *Conidia* aggregated in slimy heads, aseptate, hyaline, smooth, 12-16 x 1.5-2 μm .

Specimen examined: I. On sphenocarp litter of *Cocos nucifera* L., Mashem, Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 225AP25. II. On dead leaf sheath of *Areca catechu*, Mashem, Canacona, Goa, 17/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 314AP26. III. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 473AP18.

***Tetraploa aristata* Berk. & Broome, *Ann. Mag. nat. Hist.*, Ser. 2 5: 459 (1850)
(Plate XV- 131; Fig. 75)**

Colonies on natural substrate effuse, black, hairy. *Mycelium* superficial, composed of branched, septate, hyaline, smooth, 1.5-2.5 μm thick hyphae. *Conidiophores* micronematous, mononematous, pale brown. *Conidiogenous cells* monoblastic, terminal, integrated, determinate. *Conidia* solitary, dry, developing in 4 columns of cells each ending in a terminal appendage, finely verruculose, muriform, euseptate, brown, 22-35 x 14-25 μm ; appendages setiform, septate, pale brown, smooth, 25-110 x 3-4.5 μm .

Specimen examined: On leaf litter of *Phoenix acaulis* Roxb., Paroda, Quepem, Goa, 14/08/09, coll. A. Prabhugaonkar, Herb. No. GUBH 373AP30.

***Tetraploa* sp.**

Colonies on natural substrate effuse, black, hairy. *Mycelium* superficial, composed of branched, septate, hyaline, smooth, dark brown, 1.5-2.5 μm thick hyphae. *Conidiophores* micronematous, mononematous, pale brown. *Conidiogenous cells* monoblastic, terminal, integrated, determinate. *Conidia* solitary, dry, developing in 4 columns of cells each ending in a terminal appendage, verruculose, muriform, septate, brown, 27-38 x 17-22 μm ; appendages setiform, septate, pale brown, smooth, 15-127 x 2-3 μm .

Specimen examined: On sphenocarp, *Cocos nucifera* L. Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH- 95AP25.

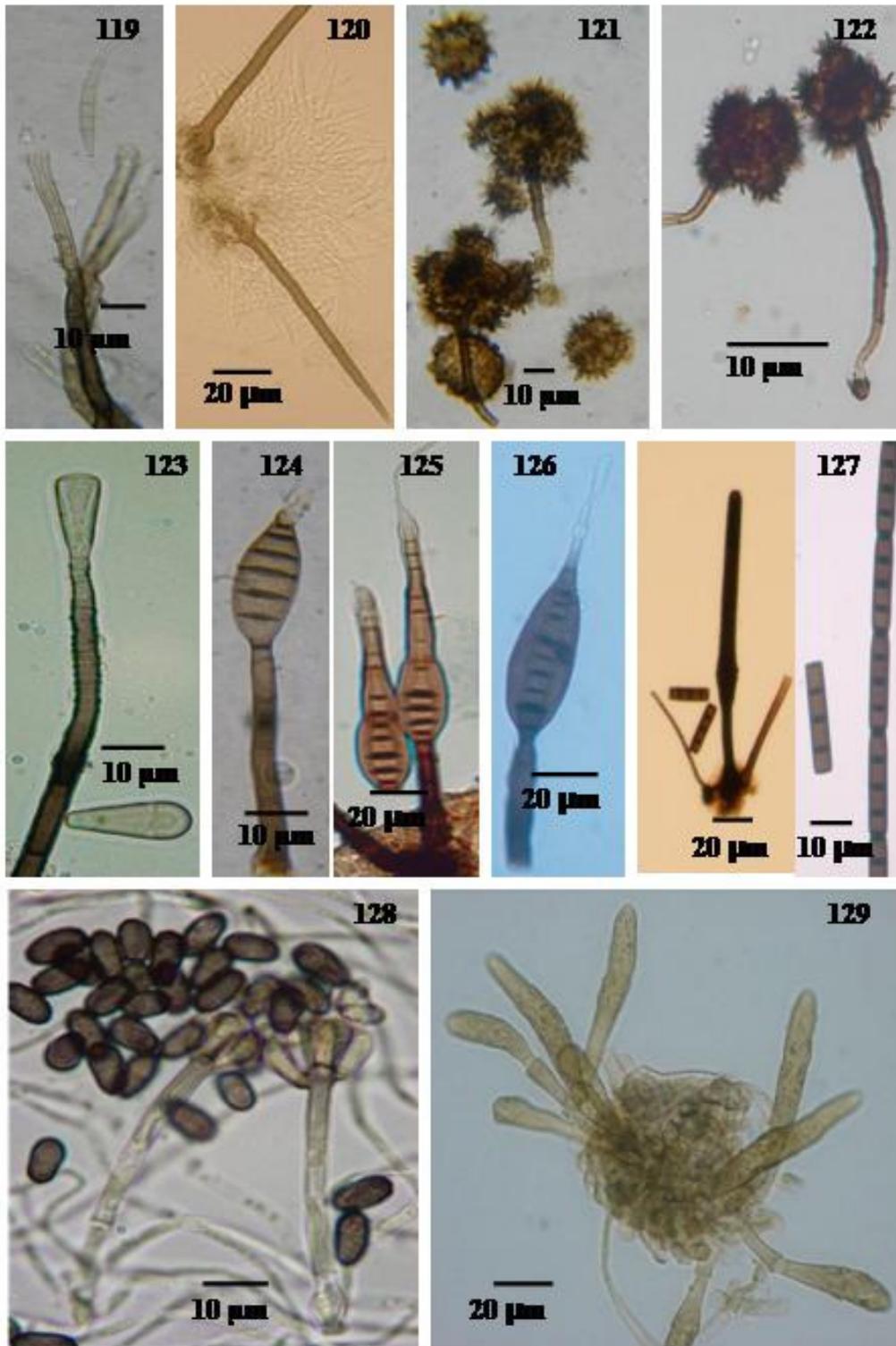
***Thozetella tocklaiensis* (Agnihotr.) Piroz. & Hodges, *Can. J. Bot.* 51(1): 171 (1973)
(Plate XV- 132)**

Colonies on natural substrate effuse, off-white. *Mycelium* immersed. Setae and hyphopodia absent. *Conidiophores* macronematous, sporodochial. *Sporodochia* 140-160 x 100-120 μm . *Conidiogenous cells* monophialidic, integrated, determinate, terminal. *Conidia* simple, falcate, aseptate, smooth, hyaline, with one appendage at both the ends, 23-25 x 3-4 μm .

Plate XIV:

- 119.** *Pyriculariopsis* sp.
- 120.** *Rattania setulifera*
- 121. *Spegazzinia parkeri*
- 122. *Spegazzinia tessarthra*
- 123.** *Sporidesmiella claviformis*
- 124. *Sporidesmium ghanaense*
- 125.** *Sporidesmium* sp.
- 126.** *Sporidesmium* sp.
- 127. *Sporoschisma mirabile*
- 128. *Stachybotrys kampalensis*
- 129.** *Stigmina palmivora*

Plate XIV. 119-129



Specimen examined: I. On litter, *Caryota urens* L. & Hook., Vengurla, Sidhudurg, Maharashtra, 07/09/07, coll. A. Prabhugaonkar, Herb. No. 55AP24. II. On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Ponda, Goa, 13/09/07, coll. A. Prabhugaonkar, Herb. No. 112AP01. Isolated by Particle plating method from litter of *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar, Sanguem, Goa, 06/01/08, col. A. Prabhugaonkar.

***Torula herbarum* (Pers.) Link, Mag. Gesell. naturf. Freunde, Berlin 3(1-2): 19 (1809) (Plate XV- 133)**

Colonies on natural substrate effuse, dark green, velvety. *Mycelium* partly immersed, partly superficial, composed of smooth, septate, branched, light brown, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* semi-macronematous, mononematous, solitary, smooth, thick walled, brown, septate, unbranched, 6-10 x 3-4 µm. *Conidiogenous cells* polyblastic, integrated, determinate, verrucose. *Conidia* catenate, dry, in branched chains, thick-walled, dark brown to black, ellipsoidal, rounded at both ends, 1-3-septate, constricted at the septum, verrucose, 18-27.5 x 4-7 µm, constricted at the septa.

Specimen examined: On sphaete litter, *Cocos nucifera* L., Mashem, Canacona, Goa, 13/03/08, coll. A. Prabhugaonkar, Herb. No. 243AP25.

***Trichoderma harzianum* Rifai, Mycol. Pap. 116: 38 (1969)**

Colonies on MEA white to olivaceous green. *Mycelium* profusely branched, septate, hyaline, smooth, 2.5-3 µm wide. *Conidiophores* macronematous, mononematous, branched at right angles to the main axis forming primary and secondary branches, straight to flexuous, hyaline, smooth, up to 100 µm long, 2-2.5 µm. *Conidiogenous cells* monophialidic, discrete, hyaline, verticillate, in groups of 2-3, terminal, lageniform, 12-20 x 2-2.5 µm. *Conidia* in green slimy heads, simple, spherical smooth, aseptate, sub-hyaline, 2.5-4 µm in diam.

Specimen examined: I. Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 03/12/07, coll. A. Prabhugaonkar, Herb No. 145AP20. II. Isolated by by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 399AP01.

***Trichothecium roseum* (Pers.) Link, Mag. Gesell. naturf. Freunde, Berlin 3(1-2): 18 (1809) (Plate XV- 134)**

Colonies on natural substrate white, cottony. *Mycelium* partly immersed, partly superficial, composed of hyaline, thin walled, branched, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, fasciculate, erect, straight to slightly flexuous, smooth, unbranched, septate, hyaline, 50-550 x 3-5 µm. *Conidiogenous cells* monoblastic, integrated,

terminal, hyaline, 20-32 x 3-4 μm . *Conidia* solitary, simple, hyaline, smooth, 0-1-septate, rounded at the apex, truncate at the base, 17-22 x 8-12 μm .

Specimen examined: I. On litter, *Areca catechu* L. Satre, Sattari, Goa, 31/01/08, coll. A. Prabhugaonkar, Herb. No. 322AP26. II. Isolated by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Dhoothsagar, Goa, 17/01/09, coll. A. Prabhugaonkar.

***Triposporium elegans* Corda, *Icon. fung.* (Prague) 1: 16 (1837)**

(Plate XV- 135; Fig. 76)

Colonies on natural substrate effuse, black, hairy. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, erect, unbranched, straight to flexuous, brown, smooth, 55-80 μm long, 5.5-7 μm broad at the base, 3-5 μm broad at the apex. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, 9-15 x 3-5 μm . *Conidia* solitary, dry, acrogenous, branched, smooth, septate, 8-22 x 8-10 μm ; conidial arms dark brown near the centre of the conidium, subhyaline at the tip, 42-50 x 5-8.8 μm .

Specimen examined: On litter, *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 438AP18.

***Vanakripa gigaspora* Bhat, W.B. Kendr. & Nag Raj, *Mycotaxon* 49: 77 (1993)**

(Plate XV- 136)

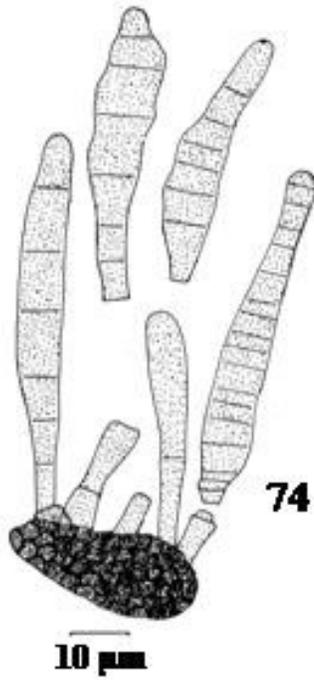
Colonies on natural substrate sporodochial, punctiform, scattered, black. *Mycelium* partly immersed, partly superficial, composed of smooth, hyaline septate, branched, 2-3 μm wide hyphae. *Conidiophores* macronematous, simple, indistinct, borne on superficial hyphae. *Conidiogenous cells* monoblastic, integrated, terminal, colourless, curved, 15-37.5 x 3-5 μm , narrow at the base and broad at the apex. *Conidia* acrogenous, ovoid to broadly fusiform, smooth, brown to dark brown, aseptate, rounded at the tip, truncate at the base, 7-10 x 4-6 μm .

Specimen examined: On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 230AP21.

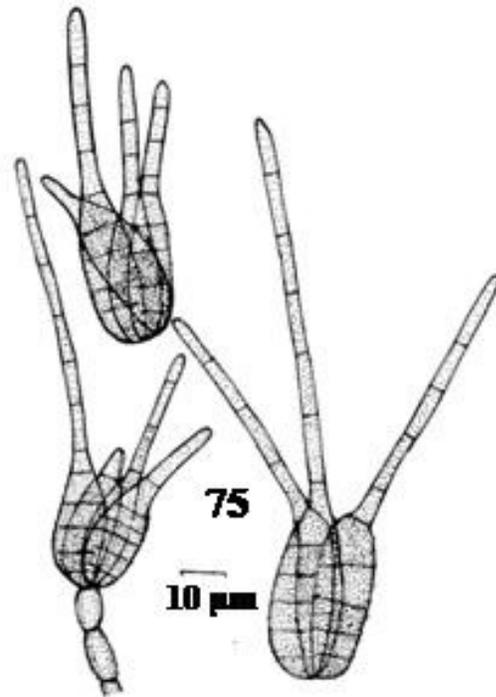
***Vanakripa parva* Bhat, W.B. Kendr. & Nag Raj, *Mycotaxon* 49: 77 (1993) (Fig. 77)**

Colonies on natural substrate effuse, black. *Mycelium* partly immersed, partly superficial, composed of smooth, hyaline septate, branched, 2-3 μm wide hyphae. *Sporodochia* punctiform, scattered, black. *Conidiophores* macronematous, simple, indistinct, borne on superficial hyphae. *Conidiogenous cells* monoblastic, integrated, terminal, colourless, curved, obpyriform, 12-35 x 5-8 μm . *Conidia* acrogenous, ovoid

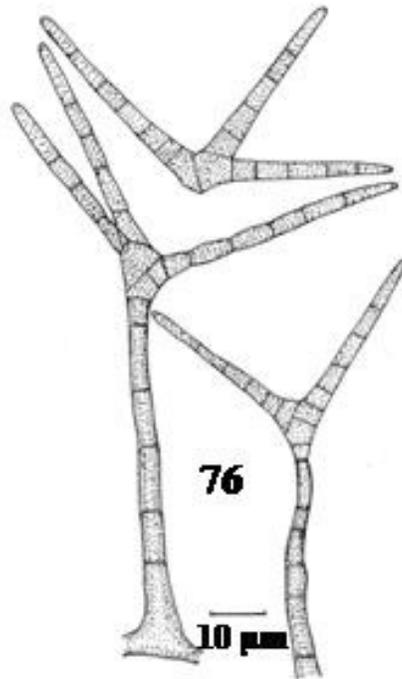
Figs. 74-76



Stigmina palmivora



Tetraploa aristata



Triposporium elegans

to broadly fusiform, smooth, brown to dark brown, aseptate, rounded at the tip, truncate at the base, 23-30 x 14-22 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 26/07/07, coll. A. Prabhugaonkar, A. Herb. No. 27AP01.

***Vanakripa* sp. 1**

Colonies on natural substrate effuse, black. *Mycelium* partly immersed, partly superficial, composed of smooth, hyaline septate, branched, 2-3 μm wide hyphae. Sporodochia punctiform, scattered, black. *Conidiophores* macronematous, simple, indistinct, borne on superficial hyphae. *Conidiogenous cells* monoblastic, integrated, terminal, colourless, obpyriform, 50-60 x 10-15 μm . *Conidia* acrogenous, ovoid to broadly fusiform, smooth, brown to dark brown, aseptate, rounded at the tip, truncate at the base, 30-50 x 22-25 μm .

Specimen examined: On litter, *Elaeis guineensis* Jacq., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 349AP31.

***Vermiculariopsiella elegans* Kesh. Prasad, D'Souza & Bhat 2003 (Plate XVI- 137)**

Colonies on natural substrate effuse, off-white to pitch. *Mycelium* partly immersed, partly superficial, composed of branched, septate, hyaline, smooth, 2-3 μm thick hyphae. *Stroma* none. *Setae* erect, straight to flexuous, unbranched, dark brown, septate, smooth, thick-walled, 140-180 x 4-6 μm . *Conidiophores* sporodochial, semi-macronematous, smooth, septate, branched, hyaline, 25-50 x 2.5-5 μm . *Conidiogenous cells* monophialidic, integrated, determinate, terminal, 10-16 x 2-3 μm . *Conidia* glioid, smooth, aseptate, cylindrical, rounded at both ends, aseptate, hyaline, 18.5-25 x 7-9 μm .

Specimen examined: I. Isolated by by 3-step sterilisation method from fresh leaves of *Calamus thwaitesii* Becc. & Hook., Dhoothsagar, Goa, 21/08/08, coll. A. Prabhugaonkar. II. Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 11/08/09, coll. A. Prabhugaonkar, Herb. No. 302AP20.

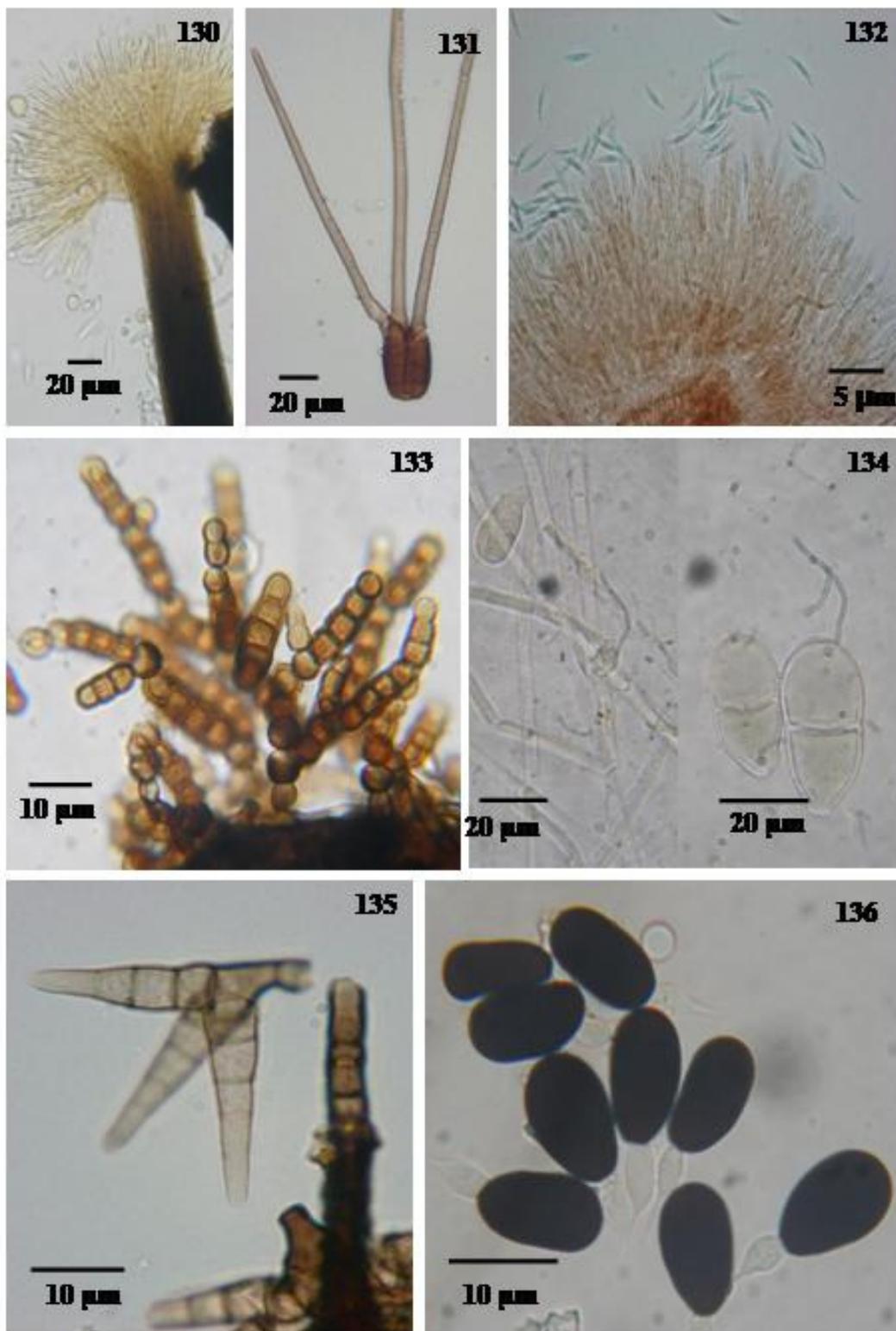
***Vermiculariopsiella parva* Kesh. Prasad, D'Souza & Bhat, (2003) (Plate XVI- 138)**

Colonies on natural substrate effuse, off-white to pale brown. *Mycelium* partly immersed, partly superficial, composed of branched, septate, hyaline, smooth, 2-3.2 μm thick hyphae. *Stroma* present, dark, pseudoparenchymatous. *Setae* unbranched, dark brown to black, paler towards the apex, smooth, 87-126 x 2.5-5 μm . *Conidiophores* semi-macronematous, sporodochial. Sporodochia scattered. Individual threads branched from base, straight to flexuous, sub-hyaline, smooth. *Conidiogenous*

Plate XV:

- 130. *Stilbella* sp.
- 131. *Tetraploa aristata*
- 132. *Thozetella tocklaiensis*
- 133. *Torula herbarum*
- 134.** *Trichothecium roseum*
- 135. *Triposporium elegans*
- 136. *Vanakripa gigaspora*

Plate XV. 130-136



cells monophialidic, integrated or discrete, determinate, terminal, 15-35 x 6-8 μm .
Conidia solitary, cylindrical, rounded at both ends, smooth, aseptate, hyaline, 22-30 x 7-10 μm .

Specimen examined: I. Isolated by by 3-step sterilisation method of fresh leaves, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 254AP21. II. Isolated by by 3-step sterilisation method from fresh leaves of *Arenga wightii* Griff., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb. No. 331AP20.

***Veronaea indica* (Subram.) M.B. Ellis, *More Dematiaceous Hyphomycetes* (Kew):**
209 (1976) **(Plate XVI- 139)**

Colonies on natural substrate effuse, brown. *Mycelium* partly superficial, partly immersed composed of dark brown, smooth, 1-2.5 μm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, branched, straight or flexuous, brown at the base, light brown at the apex, smooth, 40-60 x 3-4.5 μm . *Conidiogenous cells* polyblastic, terminal and intercalary, sympodial, smooth, light brown, straight or flexuose, geniculate, 15-30 x 3-4 μm . *Conidia* solitary, dry, acropleurogenous, subhyaline, smooth, 0-1-septate, 5-8 x 2-3 μm .

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. 168AP01. II. On Sphathe litter, *Cocos nucifera* L., Puttur, Karnataka, 20/11/07, coll. D. J. Bhat, Herb. No. GUBH-110AP25. III. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 168AP01. IV. On dead leaf sheath, *Calamus thwaitesii*, Tambdisurla, Sanguem, Goa, 20/07/08, coll. A. Prabhugaonkar, Herb. No. 248AP01. V. Isolated by by 3-step sterilisation method from fresh leaves of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. GUBH 418AP18.

***Verticimonosporium diffractum* Matsush., *Microfungi of the Solomon Islands and Papua-New Guinea* (Osaka): 68 (1971)** **(Fig. 78)**

Colonies on natural substrate, effuse. *Mycelium* immersed. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* mononematous, erect, straight to flexuous, unbranched, septate, smooth, hyaline, forming a distinct head at nodes, 325-400 x 2-3 μm . *Conidiogenous cells* formed in whorled around swollen nodes, mono-phialidic, terminal as well as intercalary, hyaline, smooth, rounded at the base, tapering towards the tip, 6-10 μm long, 2-3.5 μm broad. *Conidia* solitary, simple, hyaline, spherical, smooth, aseptate, 5-6 μm in diam.

Specimen examined: On litter, *Calamus* Becc. & Hook., Netravali, Sanguem, Goa, 15/02/07, coll. A. Prabhugaonkar, Herb. No. GUBH-172AP01.

***Verticillium* sp.**

(Plate XVI- 140)

Colonies on natural substrate effuse, white, hairy. *Mycelium* partly immersed, partly superficial, composed of sub-hyaline, smooth, branched, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, solitary, erect, straight to flexuous, smooth, unbranched, septate, pale olivaceous at the base, sub-hyaline towards the apex, bearing a group of phialides at the nodal region in verticils, 220-300 x 2-4 µm. *Conidiogenous cells* monophialidic, discrete, arranged verticillately at the upper part of conidiophore, ampulliform, hyaline, smooth, 15-35 x 2-2.5 µm. *Conidia* aggregated in slimy heads at the tip of phialide, simple, semi-endogenous, smooth, aseptate, hyaline, 5-6 x 3-4 µm.

Specimen examined: I. Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar falls Netravali, Sanguem, Goa, 30/04/08, coll. A. Prabhugaonkar. II. On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 26/04/09, coll. A. Prabhugaonkar, Herb. No. GUBH-220AP01.

***Virgaria nigra* (Link) Nees, Nat. Arr. Brit. Pl. (London) 1: 553 (1817) [1816-17]**

(Plate XVI- 141; Fig. 79)

Colonies on natural substrate effuse, dark brown. *Mycelium* partly immersed, partly superficial, composed of sub-hyaline, smooth, branched, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* macronematous, mononematous, branched, straight to flexuous, light brown, smooth, 70-155 x 2.5-4 µm. *Conidiogenous cells* polyblastic, integrated, terminal sympodial, cylindrical, denticulate, 12-20 x 2-4 µm. *Conidia* solitary, dry, acropleurogenous, simple, reniform, pale brown, smooth, aseptate, 3-5 x 2-4 µm.

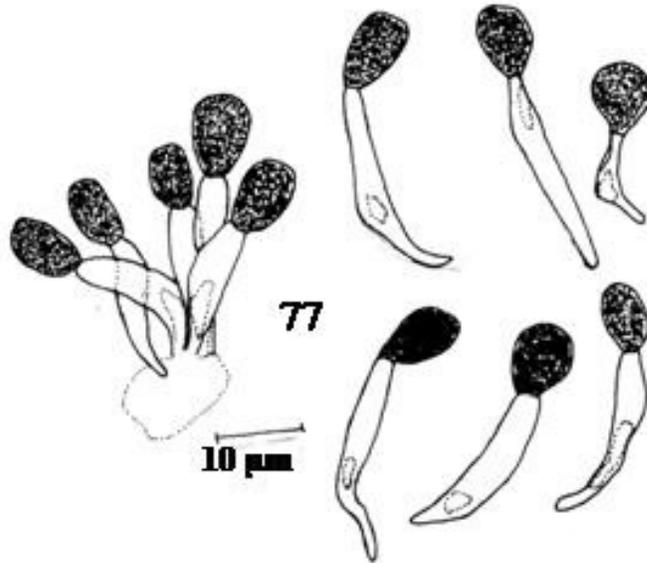
Specimen examined: On litter, *Arenga wightii* Griff. & Hook., Netravali, Sanguem, Goa, 20/10/09, coll. A. Prabhugaonkar, A. Herb. No. 380AP20.

***Volutella gilva* (Pers.) Sacc., *Michelia* 2(no. 7): 298 (1881)**

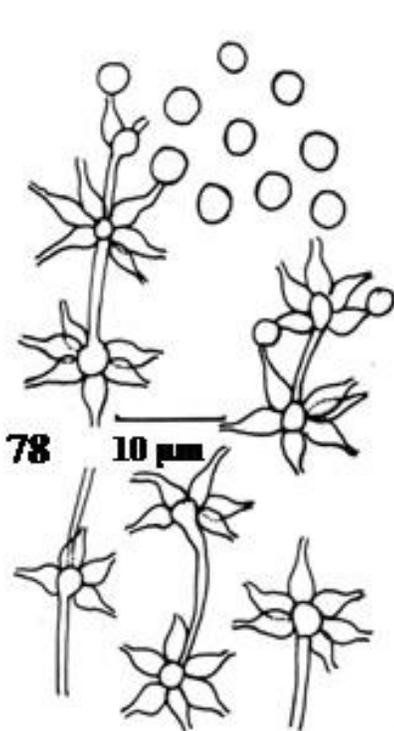
Colonies on natural substrate effuse, white. *Mycelium* partly immersed, partly superficial, composed of sub-hyaline, smooth, branched, septate, 2-3 µm wide hyphae. *Stroma* none. *Setae* erect, straight to slightly flexuous, hyaline, smooth, septate, unbranched, 175-350 x 2-3 µm. *Hyphopodia* absent. *Conidiophores* sporodochial. *Conidiogenous cells* monophialidic, discrete, hyaline, smooth, 10-15 x 2-3 µm. *Conidia* aggregated in slimy heads at the tip of phialide, simple, smooth, aseptate, hyaline, 4-6 x 2-3 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 23/08/07, coll. A. Prabhugaonkar, Herb. No. 51AP01.

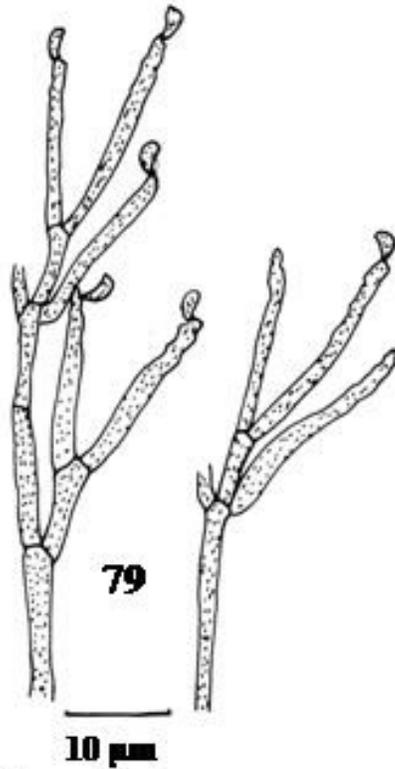
Figs. 77-79



Vanakripa parva



Verticimonosporium diffractum



Virgaria nigra

***Wardomyces* sp.**

(Plate XVI- 142)

Colonies on natural substrate effuse, black. *Mycelium* mostly superficial comprising of light brown, septate, smooth, 1.5-2 µm wide hyphae. *Stroma* none. *Setae* and *hyphopodia* absent. *Conidiophores* semi-macronematous, mononematous, scattered, straight or flexuous, subhyaline, smooth, branched, 20-40 x 2-3 µm. *Conidiogenous cells* polyblastic, discrete, determinate. *Conidia* solitary, dry, acropetrogenous, ellipsoidal, rounded at the apex, dark brown, smooth, aseptate, 8-12 x 4-5 µm.

Specimen examined: I. Isolated by 3-step sterilisation method, *Calamus thwaitesii* Becc. & Hook., Malapuzha, near Calicut, Kerala, 30/07/08, coll. A. Prabhugaonkar, Herb. No. GUBH-263AP01. II. Isolated by Particle plating method from litter of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 420AP19. III. Isolated by 3-step sterilisation method from fresh leaves of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 435AP18.

***Wiesneriomyces javanicus* Koord., Verh. K. ned. Akad. Wet., 2 Sectie 13(4): 246 (1907)**

Colonies on natural substrate effuse, off white. *Mycelium* immersed. *Stroma* none. *Setae* erect, straight to slightly flexuous, unbranched, dark-brown to black, thick-walled, smooth, septate, 100-270 x 4-6 µm. *Conidiophores* semi-macronematous, sporodochial; individual filaments narrow, branched at the apex, smooth, hyaline. *Conidiogenous cells* polyblastic, discrete, determinate, terminal, cylindrical, 8-15 x 3-4 µm. *Conidia* catenate, in unbranched acropetal chains, aggregating in slimy mass, attached to one another by a narrow isthmi, smooth, aseptate, hyaline, 10-14 x 3-4.

Specimen examined: On litter, *Arenga wightii* Griff. and Hook, Netravali, Sanguem, Goa, 16/08/07, coll. A. Prabhugaonkar, Herb. No. 143AP20

***Xenosporium africanum* Piroz., in Deighton & Pirozynski, Mycol. Pap. 105: 33 (1966)**

(Plate XVI- 143)

Colonies on natural substrate, punctiform, effuse, black. *Mycelium* partly immersed, partly superficial. *Setae* and *hyphopodia* absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, integrated, determinate, terminal, attached towards one side. *Conidia* solitary, dry, acrogenous, simple, obovate, dark brown with hyaline marginal cells, 70-110 µm long, 35-50 µm broad at the centre, 10-14 µm at the tip; microconidia, 1-4, light brown, globose, 6-9 µm diam.

Specimen examined: On litter of *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 26/04/09, coll. A. Prabhugaonkar, Herb. No. 353AP01.

***Xenosporium boivinii* S. Hughes, N.Z. J Bot. 16(3): 354 (1978) (Plate XVI- 144)**

Colonies on natural substrate, punctiform, effuse, black. *Mycelium* partly immersed, partly superficial. Setae and hyphopodia absent. *Conidiophores* micronematous, mononematous, 20-30 x 2-4 µm. *Conidiogenous cells* monoblastic, integrated, determinate, terminal, attached towards one side. *Conidia* solitary, dry, acrogenous, simple, dark brown, curved, 40-50 x 40-55 µm.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. 130AP02

***Xenosporium* sp 1. (Plate XVI- 145)**

Colonies on natural substrate effuse, black. *Mycelium* partly immersed, partly superficial. Stroma none. Setae and hyphopodia absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, integrated, determinate, terminal. *Conidia* solitary, dry, acrogenous, simple, obovate, dark brown, muriform, variable in shape, 60-175 x 35-50 µm.

Specimen examined: On litter, *Hyphaene dichotoma* (White) Furt., Miramar, Panaji, Goa, 17/10/07, coll. A. Prabhugaonkar, Herb. No. 67AP23.

***Xenosporium* sp.2 (Plate XVII- 146)**

Colonies on natural substrate, effuse, black. *Mycelium* partly immersed, partly superficial. Setae and hyphopodia absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, integrated, determinate, terminal. *Conidia* solitary, dry, acrogenous, simple, sub-globose, dark brown, 15-20 µm diam.

Specimen examined: On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 69AP24.

***Xenosporium* sp. 3**

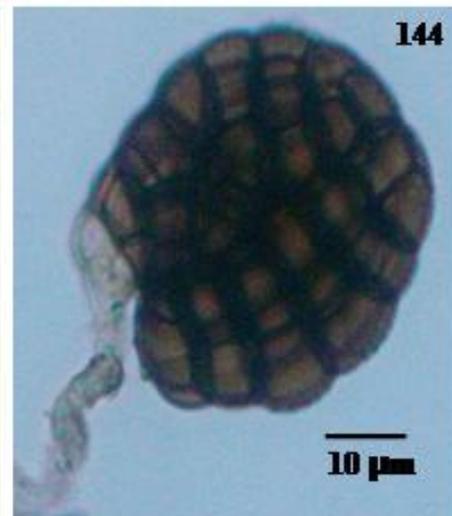
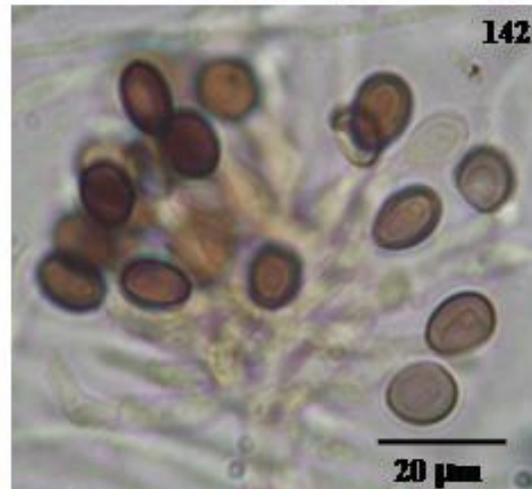
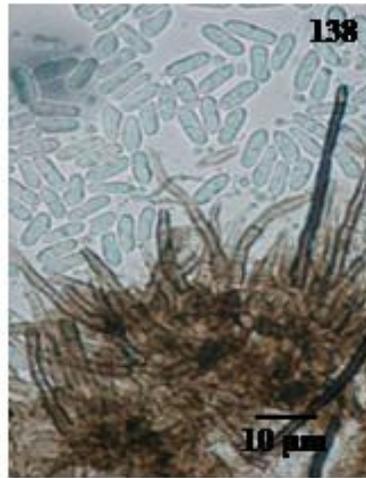
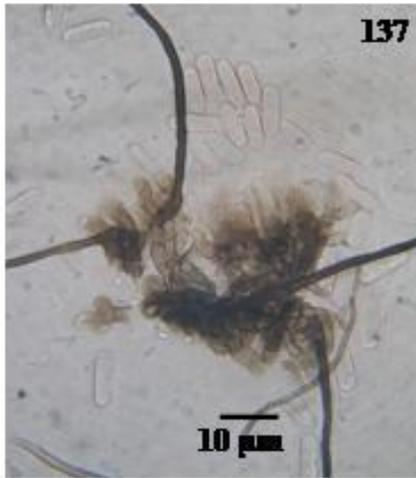
Colonies on natural substrate punctiform, effuse, black. *Mycelium* partly immersed, partly superficial. Stroma none. Setae and hyphopodia absent. *Conidiophores* micronematous, mononematous. *Conidiogenous cells* monoblastic, integrated, determinate, terminal. *Conidia* solitary, dry, acrogenous, muriform, simple, obovate, dark brown, spherical to subspherical, 25-70 µm diam.

Specimen examined: : On litter, *Calamus*, Netravali, Sanguem, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 130AP01.

Plate XVI:

- 137.** *Vermiculariopsiella elegans*
- 138. *Vermiculariopsiella parva*
- 139.** *Veronaea indica*
- 140.** *Verticillium* sp.
- 141. *Virgaria nigra*
- 142. *Wardomyces* sp.
- 143. *Xenosporium africanum*
- 144.** *Xenosporium boivinii*
- 145.** *Xenosporium* sp. 1

Plate XVI. 137-145



***Zygosporium masonii* S. Hughes, Mycol. Pap. 44: 15 (1951)**

(Plate XVII- 147; Fig. 80)

Colonies on natural substrate effuse, dark brown to black. *Mycelium* partly immersed, partly superficial, composed of thin, smooth, septate, branched, hyaline, 2-3.5 µm wide hyphae; *Conidiophores* macronematous, mononematous, solitary, unbranched, septate smooth, dark brown, erect, straight to flexuous with chains of 3-4 vesicles and a sterile hyaline apical portion which ends in a knob-like structure at the tip, 63-76 x 3-4 µm. *Conidiogenous cells* monoblastic, terminal, discrete, determinate, ampulliform, slightly curved, thin-walled, hyaline, borne in pairs at the tip of curved vesicle, 5-8 x 3-4 µm. *Vesicle* dark brown to black, smooth, thick-walled, curved. *Conidia* solitary, simple, acrogenous, ellipsoidal, smooth, hyaline, aseptate, 6-9 x 3-4 µm.

Specimen examined: On dead leaf sheath, *Areca catachu*, Mashem, Canacona, Goa, 17/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 316AP26.

***Zygosporium minus* S. Hughes, Mycol. Pap. 44: 6 (1951) (Plate XVII- 148)**

Colonies on natural substrate effuse, gray. *Mycelium* partly immersed, partly superficial, composed of branched, septate, hyaline, smooth, 2-3 µm thick hyphae. Hyphopodia absent. *Conidiophores* semi-macronematous, mononematous, scattered, unbranched, brown, smooth, setiform, 25-35 x 4-6 µm, with sterile, dark brown to black, curved, 12-15 µm wide, vesicle at the apex. *Conidiogenous cells* polyblastic, discrete, in groups of 2-3, determinate, ampulliform, borne at the apex of the vesicle, hyaline, 5-7 x 2-3 µm. *Conidia* solitary, dry, acropleurogenous, simple, spherical, echinate, aseptate, hyaline, 5-10 µm in diam.

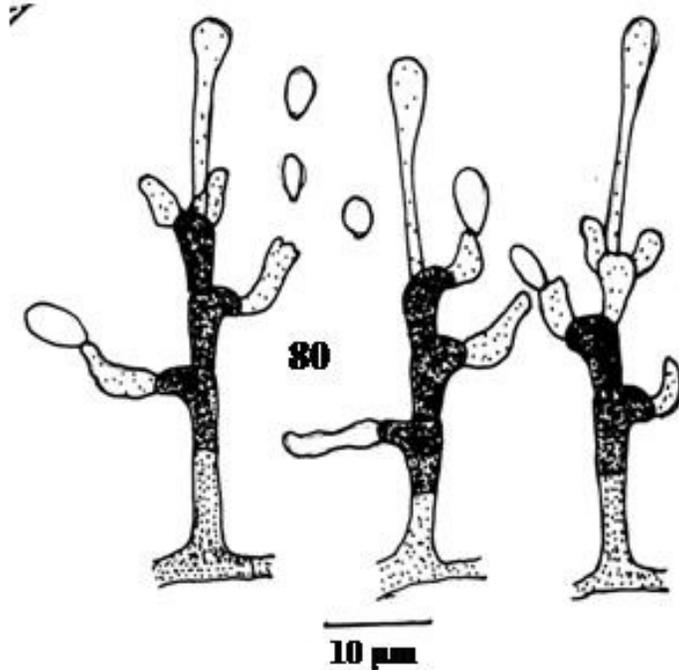
Specimen examined: I. On litter, *Areca catechu* L. Satre, Sattari, Goa, 31/01/08, coll. A. Prabhugaonkar, Herb. No. 161AP26. II. On litter, *Corypha umbraculifera* L., Yana, Karnataka, 29/06/08, coll. A. Prabhugaonkar, Herb. No. 234AP21. III. On litter, *Bentinckia condapanna* Berry, Tirunelveli, Tamilnadu, 26/03/10, coll. R. Ganesan, Herb. No. 424AP18.

Unidentified fungus 1

(Plate XVII- 152)

Colonies on MEA, light brown, mycelium 2-4 µm broad. *Stroma* none. *Setae* absent. *Conidiophores* forming dense aggregates resembling conidiomata of *coelomycetes* but not showing any wall layer instead breaking in to mass of conidiophores upon teasing. Single *Conidiophores* macronematous, mononematous, erect, straight to flexuous, septate, smooth, branched at the basal region in to 2-3 conidiogenous cells, hyaline to light brown, 12-25 x 2-3 µm. *Conidiogenous cells*

Fig. 80

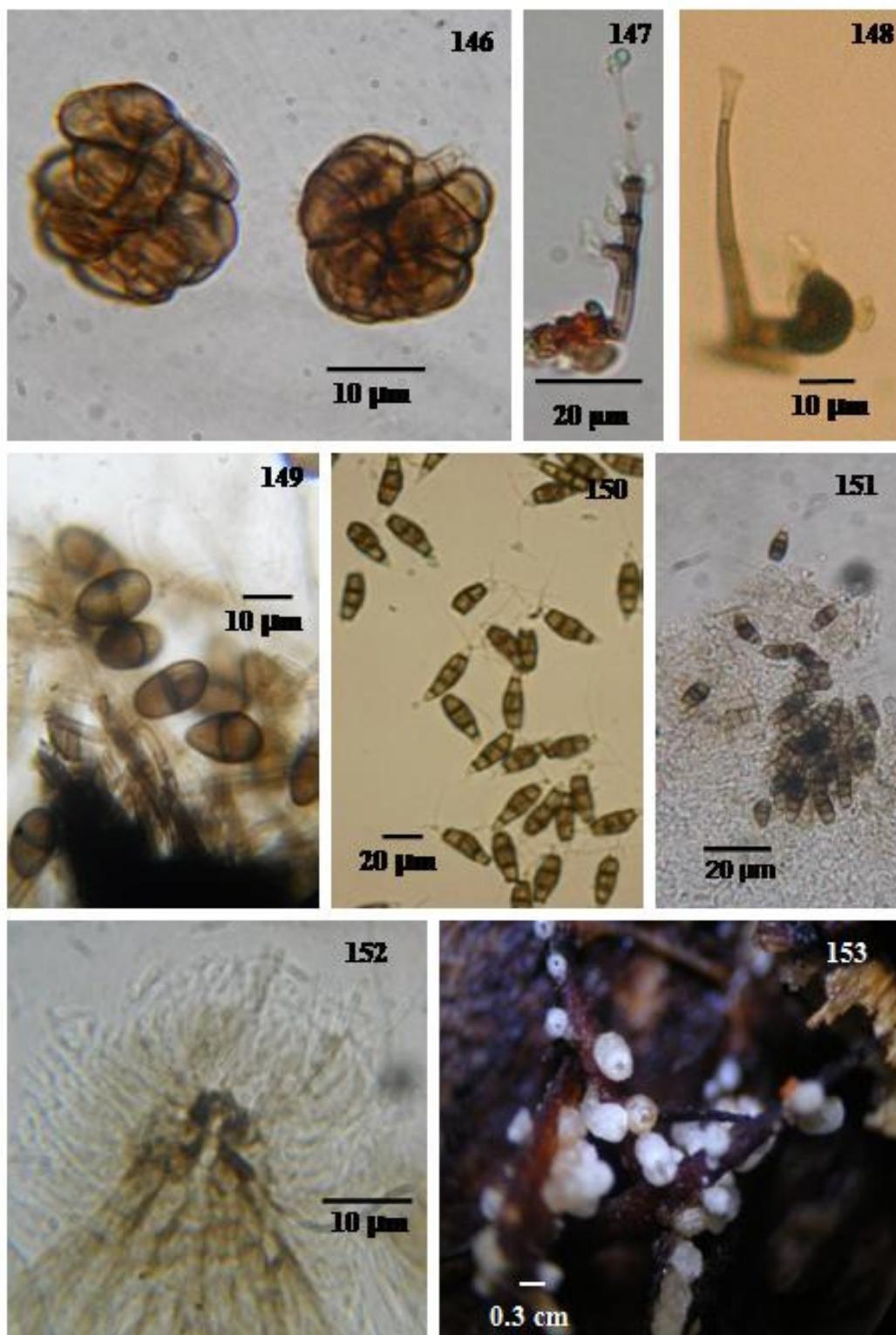


Zygosporium masonii

Plate XVII:

- 146.** *Xenosporium* sp. 2
- 147. *Zygosporium masonii*
- 148. *Zygosporium minus*
- 149.** *Lasiodiplodia theobromae*
- 150.** *Pestalotiopsis palmarum*
- 151.** *Pestalotiopsis* sp.
- 152.** Unidentified Coelomycetes
- 153.** Unidentified fungus

Plate XVII. 146-152



mono-phialidic, cylindrical, slightly tapering towards tip, discrete, 8-20 x 2-3 μm .

Conidia dry, solitary, smooth, sub-hyane, cylindrical 3-5 x 2-3 μm .

Specimen examined: Isolated by Particle plating from fresh leaves of *Pinanga dicksonii* Blume, A. Prabhugaonkar, 16/11/09. Katlekan, near gersoppa, Uttara kannada district, Karnataka, India. Herb. No. GUBH 412AP19

Unidentified fungus 2

(Plate XVII- 153)

Colonies superficial on plant litter forming dense white tuft of hyphae. *Hyphae* 3-6 μm wide, forming cup shaped conidiomata like structures. Conidiophores and conidiomata were not observed after repeated collection and observation.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Bondla, Goa, 17/05/08, coll. A. Prabhugaonkar. Herb. No 129AP01

B. Coelomycetes

Lasiodiplodia theobromae (Pat.) Griffon & Maubl., *Bull. Soc. mycol. Fr.* 25: 57 (1909) (Plate XVII- 149)

Colonies on natural substrate effuse, grayish, hairy. *Mycelium* partly immersed, partly superficial composed of branched, septate, dark brown, smooth, 2-3 μm thick hyphae. *Picnidium* superficial, globose to broadly obpyriform, dark brown to black, 250-300 x 200-275 μm . *Conidiogenous cells* monoblastic, determinate, terminal, cylindrical, hyaline, smooth, 5-10 x 2.5-3 μm . *Conidia* solitary, dry, acrogenous, simple, ellipsoidal, thick-walled, dark brown, 1-septate with longitudinal striations on the surface, rounded at both ends, slightly constricted at the septa, 18-33 x 10-13.5 μm .

Specimen examined: I. On leaf sheath litter, *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 06/02/08, coll. A. Prabhugaonkar, Herb. No. 165AP01. II. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 456AP18.

Pestalotiopsis palmarum (Cooke) Steyaert, *Bull. Jard. Bot. État Brux.* 19(3): 322 (1949) (Plate XVII- 150)

Colonies on MEA cottony white with black conidiomata. Conidiomata immersed in agar, thick walled, globose to subglobose upto 500 μm across. Conidiophores hyaline, cylindrical, arising from base of conidiomata. Conidiogenous cells holoblastic, indeterminate, cylindrical, hyaline, smooth 6-8 x 2-3 μm . *Conidia* fusiform, appendaged, slightly curved, 4 septate, central cells black, basal and terminal cells hyaline, with an hyaline filliform appendage at base and 3 hyaline filliform appendages at the tip 20-25 x 5-8 μm .

Specimen examined: I. Isolated by 3-step sterilisation method from fresh leaves *Calamus thwaitesii*, Netravali, Sanguem, Goa, 03/12/07, coll. A. Prabhugaonkar, Herb. No. GUBH 125AP01, GUFCC15543. II. Isolated by by 3-step sterilisation method from fresh leaves of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 433AP18.

***Pestalotiopsis* sp.**

(Plate XVII- 1151)

Colonies on MEA cottony white with black conidiomata. *Conidiomata* immersed in agar, thick walled, globose to subglobose upto 200-300 µm across. *Conidiophores* hyaline, cylindrical, arising from base of conidiomata. *Conidiogenous cells* holoblastic, indeterminate, cylindrical, hyaline, smooth 6-8 x 2-3 µm. *Conidia* fusiform, slightly curved, 4 septate, central cells black, basal and terminal cells hyaline, with an hyaline filiform appendage at base and 3 hyaline filiform appendages at the tip, 10-15 x 5-8 µm.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Dhoodhsagar, Goa, 21/08/08, coll. A. Prabhugaonkar, Herb. No. 219AP01. II. Isolated by by 3-step sterilisation method of fresh leaves of *Pinanga dicksonii* Blume, Katlekan, near Gersoppa, Uttara Kannada district, Karnataka, 16/11/09, coll. A. Prabhugaonkar, Herb. No. GUBH 416AP19. III. Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 469AP18.

***Pestalotiopsis* sp. 1**

Colonies on natural substrate black. *Mycelium* immersed. *Conidiomata* acervular, immersed. Conidiomatal wall composed of pale brown, thin-walled, angular cells. *Conidiophores* straight to flexuous, branched, septate, smooth, sub-hyaline. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, hyaline, smooth. *Conidia* solitary, fusiform, straight, dark brown, 4-septate, smooth, appendiculate, 20-25 x 5-7 µm; basal conidial cell conical, hyaline with 1 appendages; apical cell conical, hyaline, with 2-3 appendages.

Specimen examined: Isolated by Particle plating method from litter of *Bentinckia condapanna* Berry, Agastimalai hills, Kerala, 25/04/10, coll. A. Prabhugaonkar, Herb. No. 462AP18

***Phoma* sp.**

Colonies on MEA white with abundant black pycnidia forming creamish spores, Pycnidia immersed in agar, globose, often 1 or more fusing together, black, variable in shape and size. *Conidia* one celled, ovoid 5-6 x 2-3 µm

Specimen examined: Isolated by Particle plating method from litter of *Arenga wightii* Griff. and hook, Netravali, Sanguem, Goa, 20/10/09, coll. A. Prabhugaonkar, Herb. No. 195AP20.

***Phomopsis* sp.**

Colonies on natural substrate brown. *Mycelium* immersed. *Conidiomata* immersed, dark brown. *Conidiophores* short, branched, smooth. *Conidiogenous cells* monophialidic, integrated, determinate, terminal. *Conidia* solitary, slimy, simple, smooth, aseptate, hyaline, of 2 types: α -conidia ellipsoidal, aseptate, smootyh, hyaline, 7-10 x 1.5-2 μm . β -conidia filiform, sigmoid, hyaline, 15-25 x 0.5-1 μm .

Specimen examined: I. Isolated by 3-step sterilisation method of fresh leaves of *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar, Herb. No. 218AP01. II. Isolated by 3-step sterilisation method from fresh leaves of *Caryota urens* L., Mashem, Canacona, Goa, 25/10/2007, coll. A. Prabhugaonkar, Herb. No. GUBH 288AP24.

C. Ascomycetes

***Ascotricha* sp.**

Colonies on natural substrate dark brown to black. *Ascomata* perithecial, superficial, ovoid to obpyriform, 200-310 x 150-225 μm covered with apical and lateral hair, ostiolate. *Ascomatal hair* up to 400 μm long, 1.5-2.2 μm wide, numerous, dark brown to black, bent at certain angle, producing hyaline, clavate ampullae at every bent and at the apex. *Ampullae* 8-10 x 2-3 μm . *Asci* eight-spored, unitunicate, cylindrical, pedicellate, 7.5-9 x 5-6 μm . *Ascospores* globose, dark brown, smooth, aseptate, dorsiventrally slightly flattened, 4-5 μm diam.

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 06/01/08, coll. A. Prabhugaonkar. II. Isolated by Particle plating method, *Arenga wightii* Griff., near Sawar falls Netravali, Sanguem, Goa, 10/05/08, coll. A. Prabhugaonkar.

***Astrosphaeriella* sp.**

(Plate XVIII- 154a-154b)

Ascomata subcuticular, subepidermal, ellipsoidal opening by a longitudinal slit 0.3- 0.5 cm across. *Peridium* thick. *Pseudoparaphyses* tuberculate, upto 2 μm thick. *Asci* 8 spored, cylindrical, pedicellate, bitunicate 40-110 x 5-10 μm . *Ascospores* elongate, fusiform, broadest at center, tapering at both ends, 3 septate, central cell brown, outer pale 20-28 x 5-7 μm .

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 01/08/07, coll. A. Prabhugaonkar, Herb. No. 31AP01. II. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 15/11/09, coll. A. Prabhugaonkar.

***Caudatispora palmicola* Hyde and Frohlich.(1995)**

(Plate XVIII- 156a-156c)

Ascomata superficial, subglobose, ostiolate, ostiole central with yellow mass of spores. *Peridium* thick. *Paraphyses* present, numerous filiform upto 4 μm thick. *Asci* 8 spored, pedicellate, unitunicate 50-60 x 5-10 μm . *Ascospores* fusiform, 1

celled, hyaline, pale yellow when in masses with a basal caudate appendage having mucilaginous sheath at tip 15-25 x 3-4 μm .

Specimen examined On litter, *Cocos nucifera* L. fronds, Mashem, Canacona, Goa, 09/10/2011, Prabhugaonkar, A., Herb. No. GUBH- 477AP25

***Ceratocystis paradoxa* (Dade) C. Moreau, *Revue Mycol.*, Paris 17 : 22 (1952)**

(Plate XVII- 155)

Ascomata single, globose to subglobose, superficial or immersed in substrate with long ostiolar neck and ring of hyphae around the ostiole 70- 500 x 40-100 μm . *Asci* globose to sub-globose, 8 spored. *Ascospores* hyaline, 1 celled, circular with fine circular ring, often collapsing to form bean shaped, 2-4 μm across.

Specimen examined: I. On wood of dead *Cocos nucifera* L. tree, St-Cruz, Panaji, Goa, 21/02/11, coll. A. Prabhugaonkar, Herb. No. GUBH- 95AP25.

***Chaetomium* sp.**

(Plate XIX- 158)

Colonies effuse, black. *Mycelium* immersed. *Ascomata* perithecial, ovoid, brown to dark brown, rhizoidal, superficial, surrounded by peridial wall covered by spirally coiled, septate hair in the upper region of the ascomata. *Ostiole* single, central, surrounded by hair. *Paraphyses* absent. *Asci* eight-spored, sub-globose to broadly clavate, non-pedicellate, unitunicate, evanescent at maturity, 25-35 x 15-25 μm . *Ascospores* aseptate, dark brown, smooth, 6-10 x 6-8 μm .

Specimen examined: Isolated by 3-step sterilisation method from rachids of *Calamus thwaitesii* Becc. & Hook., near Dhoodhasagar waterfalls, Sanguem, Goa, 15/10/09, coll. A. Prabhugaonkar, Herb. No. 379AP01.

***Cochliobolus* sp.**

(Plate XVIII- 157)

Colonies on substrate black, effuse, mycelium immersed in substratum. *Ascomata* single, black, globose with long ostiolar neck 400-1000 x 20-80 μm . Neck 200-800 x 15-20 μm . *Asci* numerous, thin walled, cylindrical to broadly clavate, mostly 8 spored, 25-45 x 5-8 μm . *Ascospores* filiform, hyaline, multiseptate 25-35 x 4-5 μm .

Specimen examined: I. On litter, *Calamus thwaitesii* Becc. and Hook, Netravali, Sanguem, Goa, 16/08/07, coll. A. Prabhugaonkar, Herb. No. 39AP01. II. Isolated by Particle plating method from litter of *Arenga wightii* Griff. and hook, Netravali, Sanguem, Goa, 20/10/09, coll. A. Prabhugaonkar, Herb. No. 383AP20.

***Eurotium* sp.**

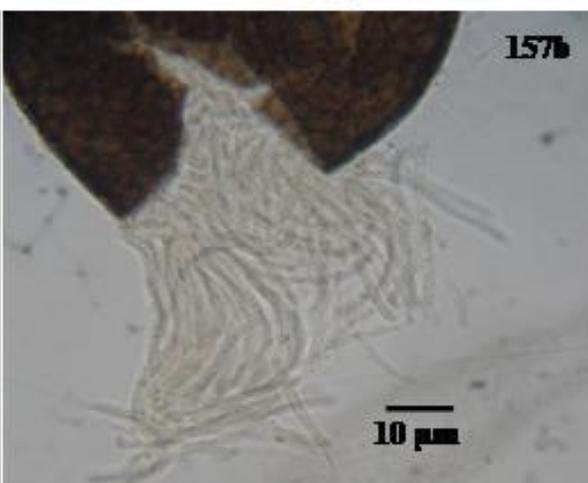
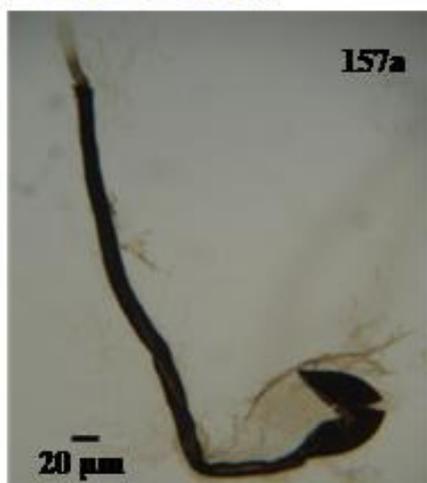
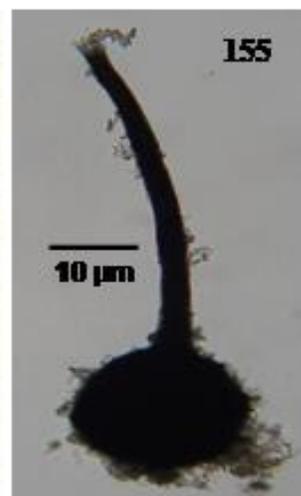
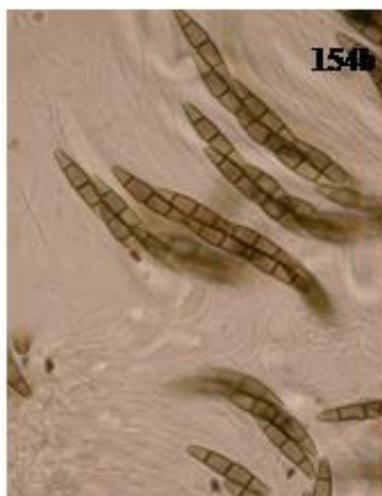
(Plate XIX- 159)

Ascomata cleistothecial, globose to sub-globose, non-ostiolate. *Paraphyses* absent. *Asci* eight-spored, globose, non-pedicellate, unitunicate, 8-10 μm in diam.

Plate XVIII:

- 154. *Astrosphaeriella* sp.
- 155. *Ceratocystis paradoxa*
- 156. *Caudatispora palmicola*
- 157. *Cochliobolus* sp.

Plate XVIII. 154-157



Ascospores aseptate, hyaline when young, turning pale brown at maturity, smooth, lenticular, with stellate ridges, 3-5 µm diam.

Specimen examined: On dry leaf sheaths, *Calamus thwaitesii* Becc. & Hook., Satre, Sattari, Goa, 13/01/08, coll. A. Prabhugaonkar, Herb. No. GUBH 152AP01.

***Hypocrea* sp.**

(Plate XIX- 160)

Stromata formed superficially on surface of substrate, irregular in shape, black, fleshy, interior white. *Ascomata* ostioled perithecium, subglobose immersed in stroma. *Paraphyses* present. *Asci* unitunicate, cylindrical, hyaline with dark black spores when matured, 60-100 x 3-5 µm. *Ascospores* aseptate, oval, black when mature 4-6 x 3-4 µm.

Specimen examined: On litter, *Elaeis guineensis* Jacq., Netravali, Sanguem, Goa, 05/01/09, coll. A. Prabhugaonkar, Herb No. 340AP31.

***Nectria* sp.**

(Plate XIX- 161a-161c)

Ascomata ostiolate perithecium globose, superficial, bright orange, wall pseudoparenchymatous 50-90 µm across. *Asci* unitunicate, clavate to cylindrical, 8 spored 40-50 x 8-10. *Ascospores* 4-5 septate, fusiform, hyaline, smooth 20-25 x 4-5 µm.

Specimen examined: I. On spatha, *Cocos nucifera* L. Mashem, Canacona, Goa, 21/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH- 93AP25. II. On dead and decaying fronds of *Caryota urens* L., near Bambolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 121AP24.

Unidentified ascomycete 1

(Plate XIX- 162a-162c)

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed. *Ascomata* superficial, globose, ostiolate 200-300 µm across. *Asci* eight-spored, bitunicate, hyaline, 162-200 x 20-25 µm. *Ascospores* fusoid, 1-septate, smooth, dark brown, striated, 50-75 x 6-10 µm, constricted at the septa.

Specimen examined: On litter, *Calamus rotang* Linn., Virajpet, Madikeri, Karnataka, 21/08/07, coll. A. Prabhugaonkar, Herb. No. 43AP02.

Unidentified ascomycete 2

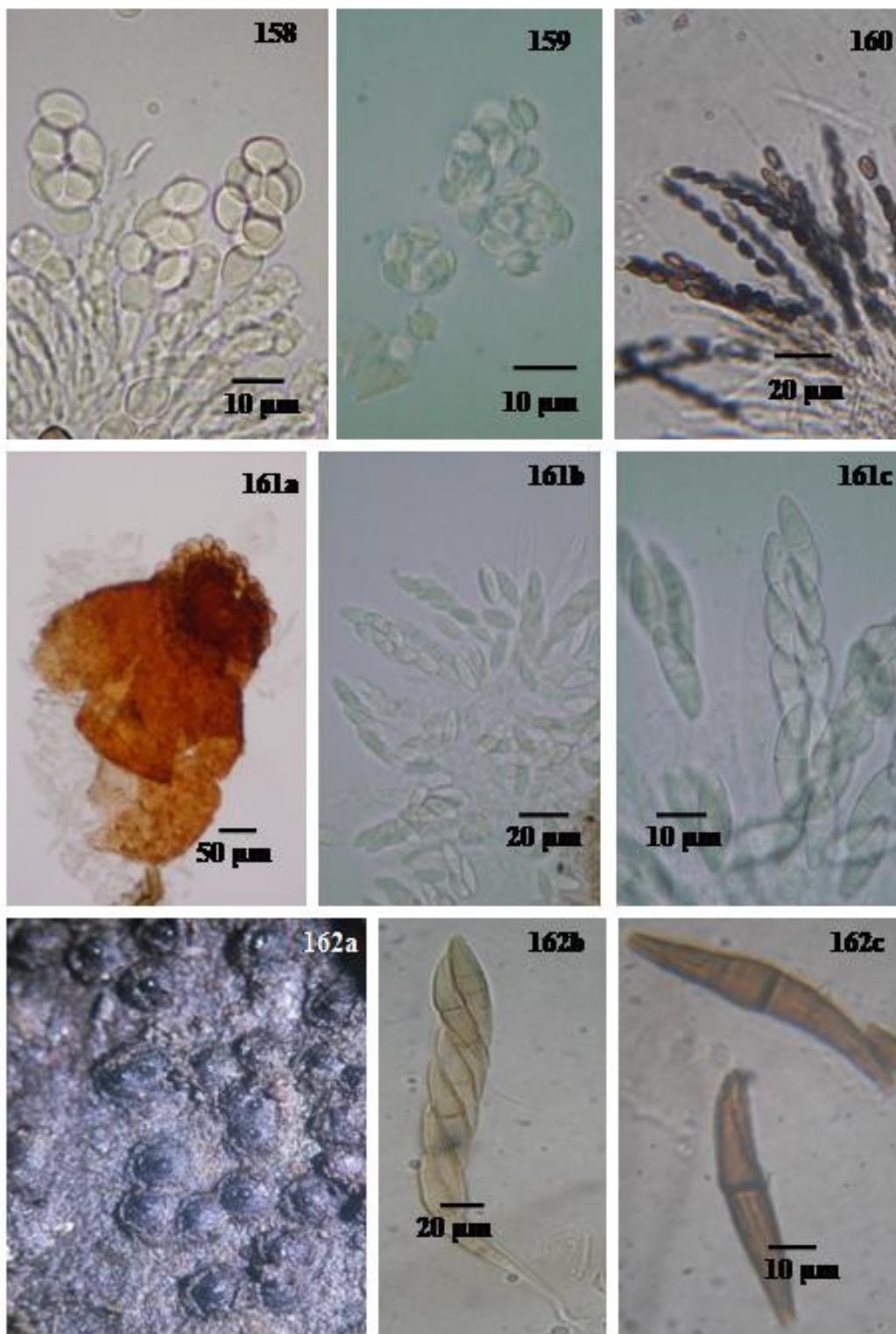
(Plate XX- 163a-163c)

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed. *Ascomata* subcuticular, subepidermal, ellipsoidal opening by a longitudinal slit 0.3-0.5 cm across. Peridium thick. *Asci* eight-spored, bitunicate, hyaline, 100-115 x 12-15 µm. *Ascospores* fusoid, 1-septate, smooth, hyaline, 25-30 x 5-10 µm, constricted at the septa.

Plate IX:

- 158. *Chaetomium* sp.
- 159. *Eurotium* sp.
- 160. *Hypocrea* sp.
- 161. *Nectria* sp.
- 162. Unidentified ascomycete 1**

Plate XVIX. 158-162



Specimen examined: On litter, *Arenga wightii* Griff. and Hook, Netravali, Sanguem, Goa, 16/08/07, coll. A. Prabhugaonkar, Herb. No. 42AP01.

Unidentified ascomycete 3

(Plate XIX- 164a-164c)

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed. *Ascomata* superficial, globose. *Asci* eight-spored, unitunicate, hyaline, 65-100 x 5-7 μm . *Ascospores* dark brown to black, aseptate, smooth, 10-15 x 5-7 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 14/08/07, coll. A. Prabhugaonkar, Herb. No. 38AP01.

Unidentified ascomycete 4

(Plate XIX- 165a-165b)

Colonies on natural substrate effuse, dark brown. *Mycelium* partly immersed. *Ascomata* immersed subglobose neck short, central 200-300 μm across. *Asci* eight-spored, unitunicate, hyaline, 50-75 x 6-8 μm . *Ascospores* hyaline, 1-septate, smooth, 7-12 x 2-4 μm .

Specimen examined: On litter, *Calamus thwaitesii* Becc. and Hook, Netravali, Sanguem, Goa, 14/08/07, coll. A. Prabhugaonkar, Herb. No. 32AP01

Unidentified ascomycete 5

Colonies on natural substrate effuse, dark brown. *Mycelium* partly immersed. *Ascomata* superficial, globose 55-70 μm across. *Asci* eight-spored, unitunicate. *Ascospores* dark brown, 6-7-septate, smooth, 35-45 x 6-8 μm , with small hyaline cells at both the ends.

Specimen examined: On litter, *Calamus thwaitesii* Becc. & Hook., Netravali, Sanguem, Goa, 10/08/07, coll. A. Prabhugaonkar, Herb. No. 35AP01.

Unidentified ascomycetes 6

Colonies on natural substrate effuse, dark brown. *Mycelium* immersed. *Ascomata* superficial, globose, ostiolate. *Asci* eight-spored, bitunicate, hyaline, 175-250 x 12-40 μm . *Ascospores* filiform, acicular, hyaline, multiseptate, smooth, 62-155 x 4-5.5 μm .

Specimen examined: On litter, *Calamus rotang* Linn., Virajpet, Madikeri, Karnataka 21/08/07, coll. A. Prabhugaonkar, Herb. No. 41AP02.

Unidentified ascomycetes 7

Colonies on natural substrate effuse, pale brown. *Mycelium* partly immersed, partly superficial, composed of septate, branched, hyaline to subhyaline, smooth, 2-3.5 μm thick hyphae. superficial, globose. *Asci* eight-spored, bitunicate, 150-200 x

Plate XX:

- 163. **Unidentified ascomycete 2**
- 164. **Unidentified ascomycete 3**
- 165. **Unidentified ascomycete 4**
- 166. *Mortierella* sp.

Plate XX. 163-166



10-15 μm . Ascospores filiform, acicular, hyaline, pluriseptate, smooth, 70-125 x 2-3 μm .

Specimen examined: On dead and decaying fronds of *Caryota urens* L., near Bombolim beach, Goa, 24/10/07, coll. A. Prabhugaonkar, Herb. No. GUBH 75AP24.

Unidentified ascomycetes 8

Colonies on natural substrate effuse, dark brown. *Mycelium* partly immersed. *Ascomata* light brown, ostiolate, 400-450 x 190-250 μm . *Asci* eight-spored, bitunicate, hyaline, 200-300 x 25-33 μm . *Ascospores* filiform, acicular, hyaline, pluriseptate, smooth, 150-190 x 5-7 μm .

Specimen examined: On litter, *Calamus thwaitesi* Becc. and Hook, Netravali, Sanguem, Goa, 26/04/09, coll. A. Prabhugaonkar, Herb. No. 350AP01.

D. Zygomycota

***Mortierella* sp.**

(Plate XX- 166)

Colonies on palm litter shiny, white. *Mycelium* immersed. Conidiophores macronematous, mononematous, erect, straight, stiff, unbranched, hyaline, smooth, 100 μm long, 5 μm broad at the base and 2 μm broad at tip with a prominent phialide. Conidia gleoid, spherical, solitary, hyaline, aseptate, smooth about 1 μm across.

Specimen examined: I. On litter, *Hyphaene dichotoma* (White) Furt., Miramar, Panaji, Goa, 29/04/08, coll. A. Prabhugaonkar, Herb. No. GUBH199AP23. II. On litter, *Calamus thwaitesii* Becc. & Hook., near Dhoodhsagar waterfalls, Sanguem, Goa, 16/08/09, coll. A. Prabhugaonkar, Herb. No. 286AP01.

Part 1.2: Distribution fungi associated with different palm plants (Table 5).

A spectrum of fungal distribution over different palms was prepared based on observed fungi. Of all, maximum number of fungi was obtained from *Calamus thwaitesii* (135 species) followed by *Arenga wightii* (55 species), *Pinanga dicksonii* (53 species), *Caryota urens* (47 species), *Bentinckia condapanna* (42 species), *Cocos nucifera* (41 species), *Corypha umbraculifera* (28 species), *Areca catechu* (20 species) and less than 20 species in remaining palms namely *Borassus flabellifer*, *Calamus rotang*, *Elaeis guineensis*, *Hyphaene dichotoma* and *Phoenix acaulis* (Fig 81).

The large number of species recovered from *Calamus thwaitesii* may be attributed to frequent collecting sorties (as many as 26) and a number of samples done at various locations. Similarly, less number of fungi isolated from certain palms is attributed to a very few (as less as 5 times) collecting visits done and few samples gathered during the study period.

Amongst the various palm tissues sampled, leaf sheaths, fronds and rachids were found to support maximum fungal species (Fig 82). It was also found out that maximum number of fungi isolated was by direct isolation method and isolation following moist chamber isolation, in dry seasons (Fig 83). Though number of isolates recovered by particle-plate and 3-step sterilisation method was high, it was observed that the number of species was less. There was a striking difference in number between the fungi isolated by direct observation and by various methods of processing the samples.

97	<i>Gliocladium cylindrosporium</i>	EN	-	+	-	-	-	-	-	-	-	-	+	-	-
98	<i>Gliocladiopsis sagariensis</i>	MC	-	-	-	-	-	-	-	-	+	-	+	-	-
99	<i>Gliomastix</i> sp.	MC	-	-	-	-	-	-	+	-	-	-	-	-	-
100	<i>Gonytrichum macrocladum</i>	EN	-	-	-	-	-	+	-	-	-	-	-	-	+
101	<i>Graphium</i> sp.	MC	-	-	-	-	-	-	+	-	-	-	-	-	-
102	<i>Graphiola phoenicis</i>	MC	-	-	-	-	-	-	-	-	-	-	-	+	-
103	<i>Gyrothrix</i> Sp.	MC	-	-	-	-	-	-	-	-	+	-	-	-	-
104	<i>Hansfordia pulvinata</i>	MC	-	-	-	-	-	+	-	-	-	-	-	+	-
105	<i>Helicoma</i> sp	MC	-	-	-	-	-	-	-	+	-	-	-	-	-
106	<i>Helicoma</i> sp. 2	MC	-	-	-	-	-	-	+	-	-	-	-	-	-
107	<i>Helicomycetes</i> sp.	MC	+	+	+	-	-	+	+	+	+	-	+	-	+
108	<i>Helicosporium cinereum</i>	MC	-	-	-	-	-	-	-	-	-	-	-	-	+
109	<i>Helminthosporium</i> sp.	MC	-	-	+	-	-	+	+	+	+	-	-	-	+
110	<i>Helminthosporium</i> sp. 2	MC	-	-	-	-	-	-	-	-	+	-	-	-	-
111	<i>Helminthosporium belgaumense</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
112	<i>Hermatomyces tucumanensis</i>	MC	-	+	+	-	-	+	+	-	-	-	-	-	+
113	<i>Hemicorynespora mitrata</i>	MC	+	+	+	+	+	+	+	-	-	-	-	-	+
114	<i>Hypocrea</i> sp.	MC	-	-	-	-	-	+	-	-	-	+	-	-	-
115	<i>Idriella fertilis</i>	EN	-	-	-	-	-	-	-	-	-	-	-	-	+
116	<i>Ityorhoptrum verruculosum</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
117	<i>Junewangia sphaerospora</i>	MC	-	-	-	-	-	+	-	-	-	-	-	+	-
118	<i>Kiliophora ubiensis</i>	MC	-	-	-	-	+	-	-	-	-	-	-	-	-
119	<i>Kostermansinda magna</i>	MC	-	-	-	-	+	+	-	-	-	-	-	-	-
120	<i>Lasiodiplodia theobromae</i>	EN	-	+	+	-	-	-	-	-	-	-	-	-	-
121	<i>Megacapitula villosa</i>	MC	-	-	-	-	-	-	+	-	-	-	-	-	-
122	<i>Melanographium citri</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
123	<i>Memnoniella echinata</i>	EN	-	-	+	-	-	-	-	-	-	-	-	-	-
124	<i>Memnoniella levispora</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
125	<i>Minimidochium setosum</i>	EN	-	-	-	-	-	+	-	-	-	-	-	-	-
126	<i>Monodictys paradoxa</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
127	<i>Monodictys</i> sp.	EN, PP	-	-	-	-	-	+	+	-	-	+	-	-	-
128	<i>Monodictys</i> sp3.	MC	-	-	-	-	-	-	+	+	-	-	-	-	-
129	<i>Monotosporella rhizoidea</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
130	<i>Mortierella</i> sp.	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
131	<i>Myrothecium</i> sp.	EN	-	-	-	-	-	+	-	-	-	-	-	-	-
132	<i>Nalanthamala</i> sp.	EN	-	+	-	-	-	-	-	-	-	-	-	-	-
133	<i>Nectria</i> sp.	MC	-	+	-	-	-	+	-	+	-	-	-	-	-
134	<i>Nigrospora oryzae</i>	EN	-	-	-	-	-	+	+	-	-	-	-	-	+
135	<i>Nodulisporium</i> sp.	EN	-	-	-	-	-	-	-	-	-	-	+	-	-
136	<i>Nodulisporium ochraceum</i>	EN	-	-	-	-	-	+	-	-	-	-	-	-	-
137	<i>Nodulisporium</i> sp.	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
138	<i>Pacilomyces</i> sp.	EN	-	-	-	-	-	+	-	-	-	-	-	-	-
139	<i>Panicillium</i> sp.	EN, PP	-	+	-	-	-	+	+	-	-	-	-	-	-
140	<i>Penicillium</i> sp. 1	EN, PP	-	+	+	-	-	+	-	-	-	-	-	-	+
141	<i>Penicillium</i> sp.2	EN, PP	-	+	+	-	-	+	-	-	-	-	-	-	+
142	<i>Penicillium</i> sp.3	EN, PP	-	-	-	+	-	+	-	-	-	-	-	-	-
143	<i>Paradictyoarthrinium diffractum</i>	MC	-	-	-	-	-	+	-	+	-	-	-	-	-
144	<i>Paraceratocladium seychellarum</i>	MC	-	-	+	-	-	-	-	-	-	-	-	-	-
145	<i>Parahelminthosporium malabaricum</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	+
146	<i>Parapericonia</i> sp.	MC	-	-	-	-	-	-	-	-	-	-	-	+	-
147	<i>Periconia hispidula</i>	MC	-	-	-	-	-	-	-	-	+	-	-	-	-
148	<i>Periconia</i> sp.	EN	-	-	+	-	-	+	-	-	-	-	-	-	-

149	<i>Periconiella</i> sp.	EN	-	-	-	-	-	+	-	-	-	-	-	-
150	<i>Pestalotiopsis palmarum</i>	EN	-	-	+	-	-	+	-	+	-	-	-	+
151	<i>Pestalotiopsis</i> sp.	EN, PP	-	-	-	-	-	+	-	-	-	-	-	-
152	<i>Phaeoisaria clematidis</i>	MC	-	-	-	-	-	+	+	-	+	-	+	-
153	<i>Phaeomonilia corticola</i>	MC	-	-	-	+	-	-	-	-	+	-	-	-
154	<i>Phialophora cinerescens</i>	EN	-	-	-	-	-	+	-	-	-	-	-	-
155	<i>Phialophora richardsiae</i>	MC	-	-	-	-	-	+	-	-	-	-	-	+
156	<i>Phoma</i> sp.	EN	-	+	+	-	-	+	-	-	-	-	-	+
157	<i>Phomopsis</i> sp.	EN,PP	-	-	-	-	-	+	+	-	-	-	-	-
158	<i>Piricauda cochinchensis</i>	MC	-	-	-	-	-	-	+	+	-	-	-	-
159	<i>Piricauda</i> sp. 2	MC	-	-	-	-	-	+	-	-	+	-	-	-
160	<i>Pithomyces africanus</i>	MC	-	-	-	+	-	-	-	-	-	-	-	-
161	<i>Pithomyces chartarum</i>	PP	-	-	-	-	-	-	-	-	-	-	+	+
162	<i>Pithomyces ellisii</i>	MC	-	-	-	-	-	-	-	-	-	-	-	+
163	<i>Pithomyces flavus</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-
164	<i>Pithomyces</i> sp	MC	-	-	-	-	-	-	-	+	+	-	-	+
165	<i>Pithomyces multiappendiculata</i> sp. Nov.	MC	-	-	-	-	-	+	-	+	-	-	-	-
166	<i>Pseudoepicoccum cocos</i>	MC	-	-	-	-	-	-	-	+	-	-	-	-
167	<i>Pyriculariopsis</i> sp.	MC	-	-	-	-	-	-	-	-	-	-	+	-
168	<i>Rattania setulifra</i>	EN	-	-	-	-	-	+	-	-	-	-	-	-
169	<i>Rhinocladiella atrovirens</i>	PP,EN, MC	-	+	+	-	-	+	+	+	-	-	-	+
170	<i>Sesquicillium pseudosetosum</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-
171	<i>Scolecobasidium</i> sp.	EN	-	-	-	-	-	-	-	-	-	-	-	+
172	<i>Scolecobasidium</i> sp1.	EN	-	+	-	-	-	+	-	-	-	-	-	-
173	<i>Sorocybe resiniae</i>	MC	-	-	-	+	-	-	-	-	-	-	-	-
174	<i>Spegazzinia parkeri</i>	MC	-	-	-	-	-	-	-	+	-	-	-	-
175	<i>Spegazzinia tessartha</i>	MC	-	-	-	-	-	-	-	+	-	-	-	+
176	<i>Spondylocladiopsis aseptata</i>	MC	-	-	-	-	+	-	-	-	-	-	-	-
177	<i>Sporidesmium ghanaense</i>	MC	-	-	-	-	-	-	-	-	-	-	-	+
178	<i>Sporidesmium paradecorosum</i>	MC	-	-	-	-	-	-	-	-	+	+	-	-
179	<i>Sporidesmium</i> sp	MC	-	-	-	-	-	+	-	-	-	-	-	-
180	<i>Sporidesmium</i> sp1.	MC	-	-	-	-	-	+	-	-	-	-	-	-
181	<i>Sporidesmium</i> sp2.	MC	-	-	+	-	-	-	+	-	-	-	-	-
182	<i>Sporidesmiella claviformis</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-
183	<i>Sporochisma mirabile</i>	MC	+	-	+	-	-	+	+	-	-	-	-	+
184	<i>Stachybotrys nephrospora</i>	MC	-	-	-	-	-	-	-	+	-	-	-	-
185	<i>Stachybotrys kampalensis</i>	EN	-	-	-	-	-	-	-	-	-	-	-	+
186	<i>Stigmia palmivora</i>	MC	-	-	-	-	-	-	-	-	-	-	+	+
187	<i>Stilbella</i> sp.	MC	-	-	-	-	-	-	-	+	-	-	-	-
188	<i>Tetraploa aristata</i>	MC	-	-	-	-	-	-	-	-	-	-	-	+
189	<i>Tetraploa</i> sp.	MC, PP	-	-	-	-	-	+	-	+	-	-	-	-
190	<i>Thozetella tocklaiensis</i>	MC, PP	-	-	-	-	-	+	+	-	-	-	-	-
191	<i>Torula herbarum</i>	MC	+	-	-	-	-	+	+	-	-	-	-	+
192	<i>Trichoderma harzianum</i>	MC	+	+	+	+	+	+	+	+	+	+	+	+
193	<i>Trichoderma</i> sp.	MC, PP	-	+	-	-	-	-	-	-	-	-	-	-
194	<i>Trichothecium roseum</i>	MC	+	-	-	-	-	-	-	-	-	-	-	-
195	<i>Tripodosporium elegans</i>	MC	-	-	+	-	-	-	-	-	-	-	-	-
196	<i>Tritirachium</i> sp.	MC	-	+	-	-	-	-	-	-	-	-	-	-
197	<i>Tubeufia</i> sp.	MC	-	-	-	+	-	-	-	-	-	-	-	-
198	<i>Vanakripa parva</i>	MC	-	-	-	-	-	+	-	-	+	-	-	-

199	<i>Vanakripa gigaspora</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
200	<i>Vanakripa</i> Sp 1	MC	-	-	-	-	-	-	-	-	+	+	-	-	-
201	<i>Vermiculariopsiella elegans</i>	PP, EN	-	+	-	-	-	+	+	-	-	-	-	-	-
202	<i>Vermiculariopsiella parva</i>	PP, EN	-	+	+	-	-	+	-	-	-	-	-	-	+
203	<i>Veronaea indica</i>	MC, PP	-	-	-	-	-	+	-	-	-	-	-	-	-
204	<i>Veronaea</i> sp	PP	-	-	-	-	-	+	-	-	-	-	-	-	+
205	<i>Verticimonosporium diffractum</i>	MC	-	-	-	-	-	+	-	-	+	-	-	-	-
206	<i>Verticillium</i> sp.	PP	-	+	-	-	-	-	-	-	-	-	-	-	-
207	<i>Virgaria nigra</i>	EN	-	+	-	-	-	-	-	-	-	-	-	-	-
208	<i>Volutella gilva</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
209	<i>Wardomyces</i> sp.	MC	-	+	-	-	-	-	-	-	-	-	-	-	-
210	<i>Wiesneriomyces javanicus</i>	MC	-	+	-	-	-	-	-	-	-	-	-	-	-
211	<i>Xenosporium africanum</i>	MC	-	-	-	-	-	+	-	-	-	+	-	-	-
212	<i>Xenosporium boivinii</i>	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
213	<i>Xenosporium</i> sp 1.	MC	-	-	-	-	+	+	+	-	-	-	-	-	-
214	<i>Xenosporium</i> sp.2	MC	-	-	-	-	-	+	-	+	-	-	-	-	-
215	<i>Xenosporium</i> sp. 3	MC	-	-	-	-	-	+	-	-	-	+	-	-	-
216	<i>Xylaria</i> sp.	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
218	<i>Zygosporium masonii</i>	MC	+	-	-	-	-	+	-	-	-	-	-	-	-
217	<i>Zygosporium minus</i>	MC	+	-	+	-	-	+	-	-	+	-	-	-	+
219	Unidentified ascomycetes	MC	-	-	-	-	-	+	-	-	-	-	-	-	+
220	Unidentified ascomycetes	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
221	Unidentified ascomycetes	MC	-	+	-	-	-	+	-	-	-	+	-	-	-
222	Unidentified ascomycetes	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
223	Unidentified ascomycetes	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
224	Unidentified ascomycetes	MC	-	+	-	-	-	+	-	-	-	-	-	-	-
225	Unidentified ascomycetes	MC	-	+	-	-	-	-	-	-	-	-	-	-	-
226	Unidentified ascomycetes	EN	-	-	-	-	-	+	-	-	-	-	-	-	-
227	Unidentified ascomycetes	MC	-	-	-	-	-	-	+	-	-	-	-	-	-
228	Unidentified ascomycetes	MC	-	-	-	-	-	-	-	+	-	-	-	-	-
229	Unidentified ascomycetes	MC	-	-	-	-	-	-	-	-	+	-	-	-	-
230	Unidentified Coelomycetes	MC	-	-	-	-	-	-	-	-	-	-	-	-	+
231	Unidentified Coelomycetes	MC	-	-	-	-	-	-	-	+	-	-	-	-	-
232	Unidentified Coelomycetes	MC	-	-	-	-	-	+	-	-	-	-	-	-	-
233	Unidentified Coelomycetes	EN	-	-	-	-	-	-	-	-	-	-	-	-	+

Abbreviations used:

AC- *Areca catechu*, AW- *Arenga wightii*, BC- *Bentinckia condapanna*, Bs- *Borassus flabellifer*, CR - *Calamus rotang*, CT - *Calamus thwaitesii*, CU- *Caryota urens*, CN- *Cocos nucifera*, Cs- *Corypha* sp., EG- *Elaeis guineensis*, HD- *Hyphaene dichotoma*, PA- *Phoenix acaulis*, PD- *Pinanga dicksonii*

MC- Moist chamber incubation, EN- Endophytes, PP- Particle plating method

Fig. 81: Diversity of fungi on different palms

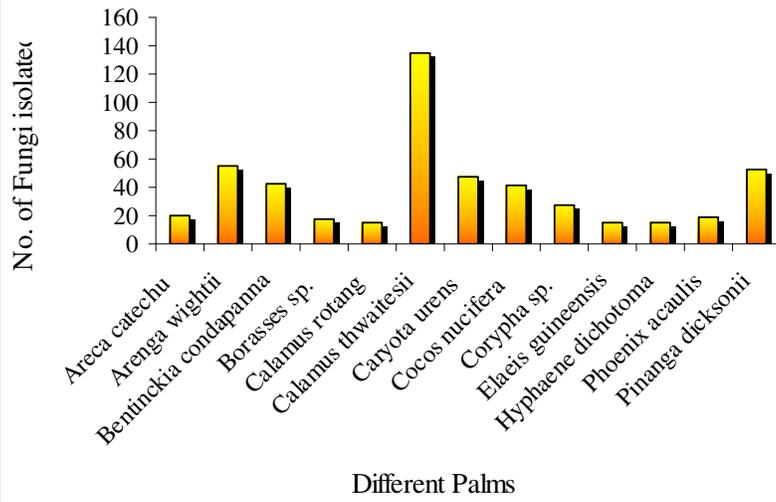


Fig. 82: Distribution of Fungi over palm tissue

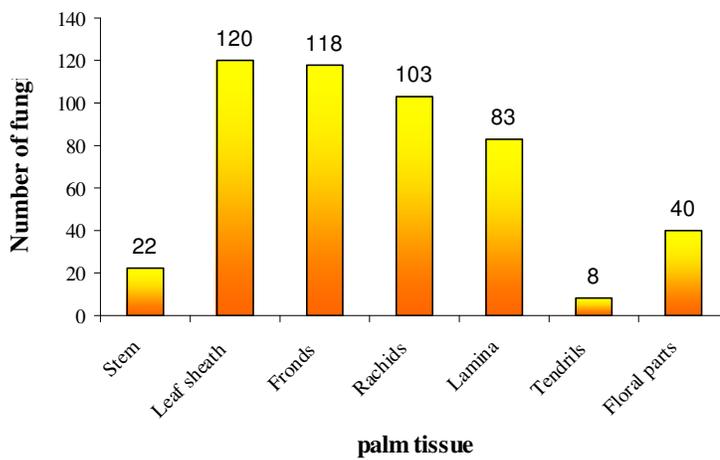
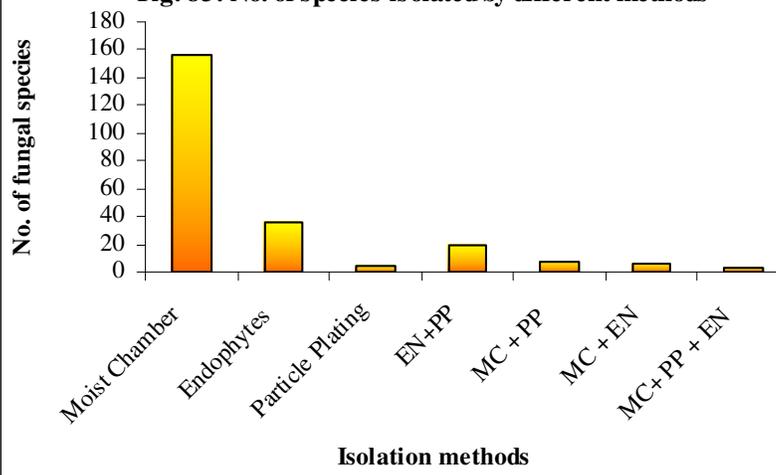


Fig. 83: No. of species isolated by different methods



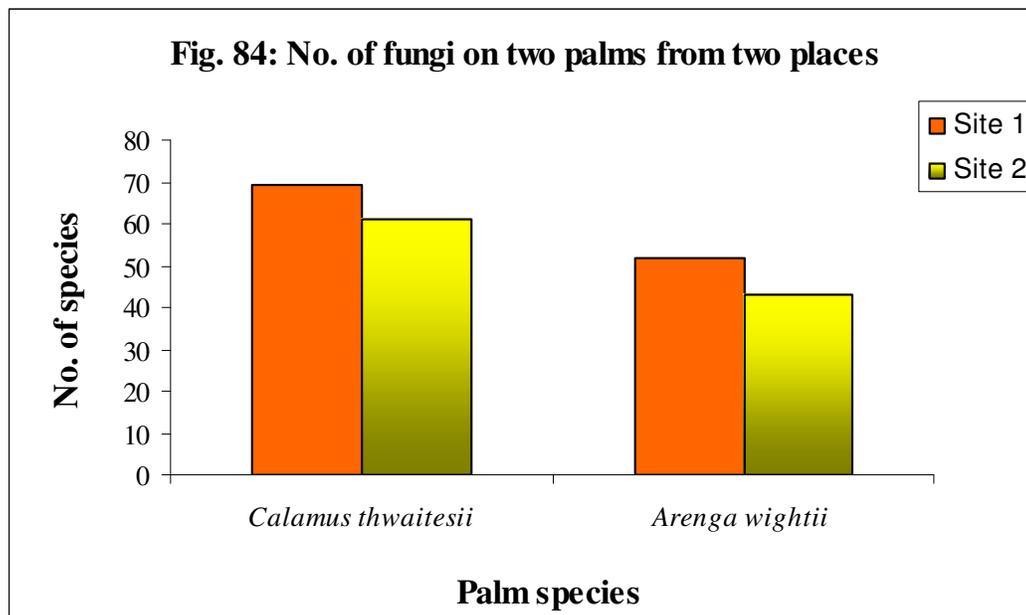
Part II: Studies on seasonal variation on occurrence of fungi at two locations

Two wild palms, viz. *Arenga wightii* and *Calamus thwaitesii*, found growing at two different locations, namely Dhoodhsagar and Netravali, were studied for their associated fungal diversity using different isolation methods. Results obtained were analyzed using appropriate statistical programme and presented here.

Results of analysis of data and diversity indices

Diversity indices of palm fungi studied from two locations highly resembled each other with Shannon (H) index ranging from 2.072- 3.37 and Simpson (1-D) ranging from 0.8228- 0.9607 showing a diverse and stable community of microfungi on palms at both locations.

Species Richness (S) -. *Calamus thwaitesii* was observed to harbor more number of species than *Aenga wightii* at both sites. It was also observed that site 1 that is near Dhoodhsagar waterfalls showed more number of species than site 2 which is near Sawar falls, Netravali (Fig. 84).



Evenness (E)- The values of evenness ranged from 0.6-0.8 throughout the sampling sites and seasons indicating fairly similar proportions of abundances of all the species in all communities studied.

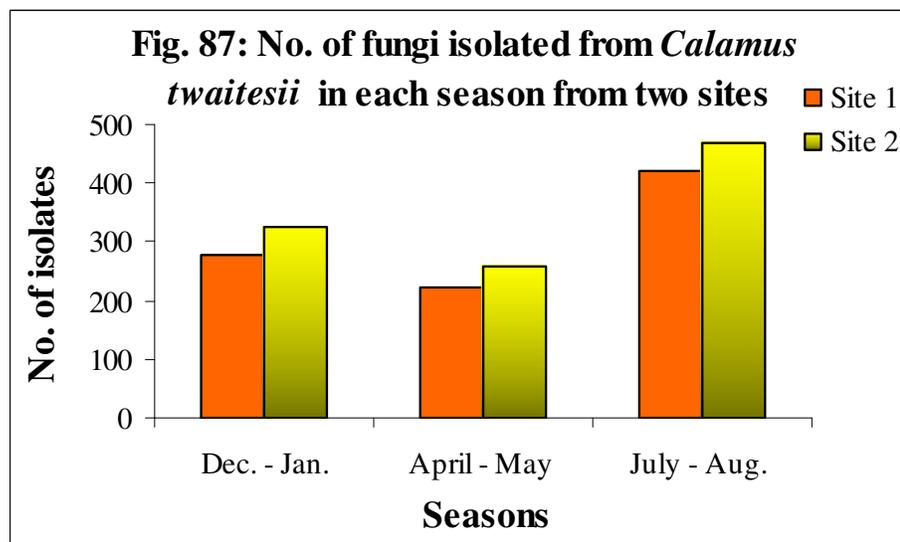
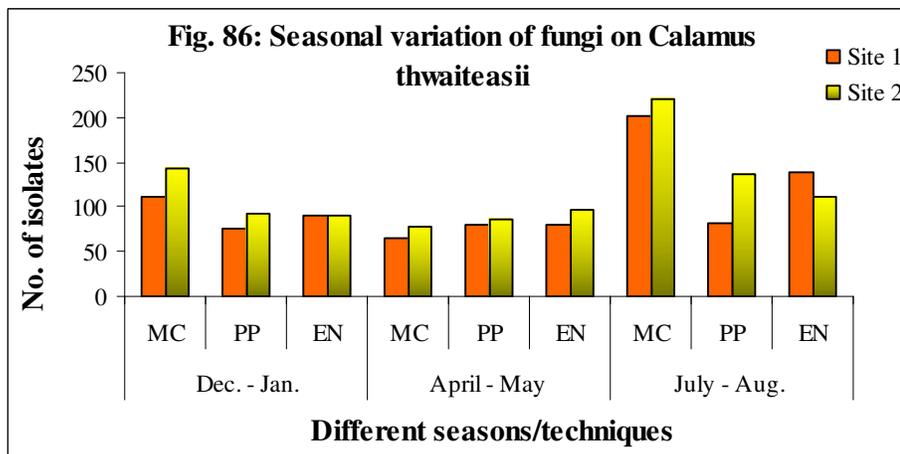
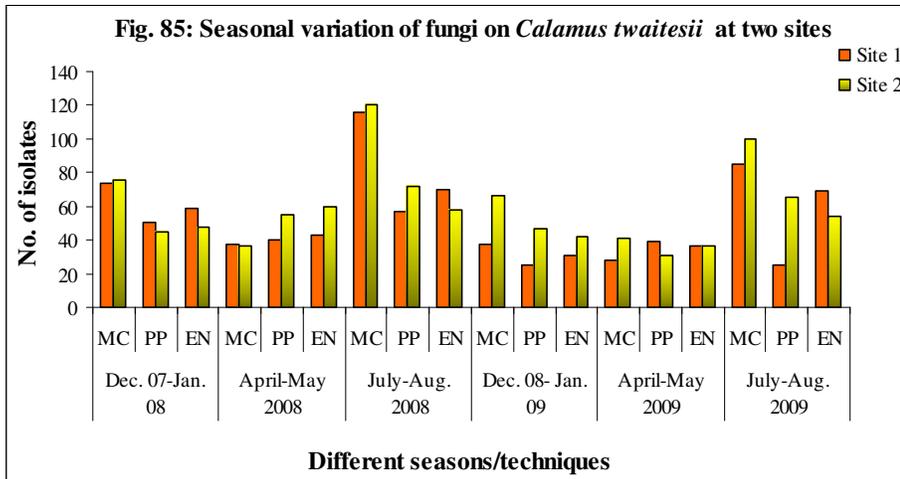
Simpson's Index (1-D) and Shannon (H) - with these diversity indices it was observed that structure of both litter and endophytic fungi was diverse and stable. It was also observed that litter community was consistently more stable and diverse throughout the study period. This is in accordance with the observation that similar species dominated endophytic community.

A. Fungi isolated from *Calamus thwaitesii* Becc. & Hook. in different seasons

Studies on fungal diversity of *Calamus thwaitesii* for two years showed that wet season was the best to isolate large number of fungi. By isolation methods such as direct observation and moist chamber incubation, large number of isolates was obtained in wet season, i.e. during July-Aug, and less number of isolates was obtained in dry season, i.e. April-May. Number of isolates obtained by particle-plating and endophytes also showed similar trend, although number did not differ as much within different seasons (Fig. 87).

According to Shannon diversity indices, most stable community observed on *Calamus* was of litter fungi in July-Aug for Site 2 (3.37) followed by litter fungi in Dec- Jan. (3.315) for Site 1. In endophytes most stable community observed was in July- Aug at site 1 (2.96), followed by all other with lowest value being 2.803 for Dec-Jan at site 2 (Fig. 89, 92).

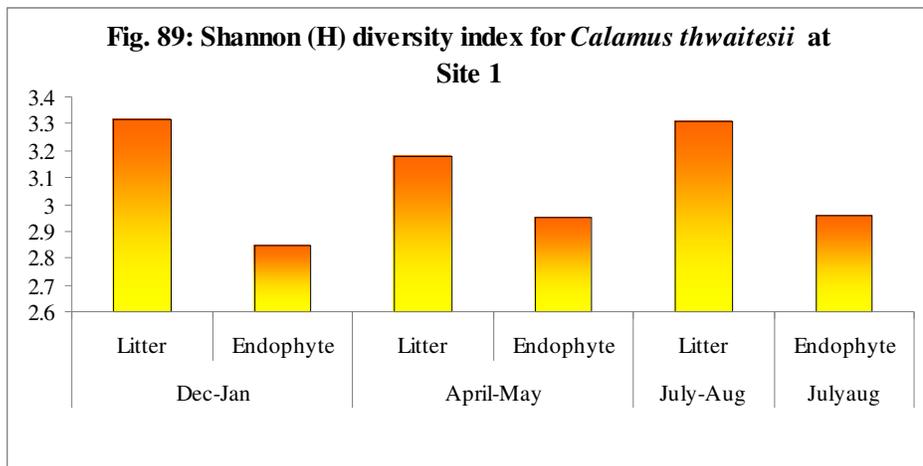
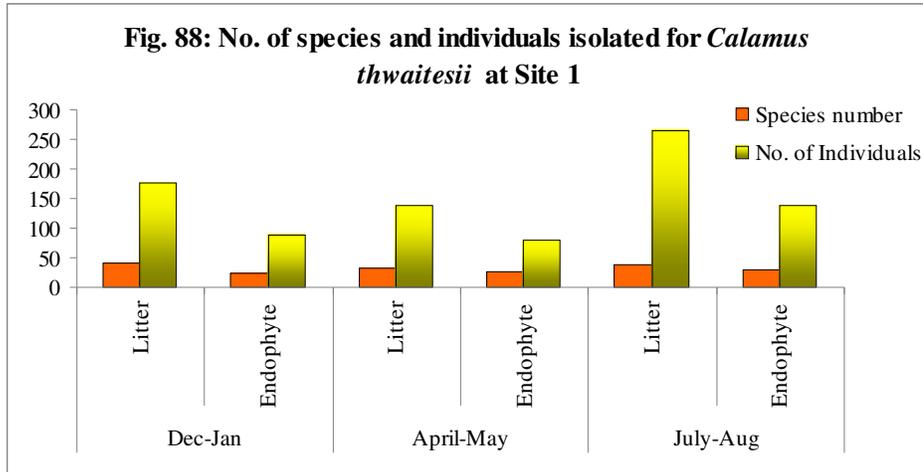
Simpsons Index of diversity also showed that litter fungi is more diverse community than endophytes with Simpsons values ranging from 0.9486 to 0.9607 compared with values ranging from 0.9230 to 0.9349 for endophytes (Fig. 90, 93).



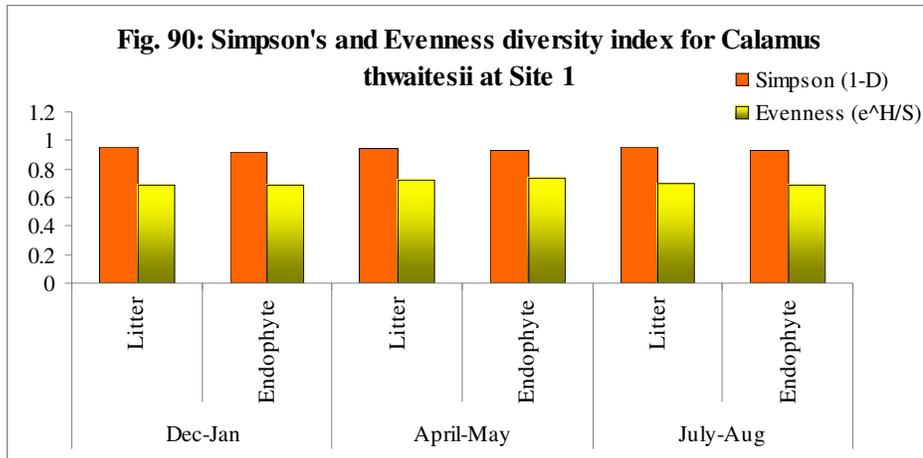
***Calamus thwaitesii* at site 1**

Diversity Indices for *Calamus thwaitesii* at site 1:

1. Shannon (H)



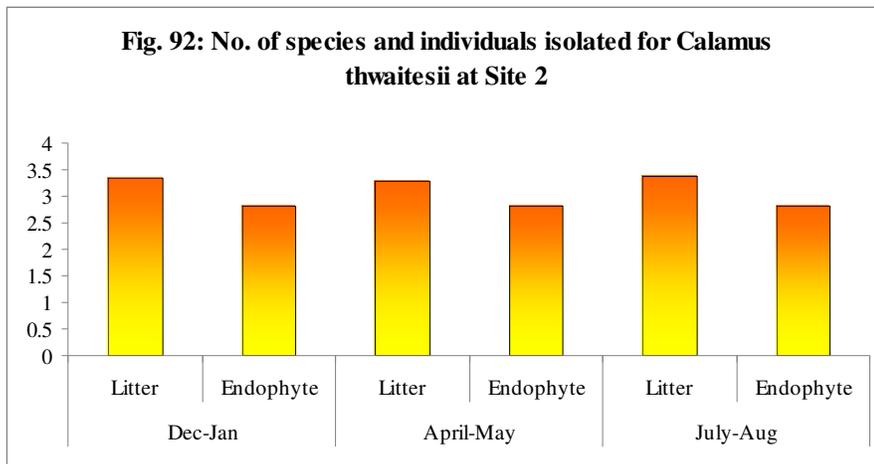
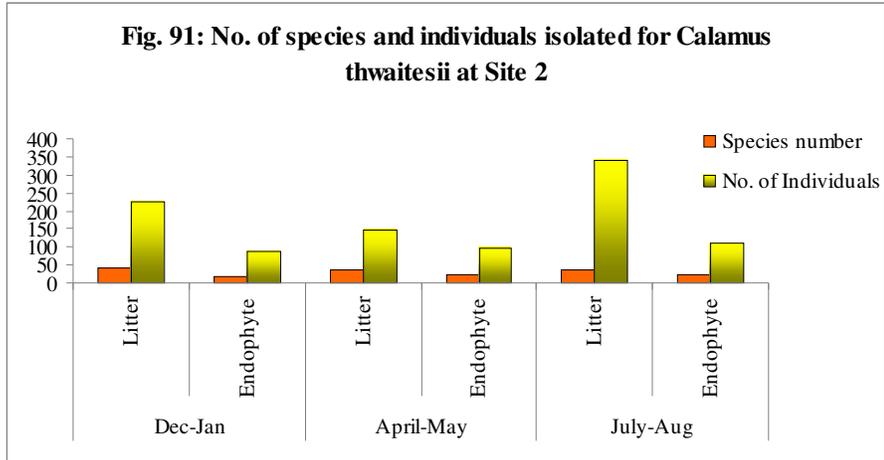
2. Simpson's Diversity



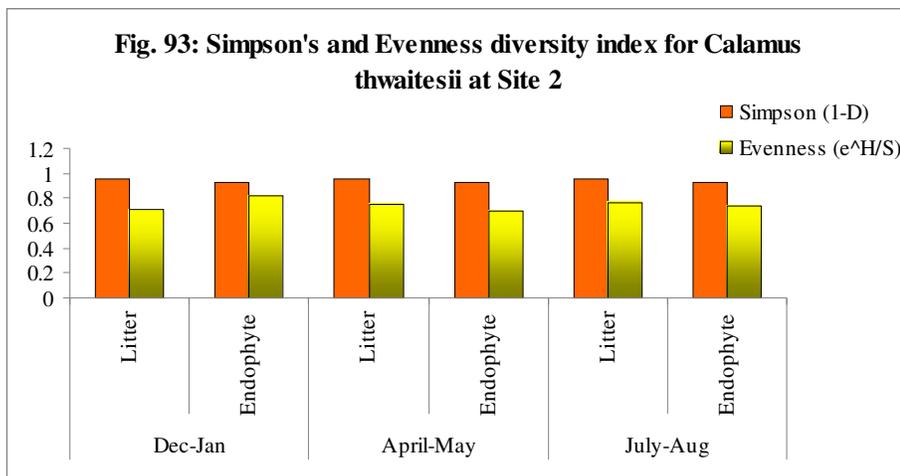
Calamus thwaitesii at Site 2:

Diversity Indices for *Calamus thwaitesii* at site 1:

1. Shannon (H)



2. Simpson's Diversity

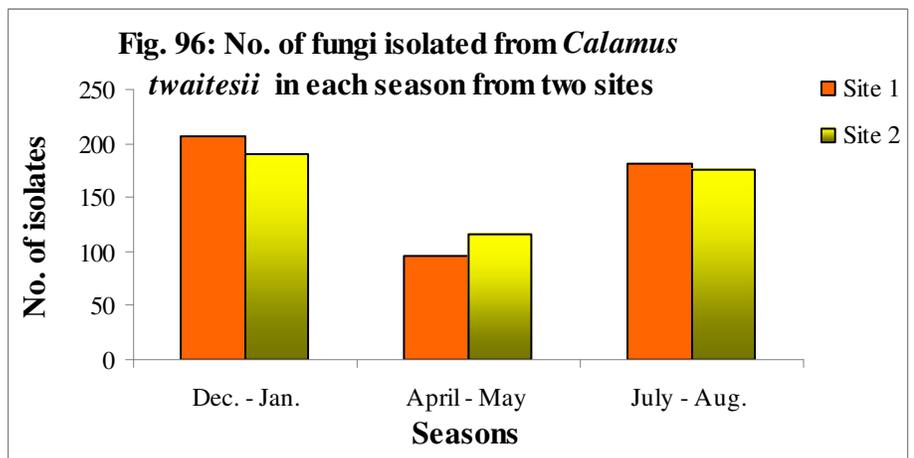
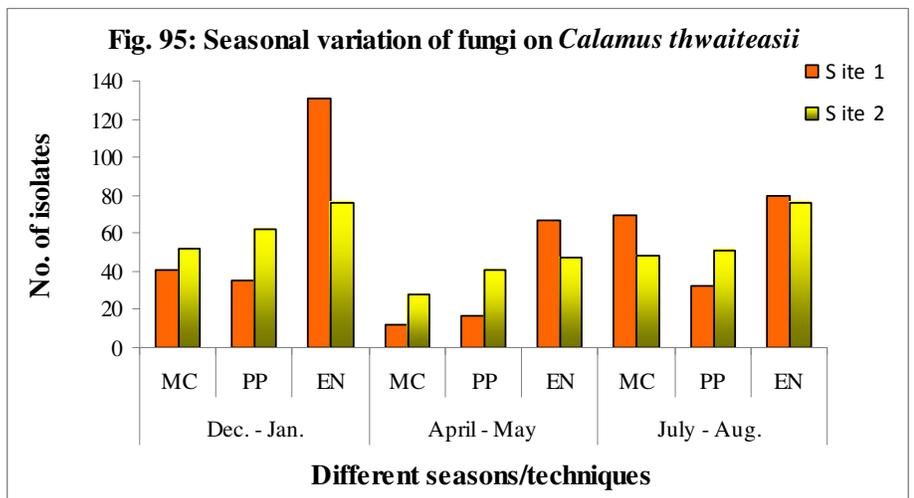
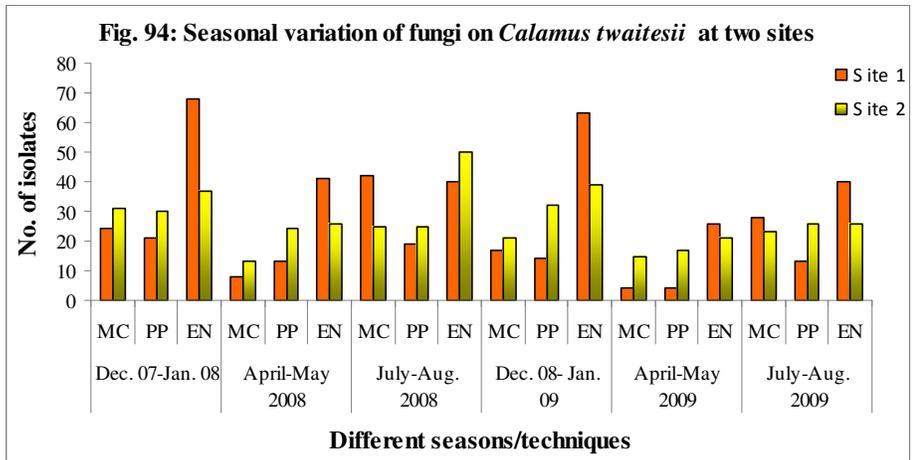


B. Fungi isolated from *Arenga wightii* Griff in different seasons

Studies on *Arenga wightii* for two years showed that rainy and winter seasons were the best to isolate largest number of fungi (Fig. 94, 95, 96). In all seasons highest numbers of fungal isolates were obtained as endophytes by 3-step sterilization method. By this method highest numbers of isolates were obtained in winter season that is Dec-Jan. Number of isolates obtained by particle-plating also showed similar trend. As in previous study number of isolates obtained by moist chamber isolation method was highest in rainy season.

It can be inferred from Shannon Indices for *Arenga wightii* that except for April-May at Site 1, litter fungi were more stable group than that of endophytes. In the entire study period, most stable community observed was litter fungi in Dec-Jan (3.075) at Site 1, followed by all other communities with least stable being litter at Site 1 in April-May. Endophytes associated with *Arenga wightii* at Site 1 were consistently dominant with values above 2.5 than those with Site 2 with maximum value 2.444 (Fig. 98 & 101).

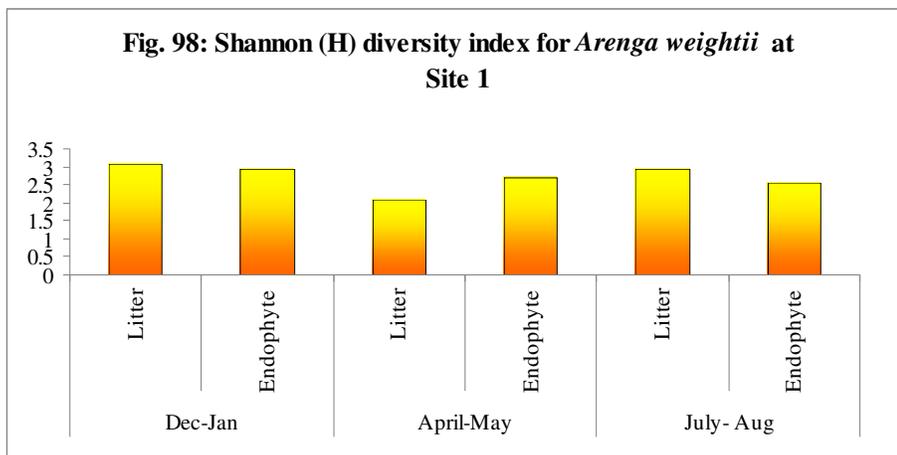
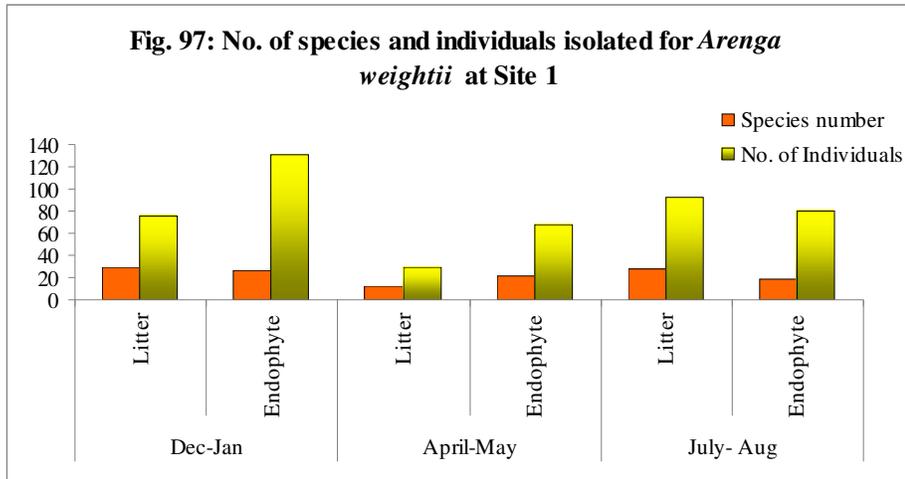
From Simpsons diversity indices we can observe well distributed and diverse community of fungi. Values for Simpson diversity indices for litter fungi were highest at 0.9404 in Dec.-Jan at Site 1 whereas for endophytes they were highest at 0.93337 for site 1 in Dec-Jan (Fig. 99 & 102).



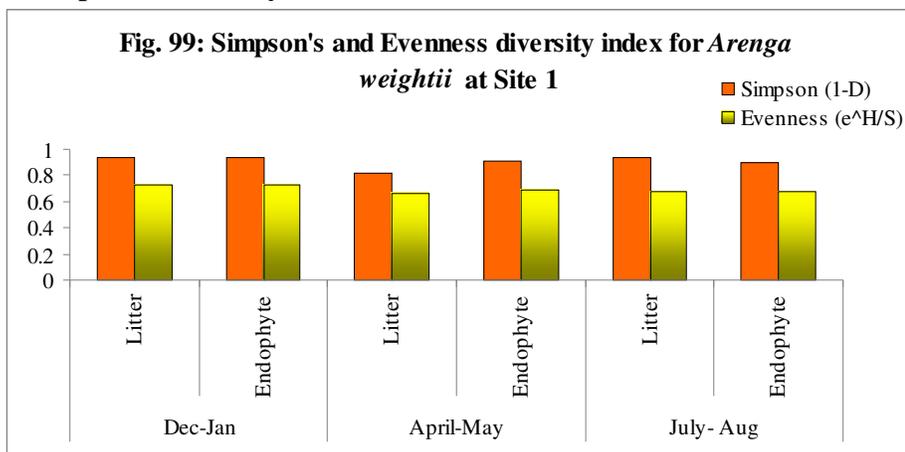
Arenga wightii at Site 1

Diversity Indices

1. Shannon (H)



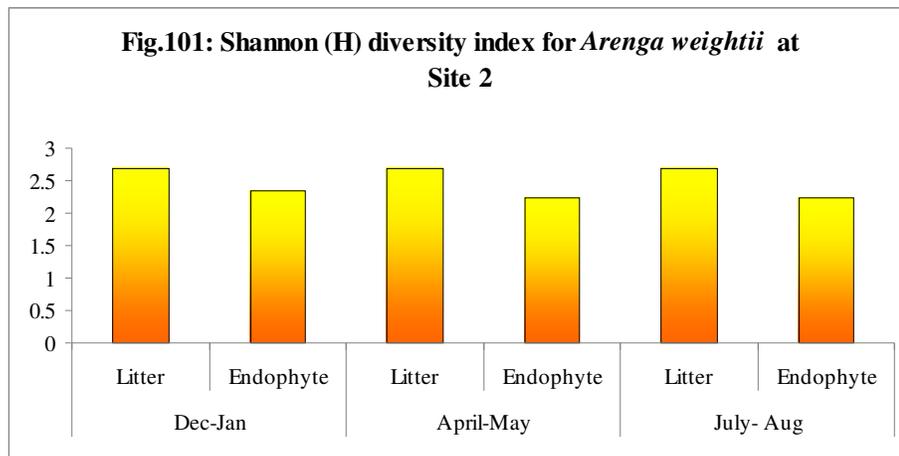
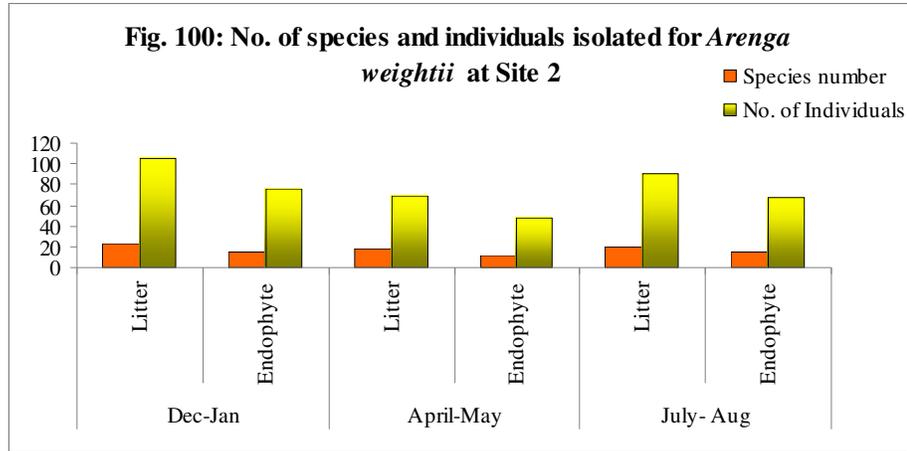
2. Simpson's Diversity



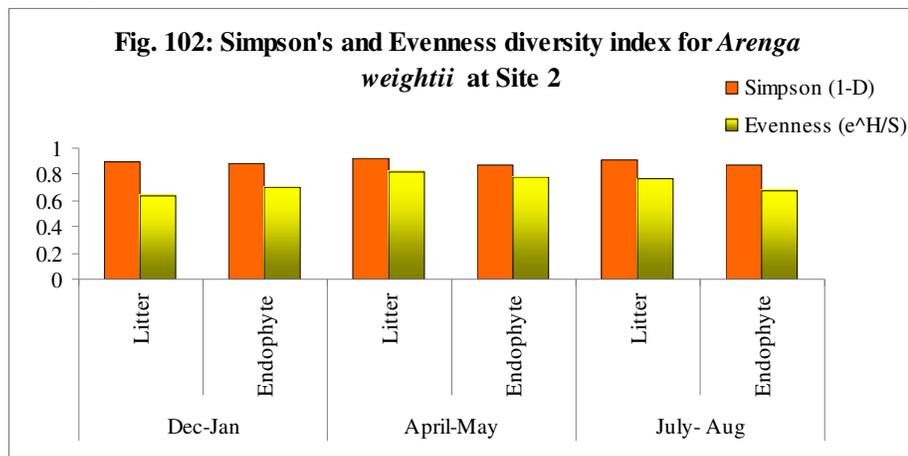
Arenga wightii at Site 2

Diversity Indices

1. Shannon (H)



2. Simpson's Diversity



Part III. List of cultures deposited in Goa University Fungal Culture Collection facility.

Serious efforts were made to establish pure cultures of fungi found on 13 palm plants studied, by different methods of isolation and culturing described before. The isolated fungi are being deposited at an in-house facility entitled 'Goa University Fungal Culture Collection' (GUFCC), as an *ex situ* fungal conservation effort.

Part-cultures of the isolated fungi are being housed at two nationally recognized repositories, (i) National Fungal Culture Collection (NFCCI) located at Agarkar Research Institute, Pune, and (ii) Microbial Type Culture Collection (MTCC) housed at Institute of Microbial Technology, Chandigarh. List of cultures submitted are given below.

Table 6: List of cultures deposited at GUFCC

GUFCC Number	Name	Place of Isolation	Host
15501	<i>Rattania setulifera</i>	Dhoodhsagar, Goa	<i>Calamus thwaitesii</i>
15502	<i>Pithomyces multiappendiculata</i>	Bondla, Goa	<i>Calamus thwaitesii</i>
15503	<i>Pithomyces</i> sp. New 1	Mashem, Goa	<i>Cocos nucifera</i>
15504	Unidentified fungus	Dhoodhsagar, Goa	Unidentified
15505	<i>Pithomyces africanus</i>	Bambolim, Goa	<i>Borassus flabellifer</i>
15506	<i>Pithomyces chartarum</i>	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15507	<i>Pithomyces ellisii</i>	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15508	<i>Pithomyces flavus</i>	Netravali, Goa	<i>Calamus thwaitesii</i>
15509	<i>Acremonium byssoides</i>	Dhoodhsagar, Goa	<i>Calamus thwaitesii</i>
15510	<i>Bharatheeya mucoidea</i>	Dhoodhsagar, Goa	<i>Calamus thwaitesii</i>
15511	<i>Cirrenalia pseudomacrocephala</i>	Netravali, Goa	<i>Elaeis guineensis</i>
15512	<i>Curvularia senegalensis</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15513	<i>Phaeoisaria clematidis</i>	Bambolim, Goa	<i>Caryota urens</i>
15514	<i>Paradictyoarthrinium diffractum</i>	Mashem, Goa	<i>Cocos nucifera</i>
15515	<i>Megacapitula villosa</i>	Bambolim, Goa	<i>Caryota urens</i>
15516	Unidentified fungus		
15517	<i>Lasiodiplodia theobromae</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15518	<i>Gliocladium roseum</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15519	<i>Dictyochaeta fertilis</i>	Netravali, Goa	<i>Arenga wightii</i>
15520	Unidentified ascomycetes		
15521	<i>Vermiculariopsiella</i> sp.	Dhoodhsagar, Goa	<i>Calamus thwaitesii</i>
15522	<i>Penicillium</i> sp.	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15523	<i>Dictyosporium elegans</i>	Dhoodhsagar, Goa	<i>Calamus thwaitesii</i>

15524	<i>Pestalotiopsis</i> sp.	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15525	<i>Stilbella</i> sp.	Mashem, Goa	<i>Cocos nucifera</i>
15526	<i>Pithomyces chartarum</i>	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15529	<i>Veronaea</i> sp.	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15530	Unidentified coelomycetes		
15531	Unidentified coelomycetes		
15532	<i>Vermiculariopsiella parva</i>	Netravali, Goa	<i>Arenga wightii</i>
15533	<i>Veronaea</i> sp.	Tambdisurla, Goa	<i>Calamus thwaitesii</i>
15534	<i>Cylindrocladium quinquesseptatum</i>	Netravali, Goa	<i>Arenga wightii</i>
15535	Stilbaceous culture	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15536	<i>Alternaria</i> sp.	Netravali, Goa	<i>Calamus thwaitesii</i>
15538	<i>Curvularia senegalensis</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15539	<i>Costantinella palmicola</i>	Calicut, Kerala	<i>Calamus thwaitesii</i>
15540	<i>Cladosporium</i> sp.	Bondla, Goa	<i>Caryota urens</i>
15541	<i>Memnoniella echinata</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15542	<i>Pestalotiopsis</i> sp.	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15543	<i>Pestalotiopsis</i> sp.	Netravali, Goa	<i>Calamus thwaitesii</i>
15544	<i>Aureobasidium</i> sp.	Netravali, Goa	<i>Arenga wightii</i>
15545	<i>Aspergillus niger</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15546	<i>Bharatheeya mucoidea</i>	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15547	<i>Megacapitula villosa</i>	Bambolim, Goa	<i>Caryota urens</i>
15548	<i>Dictyoarthrinium quadratum</i>	Mashem, Goa	<i>Cocos nucifera</i>
15549	<i>Helicomycetes</i> sp.	Satre, Goa	<i>Calamus thwaitesii</i>
15550	<i>Corynespora cassiicola</i>	Netravali, Goa	<i>Arenga wightii</i>
15551	Unidentified fungus	Agastimalai hills, Kerala	<i>Bentinckia condapanna</i>
15552	<i>Alysidium resinae</i>	Quepem, Goa	<i>Phoenix acaulis</i>
15553	<i>Alternaria</i> sp.	Netravali, Goa	<i>Calamus thwaitesii</i>
15557	<i>Phomopsis</i> sp.		
15559	<i>Nigrospora oryzae</i>	Bambolim, Goa	<i>Caryota urens</i>
15560	<i>Graphiola phoenicis</i>	Dona paula, Goa	<i>Phoenix</i> sp.
15561	<i>Pithomyces chartarum</i>	Miramar, Goa	<i>Hyphaene dichotoma</i>
15562	<i>Dictyochaeta fertilis</i>	Dhoodhsagar, Goa	<i>Arenga wightii</i>
15564	<i>Ceratocystis paradoxa</i>	St. Cruz, Goa	<i>Cocos nucifera</i>
15566	<i>Phomopsis</i> sp.	Dhoodhsagar, Goa	<i>Calamus thwaitesii</i>
15567	<i>Fusarium</i> sp.	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15568	<i>Aspergillus niger</i>	Netravali, Goa	<i>Calamus thwaitesii</i>
15569	<i>Helicosporium cinereum</i>	Katlekana, Karnataka	<i>Pinanga dicksonii</i>
15570	<i>Alysidium</i> sp.	Netravali, Goa	<i>Arenga wightii</i>
15571	<i>Virgaria nigra</i>	Netravali, Goa	<i>Arenga wightii</i>
15572	<i>Spondylocladiopsis aseptata</i>	Netravali, Goa	<i>Calamus rotang</i>
15573	<i>Ascotricha</i> sp.	Netravali, Goa	<i>Arenga wightii</i>

Part IV: Screening of selected fungal cultures for cellulase, laccase and antimicrobial activity

Taxonomically distinct and pure cultures isolated from different palm substrates, using various recovery methods, were subjected for cellulase, laccase and antimicrobial activity. In all, 60 isolates were considered for biochemical screening. According to the methods used, results are divided into primary qualitative and secondary quantitative screening for laccase and cellulose activities. On secondary screening, *Dictyoarthrinium quadratum* was found to be a good candidate for all the three assays and *Dictyosporium elegans* with maximum laccase activity (i.e. 326 nKat/L).

Primary qualitative screening for Cellulase, Laccase and Antimicrobial Activity

Primary screening for cellulase was done on carboxymethylcellulase agar medium. The culture plates were incubated for 5-10 days and flooded with 0.1 % Congo red followed by zone enhancement using NaCl and Acetic Acid solutions. The contrasting zones appeared around the colony indicated cellulase activity.

Primary screening for laccase was done on medium incorporated with Guaicol. The culture plates were incubated for 7 days and reddish zone around the colony indicated laccase activity.

For selection of candidates for antimicrobial screening, agar discs of 7-day old cultures were plated against test organisms. Colonies producing inhibition zones of growth in test organisms were selected for secondary screening.

Results of primary qualitative screening for Cellulase, Laccase and Antimicrobial Activity (Table 7)

Of the 60 isolates subjected for primary screening, 40 (67%) were positive for cellulase, 15 (25%) for laccase and 12 (12%) showed activity against test pathogenic

microbes (Fig. 107). Based on the width of inhibition zone produced, 6 cultures namely *Dictyoarthrinium quadratum* (GUFCC 15548), *Megacapitula villosa* (GUFCC 15515), *Penicillium sp.* (GUFCC 15522), *Dictyosporium elegans* (GUFCC 15523), *Bharatheeya mucoidea* (GUFCC 15546) and *Alysidium resinae* (GUFCC 15552) were selected for secondary screening for cellulose (Figs. 103, 104). *Dictyoarthrinium quadratum* and *Dictyosporium elegans* were selected for laccase (Fig. 105) and *Alternaria alternata* (GUFCC 15536), *Dictyoarthrinium quadratum* and an unidentified fungal culture (GUFCC 15552) were selected for antimicrobial screening (Fig. 105).

Table 7. Results of primary qualitative screening for Cellulase, Laccase and Antimicrobial Activity

GUFCC No.	Fungi Isolated	Cellulase		Laccase		Antimicrobial		
		I	II	I	II	I	II	III
15501	<i>Rattania setulifra</i>	+	+	+	+	-	-	-
15502	<i>Pithomyces sp.</i>	+	+	-	-	-	-	-
15503	<i>Pithomyces sp.</i>	+++	+++	-	-	-	-	-
15504	Unidentified fungus	+	+	-	-	-	-	-
15505	<i>Pithomyces africanus</i>	-	-	-	-	-	-	-
15506	<i>Pithomyces chartarum</i>	+	+	-	-	-	-	-
15507	<i>Pithomyces ellisii</i>	+	+	+++	A+	-	-	-
15508	<i>Pithomyces flavus</i>	+	+	A++	A+	+	+	+
15509	<i>Acremonium byssoides</i>	-	-	-	-	-	-	-
15510	<i>Bharatheeya mucoidea</i>	A+	+	-	A+	+	+	+
15511	<i>Cirrenalia pseudomacrocephala</i>	+	+	-	-	-	-	-
15512	Unidentified culture	-	-	-	-	+	+	+
15513	<i>Phaeoisaria clematidis</i>	+	++	-	-	-	-	-
15514	<i>Paradictyoarthrinium diffractum</i>	A+	A+	-	-	-	-	-
15515	<i>Megacapitula villosa</i>	A++	A++	-	-	-	-	-
15516	<i>Gliocladium penicillioides</i>	++	++	-	-	-	-	-
15517	<i>Lasiodiplodia theobromae</i>	-	-	-	-	-	-	-
15518	<i>Verticillium sp.</i>	-	-	-	-	+	+	+
15519	<i>Dictyochaeta fertilis</i>	+	+	+	+	-	-	-
15520	Unidentified ascomycetes	-	-	-	-	-	-	-
15521	<i>Vermiculariopsiella elegans</i>	+	+	-	-	-	-	-
15522	<i>Penicillium sp.</i>	A+	A+					
15523	<i>Dictyosporium elegans</i>	A++	A++	-	-	-	-	-
15524	<i>Pestalotiopsis sp.</i>	++	++	-	-	-	-	-
15525	<i>Wardomyces sp.</i>	+	+	-	-	-	-	-
15526	<i>Pithomyces chartarum</i>	+	+	-	-	-	-	-

15527	Unidentified culture	-	-	-	-	-	-	-
15528	<i>Curvularia senegalensis</i>	-	-	+	+	-	-	-
15529	<i>Stachybotrys kampalensis</i>	-	-	-	-	-	-	-
15530	Unidentified coelomycetes	-	-	-	-	-	-	-
15531	Unidentified coelomycetes	-	-	-	-	-	-	-
15532	<i>Vermiculariopsiella elegans</i>	+	+	-	-	-	-	-
15533	<i>Veronaea</i> sp.	-	-	-	-	-	-	-
15534	<i>Cylindrocladium quinqueseptatum</i>	+++	A+	-	-	+	+	+
15535	<i>Stilbella</i> sp.	-	-	-	-	-	-	-
15536	<i>Alternaria alternata</i>	++	++	+	+	+	+	+
15537	<i>Rhinoclaadiella atrovirens</i>	++	++	++	-	+	+	+
15538	Unidentified coelomycetes	A+	A+	-	-	-	-	-
15539	<i>Costantinella clavata</i>	A++	-	-	-	-	-	-
15540	<i>Cladosporium</i> sp.	++	++	-	-	-	-	-
15541	<i>Memmoniella echinata</i>	+	+	-	-	-	-	-
15542	<i>Pestalotiopsis</i> sp.	++	-	-	-	-	-	-
15543	<i>Cylindrocladium quinqueseptatum</i>	+	++	-	-	-	-	-
15544	<i>Aureobasidium</i> sp.	-	-	-	-	-	-	-
15545	<i>Aspergillus niger</i> Tiegh.	+++	+++	-	-	-	-	-
15546	<i>Bharatheeya mucoidea</i>	A++	A++	+	++	+	+	+
15547	<i>Megacapitula villosa</i>	A+	+	A++	A+	+	+	+
15548	<i>Dictyoarthrinium Quadratum</i>	A+	A++ +	+	+	+	+	+
15549	<i>Helicomycetes</i> sp.	-	-	-	-	-	-	-
15550	<i>Corynespora cassiicola</i>	-	-	A+	A+	+	+	+
15551	Unidentified culture	A+	A+	-	-	-	-	-
15552	<i>Alysidium resinae</i>	A+	A+	A+	A+	-	-	-
15553	<i>Alternaria</i> sp.	-	-	-	-	-	-	-
15554	Unidentified fungus	A+	-	-	-	-	-	-
15555	Unidentified fungus	A+	A+	-	-	-	-	-
15556	<i>Penicillium</i> sp.	-	-	-	-	-	-	-
15557	<i>Phomopsis</i> sp.	+	+	-	-	-	-	-
15558	<i>Pestalotiopsis</i> sp.	-	-	-	-	-	-	-
15559	<i>Nigrospora oryzae</i>	-	-	+	+	-	-	-
15560	<i>Graphiola phoenicis</i>	+	+	-	-	-	-	-

1-3 mm +
3-6 mm ++
7-9 mm +++
1-1.5 cm A+
1.5-2 cm A++

Fig. 103: Cellulase

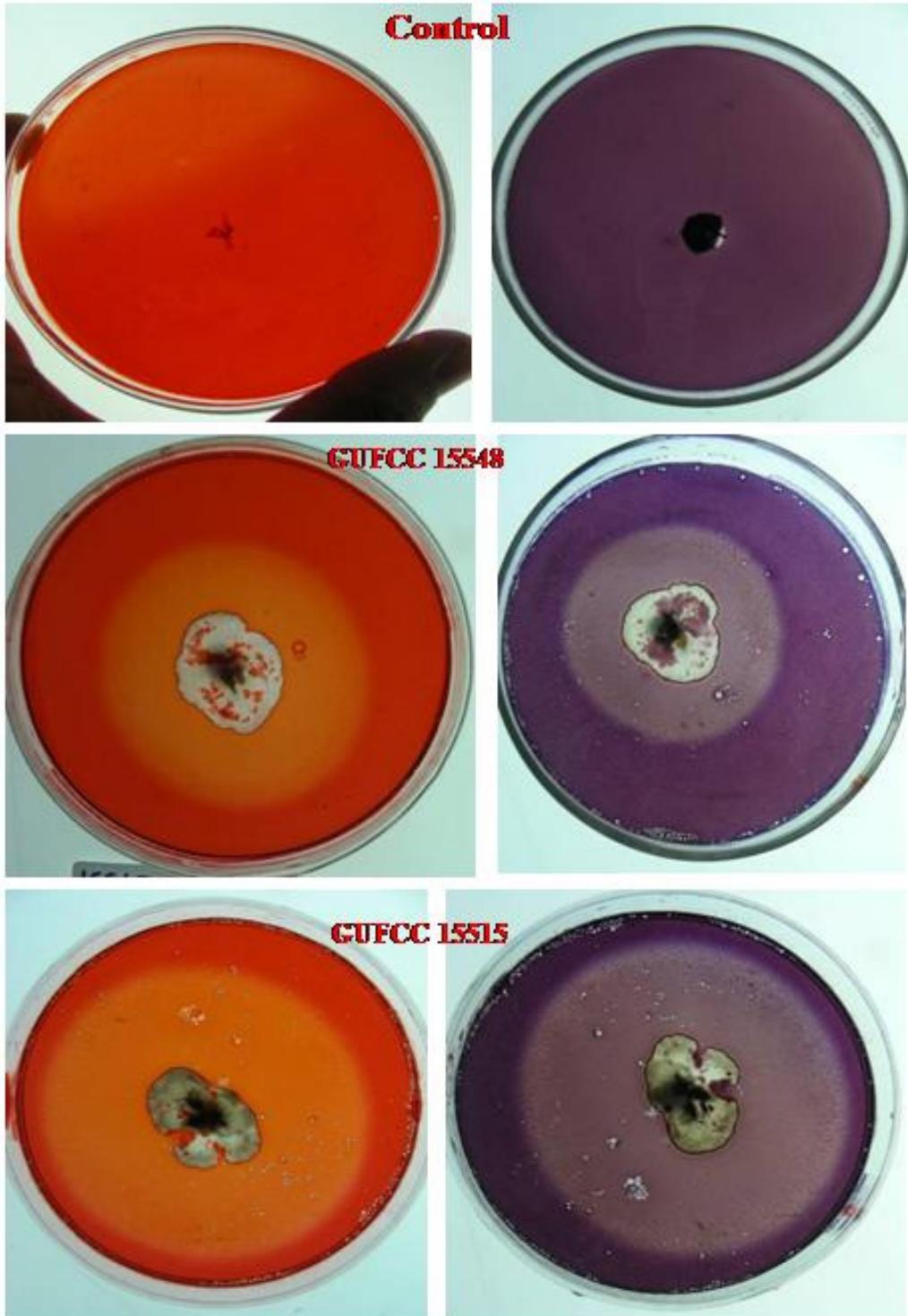


Fig. 104: Cellulase

GUFCC 15523



GUFCC 15551



GUFCC 15539

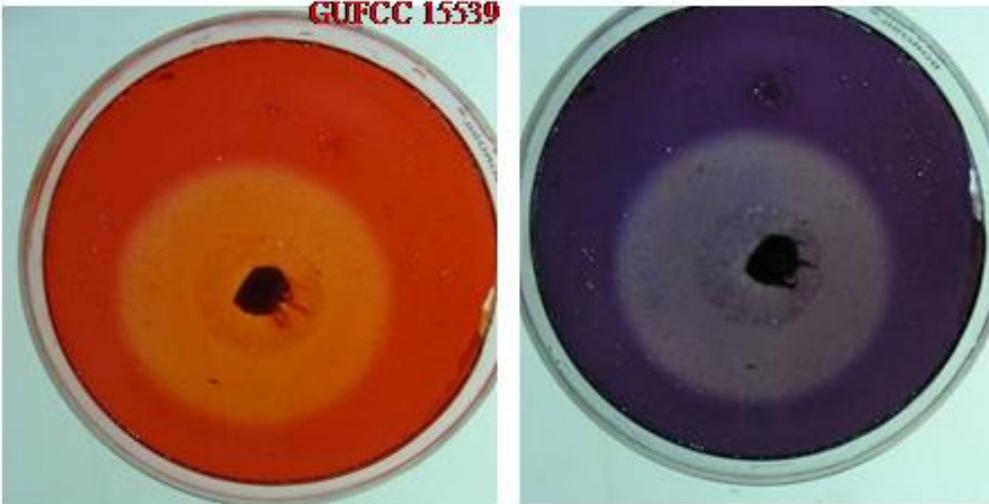


Fig. 105: Laccase

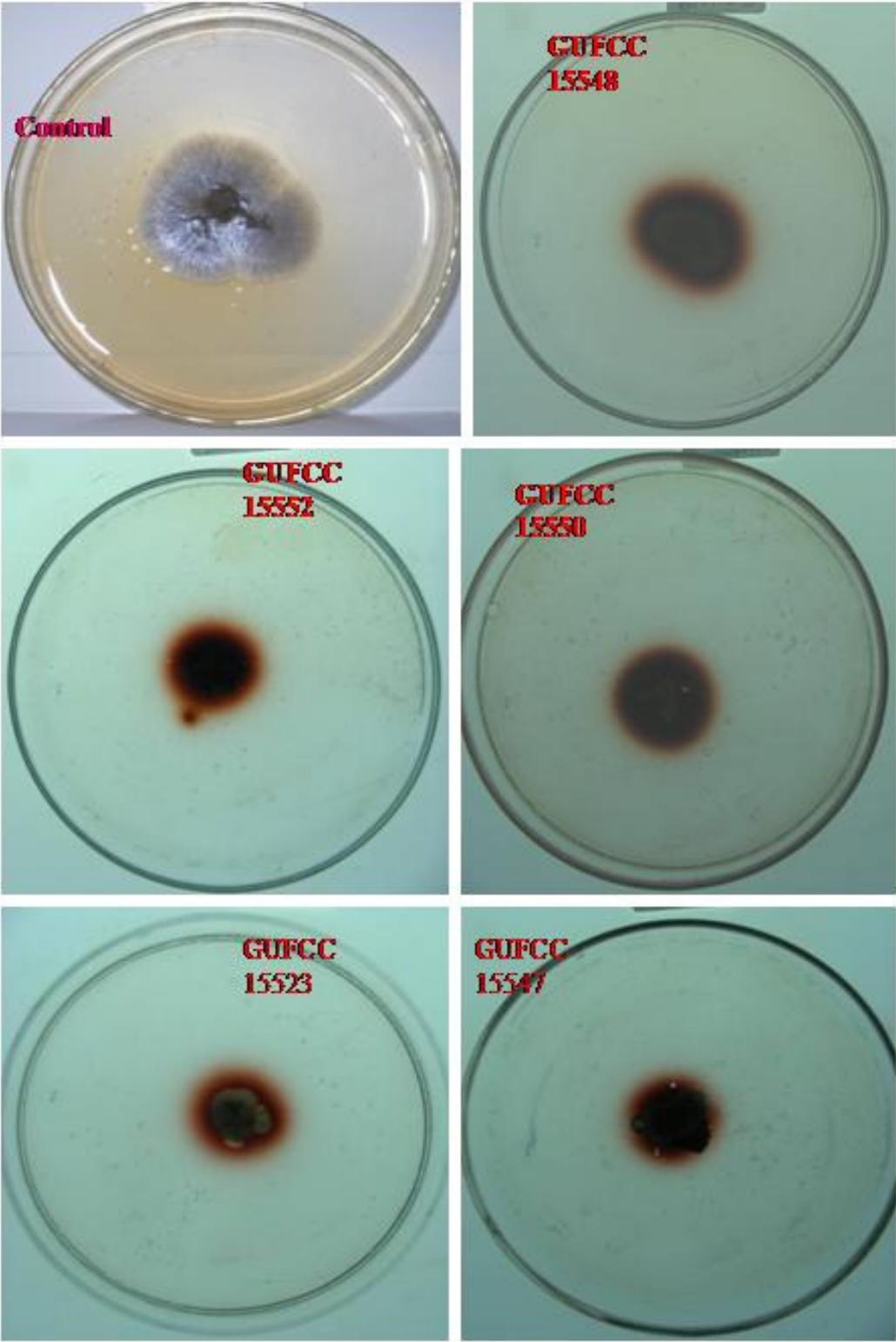


Fig. 106a: Antimicrobial preliminary screening

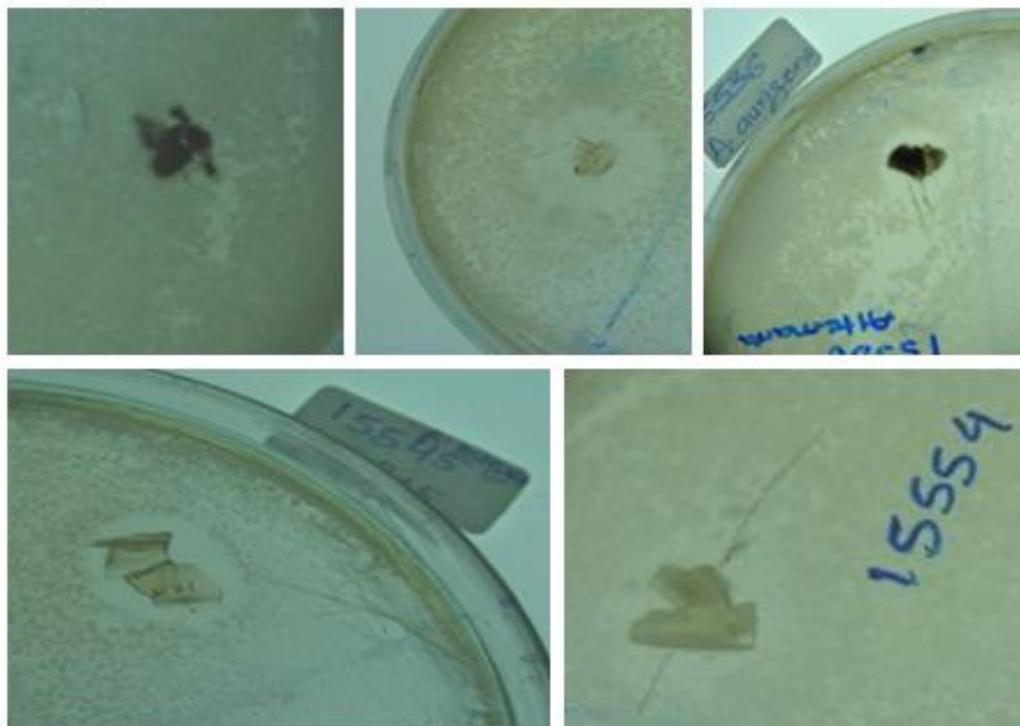
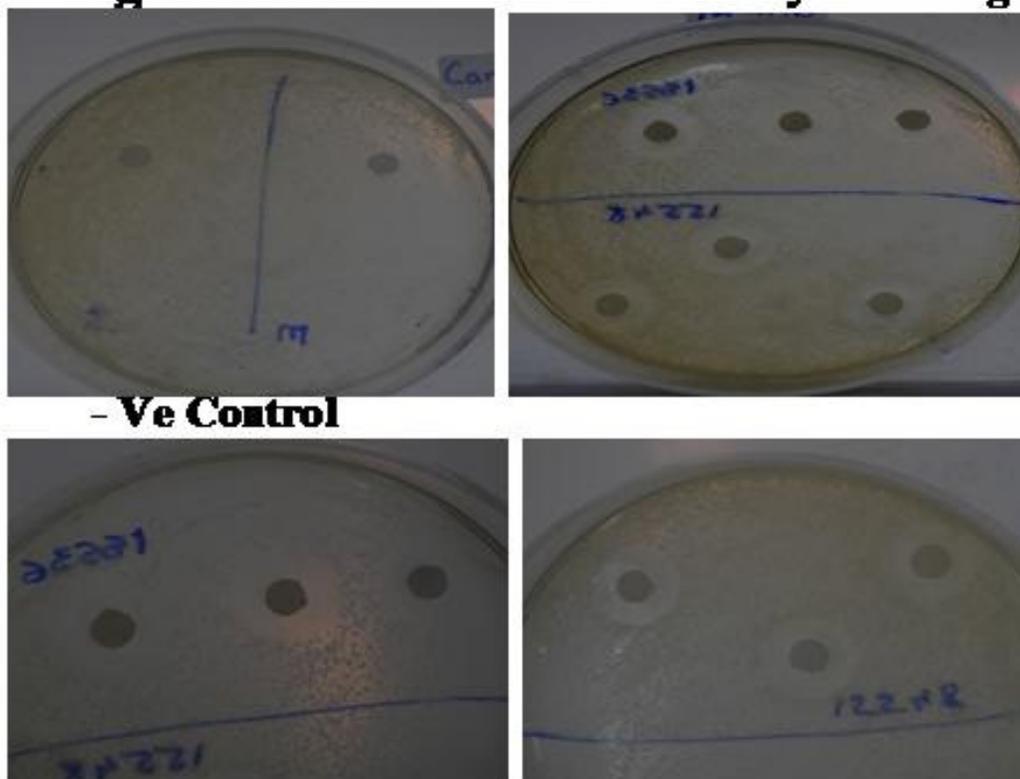
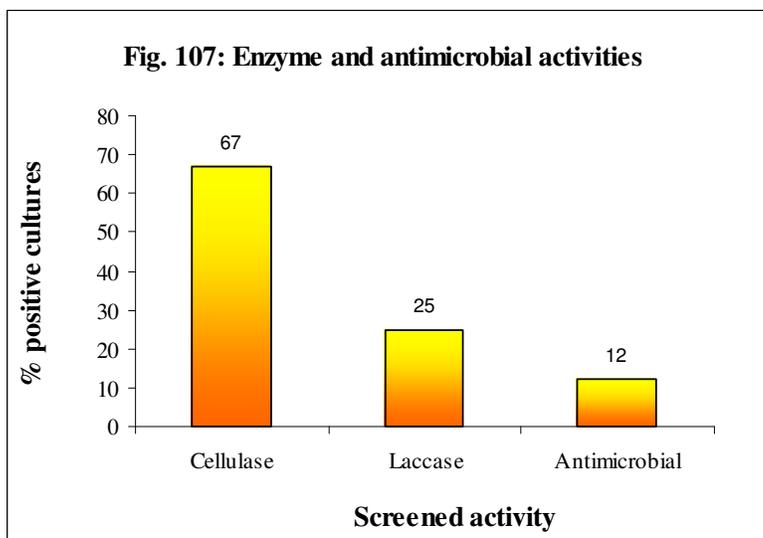


Fig. 106b: Antimicrobial Secondary screening



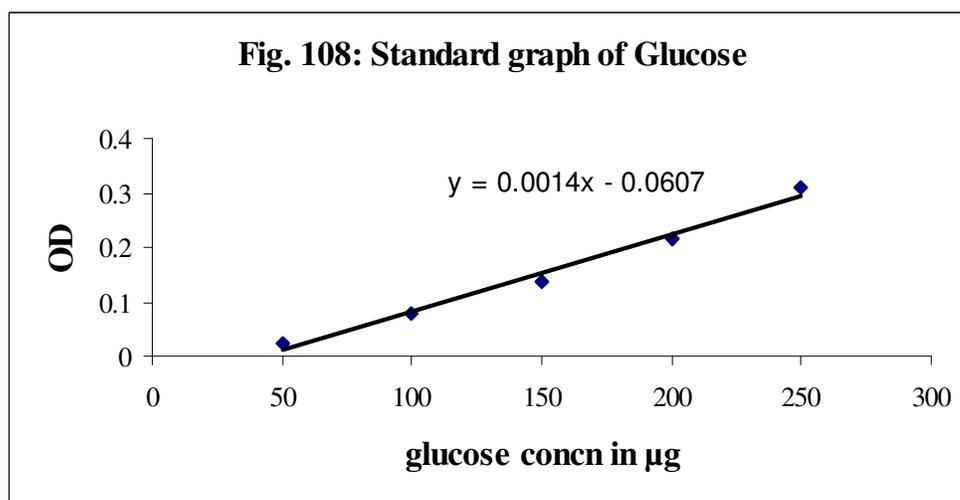
GUFCC 15536 & 15548



Secondary quantitative screening

Assay of cellulase By DNSA method

Assay reaction : 1 ml enzyme + 2ml 0.5% CMC substrate in 0.05M phosphate buffer (pH 7). Mix well; Incubate at 37 deg C, 30 min; + 1 ml DNSA, Mix. Heat in boiling water bath for 5 min. O.D. at 575 nm



$$X = (y+0.0607)/0.0014$$

Blank : 1 ml denatured enzyme + 0.5% CMC substrate +1 ml DNSA, Mix +Immediately heat in boiling water bath for 5 min. O.D. at 575 nm

Units calculation : μg glucose released x vol. of reaction x dilution factor/(mol wt.of glucose x incubation time x vol. of enz)

Table 8: Results of cellulose assay

Sample No.	Blk	blank:ug glucose released	Rction 1	Rction 2	Av. Reaction	reaction:ug glucose released	Reaction-blank: ug released	Dil. factor*	Units/ml/min	Units/L
15515	0.082	101.9286	0.164	0.148	0.156	154.7857	52.85714	1	0.039118667	39.11867
15522	0.249	221.2143	0.315	0.315	0.315	268.3571	47.14286	1	0.034889622	34.88962
15523	0.096	111.9286	0.186	0.181	0.1835	174.4286	62.5	1	0.046255181	46.25518
15546	0.286	247.6429	0.385	0.584	0.4845	389.4286	141.7857	1	0.104933181	104.9332
15548	0.284	246.2143	0.603	0.397	0.5	400.5	154.2857	1	0.114184217	114.1842
15552	0.324	274.7857	0.46	0.449	0.4545	368	93.21429	1	0.068986298	68.9863

Vol of reaction=4 ml

mol. wt. of glucose= 180.16

Incubation time= 30 min

Volume of enzyme= 1 ml

1 unit= micromoles of glucose liberated per min per ml of the enzyme under given conditions

Assay of Laccase activity based on oxidation of ABTS (2,2'-azino-bis (3-ethylbenzothiazoline)-6-sulphonic acid)

Assay reaction: 1ml ABTS (5 mM), 1ml culture filtrate (enzyme) was incubated for 3 min at 300C

Blank: Culture filtrate boiled for 30 min. to denature enzyme was used as blank in above reaction mixture

Units calculation: Units calculation= $\Delta A_{405} \times \text{total volume} \times 10^9 / (\epsilon (\text{ABTS}) \times \text{dt} \times \text{Sample volume}$

$\epsilon (\text{ABTS}) = 35000$ (Molar extinction coefficient of ABTS)

Table 9: Results of Laccase assay

Sample No.	Initial 1	Initial 2	Avg. Initial	Final 1	Final 2	Avg. Final	Sample volume (ml)	Final-Initial	Units= nKat/L
15523	0.299	0.307	0.303	0.405	0.408	0.4065	0.1	0.1035	326.98
15548	0.827	0.791	0.809	1.233	1.147	1.19	1	0.381	120

Volume of reaction: 2 ml

Discussion

As detailed out in the review of literature at Chapter III (p. 8), sizable amount of information is available on host-range and plant-associated fungal diversity from studies around the world (USDA database; Mycobank). Mycologists are now looking at unexplored plants for associated fungal diversity. Hitherto conducted studies (Hyde et al., 2000) have proved that with abundant evergreen foliage and concomitant litter fall, palms are considered as hosts for large number of saprophytic fungi.

Work carried out in this thesis showed similar results. Fungal associations with 13 palms of Western Ghat region were studied in detail. In all, 220 species of fungi were recorded. Of these, biodiversity data on fungal associations with endemic palms of Western Ghats, viz. *Bentinckia codapanna*, *Pinanga dicksonii*, *Arenga wightii*, *Hyphaene dicotoma*, *Corypha umbraculifera*, *Phoenix robusta*, *Phoenix acaulis* and *Calamu rotang* was obtained for the first time.

Three cultivated species of Arecaceae, viz. *Areca catechu*, *Borassus flabellifer* and *Cocos nucifera*, found growing in this region were studied in detail for fungal diversity in this thesis. Though sporadic records of documentation of species of fungi were reported earlier from these palms (Sarbhoy et al., 1986; 1996) detailed investigation was done for the first time through this thesis.

Two wild palms, namely *Arenga wightii* and *Calamus thwaitesii*, from two distant locations, were studied for litter fungi and endophytes, for two years. The study showed temporal variations in diversity and abundance of fungi associated with palms. 69 species were obtained from *Calamus thwaitesii* from site 1 and 61 species from site 2, where as 52 species were isolated from site 1 and 42 species from site 2 from *Arenga wightii*.

It has been realized that most of the hitherto diversity studies on palm fungi in India (Sarbhoy et al., 1986; 1996; Jamalidheen et al., 2004) did not attempt culturing of fungi. In this thesis, details of the fungi isolated in pure culture form from the palms and deposited in *ex-situ* culture collections at Goa University Fungus Culture Collection, Mycology Division of Agarkar Research Institute, Pune, and Microbial Type Culture Collection of Institute of Microbial Technology, Chandigarh are given. These cultures are invaluable bioresources and will now be readily available for future research work, especially in bioprospecting studies.

In order to have additional information on bioactivity of the isolated fungi, some of the cultures were screened and promising candidates of Cellulase, Laccase and Antimicrobial activity were identified.

Taxonomic documentation of distribution of microfungi over palms in Western Ghats.

Altogether, 13 palm plants, viz. *Areca catechu*, *Arenga wightii*, *Bentinckia condapanna*, *Borassus flabellifer*, *Calamus rotang*, *Calamus thwaitesii*, *Caryota urens*, *Cocos nucifera*, *Corypha umbraculifera*, *Elaeis guineensis*, *Hyphaene dichotoma*, *Phoenix acaulis* and *Pinanga dicksonii* were scanned for fungi. Different methods of isolation, viz. direct isolation, isolation following moist chamber incubation, particle-plating and isolation following 3-step sterilization, were used. In all, 217 fungi, belonging to 142 genera were recovered from different palm plants. These included Zygomycota (1 species in 1 genus), teleomorphic Ascomycota (17 species in 10 genera), anamorphic Ascomycota and Basidiomycota [Hyphomycetes (193 species in 128 genera) and Coelomycetes (6 species in 4 genera)]. They are listed out in Table 5.

With direct isolation and isolation following moist chamber incubation methods, it was observed that many fungi were based on single collections which indicated rarity of such fungi. A number of species were collected many times from the same plant or plant part indicating that these fungi have host preferences. There were other fungi which mostly were recovered in all collections indicating that these fungi have wide host range amongst palms.

Many of the fungi isolated in this study were found to be reported previously only from palms. Repeated isolation from the same host or a group of hosts indicates host specificity of these fungi and underlines the need for exploration of rare habitats for documentation of fungal diversity. Some of these fungi are listed below:

Agaricostilbum palmicola J.E. Wright: The genus *Agaricostilbum* was established by Wright (1970) for a synnematous hyphomycete, *A. palmicola*, isolated on *Phoenix* sp. from Argentina. Subsequently, the fungus was isolated from *Cocos nucifera* from India, by Subramanian and Natarajan (1975). In the present study, the fungus was found on *Arenga wightii*, *Borassus flabellifer*, *Cocos nucifera*, *Corypha umbraculifera* and *Phoenix acaulis*.

Bahusandhika indica (Subram.) Subram.

The fungus was mostly isolated from floral litter of *Cocos nucifera*. The fungus was first described as *Polydesmus indicus* by Subramaniam and later elevated to a genus level (Subramanian, 1956).

Bharatheeya mucoidea D'Souza & Bhat

D'Souza and Bhat (2002) described this fungus on *Calamus thwaitesii*. The fungus is again isolated as an endophyte on the same palm, during the present study.

Caudatispora palmicola J. Fröhl. & K.D. Hyde

Fröhlich & Hyde (1995) described this fungus on dead rachis of palm *Phytelaphas* from Ecuador. This fungus is reported in this study from fronds of *Cocos nucifera*.

Chalara indica Pratibha K.D. Hyde & Bhat

Pratibha et al. (2005) described this fungus on leaf spots of *Areca catechu*. The fungus is reported in the present study on same palm but from a different location.

Costantinella palmicola M.K.M. Wong, Yanna, Goh & K.D. Hyde

Wong et al. (2001) described this fungus from dead petiole of *Livistona chinensis* in Hong Kong. In the present study, the fungus was isolated from litter of *Calamus thwaitesii*.

Dictyoarthrinium quadratum S. Hughes

Hughes (1952) described this fungus from an unidentified litter. In present study, the fungus was often reported on litter of floral parts of *Cocos nucifera*

Graphiola phoenicis (Moug.) Poit.

This basidimycetous fungus was always found associated with healthy and senescent leaves of species of *Phoenix*.

Kostermansinda magna (Boedijn) Rifai

This fungus was first described as *Sclerographium magnum* Boedijn and currently known as *Kostermansinda magna* (Boedijn) Rifai. The fungus is frequently isolated in the present study from litter of *Calamus thwaitesii*.

Pithomyces africanus M.B. Ellis

Ellis (1960) described this fungus from leaf spots of *Borassus flabellifer* in Africa. The fungus in this study was isolated on leaves of same palms from Goa.

Pithomyces flavus Berk. & Broome

Berk. & Broome (1873) described this fungus from an unidentified palm litter from Sri Lanka. In the current study, the fungus was repeatedly isolated from litter of *Calamus thwaitesii*.

Pseudoepicoccum cocos (F. Stevens) M.B. Ellis

This fungus, causing leaf spots of *Cocos nucifera*, has wide distribution in all coconut growing regions of Asia.

Stigmina palmivora (Sacc.) S. Hughes

This fungus has global distribution and is known to be associated with leaf spot disease in *Borassus flabellifer*. In this study, in addition to *Borassus*, the fungus was found to cause severe leaf spots on *Hyphaene dichotoma*.

First record of fungi associated with several endemic palms

Few endemic palms, namely *Arenga wightii* Griff. *Bentinckia condapanna* Berry, *Hyphaene dichotoma* (White) Furt. and *Pinanga dicksonii* Blume were studied for fungal associations for the first time. This study resulted with isolation of 55 species of fungi from *Arenga wightii*, 42 from *Bentinckia condapanna*, 15 from *Hyphaene dichotoma* and 53 from *Pinanga dicksonii*. Several of these mycota are rare isolates. *Paraceratocladium seychellarum*, *Triposporium elegans*, *Sporidesmiella claviformis* are a few rare and taxonomically interesting fungi isolated from *Bentinckia condapanna*. *Bioconiosporium berberidis*, *Gonytrichum macrocladum*, *Phialophora richardsiae* along with an unidentified conidial form are some of the rare fungi isolated from *Pinanga dicksonii*. *Dictyochaeta guadalcanalensis*, *Didymostilbe sundara*, *Virgaria nigra* are some of the rare and taxonomically interesting fungi observed on *Arenga wightii*. Comparatively, a few fungi observed on *Hyphaene dichotoma* were found to be common litter fungi.

Fungal taxa new to science and to flora of India

During the course of this work, a few fungi new to science were isolated. *Rattania setulifera* Prabhugaonkar & Bhat has been published as a new species in a genus (Prabhugaonkar & Bhat, 2009). The paper is appended to the thesis at the end. Two novel species of *Pithomyces* are recognized during this work and these are now under further study.

Genus *Pithomyces*

Genus *Pithomyces* was described by Berkley & Broome (1873) with *P. flavus* Berk. & Br. as type species and genera *Neomichelia* Penz. & Sacc. and *Scheleobrachea* S. Hughes as its synonyms. Ellis (1976) reviewed the genus and provided a comprehensive account of the 15 described species. Rao & Reddy (1978) described *P. subramanianii* Rao & Reddy, the first species in the genus with more than one appendage-like extension. Rao & de Hoog (1986) provided a key to 25 species. Additional species have been described by Morgan-Jones (1987), Matsushima (1987, 1993), Rao & Manoharachary (1988), Zhang & Wu (2003), Zhang & Zhang (2003), Manoharachary et al. (2006) and Zhang & Zhang (2007). *Pithomyces* till date has 46 species

During the course of study 4 identified species of *Pithomyces*, viz. *Pithomyces africanus*, *P. chartarum*, *P. ellisii* and *P. flavus*, were isolated along with two more unidentified strains akin to *Pithomyces*. The genus *Pithomyces* has been carefully reviewed and a taxonomic key is prepared, with recognition of a new species. (Appendix 3).

Molecular phylogeny of rare fungal isolates

As a supplement to morpho-taxonomy, two morphologically rare isolates of monotypic genera: *Megacapitula* and *Paradictyoarthrinium* were further analyzed for

molecular phylogeny based on sequence of ITS/ 5.8S region. Blast analysis and alignment of sequences and construction of maximum likelihood tree using software MEGA 5.05 showed that the sequences to be distinct with less than 87% similarity with any of the named sequences available in genebank. This study confirmed that the fungi observed and described in literature based on morphological observations as rare monotypic genera were indeed rare collections even based on fungal sequence data in genebank.(Prabhugaonkar and Bhat 2011.)

Ecology of fungi associated with palms

Two palm plants, viz. *Arenga wightii* and *Calamus thwaitesii* from Dhoodhsagar and Netravali were observed for two years in three different seasons using different isolation methods for their associated fungal diversity. Results of the analysis of data presented in this part were aimed at understanding the ecological associations between the hosts and the fungi.

It was observed that *Calamus thwaitesii* harbored more number of species than *Arenga wightii* at both study sites. Site 1, near Dhoodhsagar waterfalls, showed more number of fungal species than site 2 at Netravali. The fungal taxa associated with plants of immediate neighborhood may have a strong impact on fungal flora of any plant. The higher altitude at site 1 might have an effect on diversity of the fungi observed. Diversity indices applied to the studies indicated that the fungal communities observed were diverse and stable. This was in expected lines as both the locations are in undisturbed forests.

Studies on fungal diversity of *Calamus thwaitesii* for two years showed that wet season was the best to recover more number of fungi. Direct isolation and isolation after moist chamber incubation methods were used to isolate the fungi.

Higher number of isolates was obtained in wet season, i.e. July-Aug, and lower number in dry season, i.e. April-may. This showed that the high moisture content and warm temperature played definitive role in determining the composition of fungal communities. Number of isolates obtained by particle-plating and endophytes was also more in wet season compared to dry season, although number of isolates by these methods did not differ as much as by moist chamber method within the different season. With moist chamber isolation method, 220 fungi were obtained in rainy season, 142 in winter season and 77 fungi in summer season. This could be due to a large number of opportunistic litter fungi colonizing litter in the rainy season.

Studies on *Arenga wightii* for two years showed that rainy and winter seasons were the best to isolate large number of fungi. In all the seasons, higher numbers of fungal isolates were obtained as endophytes, following 3-step sterilization method. By this method more numbers of isolates were obtained in the winter season, i.e. Dec-Jan. Number of isolates obtained by particle-plating method also showed similar trend. As in previous studies (D'Souza, 2002; Gawas, 2006) number of isolates obtained by moist chamber isolation method was higher in rainy season. Less number of litter fungi was obtained by moist chamber method compared to *Calamus thwaitesii*. This might be because of waxy nature of cuticle in *Arenga*. Also many of the litter fungi on *Calamus* were isolated from leaf sheaths (Fig. 82), while in *Arenga* the leaf sheath is reduced to fronds.

Ex-situ conservation fungi in culture collections

Large number of fungi was obtained in culture during course of the study. These are being deposited in various culture collections. Pure cultures of fungi are precious gene representation of wild forms. When these cultures are deposited in repositories, it is realized that a significant national biodiversity conservation job is done because in

most cases it is impossible to go back to the wild and sample out the concerned substrates, as done here. The deposited cultures at Goa University Fungal Culture Collection (GUFCC), National Fungal Culture Collection of India (NFCCI), at ARI, Pune and Microbial Type Culture Collection (MTCC), at IMTECH, Chandigarh, will remain always as immortals.

Foliicolous fungi and fungal pathogens of palms (Fig. 109, 110)

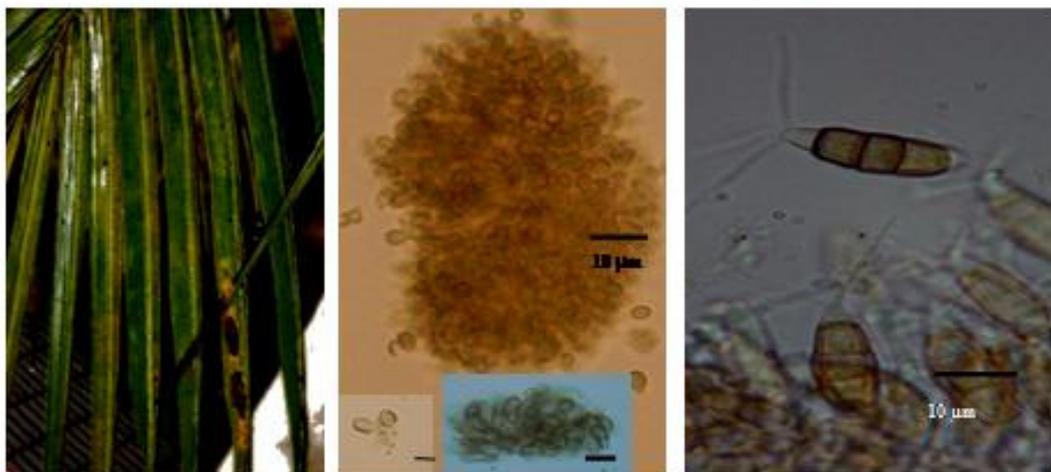
During the course of study some of the fungi isolated were known to be associated with symptoms of diseases like leaf spots, wilts etc. Leaf spots of Coconut palm were observed to be caused by *Pseudoepicoccum cocos* and *Pestalotiopsis palmivora*. Leaf spots of *Borassus flabellifer* and *Hyphaene dichotoma* were observed to be caused by *Stigmina palmivora*. Stem bleeding and wilt disease of coconut palm was observed to be caused by *Ceratocystis paradoxa* and its anamorphs. *Graphiola phoenicis* causing leaf spots and wilt of *Phoenix sp.* was also found to be always associated with the plant. Some other fungi such as *Cladosporium sp.* on leafspots of *Coryota urens* and *Chalara indica* on leaf spots of *Areca catechu* were also observed but there pathogenicity is not confirmed as there is lack of knowledge about there life cycle.

Fungi on palms with unusual morphology

Interestingly, some of the fungi encountered on palms are found to be with unusual morphology. Some examples are as follows:

***Agaricostilbum*:** An Auricularioid basidiomycete *Agaricostilbum palmicola*, originally placed in the Deuteromycetes, is shown to be a basidiomycete related to the stilboid Auriculariales. The species has a haploid yeast phase, with cylindric-celled basidia, and blastogenous basidiospores. The generic description is emended in accordance with these findings (Wright 1970).

Fig. 109: Follicolous fungi from palm



Leaf spot or leaf blight of Coconut, *Pseudoepicoccum cocos* & *Pestalotiopsis palmivora*

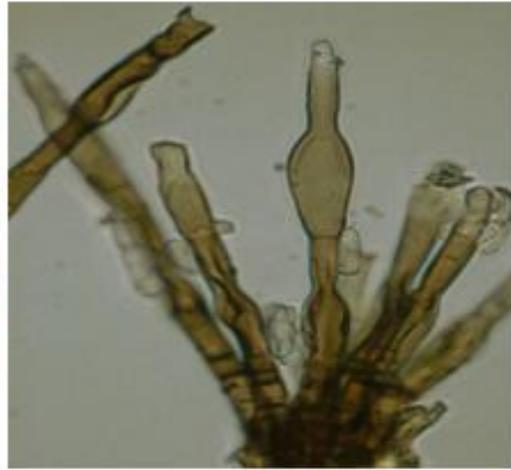


Leaf spots of Borasses by *Stigmina palmivora*



Wilt and stem bleeding of Coconut by *Ceratocystis paradoxa*

Fig. 110: Follicolous fungi from palm



Leaf spots of Arecanut by *Chalara indica*



Cladosporium* sp. on leaf spots of *Caryota urens



***Graphiola phoenicis* on *Phoenix* sp.**

Graphiola: Cole (1983) described *Graphiola* leaf spot (False Smut) of Palm. *Graphiola phoenicis*, a biotrophic parasitic fungus of palms, was originally identified as a myxomycete and later classified as a discomycete, rust, pyrenomycete, smut-like fungus and hyphomycete. The taxonomic confusion has persisted for approximately 160 years and was primarily due to the lack of understanding of fructification development and the nuclear cycle of the fungus. In their investigations, *Phoenix canariensis* Hort., which is one of the hosts of *G. phoenicis*, was maintained in a growth chamber under conditions suitable for dissemination of the parasite. On the basis of ultrastructural and histological data obtained from a study of infected leaves, mechanisms of ingress, ramification and egress of *G. phoenicis* were proposed. Techniques of fluorescent microscopy and flow cytometry showed that the air-dispersed propagules and yeast cells were of same ploidy and supported results of a recent study which demonstrated that meiosis occurred in the chain of fertile cells (basidia). The fungus is a member of the Heterobasidiomycetes and accommodated in the separate order Graphiolales.

Endocalyx melanoxanthes: This fungus forms yellow cup like structures on the litter of palms around the world. Smooth thick walled conidia are formed from minute polybasic conidiogenous cells which fill the cavity of cup (Ellis, 1971)

Aurobasidium: *Aurobasidium* is a yeast-like fungus often found also in short dematiaceous mycelial phase. In this study, it was often isolated as an endophyte from *Bentinckia condapanna* and *Calamus thwaitesii*.

Screening of isolated fungi for Cellulase, Laccase and Antimicrobial activity

In the primary screening of the 60 cultures, 40 (67%) were positive for cellulase, 15 (25%) for laccase and 12 (12%) showed activities against pathogenic microbes. The cultures showing good activity in primary screening were selected for secondary

screening. Cultures of *Dictyoarthrinium quadratum* (GUFCC 15548), *Megacapitula villosa* (GUFCC 15515), *Penicillium sp.* (GUFCC 15522), *Dictyosporium elegans* (GUFCC 15523), *Bharatheeya mucoidea* (GUFCC 15546) and *Alysidium resinae* (GUFCC 15552) were selected for cellulase assay by DNSA method. *Dictyoarthrinium quadratum* and *Dictyosporium elegans* were selected for laccase assay by ABTS method. *Alternaria alternata* (GUFCC 15536), *Dictyoarthrinium quadratum* and an unidentified fungal culture (GUFCC 15552) were selected for antimicrobial screening by preparation of methanol extracts.

With secondary quantitative screening *Dictyoarthrinium quadratum* was found to be a good candidate for all three assays whereas *Dictyosporium elegans* showed maximum laccase activity, that is 326 nKat/L.

Summary

In this thesis entitled 'Studies on Diversity and Activity of Microfungi Associated with Indigenous Palms of Western Ghats, India', palm-associated microfungi were studied in detail for the first time from the forests of Western Ghats, India. This included investigations on fungal associations with endemic palms such as *Bentinckia condapanna*, *Pinanga dicksonii*, *Arenga wightii*, *Hyphaene dichotoma*, *Corypha umbraculifera* and endemic and restricted species of *Calamus* for which no fungal records were available till date. (USDA online database (Farr and Rossman 2011)).

The thesis dealt with taxonomy, diversity, ecology and activity of palm-associated fungi.

For taxonomic documentation and distribution of microfungi of palms, altogether 13 palm plants, viz. *Areca catechu*, *Arenga wightii*, *Bentinckia condapanna*, *Borassus flabellifer*, *Calamus rotang*, *Calamus thwaitesii*, *Caryota urens*, *Cocos nucifera*, *Corypha umbraculifera*, *Elaeis guineensis*, *Hyphaene dichotoma*, *Phoenix acaulis* and *Pinanga dicksonii* were studied for fungal associations using standard isolation methods. The study resulted in documentation of 217 fungi, belonging to 142 genera. These included, Zygomycota (1 species in 1 genus), teleomorphic Ascomycota (17 species in 10 genera), anamorphic Ascomycota and Basidiomycota [Hyphomycetes (193 species in 128 genera) and Coelomycetes (6 species in 4 genera)]. Anamorphic hyphomycetous forms were the most dominant group of fungi encountered during the study, followed by Ascomycota and anamorphic coelomycetes. All these fungi are described in detail in the thesis with photomicrographs and camera lucida illustrations for rare fungal isolates. This documentation revealed several interesting aspects of distribution of fungi over palms.

Many of the fungi isolated were reported previously only from palms. These included *Agaricostilbum palmicola*, *Bahusandhika indica*, *Bharatheeya mucoidea*, *Caudatispora palmicola*, *Chalara indica*, *Costantinella palmicola*, *Dictyoarthrinium quadratum*, *Graphiola phoenicis*, *Kostermansinda magna*, *Pithomyces africanus*, *Pithomyces flavus*, *Pseudoepicoccum cocos* and *Stigmina palmivora*. Repeated isolation on same host indicates host specificity of these fungi and underlines the need for exploration of rare habitats for documentation of fungal diversity. Taxonomic documentation also resulted in the 'first record' of fungi associated with endemic palms of western ghats, i.e. 55 species of fungi from *Arenga wightii*, 42 from *Bentinckia condapanna*, 15 from *Hyphaene dichotoma* and 53 from *Pinanga dicksonii*. Several of these mycota are 'rare isolates'. *Paraceratocladium seychellarum*, *Triposporium elegans* and *Sporidesmiella claviformis* are rare and taxonomically interesting fungi isolated from *Bentinckia condapanna*. *Bioconiosporium berberidis*, *Gonytrichum macrocladum* and *Phialophora richardsiae* along with an unidentified conidial form are some of the rare fungi isolated from *Pinanga dicksonii*. *Dictyochaeta guadalcanalensis*, *Didymostilbe sundara* and *Virgaria nigra* are some of the rare and taxonomically interesting fungi observed on *Arenga wightii*.

During the course of this work, a few fungi 'new to science' were isolated. *Rattania setulifera* Prabhugaonkar & Bhat has been published as a new species in a genus (Prabhugaonkar & Bhat, 2009). The paper is appended to the thesis at the end. Two novel species of *Pithomyces* are recognized during this work. These, along with a complete revision of taxonomy of the genus *Pithomyces* formed manuscript of a paper communicated for publication (Appendix, V).

As a supplement to morpho-taxonomy, two morphologically rare isolates of monotypic genera *Megacapitula* and *Paradictyoarthrinium* were further analyzed for molecular phylogeny based on sequence of ITS/ 5.8S region. Blast analysis and alignment of sequences and construction of maximum likelihood tree using software MEGA 5.05 showed that the sequences to be distinct with less than 87% similarity with any of the named sequences available in genebank. This study confirmed that the fungi observed and described in literature based on morphological observations as rare monotypic genera were indeed rare collections even based on fungal sequence data in genebank (Prabhugaonkar and Bhat 2011)

In an attempt to understand seasonal distribution of fungi over palms, two palm plants, viz. *Arenga wightii* and *Calamus thwaitesii* from Dhoodhsagar and Netravali were observed for two years in three different seasons using different isolation methods for their associated fungal diversity. It was observed that *Calamus thwaitesii* harbored more number of species than *Arenga wightii* at both study sites. Study also showed that wet season was the best to recover more number of fungi. Diversity indices of palm fungi studied from two locations highly resembled each other with Shannon (H) index ranging from 2.072- 3.37 and Simpson (1-D) ranging from 0.8228- 0.9607 showing a diverse and stable community of microfungi on palms at both locations over the seasons.

In an attempt for *ex-situ* conservation, of the isolated, 60 species of fungi were maintained in culture collections, viz. deposited at Goa University Fungal Culture Collection (GUFCC), National Fungal Culture Collection of India (NFCCI), at ARI, Pune and Microbial Type Culture Collection (MTCC), at IMTECH, Chandigarh.

In an effort to study the activity, isolated fungal cultures were screened for Cellulase, Laccase and Antimicrobial activity. In the primary screening of 60 cultures,

40 (67%) were positive for cellulase, 15 (25%) for laccase and 12 (12%) showed activities against pathogenic microbes. With secondary quantitative screening *Dictyoarthrinium quadratum* was found to be a good candidate for all three assays whereas *Dictyosporium elegans* showed maximum laccase activity, that is 326 nKat/L.

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Appendix 1: Seminars , training programs attended papers presented

A. Seminars attended papers presented

- Poster paper 'Micro-fungal diversity associated with two endemic palms of Western Ghats, India' at the national conference on 'Recent advances in mycological research' organised by Mycological society of India, CAS in Botany, University of Madras, Chennai, 8-9th Feb'2011. Selected for Dr. M.J. Thirumalachar award for best poster presentation.
- Poster paper 'Study of micro fungal diversity associated with Rattans of Goa' in the First Indian Biodiversity Congress (IBC2010) organised by CISSA, held at Thiruvananthapuram, Kerala, 28-30th Dec. 2010
- Poster paper 'Study of microfungi associated with Rattans of Goa' at national symposium on 'New vistas for mycology in meeting global challenges' organised by Mycological society of India, CAS in Botany, University of Madras, Chennai, 29 th -30th Jan'2009.
- Attended national conference on 'Fungal diversity: Impact & Exploitation' organised by Mycological society of India, at Thapar University, Patiala, 5-6th Oct. 2007.

B. Training programs attended

C.

- '*Winter school on microbial genome typing*', by Networking resource centre in biological sciences, Madurai Kamaraj University, Madurai, 10-24 Dec. 2008

Appendix II- A

A. Fungi isolated from *Calamus thwaitesi* Becc. & Hook in different seasons

Site 1: Near dhoodhsagar waterfalls, Mollem

Name	Dec. 07-Jan. 08			April-May 2008			July-Aug. 2008			Dec. 08- Jan. 09			April-May 2009			July-Aug. 2009		
	MC/ 500 g	PP/ 100 mg	EN/ 100 bits	MC / 500 g	PP/ 100 mg	EN/ 100 bits												
1. <i>Acremonium byssoides</i>	-	8	-	-	5	3	-	12	7	-	5	-	-	6	1	-	-	2
2. <i>Acrogenospora sphaerocephala</i>	2	-	-	-	-	-	5	-	-	1	-	-	-	-	-	3	-	-
3. <i>Alternaria alternata</i>	-	2	1	-	1	1	-	5	2	-	2	1	-	-	-	-	2	1
4. <i>Alysidium resiniae</i>	-	-	4	-	-	3	-	-	1	-	-	3	-	-	-	-	-	1
5. <i>Ardhachandra selenoides</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. <i>Aspergillus niger</i>	-	10	12	-	8	2	-	5	7	-	6	3	-	3	6	-	5	14
7. <i>Aspergillus oryzae</i>	-	-	2	-	4	7	-	2	1	-	2	5	-	8	2	-	2	-
8. <i>Aspergillus terreus</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
9. <i>Aspergillus ustus</i>	-	-	-	-	2	3	-	1	-	-	2	1	-	2	2	-	-	-
10. <i>Aspergillus fumigatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11. <i>Aspergillus nidulans</i>	-	-	1	-	1	1	-	2	1	-	-	1	-	4	1	-	3	2
12. <i>Berkleasmium typhae</i>	5	-	-	2	-	-	9	-	-	4	-	-	3	-	-	8	-	-
13. <i>Bisporomyces</i> sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
14. <i>Brachysporiella gayana</i>	2	-	-	1	-	-	10	-	-	-	-	-	1	-	-	8	-	-
15. <i>Catanularia</i> sp.	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-
16. <i>Cladosporium</i>	-	7	5	-	6	4	-	5	5	-	3	4	-	1	3	-	6	8

	<i>cladosporioides</i>																		
17.	<i>Corynespora cassicola</i>	-	-	4	-	-	2	-	1	5	-	-	-	-	-	2	-	-	6
18.	<i>Curvularia senegalensis</i>	-	-	1	-	-	4	-	-	2	-	-	1	-	-	3	-	-	2
19.	<i>Curvularia</i> sp.	-	1	-	-	-	-	-	1	2	-	1	-	-	1	1	-	-	-
20.	<i>Dactylaria biseptata</i>	-	-	3	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
21.	<i>Dictyochaeta assamica</i>	2	-	1	-	4	1	1	2	1	-	2	-	1	2	-	-	-	1
22.	<i>Dictyochaeta fertilis</i>	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	1	-	-
23.	<i>Dictyosporium elegans</i>	1	-	-	4	-	-	6	-	1	2	-	-	1	-	2	3	-	1
24.	<i>Ellisembia adscendens</i>	3	-	-	2	-	-	7	-	-	2	-	-	1	-	-	5	-	-
25.	<i>Exserticlava vasiformis</i>	2	-	-	-	-	-	3	-	-	1	-	-	-	-	-	2	-	-
26.	<i>Fusarium graminearum</i>	-	-	3	-	-	-	-	-	2	-	-	-	-	-	1	-	-	2
27.	<i>Fusarium</i> sp.	-	1	-	2	-	-	-	-	-	1	-	-	-	-	-	2	1	1
28.	<i>Gliocladium penicillioides</i>	-	2	1	-	1	1	-	5	1	-	-	-	-	2	1	-	2	2
29.	<i>Helicoma</i> sp. 2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
30.	<i>Helicomycetes</i> sp.	3	-	-	2	-	-	6	-	-	1	-	-	-	-	-	3	-	-

31.	<i>Helminthosporium</i> sp	6	-																
32.	<i>Helminthosporium belgaumense</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
33.	<i>Hemicorynespora mitrata</i>	8	-	-	3	-	-	6	-	-	2	-	-	1	-	-	7	-	-
34.	<i>Idriella fertilis</i>	-	-	1	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-
35.	<i>Junewangia sphaerospora</i>	3	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-
36.	<i>Kostermansinda magna</i>	9	-	-	4	-	-	14	-	-	7	-	-	5	-	-	12	-	-
37.	<i>Melanographium citri</i>	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
38.	<i>Monodictys</i> sp.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
39.	<i>Nigrospora oryzae</i>	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
40.	<i>Nodulisporium ochraceum</i>	-	-	2	-	-	-	-	-	7	-	-	4	-	-	1	-	-	-
41.	<i>Pacilomyces</i> sp.	1	-	1	-	-	2	-	-	1	-	-	2	-	-	-	-	-	8
42.	<i>Panicillium</i> sp.	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.	<i>Penicillium</i>	-	1	-	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-
44.	<i>Penicillium</i>	-	-	1	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-

45.	<i>Parahelminthosporium malabaricum</i>	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
46.	<i>Pestalotiopsis palmarum</i>	-	3	-	-	2	-	-	7	-	-	-	-	-	4	-	-	2	-
47.	<i>Pestalotiopsis</i> sp.	-	-	3	-	-	-	-	-	4	-	-	-	-	-	-	-	-	6
48.	<i>Phaeoisaria clematidis</i>	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
49.	<i>Phoma</i> sp.	-	-	1	-	-	4	-	-	-	-	-	1	-	-	3	-	-	-
50.	<i>Phomopsis</i> sp.	-	-																
51.	<i>Pithomyces flavus</i>	2	-	-	1	-	-	2	-	-	4	-	-	1	-	-	1	-	-
52.	<i>Rattania setulifra</i>	-	-	-	-	-	1	-	-	3	-	-	1	-	-	-	-	-	6
53.	<i>Rhinocladiella atrovirens</i>	-	-	-	3	2	1	-	-	-	-	-	-	2	1	-	-	-	-
54.	<i>Scolecobasidium</i> sp.	-	-	1	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-
55.	<i>Sporidesmium</i> sp	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
56.	<i>Sporochisma mirabile</i>	7	-	-	6	-	-	13	-	-	2	-	-	6	-	-	10	-	-
57.	<i>Tetraploa aristata</i>	-	-	-	2	-	-	5	-	-	2	-	-	1	-	-	3	-	-
58.	<i>Trichoderma harzianum</i>	3	10	7	-	1	1	6	3	8	-	1	2	-	-	-	-	-	-

59.	<i>Vanakripa parva</i> Bhat	1	-	-	-	-	-	3	-	-	1	-	-	-	-	-	2	-	-
60.	<i>Vermiculariopsiella</i> <i>elegans</i>	-	-	1	-	-	-	-	2	1	-	-	1	-	1	1	-	1	2
61.	<i>Vermiculariopsiella</i> <i>parva</i>	-	-	1	-	1	1	-	2	1	-	-	-	-	1	1	-	1	3
62.	<i>Xenosporium</i> <i>africanum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
63.	<i>Xenosporium</i> sp 1.	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64.	<i>Xenosporium</i> sp.2	1	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-
65.	<i>Zygosporium minus</i>	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2	-	-
66.	Unidentified ascomycetes	4	-	-	2	-	-	6	-	-	1	-	-	-	-	-	4	-	-
67.	Unidentified ascomycetes	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
68.	Unidentified fungus	1	-	-	2	-	-	3	-	-	1	-	-	3	-	-	4	-	-
69.	Unidentified Coelomycetes	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
		74	50	59	37	40	43	11 6	57	70	37	25	31	28	39	36	85	25	69

14.	<i>Cladosporium cladosporioides</i>	-	3	2	-	12	-	-	7	-	-	9	-	-	4	1	-	13	-
15.	<i>Corynespora cassiicola</i>	-	2	3	-	1	1	-	7	4	-	1	1	-	-	1	-	7	1
16.	<i>Curvularia senegalensis</i>	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
17.	<i>Dictyochaeta assamica</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
18.	<i>Dictyochaeta fertilis</i>	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	1	-	-
19.	<i>Dictyosporium elegans</i>	-	-	-	1	-	-	10	-	-	4	-	2	-	-	-	8	-	-
20.	<i>Ellisembia adscendens</i>	-	-	-	-	-	-	7	-	-	1	-	-	3	-	-	-	-	-
21.	<i>Exserticlava vasiformis</i>	7	-	-	-	-	-	1	-	-	4	-	-	2	-	-	-	-	-
22.	<i>Fusarium</i> sp.	-	1	2	2	4	-	1	1	-	1	-	-	-	2	12	-	-	1
23.	<i>Gliocladium penicillioides</i>	-	12	3	-	5	1	-	6	10	-	7	7	-	1	-	-	7	10
24.	<i>Hansfordia pulvinata</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
25.	<i>Helicoma</i> sp.	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
26.	<i>Helicomycetes</i> sp.	1	-	-	1	-	-	9	-	-	-	-	-	1	-	-	5	-	-
27.	<i>Helminthosporium</i> sp	6	-	-	4	-	1	12	-	-	5	-	-	1	-	-	6	-	-
28.	<i>Hemicorynespora mitrata</i>	7	-	-	2	-	-	4	-	-	8	-	-	5	-	-	13	-	-
29.	<i>Idriella fertilis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
30.	<i>Junewangia sphaerospora</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	6	-	-
31.	<i>Kostermansinda magna</i>	8	-	-	2	-	-	12	-	-	4	-	-	5	-	-	9	-	-

32.	<i>Melanographium citri</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
33.	<i>Monodictys</i> sp.	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-
34.	<i>Nigrospora oryzae</i>	-	6	-	-	5	-	-	8	-	-	6	-	-	-	1	-	2	4
35.	<i>Nodulisporium ochraceum</i>	-	-	2	-	-	1	-	-	-	-	-	1	-	-	-	-	-	3
36.	<i>Pacilomyces</i> sp.	-	1	1	-	2	2	-	7	1	-	9	1	-	8	3	-	5	2
37.	<i>Penicillium</i>	-	1	-	-	7	-	-	-	-	-	1	-	-	3	-	-	2	-
38.	<i>Penicillium</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
39.	<i>Parahelminthosporium malabaricum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
40.	<i>Pestalotiopsis palmarum</i>	-	6	2	-	-	7	-	4	7	-	3	1	-	-	-	-	6	-
41.	<i>Phaeoisaria clematidis</i>	4	-	-	1	-	-	8	-	-	2	-	-	1	-	-	-	1	-
42.	<i>Phoma</i> sp.	-	-	3	-	-	2	-	-	1	-	-	3	-	-	1	-	-	1
43.	<i>Phomopsis</i> sp.	-	-	6			4			2			1			5			3
44.	<i>Pithomyces flavus</i>	1	-	-	3	-	-	1	-	-	6	-	-	-	-	-	4	-	-
45.	<i>Rattania setulifra</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3
46.	<i>Rhinocladiella atrovirens</i>	1	2	7	-	4	-	2	3	6	-	1	-	-	-	-	6	4	-
47.	<i>Scolecobasidium</i> sp.	-	-	-	-	-	6	-	-	1	-	-	-	-	-	-	-	-	-
48.	<i>Sporidesmium</i> sp	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
49.	<i>Sporochisma mirabile</i>	7	-	-	7	-	-	10	-	-	6	-	-	2	-	-	12	-	-
50.	<i>Tetraploa aristata</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-

51.	<i>Trichoderma harzianum</i>	-	-	-	-	3	11	-	6	3	-	-	-	-	1	-	-	1	-
52.	<i>Vanakripta parva</i>	1	-	-	-	-	-	-	-	-	6	-	-	3	-	-	-	-	-
53.	<i>Vermiculariopsiella elegans</i>	-	-	4	-	-	-	-	-	3	-	-	-	4	2	-	-	5	
54.	<i>Vermiculariopsiella parva</i>	-	-	3	-	-	1	-	-	4	-	-	8	-	-	2	-	-	3
55.	<i>Xenosporium</i> sp -.	4	-	-	2	-	-	7	-	-	2	-	-	-	-	-	3	-	-
56.	<i>Xenosporium</i> sp.2	-	-	-	-	-	-	4	-	-	1	-	-	-	-	-	2	-	-
57.	<i>Zygosporium minus</i>	1	-	-	1	-	-	4	-	-	3	-	-	2	-	-	1	-	-
58.	Unidentified ascomycetes	7	-	-	5	-	-	5	-	-	2	-	-	5	-	-	4	-	-
59.	Unidentified ascomycetes	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	2	-	-
60.	Unidentified fungus	1	-	-	2	-	-	3	-	-	1	-	-	3	-	-	4	-	-
61.	Unidentified Coelomycetes	-	-	3	-	-	1	-	-	1	-	-	-	-	-	-	-	-	1
	Total	76	45	48	36	55	60	120	72	58	66	47	42	41	31	36	100	65	54

15	<i>Cladosporium cladosporioides</i>	2	1	-	3	2	-	2	2	-	-	-	-	1	1	-	1	2	-
16	<i>Corynespora cassiicola</i>	4	-	6	2	-	1	7	-	2	4	-	4	-	-	2	-	-	4
17	<i>Corynespora</i> sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	<i>Curvularia</i> sp.	-	1	-	-	-	-	-	1	-	-	-	1	-	-	1	-	-	-
19	<i>Cylindrocladium quinqueseptatum</i>	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-
20	<i>Dictyochoaeta assamica</i>	2	1	1	-	-	1	4	2	-	6	-	8	-	-	-	3	1	-
21	<i>Drechslera</i> sp.	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	<i>Fusarium</i> sp.	1	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
23	<i>Gliocladium penicillioides</i>	-	2	7	-	1	3	-	1	3	-	3	4	-	-	-	-	1	1
24	<i>Gliocladium</i> sp.	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
25	<i>Hansfordia pulvinata</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
26	<i>Helicomyces</i> sp.	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
27	<i>Helminthosporium</i> sp.	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
28	<i>Hermatomyces tucumanensis</i>	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	3	-	-
29	<i>Idriella fertilis</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
30	<i>Nigrospora oryzae</i>	-	-	1	-	-	-	-	-	1	-	-	3	-	-	1	-	-	2
31	<i>Nodulisporium ochraceum</i>	-	-	4	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-
32	<i>Pacilomyces</i> sp.	-	-	2	-	-	7	-	-	1	-	-	4	-	-	-	-	-	1
33	<i>Panicillium</i> sp.	-	2	1	-	9	-	-	1	1	-	1	-	-	-	-	-	-	-
34	<i>Penicillium</i> sp.2	-	-	-	-	-	2	-	-	8	-	-	4	-	-	2	-	-	9
35	<i>Pestalotiopsis palmarum</i>	-	-	6	-	-	4	-	-	2	1	-	6	-	-	1	-	-	9

36	<i>Phaeoisaria clematidis</i>	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-
37	<i>Phialophora richardsiae</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
38	<i>Phomopsis</i> sp.	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
39	<i>Rhinoctadiella atrovirens</i>	-	2	-	-	1	-	-	4	-	-	2	-	-	-	-	2	-	-
40	<i>Scolecobasidium</i> sp.	-	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
41	<i>Sporidesmium</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
42	<i>Sporochisma mirabile</i>	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	1	-	-
43	<i>Tetraploa aristata</i>	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
44	<i>Tetraploa</i> sp.	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-
45	<i>Trichoderma harzianum</i>	4	2	1	2	-	-	3	1	1	1	-	2	-	-	2	-	-	1
46	<i>Vermiculariopsiella parva</i>	-	1	12	-	-	6	-	-	3	-	-	7	-	-	8	1	-	5
47	<i>Wardomyces</i> sp.	1	-	2	-	-	1	-	-	-	-	-	2	-	-	1	0	-	-
48	<i>Xenosporium africanum</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
49	<i>Xenosporium boivinii</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
50	<i>Zygosporium minus</i>	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
51	<i>Phoma</i> sp.	-	-	2	-	-	1	-	-	-	1	-	3	-	-	1	-	-	1
52	<i>Ascomycetes</i>	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
		24	21	68	8	13	41	32	19	40	17	14	63	4	4	26	28	13	40

Appendix II- D

Site 2: Near Sawar falls, Netravali

Name		Dec. -Jan. -8			April-May 2--8			July-Aug. 2--8			Dec. - Jan. -9			April-May 2--9			July-Aug. 2--9		
		MC / 5- - g	PP/ 1- - mg	EN/ 1-- bits	MC / 5- - g	PP/ 1-- mg	EN/ 1-- bits	MC / 5- - g	PP/ 1-- mg	EN/ 1-- bits	MC / 5- - g	PP/ 1-- mg	EN/ 1-- bits	MC / 5- - g	PP/ 1-- mg	EN/ 1-- bits	MC / 5- - g	PP/ 1-- mg	EN/ 1-- bits
1	<i>Acremonium byssoides</i>	-	1	-	-	-	-	7	-	-	-	-	-	-	-	-	3	-	
2	<i>Alternaria alternata</i>	-	4	1	-	2	-	-	1	-	1	5	-	-	-	-	1-	-	
3	<i>Alysidium resiniae</i>	-	4	3	-	3	2	-	-	8	-	2	4	-	-	4	-	7	
4	<i>Ardhachandra selenoides</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
5	<i>Aspergillus niger</i>	-	4	3	-	2	1	-	-	-	-	2	-	-	-	2	-	3	7
6	<i>Aspergillus oryzae</i>	-	-	1	-	-	-	-	-	-	-	-	-	8	-	-	-	-	
7	<i>Aspergillus terreus</i>	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	
8	<i>Aspergillus fumigatus</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
9	<i>Bisporomyces</i> sp	1	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	
10	<i>Brachysporiella gayana</i>	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	
11	<i>Candelabrum brocciatum</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	2	-	-	
12	<i>Chaetomium</i> sp.	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	
13	<i>Chloridium reniforme</i>	-	-	-	-	-	-	5	-	-	1	-	-	-	-	-	-	-	
14	<i>Cladosporium cladosporioides</i>	4	2	-	3	1	-	7	1	-	-	-	2	2	-	1	8	-	
15	<i>Corynespora cassiicola</i>	-	-	4	-	-	2	-	-	3	-	-	7	-	-	-	-	-	
16	<i>Corynespora</i> sp.	13	-	-	4	-	-	-	-	-	9	-	-	3	-	-	5	-	

17	<i>Curvularia</i> sp.	-	-	-	-	3	-	-	2	-	-	-	-	-	-	-	2	-
18	<i>Cylindrocladium quinqueseptatum</i>	-	-	-	-	7	-	-	-	-	-	-	2	-	-	-	-	-
19	<i>Dietyochaeta assamica</i>	-	1	-	-	-	-	1	6	-	-	9	-	-	4	-	-	-
20	<i>Fusarium</i> sp.	-	3	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
21	<i>Gliocladium penicillioides</i>	-	1-	-	-	1	1	-	1	-	-	6	-	-	-	-	-	-
22	<i>Hansfordia pulvinata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-
23	<i>Helicomyces</i> sp.	2	-	-	1	-	-	1	-	1	-	-	1	2	-	-	1	-
24	<i>Helminthosporium</i> sp.	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
25	<i>Hermatomyces tucumanensis</i>	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-
26	<i>Idriella fertilis</i>	-	-	2	-	-	1	-	-	-	-	-	-	-	5	-	-	-
27	<i>Nigrospora oryzae</i>	-	-	6	-	-	3	-	-	6	-	-	12	-	-	1	-	2
28	<i>Pacilomyces</i> sp.	-	-	6	-	-	-	-	4	-	-	2	-	-	-	-	-	-
29	<i>Panicillium</i> sp.	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-
30	<i>Penicillium</i> sp.2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
31	<i>Pestalotiopsis palmarum</i>	1	-	-	-	-	9	2	-	7	1	-	3	-	-	-	-	-
32	<i>Phaeoisaria clematidis</i>	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
33	<i>Phomopsis</i> sp.	-	1	1	-	-	3	-	-	-	-	-	-	-	6	-	-	1
34	<i>Scolecobasidium</i> sp.	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	2
35	<i>Sporidesmium</i> sp	2	-	-	1	-	-	1	-	-	1	-	1	-	-	1	-	-
36	<i>Tetraploa aristata</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
37	<i>Trichoderma</i>	-	-	5	4	-	1	4	-	1-	7	9	2	-	-	-	-	-

	<i>harzianum</i>																		
38	<i>Vermiculariopsiella parva</i>	-	-	5	-	-	2	-	-	7	-	-	-	-	-	1	-	-	6
39	<i>Wardomyces</i> sp.	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
40	<i>Xenosporium boivinii</i>	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
41	<i>Zygosporium minus</i>	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-
42	<i>Phoma</i> sp.	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	<i>Ascomycetes</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		31	20	37	13	24	26	25	25	40	21	32	39	15	17	21	23	16	26

***Rattania setulifera*,
an undescribed endophytic hyphomycete
on rattans from Western Ghats, India**

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Abstract – *Rattania setulifera* gen. et sp. nov., isolated from fresh leaves of rattan (*Calamus thwaitesii*), is described and illustrated. The endophytic hyphomycete is characterized by setose sporodochia, branched conidiophores, monoblastic, sometimes sympodial conidiogenous cells and slimy, fusiform, aseptate to multiseptate, curved conidia bearing tiny setulae at both ends.

Key words – biodiversity, anamorphic fungi, taxonomy, tropical forests

Introduction

During studies on the diversity of microfungi associated with plants of the Western Ghats, an undescribed dematiaceous hyphomycete was isolated from fresh leaves of rattan. This fungus is distinguished by a unique combination of features that warrant its accommodation in a new genus, described here.

Materials and methods

Freshly collected leaf laminae of *Calamus thwaitesii* Becc. (*Arecaceae*) were surface sterilized in 70% ethanol (1 min), 4% sodium hypochloride (3 min) and 70 % ethanol (30 s) and thoroughly rinsed in sterile distilled water. Each leaf lamina was cut into 5 mm square pieces and plated on malt extract agar (MEA, HiMedia) plates (9 cm diam., Borosil glass) with antibiotics incorporated (composition in 1 L: 5 g malt extract, 20 g agar, 20 mg each of bacitracin, neomycin, penicillin, streptomycin and tetracycline). The plates were incubated at 25°C with diurnal light for 15 days. The fungus appeared on the surface of cut leaf pieces as sporodochia. A pure culture of the fungus was obtained by transferring spores from the sporodochium into fresh MEA plates.

Taxonomic description

Rattania Prabhugaonkar & Bhat, gen. nov.

MYCOBANK MB512876.

Ad fungos conidiales, hyphomycetes. Sporodochia atro brunnea, setosus. Setae rectae vel flexuosae, non ramosae, atro brunneae. Conidiophora distinctus, ramosa, laevia, hyalina, formans densus fasciculus. Cellulae conidiogenae integratae vel discretae plerumque monoblasticae, aliquando extensus sympodialiter semel vel bis ad producens successivus solitaria holoblastica conidia, cicatrices conidiales inconspicuae, planus. Conidia mucosus, solitaria, fusiformis, curvatus, hyalina, laevia, 0–multiseptatus, basi anguste truncata, acuminatus ad apicem, utrinque una setula praedita.

SPECIES TYPICA: *Rattania setulifera* Prabhugaonkar & Bhat

ETYM.: *Rattania* — Host of type species is a rattan

Conidial fungus, hyphomycetes. SPOROCHIA superficial, gregarious, dark brown, setose, with a small stroma at the base. SETAE erect, straight to flexuous, unbranched, rhizoidal at base, tapering to a pointed apex, septate, smooth, thick-walled, dark brown. CONIDIOPHORES distinct, branched, smooth, hyaline, arising in a palisade layer from a pseudoparenchymatous stroma. CONIDIOGENOUS CELLS terminal, integrated or discrete, usually monoblastic, sometimes extending sympodially once or twice to produce successive solitary holoblastic conidia, after secession leaving an inconspicuous, flat secession scar with no evident wall thickening. CONIDIA slimy, solitary, fusiform, curved, hyaline, smooth, 0–multiseptate, thin-walled, truncate at the base, acuminate at the tip, setulate at both ends.

With sporodochial conidiomata, holoblastic conidiogenous cells and setulate conidia, genera such as *Fumagopsis* Speg., *Hyphodiscosia* Lodha & K.R.C. Reddy, *Mycocentrospora* Deighton and *Megalodochium* Deighton show some affinity with *Rattania* (Ellis 1971, 1976, Carmichael et al. 1980) (TABLE 1, p. 222). The genus *Fumagopsis*, typified by *F. triglifoides* Speg., has setose sporodochia and holoblastic, discrete conidiogenous cells but differs from *Rattania* by producing catenate, non-setulate conidia (Spegazzini 1910). In *Hyphodiscosia*, typified by *H. jaipurensis* Lodha & K.R.C. Reddy, conidiophores are mononematous and conidia are holoblastic and setulate. In *Mycocentrospora*, typified by *M. acerina* (R. Hartig) Deighton, conidiophores develop in fascicles without setae and conidia bear a 1-septate appendage at the base. In *Megalodochium*, typified by *M. palmicola* Deighton, conidiomata are sporodochial, without setae, conidiogenous cells integrated, terminal or discrete and conidia are aseptate, dark brown, densely spinulose and without setulae (Ellis 1976). None of these have the combination of characters that define *Rattania*, namely setose sporodochia, monoblastic, sometimes sympodial, integrated as well as discrete conidiogenous cells and 0–multiseptate, slimy, hyaline, fusiform conidia with setulae at both ends.

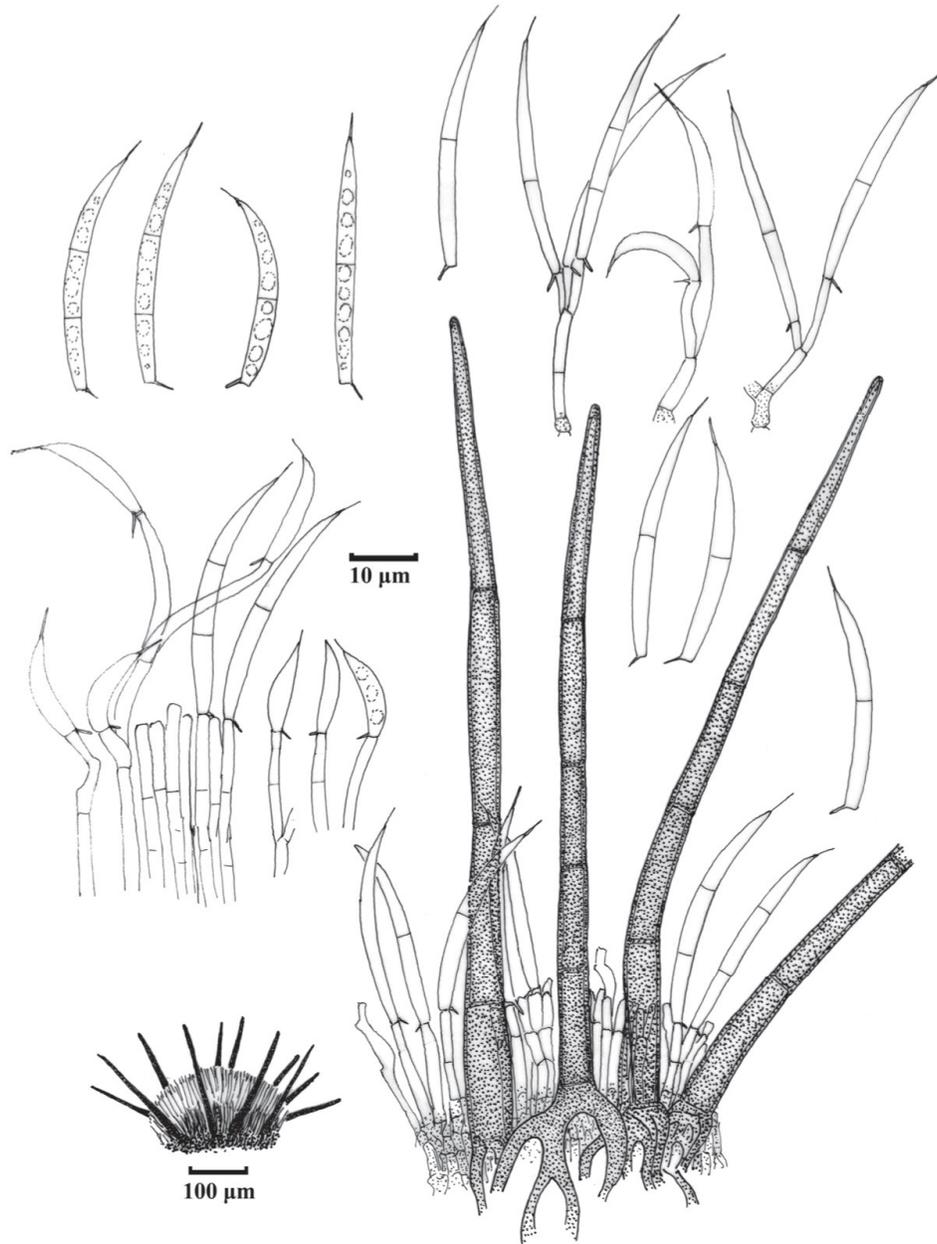


FIG. 1: *Rattania setulifera*. Sporodochium, setae, conidiogenous cells and conidia.

The hyphomycete genus *Minimidochium* B. Sutton has much similarity with *Rattania* in having a stromatic base, setose sporodochia and fusiform, setulate conidia; it differs by having phialidic conidiogenous cells with a distinct collarette and aseptate conidia with rounded ends (Ellis 1976).

Coelomycetes genera such as *Chaetopatella* I. Hino & Katum. (Nag Raj 1974), *Shanoria* Subram. & K. Ramakr. (Morgan-Jones et al. 1972a) and *Heteropatella* Fuckel (Morgan-Jones et al. 1972b) have similar setulate conidia but possess pycnidial fruiting bodies.

***Rattania setulifera* Prabhugaonkar & Bhat, sp. nov.**

FIGS 1–2

MYCOBANK MB 512877

Coloniae in substrato effuse; in MEA-cultura effusae, planus, margine fimbriatus, granularis, pallide aurantiacus 3 cm diametro in 10 dies. Sporodochia atro brunnea, setosus, 160–490 × 100–450 µm. Setae non ramosae, ad apicem acutus, saepe e rhizoideis conspicuis, 2–6 septis, atrobrunneae, 85–370 µm longa, 4–13 µm lat. ad basim, 3–10 µm lat. in medius, crassitunicatae, usque ad 1 µm lat. Conidiophora ramosa, hyalina, formans densus fasciculus, usque ad 30 µm longa. Cellulae conidiogenae terminales, integratae vel discretiae plerumque monoblasticae, aliquando extensus sympodialiter semel vel bis ad producens successivus solitaria holoblastica conidia, uterque extensus circa 4–8 µm longa, cicatrices conidiales inconspicuae, planus, non-incrassatae 3–13 × 1.5–2.5 µm. Conidia mucosus, fusiformis, deorsum truncata, acuminatus ad apicem, 0–5 (plerumque 1–2) septis, utrinque una setula praedita, 25–50 µm longa, 1.5–3.5 µm lat. ad basim. Setula basalis, excentrica, 1–3 µm longa. Setula apicalis extensus e conidia acutatus apicem, 2–5 µm longa.

HOLOTYPE: On fresh leaves of *Calamus thwaitesii*, A. Prabhugaonkar, 21/08/2008, Dhoothsagar, Goa, India. Herb. No. HCIO 48776; ex type culture No. GUFCC 15501.

ETYM.: *setulifera* – having setulate spores

COLONIES on the substratum effuse; on MEA slow growing, effuse, flat, with fringed margin, granular, pale orange, up to 3 cm diam. in 10 days. SPOROCHIA superficial, gregarious, scattered on leaf pieces placed on MEA, dark brown, setose, with dark brown stromatic base, 160–490 × 100–450 µm. SETAE unbranched, erect, straight to flexuous, rhizoidal at the base, tapering towards apex into an acute tip, smooth, 2–6-septate, unbranched, thick-walled, walls up to 1 µm wide, dark brown, 85–370 µm long, 4–13 µm wide at base, 3–10 µm wide in middle. CONIDIOPHORES arising from the stroma, branched, hyaline, forming dense clusters, up to 30 µm tall. CONIDIOGENOUS CELLS terminal, integrated or discrete, usually monoblastic, sometimes extending sympodially once or twice to produce successive solitary holoblastic conidia, each extension about 4–8 µm long, after secession leaving an inconspicuous, flat secession scar with no evident wall thickening, 3–13 × 1.5–2.5 µm. CONIDIA slimy, solitary, fusiform, truncate at the base, acuminate at the tip, hyaline, smooth, thin-walled, 0–5 (mostly 1–2) septate, 25–50 µm long, 1.5–3.5 µm wide at base and middle; setulate at both ends, setula at the base attached to one side, 1–3 µm long, at the apex 2–5 µm long.

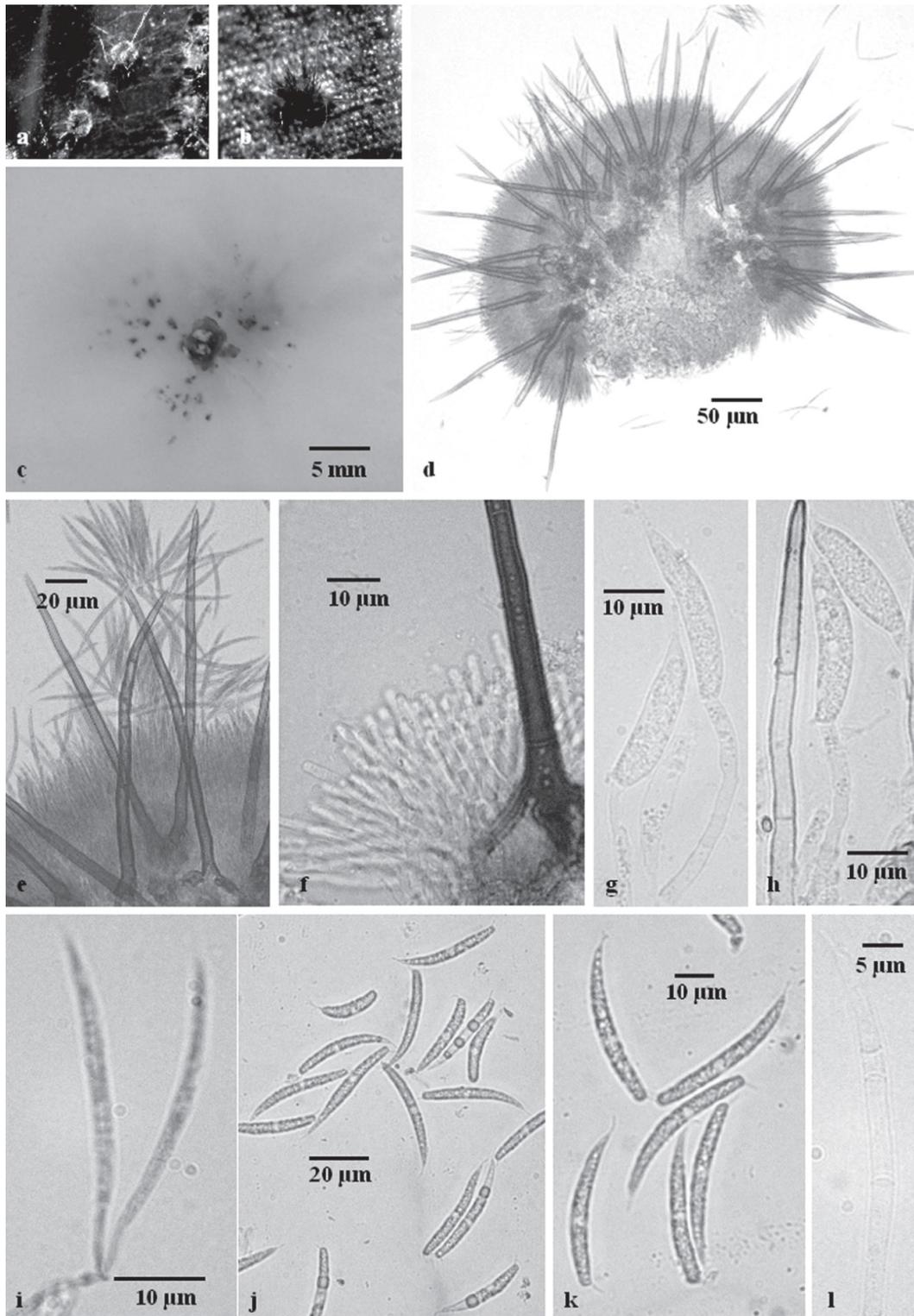


FIG. 2: *Rattania setulifera*. a–b. Sporodochia on host tissue; c. Colony on agar plate; d. Sporodochium; e–f. Setae, conidiogenous cells and conidia; g–i. Symphydial conidiogenous cells with attached conidia; j–l. Conidia with setulae.

TABLE 1: Comparison of *Fumagopsis*, *Hyphodiscosia*, *Megalodoichium*, *Mycocentrospora* and *Rattania*.

GENUS	CONIDIOMATA	CONIDIOGENOUS CELLS	CONIDIA & SETULAE
<i>Fumagopsis</i>	Sporodochia, with setae	Discrete, determinate, subcylindrical, holoblastic	Catenate, triradiate, with truncate base and obtuse apex, without setulae
<i>Hyphodiscosia</i>	Mononematous, without setae	Integrated, polyblastic	Rounded at apex, truncate at base with setulae at each end
<i>Mycocentrospora</i>	Mononematous, fasciculate, without setae	Integrated terminal, polyblastic	Hyaline with broader cells pale brown, obclavate with truncate base and with 1-septate lateral appendage at basal end
<i>Megalodoichium</i>	Sporodochia, without setae	Holoblastic, mostly integrated and terminal but sometimes discrete	Ellipsoidal, somewhat flattened, 0-septate, dark brown, densely spinulose, without setulae
<i>Rattania</i>	Sporodochia, with setae	Integrated, terminal or discrete, monoblastic, sometimes sympodial	Hyaline, fusoid, acuminate apex, truncate base, 0–3 septate, with setula at each end

Acknowledgments

We are indebted to Dr. Keith Seifert, Agriculture and Agri-Food Canada, Ontario, Canada, and Dr. Eric McKenzie, Landcare Research, New Zealand, for kindly reviewing the manuscript. DJB thanks the University Grants Commission, New Delhi, for support of a Special Assistance Programme to the Department of Botany and to the Ministry of Environment & Forests for a research grant. AP thanks the Ministry of Environment & Forests, New Delhi, for a research Fellowship.

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New record of *Megacapitula villosa* and *Paradictyoarthrinium diffractum* from India

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Prabhugaonkar A, Bhat DJ. 2011 – New record of *Megacapitula villosa* and *Paradictyoarthrinium diffractum* from India. *Mycosphere* 2(4), 463–467.

Two monotypic genera, *Megacapitula* and *Paradictyoarthrinium*, are reported for the first time from palm litter from India. ML analysis suggests that they have a close affinity with members of the order *Pleosporales*, *Dothideomycetes*.

Key words – Western Ghats – palm fungi – fungal diversity – taxonomy

Article Information

Received 20 June 2011

Accepted 4 July 2011

Published online 23 September 2011

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Introduction

During studies on palm-associated micro-fungi of the Western Ghats of India, a large number of fungi were collected. This paper illustrates two interesting species, namely, *Megacapitula villosa* J.L. Chen & Tzean and *Paradictyoarthrinium diffractum* Matsush., forming the first report of their occurrence in India. The species, which belong to monotypic genera, are described and illustrated with micro-photographs. The cultures obtained from single spore isolation were used to generate ITS/5.8S rRNA gene sequence-data. Maximum likelihood analysis based on this gene marker suggests that these fungi have a close affinity with members of the order *Pleosporales*, *Dothideomycetes*.

Methods**Isolates and morphology**

Direct isolation from plant litter: Palm fronds and spathe were scanned under a stereomicroscope to locate the fungi. A small portion of any fungal material was picked up with a fine-tipped needle and placed in distilled water or lactophenol on a slide and examined

under a microscope. Detailed morpho-taxonomic study of the fungi were done using a light-transmitted microscope. Photographs were taken on an Olympus microscope with a DP12 camera attached. The specimens were deposited in the Botany Herbarium of Goa University (GUBH). Pure cultures were obtained by aseptically transferring single spore on malt extract agar incorporated with a mixture of antibiotics (Bacitracin 0.02 g, Neomycin 0.02 g, Penicillin G 0.02 g, Polymixin 0.02 g, Streptomycin 0.02 g and Tetramycin 0.04 g dissolved in 10 ml of distilled water and added to 1 L of MEA medium). The cultures were deposited in Goa University fungal culture collection (GUFCC).

DNA Isolation and PCR conditions

Ten-days-old fungal cultures grown as above were used for DNA isolation. Using a sterile spatula, the fungal cells were scraped and transferred to a 1.5 mL centrifuge tube and resuspended in 500 µL extraction buffer (100 mM tris HCl, pH 8.0, 10 mM EDTA, 2% SDS, 100 µg/mL proteinase-k, 1% B-mercaptoethanol) and incubated for 20 min at 60°C. Salt concentration was adjusted to 1.4 M with 5 M

NaCl, 1/10th volume of 10% CTAB was added and samples incubated a further 10 min at 65°C, before 1 vol chloroform: isoamyl alcohol mixture was added and gently emulsified by inversion, and centrifuged for 10 min at 4°C at rpm max. Top phase was then transferred to fresh 1.5 mL microfuge tube, 1/2 vol 5M NH₄O-Ac was then added and mixed gently, and incubated on ice for 60 min; the sample was centrifuged at 4°C at rpm max. Supernatant was transferred to fresh tube and treated with RNase 10 mg/mL to a final concentration of 0.02 µg/µL. To this 0.55 vol isopropanol was added, and centrifuged 5–10 min at rpm max. to precipitate the DNA. Supernatant was aspirated off and the DNA pellet was washed twice with 70% ETOH and air dried for 20 min. The pellet was finally resuspended in 50 µL TE buffer.

PCR and DNA sequencing

The ITS/ 5.8S rRNA gene from the fungal cultures were amplified by Polymerase Chain Reaction (PCR) using ITS4-ITS5 primer-pair (White et al. 1990). This was done by M/S Royal Life Sciences, Secunderabad, attached with MIDI Labs. DNA sequencing was done using the above-mentioned primer pair in an Applied Biosystem MicroSeq System.

Sequence alignment and phylogenetic analysis

Sequences obtained from the respective primers were aligned in MEGA version 5.02 (Tamura et al. 2011) and the consensus sequences were deposited in NCBI-GeneBank with accession numbers JN128868 and JN128869. A dataset based on ITS/5.8S rRNA gene sequence data was prepared using MEGA. Phylogenetic analyses were conducted in MEGA. First 100 blast search results in NCBI-GenBank were considered to select the taxa and most of the sequences with repetitive names were ignored. Phylogenetic relationships of *Paradictyoarthrinium diffractum* GUFCC 15514 and *Megacapitula villosa* GUFCC 15515 with closely related members of the *Pleosporales*, *Dothideomycetes* were inferred based on Maximum Likelihood method and GTR model incorporated in MEGA. The tree with the highest log likelihood (-3249.0486) is shown in Fig. 15.

Taxonomy

Megacapitula villosa J.L. Chen & Tzean

Fig 1–7

Colonies on MEA growing up to 4 cm in 10 days, dark green to brown, cottony, reverse black, forming thick mat of mycelium. Mycelium brown, septate, 2–3 µm broad, often verruculose, forming mycelial cords from which conidia arise. Conidiogenous cells integrated or terminal on mycelial extensions. Conidia holoblastic, rounded when very young then elongating and forming a beak-like structure from which dense hairy appendages arise at maturity, mature conidia ovoid to obclavate, muriform having distinct outer wall which breaks and starts peeling off after mounting, 80–240 µm tall standing erect from mycelial mat, up to 20 to 45 µm broad at base, 60–180 µm broad at centre and 20–40 µm broad at tip from where numerous appendages arise; appendages few to many, grey to brown, smooth, up to 3 µm broad.

Known distribution – As per USDA fungal distribution database and other available literature, the fungus is so far known only from its type locality in Taiwan on fallen decayed petiole.

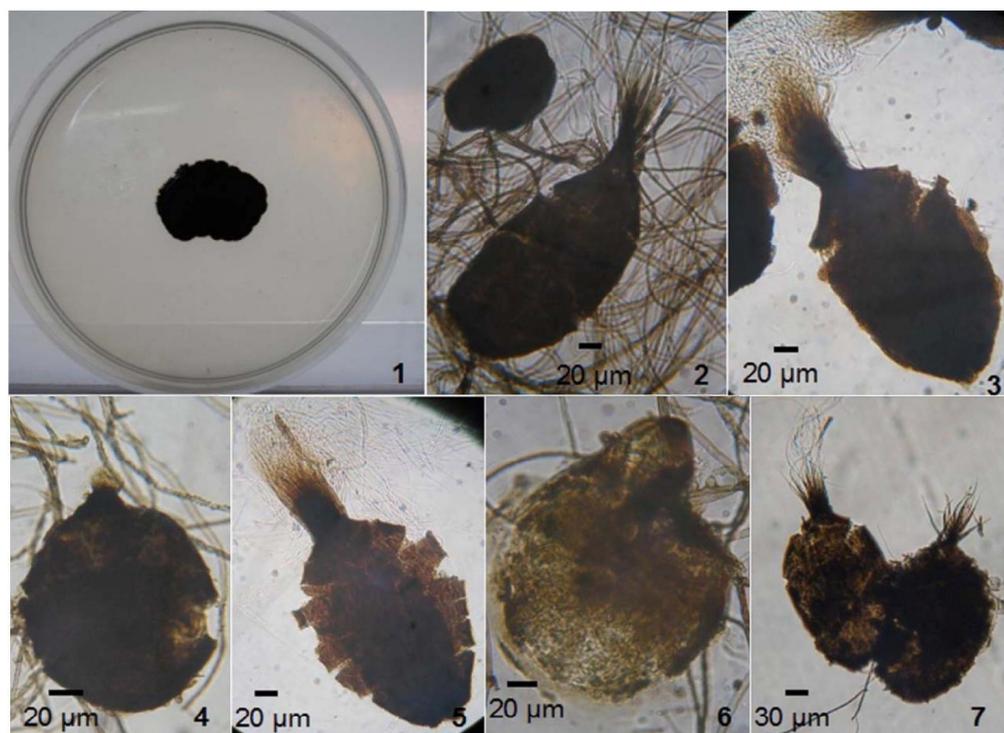
Material examined – India, Goa, near Bombolim beach, on dead and decaying fronds of *Caryota urens*, 3 December 2007, A. Prabhugaonkar Herb. No. GUBH 131AP24; culture no. GUFCC 15515.

Paradictyoarthrinium diffractum Matsush.

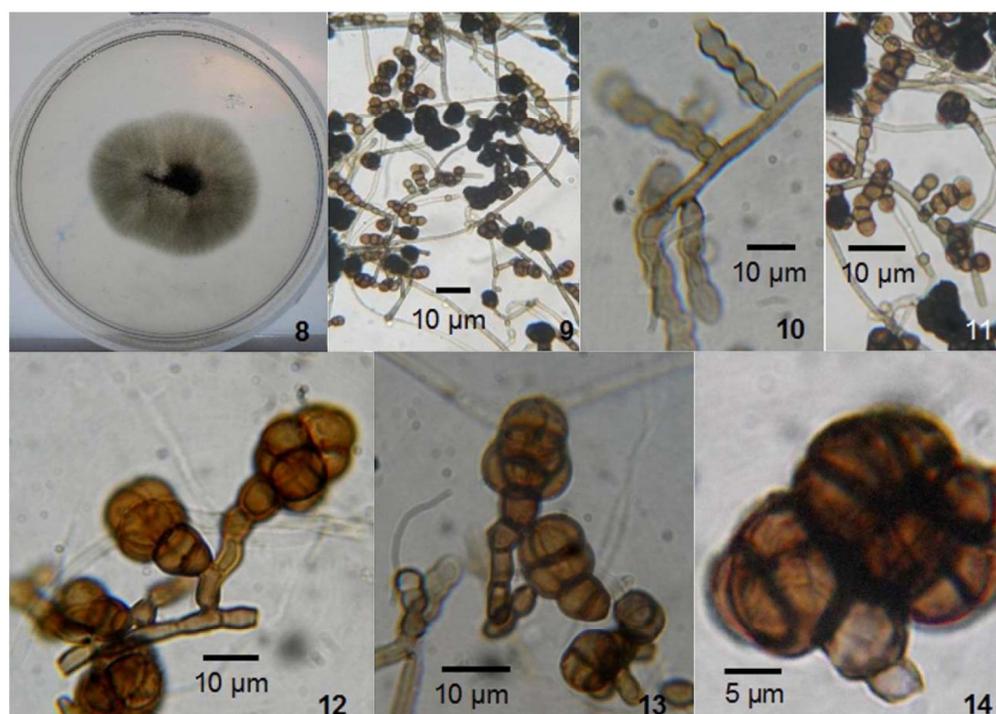
Fig 8–14

Colonies on MEA growing up to 6 cm in 10 days, off-white to brown, becoming dark brown to black after sporulation. Mycelium 1–3 µm broad. Conidiophores macronematous, rarely micronematous, short, when macronematous showing much varied morphology, unbranched to much branched, uneven, constricted at septa, turning brown to dark brown on maturity, 10–75×4–5 µm, part of mature conidiophores often released along with conidia. Conidiogenous cell blastic, mostly terminal, 4–10×4–5 µm. Conidia 2 to many unevenly dictyoseptate, circular to irregular, dark brown to black on maturity, 8–33×10–30 µm.

Known distribution – As per USDA fungal distribution database and other available



Figs 1–7 – *Megacapitula villosa*. 1 Colony on MEA, 2 Mycelia and attached conidia, 3–7 Mature and young conidia.



Figs 8–14 – *Paradictyoarthrinium diffractum*, 8 Colony on MEA, 9 Conidiophores and conidia, 10 Conidiophores, 11–13 Conidiophores and conidia, 14 Single conidium.

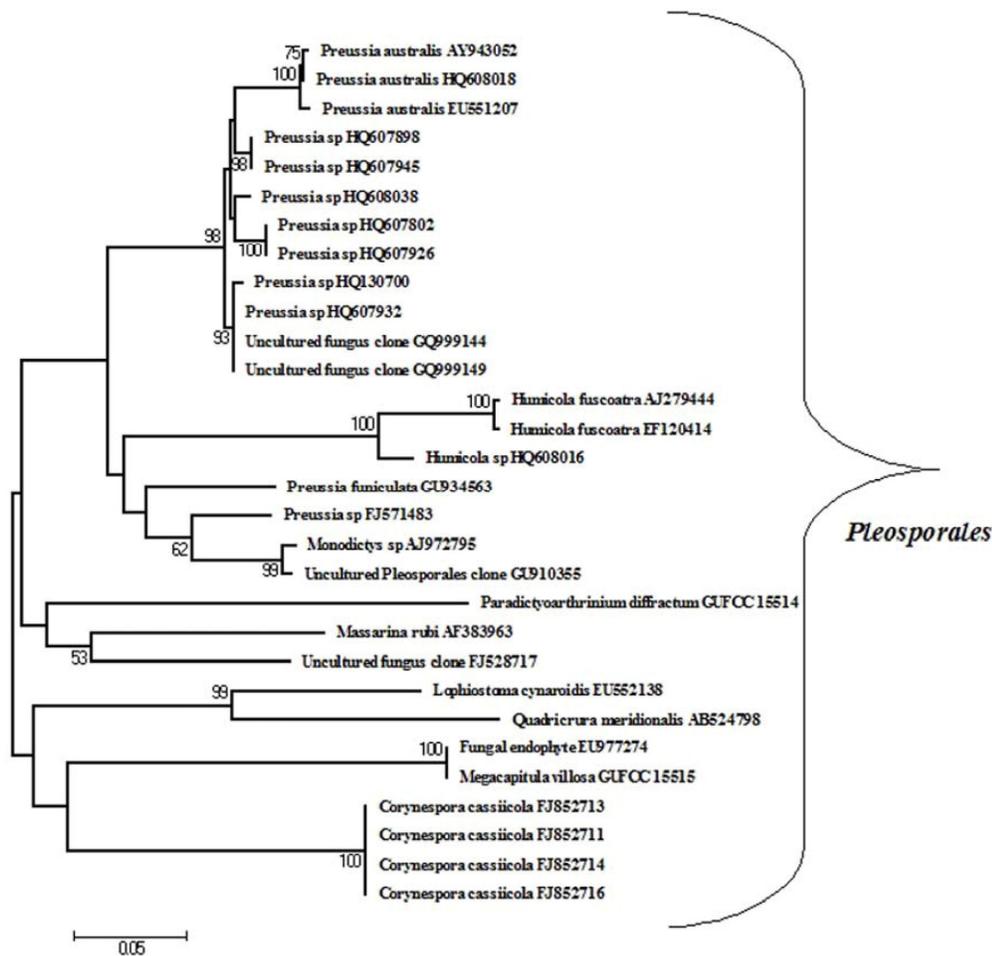


Fig. 15 – Phylogenetic relationships of *Paradictyoarthrinium diffractum* GUFCC 15514 and *Megacapitula villosa* GUFCC 15515 with closely related members of the Pleosporales, Dothideomycetes. The tree with the highest log likelihood (-3248.7706) is shown. The percentage of trees in which the associated taxa clustered together is shown next to the branches. Initial tree(s) for the heuristic search were obtained automatically as follows: When the number of common sites was used; otherwise BIONJ method with MCL distance matrix was used (Tamura et al 2011). A Discrete Gamma distribution was used to model evolutionary rate differences among site [5 categories (+G, Parameter = 0.4775)]. The rate variation model allowed for some sites to be evolutionarily invariable [(+I), 28.1848% sites]. The tree is drawn to scale, with branch lengths measured in the number of substitutions per site. The analysis involved 30 nucleotide sequences. There were a total of 589 positions in the final dataset.

literature the fungus is so far known only from its type locality at Rustenbusg in South Africa from dead plant material collected from a rivulet.

Material examined – India, Goa, Canacona, Mashem, on dead decaying spathe of *Cocos nucifera*, 2 January 2007, A. Prabhugaonkar, Herb. No. GUBH 136AP25; culture no. GUFCC 15514

Phylogenetic analyses

ML analysis suggests that *Megacapitula villosa* and *Paradictyoarthrinium diffractum* have a close affinity with the members of the order Pleosporales, Dothideomycetes. Multi-gene phylogenetic analysis with an extended dataset and the relevant type strains are required to resolve their placement within suitable fungal families.

Discussion

Chen & Tzean (1993) described *Megacapitula villosa* from fallen, decayed, unidentified petiole in Taiwan. In the present study, the fungus was collected on fronds of palm *Caryota urens* from Goa, India. The sequence of *Megacapitula villosa* showed much similarity with an unidentified fungal endophyte sequence (GenBank No. EU977274) isolated from an unidentified plant in Peru (Smith et al. 2008). *Paradictyoarthrinium diffractum* Matsush. was described by Matsushima (1996) from dead plant material collected from a rivulet at Rustenbusrg in South Africa. In the present study, the fungus was collected on dead decaying spathe of *Cocos nucifera* from Goa, India. On perusal of literature on fungi of India (Mukerji et al. 1974, Sarbhoy et al. 1986, 1996, Jamaluddin et al. 2004, Farr et al. 2011), both these collections formed new records to fungal flora of India.

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Discussion

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Paper Under revision

The genus *Pithomyces*, revisited; *Kalashamyces* gen. nov. proposed to accommodate species with large, rostrate, appendaged conidia

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ABSTRACT

The genus *Pithomyces*, composed of 46 published species, is reviewed. Species with large, rostrate, appendaged conidia are separated into a new genus, *Kalashamyces* with *K. quadratus* as type. *K. pluriappendiculata* is a new species from the forests of Western Ghats, India. Keys are provided to both genera.

INTRODUCTION

During studies on diversity of microfungi associated with flowering plants of Western Ghats, a fungus producing large, muriform, obpyriform conidia, with 1–7 conspicuous apical, setiform appendages was isolated. The collection was thought to be congeneric with *Pithomyces*, typified by *P. flavus* Berk. & Broome (Berkeley & Broome 1873). Using numerical taxonomic method (Sokal & Sneath 1963) our collection emerged as a distinct group along with eight other *Pithomyces* spp. — *P. bulbilus* Satya, *P. djbhatii* Manohar., Kunwar & N.K. Rao, *P. ellisii* V.G. Rao & Chary, *P. niger* Mercado & J. Mena, *P. pulvinatus* (Cooke & Masee) M.B. Ellis, *P. quadratus* (G.F. Atk.) M.B. Ellis (fig.3), *P. sivaramaprasadii* N.K. Rao & Manohar. and *P. subramanianii* G.V. Rao & A.P. Reddy. Except for *P. sivaramaprasadii*, which is distinct being the only distoseptate species in *Pithomyces*, the other species in this group possess large, irregularly muriform, rostrate or beaked conidia unlike the typical *Pithomyces*. Therefore, it is proposed to accommodate our collection and the other *Pithomyces* species with muriform, rostrate or beaked conidia in a new genus.

MATERIALS AND METHODS

Freshly collected leaf litter of *Calamus thwaitesii* (*Arecaceae*) was taken to the laboratory in zip-seal polythene bags. The sample was scanned under a stereomicroscope. Fungal material from the spathe was scrapped with a fine-tipped needle, mounted on a slide containing a drop of lactophenol solution and examined under a light microscope. Single spores from the spathe were transferred aseptically to antibiotic-embedded malt extract agar medium for culturing. The leaf litter with fungus was air-dried as a herbarium specimen. UPGMA Euclidean cluster analysis was performed on numerically scored characters such as conidiogenous cell and conidial morphology of species belonging to *Pithomyces* and to the new genus using Multi-Variate Statistical Package.

TAXONOMY AND DISCUSSION

Kalashamyces Prabhugaonkar & Bhat gen. nov.

Etym.: Kalasha (Sanskrit) = Copper pot with mango leaves and coconut which is used during hindu rituals. Conidial shape resembles Kalash.

Ad fungos conidiales, hyphomycetes. Coloniae effusae, atro brunneae. Conidiophora micronemata. Cellulae conidiogenae monoblasticae, terminaliae, rhexolyticam, determinatae. Conidia solitaria, sicca, muriformia, obpyriforma, ellipsoidea vel limoniformea, brunnea vel atro

brunnea, rotundata ad basim, ad apicum rostratus vel appendiculata; rostrum cum 1 ad plures, terminalis contractus, pallide brunnea, crassitunicata, septata, rigidus, flexuosa, brevis vel longus appendicibus.

Species typica: - *K. quadratus* (G.F. Atk.) Prabhugaonkar & Bhat comb. nov.

Conidial fungi, hyphomycetes. Colonies effuse, dark brown. Conidiophores micronematous. Conidiogenous cells monoblastic, terminal, rhexolytic, determinate. Conidia solitary, dry, unevenly septate, muriform, obpyriform to ellipsoid-limoniform, brown to dark brown, rounded at the base, terminally rostrate or appendaged; rostrum with 1 to several, terminally tapering, light brown, thick-walled, septate, rigid, flexuous, short or long, appendages.

Notes: With micronematous conidiophores, determinate, monoblastic, rhexolytic conidiogenous cells and rostrate or appendaged, large, muriform (dictyosporous) conidia, *Kalashamyces* shows similarity with genera such as *Acrodictys* M.B. Ellis, *Bioconiosporium* Bat. & J.L. Bezerra, *Ernakulamia* Subram., *Manoharachariella* Bagyan., N.K. Rao & Kunwar, *Megacapitula* J.L. Chen & Tzean, *Monodictys* S. Hughes, *Petrakia* Syd. & P. Syd., *Orbimyces* Linder, *Pithomyces* Berk. & Broome, *Piricauda* Bubák, *Piricaudilium* Hol.-Jech., *Pseudopetrakia* M.B. Ellis, *Pseudotetraploa* Kaz. Tanaka & K. Hirayama, *Quadricrura* Kaz. Tanaka, K. Hirayama & Sat. Hatak., *Santapauinda* Subram., *Shrungabeeja* V.G. Rao & K.A. Reddy and *Tetraploa* Berk. & Broome (Table 2).

Though having some similarity in conidial morphology the genera such as *Ernakulamia* Subram., *Piricauda* Bubák and *Piricaudilium* Hol.-Jech. differ from *Kalashamyces* in having tretic conidiogenesis. Other Blastic genera show following differences with *Kalashamyces*. *Acrodictys* (type: *A. bambusicola* M.B. Ellis) differs with its long conidiophores and schizolytically dehiscing conidia without apical appendages (Ellis 1971). *Bioconiosporium* (type: *B. baccharidis* Bat. & J.L. Bezerra) has polyblastic conidiogenous cells, schizolytic dehiscence and conidia with areolate walls (Ellis 1976). *Manoharachariella* (type: *M. lignicola* Bagyan., N.K. Rao & Kunwar) differs in having macronematous conidiophores, monoblastic, acrogenous conidiogenous cells and evenly transverse and longitudinally septate conidia. *Megacapitula* (type: *M. villosa* J.L. Chen & Tzean.) differs with its integrated conidiogenous cells, and with dense hairy apical appendages. The genus *Monodictys* (type: *M. putredinis* (Wallr.) S. Hughes) with micronematous conidiophores, monoblastic, determinate conidiogenous cells and muriform, pyriform conidia shows some similarity to *Kalashamyces* but differs in its doliiform to subspherical conidiogenous cells and schizolytically dehiscing conidia with rounded tip lacking rostrum or appendage. *Orbimyces* (type: *O. spectabilis*) Linder, differs with integrated, schizolytic conidiogenous cells and conidia with one or two appendages which are branched and multiradiate. The genus *Petrakia* (type: *P. echinata* (Peglion) Syd. & P. Syd.) is unique in that it has sporodochia, macronematous conidiophores, schizolytic dehiscence and non-terminal setiferous conidial appendages (Ellis 1971). *Pseudotetraploa* (type: *P. curviappendiculata* (Sat. Hatak., Kaz. Tanaka & Y. Harada) Kaz. Tanaka & K. Hiray. differ in having monoblastic integrated conidiogenous cells and pseudoseptate conidia with 4-8 columns of cells. *Pseudopetrakia* (type: *P. kambakkamensis* (Subram.) M.B. Ellis) differs by schizolytic dehiscence, verrucose conidia and dark brown to black, spine-like appendages (Ellis 1976). *Quadricrura* (type: *Q. septentrionalis* Kaz. Tanaka, K. Hirayama & Sat. Hatak.) is different in having integrated conidiogenous cells and conidia with thin outer wall and with its two types of appendages that is one long terminal appendage and many short non terminal appendages. *Santapauinda* (type: *S. pulchra* Subram.) shows similarity in rhexolytic conidial secession and apical appendage but differs with its superficial mycelia, macronematous conidiophores, ganglier, integrated conidiogenous cells and with its conidia variable in shape and size. *Shrungabeeja*

(type: *S. vadirajensis* V.G. Rao & K.A. Reddy) differs by possessing macronematous conidiophores, schizolytic dehiscence and subterminal appendages. *Tetraploa* (type: *T. aristata* Berk. & Br.) differs by having integrated conidiogenous cells and conidia having 3-4 columns of cells each ending in apical appendage.

The genus *Pithomyces* is similar in having poorly differentiated, single conidiophores, monoblastic, determinate conidiogenous cells and conidia dehiscing rhexolytically (Ellis 1971). The conidia in *Pithomyces* (type: *P. flavus* Berk. & Br.) were described as having 0-13 transverse and often 1 or more oblique or longitudinal septa, seceding by rhexolytic mode of dehiscence. Taxa with large muriform, unevenly septate, rostrate, appendaged conidia were accommodated in *Pithomyces* only subsequently (Ellis 1960, Satya 1975) (Table 1).

Table 1. Comparison of genus *Kalashamyces* with *Pithomyces*

Genus	<i>Pithomyces</i>	<i>Kalashamyces</i>
Mycelia	Mostly superficial on host	Mostly mycelia immersed in the host tissue
Conidiogenous cells	Monoblastic and Polyblastic	Monoblastic
Conidial shape	Ellipsoidal, clavate, pyriform, obpyriform	obpyriform
Conidial septation	0-13 transverse and one or more longitudinal	Irregularly septate, Muriform
Conidial tip	Rounded at tip	Beaked or appendaged at tip

Kalashamyces pluriappendiculata Prabhugaonkar & Bhat, sp. nov. (Figs. 1–2)

Etym.: *Pluriappendiculata* = with more than one appendaged conidia.

Ad fungos conidiales, hyphomycetes. Coloniae in substrato naturalis effusae, nigrae. Mycelium substrato immersum. Conidiophora micronemata. Cellulae conidiogenae monoblasticae, rhexolyticam, determinatae. Sustinens cellulae cylindrica, brevis, pallidus vel hyalinus, usque ad 21 µm latus. Conidia solitaria, sicca, muriformia, obpyriforma, stans erecta in substrata, scattered, atrobrunnea vel nigra ad basim, brunnea ad apicem, roundata ad basim, 65–115 × 40–60 µm, cum 1–7 appendicibus fasciculatus ad apicem; conidial appendices flexuosus, 2–9 septatis, laeviae, rigidus, pallide brunneae ad affixus et sub-hyalinum ad apicem, parvus in juvenis sporas, longus in maturus sporas, 4–6.5 µm × 14–100 µm.

Holotype: On dead spathe of *Calamus thwaitesii*, A. Prabhugaonkar, 28/06/09, Bondla Wildlife Sanctuary, Goa, India. GUBH AP358.

Conidial fungi, hyphomycetes. Colonies on natural substrate effuse, black. Mycelium immersed in the host tissue. Conidiophores micronematous. CONIDIOGENOUS CELLS monoblastic, rhexolytic, determinate; supporting basal cell cylindrical, short, pale to hyaline, up to 21 µm wide. Conidia solitary, dry, muriform, obpyriform, standing erect on the substratum, scattered, dark brown to black at the base and brown at the apex, rounded at the base, 65–115 × 40–60 µm, with 1–7 appendages clustered at the apex; conidial appendages flexuous, 2–9-septate, smooth, stiff, light brown at the base, sub-hyaline towards the tip, beaked to long, 4–6.5 × 14–100 µm.

Species transferred from *Pithomyces* to *Kalashamyces*: (Table 3, Fig. 4)

Seven species of *Pithomyces* are congeneric with *Kalashamyces* and they are transferred to *Kalashamyces* in this paper. The restricted genus *Pithomyces* differs in having smaller, evenly septate conidia, with a rounded apex without rostrum or appendages.

Kalashamyces bulbilus (Satya) Prabhugaonkar & Bhat, comb. nov.

Basionym: *Pithomyces bulbilus* Satya, Cur. Sci. 44: 523, 1975.

Kalashamyces djbhatii (Manohar, Kunwar & N.K. Rao) Prabhugaonkar & Bhat comb. nov.

Basionym: *Pithomyces djbhatii* Manohar, Kunwar & N.K. Rao, Geophytology 36(1&2): 87, 2006.

Kalashamyces ellisii (V.G. Rao & Chary) Prabhugaonkar & Bhat, comb. nov.

Basionym: *Pithomyces ellisii* V.G. Rao & Chary, Cur. Sci. 41: 822, 1972.

Kalashamyces niger (Mercado & J. Mena) Prabhugaonkar & Bhat, comb. nov.

Basionym: *Pithomyces niger* Mercado & J. Mena, Acta bot. Szeged 32(1–4): 201, 1986.

Kalashamyces pulvinatus (Cooke & Masee) Prabhugaonkar & Bhat, comb. nov.

Basionym: *Alternaria pulvinata* Cooke & Masee, Grevillea 18: 56, 1890.

Synonym: *Pithomyces pulvinatus* (Cooke & Masee) M.B. Ellis, Mycol. Pap. 103: 41, 1965.

Kalashamyces quadratus (G.F. Atk.) Prabhugaonkar & Bhat, comb. nov.

Basionym: *Sporidesmium quadratum* G.F. Atk., Bulletin of Cornell University 3: 40, 1897

Synonym: *Pithomyces quadratus* (G.F. Atk.) M.B. Ellis, Mycol. Pap. 76: 18, 1960.

Kalashamyces subramanianii (G.V. Rao & A.P. Reddy) Prabhugaonkar & Bhat, comb. nov.

Basionym: *Pithomyces subramanianii* G.V. Rao & A.P. Reddy, Indian J. mycol. Res. 16(2): 362, 1978

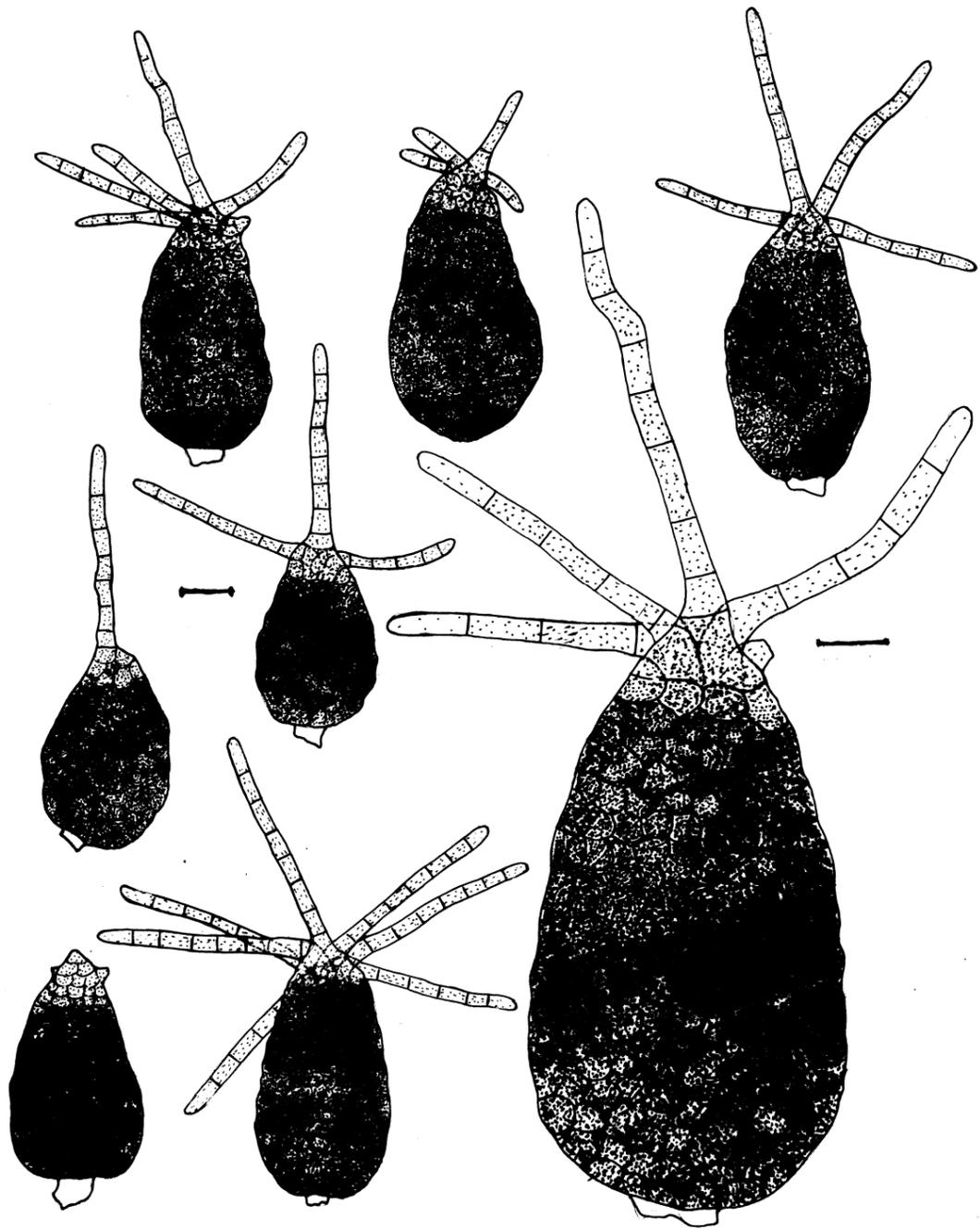


Fig. 1. *Kalashamyces pluriappendiculata*. Conidia with apical appendages.

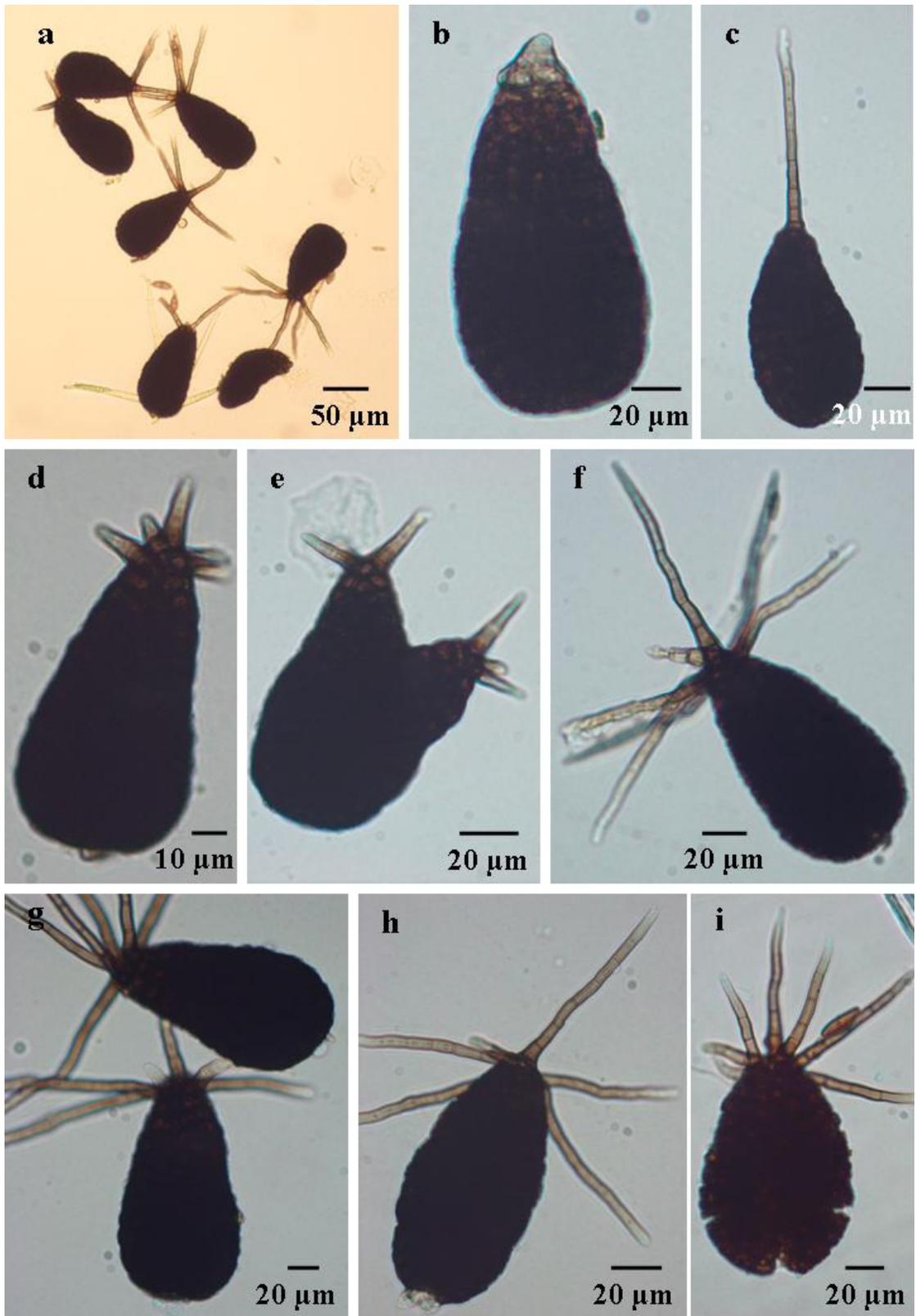


Fig. 2. *Kalashamyces pluriappendiculata*. a–i. Conidia with beak or appendages.

Table 2. Comparison of *Kalashamyces* with similar hyphomycete genera with muriform, appendaged, blastic conidia.

Genus	Conidophores	Conidiogenous cells	Conidia	Appendages
<i>Acrodictys</i>	Macronematous	Terminal, monoblastic, often percurrent	Dictyoseptate, schizolytic, clavate to pyriform	Nil
<i>Bioconiosporium</i>	Macronematous	Mono- or polyblastic, integrated, terminal and intercalary	Dictyoseptate, schizolytic, spherical, ellipsoidal to obpyriform or irregular	Often with 1–2 large protuberances
<i>Manoharachariella</i>	Macronematous	Monoblastic, Integrated, terminal, acroauxic	Dictyoseptate, schizolytic, doliiform, obpyriform, ellipsoidal	With single terminal beak
<i>Megacapitula</i>	Micronematous	Monoblastic, integrated, intercalary	Dictyoseptate, schizolytic, ellipsoidal, obclavate, obpyriform	with dense hairy apical appendages
<i>Monodictys</i>	Micro- or semi-macronematous	Monoblastic integrated, terminal, determinate, cylindrical, doliform or subspherical	Dictyoseptate, schizolytic, acrogenous, pyriform, clavate, ellipsoidal	Nil
<i>Orbimyces</i>	Micronematous	Monoblastic, integrated, intercalary	Dictyoseptate, schizolytic, globose to ovoid	One or two multiradiate appendages
<i>Petrakia</i>	Macronematous	Monoblastic, integrated, terminal, determinate, cylindrical	Dictyoseptate, schizolytic, acrogenous, corniculate, ellipsoidal, irregular in shape	With projecting stalk cells
<i>Pithomyces</i>	Micro- or semi-macronematous	Mono- or polyblastic, integrated, intercalary, sometimes terminal, determinate, denticulate	Simple, rhexolytic, ellipsoidal, clavate, pyriform, obpyriform	Nil
<i>Pseudopetrakia</i>	Micronematous	Monoblastic, integrated,	Dictyoseptate, schizolytic, straight	Several, subulate, pointed, dark brown

	or semi-macronematous, branched, erect	terminal, determinate	or curved, ellipsoidal, obovoid	or black spines
<i>Pseudotetraploa</i>	Micronematous	Monoblastic, integrated	Dictyoseptate, pseudoseptate, schizolytic, obpyriform to long obpyriform	Mostly 4 rarely upto 8 setose appendages at apex
<i>Santapauinda</i>	Macronematous	Ganglier, integrated	Dictyoseptate, rhexolytic, oval to subglobose, variable in shape and size	With single apical appendage
<i>Shrungabeeja</i>	Macronematous	monoblastic, terminal	Dictyoseptate, schizolytic, clavate to pyriform	Up to 5 appendages
<i>Tetraploa</i>	Micronematous	Monoblastic, rarely polyblastic, integrated	Dictyoseptate, schizolytic, oblong with 3-4 columns of cells	With 3-4 apical appendages arising from each column
<i>Quadricrura</i>	Micronematous	Monoblastic, integrated	Dictyoseptate, globose to subglobose	1-2 long terminal appendages and 4-5 short non terminal appendages
<i>Kalashamyces</i>	Micronematous	Monoblastic, determinate; supporting basal cell cylindrical, short, pale to hyaline	Dictyoseptate, rhexolytic, obpyriform	beaked or 1-7 appendages clustered at the apex

Table 3. Comparison of the species of *Kalashamyces*.

Species	Conidia				
	Shape	Size (µm)	Color and ornamentation	Septation	Apex and appendages
<i>Kalashamyces bulbilus</i>	Obovate to obpyriform, sometimes spherical to oval muriform, bulbils globose	20–38 × 15–23	Dark brown, smooth	Multiseptate, irregularly dictyoseptate	Rounded in conidia, Bulbiliophores with 5-20 radial appendages
<i>K. djbhatii</i>	Ovate to pyriform, rostrate	21–97 × 19–26	Dark brown, smooth	Mutiseptate, irregularly dictyoseptate	Terminaly rostrate. Rostrum single, short to very long
<i>K. ellisii</i>	Obturinate or obpyriform	21.6–43.2 × 14.4–20.7	Dark brown to black, smooth	5–15 transverse and 1–10 oblique	Obtuse, acute, acuminate, often beaked
<i>K. niger</i>	Limoniform, ellipsoidal to subglobose	30.5–41 × 23–28	Black with brown appendage, smooth	Multiseptate, dictyoseptate	Round mostly with single terminal appendage
<i>K. pulvinatus</i>	Obpyriform	45–90 × 25–45	Dark brown with brown base and beak, smooth	Multiseptate, irregularly dictyoseptate	Round, often beaked
<i>K. quadratus</i>	Broadly ellipsoidal, obpyriform	15–53 × 11–23	Brown, ehinulate	Multiseptate, irregularly dictyoseptate	Round, often beaked
<i>K. subramanianii</i>	Oval to obovoid, pyriform to obturinate, tapering at apices	40–60 × 20–35	Dark brown, smooth	Multiseptate, irregularly dictyoseptate	Ending in 1-3 beak like structures
<i>K. pluriappendiculata</i>	Obpyriform	65–115 × 40–60	Dark brown, smooth	Multiseptate, irregularly dictyoseptate	Ending in 1–7 appendages clustered at the apex. Appendages short beak like to as long as conidia.

Key to species of *Kalashamyces* based on conidial morphology

- 1. Conidia of two kinds, one with appendages*K. bulbilus*
- 1. Conidia of one kind 2
- 2. Conidia beaked or rostrate 3
- 2. Conidia with appendage often more than 20 μm long6
- 3. Conidia echinulate*K. quadratus*
- 3. Conidia smooth..... 4
- 4. Conidia often with more than one rostrum or beak.....*K. subramaniani*
- 4. Conidia with single terminal beak 5
- 5. Conidia more than 45 μm long and 25 μm broad*K. pulvinatus*
- 5. Conidia less than 43 long μm and 21 μm broad *K. ellisii*
- 6. Conidia ellipsoid, limoniform, black*K. niger*
- 6. Conidia ovate, pyriform, not black7
- 7. Appendage single terminal, conidia up to 30 μm broad.....*K. djbhatii*
- 7. Appendages 1–7, conidia more than 30 μm broad *K. pluriappendiculata*

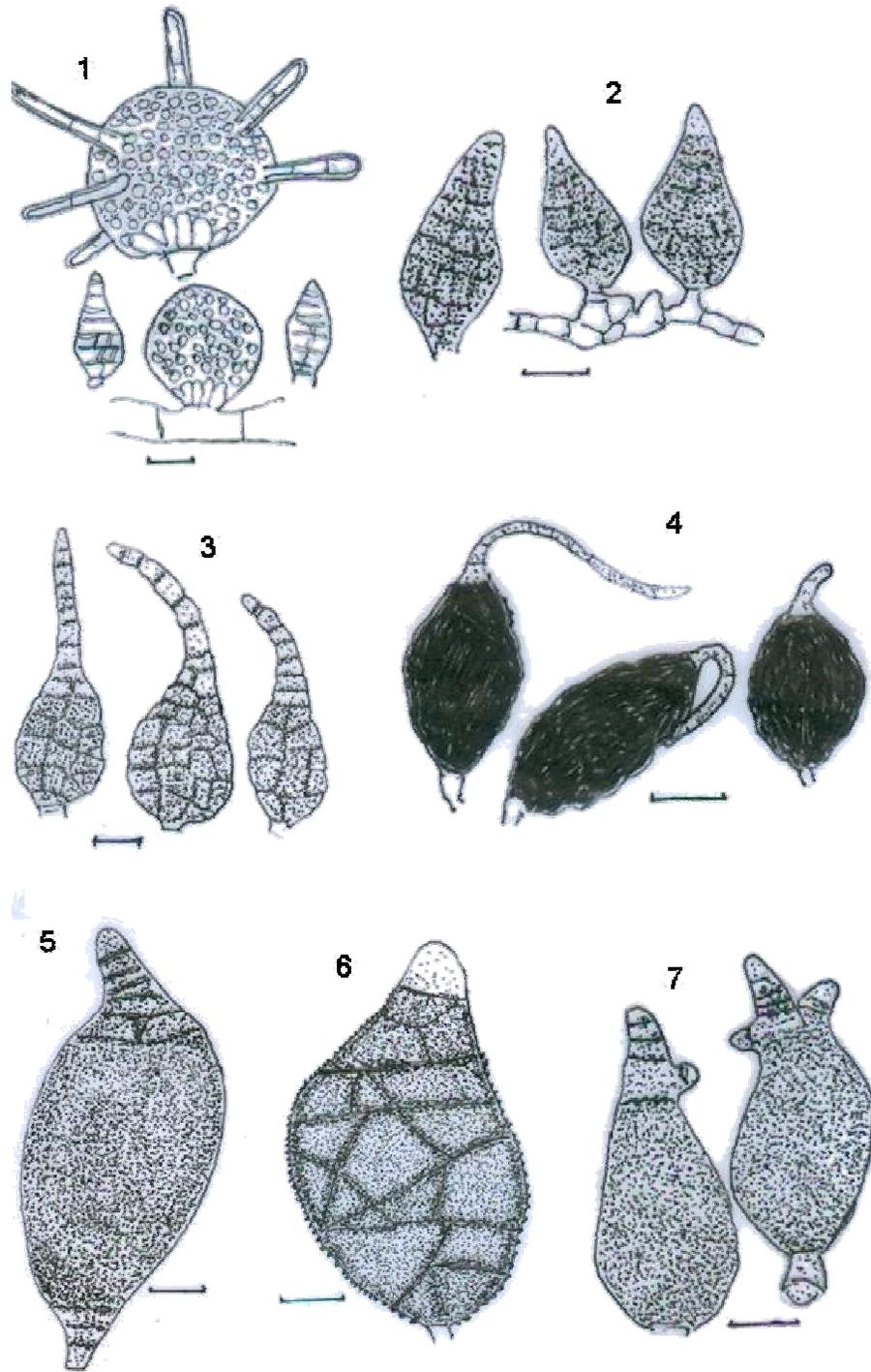


Fig. 4. Species of *Kalashamyces*. 1. *K. bulbilus*, 2. *K. ellisii*, 3. *K. djbhatii*, 4. *K. niger*, 5. *K. pulvinatus*, 6. *K. quadratus*, 7. *K. subramanianii*. Scale bars = 10 μm

REVIEW OF GENUS PITHOMYCES (Table 4, Fig. 5)

Pithomyces was described by Berkley & Broome (1873) with *P. flavus* Berk. & Br. as type species and genera *Neomichelia* Penz. & Sacc. and *Scheleobrachea* S. Hughes as its synonyms. Ellis (1976) reviewed the genus and provided a comprehensive account of the 15 described species. Rao & Reddy (1978) described *P. subramanianii* Rao & Reddy, the first species in the genus with more than one appendage-like extension. Rao & de Hoog (1986) provided a key to 25 species. Additional species have been described by Morgan-Jones (1987), Matsushima (1987, 1993), Rao & Manoharachary (1988), Zhang & Wu (2003), Zhang & Zhang (2003), Manoharachary et al. (2006) and Zhang & Zhang (2007). *Pithomyces* till date has 46 species and, of these, 7 species are now transferred to *Kalashamyces*.

Table 4 : Comparison of *Pithomyces* species.

Species	Conidia			
	Shape	Size (µm)	Color and ornamentation	Septation
<i>P. africanus</i>	Obovate, straight to slightly curved	10–19 × 5–8	Dark brown, smooth	0-septate
<i>P. alabamensis</i>	Fusiform to ellipsoidal	28–44 × 10.5–16	Brown at center, paler towards sides, smooth	6–8 transverse
<i>P. arecastri</i>	Clavate, straight to curved	14–21 × 5–6	Brown, smooth	2–3 transverse
<i>P. atro-olivaceus</i>	Clavate, subcylindrical, slightly curved	14–35 × 7–10	Brown, echinulate	3–7 transverse
<i>P. cateniformis</i>	Clavate, straight to curved, catenulate	17–25 × 6–7	Brown to hyaline, smooth	2–4 transverse
<i>P. chartarum</i>	Elliptical, oblong, straight	18–29 × 10–17	Mid to dark brown, echinulate or verruculose	3–4 mostly 3-transverse, 1–3 longitudinal in middle part
<i>P. cinnamomeus</i>	Ellipsoidal, ovoid, subglobose to irregular	20–31 × 13–20	Cinnamon to brown, smooth	4–5 transverse, several longitudinal
<i>P. clavisporopsis</i>	Oblong to clavate, straight to curved	13–27 × 6.5–8.5	Pale brown, smooth	1–4 transverse
<i>P. clavisporus</i>	Clavate, straight to slightly curved	13–24 × 5–7	Brown, finely echinulate or smooth	0–4 mostly 2 transverse
<i>P. cupaniae</i>	Ellipsoidal, clavate, straight or slightly curved	10–20 × 3–5	Hyaline to pale brown, echinulate	1 transverse
<i>P. cynodontis</i>	Oblong, clavate, straight to slightly curved	20–55 × 10–25	Brown, echinulate	3–8 transverse, 2–4 longitudinal
<i>P. divaricatus</i>	Obpyriform to ovoid, mostly divaricate	7.5–43.2 × 3.2–9.7	Olivaceous brown, smooth	1–7 transverse
<i>P. elaeidicola</i>	Broadly	33–55 × 15–24	Brown, echinulate	1–7, mostly 5–

	ellipsoidal, straight			6 transverse
<i>P. ellipticus</i>	Ellipsoidal to oblong ellipsoidal	14.5–35.5 × 11.5–19.5	Brown, smooth	2–6 transverse and 0–4 oblique
<i>P. flavus</i>	Broadly ellipsoidal, straight	28–45 × 15–26	Brown, verruculose to echinulate	3–5 transverse
<i>P. funiculosus</i>	Clavate, obovate, obpyriform to fusiform, ellipsoidal to reniform	10–25 × 6–12	Pale to dark brown, smooth	1–3 transverse, rarely with 1–2 oblique
<i>P. gladioli</i>	Oblong or clavate	23–32 × 9.5–12	Brown to dark blackish brown, smooth	3–5 transverse
<i>P. graminicola</i>	Cylindrical, rounded at apex or clavate	10–20 × 5–8 Mostly 12–15 × 6–7	Olivaceous brown, smooth or minutely verruculose	1–2 transverse
<i>P. helminthosporioi-des</i>	Ellipsoidal to vermiform, straight to curved	34.5–48.5 × 10–16	Brown, pale brown at ends, smooth	3–8 transverse, 1–6 longitudinal, 0–1 oblique
<i>P. karoo</i>	Variable, ellipsoidal, pyriform, clavate, cruciform, etc.	17–30 × 8–18	Straw to dark brown, verrucose	2 transverse, 1 longitudinal
<i>P. leprosus</i>	Cylindrical, ellipsoidal or clavate	15–22 × 5–7	Brown, with plates of epispore cracking	2 transverse
<i>P. longiclavisporus</i>	Clavate to subellipsoidal to subcylindrical	18–37.5 × 6–9.5	Light brown, minutely verruculose	2–6 transverse, rarely one oblique septa
<i>P. longipes</i>	Ellipsoidal to oblong	20.5–31.0 × 6.0–8.0	Pale brown, echinulate	2–3 transverse
<i>P. maydicus</i>	Broadly ellipsoidal	12–20 × 6–12	Pale brown, verrucose	2 transverse, 1 longitudinal
<i>P. musae</i>	Ellipsoidal, oblong to clavate, often with attached conidiophore part	14–40 × 5–7	Brown to dark blackish brown, smooth	1–7 transverse
<i>P. obpyriformis</i>	Clavate to subobpyriform, straight to curved	20–27.5 × 9.5–16.0	Brown, paler on sides, smooth	2–3 transverse, 0–2 longitudinal
<i>P. obscuriseptatus</i>	Obovate, muriform	16–22.5 × 11–15.5	Brown, verrucose	Multiseptate, dictyoseptate, septation obscure at maturity
<i>P. pallidus</i>	Obovoid, ellipsoidal	17–34 × 7–14	Light brown,	1–4 transverse

	to broadly clavate, straight to slightly curved		verrucose	0–1 longitudinal
<i>P. pavgii</i>	Variable, clavate, obovate to obpyriform or fusiform ellipsoidal to reniform	10–26 × 4.5–12	Pale to dark brown, verrucose	0–4 mostly 2 transverse, rarely 1–2 oblique septa
<i>P. prolatus</i>	Broadly fusiform	51–80 × 10–20	Golden brown, pale at apex and base, verrucose	6–9 mostly 7 transverse
<i>P. sacchari</i>	Oblong, clavate, slightly curved	12–25 × 5–15	Brown to pale brown, echinulate	0–3 transverse, 1–2 longitudinal
<i>P. saccharicola</i>	Ellipsoidal to oblong, obovoid to obpyriform	17–29 × 7–11.5	Pale brown, smooth	1–3 transverse
<i>P. sivaramaprasadii</i>	Spherical, subspherical or ellipsoidal	19–30 × 14–22	Brown to dark brown, finely verruculose	Multiseptate, dictyoseptate
<i>P. sumiderensis</i>	Ellipsoidal, ovoid to clavate, irregularly muriform	24–46.5 × 17.5–26	Pale brown to brown with basal part subhyaline, smooth	Multiseptate, dictyoseptate
<i>P. taiwanensis</i>	Naviculiform with acute apex	19–27 × 4–6.5	Brown to dark brown, smooth	With no visible septa
<i>P. terricola</i>	Fusiform to broadly fusiform or broadly ellipsoidal	18.8–40.8 × 5.2–12.2	Brown, paler and verruculose at both ends	3–5 transverse, mostly 5
<i>P. trachelospermi</i>	Ellipsoid, obovoid to clavate	7.5–15.5 × 4.5–7.0	Brown, verruculose to echinulate	1–3 transverse
<i>P. valparadisiacus</i>	Broadly ellipsoidal	17.5–26.5 × 8–13.5	Dark brown, paler terminally, echinulate	3, rarely 4 transverse
<i>P. variegatae</i>	Subspherical, oblong to ellipsoidal	12–17 × 7.5–10.5	Brown to pale brown, echinulate	2–3 transverse

Key to species of *Pithomyces* based on conidial morphology

1. Mature conidia clearly without longitudinal septa (phragmoseptate).....2
 1. Mature conidia with longitudinal septa (dictyoseptate).....
 - 24
 2. Conidia smooth
 - 3
 2. Conidia not smooth14

3. Conidia mostly 3- or fewer- septate.....	4
3. Conidia often more than 3-septate	12
4. Conidia 0–1-septate	5
4. Conidia mostly 2–3-septate.....	6
5. Conidia navicular,acute at apex, 0-septate	<i>P. taiwanensis</i>
5. Conidia ellipsoidal, oblong, rounded at apex, 0–1-septate.....	<i>P. africanus</i>
6. Conidia up to 2-septate	7
6. Conidia often 3-septate.....	8
7. Conidia evenly pale brown, with 1–2 transverse septa	<i>P. graminicola</i>
7. Conidia with cracked outer wall, 2-septate	<i>P. leprosus</i>
8. Conidia distinctly constricted at septa	9
8. Conidia not or slightly constricted at septa, conidiophores funiculosose	<i>P. funiculosus</i>
9. Conidia 7.5–11.5 µm broad	<i>P. saccharicola</i>
9. Conidia less than 8.5 µm broad	10
10. Conidia catenulate, 17–25 x 6–7 µm	<i>P. cateniformis</i>
10. Conidia not catenulate	11
11. Conidia less than 6 µm broad, up to 3-septate	<i>P. arecastri</i>
11. Conidia 6.5–8.5 µm broad, 0–4-septate	<i>P. clavisporopsis</i>
12. Conidia often branched or divaricate	<i>P. divaricatus</i>
12. Conidia unbranched	13
13. Conidia clavate, often carrying most of conidiophore	<i>P. musae</i>
13. Conidia broadly fusiform to ellipsoidal	<i>P. alabamensis</i>
14. Conidia 1-septate	<i>P. cupaniae</i>
14. Conidia more than 1-septate	15
15. Conidia clavate, subcylindrical, slightly curved.	16
15. Conidia broadly ellipsoidal, straight	20
16. Conidia not constricted at septa	17
16. Conidia constricted at septa	18
17. Conidia 18–37 x 6–9.5 µm, 2–6-septate.	<i>P. longiclavisporus</i>
17. Conidia 13–24 x 5–7 µm, 0–4-septate	<i>P. clavisporus</i>
18. Conidia up to 15.5 µm long	<i>P. trachelospermi</i>
18. Conidia often longer than 16 µm	19
19. Conidiophores more than 20 µm long	<i>P. longipes</i>
19. Conidiophores micronematous, denticulate	<i>P. atro-olivaceus</i>
20. Conidiophores macronematous, conidiogenous cell terminal	21
20. Conidiophores undifferentiated, conidiogenous cell intercalary or denticulate	22
21. Conidia up to 5-septate, up to 50 µm m long.....	<i>P. terricola</i>
21. Conidia 6–9-septate, 51–80 µm m long.....	<i>P. prolatus</i>
22. Conidia up to 13.5 µm m broad, evenly 3–4-septate	<i>P. valparadisiacus</i>
22. Conidia more than 13.5 µm m broad, 1–7-septate	23
23. Conidia up to 5-septate	<i>P. flavus</i>
23. Conidia mostly 5–6-septate	<i>P. elaeidicola</i>
24. Conidia with up to 8 transverse septa, number of longitudinal or oblique septa equal or less than transverse septa.....	25
24. Conidia with several transverse, uneven septa, number of longitudinal or oblique septa more than transverse septa.....	37
25. Conidia smooth	26
25. Conidia not smooth	29

26. Conidia 34–48 μm long, often with more than 5 transverse septa	<i>P. helminthosporioides</i>
26. Conidia up to 35 μm long, with less than 5 transverse septa	27
27. Conidia 9.5–12 μm broad	<i>P. gladioli</i>
27. Conidia often more than 12 μm broad.....	28
28. Conidia ellipsoid to oblong, often with more than 3 transverse septa, mostly straight	<i>P. ellipticus</i>
28. Conidia clavate, obpyriform, up to 3 transverse septate, often slightly curved	<i>P. obpyriformis</i>
29. Conidia ellipsoidal, oblong, straight	30
29. Conidia, asymmetrical, oblong, clavate, slightly curved	31
30. Conidia with 2 transverse, 1 longitudinal septa	<i>P. maydicus</i>
30. Conidia with 3–4 transverse, 1–3 longitudinal septa.....	<i>P. chartarum</i>
31. Conidia 12-17 μm long	<i>P. variegatae</i>
31. Conidia often longer than 18 μm	32
32. Conidia rarely with longitudinal septa	33
32. Conidia often with longitudinal septa	34
33. Conidia distinctly constricted at septa	<i>P. pallidus</i>
33. Conidia not or slightly constricted at septa	<i>P. pavgii</i>
34. Conidia with more than 4 longitudinal septa	36
34. Conidia with not more than 4 longitudinal septa	<i>P. cynodontis</i>
35. Conidia straw colored, verrucose, mostly with 1 longitudinal septum	<i>P. karoo</i>
35. Conidia often dark brown, echinulate, often with 2 longitudinal septa	<i>P. sacchari</i>
36. Conidia smooth	37
36. Conidia not smooth	38
37. Conidia mostly with 4-5 transverse septa and several longitudinal septa, 20-31 μm long and 13-20 μm broad.....	<i>P. cinnamomeus</i>
37. Conidia irregularly muriform, 24-46.5 μm long and 17.5- 26 μm broad.....	<i>P. sumiderensis</i>
38. Conidia distoseptate	<i>P. sivaramaprasadii</i>
38. Conidia obscurely septate when mature.....	<i>P. obscuriseptatus</i>

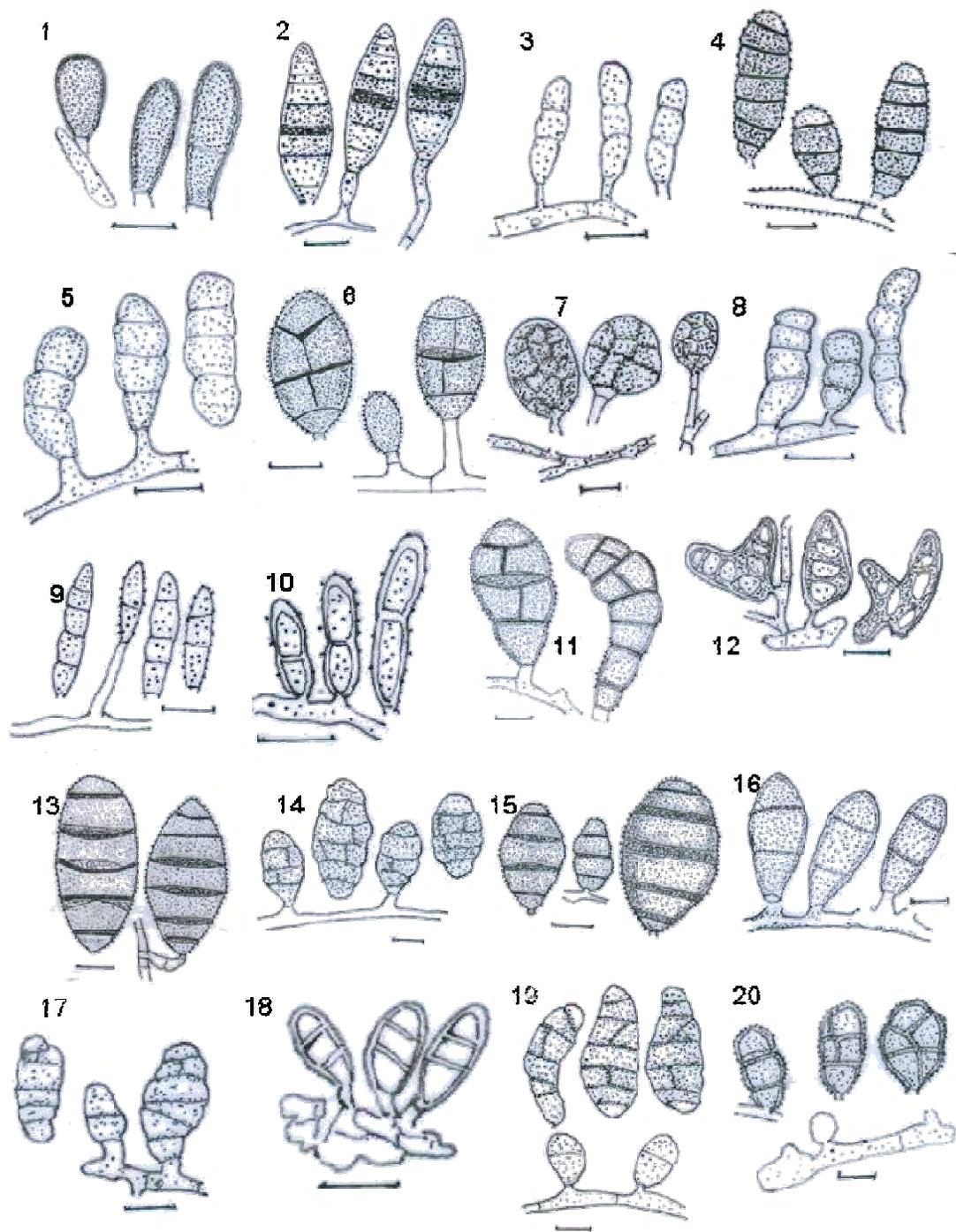


Fig. 5a. Species of *Pithomyces* 1. *P. africanus*, 2. *P. alabamensis*, 3. *P. arecastri*, 4. *P. atro-olivaceus*, 5. *P. cateniformis*, 6. *P. chartarum*, 7. *P. cinnamomeus*, 8. *P. clavisporopsis*, 9. *P. clavisporus*, 10. *P. cupaniae*, 11. *P. cynodontis*, 12. *P. divaricatus*, 13. *P. elaeidicola*, 14. *P. ellipticus*, 15. *P. flavus*, 16. *P. funiculosus*, 17. *P. gladioli*, 18. *P. graminicola*, 19. *P. helminthosporioides*, 20. *P. karoo*. Scale bars = 10 μ m

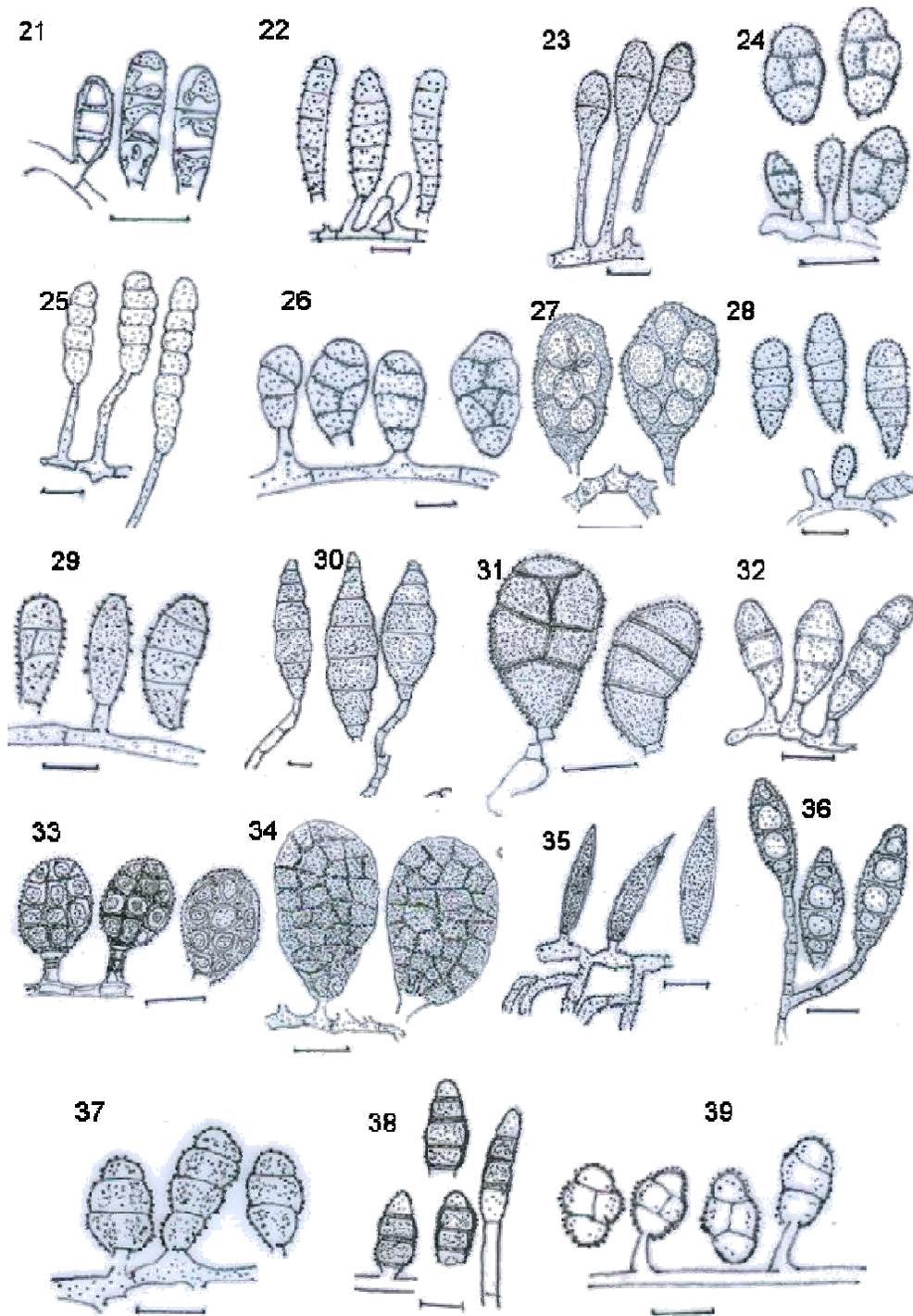


Fig. 5b. Species of *Pithomyces*, 21. *P. leprosus*, 22. *P. longiclavisporus*, 23. *P. longipes*, 24. *P. maydicus*, 25. *P. musae*, 26. *P. obpyriformis*, 27. *P. obscuriseptatus*, 28. *P. pallidus*, 29. *P. pavgii*, 30. *P. prolatus*, 31. *P. sacchari*, 32. *P. saccharicola*, 33. *P. sivaramaprasadii*, 34. *P. sumiderensis*, 35. *P. taiwanensis*, 36. *P. terricola*, 37. *P. trachelospermi*, 38. *P. valparadisiacus*, 39. *P. variegatae*. Scale bars = 10 μ m

ACKNOWLEDGMENTS

We are indebted to Dr Eric McKenzie, Landcare Research, New Zealand, Prof. Bryce Kendrick, Canada for their pre-submission suggestions on manuscript. We thank Profs Gabriela Heredia, Instituto de Ecología, Mexico and Xiu-Guo Zhang, Shandong Agricultural University, Taian, China, for providing necessary literature. DJB thanks the University Grants Commission, New Delhi, for support of a Special Assistance Program to the Department of Botany and to the Ministry of Environment & Forests for a research grant. AP thanks the Ministry of Environment & Forests, New Delhi, for a research Fellowship.

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