STUDIES ON DIVERSITY, ECOLOGY AND BIOLOGY OF MICROFUNGI ASSOCIATED WITH A FEW DICOT AND MONOCOT PLANT SPECIES OF WESTERN GHATS IN GOA STATE, INDIA.

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By

Maria A. D'Souza, M. Sc.

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Department of Botany
GOA UNIVERSITY
Goa-403 206, India.

(Mrs ALAKA PANDE)
External Examiner

MARCH 2002

5/9/02 (D. J. Bhat)
(Guide)

DECLARATION

I hereby declare that the Ph.D. thesis entitled "STUDIES ON THE DIVERSITY, ECOLOGY AND BIOLOGY OF MICROFUNGI ASSOCIATED WITH A FEW DICOT AND MONOCOT PLANT SPECIES OF WESTERN GHATS IN GOA STATE, INDIA " submitted to Goa University, forms an independent work carried out by me in the Department of Botany, Goa University, under the supervision of Dr. D. J. Bhat, Professor and Head, Department of Botany, Goa University and the thesis has not formed previously the basis for the award of any degree, diploma, associateship or other similar titles.

(Maria A. D'Souza)

Countersigned by

D. J. [illegible], Ph.D.
Professor and Head
Department of Botany
GOA University
GOA-403 206, INDIA

CERTIFICATE

I certify that the thesis entitled "STUDIES ON THE DIVERSITY, ECOLOGY AND BIOLOGY OF MICROFUNGI ASSOCIATED WITH A FEW DICOT AND MONOCOT PLANT SPECIES OF WESTERN GHATS IN GOA STATE, INDIA" submitted by Ms. Maria A. D'Souza, is a record of research work done by her during the period from 1999-2002 when she worked under my supervision. The thesis has not formed the basis for the award of any degree, diploma, associateship, or fellowship to Ms. Maria A. D'Souza.

I affirm that the thesis submitted by Ms. Maria A. D'Souza incorporates the independent research work carried out by her under my supervision.

(Supervisor)
D. J. Bhat, M.Sc., Ph.D.
Professor and Head
Department of Botany
GOA UNIVERSITY
GOA-403 206, INDIA

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CONTENTS

CHAPTER I

INTRODUCTION

Fungi constitute an important and integral component of the ecosystems in nature. Being heterotrophs, they exist on a wide range of habits and habitats such as the decaying remains and living parts of plants and animals, in soil, dung, air, freshwater and the sea and exhibit a great diversity in form and function. As saprophytes, along with bacteria and micro- and macrofauna, fungi bring about complete decomposition of plant and animal remains. As parasites, they cause diseases in plants and animals. As mutualists, fungi are known to live in harmony with other organisms; as endophytes, they are believed to extend support in providing defence and endurance to living plants. It is now known that with their grand species composition and ability to produce a variety of enzymes and establish simple to complex ecological association with plants and other organisms, fungi act as fine tuners of the structure, function and dynamics of plant and animal community in nature (Dix and Webster, 1995).

Diversity:

Of the estimated 1.5 million, 72,036 species of fungi have so far been described and documented (Hawksworth, 1991; 1997). Communities of saprophytic, parasitic, mutualistic and endophytic fungi living in the wild contributed significantly to species diversity (Frankland, 1998). Recent studies have revealed that tropical plant substrate and habitats harbour diverse microfungi in abundance (Hyde, 1997). Investigations have pointed out that the microfungi of the tropics are possible sources of biotechnologically significant, pharmaceutically important and industrially valuable organic molecules (Dreyfuss and Chapela, 1994; Rossman, 1994; Bills, 1995). Taking a clue from these utilitarian points of observations, Bills (1995) and Hawksworth (1997) made an

emphatic plea for urgent and comprehensive documentation of and investigation on the fungi of various habitats in the tropical region.

Several studies on diversity of fungi associated with plant and animal substrates are available (Ellis, 1971, 1976; Ingold, 1975; Lundqvist, 1972; Matsushima, 1971, 1975; Sivanesan, 1984; Subramanian, 1971, 1983; Sutton, 1980). Amongst these, a few were directed at measuring the abundance, besides diversity, of microfungi that inhabit plant litter (Heredia, 1993; Wicklow and Carroll, 1981). A few investigations were carried out to elucidate the process of decomposition of plant litter in a variety of habitats (Barlocher, 1992; Wicklow, 1981, 1992; Dickinson and Pugh, 1974).

Recent studies have revealed that decomposing litter, live plant parts and their habitats in the tropics harbour fungi in abundance (Bills, 1995; Hyde, 1997; Bills and Polishook, 1994). Relative to the understanding of extent of diversity, ecology, geography and biochemical functioning of terrestrial plants and animals, knowledge on the microfungi so far remained less understood.

Ecology:

Aerial plant surface as a habitat for fungal growth has been first recognized by Last (1955). The decay of plant parts, in which fungi exerting a decisive role in the release of nutrients is generally completed in the soil but set in motion in senescing organs before they are shed. That is, of the many fungal spores impacted on the aerial surface, a few succeed in colonizing and growing on the leaf tissue (Frankland, 1998).

Fungal endophytes live within the tissues of higher plant leaves, twigs, bark and root. They do not cause any visible symptoms on host plant. The endophytes associated with temperate tree species have been studied since the middle of 1970's but not much is

known on diversity, ecology and biology of endophytic fungi from the tropics. Dreyfuss and Chapela (1994) and Bills (1996) observed that the fungal endophytes within the tissues of higher plants exhibit notable diversity and proposed that a comprehensive investigation on green and senescing leaf-tissue and decaying leaves would give a complete picture on the form and function of mycoflora associated with plant species.

Although earlier studies on the ecology of fungi were concentrated on soil and soil organic matter, later investigations were directed mostly on understanding the relationship of fungi with plant litter (Hudson, 1968; Dix and Webster, 1995). It is now well established that the ability of fungi to grow on a particular plant substrate is determined by their role in decomposition of the organic matter. Besides the chemical composition, environmental factors such as temperature, moisture content, availability of nutrients and energy-source, regulate the process of litter decomposition. It is known that no single species of fungi is able to use all components of plant litter completely and different fungi appear in succession on the substrate over a period of time in order to decompose the organic matter and release the bound nitrogen back to nature. Abundant literature is available on colonization of living plants as well as their dead remains by fungi, both in the temperate and tropical habitats (Kendrick, 1992; Dix and Webster, 1995; Frankland, 1998).

Activity:

The colonization and subsequent decomposition of plant substrate depended as much upon on the ability of the fungi to produce enzymes necessary to degrade particular plant polymers. The degradation of the substrate is achieved only through a range of enzymes produced by the fungi and other microorganisms. There is a growing

realization that fungi inhabiting plants, living tissues and fallen leaf litter produce enzymes and secondary metabolites which besides have many uses and application in industry and human welfare (Rossman, 1994; Dreyfuss and Chapela, 1994; Bills, 1995; Dix and Webster, 1995).

The Present work:

Considering the vast array of plants and a wide range of vegetation types distributed along the Western Ghats' forests in southern India, it is presumed that a high degree of fungal diversity may be present in this region. Encouraged by positive results obtained from an earlier study carried out in this Laboratory by Miriam (2000) on *Ficus benghalensis* Linn. and *Carissa congesta* Wight, an additional effort is made in this thesis to investigate and present information on studies on the diversity, ecology and activity of the microfungi associated with several dicotyledonous and monocotyledonous plant species of the forests of Western Ghats in Goa region.

The work has focused on the following key objectives:

- Taxonomy, diversity and substrate specificity of litter and endophytic microfungi associated with different plant species.
- Seasonal occurrence and species richness of fungi in relation to four selected plant species.
- Ecological succession of microfungi on litter of *Careya arborea* and *Dendrocalamus strictus*.
- Assaying of cultures of isolated fungi for enzymes.

Litter and endophytic microfungi associated with 4 native plant species of the Western Ghat forests in Goa State, namely *Saraca asoca* (Roxb.) de Wilde:

Leguminosae; Caesalpinnoideae (dicot) and *Calamus thwaitesii* Becc.: Arecaceae (monocot) in Bondla wildlife sanctuary and *Careya arborea* Roxb.: Lecythidaceae (dicot) and *Dendrocalamus strictus* Wall.: Poaceae (monocot) from Molem wildlife sanctuary, were studied during the pre-monsoon (February–May), monsoon (June-September) and post-monsoon (October-January) period of 1999-2001. In addition, several widely distributed plant species of the Western Ghat forests of Goa were scanned extensively for associative litter and endophytic fungi.

A detailed review of literature on diversity, taxonomy and ecology of litter and endophytic fungi precedes the results presented in the thesis. State-of-the-art techniques used to recover the fungi associated with the plant parts are detailed out in Chapter III. A novel 'litter-bag incubation experiment' was conducted to study the succession of microfungi on the substrate. Along with morphological and cultural characters, diagnostic ecological and habitat features were considered in distinguishing the taxa. All these information were compiled using a specially prepared 'database' on terrestrial fungi.

Standard and relevant literature on taxonomy was referred for identification of the fungi. The diversity and abundance of these fungi in different plant species were statistically analysed and discussed. Dried specimens were housed at the Herbarium of Botany Department, Goa University, and cultures maintained at the Goa University Fungus Culture Collection. The litter and endophytic fungi were screened for various enzymes following standard techniques.

The results are detailed out and discussed in four parts in the thesis. A comprehensive list of references and a list of papers published during the study period are appended at the end of the thesis.

CHAPTER II

REVIEW OF LITERATURE

In his presidential address to the British Mycological Society, Hawksworth (1991) estimated that there may be about 1.5 million species of fungi existing on earth in a wide range of habitats and on a variety of substrates such as freshwater and sea, soil, dung, decaying remains of plants and animals and living plants and animals. Fungi are diverse in nature and ubiquitous in distribution. They are the important constituents of decomposers' community in nature (Anderson and Domsch, 1975). As Mycota are primarily dependent on plant organic matter for their sustenance, diversity in fungi is attributed to the exceedingly large and complex diversity of terrestrial plants present on earth surface (Hawksworth, 1997).

Saprophytic fungi have evolved themselves to exploit every possible habitat and substrate, wherever and whatever degradable organic matter exists. Fungi within an ecological grouping are said to have a restricted distribution and confined to a particular type of resource such as plant litter, wood, roots, herbivore dung, insects, etc. (Kendrick, 1992). Being primary decomposers of organic materials, the fungi vary with the kinds of substrate and habitat and each type of tissue in a given substrate is known carry a specific fungus flora (Frankland, 1981).

2.1. Leaf surface: An interesting ecological niche

The leaf is linked to the environment by flow of energy between them. The level of energy exchange taking place at the surface is dependent on the leaf or plant structure but overall exchange is determined by prevailing climatic factors (Hudson, 1971). The leaf surface of higher plants is covered by noncellular, heterogeneous cuticle consisting of lipids, wax and cutin. The cellwall has cellulose and pectin, besides various other

sugars. Upper surface of most leaves is usually hydrophobic although some leaves show little differences between the two surfaces (Dickinson, 1976).

2.1.1. Phylloplane and phyllosphere:

Colonization of leaf surface by fungi and their interaction have been recognised since long. De Bary in 1866 described *Dematium pullulans*, a fungus commonly occurring on the surface of plants. Last (1955) referred the surrounding environment of leaves as 'phyllosphere'. The leaf surface, considered as a distinct microhabitat inhabited by a variety of saprophytic and parasitic microorganisms, was referred as 'phylloplane' by Dickinson (1971). The surface of living leaves, however, has been described as a hostile environment for fungal growth because of the widely fluctuating ambient temperature, level of desiccation and incidence of radiation from sunlight (Pugh and Buckley, 1971). The microflora of leaf surface and their dynamics therefore became a subject of interesting study.

The physical and chemical properties of phylloplane region are characteristic of a plant species (Hallam and Juniper, 1971) and known to determine the distribution and composition of resident microflora (Ruinen, 1961; Tukey, 1971; Baker, 1974). Several workers have investigated leaf surface microflora of different plants (Dickinson, 1965, 1967). Sinha (1965), Mishra and Srivastava (1970; 1971), Rai (1973), Vittal (1973), Sudha (1978) and others have studied the microflora associated with the leaf surface of various plants, in India.

It was long recognized that surfaces of healthy green leaves are colonized by a number of microrganisms analogous to the concentration of organisms in the rhizosphere and rhizoplane region in the soil. The saprophytic fungi may grow actively

on leaf surface or exist as inactive propagules. Of the multitude of species of fungi impacting on leaf surface, only a few succeed in colonizing the leaves. As the leaves senesce, the saprophytic fungi become active within the leaf tissue (Dickinson, 1976). Investigations by Last (1955) and Ruinen (1966) conclusively proved that the leaf surface is a distinct ecological niche for saprophytic microorganisms. Numerous reports have been published describing the phylloplane microflora of different plants (Dickinson, 1976) and majority of these dealt with either annuals or perennials. Less is known about the evergreens, though Ruinen (1961) reported that persistent leaves of tropical plants supported complex and large amount of microorganisms.

Dickinson (1965, 1967) studied the fungal population associated with *Halimione portulacoides* and *Pisum sativum* leaves. Ruinen (1963, 1965, 1966) described the phylloplane microbial population of several plants and their effect on cuticle decomposition. Mishra and Srivastava (1970, 1971) studied microflora associated with leaf surface of crop plants such as *Oryza sativa, Triticum aestivum, Hordeum vulgare* and *Echinochloa crusgalli* and concluded that the free surface of young leaves provided an open space for various microorganisms which later succeed to colonize.

2.1.2. Role of phylloplane fungi in litter decomposition:

Phylloplane became a subject of interest for different reasons. It has been shown to be a site of antagonistic action between microorganisms, toxic reactions for cattle, nitrogen fixation, source of allergenic airborne spores and source of microbes for decomposition of plant material after leaf fall. Green leaves exhibit a high degree of resistance. Although mature green leaves contained more nutrients than dead leaves, their resistance to fungal growth and colonization is said to be due to nonavailability of

free nutrients. Under normal environmental conditions, fungal population is at its lowest on green leaves and gets increased only on aged and dried leaves. Recent studies have concluded that many of the saprophytes settled on aerial surfaces prior to senescence are better placed to take advantage of the substrate decomposition (Frankland, 1998).

2.1.3. Impact of physical factors:

In plant litter, lignin is more resistant to decay than protein and cellulose. Kendrick and Burges (1962) have suggested that chemical properties of the litter determine the fungi attempting colonization and successful early colonizers may produce fungistatic substances in turn acting selectively on secondary colonizers. The other factors determining the dominant species of the litter mycoflora are the microclimate, maturity of the mycoflora and the stage in the development of the tree.

Temperature is one of the cardinal factors affecting microbes, especially fungi growing on plant surface. Fahey (1983) reported changes in the concentration of N, P, K, Ca and Mg, of up to 2 to 8 fold in wood that had decayed for varying lengths of time. Phosphorus and nitrogen in particular are often rapidly accumulated by fungi. It is well documented that the physico-chemical features of leaf litter caused marked interspecific differences in decomposition rates (Swift et al., 1979; Cornellison, 1996).

The relative contributions of various cations to the decomposition process are said to be different in monocots and dicots. Graminoid monocots have lower base contents and litter decomposition rates are faster than in herbaceous dicots. Dicot leaves contain and retain relatively large amounts of Ca and Mg. It has been shown that basic n enhance the palatability of leaf litter by providing an important base for decomposers (Nicolai, 1988) or by making the litter less acidic (Swift et al., 1979). Low base content

also coincided with high concentrations of compounds that reduced the palatability of the leaves and litter. Total base content of living leaves, although represented different ecological phenomena in monocots and dicots, is a potential indicator of litter decomposition rate in ecosystem modelling (Frankland, 1998).

2.1.4. Litter deposition:

Litter includes fallen leaves, dead herbaceous material, parts of flowers and fruits, twigs, branches, and logs including bark, and for some, even the roots which penetrate shallowly or even deeply into the soil. It also accommodates any organic matter which is still recognizable as having come from plant or animal sources and which has died from one cause or another including pathogenesis. The litter environment is heterogeneous and contains many kinds of resources. Swift (1976) considered that every part (i.e. leaves, flowers, fruits, branches, etc.) of plant species is a separate resource. Many fungi are resource specific and spores landing on other resources do not develop.

Annual litter fall is a dynamic, ever-changing process. A considerable amount of data has been gathered on the quantity of litter produced by forests and factors affecting litter fall (Bray and Gorham, 1964) The nutrient content of litter is very variable because of variation in nutrients concentrations of plant tissue and of changes in the type and timing of litter fall (Gosz et al., 1972). The fungal population of the litter can be derived from previous generations of litter, the soil or the phyllosphere and related areas of plant surfaces which get colonized from their initiation by one fungus or another.

The nutrients returned in plant material to the soil are important because of its influence on both the rate of litter decomposition and the amount of nutrients liberated

during decomposition. Annual and seasonal differences in litter deposition due to climatic fluctuations and/or changes in vegetative composition and phenology are known. These together affect the process of decomposition, mineralization and immobilization (Jenson, 1974).

The accumulation of organic matter on the forest floor represents a nutrient storage pool, an attractive habitat for many different types of heterotrophic organisms. The amount of accumulation of organic matter is dependent on litter input, organismal succession and rate of decomposition (Olsen, 1963). The decomposition rate is in turn determined by the nature of the litter input, temperature, moisture, soil type and other aspects (Dickinson and Pugh, 1974).

Mc Claugherty and Berg (1987) have found out that in addition to climatic factors, the chemical composition of litter strongly regulates biomass-loss rates and concentration of certain nutrients such as N and P. In litter, these have been considered as decomposition rate enhancing factors (Millar et al., 1948) whereas lignin has been suggested as a rate-retarding compound (Fogel and Cromack, 1977)

As a specific habitat for association of fungi, litter is becoming an important component for studies. The ability of certain specific species of litter fungi to use lignin and cellulose is known and a large population of such fungi growing on remains of plants has been recognised (Dix and Webster, 1995).

Litter quality influences the nature of colonizing and decomposing saprophytic fungi. It determines the successional changes in its population and enhances the litter mineralization rates (Dickinson and Pugh, 1974; Cooke and Rayner, 1984). Rustad (1994) followed changes in the chemical composition and rate of decomposition of litter from freshly fallen leaves until its incorporation into soil organic matter and showed P,

Mg, and Mn being rapidly lost (up to 70-75%) during the first 6, 24 and 40 months and then levels remaining fairly constant. Nitrogen was also initially lost and then gradually accumulated over the first 18 months until critical C:N ratios were achieved.

2.1.5. Enzymes in litter decomposition:

Pugh et al. (1972) reported that fungal colonizers on living leaves, the phyllosphere fungi, together possess a multi-enzyme system (cutinase, pectinase and cellulase) which during senescence and death of the leaf undertake breakdown of the tissues. Although study of enzymatic activity under field conditions is difficult, it is known that colonization of plant resources by fungi depended on the ability to overcome presence of inhibitory substances and to produce enzymes necessary to degrade particular plant polymers.

Saprophytic fungi have a range of enzyme machinery capable of degrading organic residues. Very few fungi possess the complete suite of enzymes necessary for the complete breakdown of a complete resource. Hence, there is a need for a succession of fungi to colonize a resource unit to utilize the various components (Ljungdahl and Eriksson, 1985). Extracellular enzymes are extremely stable glycoproteins that operate in the fluids of the substratum and secreted for the purpose of solubilizing the substratum on which the fungal hyphae grow. Ecological adaptation is achieved through the range of enzymes produced and the multiple forms of individual enzymes. The full range of these and the substrates that can be utilized depended upon the species of fungi (Kendrick, 1992).

Leaf inhabiting fungi persist for varying period of time on the surface of litter. The survival is related to their cellulolytic ability, which has been shown to be

characteristic of all the fungi tested. The ability to utilise cellulose is often regarded as an essential property of saprophytic fungi (Melin, 1948). Repeated isolation of particular fungi from litter at various stages of decay and demonstration of their cellulolytic ability in pure culture proved useful for competitive saprophytic survival in litter (Chesters, 1960). The enzymes xylanase and cellulases have important role in the decomposition process because of the dominance of hemicellulose and cellulose in leaf litter. Amylase and invertase are also important because of their role in angiosperm leaf litter breakdown (Fogarty and Kelly, 1979).

2.1.6. Earlier work:

Succession of fungi on a variety of substrates has been described (Hudson, 1968). As plant materials get decomposed, a variety of organic constituents are presented in turn to a succession of ecological groups of fungi, each group of organisms altering the organic constituents until complete decomposition has been accomplished (Alexander, 1961). Although studies on fungal succession were initiated by Chesters (1950) and Mangenot (1952), working on decaying timber and culms of *Dactylis glomerata,* Webster (1956, 1957) offered new inputs on the subject. Several later workers studied succession of microorganisms, especially fungi, on plant parts of bryophytes, pteridophytes, gymnosperms and angiosperms (Hudson and Webster, 1958; Pugh, 1958; Meridith, 1960, 1962; Hudson, 1962; Kendrick and Burges, 1962; Khanna, 1964; Hering, 1965, 1967; Hayes, 1965; Hogg and Hudson, 1966; Macauley and Thrower, 1966; Yadav, 1966; Frankland, 1966, 1969; Mangenot, 1966; Dickinson, 1965, 1967; Kamal and Singh, 1970, 1975; Sharma and Dwivedi, 1972; Rai, 1973, Watson et al., 1974; Kamal and Srivastava, 1975).

Successions of fungi on moribund leaves have been examined in great detail, particularly of monocots by Pugh (1958), Webster (1956,1957) and Hudson (1962). These studies have concluded that a general pattern of succession of fungi occurs on leaves of a similar nature but variations in mycoflora have been found when leaves of different types are examined.

Dickinson (1965, 1967) examined succession of fungi on green and moribund leaves of dicot herbs such as *Halimione portulacoides* and found out that air-borne spores were in abundance on the leaves. Yadav (1966) investigated the litter decomposition on *Heracleum sphondylium* and recognised different groups of fungi based on frequency of their occurrence in succession on dead stems. Mangenot (1966) assessed fungal colonisation at different stages of decomposition of herbaceous plants. It was evident from the results that decomposition process of litter is an orderly event and undertaken by participation of a number of fungi.

Rishbeth and Meredith (1957) indicated that forest tree canopy (phylloplane) could act as a large reservoir of spores and there is evidence that the microbes present may also be important as leaf pathogens. Despite many investigations on other plant species, comparatively little was known of the species composition and microbial population on the phylloplane of conifers. Ward (1952) isolated microfungi from decomposing pine leaf litter. Mc Bride (1969), Collins (1974) and Foster (1974) examined the phylloplane microflora of *Pseudotsuga menziessii*, *Picea abies* and *P. sitchensis* respectively. Kendrick and Burges (1962), Hayes (1965) and Macauley and Thrower (1966) have shown that the microorganisms present on leaves at senescence are important in determining the subsequent pattern of decomposition. Mc Bride and Hayes (1977) undertook a study on European larch (*Larix decidua*) to compare the

development of bacterial, yeast and filamentous fungal populations on leaves of increasing age.

Previous similar studies have found out that the composition of decomposer community is largely dependent on concentration of particular nutrients in the ecosystem. Garrett (1963) suggested that fungal successions are autogenic processes in which the sequential appearance of taxa is determined by the depletion of available carbon. More recent workers (Swift, 1976; Frankland, 1981) have challenged this and suggested that a variety of physical and chemical changes occur as decay proceeded which in turn influenced the composition of the fungal community. Gessner (1977) and Tubaki and Yokoyama (1971, 1973) have independently proposed that fungal successions are seasonal, i.e. changes in climatic conditions are the primary factors determining the successive appearance and disappearance of taxa.

The importance of seasonal conditions on appearance and disappearance of fungi was examined by Smith et al. (1969) and Sudha (1978) by placing litter bags containing undecayed leaf litter in the woods at various times of the year. They observed that if seasonal conditions are the primary determinants of the fungal populations recovered from the litter then the populations obtained from the leaves collected in any given month of the year should be similar regardless of when decay was initiated. On the other hand, if succession is an autogenic process, changes in the composition of fungal communities should follow a consistent pattern that could be associated with the degree of litter decay. Changes in species diversity associated with the progressive decay of the leaf litter showed a consistent pattern from year to year. The composition of the fungal populations changed gradually as the leaves decayed. As the decay progressed, a variety of species was encountered. Although these taxa rarely accounted for more than 5% of

the sample population at the time they were first isolated, they often increased in relative abundance with progressive decay of the litter.

The increase in species diversity associated with the seasonal changes coincided with observable changes in the contents of the litter bags. The leaves became highly fragmented. Seasonal conditions had an impact on the composition of fungal populations colonizing the sterilized leaves. The C : N ratio was altered in infected leaves and changes in the carbohydrates of infected tissues occurred. No single fungal species was able to use all the components and it is now well established that succession of fungi occurs on the substrate (Dix and Webster, 1995).

2.1.7. Succession of fungi on leaf litter

Garrett (1951, 1963) pointed out that whereas a succession of higher plants in a climax community tends to improve the habitat, a succession of heterotrophic microrganisms causes progressive deterioration in the capacity of the substrate to support further growth, because the substrate is finite and exhaustible. He distinguished four distinct stages in the succession. (i) A group of early colonizers, comprising the transient fungi present on the leaf surface, only as deattachable propagules, which have germinated in the moist conditions. (ii) Fungi growing and sporulating actively throughout the decay process. (iii) A group found early in the decay process but disappeared later. (iv) A group of later colonizers uncommon early in the decay process.

Frankland (1992, 1998) defined succession of fungi on leaf litter as a directional change in the composition, relative abundance and spatial pattern of species comprising communities. Fungi replace one another as their dynamic communities of mycelia alter in space and time, as each species is adapted for occupation of particular niches.

2.1.8. Process of litter decomposition:

The decomposition of plant litter is one of the most crucial stages in the biogeochemical cycle of forest ecosystems. The decomposition rate determines the rate at which nutrients become available for renewed uptake by plants and thereby plays an important role in determining ecosystem productivity. The rate of litter decomposition is a major determinant of biomass and nutrient content of the forest floor and thereby has a direct influence on the physical and chemical properties of the soil.

Litter decomposition is regulated by numerous factors, of which the most important are (i) the environment under which the decay takes place and (ii) the physicochemical properties of the substrate. Both the chemical composition of the substrate and the effect of confinement are important in determining decomposition rates. When climate and site factors such as soil type are constant, decomposition rates are regulated primarily by the chemical composition and physical structure of the litter, features often termed as substrate quality (Swift et al., 1979).

Tukey (1971) recognized that the increased flow of nutrients onto the surface of older leaves appears to be due to two factors, (i) the cessation of growth with reduced metabolic demand for ions and molecules and (ii) the onset of senescence with ultimate disorganization of organelle function. Litter decomposition has basic implications, both for the cycling of carbon and nitrogen, and for the supply of macro and micronutrient elements to green plants (Berg and Staff, 1980; Berg and Ekbohm, 1983; Mc Claugherty and Berg 1987; Taylor et al., 1989). Studies conducted by others have shown that the phosphorus content and the C : P ratio may be the determinant factors (Schlesinger and Hasey, 1981; Staff and Berg, 1982). Researches have demonstrated the role of water-soluble substances present in the litter (Berg and Tamm, 1991; Berg and

Ekbohm, 1991), the influence of the lignin in litter decomposition processes in the start (Fogel and Cromack, 1977; Meentemeyer, 1978; Berendse et al., 1987; Berg and Tamm, 1991), the lignin plus cellulose (Aber et al. 1990) and of the lignin to nitrogen ratio (Aber and Melillo, 1980; Melillo et al., 1982). Gallardo and Merino (1993) found out that leaves of *Butea monosperma* decomposed rapidly (possessing higher ash and nitrogen, but lower C:N and lignin content) whereas the leaves of *Disopyros melanoxylon* decomposed slowly (lower ash and nitrogen, but higher C:N and lignin content)

When substrata containing adequate supplies of available nutrients and respirable substrates become available for colonization, fungi colonise the substrate rapidly. This has been called the flare-up phase of colonization and during this phase, early establishment and rapid growth by some species occurs which competitively excludes others. At the end of this phase when soluble carbohydrates and nutrients have become seriously depleted, intense competition arises for any remaining supplies. This caused a shift in favour of populations that can successfully scavenge for nutrients and utilize the cellulose and lignin for energy supplies. These fungi are known to flourish and by competitive antagonisms eliminate those that cannot compete due to nutritional stress (Park, 1976a).

Although fungi grow over a range of C : N ratios, they have optima for maximum growth and metabolic activity. As nitrogen supplies become depleted, the competitiveness of certain species change (Park, 1976 b,c). When nitrogen level falls, spore germination is inhibited by competition for nitrogen uptake (Blakeman and Brodie, 1976). Because litter accumulates exogenous nitrogen during decay, the initial nitrogen content or the ratio of C : N is often considered to be critical to decomposition

(Anderson, 1973, Edmonds, 1980, Hunt et al., 1988).

Bocock (1964) and Gosz et al. (1973) observed an increase in N concentration over the time in conifer needle litter and attributed this to microbial retention of N while carbon being respired. Increases in N mass reflected inputs of N by precipitation, N fixing, addition by leaching from new litter and translocation by fungi. Similar increases in N concentration during decomposition have been noted in oak, hazel and elm litter (Lousier and Parkinson, 1978).

Sharma (1973) followed the succession of fungi on shoots of the grass *Setaria glauca* Beauv., beginning with their early senescence until they fell to the ground and found that successive groups of sporulating fungi on tropical monocots are more than those on temperate monocots. The high proportion of fungi found exclusively in tropical latitudes was probably the outcome of evolution in a habitat favourable to dematiceous fungi living on leaves, branches and trunks of forest trees (Hudson, 1968).

2.1.9. Effects on different factors:

Effect of different concentrations of mercuric chloride on the qualitative and quantitative nature of mycoflora of soil was studied by Rai and Tiwari (1975). The fungal populations and the number of species decreased in all the samplings at various concentrations of the chemical due its prolonged inhibitory effect.

2.1.10. Diversity of fungi:

How many species of fungi are likely to be found on a single tree? While rallying around the magic figure of 1.5 million, Hawksworth (1991, 1997) observed that the number of fungi estimated would have been greater if every fungus found on tree litter

had been identified and documented. Fisher et al. (1984a) and Dreyfuss (1986, 1989), suggested that intensive studies on isolation and documentation of fungi that might produce metabolites of usage as therapeutic, food, colourant and other industrial agents from woody and perennial herbaceous plants especially from tropical belt might increase the knowledge on diversity of fungi on earth surface.

2.1.11. Work on litter fungi in India:

Substantial researches have been done on the biology of litter fungi in India. Sharma and Divedi (1972) recorded mycoflora colonising different portions of shoot system of fodder grass, *Setaria glauca,* from early senescence onwards. Rai (1973) studied succession of fungi on decaying leaves of *Saccharum munja* and suggested a general scheme for decaying grasses of the tropics. All grasses that had been studied commonly showed presence of dominant members, though they differed in the frequency of occurrence on different substrates. He observed that deuteromycetes and a few ascomycetes were the major colonisers of grasses.

Yadav (1966) recognised five groups of fungi based on the frequency of their occurrence on decaying stems of *Heracleum sphondylium.* He concluded that the primary mycoflora, which appeared on the stem in the year of their growth were possibly deposited by wind. The secondary mycoflora which appeared in the winter, characteristic of lower internodes, probably arrived from the soil and gradually spread upwards. His findings were similar to those reported on *Dactylis* by Webster (1957). Sharma and Mukerji (1972) reported the results of taxo-ecological investigations on the mycoflora of leaves of *Gossypium hirsutum* at different stages of senescence, while still attached to the mother plant and after abscission.

Vittal (1973) made a detailed study of the fungi colonising leaves and litter of *Atlantia monophylla* and *Gymnosporia emarginata* collected from Madras, over a two year period and observed that the number of fungi recorded were greater on *Atlantia* than on *Gymnosporia*. Deuteromycetes were the dominant members on both the plants; in addition, myxomycetes, phycomycetes and ascomycetes were also observed on *Atlantia*. A number of fungal species were common to both the plants although the frequency and percentage occurrence differed for both plant litter types. He also compared the fungi isolated on *Atlantia* and *Gymnosporia* litter collected from different localities and highlighted the qualitative similarity in the mycoflora of litter of both plants. He further observed that a sizeable number of species of fungi found on the phylloplane of *Atlantia* and *Gymnosporia* were similar to the prevailing air mycoflora.

Sudha (1978) studied the litter decomposition of *Glycosmis cochinchinensis* and *Ixora parviflora.*. In her results, similarity indices of the mycoflora of litter of the 2 plant species from the different layers of experimental set up showed that mycoflora on litter from adjacent layers had the greatest similarity, the similarity decreasing with increasing distance of the layers. On the basis of the frequency and the colonising efficiency of the different species, she proposed that for both plant species, the first colonisers on litter were predominantly a few weak parasites on living or senescent leaves, followed in succession by true litter fungi which were replaced in the final stages of decomposition by soil inhabiting fungi.

Dorai (1988), worked on the taxonomic and ecological aspects of the fungi colonising the leaf litter of *Eucalyptus* species in India. The examination of the leaf litter of 13 species of *Eucalyptus* resulted in the isolation of a vast number of species of fungi belonging to Deuteromycetes, Myxomycetes, Zygomycetes, Ascomycetes and

Basidiomycetes. He observed both host specific and non-specific species of fungi in the litter. Comparing the microfungi from studies of Vittal (1973) and Sudha (1978), Dorai (1988) listed several fungi common to all plants. He concluded that the similarity in the mycoflora associated with leaf litter of plants belonging to unrelated but growing in the same locality suggests that while the nature of substrate is an important factor, the geographical location of the sampling area and its biogeoclimate also plays a major role in deciding the nature of the mycoflora of that particular area.

Bhat and Kaveriappa (1998) studied the phylloplane and surface mycoflora of aerial parts of *Myristica fatua* var. *magnifica* and *M. malabarica*, in the forests of Western Ghats in Karnataka State. They found that maximum number of fungal species were recorded on mature leaves and shoot buds during summer months, while minimum number of species were recorded during rainy season.

2.2. Fungi as endophytes:

The inconspicuous presence of fungi within healthy trees and shrubs was suspected by the earliest tree pathologists. Ecologists understanding that a plant out in the field is not simply a plant but rather a merger of fungal cells with plant tissues: from endophytic fungi in the stems and leaves to saprophytic forms on litter and mycorrhizal fungi in the roots - was reviewed by Wilson (1993). Endophytic fungi have a number of distinguishing properties amongst which the unique ability is to colonize the interior of plant tissues without causing obvious disease symptoms (Carroll, 1988, 1986). They are believed to occupy a unique ecological niche and have major influences on plant's good health, physiology, biochemistry, ecology and distribution, Communities of endophytic fungi are known to contribute significantly to the biological diversity in forest ecosystem (Bills, 1996).

2.2.1. Definition:

De Bary in 1866 first coined the term endophyte for all those organisms that colonize internal plant tissues, distinct from the epiphytes that live on plant surfaces. Carroll (1986) restricted the use of the term endophyte to organisms that cause asymptomatic infections within plant tissues, excluding pathogenic fungi and mutualists such as mycorrhizal fungi. Petrini (1991) proposed an expansion to Carroll's definition to include all organisms inhabiting plant organs that at sometime in their life, can colonize internal plant tissues without causing apparent harm to their host. He incorporated latent pathogens within the plant tissues. Wilson (1995) recently expanded the definition for endophytes as 'fungi or bacteria which, for all or part of their life cycle invade the tissue of living plants by asymptomatic infection and cause no symptoms of disease'.

2.2.2. Occurrence:

All plant species so far surveyed have shown presence of endophytic fungi. (Petrini, 1986), though they differed in frequency among organs or even parts of organs (Fisher and Petrini, 1992: Rodrigues, 1994; Carroll, 1995). In terrestrial plant organs, even environmental differences had influenced differences in endophyte flora (Fisher et al., 1991). For example, roots of *Alnus* in soil were shown to have different endophytes from those in water (Fisher et al., 1991). The presence of endophytic bacteria in healthy plant tissues has also been demonstrated in many plants (Fisher et al., 1992).

2.2.3. Taxonomy:

Growth of hyphae outwardly from internal tissue of rigorously surface-sterilized

plant organs generally is considered evidence that the fungi are endophytic (Petrini et al., 1991). Endophytic fungi are taxonomically a heterogeneous group, mainly belonging to Ascomycotina and Deuteromycotina. Within the ascomycetes, they belonged to Loculoascomycetes, Discomycetes, and Pyrenomycetes (Petrini, 1986). Endophytes in woody plants are more diverse than grasses in terms of genera and species (Petrini et al. 1992 a,b). Vast literature is available on taxonomy, distribution and possible function have of endophytes (Butin, 1986, Carroll, 1986; Clay, 1986; Petrini, 1986; Bills, 1995).

2.2.4. Substrate for endophytes:

Endophyte associations in aerial plant organs range from intimate contact where the fungus inhabits the intercellular spaces and xylem vessels in the plant, to more or less superficial colonization of peripheral, often dying or dead tissues such as bark layers in plants with secondary growth (Petrini, 1986; Sieber, 1989; Petrini and Fisher, 1987; Fisher and Petrini, 1990).

Latent fungal infections have been reported in grasses (Bacon et al., 1977; Clay, 1988), shrubs (Petrini et al., 1982) and evergreen trees (Carroll and Carroll, 1978; Katz and Leith, 1980) and it has now been realized that endophytic fungi are likely to be found within any host plant investigated. They have been isolated from a variety of evergreen tree species situated in a number of geographical locations. (Carroll and Carroll, 1978; Suske and Acker, 1987; Sieber-Canavasi and Sieber, 1988, Johnson and Whitney, 1989 a,b, 1992; Rollinger and Langenhein, 1993; Sieber-Canavesi and Sieber, 1993). Other studies on deciduous species have focused on endophytes from bark (Bills and Polishook, 1991), xylem (Fisher and Petrini, 1990), whole stem (Petrini and Fisher 1988) and shoots (Schnell et al., 1985).

Such endophytes have now been reported from a diverse group of plants, mostly with evergreen leaves (Carroll and Carroll, 1978; Petrini and Carroll, 1981; Petrini and Dreyfuss, 1981, Petrini et al., 1982., Fisher et al., 1984), from marine algae (Cubit, 1974), mosses and ferns (Petrini, 1986), cool-season grass hosts (Clay, 1991), coniferous trees (Berntsein and Carroll, 1977; Carroll and Carroll, 1978; Sieber, 1988; Wilson and Carroll, 1994), tropical trees, palms and monocots (Bills 1996; Rodrigues 1994; Rodrigues and Samuels, 1990) and tropical grasses (Suryanarayan et al 1998). Infections by endophytes of woody plants are said to be highly localized within leaves, petioles, bark or stems (Petrini et al., 1992; Carroll, 1988, 1991 a,b; Faeth and Wilson, 1996).

2.2.5. Distribution:

Endophytes of grasses and woody plants are thought to have evolved from parasitic or pathogenic fungi (Carroll, 1991, 1992). They are ubiquitous in a given host over a wide geographical range and have been isolated from a range of evergreen, deciduous and coniferous plants (Carroll et al., 1977; Cabral, 1985; Fisher and Petrini, 1987; Petrini and Fisher, 1987, 1988; Bertoni and Cabral, 1988). This effort has resulted with substantial increase in the total number of species now known. Fisher et al. (1994) confirmed that, within a given geographical range, endophyte colonization is more dependent on the availability of innoculum and position of the plant tissue than on the geographical location of the samples.

2.2.6. Dissemination:

Endophytes get transmitted from one generation to the next through the tissue of host seed or vegetative propagules (Bills, 1996). Except in the grasses, most endophytes

appear to be transmitted horizontally, external to host tissues, by spores, but in grass endophytes transmission from one generation to another occurs vertically through occupation of host seed tissue by hyphae. Such permanent association, involving perpetuation through the seed and the available fungal biomass in the host tissue has been termed constitutive mutualism (Carroll, 1988). Many non-systemic endophytes in woody plants are transmitted horizontally by asexual spores through seeds (Petrini et al., 1992). However, the frequency of asexual and sexual reproduction of endophyte fungi has not been extensively studied in woody plants.

2.2.7. Effect of different factors:

In the understanding of infection levels of endophytic fungi among trees growing in ecologically diverse sites, precipitation (rain, dew or fog) appears as an important factor responsible for endophyte infection frequencies. In a recent study of a tropical palm, *Euterpe oleracea*, Rodrigues (1994) found that the leaves were more highly infected when collected during the wet season than the dry season. Such effects probably resulted from higher relative humidity and higher incidence of propagules from within or beneath a canopy. A number of factors such as age of the plant, location and wetness of the site, and season have been shown to affect the distribution and species diversity of fungal endophytes (Petrini, 1991). According to Petrini et al. (1992), the occurrence and distribution of endophytic species are not only host specific but also site dependent.

Study conducted by Sieber et al. (1991 a,b) on assemblages of endophytic fungi in *Acer macrophyllum* in British Columbia indicated that the habit of an endophyte is controlled not only by its genotype but also by external factors such as health and age of the host plant. Stone (1987) has shown that newly emerged needles do not get infected

until the rains. Factors such as seasonal changes, collection site, age of the host plant and foliage have been reported to influence the species composition and frequency of the endophyte assemblage.

Differences in number of isolates and colonization rates were observed between two localities where sites with more moisture supported higher colonization rates (Carroll and Carroll, 1978; Petrini and Carroll, 1981; Petrini et al., 1982). In a preliminary study of endophytic fungi in *Ulex* spp., Fisher et al (1986) recorded endophytes isolated from *U. europaeus* and *U. gallii* and found a positive correlation between the age of the plant and number of endophytic fungi colonizing the tissues. Reports also have indicate that endophytic species can be affected by season (Petrini, 1991) suggesting that surveys of endophytic fungal communities at different seasons of the year might favour a higher recovery of particular species.

2.2.8. Ecological role:

The endophytic fungi may live as dormant saprobes (Chapela and Boddy, 1988), latent pathogens (Verhoeff, 1974; Carroll, 1986), antagonizing plant enemies (Clay et al., 1985; Latch et al., 1985; Bacon et al., 1986) or stimulating host growth and competitive ability (Bose, 1956; Bradshaw, 1959; Clay, 1986,1989). Although the role played by individual endophytes is said to be interesting, the importance of entire endophytic communities for plant ecology has not been assessed yet.

In the past 15 years, a series of investigations have been carried out on elucidation of internal mycota of living plant tissues and its functions. Endophytic fungi are now recognized as important mediators of interactions between plants and their competitors, seed dispersers, herbivores and pathogens (Petrini, 1991). Although plant

and fungal metabolites are believed to play a definitive role in their interactions, little is known about the role of the biologically active secondary metabolites that endophytes synthesize (Dreyfuss and Chapela, 1994; Schulz et al., 1995) and offer for endophyte-host interactions. The production of substances inhibitory to fungus pathogens of grasses by endophytes (White and Cole, 1985) suggested possible increase in disease resistance by plants.

2.2.9. Insect antagonism:

Enhancement of plant defense by endophytic fungi against insect pests was suggested by Carroll (1986, 1988). *Discula quercina* was found inside the galls of several species of leaf-galling cynipid wasps and shown to be the causative agent of gall mortality (Wilson, 1992). It was postulated that to improve their fitness in a given environment, plants might have acquired/accommodated the endophytes (Clay, 1991). Grasses infected with *Acremonium* endophytes contain several alkaloids which are implicated in disorders of grazing animals (Siegel et al., 1987).

There is a growing interest in the potential use of Clavicipitaceous endophytes infecting grasses in pest control and biotechnology. These fungi which are systemic and often seed-transmitted, are widely distributed in many grass genera and tribes (White, 1987; Clay, 1990). In some grasses endophyte infections have induced increased resistance to feeding by particular insects (Funk et al., 1983; Clay, 1989) and increased drought tolerance (West et al., 1990). In the temperate regions, endophytic fungi are found to play a protective role against insect herbivory not only in grasses but also in conifers (Carroll, 1991).

2.2.10. Mutualism:

Endophytes are considered as protective mutualists acting against herbivorous insects and pathogenic fungi. They receive nutrition and protection from the host plant while the host plant may benefit from enhanced competitive abilities and increased resistance to herbivores pathogens and various biotic stresses (Saikkonen et al., 1998). Discovery of severe biological effects of endophytes of grasses on livestock, such as toxicosis and hoof gangrene by Clay (1988, 1990) and on invertebrate pest species by Bultmann and Murphy (1998) led to the concept that grass endophytes may be plant mutualists, primarily for deterring herbivores, as 'acquired defenses'. In turn, host plants provide endophytic fungi with a protective refuge, nutrients and dissemination channel to the next generation of hosts.

Carroll (1988) proposed that endophytes of woody plants provide a defensive role for the host plant because they elaborate a wide array of mycotoxins and enzymes that inhibit growth of microbes and invertebrate herbivores. Because of endophytes of woody plants are diverse and have a shorter life cycles than their perennial host plants, defense via endophytes is considered as a mechanism by which long-lived woody plants could keep pace evolutionarily with shorter generationals (Carroll, 1991; Petrini et al., 1992; Stone and Petrini, 1997).

2.2.11. As latent pathogens:

Endophytes often reside within the plant tissue for most of their life cycle and manifest as host symptoms are triggered by appropriate ecological or physiological stimuli (Leslie et al., 1990; Petrini, 1991). The presence of latent pathogens as endophytes in apparently healthy plants has been reported (Carroll, 1988). An example

of latent pathogenecity is *Fusarium monoliforme* which causes serious disease of maize but can also be isolated from most healthy maize plants (Leslie et al., 1990)

2.2.12. As saprophytes:

Endophytic infections are often quiescent; they inhabit the host without causing obvious damage, but colonize other areas quickly when host tissue becomes damaged or senescent. The presence of some of the more common endophytes of healthy beech and oak twig bark in the decaying woody tissue of dead attached twigs indicated that these particular endophytes have a saprotrophic capacity (Chapela and Boddy, 1988). Griffith and Boddy (1990) reported that the endophytes that are able to colonize and decompose dead host tissues are at a positional advantage over other saprotrophic wood decay species and able to utilize the resource before the arrival of secondary colonizers which may be more combative.

2.2.13. Role in leaf senescence:

There is evidence that saprophytic phylloplane fungi may influence the development of pathogens and accelerate the process of leaf senescence (Dickinson and Preece, 1976). Leaf senescence is a programmed developmental process preceding tissue death during which photosynthetic activity stops and many leaf constituents are broken down and retrieved. This process is followed by leaf abscission, colonization and decomposition by saprophytic fungi. Because endophytic fungi are present in healthy leaves of many plants before senescence, they are considered to be the first to capitalizers on senescing and abscised leaves and therefore the first species in the succession of decomposing fungi. Production of enzymes which degrade plant cell wall

constituents such as pectin and cellulose is widespread amongst endophytes (Petrini et al., 1992a,b). The role of endophytic fungi in decomposition is probably limited to utilizing low molecular weight carbohydrates before being succeeded by saprophytic fungi which are stronger competitors (Carroll and Petrini, 1983).

2.2.14. Tissue specificity:

Certain endophytes apparently specialize on particular host plants, have a rather reduced host range and in some cases even get restricted to a single plant species (Carroll and Carroll, 1978; Bacon et al., 1986; Sherwood-Pike et al., 1986) whereas others are widespread and can be considered as generalists (Petrini, 1986). A large number of endophytes can be isolated from a single plant species, but only few fungal taxa are dominant in each host and can be considered specific. In a study on endophytic fungi of twigs of *Pinus sylvestris* and *Fagus sylvatica* growing at the same site, distinct fungal communities colonizing the two hosts have been observed (Petrini and Fisher, 1988).

Most endophytic species are however less host specific and confined to broader taxonomic groupings of hosts. For example, *Phyllosticta vaccinii* Ealer, *Physalospora arctostaphili* B. Erikss and *Pleospora herbarum* (Fr.) Rabenh. are common endophytes in a variety of ericaceous hosts, both in U.S.A. and Western Europe (Petrini et al., 1990) whereas *Phomopsis occulta* Trav. is a common endophyte in a wide variety of coniferous hosts and *Fagus sylvatica* (Carroll and Carroll, 1978). A few endophytic species are host-neutral including *Epicoccum nigrum* Link and *Aureobasidium pullulans* (de Bary) Arnaud (Petrini and Fisher, 1988). *Rhabdocline parkeri* is a fungal endophyte which causes latent infections in the needles of Douglas-fir (Sherwood-Pike et al., 1986)

and has been found inhabiting nearly every tree in which it has been sought in Western Oregon and Washington (Carroll and Carroll, 1978).

2.2.15. Specific organ specificity:

Many endophytic species are not only restricted to certain hosts but also to specific tissues within them. Organ specificity by endophytic fungi was first demonstrated for wheat endophytes by Sieber (1985). In the conifer *Pinus nigra*, *Lophodermium pinastri* (Schrad: Fr.) Chev. is confined to needles and *Geniculosporium serpens* Chesters & Greenhalgh to petioles (Carroll et al., 1977). Aquatic and soil root samples of *Alnus glutinosa* are colonized by two different endophytic populations (Fisher et al., 1991).

2.2.16. Significance of host specificity:

Carroll et al. (1977) first postulated tissue specificity by endophytes because many of the fungi isolated from the petiole of European conifers were restricted to that part only and rarely detected in more distal portions of the needle. Petrini and Muller (1979) and Stone (1986) showed that *Rhabdocline parkeri* and *Phyllosticta* sp. co-exist in needles of *Pseudotsuga menziesii*, with *R. parkeri* confined to epidermal and hypodermal cells whereas *Phyllosticta* sp. occurring intercellular in the mesophyll. Subsequent investigations (Bertoni and Cabral, 1988; Fisher and Petrini, 1990) confirmed that many endophytic fungi show certain degree of tissue specificity.

2.2.17. Secondary metabolites:

Endophytic fungi are increasingly recognized as a group of organisms that are

likely to provide potential sources for new secondary metabolites useful in biotechnology and agriculture (Bills and Polishook, 1992). The search for novel habitats from which isolates for screening is becoming a thrust area for pharmaceutical and agricultural industries (Bills and Polishook 1994). Given the large number of endophytic species to be expected from each host and diverse flora present especially in the tropical regions, it is reasonable to expect a large number of interesting metabolites to be isolated from tropical endophytes (Bills, 1995).

2.2.18. Production of enzymes:

Endophytes of coniferous foliage with an ability to utilise complex substrates including cellulose, hemicelluloses, lipids and pectin, and that petiolar endophytes could utilise a wider range of substrates than needle fungi, suggest that the latter are dependent upon the host for simple carbon sources whereas the former are more active decomposers (Carroll and Petrini, 1983). Endophytes usually produce the enzymes necessary for the colonization of plant tissues. Substrate utilization studies and isozyme analysis have demonstrated that most endophytes are able to utilize plant cell components. The production of growth promoting factors and of metabolites useful in the pharmaceutical and agricultural industry is known among the endophytic fungi (Hankin and Anagnostakis, 1975).

2.2.19. Production of bioactive compounds:

Endophytic fungi are known to produce bioactive compounds such as antibiotics (Fisher et al., 1984 a,b) and plant growth stimulating substances (Petrini, 1991). Dreyfuss (1986) described penicillin N activity in an endophytic isolate of

Pleurophomopsis and sporiofungin A, B, and C in an endophytic *Cryptosporiopsis* sp. isolated from *Cardamine heptaphylla* as well as in a sterile endophyte derived from *Abies alba*. The production of taxol from *Pestalotiopsis microspora*, an endophytic fungus of *Taxus wallachiana* (Young et al., 1996) is known. Dreyfuss (1989) reported the production of a new family of cytochalasines in endophytic *Xylaria* spp. from South America and Mexico.

2.2.20. Antimicrobial activity:

Fisher et al. (1984a) have reported antibacterial and antifungal activity for more than 30% of the endophytic isolates from ericaceous plants they tested in a small-scale screening. Fisher et al. (1984b) have described broad spectrum antibiotic activity in species of *Crytosporiopsis*, *Coniothyrium* and *Microsphaeropsis*, isolated as endophytes from *Vaccinium myrtillus*. Studies by Tscherter and Dreyfuss (1982) and Nobel et al. (1991) confirmed that endophytic strains of *Crytosporiopsis* are producers of secondary metabolites with broad spectrum antifungal activity. *Acremonium* spp. and *Epichloe typhina* isolates grown in culture have been reported to have antifungal activity (Siegel and Latch, 1991).

2.2.21. As biocontrol agents:

Dewan and Sivasithamparam (1989) reported a sterile red fungus isolated from wheat roots providing protection to the host from infection by *Gaeumannomyces graminis* Arx et Oliver var. *tritici* Walker. Cytotoxicity and insecticidal activity of endophytic fungi from black spruce needles have been worked out by Johnson and Whitney (1994). *Rhabdocline parkeri*, an endophyte of Douglas-fir needles, has been

found to significantly increase the mortality of the gall midge *Contarinia* spp. (Sherwood-Pike et al., 1986). Endophyte toxins have been thought of as a probable cause of herbivore antagonism and a number of toxins have been isolated and described from endophytic fungi in trees (Bills, 1996). Many plant secondary metabolites have structural and qualitative similarities with endophytic allelochemicals (Wilson, 1993).

2.2.22. Presence in temperate forests:

Endophytic fungi from conifer needles have been reported from the northwest of the United States (Bernstein and Carroll, 1977a,b; Carroll and Carroll, 1978; Sherwood et al., 1986), Europe (Carroll et al, 1977; Suske and Acker, 1987) and Canada (Johnson and Whitney, 1989 a,b). Differences in endophytic flora of needles from different locations in the North America have been reported from the west-coast (Carroll and Carroll, 1978; Petrini and Carroll, 1981)

Fungal endophytes were isolated from roots and leaves of epiphytic and lithophytic orchids in the genus *Lepanthus* (Bayman et al., 1997). Petrini (1991) observed that the composition of endophytic community of Arizona fescue parallels with patterns of endophyte communities in woody plants.

Aerial plant organs of conifer needles and ericaceous plants were scanned extensively for endophytic fungi. (Carroll and Carroll, 1978; Petrini, 1984; Barklund, 1987). They observed fungal colonization of living, healthy tissues to the tune of 30-80% of sampled organs. Fungi isolated included species that protect the trees against herbivory (Carroll, 1986), that are closely related to pathogens of host tree (Minter and Millar, 1980; Sherwood-Pike et al., 1986), or some of those important pathogens themselves (Butin, 1986; Carroll, 1988). These observations now have relevance in the

eventual manipulation of endophytes as biocontrol agents, sources of antibiotics and other utilization of commercial significance.

2.2.23. Presence in tropics:

Most work on endophytic fungi have been on coniferous and angiosperms from the temperate regions and only recently that researches on endophytic mycobiota of tropical forests have been initiated (Bills, 1996). Riunen (1961) observed that evergreen tree leaves in the tropics supported dense fungal communities. A few studies have documented endophytes in the tropics. Petrini and Dreyfuss (1981, 1984) isolated fungal endophytes of Araceae, Bromeliaceae and Orchidaceae from French Guyana, and from Piperaceae and Crassulaceae in Brazil and Columbia.

Fungal endophytes of leaves of palm *Licuala ramsayi* (Muell.) Domin. from tropical rain forests in Australia and *Euterpe oleraceae* Mart. from Amazonian river-island, Brazil, have been documented (Rodrigues, 1993; Rodrigues and Samuels, 1990, 1992, 1994). They found that endophytic fungi spread via a single infection throughout the plant, possibly originating in the seed.

2.2.24. Number and diversity of endophytes:

Endophytic fungi isolated from a given host are usually many but only 4 to 5 species generally are likely to be host-specific. No host so far has been reported to be endophyte free (Rodrigues and Samuels, 1990, 1992). Undetermined taxa of endophytic fungi are frequently isolated from almost all plant species (Fisher and Petrini, 1988; Rodrigues, 1994). Investigations of species composition of fungal endophyte communities in woody plants have shown that a large number of species can be

recovered from a single host species (Petrini, 1991). Considering the vast number of vascular plant taxa present in tropical regions, it is predicted that future surveys on endophytes will yield a large number of new taxa. Dreyfuss and Chapela (1994) have estimated that the endophyte species awaiting discovery may well be over 1.3 million.

2.3. A recent work from this laboratory:

A modest effort was done on similar line of study in this laboratory by Miriam (2000). Diversity, ecological association and activity of the saprophytic fungi associated with leaf litter and live leaves of *Ficus benghalensis* and *Carissa congesta* were investigated for a two year period. The litter fungi were recovered using particle plating and moist-chamber incubation techniques whereas the endophytes were isolated using 3-step isolation method. The immediate neighbourhood of these plants were also scanned for fungi. Pure cultures of 60 species of fungi were subjected to amylase, cellulase, protease, pectinase, ligninase, laccase and xylanase enzyme assays.

Different techniques used in the study helped her to recover maximum number of species of fungi. Of these, 22 species and 5 genera were new to science. The results showed that on the whole maximum percentage of isolates exhibited protease activity, followed by laccase, pectinase, ligninase, amylase, xylanase and the least were with cellulase activity. Of the 60 isolates subjected to enzyme assay, 29 showed positive activity only against lignin. Miriam's study showed that in an effort such as this not only a wealth of information would get generated but also a huge collection of pure cultures of fungi with proper taxonomic database get accumulated.

2.4. The future:

Dreyfuss and Chapela (1992) described endophytes as an untrapped pool of producers of secondary metabolites. Continuos investigation of physiology and biochemistry of these organisms will probably lead to the discovery of a vast array of novel chemical substances that may find applications in most diverse fields of biology and medicine (Bills, 1996).

According to Isaac et al. (1993), available literature may not provide a final statement as to whether tropical forests represent a higher repository of species diversity than temperate forests. Considering the vast array of plant species and the wide range of vegetation types present in the tropics, Campbell and Hammond (1989) postulated that a high diversity of fungal species can be expected from the wild. According to Bills (1996), tropical forests are the 'black box' with respect to our knowledge on diversity and distribution of microfungi and would offer new and exciting opportunities for all interested in fungal ecology, taxonomy and biotechnology. Intensive collaboration is needed between chemists and biologists to understand the biology and the ecology of endophytes. While the chemists may discover new useful compounds or enzymes, the mycologist will have the opportunity to gain more insight in the multifarious diversity of the fungal kingdom.

CHAPTER III

MATERIALS AND METHODS

This investigation on the diversity, seasonal occurrence and activity of litter and endophytic microfungi associated with several plant species of the Western Ghat forests in Goa region, was carried out for a period of over two years from February 1999 to June 2001. In this Chapter, the materials used and methods followed in the study are elaborated.

3.1. Sampling sites:

Two kinds of sampling were made for this investigation. In the first category, aimed at documentation of fungal diversity of the region, specimens of several widely distributed native monocot and dicot plant species were randomly gathered from forests of places such as Alorna, Baga, Bondla, Chorlem, Cotigao, Molem, Taleigao and Tambdisurla of Goa State. In the second, aimed at elucidation of seasonal occurrence of fungi, samples of four predetermined plants were gathered from two defined localities, Bondla and Molem, at regular seasonal intervals, over a period of two years. The sampling locations are indicated in Fig. 3.1.

The two sites of seasonal study are well recognized wildlife sanctuaries stretched along the Western Ghats in Goa State. The Bondla Wildlife Sanctuary, an area of 8 sq. km and smaller of the two, is located about 55 km north-east of Goa University campus. The vegetation in the region is largely moist deciduous with small patches of evergreen trees covered by stranglers, lianas and canes. The Molem Wildlife Sanctuary, about 240 sq. km area along the eastern side of the State, is the largest sanctuary in Goa. The vegetation ranged from moist-deciduous and semi-evergreen to evergreen type. At several places in the sanctuary one would notice good understorey cover of shrubs.

Being in the tropical belt and proximity of the west coast, ambient temperature of

the collection sites in the Western Ghats in Goa State always ranged between 22-35°C, the temperature seldom falling below 16°C. Mean annual rainfall along the ghats was 220-300 cm and humidity ranged between 60-90%.

The vegetation of various sites where sampling was done included the following common plant species.

(i) Tree species: *Abrus precatorius* Linn., *Alstonia scholaris* (Linn.) R.Br., *Artocarpus hirsutus* Lam., *Calophyllum elatum* Beddome, *C. inophyllum* Linn., *Carallia brachiata* (Lour.) Merril, *Careya arborea* Roxb., *Cinnamomum zeylanicum* Bl. Bijdr., *Costus speciosus* (Koenig) Smith, *Dalbergia latifolia* Roxb., *Dellenia indica* Linn., *Flacourtia montana* Grah., *Garcinia indica* (Dupetit-Thouars) Choisy, *Hopea ponga* (Dennst.) Mabb., *Hydnocarpus laurifolia* (Dennst.) Sleumer, *Lagerstroemia parviflora* Roxb., *Mangifera indica* Linn., *Mesua ferrea* Linn., *Mimusops elengi* Linn., *Murraya koenigii* (Linn.) Spreng., *Myristica malabarica* Lamk., *Olea dioica* Roxb., *Pongamia pinnata* (Linn.) Pierre, *Pterospermum acerifolium* Willd., *Saraca asoca* (Roxb.) De Wilde., *Sterculia foetida* Linn., *Syzygium cumini* (Linn.) Skeels, *Terminalia bellirica* (Gaertn.) Roxb., *T. crenulata* Roth., *T. paniculata* Roth. and *Xylia xylocarpa* Taub.

(ii) Climbers and lianas: *Entada pursaetha* D.C., and *Gnetum ula* Brongn.

(iii) Shrubs: *Rauvolfia serpentina* (Linn.) Benth. ex Kurz, *Holigarna arnotiana* (Wt. & Arn.) Hook.f., *Strobilanthus* sp. and *Ixora brachiata* Roxb.

(iv) Cane and bamboos: *Calamus thwaitesii*.Becc., *Dendrocalamus strictus* (Roxb.) Nees and *Bambusa arundinacea* (Retz.)Willd.

3.2. Sampling material:

In the present study, several plant species of the region were scanned for litter

inhabiting (epiphytic) and endophytic fungi. The sampling materials included the following:

(a) Senescent or dried leaves fallen to the ground and exposed to a prolonged time of decay. These leaves were generally blackish brown, brittle and sometimes had no interveinal laminar regions,

(b) Dead and decaying, fallen twigs, culms, spathe, etc., and

(c) Intact fresh, green, disease free and healthy leaves.

The leaf litter, twigs and live leaves were sampled out at regular seasonal intervals during the period of study and analyzed for litter and endophytic fungi. The samples were transported to the laboratory in fresh polythene bags and stored in a refrigerator at 4°C until they were processed. Two types of sampling were done during this study.

(i) For taxonomy and diversity study of the litter and endophytic fungi, sampling materials of both dicot and monocot plants were randomly gathered from different sites in the forest. The collection dates and the kind of samples gathered are given in Table 3.1. and 3.2.

(ii) Seasonal studies were carried out during the pre-monsoon, monsoon and post-monsoon season with following native monocot and dicot plant species, one plant each from Bondla and Molem wildlife sanctuaries. The test plants are further described below (C.S.I.R. 1988, 1989; Rao, 1986):

A. Bondla wildlife Sanctuary: Dicot representative: *Saraca asoca* (Roxb.) De Wilde

Monocot plant: *Calamus thwaitesii* Becc.

B. Molem wildlife sanctuary: Dicot representative: *Careya arborea* Roxb.

Monocot plant: *Dendrocalamus strictus* (Roxb.) Nees

A. Bondla wildlife sanctuary:

1. *Saraca asoca* (Roxb.) De Wilde (F. Leguminosae; Sub F. Caesalpinaceae), small evergreen tree of 6-9 m high, found wildly growing along freshwater streams or in the shade of evergreen forests of the Western Ghats (Plate 3.1.) in Goa State. Leaves are paripinnate and with 6-12, oblong, conspicuous leaflets. Flowers are in dense axillary corymbs, orange or orange-yellow in colour and very fragrant. Several medicinal properties of the plant are known; bark of the tree being used against biliousness, dyspepsia, dysentery, colic, piles, ulcers and pimples; leaves are used as blood-purifiers; flowers in haemorrhagic dysentry. Tree wood is light reddish brown in colour and soft in texture.

2. *Calamus thwaitesii* Becc. (F. Arecaceae), is a common cane found growing all along the forests of Western Ghats. The stem is long, usually cylindrical, of uniform thickness, straw-yellow in colour and covered by spiny leaf sheaths (Plate 3..2.). The dried stems are flexible, elastic and strong. These form the common canes or rattan of commerce.

B. Molem wildlife sanctuary:

1. *Careya arborea* Roxb. (F. Lecythidaceae), locally referred as 'kumbo', is a large deciduous tree, 10-20 m high (Plate 3.3.). The timber has a variety of uses including in making of agricultural implements and furniture. The plant has several medicinal properties. Bark is used in coughs and colds and as antipyretic in eruptive fevers. The calyces of the flowers contain mucilage and are used as demulcent. The fruit is edible, aromatic and contains an astringent gum. Decoction of the fruit is given to promote digestion. The leaves are used for ulcers and seed is reported to be poisonous.

2. *Dendrocalamus strictus* Roxb. (F. Poaceae), a tall grass, thrives well in monsoon forests and forms rich belt of vegetation along the Western Ghats (Plate 3.4.). They are characterized by woody pointed stems arising from solid rhizomes. Nearly 30 species of higher fungi are reported on living bamboos. These include *Poria diversipora* Berk.& Br., *Guepinia spathularia* (Schw.)Fr., *Daedalea flavida* Lev., *Polyporus durus* Jungh., *Ipex flavus* Klotzsch, and *Nectria* sp. The bamboo is extensively used in place of timber and frequently houses are made entirely out of the plant. It is sometimes reinforced with cane. Bamboo leaves are much valued as fodder for cattle, horses and elephants. Its stem is the most important raw material for Indian paper industry.

3.3. Sampling intervals:

For seasonal study, specimens such as leaf litter and fallen twigs and fresh and disease free leaves were sampled out in pre-monsoon (February -May), monsoon (June-September) and post-monsoon (October -January) seasons during the two year study period. Sampling dates are given in the Table 3.3.

3.4. Isolation methods:

In the studies of litter and phylloplane fungi, simultaneous use of more than one isolation techniques has been found to be advantageous in the understanding of microbial population (Dickinson and Wallace, 1976). In the present study, two kinds of isolation techniques, namely 'moist chamber incubation' (Hawksworth, 1974) and 'particle-plating' (Bills and Polishook, 1994) methods were used in order to accomplish maximum recovery of fungi associated with the plant substrate. The endophytic fungi were isolated by employing '3- step surface sterilization process' elaborated by Petrini and Fisher (1986).

3.4.1. Moist chamber incubation method:

A thin layer of absorbent cotton super-imposed by a circular piece of blotter paper placed in a petriplate (20 cm diam) and drenched with distilled water served as a moist-chamber. Six micro-slides were placed on the surface of the filter paper (Plate 3.4). The plates were sterilized at 121°C and 15 lbs/cm^3 pressure in an autoclave.

Partially decomposed whole or cut pieces of plant material (leaves, twigs, culms, spathe, etc.) were thoroughly washed in tap water, placed separately in sterile moist chambers and incubated at room temperature (22-25°C). Growth and fructification of fungi were visible after a few days. The moist chambers were examined at 2-day intervals under a stereoscope fitted with an incident light for up to 14 days. Sporulating fungi were isolated using a fine-tipped needle.

3.4.2. Particle-plating method:

Freshly gathered decaying leaves of were transported to the laboratory in separate polythene bags. The leaf litter was washed thoroughly in tap water followed by sterile distilled water and ground into fine particles in an electric blender. The pulverized sample was filtered through two super-imposed metal sieves of mesh size of 250 and 100 μm. The particles trapped in the lower sieve, those between 100 and 250 μm size, were repeatedly washed in sterile distilled water. About 1 g of particles was resuspended in 5 ml sterile water and 0.05ml of the dilution was plated out into 5 petridishes containing malt extract agar (MEA) medium mixed with a mixture of antibiotics. The plates were incubated at 22-25°C. The colony originated from each particle was individually and aseptically transferred into fresh MEA plates cut into sectors of equal size before finally parked in MEA slants. The flow chart of particle-plating method is given below in Fig 3.2.

3.4.3. 3-Step surface sterilization method for endophytic fungi:

A set of five, disease free, fresh young, mature and senescent leaves of test plants were collected in separate polythene bags and transported to the laboratory. The samples were either processed immediately or maintained in a refrigerator at 4°C. The leaves were thoroughly washed in tap water and subjected to a '3- step surface sterilization' process (Petrini and Fisher, 1986).

The leaves were surface-sterilized, first in 70% alcohol for 1 min., second in 4% sodium hypochlorite for 3 min. and, third in 70% ethanol for 30 sec. Each surface-sterilized leaf was thoroughly rinsed in sterile distilled water for at least 5 min., cut into 2-5 mm^2 segments with a sterile razor blade and plated on antibiotic-incorporated 2% MEA plates. The plates were incubated at 22°C for 7-28 days and the fungal colonies emerged from the edges of each segment and extended into the agar medium were transferred separately into fresh culture tubes without antibiotics. The flow chart of 3-step surface sterilization is given below in Fig 3.3. Endophytic fungi of fresh bark and cortex of twigs of the same sample plants were isolated by the same process.

3.5. Observation of Fungi:

The fungal colonies emerging out from the litter particles and leaf or twig segments in the isolation plates were counted as 'colony forming units' (CFU). On the 2nd, 7th, 15th and 21st day of incubation, five colonies each were randomly picked up and aseptically transferred into fresh 2% MEA plates cut into 9 equal segments. After 4-7 days of incubation, growing colonies were compared and dissimilar colonies were individually picked up and transferred into 2% MEA slants (Fig.3.2 and 3.3). Each such isolated distinct fungal colony was considered as a 'morphotype'. The isolates were

grouped into 'sporulating' and 'nonsporulating' forms.

The cultural characters of the fungi in MEA were recorded as stipulated in 'Ainsworth & Bisby's Dictionary of The Fungi' edited by Hawksworth et al. (1995).

3.6. Culture medium for isolation and maintenance of fungi:

Malt extract agar (MEA) medium (composition: dehydrated malt extract 5 g, agar 20 g, distilled water 1 L.: HiMedia Pvt. Ltd, Mumbai) was used to isolate and maintain the fungal cultures during the study. A mixture of antibiotics consisting of bacitracin 0.02 g, neomycin 0.02 g, penicillin G 0.02 g, polymixin 0.02 g, streptomycin 0.02 g and terramycin 0.04 g dissolved in 10 ml of sterile distilled water added to 1 litre of MEA medium was used in all isolation plates.

3.7. Microscopic observations:

Semi-permanent slides of sporulating structures such as sporangiophores and sporangia (Zygomycetes-Mucorales), conidiophores and conidia (Hyphomycetes), pycnidia, conidiogenous cells and conidia (Coelomycetes) and ascocarp, asci and ascospores (Ascomycetes) from the colonies were prepared using water or lactophenol cotton blue as mountant (Hawksworth, 1974). The edges of the coverglass were sealed with nail lacquer. Illustrations of the fungi were made using a camera-lucida drawing tube attached to a binocular microscope (Olympus Make). Photomicrographs were taken using an automatic camera fitted to a bright-field research microscope (Nikon Make).

3.8. Identification:

Sporulating structures were considered as diagnostic characters in the

identification of fungi. Using standard taxonomic keys and monographs, the isolates were identified and assigned to respective genera and species. Along with morphological features, ecological and cultural characters of each taxonomic entity were compiled on a specially prepared 'database' (Table 3.4). The descriptions of all the fungi were written in a diagnostic form.

3.9. *Ex situ* preservation of fungi:

The description of each species was based on definite specimen, material or culture of fungi, as prescribed in the International Code of Botanical Nomenclature (Hawksworth, 1974). A representative pure culture of each taxonomic entity (identified fungal species or morphotype) from each sample was labeled, numbered and maintained in the collections of the 'Goa University Fungus Culture Collection' (GUFCC). Dried herbarium specimen and the micro-slides containing fungal diagnostic structures on which the descriptions based were made, properly sealed, labeled and maintained in the Herbarium of Goa University Botany Department (GUBH).

Holotypes of all new taxa described in this thesis are maintained at the International Mycological Institute, Cabiscience, U.K. Where the new taxon is based on a live fungus, dried and dead culture mats in herbarium sheets were maintained in the Herbarium of the IMI, U.K. and/or the GUBH, Goa University, so as to satisfy the nomenclatural rules.

3.10. 'Litter bag experiment':

An *in situ* exercise termed 'litter-bag experiment' was conducted at one of the sampling sites of seasonal studies, the Molem wildlife sanctuary, on two plant species,

i.e. *Careya arborea* and *Dendrocalamus strictus*, for a duration of 8 months, to study the colonisation and succession of fungi during the process of decomposition of litter. A hand-full of each plant litter placed in A4 size nylon mesh bags (mesh size # 2 mm), labeled and together tied in a nylon rope, were tied in the vicinity of respective plant (Plate 3.5.).

The time of placing the samples for experiment was considered as the first sample and treated as control. Subsequently the bags were examined at monthly intervals. The litter-bags were subjected to both moist-chamber incubation and particle-plating isolation techniques for recovery of fungi. The C and N content of the dried leaf litter was calculated on dry matter basis by Walkley-Black method (Jackson, 1973) and by a modified Kjeldahl's method (AOAC, 1984) respectively.

3.10.1. Determination of organic Carbon in plant litter (Walkey-Black's Rapid titration method):

Principle: The organic carbon is oxidized to CO_2 by $K_2Cr_2O_7$ making use of heat of dilution of H_2SO_4. The excess of $K_2Cr_2O_7$ unused in oxidation is titrated back against standard ferrous ammonium sulphate solution using diphenylamine indicator. The interference of iron (Fe^{2+}) and Cl^- ions during titration are eliminated by the use of phosphoric acid (H_3PO_4) and Ag_2SO_4, respectively. At the end point the colour of the suspension changes from violet, through blue to bright green.

Apparatus used: 500ml conical flasks, Pipettes (10 ml), Burretes, Measuring cylinder, Analytical balance, Asbestos sheet

Reagents:

1. 1N $K_2Cr_2O_7$ solution: Dissolve 49.04 g of $K_2Cr_2O_7$ in distilled water and make up the

volume to 1 litre.

2. Concentrated H_2SO_4: Containing 15 g of Ag_2SO_4 per 1 litre.
3. 0.5N Ferrous ammonium sulphate (Mohr's salt): Dissolve 196.1 g of $FeSO_4(NH_4)_2.6H_2O$ (AR) in distilled water, add 15 ml of concentrated H_2SO_4 and make up the volume to 1 litre using distilled water to prevent hydrolysis of ferrous salt.
4. H_3PO_4 - 85%
5. Diphenylamine indicator : Dissolve 0.5 g diphenylamine in a mixture of 100ml conc. H_2SO_4 and 20 ml distilled water and store in a amber coloured bottle.

Procedure:

1. Weigh 0.5g of oven dried sieved plant litter and add to 500ml conical flask.
2. Add 10 ml of 1N $K_2Cr_2O_7$ solution and shake it to mix the contents of the flask thoroughly.
3. Add 20 ml of conc. H_2SO_4 (containing Ag_2SO_4) from the sides of the flask successively, shaken for 2-3 minutes and mix thoroughly.
4. Allow the reaction to proceed for 30 minutes on asbestos sheet to avoid burning of table due to release of intense heat due to reaction of H_2SO_4.
5. Add 200 ml of distilled water, and 10 ml of H_3PO_4 to flask and shake vigorously.
6. Add 10 drops of diphenylamine indicator which gives violet colour to the suspension.
7. Titrate the contents of the flask against 0.5N ferrous ammonium sulphate solution taken in burette till the colour changes from violet through blue to bright green (brilliant green) and note down the volume of ferrous ammonium sulphate solution consumed.
8. Run a blank without the litter in a similar manner simultaneously.

Observations and calculations:

1. Weight of the litter sample = 0.5 g
2. Volume of the 0.5N Ferrous ammonium sulphate solution consumed for blank titration (BTV) = ...ml
3. Volume of the 0.5N Ferrous ammonium sulphate solution consumed for sample titration (STV) = ...ml
4. Normality of Ferrous ammonium sulphate solution = 0.5N

To calculate the percentage of carbon the following formula was used:

$$\% \text{ OC} = \frac{(\text{BTV-STV}) \times \text{N Ferrous Ammonium } SO_4 \times 0.003 \times 100}{\text{W}}$$

Where,

BTV = Volume of N Potassium dichromate

STV = Volume of N Ferrous ammonium sulphate in ml

W = Weight of the litter sample taken (.02g)

3.10.2. Determination of organic Nitrogen in the plant litter (Modified Kjeldahl Method).

Apparatus: Kjeldahl digestion manifold, Kjeldahl NH_3 distillation rack, 800 ml Kjeldahl digestion flasks, Pipettes (25 ml), 500 ml conical receiver flasks, Burretes, Measuring cylinder, Analytical balance.

Reagents:

1. Concentrated H_2SO_4
2. Standard 0.1N H_2SO_4
3. $CuSO_45H_2O$ (20 g)
4. Standard 0.1 N NaOH

5. 40%NaOH for Ammonium distillation

6. Methyl red indicator: 0.1% Methyl red

7. Phenolphthalein indicator

Procedure:

1. A sample of 0.5 g of dried plant tissue that has been ground to pass a 0.4mm (40 mesh per in.) screen is wrapped in a 11cm qualitative filter paper and dropped as a package into a 800ml Kjeldahl digestion flask.
2. About 2g of $CuSO_4.5H2O$ is added to the 800ml Kjeldahl digestion flask.
3. Add 20 ml of concentrated H_2SO_4 and the digestion follows.
4. Digestion in H_2SO_4 is effected on the Kjeldahl digestion flask with a low flame for the first 10 to 30 minutes, until frothing stops, and then gradually more strongly until the sample is completely charred. The heat is gradually raised until the acid reaches a boil, and condensation of acid reaches aproximately one-third the way up the neck of the digestion flask.The flask is rotated at intervals and heating is continued until the organic matter is destroyed, best judged by timing the digestion for 1± 0.25 hour after the solution has cleared or clear blue (light yellow or gray color).
5. At the end of the digestion, the heating is stopped, but the fume exhaustion is continued until fuming stops. When the flasks are cooled 100ml of NH_3-free water is added as the solution is cautiously mixed. This solution is further cooled (heat of dilution) and the volume of the cleared blue sample solution is made to 100ml in a volumetric flask.
6. From this solution 20 ml is taken in the 800ml Kjeldahl digestion flask and 1-2 drops of Phenophthalein is added as an indicator.
7. Attach this disgestion flasks to the distillation unit at one end and at the other end put

standard 0.1N H_2SO_4 and the distillation is carried out with the help of the Kjel Plus Distil-M distillation unit and the content was made alkaline using 40% NaOH.

8. After distillation is over the liberated steam distilled ammonia was collected the beaker with the standard 0.1N H_2SO_4 and add 2 drops of methyl red.
9. Titrate the contents in the beaker against 0.1N NaOH in a 10 ml burette.
10. Carry out the titration till colour changes from red to light yellow. Add drop by drop to get no errors in the readings.Prepare blank digests with reagents alone.
11. The nitrogen concentration was then calculated and expressed as percentage.

Observations and calculations:

1. Weight of the litter sample = 0.5 g
2. Volume of the standard 0.1N H_2SO_4 solution consumed for blank titration (BTV) = ...ml
3. Volume of the 0.5N H_2SO_4 solution consumed for sample titration (STV) = ...ml
4. Normality of Standard acid solution = 0.1N H_2SO_4 solution
5. Normality of Standard base solution = 0.1N NaOH solution
6. Weight of the litter sample (s) = 0.5 g

To calculate the percentage of nitrogen the following formula was used:

$$\% N = \frac{(BTV-STV) \times N \times 1.4}{s}$$

Where BTV = blank titration, ml standard acid

STV = sample titration, ml standard acid

N = Normality of standard acid

s = Weight of the litter sample

3.11. Enzyme Assays:

A number of fungal isolates were recovered from leaf-litter, fresh leaves and twigs during this study. Of these, 140 different individual fungi that appeared commonly or exclusively as litter and/or endophytic fungi were randomly selected for screening experiments in order to detect the presence of degradative enzymes such as amylase, cellulase and pectinase (Plate 3.6.). The methods prescribed by Carder (1986) for amylase and Hankin and Anagnostakis (1975) for cellulase and pectinase were followed.

Discs of 5 mm, cut from 7-10 day old colonies grown on MEA at room temperature (22-25^0 C) were used as the source of inoculum for enzyme assays.

3.11.1 Amylolytic activity:

The ability to decompose starch was used as a criterion for analysis of amylolytic activity of fungi. The composition of the 'starch agar' medium is as follows: malt extract 5g/l, agar 20g/l, soluble starch 0.2%. The mineral salts solution contained per litre: $(NH_4)_2SO_4$, 2g; KH_2PO_4, 4g; Na_2HPO_4, 6g; $FeSO_4.7H_2O$, 0.2g; $CaCl_2$, 1mg; H_3BO_3, 10µg; $MnSO_4$, 10µg; $ZnSO_4$, 70µg; $CuSO_4$, 50µg; MoO_3, 10µg; pH 6. The test fungus was point-inoculated in the centre of the medium and allowed to grow for 7 days. Amylolytic activity was observed by flooding the plates with a 1% iodine solution. A clear yellow zone developed around the colony indicated the production of amylase in an otherwise dark blue medium

3.11.2. Cellulolytic activity:

The composition of test medium is as follows: agar 20g/l, carboxymethylcellulose 10g/l. The mineral salts solution contained per litre: $(NH_4)_2SO_4$, 2g; KH_2PO_4, 4g; Na_2HPO_4,

6g; $FeSO_4.7H_2O$, 0.2g; $CaCl_2$, 1mg; H_3BO_3, 10µg; $MnSO_4$, 10µg; $ZnSO_4$, 70µg; $CuSO_4$, 50µg; MoO_3, 10µg; pH 6. After 7 d incubation, the plates were flooded with 1% Congo Red solution. Cellulase production was indicated by a clear zone in positive colonies (Carder, 1986). The plates were subsequently flooded with 20ml of 1N NaCl to allow the clearance zone to remain for a longer duration (Hankin and Anagnostakis, 1975).

3.11.3. Pectinolytic activity:

To detect the production of pectate lyase, pectin agar medium was used. The composition is as under: agar 15g/l, yeast extract 1.0g, pectin 5g. The mineral salts solution contained per 500ml: $(NH_4)_2SO_4$, 1g; KH_2PO_4, 2g; Na_2HPO_4, 3g; $FeSO_4.7H_2O$, 0.1g; $CaCl_2$, 0.5mg; H_3BO_3, 5µg; $MnSO_4$, 5µg; $ZnSO_4$, 35µg; $CuSO_4$, 25µg; MoO_3, 5µg; pH 7. The plates were incubated for 5-7 days and later flooded with Centrimide (Cetyltrimethyl-ammoniumbromide). The centrimide precipitates the intact pectin in the medium and pectin utilized is revealed as clear zones around active colonies in an otherwise opaque medium (Hankin and Anagnostakis, 1975).

3.12. Statistical Analysis:

The relative frequency was calculated using the formula, (R_f = n/N x 100, where n= number of fungal colonies of one species in a collection, N = total number of fungal colonies of all species in the same collection). The mean density of colonisation of single endophyte species was calculated by the method of Fisher and Petrini (1987), [i.e. the number of colonized segments divided by the total number of segments plated x 100]. The species richness (S_r = S^1/N x 100, where S^1 = total number of all fungal species in a collection, N = total number of all fungal species in a collection, N = total

number of fungal colonies of all species in the same collection) at each collection was calculated.

Jaccard Similarity Coefficients were calculated for all possible pairs of hosts to compare the endophyte assemblages, according to the following formula

Similarity coefficient = C/ (A+B-C),

where A and B are the total number of fungal species isolated from any two hosts and C the number of fungal species found in common (Sneath and Sokal, 1973). The results were expressed as percentages.

The data gathered during the 2-year study period was subjected to statistical analyses. To compare species richness among samples of unequal size, rarefaction curves were constructed. To estimate the number of expected species [E(s)] from the isolates obtained in the pre-monsoon, monsoon and post-monsoon season of each plant species, rarefaction index was performed following the method of Ludwig and Reynolds (1988). The expected number of species, E(s), in a random sample of n individuals taken from a total population of N individuals is calculated by the formula:

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

where ni, is the number of individuals of the ith species.

To see whether there is a correlation between the period of decomposition and the C : N ratio, the correlation coefficient was calculated. To analyze the enzyme activity, Euclidean distance average linkage method of Cluster analyses using Systat 5.1 was used.

Table 3.1. **Dicot plant species sampled during the study period:**

Sr. No	Place of collection	Date of collection	Name of the Plant species sampled
1.	Alorna	19.11.1999	*Helictris ixora* Linn., *Tectona grandis* Linn.f.
		08.08.2000	*Zanthoxylum rhetsa* (Roxb.) DC.
2.	Baga	11.10.1999	*Ficus benghalensis* Linn.
3.	Bondla	03.09.2000	*Bauhinia purpurea* Linn.
		15.08.1999	*Hydnocarpus laurifolia* (Dennst.) Sleumer
			Terminalia paniculata Roth
4.	Cotigao	11.04.1999	*Flacourtia montana* Graham
		19.07.1999	*Dillenia indica* Linn., *Psychotria dalzellii* Hk.f.
		09.12.1999	*Ixora brachiata* Roxb., *Xylia xylocarpa*(Roxb.)Taub.
		10.08.2000	*Ficus tinctorius* var. *parasitica* (Willd.) Corner
5.	Chorlem	02.07.1999	*Ficus religiosa* Linn.
6.	Molem	03.09.1999	*Sageraea laurifolia* (Grah.)Blatter
7.	Tambdisurla	08.07 2000	*Syzygium cumini* (Linn.) Skeels
8.	Taleigao	10.07.1999	*Mangifera indica* Linn.

Table 3.2. **Monocot plant species sampled out during the study period:**

Sr. No	Place of collection	Date of collection	Name of the Plant species sampled
1.	Alorna	19.07.1999	*Pandanus tectorius* Soland. ex Parkinson
2.	Bondla	15.08.1999	*Dendrocalamus strictus* (Roxb.) Nees; *Bambusa arundinacea* (Retz.)Willd.
		01.10.1999	*Sanseiviera zeylanica* Willd.
3.	Chorlem	02.07.1999	*Calamus thwaitesii* Becc. ex Hook., *Ensete superbum* (Roxb.) Cheesmen
4.	Cotigao	11.04.1999	*Caryota urens* Linn.
		10.08.1999	*Curcuma decipens* Dalz.
5.	Tambisurla	08.07.2000	*Elaeis guineensis* Jacq.

Table: 3.3. **Sampling dates of seasonal collection:**

	Pre-monsoon		**Monsoon**		**Post-monsoon**	
Year	Bondla	Molem	Bondla	Molem	Bondla	Molem
1999-2000	11.02.99	11.03.99	09.06.99	03.09.99	01.10.99	29.12.99
2000-2001	14.02.00	11.04.00	08.06.00	20.08.00	11.10.00	20.12.00

Table 3.4. **DATA-BASE FOR TERRESTRIAL MICROFUNGI COLLECTED, ISOLATED AND DOCUMENTED FROM THE FORESTS OF WESTERN GHATS:**

1. Name of Fungus Taxon:_____; Common name (if any):_____
2. Collection details: Collection No._____; Coll. by_____
Date:_____; Season (Weather)____ Rainy /Dry /Windy /Foggy /.....
Locality:___ (Site); ____ (taluka);___ (Dist);____ (State); ___ (Altitude)
3. Habitat: (Appropriate type to be specified in the dotted or continuous line/space given at the end of each item)
3.1. Type: Terrestrial:__; Freshwater:__; Lotic:__ (Rivulet/Stream/River); Lentic:__(Pond/Lake/Dam)
Marine:___; Mangrove: ___; Extra-terrestrial:___ (Above ground /Tree-hole/Bird nest/....)
4. Vegetation: Evergreen /Deciduous /Moist deciduous /Mixed deciduous /Shola /Riparian Forest /Barren /Burnt /Grassland /Scrub /Dry /Jungle /Plantation /Epiphytic /----------
5. Soil: Clay /Red /Black /Mudflat /Laterite /Granite /Humus /Fertilized /Nonfertilized /pH__
6. Substrate: *Plant*: Dry or Fresh leaf /Twig /Log /Root /Fruit /Flower /Seed /Grain /Latex /Gum /Fiber;
Dung: Goat /Rabbit /Monkey /Deer /Antelope /Elephant /Bison /Bird /Lizard /Frog /.....
Miscellaneous: Hair /Feather /Paper /Cloth /Lipstick /Contact Lens /Glass /Leather /Plastic /Metal /Paint .....(Type) /Rubber /Cement /Jute /.....
7. Temperature: _____^{0}C (Range recorded at the sample collecting site)
8. Sample: _____(Name of material/substrate); Size.....; Status/Condition.....(dry /wet/fixed)
9. Mode/Method of Transport to Lab:_____(In paper bag /polythene bag /Bottle /Culture Plate;
10. Method of Isolation: _____(Direct /Moist Chamber Incubation /Particle Plating)
11.Cultural characters :
Starting Unit: _____(hypha /spore /Conidium); Germinated: Yes/No
Colony: Shape_____; Height:___; Colour:_____; Size: ___ (diam. range in cm/7 days.)
Margin:_____(Smooth /Serrated /Wavy /Rhizoidal /.....)
Reverse:_____(white /brown /colourless /black /--------etc.)
Growth :_____ (Slow: 0.2 -1.0 cm; Median: 1.1- 4.9 cm; Fast: 5.0- 9.0 cm diam.)
Texture : _____(Cottony /Slimy /Dry /Powdery /Wet /Floppy /Flat /Concentric rings Convex /Dome /Wavy /Parched /Stubs /Exudates /Crystals /Fruit-bodies)
12. Microscopic:
Mycelium/Hyphae: _____(Smooth /Verrucose /Septate /Branched /Hyaline /Dark or light Brown / Guttulate /Thick or Thin-walled /----um wide)
Conidiomata: _____(Synnematous /Mononematous /Sporodochial /Pycnidial)
Conidiophore:_____(Smooth /Verrucose /Septate /Branched /Hyaline /Dark or light /Brown /Thick or Thin-walled /------um long and wide)
Conidiogenous cell: _____ (Poly or Monoblastic /Phialidic /Annelidic /Percurrent /Tretic /Basauxic /Gangliar /integrated /discrete)
Conidia: _____(Dry /Wet /Catenate /Solitary /Globose /Clavate /Pyriform /Fusiform /Cylindrical /helicoid /....Septate /.....Branched /Smooth /Verrucose /Velvety)
Ascocarp:_____(Stromatic /Solitary /Gregarious /Superficial /Submerged /Perithecial /Apothecial /Cleistothecial /Stalked /Sessile /Ostiolate /.....)
Ascocarp Wall:_____ (Textura angularis /Pseudo-parenchymatous /Plectenchymatous Mycelial /Carbonaceous /Colourless /.....
Centrum:_____(Paraphysoid /Pseudo-/Apical paraphysoid /Loculate /.....)
Ascus: _____(Bi-/Uni-tunicate /Stalked /Sessile /With-/Without Apical Apparatus Operculate /Inoperculate /Clavate /Cylindrical /Curved /.....)
Ascospore: _____(Shape, colour, size....., appendaged, septate....)
Pycnidium: _____(Stromata /Wall /Colour /.....)

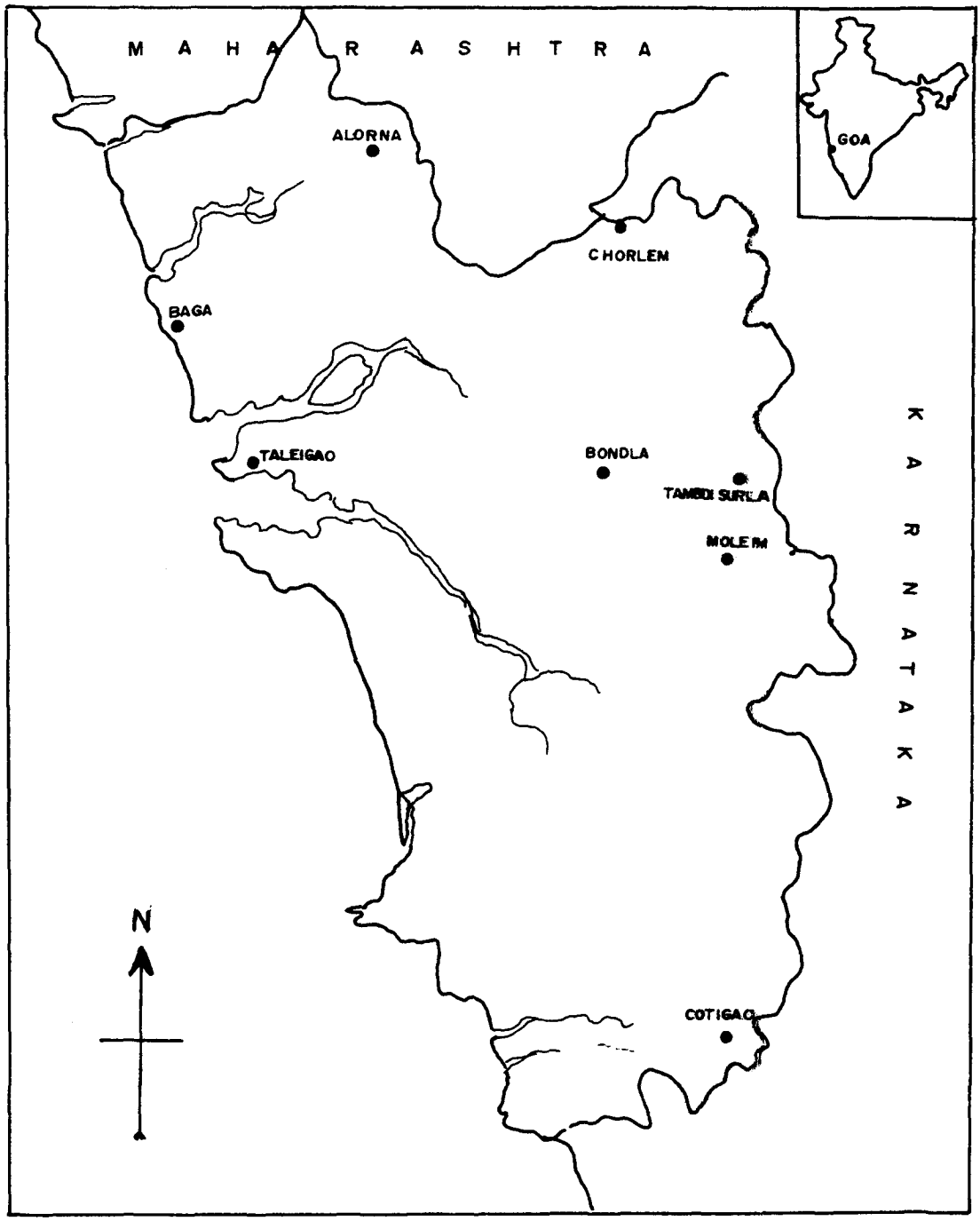
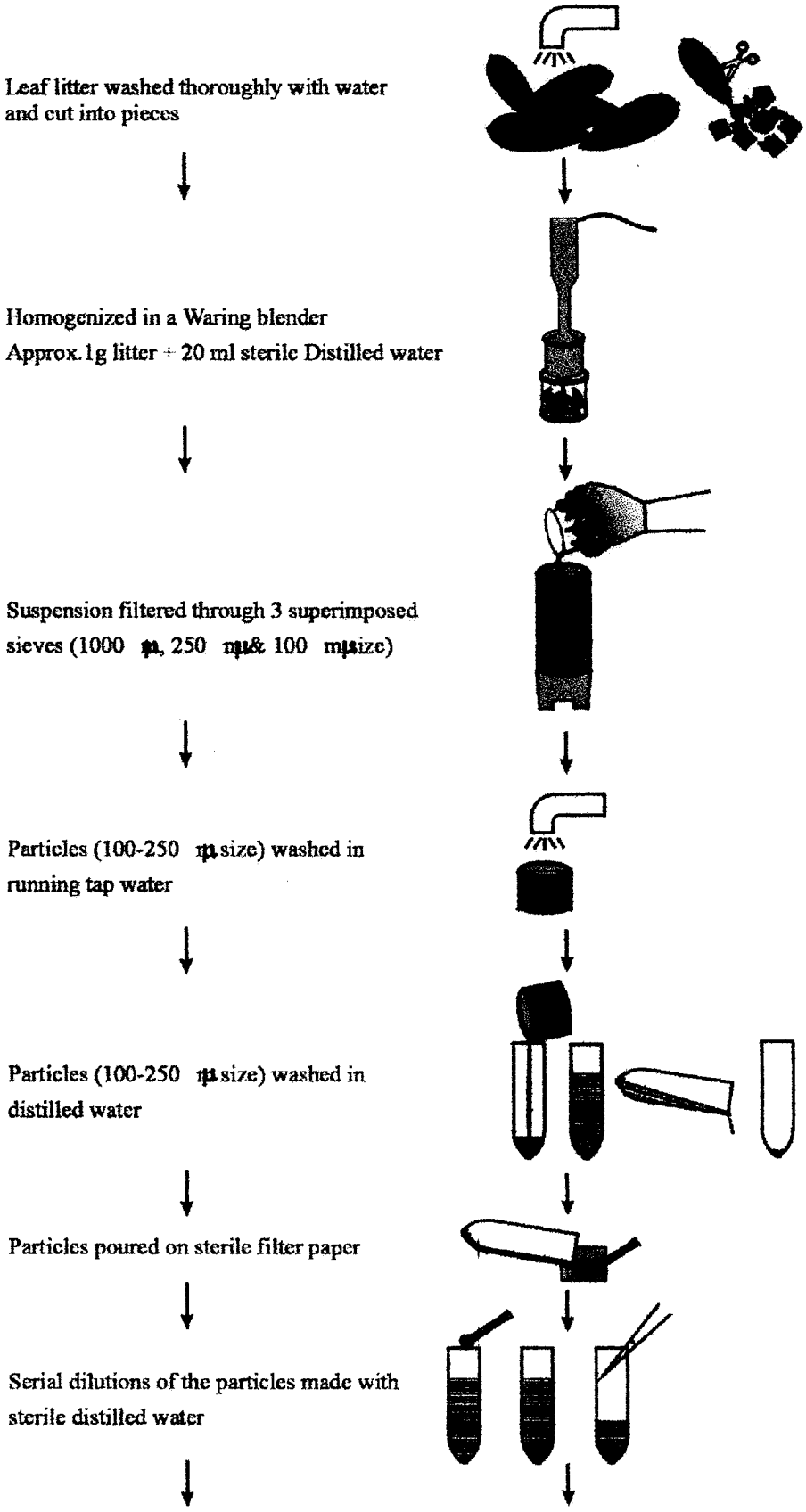


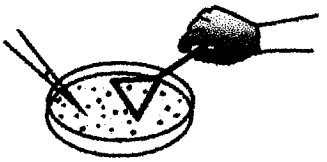
Fig. 3.1. Map showing the sampling sites

Fig. 3.2. Processing of litter sample (Bills & Polishook, 1994)



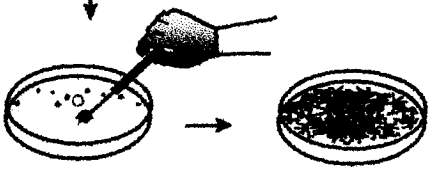
cont...

Particles (0.1 ml) plated and spread onto 2% Malt Extract Agar plates



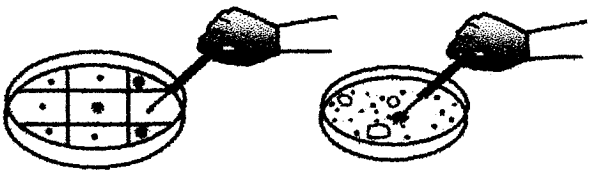
Incubated at 22° C for 7-28 days

Selected colonies isolated (2nd day isolation)



2nd day Unattended plates

Selected colonies transferred onto sectored agar plates



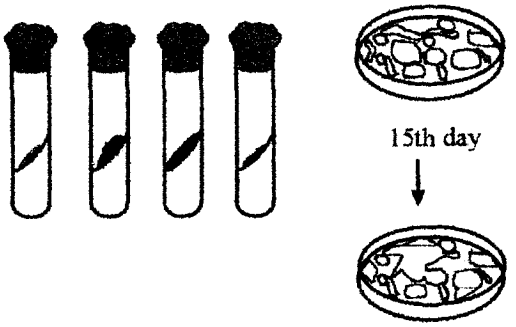
2nd day

Extra colonies growing on plates controlled by cutting

Growth of colonies after 7 days incubation

7th day

Representative colonies transferred and maintained in culture tubes



15th day

21st day

Taxonomic identification

Fig. 3.3. Processing of fresh leaf sample (Petrini & Fisher, 1986)

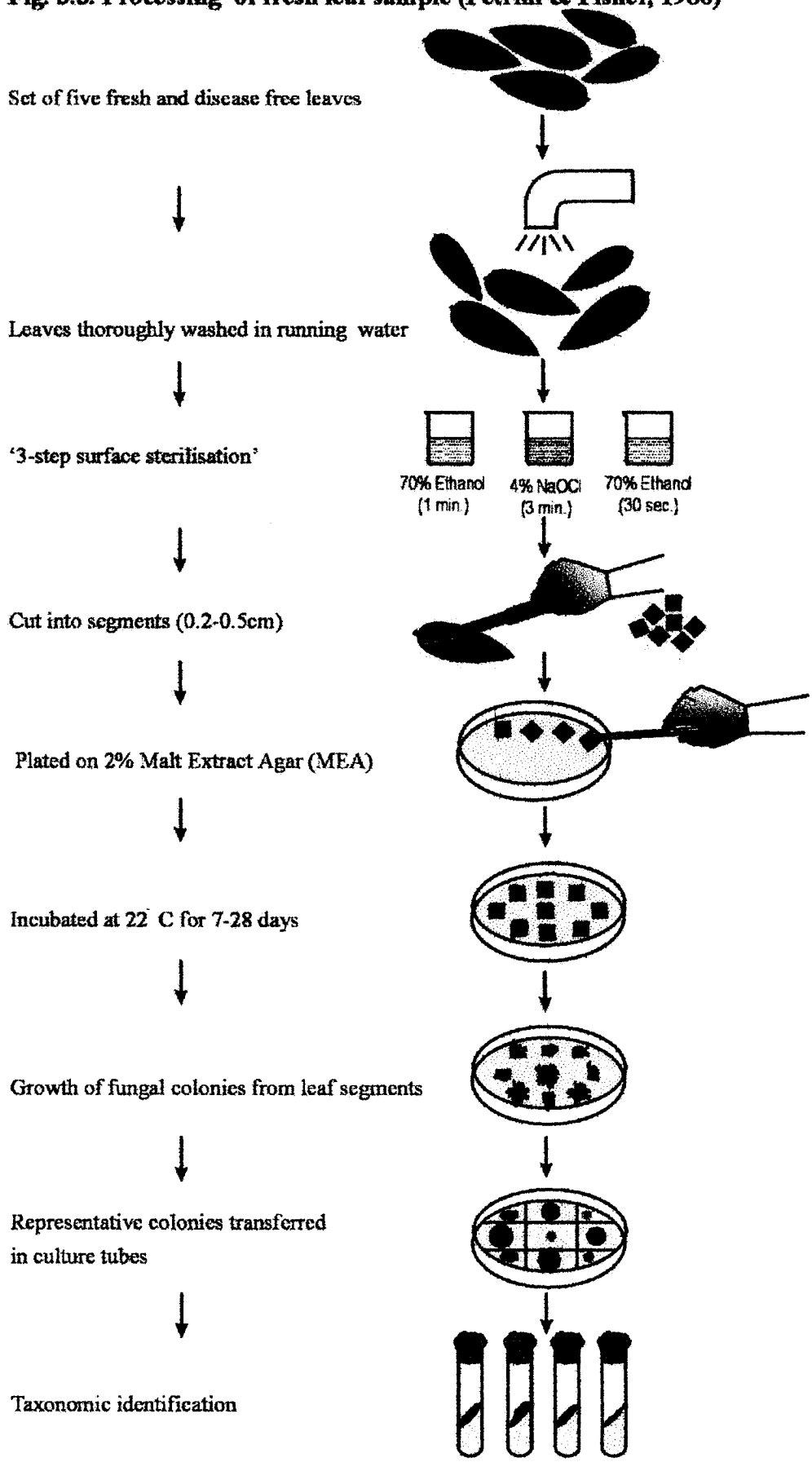


Plate: 3.1.

1. *Saraca asoca* - Entire plant

2. *Saraca asoca* - A flowering twig

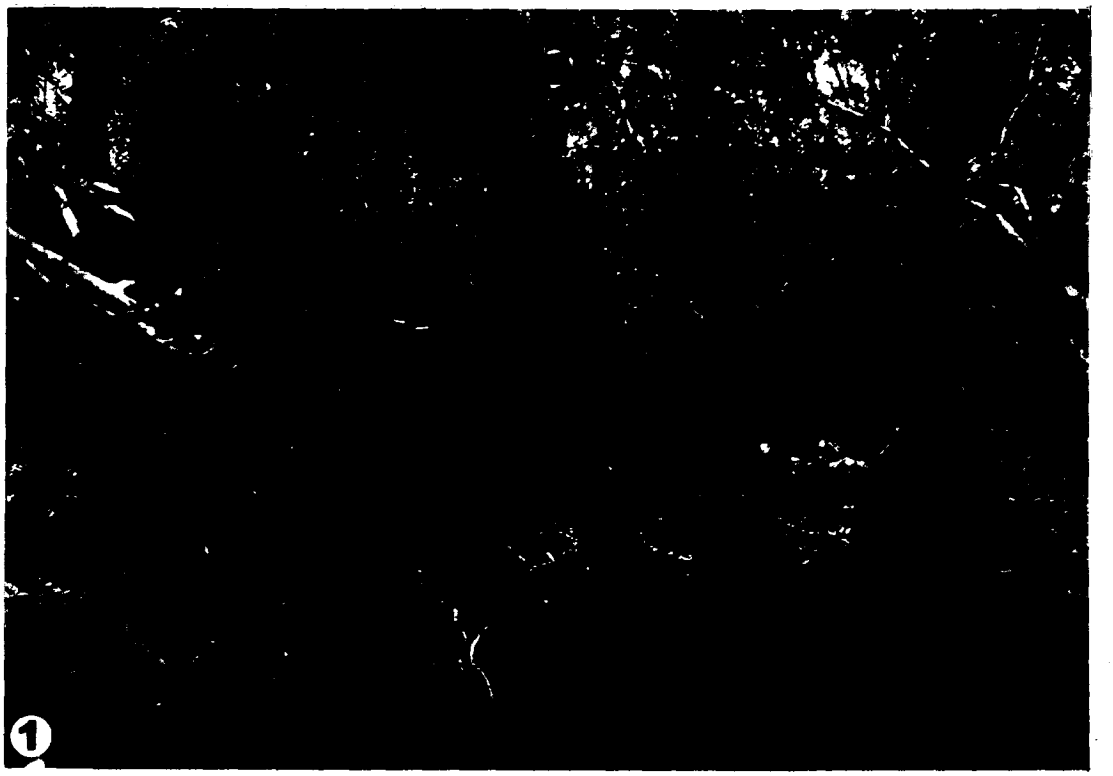


Plate: 3.1

Plate: 3.2.

1. *Calamus thwaitesii*

2. *Careya arborea*

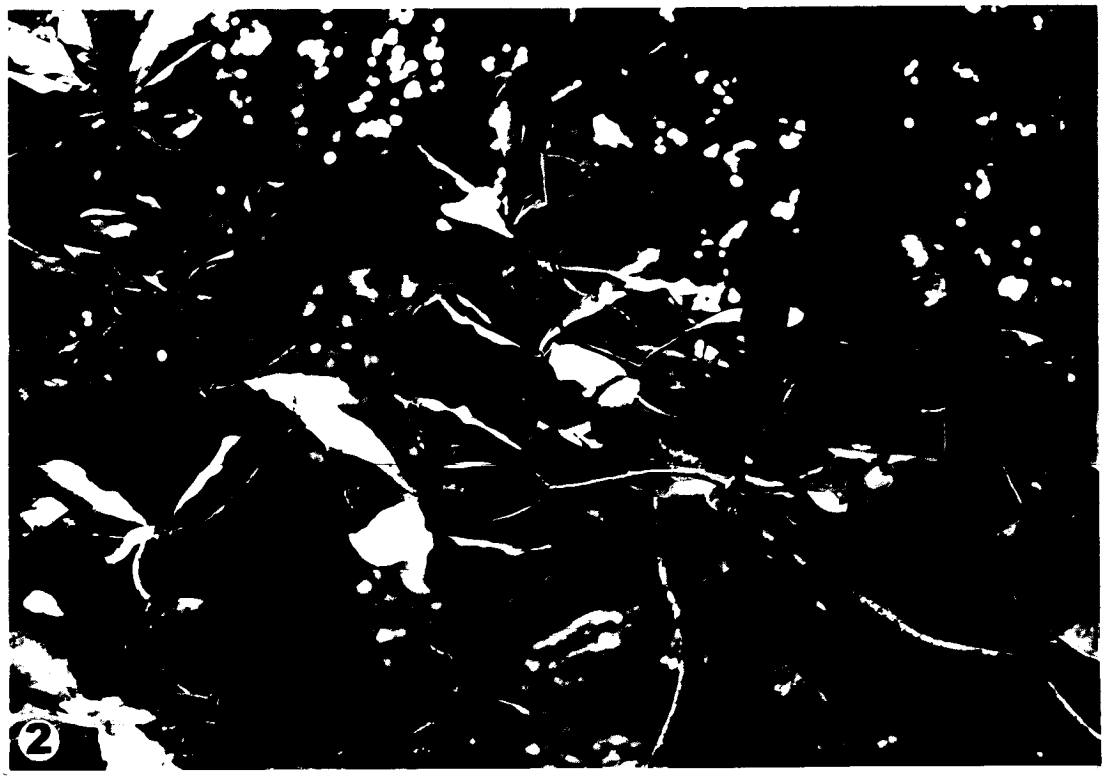


Plate: 3.2

Plate: 3.3.

1. *Dendrocalamus strictus* - **Entire plant**

2. *Dendrocalamus strictus* - **Closer view of an individual branch.**

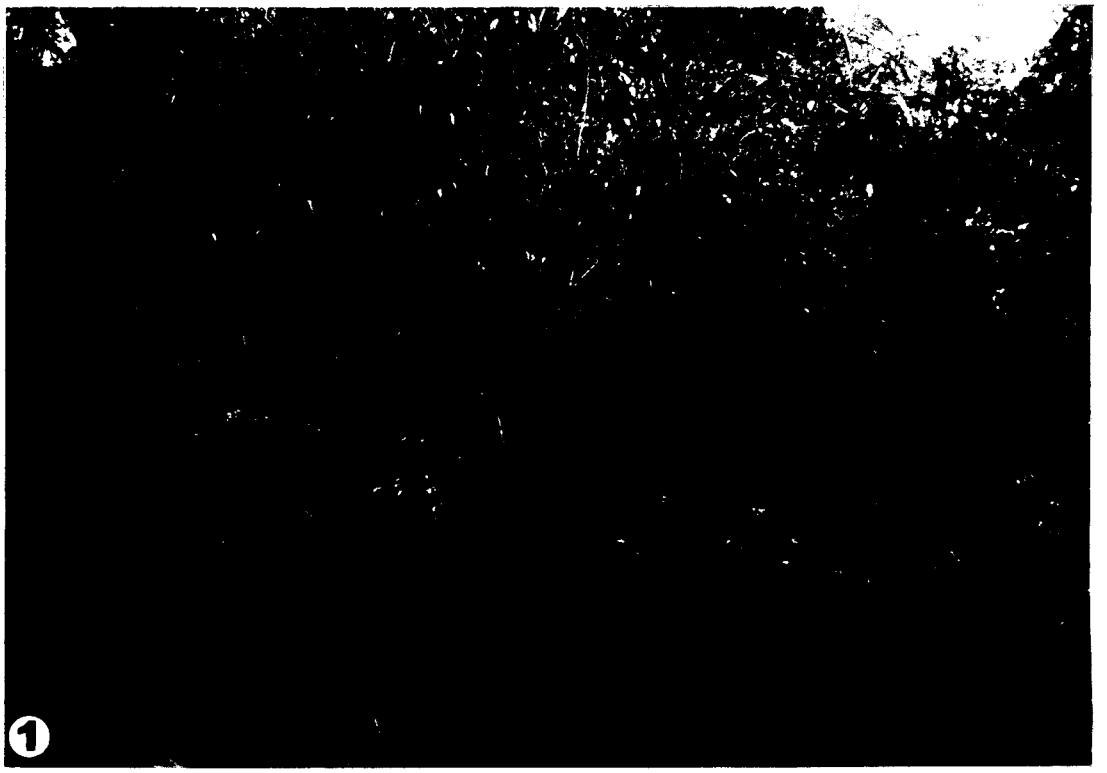


Plate: 3.3

Plate: 3.4.

Litter-bag experiment:

1. **Nylon bags containing litter of *Careya arborea* placed in the vicinity of the plant.**

2. **An individual bag with litter of *Careya arborea.***

3. **Nylon bags containing litter of *Dendrocalamus strictus* placed in the vicinity of the plant.**

4. **An individual bag with litter of *Dendrocalamus strictus.***

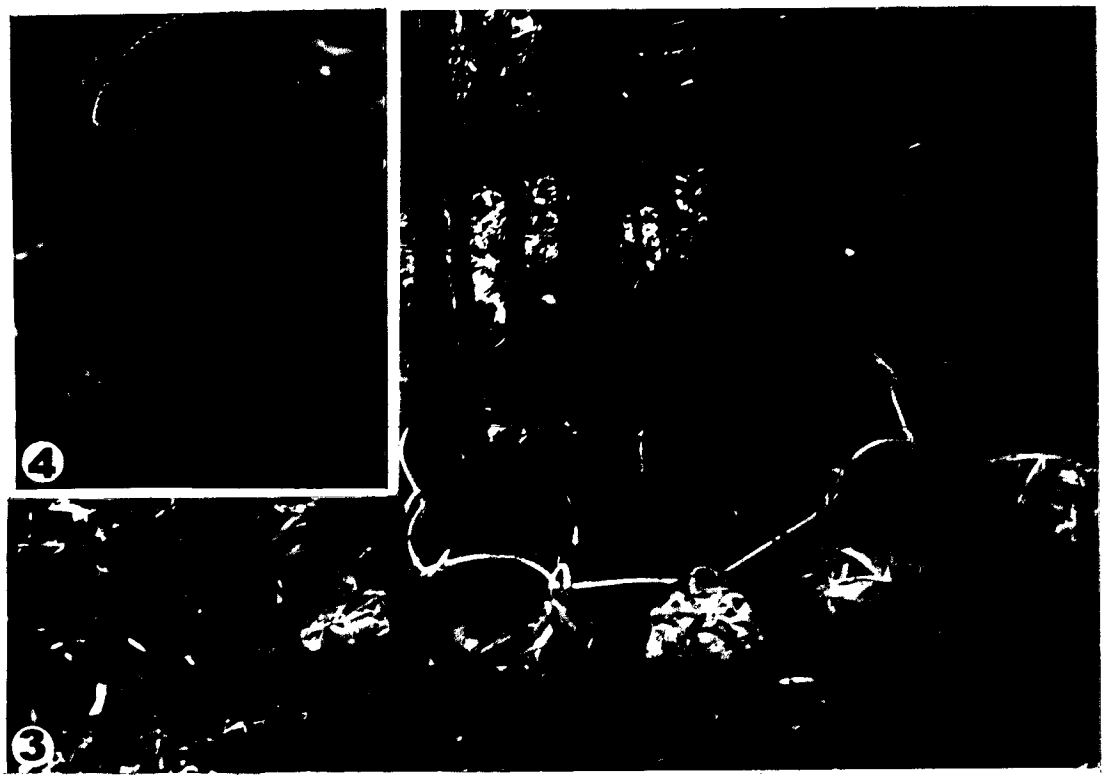


Plate: 3.4

Plate: 3.5.

1. Dried leaf-litter of *Saraca asoca* (A)

1. Dried leaf-litter of *Calamus thwaitesii* (B)

2. Leaf litter incubated in moist chambers.

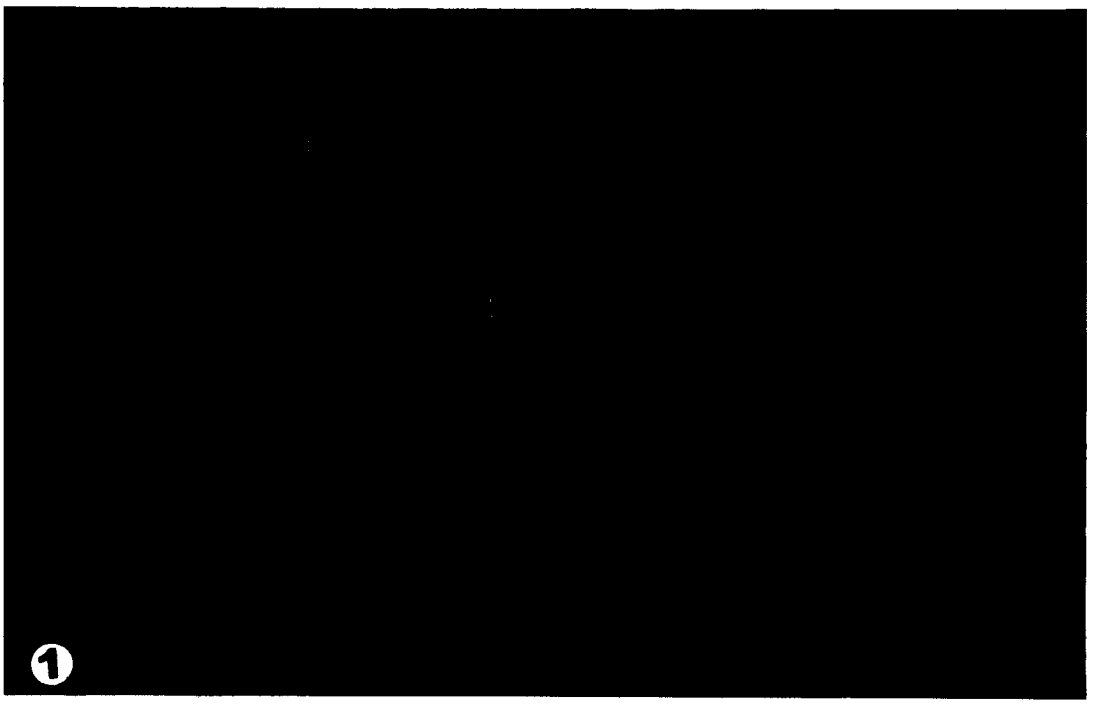


Plate: 3.5

Plate: 3.6.

Enzyme assays:

1. A. Control; **B. Amylolytic activity**

2. A. Control; **B. Cellulolytic activity**

3. A. Control; **B. Pectinolytic activity**

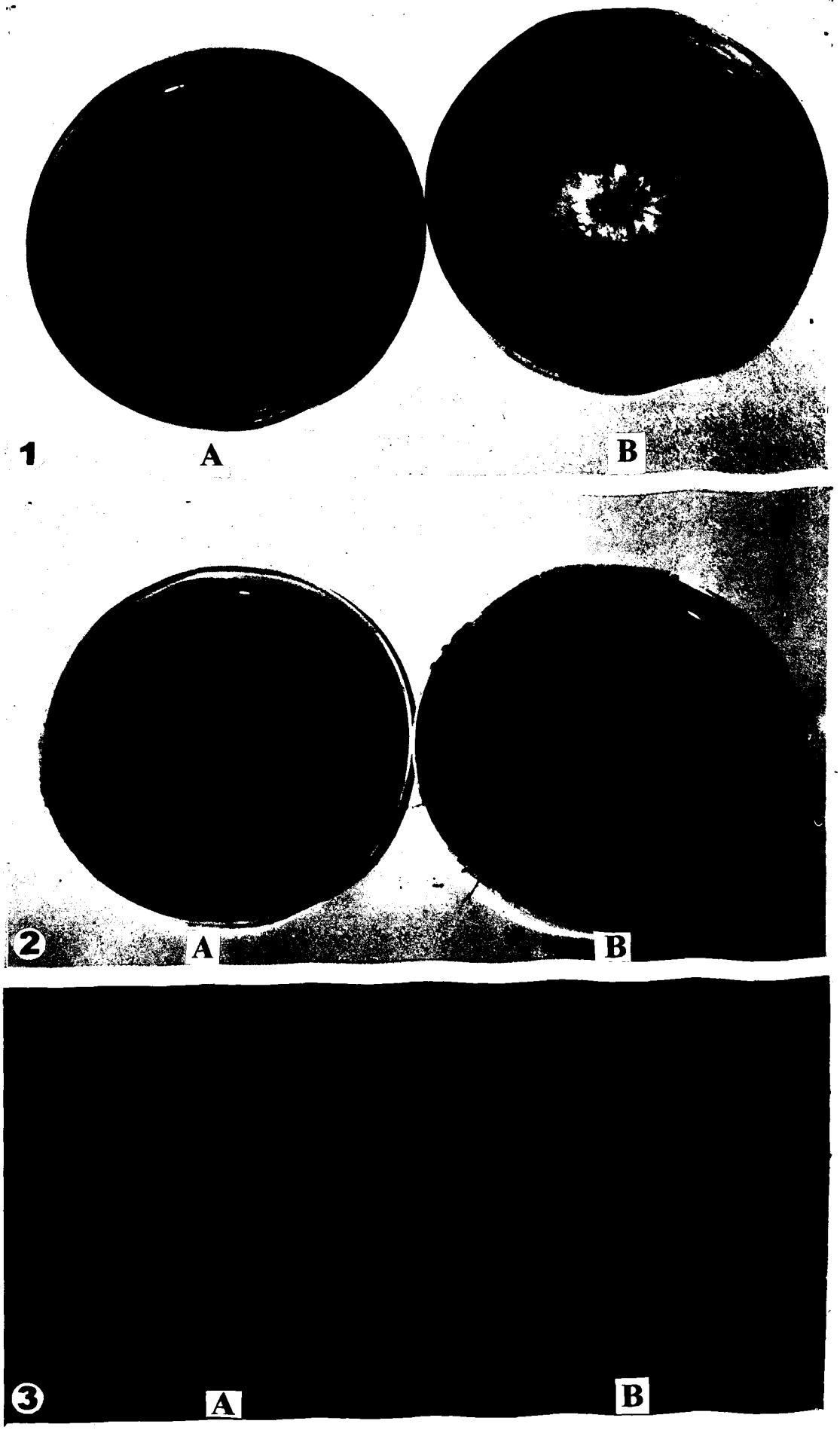


Plate: 3.6

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS

Although the biology of litter and endophytic fungi has been studied independently by many workers, composite investigations aimed at understanding the diversity, ecology and activity of microfungi associated with plant species of tropical ecosystem were very few. World literature, including the researches so far done in India on the subject, has been reviewed in Chapter II.

In this Chapter, results of a detailed study carried out during February 1999 to June 2001 on floristics, seasonal occurrence, succession and activity of microfungi associated with litter and live leaves of several monocot and dicot plant species of forests of Western Ghats in Goa are presented in four Parts as follows:

Part I-A: Taxonomy and diversity of microfungi associated with different plant species.

Part I-B: Substrate specificity of microfungi associated with different plant species.

Part II: Seasonal occurrence of and species richness in litter-inhabiting and endophytic fungi of four plant species.

Part III: Succession of microfungi on *Careya arborea* and *Dendrocalamus strictus.*

Part IV: Assaying of cultures of litter and endophytic fungi for production of enzymes.

PART I-A: TAXONOMY AND DIVERSITY OF MICROFUNGI ASSOCIATED WITH DIFFERENT PLANT SPECIES:

Of the fungi so far isolated from various plant substrates and habitats, maximum species diversity was recorded from fallen decaying leaves, twigs, bark, roots, fruits, seeds, flowers, etc. (Dix and Webster, 1995). Several floristic studies were carried out

on litter and endophytic fungi of India and these resulted in the documentation of a very large number of known and new fungi (Vittal, 1973; Sudha, 1978; Rai, 1973; Dorai, 1988; Rao and De Hoog, 1986; Subramanian and Bhat, 1987; Bhat and Kendrick, 1993; Subramanian and Shekar, 1990; Hawksworth et al., 1995; Sarbhoy et al., 1986, 1996; Suryanarayanan et al., 1998 and Miriam, 2000).

In the present study, floristic investigation on microfungi occurring in association with 30 monocot and dicot native plants (Table 4.1.1 and 4.1.2) of forests of Western Ghats in Goa was carried out over a period of 2 years (February 1999 to June 2001) following moist-chamber incubation, particle-plating and endophyte isolation techniques.

The exercise resulted with recovery of more than 6500 isolates of microfungi. These were assignable to 675 taxa of fungi belonging to 275 genera which included Zygomycetes (1), Ascomycetes (18), Hyphomycetes (289), undetermined conidial forms (77), Coelomycetes (22), and non-sporulating morphotypes (268). In the absence of adequate reference material, 77 sporulating conidial fungi could not be assigned to any species and genera and are treated in this thesis as 'undetermined taxa'.

The floristic report includes taxonomic description of common, interesting, rare and novel taxa of microfungi isolated from dead and decaying leaf litter and live leaves. As can be seen in Table 4.1.1 and 4.1.2, hyphomycetous fungi are largest group along with sizable number of non-sporulating forms. Amongst the fungi brought into pure culture, 268 isolates did not sporulate and these were considered here as 'non-sporulating morphotypes' (NSM) based on cultural characters such as colour, shape, growth rate and presence or absence of exudates in the colony. In the absence of any sporulating structures the taxonomy of these forms also remained undetermined.

Diagnostic characters of microfungi such as morphology, colour and size of the colony and sporulating structures such as ascomata, asci, centrum and ascospores in case of Ascomycotina and conidiomata, conidiophores and conidia in case of Deuteromycotina, were considered for identification. Detailed description of each species is given in the text along with illustration and photomicrograph wherever possible.

The description of the species is based on definite specimen, material or culture of the fungus, as prescribed in the International Code of Botanical Nomenclature (Hawksworth, 1974). Representative pure culture of each taxonomic entity (identified fungal species or morphotype) from each sample was properly labeled, numbered and maintained in the collection of 'Goa University Fungus Culture Collection' (GUFCC). Dried specimen and microslides containing fungal diagnostic structures on which the description based was prepared, properly sealed, labeled, numbered and maintained in the Herbarium of Botany Department, Goa University (GUBH).

Diagnoses of the new taxa are given along with designation of holotypes. At this stage, only the names are latinised in the text. In the absence of latin diagnosis, as per Article 36 of the International Code of Botanical Nomenclature, the novelty of these taxa remains only provisional. As and when the new taxa are being published, the diagnosis will be latinised. Holotypes of all the new taxa were deposited at the International Mycological Institute, Cabiscience, U.K., so as to satisfy the nomenclatural rules. Where the new taxon is based on a live fungus, dried and dead culture mats in standard herbarium sheets were maintained in the Herbarium of the IMI, U.K. and/or at the GUBH, Goa University.

TAXONOMIC PART

A total of 144 species of well-sporulating, properly diagnosed hyphomycetous fungi are described below in alphabetical order with notes on their taxonomy, substrate/s and habitat affinity, cultural character and detailed microscopic observations. Wherever possible camera lucida drawings and photomicrographs are provided. For the new taxa described, brief notes are provided on their uniqueness. A dichotomous key has been given for all the hyphomycetous fungi described in this study based on their diagnostic characteristics (Table 5.1).

***Acremonium* sp.** **(Fig. 1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, slow growing, flat, with exudates, attaining a diam. of 1 cm in 7 days, rhizoidal at the margin, offwhite; reverse of the colony offwhite. *Mycelium* fully immersed, composed of smooth, septate, branched, hyaline, thin-walled, 1-2 µm wide hyphae. *Conidiophores* semi-macronematous, simple, erect, unbranched, thin-walled, smooth, hyaline, 15-23 µm long, 1-2 µm wide at the base, 1-1.5 µm wide in the middle, narrow at the tip. *Conidiogenous cells* monophialidic, terminal, integrated, elongated to cylindrical, hyaline, 12-20 µm long, up to 1.5 µm wide at the base, 1 µm wide at the tip. *Conidia* solitary, wet, simple, oval, non-septate, thin-walled, smooth, hyaline, 4 x 3 µm.

Specimen examined: On fallen dead leaves of *Psychotria dalzellii*, evergreen forest, 25°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1162; leg. Maria D'Souza, 19-7-1999.

The fungus was isolated by the particle-plating method. This species has been encountered several times during the study period.

Acrodictys bambusicola M.B. Ellis, 1961, *Mycol. Pap.*, **79:** 6. **(Pl. 4.1.1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, black. *Mycelium* superficial, composed of smooth, septate, branched, mid-brown, guttulate, thin-walled, 2-3 µm wide hyphae. *Conidiophores* mononematous, erect, straight or slightly flexuous, smooth, 2-5-septate, thick-walled, light to dark brown, 25-150 x 3.5-5 µm with percurrent proliferations. *Conidiogenous cells* monoblastic, terminal, integrated, 2.5-7.5 x 4-5 µm. *Conidia* solitary, broadly clavate to pyriform, dark brown to blackish brown, smooth, with 2-5 transverse and usually 1 or more longitudinal septa, 20-35 x 15-22 µm.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, evergreen forest, 25°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1348; leg. Maria D'Souza, 03-09-1999.

The fungus has earlier been reported on *Bambusa* sp. and *Pennisetum* sp. from Uganda and Venezuela (Ellis, 1976). This is the first record from the forests of Western Ghats in Goa State.

Acrogenospora sphaerocephala (Berk. & Br.) M.B. Ellis. 1971. *Dematiaceous Hyphomycetes*. pp.114-115 **(Pl. 4.1.3)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate black, effuse, superficial. *Conidiophores* mononematous, produced singly or in groups of 2-4, erect, straight or slightly flexuous, unbranched, smooth, dark brown, 4-7-septate, 145-220 µm long, 6-9 µm thick at the base, tapered gradually at the apex up to 4.5 µm wide.

Conidiogenous cells monoblastic, terminal, elongated, percurrent, unbranched, smooth, pale brown, thick-walled, 30-90 µm long, 2-6 µm wide at the above. *Conidia* dry, solitary, velvety, initially broadly obovoid, spherical, non-septate, smooth, hyaline to translucent when young and dark brown at maturity, 10-13 µm diam.

Specimen examined: On fallen dead and decaying twigs of *Careya arborea*, evergreen forest, 29°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2633; leg. Maria D'Souza, 22-05-2001.

The fungus has been reported earlier from Australia, New Zealand and Europe (Ellis, 1971; Hughes, 1978). In India, it was recorded earlier on unidentified wood from Balimala, Orissa (Sarbhoy et al., 1986). Here, it is a new record from the forests of Western Ghat in Goa State.

Actinocladium rhodosporum Ehrenb. ex Pers.; Ehrenberg, 1819, *Jb. Gewachskde*, **1:**52; Persoon, 1822. *Mycol. eur.*, **1:** 32; Fries, 1832. *Syst. Mycol.*, **3:** 352. **(Fig. 2)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, erect, straight, hairy, dark brown. *Mycelium* immersed. *Conidiophores* mononematous, arising singly or in groups terminally and laterally on the hyphae, simple, straight or flexuous, unbranched, smooth, 6-septate, medium to dark brown below, paler above, up to 75 long, 7.5 µm wide at the base, 2.5-4.5 µm wide in the middle and above. *Conidiogenous cells* monoblastic, terminal, integrated, cylindrical to doliiform, percurently proliferating, medium brown. *Conidia* solitary, dry, pale to dark brown, each composed of a 1-2-celled stalk, 4-5.5 x 2-3 µm, surmounted by a group of cells 10 µm diam. with 3-6 upwardly radiating arms, each 4-6-septate, smooth, 40-65 µm long, 4-7 µm thick at the base, 2-3.5 µm at the rounded apex.

Specimen examined: On fallen dead leaves of *Careya arborea*, evergreen forest, 31°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1731; leg. Maria D'Souza, 29-12-1999.

The fungus was so far known only from temperate countries (Ellis, 1971, 1976) and it is in this thesis reported for the first time from India.

Alternaria alternata (Fr.) Keissler, 1912. *Beith, Bot. Zbl.* **29**: 434

(Fig. 3)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, in clusters, velvety. *Mycelium* partly immersed, composed of smooth, septate, branched, pale brown, thick walled, 2.5 µm hyphae. *Conidiophores* mononematous, simple to irregularly branched, smooth, pale brown, 40-70 x 3.5-8 µm. *Conidiogenous cells* monotretic, terminal, smooth, septate, pale brown, 6-30 x 1.5-3.5 µm, with cicatrized pores 2.5 µm diam. *Conidia* dry, solitary, ovoid or obclavate, often rostrate, smooth, with transverse and frequently oblique or longitudinal septa, pale or mid brown, 25-56 µm long, 10-17.5 µm wide at the base, 2.3-4.5 µm wide at the tip.

Specimen examined: (i) On fallen dead leaves of *Dendrocalamus strictus*, evergreen forest, 25°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1348; leg. Maria D'Souza, 03-09-1999. (ii) On dead and decaying twigs of *Elaeis guineensis*, moist deciduous forest, 26°C, Tambdisurla, Goa, India; Herb. No. GUFCC No. 2257; leg. Maria D' Souza, 1-10-1999. (iii) On fallen dead leaves of *Careya arborea*, evergreen forest, 24°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2408; leg. Maria D'Souza, 20-12-2000. (iv) On fallen dead and fresh leaves of *Saraca asoca*, moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2146; leg. Maria D'Souza, 08-06-2000.

Alternaria alternata, the most common of the genus, has been isolated several times from different substrates during the study period through moist-chamber incubation and particle plating recovery techniques. It was also reported from an earlier

study carried out in this laboratory (Miriam, 2000).

Aquaphila ramdayalea Maria et Bhat **sp. nov.,** 2001. *Microbes and Plant.* pp. 1-6.

(Fig. 4; Pl. 4.3.3)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, addressed at first, later becoming floccose, with circular margin, rhizoidal, dark brown, slow growing attaining 1 cm in 7 days. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown, 2.5-4 µm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, unbranched, slightly narrower at the base, smooth, 1-4 septate, medium to dark brown at the base, slightly paler towards the apex, 30-110 x 2.5-5 µm. *Conidiogenous cells* mono- to polyblastic, terminal, integrated, cylindrical, medium brown, 30-60 x 4-6 µm, with up to 1.5 µm long 1-10 denticles distributed in the upper half. *Conidia* dry, solitary, fusoid to falcate, rounded at both ends, 5-10-septate, thick-walled, with dense cytoplasm, medium brown, smooth, 35-80 x 3-5 µm.

Specimen examined: On dry leaves of *Flacourtia montana*, moist evergreen, 30°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 162; leg. Maria D'Souza, 11-04-1999.

With its mononematous conidiophores, monoblastic to polyblastic and denticulate conidiogenous cells and fusoid to falcate and multiseptate conidia *A. ramdayalea* clearly belongs to the monotypic genus *Aquaphila* Goh, Hyde & Ho, typified by *A. albicans* Goh, Hyde & Ho (Goh et al., 1998). It differs from the type species by its dematiaceous nature and affinity to terrestrial habitat. The conidiophores, conidiogenous cells and conidia are medium to moderately dark brown in *A. ramdayalea* whereas these in *A. albicans* are moniliaceous. Further, *A. albicans* is a representative of freshwater habitat. The conidia of *A. ramdayalea*, similar to *A. albicans*, superficially

resemble those of *Fusarium* Link in shape, but they differ markedly in conidiogenesis. In *Fusarium*, the conidia are phialidic (Minter et al., 1983) whereas in *Aquaphila* these are mono- to polyblastic. The fungus has already been published (Maria and Bhat, 2001). It was isolated by particle-plating method.

Ardhachandra parva Maria et Bhat **sp. nov.** **(Fig. 5)**

Terrestrial conidial fungus, Hyphomycete. *Colonies* on MEA circular, brownish, with an irregular rhizoidal margin, fast growing attaining a diam. of 5.5 cm in 7 days; reverse of the colony brown. *Mycelium* composed of smooth, septate, branched, pale brown, thin-walled, 0.5-2 µm wide hyphae. *Conidiophores* mononematous, erect, slightly flexuous, 2-4-septate, branched, thin-walled, smooth, light brown, paler to hyaline at the tip, 15-35 µm long, up to 2-5.5 µm wide at base, 2-4.5 µm in middle and 2.5-4.5 µm wide at tip. *Conidiogenous cells* polyblastic, terminal, later becoming intercalary, 6-14 µm long, 1.5-3.5 µm wide below half, 2-3.5 µm wide above half, 2-7-denticulate; denticles cylindrical, with a truncate tip, 0.5-2 x 1.0 µm. *Conidia* solitary, lenticular, aseptate, velvety, hyaline, smooth, with pointed ends, 12-16 x 5-7 µm, 0.5-1 µm at the ends.

HOLOTYPE: On fallen dead leaves of *Saraca asoca,* moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1887; leg. Maria D'Souza, 29-12-1999. Additional specimen examined: On fallen dead leaves of *Xylia xylocarpa*, moist deciduous forest, 28°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1624; leg. Maria D'Souza, 09-12-1999.

The genus *Ardhachandra* Subram. & Sudha (1978), typified by *A. selenoides* (de Hoog) Subram. & Sudha, is characterised by mononematous conidiophores, polyblastic and denticulate conidiogenous cells and lenticular conidia. Seven species are

so far known in the genus. *A. parva* differs from the type and remaining six species by its small-sized conidia which are longitudinally ridged at the centre.

Ardhachandra selenoides (de Hoog) Subram. & Sudha. 1978. *Can.J.Bot.* **56:** 731.

(Fig. 6)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, black at the centre, colourless on the periphery, with a smooth margin, slow growing, attaining a diam. of 1.4 cm in 7 days; reverse of the colony black. *Mycelium* composed of smooth, septate, branched, pale brown, thin-walled, 1-2 µm wide hyphae. *Conidiophores* mononematous, erect, 2-10-septate, branched, thick-walled, smooth, light brown at the base, dark at the tip, 50-125 x 1.5-4 µm. *Conidiogenous cells* polyblastic, terminal, 13-30 x 2-4 µm, 1-3-denticulate; denticles peg like, cylindrical, often upwardly directed, 0.5-1 x 0.5 µm. *Conidia* solitary, lenticular, aseptate, smooth, dark brown, thick-walled, 20-24 x 5-7 µm.

Specimen examined: (i) On fallen dead leaves of *Saraca asoca*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 236; leg. Maria D'Souza, 11-02-1999. (ii) On fallen dead leaves of *Saraca asoca,* moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 282; leg. Maria D'Souza, 08-06-2000. (iii) On fallen dead leaves of *Saraca asoca,* moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1887; leg. Maria D'Souza, 14-02-2000. (iv) On fallen dead leaves of *Saraca asoca,* moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 302; leg. Maria D'Souza, 11-02-1999. (v) On fallen dead leaves of *Sagarea laurifolia*, evergreen forest, 24°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1328, leg. Maria D'Souza, 03-09-1999. (vi) On fallen dead leaves of *Careya arborea* Roxb., evergreen forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1306; leg. Maria D'Souza, 03-09-1999. particle plating. (vii) On fallen dead leaves of *Careya arborea* Roxb., evergreen forest, 28°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1728; leg. Maria D'Souza, 30-12-1999. (viii) On fallen dead leaves of *Careya arborea* Roxb., evergreen forest, 28°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 353; leg. Maria D'Souza, 31-03-1999.

A. selenoides is a common litter inhabitant in the forests and was isolated several times from a variety of substrates by both moist chamber incubation and particle-plating methods.

Arthrobotrys oligospora Fresenius ex Matsushima, 1975. *Icones fungorum a lectus Matsushima.*, p.10 **(Fig. 7)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, shiny. *Mycelium* immersed, composed of smooth, septate, branched, hyaline, 3-4 µm wide hyphae. *Conidiophores* mononematous, erect, straight to flexuous, 8-10-septate, unbranched, thin-walled, smooth, hyaline, up to 310 µm long, 7-10 µm wide at base, up to 5 µm wide in the above half. *Conidiogenous cells* polyblastic, cylindrical, integrated, terminal or intercalary, smooth, hyaline, 13-20 x 2-3.5 µm. *Conidia* oval to clavate, 1-septate, rounded at the tip, flat at the base, 14-33 x 8-13 µm, 1.5-3.5 µm wide at the basal scar, aggregated in slimy mass at the tip of conidiophores.

Specimen examined: (i) On fallen dead leaves of *Curcurma decipens*, moist deciduous forest, 24°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2352; leg. Maria D'Souza, 09-06-1999. (ii) On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2118, leg. Maria D'Souza, 08-06-2000.

The fungus is a common soil inhabitant but often makes appearance on decaying leaf litter. It was isolated by moist chamber incubation method. The fungus has been earlier isolated from soils in Coimbatore, in Tamil Nadu, India (Sarbhoy et al., 1986).

Aspergillus restrictus Smith, 1931. *J. Textile Inst.* **22:** T115 (Ref: Tzean et al., 1990) **(Fig. 8)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, initially

light green, later becoming white to pale brown, with rhizoidal branched margin, slow growing, attaining a diam. of 0.3 cm in 7 days, with droplets aggregated on the surface; reverse offwhite. *Mycelium* completely immersed, composed of smooth, septate, branched, hyaline, up to 3 µm wide hyphae. *Conidiophores* mononematous, erect, straight or flexuous, smooth, 1-4-septate, unbranched, colourless and slightly narrower at the base, pale brown towards the apex, 70-170 x 2-3 µm, swollen at the apex into a spherical to clavate 10-30 x 6-14 µm vesicle. *Conidiogenous cells* monophialidic, discrete, monoseriate, ellipsoidal to ampulliform, smooth, aseptate, hyaline, arising together, without collarettes, 6-10 x 1.5-2.5 µm. *Conidia* dry, catenate, ellipsoidal to doliiform, olive green to pale brown, smooth, aseptate, thin-walled, 5-5.5 x 2-3.5 µm.

Specimen examined: On fallen dead leaves of *Xylia xylocarpa*, moist deciduous forest, 28°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1612; leg. Maria D'Souza, 09-12-1999.

This fungus was reported on feed stuff in Taiwan and India (Tzean et al., 1990). The fungus in hand was isolated by particle-plating method and is the first record on leaf litter.

Bahusakala olivaceonigra (Berk. & Br.) Subram., 1958, *J. Indian Bot. Soc.* **37:** 61-63.

(Fig. 9)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, effuse, adpressed at first, later becoming floccose, with circular margin, rhizoidal, offwhite with dull brown tinge to dark brown, slow growing, attaining a diam. of 1 cm in 7 days; reverse of the colony dark brown. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown, 1.5-2.5 µm wide hyphae. *Conidiophores*

macronematous, mononematous, flexuous, smooth, irregularly branched, pale brown, variable in length, 2.5-3.5 µm thick. *Conidiogenous cells* integrated, intercalary, terminal, cylindrical, determinate, medium brown, fragmenting to form arthroconidia, 9-10 x 2.5-3.5 µm; *arthroconidia* simple, solitary, sometimes in chains, cylindrical, truncate or rounded at both ends, occasionally septate, pale brown, 4-5 x 2-2.5 µm.

Specimen examined: On fallen dead leaves of *Ficus tinctorius* var. *parasitica*, evergreen forest, 28°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2311; leg. Maria D'Souza, 10-08-2000.

The fungus was recovered by both moist chamber incubation and particle plating methods. It was earlier reported from India from Jaipur (Ellis, 1971; Sarbhoy et al., 1996).

Bahusutrabeeja angularis Rao & de Hoog, 1986. *Stud. Mycol.* **28**: 67-68. **(Fig. 10)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate dark brown, effuse. *Conidiophores* mononematous, erect, straight or flexuous, smooth, 7-10-septate, unbranched, dark brown at the base, slightly paler towards the apex, 100-135 x 7-10 µm, tapered towards the apex to 3-4 µm wide. *Conidiogenous cells* terminal or intercalary, integrated, polyphialidic, slightly swollen towards the base, 10-25 x 4-6.5 µm, with conspicuous and flared collarette. *Conidia* rounded to cuboid, smooth, aseptate, thick-walled, colourless, accumulating in a slimymass at the apex of the phialide, 7-10 x 6-7 µm, with 3-5 slender, unevenly distributed, 5-7 µm long, setulae.

Specimen examined: On fallen dead leaves of *Sageraea laurifolia*; moist deciduous forest, 25°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1356; leg. Maria D'Souza, 03-09-1999.

This fungus was first reported from the forests of Western Ghats in Karnataka

State, India. (Rao and De Hoog, 1986). In this study, it was isolated by moist chamber incubation method.

Bahusutrabeeja dwaya Subram. & Bhat, 1977. *Can. J. Bot.* **55:**2202-2206. **(Fig. 11)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate dark brown, effuse, velvety. *Conidiophores* mononematous, erect, straight or flexuous, arising from 30-45 x 25-35 µm stroma, smooth, 10-12-septate, unbranched, dark brown at the base, slightly paler towards the apex, 300-365 x 7.5-12 µm, tapered towards the apex to 4.5 µm wide. *Conidiogenous cells* terminal, integrated, monophialidic, slightly swollen towards the base, 44-65 x 4-8 µm, with an inconspicuous phialide opening and slightly flared collarette 4-6.5 µm wide. *Conidia* globose, smooth, aseptate, thick-walled, colourless with granular cytoplasm, accumulating in a slimymass at the apex of the phialide, 12-14 µm diam., with 6-10 slender, evenly distributed, 6-14 µm long, setulae.

Specimen examined: On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2010, leg. Maria D'Souza, 08-06-1999.

The fungus was originally isolated from leaf litter of *Coffea arabica* from the forests of Western Ghats in Karnataka State (Subramanian and Bhat, 1977). Subsequently, it has been recovered from several places along the Western Ghat forests. Here, it was isolated by moist chamber incubation.

Beltrania rhombica O.Penzig, 1882, *Nuovo G. bot. ital.*, **14:**72-75. **(Pl. 4.4.2)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse,

velvety, light brown. *Mycelium* immersed, composed of smooth, septate, branched, hyaline to pale brown, up to 3 µm wide hyphae. *Setae* simple, smooth, thick-walled, dark brown, arising from flat, radially lobed basal cells, 165-510 µm long, 4.5-20 µm thick at the base, 4-6 µm at the tip. *Conidiophores* mononematous, simple, straight or slightly flexuous, smooth, 4-6-septate, unbranched, dark brown at the base, paler towards the apex, 200-245 x 3-5 µm. *Conidiogenous cells* polyblastic, integrated, terminal, sympodial, clavate to cylindrical, pale brown, denticulate; denticles cylindrical, with swollen, ellipsoid to obovoid separating cells 8-10 x 4-5 µm. *Conidia* solitary, velvety, biconic, obovoid, smooth, aseptate, pale brown to brown, with a distinct hyaline 3 µm wide transverse band immediately above the widest part of the conidium, smooth, papillate at the base, 20-35 x 4-10 µm, the free end with up to 7-12 µm long, tapering to a pointed appendage.

Specimen examined: (i) On fallen dead leaves of *Careya arborea*, evergreen forest, 25°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1344; leg. Maria D'Souza, 03-09-1999. (ii) On fallen dead leaves of *Careya arborea*, evergreen forest, 26°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2432; leg. Maria D'Souza, 20-09-2000. (iii) On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1915, leg. Maria D'Souza, 14-02-2000; (iii) On fallen dead and decaying leaves of *Saraca asoca*, moist decidous forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2489; leg. Maria D'Souza, 11-10-2000.

This is a most common leaf litter fungus known from the tropical forests (Ellis, 1971). It was earlier reported on aquatic foam samples from Silent valley in Kerala State, on *Psidium guajava* in Allahabad, U.P. (Sarbhoy et al., 1986,1996). Here it was isolated by both moist chamber incubation and particle plating methods. The fungus was also reported from an earlier study carried out in this laboratory (Miriam, 2000).

Beltraniella pini M.B.Ellis, 1972, *Mycol. Pap.* **132:** 14-15 **(Pl. 4.4.4)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, velvety, light brown. *Mycelium* immersed, composed of smooth, septate, branched, hyaline to pale brown hyphae. *Setae* simple, smooth, thick-walled, dark brown, arising from flat, radially lobed basal cells, 75-210 µm long, up to 12 µm thick at the base, 2.5-5 µm above. *Conidiogenous cells* polyblastic, integrated, terminal, clavate, pale brown, 7-15 x 4.5-7.5 µm, arising from basal cells of setae, ampulliform with 1-3 denticles. *Conidia* solitary, velvety, biconic, aseptate, hyaline, with a distinct hyaline transverse band above the middle, 19-30 x 4-4.5 µm.

Specimen examined: (i) On fallen dead leaves of *Bauhinia purpurea*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2369; leg. Maria D'Souza, 03-09-2000. (ii) On fallen dead twigs of *Syzygium cumini*, Plantation, 23°C, Tambdisurla Goa, India; Herb. No. GUFCC No. 2232; leg. Maria D'Souza, 08-07-2000.

The fungus was isolated by moist chamber incubation method.

Bharatheeya goanensis (Bhat et Kendrick) D'Souza et Bhat **gen. et sp. nov.** [Accepted for publication in *Mycotaxon* of 2002[. **(Fig. 12)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate gregarious, olivaceous to dark brown, hypophyllous, on MEA moderately fast growing, slightly floccose on the surface, white to slightly greenish, with circular margin, attaining 10 mm diam. in 7 days. *Mycelium* partly immersed, partly superficial, composed of smooth, septate, branched, hyaline hyphae 2.5-4 µm wide. *Conidiophores* mononematous arising in groups of 6-18, erect, curved in the middle, thick-walled, 3-5-septate, unbranched, 160-200µm long, 4-8-lobed and inflated at the up to 15 µm wide

base, 6-8.5 μm wide above, lower half smooth to faintly verruculose, above half distinctly verrucose, dark brown and rounded at tips and slightly paler towards the apex. *Conidiogenous cells* intercalary, integrated, polytretic, with several (1-5) minute, non cicatrized, simple pores just below the septum, 25-32 x 6-8.5 μm, smooth to verrucose, dark brown. *Conidia* dry, solitary, more than one, cylindrical-ovoid to clavate, 3-distoseptate, central two cells thick-walled with reduced lumen, verrucose, medium to moderately dark brown, darker at the base, 23-40 x 14-22 μm.

Specimen examined: On fallen dead and decaying leaves leaves of *Saraca asoca*, evergreen forest, 28°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 206; leg. Maria D'Souza, 11-02-1998; On fresh leaves of *Saraca asoca*, evergreen forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 210; leg. Maria D'Souza, 11-02-1998.

While describing a new species in the genus *Spadicoides* Hughes (1958), Bhat and Kendrick (1993) wrote "*S. goanensis* differs from all other species of *Spadicoides* in (1) its partly verrucose conidiophores, (2) the presence of only one, monotretic conidiogenous cell on each conidiophore, and (3) the production of only a single conidium by the conidiogenous cell". The fungus was isolated using moist chamber incubation and the endophytic isolation methods. The culture of *S. goanensis* gathered from the type locality revealed a hitherto unknown feature of the fungus, namely production of several solitary, 3-distoseptate, conidia on non-cicatrized polytretic conidiogenous cells. This, along with recovery of a so far unknown fungus with similar conidiogenesis, 2-4-distoseptate conidia with a mucoid apical cap and otherwise similar characters warranted redescription of *S. goanensis* and its redisposition along with the new fungus in a new genus *Bharatheeya*.

Bharatheeya mucoidea D'Souza et Bhat **sp. nov.** (Accepted for publication in *Mycotaxon* 2002). **(Fig. 13)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse to gregarious, greyish to brown, hypophyllous, on MEA moderately growing, attaining a diam. of 15 mm in 7 days, with rhizoidal margin, raised, grayish white, cottony, velvety, producing conidiophores in concentric rows, reverse of the colony off-white. Mycelium partly immersed, partly superficial, composed of smooth, septate, branched, hyaline hyphae 2.5-3.5 µm wide. *Conidiophores* mononematous, arising in groups of 6-15, erect, curved to curled in the middle, thick-walled, dark brown, 10-18-septate, unbranched, 240-370 µm long, 6-12 µm wide at the inflated base, 7-10 µm wide above, rounded and slightly paler at the tip, smooth to faintly verrucose in the below half, distinctly verrucose in the above half. *Conidiogenous cells* intercalary, intergrated, dark brown, verrucose, polytretic, with more than one, distinct, minute, non-cecatrized, simple, pores below the septum. *Conidia* dry, solitary, pyriform to clavate, 2-4-distoseptate, thick-walled, with reduced lumen, smooth, medium to dark brown, 22-40 µm long, 10-18 µm wide in the middle, 4-8 µm wide at the base, with a conspicuous, thick, hyaline, up to 10 µm diam. mucilaginous cap at the tip.

Specimen examined: On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 28°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 209, leg. Maria D'Souza, 08-06-1999; On fresh leaves of *Calamus thwaitesii* Becc., evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 215; leg. Maria D'Souza, 08-06-1999.

This new litter fungus has been isolated in culture by moist chamber incubation, particle-plating and endophytic isolation methods. *Bharatheeya mucoidea* differs from the type species, *B. goanensis* by its pyriform to clavate, smooth, conidia, each with a

conspicuous, colourless, thick, mucilaginous cap at the tip.

Brachysporiella gayana Batista, 1959, M.B. Ellis, *Mycol. Pap.* **72:**16

(Fig. 14; Pl. 4.1.5)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, greyish black, velvety. *Mycelium* immersed. *Conidiophores* mononematous, erect, straight or slightly flexuous, smooth, 8-9-septate, unbranched, dark brown at the base, paler towards the apex, 70-140 µm long, 10-12 µm wide at the base, 3.5-6 µm thick in the middle and above. *Conidiogenous cells* monoblastic, percurrent, terminal, integrated, elongated to ellipsoidal. *Conidia* dry, solitary, velvety, clavate, smooth, 3-septate, brown, 23-34 µm long, 3-4 µm wide at the base, 10-14 µm wide above.

Specimen examined: On dry twigs of *Dendrocalamus strictus,* moist deciduous forest, 23°C, Molem wildlife sanctuary, Goa, India; Herb. No. GUFCC No. 201; leg. Maria D'Souza, 11-02-1999.

The fungus was isolated by moist chamber incubation method. It has been reported earlier from Brazil, Ghana and other temperate countries (Ellis, 1971). This is the first record from the forests of Western Ghats in India.

Canalisporium caribense (Hol.-Jech. & Mercado) Nawawi & Kuthub.1989. *Mycotaxon,* **34:** 479. **(Fig. 15)**

Terrestrial, conidial fungus, Hyphomycete. *Sporodochia* on natural substratum punctiform, minute, granular, black, scattered mass in groups, glistening. *Mycelium* mostly immersed in the substratum. *Conidiophores* micronematous, fasciculate, smooth, simple or sparsely branched, hyaline to subhyaline. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, cylindrical, often swollen, 3-5 x 4-6 µm. Conidial

secession rhexolytic. *Conidia* solitary, muriform, flattened, one cell thick, broadly ellipsoidal to obovoid in surface view, cylindrical to clavate in lateral view, smooth, thick-walled, pale to dark brown, possessing a single column of vertical septa and 3-6 equally spaced rows of transverse septa, slightly constricted at the septa which progressively becoming darker with maturity, 40-47 x 14-25 µm, each cell 4-13 x 1.5-8.5 µm; basal cell subhyaline to very pale brown, thin-walled.

Specimen examined: On fallen dead and decaying twigs of *Saraca asoca*, moist decidous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1498; leg. Maria D'Souza, 25-10-1999.

This fungus was reported from Hong Kong by Goh et al. (1998) during his observations on decaying plant material. It was isolated by moist chamber incubation method and is the first record from India.

Catenularia malabarica Subram. & Bhat, 1987, *Kavaka*, **15:** 41-74. **(Pl. 4.2.2)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, erect, straight, hairy, shiny. *Mycelium* immersed. *Conidiophores* mononematous, simple, straight or flexuous, smooth, 2-5-septate, unbranched, thick-walled, medium to dark brown at the base, slightly paler towards the apex, percurrently proliferating 1-2 times, 53-170 x 8-12 µm, with septa 27 µm apart, arising singly or in fascicles. *Conidiogenous cells* monophialidic, terminal, integrated, percurrent, smooth, thick-walled, brown, broad at the base narrowed at the neck, with a prominent collarette above, 20-47 x 3-6 µm, 3-4 µm wide at the base, 1.5-5.3 µm wide at the neck region. *Conidia* endogenous, simple, solitary or sometimes in false chains cuneiform, smooth, non-septate, thick-walled, dark brown, truncate at the base, 4-5 µm long, 14 µm wide at the distal end, 4.5 µm wide at

the flattened base; conidia in section angular with 4-5 blunt corners at the distal end, with a thin-walled pale area (pore) at each corner, 10.6-12.6 x 9.3-13.3 μm.

Specimen examined: On fallen dead leaves of *Careya arborea,* moist decidous forest, 24°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2609; leg. Maria D'Souza, 21-11-2000.

The fungus was described from identified twigs from Silent Valley, Kerala (Subramanian and Bhat, 1987). It was isolated in this study by moist chamber incubation method and is the first record to Western Ghats region of Goa.

Chaetendophragmia triseptata Matsushima, 1975. *Icones fungorum a lectus Matsushima.* p.25. **(Fig. 16)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, inconspicuous. *Mycelium* mostly immersed. *Conidiophores* mononematous, usually simple, straight or flexuous, smooth, 1-4-septate, unbranched, rather pale golden brown, arising from swollen, radially lobed cells, 64-85 μm long, 7-10 μm at the base and 3.5-5 μm wide at the fertile apex. *Conidiogenous cells* monoblastic, integrated, terminal and percurrent, cylindrical, medium brown, 3.5-5 x 4.5-5 μm, with 7-16 percurrent proliferations. *Conidia* dry, solitary, obclavate or narrowly conical, rostrate, appendiculate, truncate at the base, acrogenous or acropleurogenous, smooth, 3-4-septate, golden brown, thick-walled, 25-36 long without the rostrum, up to 4.8 μm thick in the broadest part and up to 6 μm wide at the above, with 3 subulate, hyaline, lateral and 1 terminal, 10-35 μm long, hyaline, smooth appendages tapering to a fine point.

Specimen examined: On fallen dead leaves of *Bauhinia purpurea*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2366; leg. Maria D'Souza, 03-09-2000.

First reported by Matsushima (1975), this interesting leaf litter fungus was often encountered in foam samples of freshwater streams of Western Ghat forests. It was isolated by moist chamber incubation method and is the first record to the Western Ghats in Goa.

***Chalara* sp.** **(Fig. 17)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, light brown, velvety. *Mycelium* completely immersed. *Stroma* dark brown, 14-17 µm diam. *Conidiophores* simple, erect, straight, sub-cylindrical, solitary, scattered or aggregated into compact fascicles, uniformly brown, smooth, septate, thick-walled, 84-120 µm long, 5-7 µm wide. *Conidiogenous cells* monophialidic, terminal, integrated, venter 24-27 x 7.2 µm, with an elongated, cylindrical, smooth, medium brown, 9-27 x 4.8 µm collar. *Conidia* shining, white, cylindrical, rounded at both ends, 1-3-septate, thin-walled, hyaline, in loose linear chains, 15-25 x 2.4 µm.

Specimen examined: On fallen dead leaves of *Syzygium cumini*, evergreen forest, 23 °C, Tambdisurla, Goa, India; Herb. No. GUFCC No. 2241; leg. Maria D'Souza, 08-07-2000.

The fungus was isolated by moist chamber incubation method. Nag Raj and Hughes, (1973) have described 5 new species in the genus *Chalara* (Corda) Rabenhorst. Matsushima (1975) added 3 new species. The species in hand could not be placed in any of these known species and therefore recognised as a hitherto unknown species.

***Clamydomyces* sp.** **(Fig. 18)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, flat, greenish black, with a rhizoidal margin, with concentric thread-like radiating rings

from the centre, slow growing, attaining a diam. of 2 cm in 10 days; reverse of the colony central black and periphery offwhite. *Mycelium* mostly immersed, composed of smooth, septate, branched, pale to medium brown, 1.5-2.5 μm wide hyphae. *Conidiophores* mononematous, smooth, septate, simple or loosely branched, pale brown. *Conidiogenous cells* monoblastic, discrete, terminal, cylindrical, medium brown, 4.5-8 x 4-10 μm. *Conidia* dry, solitary, obovoid to spherical, smooth-walled, medium brown, 13-27 x 15-27 μm.

Specimen examined: On fallen dead leaves of *Saraca asoca*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 288; leg. Maria D'Souza, 11-02-1999.

The fungus was isolated by particle-plating method. It bears close similarity with one of the species of *Idriella* Nelson & Wilhelm (Ellis, 1971), i.e. *Idriella mycogonoidea* Matsushima, (1971) in the production of similar chamydospore-like structures but it differs in the absence of the conidiophores and conidia. Therefore, tentatively it is placed here as a species of *Chamydomyces* Bainier (Ellis, 1976).

Choridium ghaticum Maria et Bhat **sp. nov.** **(Fig. 19)**

Terrestrial conidial fungus, Hyphomycete. *Colonies* on MEA regular, effuse, with circular margin, attaining a diam. of 1.5 cm in 7 days, dark brown, with peripheral white rim. *Mycelium* partly immersed, composed of smooth, septate, rhizoidal to densely branched, pale to medium brown 2.5-4 μm wide hyphae. *Conidiophores* mononematous, lateral, erect, straight or flexuous, smooth, 1-2-septate, unbranched, slightly narrower at the base, medium brown, dark brown at the base, paler towards the apex, 20-75 μm long, 3.6-4.8 μm wide at the base and 2.4 μm wide at the tip.

Conidiogenous cells endogenous, polyblastic, terminal, integrated, paler brown to hyaline, 24-35 x 2.4 μm, with a distinct flares tip up to 2 μm wide. *Conidia* slimy, more than one, synchronously developing, cuneate-shaped, smooth, aseptate, thin-walled, hyaline, 4-5 x 2.5 μm.

HOLOTYPE: On fallen dead leaves of *Ficus tinctorius* var. *parasitica*, evergreen forest, 28^{0}C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2307; leg. Maria D'Souza, 10-08-2000.

The genus *Choridium* Link ex Fries, typified by *C. viride* Link ex Link (Ellis, 1971), is characterised by mononematous conidiophores producing synchronously developing endogenous conidia in 3-4 columns. Several species are known in the genus (Matsushima, 1975). *C. ghaticum* differs from the hitherto known species with its cuneate conidia which are slightly larger in size.

***Chrysosporium* sp.** **(Fig. 20)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, with serrated margin, white, flat, median growing, attaining 3 cm diam. in 7 days; reverse of the colony white. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline, 1-1.5 μm wide hyphae. *Conidiophores* macronematous, simple, smooth, branched, hyaline, thin-walled, 1.5 μm wide. *Conidiogenous cells* monoblastic, terminal, intergrated, cylindrical, smooth, hyaline. *Conidia* solitary, slimy, simple, white, pyriform to clavate, rounded at the distal end and truncate at the point of attachment, smooth, aseptate, thin-walled, hyaline, 3-5 x 0.5-2 μm.

Specimen examined: On fallen dead leaves of *Ficus tinctorius* var. *parasitica*, evergreen forest, 28^{0}C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2308; leg. Maria D'Souza, 10-08-2000.

The fungus was isolated by particle plating method.

Cladosporium elegans Matsushima, 1975. *Icones fungorum a lectus Matsushima.* p.3 **(Fig. 21)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* natural substrate effuse, dark brown. *Mycelium* immersed. *Conidiophorse* erect, straight or flexuous, smooth, 6-septate, unbranched, medium to dark brown at the base, slightly paler towards the apex, 80-110 x 2.5-4 µm. *Conidiogenous cells* polyblastic, terminal, integrated, cylindrical, 15-20 x 2.5-3.6 µm, with cicatrized scars up to 1.33 µm wide. *Ramoconidia* smooth, non-septate, hyaline, 5-8 x 2-3 µm. *Conidia* dry, solitary, cylindrical to ellipsoidal, smooth, 1-septate, thick-walled, hyaline, with dense cytoplasm, 4-6 x 1-2 µm.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*; moist deciduous forest, 30°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 368; leg. Maria D'Souza, 11-03-1999.

First reported by Matsushima (1975), the fungus was isolated by moist chamber incubation method.

Conioscypha bambusicola Matsushima, 1975. *Icones fungorum a lectus Matsushima.* p.38 **(Fig. 22)**

Terrestrial conidial fungus, Hyphomycete. *Colonies* on MEA irregular, adpressed, greenish black, slimy, with rhizoidal margin, slow growing, attaining 1 cm diam. in 7 days; reverse pale black. *Mycelium* fully immersed, with smooth, septate, branched hyaline, thin-walled, 1.5-2.5 µm wide hyphae. *Conidiophores* mononematous, flexuous, thick-walled, smooth, hyaline, 5-10 x 2-4 µm. *Conidiogenous cells* monphialidic, integrated, distinctly cup-shaped, with a slightly flared collarette rim, hyaline, percurrently proliferting 2-6 times. *Conidia* slimy, solitary, ellipsoidal to ovate, truncate at the base, acuminate at the tip, aseptate, smooth, dark brown, 10-16.5 x 7.5-10 µm.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, evergreen forest, 25°C, Molem Wildlife Sanctuary, Goa, India , Herb. No. GUFCC No. 2505; leg. Maria D'Souza, 11-03-1999.

The fungus was isolated by moist chamber incubation and brought to culture by single spore isolation. This is the first record from the Western Ghat forests in Goa.

Craspedodidymum abigianense Lunghini & Onofri, 1980. *Trans. Brit. mycol. Soc.* **74:** 208-211. **(Fig. 23)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate dark black, effuse, velvety, superficial on the exposed surface of the twig. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline, hyphae 2.5 µm thick. *Conidiophores* mononematous, unbranched, erect, straight or slightly flexuous, smooth, dark brown at the base, paler towards the apex, 4-6-septate, 100-170 x 2.5-5 µm, tapering gradually towards the apex. *Conidiogenous cells* terminal, elongated to ellipsoidal, mono- to polyphialidic, percurrent, 10-50 x 2.5-7 µm, pale brown with a distinct funnel-shaped collarette 5 µm high and 2.5 µm thick. *Conidia* dry, solitary, velvety, spherical to obovoid, smooth, aseptate, brown, papillate at the base, 12-17 x 8-10 µm.

Specimen examined: On fallen dead and decaying twigs of *Careya arborea*, evergreen forest, 28°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2625; leg. Maria D'Souza, 23-3-2001.

The fungus was isolated by moist chamber incubation method. Several species of the genus *Craspedodidymum* were described earlier from the forests of Western Ghats in southern India (Subramanian and Bhat, 1987; Bhat and Kendrick, 1993).

Curvularia lunata (Wakker) Boedijn, (Ellis, M.B., 1971. *Dematiaceous Hyphomycetes.* p. 456. **(Pl. 4.3.1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown, erect, straight, hairy, shiny. *Mycelium* immersed. *Conidiophores* mononematous, simple, straight or flexuous, smooth, 4-7-septate, unbranched, thick-walled, medium to dark brown at the base, slightly paler towards the apex, geniculate, up to 96 µm and 2.5-3.5 µm wide. *Conidiogenous cells* polytretic, terminal, integrated, Later becoming intercalary, sympodial, swollen, cicatrized, smooth, thick-walled, pale brown, 24 x 2.5-5 µm. *Conidia* simple, solitary, often curved, clavate with 3 transverse septa, with dark brown cells in the middle and paler towards the sides, smooth, 24-36 x 4.5-12 µm, hilum present.

Specimen examined: (i) On dead and decaying twigs of *Elaeis guineensis*, moist deciduous forest, 26°C, Tambdisurla, Goa, India; Herb. No. GUFCC No. 2262; leg. Maria D' Souza, 08-07-2000. (ii) On fallen dead and decaying leaves of *Zanthoxylum rhetsa*; grassland plateau type, 25°C Alorna, Goa, India; Herb. No. GUFCC No. 1549; leg. Maria D'Souza, 19-11-1999. (iii) On fallen dead and leaves of *Dendrocalamus strictus*, moist deciduous forest, 30°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2063; leg. Maria D'Souza, 11-04-2000.

The fungus is cosmopolitan in distribution and common on a variety of substrates (Ellis, 1971). It has been isolated in this study both by moist chamber and particle plating methods.

***Cylindrotrichum* sp. 1** **(Fig. 24)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, with serrated margin, rhizoidal, white, flat, fast growing, attaining 8 cm diam. in 7 days; reverse of the colony white. *Mycelium* partly immersed, composed of smooth, septate,

branched, hyaline, 2.3 µm wide hyphae. *Conidiophores* micronematous to semi-macronematous, simple, smooth, branched, hyaline, thin-walled, 8-10 x 2-6.5 µm, with terminal phialides. *Conidiogenous cells* monophialidic, terminal, intergrated, elongated to cylindrical, smooth, aseptate, hyaline, 13-35 x 2-3.5 µm, 1-1.5 µm wide at the tip. *Conidia* solitary, slimy, simple, white, fusiform to cylindrical, rounded at both ends, smooth, aseptate, thin-walled, hyaline, 26-34 x 4-5 µm.

Specimen examined: On fallen dead leaves of *Sanseiviera zeylanica*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1361; leg. Maria D'Souza, 15-9-1999.

The fungus has been isolated by particle plating method.

***Cylindrotrichum* sp. 2** **(Fig. 25)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, with serrated margin, rhizoidal, white, flat, fast growing, attaining 8 cm diam. in 7 days; reverse of the colony white. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline to sub-hyaline, 2.5 µm wide hyphae. *Conidiophores* sporodochial, semi-macronematous, simple, smooth, branched, hyaline to pale brown, thin-walled, with terminal phialides. *Conidiogenous cells* monophialidic, terminal, elongated to cylindrical, smooth, hyaline, 15-30 x 2-3.5 µm. *Conidia* solitary, slimy, simple, white, fusiform to cylindrical, rounded at both ends, smooth, 7-8-septate, thin-walled, hyaline, 65-90 x 6-7 µm, slightly notched at the point of attachment, 1.5-2 µm.

Specimen examined: On fallen dead leaves of *Flacourtia montana*; moist deciduous forest, 25.5°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.382; leg. Maria D'Souza, 11-04-1999.

The fungus has been isolated by particle plating method.

***Dactylaria* sp.** **(Fig. 26)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, leafy green, flat, with concentric rings, slow growing, attaining a diam. of 1.2 cm in 7 days; reverse of the colony green. *Mycelium* partly immersed. *Conidiophores* micronematous, smooth, colourless, 1.5-8.5 x 1-2 µm. *Conidiogenous cells* polyblastic, terminal, integrated, determinate, often curved, cylindrical, lobed or branched at the apex, 10-20 µm long, 1.5-3 µm wide at the base, 3-8 µm above. *Conidia* dry, solitary or in small groups, smooth, simple, straight to slightly flexuous, rounded at the apex, truncate at the base, smooth, 3-septate, thin- walled, hyaline, 26-36 µm long, 1.5 µm at the base, 2-3 µm in the middle and above, radially disposed at the tip of the conidiogenous cell, minutely denticulate at the base.

Specimen examined: (i) On fallen dead leaves of *Saraca asoca*, moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2125; leg. Maria D'Souza, 08-06-2000. (ii) On fallen dead leaves of *Saraca asoca*, moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.298; leg. Maria D'Souza, 11-02-1999. (iii) On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 23 °C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1946 leg. Maria D'Souza, 14-02-2000. (iv) On fallen dead leaves of *Bauhinia purpurea*, evergreen forest, 25.3°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2209; leg. Maria D'Souza, 03-09-2000. (v) On fallen dead leaves of *Syzygium cumini*; moist deciduous forest, 30°C, Tambdisurla, Goa, India; Herb. No. GUFCC No.1039; leg. Maria D'Souza, 08-07-2000. (vi) On fallen dead and decaying leaves of *Mangifera indica*, evergreen forest, 25.5°C, Taleigao, Goa, India, , Herb. No. GUFCC No.1136; leg. Maria D'Souza, 10-07-1999. (vii) On dead and decaying leaves of *Elaeis guineensis*, moist deciduous forest, 26°C, Tambisurla, Goa, India; Herb. No. GUFCC No.2245; leg. Maria D'Souza, 08-07-2000.

The fungus has been isolated several times by both moist chamber incubation and by particle plating method. Several species of the genus *Dactylaria* have been isolated from forest litter. The fungus in hand has close similarity with the species

Dactylaria obtriangularia Matsushima (1975) with respect to the type of conidial production and conidia, but it differs in having characteristically having 3-septate conidia.

Dendrosporium lobatum Plakidas et Edgerton ex Crane, 1936, *Mycologia*, **28:** 84. **(Fig. 27)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, hyaline, flat, slow growing, attaining a diam. of 1.5 cm in 7 days; reverse of the hyaline. *Mycelium* partly immersed composed of smooth, septate, branched, hyaline, hyphae up to 1.5 µm. *Conidiophores* mononematous, smooth, colourless, with conscpicous denticles. *Conidiogenous cells* polyblastic, terminal, determinate. *Conidia* dry, solitary, smooth, simple, straight, phragmospore, broader at the base and narrower at the tip, distinctly branched, symmetrical, truncate at the base, smooth, aseptate, thin- walled, hyaline, 8-12 x 3-7 µm long, 1-1.5 µm at the tip, with a basal stalk like up to 1.5 µm long.

Specimen examined: On fallen dead leaves of *Careya arborea,* moist decidous forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2638; leg. Maria D'Souza, 20-09-2000.

The fungus has been isolated by both moist chamber incubation method and particle plating method.

Dictyoarthrinium rabaulense Matsushima, 1971, apud Kobayasi et al. *Bull. Natn. Sci. Mus. Tokyo* **4:** 464. **(Fig. 28)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate dark brown, velvety. *Mycelium* composed of smooth, septate, branched, hyaline, up to 2 µm

wide hyphae. *Conidiophores* basauxic, mononematous, branched, arising usually singly from subspherical to cupulate conidiophore mother cells, straight or slightly flexuous, narrow, cylindrical, smooth, with 7-12 dark brown transverse septa or bands, hyaline, 60-75 x 3-4.5 µm. *Conidiogenous cells* mono- to polyblastic, integrated, terminal and intercalary, cylindrical, 3.5-5 x 3-3.5 µm. Conidia dry, solitary, spherical, 6.5-14.5 µm diam., dark brown to almost black, peripheral edge slightly rough in nature.

Specimen examined: (i) On fallen dead and leaves of *Dendrocalamus strictus*, moist deciduous forest, 26.5°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1236; leg. Maria D'Souza, 5-08-1999. (ii) On fallen dead leaves of *Xylia xylocarpa*, moist deciduous forest, 28 °C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1607; leg. Maria D'Souza, 09-12-1999.

The fungus has been isolated by moist chamber incubation method. The fungus has been reported for the first time Matsushima, 1971. It is a new recod to the Western Ghats in Goa.

Dictyochaeta assamica (Agnihothrudu) Hughes & Kendrick, 1968, *N.Z.Jl. Bot.*, **6:** 334-335. **(Fig. 29)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, mid to dark brown, composed of setae and groups of conidiophores arising individually from flat, dark brown stromata up to 30 µm long, 14 µm wide, velvety. *Mycelium* partly immersed, partly superficial, composed of smooth, septate, branched, pale to medium brown 2.4-3.6 µm wide hyphae. *Conidiophores* mononematous, straight or flexuous, smooth, 5-11-septate, unbranched, medium to dark brown at the base, slightly paler towards the apex, 60-335 x 2.5-5.5 µm, 4.5-7.5 µm wide at the base. *Conidiogenous cells* polyphialidic, integrated, terminal, often becoming intercalary, sympodial,

cylindrical, with conspicuous collarettes, medium brown, 5-18 x 2.5-4.5 μm, 1.5-2.5 x 2.5 μm at the collarette region. *Conidia*, semi-endogenous, simple, cylindrical, falcate, rounded at both ends, curved, smooth, aseptate, colourless, 11-15 x 2-5 μm, with a fine setulae at each end, 6.5-8.5 μm long, aggregated in slimy groups.

Specimen examined: (i) On fallen dead leaves of *Saraca asoca*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2475; leg. Maria D'Souza, 11-10-2000. (ii) On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 30 °C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 204, leg. Maria D'Souza, 11-02-1999. (iii) On dead and decaying leaves of *Elaeis guineensis*, moist deciduous forest, 26°C, Tambisurla, Goa, India; Herb. No. GUFCC No.2294; leg. Maria D'Souza, 08-07-2000. (iv) On fallen dead and decaying leaves of *Calamus thwaitesii*, evergreen forest, 24.8 °C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1483, leg. Maria D'Souza, 25-10-1999; (v) On fallen dead leaves of *Xylia xylocarpa*, moist deciduous forest, 28 °C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1616; leg. Maria D'Souza, 09-12-1999.

The fungus has been repeatedly isolated by moist chamber incubation method and found most abundantly occurring on the substrates observed. It was also reported from an earlier study carried out in this laboratory (Miriam, 2000).

Dictyosporium elegans Corda, 1836, *Weitenweber's Beitrage*, : 87.(Ellis, M.B., 1971)

(Fig.30; Plate 4.4.3)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, circular, initially white, later becoming yellow to intense orange, often granular, attaining a diameter of 1.2 cm in 7 days, with a rhizoidal margin, velvety; reverse of the colony orange. *Mycelium* partly immersed, slightly raised in the centre, mostly composed of smooth, septate, branched, pale to medium brown, 1.5-2 μm wide hyphae. *Conidiophores* micronematous, flexuous, smooth, aseptate, irregularly branched, pale brown. *Conidiogenous cells* monoblastic, integrated, terminal, sometimes intercalary,

determinate, cylindrical, doliiform, spherical or subspherical, 10-14 x 3-4 μm. *Conidia* dry, solitary, cheiroid, smooth, multiseptate, branched, light to dark brown, 33-55 μm long, 10-24 μm wide at the base, 12-18 μm wide at the distal end, flattened in one plane, broadly ellipsoidal, with 3-6 curved rows of cells with each row terminating at the apical end; the row of cells separate only under pressure; cells 37-70, each 2-5 μm thick.

Specimen examined: (i) On fallen dead and decaying leaves of *Elaeis guineensis* Jacq., moist deciduous forest, 30°C, Tambisurla, Goa, India; Herb. No. GUFCC No.2251; leg. Maria D'Souza, 08-07-2000; (ii) On fresh leaves of *Elaeis guineensis* Jacq., moist deciduous forest, 30°C, Tambisurla, Goa, India; Herb. No. GUFCC No.2270; leg. Maria D'Souza, 08-07-2000.

The fungus has earlier been reported on dead wood and herbaceous plants, found several times on barley and oat stubble in Europe, Africa and North America. (Ellis, 1971). The fungus has been isolated both by particle-plating method and also encountered on endophytic isolation method. This is the first report to India.

Didymobotryum spirillum D'Souza et Bhat **sp. nov.**, 2002. *Mycologia,* **94(3)**: **(Fig. 31)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, olivaceous to dark brown, velvety, mostly immersed, composed of septate, branched, thick-walled, subhyaline hyphae up to 3.5 μm wide. *Conidiomata* synnematous, mostly in groups of 3-4, sometimes arising singly, erect, straight or flexuous, fertile at the apex; olivaceous to dark brown, 650-980 μm long, up to 60 μm wide at the base, 35-55 μm wide in the middle, stipe compact, spirally twisted, flared to a spherical head up to 200 μm wide at the apex, composed of septate, branched, smooth, olivaceous brown hyphae 2-2.5 μm wide. *Conidiogenous cells* monotretic, terminal, integrated or discrete, cylindrical to clavate, olivaceous brown, thick-walled, verrucose in the upper half, slightly truncate

and 2.5-4 µm wide at the aperture on conidial secession, 7-10 x 3.5-5 µm. *Conidia* catenate, dry, acrogenous, cylindrical, rounded at the tip, slightly truncate at the base, thick-walled, verrucose, 1-septate, slightly constricted at the septa, olivaceous brown, 10-18 x 4.5-6 µm; intercalary conidia in chains slightly truncate at both ends on secession.

HOLOTYPE: In putrido culms *Dendrocalamus strictus*, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India; IMI 384381, leg. Maria D'Souza, 11-04-2000. Additional specimens examined: (i) On dead culms of *Dendrocalamus strictus*, Bhagwan Mahavir Wildlife Sanctuary , Mollem, Goa, India; Herb. No. GUFCC 0256; leg. Maria D'Souza, 20-09-2000. (ii) On dead culms of *Dendrocalamus strictus*, Bhagwan Mahavir Wildlife Sanctuary , Mollem, Goa, India; Herb. No. GUFCC 0267; leg. Maria D'Souza, 19-10-2000. (iii) On dead culms of *Dendrocalamus strictus*, Bhagwan Mahavir Wildlife Sanctuary , Mollem, Goa, India; Herb. No. GUFCC 0289; leg. Maria D'Souza, 20-11-2000. (iv) On dead culms of *Dendrocalamus strictus*, Bhagwan Mahavir Wildlife Sanctuary , Mollem, Goa, India; Herb. No. GUFCC 0316; leg. Maria D'Souza, 21-12-2000. (v) On dead culms of *Dendrocalamus strictus*, Bhagwan Mahavir Wildlife Sanctuary , Mollem, Goa, India; Herb. No. GUFCC 0357; leg. Maria D'Souza, 23-01-2001.

Amongst the several species described in the genus *Didymobotryum* Sacc., lectotypified by *D. rigidum* (Berk. & Br.) Sacc., *D. spirillum* may be compared with *D. rigidum* and *D. verrucosum* Hino & Katumoto (Ellis 1971). *Didymobotryum rigidum* is characterized by catenate, smooth conidia with a distinguished thick brown band at the septum, developing on synnema with a clavate head and untwisted stipe. In *D. verrucosum*, the verrucose and catenate conidia are broadly ellipsoidal to cylindrical with a septum, and the conidiophores are straight and parallely compacted before terminating into a clavate head. *Didymobotryum spirillum* has verrucose and catenate conidia that are similar to those of *D. verrucosum* but differs from the latter by its spirally twisted stipes that terminate in a spherical head. The spiral nature of the stipe in the synnema was very consistent and observed in all subsequent collections, including

those made in the dry seasons. We compared *D. spirillum* with our own collections of *D. verrucosum* on bamboo from the Western Ghats in southern India, and the overall distinctiveness of the two species was very evident. The fungus has been isolated moist chamber isolation method.

Dischloridium minutum Maria et Bhat **sp. nov.** **(Fig.32)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on substrate effuse, dark brown, velvety. *Conidiophores* mononematous, erect, straight or flexuous, smooth, 2-10-septate, unbranched, slightly narrower at the base, medium to dark brown at the base, 40-137 x 3.5-4μm, slightly paler towards the apex about 2.5 μm, with 1-3 percurrent proliferations, 26-16.5 x 3.5-4 μm. *Conidiogenous cells* monophialidic, terminal, integrated, cylindrical, medium brown, 15-27 x 2.5-4 μm, with a conspicuous flared collarette, 1.5-2.5 x 2.5-4 μm. *Conidia* solitary, cylindrical, with broadly rounded ends, smooth, aseptate, thick-walled, pale brown, arising in false chains, 5 -7.5 x 2.5-4 μm.

HOLOTYPE: On fallen dead and decaying leaves of *Careya arborea*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2605; Maria D'Souza, 21-11-2000.

The genus *Dischloridium* was introduced by Sutton for *Chloridium laeense* Matsushima (1971) as *Dischloridium laeense* (Matsushima) Sutton. In all 8 species are known so far. Out of these, 5 have aseptate conidia. *D. minutum* differs from rest of species with aseptate conidia in their colour and size.

Edmundmasonia pulchra Subram., 1958, *J. Indian Bot. Soc.* **37**:401 **(Fig. 33)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse,

light brownish to grey on dark brown. *Mycelium* mostly immersed. *Conidiophores* mononematous, arising singly, erect, straight or flexuous, smooth, 8-10-septate, thick-walled, dark brown below, paler towards the apex, 90-150 µm long, 4-11 µm wide at the base, 2-5 µm wide in the middle and above. *Conidiogenous cells* monoblastic, terminal, integrated, sometimes discrete, cylindrical to clavate, solitary or sometimes in chains, smooth, thin-walled, pale brown, 6-8.5 µm long, at the base up to 3.5 µm wide, 1-2 µm at the apex. *Conidia* simple, solitary, dry, clavate, rounded at the tip, truncate at the base, sometimes with remnants of conidiogenous region, smooth, 3-septate, not constricted at the septa, thick-walled, light brown, 6-20 µm long, 1-1.5 µm wide at the base, 2-6 µm wide in the middle, 5-10 µm wide in the apex.

Specimen examined: On fallen dead and dry twigs of *Careya arborea*, moist deciduous forest, 23.4°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2607; leg. Maria D'Souza, 30-12-2000.

The fungus has been isolated by moist chamber incubation method and is the first record to the Western Ghats in Goa.

Elegantimyces sporidesmiopsis Goh, Tsui & Hyde, 1998. *Mycol. Res.***102:** 239-242.

(Fig. 34)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, velvety, dark brown. *Mycelium* mostly immersed. *Conidiophores* mononematous, arising singly, erect, straight, smooth, 6-9-septate, thick-walled, dark brown, paler at the apex, 125-200 µm long, 12-14 µm wide at the base, up to 4.5 µm wide in the middle and above, *Conidiogenous cells* monoblastic, terminal and intercalary, integrated or discrete, developing below the septa in whorls, cylindrical to clavate, smooth, thin-walled,

hyaline, 6-8 x 2.5-4 μm. *Conidia* simple, solitary, dry, acrogenous, monoblastic, obclavate, truncate at the base, smooth, 3-septate, slightly constricted at the septa, thick-walled, central cells dark brown, adjacent cells pale brown, subhyaline in the basal and the apical cells, 20-26 x 4-10.5 μm, up to 3-5 μm wide at the apex, with apical cells bearing synanamorph. Conidial secession rhexolytic, leaving a distinct frill up to 1 μm long at the base of primary conidia. *Synanamorph Idriella*-like, conidia formed from sympodially proliferating conidiogenous cells, asetulate, hyaline, aseptate, slightly curved, cylindrical to falcate, rounded at the apex, truncate at the base, 4.5-5 x 1-1.5 μm, with a minute frill resulting from rhexolytic secession.

Specimen examined: (i) On fallen dead leaves of *Careya arborea*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2612; leg. Maria D'Souza, 20-01-2001. (ii) On fallen dead leaves of *Careya arborea*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2617; leg. Maria D'Souza, 20-01-2001.

The fungus has been isolated by moist chamber incubation method. The fungus was originally thought of as a *Sporidesmiella,* but now placed in the new genus (Goh et al., 1998).

Epicoccum purpurascens Ehrenb. Ex Schlecht., 1824, Synop. Pl. crypt.: 136. **(Fig. 35)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, velvety, blackish brown. *Mycelium* mostly immersed. *Conidiogenous cells* monoblastic. *Conidia* dry, solitary, acrogenous, simple, globose to sub-spherical, at first smooth later becoming verruculose, constricted at the septa, mid to dark reddish brown to dark golden brown, 13-27 x 17-25 μm, basal cell sometimes inflated, paler to hyaline and thinner-walled than the other cells, 2.5 x 3.5 μm, 7-10-celled, each cell 8-11 μm.

Specimen examined: On fallen dead and decaying leaves of *Calamus thwaitesii*, moist deciduous forest, 25.6°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2105; leg. Maria D'Souza, 08-06-2000.

According to Ellis, 1971 this fungus is a common early secondary invader on all sorts of plants, air, animals, foodstuffs, textiles. On *Cannabis sativa*, in Dharwar, Karnataka; on living leaves of *Desmodium gangeticum* in Janighat, Ayodhya, Uttar Oradesh; on living leaves of *Schoencus nigricans* in Faizabad, Uttar Pradesh.; on *Sorghum vulgare* Lucknow, U.P.; on living leaves of *Trigonella foenum-graceum*, Jaunpur, U.P.; on seeds of *Zea mays* Jorhat, Assam. Also found on living leaves of *Trifolium alexandrinum* in Harayana and on living leaves of *Glycosmis pentaphylla*, Gorakhpur. (Sarbhoy, et al., 1986; 1996). The fungus was isolated from the dead and decaying leaves by moist chamber incubation method. It was also reported from an earlier study carried out in this laboratory (Miriam, 2000).

Exserticlava vasiformis Matsushima, 1975. *Icones fungorum a lectus Matsushima.* Kobe, Japan, p.40 **(Plate 4.2.4)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate brown, thin, effuse, velvety. *Mycelium* mostly immersed, composed of smooth, septate, branched, pale brown hyphae. *Conidiophores* arising singly, erect, straight or flexuous, smooth, 1-3-septate, unbranched, cylindrical, broader (16-18 µm) and dark brown to black at the base, slightly paler towards the apex, 100-210 x 4.5-7 µm. *Conidiogenous cells* terminal, polyblastic, 25-38 x 9-20 µm; upper cells hyaline, 7-8-pseudoseptate, 95-105 x 10.5-15 µm. *Conidia* dry, solitary, broadly ellipsoidal, 3-euseptate, thick-walled, pale brown, 20-25 x 8-13 µm, somewhat pendant at maturity with the conidium scar

lateral rather than strictly basal, produced successively in a cluster.

Specimen examined: (i) On fallen dead and leaves of *Calamus thwaitesii*, moist deciduous forest, 23.4°C, Bondla Wildlife Sanctuary, Goa, Herb. No. GUFCC No.207; leg. Maria D'Souza, 14-02-2000. (ii) On fallen dead and leaves of *Calamus thwaitesii*, moist deciduous forest, 24.8°C, Bondla Wildlife Sanctuary, Goa, Herb. No. GUFCC No.1484; leg. Maria D'Souza, 25-10-1999.

The fungus has been isolated by moist chamber incubation method. This is the first record for Western Ghats in Goa State.

Fusariella bizzozeriana (Sacc.) Hughes, 1949, *Mycol. Pap.* **28:** 6. **(Fig. 36)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, ark brown. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline up to 2.5 µm wide hyphae. *Conidiophores*, mononematous, straight to flexuous, smooth, unbranched, colourless except in the above half, light olive green below the tip, 76-120 µm x 4.5-7 µm. *Conidiogenous cells* monophialidic, terminal, integrated, determinate, cylindrical, with distinct collarettes, just below the collarette region pale olive green, 54-67 x 2-3.5 µm. *Conidia* solitary, in false chains, simple, straight or flexuous, cylindrical to fusiform, slightly pointed at the apex, truncate at the base, verruculose, 1-4-septate, slightly constricted at the septa, thick-walled, acrogenous, developing in basipetal succession and remaining in false chains, olive green, black in mass, 16-33 x 4.5-8 µm.

Specimen examined: On fallen dead dry leaves of *Ixora brachiata*, Cotigao, moist deciduous forest, 24°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1650; leg. Maria D'Souza, 09-12-1999.

It was isolated from the leaves of *Erythrina* and isolated from soil in Europe and North America. (Ellis, 1971). The fungus has been isolated by moist chamber incubation method. This is the first record for Western Ghats in Goa State.

Fusariella hughesii Chabelska-Frydman, 1964, *Can.J. Bot.*, **42:** 1485-1487. **(Fig. 37)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, white, velvety. *Mycelium* partly immersed. *Conidiophores* mononematous, flexuous, smooth, branched irregularly, sometimes dichotomously, colourless, 15-20µm x 2-3µm. *Conidiogenous cells* monophialidic, terminal, integrated, discrete, determinate, often curved, cylindrical, subulate or lageniform, with collarettes, 12-20 x 1.5-3 µm. *Conidia* solitary, simple, straight or flexuous, often fusiform, rounded at the apex blunt at the base, sometimes cylindrical, acrogenous, developing in basipetal succession and frequently remaning in false chains, hyaline, 3-septate, smooth, 15-20 µm long, 2-3.5 µm in the above half and 1-2 µm at the base.

Specimen examined: On fallen dead twigs of *Elaeis guineensis*, moist deciduous forest, 23.5°C, Tamdisurla, Goa, India; Herb. No. GUFCC No.2282; leg. Maria D'Souza, 08-07-2000.

The fungus was isolated from dead stems and leaves of *Dipsacus, Foeniculum, Lupinus, Phalaris, Trigonella* and *Urtica* in Great Britian and Israel (Ellis, 1971). In India it has been recovered from dead stems of *Solanum tuberosum, Achyranthes aspera,* in Ayodhya, Faijabad, U.P. and from *Cichorium intybus* from Solan and Chambaghat in Himachal Pradesh (Sarbhoy, et al., 1986; 1996). The fungus was isolated by moist chamber incubation method.

Fusariella indica Roy & B. Rai, 1968, *Trans. Br. mycol. Soc.*, **51:** 333-334. **(Fig. 38)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, greyish green. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown, 2.5 µm wide hyphae. *Conidiophores* mononematous, branched irregularly and

dichotomously, flexuous, colourless, smooth, 66-84 x 2.5-3.5 µm. *Conidiogenous cells* monophialidic, terminal, integrated, determinate, cylindrical to elongated, 21-30 x 2-3 µm. *Conidia* solitary, straight or flexuous, often fusiform, pointed at the tip, blunt at the base, smooth, 1-3-septate, dark olive green, developing in basipetal succession and frequently hanging together in slipped chains, 10-15 x 4-5 µm, 1.5 µm wide at the apex.

Specimen examined: On fallen dead dry leaves of *Dendrocalamus strictus*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2059; leg. Maria D'Souza, 11-04-2000.

The fungus has been isolated by moist chamber incubation method. This fungus was first reported from the rhizosphere of *Abelmoschus esculentus*, in Varanasi, U.P. (Sarbhoy, et al., 1986) and is the first record for Western Ghats in Goa State.

Fusichalara bipodia Maria et Bhat **sp. nov.** **(Fig.39)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* regular, circular, wet on the surface, adpressed at first later becoming floccose, with serrated, rhizoidal margin, offwhite to slightly grey at the centre, slow growing, attaining a diam. 0.7 cm in 7 days; reverse of the colony grey. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown, 2 µm wide hyphae. *Conidiophores* simple, solitary, scattered to aggregated into compact fascicles, erect, straight, sub-cylindrical, smooth, uniformly brown, thick- walled, 80-95 x 10-14 µm, bilobed to forked at the basal region, with basal cell 2-5.5 µm long, 2-5 µm wide in the middle, 2-3 µm wide at the terminating end. *Conidiogenous cells* monophialidic, terminal, integrated, with an elongated, cylindrical, medium brown collar, 34-52 x 2-3 µm. *Conidia* cylindrical, broadly rounded at both ends, smooth, septate, hyaline, thin-walled, seceding in false

chains, two-types; first-formd conidia 3-4 septate, 10-13 x 2-2.5 μm; later-formed conidia 1-2-septate, 6-9 x 2-2.5 μm.

HOLOTYPE: On fallen dead leaves of *Terminalia paniculata*, evergreen forest, 25.5°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1288; leg. Maria D'Souza, 03-09-1999.

The genus *Fusichalara* was establsihd by Nag Raj and Hughes (1973) to distinguish those *Chalara*-like fungi having (i) a clear thickened wall at the transition point between venter and collarette, and (ii) two kinds of multiseptate conidia, the forst-formed conidia big and later formed ones small in size. So far 4 species are known in the genus (Bhat and Kendrick, 1993). *F. bipodia* differs from the hitherto known species by its (a) lobed basal cell of the conidiophore, (b) 3-4-septate first-formed conidia (10-13 x 2-2.5 μm) and (c) 1-2-septate later-formed conidia (6-9 x 2-2.5 μm).

Gangliostilbe indica Subramanian & Vittal, 1975. *Kavaka*, **3:** 69-71. **(Plate 4.4.1)**

Terrestrial, synnematous fungus, Hyphomycete. *Colonies* effuse, olivaceous to dark brown, velvety, mostly immersed, composed of smooth, septate, branched, thick-walled, subhyaline, up to 3.5 μm wide hyphae. *Conidiophores* synnematous, arising singly, erect, straight or flexuous, terminating in fertile heads, with stalks compact and dark brown, fertile heads flared to clave and brown, 400-450 μm long, up to 50-66 μm wide at the base, up to 14 μm wide in the middle, heads 46-86 μm wide. *Conidiogenous cells* monoblastic, terminal, integrated, cylindrical, brown, thick-walled, 10-30 x 3.5-5 μm. *Conidia* gangliar, dry, fusiform, elongated, rounded at the tip, truncate at the base, smooth, 3-septate, slightly constricted at the septa, thick-walled, olivaceous brown with a conspicuous oblong, guttulate, 24-40 μm long, 3-4 μm wide at the base, 10-17 μm wide in the middle and 13-19 μm wide at the tip.

Specimen examined: On fallen dead and decaying leaves of *Dendrocalamus strictus*, moist deciduous forest, 23°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2665; leg.Maria D'Souza, 21-11-2000.

The fungus was first reported by Vittal (1975). It is isolated by moist chamber incubation method and is the first record for the Western Ghats in Goa.

Gliocladium penicilloides Corda, (Gilman.J.C., 1959, *A manual of soil Fungi*, The Lowa State University Press, pp. 288-289). **(Fig. 40)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* irregular, effuse with circular rhizoidal margin, moderately growing, attaining a diam. of 3.2 cm in 7 days; reverse of the colony light yellow. *Mycelium* partly superficial, composed of smooth, septate, branched, hyaline, 2.7-3.5 µm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, smooth, 3-4-septate, branched, hyaline, narrow at the base, 144-215 x 2.5-3.5 µm, 4.13 µm wide in the nodal region, with branches 172 x 3.5 µm. *Conidiogenous cells* monophialidic, terminal, discrete, hyaline, 20-45 x 2-2.75 µm. *Conidia* slimy, solitary, ellipsoidal, pinched off from the phialide, smooth, non-septate, thin-walled, hyaline, 4-10 x 2-3.5 µm.

Specimen examined: On fallen dead and decaying leaves of *Saraca asoca*; Streamedge, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.479; leg. Maria D'Souza, 11-02-1999.

The fungus was initially isolated from soil and also on other fungi, (Carmicheal et al, 1980) and is presently isolated by particle plating method. It bears close resemblance to *Gliocladium* Corda, in its white to cream nature of the colony and the penicillous arrangement of the conidiogenous cells and hence is placed in this genus.

***Gliocladium* sp.** **(Fig. 41)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* irregular, effuse with circular rhizoidal margin, moderately growing, attaining a diam. of 3.2 cm in 7 days; reverse of the colony light yellow. *Mycelium* partly superficial, composed of smooth, septate, branched, hyaline, 2.7-3.5 µm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, smooth, 3-4-septate, branched, hyaline, narrow at the base, 144-215 x 2.5-3.5 µm, 4.13 µm wide in the nodal region, with branches 172 x 3.5 µm. *Conidiogenous cells* monophialidic, terminal, discrete, hyaline, 20-45 x 2-2.75 µm. *Conidia* slimy, solitary, ellipsoidal, pinched off from the phialide, smooth, non-septate, thin-walled, hyaline, 4-10 x 2-3.5 µm.

Specimen examined: On fallen dead and decaying leaves of *Saraca asoca*; Streamedge, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.479; leg. Maria D'Souza, 11-02-1999.

The fungus in hand recovered by particle plating method, is similar to *Gliocladium* Corda, but differs in its irregulary branched conidiophores without penicillous arrangement with a slimy ball of conidia at the terminal part of the conidiophore covering the penicillium, but is similar in its conidial ontogeny and hence is placed in this genus.

Gliomastix murorum (Corda) Hughes, 1958, *Can. J. Bot.* **36:**769. **(Fig. 42)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, wavy, flat, with serrated margin, moderately growing, attaining a diam. of 3.2 cm in 7 days; reverse white. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline, 1.5-2 µm wide hyphae. *Conidiophores* mononematous, erect, straight or flexuous, smooth,

unbranched, hyaline, 17-40 x 1.3-2 μm. *Conidiogenous cells* monophialidic, terminal, integrated, determinate, hyaline, 12-34 x 2-2.66 μm, 1-1.5 μm wide in the middle and above; collarette very small. *Conidia*in false chains, semi-endogenous, simple, ellipsoidal, smooth, aseptate, olive green, 3-5.5 x 2-2.66 μm.

Specimen examined: On fallen dead and decaying leaves of *Dendrocalamus strictus*; moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.342; leg. Maria D'Souza, 11-4-1999.

The fungus is frequently collected on litter, wood plant debris and isolated from textiles, cellulosic materials, wood, soil from Europe, New Zealand and North America (Ellis, 1971; Carmicheal et al. , 1980). In India it has been recovered from the leaves of *Ficus reliogiosa* in Jabalpur, MadhyaPradesh; on soil and decaying plants of *Cassia tora* in Rohilkhand region, Uttar Pradesh. (Sarbhoy, et al., 1986). Subsequently isolated from decaying cotton cloth, fibres and on writing paper, Chandigarh, Pb. Presently it has been isolated by particle plating method. It was also reported from an earlier study carried out in this laoratory (Miriam, 2000).

Gliomastix novae-zelandiae Hughes & Dickinson, 1968, *N. Z. Jl. Bot.* **6:**108. **(Fig. 43)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate dark brown, later becoming to grey. *Mycelium* superficial, composed of smooth, septate, branched, colourless, 1-2 μm wide hyphae. *Conidiophores* mononematous, erect, straight or flexuous, smooth, aseptate, unbranched, hyaline, 23-47 x 2-3.5 μm, 1.5-2 μm wide at the apex, with a dark deposition near the apex forming a cupulate collarette 3.4 x 1.4 μm. *Conidiogenous cells* monophialidic, terminal, integrated, determinate, hyaline, 8-27 x 1.4-2.7 μm. *Conidia* in false chains or aggregated in slimy heads, semi-

endogenous, simple, doliiform to ellipsoidal, smooth, aseptate, olive green, 5-8 x 4-5 μm, at the attached portion 1.33-2 μm wide.

Specimen examined: On fallen dead and decaying leaves of *Xylia xylocarpa*; moist deciduous forest, 24°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1625; leg. Maria D'Souza, 09-12-1999.

It has been found to occur *Coprosma* and *Beilschmiedia* in New Zealand and isolated from some members of Compositae in India. (Ellis, 1976). Matsushima (1975) also has recorded this fungus. The fungus has been isolated by moist chamber method.

Gonatobotryum apiculatum (Peck) Hughes, 1953, *Can,.J. Bot.*, **31:** 594 **(Fig. 44)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, stalk black, white above, in aggregates on the substrate. *Mycelium* immersed. *Conidiophores* mononematous, straight or slightly flexuous, smooth, unbranched, dark brown, paler towards the apex, 4-8-septate, 100-160 x 5-23 μm, 3.5-4.5 μm wide above. *Conidiogenous cells* terminal, later becoming intercalary, polyblastic, smooth, pale brown to almost hyaline, 13-30 μm long, 3.5 μm thick, with short denticle portion emerging at intervals, 1.37-6.89 x 2.5- 8.5 μm. *Conidia* dry, hyaline, ellipsoidal, smooth, pointed at the tip, aseptate, thin-walled, guttulate, 10-15 x 2-3.5 μm.

Specimen examined: (i) On fallen leaves of *Calamus thwaitesii* Becc., moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.272; leg. Maria D'Souza, 11-02-1999; (ii) On fallen leaves of *Calamus thwaitesii*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.294; leg. Maria D'Souza, 11-02-1999.

The fungus has been found to be parasitic on leaves of *Hamamelis*, also recorded on *Rhus* and isolated from soil in North America. (Ellis, 1971). It was isolated by both moist chamber incubation method and particle plating method. This is the first record to the Western Ghats in Goa.

Helicomyces roseus Link, 1929, *Ann. Mo. Bot. Gardn.* **16:** 271. **(Fig. 45)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, velvety, silvery white. *Mycelium* composed of smooth, septate, branched, hyaline, 2-3.3 µm thick hyphae. *Conidiophores* mononematous, lateral, straight or slightly flexuous, smooth, 1-3-septate, unbranched, pale brown, 26-45 x 3-5 µm, tapered gradually towards the apex into 2.5 µm. *Conidiogenous cells* terminal, mono- or polyblastic, 13-27 µm long, 1.5-4 µm thick, pale brown to almost hyaline, with short denticles up to 2 µm. *Conidia* dry, solitary, helicoid, papillate at the base, smooth, 30-33-septate, hyaline, 50-70 µm diam.; conidial filament coiled 3 times, basal cell frequently enlarged to 4 x 14 µm.

Specimen examined: (i) On fallen dead and decaying spathe of *Sansievierra zeylanica*; moist deciduous forest, 25.5°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1436; leg. Maria D'Souza, 01-10-1999. (ii) On fallen dead and decaying leaves of *Careya arborea*; moist deciduous forest, 25.4°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1740; leg. Maria D'Souza, 29-12-1999. (iii) On fallen dead and decaying leaves of *Careya arborea*; moist deciduous forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2016; leg. Maria D'Souza, 11-04-1999. (iv) On fallen dead and decaying leaves of *Dendrocalamus strictus*; moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.365; leg. Maria D'Souza, 11-2-1999.

A commonly occuring litter fungus and mostly grows on fallen twigs along the streams. (Carmicheal, etal, 1980). The fungus has been isolated by moist chamber method. It was also reported from an earlier study carried out in this laoratory (Miriam, 2000).

Helicosporium **sp.** **(Fig. 46)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse,

velvety. *Mycelium* composed of smooth, septate, branched hyaline hyphae up to 2.75 µm thick. *Conidiophores* mononematous, straight or slightly flexuous, lateral, smooth, 7-10-septate, unbranched, pale brown, 135-194 x 3.5-5.5 µm. *Conidiogenous cells* mono- or polyblastic, terminal and intercalary, integrated, 13-24 x 3-4.5 µm, with short denticles 1.5-2 x 2 µm. *Conidia* dry, solitary, helicoid, papillate at the base, smooth, 8-18-septate, hyaline, 24-35 µm in diam.; conidial filament coiled 2-3 times, with basal cell frequently enlarged up to 8-11x 1.3-2 µm.

Specimen examined: On fallen dead and decaying leaves of *Saraca asoca*; moist deciduous forest, 24.8°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1488; leg. Maria D'Souza, 25-10-1999.

The fungus has been isolated by moist chamber method.

Helminthosporium palmigenum Matsushima, 1971, *Microfungi of the Solomon Islands and Papua-New Guinea,* Kobe, Japan, p.30. **(Plate 4.5.2)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown, hairy. *Mycelium* immersed. *Stroma* brown to dark brown, pseudoparenchymatous, 6-35 µm wide. *Conidiophores* mononematous, straight or flexuous, usually caespitose, subulate, smooth, up to 10-septate, unbranched, mid to very dark brown, 145-175 x 4-6.5 µm. *Conidiogenous cells* polytretic, terminal and intercalary, integrated, determinate, cylindrical, medium brown, non-cicatrized, 7-22 x 4-5 µm. *Conidia* dry, catenate, simple, acropleurogenous, developing laterally through small pores beneath the septa while the tip of the conidiophore ceasing with the formation of terminal conidia, straight or flexuous, obclavate, pale golden brown with a subhyaline tip, 1-6-pseudoseptate, 7-35 x 5-8 µm, 1.5-2 µm wide and with a black scar at the base, 2.75-4 µm wide near the apex.

Specimen examined: (i) On fallen dead twigs of *Calamus thwaitesii*; evergreen forest, 24.8°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1485; leg. Maria D'Souza, 25-10-1999; (ii) On dead and decaying dry leaves of *Sansievierra zeylanica*, , moist deciduous forest, 25.5 ° C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1447; leg. Maria D'Souza, 08-07-2000.

The fungus was isolated from the bark of living and dead stems from New Zealand (Hughes, 1978). Presently this fungus has been isolated by moist chamber incubation method.

Helminthosporium velutinum Link ex Ficinus and Schubert, 1823, *Fl. Geg. Dresd. Krypt.* : 283. **(Plate. 4.5.1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown, hairy. *Mycelium* immersed. Stroma present, brown to dark brown, pseudoparenchymatous, 36-60 µm wide. *Conidiophores* mononematous, straight or flexuous, smooth, 15-20-septate, unbranched, usually caespitose, subulate, mid to very dark brown, 600-1000 x 12-30 µm. *Conidiogenous cells* polytretic, terminal and intercalary, integrated, determinate, cylindrical, medium brown, 12-36 x 6-9 µm. *Conidia* dry, solitary, simple, acropleurogenous, developing laterally often in verticels from small pores beneath the septa while the tip of the conidiophore ceasing with the formation of terminal conidia, straight or flexuous, obclavate, subhyaline to rather pale golden brown, 7-13-pseudoseptate, 45-90 x 6-12 µm, with a large black scar at the base.

Specimen examined: On fallen dead and decaying leaves of *Careya arborea*; moist deciduous forest, 25.4°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2170; leg. Maria D'Souza, 08-06-2000.

It is a very common fungus on dead stems of herbaceous plants, twigs and branches of many different kinds of trees in Europe, Ceylon, India, North America,

Pakistan, Venezuela, most abundant in temperate regions. The fungus was isolated from *Ficus asperrina* Roxb., Radhanagari, Maharashtra. Later, it was isolated from on dead twigs of *Lantana camara* in Pauri Garhwal, Uttar Pradesh (Sarbhoy, et al., 1986; 1996). The fungus has been isolated by moist chamber incubation method

Hemicorynespora mitrata (Penz. & Sacc.) M.B. Ellis, 1972, *Mycol. Pap.* **131:** 21-22.

(Fig. 47; Plate 4.2.5)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark blackish brown, hairy. *Mycelium* immersed. *Conidiophores* mononematous, unbranched, straight or flexuous, mid to very dark brown, smooth, 3-7-septate, 75-162 x 2-4 µm, 5-28 µm wide at the base. *Conidiogenous cells* monotretic, terminal, integrated, determinate, cylindrical, medium brown, 10-26 x 3-4 µm. *Conidia* dry, solitary, simple, straight, 1-median septate, dark brown to black, thick-walled, limoniform, smooth, 10-20 x 7-10 µm, with a prominent dark brown to black septal band in the middle, up to 3 µm wide.

Specimen examined: On fallen dead and decaying twigs sheath of *Calamus thwaitesii*; moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.318; leg. Maria D'Souza, 11-02-1999.

The fungus was recovered from rotting rotting monocotyledon leaves in Java. (Ellis, 1976). In India, it has been reported on dead stems of *Bambusa* sp. in Orissa (Sarbhoy, et al., 1986). The fungus has been isolated by moist chamber incubation method.

Hermatomyces tucumanensis Speg., 1911, *An. Mus. Nac. Hist. Nat. B. Aires, Ser. 3*, **13:** 446. **(Plate 4.4.4)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, blackish brown, velvety. *Mycelium* partly immersed. *Conidiophores* mononematous, fasciculate, smooth,

septate, unbranched, short, straight or flexuous, pale brown, 7-12 x 2.5-3.5 µm. *Conidiogenous cells* monoblastic, terminal, integrated, determinate, cylindrical, medium brown. *Conidia* dry, acrogenous, spherical to globose, elliptical to almost round in one plane, thick-walled, muriform, with pale peripheral cells surrounding central dark brown to black cells, 20-45 x 19-24 µm.

Specimen examined: On fallen dead and decaying leaves of *Caryota urens*; moist deciduous forest, 25.5°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.409; leg. Maria D'Souza; 11-04-1999.

Ellis (1971), reported the fungus from fallen branches of *Alchornea, Celtis, Coffea, Smilax* and rachides of *Elaeis*, Argentina, Ghana, Sierra Leone. It has also been reported from *Acacia pinnata*, Amboli, Ratnagiri in Maharashtra. has been isolated by moist chamber method has been isolated by moist chamber method (Sarbhoy, et al. 1986). Here it is a new record to the Western Ghats in Goa.

***Heteroconium* sp.** (Pl. 4-2.3)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown, velvety. *Mycelium* partly immersed, composed of smooth, septate, branched, pale brown hyphae. *Conidiophores* mononematous, erect, straight, smooth, 3-4-septate, unbranched, dark brown, 26-56 x 2.5-4 µm. *Conidiogenous cells* monoblastic, terminal, integrated, pale brown, with a truncate apex on conidium cessation. *Conidia* dry, catenate, fusiform, narrow and truncate at both ends, smooth, 1-septate, dark brown, 4-10 x 2-3.5 µm.

Specimen examined: On fallen dead and decaying leaves of *Calamus thwaitesii*; moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1905; leg. Maria D'Souza, 11-02-1999.

The fungus has been isolated by moist chamber incubation method.

Idriella fertilis (Pirozynski et Hodges) Matsushima, 1975. *Icones fungorum a lectus Matsushima.* Kobe, Japan, p.86. **(Fig. 49)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, flat, effuse with circular margin, rhizoidal, dark brown, slow growing, attaining 1 cm in 7 days; reverse of the colony greenish brown. *Mycelium* immersed, raised in the centre, fringed with furrows in the periphery, composed of smooth, septate, branched, pale to medium brown 1.5 µm hyphae. *Conidiophores* mononematous, lateral, erect, straight or flexuous, smooth, 4-6-septate, unbranched, mdium to pale brown, 46-120 x 2.5-4 µm. Chamydospores absent. *Conidiogenous cells* polyblastic, terminal, integrated, pale brown to hyaline, 14-45 x 1.5-2 µm, denticulate at the tip; denticles 3-4. µm long. *Conidia* dry, solitary, falcate to lunate, pointed at both ends, smooth, globulate, aseptate, thin-walled, hyaline, 8-15 x 1.5 µm.

Specimen examined: On fallen dead and decaying leaves of *Saraca asoca*, moist deciduous forest, 31°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1871, 1888; leg. Maria D'Souza, 29-12-1999.

The fungus has been isolated by particle plating method. It was also reported earlier by Matsushima (1975). It was also reported from an earlier study carried out in this laboratory (Miriam, 2000).

Idriella goanensis Maria et Bhat **sp. nov.** **(Fig. 50)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown at the base, velvety. *Mycelium* mostly immersed, composed of a pseudoparenchymatous stroma. *Conidiomata* mononematous, aggregated to form a cluster, mostly in groups of 10-15, also arising singly, erect, straight or flexuous, fertile at the apex, smooth, 1-3

septate, dark brown below, paler towards the apex, 30-54 x 2.5-3.5 µm, 2-3.5 µm wide at the apex, *Conidiogenous cells* polyblastic, terminal, integrated, subcylindrical to elongated, inflated at the tip 3.5 µm, pale brown, smooth, 16-30 x 2-3.5 µm. *Conidia* solitary, slimy, fusiform to lenticular, slightly curved, pointed at both ends, thin-walled, hyaline, 1-septate, guttulate, 6-10 x 2-4 µm.

Specimen examined: On fallen dead and decaying leaves of *Psychotria dalzellii*; evergreen forest, 25.5°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1166; leg. Maria D'Souza, 19-07-1999.

The fungus was recovered by moist chamber incubation method. Of the hitherto described species of *Idriella* Nelson & Wilhelm (Ellis, 1971; Matsushima, 1975), typified by *I. lunata* Nelson & Wilhelm, none of them are known to produce similar lenticular conidia measuring 6-10 x 2-4 µm.

Idriella hyalina Maria & Bhat **sp. nov.** **(Fig. 51)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, light brown, velvety, present on the upper surface of the leaves. *Mycelium* completely immersed, composed of smooth, septate, branched, hyaline, 2.5-3.5 µm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, sometimes fasciculate, smooth, 0-1-septate, unbranched, thick-walled, broader and swollen at the base slightly narrower at the tip, slightly pale brown at the base, hyaline towards the apex, 13-28 x 2-3.5 µm. Chamydospores absent. *Conidiogenous cells* polyblastic, terminal, integrated, hyaline, thin-walled, 9-20 x 2-3.5 µm. *Conidia* dry, solitary, falcate, pointed at both ends, smooth, with a median septum, thin-walled, hyaline, 24-30 x 2-3.5 µm, with a 2-3 µm. long setula at the distal end.

HOLOTYPE: On fallen dead and decaying leaves of *Psychotria dalzellii*; moist deciduous forest, 25.5°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1164;

leg. Maria D'Souza, 19-7-1999.

The genus *Idriella* Nelson & Wilhelm (Ellis, 1971) , typified by *I. lunata* Nelson & Wilhelm, has 22 so far described species (Hawksworth et al. 1995). In general, almost all the known species are dematiaceous and with nonsetulate, hyaline, lunar-shaped conidia.. The species in hand differs from the rest by its hyaline conidiophores and conidia and setulate, 1-septate conidia. The fungus has been isolated by moist chamber incubation method. The species of *Idriella* are common inhabitats of forest litter.

Idriella lunata Nelson et Wilhelm, 1956, *Mycologia*, **48:** 547-551. **(Fig. 52)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, effuse with circular margin, rhizoidal, pinkish brown, median growing, attaining 3 cm diam. in 7 days; reverse of the colony black at the centre and offwhite at the periphery. *Mycelium* immersed completely, composed of smooth, septate, branched, pale to medium brown 1.5-3 µm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, unbranched, broader and swollen at the base, slightly narrower at the apex, smooth, septate, pale brown, 13-22 µm long. *Chamydospores* subglobose, pale to dark brown, aseptate, smooth, 12-18 x 10-12 µm, with the stalk cell 5-10 x 4-8 µm. *Conidiogenous cells* polyblastic, terminal, denticulate, integrated, medium brown, 11-20 x 2-4 µm. *Conidia* dry, solitary, falcate to lunate, pointed at both ends, aseptate, thin-walled, hyaline, smooth, 10-18 x 1-1.5 µm.

Specimen examined: (i) On fallen dead and decaying leaves of *Saraca asoca*; moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 281; leg. Maria D'Souza, 11-02-1999. (ii) On fallen dead and decaying leaves of *Saraca asoca*; moist deciduous forest, 24.8°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1455; leg. Maria D'Souza, 25-10-1999. (iii) On fallen dead and decaying leaves of *Saraca asoca*;

moist deciduous forest, 23.5°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1879; leg. Maria D'Souza, 14-02-2000. (iv) On fallen dead and decaying leaves of *Saraca asoca*; moist deciduous forest, 25.5°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 2130; leg. Maria D'Souza, 08-06-2000. (v) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 27°C, Mollem Wildlife Sanctuary Goa, India; Herb. No. GUFCC No.1971; leg. Maria D'Souza, 11-04-2000. (vi) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 26.8°C, Mollem Wildlife Sanctuary Goa, India; Herb. No. GUFCC No.2407; leg. Maria D'Souza, 20-09-2000. (vii) On fallen dead leaves of *Ficus benghalensis*; coastal area, 27°C, Baga, Goa, India; Herb. No. GUFCC No. 1398; leg. Maria D'Souza,; Maria D'Souza,, 11-10-1999. (viii) On fallen dead leaves of *Mangifera indica*; evergreen forest, 23°C, Taleigao, Goa, India; Herb. No. GUFCC No.1042; leg. Maria D'Souza, 02-07-1999. (ix) On fallen dead leaves of *Syzygium cumini*; moist deciduous forest, 30°C, Tambdisurla, Goa, India; Herb. No. GUFCC No.2187; leg. Maria D'Souza, 08-07-2000. (x) On dead and decaying leaves of *Terminalia paniculata*, evergreen, 25.5°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1337; leg. Maria D' Souza, 03-09-1999, particle plating method. (xii) On fallen dead leaves of *Curcuma decipens*, moist deciduous forest, 24°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2318; leg. Maria D'Souza, 10-08-2000. (xii) On fallen dead leaves of *Sagarea laurifolia*, evergreen forest, 24.8°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1266, 1267, 1268, 1273, leg. Maria D'Souza, 03-09-1999.

The fungus was isolated from soil and *Fragaria* roots in North America. (Ellis, 1971) and also from different types of litter (Carmicheal et al., 1980). The fungus has been isolated several times by both moist chamber incubation and particle plating method. It was also reported from an earlier study carried out in this laoratory (Miriam, 2000).

Idriella malabarica Subramanian & Bhat, 1987, *Kavaka,* **15:** 41-74. **(Fig. 53)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, compact, velvety, brown. *Conidiophores* mononematous, mostly in fascicles, erect, straight or flexuous, unbranched, broader at the base slightly narrower at the apex, smooth, 3-8-septate, dark

brown at the base, slightly paler towards the apex, arising from globose hyphal cells, and of two types: setose and non-setose; setose conidiophores developing intermixed with normal ones, fewer in number, unbranched, dark brown, 73-195 x 3.5-5 μm; normal conidiophores in a pallisade, branched. Chamydospores absent. *Conidiogenous cells* polyblastic, penicillate, discrete, terminal, medium brown at the base, hyaline above, monoblastic, integrated or discrete, terminal, cylindrical to ampulliform, with inflated distal fertile region, madium brown to paler at the apex, smooth, 10-16 x 2-3 μm. *Conidia* dry, solitary, falcate, pointed at both ends, with a medium septum, thin-walled, hyaline, smooth, 24-30 x 1-1.5 μm.

Specimen examined: On fallen dead and decaying leaves of *Careya arborea*; moist deciduous forest, 23.4°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2022; leg. Maria D'Souza, 21-11-1999.

The fungus was first isolated from unidentified leaf in liiter from Silent Valey, Palghat, Kerala (Subramanian and Bhat, 1987). In this work it was isolated by moist chamber incubation method. This is the first recod for the Western Ghats in India.

Idriella septata Maria et Bhat **sp. nov.** **(Fig. 54)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* in MEA regular, adpressed, circular, with a rhizoidal margin, offwhite, attaining 2.2 cm in 7 days; reverse of the colony yellowish offwhite. *Mycelium* immersed completely, composed of smooth, septate, branched, pale to medium brown, 1.5-2 μm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, smooth, non-septate, unbranched, swollen at the base, slightly narrower at the apex, pale to mid brown at the base, subhyaline towards the apex, 7-20 x 2-3.5 μm. Chamydospores absent. *Conidiogenous cells* polyblastic, sympodial, terminal,

integrated, medium brown, 7-20 µm long, 2-3.5 µm wide at the base, 1.3-2 µm wide in the middle and tapering tip, denticulate at the tip; denticles up to 2.5 µm long. *Conidia* dry, solitary, falcate, pointed at both the ends, smooth, 2-3-septate, thin-walled, hyaline, 11-16 x 1.5-2 µm.

HOLOTYPE: On fallen dead and decaying leaves of *Ficus religiosa*; moist deciduous forest, 30°C, Chorlem Ghat, Goa, India; Herb. No. GUFCC No.1071; leg. Maria D'Souza, 02-07-1999.

The genus *Idriella* Nelson & Wilhelm (Ellis, 1971), typified by *I. lunata* Nelson & Wilhelm, has 22 so far described species (Hawksworth et al. 1995). Most of the described species are dematiaceous and with aseptate, hyaline, lunar-shaped conidia. The species in hand differs from the rest by sympodial conidiogenous cells, and 2-3-septate conidia.

Idriella sigmoidea Maria et Bhat **sp. nov.** **(Fig. 55)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on substrate effuse, velvety. *Mycelium* mostly immersed, composed on branched, septate, hyaline hyphae 2.5 µm wide. *Conidiophores* mononematous, composed of straight or flexuous, branched, smooth, 2-7 septate, arising from a basal dark brown stroma, pale brown to subhyaline at the tip, 34-67 µm long, 4-6 µm at the base, 3.33 µm at the apex. *Conidiogenous cells* polyblastic, integrated, often arising in groups, determinate, pale brown, smooth, 8-24 µm long, 2-4 µm wide at the base, 1-2.5 µm wide at the apex. *Conidia* simple, thin, elongated, thread-like, sigmoid to slightly curved, colourless, smooth, aseptate, 18-22-0.5-1 µm.

Specimen examined: On fallen dead and decaying leaves of *Zanthoxylum rhetsa*; grassland plateau type, 25°C Alorna, Goa, India; Herb. No. GUFCC No.1553; leg. Maria

D'Souza, 19-11-1999.

The fungus was isolated by moist chamber incubation method. Of the so far described species of *Idriella* Nelson & Wilhelm (Ellis, 1971; Matsushima, 1975), none of them are known to produce sigmoid, thread-like and thin conidia.

Idriella verticillata Maria et Bhat **sp. nov.** **(Fig. 56)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, pale brown. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown, 1.5 µm wide hyphae. *Conidiophores* mononematous, scattered, each composed of an erect, straight or flexuous, smooth, slightly narrower and dark brown at the base, slightly paler towards the apex, 135-220 x 3-5 µm, 2-6-septate, branched stipe, with branches in verticils beneath the septa, each branch 20-40 x 2.5-5 µm. *Conidiogenous cells* polyblastic, discrete, arranged in verticils, determinate, smooth, medium brown, 20-35 x 2-3.5 µm, terminating in a globose tip up to 5 µm diam. *Conidia* solitary, often in slimy masses, simple, falcate, guttulate, smooth, aseptate, colourless, 8-10 x 2-4 µm, pointed at both ends.

HOLOTYPE: On fallen dead twigs of *Elaeis guineensis*, Plantation, 23°C, Tambdisurla, Goa, India; Herb. No. GUFCC No.2281; leg. Maria D'Souza, 08-07-2000.

The fungus was isolated by moist chamber incubation method. The verticillate arrangement of conidiogenous cells on the conidiophore warranted establishment of a new species in the genus.

***Idriella* sp.** **(Fig. 57)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, flat, effuse, with circular margin, rhizoidal, centre brown periphery colourless, moderately growing, attaining a diam.of 1.7cm in 7 days; reverse of the colony brown. *Mycelium* immersed completely, composed of smooth, septate, branched, pale to medium brown 1.5-4 µm wide hyphae. *Conidiophores* lateral, erect, straight or flexuous, branched, broader and swollen at the base, slightly narrower at the apex, smooth, 1-10-septate, medium to dark brown at the base, slightly paler towards the apex, 14-180 x 2-4 µm; branches 1-2-septate, 8-34 x 2.5-4 µm. *Conidiogenous cells* polyblastic, terminal, integrated, medium brown, denticulate above, 8-15 x 1.5-3 µm. *Conidia* dry, solitary, falcate to lunate, pointed at both ends, smooth, aseptate, thin-walled, hyaline, 8.5-12.5 x 1-1.5 µm.

Specimen examined: On fallen dead and decaying leaves of *Saraca asoca*; moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1892; leg. Maria D'Souza, 14-02-2000.

The fungus was isolated by particle plating method.

Iyengarina saprophyticus Maria et Bhat **sp. nov.** **(Fig. 58)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown to black. *Mycelium* partly immersed and partly superficial, composed of septate, branched, hyaline, 2.5 µm wide hyphae. *Conidiophores* mononematous, erect, straight or flexuous, smooth, 3-8-septate, unbranched, dark brown, 90-170 x 3.5-6.5 µm. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, cylindrical, dark brown, smooth, thick-walled, 6-12.5 x 3.5-6.5 µm. *Conidia* dry, solitary, acrogenous, Y-shaped, with each of

the three divergent branches arising from the upper cell of the conidium ends in a narrow, pointed appendage; body of conidium septate, smooth, thick-walled, upper and central cell dark brown, basal cell pale to medium brown, 3-5 μm wide at the base; branched portion 35-30 μm long, 20-30 μm wide; appendages up to 4-12 μm long, 2-5 μm thick at the base, 1-2 μm at the tip.

HOLOTYPE: On fallen dead and decaying leaves of *Careya arborea*; moist deciduous forest, 26°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2425; leg. Maria D'Souza, 20-09-2000.

The monotypic genus *Iyengarina* Subramanian, typified by *I. elegans* Subramanian (Ellis, 1971; Hawksworth et al., 1995), described from India, has conidia which are Y-shaped with two symmetrically arranged divergent branches arising from the upper part. *I. saprophyticus* differs from the type by its conidia with three branches.

Kramasamuha sundara Maria et Bhat **sp. nov.** **(Fig. 59)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, velvety. *Mycelium* immersed. *Conidiophores* mononematous, erect, straight or flexuous, swollen and lobed at the base, bracnhed dichotomously from the base, 10-17 septate, smooth, dark brown below, pale brown in the middle and above, 730-2130 μm long, 10-20 μm at the base, 6-13 μm in the middle and above; stipe with 2-3 conidiogenous cells at the nodal points. *Conidiogenous cells* monoblastic, discrete, obclavate, smooth, hyaline, 15-30 x 2-4 μm. *Conidia* solitary, ellipsodal to obovoid, rounded at the tip, narrower and with a remnent of attachment cell at the base, smooth, 2-3-septate, pale to medium brown, 55-100 μm long, 10-20 μm wide at the distal and basal end, 18-25 μm wide in the middle.

HOLOTYPE: On fallen dead and decaying leaves of *Careya arborea*; moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1725; leg. Maria D'Souza, 20-12-1999.

The monotypic genus *Kramasamuha* Subram. & Vittal, typified by *K. sibika* Subram. & Vittal (1973) is characterised by mononematous, branched, erect, basally lobed conidiophores which are fertile in the above half. Three to four, discrete and sympodial conidiogenous cells arise in groups at the nodal region. *K. sundara* differs from *K. sibika* by its longer conidiophores (in *K. sibika* it is 120-230 x 3-6 µm and in *K. sundara* 730-2130 x 10-20 µm), conidiogeous cells (in *K. sibika* it is 5-11.5 x 2.5-4 µm and in *K. sundara* 15-30 x 2-4 µm) and conidia (in *K. sibika* it is 24-30 x 10-12.5 µm and in *K. sundara* 55-100 x 10-25 µm) Further, the conidia in *K. sundara* are 2-septate whereas in *K. sibika* these are up to 3-septate.

Kumbhamaya aseptata Maria et Bhat **sp. nov.** **(Fig. 60)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA adpressed at first, later becoming floccose, with circular margin, white transparent, slow growing, attaining a diam of 1.7 cm in 7 days. *Mycelium* partly immersed, composed of densely branched, smooth, septate, hyaline hyphae up to 1.7 µm wide. *Conidiophores* mononematous, indistinct, flexuous, septate, unbranched, medium brown, 1.5-2.5 µm. *Conidiogenous cells* monophialidic, integrated, terminal, sometimes intrcalary, vase-like, vermiform, oblong at the base, with a distinct collarette, smooth, pale brown, 3-17 x 1.5-3.5 µm, up to 1.5 µm wide at the collarette region. *Conidia* slimy, solitary, straight to flexuous, aseptate, thin-walled, hyaline, smooth, 9-17 x 1-1.5 µm, aggregating at the apex of the phialide.

HOLOTYPE: Dried culture mat of the isolate derived from fallen decaying leaves of *Zanthoxylum rhetsa*, moist deciduous forest, 31°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1543; leg. Maria D'Souza, 19-11-1999.

The genus *Kumbhamaya* Miriam & Bhat, typified by *K. indica* Miriam & Bhat (2000), was established for those mononematous, phialidic, dematiaceous endophytic fungi with conspicuous collartettes and septate, fusiform conidia. The second species *K. goanensis* Maria & Bhat (2001) differs from the type by differences in the size of conidiophores, conidiogenous cells and conidia. *K. asptata* differs from the earlier described two species by its straight to slightly flexuous, 9-17 x 1-1.5 μm and aseptate conidia.

Kumbhamaya goanensis Maria et Bhat **sp. nov.** 2001. *Microbes and Plant* pp.1-6 **(Fig. 61)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA addpressed at first, later becoming floccose, rhizoidal towards the periphery, with circular margin, grayish black, slow growing, attaining a diam. of 1 cm in 7 days. *Mycelium* partly immersed, composed of densely branched, smooth, septate, pale to medium brown, 2.5-3.5 μm wide hyphae. *Conidiophores* mononematous, indistinct, smooth, septate, unbranched, medium brown, 2-8 x 2.5-4.5 μm. *Conidiogenous cells* monophialidic, integrated, terminal or lateral, vase-like, vermiform, flexuous, erect to curved, oblong at the base, with a collarette, smooth, medium brown, 8-12 x 2-6.5 μm, 1.5-2.5 μm at the collarette region. *Conidia* slimy, solitary, fusoid to falcate, pointed at both ends, 2-5-septate, thin-walled, with dense cytoplasm, hyaline, smooth, 7-30 x 1.5-2.5 μm, aggregating at the apex of the phialide.

Specimen examined: On fallen dead and decaying leaves of *Flacourtia montana*, moist

deciduous forest, 25°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.214; leg. Maria D'Souza, 11-04-1999.

The fungus was isolated by particle plating method. The monotypic genus *Kumbhamaya* M.Jacob & D.J.Bhat, typified by *K. indica* M. Jacob & D.J.Bhat (Jacob and Bhat, 2000), is characterised by kettle or pitcher-shaped monophialidic conidiogenous cells bearing flared collarettes and producing slimy, fusiform, curved, septate and hyaline conidia which are pointed at both ends. *K. goanensis*, differs from the type species by its smaller conidiogenous cells and conidia. The conidiogenous cells and conidia in *K. indica* are 12-50 x 2.5-8.5 µm and 25-40 x 3.5-5.5 µm respectively whereas in *K. goanensis* these are 8-11.5 x 2.5-6.5 µm and 7-25 x 1.5-2.5 µm. The conidia in *K. indica* are mostly 3-septate whereas in *K. goanensis* the conidia are up to 5-septate.

Kumbhamaya indica Jacob & Bhat, 2000, *Crypt. Mycol.*, **21(2):** 81-88 **(Fig. 62)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, with moderately dense aerial mycelium, irregular at margin, medium brown at the centre, pale brown towards the periphery, median growing 2-3.5 cm diam. in 7 days; reverse of the colony offwhite. *Mycelium* partly immersed, smooth, densely branched, medium to dark brown hyphae 2-3.5 µm wide. *Conidiophores* mononematous, indistinct, septate, unbranched, medium brown, 2-2.5 µm wide. *Conidiogenous cells* monophialidic, integrated, terminal or lateral, vase-like, flexuous, thick-walled, with a collarette, smooth, medium brown, 12-50 x 2.5-4.5 µm, 2-3.5 x 1.5-2.5 µm at the collarette region. *Conidia* solitary, fusiform, curved, pointed at both ends, rostrate, hyaline, thick-walled, smooth, mostly 3-septate, 25-40 x 3.5-5.5 µm, aggregating in a slimy mass at the apex of

the phialide.

Specimen examined: (i) On fallen dead and decaying leaves of *Dendrocalamus strictus*, Cultured on MEA from fresh leaves; moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.238; leg. Maria D'Souza, 11-03-1999. (ii) On fallen dead and decaying leaves of *Dendrocalamus strictus*; evergreen forest, 24°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1004; leg. Maria D'Souza, 15-08-1999.

The fungus was isolated by particle plating and endophytic isolation methods. It was first reported from an earlier study carried out in this laoratory (Miriam, 2000).

Kylindria excentrica Bhat & Sutton, 1985, *Trans. Br. mycol. Soc.* **84:**723-730. **(Fig. 63)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, hairy, velvety. *Conidiophores* mononematous, smooth, erect, simple, straight or flexuous, thick-walled, dark brown at the base, paler towards the apex, 8-12-septate, percurrently regenerating, 253-376 µm long, 24-37 µm wide at the base, 6-8 µm wide in the middle, up to 9.5 µm wide flared at the apex. *Conidiogenous cells* phialidic, terminal, integrated, lageniform, 38-54 µm long, up to 4.5-7 µm wide at the base, broadest above the middle 6-10.5 µm wide, narrower at the apical aperture 1.5-3 µm wide. *Conidia* solitary, accumulating in translucent slimy masses at the apices of conidiogenous cells, cylindrical, obtuse at the apex, slightly tapered towards the truncate base, hyaline, 3-septate, smooth, guttulate, 20-24 x 6-8 µm, with an excentric lateral flat unthickened basal scar.

Specimen examined: (i) On fallen dead and decaying leaves of *Psychotria dalzellii*; moist deciduous forest, 25°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1168; leg. Maria D'Souza, 19-07-1999. (ii) On fallen dead and decaying leaves of *Sanseiviera zeylanica*, moist deciduous forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1438; leg. Maria D'Souza, 15-08-1999.

The fungus was first reported from Ethiopia (Bhat and Sutton, 1985). It was isolated by moist chamber incubation method.

Kylindria hyalina Maria et Bhat **sp.nov.** **(Fig. 64)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, hairy, velvety. *Conidiophores* mononematous, smooth, erect, simple, straight or flexuous, thick-walled, dark brown at the base, paler towards the apex, 3-6-septate, 70-120 µm long, 5-15 µm wide at the base, bilobe and forked at the base, 3.5-4 µm wide in the middle, up to 2-3.5 µm wide flared at the apex. *Conidiogenous cells* phialidic, terminal, integrated, lageniform, partly the conidiogenous cell is pale brown and hyaline tip above, the dark brown portion is 13-17 x 3-4.5 µm, narrower at the apical aperture, 6-10 x 6-10.5 µm hyaline tip. *Conidia* solitary, accumulating in translucent slimy masses at the apices of conidiogenous cells, oval, pinched off from the phialide, slightly narrower at the truncate base, hyaline, aseptate, smooth, 4-5.5 x 2.5-3.5 µm.

Specimen examined: (i) On fresh leaves of *Careya arborea*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2017; leg. Maria D'Souza, 11-04-2000.

The fungus is very unique with its hyaline extended tip of the phialide from which the spores are pinched off. None of the so far known species exhibit such as feature.

Lacellinopsis spiralis M.B. Ellis, 1971, *Dematiaceous Hyphomycetes*, pp. 355-356. **(Plate 4.6.1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* small, effuse, brown. *Mycelium* mostly immersed. *Setae* straight or flexuous, smooth, unbranched, subulate,

mid to dark brown, paler near the apex, often swollen at the base, 150-400 x 6-8 µm, gradually becoming narrower at the tip. *Conidiophores* mononematous, smooth, unbranched, straight or flexuous, pale to mid brown, 15-30 x 2-2.5 µm, with terminal and often also intercalary ampullae bearing conidiogenous cells or themselves functioning as conidiogenous cells; lower part of the ampulla dark and non-fertile and the upper part pale and fertile, 4.5-7.5 x 4.5 µm. *Conidiogenous cells* polyblastic, integrated, terminal and intercalary or discrete, spread over the upper surface of the ampulla, spherical, determinate, often percurrent, sometimes becoming calyciform. *Conidia* dry, catenate, simple, spherical or subspherical, smooth, aseptate, thick-walled, reddish medium brown, 3.5-5 µm in diam.

Specimen examined: On fallen dead and decaying leaves of *Dendrocalamus strictus*; moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1694; leg. Maria D'Souza, 29-12-1999.

This fungus was known to occur on leaf litter of many grasses (Carmicheal et al., 1980). It was reported on *Pennisetum* from Ghana (Ellis, 1971). The fungus was isolated by moist chamber incubation method and this is the first record from the forests of Western Ghats in India.

Mariannea elegans (Corda) Samson, 1974, *Stud. Mycol.*, **6:** 75. **(Fig. 65)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, white. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline 4-6 µm wide hyphae. *Conidiophores* mononematous, scattered, composed of an erect, straight or flexuous, smooth, 7-9-septate, unbranched, narrower and subhyaline at the base, hyaline towards the apex; stipe with branches and phialides are slender thin-walled, in verticils beneath

the septa nearest the apex, 270-480 µm long, 16-20 µm wide at the base, 4-8.5 µm wide in the middle and tapering to 2-4 µm wide at the tip, branches 27-96 x 2.7-5 µm. *Conidiogenous cells* monophialidic, discrete, arranged verticillately, determinate, without collarettes, smooth, hyaline, 10-30 x 2.5-5 µm. *Conidia* in slimy masses, in obliquely imbricate chains, continous, ellipsoidal to fusiform with blunt ends, smooth, aseptate, hyaline, 4.5- 7.5 x 1.3- 2 µm.

Specimen examined: On fallen dead and decaying leaves, twigs of *Dendrocalamus strictus*, moist deciduous forest, 25°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2536; leg. Maria D'Souza, 19-10-2000.

The fungus was isolated by both moist chamber incubation and particle plating methods. It was ealier recorded on wood of *Picea, Pseudotsuga* and *Acer*. It is a first record from the forests of Western Ghats in Goa State.

Mirandina longispora Maria et Bhat **sp. nov.** **(Fig. 66)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, black, velvety. *Mycelium* immersed. *Conidiophores* mononematous, erect, straight or slightly flexuous, unbranched, smooth, dark brown at the base, pale brown in the middle, paler towards the apex, 2-4-septate, 25-80 µm long, 12-17 µm wide at the base, 3-5 µm wide above. *Conidiogenous cells* polyblastic, integrated, terminal, determinate, brown to subhyaline, smooth, denticulate at the tip, 10-20 x 2.5-3.5 µm; denticles hyaline, inflated, subspherical, 3.5-5 µm wide. *Conidia* solitary, simple, elongated, cylindrical to subulate, narrow and truncate at the base, slightly broader in the middle, pointed and narrower at the distal end, hyaline, smooth, 5-10-septate, 100-250 x 2.5-4.5 µm.

HOLOTYPE: On leaf margin of fallen dead leaves of *Ficus tinctorius var.parasitica*, evergreen forest, 28°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2323;

leg. Maria D'Souza, 10-08-2000.

The genus *Mirandina* Arnaud ex Matsushima (Matsushima, 1975), typified by *M. corticola* Arnaud ex Matsushima, accomodates 6 species. *M. longispora* differs from the earlier known species by its long-sized conidia. The fungus was isolated by incubating the substrate in moist chamber.

Monodictys monilicellularis Matsushima, 1975. *Icones fungorum a lectus Matsushima.* p.97 **(Pl. 4.3.4)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, velvety, brown. *Mycelium* composed of smooth, septate, branched, hyaline hyphae 2-3 µm wide. *Conidiophores* semi-macronematous, mononematous, flexuous, irregularly branched, pale brown, smooth, aseptate. *Conidiogenous cells* monoblastic, integrated, terminal, sometimes also intercalary, determinate, cylindrical, doliiform, 1.3-3.5 µm diam. *Conidia* dry, solitary, unbranched, cheiroid, dark brown, smooth, multiseptate, 24-32 µm long, 8-14 µm wide at the base, 17-20 µm wide in the above.

Specimen examined: On fallen dead and decaying leaves of *Bambusa arundinacea*, moist deciduous forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1240; leg.Maria D'Souza, 15-08-1999.

The fungus was isolated by moist chamber incubation method.

Monodictys putredinis (Wallr.) Hughes, 1958. *Can.J.Bot.* **36**: 785 **(Fig. 67)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, shiny, brown, in aggregates. *Mycelium* mostly composed of smooth, septate, branched, hyaline 3.5 µm wide hyphae. *Conidiophores* micronematous, mononematous, flexuous, smooth, non-septate irregularly branched, hyaline. *Conidiogenous cells* monoblastic, integrated, terminal, sometimes also intercalary, determinate, cylindrical, doliiform, 3.5-8.5 x 3.5-

4.13 µm. *Conidia* dry, solitary, smooth, multiseptate, unbranched, cheiroid, dark brown, 24-58 µm long, 22-38 µm wide at the base, 20-24 µm wide in the above.

Specimen examined: On fallen dead and decaying leaves of *Pandanus tectorius*, grassland type, plateau, 25°C, Alorna, Goa, India; Herb. No. GUFCC No.2498; leg. Maria D'Souza, 11-4-1999.

It was earlier recovered from rotten wood from Europe (Ellis, 1971). In India it has been reported from dead wood from Anantagiri, A.P. (Sarbhoy et al., 1986). The fungus was isolated by moist chamber incubation method.

Nigrospora sphaerica (Sacc.) Mason, 1927, *Trans. Br. mycol. Soc.*, **12:** 158. **(Fig. 68)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA adpressed at first, later becoming floccose, with circular margin, rhizoidal, white with shining black conidial mass, slow growing, attaining a diam. of 1 cm in 7 days. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline 1.5-3 µm wide hyphae. *Conidiophores* semi-macronematous, flexuous, smooth, branched, almost hyaline, 8-17 x 8-16 µm. *Conidiogenous cells* monoblastic, discrete, solitary, determinate, ampulliform or subspherical, pale brown, 2-8.5 x 3.5-6 µm. *Conidia* dry, solitary, acrogenous, simple, spherical or broadly ellipsoidal, compressed dorsiventrally, smooth, aseptate, thick-walled, black, shining, 9-12 x 14.5-16.5 µm.

Specimen examined: (i) On fallen dead and decaying leaves of *Calamus thwaitesii* Roxb., moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.557; leg. Maria D'Souza, 14-02-2000. (ii) On fresh leaves of *Careya arborea*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1990; leg. Maria D'Souza, 11-04-2000.

A very common species, widespread in tropical cuntries on many different kinds of plants (Ellis, 1971). It has been isolated occassionally from food stuffs and soil

(Sarbhoy et al., 1986, 1996). It was also reported from an earlier study carried out in this laoratory (Miriam, 2000). The fungus was isolated by particle plating method.

Nodulisporium gregarium (Berk. & Curt.) Meyer, 1965, *Revue Mycol.*, **29:** 310. **(Fig. 69)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, light brown, dry to wet, often velvety. *Colonies* on MEA regular, circular, white, radiating, fast growing, with smooth margin, rhizoidal, colourless, attaining a diam. of 4.5 cm in 7 days; reverse of the colony light brown. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown 1.5 µm wide hyphae. *Conidiophores* mononematous or synnematous, individual threads often much branched towards the apex, flexuous, verrucose, 4-10-septate, pinkish in colour, 100-155 x 2-3.5 µm. *Conidiogenous cells* polyblastic, integrated, terminal, later becoming intercalary or discrete, solitary or penicillate, sympodial, pink, verrucose, denticulate, cylindrical to clavate, 13-35 x 2-3.3 µm. *Conidia* dry, solitary, simple, ellipsoidal or obovoid, pointed at the base when detached, smooth, aseptate, pink, 4-5.5 x 2-3 µm.

Specimen examined: (i) On fallen dead and decaying leaves of *Careya arborea*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2018; leg. Maria D'Souza, 29-12-1999. ii) On fallen dead and decaying leaves of *Dendrocalamus strictus*; evergreen forest, 24°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1015; leg. Maria D'Souza, 15-08-1999.

The fungus was isolated from soil in Calicut, Kerala on culms of *Saccharum spontaneum* (Sarbhoy et al., 1986, 1996). In this work the fungus was isolated by both moist chamber incubation and particle plating methods.

***Nodulisporium* sp.** **(Fig. 70)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, grey. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown hyphae 2-3 µm wide. *Conidiophores* mononematous, erect, flexuous, branched towards the apex, verrucose, 7-10-septate, dark brown at the base, pale brown above, up to 225 µm long, up to 10 µm wide in the middle, 3.5-5.5 µm above; branches 8-66 x 3.5-4.5 µm. *Conidiogenous cells* polyblastic, discrete, cylindrical, terminal, later becoming intercalary, penicillately arranged, sympodial, pale brown, verrucose, denticulate; *Conidia* dry, solitary, simple, ellipsoidal, with a small frill at the base when detached, 1.5-2.8 µm, hyaline, non-septate, smooth, 4.5-6.5 x 2-3 µm.

Specimen examined: On fallen dead and decaying twigs of *Terminalia paniculata*, moist deciduous forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1246; leg. Maria D'Souza, 15-08-1999.

The genus *Nodulisporium* Preuss accommodates the imperfect states of *Xylaria, Hypoxylon and Rosellinia* (Hawksworth et al., 1995). So far, 10 species are known. The recent description of a similar fungus (imperfect state of *Xylaria*) without any spores or spore bearing structures in a new genus *Muscodor* Worapong et al. (2001) based exclusively on molecular techniques calls for use of similar methods in identification of all species of similar wood-inhabiting fungi in the future. The fungus was isolated by moist chamber incubation method.

Parahelminthosporium malabaricum Subramanian & Bhat, 1987, *Kavaka*, **15:** 41-74. **(Fig. 71)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown. *Mycelium* immersed. *Conidiophores* mononematous, erect, straight or flexuous,

unbranched, slightly broader at the base, smooth, 10-20-septate, dark brown at the base, pale brown towards the apex, fertile at the above half, 220-370 x 7-11 μm. *Conidiogenous cells* intergrated, terminal to intercalary, cylindrical to slightly doliiform, smooth, with 5-10 distinct uncicatrized 1.5 μm diam. pores, medium brown, 8-30 x 6.5-10 μm. *Conidia* dry, solitary, ampuliform, bicelled, smooth, constricted at the septum, dark brown at the attached end, hyaline at the apical cell region, rounded at the apex, thick-walled, 3.5 μm at the base, basal cell 20-35 x 7.5-10 μm, apical cell 11-14 x 2.5-3.5 μm.

Specimen examined: On fallen dead and decaying leaves *Calamus thwaitesii,* moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.291; leg. Maria D'Souza, 11-02-1999.

The fungus was first isolated from dead rachis of *Calamus* sp. in Poochipara, Silent valley, Kerala (Subramanian and Bhat, 1987). The fungus was isolated by moist chamber incubation method and is a first record from the forests of Western Ghats in Goa.

Parapathramaya Maria et Bhat **gen nov.**

(Etym. Para = similar to pathramaya)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown. *Mycelium* partly immersed, composed of smooth, septate, branched, pale brown, hyphae. *Conidiophores* mononematous, straight to slightly flexuous, branched or unbranched, smooth, septate, pale brown. *Conidiogenous cells* mon- to polyblastic, integrated or discrete, terminal or intercalary, spherical to sub-spherical, cupulate, sometimes closely arranged on the conidiophore, pale to dark brown, smooth. *Conidia* solitary, simple,

verruculose, ellipsoidal to spherical, pale brown, aseptate.

Type species: *P. haarea* Maria et Bhat **sp.nov.**

(Etym.: In Samskrit: Haara = Necklace)

The genus *Paathramaya* Subramanian, with *P. sundara* Subram. as type species, was described for a synnematous, dematiaceous, fungus with cupulate, monoblastic, conidiogenous cells and huge, aseptate, black, verrucose conidia (Ellis, 1971). While describing a new species in the genus from Ethiopia, *P. suttonii* Bhat (1985), *Panchanania* Subramanian was also accommodated in the genus as *P. jaipurensis* (Subram.) Bhat. The fungus in hand although shows some similarity with *Paathramaya* by its cupulate conidiogenous cells and aseptate, verrucose conidia, it differs by mononematous conidiophores, mono-to polyblastic conidiogenous cells and very small, subhyaline conidia.

Parapaathramaya haarea Maria et Bhat **gen. et sp.nov.** **(Fig. 72)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, brown, slow growing, attaining a diam. of 1 cm in 7 days, with a rhizoidal margin; reverse of the colony light brown. *Mycelium* partly immersed, composed of smooth, septate, branched, pale brown, 1.5-2 µm hyphae. *Conidiophores* mononematous, erect, straight to slightly flexuous, branched, slightly narrower at the base, smooth, 1-7-septate, yellowish to pale brown, 6-37 x 1.5-2 µm. *Conidiogenous cells* mono- to polyblastic, integrated, terminal or intercalary, closely arranged all around the conidiophore, determinate, pale brown to dark brown, smooth, spherical to sub-spherical, 2-6.5 x 2-2.7 µm when ellipsoidal, 1.3-2.6 µm diam. when collapsed. *Conidia* solitary, simple,

verruculose, ellipsoidal to spherical, pale brown, aseptate, 2.6-6.5 x 2-3.5 µm.

HOLOTYPE: On dead and decaying leaves of *Terminalia paniculata*, evergreen, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1282; leg. Maria D' Souza, 03-09-1999.

Paschimghateeya Maria et Bhat, **gen. nov**.

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, erect, straight, velvety. *Mycelium* immersed. *Conidiophores* mononematous, simple, straight, smooth, septate, unbranched, thick-walled, dark brown, slightly paler above. *Conidiogenous cells* polyblastic, terminal, integrated, later becoming discrete, smooth, thick-walled, brown, with nonciccatrized loci. *Conidia* simple, solitary or in chains, doliiform, smooth, thickly septate, thick-walled, dark brown.

Several genera of dematiaceous Hyphomycetes producing polyblastic conidiogenous cells on mononematous conidiophores and septate conidia are known. *Paschimghateeya* differs from closely related genera such as *Septonema* Corda, *Heteroconium* Petrak and *Hemicorynespora* Ellis (Ellis, 1971, 1976) by its smooth-walled, thickly septate, doliiform, conidia developing on branched conidiophores with nonciccatrized polyblastic conidiogenous cells.

Type species: ***P. goanensis*** Maria et Bhat **gen. et sp. nov.** **(Pl. 4.6.3; Fig. 73)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, erect, straight, hairy, shiny. *Mycelium* immersed. *Conidiophores* mononematous, simple, straight, smooth, 4-8-septate, unbranched, thick-walled, dark brown, slightly paler towards the apex, 120-175 x 8-15 µm, with septa 20-35 µm apart, arising singly. *Conidiogenous cells* mono- to polyblastic, terminal, integrated, smooth, thick-walled,

brown, 8-13 x 4-6 μm, with nonciccatrized conidiogenous loci. *Conidia* simple, solitary, some times in chains, doliiform, smooth, with 1-median thick septum, constricted at the septum, thick-walled, dark brown, truncate at the base, 15-20 x 5-6 μm.

HOLOTYPE: On fallen dead and leaves of *Dendrocalamus strictus*, moist deciduous forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2540; leg. Maria D'Souza, 20-09-2000.

Periconia atra Corda, 1837, *Icon. Fung.*, **1:** 19 **(Pl. 4.5.4)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, small, compact, brown to black, hairy. *Mycelium* partly immersed. *Conidiophores* mononematous, erect, straight or flexuous, smooth, 1-4 septate, branched at the tip, slightly narrower at the base, medium to dark brown, smooth, 540-750 x 15-30 μm, 6-12 μm wide just below the apex. *Conidiogenous cells* mono- or polyblastic, discrete on stipe and branches, determinate, ellipsoidal. *Conidia* catenate, chains often branched, arising at one or more points on the branches of the conidiogenous cell, simple, usually spherical, verrucose, aseptate, thick-walled, pale to dark brown, 9-12 μm diam.

Specimen examined: On fallen dead and decaying leaves of *Careya arborea*, moist deciduous forest, 26°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2414; leg. Maria D'Souza, 20-09-2000.

The fungus was recovered from dead leaves of grasses and sedges from Europe (Ellis, 1971). The fungus was isolated by moist chamber incubation method.

Periconia byssoides Pers. ex Merat, 1821, *Nouv. Fl. Environs Paris, Ed.* 2, **1:** 18-19. **(Fig.74)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, with a rhizoidal margin, white initially, later changing to dark olive green, flat,

moderately growing, attaining a diam. of 2.5 cm in 7 days; reverse of the colony olive green. *Mycelium* immersed completely, composed of smooth, septate, branched, pale to medium brown, 4-7 µm wide hyphae. *Stroma* absent. *Conidiophores* mononematous, erect, straight or flexuous, smooth, 6-7-septate, unbranched, slightly narrower at the base, medium to dark brown, smooth, up to 850 µm long, up to 20 µm thick at the base, up to 13.5 µm wide below the apex. *Conidiogenous cells* monoblastic or polyblastic, discrete, determinate, sub-spherical, 46-115 x 13 µm. *Conidia* catenate, chains often branched, arising at one or more points on the curved surface of the conidiogenous cell, simple, usually spherical, smooth or verrucose, aseptate, thick-walled, pale to dark brown, 12-15 µm diam.

Specimen examined: On fallen dead leaves of *Calamus thwaitesii*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.420; leg. Maria D'Souza, 08-06-1999.

It is an extremely common fungus found growing on dead leaves, stems, friuts, pods, twigs, etc of different plant species (Sarbhoy et al., 1986, 1996). The fungus was isolated by moist chamber and partcile plating methods.

Periconia echinochloae (Batista) M.B.Ellis, 1971, *Dematiaceous Hyphomycetes*, pp-347. **(Pl. 4.5.3)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, small, compact, brown, olivaceous brown or black, hairy. *Mycelium* partly immersed. *Conidiophores* mononematous, mostly with a stipe and a spherical head, stipe erect, straight or flexuous, branched, slightly narrower at the base, smooth, 1-4-septate, medium to dark brown, smooth, 150-350 x 10-18 µm. *Conidiogenous cells* monoblastic or polyblastic,

discrete on stipe and branches, determinate, ellipsoidal, spherical or sub-spherical. *Conidia* catenate, chains often branched, arising at one or more points on the branches of the conidiogenous cell, simple, ellipsoidal, pale to dark brown, aseptate, thick-walled, verrucose, 15-18 x 6-9 μm.

Specimen examined: (i) On fallen dead and decaying leaves of *Calamus thwaitesii*, moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2113; leg. Maria D'Souza, 08-06-2000. (ii) On fallen dead and decaying leaves *Dendrocalamus strictus*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1693; leg. Maria D'Souza, 29-12-1999.

According to Ellis (1971), the fungus was reported on many different types of grasses and also isolated from air and soil. It was also known to occur on dead pseudobulbs of *Monochoria hastaefolia* in India (Sarbhoy et al., 1996). The fungus was isolated by moist chamber incubation method.

***Phiacephala* sp.** **(Fig. 75)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, shining, white. *Mycelium* immersed, composed of smooth, septate, branched, hyaline, 1.5-3.5 μm wide hyphae. *Conidiophores* mononematous, composed of a stout, erect, straight or flexuous, above branched in one series, smooth, stipe, 5-septate, hyaline, 180-200 x 4-6.5 μm, 4-6.5 μm. *Conidiogenous cells* monophialidic, discrete, arranged penicillately, determinate, elongated, 11-18 x 1.3-2 μm, with collaretes, smooth, hyaline, up to 1.5 μm wide. *Conidia* dry, often in false chains, aggregated in slimy heads, endogenous, simple, ellipsoidal to sub-spherical, smooth, aseptate, colourless, 4-7 x 1.5-3.5 μm.

Specimen examined: (i) On fallen dead and decaying leaves *Dendrocalamus strictus*, moist deciduous forest, 23°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2545; leg. Maria D'Souza, 14-02-2000. (ii) On fallen dead and decaying *Calamus thwaitesii*,

moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1903; leg. Maria D'Souza, 22-11-2001. (iii) On fallen dead and decaying leaves *Saraca asoca,* moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1855; leg. Maria D'Souza, 14-02-2000.

The fungus was isolated by moist chamber incubation method.

Pithomyces chartarum (Berk. & Curt.) M. B. Ellis, 1960, *Mycol. Pap.*, **76:** 13-15. **(Fig. 76)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, rhizoidal margin, yellowish to light brown, slow growing, attaining a diam. of 1 cm in 7 days; reverse offwhite. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline 2.5-4.16 µm wide hyphae. *Conidiophores* semi-macronematous, branched, straight or flexuous, subhyaline to pale brown, smooth, 4-12.5 x 2.5 µm. *Conidiogenous cells* monoblastic to polyblastic, integrated, intercalary, sometimes terminal, determinate, cylindrical, very pale brown, 5 x 3 µm. *Conidia* dry, solitary, simple, detached through fracture of the denticle, a portion of which often remains attached to the base of the conidium, ellipsoidal, clavate, oblong, rounded at the ends, dark blackish brown, smooth, verruculose, with 2-3 transverse and often 1 longitudinal septa, 13-24 x 5 -10 µm.

Specimen examined: (i) On fallen dead and decaying leaves *Xylia xylocarpa*, moist deciduous forest, 24°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1609; leg. Maria D'Souza, 09-12-1999. (ii) On fallen dead and decaying leaves of *Pandanus tectorius*, grassland type, plateau, 25°C, Alorna, Goa, India; Herb. No. GUFCC No.1587; leg. Maria D'Souza, 11-4-1999.

It is a cosmopolitan species found on paper and dead leaves of many different plants (Sarbhoy et al., 1986,1996). The fungus was isolated by particle plating method and reported from an earlier study carried out in this laoratory (Miriam, 2000).

Pleurophragmium minutispora Maria et Bhat **sp. nov.** **(Fig. 77)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown. *Mycelium* partly immersed, partly superficial, composed of smooth, septate, branched, hyaline hyphae 1-1.5 µm wide. *Conidiophores* semi-macronematous, mononematous, simple, unbranched, smooth, sub-hyaline to pale brown, thick-walled, 20-36 x 2-3.5 µm, 1-1.5 µm wide at the apex. *Conidiogenous cells* polyblastic, terminal, sympodial, integrated, elongated, cylindrical, sub-hyaline, smooth, 15-30 x 2-2.75 µm, denticulate above; denticles short, cylindrical, 0.5-1 x 0.5 µm. *Conidia* solitary, fusiform and pointed at both ends, 2-4-septate, thick-walled, smooth, hyaline, 7-10 x 2-2.75 µm.

Specimen examined: On fallen dead and decaying leaves of *Psychotria dalzellii*; evergreen forest, 25°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1129; leg. Maria D'Souza, 19-07-1999.

The fungus was isolated by particle plating method. The genus *Pleurophragmium* Costantin, typified by *P. simplex* (Berk. & Br.) Hughes, so far accommodated 15 species. These are typical litter inhabiting fungi also well known from the tropics. *P. minutispora* differs from the rest by its smooth, septate conidia and short conidiophores.

Pleurophragmium simplex (Berk. & Br.) Hughes, 1958, *Can. J. Bot.*, **36:** 798. **(Fig.78)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, hairy, pale brown. *Mycelium* mostly immersed. *Conidiophores* mononematous, straight or flexuous, unbranched, smooth, 6-9-septate, medium to dark brown at the base, slightly paler towards the apex, 90-138 x 3-9 µm, at the tip up to 2-2.5 µm wide.

Conidiogenous cells polyblastic, integrated, terminal, sympodial, cylindrical, medium brown, 13-19 x 2-3 µm, denticulate; 2-6 denticles tapered to a point and distributed in the upper half. *Conidia* dry, solitary, simple, narrowly ellipsoidal to subclavate, rounded at the apex, tapered to a point at the base, smooth, 3-septate, hyaline, 8-15 x 2-3.5 µm.

Specimen examined: On fallen dead and decaying leaves of *Careya arborea*, moist deciduous forest, 23°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2663; leg. Maria D'Souza, 21-11-2000.

The fungus is common on partly decorticated dead stems of *Urtica* and other plants from Europe (Ellis, 1971). It was isolated by moist chamber incubation method.

Pleurothecium pulneyensis Subramanian & Bhat, 1987, *Kavaka*, **15:** 41-74. **(Fig. 79)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, thinly hairy, pale brown. *Mycelium* mostly immersed. *Conidiophores* mononematous, straight or flexuous, smooth, 6-9-septate, unbranched, medium to dark brown, 140-258 µm long, 2-4 µm wide in the middle, and often swollen at the base 7-10 µm wide. *Conidiogenous cells* polyblastic, integrated, terminal, sympodial, cylindrical, medium brown, 33 x 2-3 µm, conspicously denticulate at the tip; with 3-5 denticles tapered to a point. *Conidia* dry, solitary, simple, narrowly ellipsoidal to fusiform, rounded at the apex, slightly curved, tapered to a point at the base, smooth, 3-septate, hyaline, 15-20 x 2-5 µm.

Specimen examined: On dead and decaying twigs of *Elaeis guineensis*, moist deciduous forest, 26°C, Tambisurla, Goa, India; Herb. No. GUFCC No.2296; leg. Maria D' Souza, 01-10-1999.

The fungus was first isolated from unidentified dead twigs in Kodaikanal, Tamil Nadu (Subramanian and Bhat, 1987). The fungus was isolated by moist chamber incubation method.

Pleurothecium ramosa Maria et Bhat **sp. nov.** **(Fig. 80)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, colourless, fast growing, with a rhizoidal margin, attaining a diam. of 4 cm in 7 days; reverse of the colony same. *Mycelium* immersed, composed of smooth, septate, unbranched, hyaline hyphae 2.5-3.5 µm wide. *Conidiophores* macronematous, mononematous, simple, branched, dark brown at the base, pale brown to subhyaline above, smooth, thick-walled, 1-6-septate, 140-175 x 2.75-4.5 µm, with branches smooth, 1-2-septate, 30-45 x 2-3 µm. *Conidiogenous cells* polyblastic, terminal, integrated, elongated to cylindrical, pale brown, smooth, aseptate, 13-30 x 1.5- 2.75 µm, developing on conspicuous 3-5 denticles up to 2 µm long. *Conidia* ellipsoidal, slightly curved, 2-6-septate, constrited at the septa, thick-walled, hyaline, smooth, solitary, 14-27 x 2.5-4.5 µm.

Specimen examined: (i) On dead and decaying leaves of *Dendrocalamus strictus*, evergreen, 26^{0}C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1658; leg. Maria D' Souza, 20-09-2000. (ii) On dead and decaying leaves of *Dendrocalamus strictus*, evergreen, 27°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2058; leg. Maria D' Souza, 11-04-2000, moist chamber incubation method. (iii) On dead and decaying leaves of *Dendrocalamus strictus*, evergreen, 27°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2039; leg. Maria D' Souza, 11-04-2000.

The fungus was isolated by both particle plating and moist chamber incubation methods. The genus *Pleurothecium* Hohnel, typified by *P. recurvatum* (Morgan) Hohnel (Ellis, 1976; Subramanian and Bhat, 1987) was often confused with *Cucumisporium* Preuss (Carmichael et al., 1980). So far only two species are known. The fungus in hand differs from these by its smaller sized conidia and branched conidiophores.

***Podosporium* sp.** **(Fig. 81)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, light dark brown, velvety. *Mycelium* immersed. *Conidiomata* synnematous; synnema erect, straight or slightly flexuous, fertile at the apex, pale brown, 430-770 x 33-70 µm, flared to a clavate head 90-110 x 40-75 µm, composed of septate, branched, smooth, pale brown hyphae 2.5-5 µm wide. *Conidiogenous cells* monotretic, terminal, integrated or discrete, cylindrical to clavate, pale brown, thick-walled, smooth walled, truncate and 2.3-3 µm wide at the aperture on conidial secession, 6-30 x 3-6.5 µm. *Conidia* solitary, dry, acrogenous, cylindrical, rounded at the tip, slightly truncate at the base, cicatrized, thick-walled, smooth, 2-5-pseudoseptate, pale brown, 50-130 x 4-10 µm.

Specimen examined: On fallen dead leaves of *Bauhinia purpurea*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2371; leg. Maria D' Souza, 03-09-2000.

The fungus was isolated by moist chamber incubation method.

Polyschema indica Behera et al., 1973, *Norwegian J. Bot.* **20**(1): 27. **(Pl. 4.7.2)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, yellowish, wooly, scattered. *Mycelium* immersedcomposed of verruculose, septate, regularly branched, pale brown hyphae, up to 2.4 µm wide. *Conidiogenous cells* monotretic, spherical or sub-spherical, integrated, verruculose, thick-walled, pale brown. *Conidia* ellipsoidal or occassionally pyriform, mid dark golden brown with the end cells paler, verruculose or echinulate, with 2-4-dark transverse septa, 25-35 x 12-17 µm.

Specimen examined: On fallen dead and decaying leaves of *Calamus thwaitesii*, moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1917; leg. Maria D'Souza, 14-02-2000.

The fungus was recorded from soil from India (Ellis, 1976). It was isolated in this study by moist chamber incubation method. This is the first record from the forests of Western Ghats in Goa.

Pteroconium pterospermum (Cooke & Massee)Grove, 1914, *Hedwigia,* **55:** 146. **(Pl. 4.7.5)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* punctiform, gregarious, superficial, dark brown. *Mycelium* partly superficial, with branched, smooth, septate, thick-walled, hyphae 2.5 µm wide. *Conidiomata* sporodochial. *Conidiophores* mononematous, slightly verrucose, septate, branched light coloured, 3.5 µm wide. *Conidiogenous cell* basauxic, polyblastic. *Conidia* dry, velvety, solitary, globose, aseptate, slightly verrucose, dark brown with a conspicous germ slit and collapsing on drying, 13-25 µm diam.

Specimen examined: (i) On fallen dead and decaying leaves of *Dendrocalamus strictus*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.329; leg. Maria D'Souza, 11-03-1999. (ii) On fallen dead and decaying leaves of *Dendrocalamus strictus*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1697; leg. Maria D'Souza, 30-12-1999.

The fungus was known earlier from Australia. (Ellis, 1971). It was isolated by moist chamber incubation method.

***Pyricularia* sp.** **(Fig. 82)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, light brown, foliicolous. *Mycelium* immersed. *Conidiophores* macronematous, mononematous, scattered, erect, straight or flexuous, unbranched, smooth, dark brown at the base, pale brown in the

middle and apex, 80-250 x 2.5-5 µm. *Conidiogenous cells* polyblastic, integrated and terminal, determinate, with well defined, cylindrical, denticles, pale brown, smooth, 10-25 x 2.75 µm. *Conidia* simple, narrow at the point of attachement, broad in the middle, narrow at the apex, pale brown, smooth, 1-septate, cicatrized at the base, 3.5-8.5 x 3.5-4.5 µm, developing on denticles 0.5-1.5 µm.

Specimen examined: On dead and decaying leaves of *Ficus benghalensis*, coastal vegetation, 25°C, Baga, Goa, India; Herb. No. GUFCC No.1434; leg. Maria D' Souza, 11-10-99.

The fungus was isolated by moist chamber incubation method.

Raperia swedaja Maria et Bhat **sp. nov.** **(Fig. 83)**

(Etym. In Sanskrit, swedaja = from decaying substrate)

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, yellowish, with a rhizoidal margin, median growth, attaining a diam. of 1.2 cm; reverse of the colony yellow. *Mycelium* mostly immersed, composed of smooth, septate, branched, hyaline to yellowish, thin-walled, 3 µm wide hyphae. *Conidiophores* mononematous, straight or flexuous, smooth, 8-12-septate, pale yellow to orange, 130-455 x 3-10 µm, verticillately branched at the apical region; branches smooth, light yellow, 1-septate, 23-107 x 4-6 µm, terminating into a distinct, fertile, clavate head 19-45 x 6-18 µm. *Conidiogenous cells* monophialidic, arising directly on the vesicle, terminal, clavate, yellowish orange, 6-8.5 x 3.5-5 µm, 1.5-2 µm wide at the tip. *Conidia* catenate, simple, aseptate, spherical, narrowly ellipsoidal, smooth, orange yellow, 3.5-5.5 µm diam.

Specimen examined: On fallen dead and decaying leaves *Saraca asoca,* moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.304; leg. Maria D'Souza, 11-02-1999.

The fungus was isolated by particle plating method.

Saccardaea indica Maria et Bhat **sp. nov.** **(Fig. 84)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, olivaceous black, velvety. *Mycelium* mostly immersed, composed of cylindrical, smooth, septate, branched, thick-walled, pale brown, 1.5-2 µm wide hyphae. *Conidiophores* synnematous, smooth, septate, branched, olivaceous green, up to 3 µm wide, terminating in sterile, robust ends; synnemata arising singly, erect, straight or flexuous, with compact stipe, cupulate and fertile at the apex, olivaceous green, 180-285 µm long, 40-60 µm wide at the base, 12-17 µm wide in the middle, 50-55 x 30-48 µm wide at the cupulate apex; terminal sterile ends broad at the base, 2-5 septate, smooth, pale olive green, 40-75 µm long, up to 5 µm wide at the base, up to 2-3.5 µm wide in the middle and above. *Conidiogenous* cells monophialidic, terminal, integrated or discrete, cylindrical to clavate, slightly truncate, smooth, thick-walled, olivaceous green, 4.5-12.5 x 2.75 µm, up to 1.5 µm wide at the tip. *Conidia* solitary, slimy, ellipsoidal, rounded at the ends, slightly narrower and denticulate at the base, with 1 median septum, slightly constricted at the septum, thick-walled, smooth, olivaceous brown, 4.5-8 x 2-3.5 µm.

HOLOTYPE: On dead and decaying leaves of *Calamus thwaitesii*, moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.474; leg. Maria D' Souza, 09-06-1999.

The genus *Saccardaea* Cavara, typified by *S. echninocephala* Cav. (Ellis, 1971) is characterized by synnematous conidiophores which are cupulate at the tip. Tulloch considered *Saccardaea* Cav. as a *nomen dubium* in view of its small conidiomata which was considered to be similar to the sporodochia of *Myrothecium* Tode ex Fr.

(Carmichael et al., 1980). However, it is noticed that the conidiomata in *Saccardaea* are really not sporodochial but synnematous. Hence *Saccardaea* is recognised as a valid genus. Two species, *S. atra* (Desm.) Mason & M.B. Ellis and *S. echinocephala* Tode ex Gray, are the so far known species in the genus. *S. indica* differs from these by its smaller sized synnema and 1-septate, small conidia. The fungus was isolated by particle-plating method and it readily produces the synnemata in culture.

***Scolecobasidium* acuminatous** Maria et Bhat **sp. nov.** **(Fig. 85)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, brown, with serrated margin, slow growing attaining a diam. of 0.8 cm in 7days; reverse of the colony offwhite. *Mycelium* immersed, partly superficial, composed of smooth, septate, unbranched, sub-hyaline, 0.5-2 µm diam. hyphae. *Conidiophores* mononematous, macronematous, often short, straight to flexuous, smooth, 0-2-septate, unbranched, sub-hyaline at the base, pale brown towards the apex, thick-walled, 15-20 x 1.5-3.5 µm. *Conidiogenous cells* polyblastic, integrated, terminal, cylindrical, 6-14 x 1.5-3.5 µm, denticulate; denticles short, narrow, cylindrical, up to 0.5-2 µm. *Conidia* dry solitary, simple, acuminate, 2-septate, unbranched, verruculose, pale brown, 12-20 x 3-4.5 µm.

Specimen examined: On fresh leaves of *Careya arborea*, coastal vegetation, 27°C, Molem wildlife sanctuary, Goa, India; Herb. No. GUFCC No.1994; leg.; Maria D'Souza, 30-12-1999.

The fungus differs from the known species by its verruculose and boat shaped conidia. (Ellis, 1971, 1976). Here it is recovered in culture by endophytic isolation and particle plating method.

Scolecobasidium constrictum Abbott, 1972, *Mycologia*, **19:** 29-31. **(Fig. 86)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, slow growing, floccose, circular, light brown, attaining a diam. of 0.3 cm in 7 days; reverse radiating from the centre. *Mycelium* partly superficial, composed of smooth, septate, branched, pale brown, thin-walled 1.5-3.6 µm wide hyphae. *Conidiophors* mononematous, arising in groups, straight to flexuous, smooth, septate, unbranched, dark brown at the base, paler towards the apex, thick walled, 4.5-12 µm long. *Conidiogenous cells* polyblastic, intergrated, terminal, clavate to cylindrical, denticulate; denticles long, narrow cylindrical, oblong, ellipsoidal, rounded at both the ends. *Conidia* dry solitary, simple, clavate to ellipsoidal, unbranched, minutely verruculose, pale to mid brown, 1-3-septate, constricted at the septa, 3.5-5 x 2.4 µm.

Specimen examined: (i) On dead and decaying leaves of *Ficus benghalensis*, Baga, Goa, moist deciduous forest, 25°C, India; Herb. No. GUFCC No. 1402, Maria D' Souza, moist chamber incubation method, 11-10-99. (ii) On fallen dead leaves of *Calamus thwaitesii*; Streamedge, moist deciduous forest, 23.5°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1950; leg. Maria D'Souza, 14-02-2000.(iii) On fallen dead leaves of *Calamus thwaitesii*, moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2071; leg. Maria D'Souza,; Maria D'Souza, 08-06-2000.(iv) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 27°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1974; Maria D' Souza, 11-03-99. (v) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1758; Maria D' Souza, 30-12-99. (vi) On dead and decaying leaves of *Careya arborea*, deciduous forest, 28°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 338; leg. Maria D' Souza, 11-04-2000.

The fungus was isolated by both moist chamber incubation and particle plating methods. It was also reported from an earlier similar work carried out in this laboratory (Miriam, 2000)

Scolecobasidium humicola Barron et Busch, 1962, *Can J. Bot.*, **40:** 83. **(Fig. 87)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* MEA regular, effuse, flat with serrated margin, raised in the centre, light brown, slow growing, attaining a diam. of 0.6cm in 7 days; reverse of the colony dark brown. *Mycelium* immersed, composed of smooth, septate, branched, pale brown, thin-walled, 2.4-3.6 µm wide hyphae. *Conidiophores* mononematous, arising in groups, often short, straight to flexuous, smooth, septate, unbranched, thick walled, dark brown at the base and paler towards the apex, up to 60 x 2.5 µm. *Conidiogenous cells* polyblastic, integrated, terminal, clavate to cylindrical, denticulate; denticles long, narrow, cylindrical, oblong, ellipsoidal, rounded at both the ends. *Conidia* dry, solitary, simple, clavate to ellipsoidal, smooth, 1-septate, not constricted at the septum, pale to mid brown, 4.5-10 x 2.4-3.6 µm.

Specimen examined: On fallen dead twigs of *Elaeis guineensis* Jacq., Plantation, 23°C, Tambdisurla, Goa, India; Herb. No. GUFCC No.2259; leg.Maria D'Souza, 08-07-2000.

The fungus has been isolated from soil and on *Borassus* from India, Japan and North America (Ellis, 1971; Matsushima, 1975). The fungus was isolated by particle plating method. It was also reported from an earlier study carried out in this laoratory (Miriam, 2000).

Scolecobasidium saprophyticus Maria et Bhat **sp. nov.** **(Fig. 88)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, dark brown, with offwhite rim, with serrated margin, slow growing attaining a diam. of 0.5 cm in 7days; reverse of the colony offwhite to light brown. *Mycelium* immersed, partly superficial, composed of smooth, septate, unbranched, 1.3-2 µm diam. hyphae. *Conidiophores* mononematous, macronematous, arising in groups, often short, straight

to flexuous, smooth, 0-1-septate unbranched, dark brown at the base, paler towards the apex, thick-walled, 10-16 x 2 μm. *Conidiogenous cells* polyblastic, integrated, terminal, cylindrical, 6-20 x 2 μm, denticulate; denticles short, narrow, cylindrical, up to 1.3 x 0.6 μm. *Conidia* dry solitary, simple, clavate, 2-septate, acuminate at the tip, unbranched, verruculose, pale to mid brown, 9-17 x 1.5-3.5 μm.

Specimen examined: On fallen dead leaves of *Ficus benghalensis*, coastal vegetation, 27°C, Baga, Goa, India; Herb. No. GUFCC No.1416; leg.; Maria D'Souza, 11-10-99.

The fungus differs from the known species by its acuminate conidia which are verruculose on the surface (Ellis, 1971, 1976). Here it is recovered in culture by particle plating method

***Scolecobasidium* sp.1** **(Fig. 89)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse. *Mycelium* partly superficial, composed of smooth, septate, branched, pale brown, thin-walled, 2 μm wide hyphae. *Conidiophores* mononematous, arising in groups, short, straight to flexuous, smooth, 3-septate, branched, sometimes unbranched, dark brown at the base, paler towards the apex, thick walled, 37-94 x 2-3 μm. *Chamydospores* smooth, hyaline, in branched chains up to 23-34 x 6.7 μm. *Conidiogenous cells* polyblastic, integrated, terminal, clavate to cylindrical, denticulate, 8-14 x 1.5-2 μm; denticles 0.7 μm long, narrow, cylindrical, oblong to ellipsoidal. *Conidia* dry, solitary, simple, clavate to ellipsoidal, 1-septate, unbranched, smooth, pale to mid brown, 4-8 x 2.3-3.3 μm long.

Specimen examined: On fallen dead leaves of *Schizigium cumini*, moist deciduous forest, 30°C, Tambdisurla, Goa, India; Herb. No. GUFCC No.2208; leg. Maria D'Souza, 08-07-2000.

The fungus was isolated by particle plating method.

***Scolecobasidium* sp.2** **(Fig.90)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, brown, velvety, with a rhizoidal branched margin, slow growing, attaining a diam. of 0.8 cm in 7 days; reverse of the colony brown. *Mycelium* immersed and superficial composed of smooth, septate, branched, pale brown 1-2.75 µm hyphae. *Conidiophores* mononematous, often very short, straight to flexuous, smooth, 0-1-septate, unbranched, dark brown at the base and paler towards the apex, thick walled, 4-18 µm long and 2 µm wide *Conidiogenous cell* polyblastic, integrated, terminal, cylindrical, 6-19 x 2 µm, denticulate; denticles short, narrow cylindrical, up to 1.3 x 0.6 µm. *Conidia* dry solitary, simple, clavate, 2-septate, unbranched, smooth, pale to mid brown, 9-17 x 3-3.5 µm, 1.5 µm wide at the apex.

Specimen examined: On dry leaves of *Ensete superbum*, moist deciduous, 27°C, Chorlem, Goa, India; Herb. No. GUFCC No.1066; leg. Maria D'Souza, 02-07-1999.

The fungus was isolated by particle plating method.

Selenoidriella indica Bhat and Kendrick, 1993, *Mycotaxon*, **69:** 19-90. **(Fig. 91)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, light to dull grey, foliicolous. *Mycelium* partly superficial, composed of smooth, septate, branched, brown, thin-walled up to 2.4 µm wide hyphae. *Conidiophores* mononematous, differentiated, erect, straight or flexuous, smooth, 7-9-septate, unbranched, mid to very dark brown, regenerating percurrently, 145-175 x 4-7 µm, at the nodal region where the branches develop up to 7.5 µm wide; base rhizome-like, contorted, vermiform, brown to dark brown, very thick walled, smooth, 12-36 µm wide. *Conidiogenous cells* polyblastic, sympodial, terminal and sub-terminal, integrated and discrete, developing in whorls or

clusters at the tip and also below the tip, lageniform, with minute denticles, 4.8 µm long, 2.4-4.8 µm wide at the base and up to 3.6 µm wide at the apex, pale brown to sub-hyaline, arising directly from the conidiophores or from 1-2 septate, 5-7 long and 2.4 µm wide branches or from the terminal cell. *Conidia* falcate, smooth, non-septate, pointed at both the ends, colourless, 5-7.5 x 2.4 µm.

Specimen examined: On fallen dead leaves of *Ficus tinctorius var. parasitica* (Willd.) Corner, evergreen forest, 24°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2322; leg. Maria D'Souza, 10-08-2000.

The fungus was isolated by moist chamber incubation method. This is the second record from the forests of Western Ghats (Bhat and Kendrick, 1993).

Sesquicillium indicum Maria et Bhat **sp. nov.** **(Fig.92)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, circular in shape, initially brownish green, later changing to dull green, median growth, attaining a diameter of 1.4 cm; reverse of the colony dull green. *Mycelium* immersed, partly superficial, composed of smooth, septate, branched, 2-2.7 µm hyphae. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, branched, slightly narrower at the base, smooth, 2-7-septate, colourless to slightly pale yellowish, 20-100 µm long, 2 µm at the base, 1-1.5 µm at the apex. *Conidiogenous cells* monophialidic, integrated, determinate, terminal, later becoming intercalary and asymetrical, with phialide opening immediately below the septa, with minute collarette, colourless to slightly offwhite, smooth, 6-16 x 1.5-2 µm. *Conidia* solitary, simple, fusiform to elongated, colourless, smooth, 1-septate, 4-7 x 2 µm.

Specimen examined: On fresh leaves of *Sanseiviera zeylanica*; evergreen, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1371; leg. Maria D'Souza, 15-09-1999.

The fungus was recoverd here as an endophyte. So far 3 species were recognised in the genus *Sequicillium* Gams, typified by *S. buxi* (Schmitdt.) Gams. The hitherto known species have phialides arranged in penicillate manner at the tip of the conidiophores, although new phialide arouse from the subtending cells of previous phalide. In *S. indicum* the penicillate arrangement of conidiogenous cells was absent and further the conidia were fusiform and one-septate.

Solosympodiella clavata Matsushima, 1971. *Microfungi of the Solomon Islands and Papua-New Gunea,* p. 55 **(Fig. 93)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, foliicolous. Mycelium partly immersed. *Conidiophores* swollen and dark brown at the base, macronematous, mononematous, scattered, erect, straight or flexuous, branched, smooth, 4-10-septate, paler and narrower towards the apex, 90-170 µm long, 20 µm at the base, 3-5 µm wide in the middle and above, with branches up to 20 µm long, 2-4 µm wide. *Conidiogenous cells* polyblastic, integrated, in clusters at the tip, determinate, with well defined denticules in the upper region, subhyaline, smooth, 17-20 x 2-4 µm; denticles 1.5-2.7 µm long. *Conidia* solitary, developing on denticles, simple, linear-obtriangulate, narrower at the attachment region, broader at the distal end, colourless, smooth, aseptate, 5-10 x 1.5-2 µm.

Specimen examined: On fallen dead and decaying leaves of *Ixora brachiata*; moist deciduous forest, 31°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1645; leg. Maria D'Souza, 09-12-1999.

The fungus was isolated by moist chamber incubation method. It is a new record for India.

Spadicoides calamii Maria et Bhat ***sp.nov*** **(Pl. 4.2.1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, brown, erect, straight, hairy, velvety. *Mycelium* immersed. *Conidiophores* mononematous, simple, straight or slightly flexuous, smooth, 4-5-septate, unbranched, thick-walled, medium to dark brown at the base, slightly paler towards the apex, broader at the apex, 70-120 x 4.5-7.5 µm. *Conidiogenous cells* polytretic, terminal, integrated, swollen, with unciccatrized pores, smooth, thick-walled, pale brown to subhyaline, 35-50 x 4.5-7.5 µm. *Conidia* simple, solitary, straight with 3 transverse septa, with dark brown cells in the middle and paler towards the sides, smooth, 20-30 x 4.5-12 µm, with a hilum at the base.

HOLOTYPE: On fallen dead leaves of *Calamus thwaitesii*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.367; leg. Maria D'Souza, 11-02-1999.

The fungus is unique in having straight conidia. It has been isolated in this study both by moist chamber incubation method.

Sporidesmium brachypus (Ellis et Everh.) Hughes, 1958. *Can. J. Bot.* **36:** 807. **(Fig. 94)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown. *Mycelium* immersed. *Conidiophores* mononematous, scattered, smooth, unbranched, erect, straight or flexuous, swollen, broader and black at the base 6-23 µm, thick-walled, 3-7 septate, pale brown and fertile at the apex, 68-130 x 4.5 µm. *Conidiogenous cells* monoblastic, integrated, terminal, cylindrical, smooth, medium brown, 16-22 x 3.5-5.5 µm. *Conidia* dry, solitary, simple, straight, obclavate, rostrate, smooth, 3-5-septate, constricted at the septum, pale brown at the attached end, subhyaline towards the rostrate

end, intermediate cells pale brown, thick-walled, 50-85 µm long, 3-4 µm wide at the basal portion, 8-10.5 µm in the middle portion, 1.5-3 µm at the rostrate end.

Specimen examined: On fallen dead and decaying leaves of *Calamus thwaitesii*, moist deciduous forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.208; leg. Maria D'Souza, 11-02-2000.

Occuring on twigs of various trees including *Averrhoa, Citrus, Dichrostachys, Petrea* and *Thevetia* in Sierra Leone, U.S.A. On dry twigs of *Citrus medica* Jabalpur, Madhya Pradesh. (Ellis, 1971). The fungus was isolated moist chamber incubation method.

Sporidesmium coprophilum Matsushima, 1975. *Icones Fungorum Matsushima a lectorum.* **(Fig. 95)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown. *Mycelium* immersed. *Conidiophores* mononematous, scattered, unbranched, erect, straight or flexuous, smooth, up to 5-9-septate, broader and dark brown at the 6-10 µm wide base, thick-walled, pale brown towards the apex, 56-100 x 4-5 µm. *Conidiogenous cells* monoblastic, integrated, terminal, cylindrical, smooth, pale brown, 7 x 3 µm. *Conidia* dry, solitary, simple, straight, obclavate, constricted at the septum, pale brown and narrow at the attached end, sub-hyaline towards the rostrate end, smooth, 4-5 septate, thick-walled, intermediate cells pale brown, 30-55 x 6-8 µm, 2-3.5 µm wide at the basal portion.

Specimen examined: On fallen dead and decaying leaves of *Dendrocalamus strictus*, moist deciduous forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2551; leg. Maria D'Souza, 20-02-2001.

The fungus was originally isolated from herbivore dung (Matsushima, 1975)

but here was isolated from leaf litter by moist chamber incubation method. This is the first record for India.

Sporidesmium flagelliforme Matsushima, 1975 *Icones fungorum a lectus Matsushima.* p. 137. **(Fig. 96)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown. *Mycelium* immersed. *Conidiophores* mononematous, scattered, erect, straight or flexuous, smooth, up to 8-septate, unbranched, swollen and dark brown at the base, thick-walled, slightly paler and fertile at the apex, 170 x 3-7 µm. *Conidiogenous cells* polyblastic, integrated, terminal becoming intercalary, cylindrical, smooth, medium brown, 8 x 2 µm. *Conidia* dry, solitary, simple, straight, obclavate, rostrate, smooth, 4-5 septate, constricted at the septum, thick-walled, pale brown at the base, sub-hyaline at the tip, intermediate cells pale brown, 38-56 x 6-7.5 µm, 1.5-2.5 µm wide at the basal and apical portion.

Specimen examined: On fallen dead and decaying leaves of *Dendrocalamus strictus*, moist deciduous forest, 30°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2065; leg. Maria D'Souza, 11-04-2000.

The fungus has been reported by Matsushima (1975) from Japan. This species is unique in having a long hyaline seta. The fungus was isolated by moist chamber incubation method.

Sporidesmium harknesii (Sacc.) M.B.Ellis, 1958, *Mycol. Pap.* **70:** 24-25. **(Fig. 97)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, erect, dark brown observed on twigs. *Mycelium* mostly immersed. *Conidiophores* mononematous, straight or flexuous, smooth, 3-5-septate, unbranched, mid to dark brown, thick-walled, 40-50 x

4-13 µm. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, cylindrical, 8-10 x 5-7µm. *Conidia* dry, solitary, smple, straight, cylindrical, truncate at the base, rounded at the apex, smooth, 15-25-pseudoseptate, dark brown, 70-120 x 4-14 µm.

Specimen examined: (i) On fallen dead twigs of *Saraca asoca*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1500; leg. Maria D'Souza, 25-10-1999. (ii) On fallen dead twigs of *Elaeis guineensis* Jacq., Plantation, 23.5°C, Tambdisurla Goa, India; Herb. No. GUFCC No.2285; leg.; Maria D'Souza, 08-07-2000. (iii) On fallen dead leaves of *Calamus thwaitesii*, moist deciduous forest, 30°C, Stream edge, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.213; leg. Maria D'Souza, 11-02-1999. (iv) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary India; Herb. No. GUFCC No.1743; leg., Maria D' Souza, 29-12-1999.

It was earlier recorded on Cedar planks in U.S.A. (Ellis, 1976). The fungus was isolated by both particle platimg and direct observation methods.

Sporidesmium leonense M.B.Ellis, 1958, *Mycol. Pap.* **70:** 28. **(Fig. 98)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown to black. *Mycelium* partly superficial, composed of smooth, septate, branched, brown, thin-walled 6-9 µm wide hyphae. *Conidiophores* mononematous, straight or flexuous, smooth, 3-6-septate, unbranched, mid to dark brown, thick-walled, 65-100 x 14-20 µm, 4-7 µm wide at the apex. *Conidiogenous cells* monoblastic, integrated, terminal, determinate, cylindrical, pale brown, thick-walled, 10-17 x 3-4.5 µm. *Conidia* dry, solitary, simple, straight, cylindrical, truncate at the base, slightly rostrate at the apex, smooth, 7-11- pseudoseptate, dark brown, 33-67 x 14-17 µm , 4-5 µm wide at the tip.

Specimen examined: On fallen dead twigs of *Calamus thwaitesii*, moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.499; leg. Maria D'Souza, 25-10-1999.

The fungus earlier recorded on on *Ancistrophyllum* and *Pennisetum* from Ghana and Sierra Leone (Ellis, 1976). The fungus was isolated by both moist chamber incubation and direct observation methods.

Sporidesmium vagum Nees ex Link, 1825, in *Linne's Sp. Pl.*, Ed.4 **6 :** 120. **(Fig. 99)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, black. *Mycelium* mostly immersed. *Conidiophores* mononematous smooth, unbranched, straight or flexuous, mid to dark brown, 5-septate, thick-walled, 150-170 x 6-13 µm. *Conidiogenous cell* monoblastic, integrated, terminal, cylindrical, pale brown, thick-walled, 20 x 4.5 µm. *Conidia* dry, solitary, simple, flexuous, obclavate, elongated, cylindrical, conico-truncate at the base, 24-50-pseudoseptate, smooth, dark brown, 115-200 x 9-11 µm, 3-4.6 µm wide at the base and tip.

Specimen examined: (i) On fallen dead leaves of *Sageraea laurifolia*; moist deciduous forest, 28°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1357; leg. Maria D'Souza, 03-09-99. (ii) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, India; Herb. No. GUFCC No.1744; leg. Maria D' Souza, 29-12-1999. (iii) On fallen dead leaves of *Dendrocalamus strictus* Nees., moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1710; leg.; Maria D'Souza, 29-12-1999.

Known earlier from Ghana, Europe and Pakistan. (Ellis, 1971) and India (Sarbhoy et al., 1996). The fungus in hand was isolated by moist chamber incubation method.

***Sporidesmium* sp. 1** **(Pl. 4.6.4)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, black. *Mycelium* mostly immersed. *Conidiophores* mononematous, straight or flexuous, smooth, 3-5-septate, unbranched, dark brown to black, thick-walled, 30-77 x 4-6 µm. *Conidiogenous*

cells monoblastic, integrated, terminal, cylindrical, pale brown, thick-walled, 3-8 x 3 µm. *Conidia* dry, solitary, simple, flexuous, obclavate, cylindrical, with an elongated rostrate end, conico-truncate at the base, smooth, 11-14-pseudoseptate, dark brown to pale brown in the middle and hyaline towards the rostrate end, 72-127x 4.5 -10 µm, up to 1.53 µm wide at the tip.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, moist deciduous forest, 26.5°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1238; leg. Maria D'Souza, 15-08-1999.

The fungus was isolated by moist chamber incubation method

***Sporidesmium* sp.2** **(Fig. 100)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, erect, dark brown. *Mycelium* mostly immersed. *Conidiophores* mononematous, straight or flexuous, smooth, 10-20-septate, unbranched, thick-walled, mid to dark brown, 200-355 x 8-12.5 µm. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent with 1-3 proliferations, cylindrical, pale brown, thick-walled, 10-20 x 8.33 µm. *Conidia* dry, solitary, simple, straight, cylindrical, truncate at the base, with a small curved septate projection at base, slightly rostrate at the apex, smooth-walled, 7-8-pseudoseptate, dark brown, 70-95 x 6.5-12.5 µm, 3-6.5 µm wide at the tip.

Specimen examined: On fallen dead twigs of *Saraca asoca*, moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.496; leg. moist deciduous forest, 23°C; Maria D'Souza, 09-06-1999.

The fungus was isolated by moist chamber incubation method

Sporoschima nigroseptatum D.Rao & R.Rao (Ellis, 1971) **(Plate 4.6.2)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown, velvety. *Conidiophores* mononematous, erect, straight or flexuous, 125-215 µm long, 4-18 µm wide at the base, venter up to 30 x 16 µm, smooth, septate, thick-walled, dark brown, arising from dark brown stromata up to 46 µm diam. Sterile capitate hyphae arising from the same stromata, erect, flexuous, wide and cupulate at the flared apex, 1-3 septate, regenerating percurrently 2-3 times, 45-85 x 3-4 µm, 3.5-6 µm wide at the tip. *Conidiogenous cells* phialidic, terminal, integrated, smooth, 4-5-septate, thick walled, dark brown to black, consisting of a slightly swollen venter up to 15 µm wide and a tubular collarette12.5 µm long. *Conidia* solitary, in lenear false chains of 10-15 conidia, cylindrical, truncate at both ends, smooth, 3-5-septate, thick-walled, dark brown to black, 37-46 x 8.5-12 µm, 4.6 µm at the point of attachment of the chains.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, moist deciduous forest, 25°C , Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.366; leg. Maria D'Souza, 11-03-1999. On dead and decaying leaves of *Calamus thwaitesii* Jacq., moist deciduous forest, 23 °C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1919; leg. Maria D' Souza, 14-02-2000.

The fungus was isolated by moist chamber incubation method.

Stachybotrys atra Corda, 1837, *Icon, Fung.*, **1:** 21. **(Fig. 101)**

Terrestrial, conidial fungus, Hyphomycete. *Mycelium* superficial, with smooth, septate, unbranched, hyaline, guttulate, thin-walled hyphae 2µm wide. *Conidiophores* mononematous, smooth, 1-3-septate unbranched, hyaline, thin-walled, 66-94 x 4-7 µm, 2-3µm wide at the apex. *Conidiogenous cell* monophialidic, hyaline, smooth walled, non-septate, 8-10 x 1.5-3 µm, with the conidiogenous aperture 1.3 µm wide. *Conidia*

wet, solitary, oval to elongated, smooth, aseptate, 1-celled, olive green, verruculose, 4-5 x 2-3 µm.

Specimen examined: On fallen dead leaves of *Saraca asoca,* evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.309; leg. Maria D'Souza, 11-02-1999.

The fungus is cosmopolitan and frequently isolated from paper, seeds, soil, textiles and dead plants (Ellis, 1971). In India it was collected from decaying stems of *Andropogon sorghum* in from Delhi and Goa (Miriam, 2000). It was isolated by moist chamber incubation method.

Stachybotrys aurantia Barron, 1962, *Can. J. Bot.* **40:** 258. **(Fig.102)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, floccose, 1 cm diam. in 7 days. *Mycelium* partly superficial, with smooth, septate, unbranched, hyaline, guttulate, thin-walled, hyphae 2-5 µm wide. *Conidiophores* mononematous, smooth, 2-4-septate, unbranched, hyaline, thin-walled, 93-128 x 2-4 µm. *Conidiogenous cell* monophialidic, elliptical, hyaline, smooth-walled, aseptate, 10-14 x 3-4 µm, 1.5 µm at the tip. *Conidia* wet, solitary, elongated to ellipsoidal to boat shaped, smooth, hyaline, 1 median-septate, 9-11 x 3-4 µm.

Specimen examined: On fallen dead leaves of *Sansievierra zeylanica,* evergreen forest, 28°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1364; leg. Maria D'Souza, 01-10-1999.

Matsushima (1971) isolated the fungus from rotten wood from Japan. The fungus was isolated by particle plating method and is the first record from forests of Western Ghats.

Stachybotrys hyalina Maria et Bhat **sp.nov.**

(Fig.103)

Terrestrial, conidial fungus, Hyphomycete. *Mycelium* superficial with smooth, septate, unbranched, hyaline, thin-walled, guttulate, 2 μm wide hyphae. *Conidiophores* mononematous, smooth, 1-2-septate, unbranched, hyaline, thin-walled, 53-96 x 2.5-7 μm, 2 μm wide at the apex. *Conidiogenous cels* monophialidic, elongated, hyaline, smooth-walled, aseptate, 6-7.5 x 1.5-2 μm, with the conidiogenous apex 0.5-1 μm wide. *Conidia* wet, solitary, cylindrical to elongated, smooth-walled, 0-septate, hyaline, 4.5-6.5 x 1.5-2 μm.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus,* moist deciduous, 24°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.333; leg. Maria D'Souza, 11-02-1999.

The genus *Stachybotrys* Corda, typified by *Stachybotrys atra* Corda, (Ellis,1971) is characterised by the production of dark olive green conidia on pale olive green to almost hyaline conidiophores. The fungus in hand differs from the all know species by its hyaline, aseptate, conidia borne on entirely hyaline conidiophores. The fungus was isolated by particle plating method.

Stachybotrys hyaloseptata Maria et Bhat **sp.nov.** **(Fig. 104)**

Terrestrial, conidial fungus, Hyphomycete. *Mycelium* superficial with smooth, septate, unbranched, hyaline, thin-walled, guttulate, hyphae. *Conidiophores* mononematous, smooth, 1-2-septate, unbranched, hyaline, 46-80 x 2.5-7 μm, 3 μm at the apex. *Conidiogenous cells* monophialidic, smooth-walled, hyaline, 10-13 x 2-3.5 μm, with conidiogenous aperture up to 1.5 μm diam. *Conidia* wet, solitary, elongated to

boat shaped, smooth, 5-7-septate, 6-8-celled, hyaline, 12-16 x 2-4 μm, 1.5-2 μm at the apex.

Specimen examined: On fallen dead leaves of *Sansievierra zeylanica*, evergreen forest, 24°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1435; leg. Maria D'Souza, 01-10-1999.

The fungus in hand differs from the all know species of the genus *Stachybotrys* Corda, by its hyaline, 5-7-septate, conidia borne on entirely hyaline conidiophores. The complete absence of olive green conidia is an added dissimilarity. The fungus was isolated by particle plating method.

Stachybotrys nephrospora Hansf., 1943, *Pro.Linn. Soc.Lond.*, 1942-1943: 44-45.

(Fig. 105)

Terrestrial, conidial fungus, Hyphomycete. *Mycelium* superficial with smooth, septate, unbranched, hyaline, thin-walled hyphae. *Conidiophores* mononematous, smooth, 3-5-septate, unbranched, hyaline, thin-walled, 144-210 x 10-20 μm, 3-4.5 μm at the apex. *Conidiogenous cells* monophialidic, simple, elongated, hyaline, smooth, thin-walled, 12- 20 x 3-4 μm, with conidiogenous aperture 0.67 μm diam. *Conidia* wet, solitary, slimy, oval to slightly curved at the point of attachment, verruculose, 1-septate, olive green, 7-10 x 4-5.5 μm.

Specimen examined: On fallen dead leaves of *Bauhinia purpurea*, evergreen forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2372; leg. Maria D'Souza, 03-09-2000.

The fungus was isolated by moist chamber incubation method. It was also reported from an earlier study carried out in this laoratory (Miriam, 2000).

Stachybotrys oenanthes M.B. Ellis, 1971, *Mycol. Pap.* **125:** 29-30. **(Fig. 106)**

Terrestrial, conidial fungus, Hyphomycete. *Mycelium* superficial, with smooth, septate, unbranched, hyaline, guttulate, thin-walled, hyphae 1.5-2 μm wide. *Conidiophores* mononematous, smooth, 1-2-septate, unbranched, thin-walled, dark olive green at the apex, pale green towards the base, 60-115 x 7-10 μm, 4-7 μm wide at the apex. *Conidiogenous cells* monophialidic, smooth-walled, 10-12 μm x 4-5 μm, with the conidiogenous aperture 1.5 μm diam. *Conidia* wet, solitary, cylindrical, verruculose, 1-septate, dark olive green, 10-11.5 x 6-7.5 μm.

Specimen examined: On fallen dead leaves of *Zanthoxylum rhetsa*, moist deciduous, 24°C Alorna; Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1545; leg. Maria D'Souza, 19-11-1999.

It was earlier recovered from dead stems of *Oenanthe crocata* in Germany (Ellis, 1971). The fungus was isolated by moist chamber incubation method.

Stachybotrys state of ***Melanopsamma pomiformis*** (Pers. ex Fr.) Sacc., 1878, *Michelia*, **1:** 347. **(Fig. 107)**

Terrestrial, conidial fungus, Hyphomycete. *Mycelium* superficial, with smooth, septate, unbranched, hyaline, guttulate, thin-walled, hyphae up to 1.5-2.5 μm wide. *Conidiophores* mononematous, smooth, 1-3-septate, unbranched, thin-walled, hyaline, 60-75 μm. *Conidiogenous cells* monophialidic, smooth-walled, 6-10 x 2-4 μm, with the conidiogenous aperture 0.5 μm diam. *Conidia* wet, solitary, cylindrical, smooth, aseptate, light olive green, 4-16 x 2-2.5 μm.

Specimen examined: On freshleaves of *Calamus thwaitesii* Jacq., moist deciduous forest, 25°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2099; leg. Maria D' Souza, 14-02-2000.

It has been isolated from various deciduous trees in cluding *Aesculus, Carpinus, Fagus, Fraxinus, Juglans, Populus* and *Ulmus* in Europe (Ellis, 1971). The fungus was isolated by endophytic isolation method.

Subulispora procurvata Tubaki, 1971. *Trans. Mycol. Soc. Japan,* **12:** 18-28. **(Fig.108)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, dark brown. *Mycelium* partly immersed. *Conidiophores* mononematous, solitary, simple, erect, straight or flexuous, unbranched, upper part distinctly geniculate, with a zig-zag appearance, smooth, septate, medium to dark brown at the base, slightly paler towards the apex. *Conidiogenous cells* polyblastic, terminal, integrated, smooth, sympodial, with numerous cicatrized, very thin, brown scars. *Conidia* borne apically, later becoming lateral by sympodial development of conidiophores, dry, solitary, subuliform, hyaline, truncate at the base, acute at the tip, curved sharply, smooth, 3-septate, thin-walled, hyaline, 37-50 x 2-3.5 µm, 12-20 x 1.5-2 µm at the bent end, 1 µm wide at the tip.

Specimen examined: On dead and decaying twigs of *Careya arborea*, moist deciduous forest, 26°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2422; leg. Maria D' Souza, 20-09-1999.

The fungus, originally described from decaying leaves of *Castanopsis cuspidata* var. *sieboldii* from Japan (Tubaki and Yokoyama, 1971), was isolated by moist chamber incubation method.

Sympodiella laxa Subramanian & Vittal, 1973, *Can. J. Bot.* **51:** 1131. **(Fig. 109)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, black, velvety. *Conidiophores* mononematous, smooth, solitary, simple, straight or flexuous, geniculate, smooth, 10-17-septate, unbranched, thick-walled, dark brown throughout except apex,

paler near the apex, increasing in length by sympodial growth, hyaline, 160-510 x 4.5-8 µm, base up to 16 µm. *Conidiogenous cell* sympodial, arthric, simple, hyaline, smooth, thin-walled, 30-47 x 4-5 µm. *Conidia* simple, solitary, long cylindrical, slightly expanded, truncate at both ends, smooth, 1 median septate, hyaline, 24-55 x 4.5-6.5 µm.

Specimen examined: On fallen dead leaves of *Saraca asoca*, evergreen forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2490; leg. Maria D'Souza, 11-10-2000.

Originally decribed by Subramanian and Vittal (1973) on dead leaves of an unidentified litter, the fungus was isolatd by moist chamber incubation method.

Tetraploa aristata Berk. & Br., 1850, *Ann. Mag. nat. Hist., 2,* **5 :** 459. **(Pl. 4.7.1)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, foliicolous. *Mycelium* partly immersed. *Conidiophores* micronematous, branched, flexuous, pale yellowish brown, verruculose, with1 µm thick hyphae. *Conidiogenous cells* monoblastic or occasionally polyblastic, integrated, intercalary, determinate, medium brown. *Conidia* dry, solitary, appendaged, brown, verrucose, muriform, mostly with 4 cells in each column, 16-180 14-20 µm, 20-27 µm at the apical septate appendages 16-180 x 3-5 µm; in mature conidia with shallow furrows between 4 columns of cells which develop independently, tend to diverge from one another apically and terminate each in a septate setiform very long appendage. A second type of conidium with 2 cells to each column, 34-52 x 12-22 µm; appendages 5-17 x 3-5 µm.

Specimen examined: (i) On dead and decaying dry leaves of *Sansievierra zeylanica*, moist deciduous forest, 25.5 ° C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2296; leg. Maria D' Souza, 08-07-2000; (ii) on dead and decaying twigs of *Elaeis guineensis* Jacq., moist deciduous forest, 26°C, Tambisurla, Goa, India; Herb. No. GUFCC No.1502; leg. Maria D' Souza, 1-10-1999.

Earlier recorded on leaf litter of *Chloris, Dactylis and Zea* from Argentina, Rhodesia and North America (Ellis, 1971), the fungus was collected from a variety of substrates including foam samples in India (Sarbhoy et al., 1996). The fungus in hand was isolated by moist chamber incubation method.

Torula herbarum (Pers.) Link ex Gray, 1821, *Nat.Arr.Br.Pl.*, **1:** 557. **(Pl. 4.7.3)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, velvety, brown. *Mycelium* partly immersed. *Conidiophores* semi-macronematous, unbranched or irregularly branched, straight or flexuous, smooth, 1-2-septate, subhyaline to mid brown, 7.2 x 2.4 µm thick. *Conidiogenous cells* polyblastic, sometimes monoblastic, integrated and terminal, sometimes discrete, determinate, usually spherical, sometimes becoming cupulate, verrucose, pale brown to brown, 6 x 4.8-5 µm. *Conidia* dry, in simple or branched chains, arising from the upper half of conidiogenous cells, cylindrical, rounded at the ends, ellipsoidal or subspherical, straight to slightly curved, dark to pale brown, verrucose, 1-3-septate, constricted at the septa, dark brown at the peripheral wall, pale brown towards the centre, 9-20 x 4.5-6 µm.

Specimen examined: On dead and decaying twigs of *Elaeis guineensis*, moist deciduous forest, 26°C, Tambisurla, Goa, India; Herb. No. GUFCC No.2291; leg. Maria D' Souza, 08-07-2000.

Very common litter fungus on dead stems, leaves and twigs of many plant species (Sarbhoy et al., 1986,1996), was isolated by particle-plating method. It was also reported from an earlier study in this laboratory (Miriam, 2000).

Trichobotrys ramosa Maria & Bhat **sp. nov.** 2000. *Mycotaxon,* **80:** 105-108. **(Fig. 110)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, olivaceous brown, velvety. *Mycelium* partly superficial, composed of branched, colourless to pale brown hyphae 1.5-2.5 μm wide. *Setae* absent. *Conidiophores* mononematous, erect, straight or flexous, septate, dichotomously branched in the above half, fertile in the middle, dark to reddish brown, verruculose, 330-600 x 10-18 μm, 8-10 μm wide and conspicously echinulate in the below half, terminating in sterile, setiform, variously curved, pale brown to hyaline, up to 6 μm wide apical branches; conidiophore branches bear short, fertile, dark to pale brown, verruculose, widely spaced, 1-2-septate, up to 25 μm long, 3-5 μm wide laterals. *Conidiogenous cells* polyblastic, integrated, terminal to subterminal on fertile branches, elongated, denticulate in the upper half, sometimes collapsing into cupulate form, 5-10 x 2-3 μm. *Conidia* dry, catenate, usually in branched, acropetal chains, spherical, dark brown, verruculose, aseptate, 3-5 μm diam.

Specimen examined: (i) On dead and decaying leaves of *Dendrocalamus strictus*, moist deciduous forest, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 0274, isotypus, Herb. No. IMI 386393 holotypus, leg. Maria D' Souza, 11-03-1999. (ii) On dead leaves of *Dendrocalamus* Goa, India; Herb. No. GUFCC No. 0320, leg. Maria D' Souza, 29-12-1999. (iii) On dead and decaying leaves of *Dendrocalamus strictus*., moist deciduous forest, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, Herb. No. GUFCC No. 0315, isotypus, leg. Maria D' Souza, 20-09-2000. (iv) On fallen dead and decaying leaves of *Dendrocalamus strictus*; evergreen forest, 24°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1234; leg. Maria D'Souza, 15-08-99. (v) On dead leaves of *Dendrocalamus strictus*, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 20-09-2000, M.D'Souza, No. GUFCC 2388. (vi) On dead leaves of *Dendrocalamus strictus*, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 30-12-1999, M.D'Souza, No. GUFCC 1691. (vii) On dead leaves of *Dendrocalamus strictus*, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 11-03-1999, M.D'Souza, No. GUFCC 0370. (viii) On fallen dead twigs of *Calamus thwaitesii*; moist deciduous forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2460; leg. Maria D'Souza, 11-10-2000.

Besides the type species, *Trichobotrys effusa* (Berk. & Br.) Petch = *T. pannosa* Penzig & Saccardo, the genus *Trichobotrys* Penzig & Saccardo so far accommodated two species, namely *T. ipomoeae* Sawada and *T. trechispora* Petch (Ellis, 1971; Morgan-Jones et al., 1987; Hawksworth et al., 1995). The genus is characterised by mononematous conidiophores producing catenate, dark brown, spherical and echinulate conidia on fertile, smooth, short, lateral branches with polyblastic conidiogenous cells. In the type species, *T. effusa,* the conidiophore is setiform, not dichotomously branched, and the fertile lateral branches are smooth, often unciform and 0-1-septate, arise directly on the main stipe, the characters which *T. ipomoeae* and *T. trechispora* largely share. In *T. ramosa,* the conidiophore is dichotomously branched with the numerous branches terminating in setiform sterile ends. The fertile lateral branches are short, straight, 1-2-septate, pale brown towards the apex and arise only from the primary and secondary branches of the conidiophore. The fertile branches are always verrucose.

Trichobotrys saprophyticus Maria et Bhat **sp. nov.** **(Pl. 4.1.2)**

Terrestrial conidial fungus, Hyphomycete. *Colonies* on natural substrate effuse, dark brown, shiny. *Mycelium* partly immersed, composed of smooth, septate, branched, thick-walled, subhyaline to pale brown, up to 3.5 µm wide hyphae. *Conidiophores* mononematous, setiform, erect, straight or flexuous, smooth, 5-15 septate, thick- walled, laterally branched in the above half, dark brown at the base, pale brown to subhyaline at the tip, 130-220 x 3-4 µm; lateral branches fertile, short, with short cells in beaded appearance, up to 20 µm long. *Conidiogenous cells* mono- to polyblastic, doliiform, terminal, integrated, elongated to spherical, smooth, pale brown to hyaline, 5-7 x 4-5 µm. Conidia catenate, dry, spherical, aseptate, smooth, thin-walled, pale brown, formed

in simple and branched chains, 3.5-5 µm diam.

HOLOTYPE: Fallen dead leaves of *Careya arborea*, evergreen forest, 28°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1739; leg. Maria D'Souza, 30-12-2000.

With its setiform, erect, apically branched conidiophores, short conidiogenous cells and round, catenate conidia, the fungus is similar to any of the species of *Trichobotrys* Penzig & Saccardo (Ellis, 1971), typified by *T. effusa* (Berk. & Br.) Petch. However, it is distinct with its smooth conidia borne on short and smooth conidiogenous cells and smooth conidiophores.

Tripospermum myrti (Lind.) Hughes, 1951. *Mycol. Pap.*, **46 :** 17-18. **(Fig. 111)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA regular, circular, brown, moderately growing, attaining a diam. of 1cm in 7 days. *Mycelium* composed of doliiform, smooth, septate, pale brown, 3-4 µm thick hyphae. *Conidiophores* integrated, smooth, pale brown, 3-4 µm thick. *Conidiogenous cells* monoblastic, integrated, terminal or intercalary, determinate, cylindrical to doliiform, smooth, pale brown, 6-8 x 5-6 µm, at the attachment region up to 2 µm wide. *Conidia* dry, solitary, smooth, 4-11-septate, often constricted at the septa, brown, with a stalk cell 6-8 x 5-6 µm, with arms 17-28 µm long, 6-7 µm wide at the base, 4-5.5 µm in the middle, tapering to 2 µm wide.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, moist deciduous forest, 25°C, Molem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2581; leg. Maria D'Souza, 23-02-2001.

This fungus is a regular inhabitant and was encountered earlier in the streams, on submerged leaves of *Hevea brasiliensis* from India (Sarbhoy et al., 1996). The fungus was isolated by particle plating method.

***Tritirachium* sp.** **(Fig. 112)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, white. *Mycelium* immersed. *Conidiophores* swollen at the base, mononematous, scattered, erect, straight or flexuous, smooth, 8-10-septate, unbranched, slightly narrower at the base, colourless, up to 167 µm long, 1.5 µm at the base, 2.5-3.5 µm in the middle, up to 5 µm at the apex; stipe with branches commonly in verticils beneath the septa nearest the apex, up to 2-3 phialides in each verticils, with branches up to 20 µm long, 2µm wide. *Conidiogenous cells* polyblastic, discrete, often arranged verticillately, determinate, with well defined pointed denticules, hyaline, smooth, 34-48 µm long, 1.6-2 µm wide at the base, 1-1.3 µm wide in the middle. *Conidia* developing on pointed denticles, simple, oval, smooth, aseptate, colourless, 4.5-7 x 1.3-2 µm.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, moist deciduous forest, 31°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1688; leg. Maria D'Souza, 29-12-99.

The fungus was isolated by moist chamber incubation method.

Vermiculariopsiella elegans Maria et Bhat **sp. nov.** **(Fig.113)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA irregular, rhizoidal at the margin, blackish in the centre, colourless towards the periphery, with distinct fruiting bodies, fast growing, attaining a diam. of 5.4 cm in 7 days; reverse of the colony brown to white. *Mycelium* partly superficial, composed of smooth, septate, thin-walled, branched, pale brown, 3.5 µm wide hyphae. *Conidiomata* sporodochial, 25-30 µm wide, 8-10 µm high. *Conidiophores* smooth, septate, branched, dark brown, thick-walled, 8-12

x 3-5 µm. *Setae* solitary, smooth, thick-walled, 1-3-septate, dark brown at the base, paler towards the apex, 100-165 µm long, 6-7 µm wide at the base, 5-5.5 µm wide in the middle, 3.5 µm wide at the apex. *Conidiogenous cells* monophialidic, integrated, 15-30 x 4-6 µm, up to 1.5 µm wide at the tip, without conspicuous collarette. *Conidia* slimy, solitary, cylindrical, rounded at both the ends, slightly narrower at the point of attachment, smooth, aseptate, hyaline, 20-27 x 6-8 µm.

HOLOTYPE: On fallen dead and decaying leaves of *Saraca asoca*; moist decidous, 30^{0}C Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.280; leg. Maria D'Souza, 11-02-1999.

Additional specimens examined: (i) On fallen dead and decaying leaves of *Saraca asoca*; moist decidous, 25^{0}C Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1496; leg. Maria D'Souza, 25-10-1999. (ii) On fresh leaves of *Saraca asoca*; moist decidous, 30^{0}C Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.242; leg. Maria D'Souza, 11-02-1999. (iii) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 26°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.324; leg. Maria D'Souza, 11-03-1999. (iv) On fresh leaves of *Careya arborea*, moist deciduous forest, 25°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1292; leg. Maria D'Souza, 03-09-1999. (v) On fallen dead and decaying leaves of *Mangifera indica*, evergreen forest, 25°C, Taleigao, Goa, India, , Herb. No. GUFCC No.1038; leg. Maria D'Souza, 2-7-1999. (vi) On fallen dead leaves of *Flacourtia montana*; moist deciduous forest, 25^{0}C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.444; leg. Maria D'Souza, 11-04-1999. (vii) On fresh leaves of *Sanseiviera zeylanica*; evergreen, 27^{0}C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1370; leg. Maria D'Souza, 15-09-1999; endophytic isolation method. (viii) On fallen dead and decaying leaves of *Dendrocalamus strictus*; evergreen forest, 24°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1190; leg. Maria D'Souza, 15-08-1999. (ix) On fresh leaves of *Bambusa arundinaceae*; evergreen forest, 24°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1195; leg. Maria D'Souza, 15-08-1999. (x) On dead and decaying leaves of *Ficus benghalensis*, coastal vegetation, 25°C, Baga, Goa, India; Herb. No. GUFCC No.1405; leg. Maria D' Souza, 11-10-1999. (xi) On fallen dead leaves of *Helictris ixora*, grassland plataeu, 25^{0}C, Alorna,; Goa, India; Herb. No. GUFCC No.1566; leg. Maria D'Souza, 19-11-1999.

The genus *Vermiculariopsiella* Bender, typified by *V. immersa* (Desm.) Bender (Nawawi et al., 1990), so far has 7 recognised species. Of these, 3 species, viz., *V. cornuta* (Rao & de Hoog) Nawawi, Kuthubutheen & Sutton (1990), *V. cubensis* (Castaneda) Nawawi, Kuthubutheen & Sutton (1990), and *V. ramosa* (Sutton) Nawawi, Kuthubutheen & Sutton (1990) possess branched setae. The remaining 4 species produce unbranched setae and narrow conidia less than 4 µm wide. Of these, *V. falcata* Nawawi, Kuthubutheen & Sutton (1990) produces falcate, 3-sepate hyaline conidia of 36-47 x 1.5-2µm. *V. immersa* (Desm.) Bender (1932) and *V. parvula* Nawawi, Kuthubutheen & Sutton (1990) produces aseptate hyaline conidia of 13-23 x 1.5-2.5µm and 8-13 x 2-2.5 µm respectively, with rounded base and pointed, slightly curved apex. *V. arcicula* Pasqualetti & Zucconi (1992) produces aseptate, hyaline, fusiform, conidia of 15-19.5 x 2.5-4 µm. *V. elegans* differs from these by its cylindrical, smooth, unicellular, hyaline conidia of more than 4 µm wide and with rounded both ends.

Veronaea bambusae Morgan-Jones, 1979. *Mycotaxon*, **8:** 149-151 **(Fig. 114)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, light to dark brown, hairy. *Mycelium* immersed, composed of smooth, septate, branched, pale to medium brown hyphae 2µm wide. *Stroma* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, slightly broader at the base, smooth, 3-6-septate, dark brown at the base, pale brown above, smooth, 80-130 x 3-7 µm, 2.75-3 µm wide above. *Conidiogenous cells* polyblastic, integrated, terminal and intercalary, cylindrical, cicatrized, scars usually small flat, 18-54 x 2.3-3 µm, the conidiogenous regions 3-4 µm apart. *Conidia* solitary, dry, simple, ellipsoidal, pale brown, aseptate, smooth, 4-8 x 2-3.5 µm with a dark pointed scar at the point of attachment.

Specimen examined: On fallen dead leaves of *Dendrocalamus strictus*, moist deciduous forest, 31°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No. 1695; leg.; Maria D'Souza, 29-12-1999.

The fungus was first described from dead leaves of *Bambusa* sp. in North America.(Morgan-Jones, 1979). The fungus was isolated by moist chamber incubation method and is the first record to India.

Veronaea botryosa Cif.& Montemartini, 1957. *Atti Inst. bot. Univ. Lab. Crittogam. Pavia,* Ser. 5, **15**: 68 **(Fig.115)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, light brown with dark brown, hairy. *Mycelium* immersed, composed of smooth, septate, branched, pale to medium brown hyphae. *Stroma* absent. *Conidiophores* macronematous, mononematous, erect, straight or flexuous, unbranched, slightly broader at the base, smooth, 6-7-septate, dark brown at the base, pale brown above, smooth, 180-215 µm long, 4-10 µm thick at the base, 2-3 µm wide above. *Conidiogenous cells* polyblastic, integrated, terminal and intercalary, cylindrical, cicatrized scars usually small flat, 138-185 x 3-4 µm. *Conidia* solitary, dry, simple, ellipsoidal, pale brown, aseptate, smooth, 3-5.5 x 1.5-2.75 µm, with a dark pointed scar at the point of attachment.

Specimen examined: (i) On fallen dead leaves of *Calamus thwaitesii*, moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2115; leg. Maria D'Souza, 14-02-2000. (ii) On fallen dead leaves of *Dendrocalamus strictus*, moist deciduous forest, 26°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1191; leg. Maria D'Souza, 15-09-1999.

The fungus originally isolated on olive slag from Italy (Ellis, 1971), was recovered by moist chamber incubation method

Verticillium cinnabarinum (Corda) Reinke et Berthold (Matsushima, 1975. *Icones fungorum a lectus Matsushima.* Kobe, Japan, p.162) **(Fig. 116)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, colourless, regular, circular, colourless with pinkish tinge, radiating with two concentric rings, median growing, attaining a diam. of 2cm in 7 days; reverse of the colony same. *Mycelium* immersed composed of smooth, septate, branched, pale to hyaline, colourless, 2.7 µm wide hyphae. *Conidiophores* swollen at the base, mononematous, scattered, each composed of an erect, straight or flexuous, smooth, 3-4 septate, unbranched and sometimes branched, slightly narrower at the base, colourless, 103-106 µm long, 3.7 µm at the base, 3.4-4 µm in the middle and 3.7 µm at the nodal region, stipe with branches and phialides commonly in verticils beneath the septa nearest the apex, 50 x 2.7 µm. *Conidiogenous cells* monophialidic, discrete, often arranged verticillately, determinate, ampulliform, lageniform or subulate, with well defined collarettes, smooth, hyaline, 16-33 µm long, 1.6-2.7 µm wide at the base, 2 µm wide in the middle and 0.7-1.4 µm at the apex. *Conidia* aggregated in slimy masses, semi-endogenous or acrogenous, simple, ellipsoidal, smooth, 1-septate, colourless, 4-7 x 2-2.7 µm, narrower at the tip where it is pinched off and broader at apical end.

Specimen examined: On fallen dead leaves of *Dellenia indica* L., moist deciduous forest, 25^{0}C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1502; leg. Maria D'Souza, 19-7-1999.

The fungus in hand was isolated by particle plating method and has conspicous collarettes on dematiaceous conidiophores, unlike typical *Verticillium* sp. (Matshushima, 1975).

Virgatospora natarajanensis Maria., Singh & Bhat, **sp. nov.** 2002. *Mycotaxon* (Accepted for publication) **(Fig. 117)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* effuse, olivaceous black, velvety. *Mycelium* partly immersed, composed of smooth, septate, branched, hyaline, thin-walled, hyphae 2-3 µm wide. *Conidiophores* synnematous, thick-walled, septate, branched, smooth at the basal portion, distinctly echinulate at the apical region, subhyaline, with synnema up to 680 µm long, up to 90 µm wide at the base, 25-35 µm wide in the middle, up to 170 µm wide at the flared apex. *Conidiogenous cells* monophialidic, discrete, mostly terminal, sometimes subterminal, elongated, subcylindrical, straight or slightly curved, smooth, 18-25 µm long, 2-2.5 µm wide at the base, 2-3.5 µm wide in the middle, up to 1.5 µm wide at the tip, with a distinct 2.5 µm wide collarette at the apex. *Conidia* solitary, ellipsoidal to fusiform, aseptate, light olive green to brown, with distinct longitudinal ridges on the surface, 10-13.5 µm long, 3.5-4.5 µm wide in the middle, rounded at both ends, thick-walled, aggregated in large slimy heads at the tip of synnema.

Specimen examined: (i) On fallen dead leaves of *Calamus thwaitesii*, evergreen forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1502; leg. Maria D'Souza, 11-02-1999. IMI 386680. (ii) On fallen dead leaves of *Calamus thwaitesii*, evergreen forest, 30°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.229; leg. Maria D'Souza, 11-02-1999. (iii) On fallen dead and fresh leaves of *Dendrocalamus strictus*, moist deciduous forest, 27°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.2387; leg. Maria D'Souza, 20-09-2000.

The fungus was recovered several times by moist chamber incubation. The monotypic genus *Virgatospora* Finley (1967), with *V. echinofibrosa* Finley as type species, was described for synnematous fungi producing slimy, septate, phialidic conidia with distinct longitudinal ridges, on the surface on echinulate conidiophores (Bills et al.,

1994). *V. natarajanensis* differs from the type by its fusiform, non-septate, smaller conidia. The conidia in *V. echinofibrosa* are ellipsoidal to limoniform, curved, papillate at both ends, 3-septate (phragmosporous), grey to dark brown and 38-45 x 12-15 µm, whereas in *V. natarajensis* the conidia are fusiform, non-septate (amerosporous), rounded at both ends and 10-13.5 x 3.5-4.5 µm.

Wardomyces septata Maria et Bhat **sp. nov.** **(Fig. 48)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* regular, circular, brown with central light brown zone, with serrated margin, slow growing, attaining a diam. of 0.7 cm in 7 days; reverse of the colony same. *Mycelium* partly immersed, composed of smooth, septate, branched, pale to medium brown 1.5-2 µm wide hyphae. *Stroma* absent. *Conidiophores* semi-macronematous, flexuous, smooth, 1-2-septate, branched, slightly narrower and dark brown at the base, pale brown above, 37-56 x 2 µm. *Conidiogenous cells* polyblastic, discrete, terminal or intercalary, cylindrical to doliiform, with small flat scars, 4-12 x 2-3 µm. *Conidia* solitary, dry, simple, ellipsoidal or dumbell-shaped, smooth, with a medium septum, constricted at the septum, pale brown, 8-11 x 3-4 µm.

HOLOTYPE: On fallen dead leaves of *Psychotria dalzellii*, evergreen forest, 25^{0}C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1133; leg. Maria D'Souza, 19-7-1999.

The genus *Wardomyces* Brooks & Hansford, typified by *W. anomalus* Brooks & Hansf. (Ellis, 1971), is characterized by polybalstic, terminal, ampulliform to doliiform conidiogenous cells producing smooth, round, ellipsoidal, aseptate conidia bearing a longitudinal germ slit. The fungus in hand matches with all other characters of the genus except for the presence of a longitudinal germ slit in the conidium. Therefore, it is

tentatively placed as a new species, *W. septata,* of the genus. The conidia in *W. septata* are 1-median septate with a conspicuous constriction whereas in all other species the conidia are aseptate.

Zalerion curcumensis Maria et Bhat **sp. nov.** **(Fig. 11ϑ)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA adpressed at first, later becoming floccose, with serated margin, slow growing, attaining a diam. of 0.3 cm in 7 days, dark brown with gray mycelium, raised above. *Mycelium* partly immersed, composed of densely branched, smooth, septate, pale to medium brown, 1.5-2.5 µm wide hyphae. *Conidiophores* micronematous, flexuous, septate, branched, medium brown, 1.5-2 µm wide. *Conidiogenous cells* monoblastic, smooth, medium brown, integrated, terminal or lateral, cylindrical to doliform, straight to flexuous, narrower at the base, up to 10 µm long, 1.5-2 µm wide, 2-5 µm wide above. *Conidia* solitary, dry, helicoid, smooth, phragmo-septate, constricted at the septa, branched, mid to dark brown, coiled irregularly in several planes and sometimes forming a knot or a ball of cells, when coiled 13-30 µm diam.

HOLOTYPE: On fallen dead leaves of *Curcuma decipens*, moist deciduous forest, 24^{0}C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1094; leg. Maria D'Souza, 10-08-2000.

The genus *Zalerion* Moore & Meyers, typified by *Z. maritima* (Linder) Anastasiou (Ellis, 1975) accomodated till date 7 species (Hawksworth et al., 1995). All the species so far described were from marine habitat. *Z. curcumensis* differs from the others by its terrestrial occurrence and branched nature of the conidia.

Zygosporium gibbum (Sacc., Rouss. & Bomm.) Hughes, 1958, *Can. J. Bot.*, **36:** 825. **(Fig. 119)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, irregular, smooth margin, white, slow growing attaining diam. of 1 cm in 7 days; reverse white with black at the centre. *Mycelium* partly superficial, composed of smooth, septate, branched hyaline, 2.4 µm, thin walled hyphae. *Conidiophores* mononematous, scattered, straight or slightly flexuous, smooth, unbranched, dark brown at the base, paler towards the apex, bearing dark brown, curved, swollen vesicles on short stalk arising directly from the mycelium, 16-22 x 4.8 µm, 7-9 µm thick in the broadest part of the vesicle. *Conidiogenous cells* monoblastic, discrete, terminal, ellipsoidal to ampulliform, curved and tapering to a point, thin-walled, colourless, borne in pairs, threes or fours on the dark brown vesicles, 4.5-5 x 2-2.5 µm. *Conidia* solitary, acrogenous, simple, spherical, smooth, 0-septate, hyaline, 2.5-7.5 µm diam.

Specimen examined: (i) On fallen dead leaves of *Flacourtia montana*; moist deciduous forest, 25°C, Cotigao Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.418; leg. Maria D'Souza, 11-04-99. (ii) On dead and decaying leaves of *Careya arborea*, moist deciduous forest, 26°C, Mollem Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.352; leg. Maria D'Souza, 11-03-1999. (iii) On fallen dead leaves of *Saraca asoca*; moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1890; leg. Maria D'Souza, 09-06-1999.

Isolated from dead leaves of different plant species, the fungus was so far known from British Solomon Islands, Costa Rica, Europe, Ghana, Hong Kong, India, Pakistan, Sabah and Sierra Leone (Ellis, 1971). In India, it was known to occur on dead leaves of *Borassus flabellifer* in Korattikara, Kerala (Mukerji and Juneja, 1974). The fungus was isolated by particle plating method and also reported from an earlier study carried out in this laboratory (Miriam, 2000).

Zygosporium minus Hughes, 1951, *Mycol. Pap.*, **44:** 6-7. **(Fig. 120)**

Terrestrial, conidial fungus, Hyphomycete. *Colonies* on MEA effuse, regular, white, smooth with rhizoidal margin, slow growing, attaining a diam. of 1 cm in 7 days; reverse offwhite. *Mycelium* partly superficial, composed of smooth, septate, branched hyaline, 1.5-3.5 µm wide, thin walled hyphae. *Conidiophores* mononematous, scattered, straight or slightly flexuous, smooth, unbranched, dark brown at the base, paler towards the apex, bearing dark brown curved, swollen vesicles 18-22 µm long arising directly from the mycelium on short stalk, 1-3-septate, 55-67 µm long, 4.13 µm thick in the broadest part, 2-2.75 µm wide in the above, upper part of the stipe sterile ending in a knob like structure. *Conidiogenous cells* monoblastic, discrete, terminal, ellipsoidal to ampulliform, often curved and tapering to a point, thin-walled, colourless, borne in pairs, threes or fours on the dark brown vesicles, 9.5-48 x 2.5-7.5 µm. *Conidia* solitary, simple, spherical, smooth, aseptate, hyaline, 4-10 µm diam.

Specimen examined: On fallen dead leaves *Calamus thwaitesii*, moist deciduous forest, 23°C, Bondla Wildlife Sanctuary, Goa, India; Herb. No. GUFCC No.1972; leg.Maria D'Souza, 11-02-1999.

Recorded earlier on dead leaves of many plant species from Cuba, Ghana, India, Phillipines, Sierra Leone, Tanzania, Venezuela and Zambia (Ellis, 1971), the fungus was presently isolated by particle plating method.

Table: 4.1.1. **Fungi isolated from four plants during seasonal study:**

Plant species	Mucorales		Ascomycete		Coelomycete		Hyphomycete		Non-sporulating	
	Li	*En*	*Li*	*En*	*Li*	*En*	*Li*	*En*	*Li*	*En*
Saraca asoca	0	0	6	4	9	6	63	10	50	11
Calamus thwaitesii	0	0	4	2	6	3	87	12	39	10
Careya arborea	1	0	6	2	12	2	82	4	43	19
Dendrocalamus strictus	0	0	2	2	4	1	82	13	52	14

(Note: Substrates: *Li* - Leaf-litter ; *En* - Endophyte)

Table: 4.1.2. **Fungi isolated from different dicot and monocot plants during diversity study:**

Plant species	Ascomycete		Coelomycete		Hyphomycete		Non-sporulating	
	Li	*En*	*Li*	*En*	*Li*	*En*	*Li*	*En*
Dendrocalamus strictus	1	3	1	0	28	4	6	1
Bambusa arundinacea	0	3	1	0	14	3	7	2
Bauhinia purpurea	0	0	5	1	21	3	11	10
Calamus thwaitesii	0	2	1	1	11	3	8	1
Caryota urens	3	0	2	0	13	1	7	6
Curcuma decipens	2	1	3	1	12	7	9	5
Dillenia indica	0	2	1	1	13	0	16	5
Hydnocarpus laurifolia	1	2	0	0	14	3	0	4
Terminalia paniculata	1	1	1	0	17	2	7	5
Elaeis guineensis	4	-	4	4	33	9	23	10
Ensete superbum	0	2	1	2	11	2	4	3
Ficus religiosa	0	1	0	2	16	2	1	3
Ficus benghalensis	0	0	0	2	23	3	10	1
Ficus tinctorius var. *parasitica*	2	2	3	1	26	1	17	14
Flacourtia montana	4	1	2	0	18	2	9	2
Helictris ixora	2	1	1	0	14	3	10	9
Ixora brachiata	0	0	1	0	16	2	14	4
Mangifera indica	0	1	0	2	12	2	6	2
Pandanus tectorius	0	3	0	0	16	4	24	3
Psychotria dalzellii	1	2	1	0	14	1	10	4
Sageraea laurifolia	1	1	0	0	21	0	3	6
Syzygium cumini	2	1	3	5	36	6	17	9
Tectona grandis	0	3	2	2	12	5	25	10
Xylia xylocarpa	0	0	3	0	22	2	15	3
Zanthoxylum rhetsa	4	3	1	0	16	3	8	5
Sanseiviera zeylanica	1	0	0	0	16	2	8	6

(Note: Substrates: *Li* - Leaf-litter ; *En* - Endophyte)

Table: 4.1.3. **Number of fungi recovered from dicot plant species using different isolation techniques:**

Plant species	Moist chamber	Particle-plating	Endophyte	Total isolates
Bauhinia purpurea	19	21	14	54
Dillenia indica	3	28	8	39
Hydnocarpus laurifolia	12	3	9	24
Terminalia paniculata	7	19	8	34
Ficus religiosa	1	17	8	26
Ficus benghalensis	1	32	6	39
Ficustinctorius var.*parasitica*	18	37	18	73
Flacourtia Montana	6	29	5	40
Helictris ixora	7	26	13	46
Ixora brachiata	13	20	6	39
Mangifera indica	2	18	7	27
Psychotria dalzellii	5	21	7	33
Sageraea laurifolia	14	13	7	34
Syzygium cumini	0	45	21	66
Tectona grandis	5	35	20	60
Xylia xylocarpa	17	32	5	54
Zanthoxylum rhetsa	16	14	11	41

Table: 4.1.4. **Number of fungi recovered from monocot plant species using different isolation techniques:**

Plant species	Moist chamber	Particle plating	Endophyte isolation	Total isolates
Dendrocalamus strictus	12	26	8	46
Bambusa arundinacea	2	20	8	30
Calamus thwaitesii	4	17	7	28
Caryota urens	6	19	7	32
Curcuma decipens	10	17	14	41
Elaeis guineensis	22	45	23	90
Ensete superbum	2	15	9	26
Pandanus tectorius	13	27	10	50
Sanseiviera zeylanica	13	8	8	29

Table: 4.1.5. **Number of species/morphotypes of different groups of fungi appeared on plant substrates studied:**

Plant species	Abbr.	Asco-	Coelo-	Hypho-	Non-sporulating
Dendrocalamus strictus	Dst.	4	2	30	7
Bambusa arundinacea	Bar.	3	1	20	9
Bauhinia purpurea	Bpu.	0	5	21	22
Calamus thwaitesii	Cth.	1	2	11	9
Caryota urens	Cur.	3	1	13	13
Curcuma decipens	Cde.	2	4	19	14
Dillenia indica	Din.	2	2	13	21
Hydnocarpus laurifolia	Hla.	2	0	15	4
Terminalia paniculata	Tpa.	2	1	17	12
Elaeis guineensis	Egu.	0	4	39	33
Ensete superbum	Esu.	1	3	15	6
Ficus religiosa	Fre.	1	2	18	4
Ficus benghalensis	Fbe.	0	2	23	10
Ficus tinctorius var.*parasitica*	Fti.	2	3	27	30
Flacourtia montana	Fmo.	4	1	21	11
Helictris ixora	Hix.	2	1	17	19
Ixora brachiata	Ibr.	0	1	14	18
Mangifera indica	Min.	1	2	15	8
Pandanus tectorius	Pte.	3	0	20	28
Psychotria dalzellii	Pda.	3	1	14	14
Sageraea laurifolia	Sla.	2	0	20	9
Syzygium cumini	Scu.	2	5	36	23
Tectona grandis	Tgr.	3	2	26	35
Xylia xylocarpa	Xxy.	0	1	30	18
Zanthoxylum rhetsa	Zrh.	4	1	17	15
Sanseiviera zeylanica	Sze.	1	0	21	8

Table: 4.1.6. **Exclusive genera of microfungi present in the plant species studied:**

Name of the fungus	Name of plant species
Aquaphila ramdayalea	*Flacourtia montana*
Clonostachys cylindrospora	*Syzygium cumini*
Dictyoarthrinium rabaulense	*Dendrocalamus strictus*
Dictyosporium elegans	*Elaeis guineensis*
Kumbhamaya gonensis	*Flacourtia montana*
Kumbhamaya indica	*Dendrocalamus strictus*
Pseudobeltrania sp.	*Bauhinia purpurea*
Trichobotrys ramosa	*Dendrocalamus strictus*
Zalerion curcumensis	*Curcuma decipens*

LEGEND TO THE FIGURES:

Fig. 1. *Acremonium* sp.

Fig. 2. *Actinocladium rhodosporum*

Fig. 3. *Alternaria alternata*

Fig. 4. *Aquaphila ramdayalea* **sp.nov.**

Fig. 5. *Ardhachandra parva* **sp.nov.**

Fig. 6. *Ardhachandra selenoides*

Fig. 7. *Arthrobotrys oligospora*

Fig. 8. *Aspergillus restrictus*

Fig. 9. *Bahusakala olivaceonigra*

Fig. 10. *Bahusutrabeeja angularis*

Fig. 11. *Bahusutrabeeja dwaya*

Fig. 12. *Bharatheeya goanensis*

Fig. 13. *Bharatheeya mucoidea*

Fig. 14. *Brachysporiella gayana*

Fig. 15. *Canalisporium caribense*

Fig. 16. *Chaetendrophragmia triseptata*

Fig. 17. *Chalara* sp.

Fig. 18. *Chamydomyces* sp.

Fig. 19. *Choridium ghaticum* **sp.nov.**

Fig. 20. *Chrysosporium* sp.

Fig. 21. *Cladosporium elegans*

Fig. 22. *Conioscypha bambusicola*

Fig. 23. *Craspedodidymum abigianense*

Fig. 24. *Cylindrotrichum* sp.1

Fig. 25. *Cylindrotrichum* sp.2

Fig. 26. *Dactylaria* sp.

Fig. 27. *Dendrosporium lobatum*

Fig. 28. *Dictyoarthrinium rabaulense*

Fig. 29. *Dictyochaeta assamica*

Fig.30. *Dictyosporium elegans*

Fig.31. *Didymobotryum spirillum* **sp.nov.**

Fig.32. *Dischloridium minutum* **sp.nov.**

Fig.33. *Edmundmasonia pulchra*

Fig.34. *Elegantimyces sporidesmiopsis*

Fig.35. *Epicoccum purpurascens*

Fig.36. *Fusariella bizzozeriana*

Fig.37. *Fusariella hughesii*

Fig.38. *Fusariella indica*

Fig.39. *Fusichalara bipodia* **sp.nov.**

Fig.40. *Gliocladium penicilloides*

Fig.41. *Gliocladium* sp.

Fig.42. *Gliomastix murorum*

Fig.43. *Gliomastix novae-zelandiae*

Fig.44. *Gonatobotryum apiculatum*

Fig.45. *Helicomyces roseus*

Fig.46. *Helicosporium* sp.

Fig.47. *Hemicorynespora mitrata*

Fig.48. *Wardomyces septata* **sp. nov.**

Fig.49. *Idriella fertilis*

Fig.50. *Idriella goanensis* **sp. nov.**

Fig.51. *Idriella hyalina* **sp. nov.**

Fig.52. *Idriella lunata*

Fig.53. *Idriella malabarica*

Fig.54. *Idriella septata* **sp. nov.**

Fig.55. *Idriella sigmoidea* **sp. nov.**

Fig.56. *Idriella verticillata* **sp. nov.**

Fig.57. *Idriella* sp.

Fig.58. *Iyengarina saprophyticus* **sp. nov.**

Fig.59. *Kramasamuha sundara* **sp. nov.**

Fig.60. *Kumbhamaya aseptata* **sp. nov.**

Fig.61. *Kumbhamaya goanensis* **sp. nov.**

Fig.62. *Kumbhamaya indica*

Fig.63. *Kylindria excentrica*

Fig.64. *Kylindria hyalina* **sp. nov.**

Fig.65. *Mariannea elegans*

Fig.66. *Mirandina longispora* **sp.nov.**

Fig.67. *Monodictys putredinis*

Fig.68. *Nigrospora sphaerica*

Fig.69. *Nodulisporium gregarium*

Fig.70. *Nodulisporium* sp.

Fig.71. *Parahelminthosporium malabaricum*

Fig.72. *Parapathramaya haarea* **gen. et sp. nov.**

Fig. 73. *Paschimghateeya goanensis.*

Fig. 74. *Periconia byssoides*

Fig. 75. *Philoacephala* sp.

Fig. 76. *Pithomyces chartarum*

Fig. 77. *Pleurophragmium minutispora* **sp. nov.**

Fig. 78. *Pleurophragmium simplex*

Fig. 79. *Pleurothecium pulneyensis*

Fig. 80. *Pleurothecium ramosa* **sp. nov.**

Fig. 81. *Podosporium* sp.

Fig. 82. *Pyricularia* sp.

Fig. 83. *Raperia swadeja* **sp. nov.**

Fig. 84. *Saccardaea indica* **sp. nov.**

Fig. 85. *Scolecobasidium acuminatous* **sp. nov.**

Fig. 86. *Scolecobasidium constrictum*

Fig. 87. *Scolecobasidium humicola*

Fig. 88. *Scolecobasidium saprophyticus* **sp. nov.**

Fig. 89. *Scolecobasidium* sp.1

Fig. 90. *Scolecobasidium* sp.2

Fig. 91. *Selenoidriella indica*

Fig. 92. *Sesquicillium indicum* **sp. nov.**

Fig. 93. *Solosympodiella clavata*

Fig. 94. *Sporidesmium brachypus*

Fig. 95. *Sporidesmium coprophilum*

Fig. 96. *Sporidesmium flagelliforme*

Fig. 97. *Sporidesmium harknesii*

Fig. 98. *Sporidesmium leonense*

Fig. 99. *Sporidesmium vagum*

Fig. 100. *Sporidesmium* sp.2

Fig. 101. *Stachybotrys atra*

Fig. 102. *Stachybotrys aurantia*

Fig. 103. *Stachybotrys hyalina* **sp. nov.**

Fig. 104. *Stachybotrys hyaloseptata* **sp. nov.**

Fig. 105. *Stachybotrys nephrospora*

Fig. 106. *Stachybotrys oenanthes*

Fig. 107. *Stachybotrys* state of *Melanopsamma pomiformis*

Fig. 108. *Subulispora procurvata*

Fig. 109. *Sympodiella laxa*

Fig. 110. *Trichobotrys ramosa* **sp. nov.**

Fig. 111. *Tripospermum myrti*

Fig. 112. *Tritirachium* sp.

Fig. 113. *Vermiculariopsiella elegans* **sp. nov.**

Fig. 114. *Veronaea bambusae*

Fig. 115. *Veronaea botryosa*

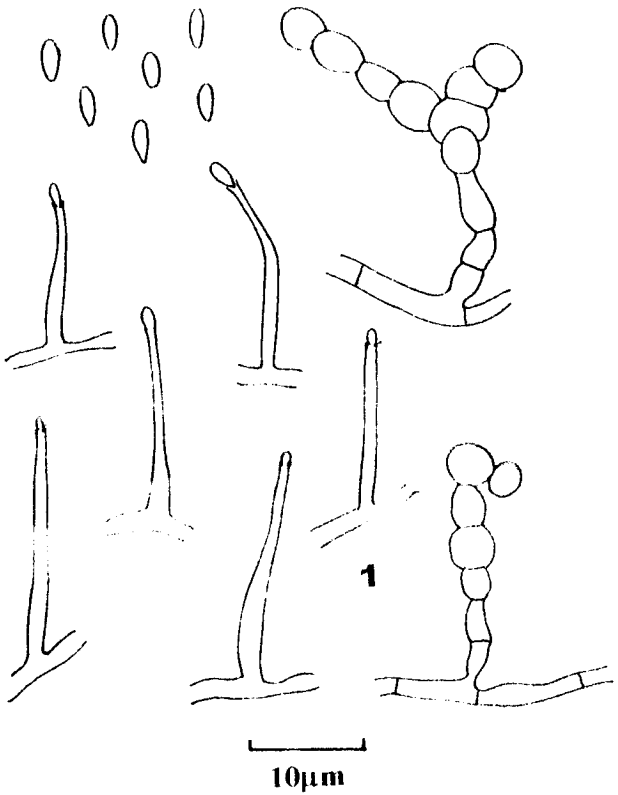
Fig. 116. *Verticillium cinnabarinum*

Fig. 117. *Virgatospora natarajanensis* **sp. nov.**

Fig. 118. *Zalerion curcumensis* **sp. nov.**

Fig. 119. *Zygosporium gibbum*

Fig. 120. *Zygosporium minus*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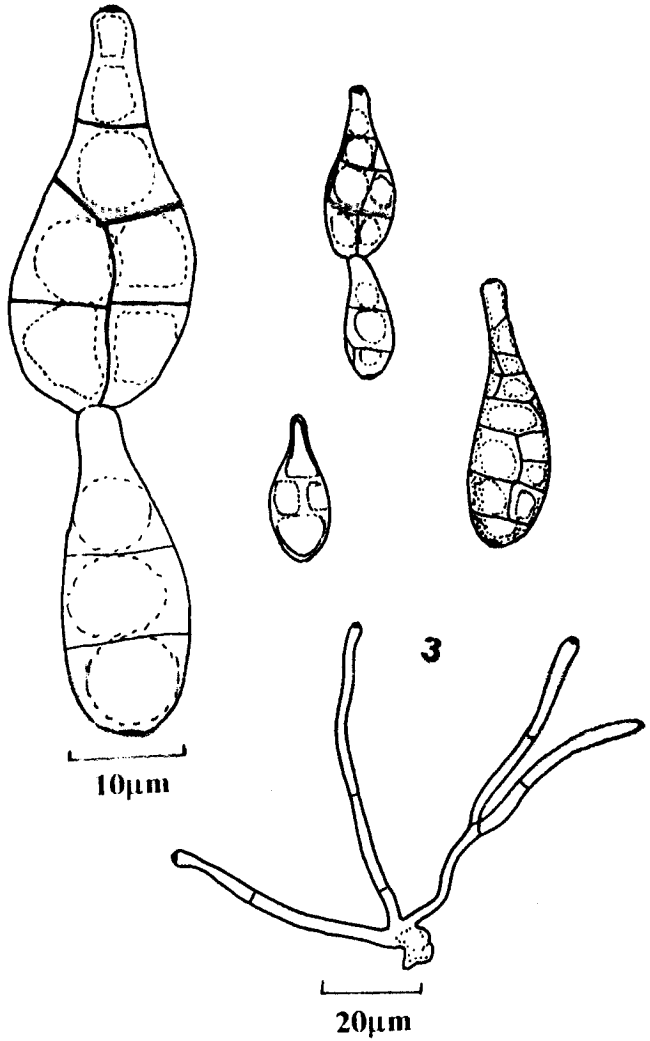
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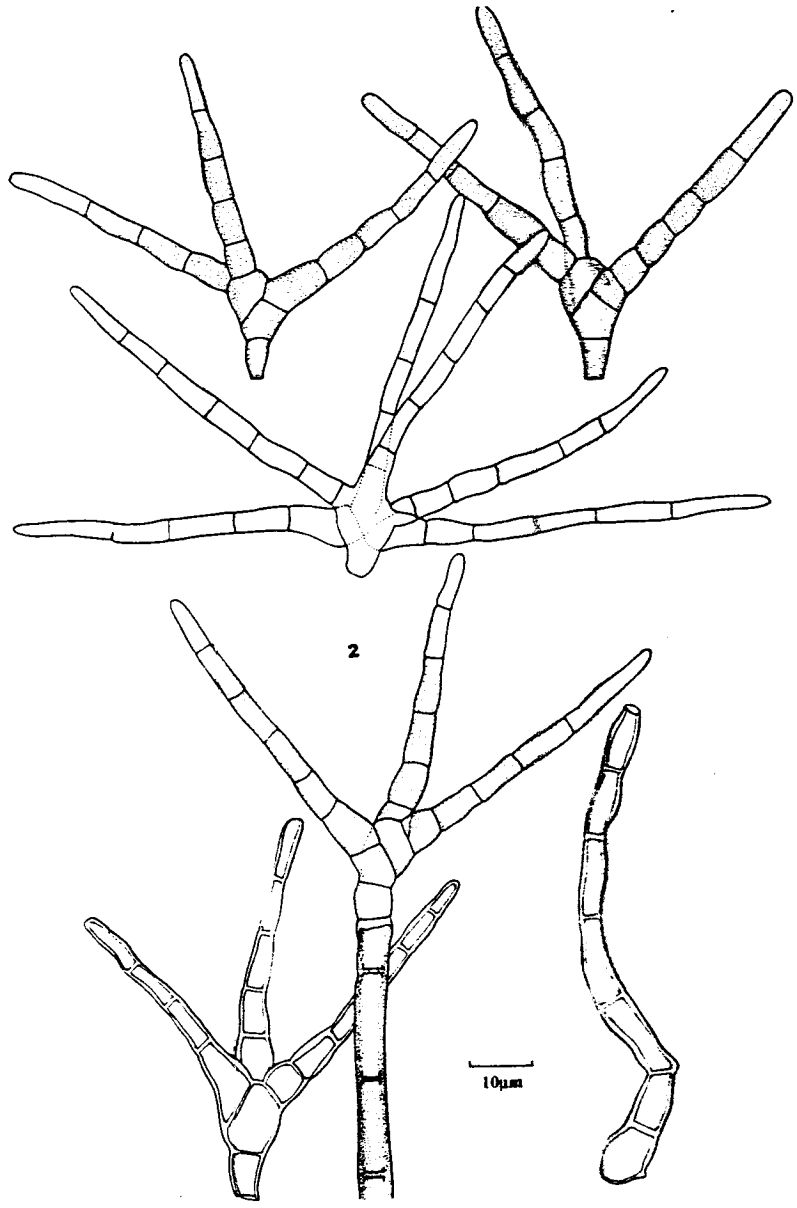
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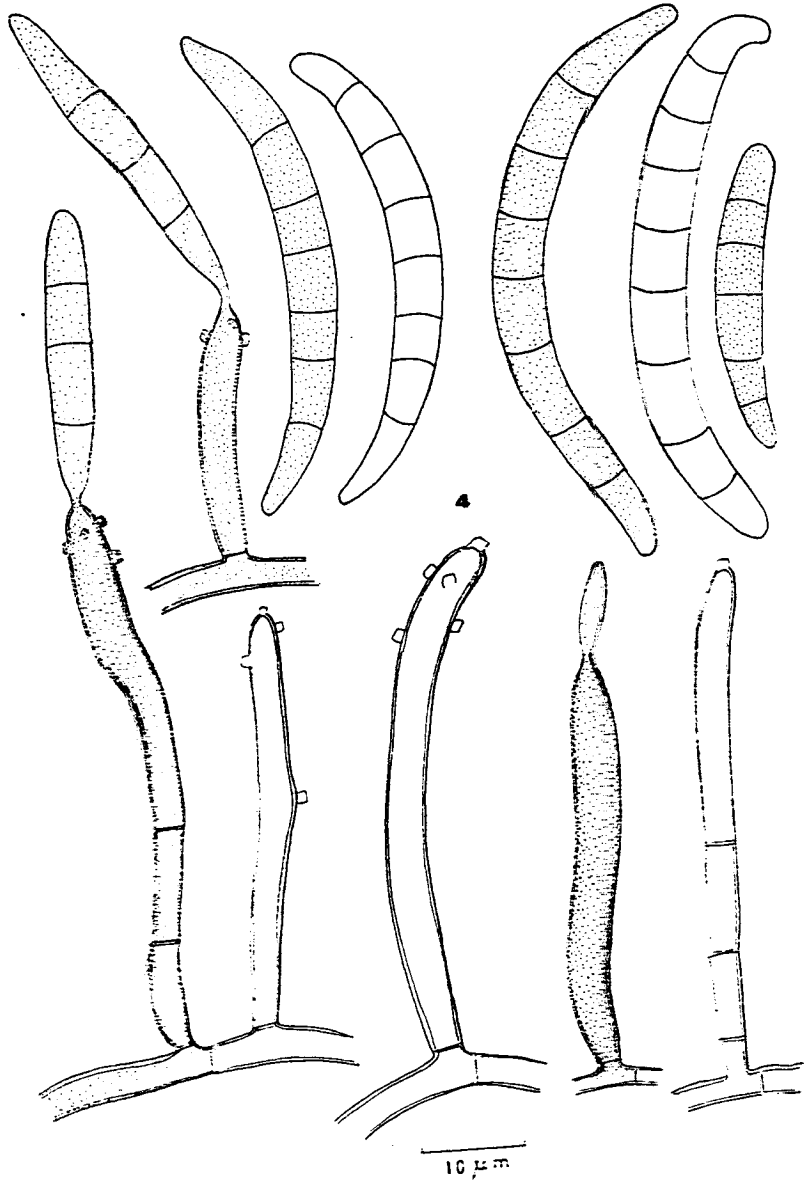
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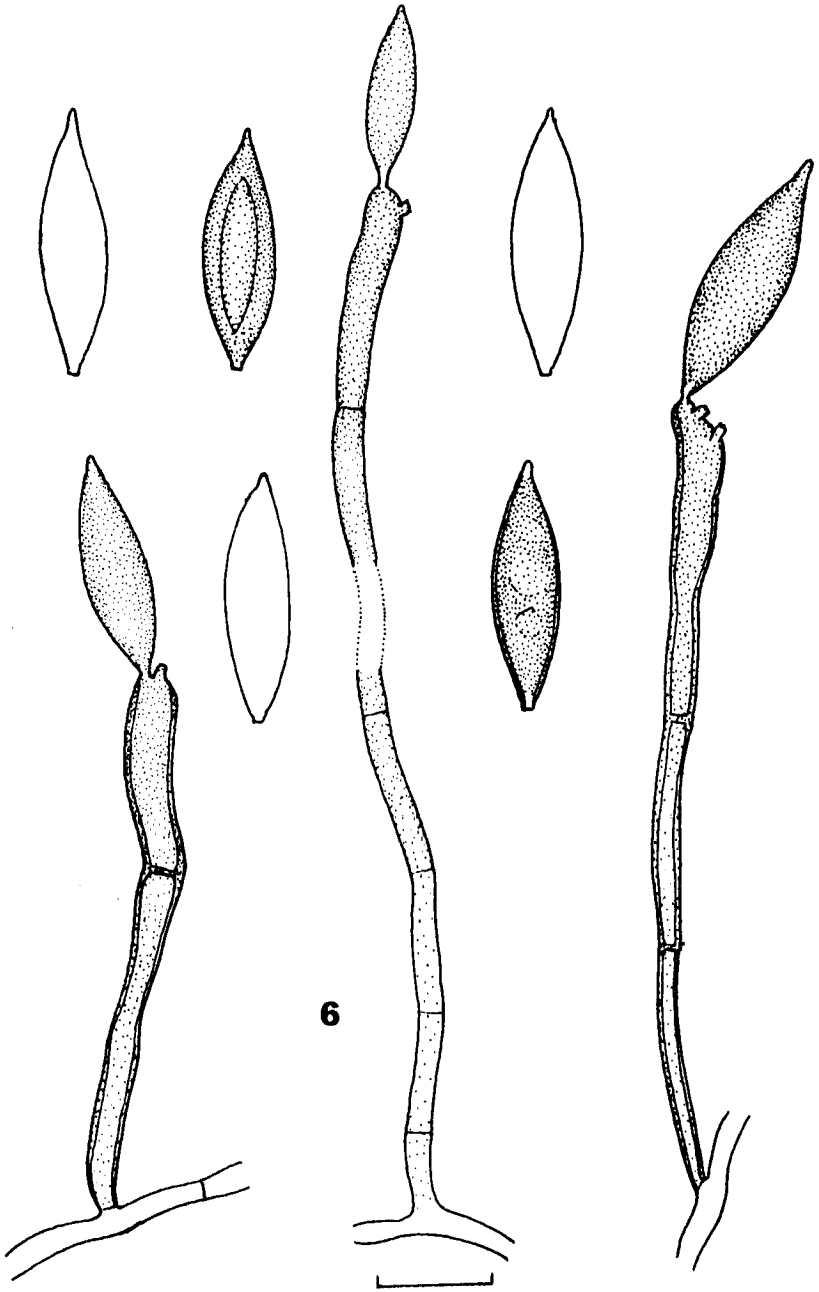
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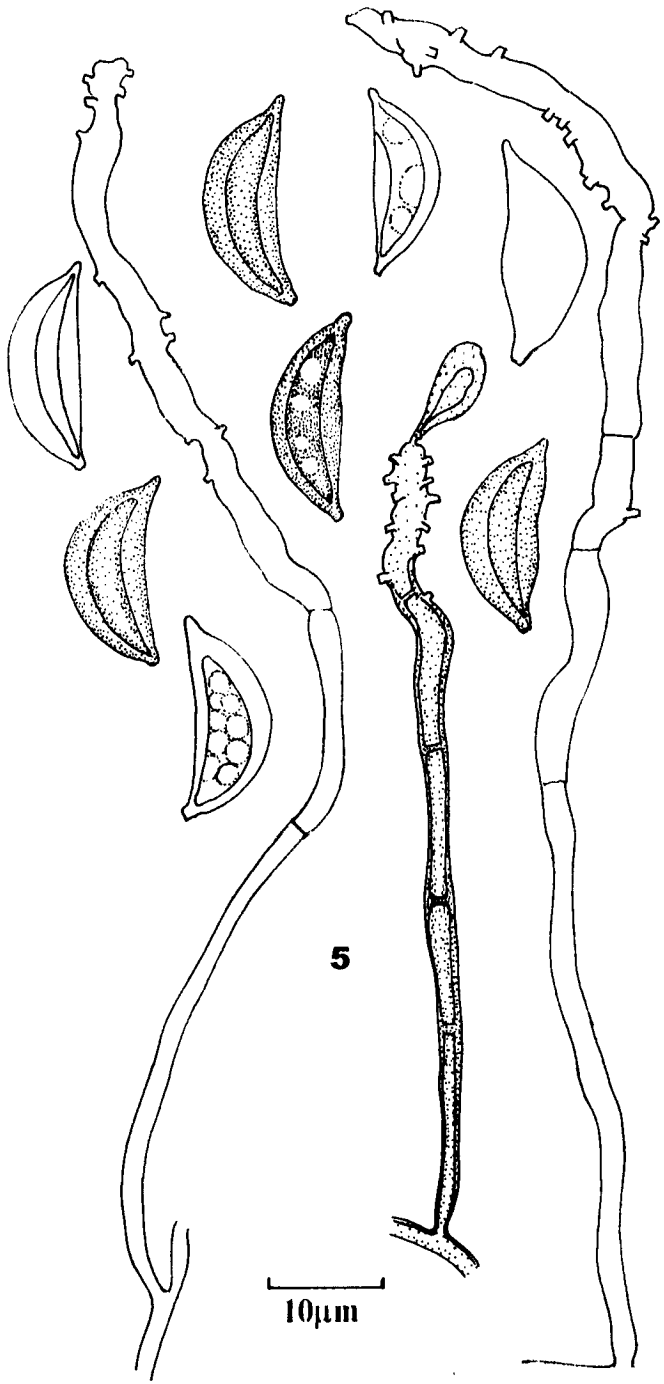
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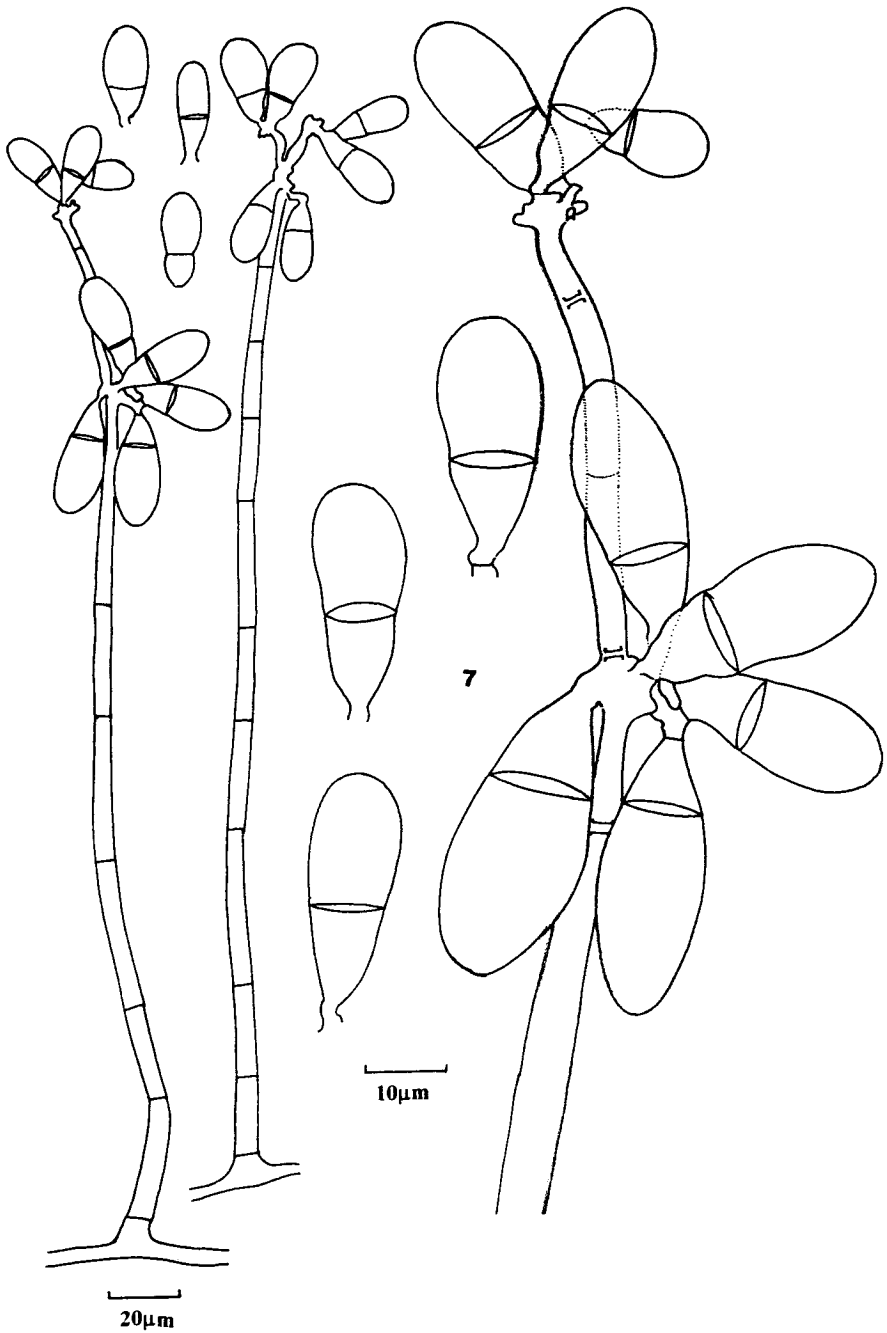
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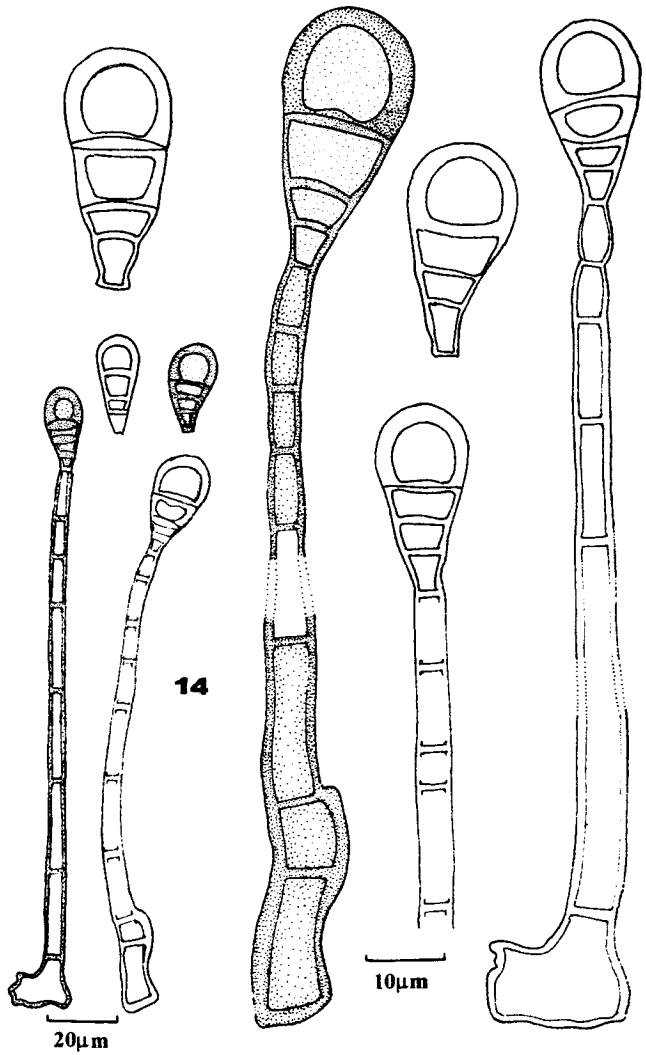
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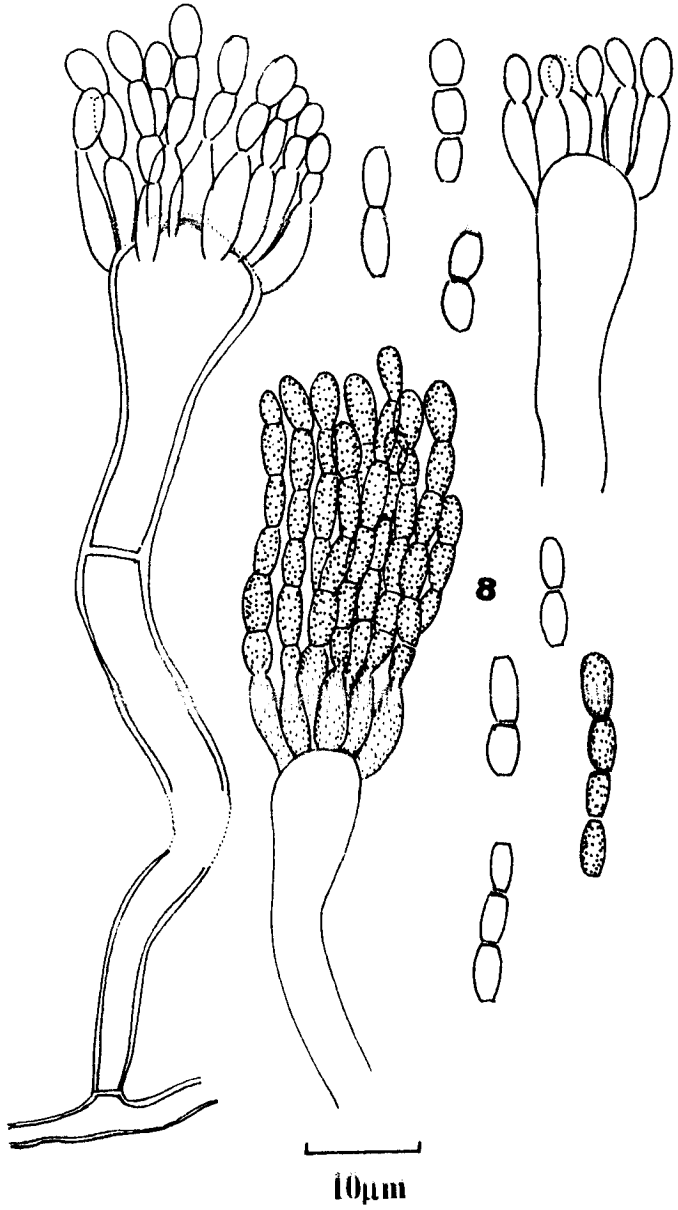
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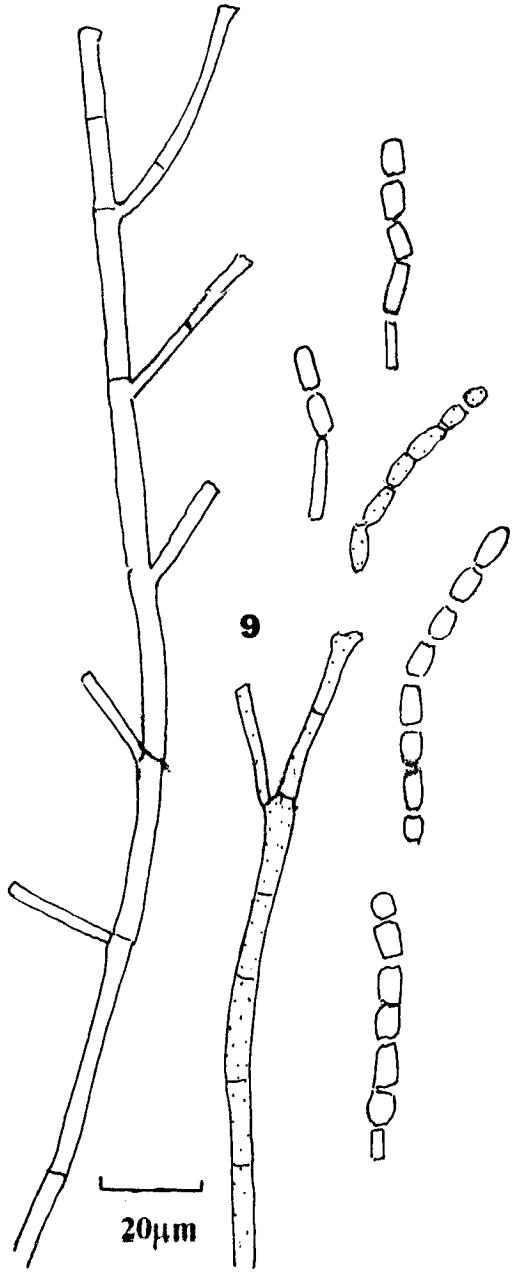
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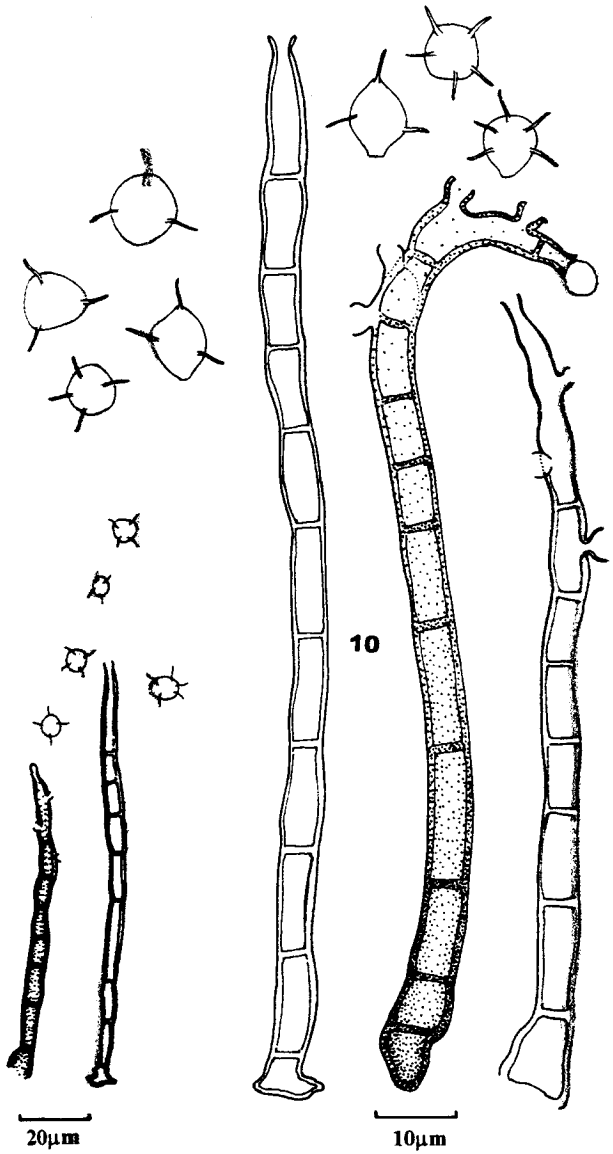
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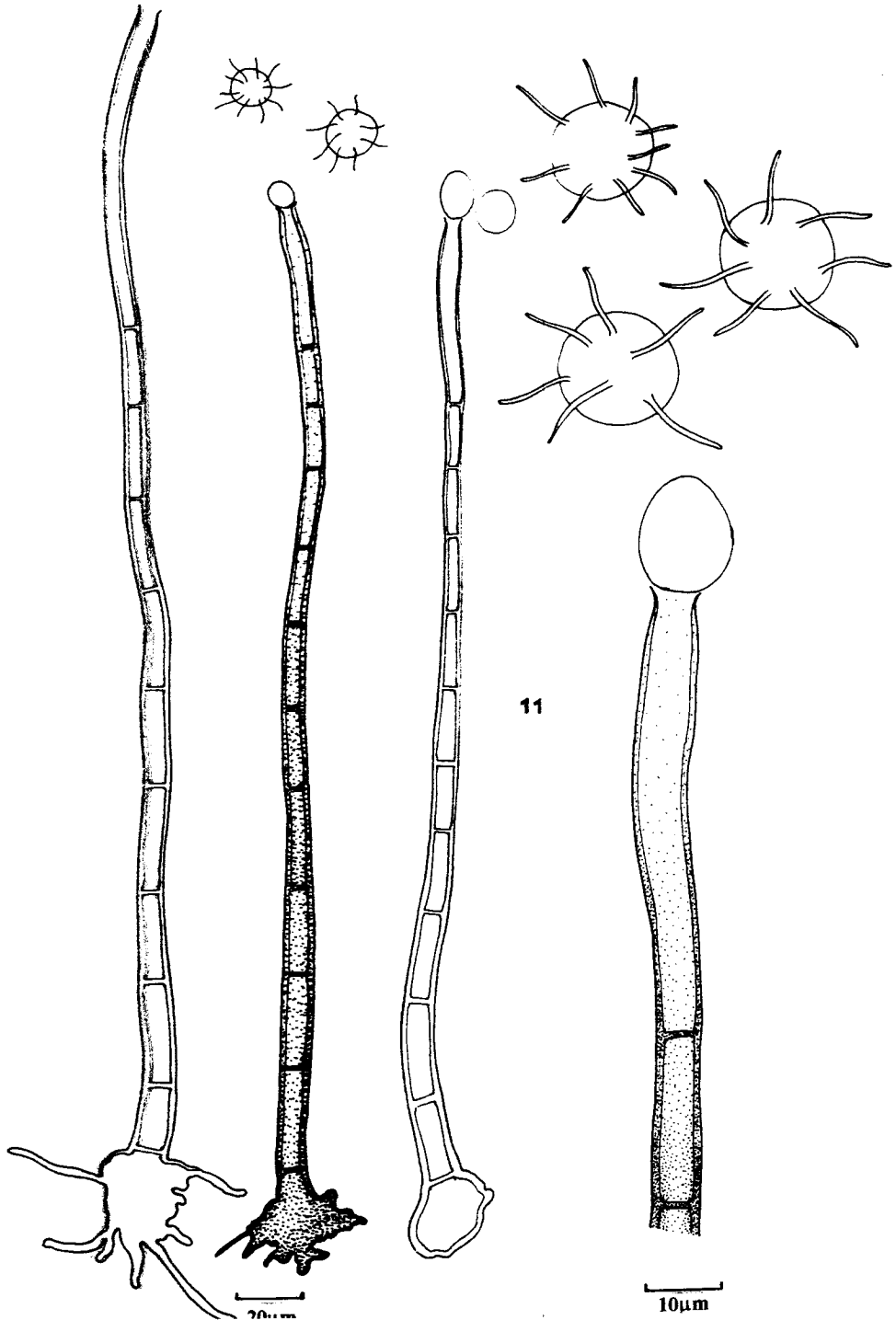
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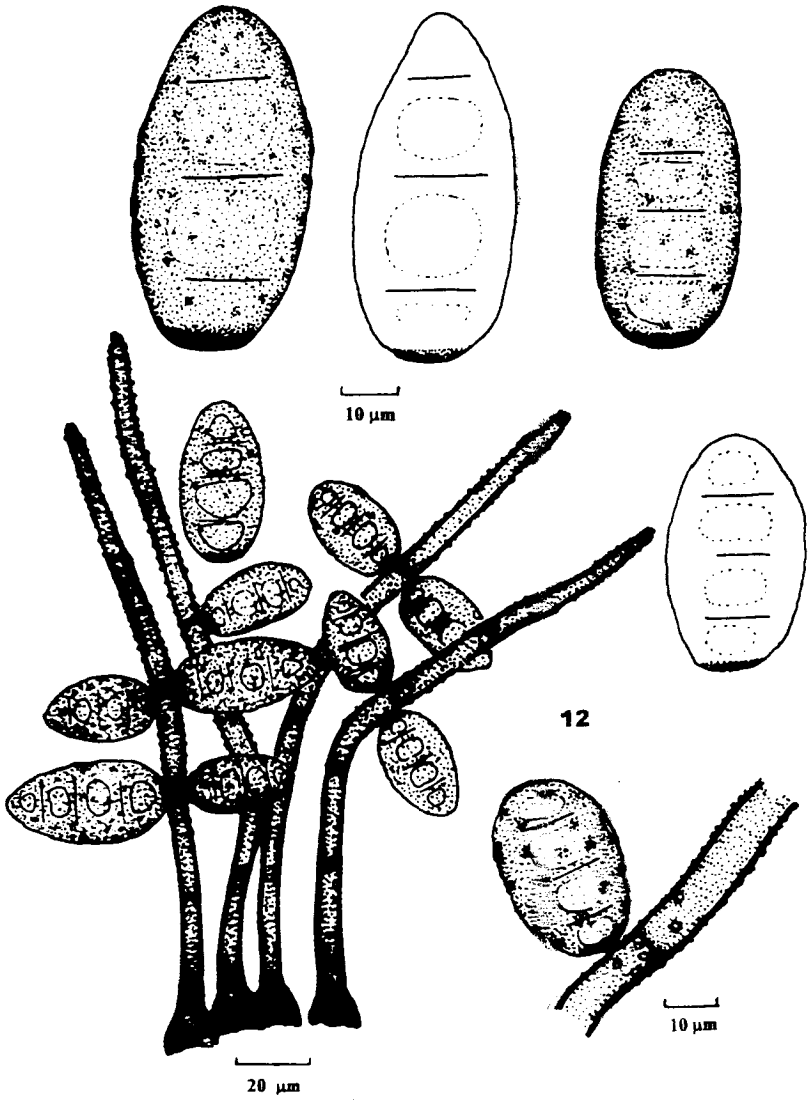
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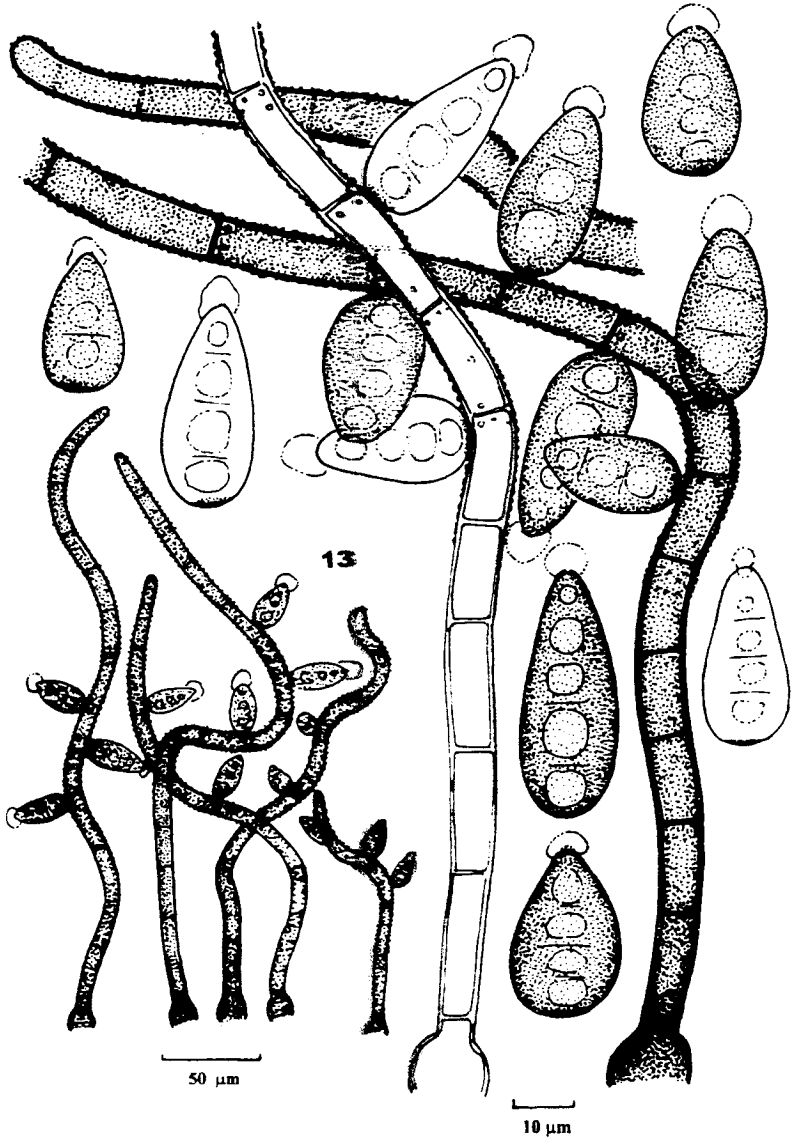
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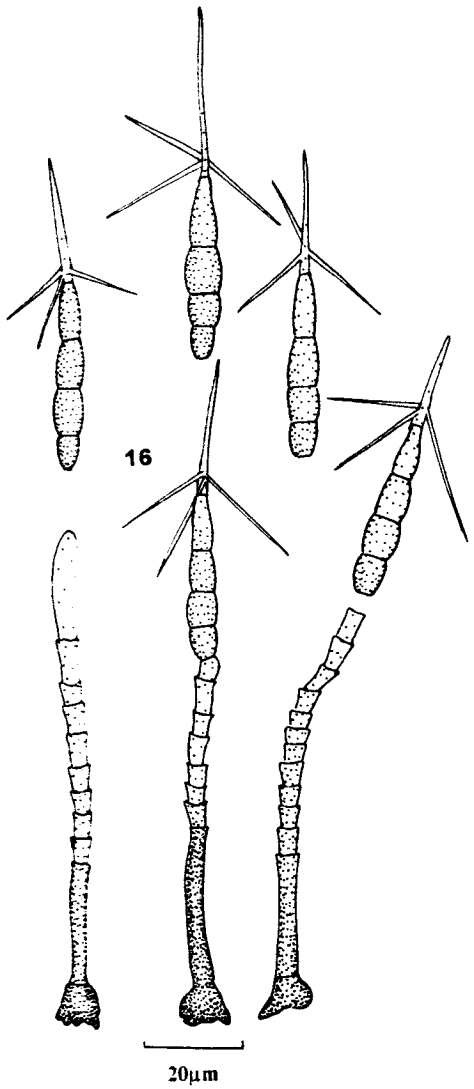
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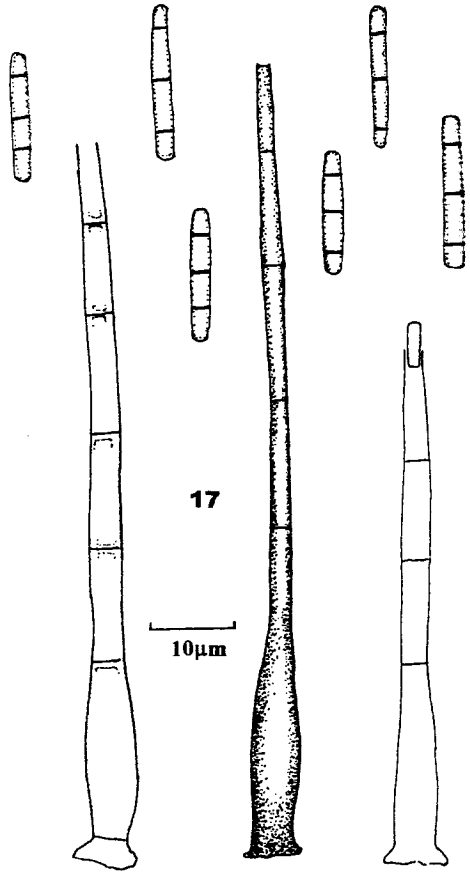
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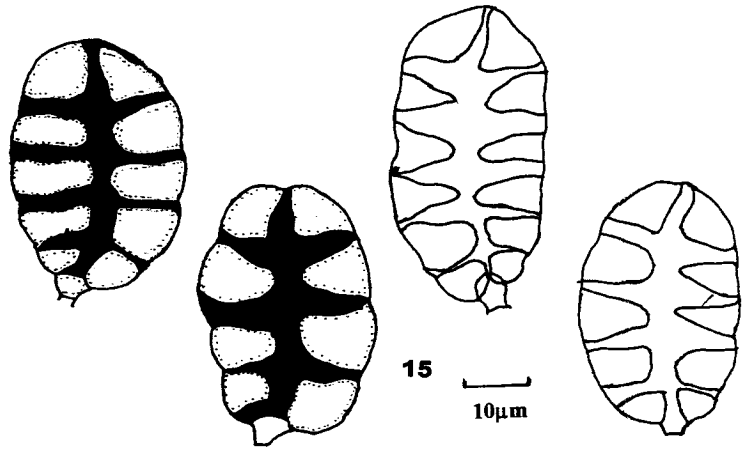
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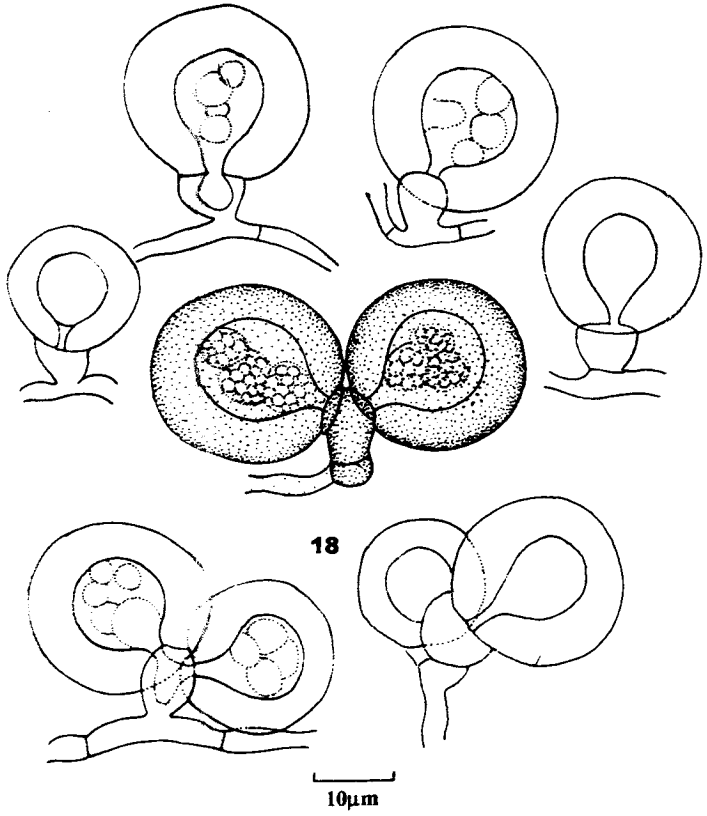
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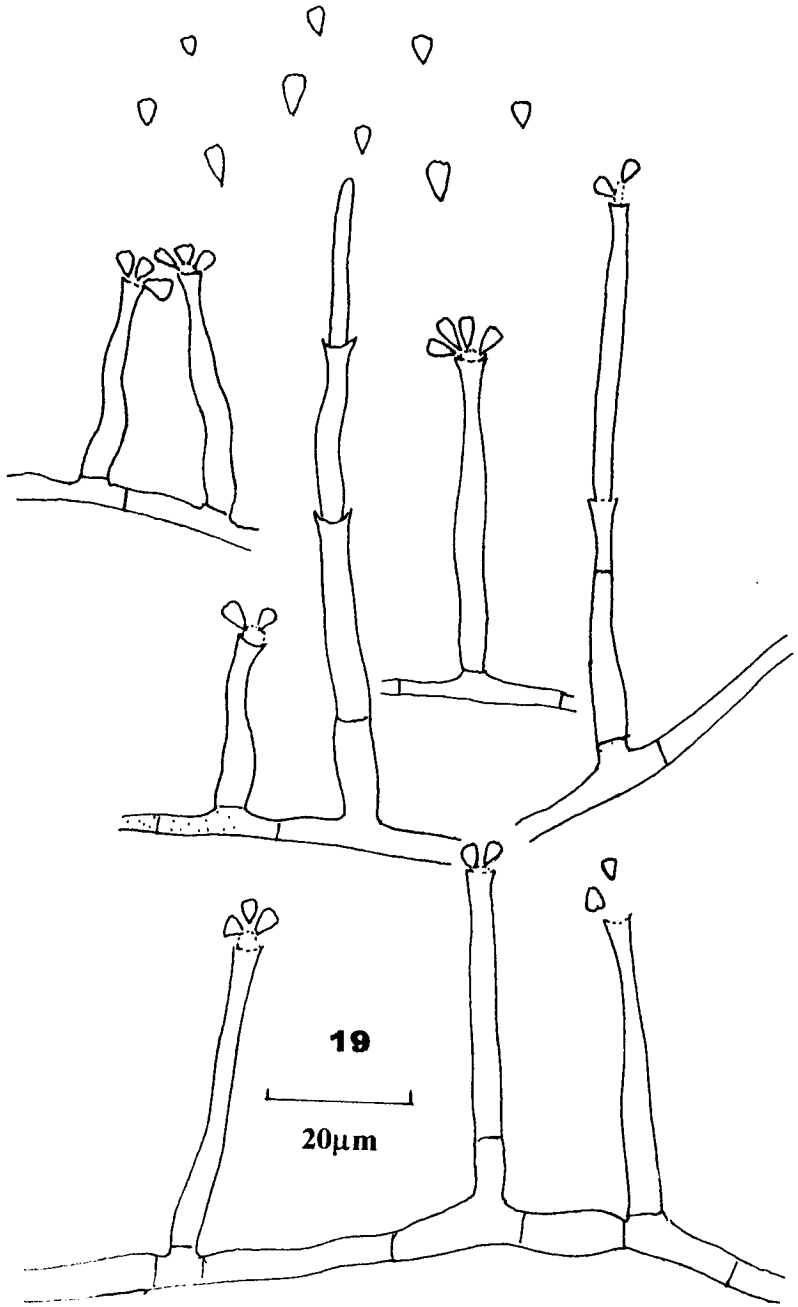
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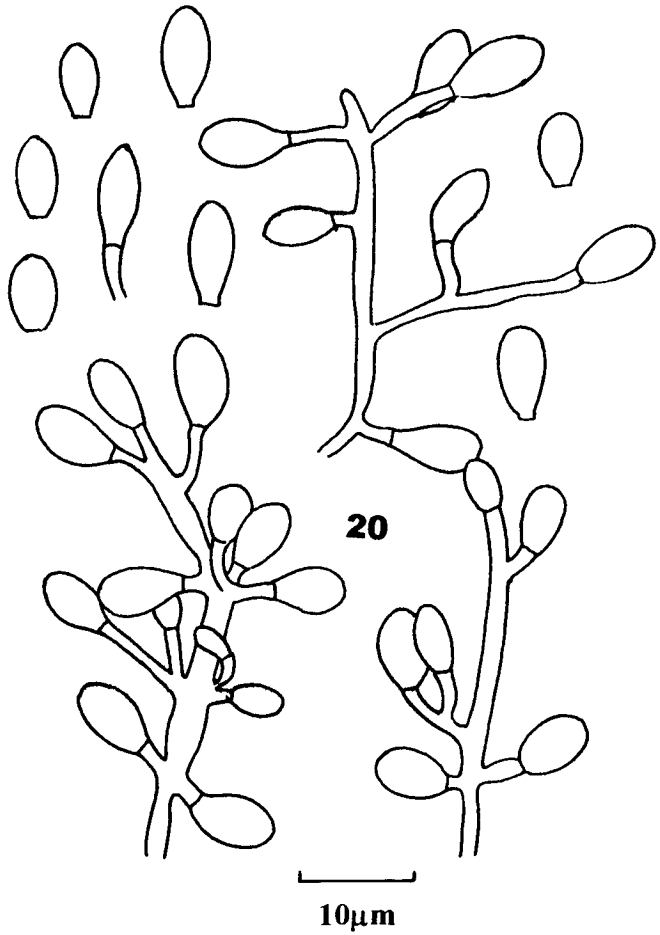
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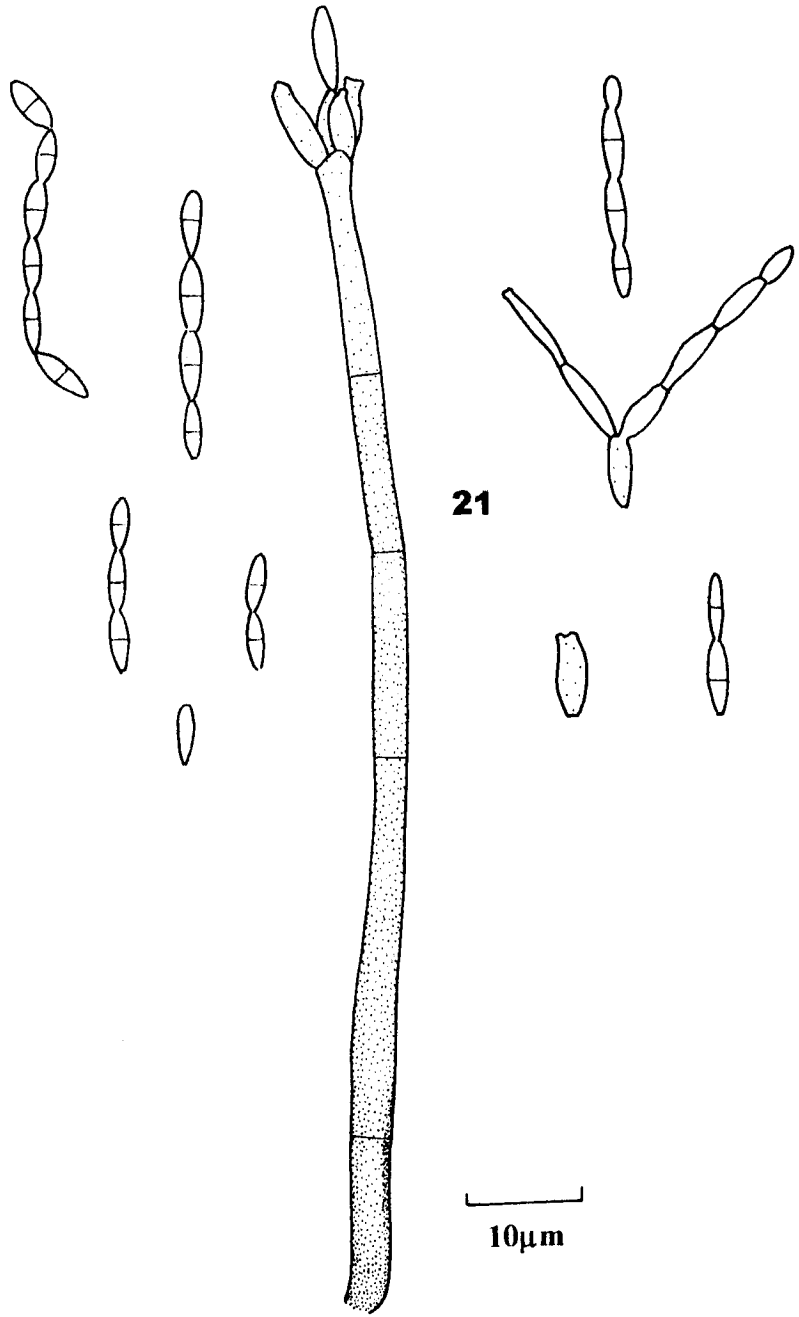
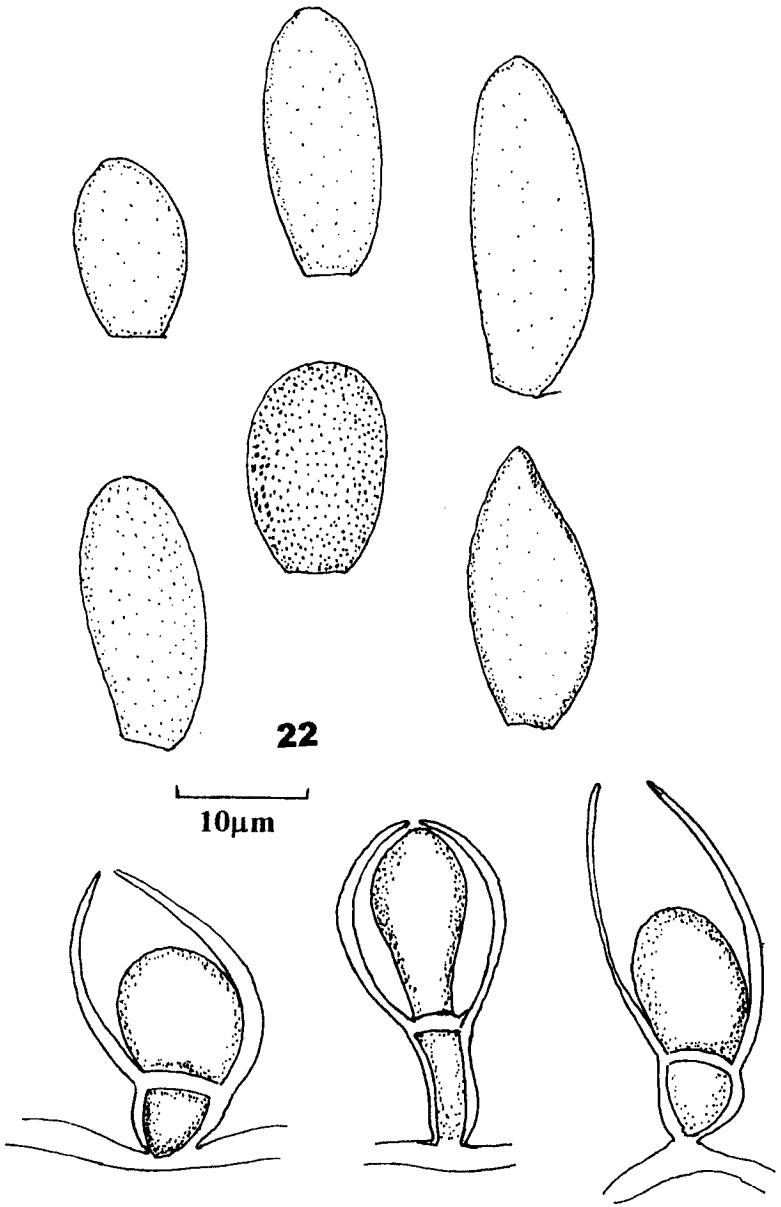
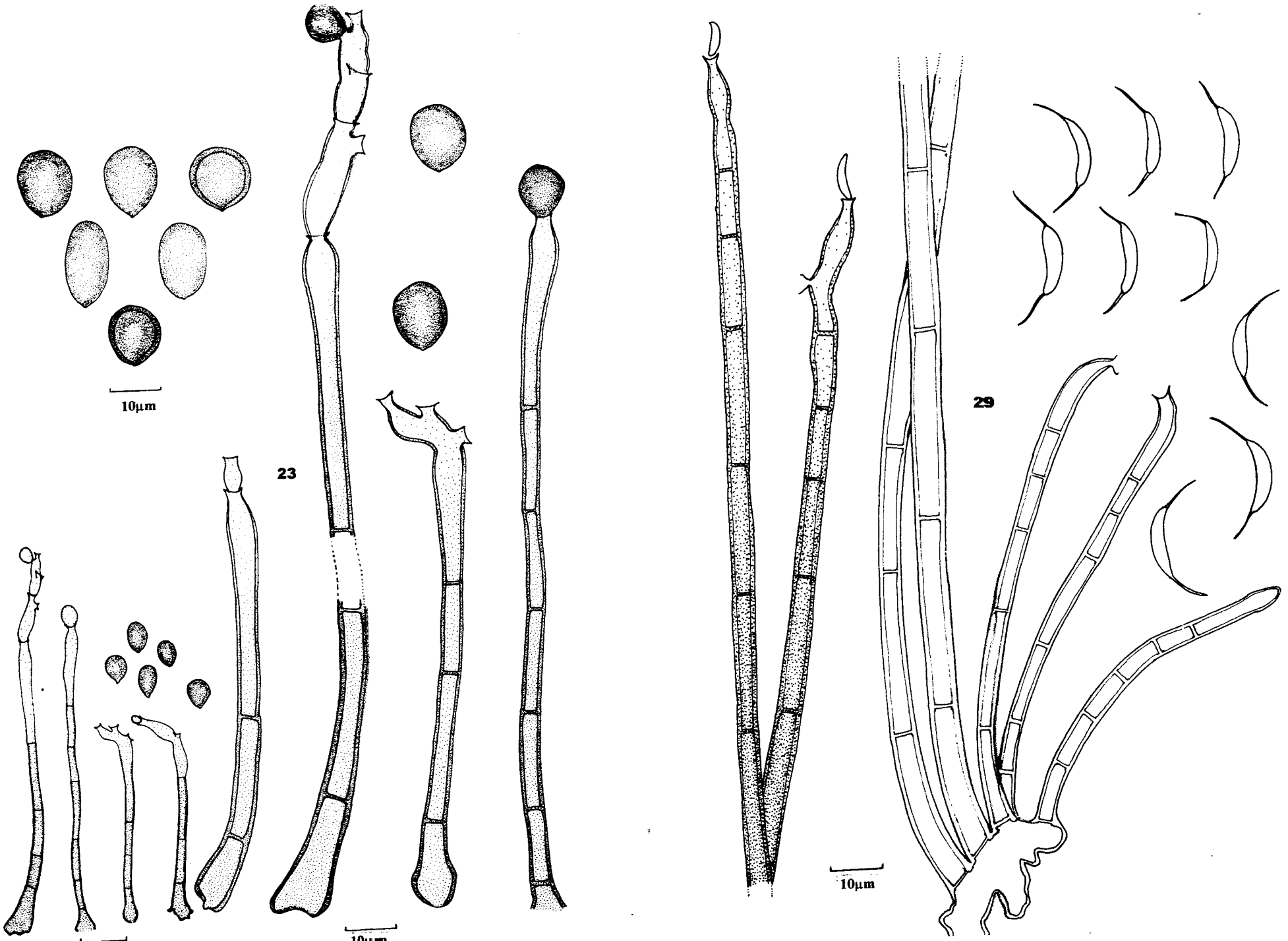
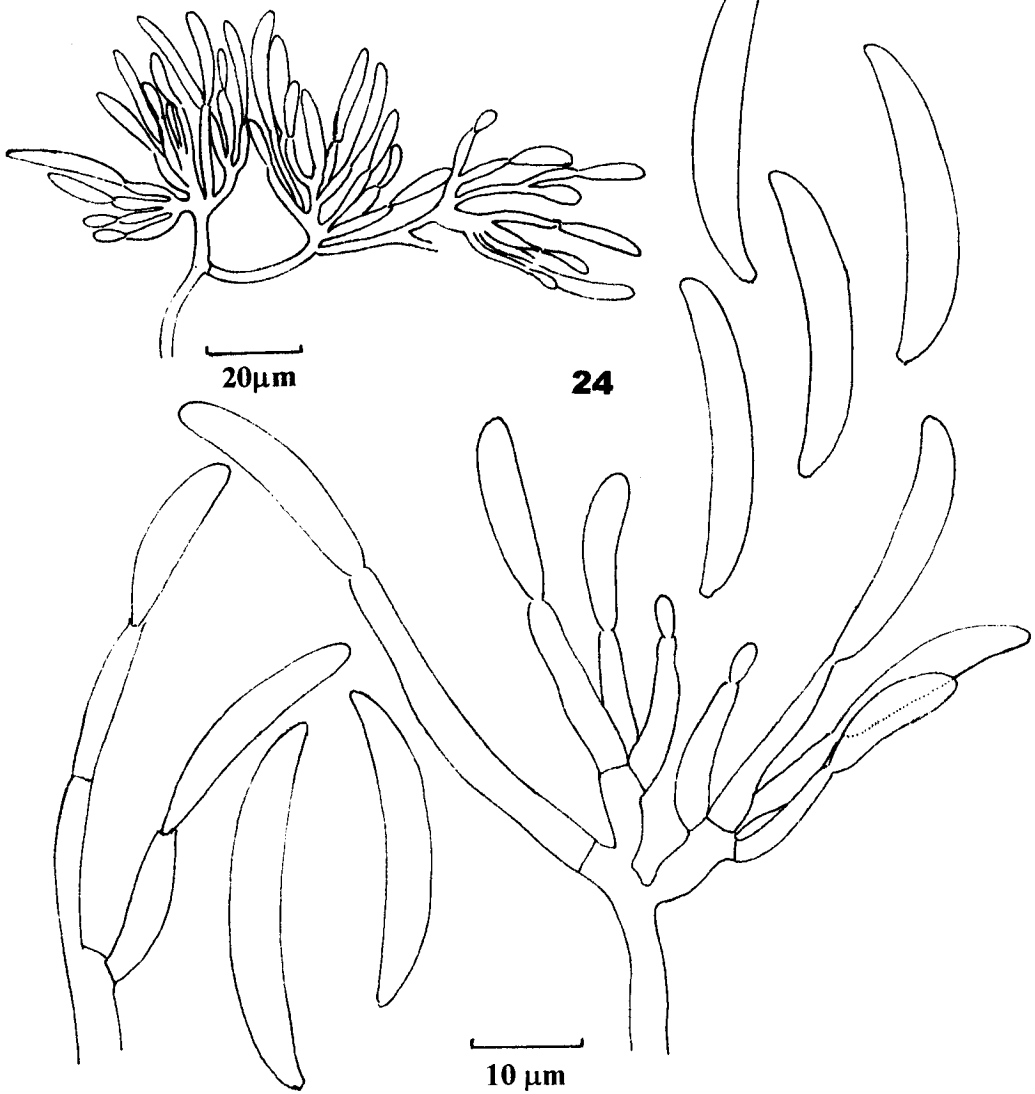
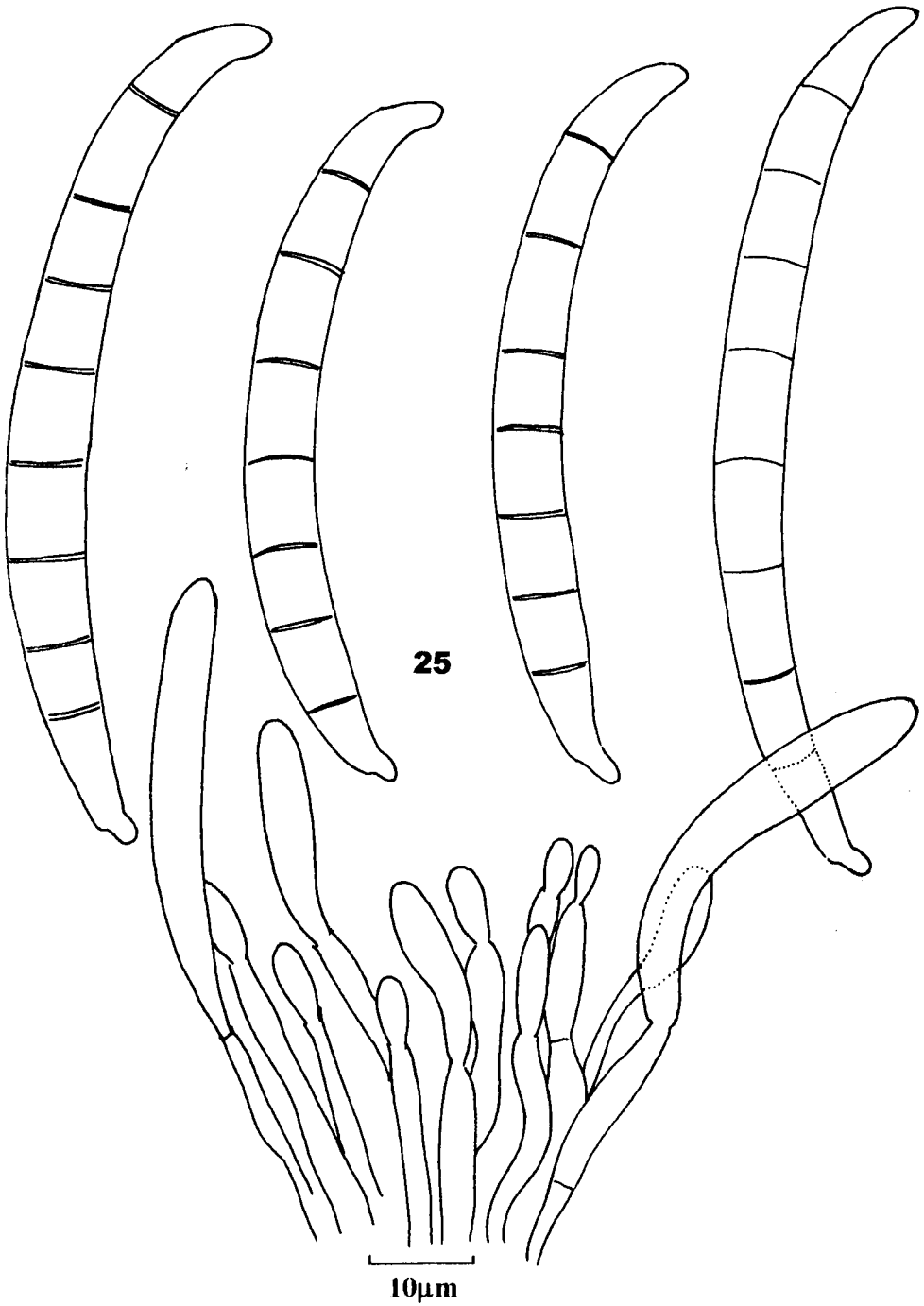

21
10µm


22
10µm


10µm
23
10µm
10µm
29


20µm
24
10 µm


25
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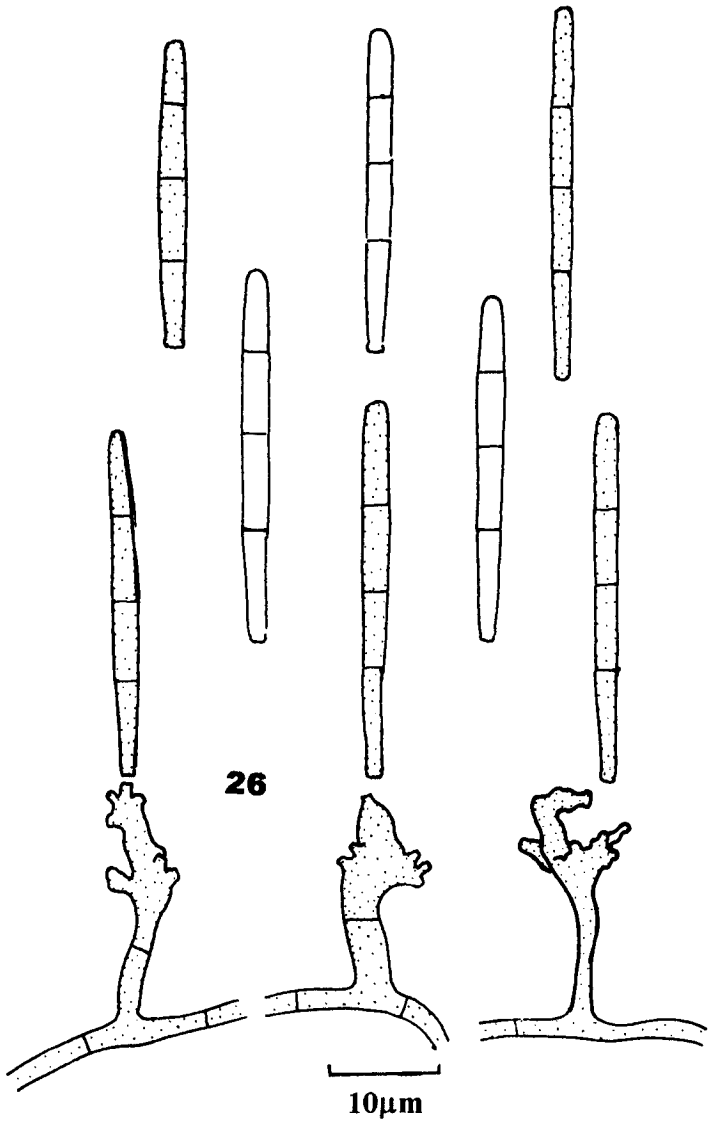
26
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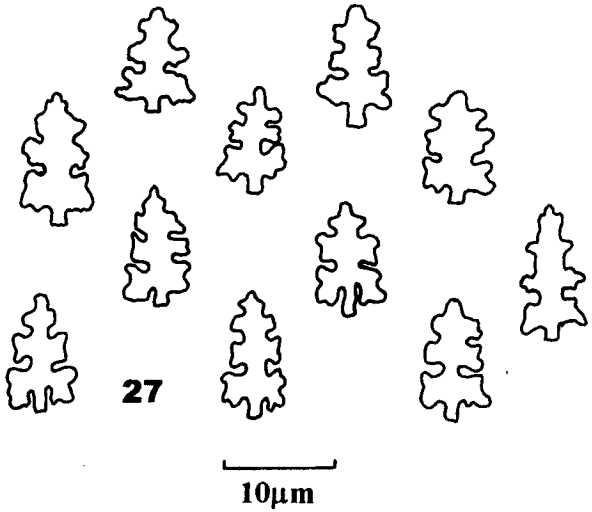
27
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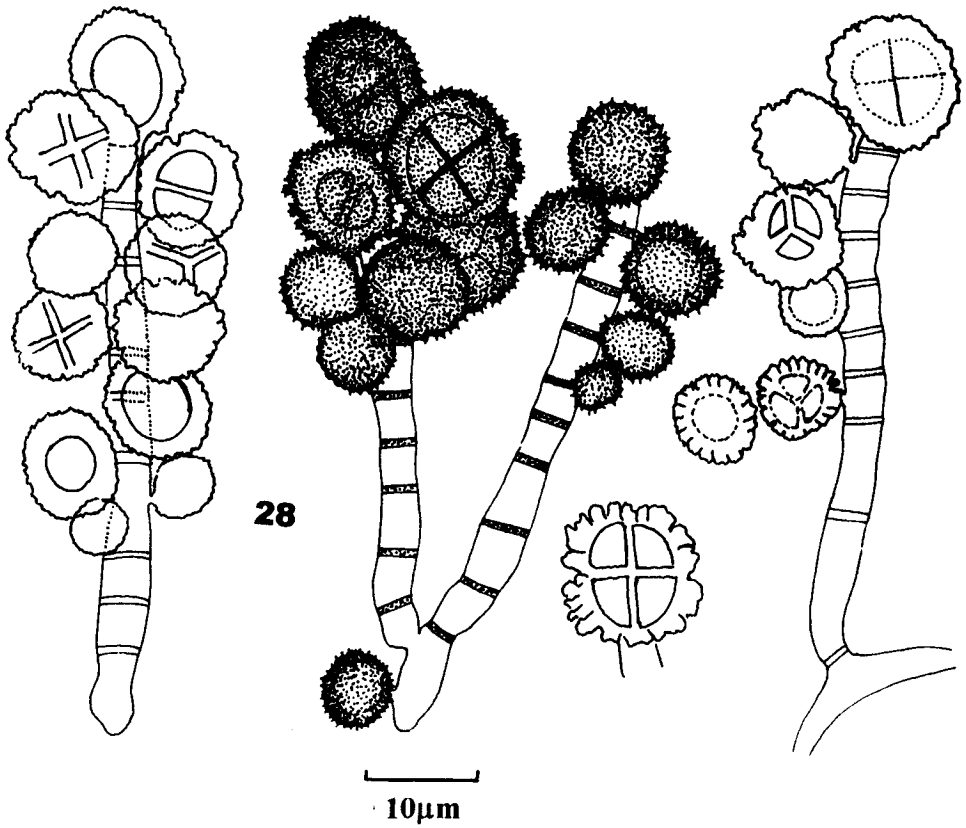
28
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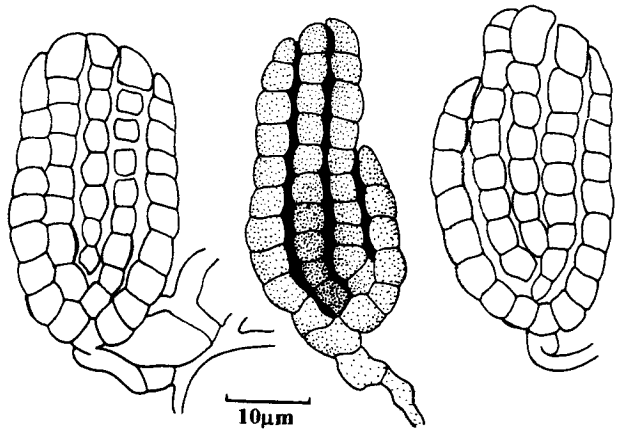

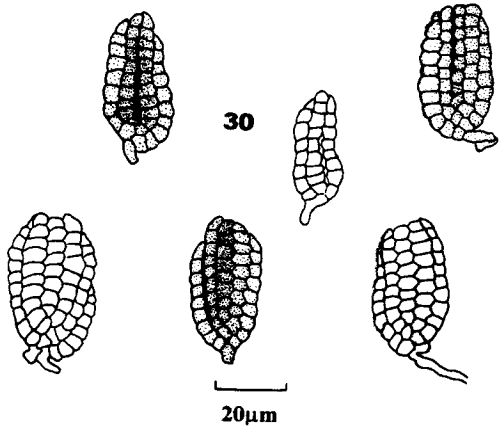

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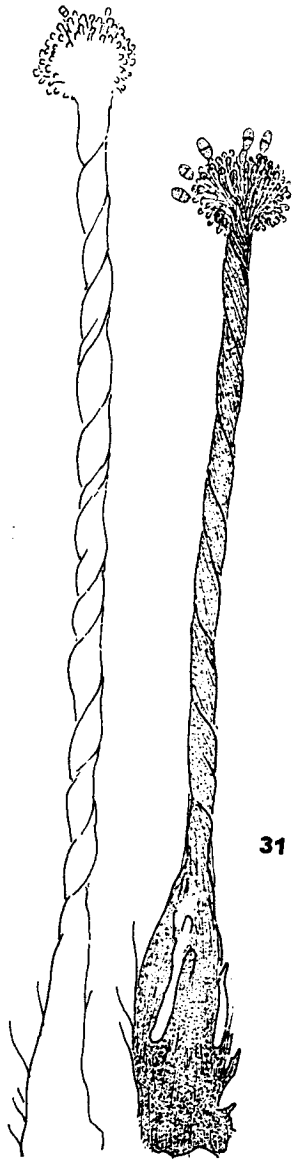

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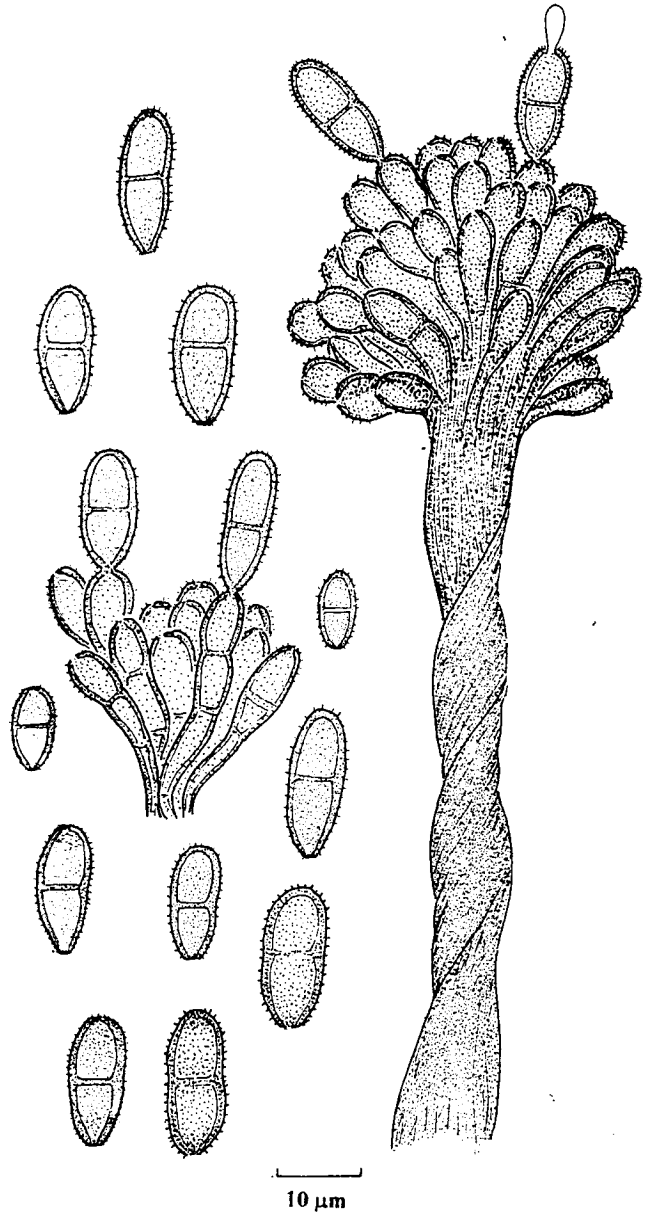

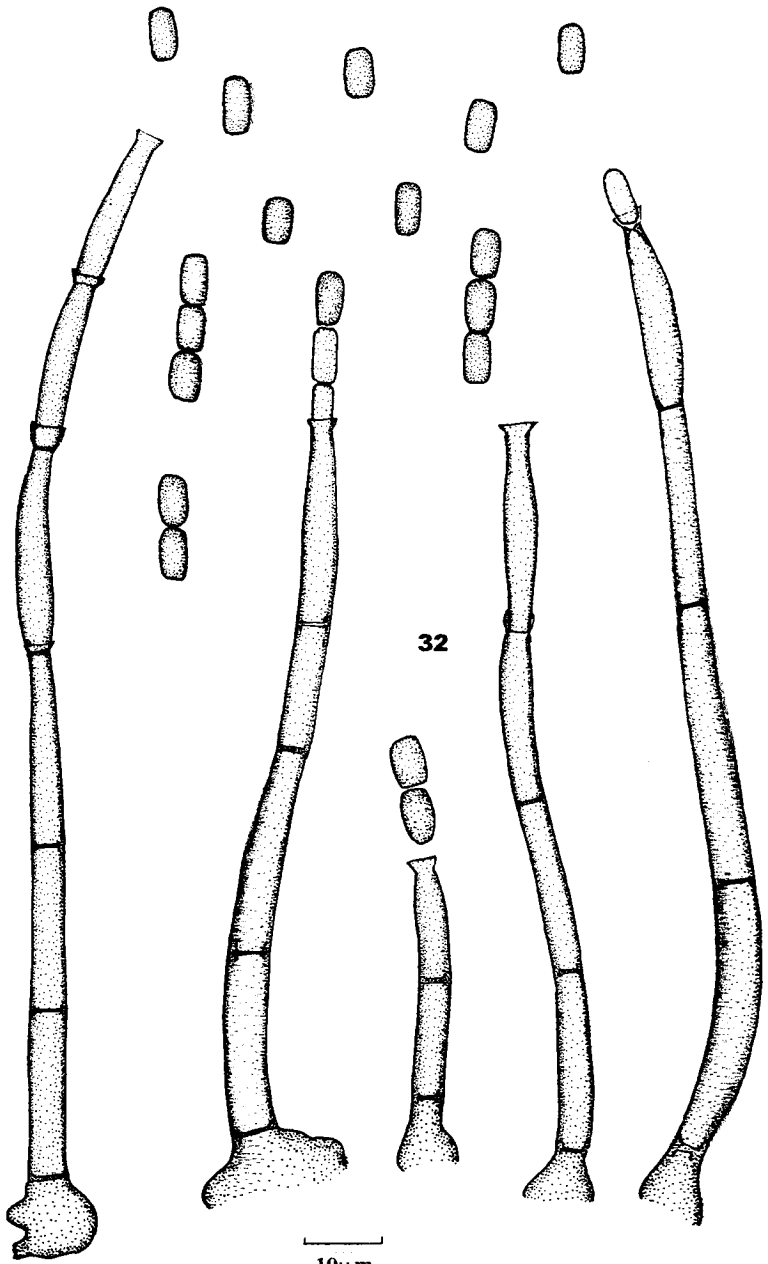
32
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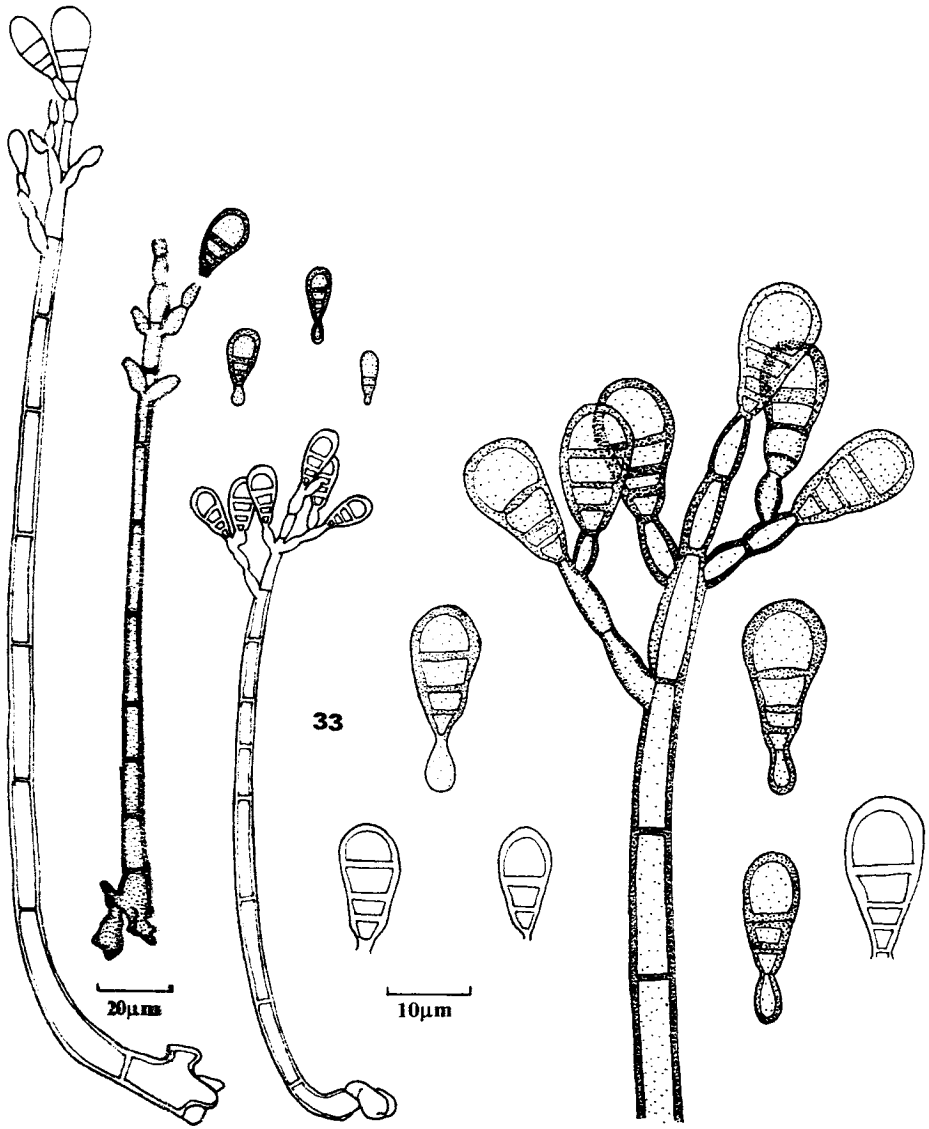
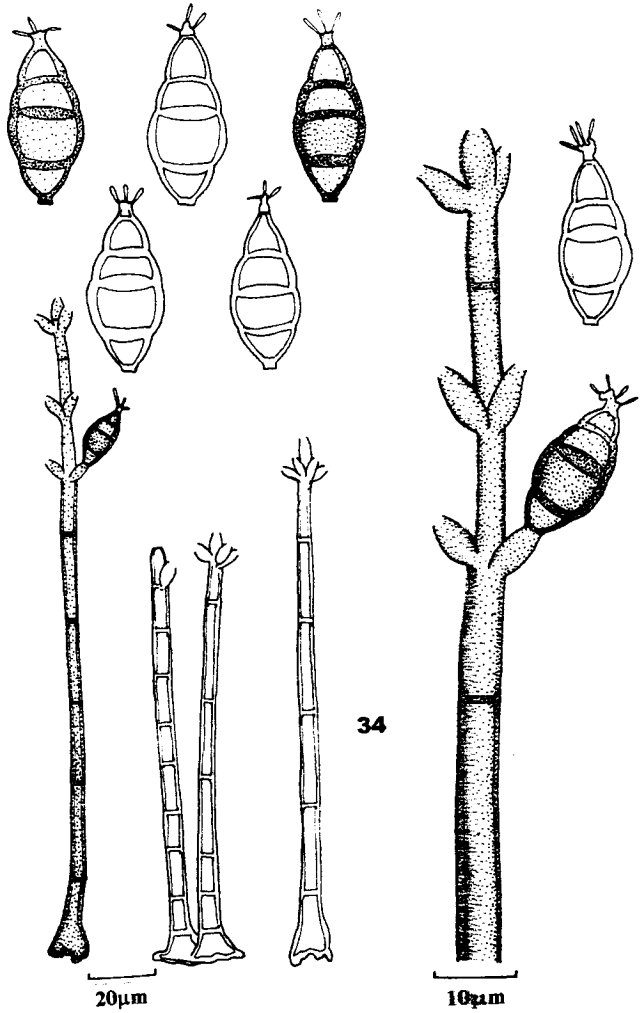
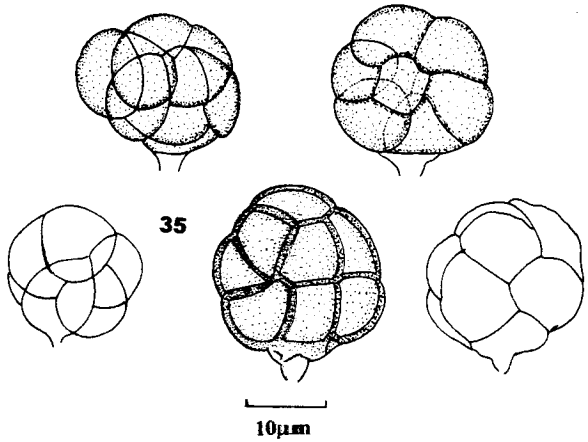

33
20µm
10µm



34



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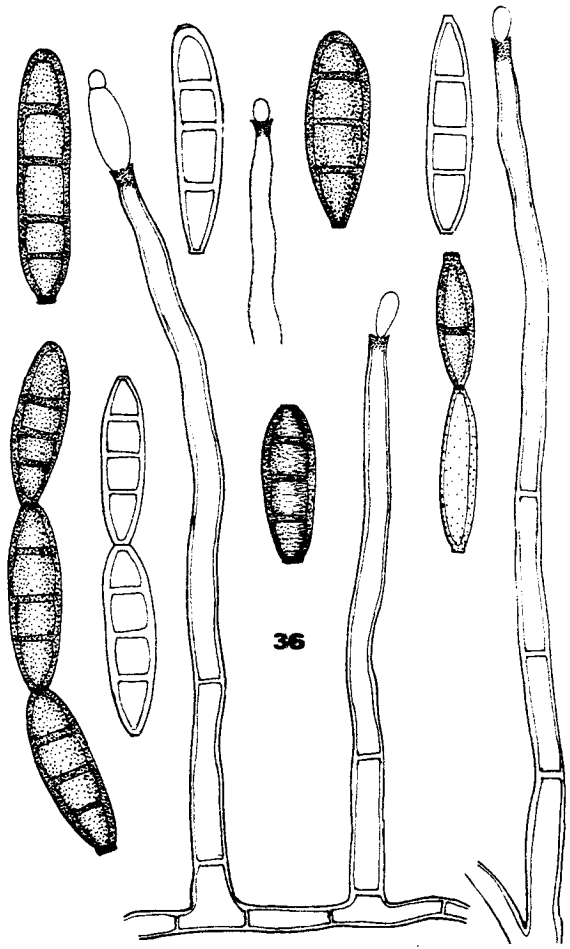

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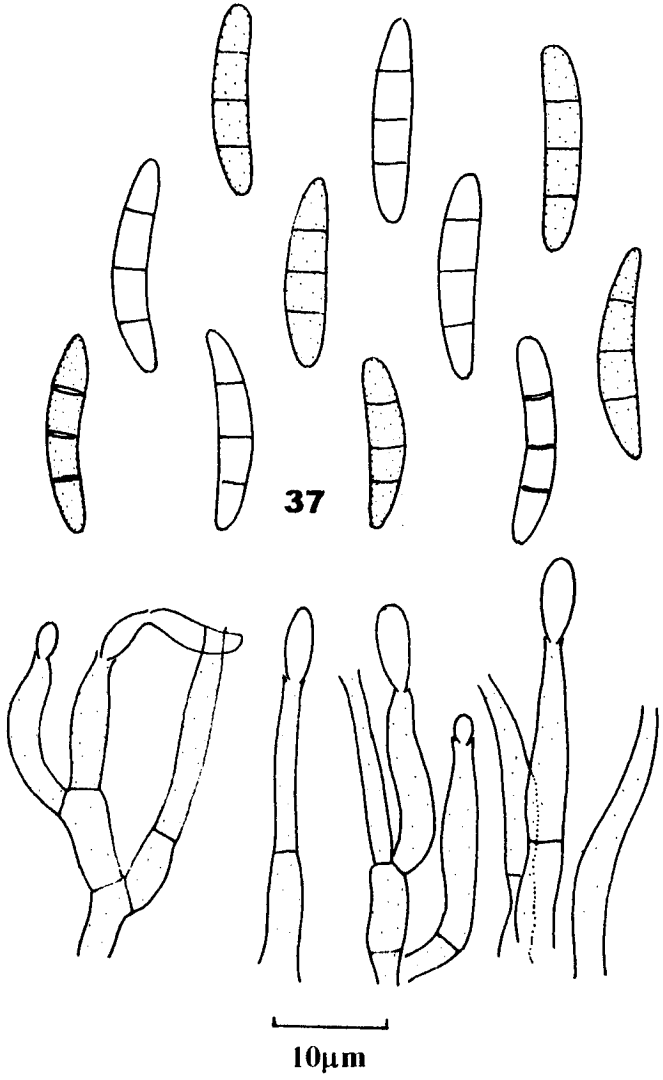
37
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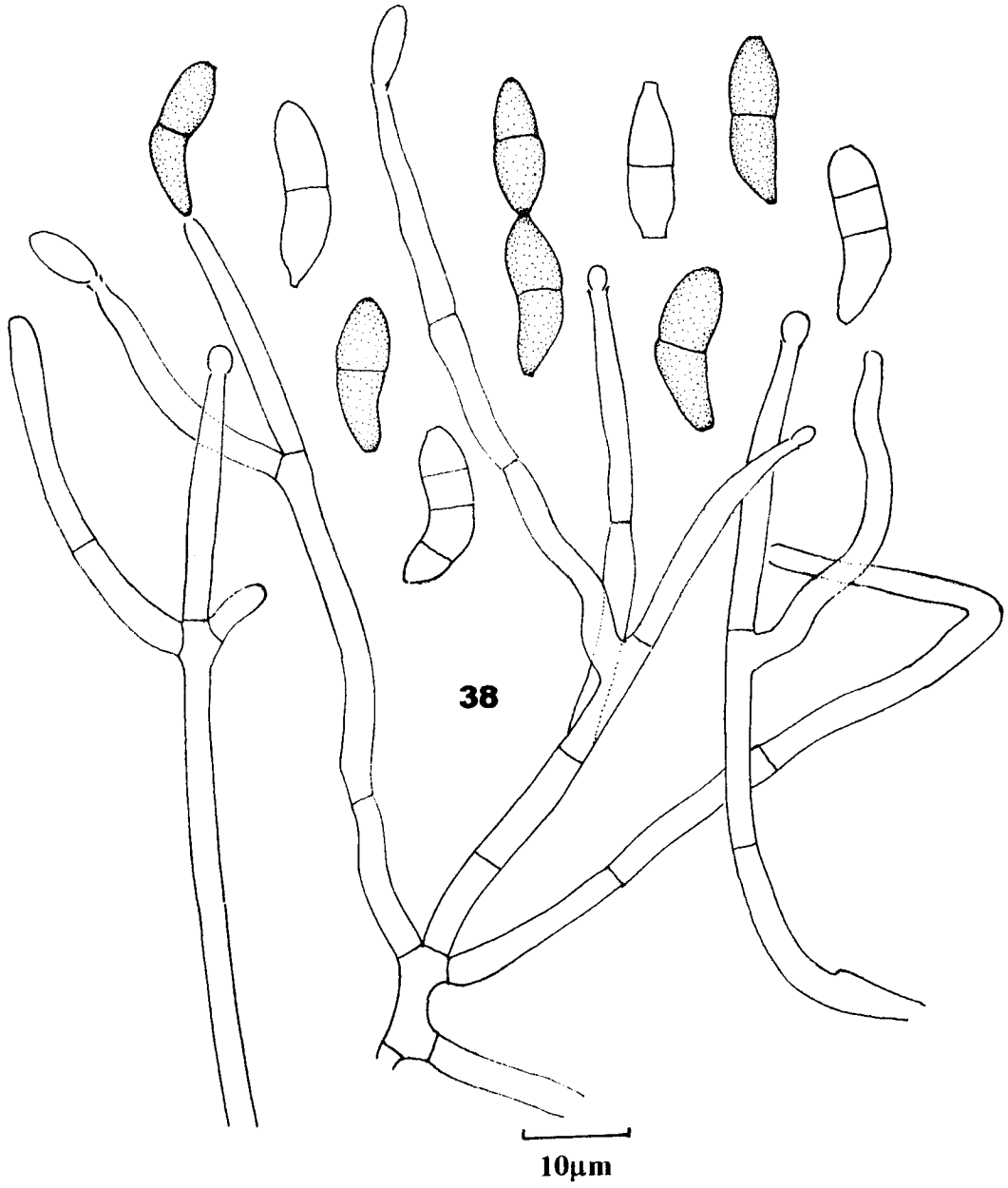
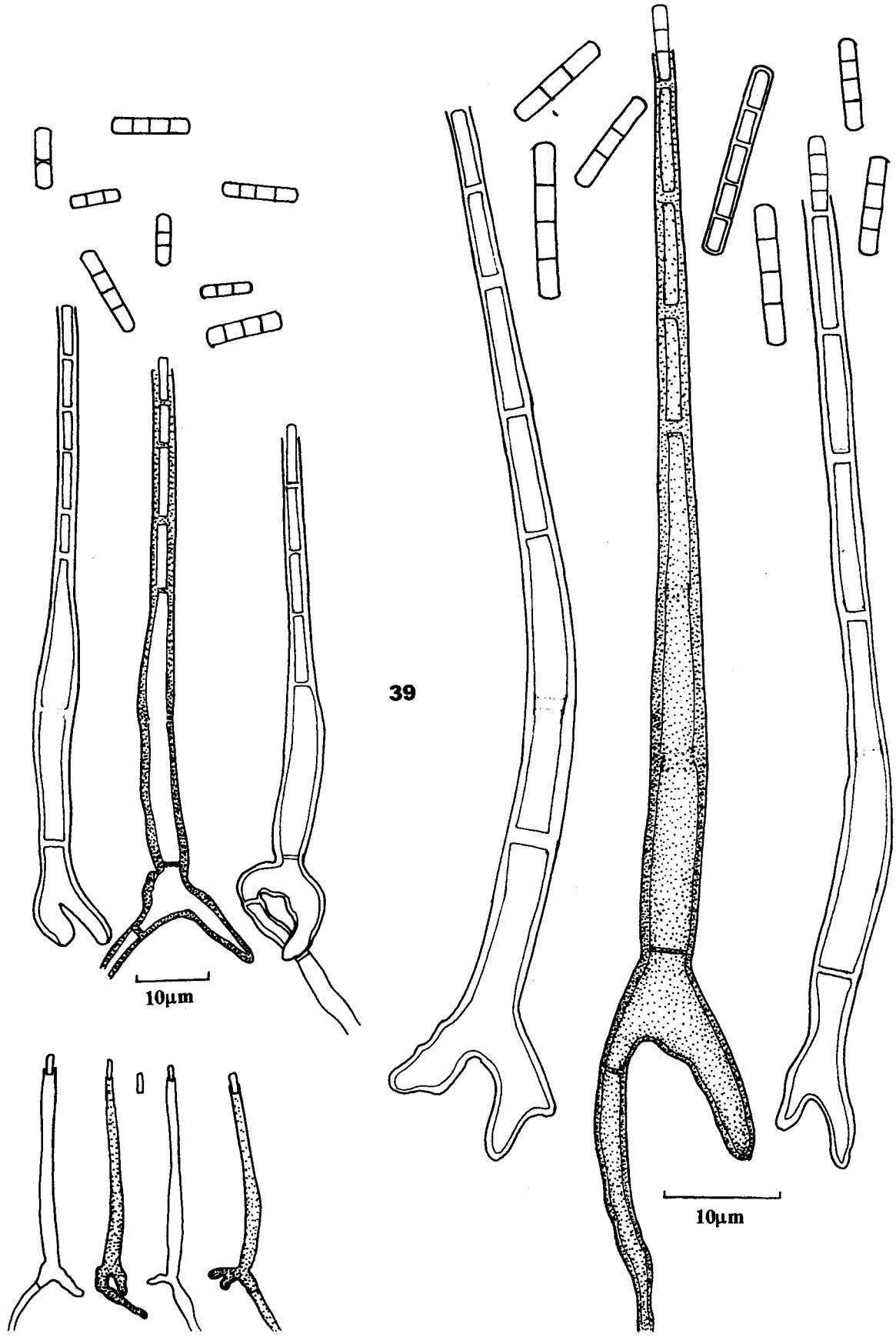
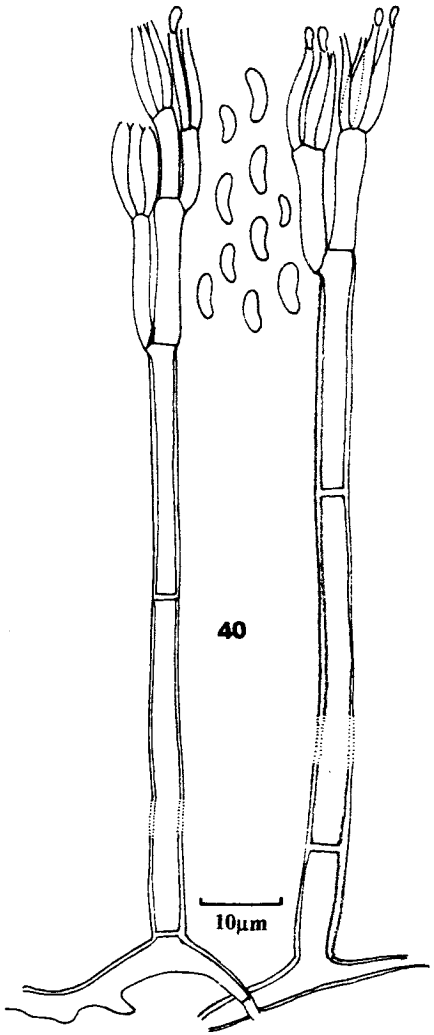

38
10µm



39


40
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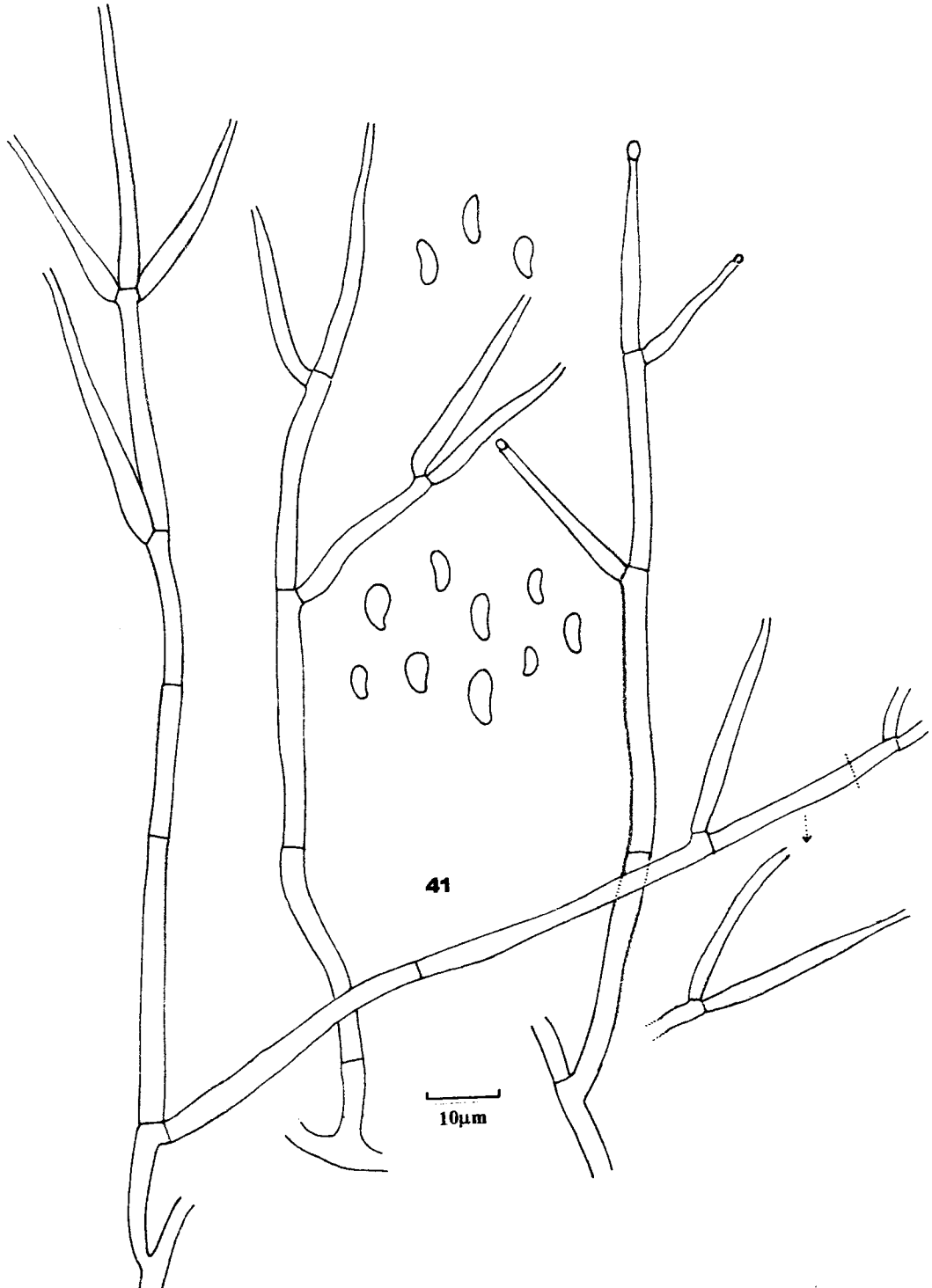
41
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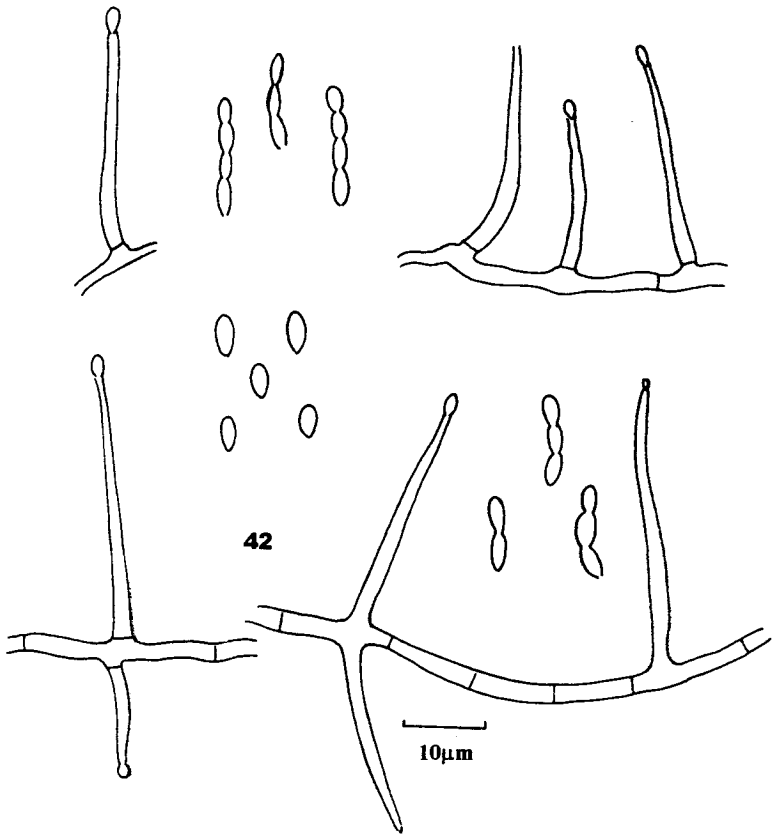
42
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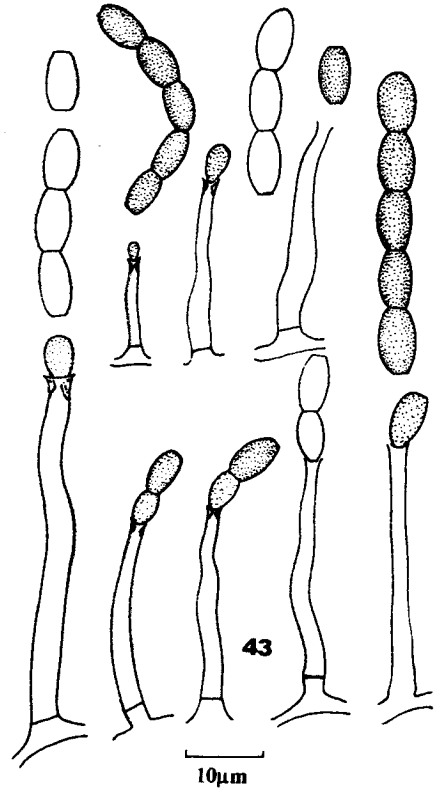
43
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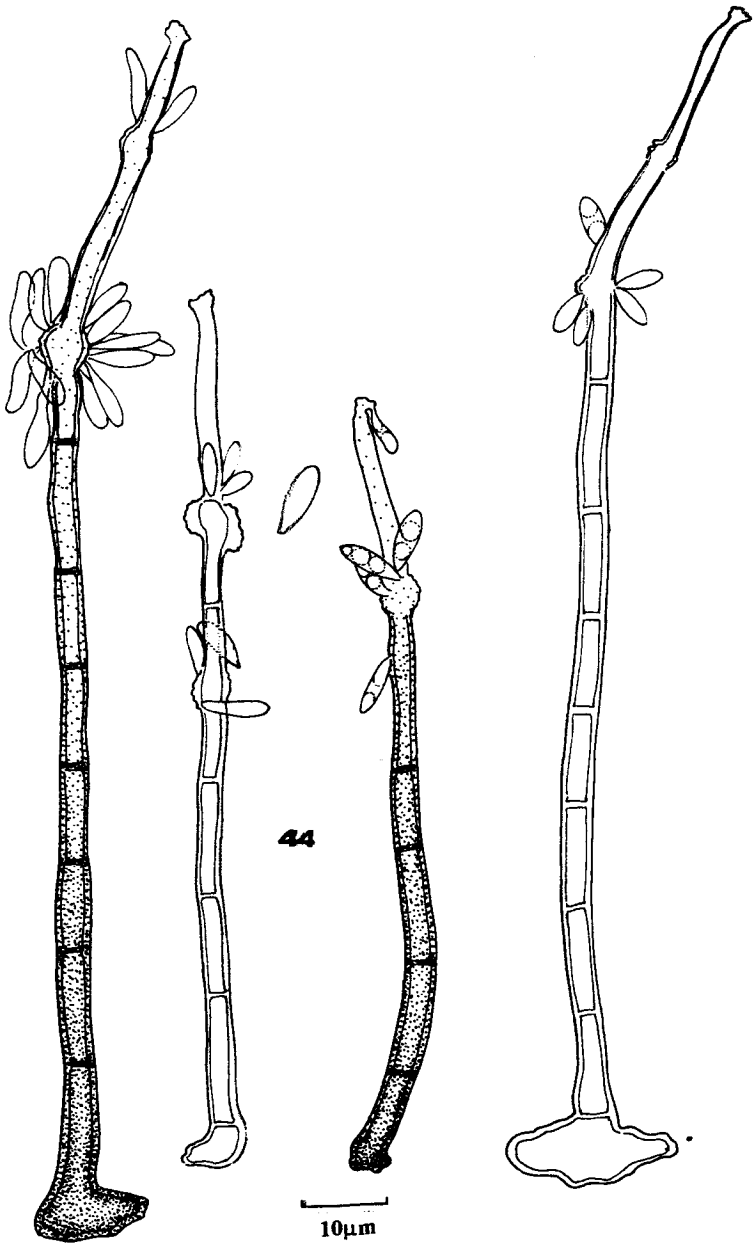
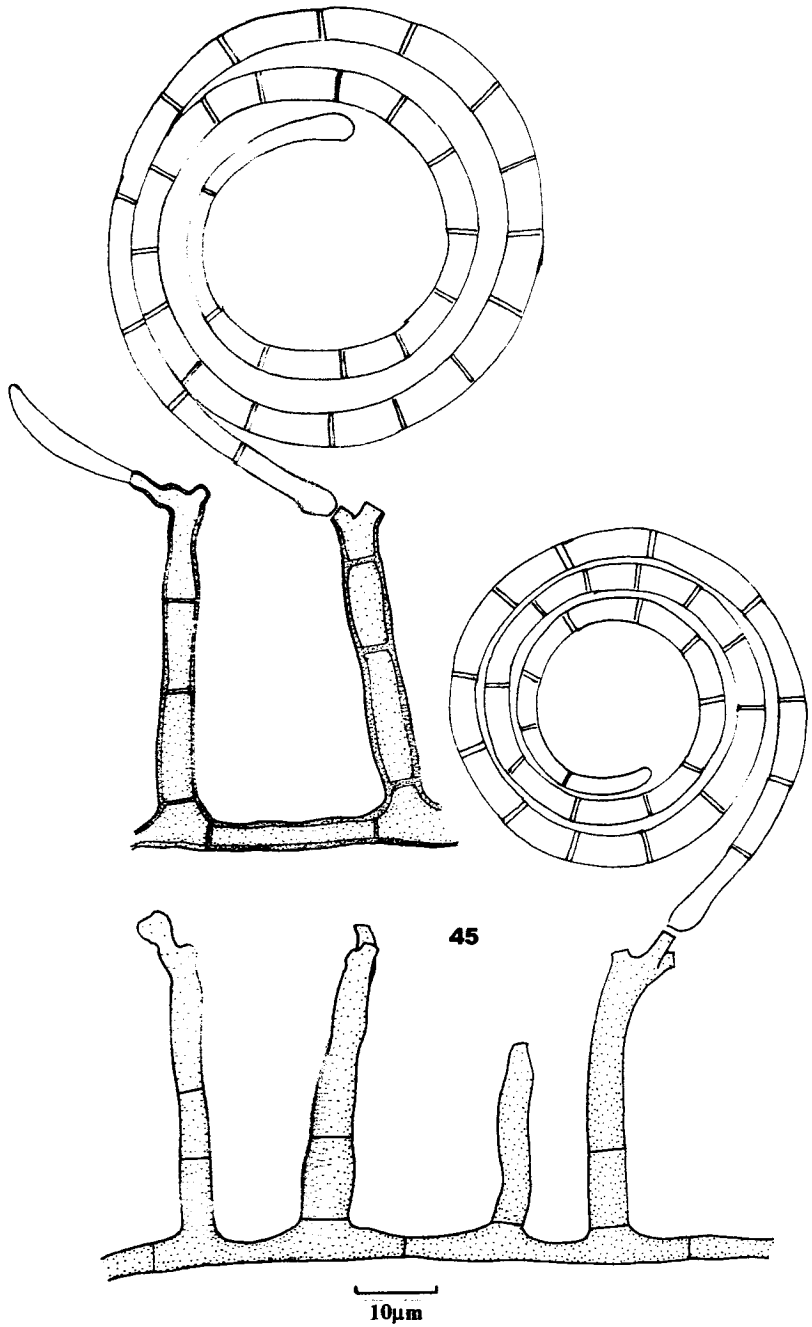


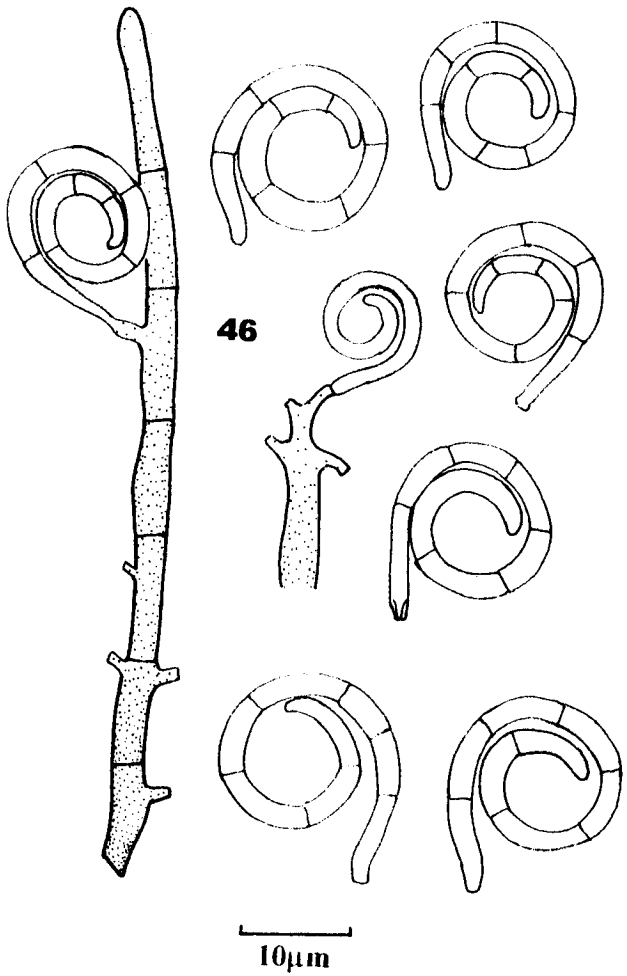
44

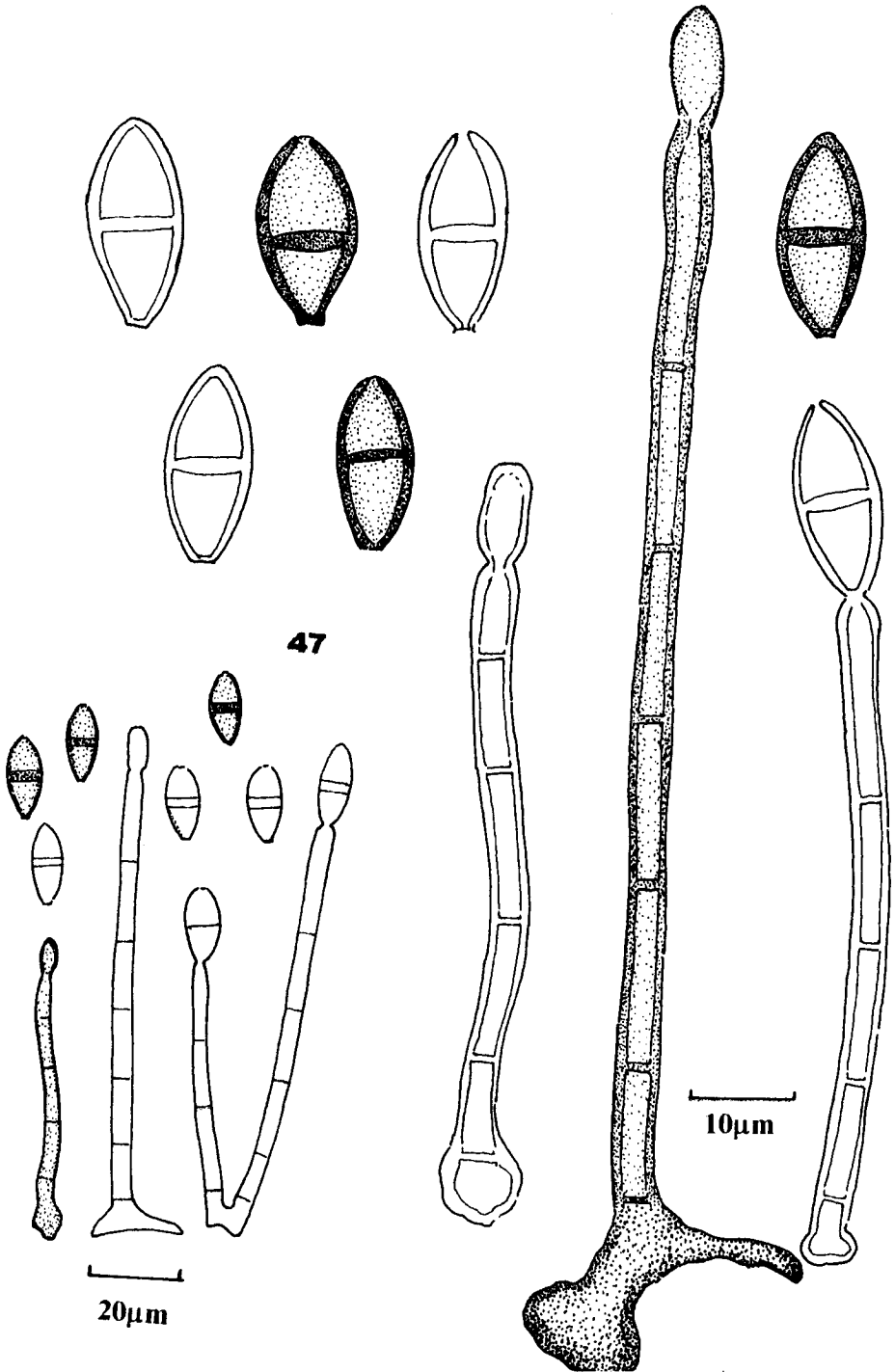
10µm

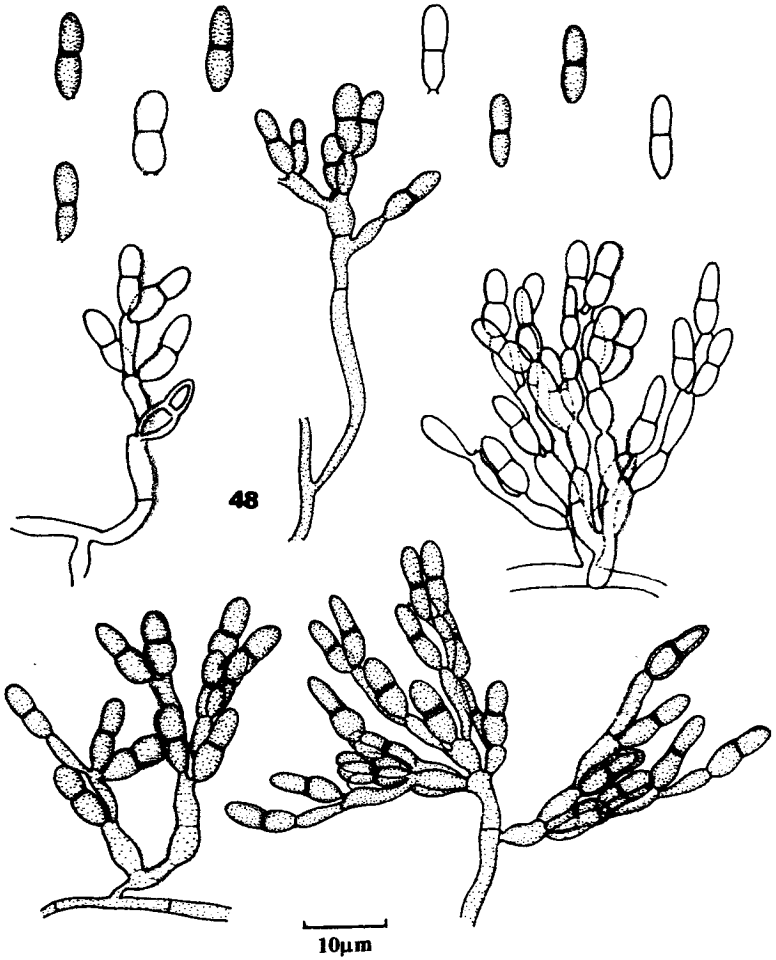


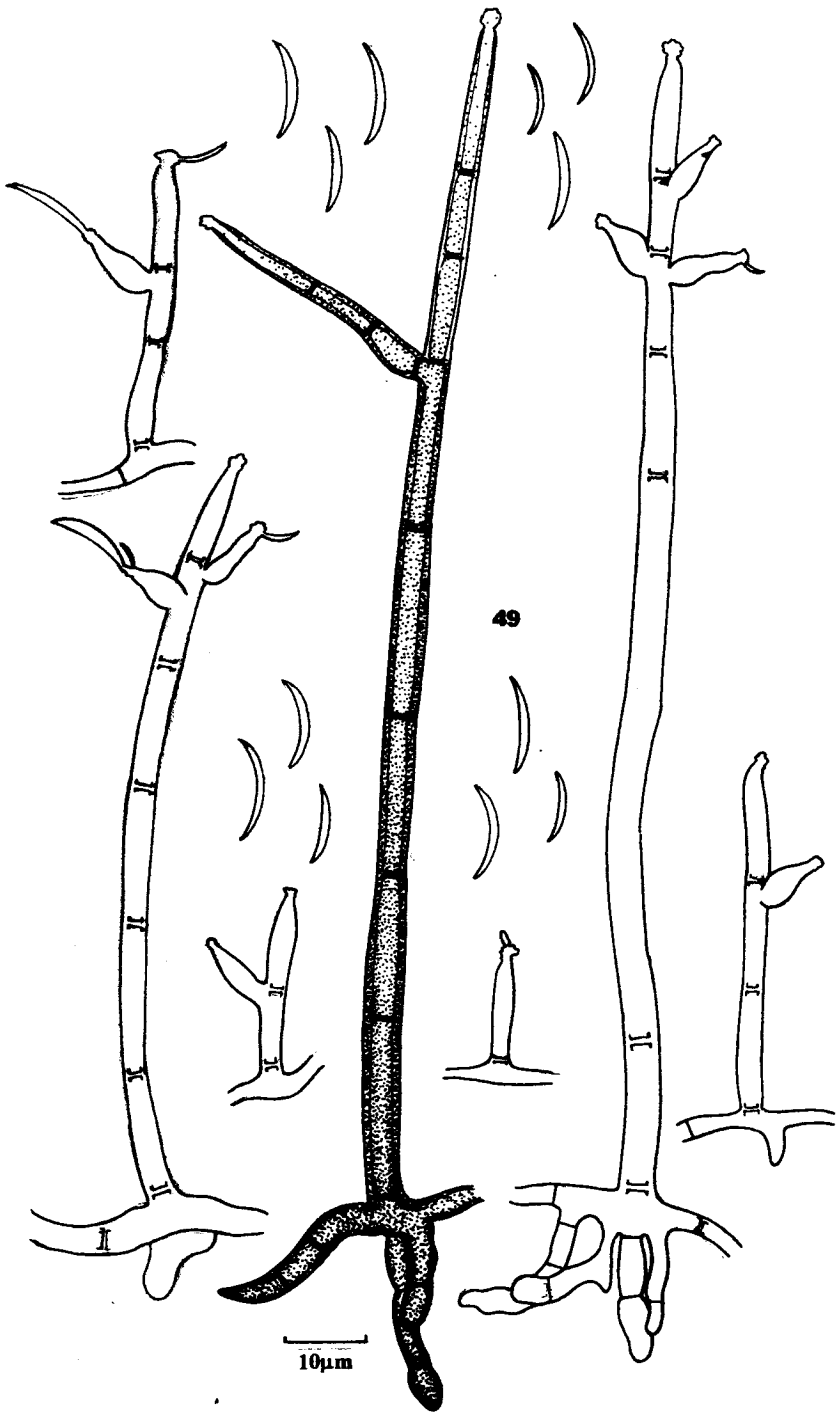
45

10µm


46
10µm


47
20µm
10µm


48
10µm


49
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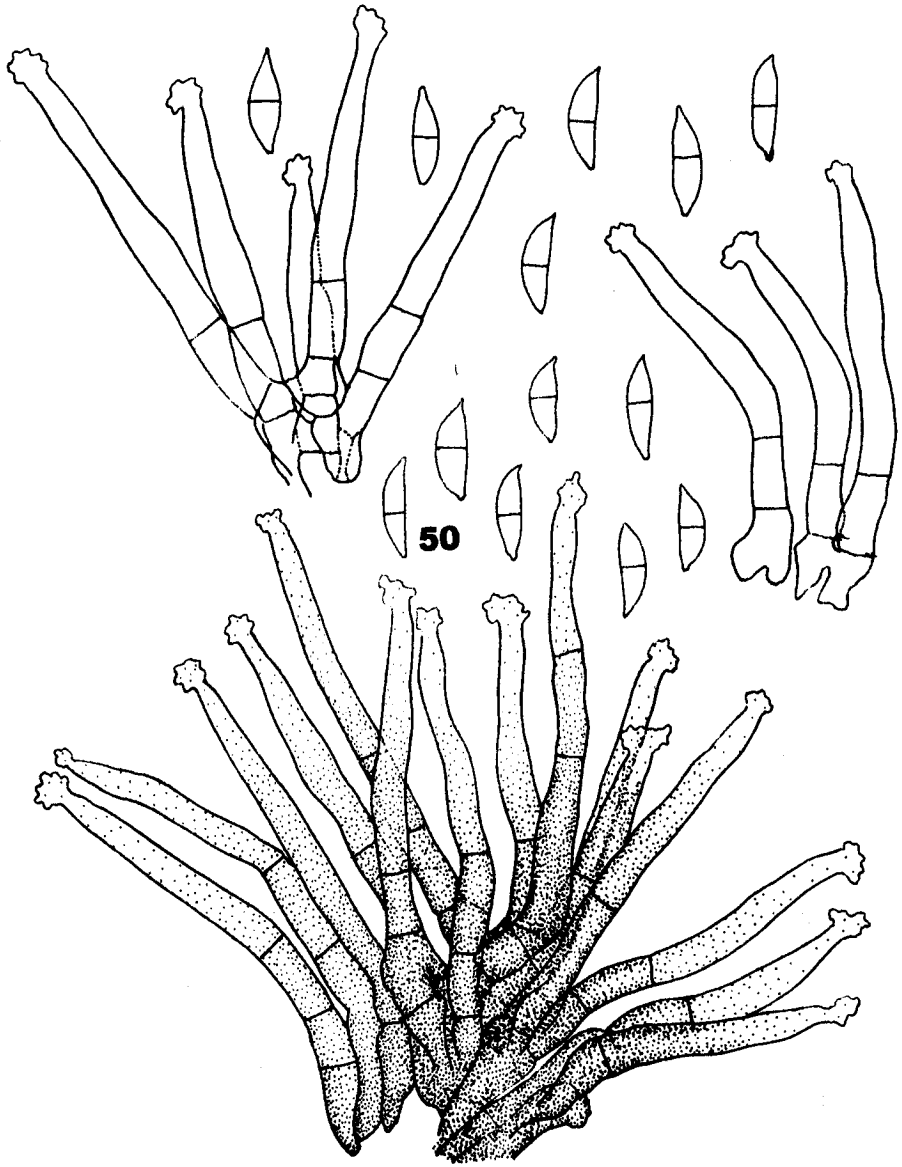
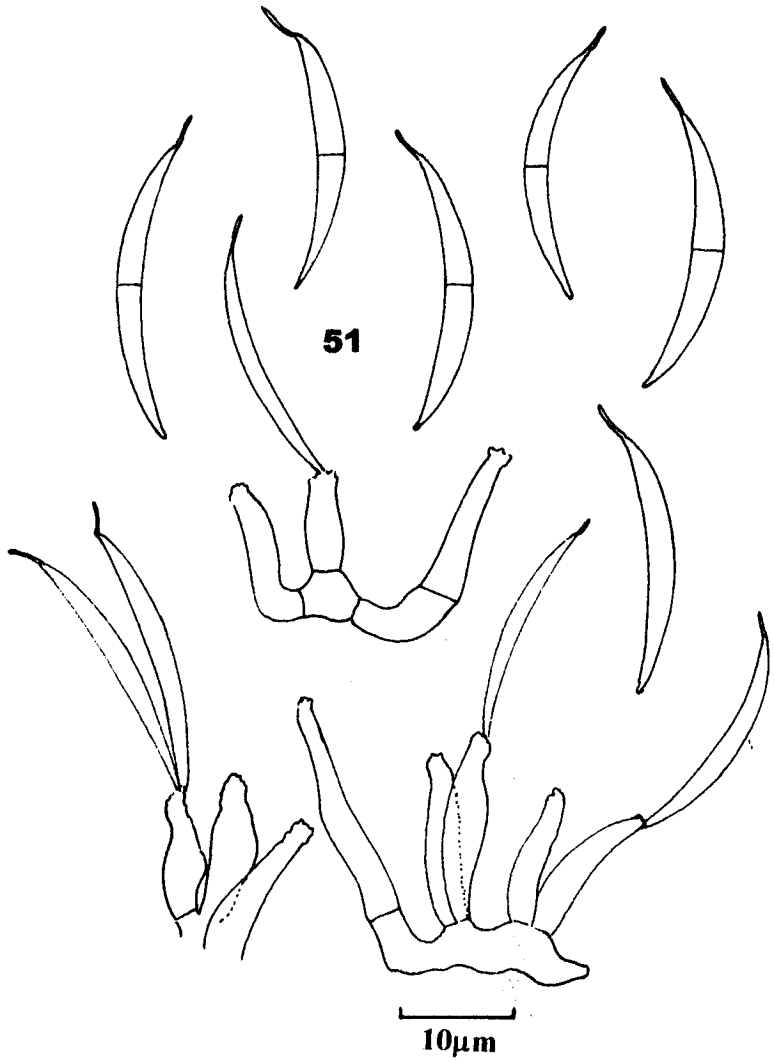

50
10µm


51
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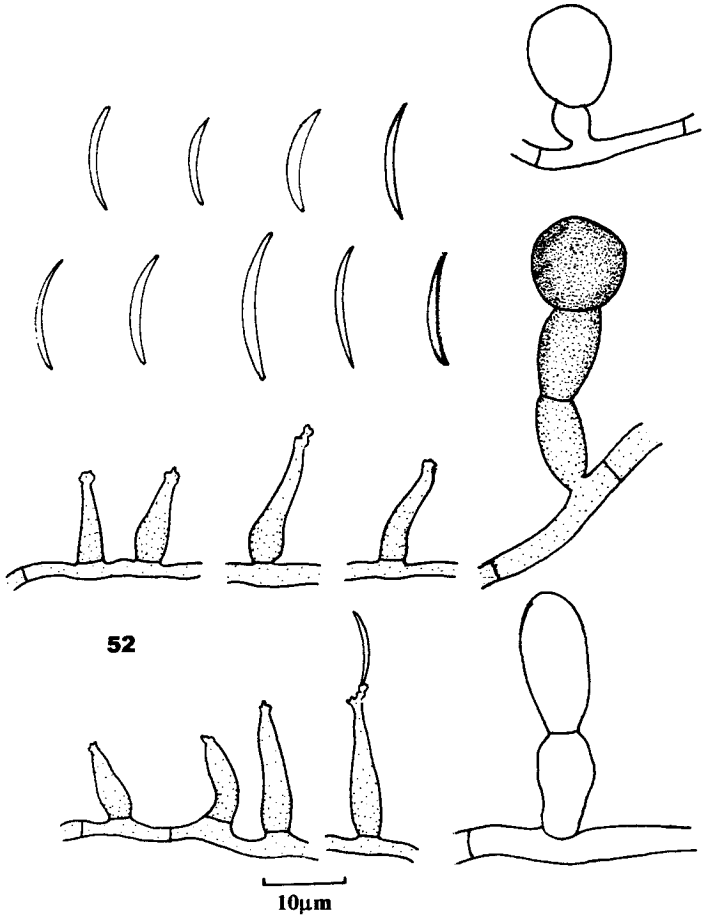
52
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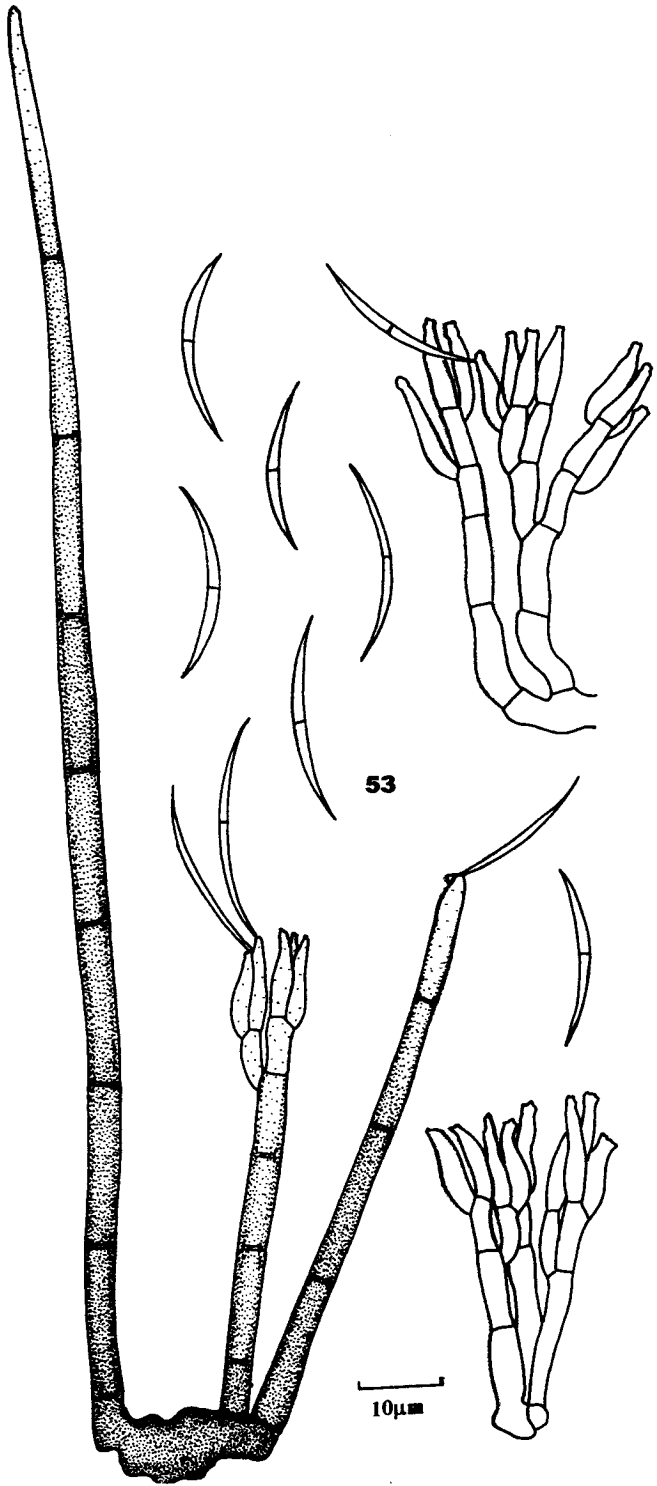
53
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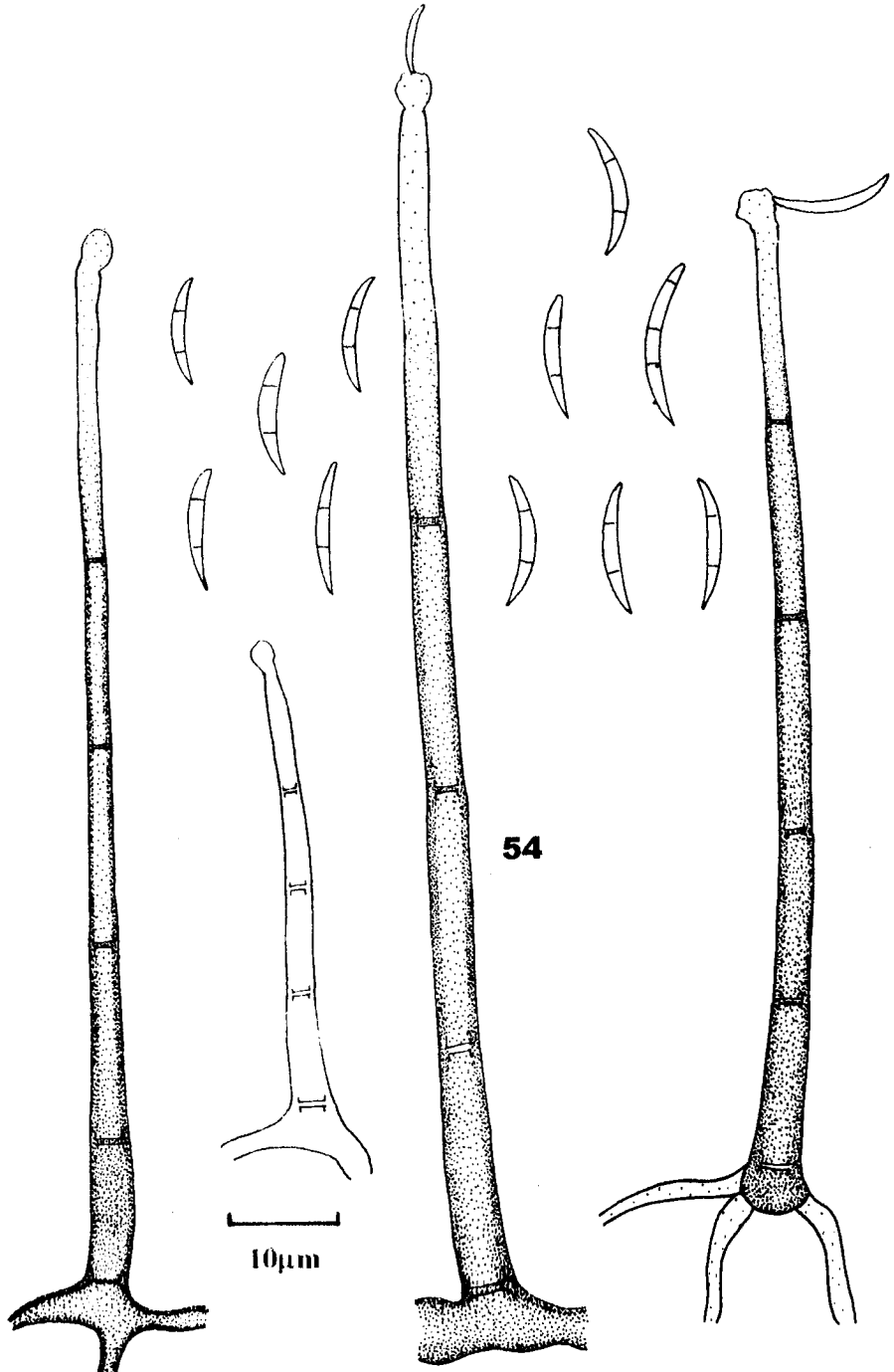
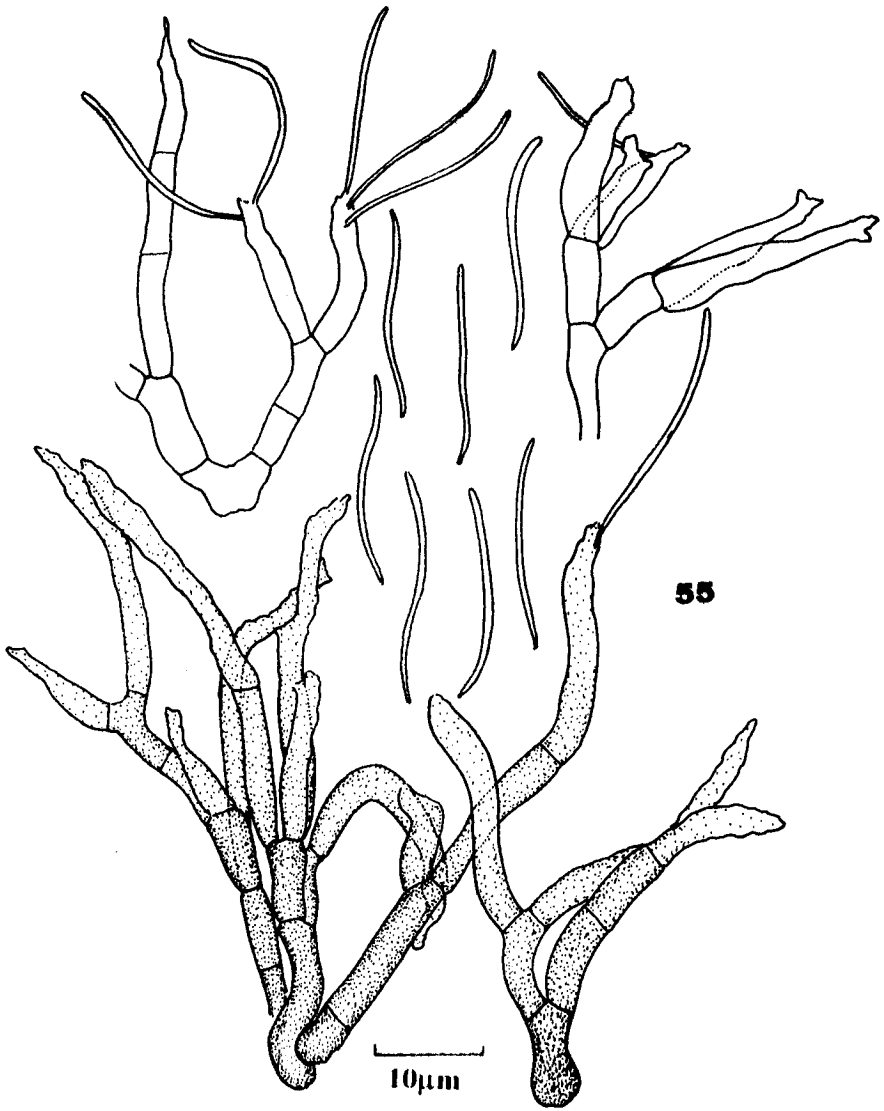
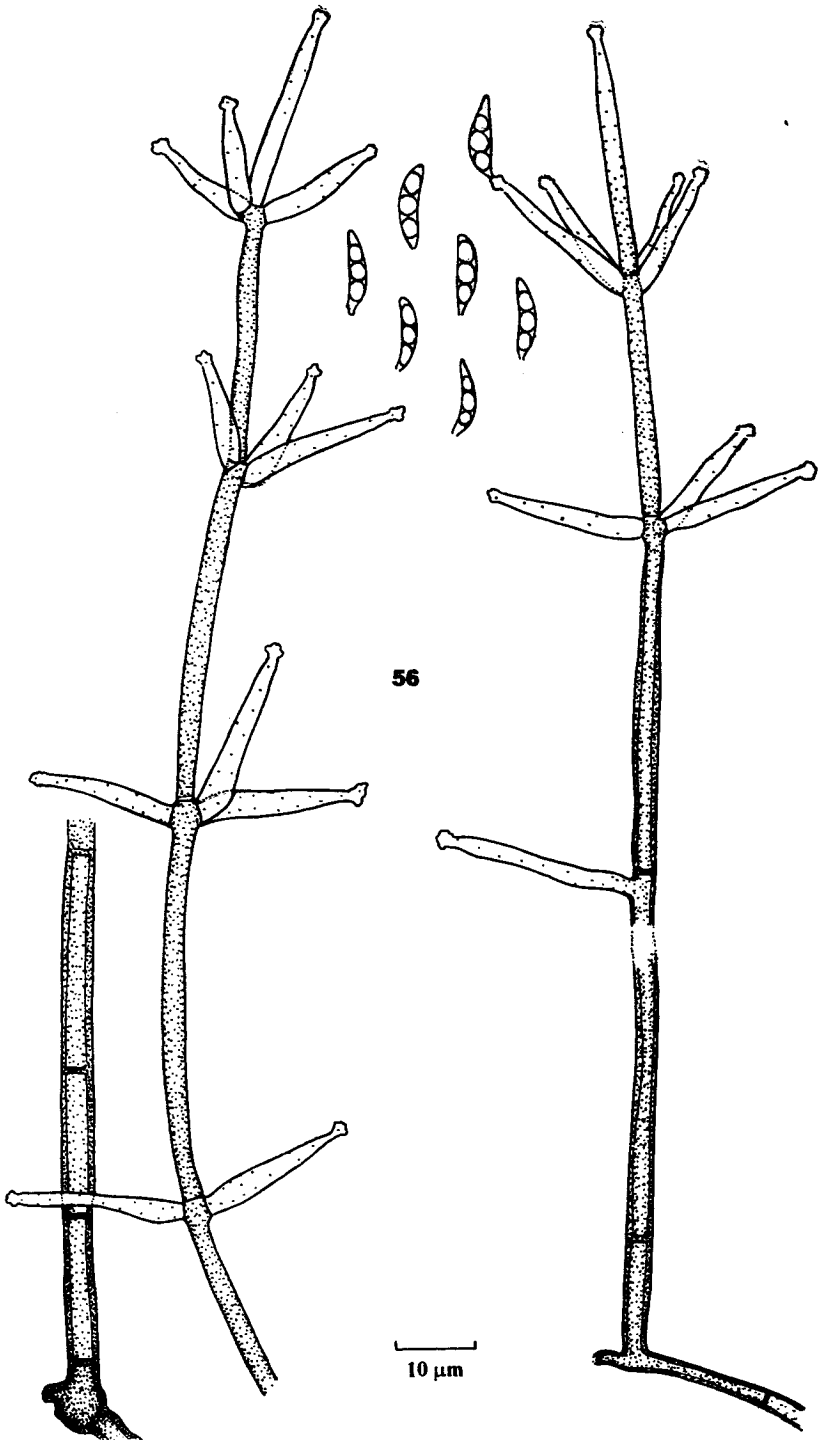
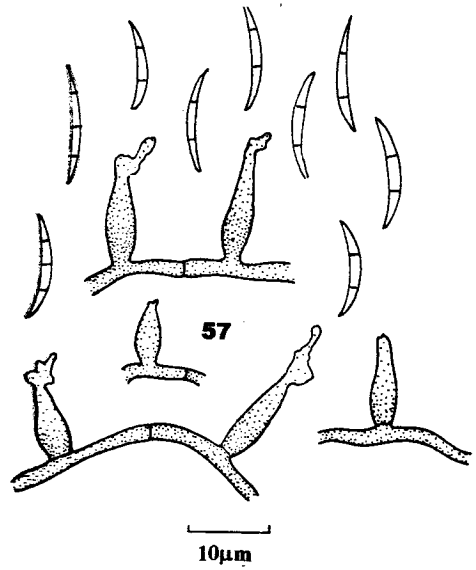


54



55


56
10 µm


57
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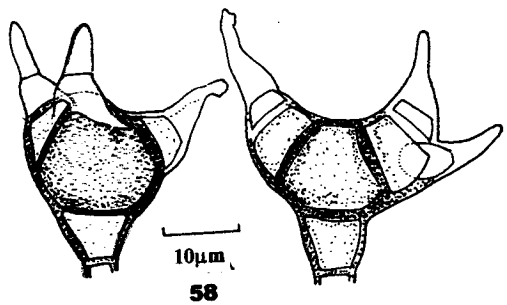
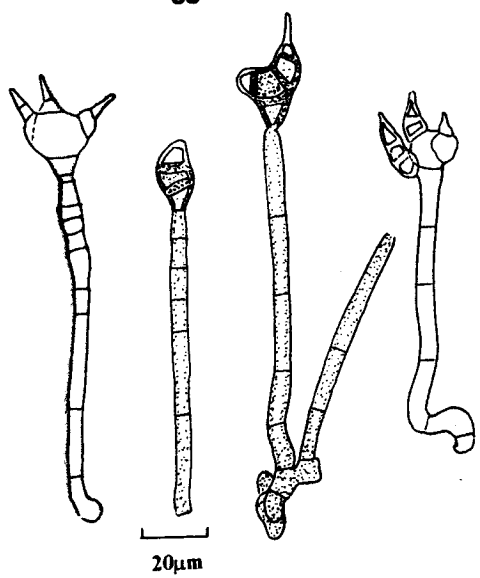
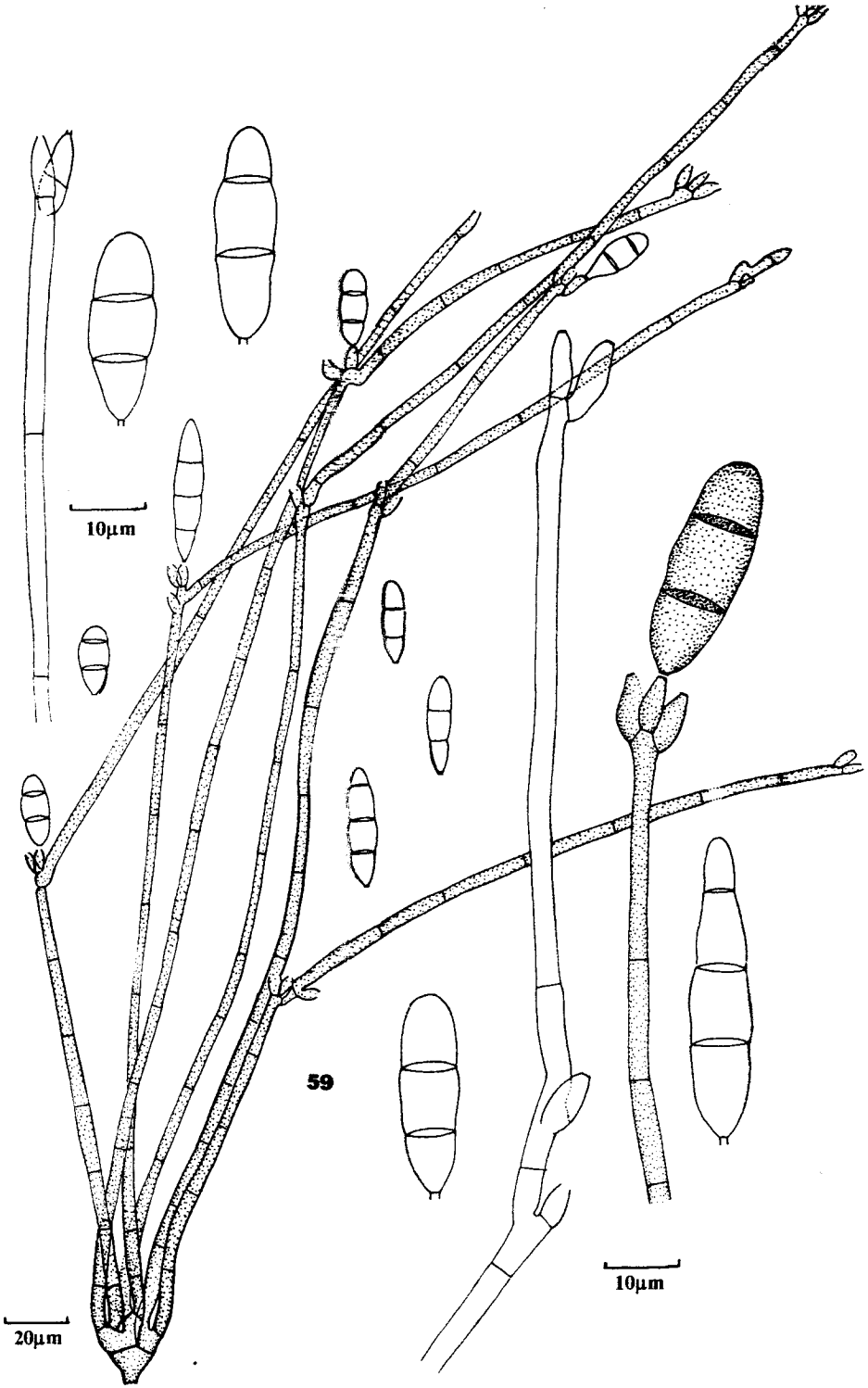
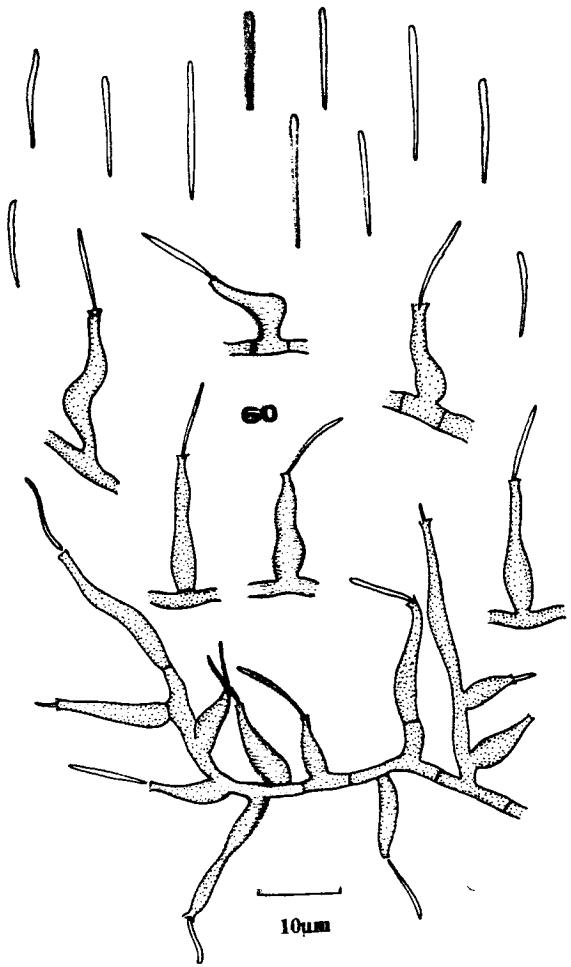

10µm
58


20µm


10µm
59
20µm
10µm


60
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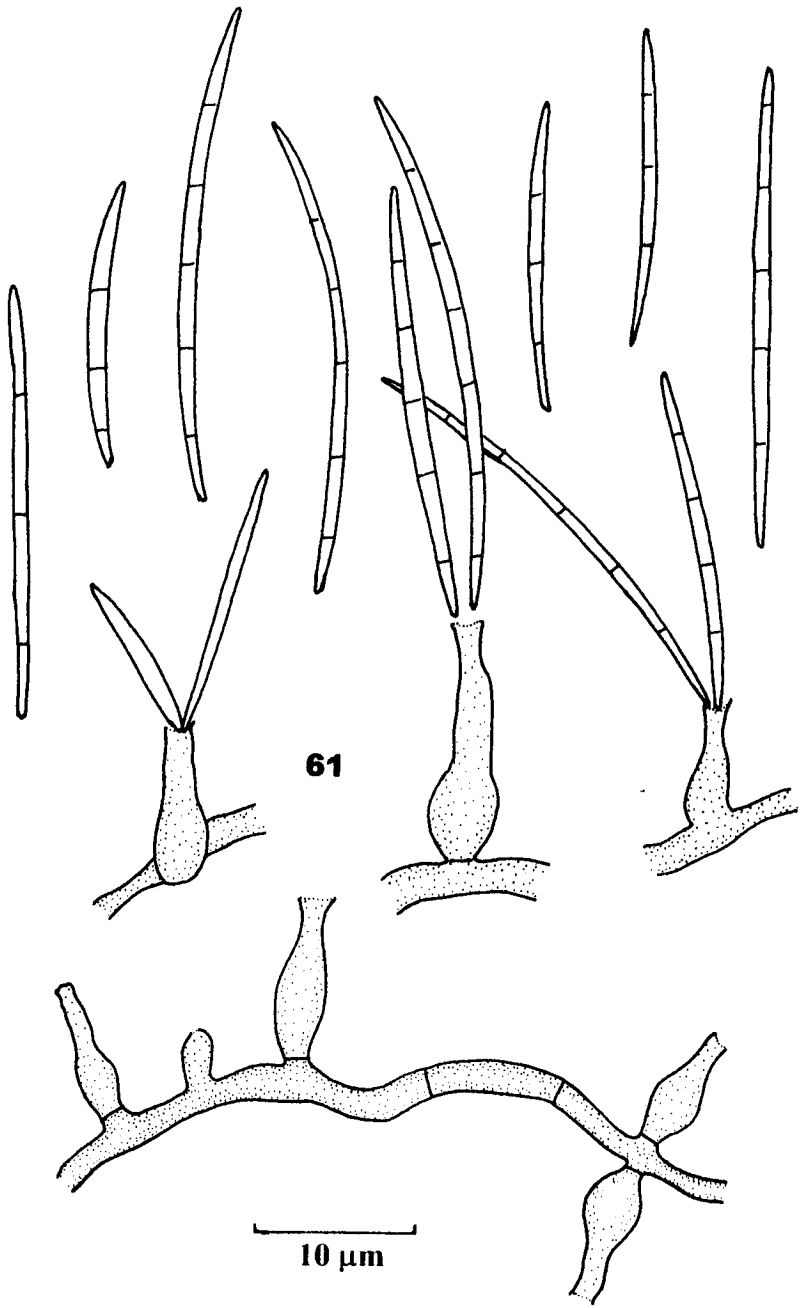
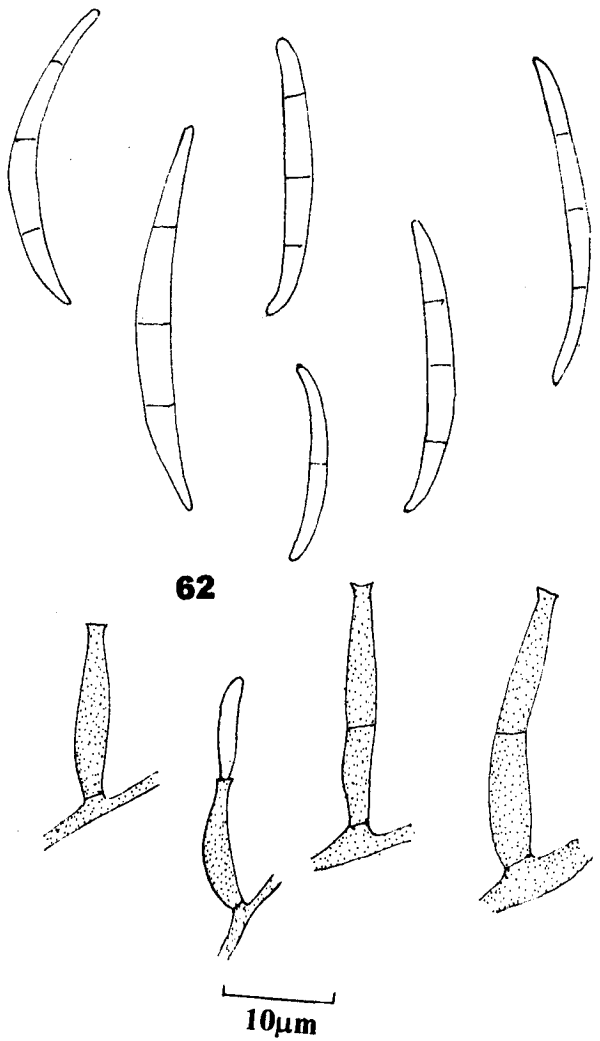

61
10 µm


62
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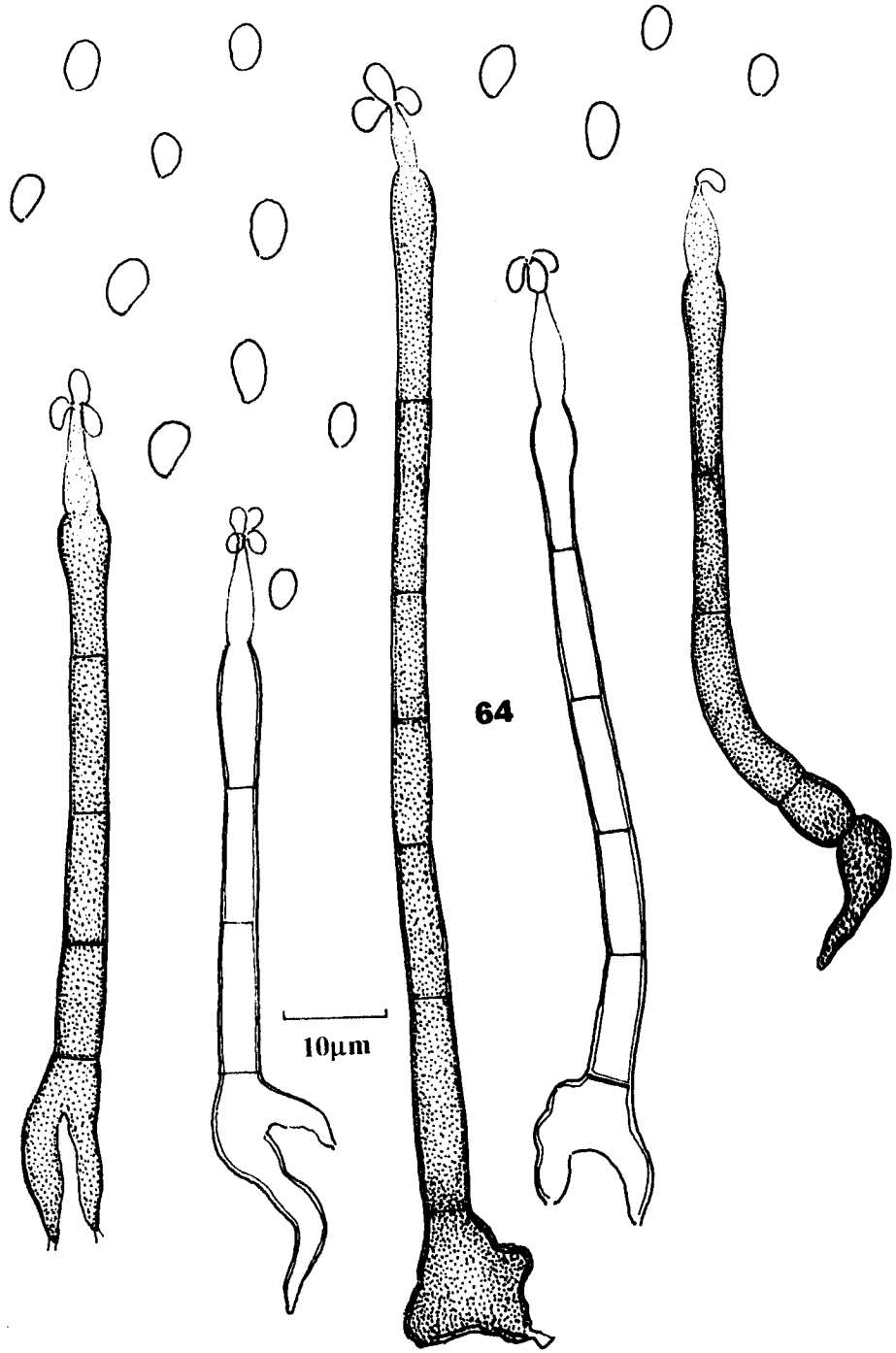
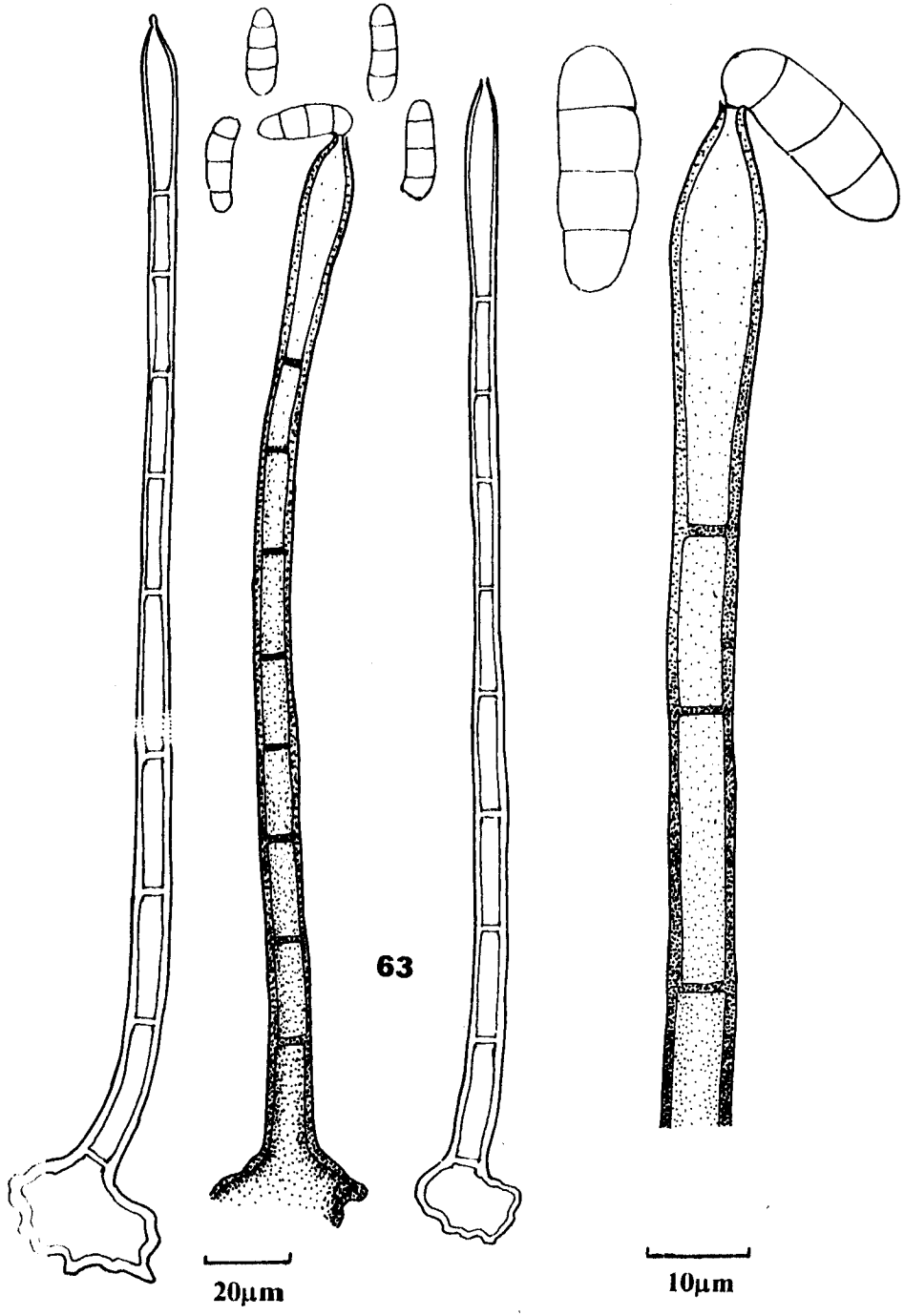
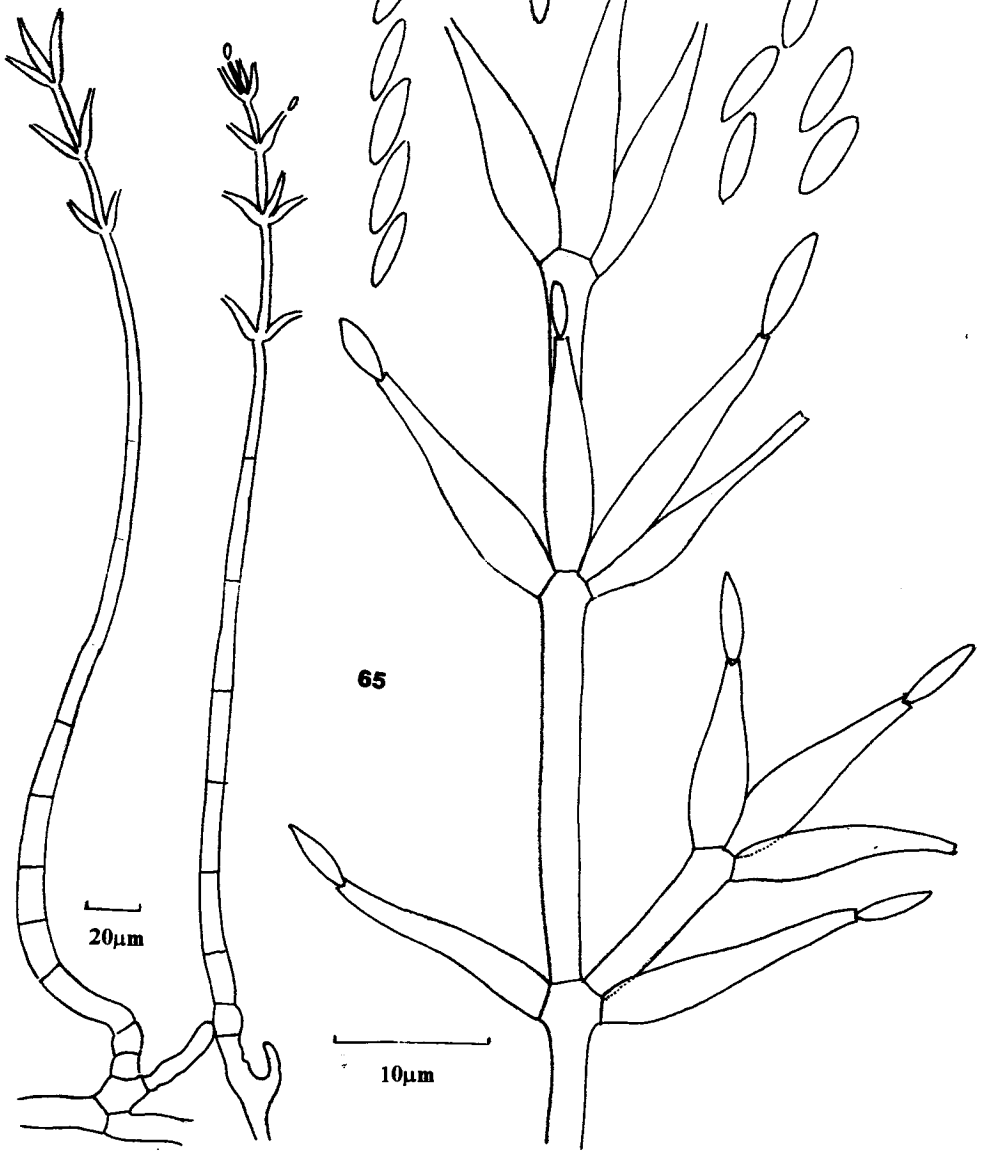

64
10µm


63
20µm
10µm



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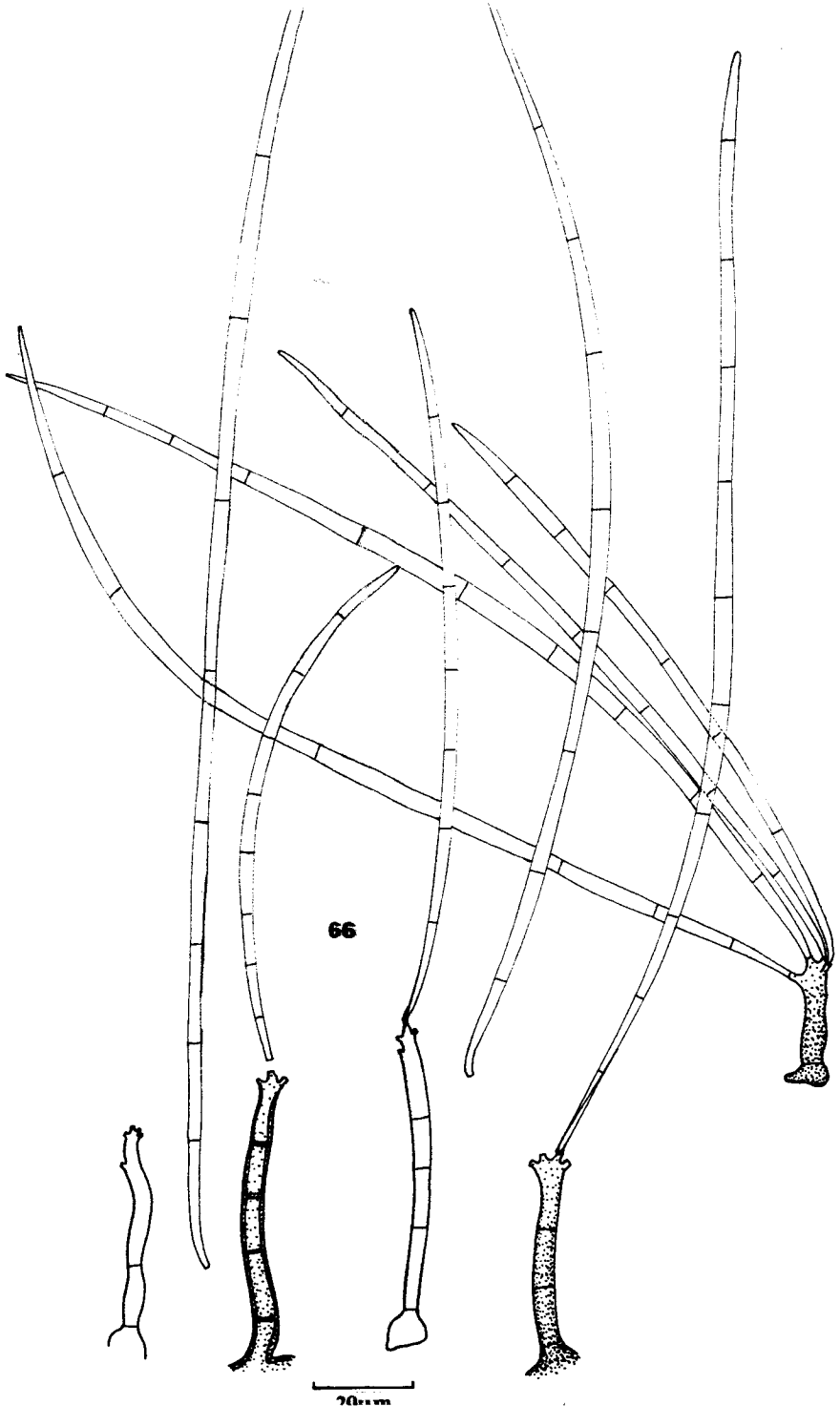
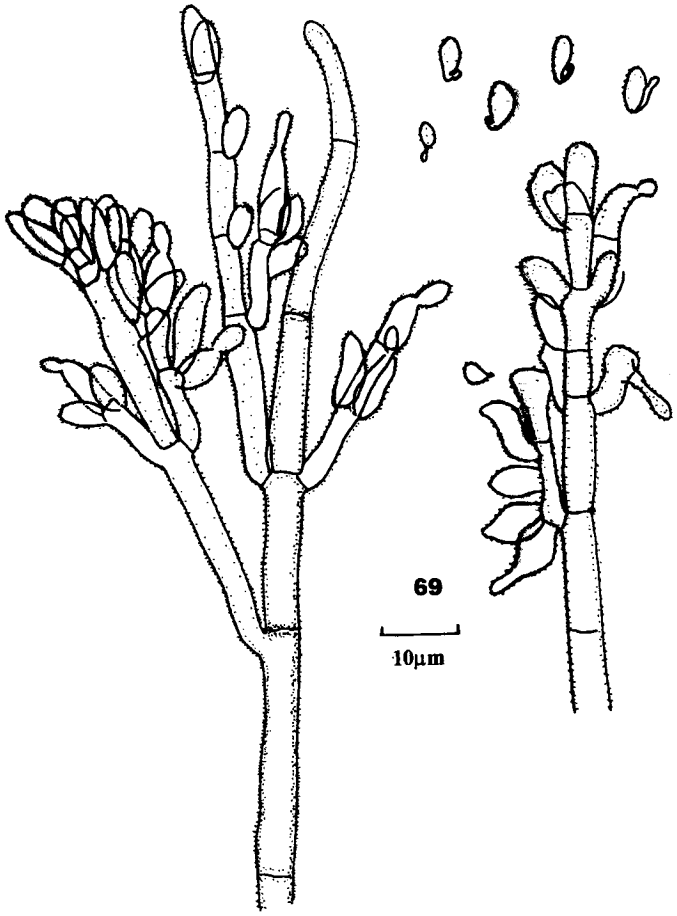
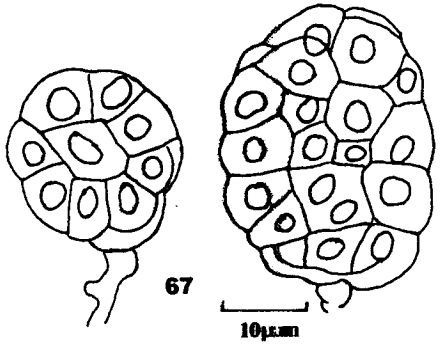
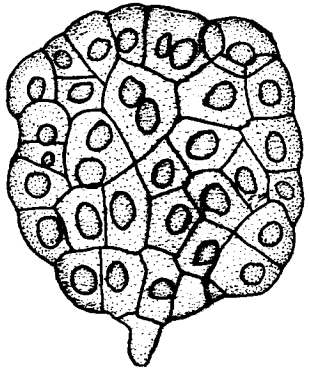
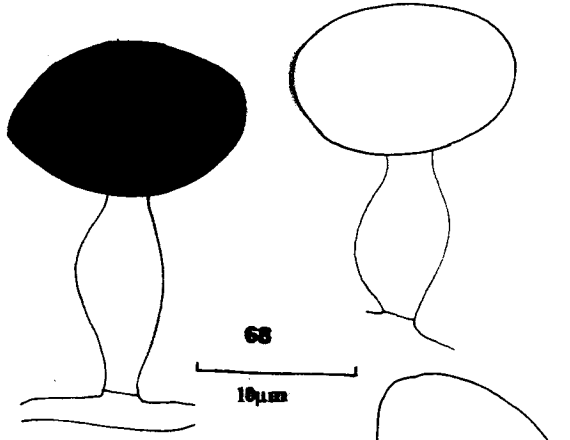


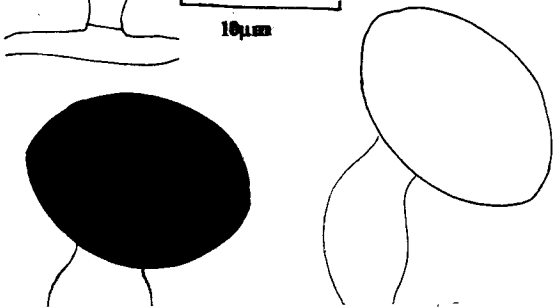
66

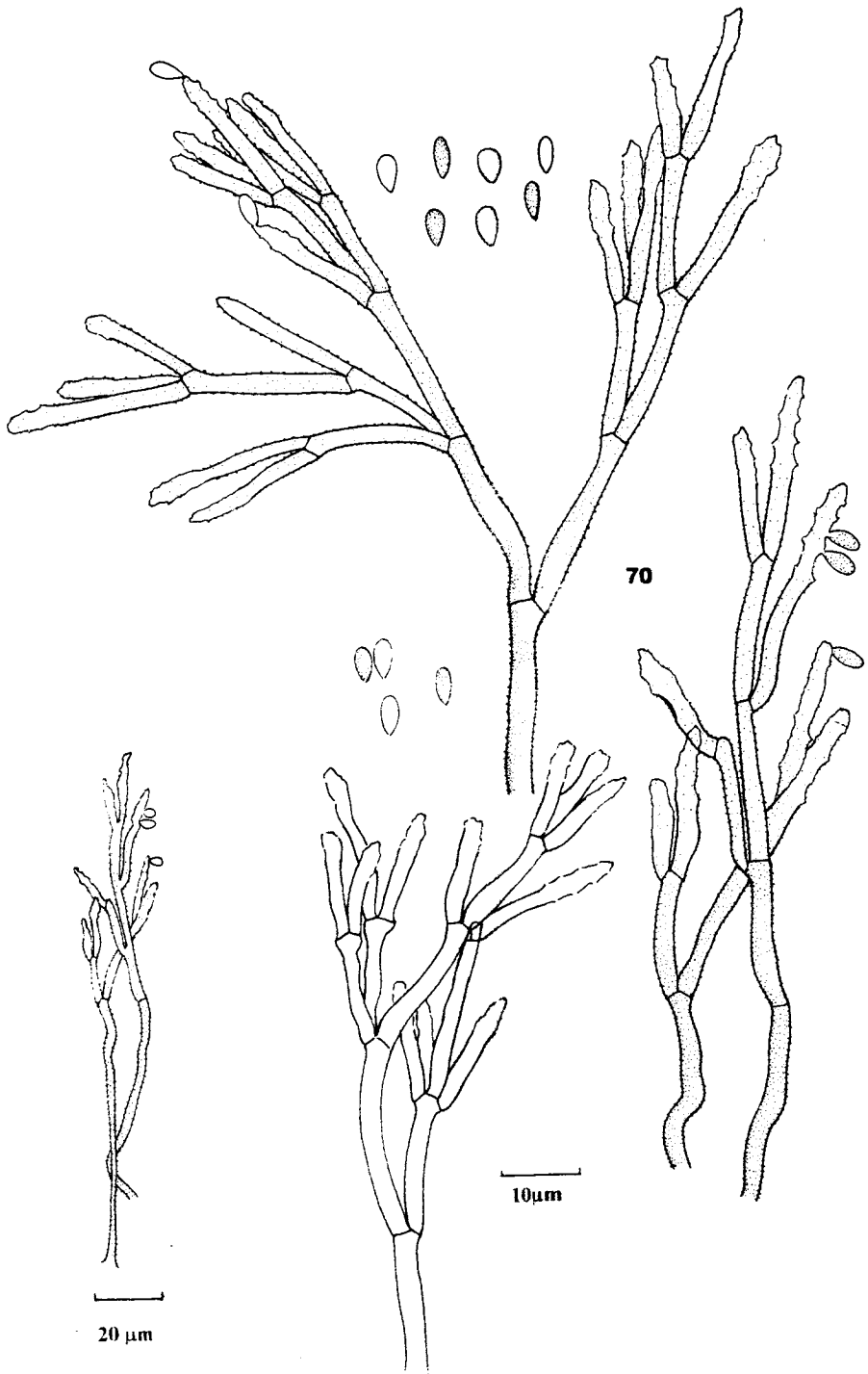

69
10µm

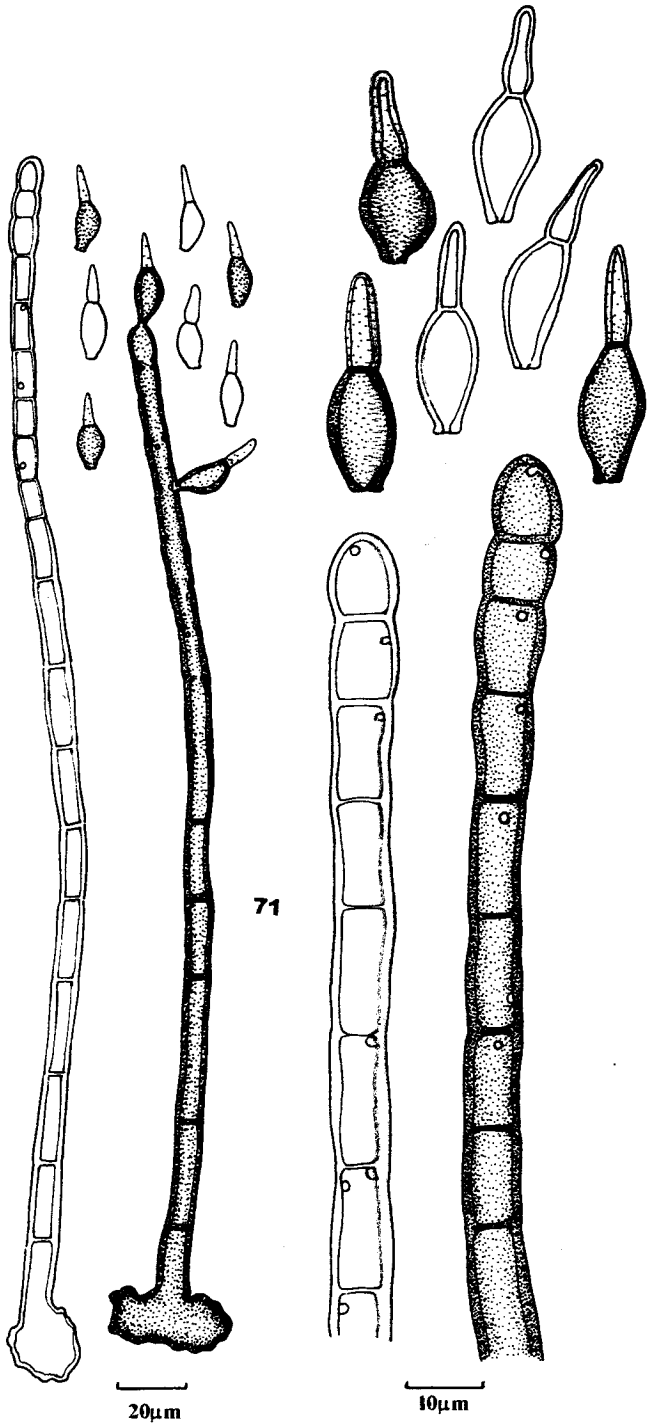

67
10µm

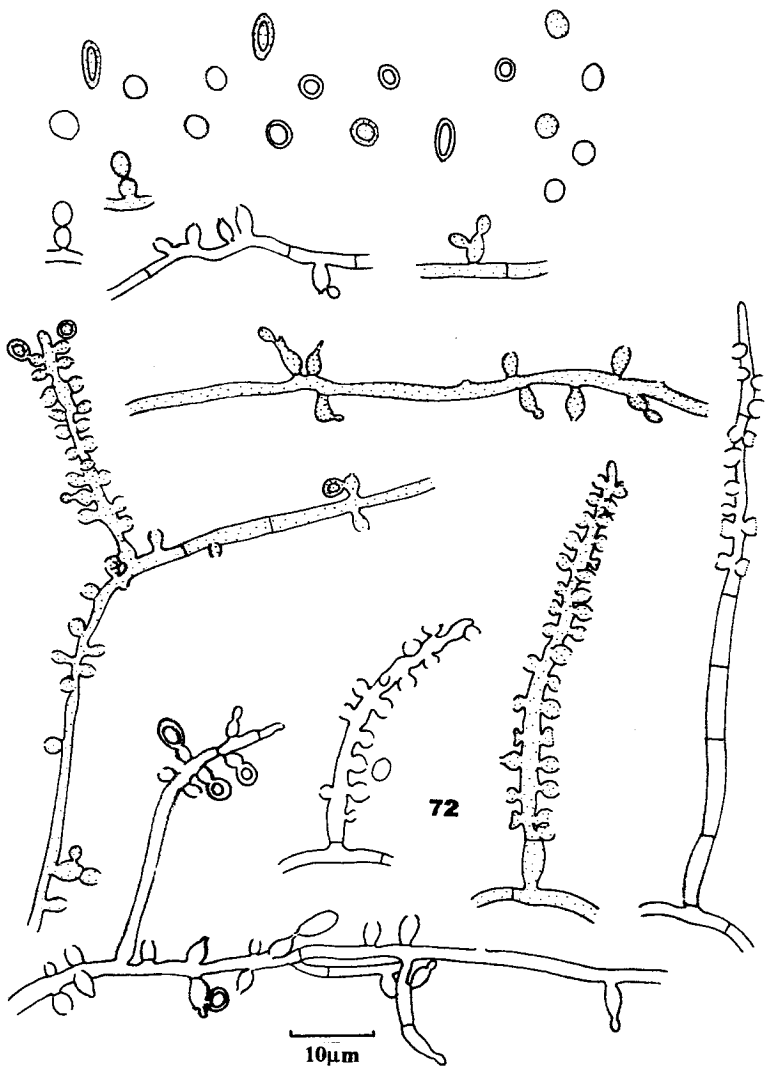


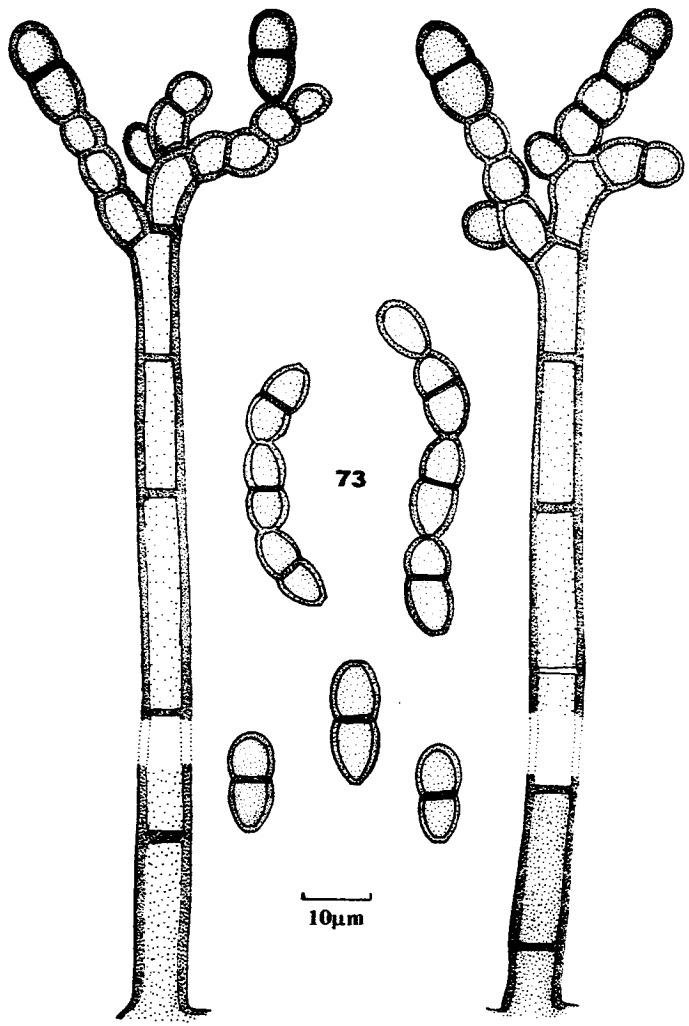

68
10µm

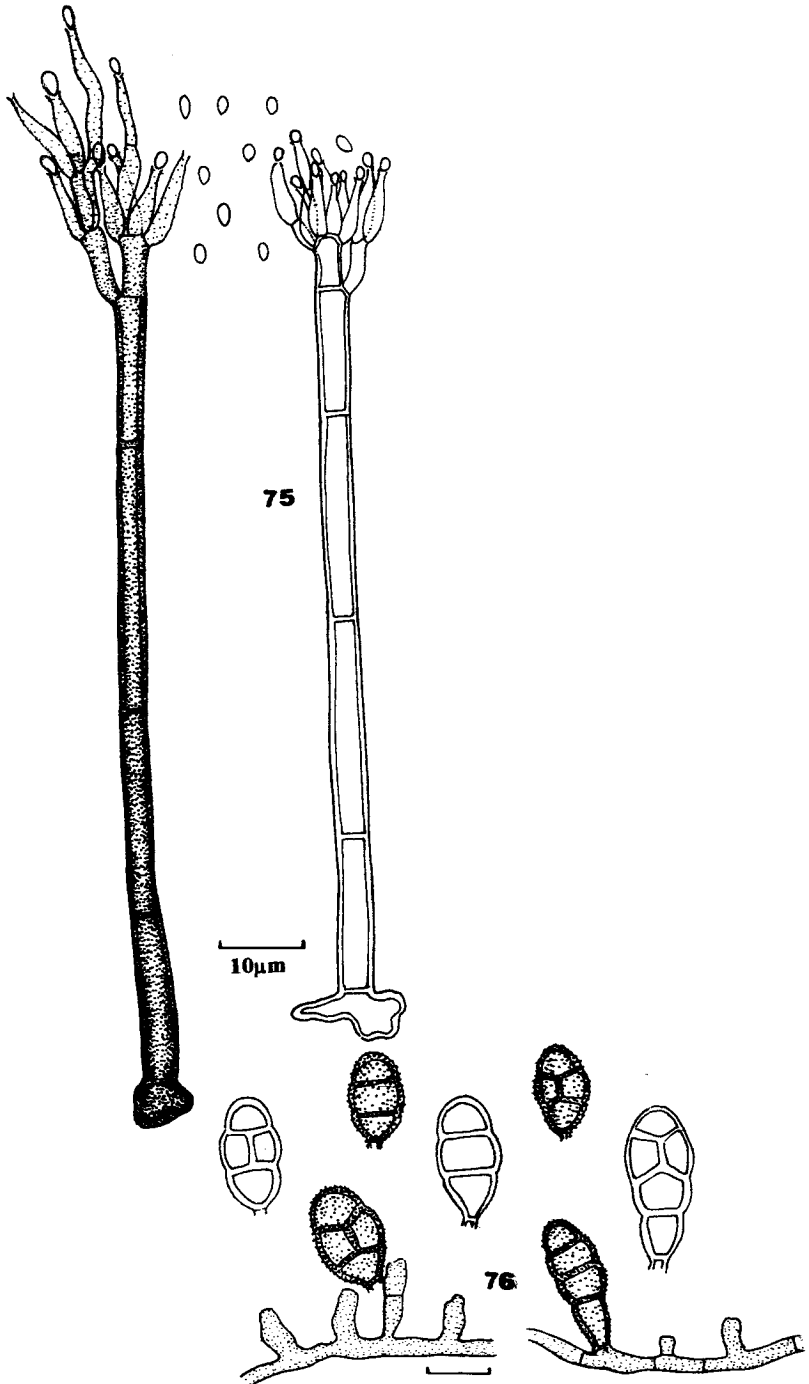


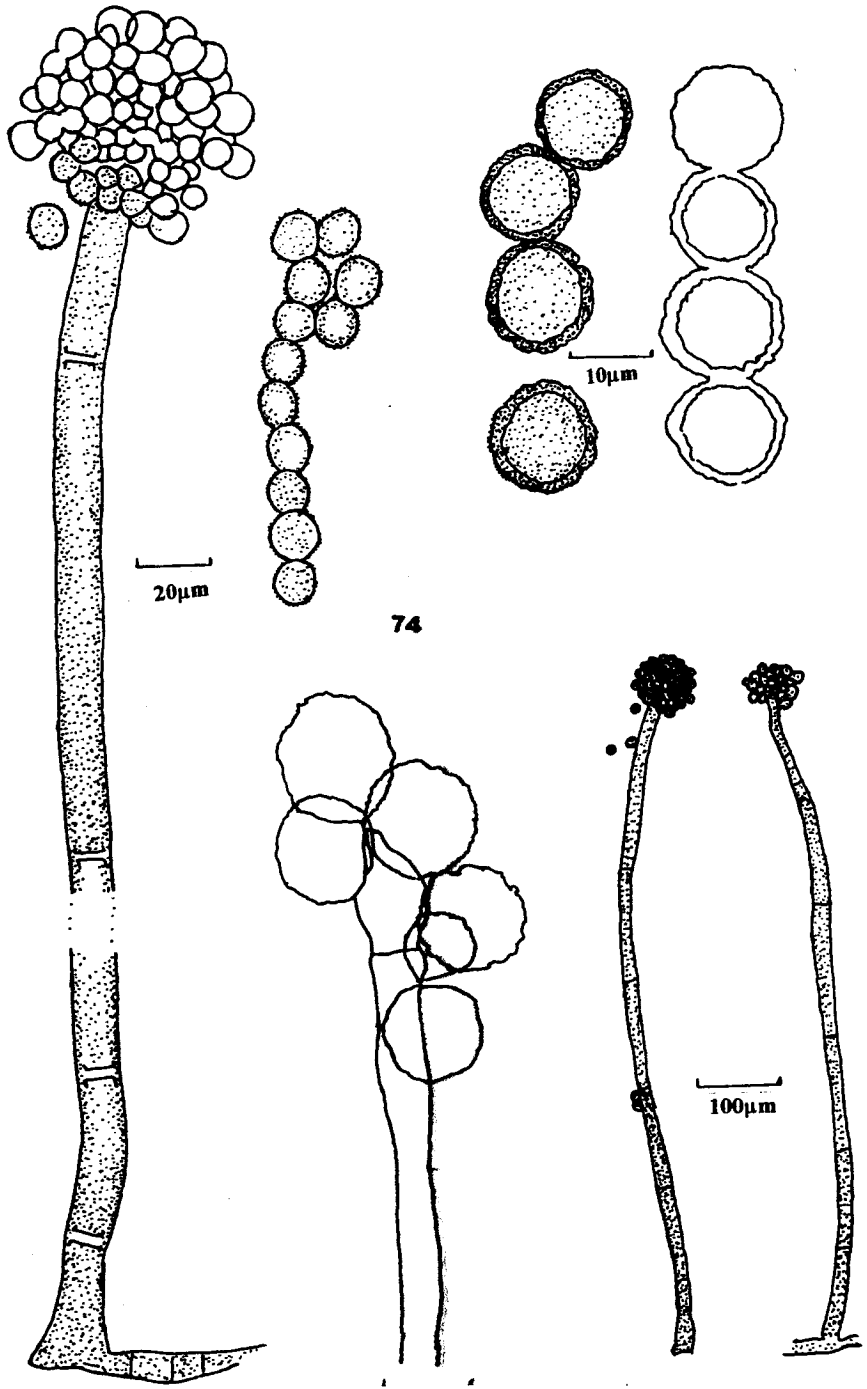

70
10µm
20 µm

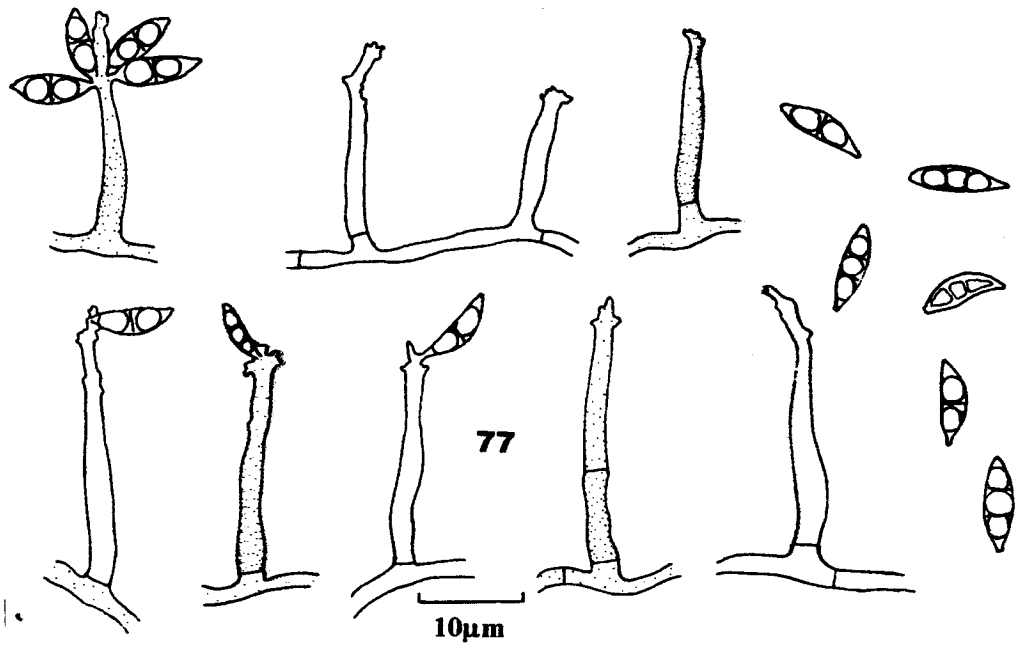

71
20µm
10µm

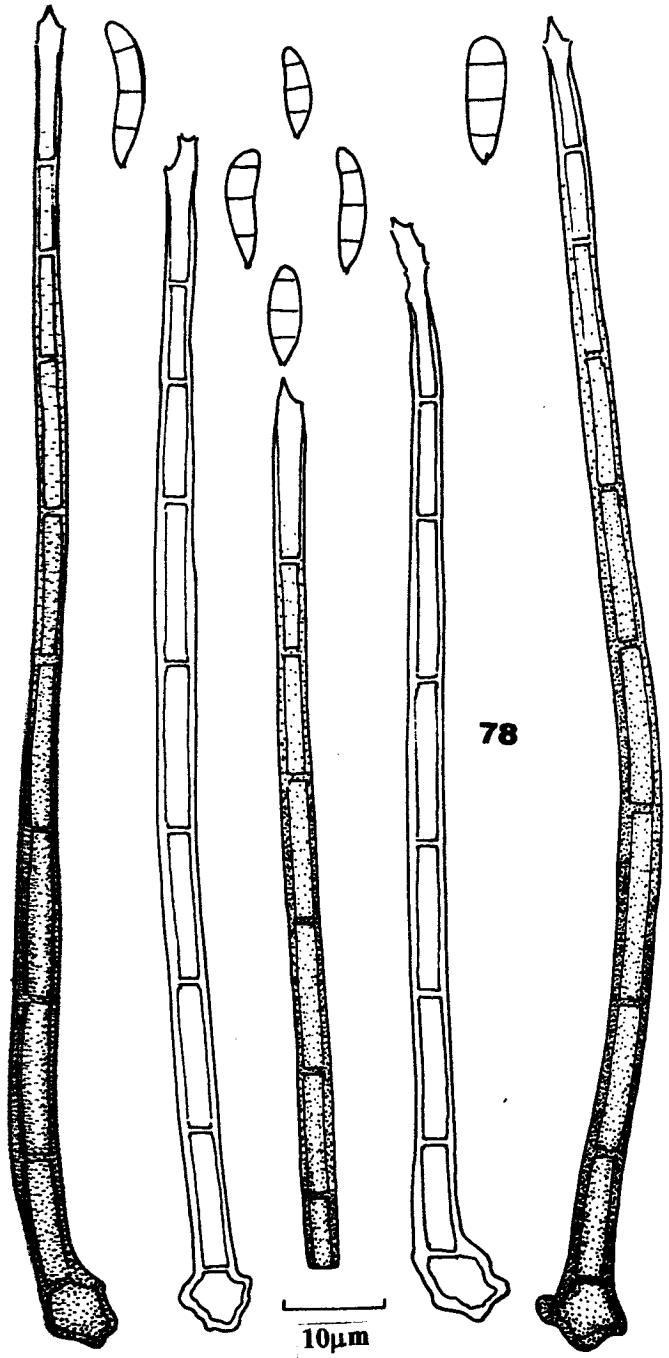

72
10µm

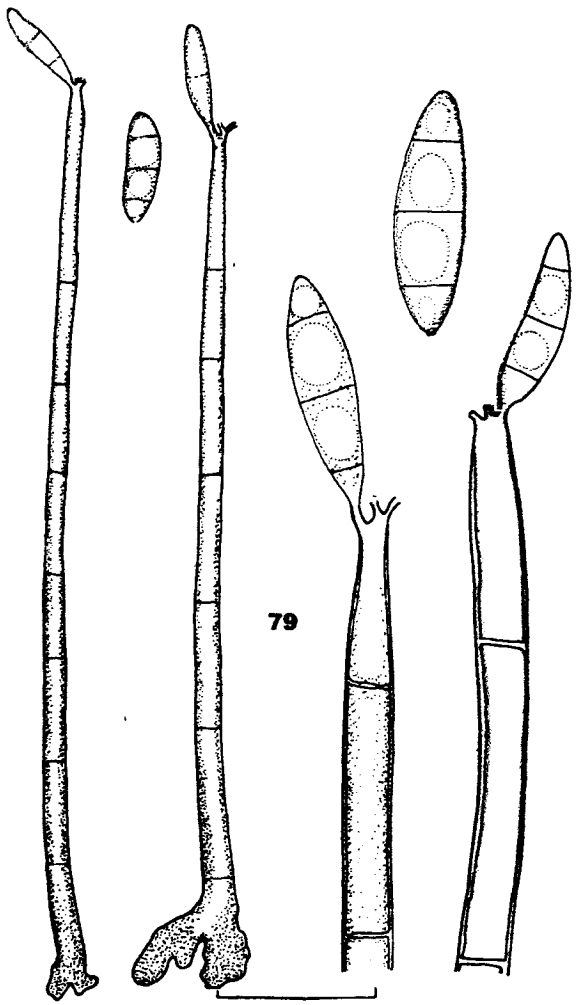

73
10µm

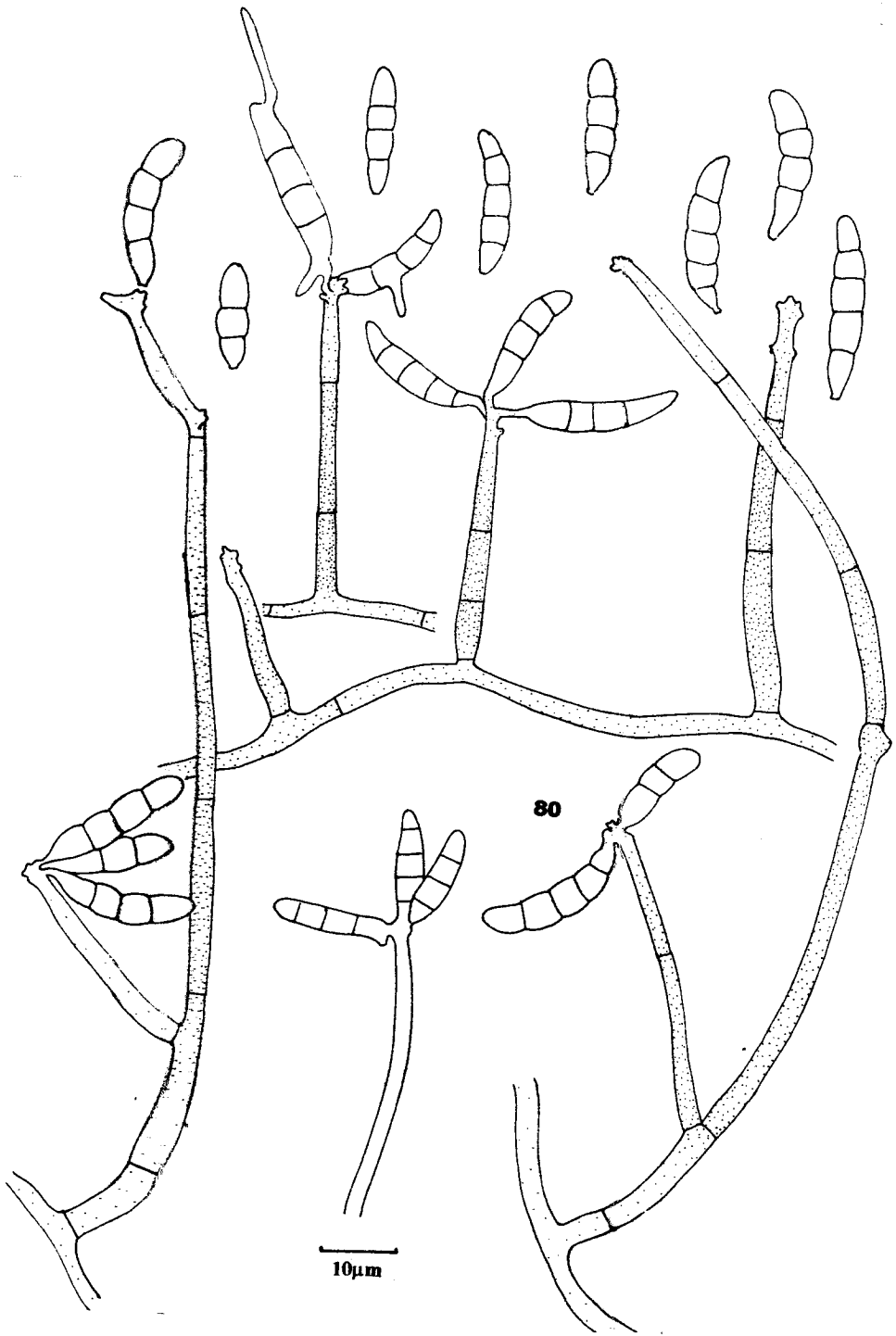

75
10µm
76

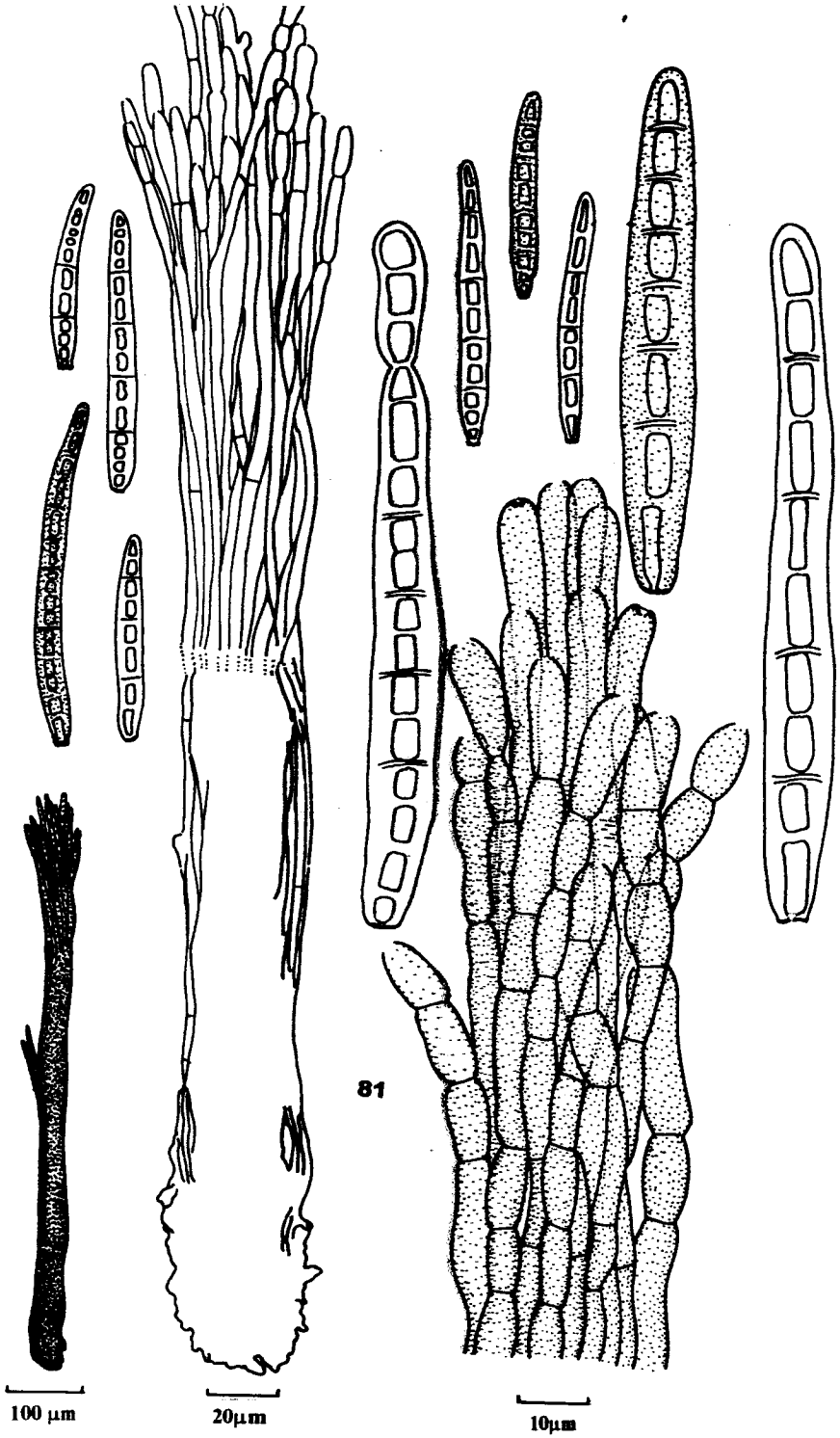

20µm
74
10µm
100µm

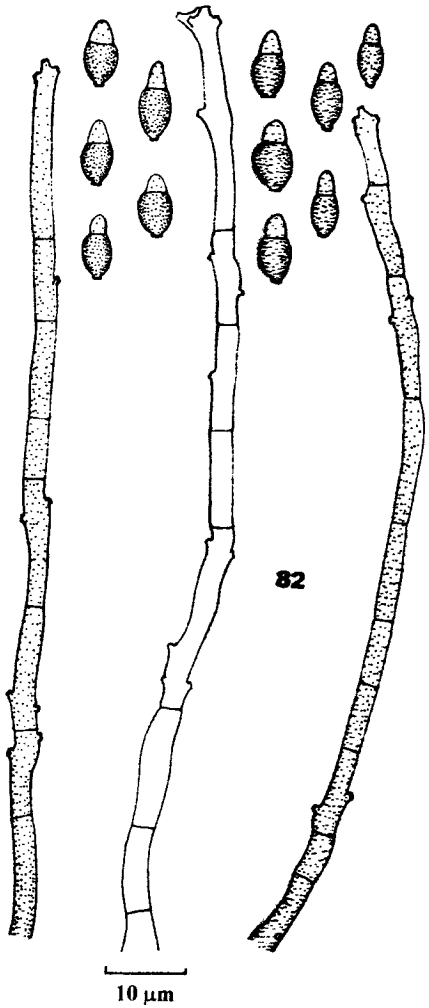

77
10µm

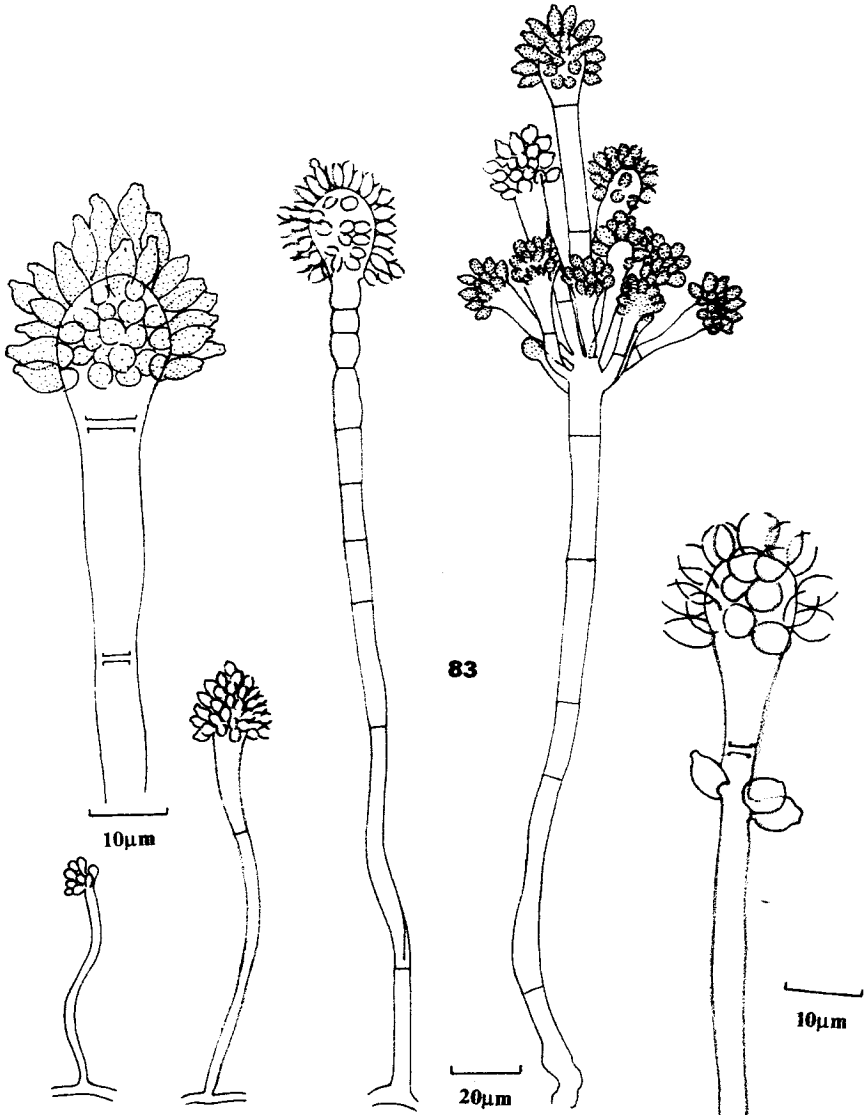

78
10µm

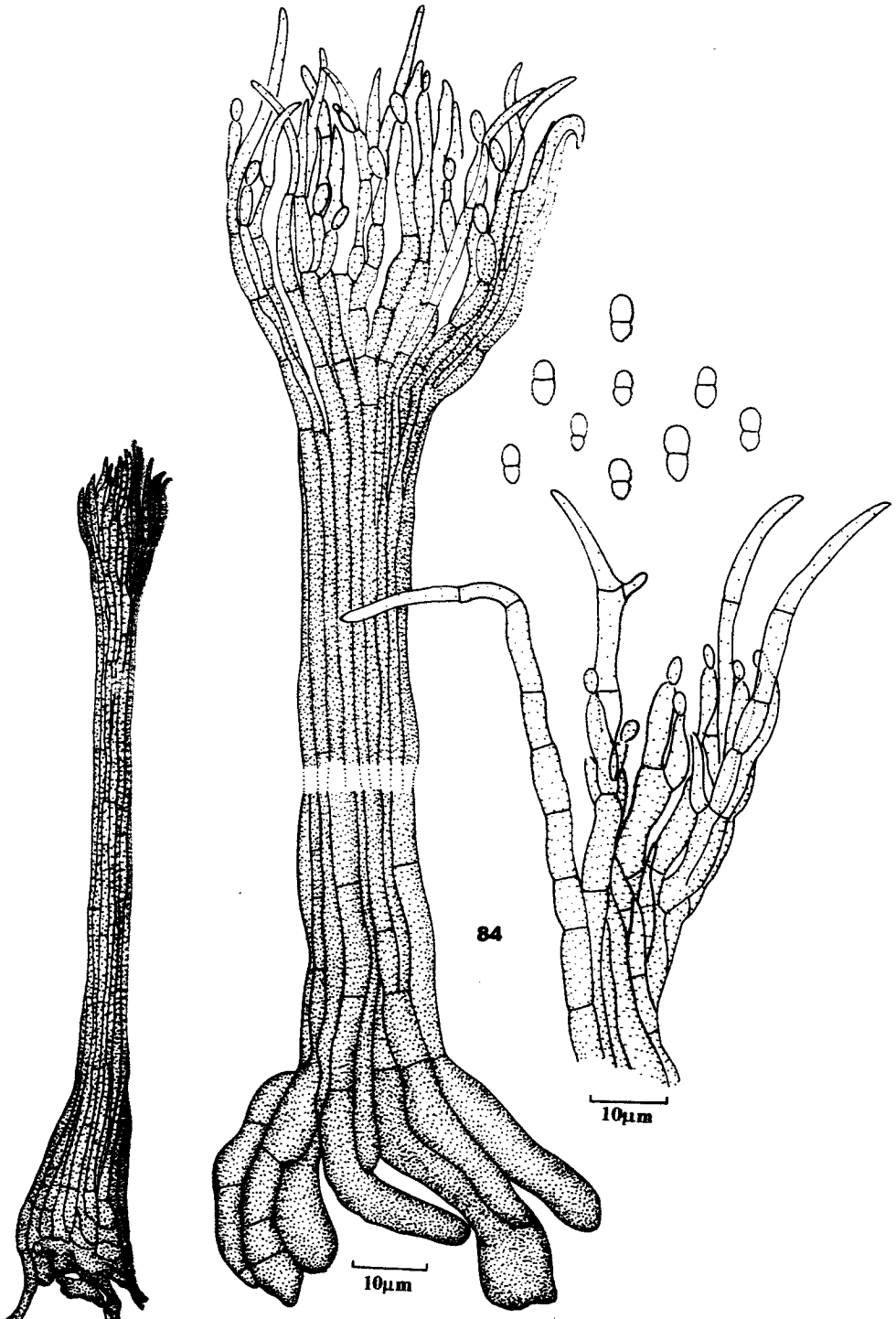

79
10µm

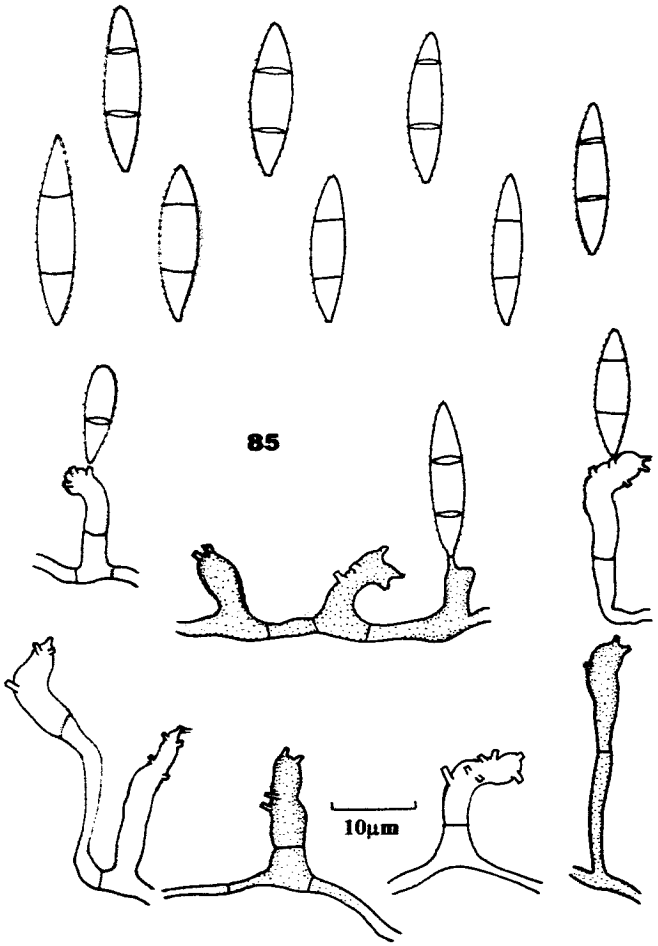

80
10µm

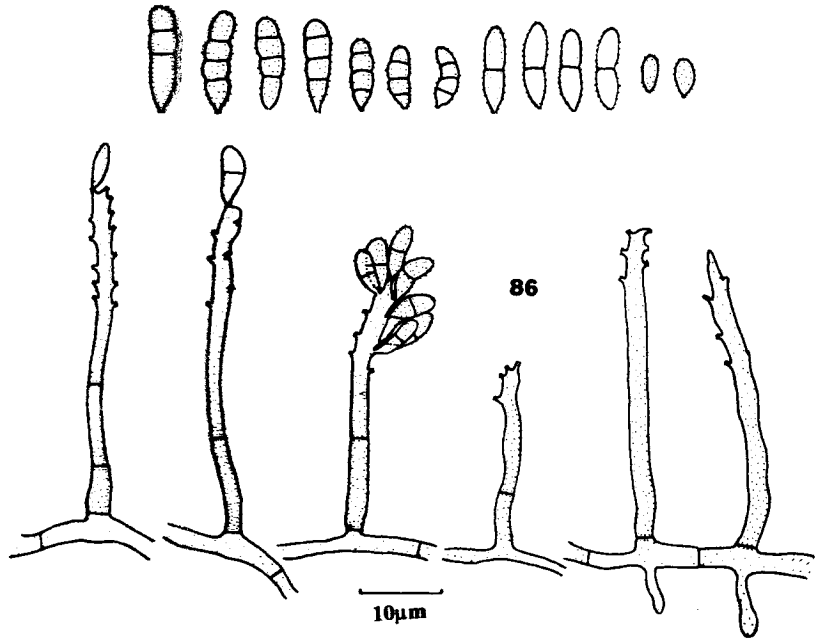

100 µm
20µm
81
10µm

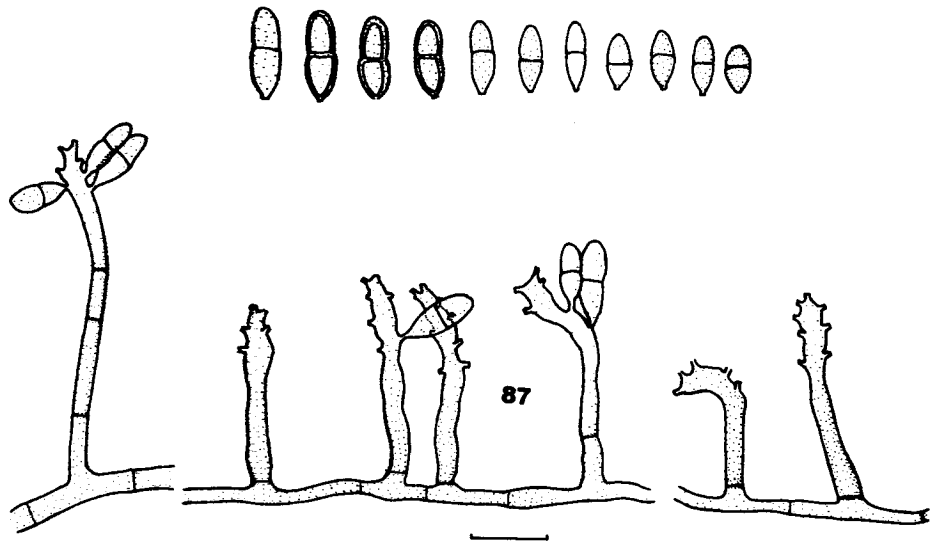

82
10 µm

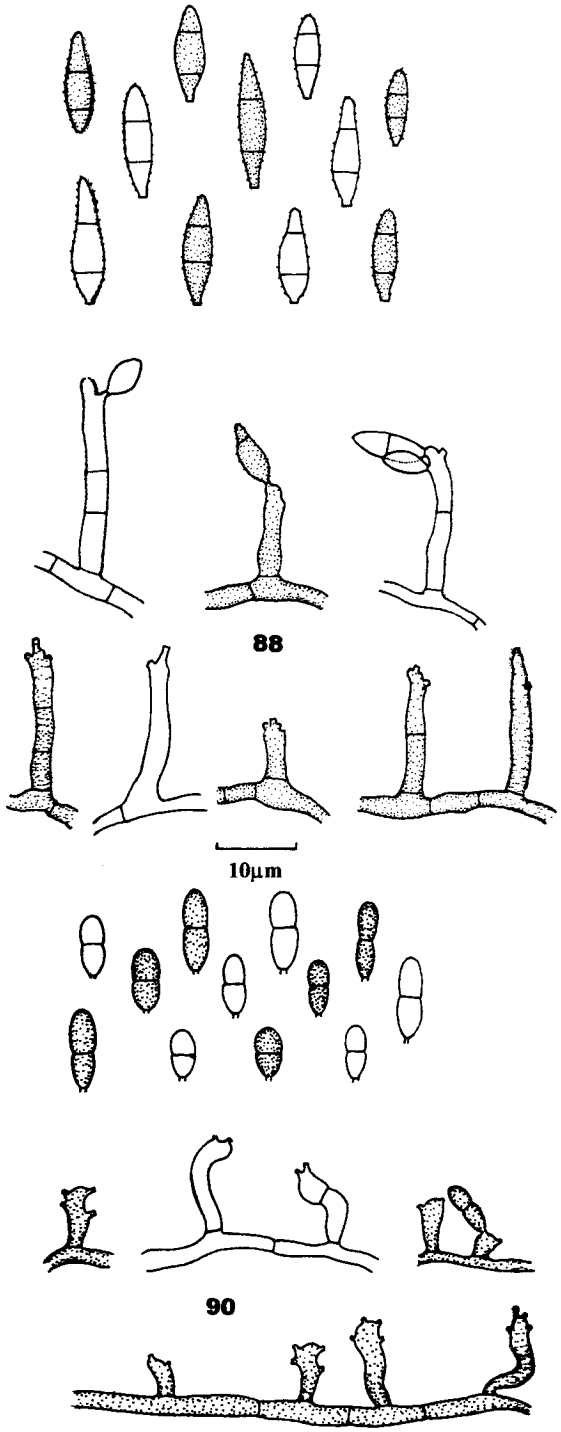

10µm
83
20µm
10µm

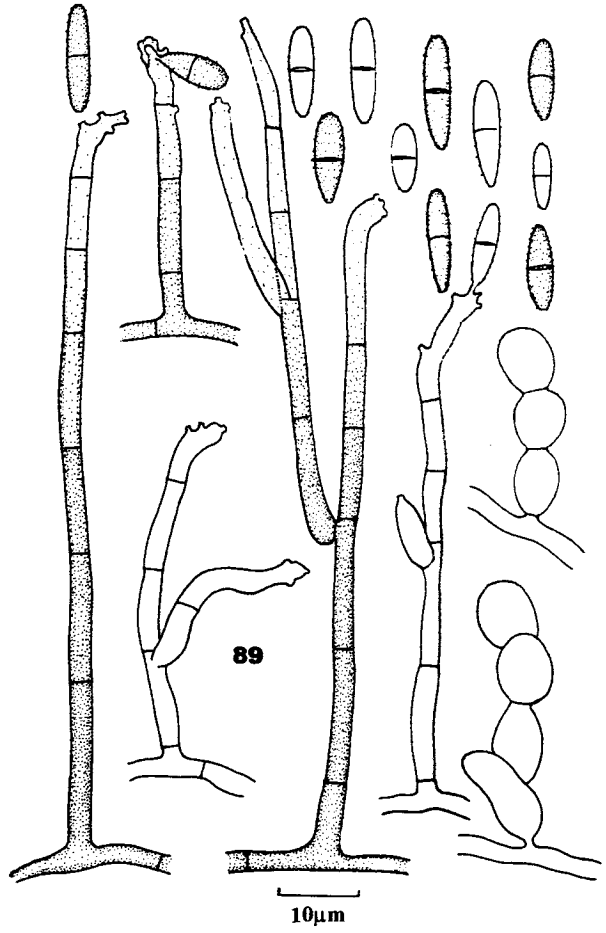

84
10µm
10µm

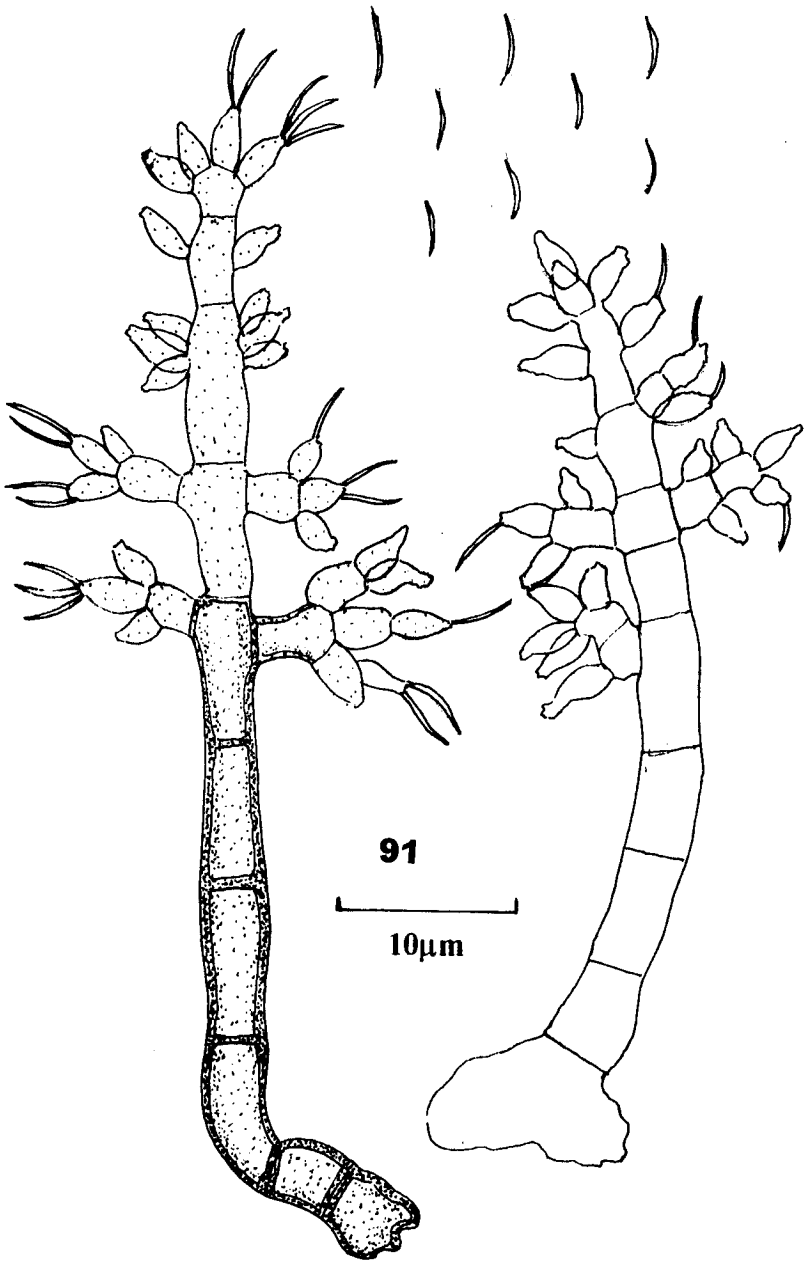

85
10µm

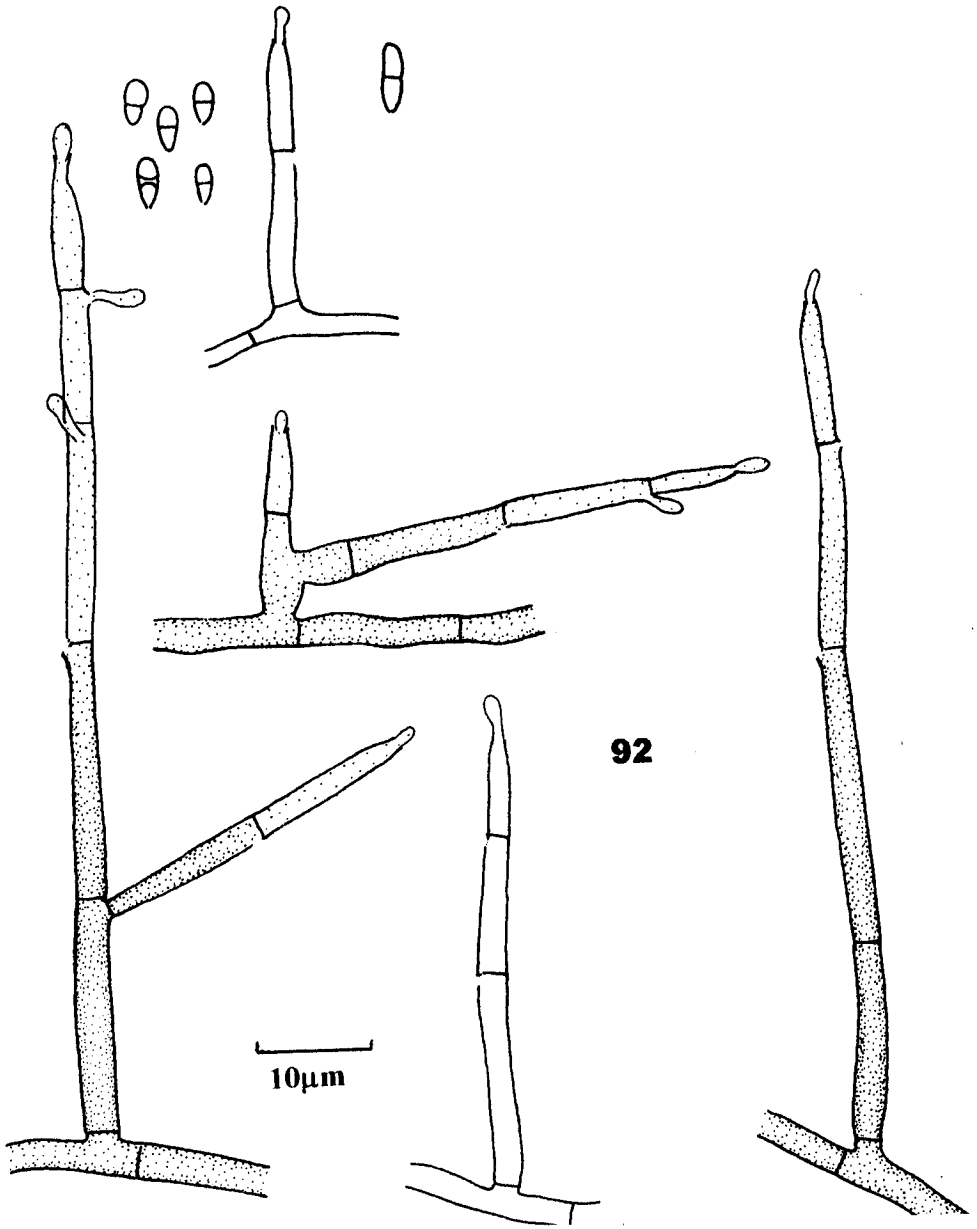

86
10µm

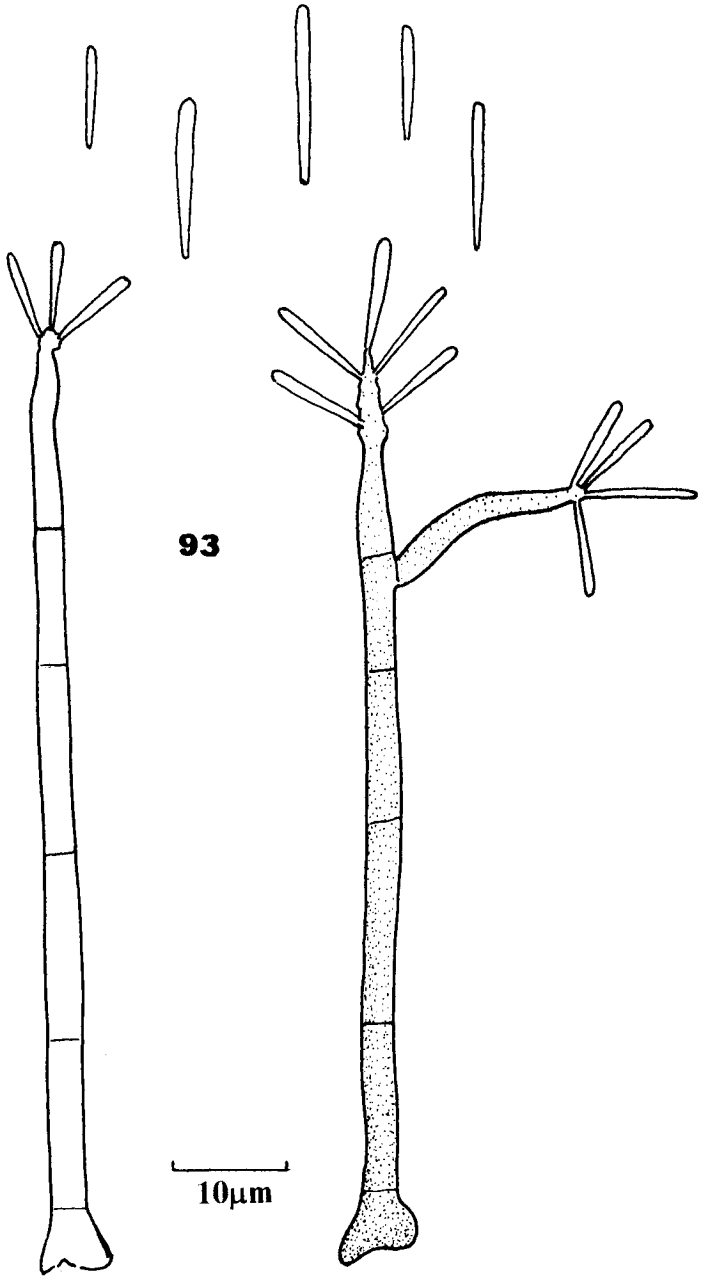

87

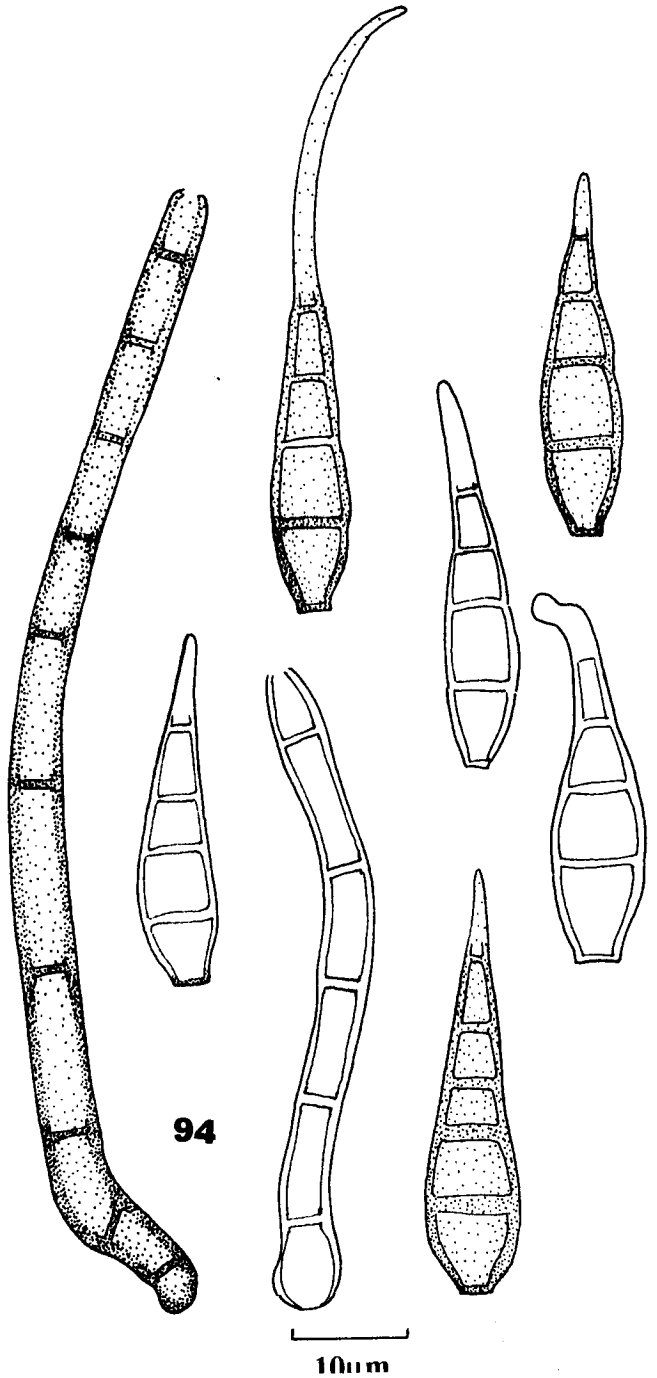

88
10µm
90

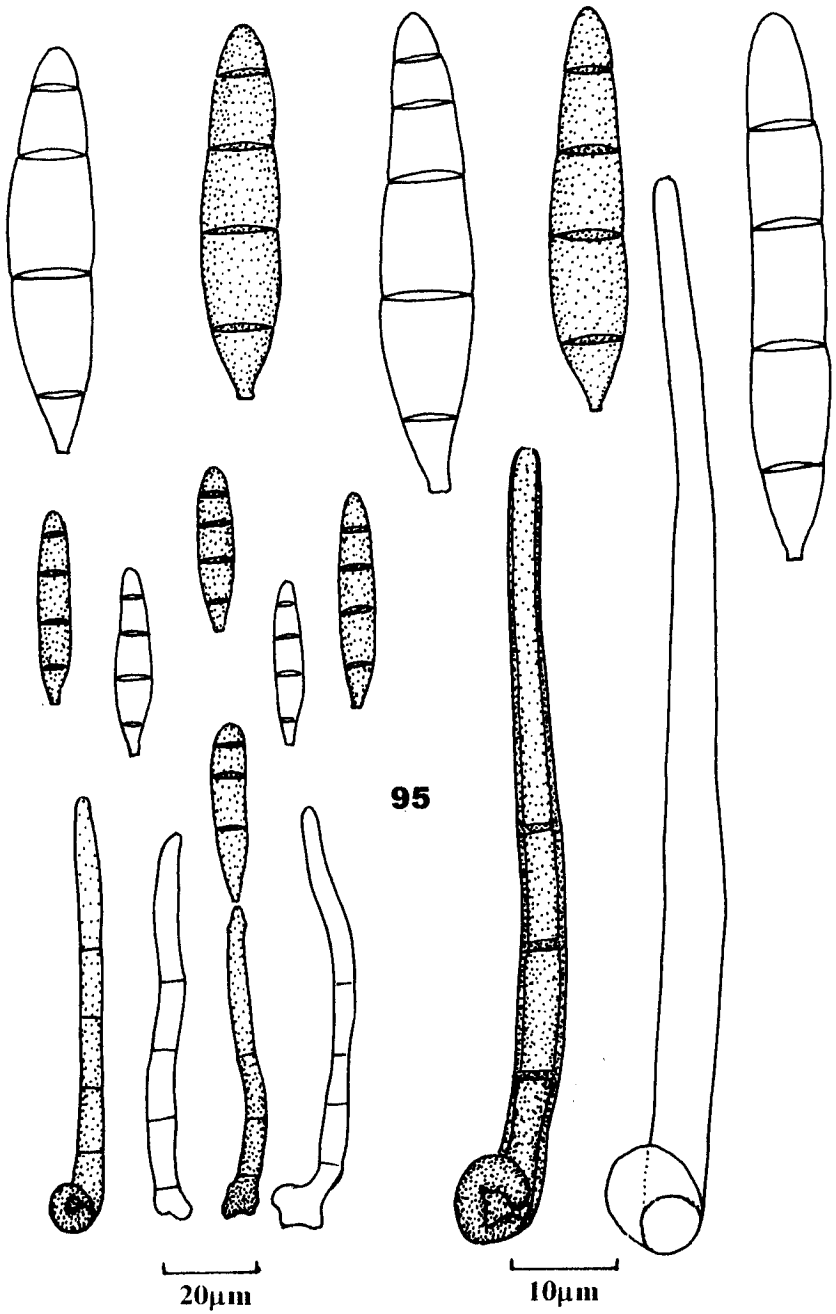

89
10µm

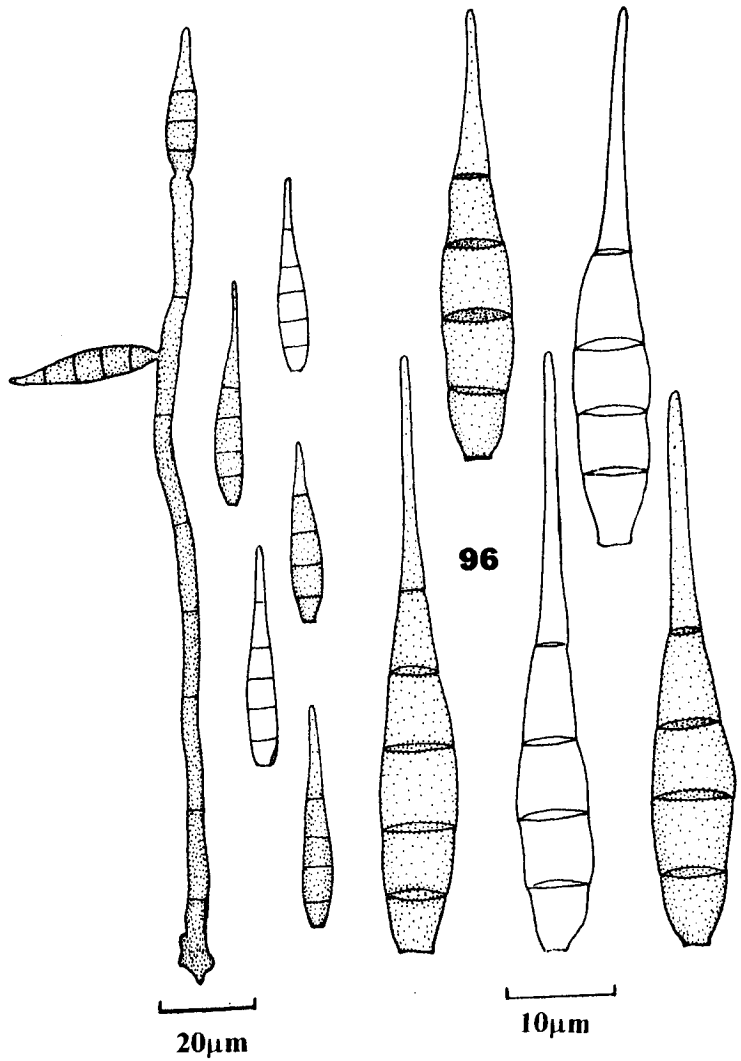

91
10µm

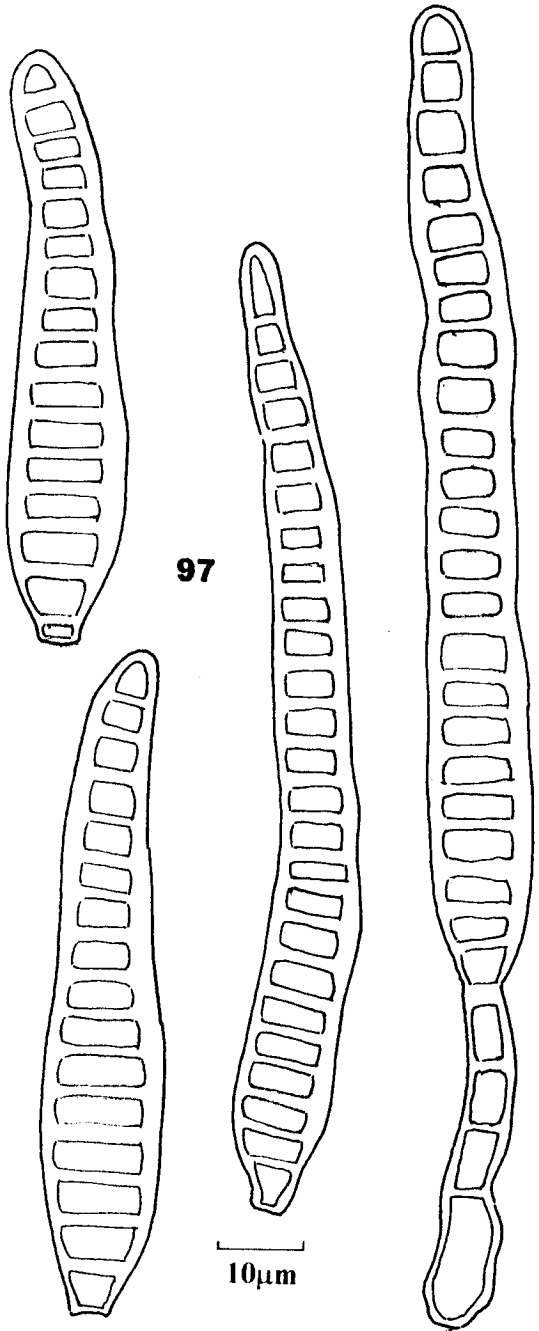

92
10µm

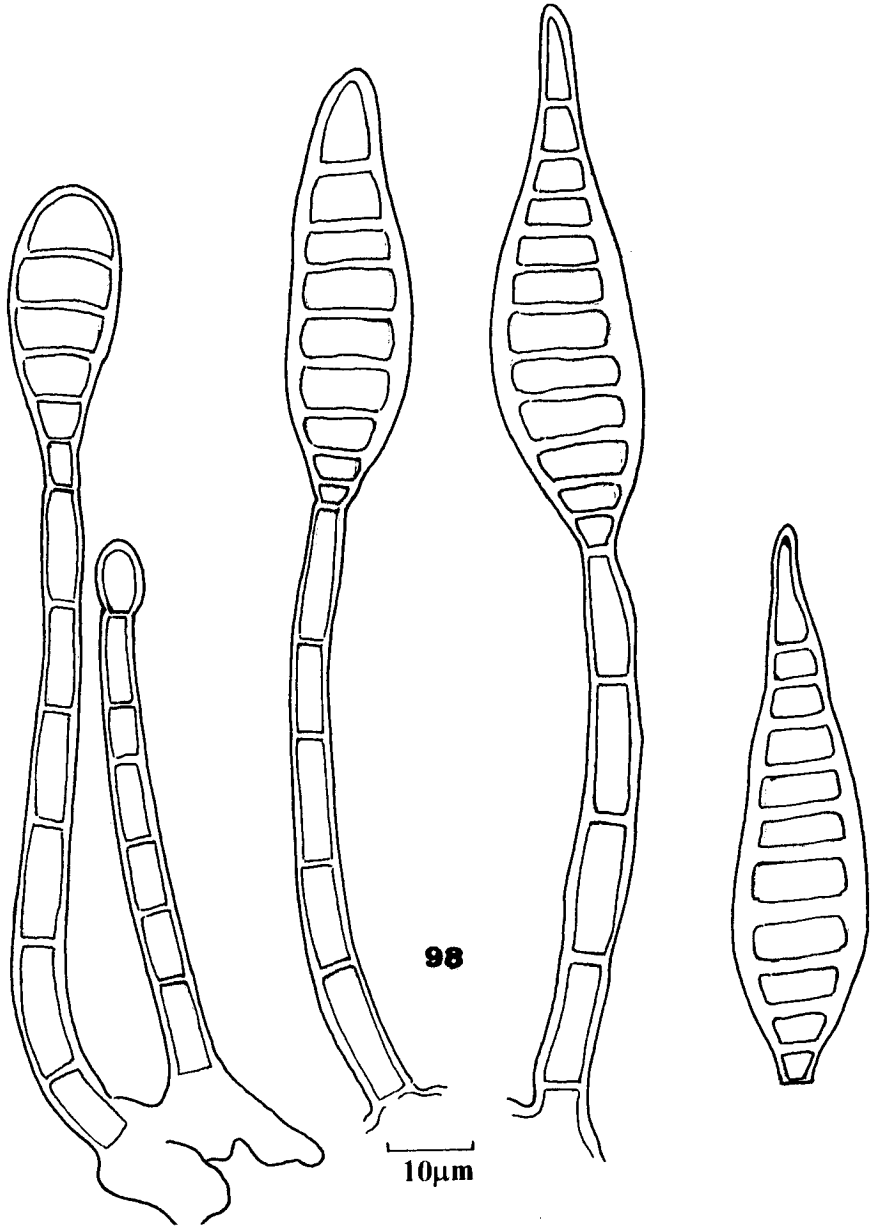

93
10μm

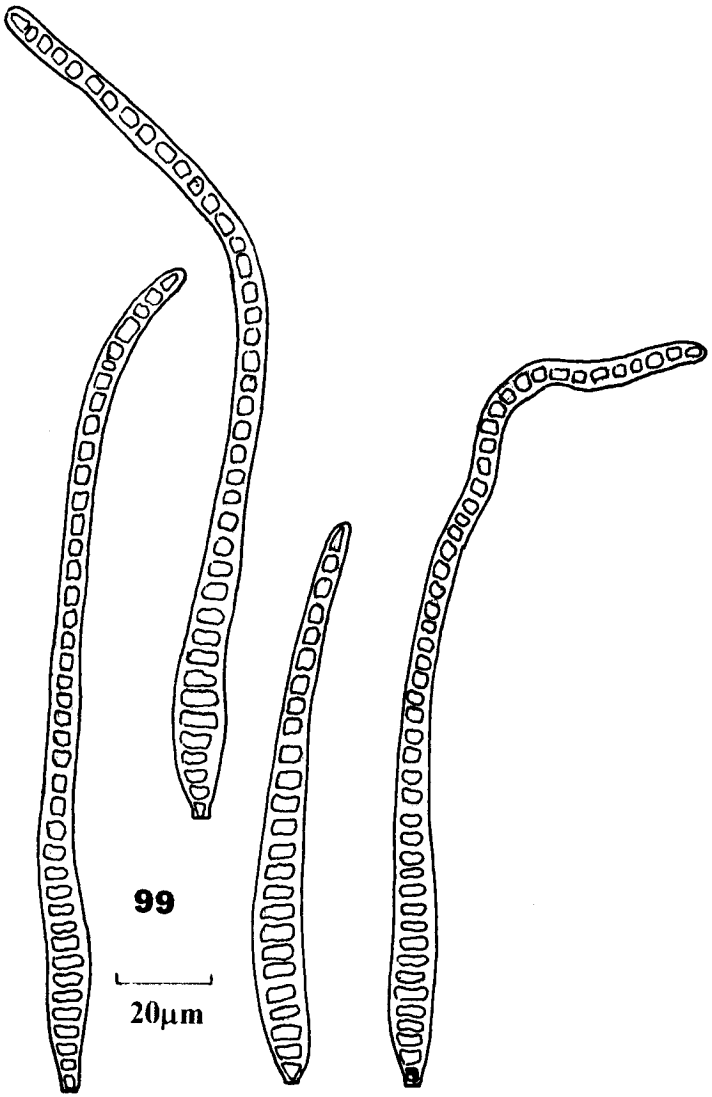

94
10μm

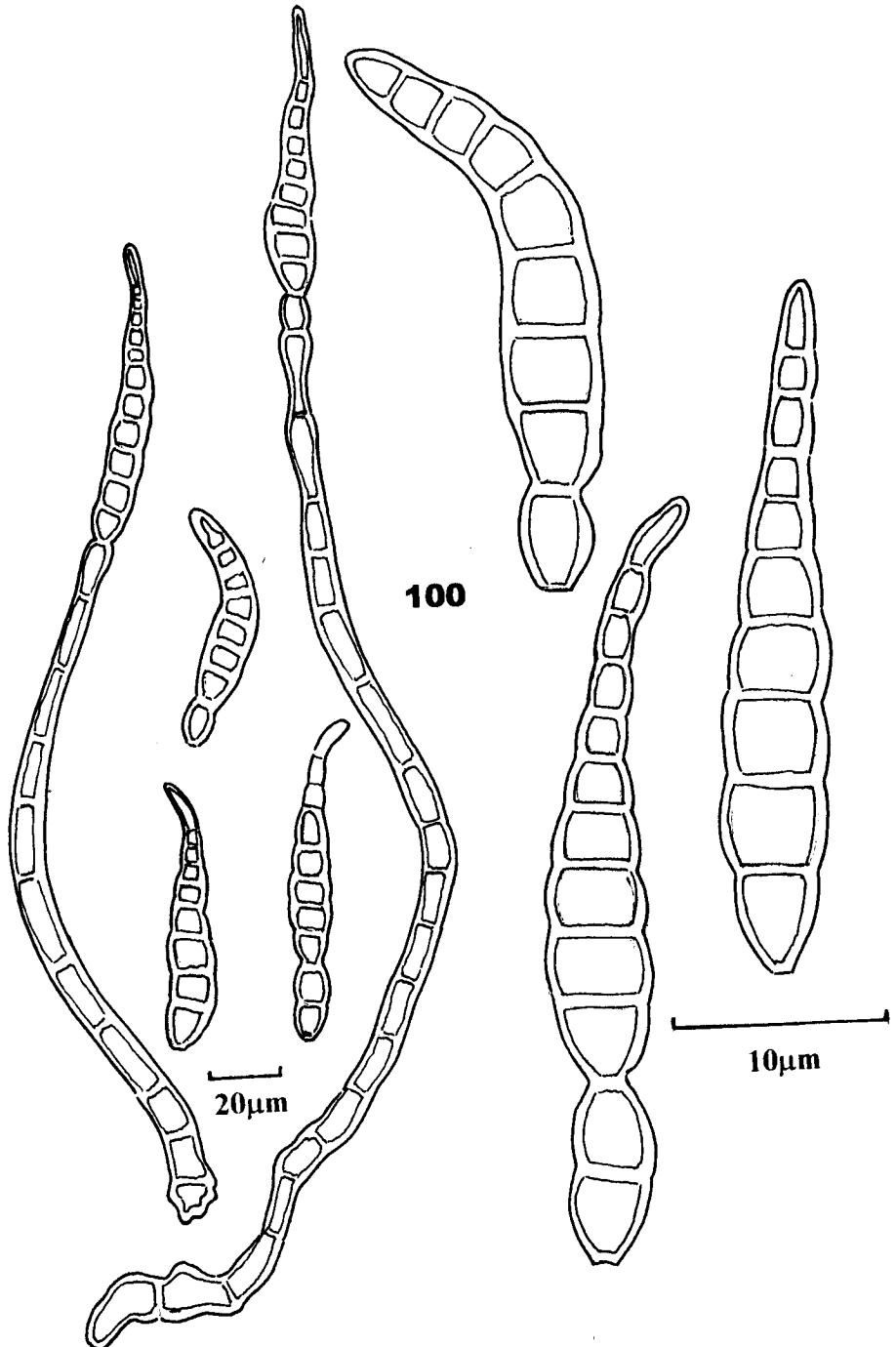

95
20μm
10μm

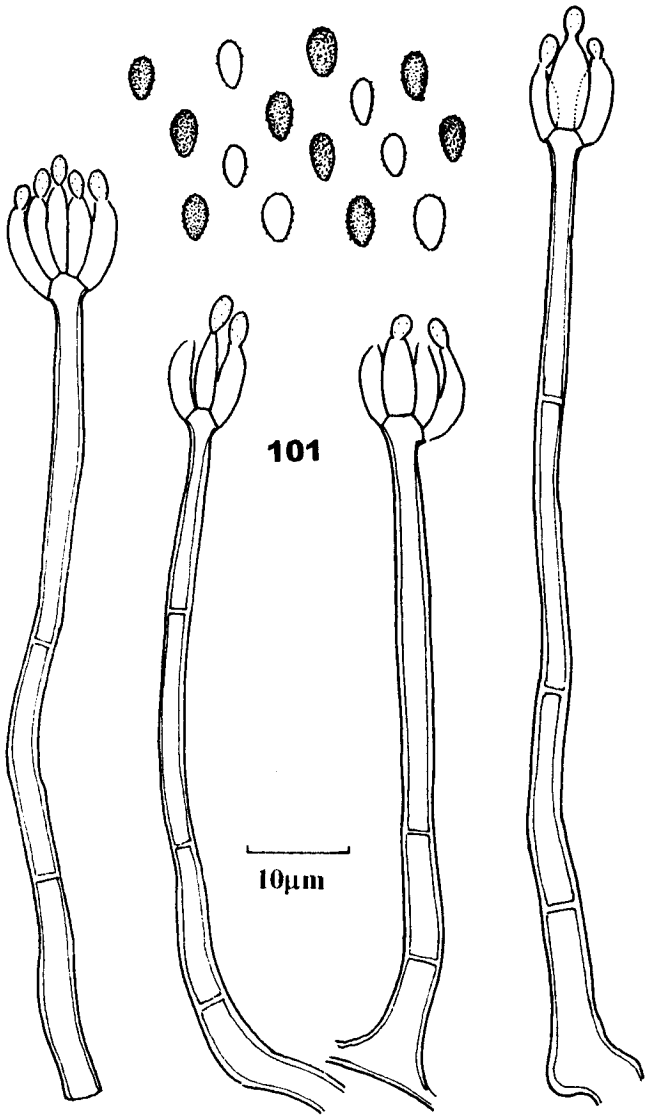

96
20μm
10μm

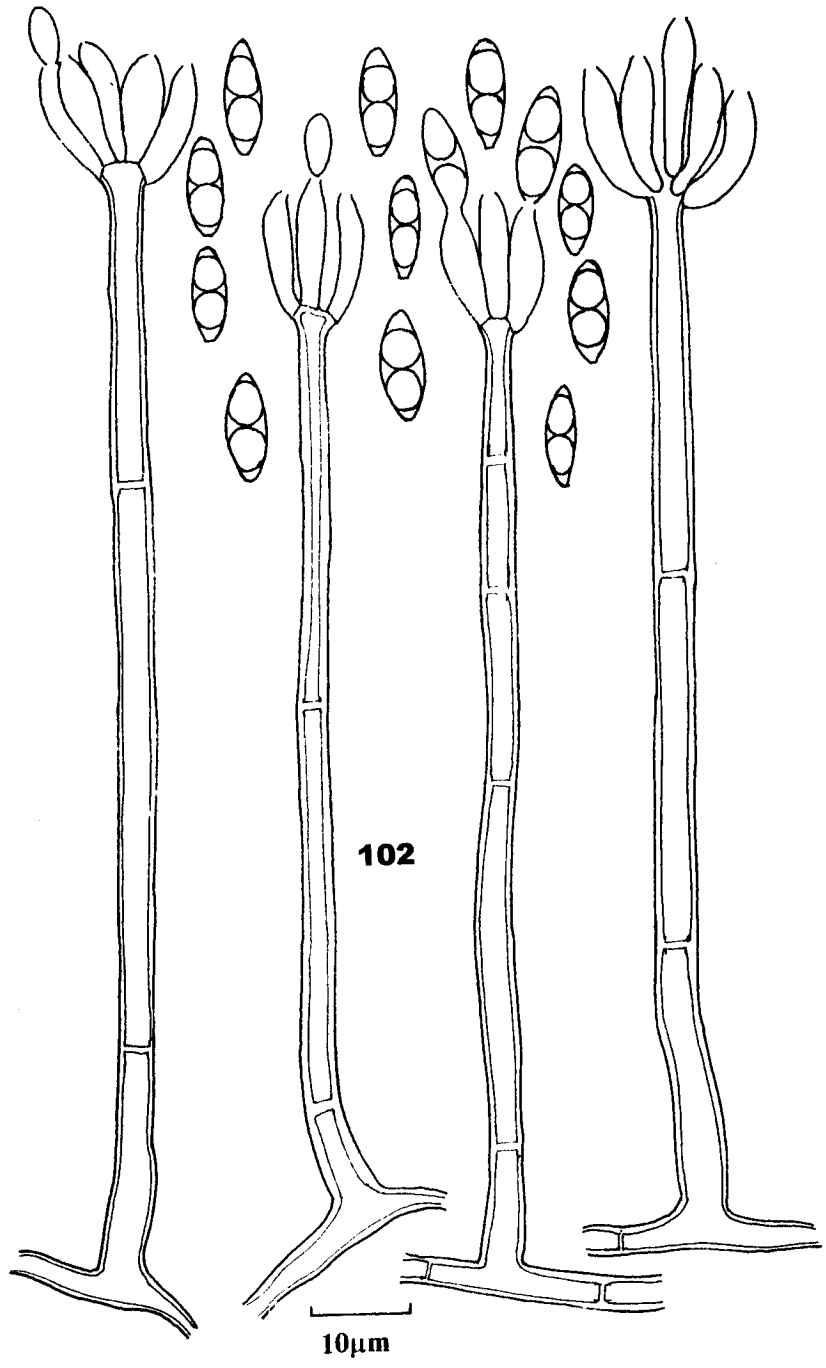

97
10μm

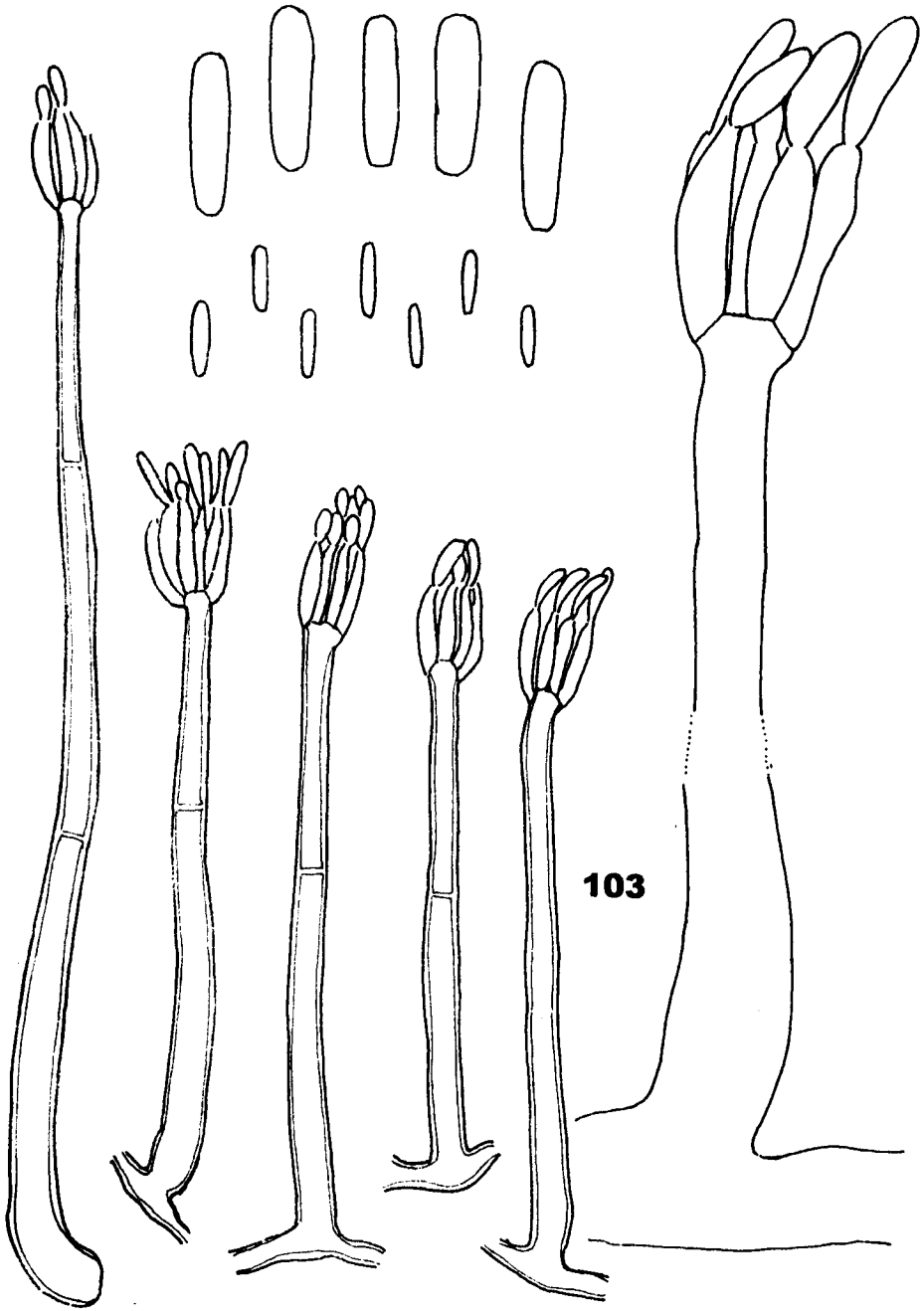

98
10μm

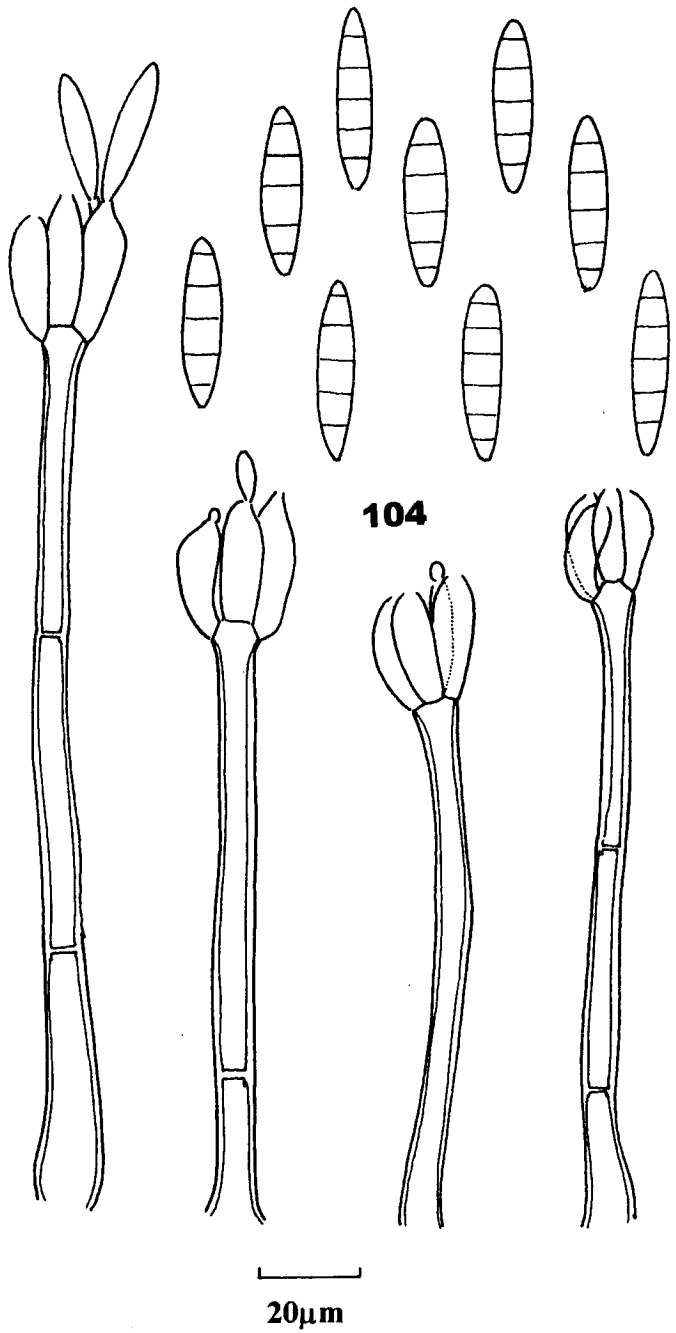

99
20µm

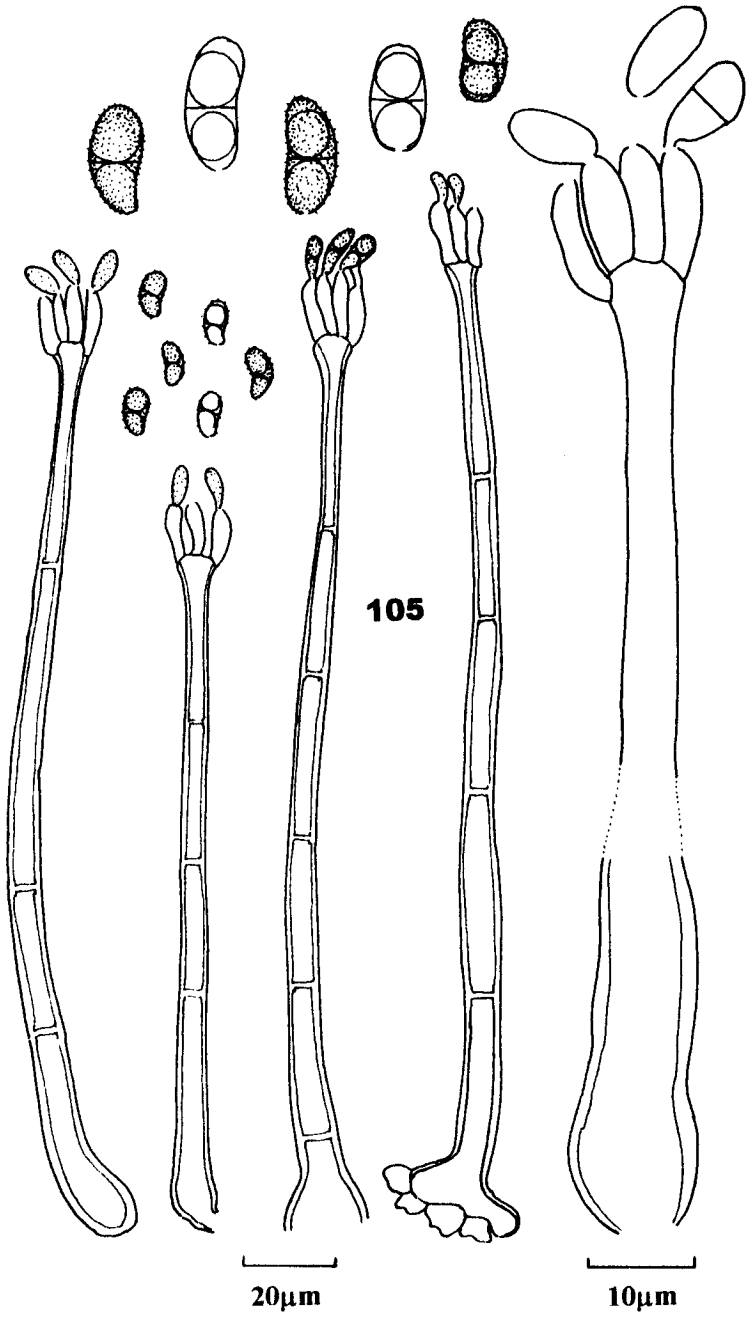

100
20µm
10µm

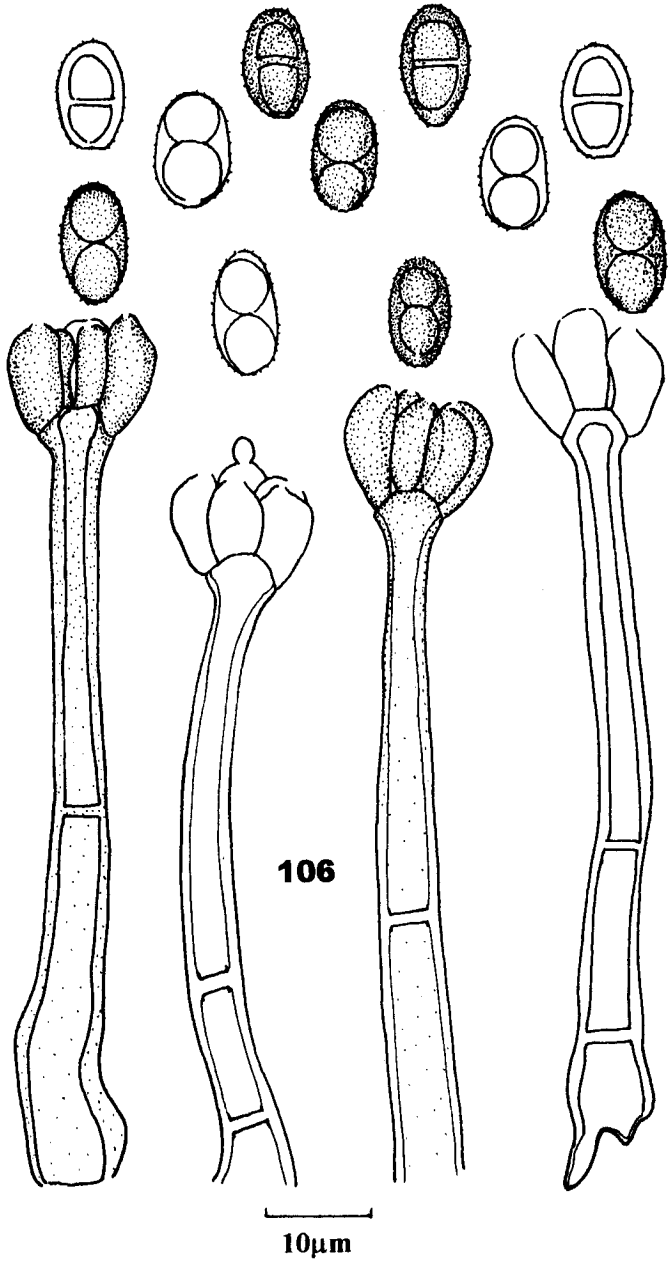

101
10µm

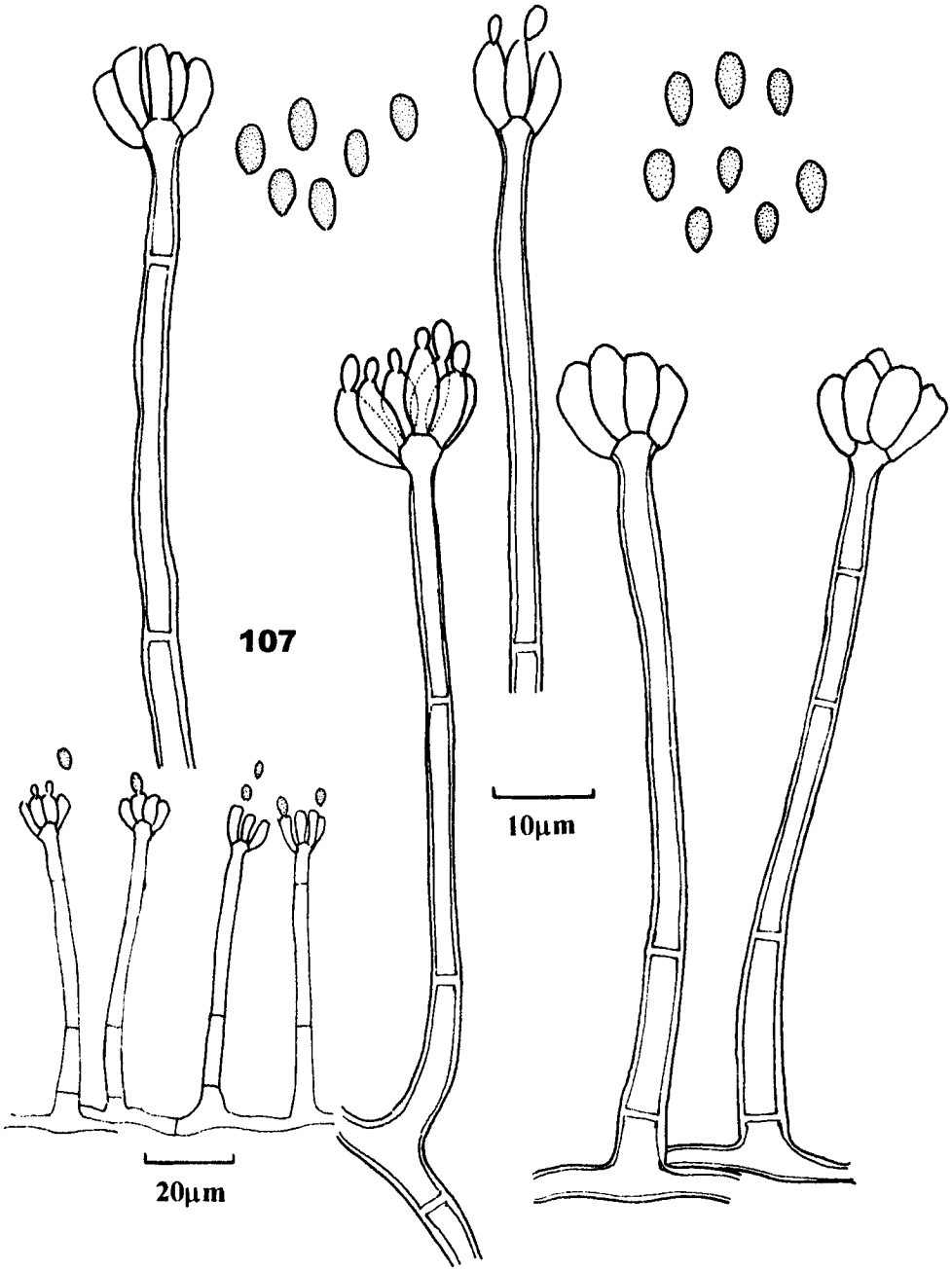

102
10µm

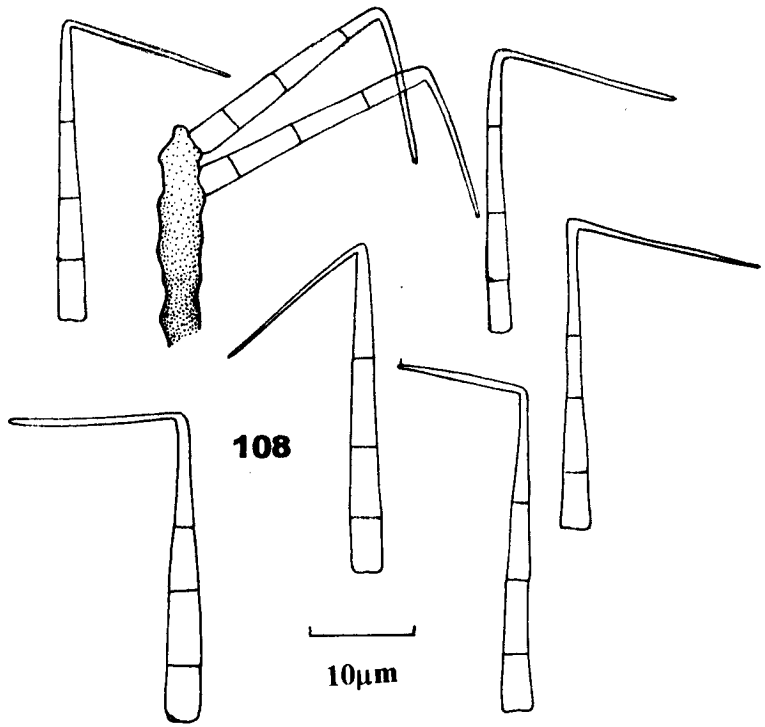

103
20µm
10µm

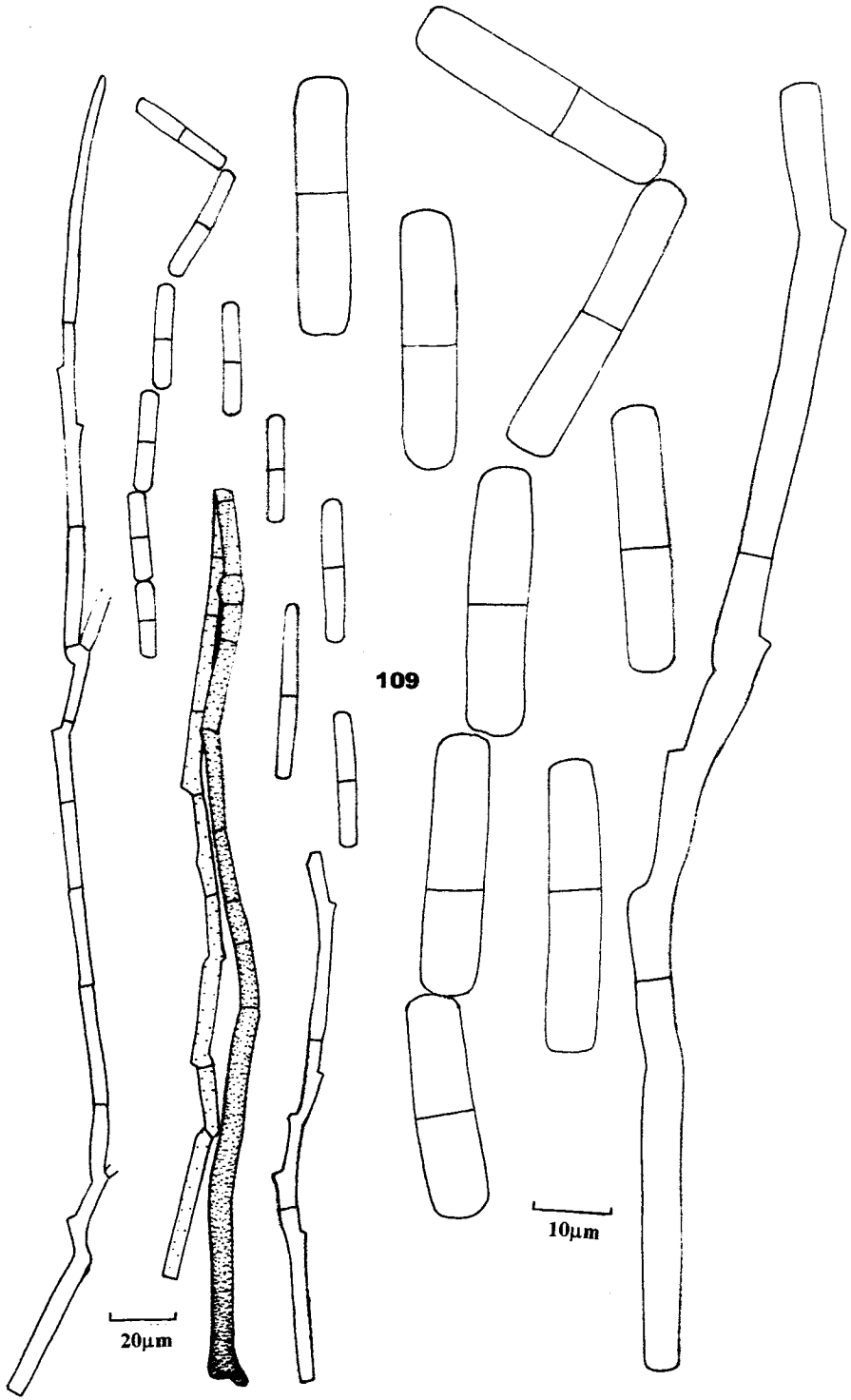

104
20µm

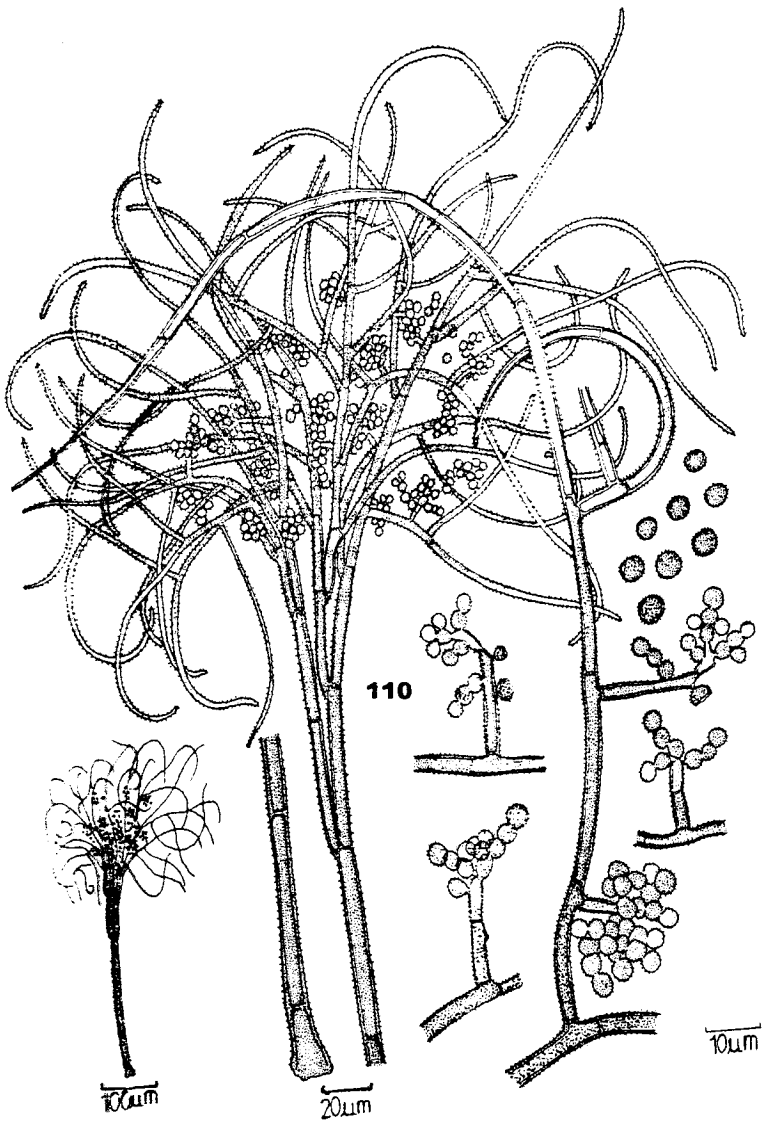

105
20µm
10µm

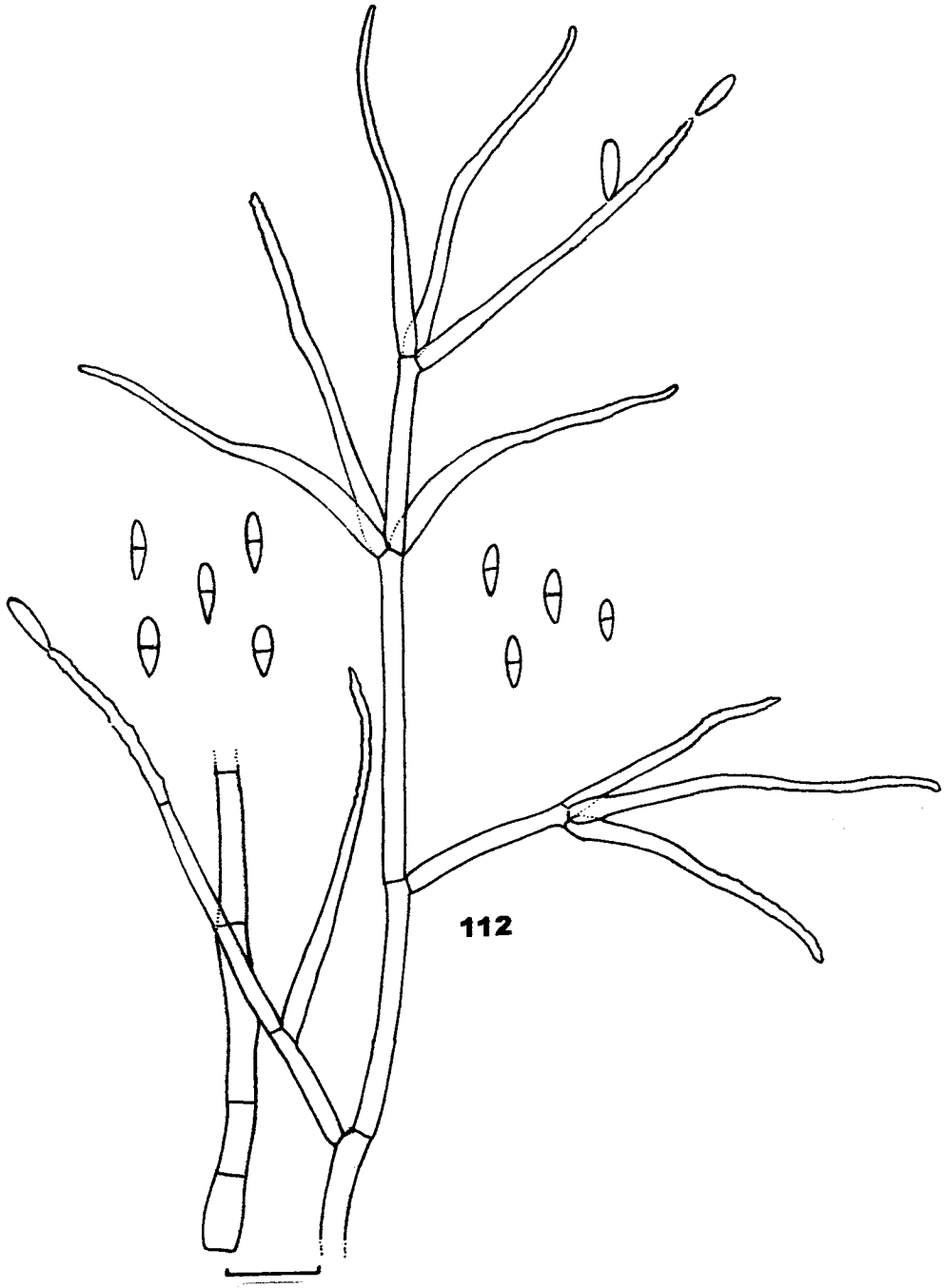

106
10µm

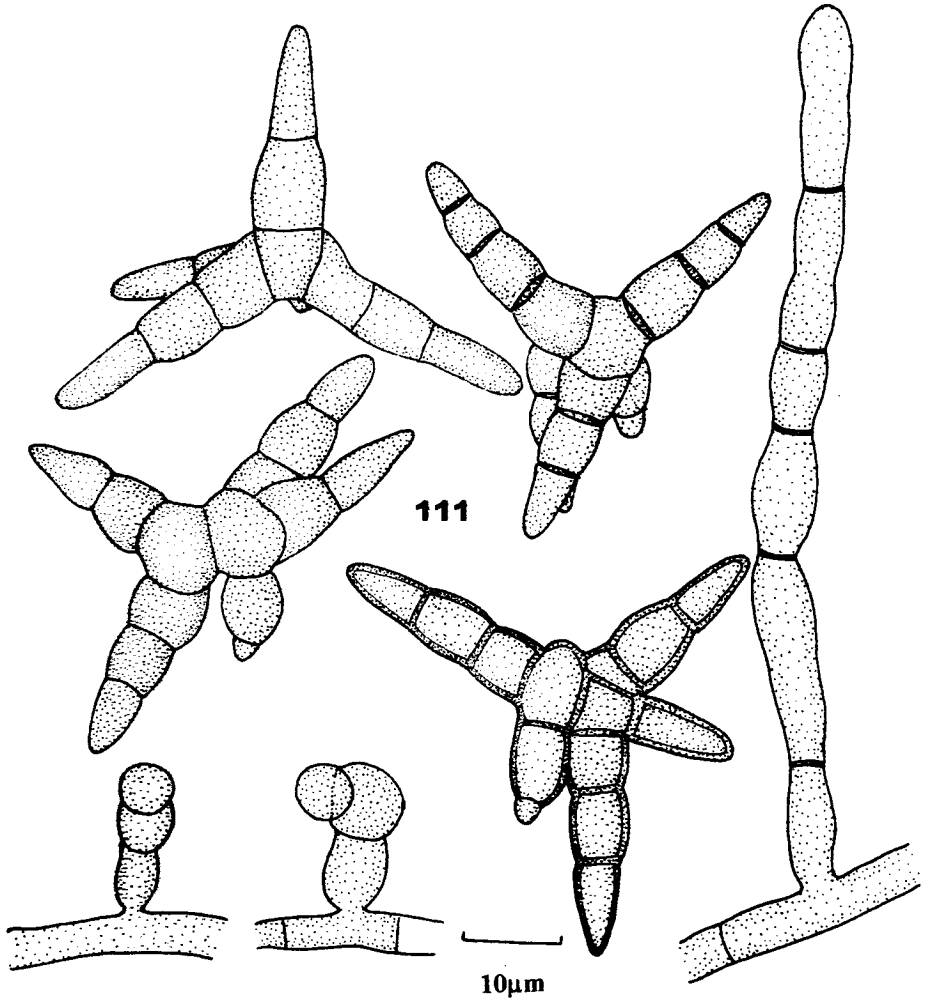

107
10µm
20µm

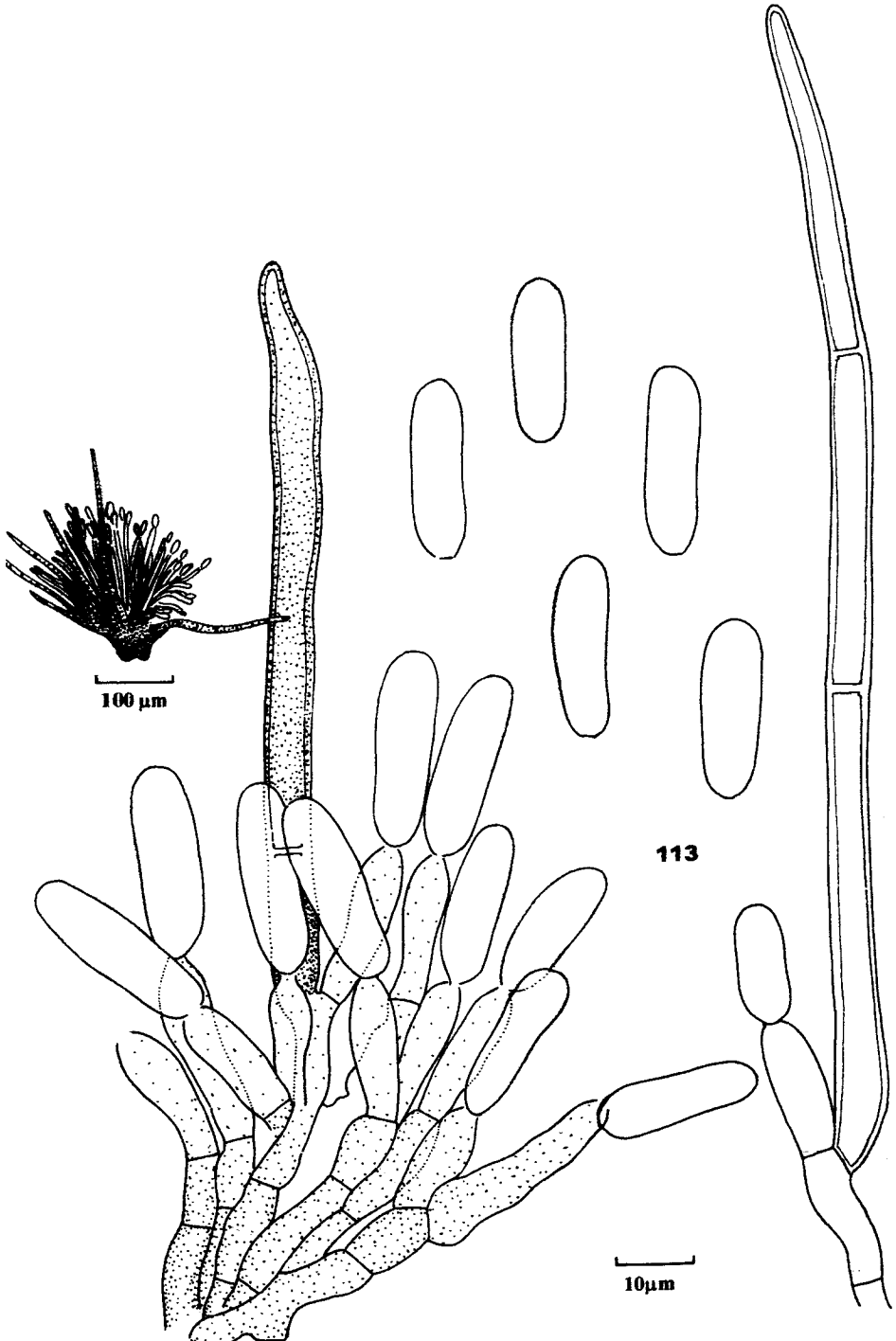

108
10µm

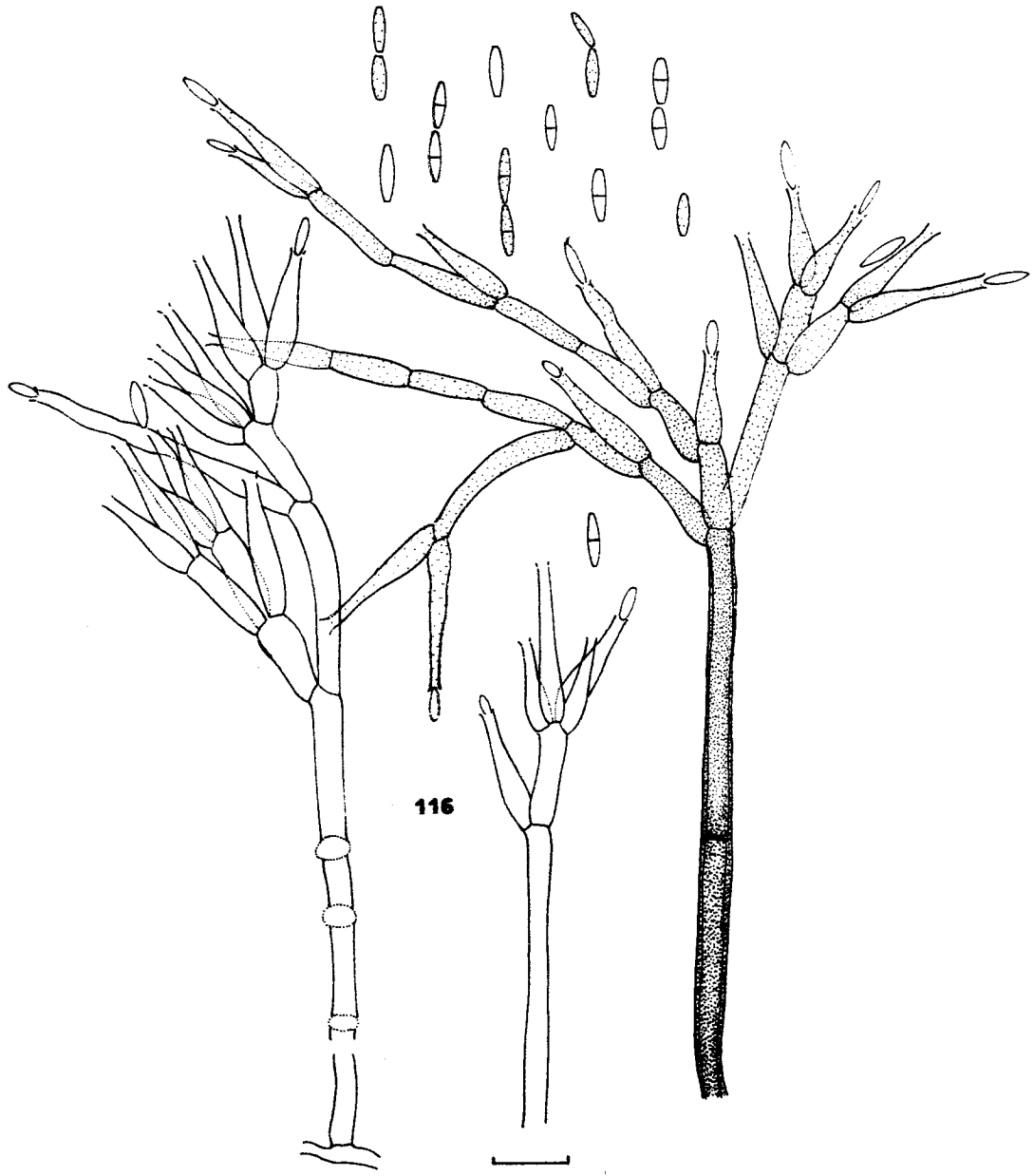

109
10µm
20µm

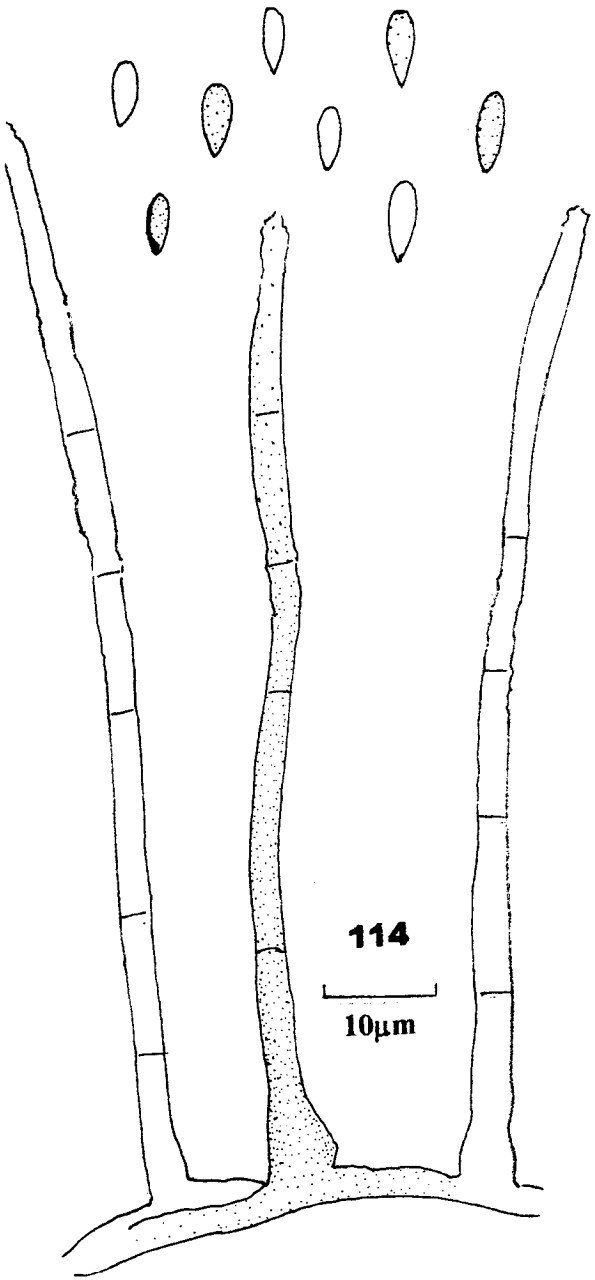

110
10µm
20µm
10µm

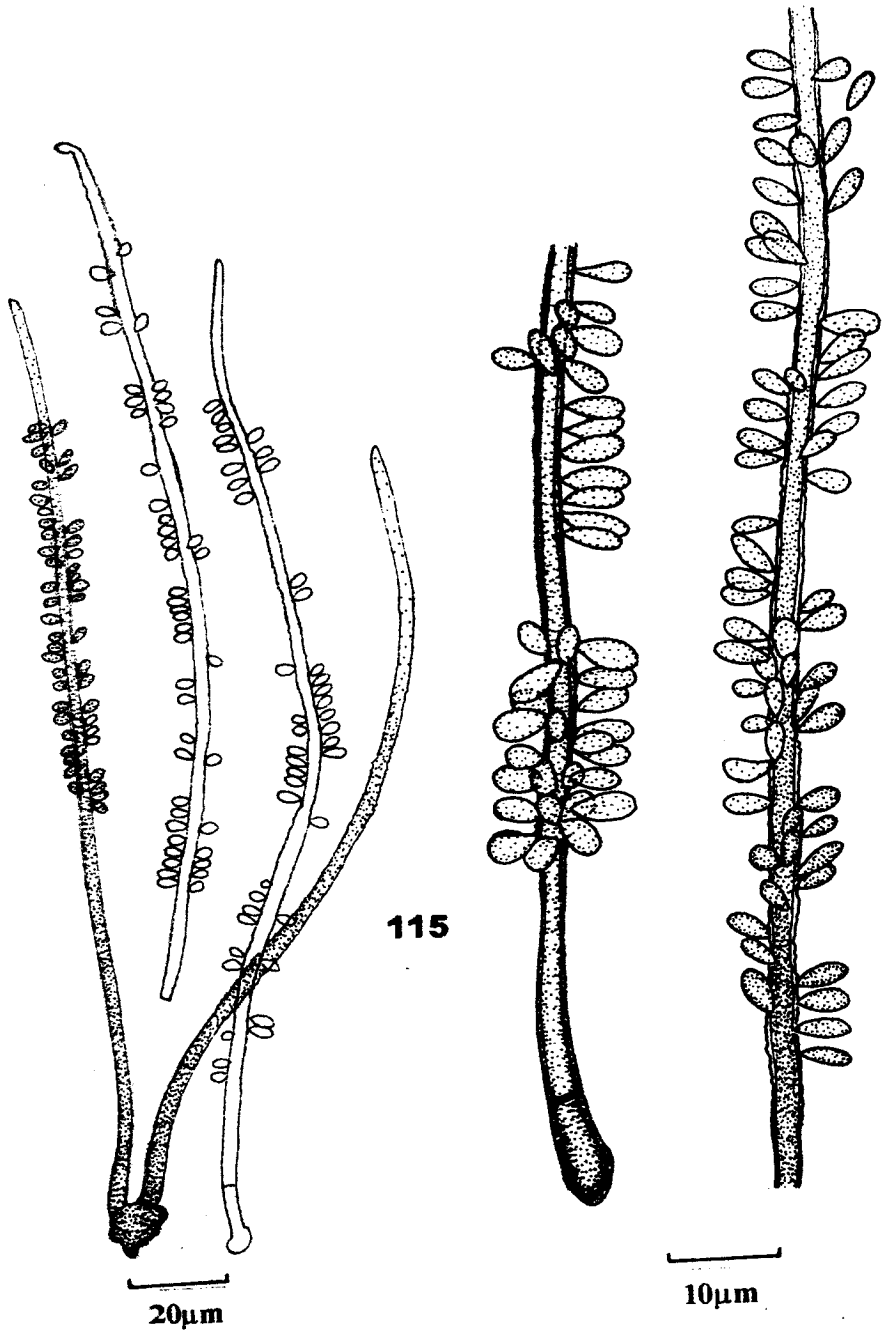

112

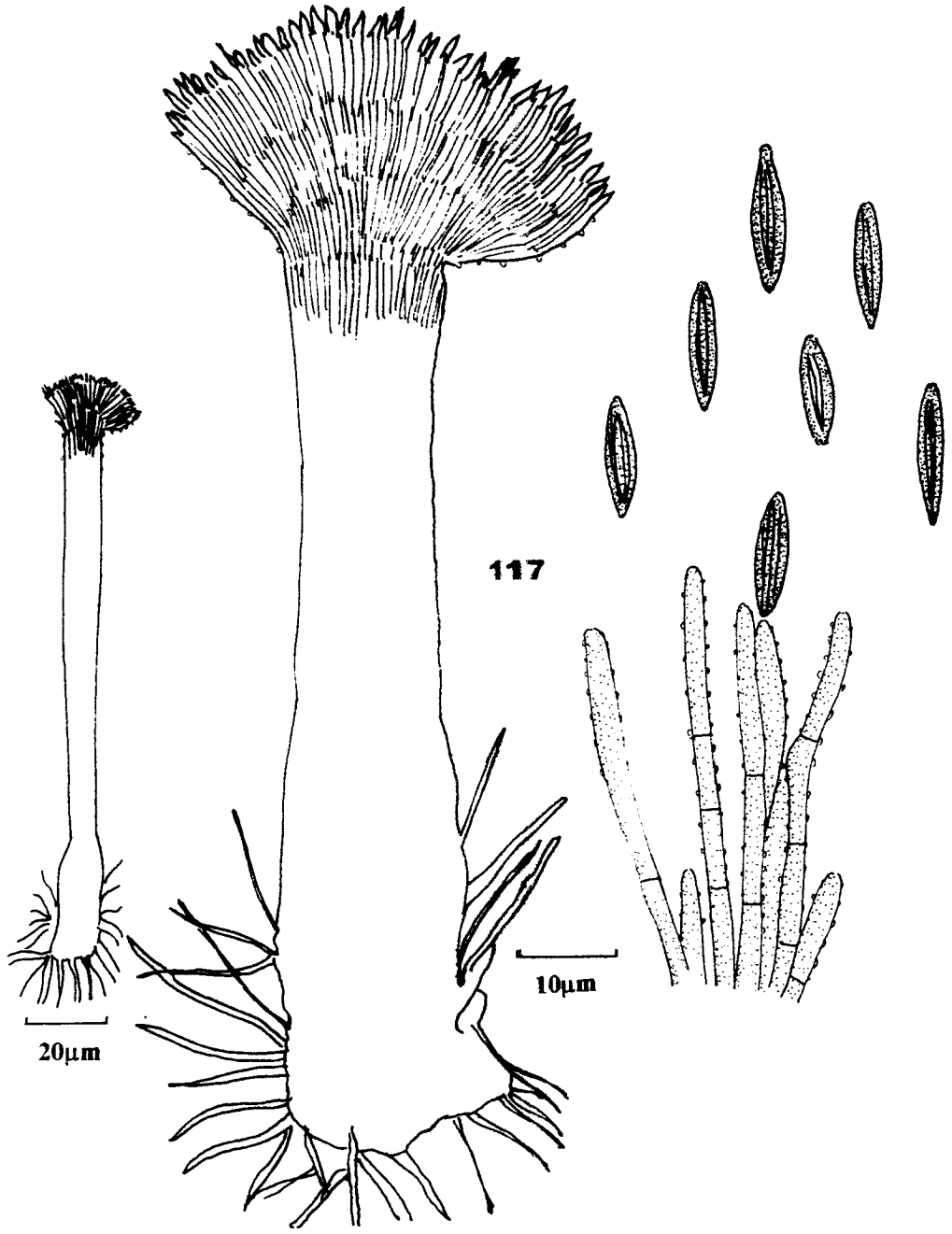

111
10µm

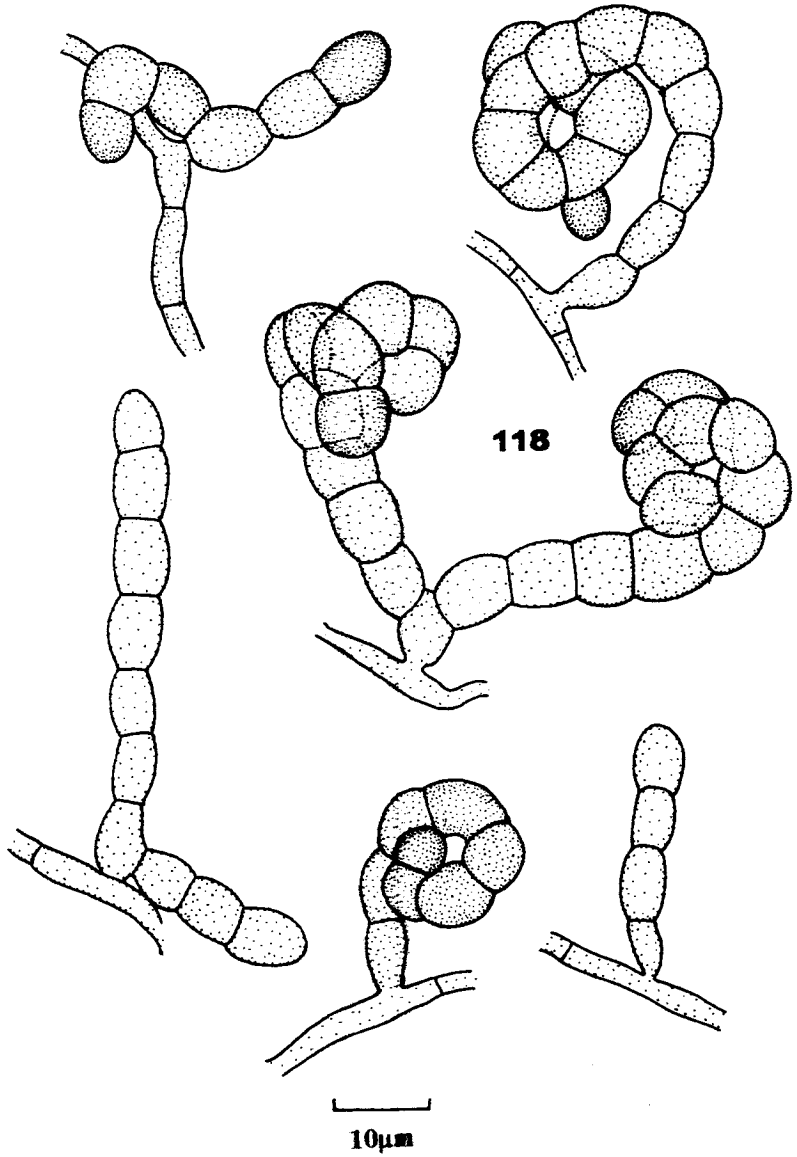

100 µm
113
10µm


116


114
10µm


115
20µm
10µm


117
20µm
10µm


118
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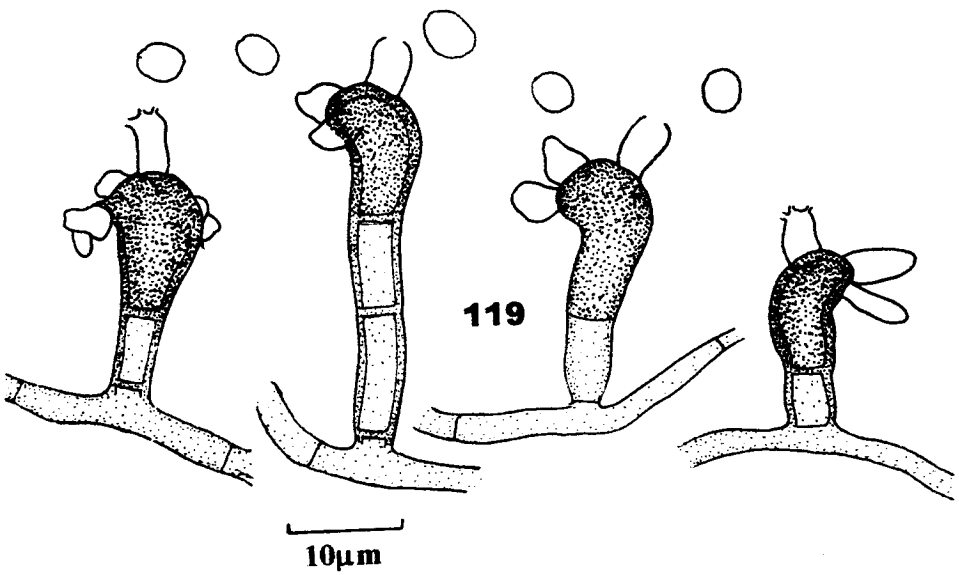
119
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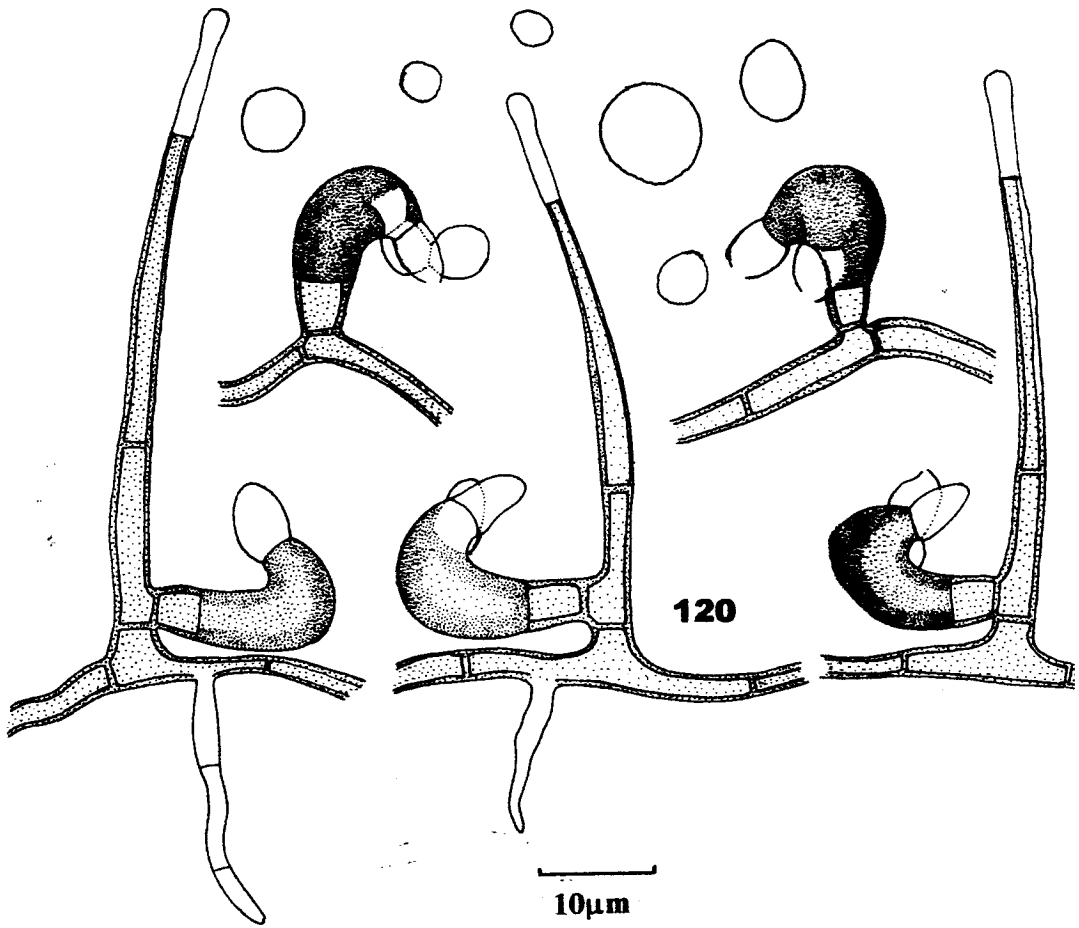

120
10µm

Plate: 4.1.

1. ***Acrodictys bambusicola***:	Conidiophore and a conidium
2. ***Trichobotrys saprophyticus*** **sp. nov.**:	Conidiophore and conidia
3. ***Acrogenospora sphaerocephala***:	Conidiophore and a conidium
4. ***Beltraniella pini***:	Conidiophore and conidia
5. ***Brachysporiella gayana***:	Conidiophore and conidia

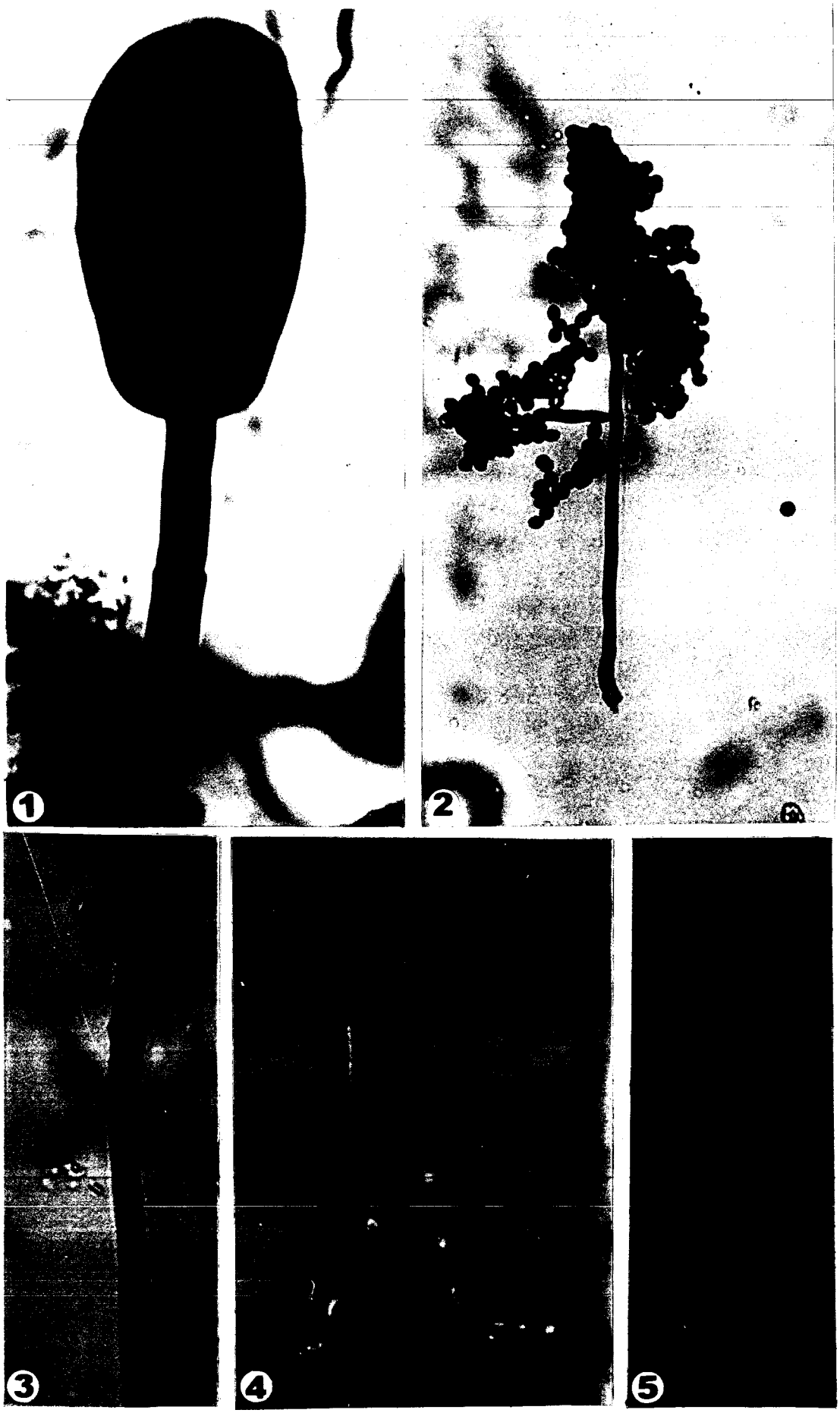


Plate: 4.1

Plate: 4.2.

1. ***Spadicoides calamii* sp. nov.**: Conidiophore and conidia

2. ***Catenularia malabarica***: Conidiophore and conidia

3. ***Heteroconium* sp.**: Conidiophore and conidia

4. ***Exserticlava vasiformis***: Conidiophore and conidia

5. ***Hemicorynespora mitrata***: Conidiophore and conidia

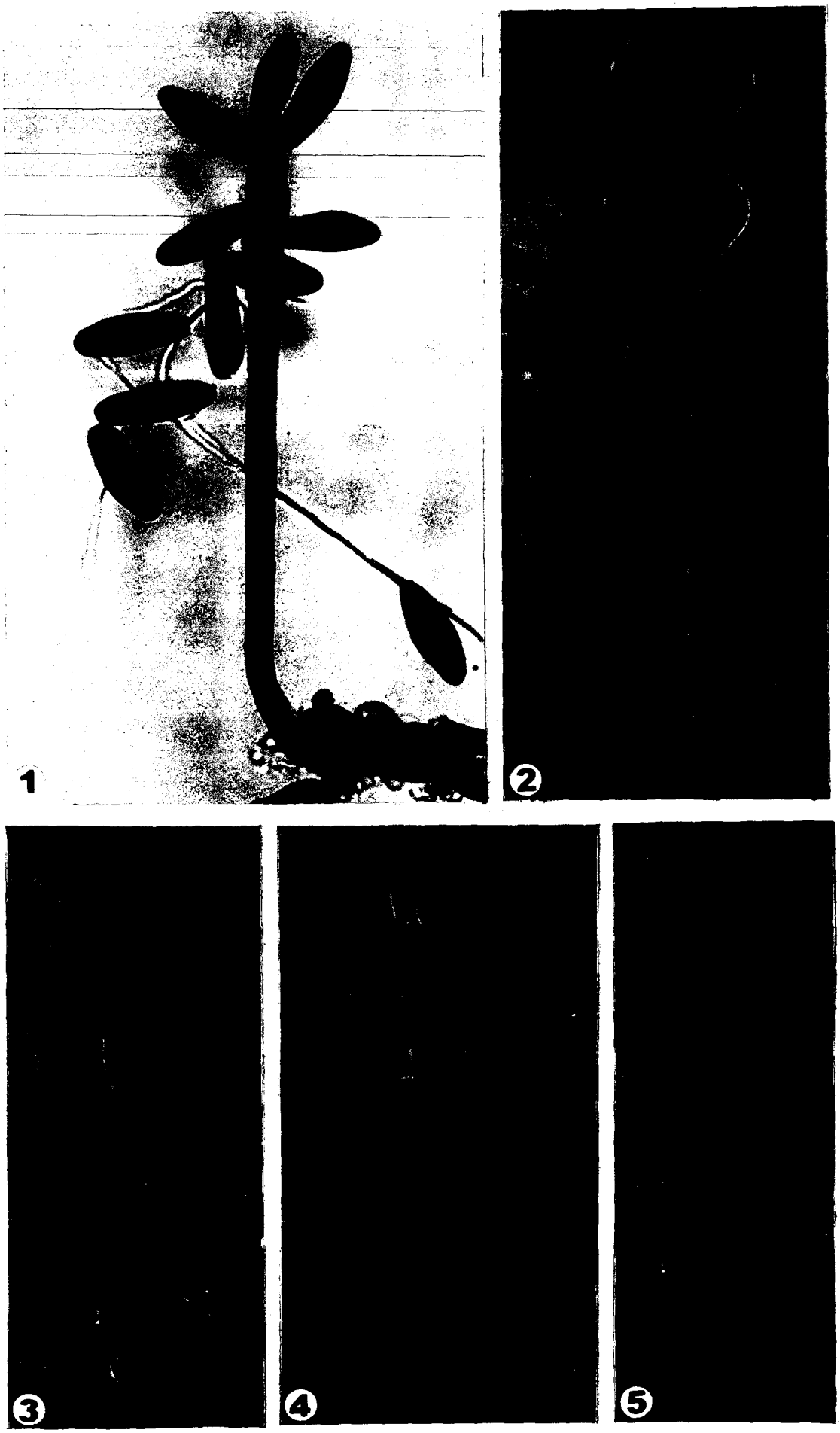


Plate: 4.2

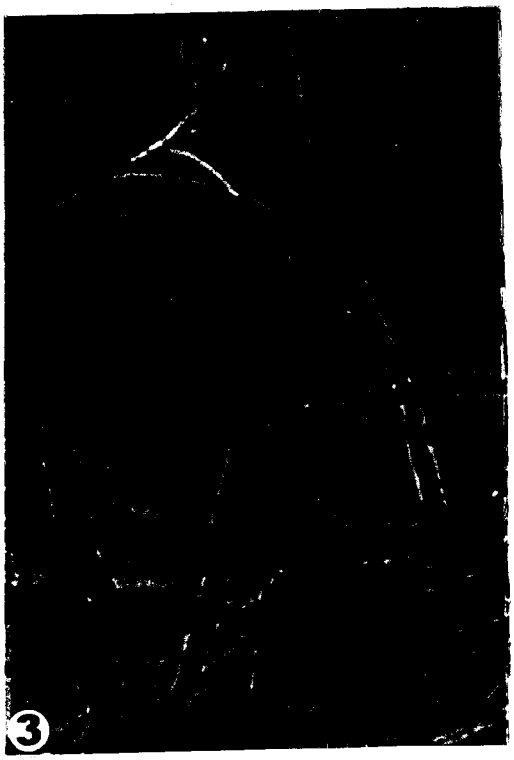
Plate: 4.3.

1. ***Curvularia lunata***: Conidiophore and conidia

2. ***Chaetomella circinata***: Conidiomata

3. ***Aquaphila ramdayalea* sp. nov.**: Conidiophores and conidia

4. ***Monodictys monilicellularis***: Conidia



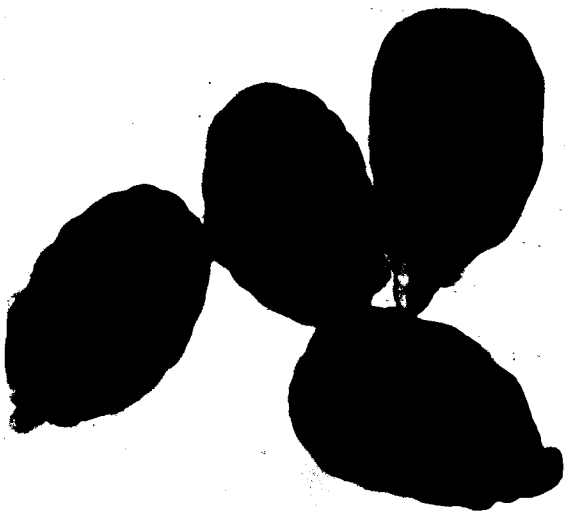


Plate: 4.3

Plate: 4.4.

1. ***Gangliostilbe indica***: Synnemata and conidia

2. ***Beltrania rhombica***: Conidiophore and conidia

3. ***Dictyosporium elegans***: Conidia

4. ***Hermatomyces tucumanensis***: Conidia

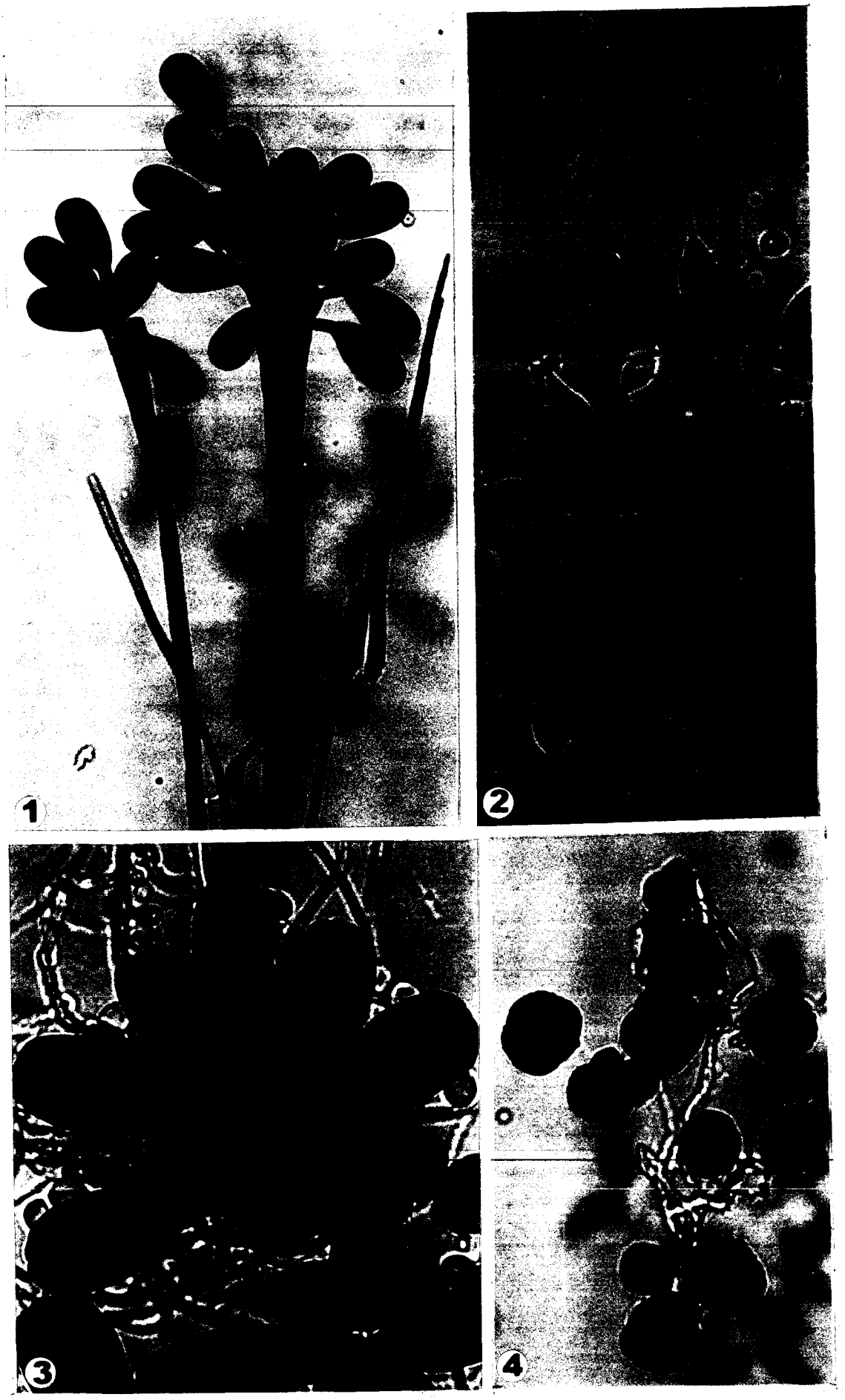


Plate:4.4

Plate: 4.5.

1. ***Helminthosporium palmigenum***: Conidiophore and conidia

2. ***Helminthosporium velutinum*** : Conidiophore and conidia

3. ***Periconia byssoides***: Conidiophore and conidia

4. ***Periconia echinochloae***: Conidiophore and conidia

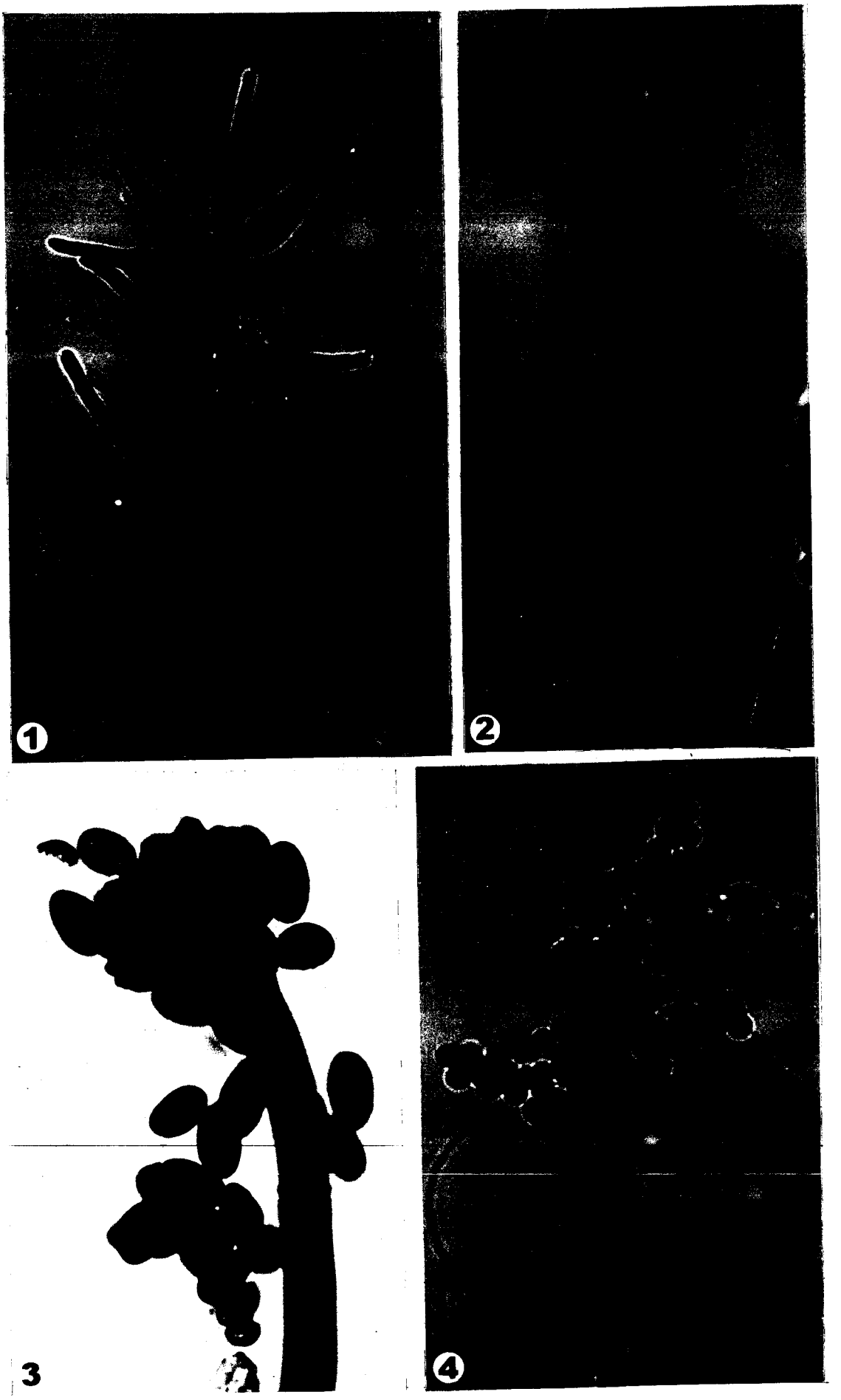


Plate: 4.5

Plate: 4.6.

1. ***Lacellinopsis spiralis***: Conidiophore and conidia

2. ***Sporoschima nigroseptatum***: Conidiophore and conidia

3. ***Paschimghateeya goanensis*** **sp. nov.**: Conidiophore and conidia

4. ***Sporidesmium*** **sp.1**: Conidiophore and conidia

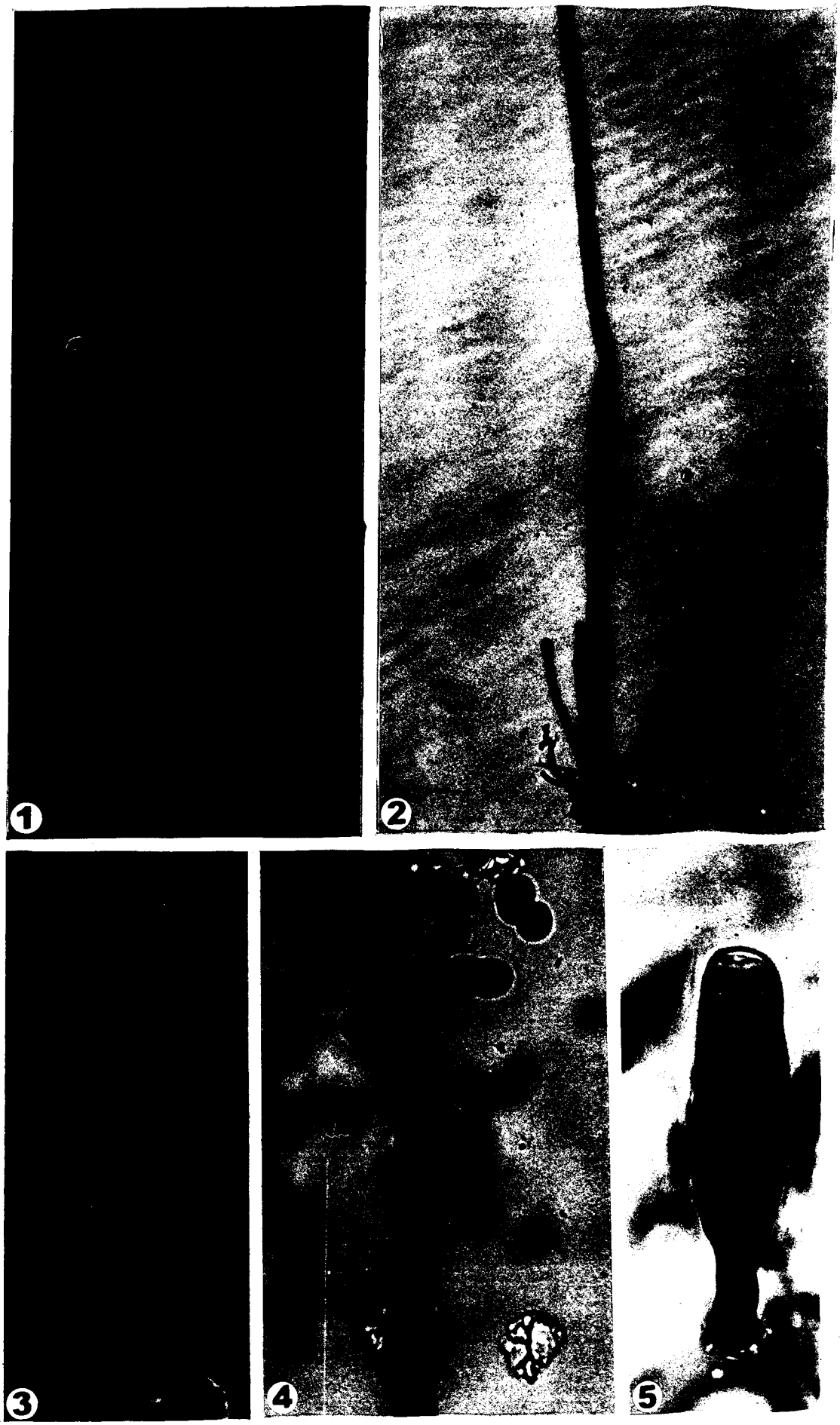


Plate: 4.6

Plate: 4.7.

1. ***Tetraploa aristata***:	Conidium
2. ***Torula herbarum***:	Conidiophore and conidia
3. ***Zalerion curcumensis*** **sp. nov.**:	Conidiophore and conidia
4. ***Pteroconium pterospermum***:	Conidiomata and conidia

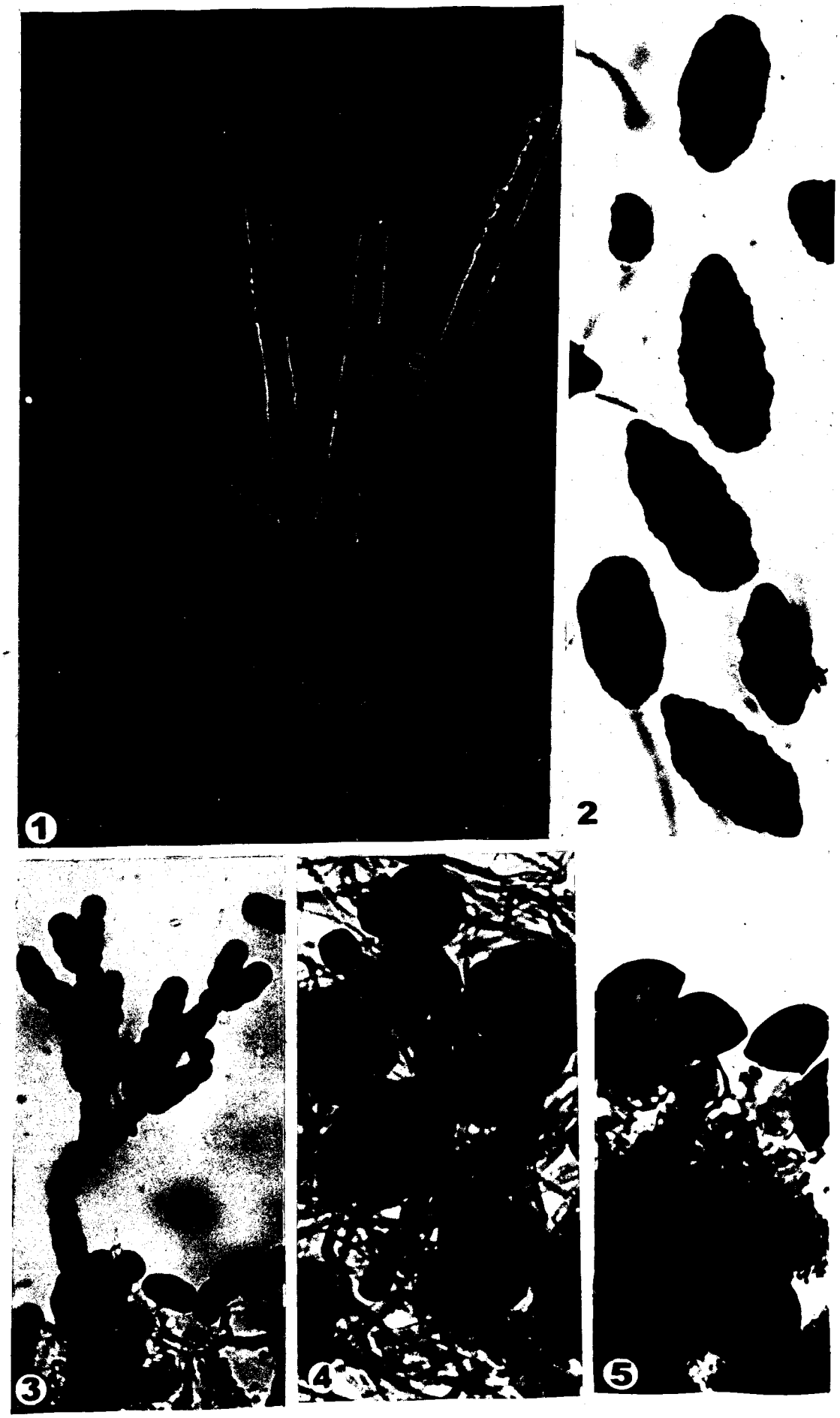


Plate: 4.7

PART 1-B: SUBSTRATE SPECIFICITY OF MICROFUNGI ASSOCIATED WITH DIFFERENT PLANT SPECIES:

In a thought provoking presidential address to the British Mycological Society, Hawksworth (1991) emphatically stressed that live and dead plant substrates in the tropics harbour diverse fungi in abundance. Bills and Polishook (1994) working with tropical plants of Costa Rica further added that fungi occurring on different hosts vary in their floristic composition, particularly at species level. These authors further indicated that the entire gamut of microfungal association with plant parts would be revealed only on application of different isolation techniques together.

In the present work, an effort was made on this direction of study. Twenty-six widely distributed plant species of both dicot and monocot from the forests of Western Ghats in Goa were subjected to recovery of associative litter and endophytic microfungi using different isolation techniques. It has been predicted that fungi in the tropics would be at their best in fruiting and production of spores during monsoon (Subramanian, 1983). It was thought that application of different recovery techniques together would not only elaborate the association of fungi with plants but also bring out a composite picture on the distribution and abundance of the mycota in a particular niche.

Fallen, decaying leaf litter and fresh, live and disease free leaves of these plants were scanned for fungi by employing 3 different isolation techniques. The litter fungi were isolated using (i) moist chamber incubation and (ii) particle- plating recovery methods and the endophytic fungi were recovered following (iii) 3-step surface sterilization method. The methods are detailed in Chapter III.

As can be seen from the results, it is evident that a diverse and large number of microfungi were isolated from different plant substrates. In all, 388 microfungi were

recovered from the 26 plant species. They belonged to major taxonomic groups such as the Hyphomycetes (224) , Ascomycetes (14) and Coelomycetes (20), besides non-sporulating forms (130). In the absence of sporulation, the taxonomic identity of several non-sporulating forms recovered is not known at this moment and they are recognised merely based on cultural characters such as colony morphology, growth rate and pigmentation. In the descending order of abundance, the fungi associated with plant species were in this order: Hyphomycetes and non-sporulating forms (maximum) and Coelomycetes and Ascomycetes (minimum). It is evident from the results that fungi belonging mainly to Hyphomycetes and non-sporulating forms were the major colonizers of the litters of plant species as exhibited by their species abundance.

When moist chamber technique was used, litter fungi isolated in case of dicot plant species ranged from a minimum of in *Ficus religiosa* and *Ficus benghalensis* and a maximum of 19 in *Bauhinia purpurea* whereas with the monocots, the fungal species recovered were in the range of a minimum of 2 in *Bambusa arundinacea* and *Ensete superbum* and a maximum of 22 in *Elaeis guineensis*. In particle plating technique, the recovery of microfungi from litter of dicot plant species was almost double and ranged from a minimum of 3 in *Hydnocarpus laurifolia* to a maximum of 45 in *Syzygium cumini*. In the monocots, however, the minimum was 8 in *Sanseiviera zeylanica* and maximum 45 species in *Elaeis guineensis* (Table No. 4.1.3.).

Isolation of endophytes from the dicot plants showed a minimum of 5 in *Flacourtia montana* and a maximum of 21 in *Syzygium cumini*. A minimum of 7 in *Calamus thwaitesii* and *Caryota urens* and a maximum of 23 in *Elaeis guineensis* was recorded from the monocot plants in endophyte recovery (Table No.4.1.4). If only one technique had been applied, as generally done elsewhere by most workers, the recovery

of fungi would have been in a very low order whereas application of different techniques yielded recovery of a large number of fungi. It is clear from the Figure 4.1.1. that application of different isolation techniques together resulted with the recovery of a large number of associative fungi from any plant species studied.

Large number and a variety of fungi were isolated from litter and live parts of the plants studied. These fungi were assignable to major groups, namely Ascomycetes, Coelomycetes, Hyphomycetes and nonsporulating forms. The Table 4.1.5. shows that Hyphomycetes were the largest group in terms of number and kinds of fungi associated, followed by non-sporulating, Coelomycetes and Ascomycetes with most plants. Of the plants studied, in monocots, the recovery of Hyphomycetes was 88% and nonsporulating forms 12%. In dicots, the recovery percent ratio of Hyphomycetes and non-sporulating forms was 70:30.

To be abundantly cautious, it should be stated that the identity of non-sporulating forms is not known at this stage. As and when these morphotypes sporulate, it will be possible to identify them down to species level and make statements with finality.

With regard to plant substrate, live or dead, the number of fungi (both litter inhabiting and endophytes) appeared were common to most of the plant species studied while a few were restricted to specific plants. Not a single fungus was found to occur on all the 26 plant species scanned. Amongst the fungi recorded, only three showed more than 50% association with plant species. That is, *Cladosporium herbarum* was found to occur on 20 plant species, viz. *Dendrocalamus strictus, Bambusa arundinacea, Bauhinia purpurea, Calamus thwaitesii, Caryota urens, Curcuma decipens, Dillenia indica, Hydnocarpus laurifolia, Elaeis guineensis, Ficus religiosa, Ficus benghalensis, Flacourtia montana, Helictris ixora, Ixora brachiata, Mangifera indica, Psychotria*

dalzellii, Syzygium cumini, Tectona grandis, Xylia xylocarpa and *Zanthoxylum rhetsa,* whereas *Vermiculariopsiella elegans* sp.nov. was common to the following 17 plants: *Bambusa arundinacea, Bauhinia purpurea, Calamus thwaitesii, Curcuma decipens, Dendrocalamus strictus, Elaeis guineensis, Ensete superbum, Flacourtia montana, Ficus religiosa, Ficus benghalensis, Helictris ixora, Hydnocarpus laurifolia, Mangifera indica, Pandanus tectorius, Psychotria dalzellii, Sanseiviera zeylanica* and *Zanthoxylum rhetsa. Cochliobolus lunatus* was common to following 17 plants: *Bambusa arundinacea, Calamus thwaitesii, Caryota urens, Dendrocalamus strictus, Ensete superbum, Ficus tinctorius* var. *parasitica, Ficus religiosa, Helictris ixora, Hydnocarpus laurifolia, Mangifera indica, Pandanus tectorius, Psychotria dalzellii, Sageraea laurifolia, Syzygium cumini, Tectona grandis* and *Zanthoxylum rhetsa.*

The following fungi showed more than 50% association with the plants studied: *Cladosporium herbarum* (84.61%), *Cochliobolus lunatus* (65.38%) and *Vermiculariopsiella elegans* sp. nov. (65.38%). It may also be inferred that these plants are major substrate or hosts for the fungi. The fungi such as *Acremonium* sp.1, *Cladosporium cladosporioides, Cylindrocladium* sp., *Dactylella* sp., *Dictyochaeta assamica, Fusarium decemcellulare, Fusarium solani, Idriella lunata, Penicillium* sp.1, *Trichoderma lignorum* and and Undetermined Ascomycete sp.3, showed association with less than 50% of the plants studied.

The common and exclusive genera found in the plant species are detailed out in the Fig. 4.1.3 and Table 4.1.6.

As seen in the Table 4.1.6., a few of the fungi recovered were isolated more than once but from the same plant during the course of study period. It has been observed that these fungi were specific to the plant host and did not occur on any other plants. It may

Fig. 4.1.1. Number of fungi (species/morphotypes) isolated from plants (dicot and monocot) using different techniques

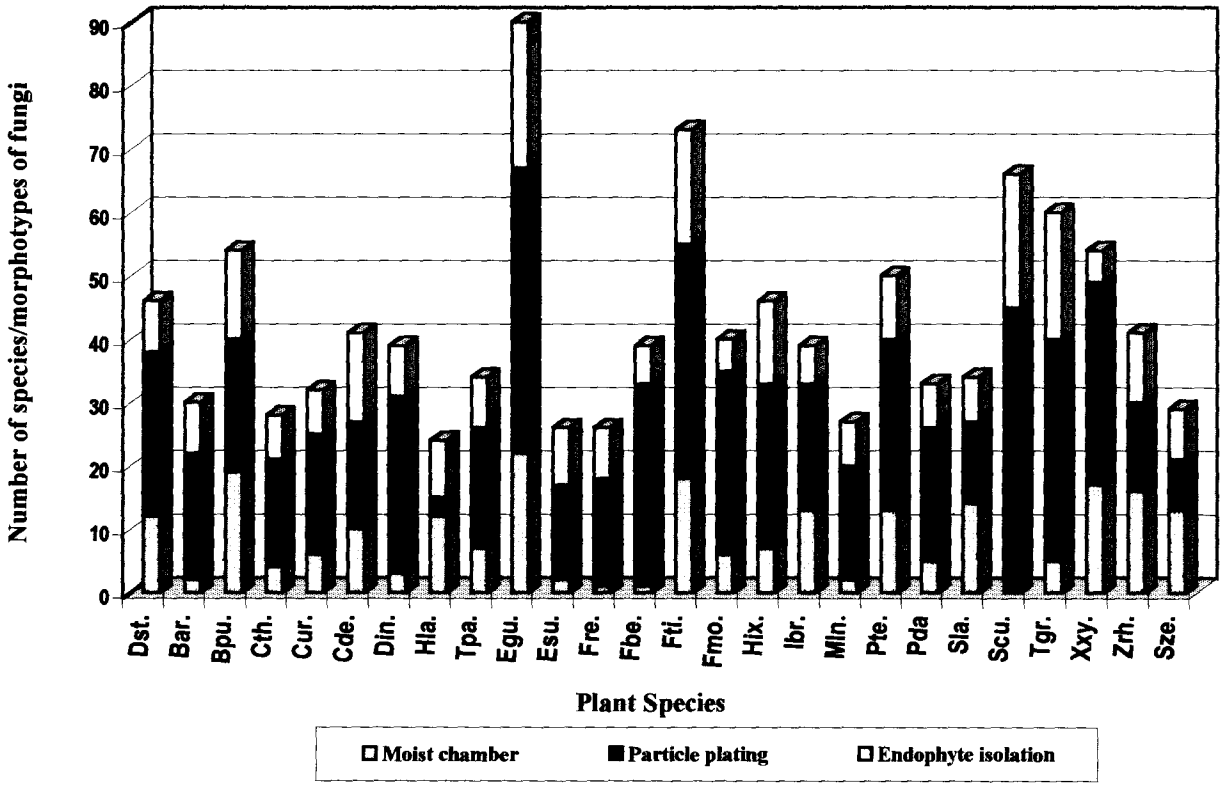


Fig. 4.1.2. Number of fungi (species /morphotypes) belonging to different groups

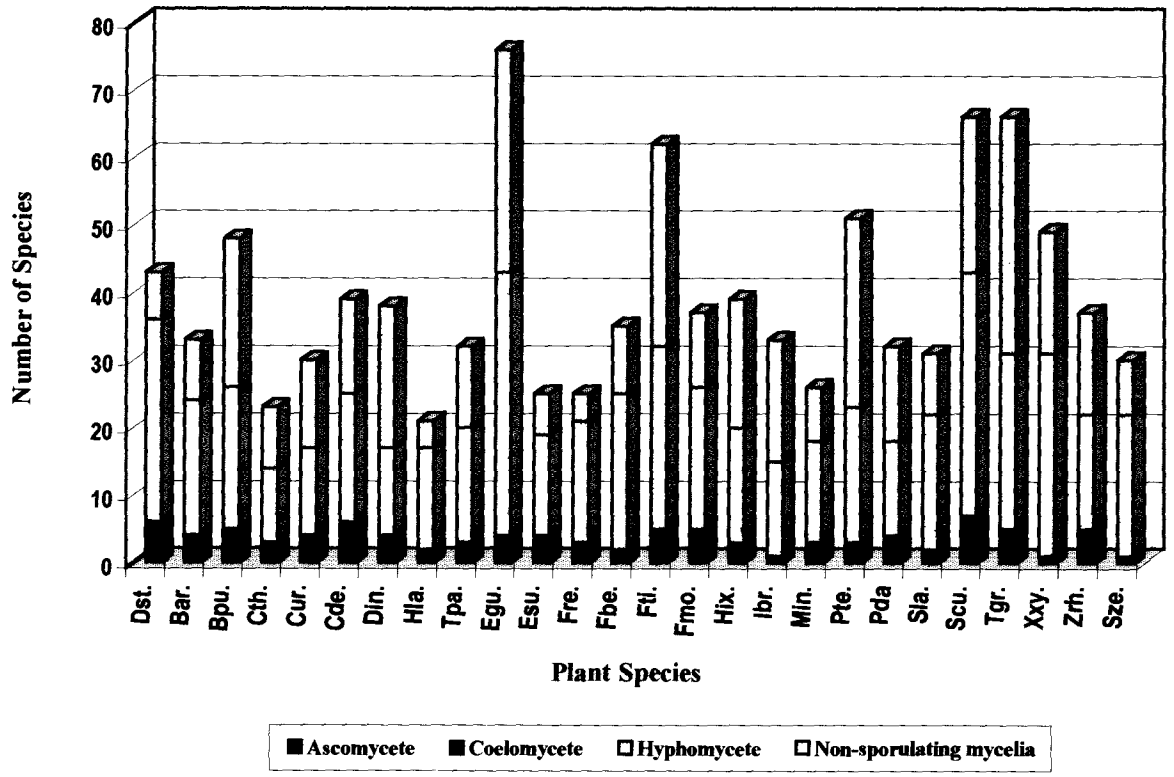
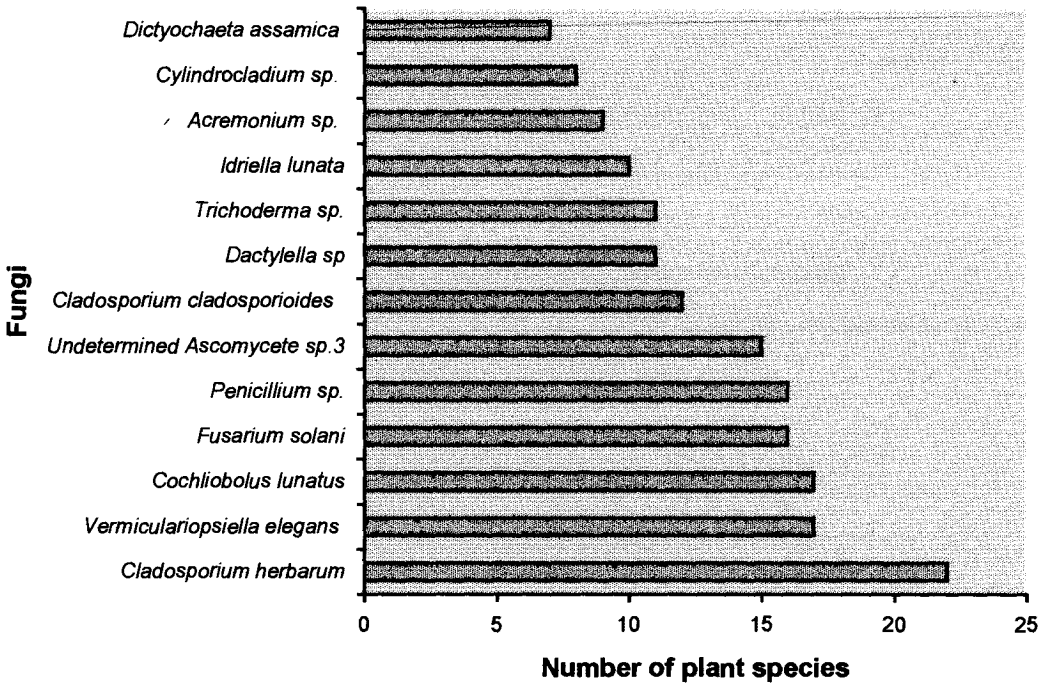


Fig. 4.1.3. Occurence of fungi on plant species.



be presumed that these fungi do not colonize other plants and their occurrence is limited to only one or a few plant species. Such substrate specificity in plants by fungi was predicted by Boddy and Griffith (1989) and Whalley (1993) and the results presented here were in conformity.

PART II: SEASONAL OCCURRENCE OF AND SPECIES RICHNESS IN LITTER AND ENDOPHYTIC FUNGI OF FOUR PLANT SPECIES STUDIED:

The interactions with plants exhibited by fungi, be it saprophytic, parasitic and/or mutualistic, are of considerable significance in the functioning of an ecosystem. In the dynamics of nutrient cycling, saprophytic fungi by their ability to decompose all kinds of substrates in variety of habitats constitute the major players. Parasitic fungi on the other hand, by inflicting harmful effects, also exert considerable pressure on plant growth and distribution. Mutualists, while deriving nutrients directly, in return supply otherwise difficult nutrients such as P and N to plants (Kendrick, 1992; Dix and Webster, 1995). A new dimension of fungal association with higher plants was realised in the last decade, the endophytes, wherein fungi asymptomatically living within the plant parts and exerting certain beneficial pressure on plant growth was brought to light (Bills, 1996).

The association of fungi with plants and plant parts and their ecology was a subject of considerable interest during the last 3-4 decades and the investigation carried out world over in this area is reviewed at length in Chapter II. Perusal of literature clearly indicates that fungi exhibit substrate/host specificity and seasonality in colonisation and spatial distribution with regard to various climatic, geographical, physical and chemical factors. Further, all groups of fungi participate, sometimes in succession, and facilitate complete decomposition of the substrate.

While some knowledge was available from elsewhere, more realistic information on this issue was gathered in this laboratory by an earlier work on association of fungi with two native dicot plants, namely *Ficus benghalensis* and *Carissa congesta* by Miriam (2000). The present work is an additional serious effort with special emphasis on study of diversity and seasonality of fungi occurring on many more and various types of plant species.

In this Part, studies on seasonal occurrence and species richness of litter and endophytic fungi with respect to four plants, viz., *Saraca asoca* and *Careya arborea* (dicot) and *Calamus thwaitesii* and *Dendrocalamus strictus* (monocot), were carried out for two years, during February 1999 to January 2001. In order to gather knowledge on commonness and contrast in qualitative and quantitative occurrence of fungi, certain ground considerations were made in the choice of the plant species. Both from Bondla and Molem, one each of monocot and dicot plants was chosen; *Saraca asoca* and *Calamus thwaitesii* were from Bondla and *Careya arborea* and *Dendrocalamus strictus* from Molem. In each locality, the chosen plants were present about 50 m apart from each other, but exposed to the same environmental conditions. Such care in the choice of plant material was taken primarily to ensure that the results could be comparable.

The seasons considered for the study were pre-monsoon (February-May), monsoon (June- September) and post-monsoon (October- January). The recovery techniques used for isolation of litter fungi included moist chamber incubation and particle plating techniques whereas for endophytes '3-step surface sterilization' technique was followed. It has been observed that all the 3 techniques were very efficient and maximum recovery of fungi was possible.

4.2.1. Seasonal occurrence of fungi

From Tables 4.2.1. and 4.2.2., it is evident that, following different isolation methods adapted in this work, the recovery of fungi from 4 plant substrates was substantial. Isolates were sorted into morphological species and identified as best as possible. Number of isolates and species derived from each sample were analysed separately.

In all, a total of 4461 isolates distinguishable into 402 taxa of litter and endophytic fungi belonging to Zygomycetes (1), Ascomycetes (12), Coelomycetes (14), Hyphomycetes (209) and Non-sporulating forms (166) were recovered. Nevertheless, from all seasonal sampling and isolations, a large number of non-sporulating forms were recovered and these were distinguishable only as morphotypes. Because of the taxonomic uncertainty of this large number of non-sporulating forms, species were not pooled across the samples. The rarefaction indices based on the expected number of species in a random sub sample of 70 individuals from each sample of plant substrate was calculated. Similarly the species richness was also recorded. The results with respect to each plant species are given below:

(i) In *Saraca asoca*, in the first year of study, a total 415 isolates assignable to 91 taxa of fungi were sourced. The minimum number of species isolated was 29 in monsoon and maximum 32 in pre-monsoon. The rarefaction indices indicated that the substrate was richer in species composition during pre-monsoon, i.e. $E(S_{70}) = 23$. In 2000-01, a total 812 isolates belonging to 186 taxa of microfungi were recovered. The number of species isolated ranged from a minimum of 57 in pre-monsoon to a maximum of 67 in post-monsoon. Rarefaction indices showed that the expected number of species was richer in the post-monsoon season, i.e. $E(S_{70}) = 35$ (Fig. 4.2.1.a.; Fig. 4.2.2.a.).

(ii) In *Calamus thwaitesii*, for the year 1999-2000, a total 387 isolates of 105 taxa of microfungi were isolated. The number of species isolated ranged from a minimum of 30 in monsoon to a maximum of 39 in pre-monsoon. The rarefaction indices based on the expected number of species in a random subsample of 70 isolates from the sample indicated that plant substrate during pre-monsoon was richer in species composition, i.e. $E(S_{70}) = 33$. In the subsequent year, 2000-01, a total 676 isolates belonging to 186 taxa of microfungi were recovered. The number of species isolated ranged from a minimum of 51 in post-monsoon to a maximum of 71 in pre-monsoon. The rarefaction indices based on the expected number of species were similarly richer in species composition in the premonsoon season, i.e. $E(S_{70}) = 36$ (Fig. 4.2.1.b; Fig. 4.2.2.b.).

(iii) In *Careya arborea*, during 1999-2000, a total 592 strains belonging to 198 taxa of fungi were isolated. The number of species ranged from a minimum of 35 in monsoon to a maximum of 73 in post-monsoon. The rarefaction indices indicated that the test plant during post-monsoon was richer in species composition, i.e. $E(S_{70}) = 32$. During 2000-01, a total 608 isolates belonging to 167 taxa of fungi were recovered. The number of species isolated was 54 (minimum) both monsoon and post-monsoon and 59 (maximum) in pre-monsoon. Rarefaction indices based on the expected number of species showed postmonsoon season as richer, i.e. $E(S_{70}) = 43$ (Fig. 4.2.1.c.; Fig. 4.2.2.c.).

(iv) In *Dendrocalamus strictus*, in 1999-2000, 403 isolates belonging to 122 taxa were isolated. The number of species recovered ranged from a minimum of 33 in monsoon to a maximum of 53 in post-monsoon. The rarefaction curve plotted indicated that the plant substrate during pre-monsoon was richer in species composition, i.e. $E(S_{70}) = 36$. In the subsequent year, 2000-01, a total 568 isolates belonging to 175 taxa of

microfungi were recovered. The number of species isolated ranged from a minimum of 52 in pre-monsoon to a maximum of 63 in post-monsoon. The rarefaction indices showed richer $E(S_{70})$ value (i.e. 38) in the post-monsoon season (Fig. 4.2.1.d.; Fig. 4.2.2.d.).

4.2.2. Species richness:

The results indicated that, in general, species composition of fungi was maximum during pre-monsoon season of both years in all the 4 plant species studied. The percent species richness in each plant studied during 1999-2000 was as follows: In *Calamus thwaitesii*, 39.4; in *Saraca asoca*, 23.19; in *Careya arborea*, 30.89; in *Dendrocalamus strictus*, 50.7. The performance of the plants in the second year of study was as follows: In *Calamus thwaitesii*, 33.49; in *Saraca asoca*, 26.63; in *Careya arborea*, 52.68; in *Dendrocalamus strictus*, 28.89. As can be seen from the results, in *Dendrocalamus strictus*, a slight decline in the species richness was observed in the second year of analysis though number of fungi was significantly higher. If one goes with the major part of the results obtained, it can safely be said that fungal species richness is highest in plants studied during pre-monsoon.

Further, amongst the plant species studied, *Dendrocalamus strictus* (30.58) and *Careya arborea* (30.41) showed more richness in their species composition than *Calamus thwaitesii* (27.37) and *Saraca asoca* (22.57). Although only four plants being analysed at this stage of work, it may be inferred that the habitat of *Dendrocalamus strictus* and *Careya arborea*, Molem wildlife sanctuary, is richer in its fungal species composition than that of *Calamus thwaitesii* and *Saraca asoca*, i.e. Bondla wilflife sanctuary.

Table: 4.2.1. **Number of isolates and species of fungi recovered from fresh leaves and decaying plant parts of 4 plants studied during 1999-2000:**

Plant species	Seasons	Total isolates	Total species	Zygo-	Asco-	Coelo-	Hypho-	NSM	$E(S_{70})$	S_r
Calamus thwaitesii	Pre-Mon	99	39	-	4	1	27	7	32.75	39.4
	Monsoon	94	30	-	2	2	18	8	26.14	31.92
	Post-Mon	194	36	-	2	2	23	9	19.73	18.55
Saraca asoca	Pre-Mon	138	32	-	3	4	15	10	22.4	23.19
	Monsoon	142	30	-	4	3	16	7	22.31	21.13
	Post-Mon	135	29	-	3	3	21	2	21.42	21.48
Careya arborea	Pre-Mon	123	38	-	4	3	20	11	27.13	30.89
	Monsoon	176	35	-	2	1	22	10	22.29	19.89
	Post-Mon	293	73	1	1	5	37	29	32.30	24.91
Dendrocalamus strictus	Pre-Mon	71	36	-	2	-	25	9	35.66	50.70
	Monsoon	110	33	-	1	2	23	7	25.84	30
	Post-Mon	222	53	-	3	3	40	7	26.53	23.87

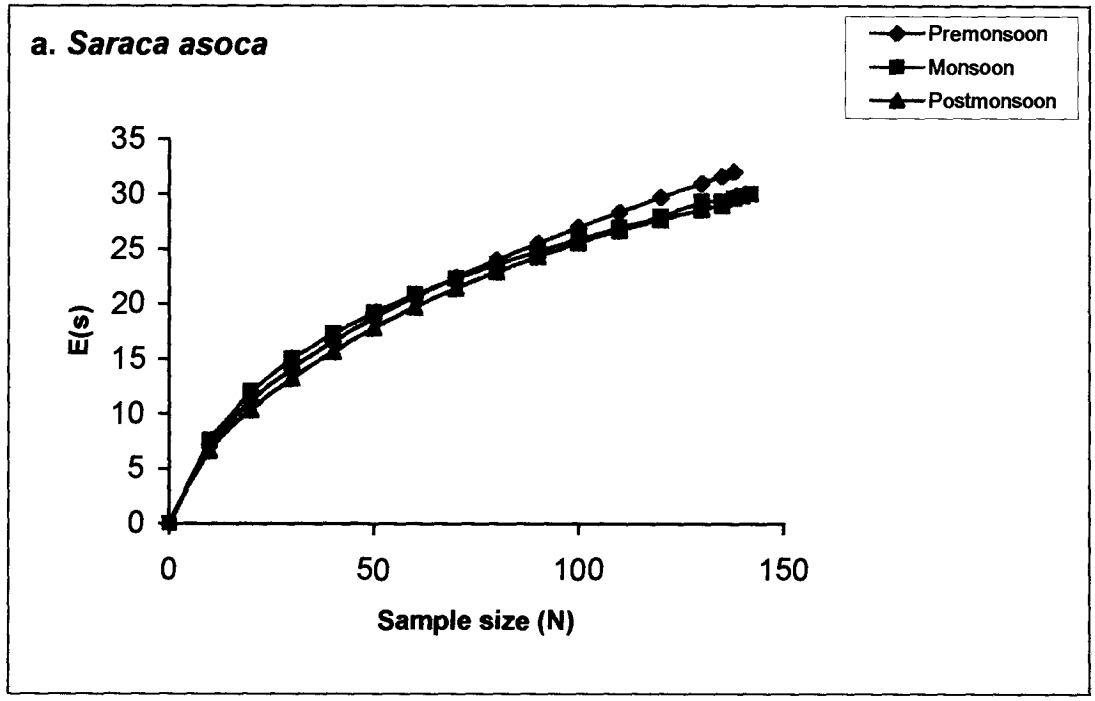
Table: 4.2.2. **Number of isolates and species of fungi recovered from fresh leaves and decaying plant parts of 4 plants studied during 2000-2001:**

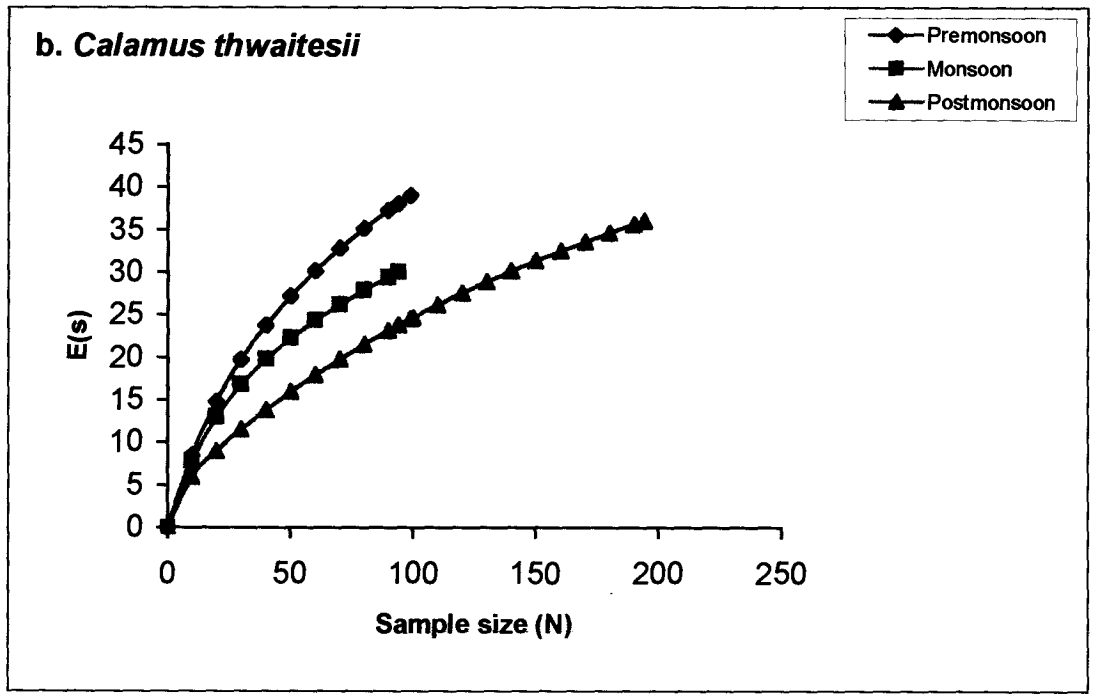
Plant species	Seasons	Total isolates	Total species	Asco-	Coelo-	Hypho-	NSM	$E(S_{70})$	S_r
Calamus thwaitesii	Pre-Mon.	212	71	1	2	49	19	36	33.49
	Monsoon	277	64	1	3	39	21	34.25	23.10
	Post-Mon.	187	51	1	4	34	12	32.06	27.27
Saraca asoca	Pre-Mon.	214	57	4	3	28	22	31.30	26.63
	Monsoon	314	62	2	3	35	22	29.75	19.74
	Post-Mon.	284	67	1	4	30	32	34.58	23.59
Careya arborea	Pre-Mon.	112	59	1	5	36	17	42.84	52.68
	Monsoon	242	54	3	7	32	12	26.45	22.31
	Post-Mon.	254	54	2	3	24	25	25.86	21.26
Dendrocalamus strictus	Pre-Mon.	198	52	-	3	32	17	30.18	26.26
	Monsoon	252	60	1	3	31	25	25.11	23.80
	Post-Mon.	218	63	-	3	37	23	37.58	28.89

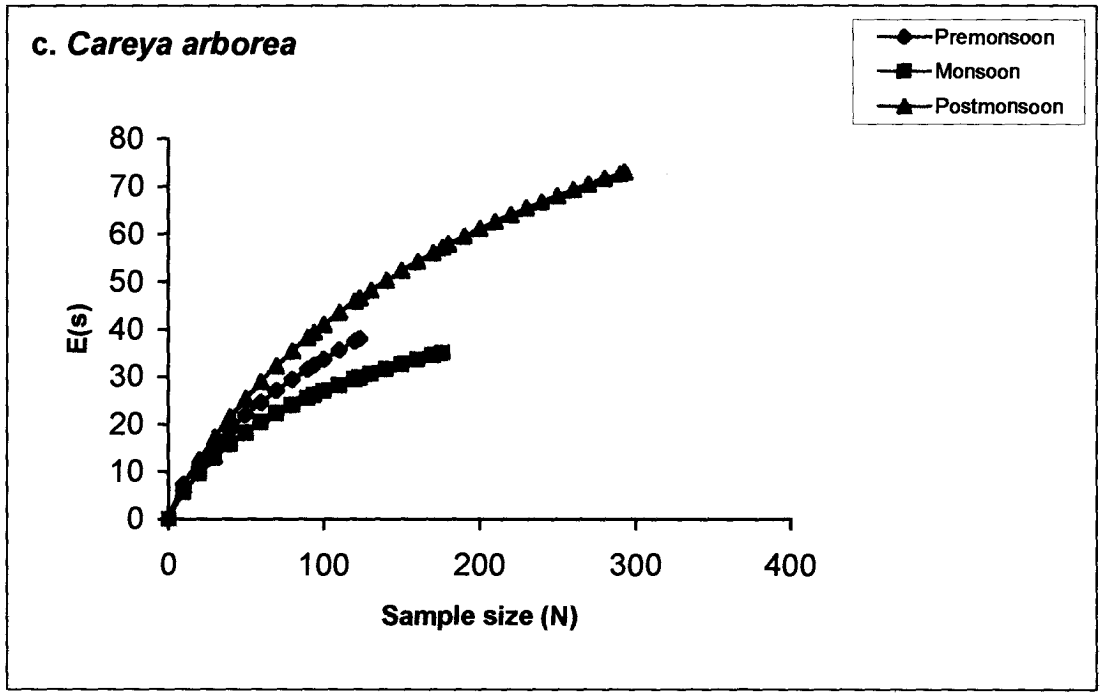
Table 4.2.3: **Jaccard Similarity Coefficient for the litter and endophytic fungi from 4 plant species as expressed in percentage (%):**

Plant species	*Calamus thwaitesii*	*Saraca asoca*	*Careya arborea*	*Dendrocalamus strictus*
Calamus thwaitesii	100	27.05	23.48	28.69
Saraca asoca		100	18.93	23.26
Careya arborea			100	21.19
Dendrocalamus strictus				100

Fig. 4.2.1.a-d. **Rarefaction curves for microfungi isolated from 4 plant species during 1999-2000. The expected number of species [E(s)] of the isolates obtained by 3 recovery techniques.**






c. Careya arborea
Premonsoon
Monsoon
Postmonsoon
E(s)
0
10
20
30
40
50
60
70
80
0
100
200
300
400
Sample size (N)

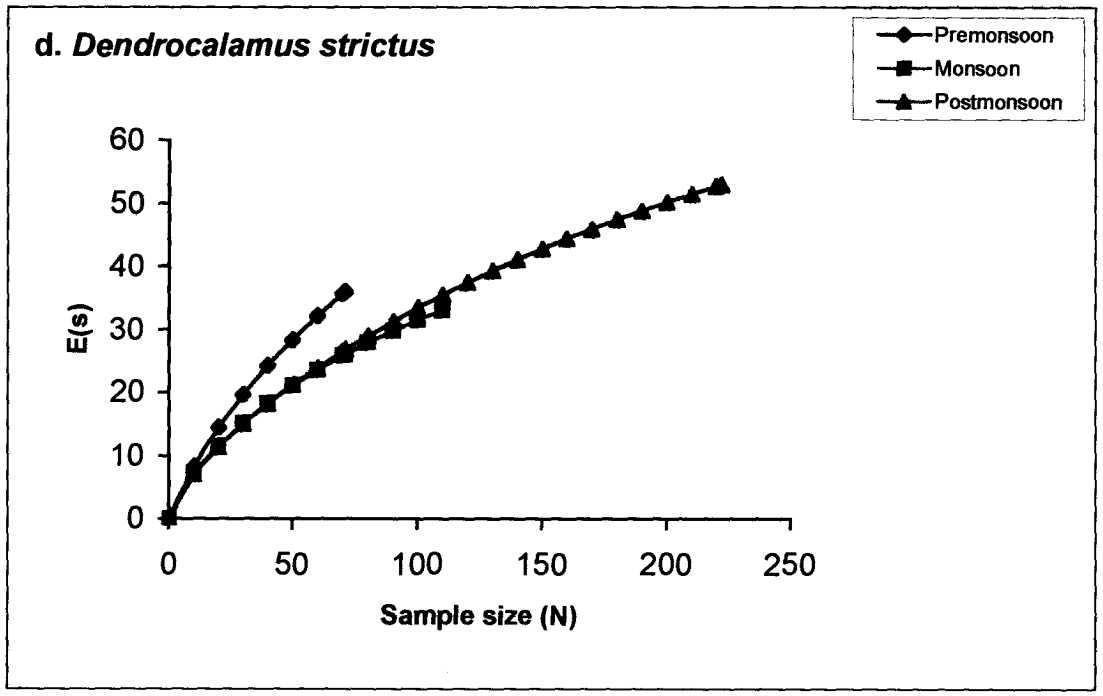
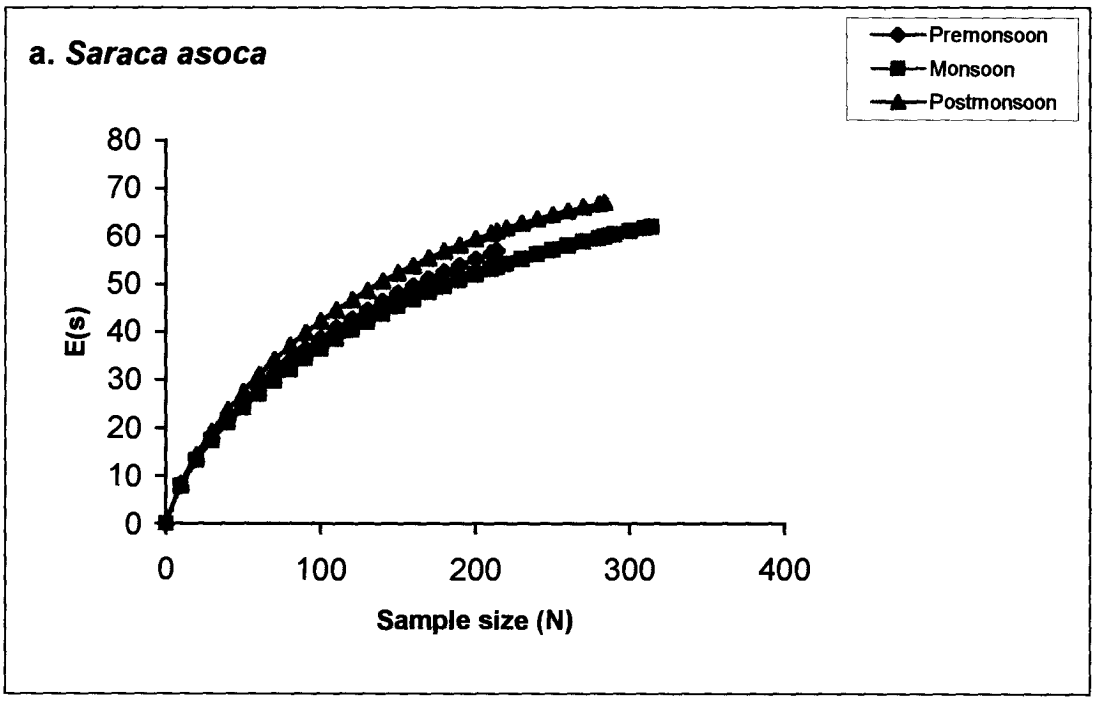
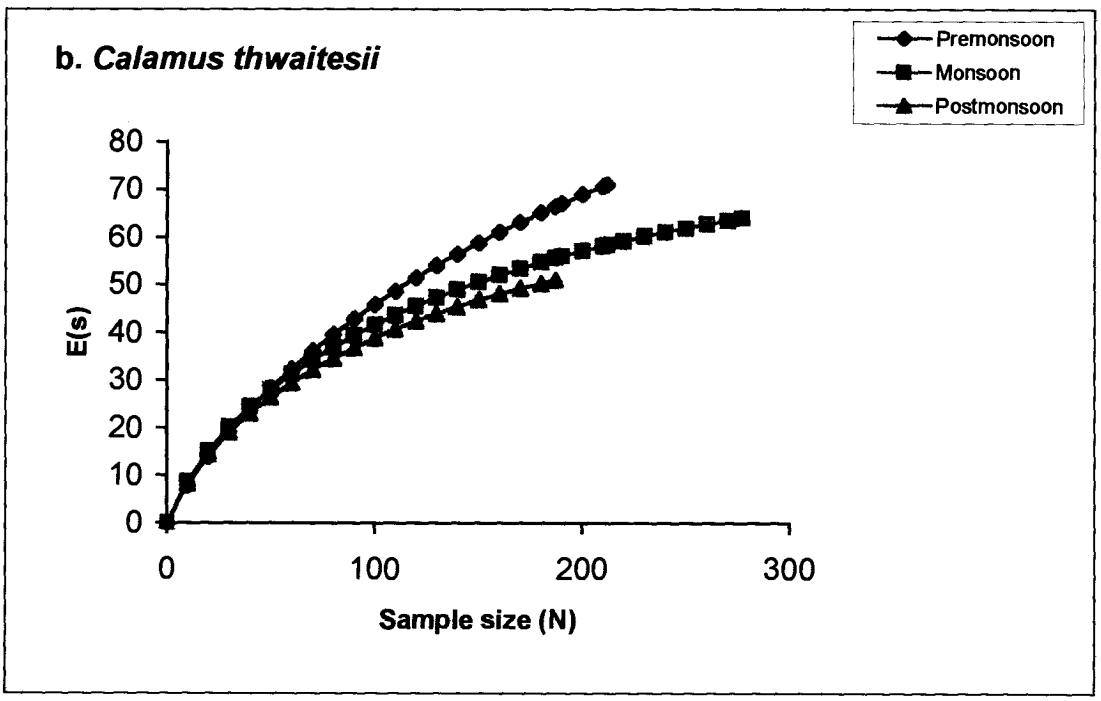
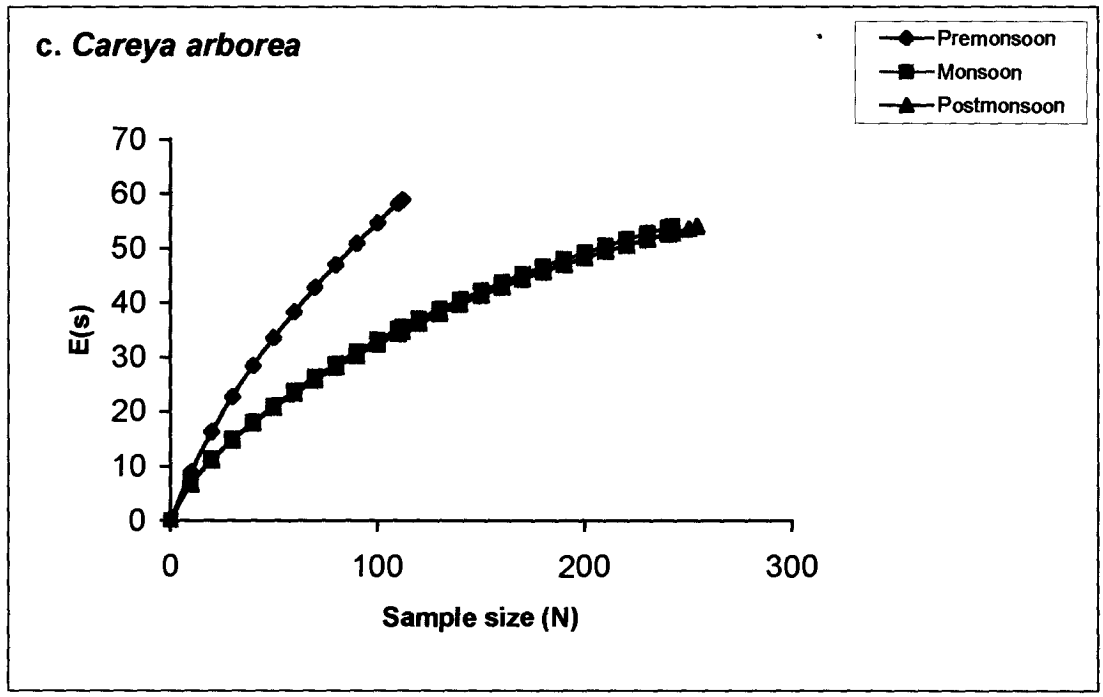
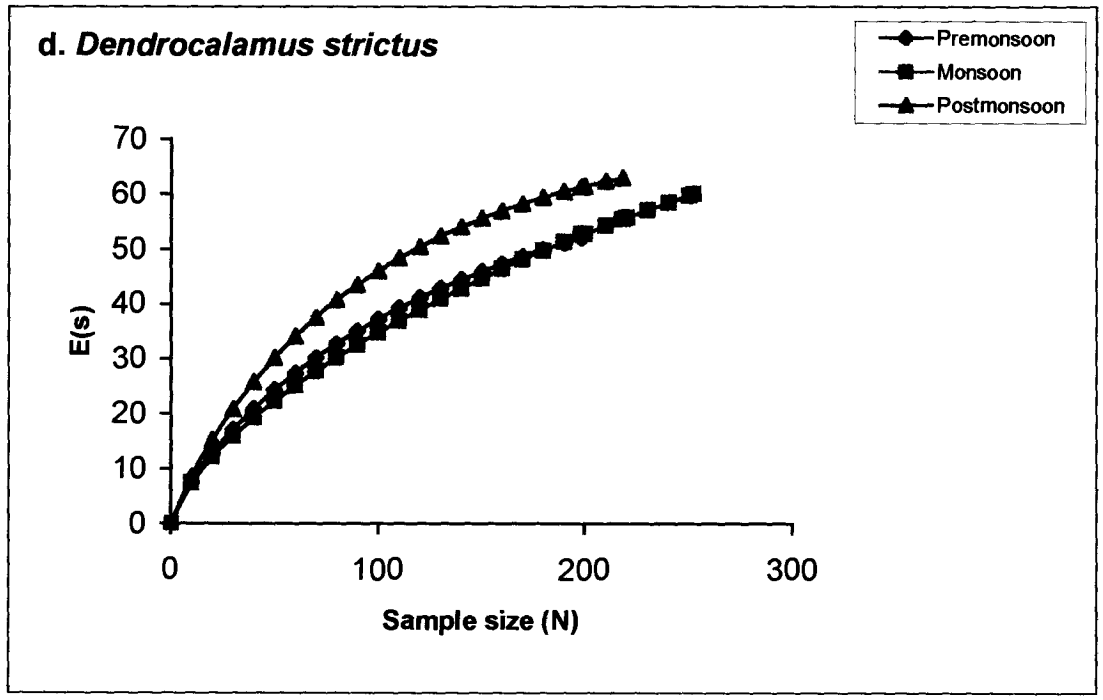

d. Dendrocalamus strictus
Premonsoon
Monsoon
Postmonsoon
E(s)
0
10
20
30
40
50
60
0
50
100
150
200
250
Sample size (N)

Fig. 4.2.2.a-d. **Rarefaction curves for microfungi isolated from 4 plant species during 2000-2001 The expected number of species [E(s)] of the isolates obtained by 3 recovery techniques.**






c. Careya arborea
Premonsoon
Monsoon
Postmonsoon
70
60
50
40
30
20
10
0
E(s)
0
100
200
300
Sample size (N)


d. Dendrocalamus strictus
Premonsoon
Monsoon
Postmonsoon
70
60
50
40
30
20
10
0
E(s)
0
100
200
300
Sample size (N)

In order to compare the similarity of species composition of fungi between host plants, the data on number of fungal species recovered from each plant was subjected to Jaccard's similarity coefficient analysis. The Jaccard's similarity coefficient showed that the composition of fungi recovered from two plant species, i.e. *Calamus thwaitesii* and *Saraca asoca* did not overlap by more than 27.05% and the other two plant species, i.e. *Careya arborea* and *Dendrocalamus strictus* by 21.19%, though these plants, i.e. *Calamus thwaitesii* and *Saraca asoca* in Bondla wildlife sanctuary and *Careya arborea* and *Dendrocalamus strictus* in Molem wildlife sanctuary, lie in proximity to each other and were practically exposed to the same environmental conditions and fungal inoculum (Table: 4.2.3.).

PART III: **SUCCESSION OF MICROFUNGI ON *CAREYA ARBOREA* AND *DENDROCALAMUS STRICTUS*:**

Decomposition of plant litter in soil is largely attributed to the activity of a composite group of microorganisms which includes fungi, bacteria, nematodes and protozoans. It is presumed that they function in succession and undertake the degradation process. The part played by fungi has been investigated by several workers (Webster, 1956, 1957; Khanna, 1964; Meridith, 1962; Dickinson, 1965; Yadav, 1966; Rai, 1973; Vittal, 1973; Sudha, 1978; Dorai, 1988) and it is reviewed in an earlier Chapter.

An *in situ* exercise termed 'litter-bag experiment' was conducted in order to analyse the role of fungi appearing in succession during the process of decompostion of organic litter. A hand-full of freshly fallen leaf litter of two plant species, namely *Careya arborea* and *Dendrocalamus strictus,* sourced from the forests of Molem wildlife

sanctuary, were kept in separate A4 size nylon mesh bags (mesh size # 3 mm) and placed in the vicinity of same plants in September 2000. The experimental set up was maintained for the subsequent 8 months. One bag each containing leaf litter was brought to the laboratory at monthly intervals and analysed for presence of fungi by subjecting the litter to moist chamber incubation and particle plating isolation techniques. A total of nine samples were examined for the duration of eight months, the first analysis being at the time of placing the bags and this served as control.

Simultaneously, the monthly samples were thoroughly washed, oven-dried, powdered in an electrical blender and analysed for two specific nutrients namely, total organic Carbon and Nitrogen. The C and N content of the leaf litter was calculated on dry matter basis by Walkley-Black method (Jackson, 1973) and by a modified Kjeldahl's method (AOAC, 1984) respectively.

The results are given in Table 4.3.1., 4.3.2. and 4.3.3. As shown in Table 4.3.1, in all, 136 species belonging to 112 genera of fungi were recovered from the two test plants during the 8 month study period. The population of colonised fungi during the period of observation showed decrease or increase in number and types. Certain fungi such as *Cylindrocladium* sp., *Dictyochaeta assamica, Gonytrichum* sp., *Mariannaea elegans* and *Trichoderma lignorum* overlapped in appearance though the fungus flora emerged out from these studies showed distinct differences. Noticeably, several newer fungi such *as Acrogenospora sphaerocephala, Choridium ghaticum* **sp. nov.**, *Dendrosporium lobatum, Dischloridium minutum* **sp. nov.**, *Gangliostilbe indica, Henicospora minor, Idriella malabarica, Kylindria hyalina* **sp. nov.** and *Mariannaea elegans* appeared on the litter which otherwise not observed when leaf litter of the same plants gathered from same place were subjected to seasonal study.

As far as the number of fungi appeared on leaf litter is concerned, in the second month of incubation, the captive litter showed low density of fungi (Fig. 4.3.1). This may be attributed to the initial adjustment of the resident fungal flora to the new environment.

Methods used to analyse the C and N content (%) are given in the Chapter III. The Correlation coefficient (r) is calculated using the period taken for decompositon against C : N ratio. In *Dendrocalamus strictus*, an overall reduction in percent Carbon and concomitant increase in Nitrogen was observed during the decomposition period of eight months. As shown in Table 4.3.2, in September, the 'zero' month which was taken as control, the leaf litter had a highest percent Carbon (39.75), followed by a month (October) where the carbon was the maximum (44.25). In the subsequent 4 months a steadied level of Carbon (38-39.75) was noticed in the litter. The Carbon content in the substrate again raised and steadied during March-May (42.75-43). The percent Nitrogen of litter was found to be highest in 'zero' month, i.e. September (1.05), and further showed similar pattern of Carbon in the following months to steady in May (1.05).

Correlation studies showed that the C : N ratio exerted an inverse relationship (r = - 65995) on rate of litter decay (Table 4.3.2). The period of decomposition is negatively correlated with C : N ratio, i.e. with increase in the duration of decomposition, the proportion of Carbon in the litter decreased whereas the nitrogen increased.

In *Careya arborea*, a clear picture did not emerge out with regard to C : N ratio of leaf litter. The Carbon content in the 'zero' month was 39.75 followed by a sharp increase to 58.5 in October, a similar pattern of *Dendrocalamus strictus*, but further during November to May unlike the monocot plant, the carbon content fluctuated in the

Table: 4.3.1. **Occurrence of fungi on leaf litter of two plants species (Litter-bag experiment):**

Name of fungus	Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		Mar.		April		May	
	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M	D	M
	Cr	Dt	Cr	Dt	Cr	Dt	Cr	Dt	Cr	Dt	Cr	Dt	Cr	Dt	Cr	Dt	Cr	Dt
Ascomycetes																		
Chaetomium funicola	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
Didymosphaeria vaitarnensis	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Xylaria fulva	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Xylaria sp.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coelomycetes																		
Botrydiploidea theobromae	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Minimidochium setosum	+	-	-	+	+	+	-	+	-	+	+	+	-	+	-	+	-	+
Pestalotiopsis sp.	+	-	+	-	-	-	-	+	+	-	-	-	+	-	+	-	-	-
Phoma sp.1	-	+	-	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-
Phoma sp.2	+	+	-	+	-	+	-	+	+	+	-	+	-	-	-	+	-	+
Pycnidial sp.2	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnidial sp.11	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnidial form 3	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	-
Pycnidial form 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Pycnidial form 7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Pycnidial form 8	-	-	-	-	-	-	-	-	+	+	-	+	-	+	-	+	-	+
Hyphomycetes																		
Acremonium sp.1	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Acremonium sp.8	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Acrodictys appendiculata	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acrodictys elaidies	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-
Acrodictys globosa	-	-	-	-	+	+	-	-	-	+	-	-	-	-	-	+	-	+
Acrogenospora sphaerocephala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Agyriella sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Ardhachandra selenoides	+	-	-	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-
Arthrobotrys oligospora	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Aspergillus sp. 1	-	-	-	-	-	-	+	-	+	-	-	-	+	+	+	-	+	-
Aspergillus sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Beltrania rhombica	+	-	-	-	+	-	+	-	-	-	+	-	-	-	-	-	-	-
Beltraniella sp.	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-
Bisporomyces sp.	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	+	-
Brachysporiella gayana	-	-	-	-	-	+	-	-	-	+	+	+	-	-	-	-	-	-
Candelabrum spinulosum	-	-	-	-	-	-	-	+	-	-	-	-	+	-	+	+	+	+
Catenularia malabarica	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-
Chaetendrophragmia triangularia	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetopsina fulva	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	+
Chalara sp.	-	-	-	-	+	-	-	-	-	-	+	-	-	+	+	-	+	-
Chloridium sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+
Circinotrichum maculiforme	+	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	-
Cladosporium sp.4	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
Cladosporium sp.1	+	+	-	-	-	+	+	+	+	-	+	+	+	+	+	+	-	-
Cladosporium sp.2	+	+	-	-	-	+	+	+	-	+	-	+	+	+	+	-	-	-
Cladosporium sp.3	+	+	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
Corynespora sp.	-	+	-	-	-	+	-	+	+	+	-	+	-	+	+	+	-	+
Craspedodidymum albigiense	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Cylindrocladium sp. 1	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	+	+	+
Cylindrocladium sp. 2	+	-	+	-	+	-	+	-	+	+	+	-	+	-	+	-	+	+
Cylindrotrichum sp1.	-	-	-	-	+	-	-	-	-	-	+	-	+	-	+	-	+	-
Cylindrotrichum sp2.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-
Dactylaria sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Dactylella sp.	-	-	+	-	-	+	+	+	-	+	-	+	+	+	+	+	-	+
Dendrosporium lobatum	-	-	+	-	+	-	+	-	+	-	+	-	+	+	+	-	+	-
Dictyochaeta assamica	-	+	+	-	+	+	+	+	+	+	+	+	+	-	+	+	+	-
Dictyosporium elegans	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Dictyosporium sp.	-	+	-	-	-	-	-	-	-	-	+	-	+	-	+	-	-	-

cont...

Didymobotryum spirillum	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Dischloridium sp.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Edmundmasonia pulchra	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+	-	+	-
Elegantimyces sp	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Exserticlava triseptata	-	-	-	-	+	+	-	-	+	-	-	-	+	-	-	-	-	-
Exserticlava vasiformis	-	+	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	-
Fusarium decemcellulare	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Fusarium solani	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+
Gangliostilbe indica	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Gliocladium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Gliomastix sp.	+	+	-	+	-	-	-	+	-	+	+	+	+	-	+	-	+	-
Gonatobotryum apiculatum .	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gonytrichum sp.	-	-	-	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+
Hansfordia sp.	+	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
Helicoma sp.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Helicomyces roseus	-	+	+	-	-	+	-	-	-	+	+	+	+	-	+	+	+	+
Helminthosporium palmigenum	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Helminthosporium velutinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Henicospora minor	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Heteroconium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Idriella lunata	+	-	-	-	-	-	+	-	+	-	-	-	-	-	+	-	-	-
Idriella malabarica	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Isthmotricladia longissima	-	-	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-
Kumbhamaya goanensis sp.	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-
Kylindria hyalina sp. nov.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Mariannea elegans		+			+	+	+	+	+	+	+	+	+	+	+	+	+	+
Monodictys sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Mycovellosiella sp.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myrothecium innundatum	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Nigrospora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Paecilomyces sp.1	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Penicillium sp.1	+	-	-	-	-	-	-	-	+	+	-	+	+	+	+	+	+	+
Penicillium sp. 2	+	-	-	-	-	+	-	-	-	+	-	-	+	-	-	-	-	-
Penicillium sp. 3	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
Phaeoisaria sp.	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Phialosporostilbe setosa	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-	+	-	+
Phialocephala sp.	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-
Piricauda cochinensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pithomyces chartarum	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pleurothecium sp.	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-
Pseudobotrytis terrestris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Pteroconium pterospermum	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	+	+
Pteroconium sp.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Scolecobasidium constrictum	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenoidriella indica	-	-	-	-	-	+	-	-	-	-	+	+	-	-	-	-	+	+
Paschimghateeya goanensis	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	+
Sphaeridium setosum	+	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-
Sporidesmium bambusae	-	-	-	-	-	-	-	-	+	+	-	+	-	-	-	+	-	+
Sporidesmium harknesii	+	-	-	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-
Sporidesmium flagelliforme	-	+	-	-	+	-	-	+	-	+	-	+	+	+	-	+	+	+
Sporodochium sp.	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Sporoschisma nigroseptatum	-	+	-	-	-	+	-	-	-	+	-	+	-	-	-	+	-	-
Stachybotrys nephrospora	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-
Stachybotrys sp.	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
Stachybotrys hyaline	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Sympodiella laxa	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetraploa aristata	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thozetella nivea	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Trichobotrys ramose	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Trichoderma sp.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tripospermum myrti	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Veronaea bambusae	-	+	-	-	-	+	-	-	-	+	-	+	+	-	-	-	-	-
Veronaea botryose	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Verticillium sp.	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Virgatospora natrajensis	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Cont...

Volutella sp.1	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+
Volutella sp.2 *(sporodo)*	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
Wiesneriomyces javanicus	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Zygosporium masonii	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mycelia sterila	-	-	-	-	+	-	+	-	-	-	-	-	-	-	+	-	-	-
Undetermined sp.1	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Undetermined sp.2	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+
Undetermined sp.3	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Undetermined sp.4	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Undetermined sp.5	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Undetermined sp.6	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Undetermined sp.7	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Undetermined sp.8	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Undetermined sp.9	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
Undetermined sp.10	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
Undetermined sp. 11	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Undetermined sp.12	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
No. of species	27	37	13	14	37	30	22	26	26	36	33	30	33	27	31	30	31	30

(Note: presence: + ; absent: -; D: dicot; M: monocot; Cr.: *Careya arborea*; Dt.: *Dendrocalamus strictus*)

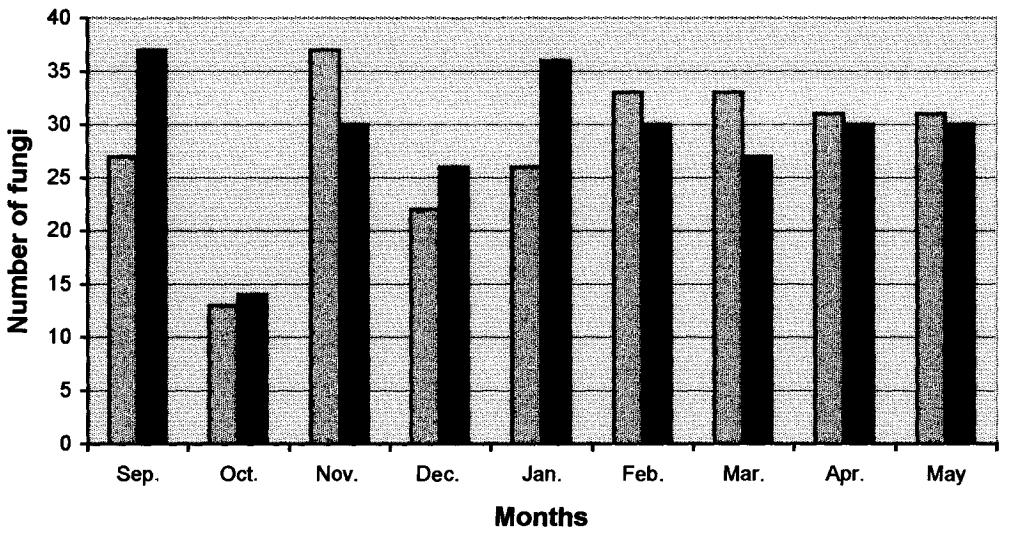
Table: 4.3.2. **Concentration (%) of organic Carbon and Nitrogen in the litter of *Dendrocalamus strictus*** :

Month	Carbon	Nitrogen	C : N	Correlation coefficient (r) Decomposition period vs		
				C : N	%C	% N
Sep.	39.75	1.05	37.85	-0.65995	-0.13681	0.082808
Oct.	44.25	1.05	58.5			
Nov.	39.75	1.19	39.75			
Dec.	39.75	0.14	39.75			
Jan.	38.25	1.19	42			
Feb.	39	0.14	36			
Mar.	42.75	1.4	33.75			
Apr.	34.5	1.19	35.25			
May	43.5	1.05	30			

Table: 4.3.3. **Concentrations (%) of organic Carbon and Nitrogen in the litter of *Careya arborea*** :

Month	Carbon	Nitrogen	C : N	Correlation coefficient (r) Decomposition period vs		
				C : N	%C	% N
Sep.	39.75	1.54	25.81	0.2326	-0.70417	-0.45218
Oct.	58.5	1.78	32.14			
Nov.	39.75	1.54	25.81			
Dec.	39.75	1.33	29.88			
Jan.	42	0.28	23.33			
Feb.	36	1.19	30.25			
Mar.	33.75	0.84	40.17			
Apr.	35.25	1.575	22.38			
May	30	0.91	32.96			

Fig. 4.3.1 Number of fungi recorded from two plant species (Litter-bag experiment)



range between 30 in May to 42 in January (Table 4.3.3).

It is seen from the results that independently C and N are negatively correlated (-0.70417) and together the C : N ratio and period of decomposition did not show any correlation.

It is therefore prudent to infer from this result that in the process of litter decomposition, C : N ratio is not the only controlling factor for decomposition but the prevailing environmental conditions such as temperature and moisture and native fungal flora in the surroundings. Presence of a sizable number of fungi while placing the litter for incubation and sudden drop in the population in the next month, as seen in Table 4.3.1, may be attributed for the initial adjustment of the litter flora to the new environment.

PART IV: **ASSAYING CULTURES OF LITTER AND ENDOPHYTIC FUNGI FOR ENZYMES :**

One hundred forty species of the litter and endophytic fungi isolated from four tests plants, namely, *Saraca asoca* and *Careya arborea* (dicot) and *Calamus thwaitesii* and *Dendrocalamus strictus* (monocot), were screened in order to test their ability to produce at least 3 common enzymes, i.e. amylase, cellulase and pectinase. Of the fungi tested, 10 of the cultures were common to both litter and live plant substrates whereas some were either only litter inhabiting (67) or endophytic (53) in their substrate relationship. The methods followed are described in detail in Chapter III.

The results showed that 61 taxa of fungi were positive for amylase (43.57 %), 69 for cellulase (49.28%) and 60 for pectinase (42.85 %) activity. Twentyfour species

exhibited ability to produce all the enzymes (17.14%) whereas a few were found to produce exclusively a particular enzyme, i.e. 13 isolates were amylase positive (9.28%), 18 cellulolytic(12.86%) and 23 with pectinolytic activity (16.43%). Of the 24 taxa with ability to produce all the 3 enzymes, *Corynespora* sp.2, *Corynespora* sp.3 and *Pestalotiopsis* sp. showed highest activity in terms of 'zone of clearance'. Interestingly, both these isolates were endophytes.

The results qualitative enzyme tests carried out on all these taxa of fungi are given in Table 4.4.1. The fungi associated with *Careya arborea* showed high percentage of cellulase (17.15%) and moderate activity of amylase (15%) and pectinase (15%).

Some of the fungi which occurred both as litter and endophytes have shown interesting results. (i) *Alternaria alternata* recovered as an endophyte and litter inhabitant in *Saraca asoca* exhibited different enzymatic activity; the endophyte derivative was pectinolytic whereas the litter fungus was positive for amylase. (ii) *Bharatheeya mucoidea* from *Calamus thwaitesii* as a litter fungus showed positiveness for both amylase and cellulase with significant quantitative difference and further as an endophyte exhibited ability to produce only cellulase. (iii) Exactly similar behaviour was shown by *Corynespora* sp.1 isolated as litter and endophyte fungus, wherein the endophyte showed amylase, cellulase and pectinase activity though of lower level and the litter isolates showed positiveness for cellulase. (iv) One more example can be cited with *Fusarium solani* from the same plant behaving differently in enzyme activity. The litter isolate was positive for amylase and cellulase whereas the endophyte showed both amylase and pectinase activity. It may be inferred that it is a unique phenomenon with *Calamus thwaitesii* exhibiting distinct substrate specificity in enzyme activity of inhabiting fungi.

It is also evident from the study (Table 4.4.1) that same species or morphotype when isolated from different plants always behaved differently in their enzyme activity.

The relationship between the fungi studied producing different enzymes was analysed by employing Cluster Analysis (Systat version 5.0) and subjecting the data to 'Euclidean distance average linkage method' (Fig 4.4.1). The result showed that the fungi producing cellulase and amylase were closer compared to pectinase. Similar results were obtained by Miriam (2000) in her studies with 60 isolates of fungi obtained from litter and endophytic substrates of *Ficus benghalensis* and *Carissa congesta.*

An effort was made to analyse the ability of fungi to produce each enzyme qualitatively by observing the clearance zone exhibited by the isolates when grown on enzyme-specific medium.

With regard to amylase (Table 4.4.2.), the following fungi showed comparatively significant activity as exhibited by clearance zone measuring more than 1.3 cm: *Corynespora* sp.2 (1.6), *Pestalotiopsis* sp. (1.5), NSM 4 (1.6) and Undetermined species 3 (1.8).

As of cellulase (Table 4.4.3.), none of the fungi tested showed significant activity as exhibited by clearance zone measuring more than 1.3 cm. However moderate activity was exhibited by *Corynespora* sp.1 (1.1) and *Scolecobasidium variable* (1.0).

The following fungi exhibited pectinolytic activity (Table 4.4.4.) as exhibited by clearance zone: *Cladosporium* sp.9 (1.3), *Trichothecium* sp. (1), NSM 19 (1.3), NSM 25 (1.2) and NSM 31 (1.3).

Table: 4.4.1. **Qualitative estimation of enzymatic activity of fungi obtained from four study plants:**

Sr.No	Fungi	Substrate	Plant sp.	Amylolytic activity	Cellulolytic activity	Pectinolytic activity
1.	*Acremoniella sp.*	E	Cth.	-	-	-
2.	*Acremonium sp.*1	L	Sas.	+	+	-
3.	*Acremonium sp.2*	L	Cth.	++	-	+
4.	*Acremonium sp.*3	L	Sas.	+	+	-
5.	*Acremonium sp.4*	L	Car.	-	+	-
6.	*Alternaria alternata*	E	Sas.	-	-	+
7.	*Alternaria alternata*	L	Sas.	+	-	-
8.	Ascomycete sp. 3 Iso-1	E	Sas.	-	-	+
9.	Ascomycete sp. 4	E	Car.	++	+	-
10.	Ascomycete sp.3 Iso-2	E	Car.	-	-	-
11.	*Bharatheeya mucoidea*	L	Cth.	+++	+	-
12.	*Bharatheeya mucoidea*	E	Cth.	-	++	-
13.	*Cladosporium sp* 1	L	Sas.	+	+	-
14.	*Cladosporium herbarum*	L	Cth.	+	+	+
15.	*Cladosporium herbarum*	E	Cth.	+	+	+
16.	*Cladosporium* sp. 2	L	Sas.	-	-	-
17.	*Cladosporium* sp. 3	L	Sas.	+	+	-
18.	*Cladosporium cladosporoides*	E	Den.	+	+	+
19.	*Cladosporium cladosporoides*	L	Cth.	+	+	+
20.	*Cladosporium* sp. 4	L	Sas.	-	+	-
21.	*Cladosporium* sp. 5	L	Sas.	-	-	-
22.	*Cladosporium* sp.6	L	Cth.	++	+	+
23.	*Cladosporium* sp.7	L	Car.	-	+	-
24.	*Cladosporium* sp.8	L	Den.	+	+	-
25.	*Cladosporium* sp.9	L	Car.	+	+	+++
26.	*Cochliobolus lunataus* Iso-1	E	Car.	-	++	++
27.	*Cochliobolus lunatus* Iso-2	E	Den.	-	-	-
28.	*Corynespora* sp. 1	E	Cth.	+	+	+
29.	*Corynespora* sp.1	L	Cth.	-	++	-
30.	*Corynespora* sp.2	E	Den.	+++	+	++
31.	*Corynespora sp.3*	E	Cth.	++	++	+
32.	*Curvularia lunata*	E	Cth.	+	-	+
33.	*Cylindrotrichum sp.*	E	Car.	-	+	-
34.	*Cylindrotrichum sp.*	L	Sas.	-	-	-
35.	*Dactylella sp.* Iso-1	L	Cth.	+	+	++
36.	*Dactylella sp.* Iso-2	L	Sas.	+	-	+
37.	*Fusarium decemcellulare*	E	Cth.	-	-	+
38.	*Fusarium decemmcelulare*	L	Sas.	+	+	-
39.	*Fusarium solani*	L	Cth.	+	+	-
40.	*Fusarium solani*	E	Cth.	+	-	+
41.	*Idriella lunata*	L	Sas.	++	+	-
42.	*Nigrospora sphaerica*	E	Car.	-	-	+
43.	NSM 1	L	Den.	-	+	-
44.	NSM 2	L	Den.	-	+	-
45.	NSM 3	L	Den.	+	+	+
46.	NSM 4	E	Den.	+	+	+
47.	NSM 5	E	Car.	-	-	+
48.	NSM 6	E	Car.	+	+	+
49.	NSM 7	E	Car.	++	+	+
50.	NSM 8	E	Car.	+++	+	-
51.	NSM 9	E	Car.	+	+	-
52.	NSM 10	E	Cth.	-	-	-

cont....

53.	NSM 11	E	Den.	-	-	-
54.	NSM 12	L	Cth.	-	+	-
55.	NSM 13	E	Cth.	-	-	-
56.	NSM 14	E	Den.	+	+	+
57.	NSM 15	E	Den.	-	+	-
58.	NSM 16	E	Cth.	-	+	-
59.	NSM 17	E	Cth.	+	+	+
60.	NSM 18	L	Cth.	-	+	++
61.	NSM 19	L	Cth.	-	++	+++
62.	NSM 20	L	Cth.	++	+	+
63.	NSM 21	E	Cth.	++	+	+
64.	NSM 22	E	Cth.	-	+	-
65.	NSM 23	L	Den.	-	-	-
66.	NSM 24	E	Car.	+	-	-
67.	NSM 25	E	Car.	-	-	++
68.	NSM 26	E	Car.	-	+	+
69.	NSM 27	E	Car.	-	+	+
70.	NSM 28	L	Car.	-	-	-
71.	NSM 29	L	Car.	-	-	+
72.	NSM 30	L	Car.	+	+	-
73.	NSM 31	L	Car.	-	-	+++
74.	NSM 32	E	Sas.	-	-	++
75.	NSM 33	E	Sas.	-	-	+
76.	NSM 34	L	Den.	-	+	-
77.	NSM 35	E	Sas.	-	-	-
78.	NSM 36	E	Sas.	-	-	+
79.	NSM 37	E	Den.	+	-	-
80.	NSM 38	E	Sas.	-	-	-
81.	NSM 39	E	Sas.	-	-	+
82.	NSM 40	E	Sas.	-	-	+
83.	NSM 41	E	Sas.	-	-	+
84.	NSM 42	E	Sas.	+	-	+
85.	NSM 43	E	Sas.	-	-	+
86.	NSM 44	E	Sas.	-	-	+
87.	NSM 45	L	Cth.	-	+	-
88.	NSM 46	E	Sas.	-	-	+
89.	NSM 47	E	Sas.	-	-	++
90.	NSM 48	E	Sas.	-	-	-
91.	NSM 49	E	Sas.	-	-	-
92.	NSM 50	E	Sas.	-	-	+
93.	NSM 51	E	Sas.	-	-	-
94.	NSM 52	E	Sas.	-	-	+
95.	NSM 53	E	Sas.	-	-	+
96.	NSM 54	L	Sas.	-	-	-
97.	NSM 55	L	Sas.	++	+	-
98.	NSM 56	L	Den.	-	-	-
99.	NSM 57	L	Sas.	-	-	-
100.	NSM 58	L	Sas.	+	-	-
101.	NSM 59	L	Sas.	++	-	-
102.	NSM 60	L	Sas.	+	+	+
103.	NSM 61	L	Sas.	-	+	-
104.	NSM 62	L	Sas.	-	-	-
105.	NSM 63	L	Den.	-	+	+
106.	NSM 64	L	Sas.	-	-	-
107.	NSM 65	L	Sas.	+	-	-
108.	NSM 66	L	Den.	-	+	-
109.	NSM 67	L	Sas.	-	-	-
110.	NSM 68	L	Sas.	++	+	-

cont....

111.	NSM 69	L	Den.	-	+	-
112.	NSM 70	L	Den.	-	-	-
113.	NSM 71	L	Sas.	++	-	-
114.	*Penicillium sp.*1	L	Cth.	+	+	+
115.	*Penicillium* sp.1	E	Den.	-	-	-
116.	*Periconia byssoides*	L	Den.	+	+	+
117.	*Pestalotiopsis sp.*	E	Car.	+++	+	+
118.	*Pestalotiopsis sp.*	L	Sas.	-	+	-
119.	Pycnidial sp.Cre111	L	Car.	+	-	-
120.	*Scolecobasidium constrictum* Iso-1	L	Car.	-	-	-
121.	*Scolecobasidium constrictum* Iso-2	L	Cth.	-	-	+
122.	*Scolecobasidium constrictum* Iso-3	L	Cth.	+	-	-
123.	*Scolecobasidium variable*	L	Cth.	-	++	-
124.	*Stachybotrys nephrospora*	L	Cth.	++	+	-
125.	*Trichothecium sp.*	L	Cth.	-	+	++
126.	Undetermined sp. 1	L	Den.	-	-	-
127.	Undetermined sp. 2	L	Sas.	-	-	-
128.	Undetermined sp. 3	L	Den.	+++	-	-
129.	Undetermined sp. 4	E	Sas.	-	-	+
130.	Undetermined sp.5	L	Sas.	-	-	-
131.	Undetermined sp.6	E	Cth.	-	++	-
132.	Undetermined sp.7	E	Den.	+	-	+
133.	Undetermined sp.8	L	Cth.	+	+	-
134.	Undetermined sp. 9	E	Cth.	+	+	++
135.	Undetermined sp.10	L	Car.	+	-	-
136.	Undetermined sp. 11	L	Car.	+	+	++
137.	Undetermined sp. 12	L	Car.	++	-	-
138.	Undetermined sp. 13	L	Sas.	++	+	-
139.	*Veronaea sp.*	L	Den.	-	-	-
140.	*Wiesneriomyces javanicus*	L	Sas.	+	-	-

Note: The activity of enzyme as denoted by the clearance zone in cm:
0.1 - 0.6 = +
0.7 - 1.2 = ++
1.3 - 2.0 = +++

Table: 4.4.2. **Amylolytic activity by fungi isolated from four study plants:**

Sr.No	Fungi	Colony size (Diam.)	Clearance zone (Diam.)	Colony colour when treated with KI-solution.
1.	*Acremoniella sp.*	2.7	-	no clear zone entire medium blue
2.	*Acremonium sp.*1	1.2	0.6	yellowish
3.	*Acremonium sp.2*	1.5	0.8	yellowish
4.	*Acremonium sp.*3	3	0.1	colony brownish dark
5.	*Acremonium sp.4*	4.2	-	Dark yellowish
6.	*Alternaria alternata*	4.4	-	Colony white only
7.	*Alternaria alternata*	6.5	0.5	entire colony turned yellowish
8.	Ascomycete sp. 3 Iso-1	4.7	-	-
9.	Ascomycete sp. 4	1.4	1.1	Slimy offwhite
10.	Ascomycete sp.3 Iso-2	4	-	Membrane bound
11.	*Bharatheeya mucoidea*	1.2	1.3	yellowish offwhite
12.	*Bharatheeya mucoidea*	1.3	-	-
13.	*Cladosporium sp* 1	2.4	0.2	colony yellowish dark
14.	*Cladosporium herbarum*	1.5	0.3	Yellowish colony
15.	*Cladosporium herbarum*	1.6	0.3	yellowish
16.	*Cladosporium* sp. 2	4.8	-	-
17.	*Cladosporium* sp. 3	4	0.1	dark orange
18.	*Cladosporium cladosporoides*	2.7	0.5	Yellowish
19.	*Cladosporium cladosporoides*	2.4	0.3	flat offwhite colony
20.	*Cladosporium* sp. 4	2.2	-	-
21.	*Cladosporium* sp. 5	3.5	-	opaque
22.	*Cladosporium* sp.6	2.2	0.7	white transparent
23.	*Cladosporium* sp.7	0.6	-	entire plate blue
24.	*Cladosporium* sp.8	2.3	0.4	Colony offwhite
25.	*Cladosporium* sp.9	2	0.3	Dull offwhite
26.	*Cochliobolus lunataus* Iso-1	3	-	-
27.	*Cochliobolus lunatus* Iso-2	0.9	1	Black colony
28.	*Corynespora* sp. 1	1.1	0.3	Yelowish
29.	*Corynespora* sp.1	0.5	-	Membrane bound
30.	*Corynespora* sp.2	1.1	1.6	Yellowish dark
31.	*Corynespora sp.3*	1.2	1.2	Yellowish dark
32.	*Curvularia lunata*	4	0.3	offwhite
33.	*Cylindrotrichum sp.*	1.7	-	Offwhite
34.	*Cylindrotrichum sp.*	2.6	0.9	Colony whitish
35.	*Dactylella sp.* Iso-1	1.7	0.5	offwhite yellowish
36.	*Dactylella sp.* Iso-2	2.9	0.3	-
37.	*Fusarium deccemcellulare*	5.2	-	Yellowish flat colony membrane bound
38.	*Fusarium decemmcelulare*	5.5	0.3	dark yellowish
39.	*Fusarium solani*	4.5	0.5	Yellowish colony
40.	*Fusarium solani*	5.5	0.5	Transparent
41.	*Idriella lunata*	2.3	0.8	-
42.	*Nigrospora sphaerica*	2	-	Membrane bound entire plate blue
43.	NSM 1	3.2	0.4	Brown Colony
44.	NSM 2	1.3	2.5	Yellowish
45.	NSM 3	2.6	0.6	White colony
46.	NSM 4	1.7	1.6	Colony dark yellow
47.	NSM 5	3	-	Membrane bound entire plate blue

48.	NSM 6	2.2	0.4	Yellowish white patchy
49.	NSM 7	1.4	1	Yellowish
50.	NSM 8	2.5	1.3	Pure white
51.	NSM 9	2	0.4	Offwhite
52.	NSM 10	1.6	1.1	Slimy yellowish
53.	NSM 11	1.4	0.6	Dark brown
54.	NSM 12	4.5	-	yellowish colony
55.	NSM 13	8.5	-	-
56.	NSM 14	7	-	Yellowish orange
57.	NSM 15	2.5	0.7	Dark brownish orange
58.	NSM 16	2.3	1.4	Dark Yellow
59.	NSM 17	4.5	-	-
60.	NSM 18	1.3	-	entire plate blue
61.	NSM 19	1.5	-	Membrane bound
62.	NSM 20	1.7	1.2	dark yellow colony
63.	NSM 21	3.2	0.7	Yellowish
64.	NSM 22	2	-	Membrane bound
65.	NSM 23	1.3	0.5	Black colony
66.	NSM 24	1	0.3	Dull green
67.	NSM 25	1.2	-	-
68.	NSM 26	2.5	-	Offwhite to white
69.	NSM 27	4.2	-	Offwhite
70.	NSM 28	1.6	-	Membrane bound offwhite
71.	NSM 29	1.2	-	entire plate blue
72.	NSM 30	2	0.6	Pure white
73.	NSM 31	0.6	-	entire plate blue
74.	NSM 32	4	-	Colony yellowish
75.	NSM 33	5.1	-	Colony white only
76.	NSM 34	7.3	0.2	yellowish orange
77.	NSM 35	8.5	-	-
78.	NSM 36	8.5	-	-
79.	NSM 37	3.2	0.3	Colony offwhite
80.	NSM 38	8.5	-	-
81.	NSM 39	7	-	-
82.	NSM 40	8.5	-	-
83.	NSM 41	8.5	-	-
84.	NSM 42	2.7	0.6	-
85.	NSM 43	5.5	-	Blue colour diffuses into media
86.	NSM 44	5.3	-	No clear zone
87.	NSM 45	3.2	0.3	greyish white
88.	NSM 46	3.5	-	Colony offwhite above
89.	NSM 47	8.5	-	-
90.	NSM 48	8.5	-	-
91.	NSM 49	8.5	-	-
92.	NSM 50	4.7	-	-
93.	NSM 51	8.5	-	-
94.	NSM 52	8.5	-	-
95.	NSM 53	3.4	-	-
96.	NSM 54	6.3	-	-
97.	NSM 55	2	0.7	-
98.	NSM 56	2.5	0.6	-
99.	NSM 57	5.4	-	pale yellowish
100.	NSM 58	2.3	0.3	

101.	NSM 59	2.2	0.7	whitish to opaque
102.	NSM 60	4.2	0.2	greyish brown
103.	NSM 61	5.5	-	-
104.	NSM 62	8.5	-	-
105.	NSM 63	4.5	-	-
106.	NSM 64	8.5	-	-
107.	NSM 65	4.5	0.2	pale white
108.	NSM 66	3.2	0.2	pale orangish
109.	NSM 67	7.3	-	greyish white
110.	NSM 68	3.1	0.7	colony brownish dark
111.	NSM 69	3	-	-
112.	NSM 70	4.5	-	Colony hyaline transparent
113.	NSM 71	1.2	0.8	
114.	*Penicillium sp.*1	2.5	0.5	offwhite to light yellow
115.	*Penicillium* sp.1	8.5	-	-
116.	*Periconia byssoides*	2	0.5	white transparent
117.	*Pestalotiopsis sp.*	1.5	1.5	2zones seen towards centre 0.5 zone periphery 0.7 partially cleared zone
118.	*Pestalotiopsis sp.*	5.5	-	colony turned brownish
119.	Pycnidial sp.Cre111	0.8	0.2	Colony yellowish
120.	*Scolecobasidium constrictum* Iso-1	0.7	-	entire plate blue
121.	*Scolecobasidium constrictum* Iso-2	1	-	entire colony with plate blue in colour
122.	*Scolecobasidium constrictum* Iso-3	1.2	0.6	Yellowish colony
123.	*Scolecobasidium variable*	1.2	-	entire colony with plate blue in colour
124.	*Stachybotrys nephrospora*	1.8	0.7	yellowish
125.	*Trichothecium sp.*	1.7	0.6	white transparent
126.	Undetermined sp. 1	6	0.3	Yellowish Orange
127.	Undetermined sp. 2	8.5	-	-
128.	Undetermined sp. 3	4.5	1.8	Yellow
129.	Undetermined sp. 4	3.8	-	Colony offwhite
130.	Undetermined sp.5	5.6	-	-
131.	Undetermined sp.6	2.2	1	Colony brownish
132.	Undetermined sp.7	6	0.1	Yellowish white
133.	Undetermined sp.8	1.2	0.4	offwhite colony
134.	Undetermined sp. 9	2.3	0.5	Yellowish offwhite
135.	Undetermined sp.10	7.5	0.2	Yellowish offwhite
136.	Undetermined sp. 11	1.5	0.4	Yellowish offwhite
137.	Undetermined sp. 12	1.2	0.8	Dull green
138.	Undetermined sp. 13	2.2	0.7	Yellowish dark
139.	*Veronaea botryosa*	1.7	-	entire colony with plate blue in colour
140.	*Wiesneriomyces javanicus*	5.7	0.6	pale yellow

Table: 4.4.3. **Cellulolytic activity by fungi isolated from four study plants:**

Sr.No	Fungi	Colony size (Diam.)	Clearance zone (Diam.)	Colony colour when treated with KI-solution.
1.	*Acremoniella* sp.	0.5	-	entire plate turned dark black
2.	*Acremonium* sp.1	2.2	0.5	-
3.	*Acremonium* sp.2	1.2	-	-
4.	*Acremonium* sp.3	3.5	0.2	centre white with black peripheral ring
5.	*Acremonium* sp.4	4.2	0.1	Red all over
6.	*Alternaria alternata*	3.7	-	Colony whitish towards periphery dark red
7.	*Alternaria alternata*	7.7	-	Colony whitish
8.	Ascomycete sp. 3 Iso-1	5	-	Entire colony black
9.	Ascomycete sp. 4	3.5	0.2	White patchy red below
10.	Ascomycete sp.3 Iso-2	1	-	Black colony
11.	*Bharatheeya mucoidea*	2	0.5	White patchy above red below
12.	*Bharatheeya mucoidea*	1.3	1	White patchy above red below
13.	*Cladosporium* sp 1	3.1	0.3	clear zone with periphery black in colour
14.	*Cladosporium herbarum*	2.3	0.3	White patchy above red below
15.	*Cladosporium herbarum*	2	0.5	Red Flat
16.	*Cladosporium* sp. 2	5	-	Hyaline clear ring towards the periphery
17.	*Cladosporium* sp. 3	5.3	0.2	blackish towards the periphery
18.	*Cladosporium cladosporoides*	1.7	0.5	Red flat colony
19.	*Cladosporium cladosporoides*	2.5	0.3	Red flat
20.	*Cladosporium* sp. 4	2.5	0.5	Clear colony black towards the periphery
21.	*Cladosporium* sp. 5	5.2	-	No clearance zone
22.	*Cladosporium* sp.6	2	0.5	Red Flat
23.	*Cladosporium* sp.7	0.7	0.2	Greyish black
24.	*Cladosporium* sp.8	1.9	0.6	Greyish red
25.	*Cladosporium* sp.9	1.6	0.3	Grey above red below
26.	*Cochliobolus lunataus* Iso-1	1.7	1	White patchy red below
27.	*Cochliobolus lunatus* Iso-2	3	-	-
28.	*Corynespora* sp. 1	1.5	0.4	Red Flat
29.	*Corynespora* sp.1	0.7	1.1	Black colony
30.	*Corynespora* sp.2	6.4	-	Red Flat Membrane bound
31.	*Corynespora sp.3*	4.5	-	Red Flat Membrane bound
32.	*Curvularia lunata*	1.5	0.5	White patchy above red below
33.	*Cylindrotrichum sp.*	1	0.2	Reddish flat
34.	*Cylindrotrichum sp.*	3.4	-	-
35.	*Dactylella sp.* Iso-1	2.2	0.4	Red flat
36.	*Dactylella sp.* Iso-2	2.4	-	culture turned reddish
37.	*Fusarium deccemcellulare*	2	0.5	Red Flat
38.	*Fusarium decemcellulare*	5.4	0.1	thin halo around the colony
39.	*Fusarium solani*	5.5	0.1	Red flat
40.	*Fusarium solani*	8.5	-	Red Flat Membrane bound
41.	*Idriella lunata*	2	0.3	-
42.	*Nigrospora sphaerica*	1	0.1	Red flat
43.	NSM 1	2.3	0.2	Light red
44.	NSM 2	3	0.6	Red flat above

45.	NSM 3	2.5	0.2	Whitish red
46.	NSM 4	0.7	0.3	Red flat colony
47.	NSM 5	3	-	-
48.	NSM 6	2.8	0.2	White patchy red below
49.	NSM 7	2	0.5	White patchy red below
50.	NSM 8	3.5	0.2	White patchy red below
51.	NSM 9	2.5	0.3	White patchy red below
52.	NSM 10	1.4	-	-
53.	NSM 11	1.2	-	-
54.	NSM 12	2.9	0.2	Red colony
55.	NSM 13	7	-	-
56.	NSM 14	5.5	0.1	Greyish above red below colony
57.	NSM 15	1.5	0.5	Greyish red
58.	NSM 16	1.4	0.5	Greyish red
59.	NSM 17	4.8	0.2	Whitish red
60.	NSM 18	2.2	0.1	-
61.	NSM 19	2.2	0.7	Red Flat
62.	NSM 20	1.5	0.1	White patchy above red below
63.	NSM 21	3	0.2	White patchy above red below
64.	NSM 22	0.2	0.6	Red Flat
65.	NSM 23	1.1	-	-
66.	NSM 24	1.7	0.7	Red Flat
67.	NSM 25	6.2	-	Reddish flat
68.	NSM 26	1	-	Black above
69.	NSM 27	5.3	0.2	Red flat
70.	NSM 28	0.7	-	-
71.	NSM 29	7	-	Entire colony red membrane bound 0.4cm diffusing zone
72.	NSM 30	2.4	0.3	Red flat
73.	NSM 31	1	-	-
74.	NSM 32	3.9	-	-
75.	NSM 33	3.9	-	-
76.	NSM 34	1.7	0.4	Reddish black
77.	NSM 35	6.8	-	Blackish colony
78.	NSM 36	8.5	-	Blackish colony
79.	NSM 37	2.6	-	Offwhite above
80.	NSM 38	8.5	-	Greyish white above
81.	NSM 39	6.4	-	Blackish above
82.	NSM 40	5.7	-	Entire colony black
83.	NSM 41	5.3	-	Whitish above black towards the periphery
84.	NSM 42	2.5	-	-
85.	NSM 43	4.2	-	-
86.	NSM 44	4.8	-	Colony whitish above
87.	NSM 45	1.9	0.3	Greyish colony
88.	NSM 46	3.8	-	-
89.	NSM 47	8.5	-	-
90.	NSM 48	8.5	-	-
91.	NSM 49	8.5	-	Blackish red
92.	NSM 50	4	-	-
93.	NSM 51	8.5	-	-
94.	NSM 52	7.6	-	Blackish colony
95.	NSM 53	3.4	-	Whitish above

96.	NSM 54	7.5	-	Culture black
97.	NSM 55	1.8	0.4	Pale clearance zone
98.	NSM 56	1.9	-	-
99.	NSM 57	5	-	Colony white to creamish
100.	NSM 58	2.2	-	-
101.	NSM 59	2	-	dark reddish colony
102.	NSM 60	4.5	0.1	hyaline ring colony red
103.	NSM 61	4.6	0.1	Thin clear halo ring around the colony
104.	NSM 62	8.5	-	Whitish patches black towards the periphery
105.	NSM 63	4	0.2	Ring of hyaline zone around the colony
106.	NSM 64	8.5	-	Whitish patches black towards the periphery
107.	NSM 65	4	-	peripheral ring
108.	NSM 66	2.2	0.3	Reddish colony
109.	NSM 67	7.5	-	Colony whitish
110.	NSM 68	2.2	0.5	clear no red pigment hyaline
111.	NSM 69	2.7	0.2	Greyish white
112.	NSM 70			
113.	NSM 71	1.3	-	No clear zone Colony red in colour
114.	*Penicillium* sp.1	3.2	0.3	White patchy above red below
115.	*Penicillium* sp.1	8.5	-	-
116.	*Periconia byssoides*	3	0.2	Red Flat
117.	*Pestalotiopsis* sp.	2.2	0.3	Red colony with little white patch
118.	*Pestalotiopsis* sp.	8.5	0.2	halo ring around the colony black towards the periphery
119.	Pycnidial sp. 1	1.2	-	-
120.	*Scolecobasidium constrictum* Iso-1	1	-	-
121.	*Scolecobasidium constrictum* Iso-2	1	-	-
122.	*Scolecobasidium constrictum* Iso-3	1.2	-	reddish colony flat
123.	*Scolecobasidium variable*	1	1	-
124.	*Stachybotrys nephrospora*	1.7	0.6	Red flat
125.	*Trichothecium sp.*	2.5	0.2	Red flat
126.	Undetermined sp. 1	7	-	-
127.	Undetermined sp. 2	8.5	-	Whitish patches black towards the periphery
128.	Undetermined sp. 3	5	-	Entire colony red membrane bound
129.	Undetermined sp. 4	3.5	-	Whitish above
130.	Undetermined sp.5	8.5	-	No clear zone patches of white and black
131.	Undetermined sp.6	1	1	reddish with white above
132.	Undetermined sp.7	7	-	-
133.	Undetermined sp.8	1.5	0.5	Red Flat
134.	Undetermined sp. 9	2.3	0.5	White with red flat
135.	Undetermined sp.10	8.5	-	White patchy red below
136.	Undetermined sp. 11	1.1	0.6	White patchy red below
137.	Undetermined sp. 12	1.8	-	-
138.	Undetermined sp. 13	2.5	0.5	clearance zone
139.	*Veronaea botryosa*	1	-	-
140.	*Wiesneriomyces javanicus*	6	-	Colony whitish

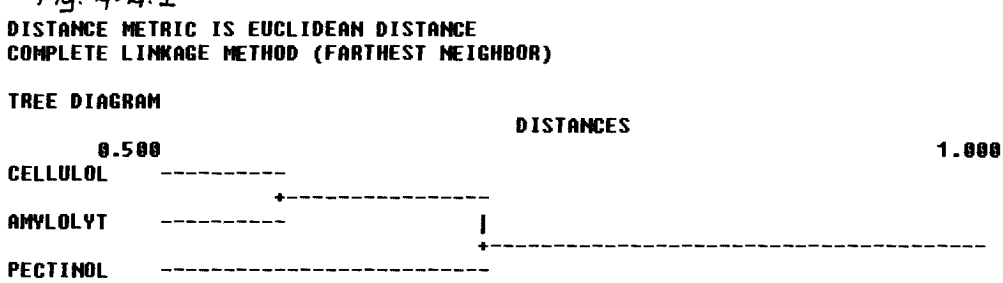
Table: 4.4.4. **Pectinolytic activity by fungi isolated from four study plants:**

Sr.No	Fungi	Colony size (Diam.)	Clearance zone (Diam.)	Colony colour when treated with KI-solution.
1.	*Acremoniella* sp.	0.9	-	-
2.	*Acremonium* sp.1	1.7	-	-
3.	*Acremonium* sp.2	0.9	0.2	colony flat white in colour
4.	*Acremonium* sp.3	2.8	-	-
5.	*Acremonium* sp.4	5.5	-	Transparent colony
6.	*Alternaria alternata*	3.5	0.5	Transparent colony
7.	*Alternaria alternata*	8.5	-	-
8.	Ascomycete sp. 3 Iso-1	2.2	0.2	Transparent colony
9.	Ascomycete sp. 4	2.2	-	Offwhite
10.	Ascomycete sp.3 Iso-2	1.4	-	-
11.	*Bharatheeya mucoidea*	0.5	-	-
12.	*Bharatheeya mucoidea*	1.2	-	-
13.	*Cladosporium* sp 1	2.5	-	-
14.	*Cladosporium herbarum*	3	0.6	Greyish green
15.	*Cladosporium herbarum*	2.2	0.5	Yellowish colony
16.	*Cladosporium* sp. 2	3.2	-	-
17.	*Cladosporium* sp. 3	3.2	-	-
18.	*Cladosporium cladosporoides*	3.7	0.5	Greyish White
19.	*Cladosporium cladosporoides*	3	0.6	Greyish green
20.	*Cladosporium* sp. 4	2	-	-
21.	*Cladosporium* sp. 5	4.2	-	-
22.	*Cladosporium* sp.6	2.5	0.4	Flat offwhite colony
23.	*Cladosporium* sp.7	0.5	-	-
24.	*Cladosporium* sp.8	2	-	-
25.	*Cladosporium* sp.9	1.4	1.3	Olive green slimy
26.	*Cochliobolus lunataus* Iso-1	1.5	1	Offwhite
27.	*Cochliobolus lunatus* Iso-2	4.2	-	-
28.	*Corynespora* sp. 1	1.3	0.2	White
29.	*Corynespora* sp.1	1.3	0.3	Greyish green
30.	*Corynespora* sp.2	1.5	0.8	white colony
31.	*Corynespora sp.3*	1.5	0.4	White colony
32.	*Curvularia lunata*	5.7	0.2	Slimy offwhite colony
33.	*Cylindrotrichum sp.*	5.2	-	Transparent colony
34.	*Cylindrotrichum sp.*	3.5	-	-
35.	*Dactylella sp.* Iso-1	1.5	0.8	Yellowish colony
36.	*Dactylella sp.* Iso-2	2.8	0.3	-
37.	*Fusarium deccemcellulare*	5.5	0.2	colony flat white in colour
38.	*Fusarium decemmcelulare*	5.2	-	-
39.	*Fusarium solani*	1.5	-	-
40.	*Fusarium solani*	5.4	0.2	Slimy offwhite colony
41.	*Idriella lunata*	2	-	-
42.	*Nigrospora sphaerica*	1.2	0.4	Offwhite slimy
43.	NSM 1	0.6	-	-
44.	NSM 2	4.2	-	White colony
45.	NSM 3	3.7	0.3	Pure white
46.	NSM 4	1.5	0.3	Offwhite
47.	NSM 5	3.7	0.3	Transparent
48.	NSM 6	1.9	0.6	Offwhite towards the periphery

49.	NSM 7	2	0.5	Green above white below
50.	NSM 8	2.5	-	White patchy
51.	NSM 9	1.5	-	Pure white
52.	NSM 10	1	-	-
53.	NSM 11	1.5	-	-
54.	NSM 12	5	-	-
55.	NSM 13	8.5	-	-
56.	NSM 14	4.5	0.1	Offwhite
57.	NSM 15	2	-	-
58.	NSM 16	1.5	-	-
59.	NSM 17	4.6	0.2	Offwhite
60.	NSM 18	2.5	0.9	Colony olive green
61.	NSM 19	2.2	1.3	colony flat white in colour
62.	NSM 20	1.7	0.5	Whitish colony
63.	NSM 21	2.7	0.2	White patchy above transparent below
64.	NSM 22	2.3	-	-
65.	NSM 23	3	-	Offwhite
66.	NSM 24	3	-	-
67.	NSM 25	1.3	1.2	Colony greenish and slimy
68.	NSM 26	4.5	0.5	Pure white
69.	NSM 27	4	0.3	Transparent to offwhite
70.	NSM 28	0.3	-	-
71.	NSM 29	6.3	0.3	Flat white
72.	NSM 30	2	-	-
73.	NSM 31	0.6	1.3	Brownish
74.	NSM 32	4.5	0.7	White patchy above below transparent
75.	NSM 33	4.8	0.5	White patchy above below transparent
76.	NSM 34	8.5	-	-
77.	NSM 35	7	-	-
78.	NSM 36	2	0.1	Transparent colony
79.	NSM 37	3	-	-
80.	NSM 38	8.5	-	-
81.	NSM 39	3.2	0.2	Transparent colony
82.	NSM 40	3.5	0.3	Transparent colony
83.	NSM 41	4.4	0.1	White patchy above below transparent
84.	NSM 42	2.5	0.4	White patchy above
85.	NSM 43	3.8	0.5	White patchy above below transparent
86.	NSM 44	2.7	0.2	Transparent
87.	NSM 45	3.5	-	Blackish
88.	NSM 46	3	0.4	Transparent colony
89.	NSM 47	1.2	1	Offwhite colony
90.	NSM 48	8.5	-	-
91.	NSM 49	7.2	-	Transparent colony
92.	NSM 50	3.7	0.5	Transparent
93.	NSM 51	8.5	-	-
94.	NSM 52	5	0.2	Transparent colony
95.	NSM 53	3.3	0.3	Transparent colony
96.	NSM 54	7	-	-

97.	NSM 55	2.8	-	-
98.	NSM 56	2.5	-	-
99.	NSM 57	4.7	-	-
100.	NSM 58	1.2	-	-
101.	NSM 59	2	-	-
102.	NSM 60	3.6	0.5	-
103.	NSM 61	3.7	-	-
104.	NSM 62	8.5	-	-
105.	NSM 63	3.9	0.4	-
106.	NSM 64	8.5	-	-
107.	NSM 65	3	-	-
108.	NSM 66	2.5	-	-
109.	NSM 67	4.7	-	-
110.	NSM 68	2.5	-	-
111.	NSM 69	4.5	-	Pure white colony
112.	NSM 70	6.3	-	Transparent Colony
113.	NSM 71	1.7	-	-
114.	*Penicillium sp.*1	2.7	0.4	Yellowish colony
115.	*Penicillium* sp.1	2	-	Offwhite colony
116.	*Periconia byssoides*	3.7	0.1	Flat offwhite colony
117.	*Pestalotiopsis sp.*	6	0.5	Trnsparent to offwhite above
118.	*Pestalotiopsis sp.*	8.5	-	-
119.	Pycnidial sp.Cre111	1	-	-
120.	*Scolecobasidium constrictum* Iso-1	0.9	-	-
121.	*Scolecobasidium constrictum* Iso-2	4.9	0.1	Flat offwhite colony
122.	*Scolecobasidium constrictum* Iso-3	1	-	-
123.	*Scolecobasidium variable*	1.5	-	-
124.	*Stachybotrys nephrospora*	2.5	-	Flat offwhite colony
125.	*Trichothecium sp.*	1.5	1	pure white above
126.	Undetermined sp. 1	5	-	-
127.	Undetermined sp. 2	8.5	-	-
128.	Undetermined sp. 3	4.7	-	entire colony transparent and cleared
129.	Undetermined sp. 4	2.3	0.3	Pure white
130.	Undetermined sp.5	2.5	-	-
131.	Undetermined sp.6	2.7	-	-
132.	Undetermined sp.7	5	0.2	White
133.	Undetermined sp.8	0.8	-	-
134.	Undetermined sp. 9	2.5	1.1	Greenish above periphery flat
135.	Undetermined sp.10	8.5	-	-
136.	Undetermined sp. 11	1.5	0.7	Slimy offwhite
137.	Undetermined sp. 12	1.5	-	Olive green slimy
138.	Undetermined sp. 13	2	-	-
139.	*Veronaea botryosa*	1.3	-	-
140.	*Wiesneriomyces javanicus*	5	-	-

Fig. 4.4.1


DISTANCE METRIC IS EUCLIDEAN DISTANCE
COMPLETE LINKAGE METHOD (FARTHEST NEIGHBOR)
TREE DIAGRAM
DISTANCES
0.500
1.000
CELLULOL
AMYLOLYT
PECTINOL

DISCUSSION

The results presented in this Chapter are based on an investigation carried out over a period of two and a half years, from February 1999 to June 2001, on the floristics, ecology and activity of litter and endophytic fungi associated with some dicot and monocot plants of forests of Western Ghats in Goa State.

Fallen, dead and decaying leaves and twigs and live, disease-free, fresh and mature leaves constituted the sample material for isolation of litter-inhabiting and endophytic fungi respectively. 'Moist-chamber incubation' and 'particle-plating technique' were used for recovery of litter-inhabiting fungi. 'Three-step surface sterilization' technique was followed for sourcing of endophytic fungi. This multi-pronged effort resulted with recovery of more than 6500 isolates of microfungi which were assignable to 675 species of fungi belonging to 275 genera which included properly recognised Mucorales (1), Ascomycetes (18), Hyphomycetes (289), Coelomycetes (22) and undetermined taxa (77), besides a sizable number of non-sporulating forms (268), during the study period (Table 4.1.1- 4.1.2).

1. Floristics of fungi

The floristic report presented in this work included taxonomic description of common, interesting, rare and novel taxa of microfungi isolated from dead leaf litter and live leaves. As can be seen, hyphomycetous fungi were the largest group followed by an equally a big number of non-sporulating forms. A total of 144 species of rare, interesting, unusual and novel hyphomycetous fungi were described in detail with notes on their taxonomy, substrate/s affinity, habitats, cultural characters and detailed microscopic features. The fungi were illustrated with camera lucida drawings and photomicrographs wherever possible.

The most exciting and wealthy contribution of this study indeed is the discovery of 35 novel species of hyphomycetous fungi in 26 genera. Of these, 3 are new at generic level. These included *Bharatheeya* **gen. nov.,** *Paschimghateeya* **gen.nov.** and *Parapathramaya* **gen. nov.**

The new species recognised and described in the thesis are the following: *Aquaphila ramdayalea* **sp. nov.,** *Ardhachandra parva* **sp. nov.,** *Bharatheeya goanensis* **gen. et sp. nov.,** *Bharatheeya mucoidea* **sp. nov.,** *Choridium ghaticum* **sp.nov.,** *Didymobotryum spirillum* **sp. nov.,** *Dischloridium minutum* **sp. nov.,** *Fusichalara bipodia* **sp.nov**, *Idriella hyalina* **sp. nov.,** *Idriella septata* **sp. nov.,** *Idriella goanensis* **sp. nov.,** *Idriella sigmoidea* **sp. nov.,** *Idriella verticillata* **sp. nov.,** *Iyengarina saprophyticus* **sp. nov.,** *Kramasamuha sundara* **sp. nov.,** *Kumbhamaya aseptata* **sp. nov.,** *Kumbhamaya curvata* **sp. nov.,** *Kumbhamaya goanensis* **sp. nov.,** *Kylindria hyalina* **sp. nov.,** *Mirandina longispora* **sp. nov.,** *Parapathramaya haarea* **gen. et sp. nov.,** *Pleurophragmium minutispora* **sp.nov.,** *Pleurothecium ramosa* **sp.nov**., *Raperia swedaja* **sp. nov.,** *Saccardaea indica* **sp.nov.,** *Scolecobasidium acuminatus* **sp.nov.,** *Scolecobasidium saprophyticus* **sp.nov.,** *Sesquicillium indicum* **sp.nov.,** *Spadicoides calamii* **sp.nov.,** *Stachybotrys hyalina* **sp.nov.,** *Stachybotrys hyaloseptata* **sp.nov.,** *Trichobotrys ramosa* **sp.nov.,** *Vermiculariopsiella elegans* **sp.nov.,** *Virgatospora natarajanensis* **sp.nov.,** *Wardomyces septata* **sp. nov.,** *Zalerion curcumensis* **sp.nov.**

In spite of several detailed floristic investigations carried out elsewhere by other workers, a sizable number of the fungi were recorded for the first time from this part of the country, in this thesis. In all 27 species of microfungi are recorded for the first time from the forests of Western Ghats in southern India. A taxonomic key has been given for all the hyphomycetous fungi described in this study based on their diagnostic

features (Table 4.5.1).

Being one of the megabiodiversity zones of the world, the forest wealth of Western Ghats have become a matter of considerable interest in the recent days, especially the floristic composition. While the higher plant flora of Goa has been worked out in detail to some extent (Rao, 1986), the hitherto floristic records of terrestrial microfungi from this region were not only scanty but in piecemeal (Bhat and Kendrick, 1993; Miriam, 2000; Miriam and Bhat, 2000; Maria and Bhat, 2000, 2001). From this angle, the in-depth and comprehensive elucidation of terrestrial fungus flora of the forests of Goa presented in this thesis is a step forward.

In this work, based on the isolation techniques used, the following distinct recovery figures are visible. That is, the number of fungi isolated by different techniques was not the same. For instance, in moist chamber incubation method- 255, in particle plating technique - 505 and in 3-step surface sterilization technique - 143. This massive figure is mainly because some of the species were isolated by more than one of the techniques applied.

It was well known that in most of the hitherto investigations, students of mycology generally applied only a single isolation method such as either direct observation and isolation, isolation after moist chamber incubation or dilution plating technique. By and large none of them could recover a large number of isolates and species of associative fungi of a magnitude as of the present effort. It is therefore prudent to attribute the recovery of such a large number of fungi from plant substrates to the several techniques applied together.

Although culture media consuming exercise, particle plating method was found to be superior with regard to the number of species of fungi recovered. Further, a slight

deviation from the original method proposed by Bills and Polishook (1994) attempted, i.e. use of sector plates, helped in economising consumption of culture media (Fig. 3.2). This is a positive and important step useful for laboratories working with limited resources in the future.

2. Fungal diversity and substrate specificity

Some of the recent workers (Hawksworth, 1991; Subramanian, 1992; Isaac et al., 1993; Rossman, 1994; Bills, 1996; Bills and Polishook, 1994), posed a few questions on species abundance and diversity which remained unanswered. These include (i) how many species are likely to be found by sampling a single tree or several trees? (ii) what and which species are likely to inhabit a particular host plant and what are their relative abundance?

Using different isolation techniques, 388 associative litter and endophytic microfungi belonging to Hyphomycetes (224), Ascomycetes (14) and Coelomycetes (20), besides non-sporulating forms (130) were recovered from 26 plant species. In the descending order, the abundance of fungi associated with plant species were in this pattern: Hyphomycetes (maximum), non-sporulating forms moderate), Coelomycetes and Ascomycetes (minimum). It is evident from the results that fungi belonging to Hyphomycetes and non-sporulating forms were the major colonizers of the litters of plant species as exhibited by their species abundance.

The results also revealed an interesting figure of species abundance in fungi. Based on mycofloristic survey done in British Isles and by extrapolating the number with the associative vascular and other plant species, Hawksworth (1991) estimated that total number of fungi existing on earth surface would be to the tune of 1.5 million. As

can be seen from the results presented here (Table 4.5.1), when moist chamber technique was used, litter fungi isolated in case dicot and monocot plants ranged from 1-22. In particle plating technique, the recovery of microfungi from litter of both plant types ranged from 3-45. Isolation of endophytic fungi including distinguishable morphotypes from dicot and monocot plants showed a range from 5-23.

Taking a clue from what Hawksworth (1991, 1997) stated and extrapolating the number based on the 15000 species of vascular plants present in India (Nayar, 1989) and barring the overlapping taxa recovered in the methods used, it may be said that the total number of fungi in the Indian subcontinent could be anywhere near 3.8 Lakhs, a figure much higher than that projected earlier (Table 4.5.1).

If only one of the techniques had been applied, as generally done elsewhere by most workers, the recovery of fungi would have been in a very low order. Application of different techniques undoubtedly yielded recovery of a large number of fungi. It is clear from the results that different isolation techniques together resulted with the recovery of a large number of associative fungi from any plant species studied.

A pointed statement can be made with regard to endophytic fungi associated with higher plants. As can be seen from the results, isolated endophytes from a given plant are many and have touched a new and higher level of 23 per plant species as in the case of *Elaeis guineensis*, many of which may be host-specific. This number is much more than that indicated by Dreyfuss (1989). Interestingly, in the present study, none of the plants scanned were found to be free of endophytes. Similar observations were made on tropical plants by Rodrigues and Samuels (1990, 1992, 1994). Fisher et al,(1986), Rodrigues (1994) and Sieber et al. (1991), had earlier reported a high magnitude of undetermined taxa of endophytic fungi from all the plant species studied. The results

presented in the thesis is in full conformity with this observation.

Considering the vast number of vascular plant taxa present in the forests of Western Ghats in southern India and with the amazingly high number of fungi being recovered from any of the plant substrate tested in this work, it may be said that surveys on plants from these habitats for endophytes and other associative fungi in future will yield many more fungi including novel taxa.

With their classic work on a few tropical plants of Costa rica, using particle plating technique, Bills and Polishook (1994) provided information that fungi in this region of the world are in abundance. Rodrigues and Petrini (1997) further considered that tropical forests will continue to remain as 'black box' with respect to our knowledge on fungal diversity. They opined that these regions of the world would offer not only new and exciting chances for all those interested in fungal taxonomy and ecology but also opportunities to investigate the fungi for their biotechnological potential.

A number of fungi (both litter inhabiting and endophytes) recovered were found to be common to most of the plant species studied while a few were restricted to specific plants. In this study, not a single fungus was found to occur on all the 26 plant species scanned. *Cladosporium herbarum* (84.61%), *Vermiculariopsiella elegans* **sp.nov.** (65.38%) and *Cochliobolus lunatus* (65.38%) however showed more than 50% association with plant species. It may be inferred that vascular plants are the major reservoir of fungi in the forest ecosystem.

A few of the fungi recovered were isolated more than once but from the same plant. These were specific to the plant host and did not occur on any other plants. It may be said that, some of the fungi are limited to only one or a few plant species. Such

substrate specificity in plants expressed by fungi was predicted by Boddy and Griffith, (1989); Whalley (1993) and the results presented here are in conformity with the earlier work.

A large number of microfungi can be occasionally isolated from a single plant species, but only a few exhibit dominance in each plant. This ability of mycota to grow over a wide range of temperature, pH, moisture content and substrates is the reason for their unique survivability in the decomposing litter and live plant parts and dominance on certain plants.

3. Seasonal occurrence of and species richness:

The interaction with plants exhibited by fungi, saprophytic, parasitic and/or mutualistic, are of considerable significance in the functioning of an ecosystem. A new dimension of fungal association with higher plants, the endophytes, was realised in the last decade. The fungi exhibit substrate/host specificity and seasonality in colonisation with regard to various climatic, geographical, physical and chemical factors. All groups of fungi participate and facilitate complete decomposition of the substrate.

Seasonal occurrence and species richness of litter and endophytic fungi with respect to four plants, viz., *Saraca asoca* and *Careya arborea* (dicot) and *Calamus thwaitesii* and *Dendrocalamus strictus* (monocot), were carried out for two years during February 1999 to January 2001. Care in the choice of plant material, locality and season was taken to ensure that the results could be comparable.

Adapting different isolation methods, maximum recovery of fungi was possible. A total of 4461 isolates distinguishable into 402 taxa of litter and endophytic fungi were recovered. Based on rarefaction curves, expected number of fungal species was

calculated with respect to each plant in a random subsample of 70 isolates. In *Calamus thwaitesii*, in both years of study, the plant substrate was richer in species composition during pre-monsoon, i.e. E(s70) = 33 and 36. In *Saraca asoca*, in the first year, the substrate was richer during pre-monsoon, i.e. E(s70) = 23 and in the second year in post-monsoon season, i.e. E(s70) = 35. In *Careya arborea*, in both years, post-monsoon was richer season for species composition of fungi, i.e. E(s70) = 32 in 1999-2000 and E(s70) = 43 in 2000-01. In *Dendrocalamus strictus*, in 1999-2000, the plant substrate was richer during pre-monsoon, i.e. E(s70) = 36 and in the subsequent year rich season was post-monsoon, E(s70) = 38.

Taking a common subsample size of 70 for all the plant species studied as done here, it is possible to postulate what could be the expected number of associative fungal species in the given plant in a particular season. In other words, it is also possible to project the best season for recovery of fungi. Generally, the species isolate-curves as estimated by rarefaction, continued to ascend at a rapid rate until the maximum numbers of isolates. It is visualised that if such studies are conducted in a big way with all kinds of plants, a vast pool of fungi which have use in many ways could be recovered.

The results also indicated that, in general, species composition of fungi was maximum during pre-monsoon season of both years in all the 4 plant species studied, although in *Dendrocalamus strictus* a slight decline in the species richness was observed in the second year of analysis. The study also brought out an interesting picture that Molem wildlife sanctuary, is richer in its fungal species composition than that of Bondla wildlife sanctuary.

Based on Jaccard's similarity coefficient it was found out that the species composition of fungi within the two plants, *Saraca asoca* and *Calamus thwaitesii* from

Bondla and *Careya arborea* and *Dendrocalamus strictus* from Molem wildlife sanctuary, did not overlap in a big way though they lived in proximity to each other and were exposed practically to the same environmental conditions and fungal inoculum. There is no exaggeration if a conclusion is drawn that every plant is unique in its composite fungus flora to offer though some fungi may appear in more than one plant species.

4. Succession of microfungi:

The litter-bag experiment conducted for a period of time was useful to analyse the role of fungi appearing in succession during the process of decompostion of organic litter. The population of colonised fungi during the period of observation showed decrease or increase in number and types. Certain fungi overlapped in appearance though the flora showed distinct differences. Noticeably, several newer fungi appeared on the litter which otherwise not observed when leaf litter of the same plants gathered from same place were subjected to seasonal study.

The study revealed that the fungi appeared on litter in a definite pattern of succession. In the first month of incubation the species density of fungi was low and this may be attributed to the time taken by the resident fungal flora to adjust to the new environment. In the subsequent months, the floristic composition gets changed and an array of new fungi comes into picture.

The study conducted to evaluate the influence of C : N ratio on the rate of colonisation and decomposition process did not yield a clear picture. However, it can only be inferred from the results that in the process of litter decomposition, C : N ratio is not the only controlling factor but in addition the lignin content, phosphorus, the

prevailing environmental conditions such as temperature and moisture and native fungal flora are equally important, as suggested by Berg and Ekbohn (1991) and Cornellisen (1996).

5. Assaying of cultures of fungi for enzymes

One hundred forty species of the litter and endophytic fungi isolated from the tests plants were screened for their ability of producing at least 3 common enzymes, amylase, cellulase and pectinase. The results showed that 17.14% of the species exhibited ability to produce all the enzymes. Of these, two endophytic forms exhibited highest activity. In general, 43.57% were amylase positive, 49.28% cellulase and 42.85 % were pectinase positive. It was also evident that a few were producing exclusively a particular enzyme.

Some of the fungi which occurred both as litter and endophytes have shown interesting results. That is, *Alternaria alternata* behaved differently in its enzyme activity when occurred separately as an endophyte and litter inhabitant in *Saraca asoca.* Similarly, *Bharatheeya mucoidea* as a litter fungus showed positiveness for both amylase and cellulase with significant qualitative difference but as an endophyte exhibited ability to produce only cellulase. Similar behaviour was shown by *Corynespora* sp.1 isolated as litter and endophytic fungus. One more example can be cited with *Fusarium solani* from the same plant behaving differently in enzyme activity. The litter isolate was positive for amylase and cellulase whereas the endophyte showed both amylase and pectinase activity. It may be deduced from this investigation that it is rather a unique phenomenon of fungi where the enzyme activity is dictated by the habit and habitat.

The ability of fungi to secrete enzymes is well known. Study such as this not only provided information on what enzymes the microfungi are endowed with but also proved their mettle to decompose particular substrate where they reside, be it the litter or fresh leaves. Qualitative enzyme assays may not denote the entire activity of the fungi living on a particular substrate but it will certainly give an indication of their capability to produce particular enzyme. For instance, majority of the endophytes tested invariably produced pectinase which is an essential enzyme for its survival inside the host plant. This is an area of newer interest and will yield rich dividend if one pursues further.

6. Culture collection of litter and endophytic fungi

With increasing realization that fungi are sources of powerful metabolites of varied usage in agriculture, biotechnology, chemical, food and pharmaceutical industries, the importance of culturing and maintaining fungi in a repository cannot be underestimated. They are not only important additions to the fungal wealth of a nation but also will serve as a ready source cultures for utilitarian work.

Although several floristic and ecological studies were carried out on litter fungi earlier, hardly any one attempted to isolate, document and conserve the fungi in a repository or culture collection. Pure cultures of litter and endophytic microfungi of the forests of Western Ghats, recovered through state-of-the-art isolation techniques as done here, are not available anywhere else in our country. The isolation, documentation and preservation of the fungi has been done with great care and all sincerity during the course of this work. In all, 675 microfungi were recovered which included species of Hyphomycetes-289, Ascomycetes-18, Coelomycetes-22, Zygomycetes-01, Undetermined taxa-77 and Nonsporulating forms-268. These are carefully maintained in

malt extract agar (MEA) maintenance medium. Details of each taxon is documented in a specially constructed 'data-sheet' which readily provided information on taxonomy, habitat affinity, diversity and activity. This is the first time that such as composite effort on native microfungi has been done in this country.

Epilogue

Earlier studies on diversity, ecological association and activity of fungi of India, barring a few detailed investigations, were of cursory in nature both in space and time. Only a handful of comprehensive surveys of litter and endophytic fungi as done in this work are known. Organised collection, isolation, documentation and maintenance of fungi both in culture and herbarium, using state-of-the-art-techniques, as an industry have not been attempted at all. Elaborate screening programme of fungi for enzymes and other metabolites is still in its infancy in our country.

Modern industrial sectors, especially the pharmaceutical, agricultural, food, defense and dye, are eyeing at fungi and other microbes with an aim to extract useful properties from them. The knowledge on the extent of fungal diversity, ecological relation and chemical properties is therefore of great importance. It is appropriate then, efficient isolation techniques should be devised, tested and used. This has been done in this work. The litter was subjected to 'particle-plating' technique besides the conventional 'moist chamber incubation' and live leaves were processed through an efficient '3-step surface sterilization technique'. The result was recovery of an extraordinary large number of pure strains of a variety of microfungi. The documented information with pure cultures of fungi now available in the 'Goa University Fungus Culture Collection Unit', Department of Botany, Goa University, will be not only remain immortal but also

available for future biotechnology and other utilization sectors in our country.

Based on superficial observations, several workers have speculated the extent of fungal diversity. To achieve near-sure estimate the method of sampling, isolation and documentation should be very efficient. This has been done in this work. The results obtained in the form of documentation of an exceedingly large number of diverse, rare and interesting species, novel taxa, new records, information on species richness, seasonality, ecological succession, enzymatic activity and above all sizeable collection of priceless, pure isolates of fungi - are of 'high value' contribution to science.

A few of the isolates, especially the litter and endophytes, are now being tested for their chemical creativity. The preliminary information known from these tests indicated that that the fungi in our custody show potential therapeutic activity against neurological disorder. This is a new dimension of value addition and added strength for such work.

Fungi are potent producers of natural semi-synthetic compounds of high value such as (i) cephalosporin, cyclosporin, tremogenic neurotoxins, taxol and mycelial autodissolving surgical sutures and so on in the pharmaceuticals, (ii) citric acid, malic acid, alcohol, etc. of beverage industry, (iii) probiotics in agriculture and veterinary sector, (iv) vitamins, proteins and nutritive additives in food industry and (v) variety of natural colourants for textiles. If the industry has to tap these properties from fungi and provide a spin-off to national economy, the basic requirement is the ready source of fungi in their purest form in a culture collection with all information on their biology, ecology and creativity. From this angle, although basic, the results presented in this work are undoubtedly of no small measure.

Table : 4.5.1. **Key to the Hyphomycetous fungi from dicot and monocot plants of Western Ghat forests in Goa, during the present study:**

1. Conidiomata micronematous or semimacronematous----------2
1. Conidiophores macronematous (distinct reproductive body)----------13

2. Conidia hyaline, pyriform and aseptate, 3-5 x 0.5-2 µm---------- ***Chrysosporium* sp.**
2. Conidia pigmented----------3

3. Conidia aseptate----------4
3. Conidia septate----------5

4. Ellipsoidal to ovate, dark brown, 10-16.5 x 7.5-10 µm----------***Conioscypha bambusicola***
4. Obovoid to spherical, medium brown, 13-27 x 15-27 µm----------***Clamydomyces* sp.**
4. Spherical to ellipsoidal, black, shining, 9-12 x 14.5-16.5 µm--------***Nigrospora sphaerica***

5. Conidia branched----------6
5. Conidia unbranched----------7

6. Conida with 4 columns of cells, which form divergent, tapering, septate appendages----------***Tetraploa aristata***
6. Conidia with stalk cell and 4 divergent arms----------***Tripospermum myrti***

7. Conidia with both tranverse and longitudinal septa----------8
7. Conidia with only transverse septa----------10

8. Conidia verrucose, broadly ellipsoidal ----------***Pithomyces chartarum***
8. Conidia smooth, cheroid, not deeply constricted at the septa----------9

9. Conidia 24-32 x 8-14µm wide at base, 17-20µm at above---***Monodictys monilicellularis***
9. Conidia 24-58 x 22-38 µm wide at base, 20-24 µm at above--------***Monodictys putredinis***

10. Conidia solitary, 1-septate----------***Wardomyces septata***
10. Conidia solitary, 2-4 septate----------***Polyschema indica***
10. Conidia in chains or slipped chains----------11

11. Conidial chains branched---------- ***Torula herbarum***
11. Conidial chains unbranched---------- 12

12. Conidia verruculose, olive green, 16-33 x 4.5-8 µm.---------- ***Fusariella bizzozeriana***
12. Conidia smooth, hyaline, 15-20 x 2-3.5 µm ----------***Fusariella hughesii***
12. Conidia smooth, olive green, 10-15 x 4-5 µm----------***Fusariella indica***

13. Conidiomata mononematous----------14
13. Conidiomata synnematous or sporodochial----------98

14. Conidiogenesis thallic----------***Bahusakala olivaceonigra***
14. Condiogenesis blastic----------15

15. Conidiogenesis holoblastic----------16
15. Conidiogenesis enteroblastic----------64

16. Conidia aseptate (amerosporous)----------17
16. Conidia septate----------40

17. Conidia catenate----------18
17. Conidia slimy and/or solitary----------22

18. Conidiogenous cells discrete----------19
18. Conidiogenous cells integrated----------20

19. Conidia spherical, verrucose, 9-12 µm diam----------***Periconia atra***
19. Conidia spherical, smooth or verrucose, 2-15 µm diam----------***Periconia byssoides***
19. Conidia ellipsoidal, verrucose, 15-18 x 6-9 µm----------***Periconia echinochloae***

20. Conidiophores unbranched----------***Gonatobotryum apiculatum***
20. Conidiophores branched at the upper half----------21

21. Conidia verruculose, aseptate, 3-5 µm diam ----------***Trichobotrys ramosa***
21. Conidia smooth, aseptate, 3.5-5 µm diam.----------***Trichobotrys saprophyticus***

22. Separate setae present---------- 23
22. Setae arise from the conidiophores ----------24
22. Setae absent----------25

23. Conidia biconic, obovoid, brown distinct hyaline transverse band above middle of the conidium, 20-35 x 4-10 µm, the free end with up to 7-12 µm long, tapering to a pointed appendage----------***Beltrania rhombica***
23. Conidia biconic, hyaline, with a distinct hyaline transverse band above the middle, 19-30 x 4-4.5 µm----------***Beltraniella pini***
23. Conidia spherical or subspherical, 3.5-5 µm in diam.----------***Lacellinopsis spiralis***

24. Vesicles on short stalks arising directly from the mycelium----------***Zygosporium gibbum***
24. Vesicles short stalked borne laterally at the base of a setiform stipe--***Zygosporium minus***

25. Conidiogenous cells discrete----------26
25. Conidiogenous cells integrated----------29

26. Conidia hyaline----------27
26. Conidia pigmented----------28

27. Conidia sickle shaped---------- ***Selenoidriella indica***
27. Conidia ellipsoidal---------- ***Tritirachium* sp.**
28. Conidiogenous cells spherical to sub-spherical cup-like, closely arranged all around the conidiophore------***Parapathramaya haarea***
28. Conidiogenous cells penicillately arranged on conidiophores----------30

29. Conidia with a distict frill ----------***Nodulisporium gregarium***
29. Conidia without a frill---------- ***Nodulisporium* sp.**

30.Conidia hyaline----------31
30. Conidia pigmented----------36

31. Conidia linear-obtriangulate----------***Solosympodiella clavata***

31. Conidia falcate to sigmoidal----------32

32. Conidiophore branched----------33
32. Conidiophore unbranched----------34

33. Conidiogenous cells arranged in a verticils----------***Idriella verticillata***
33. Conidiogenous cells in 1-2 branches----------***Idriella fertilis***

34. Conidia thread like, sigmoidal, 18-22 x 0.5-1 µm----------***Idriella sigmoidea***
34. Condia falcate----------35

35. Conidiophore 0-1 septate, conidia 10-18 x 1-1.5 µm----------***Idriella lunata***
35. Conidiophore 2-10 septate, conidia 8.5-12.5 x 1-1.5 µm----------***Idriella* sp.**

36. Conidia globose---------- ***Acrogenospora sphaerocephala***
36. Conidia not globose----------37

37. Conidia navicular or lenticular on peg like denticles ----------38
37. Conidia ellipsoidal, cicatrized scars present, conidiferous denticles absent----------39

38. Conidia 12-16 x 5-7 µm---------- ***Ardhachandra parva***
38. Conidia 20-24 x 5-7 µm---------- ***Ardhachandra selenoides***

39. Condiophores 3-6 septate, conidia 4-8 x 2-3.5 µm----------***Veronaea bambusae***
39. Condiophores 6-7 septate, condia 3-5.5 x 1.5-2.75 µm----------***Veronaea botryosa***

40. Conidia with single septum----------41
40. Conidia with 2 to many septa---------- 44

41. Conidia falcate---------- 42
41. Conidia not falcate----------43

42. Conidiophore unbranched, conidia 24-30 x 2-3.5 µm with distinct 2-3 µm long setula at the distal terminus, chlamydospores present----------***Idriella hyalina***
42. Conidiophores unbranched, conidia hyaline, 6-10 x 2-4 µm----------***Idriella goanensis***
42. Conidiophores branched, conidia 24-30 x1-1.5 µm----------***Idriella malabarica***

43. Conidia clavate to ellipsoidal, pale to mid brown, 4.5-10 x 2.4-3.6 µm, conidiophores up to 6 x 2.5 µm----------***Scolecobasidium humicola***
43. Conidia clavate to ellipsoidal, pale to mid brown, 4-8 x 2.3-3.3 µm, conidiophores 37-94 x 2-3 µm ----------***Scolecobasidium* sp.1**
43. Conidia cordate and deeply lobed ---------- ***Dendrosporium lobatum***
43. Conidia long cylindrical with truncate ends---------- ***Sympodiella laxa***
43. Conidia oval to clavate, 14-33 x 8-13 µm, 1.5-3.5 µm----------***Arthrobotrys oligospora***
43. Conidia oval to obclavate, cicatrized at the base, 3.5-8.5 x 3.5-4.5 µm-----***Pyricularia* sp.**
43. Conidia doliform, 15-20 x 5-6 µm----------***Paschimghateeya goanensis***
43. Conidia and ramoconidia present----------***Cladosporium elegans***
43. Conidia fusiform, 4-10 x 2-3.5 µm ---------- ***Heteroconium* sp.**

44. Conidia branched to form various shapes----------45
44. Conodia unbranched----------46

45. Conidia Y-shaped, with three hyaline, divergent branches arising from the upper cell of conidium and ends in a narrow, pointed appendage----------*Iyengarina saprophyticus*
45. Conidia 4-5.5 x 2-3 µm, surmounted by a group of cells 10 µm diam. with 3-6 upwardly divergent arms, each 4-6-septate----------*Actinocladium rhodosporum*

46. Conidia coiled in one or many planes to form helical or muroidal shapes----------47
46. Conidia not coiled----------48

47. Conidia 30-33-septate, hyaline, 50-70 µm diam.; conidial filament coiled 3 times in one plane, basal cell frequently enlarged to 4 x 14 µm----------*Helicomyces roseus*
47. Conidia 8-18-septate, hyaline, 24-35 µm in diam.; conidial filament coiled 2-3 times in one plane, with basal cell enlarged up to 8-11 x 1.3-2 µm----------*Helicosporium* **sp.**
47. Conidia mid to dark brown, coiled irregularly in several planes and sometimes forming a knot or a ball of cells, when coiled 13-30 µm diam.---------- *Zalerion curcumensis*

48. Conidia with both transverse and oblique septa----------49
48. Conidia with only transverse septa----------50

49. Conidia spherical, black, cruciately septate, densely echinulate, 6.5-14.5 µm diam.------*Dictyoarthrinium rabaulense*
49. Conidia broadly clavate to pyriform, brown, basal cell obconical----------*Acrodictys bambusicola*
49. Conidia spherical to globose, with pale peripheral cells surrounding central dark brown to black cells, 20-45 x 19-24 µm----------*Hermatomyces tucumanensis*

50. Conidia narrow and/or elongated with many septa ---------- 51
50. Conidia not elongated---------- 54

51. Conidia with true septa----------52
51. Condia with pseudosepta----------53

52. Conidia fusoid to falcate, 5-10-septate, brown, 35-80 x 3-5 µm---*Aquaphila ramdayalea*
52. Conidia falcate, acute, 2-3-septate, hyaline, 11-16 x 1.5-2 µm----------*Idriella septata*
52. Conidia straight to slightly flexuous, rounded at the apex, truncate at the base, 3-septate, hyaline, 26-36 x 2-3 µm radially disposed at the tip of the conidiogenous cell, minutely denticulate at the base----------*Dactylaria* **sp.**
52. Conidia cylindrical to subulate, pointed and narrower at the distal end, hyaline, 5-10-septate, 100-250 x 2.5-4.5 µm---------- *Mirandina longispora*
52. Conidia subuliform, hyaline, acute and curved sharply at the tip, 3-septate, 37-50 x 2-3.5 µm, 12-20 x 1.5-2 µm at the bent end----------*Subulispora procurvata*

53. Conidia obclavate, rostrate, 3-5-septate, 50-85µm long, 3-4 µm wide at the base, 8-10.5 µm in the middle, 1.5-3 µm at the rostrate end----------*Sporidesmium brachypus*
53. Conidia obclavate, 4-5 septate, 30-55 x 6-8 x 2-3.5 µm ------*Sporidesmium coprophilum*
53. Conidia obclavate, rostrate, 4-5 septate, 38-56 x 6-7.5 µm, 1.5-2.5 µm wide at the basal and apical portion.----------*Sporidesmium flagelliforme*
53. Conidia cylindrical, truncate at the base, rounded at the apex, 15-25 septate, 70-120 x 4-14 µm.----------*Sporidesmium harknesii*
53. Conidia cylindrical, truncate at the base, slightly rostrate at the apex, 7-11 septate, 33-67 x 14-17 µm, 4-5 µm wide at the tip---------- *Sporidesmium leonense*

53. Conidia obclavate to elongated cylindrical, conico-truncate at the base, 24-50 septate, 115-200 x 9-11 µm, 3-4.6 µm wide at the base and tip----------***Sporidesmium vagum***
53. Conidia obclavate with an elongated rostrate end, conico-truncate at the base, 11-14 septate, 72-127 x 4.5 -10 µm, up to 1.53 µm wide at the tip----------***Sporidesmium* sp. 1**
53. Conidia cylindrical, truncate at the base, with a small curved septate projection at base, rostrate at the apex, 7-8 septate, 70-95 x 6.5-12.5 µm, 3-6.5 µm wide at the tip----------***Sporidesmium* sp. 2**

54. Condiogenous cells mostly discrete----------55
54. Condiogenous cells mostly integrated----------56

55. Conidia pyriform, apical cell widest----------***Edmudmasonia pulchra***
55. Conidia obglobose, conidia widest at middle----------***Kramasamuha sundara***

56. Conidia with 3 long appendages on distal narrow tip -----***Chaetendrophragmia triseptata***
56. Conidia not appendaged----------57

57. Conidiophore without denticles----------58
57. Conidiophore with denticles----------59

58. Conidia obclavate, with distinct frill at the base of primary conidia. *Synanamorph Idriella*-like----------***Elegantimyces sporidesmiopsis***
58. Conidia broadly ellipsoidal, 20-25 x 8-13 µm, produced successively in a cluster, condiphore with a termial sterile vesicle ----------***Exserticlava vasiformis***

59. Conidiophores often short, conidogenous cells with long denticles appear like a basidium----------60
59. Conidiophores elongated ---------- 61

60. Conidia acuminate, verruculose, 12-20 x 3-4.5 µm--------***Scolecobasidium acuminatous***
60. Conidia ellipsoidal, minutely verruculose,3.5-5 x 2.4 µm--***Scolecobasidium constrictum***
60. Conidia clavate, verruculose,9-17 x 1.5-3.5 µm----------***Scolecobasidium saprophyticus***
60. Conidia smooth, 9-17 x 3-3.5 µm, 1.5 µm wide at the apex--------***Scolecobasidium* sp. 2**

61. Denticles absent, Conidia pyriform with widest distal cell--------***Brachysporiella gayana***
61. Denticles tapered to a point----------62
61. Denticles not tapered to a point----------63

62. Conidia solitary, fusiform and pointed at both ends-------***Pleurophragmium minutispora***
62. Conidia with rounded apex, and pointed base----------***Pleurophragmium simplex***

63. Conidiophores unbranched----------***Pleurothecium pulneyensis***
63. Conidiophores branched----------***Pleurothecium ramosa***

64. Conidiogenesis tretic----------65
64. Conidiogenesis phialidic----------72

65. Pores uncicatrized---------- 66
65. Pores cicatrized ----------67

66. Conidia limoniform---------- ***Hemicorynespora mitrata***
66. Conidia ampuliform----------***Parahelminthosporium malabaricum***

67. Conidia with transverse and oblique septa----------*Alternaria alternata*
67. Conidia with only transverse septa----------68

68. Conidia obclavate with pseudosepta----------69
68. Conidia with true septa----------71

69. Conidia, longer than 40 µm---------- *Helminthosporium velutinum*
69. Conidia no longer than 40 µm----------70

70. Conidia 1-6-pseudoseptate, 7-35 x 5-8 µm----------*Helminthosporium palmigenum*
70. Conidia, 3-distoseptate, verrucose, 23-40 x 14-22 µm---------- *Bharatheeya goanensis*
70. Conidia, 2-4-distoseptate, smooth, 22-40 x 4-18 µm with a conspicuous mucilaginous cap at the tip----------*Bharatheeya mucoidea*

71. Conidia curved---------- *Curvularia lunata*
71. Conidia straight----------*Spadicoides calamii*

72. Conidiogenous cells mostly integrated----------73
72. Conidiogenous cells mostly discrete----------85

73. Setae present----------*Dictyochaeta assamica*
73. Setae absent----------74

74. Sterile capitate hyphae arise from the base of the stroma----*Sporoschisma nigroseptatum*
74. Sterile capitate hyphae absent----------75

75. Phialides without collarettes----------76
75. Phialides with collerettes----------77

76. Conidia 3-septate, 20-24 x 6-8 µm----------*Kylindria excentrica*
76. Conidia aseptate 4-5.5 x 2.5-3.5 µm----------*Kylindria hyalina*

77. Conidia not catenate, solitary----------78
77. Conidia catenate----------81

78. Conidia spherical or angular with many thin long hyaline thread like appendages-------79
78. Conidia without any appendages----------80

79. Conidia spherical, 12-14 µm diam, appendages 6-10 in number---*Bahusutrabeeja dwaya*
79. Conidia angular, 7-10 x 6-7 µm, appendages 3-5 in number---*Bahusutrabeeja angularis*

80. Conidia spherical to obovoid----------*Craspedodidymum abigianens*
80. Conidia cuneate----------*Chloridium ghaticum*
81. Conidia hyaline----------82
81. Conidium brown----------83

82. Conidia 15-25 x 2.4 µm----------*Chalara* **sp.**
82. Conidia two-types; first-formed conidia 3-4 septate, 10-13 x 2-2.5 µm; later-formed conidia 1-2-septate, 6-9 x 2-2.5 µm.----------*Fusichalara bipodia*

83. Conida cunate----------*Catenularia malabarica*

83. Conidia cylindrical----------*Dischloridium minutum*
83. Conidia ellipsoidal to doliiform----------84

84. Conidia ellipsoidal, 3-5.5 x 2-2.6 µm ----------*Gliomastix murorum*
84. Conidia doliiform to ellipsoidal, 5-8 x 4-5 µm----------*Gliomastix nova-zelandiae*

85 Conidia catenate----------86
85 Conidia solitary----------90

86. Conidiophores enlarged terminally into a vesicle----------87
86. Conidiophores do not form any vesicles----------88

87. Conidiophores branched----------*Raperia swedaja*
87. Conidiophores unbranched ----------*Aspergillus restrictus*

88. Conidiogenous cells arranged in penicillous heads---------- ***Phialocephala* sp.**
88. Conidiogenous cells arranged in whorls ---------- ***Mariannaea elegans***
88. Conidiogenous cells not penicllate or whorled---------- 89

89. Conidia 26-34 x 4-5 µm.----------***Cylindrotrichum* sp. 1**
89. Conidia 65-90 x 6-7 µm ----------***Cylindrotrichum* sp. 2**

90. Conidia elongated, fusoid, conidiogenous cells vase shaped----------91
90. Conidia not elongated----------92

91. Conidia aseptate, 9-17 x 1-1.5 µm----------*Kumbhamaya aseptata*
91. Conidia 2-5-septate, 7-30 x 1.5-2.5 µm----------*Kumbhamaya goanensis*
91. Conidia 3-septate, 25-40 x 3.5-5.5 µm----------*Kumbhamaya indica*

92. Conidiogenous cells penicillate----------*Gliocladium penicilloides*
92. Conidiogenous cells not penicillate----------93

93. Condiogenous in veticills----------*Verticillium cinnabarinum*
93. Conidiogenous cells equal in size, in groups at the apex of stipe----------94
93. Conidiogenous cells not as above----------97

94. Conidia hyaline----------95
94. Conidia pigmented----------96

95. Conidia aseptate---------- ***Stachybotrys hyalina***
95. Conidia septate---------- ***Stachybotrys hyaloseptata***

96. Conidia aseptate, verruculose----------*Stachybotrys atra*
96. Conidia aseptate, smooth----------*Stachybotrys* state of *Melanopsamma pomiformis*
96. Conidia 1-septate, smooth, 9-11 x 3-4 µm----------*Stachybotrys aurantia*
96. Conidia 1-septate, verruculose, 7-10 x 4-5.5 µm----------*Stachybotrys nephrospora*
96. Conidia 1-septate, verruculose, 10-11.5 x 6-7.5 µm----------*Stachybotrys oenanthes*

97. Conidia septate---------- ***Sesquicillium indica***
97. Conidia asepate, reniform----------***Gliocladium* sp.**
97. Conidia aseptate, oval---------- ***Acremonium* sp.**

98. Synnematous----------99
98. Sporodochial----------102

99. Synnema compact and spirally twisted---------- ***Didymobotryum spirillum***
99. Synnema compact and parallel----------100

100. Conidiogenesis holoblastic---------- ***Gangliostilbe indica***
100. Conidiogenesis tretic---------- ***Podosporium* sp.**
100. Conidiogenesis phialidic----------101

101. Conidia striated, aseptate---------- ***Virgatospora natarajensis***
101. Conidia smooth, septate---------- ***Saccardaea indica***

102. Setae present----------***Vermiculariopsiella elegans***
102. Setae absent----------103

103. Conidia aseptate, a conspicous germ slit, 13-25 µm diam---***Pteroconium pterospermum***
103. Conidia septate----------104.

104. Conidia muriform, flattened, one cell thick,
40-47 x 14-25 µm----------***Canalisporium caribense***
104. Conidia cheiroid, 33-55 x 10-24 µm wide at the base, 12-18 µm wide at the distal end, flattened in one plane---------- ***Dictyosporium elegans***
104. Conidia globose to sub-spherical, 13-27 x 17-25 µm----------***Epicoccum purpurascens***

Table 4.5.1. **Estimation of total number of fungi associated with dicot and monocot plants of India, based on application of different recovery techniques:**

Isolation methods	*Average recovery of fungi*		*Total species*
	Dicot	*Monocot*	
Moist-chamber	10	11	157500
Particle plating	24	27	382500
Endophytes	13	15	210000

Table 4.5.3. **The fungi recovered during the study are listed below:**

Hyphomycetes

Acremoniella sp.1
Acremoniella sp.2
Acremonium sp. 1-9
Acrodictys appendiculata
Acrodictys bambusicola
Acrodictys elaeidis
Acrogenospora sphaerocephala
Acrophialophora sp.
Actinocladium rhodosporum
Agyriella sp.
Alternaria alternata
Alternaria tenuis
Aquaphila ramdayalea **sp.nov.**
Ardhachandra parva **sp.nov.**
Ardhachandra selenoides
Arthrinium sp.
Arthrobotrys oligospora
Aspergillus sp.1-4
Aspergillus niger
Aspergillus restrictus
Bahusakala olivaceonigra
Bahusutrabeeja angularis
Bahusutrabeeja dwaya
Beltrania rhombica
Beltraniella pini
Bharatheeya mucoidea
Bharatheeya goanensis
Bisporomyces sp.
Brachysporiella gayana
Canalisporium caribense
Candelabrum spinulosum
Catenularia malabarica
Cercosporula corticola
Chaetendrophragmia triseptata
Chaetopsina fulva
Chalara sp.
Chamydomyces sp.
Chloridium sp.
Choridium ghaticum **sp.nov.**
Chrysosporium sp.
Circinotrichum macauliforme
Cladosporium cladosporoides
Cladosporium elegans
Cladosporium herbarum
Cladosporium sp.1-9
Clonostachys cylindrospora
Conioscypha bambusicola
Corynespora cassicola
Corynespora proliferata
Corynespora sp.1
Corynespora sp.2
Corynespora sp.3
Craspedodidymum abigianense
Cryptophiale zeylanica
Curvularia eragrostidis
Curvularia lunata
Curvularia pallescens
Cylindrocarpon sp.1
Cylindrocarpon sp. 2
Cylindrocladium sp.1
Cylindrocladium sp.2
Cylindrotrichum sp.1
Cylindrotrichum sp.2
Dactylaria sp.
Dactylella sp.1
Dactylella sp.2
Dendrosporium lobatum
Dictyoarthrinium rabaulense
Dictyochaeta assamica
Dictyochaeta sp.
Dictyosporium elegans
Dictyosporium oblongum
Dictyosporium sp.
Didymobotryum spirillum **sp.nov.**
Dischloridium minutum **sp.nov.**
Drechslera australiensis
Drechslera halodes
Edmundmasonia pulchra
Elegantimyces sporidesmiopsis
Endocalyx thwaitesii
Endophragmia sp.
Epicoccum purpurascens
Epicoccum sp.
Exserticlava triseptata
Exserticlava vasiformis
Fusariella bizzozeriana
Fusariella hughesii
Fusariella indica
Fusarium decemcellulare
Fusarium moniliforme
Fusarium semitectum
Fusarium solani

Fusichalara bipodia **sp.nov.**
Gangliostilbe indica
Gliocephalis sp.
Gliocladium penicilloides
Gliocladium sp.
Gliomastix murorum
Gliomastix novae-zelandiae
Gliomastix sp.
Gliomastix state of *Wallrothiella subiculosa*
Gonatobotryum apiculatum
Gonytrichum macrocladium
Gonytrichum sp.
Gyrothrix sp.
Hansfordia sp.
Helicoma sp.
Helicomyces roseus
Helicomyces sp.1
Helicomyces sp.2
Helicosporium sp.
Helminthosporium palmigenum
Helminthosporium velutinum
Hemicorynespora mitrata
Henicospora minor
Hermatomyces tucumanensis
Heteroconium sp.
Humicola grisea
Idriella fertilis
Idriella goanensis **sp. nov.**
Idriella hyalina **sp. nov.**
Idriella lunata
Idriella malabarica
Idriella septata **sp. nov.**
Idriella sigmoidea **sp. nov.**
Idriella sp.
Idriella verticillata **sp. nov.**
Isthmolongispora intermedia
Iyengarina saprophyticus **sp. nov.**
Kramasamuha sundara **sp. nov.**
Kumbhamaya aseptata **sp. nov.**
Kumbhamaya curvata **sp. nov.**
Kumbhamaya goanensis **sp. nov.**
Kumbhamaya indica
Kylindria excentrica
Kylindria hyalina **sp. nov.**
Lacellinopsis spiralis
Mariannea elegans
Mauginiella sp.
Melanographium calami
Memnoniella echinata
Menisporopsis sp.
Minimidochium setosum
Mirandina corticola
Mirandina longispora **sp.nov.**
Monodictys erecta
Monodictys globulosa
Monodictys monilicellularis
Monodictys putredinis
Mycoenterolobium sp.
Mycoleptodiscus indicus
Mycovellosiella sp.
Myrothecium gramineum
Myrothecium innundatum
Nigrospora sphaerica
Nodulisporium gregarium
Nodulisporium sp.
Paecilomyces roseolus
Paecilomyces sp.
Parahelminthosporium malabaricum
Parapathramaya haarea **gen. et sp. nov.**
Paschimghateeya goanensis.
Penicillium sp. 1-5
Periconia atra
Periconia byssoides
Periconia cookei
Periconia echinochloae
Phaeoisaria sp.
Phaeoisariopsis sp.
Phialosporostilbe setosa
Phaeostilbe sp.
Phiacephala sp.
Piricauda cochinensis
Piricauda paraguayensis
Pithomyces chartarum
Pleurophragmium minutispora **sp. nov.**
Pleurophragmium simplex
Pleurothecium pulneyensis
Pleurothecium ramosa **sp. nov.**
Podosporium sp.
Polyschema indica
Polyschema sp.
Pseudobeltrania sp.
Pseudobotrytis terrestris
Pteroconium pterospermum
Pteroconium sp.

Pyricularia sp.
Pyriculariopsis sp
Ramichloridium sp.
Ramularia gei
Raperia swadeja **sp. nov.**
Rhinocladiella sp.
Saccardaea indica **sp. nov.**
Scolecobasidium acuminatous **sp. nov.**
Scolecobasidium compactum
Scolecobasidium constrictum
Scolecobasidium humicola
Scolecobasidium saprophyticus **sp. nov.**
Scolecobasidium sp.1
Scolecobasidium sp.2
Scolecobasidium variable
Seismatosporium sp.
Selenoidriella indica
Sesquicillium candelabrum
Sesquicillium indicum **sp. nov.**
Solosympodiella clavata
Spadicoides atra
Spadicoides calamii **sp. nov.**
Speiropsis pedatospora
Sphaeridium setosum
Sporidesmium bambusae
Sporidesmium brachypus
Sporidesmium coprophilum
Sporidesmium flagelliforme
Sporidesmium flagelliforme
Sporidesmium harknesii
Sporidesmium leonense
Sporidesmium sp. 1
Sporidesmium sp.2
Sporidesmium sp.3
Sporidesmium tenuisporum
Sporidesmium vagum
Sporoschima nigroseptatum
Stachybotrys atra
Stachybotrys aurantia
Stachybotrys hyalina **sp. nov.**
Stachybotrys hyaloseptata **sp. nov.**
Stachybotrys nephrospora
Stachybotrys oenanthes
Stachybotrys state of *Melanopsamma pomiformis*
Staphylotrichum coccosporum
Stilbum sp.
Subulispora procurvata
Sympodiella laxa
Tetraploa aristata
Tetraploa ellisii
Thozetella effusa
Thozetella nivea
Tomenticola trematis
Torula herbarum
Trichobotrys ramosa **sp. nov.**
Trichobotrys saprophyticus **sp. nov.**
Trichoderma koningi
Trichoderma lignorum
Trichothecium sp.
Tripospermum myrti
Tritirachium sp.
Vermiculariopsiella elegans **sp. nov.**
Veronaea bambusae
Veronaea botryosa
Verticillium cinnabarinum
Verticillium sp. 1
Verticillium sp.2
Virgatospora natarajanensis **sp. nov.**
Volutella ramkumarii
Volutella sp. 1
Volutella sp.2
Wardomyces septata **sp. nov.**
Wiesneriomyces javanicus
Zalerion curcumensis **sp. nov**
Zygosporium echinosporum
Zygosporium gibbum
Zygosporium masonii
Zygosporium minus
Zygosporium mycophilum

Zygomycete
Mucor hiemalis

Ascomycetes
Balansia sp.
Chaetomium funicola
Cochliobolus lunatus
Diatrype collariata
Didymosphaeria vaitarnensis
Didymosphaeria winteri
Didymospora sp.
Glomerella cingulata
Guignardia sp.
Leptosphaeria sp.
Microthelia incrustans

Nectria crenula
Nectriella vernoniana
Podosphaera clandestina
Undetermined sp. 1
Undetermined sp. 2
Undetermined sp. 3
Xylaria fulva

Coelomycetes
Botryodiplodea theobromae
Chaetomella circinata
Discosia bombycina
Linodochium sp.
Macrophoma sp.
Microascus sp.
Pestalotiopsis sp.
Phoma sp.1
Phoma sp.2
Phoma sp.3
Pycnidial sp.1-10
Robillarda sp.
Seimatosporium sp.
Tubercularia vulgaris

Undetermined sp. (1-77)

Non-sporulating mycelia (1-268)

CHAPTER V

SUMMARY

This thesis embodies results of an investigation carried out over a period of two and a half years, from February 1999 to June 2001, on floristics, ecology and activity of litter and endophytic fungi associated with several native dicot and monocot plants of forests of Western Ghats in Goa State.

Fallen, dead and decaying leaves and twigs and live, disease-free, fresh and mature leaves constituted the source materials for litter-inhabiting and endophytic fungi. Moist-chamber incubation and particle-plating techniques were used for recovery of litter fungi whereas endophytes were isolated by 3-step surface sterilization technique.

From the more than 6500 strains isolated, 675 species of fungi belonging to 275 known genera Zygomycetes (1), Ascomycetes (18), Hyphomycetes (289), Coelomycetes (22), undetermined taxa (77) and non-sporulating forms (268) were distinguished during the study period. A total of 144 species of rare, unusual, interesting and novel hyphomycetous fungi were described in detail with camera lucida illustrations and photomicrographs. A taxonomic key has been given for all the hyphomycetous fungi described in this study based on their diagnostic features.

In this study, 35 novel species in 26 genera of hyphomycetous fungi are described for the first time. Three of these, *Bharatheeya*, *Paschimghateeya* and *Parapathramaya* are new at generic level. The new species include *Aquaphila ramdayalea*, *Ardhachandra parva*, *Bharatheeya goanensis*, *Bharatheeya mucoidea*, *Choridium ghaticum*, *Didymobotryum spirillum*, *Dischloridium minutum*, *Fusichalara bipodia*, *Idriella hyalina*, *Idriella septata*, *Idriella goanensis*, *Idriella sigmoidea*, *Idriella verticillata*, *Iyengarina saprophyticus*, *Kramasamuha sundara*, *Kumbhamaya aseptata*, *Kumbhamaya curvata*, *Kumbhamaya goanensis*, *Kylindria hyalina*, *Mirandina longispora*, *Parapathramaya haarea*, *Pleurophragmium minutispora*, *Pleurothecium*

ramosa, Raperia swedaja, Saccardaea indica, Scolecobasidium acuminatus, Scolecobasidium saprophyticus, Sesquicillium indicum, Spadicoides calamii, Stachybotrys hyalina, Stachybotrys hyaloseptata, Trichobotrys ramosa, Vermiculariopsiella elegans, Virgatospora natarajanensis, Wardomyces septata, Zalerion curcumensis.

A sizable number of microfungi (27) were recorded for the first time not only from the Western Ghat region but also were new records for India. While the higher plant flora of Goa has been worked out in detail to some extent, the hitherto knowledge on terrestrial microfungi of forests of Western Ghats of Goa region were scanty and available only in piecemeal. The in-depth and comprehensive knowledge on microfungi elucidated through this thesis is therefore an important contribution.

In this work, because several techniques were applied together, it was possible to recover a large number of fungi in pure culture from plant substrates. In moist chamber incubation method-255, particle plating technique-505 and three-step surface sterilization technique-143. Though a degree of overlapping was noticed, the results clearly demonstrated that application of a single isolation method such as either direct observation and isolation, isolation after moist chamber incubation or particle-plating may not give the complete picture of mycoflora associated with the plants.

Using different isolation techniques, 388 associative litter and endophytic microfungi belonging to Hyphomycetes (224), Ascomycetes (14) and Coelomycetes (20), besides non-sporulating forms (130) were recovered from 26 plant species. In the descending order, the abundance of fungi associated with plant species were in this pattern: Hyphomycetes and non-sporulating forms (maximum) and Coelomycetes and Ascomycetes (minimum). Hyphomycetes and non-sporulating forms were the major

colonizers of the litters of plant species as exhibited by their species abundance. If only one of the techniques had been applied, the recovery of fungi would have been in a very low order. Application of different techniques undoubtedly yielded recovery of a large number of fungi.

Counting on the 15000 species of vascular plants present in India and barring the overlapping taxa recovered in the methods used, it may be said that the total number of fungi in the Indian subcontinent could be anywhere near 3.5 Lakh species, a figure much higher than that projected earlier.

Associative endophytes of a given plant have touched a new level of 25 per plant species, many of which may be host-specific, a number much more than that indicated by earlier workers. In the present study, none of the plants scanned were found to be free of endophytes. Considering the vast number of vascular plant taxa present in the forests of Western Ghats in southern India and with the amazingly high number of fungi being recovered from any of the plant substrate tested in this work, it may be said that surveys on plants from these habitats for endophytes and other associative fungi in future will yield many more fungi including novel taxa. This region of the world would continue to offer not only newer chances for all those interested in fungal taxonomy and ecology but also exiting opportunities to investigate the mycota for their biotechnological potential.

A number of fungi (both litter and endophytes) recovered were found to be common to most of the plant species studied while a few were restricted to specific plants. In this study, not a single fungus was found to occur on all the plant species scanned. *Cladosporium herbarum* (84.61%), *Vermiculariopsiella elegans* (65.38%) and *Cochliobolus lunatus* (65.38%) however showed more than 50% association with plant

species. It may be inferred that vascular plants are major reservoir for fungi in the forest ecosystem.

Some of the fungi were isolated more than once but from the same plant. These were specific to the plant host and did not occur on any other plants. Such substrate specificity in plants expressed by fungi was predicted and the results presented here are only in conformity with the earlier work.

Seasonal occurrence and species richness of litter and endophytic fungi with respect to four plants, viz., *Saraca asoca* and *Careya arborea* (dicot) and *Calamus thwaitesii* and *Dendrocalamus strictus* (monocot), were carried out for two years. Adapting different isolation methods, a total of 4461 isolates distinguishable into 402 taxa of litter and endophytic fungi were recovered. Based on rarefaction curves, expected number of fungal species was calculated with respect to each plant in a random subsample of 70 isolates.

The results indicated that, in general, species composition of fungi was maximum during pre-monsoon season of both years in all the 4 plant species studied, although in *Dendrocalamus strictus* a slight decline in the species richness was observed in the second year of analysis. The study brought out an interesting picture that Molem wildlife sanctuary, is richer in its fungal species composition than that of Bondla wildlife sanctuary. There is also no exaggeration if a conclusion is drawn that every plant is unique in its composite fungus flora to offer though some fungi may appear in more than one plant species.

Taking a common sub sample size of 70 for all the plant species studied, it was possible to postulate what could be the expected number of associative fungal species in the given plant in a particular season. It was also possible to project the best season for

recovery of fungi. Generally the species isolate-curves as estimated by rarefaction, continued to ascend at a rapid rate until the maximum numbers of isolates. It is visualized that if such studies are conducted in a big way with all kinds of plants a vast pool of fungi which have use in many ways could be recovered.

The litter-bag experiment conducted for a period of time was useful to analyze the role of fungi appearing in succession during the process of decomposition of organic litter. The study revealed that the fungi appeared on litter in a definite pattern of succession. In the first month of incubation the species density of fungi was low and this is attributed to the time taken by the resident fungal flora to adjust to the new environment. In the subsequent months, the floristic composition got changed and an array of new fungi came to picture.

The study conducted to evaluate the influence of C : N ratio on the rate of colonization and decomposition process did not yield a clear picture. However, it can only be inferred from the results that in the process of litter decomposition, C : N ratio is not the only controlling factor but in addition the lignin content, the prevailing environmental conditions such as temperature and moisture and native fungal flora are also equally important.

One hundred forty species of the litter and endophytic fungi isolated from the tests plants were screened for their ability of producing 3 common enzymes, amylase, cellulase and pectinase. The results showed that 17.14% of the species exhibited ability to produce all the enzymes. In general, 43.57% were amylase positive, 49.28% cellulase and 42.85 % were pectinase positive. It was also evident that a few were producing exclusively a particular enzyme.

Some of the fungi such as *Alternaria alternata* behaved differently in its enzyme

activity when occurred separately as an endophyte and litter inhabitant in *Saraca asoca*. *Bharatheeya mucoidea* as a litter fungus showed positiveness for both amylase and cellulase with significant qualitative difference but as an endophyte exhibited ability to produce only cellulase. Similar behaviour was shown by *Corynespora* sp.1 isolated as litter and endophytic fungus. *Fusarium solani* from the same plant behaved differently in enzyme activity. The litter isolate was positive for amylase and cellulase whereas the endophyte showed both amylase and pectinase activity. It may be deduced from this investigation that it is a unique phenomenon of fungi where the enzyme activity was dictated by the habit and habitat.

With increasing realization that fungi are sources of powerful metabolites of varied usage in agriculture, biotechnology, chemical, food and pharmaceutical industries, the importance of this work and utility of these isolates of fungi cannot be underestimated. A major result of this work is building up of a collection of pure cultures of litter and endophytic microfungi from the forests of Western Ghats in Goa region in an *ex situ* gene bank at Goa University, the 'Goa University Fungus Culture Collection'. Although several floristic and ecological studies were carried out on litter fungi earlier in this country, hardly any one has attempted to isolate, document and conserve the fungi in a repository or culture collection. The isolation, documentation and preservation of the fungi has been done with great care and all sincerity during the course of this work. A large collection of pure isolates sourced during the work and properly documented are now carefully maintained in malt extract agar (MEA) maintenance medium. Details of each taxon is documented in a specially constructed 'data-sheet' which readily provides information on taxonomy, habitat affinity, diversity and activity. This is for the first time that such a composite effort on native microfungi has been done in this country.

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APPENDIX

LIST OF RESEARCH PUBLICATIONS:

1. D'Souza, M.A. and Bhat, D.J. 2001. A new species of *Trichobotrys* from the Western Ghat Forests, India. *Mycotaxon* 80:105 – 108.

2. D'Souza, M. A. and D.J. Bhat. 2001. Two New Hyphomycetes from India. *Microbes and Plants.* pp. 1-5.

3. D'Souza, M. A. and Bhat, D.J. 2002. *Didymobotryum spirillum*, a new synnematous hyphomycete from India. *Mycologia* 94(3): (Accepted for publication).

4. D'Souza, M. A. and D.J. Bhat. 2002. *Bharatheeya*, a new hyphomycete genus from India. *Mycotaxon* (Accepted for publication).

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A NEW SPECIES OF TRICHOBOTRYS FROM THE WESTERN GHAT FORESTS, INDIA

MARIA D'SOUZA and D. J. BHAT

Department of Botany, Goa University, Goa-403 206, India

ABSTRACT

A new dematiaceous hyphomycete, *Trichobotrys ramosa* sp. nov., isolated from decaying leaves of *Dendrocalamus strictus* Nees (F. Poaceae) is described and illustrated from the forests of Western Ghats in southern India.

INTRODUCTION

During our studies on the taxonomy and diversity of microfungi occurring in association with flowering plants of the Western Ghats in southern India, an interesting hyphomycete producing catenate, dark brown, spherical and echinulate conidia on fertile lateral branches with polyblastic conidiogenous cells developing on dichotomously branched, flexuous conidiophores was isolated from fallen and dead leaves of *Dendrocalamus strictus* Nees from Mollem forest in Goa State. The fungus is described here as a new species of the genus *Trichobotrys* Penzig & Saccardo.

The dead and decaying leaves of *Dendrocalamus strictus* were thoroughly washed in distilled water and incubated in sterile moist chamber for 7-14 days. Fungal colonies appeared on the leaf surface were individually examined under the microscope.

TAXONOMIC PART

Trichobotrys ramosa Maria et Bhat sp. nov. (Figure 1)

Coloniae effusae, atro brunneae, velutinae. *Mycelium* partim superficialis, partim immersis, hyphae ramosae, hyalinae vel pallide brunneae 1.5-2.5 µm lat. compositae. *Seta* absentia. *Conidiophora* mononematosa, erecta, recta vel flexousa, septata, ramosa dichotome in supra, fertilis in media, atro- vel rubrobrunnea, verruculosa, 330-600 µm longa, 10-18 µm lata ad basim, 8-10 µm lata et conspicuus echinulata ad inferne dimidiata, terminaliter in sterilis, setiformis, diverse curvata, pale brunnea vel hyalina, usque ad 6 µm lata ad apicalis; conidiophoris ramosis fero bravis, fertilis, atro vel pallide brunnis, verruculosis, laxe spatii, 1-2-septatis, usque ad 25 µm longis, 3-5 µm latis lateralis formatis. *Cellulae conidiogenae* in conidiophoris incorporatae, polyblasticae, subterminalis vel terminalis ad ramosis fertilis, denticulatae in supra dimidiatae, elongatae, interdum lapsum into cupulatum formata,5-10 x 2-3 µm. *Conidia* sicca, catenata, plerumque in ramosa, acropetalis catenula, globosa, atro brunnea, verruculosa, aseptata, 3-5 µm diam.

In foliis putrescentibus *Dendrocalamus strictus* Nees, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 11 March 1999, M.D' Souza, Herb. No. IMI 386393 holotypus, GUFCC-0274, isotypus.

Terrestrial litter, hyphomycete. *Colonies* effuse, dark olivaceous brown, velvety. *Mycelium* partly superficial, partly immersed, composed of branched, colourless to pale brown hyphae 1.5-2.5 µm wide. *Setae* absent. *Conidiophores* mononematous, erect, straight or flexous, septate, dichotomously branched in the above half, fertile in the middle, dark to reddish brown, verruculose, 330-600 µm long, 10-18 µm wide at the base, 8-10 µm wide and conspicously echinulate in the below half, terminating in sterile, setiform, variously curved, pale brown to hyaline, up to 6 µm wide apical branches. The conidiophore branches bear short, fertile, dark to pale brown, verruculose, widely spaced, 1-2-septate, up to 25 µm long, 3-5 µm wide laterals. *Conidiogenous cells* polyblastic, integrated, terminal to subterminal on fertile branches, elongated, denticulate in the upper half, sometimes collapsing into cupulate form, 5-10 x 2-3 µm. *Conidia* dry, catenate, usually in branched, acropetal chains, spherical, dark brown, verruculose, aseptate, 3-5 µm diam.

On dead leaves of *Dendrocalamus strictus* Nees, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 11 March 1999, M.D' Souza, Herb. No. IMI 386393 holotypus, GUFCC-0274, isotypus.

ADDITIONAL SPECIMENS EXAMINED: On dead leaves of *Dendrocalamus strictus*, Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 29 Dec.1999, M.D'Souza, No. GUFCC-0320. On dead leaves of *Dendrocalamus strictus*., Mollem, Bhagwan Mahavir Wildlife Sanctuary, Goa, India, 20 Sep.2000, M.D'Souza, No. GUFCC-0315.

Besides the type species, *Trichobotrys effusa* (Berk. & Br.) Petch = *T. pannosa* Penzig & Saccardo, the genus *Trichobotrys* Penzig & Saccardo so far accommodates two species, namely *T. ipomoeae* Sawada and *T. trechispora* Petch (Ellis, 1971; Morgan-Jones et al., 1987; Hawksworth et al., 1995). The genus is characterised by mononematous conidiophores producing catenate, dark brown, spherical and echinulate conidia on fertile, smooth, short, lateral branches with polyblastic conidiogenous cells. In the type species, *T. effusa*, the conidiophore is setiform, not dichotomously branched, and the fertile lateral branches are smooth, often unciform and 0-1-septate, arise directly on the main stipe, the characters which *T. ipomoeae* and *T. trechispora* largely share. In *T. ramosa*, the conidiophore is dichotomously branched with the numerous branches terminating in setiform sterile ends. The fertile lateral branches are short, straight, 1-2-septate, pale brown towards the apex and arise only from the primary and secondary branches of the conidiophore. The fertile branches are always verrucose.

ACKNOWLEDGEMENT

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1

Two New Hyphomycetes from India

Maria D'Souza and D.J. Bhat
Department of Botany, Goa University, Goa-403 206, India
djbhat@unigoa.ernet.in

INTRODUCTION

We deem it a privilege to have been invited to submit this paper to a volume being brought out in honour of Professor Ram Dayal, Varanasi, India, who made an indelible mark in the field of mycology by his invaluable contributions to the study of zoosporic fungi in India.

During our studies on the taxonomy and diversity of microfungi occurring in association with the plant species of Western Ghat forests in southern India, two new hyphomycetous fungi were recovered in culture when litter samples of *Caryota urens* Linn., and *Flacourtia montana* (Burm.f.) Merrill. were subjected to 'particle-plating isolation technique' (Bills and Polishook, 1994). The new taxa are described and illustrated below.

Materials and Methods

Freshly gathered decaying leaves of *Caryota urens* and *Flacourtia montana* were washed separately in tap water followed by sterile distilled water and ground into fine particles in a blender. The particles were filtered through two super-imposed metal sieves with mesh size of 250 and 100µm. The particles trapped in the lower sieve, those between 100 and 250µm size, were repeatedly washed in sterile distilled water and plated in malt extract agar

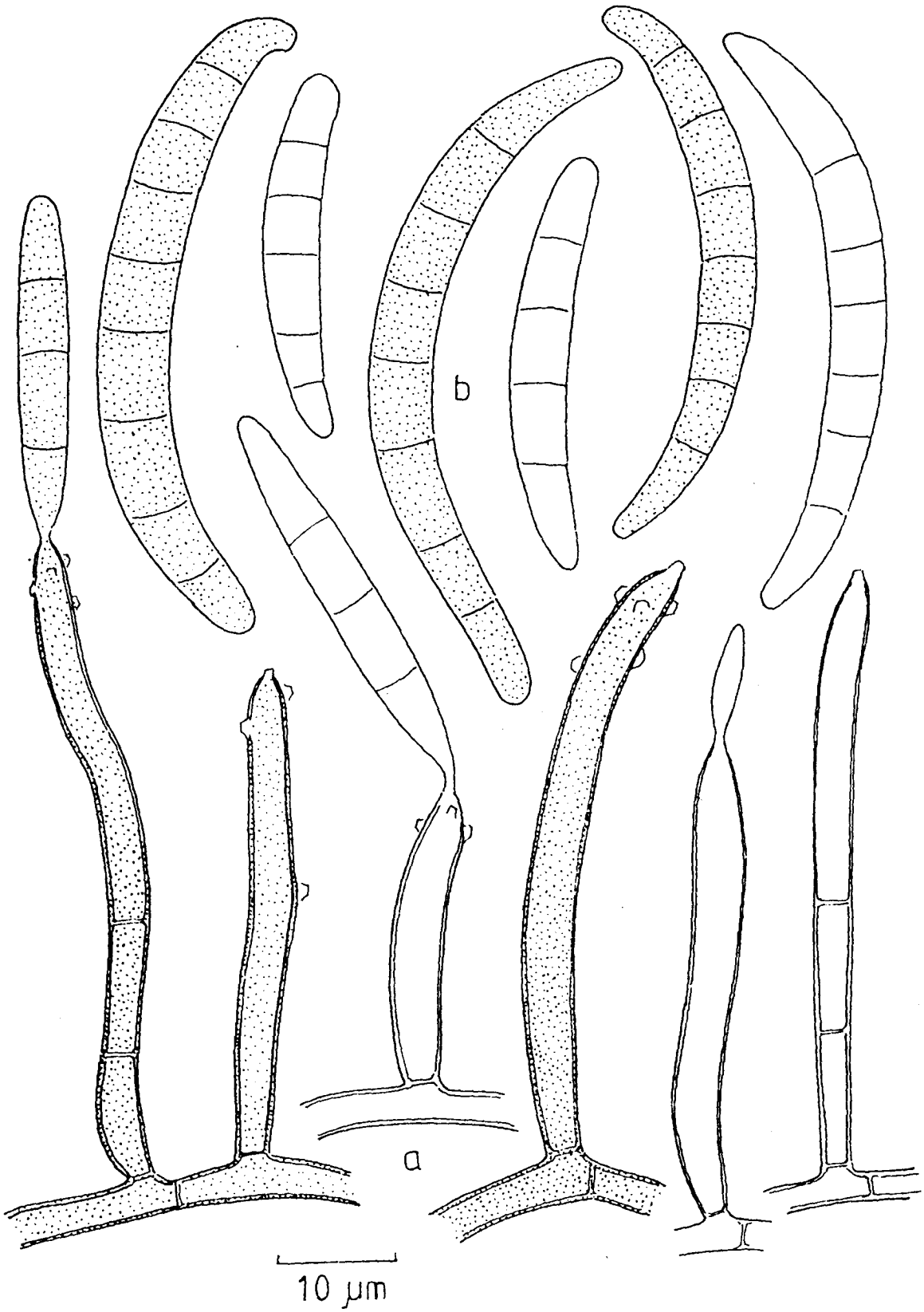

Fig. 1 : *Aquaphila ramdayalea*

(a) Conidiophore and conidiogenous cells

(b) Conidia

(MEA) medium incorporated with a cocktail of antibiotics (bacitracin 0.02g, neomycin 0.02g, penicillin G 0.02g, polymixin 0.02g, streptomycin 0.02g and terramycin 0.04g dissolved in 10ml of distilled water and added to 1 l of MEA medium). The colonies originated from each particle were aseptically transferred into fresh MEA slants.

Results

Several interesting and rare fungi were recovered in culture from the leaf particles and of these two new conidial fungi described below belonged to anamorph genera *Aquaphila* Goh, Hyde et Ho (Goh *et al.,* 1998) and *Kumbhamaya* Miriam et Bhat (2000).

Aquaphila ramdayalea Maria et Bhat anam.-sp. nov. (Fig. 1)

(Etym. specific epithet-in honour of Professor Ram Dayal).

Coloniae is agaro maltoso effusae, floccosae, atrobrunneae. *Mycelium* partim immersum partim superficiale, rhizoidae, densae, ex hyphis pallide brunneis, septatis, ramosis, 2.5—4 µm lat. compositum. *Conidiophora* mononematosa, laterales, erecta, recta, vel flexuousa, 1-4-septata, nonramosa, basim pallide vel atrobrunnea, 30-110x 2.5-5 µm. *Cellulae conidiogenae* monoblasticae vel polyblasticae, terminales, integratae, cylindricae, medium brunniae, 30-60 x 4-6 µm, 1-10 denticulatae usque ad 1.5 µm longa.*Conidia* solitaria, sicca, fusoida vel falcata, utrinque rotundata, 5-10-euseptata, crassitunicata, laevia, brunnea, 35-80 x 3-5 µm.

Holotypus : Cultura in MEA, extractis in putridinis foliis *Caryota urens* Linn. (Arecaceae), Cotigao Wildlife Sanctuary, Goa, India; Maria D'Souza, 11 April 1999; Herb. No. GUFCC-162.

Terrestrial litter hyphomycete. *Colonies* on malt extract agar effuse, slow growing with circular margin, attaining a diam. of 10 mm in 7 days, adpressed at first and later becoming floccose, dark brown. *Mycelium* partly immersed, partly superficial, composed of septate, rhizoidal to densely branched, pale to medium brown hyphae 2.5-4 µm wide. *Considiophores* mononematous, lateral, erect, striaght or flexuous, 1-4-septate, unbranched, slightly narrower at the base, smooth, medium to dark brown at the base, slightly paler towards the apex, 30-110 x 2.5-5 µm. *Conidiogenous cells* monoblastic to polyblastic, terminal, integrated, cylindrical, medium brown, 30-60 x 4-6 µm, with up to 1.5 µm long 1-10 denticles distributed in the upper half. *Conidia* solitary, dry, fusoid to falcate, rounded at both ends, 5-10-euseptate, thick-walked, with dense cytoplasm, smooth, brown, 35-80 x 3-5 µm.

With its mononematous conidiophores, monoblastic to polyblastic and denticulate conidiogenous cells and fusoid to falcate and multiseptate conidia

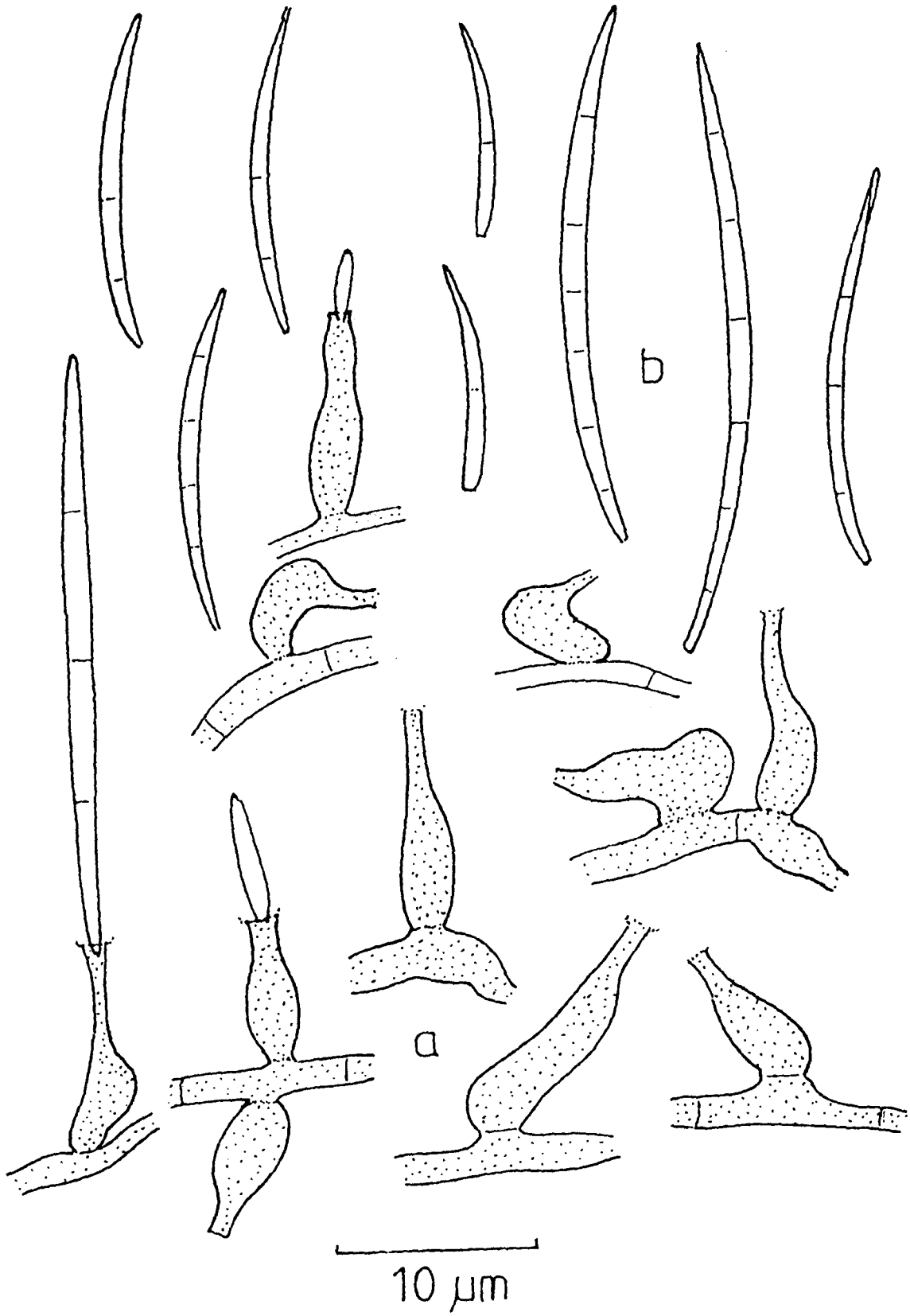

Fig. 2 : *Kumbhamaya goanensis*
(a) Conidiophore and conidiogenous cells
(b) Conidia

A. ramdayalea clearly belongs to the monotypic genus *Aquaphila* Goh, Hyde & Ho, typified by *A. albicans* Goh, Hyde & Ho (Goh *et al.,* 1998). It differs from the type species by its dematiaceous nature and affinity to terrestrial habitat. The conidiophores, conidiogenous cells and conidia are medium to moderately dark brown in *A. ramdayalea* whereas these in *A. albicans* are moniliaceous. Further, *A. albicans* is a representative of freshwater habitat. The conidia of *A. ramdayalea,* similar to *A. albicans,* superficially resemble those of *Fusarium* Link in shape, but they differ markedly in conidiogenesis. In *Fusarium,* the conidia are phialidic (Minter *et al.,* 1983) whereas in *Aquaphila* they are mono- to polyblastic.

Kumbhamaya goanesis Maria et Bhat anam.-sp. nov.

(Etym. specific epithet-from Goa)

Coloniae in agaro maltoso effusae, rhizoideae, floccosae, reverso atrobrunneo. *Mycelium* partim immersum, partim superficiale, ex hyphis densum, ramosis, crassiseptatis, medio-brunneis vel atrobrunneis, 2.5-3.5 µm lat. compositum. *Conidiophora* mononematosa, indistincta, septata, nonramosa, medio-brunneis, 2-8 x 2.5-4.5 µm *Cellulae conidiogenae* monophialidicae, in conidiophoris incorporatae, terminales vel laterales, pyriformes ad vermiformes, flexuates, ad basim oblongates, rectae vel curvatae, laeves, medio-brunneae, 8-12 µm longae et ad basim 2.5-6.5 µm latae, in medio 2-4 µm latae, collari prominente 1.5-2 µm. *Conidia* mucoidea, solitaria, fusiformia vel falcata, utrinque acuta, hyalina, crassitunicata, laevia, 2-5-septata, 7-30 x 1.5-2.5 µm, in massis mucosis aggregata.

Holotypus : Cultura in MEA, extractis in putridinis foliis *Flacourtia montana* (Burm.f.) Merill. (Flacourtiaceae), Cotigao Wildlife Sanctuary, Goa, India; Maria D'Souza, 11 April 1999; Herb. No. GUFCC No. 214.

Terrestrial litter hyphomycete. *Colonies* on MEA slow growing, attaining a diam. of 1 cm in 7 days, adpressed at first, later becoming floccose, dome shaped at the centre, rhizoidal towards the periphery, with circular margin, grayish black. *Mycelium* partly immersed, partly superficial, composed of densely branched, smooth, septate, pale to medium brown hyphae 2.5-3.5 µm wide. *Conidiophores* mononematous, indistinct, septate, unbranched, medium brown, 2-8 x 2.5-4.5 µm. *Conidiogenous cells* monophialidic, integrated, terminal or lateral, vase-like, vermiform, flexuous, erect to curved, transpose oblong at the base, with a collarette, smooth, medium brown, 8-12 µm long, 2.5-6.5 µm wide at the base, 2-4 µm wide in the middle, 1.5-2.5 µm at the collarette region. *Conidia* slimy, solitary, fusoid to falcate, pointed at both ends, 2-5 septate, thin-walled, with dense cytoplasm, hyaline, smooth, 7-30 x 1.5-2.5 µm, aggregating at the apex of the phialide.

The monotypic genus *Kumbhamaya* M. Jacob et D.J. Bhat, typified by *K. indica* M. Jacob et D.J. Bhat (Jacob and Bhat, 2000), is characterised by kettle or pitcher-shaped monophialidic conidiogenous cells bearing flared collarettes and producing slimy, fusiform, curved, septate and hyaline conidia which are pointed at both ends. *K. goanensis*, differs from the type species by its smaller conidiogenous cells and conidia. The conidiogenous cells and conidia in *K. indica* are 12-50 x 2.5-8.5 µm and 25-40 x 3.5-5.5 µm, respectively whereas in *K. goanensis* these are 8-11.5 x 2.5-6.5 µm and 7-25 x 1.5-2.5 µm. The conidia in *K. indica* are mostly 3-septate whereas in *K. goanensis* the conidia are up to 5-septate.

ACKNOWLEDGEMENT

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Goa University
Goa-403 206
Goa, INDIA

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Didymobotryum spirillum, a new synnematous hyphomycete from India

Maria D'Souza

D.J. Bhat

Department of Botany, Goa University, Goa-403 206, India

Abstract: A new synnematous hyphomycete, *Didymobotryum spirillum* D'Souza & Bhat, collected from decaying culms of bamboo, *Dendrocalamus strictus*, is described and illustrated from the forests of Western Ghats in Goa, India. The fungus produces monotretic, catenate didymoconidia on spirally twisted synnemata.

Key words: *Didymobotryum spirillum*, taxonomy, biodiversity.

A hyphomycete producing monotretic, catenate, didymoconidia on spirally twisted synnemata, collected on fallen, decaying culms of bamboo (*Dendrocalamus strictus* Nees., Poaceae), a native plant of the Western Ghats in southern India, is described here as a new species of the genus *Didymobotryum* Sacc.

Didymobotryum spirillum D'Souza et Bhat, sp. nov. (Fig. 1-8)

Ad fungos conidiales, hyphomycetes, pertinens. Coloniae effusae, olivaceae vel atrobrunneae, velutinae. Mycelium plerumque in substrato immersum, ex hyphis septatis, ramosis, crassitunicatis, subhyalinis, 3.5 µm lat., compositum. Conidiomata synnematosa, interdum singularata, plerumque 3-4 aggregata, recta vel flexuosa,

olivacea vel atrobrunnea, 650-980 µm longa, ad basim usque ad 60 µm lat., in medio 35-55 µm lat., apice in capitulum fertile expanso usque ad 200 µm lat.; ex conidiophoris parallelis et compactis, septatis, ramosis, laevibus, olivaceo-brunneis, spiralis, 2-2.5 µm lat., composita. Cellulae conidiogenae integratae, terminales, discretae, monotreticae, clavatae vel cylindrico-clavatae, olivaceo-brunneae, crassitunicatae, in partae superiore verruculosae, 7-10 (7.25 ± 1.89) x 3.5-5 (4.5 ± 0.57) µm, post secessionem cellulae conidiogenum apice truncatae, 2.5-4 µm lat. apertus. Conidia catenata, sicca, acrogena, cylindrica, apice roundata, basi truncata, crassitunicata, verruculosa, 1-septata, ad septum leniter constricta, olivaceo-brunnea, 10-18 (13.22 ± 2.3) x 4.5-6 (5.3 ± 0.86) µm; conidiae intercalaris catenatae, utrinque truncata post secessionem.

HOLOTYPUS: INDIA, Goa, Mollem, Bhagwan Mahavir Wildlife Sanctuary, in putrido culms *Dendrocalamus strictus*, 11 April 2000, Maria D'Souza, IMI 384381

ADDITIONAL SPECIMENS EXAMINED FROM INDIA: Goa, Mollem, Bhagwan Mahavir Wildlife Sanctuary, on dead stems of *Dendrocalamus strictus*, 20 Sept. 2000, Maria D'Souza, GUFCC 0256; Goa, Mollem, Bhagwan Mahavir Wildlife Sanctuary, on dead culms of *Dendrocalamus strictus*, 19 Oct. 2000, Maria D'Souza, GUFCC 0267; Goa, Bondla Wildlife Sanctuary, on dead culms of *Dendrocalamus strictus*, 20 Nov. 2000, Maria D'Souza, GUFCC 0289; Goa, Mollem, Bhagwan Mahavir Wildlife Sanctuary, on dead culms of *Dendrocalamus strictus*, 21 Dec. 2000, Maria D'Souza, GUFCC 0316; Goa, Bondla Wildlife Sanctuary, on dead culms of *Dendrocalamus strictus*, 23 Jan. 2001, Maria D'Souza, GUFCC 0357.

Colonies effuse, olivaceous to dark brown, velvety, mostly immersed, composed of septate, branched, thick-walled, subhyaline hyphae up to 3.5 µm wide. Conidiomata synnematous, sometimes arising singly, mostly in groups of 3-4, erect, straight or flexuous, fertile at the apex; olivaceous to dark brown, 650-980 µm long, up to 60 µm wide at the base, 35-55 µm wide in the middle, stipe compact, spirally twisted, flared to a spherical head up to 200 µm wide at the apex, composed of septate, branched, smooth, olivaceous brown hyphae 2-2.5 µm wide. Conidiogenous cells monotretic, terminal, integrated or discrete, cylindrical to clavate, olivaceous brown, thick-walled, verrucose in the upper half, slightly truncate and 2.5-4 µm wide at the aperture on conidial secession, 7-10 (7.25 ± 1.89) x 3.5-5 (4.5 ± 0.57) µm. Conidia catenate, dry, acrogenous, cylindrical, rounded at the tip, slightly truncate at the base, thick-walled, verrucose, 1-septate, slightly constricted at the septa, olivaceous brown, 10-18 (13.22 ± 2.3) x 4.5-6 (5.3 ± 0.86) µm; intercalary conidia in chains slightly truncate at both ends on secession.

Amongst the several species described in the genus *Didymobotryum* Sacc., lectotypified by *D. rigidum* (Berk. & Br.) Sacc., *D. spirillum* may be compared with *D. rigidum* and *D. verrucosum* Ilino & Katumoto (Ellis 1971). *Didymobotryum rigidum* is characterized by catenate, smooth conidia with a distinguished thick brown band at the septum, developing on synnema with a clavate head and untwisted stipe. In *D. verrucosum*, the verrucose and catenate conidia are broadly ellipsoidal to cylindrical with a septum, and the conidiophores are straight and parallely compacted before terminating into a clavate head. *Didymobotryum spirillum* has verrucose and catenate conidia that are similar to those of *D. verrucosum* but differs from the latter by its spirally twisted stipes

that terminate in a spherical head. The spiral nature of the stipe in the synnema was very consistent and observed in all subsequent collections, including those made in the dry seasons. We compared *D. spirillum* with our own collections of *D. verrucosum* on bamboo from the Western Ghats in southern India, and the overall distinctiveness of the two species was very evident.

ACKNOWLEDGMENTS

This work was supported by a research grant to Dr. D.J. Bhat from the Department of Science and Technology, Government of India, New Delhi.

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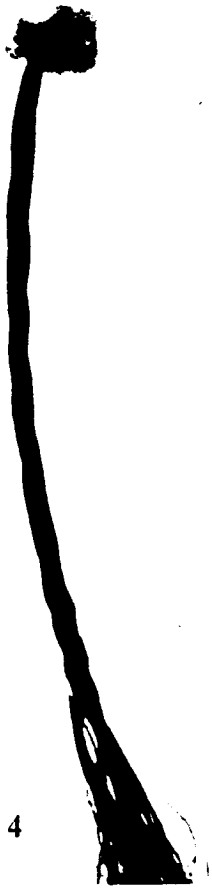

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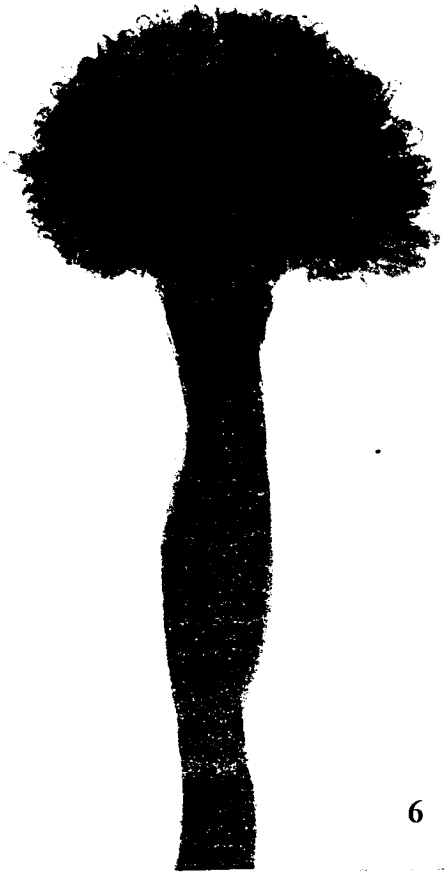

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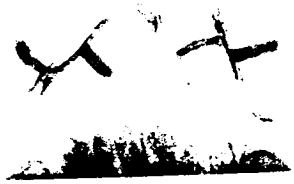

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LEGEND TO FIG. 1-8

Fig. 1-8. *Didymobotryum spirillum*

1. Synnemata,

2. A synnema consisting of stipes and conidiogenous cells.

3. Conidia and conidiogenous cells.

4, 5. Twisted synnemata.

6. Spherical head with the twisting stipe.

7. Conidia.

8. Monotretic conidiogenous cells.

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BHARATHEEYA, A NEW HYPHOMYCETE GENUS FROM INDIA

MARIA D'SOUZA and D.J. BHAT*
Department of Botany. Goa University. Goa-403 206. India
*djbhat@unigoa.ernet.in

ABSTRACT

A new genus of the dematiaceous hyphomycetes. *Bharatheeya*. is proposed for *Spadicoides goanensis* on the basis of its production of solitary. distoseptate conidia on non-cicatrized polytretic. verrucose conidiogenous cells and mononematous conidiophores. In addition. *Bharatheeya mucoidea* anam. sp. nov. isolated from decaying leaves of *Calamus thwaitesii*. is described from the forests of Western Ghats in Goa. India.

KEY WORDS: *B. goanensis*. *B. mucoidea*. Hyphomycetes. Litter fungi. taxonomy. India.

INTRODUCTION

Sinclair. Eiker and Bhat (1985). in a reassessment of the genera *Spadicoides* S. J. Hughes (1958) and *Diplococcium* Grove (1885). rejected the branching of conidiophores as a diagnostic generic character and separated the two taxa only on the basis of their respectively solitary or catenate and euseptate conidia. The generic descriptions were emended accordingly Kuthubutheen and Nawawi (1991) reviewed the taxonomy of *Spadicoides* and provided a key to then accepted 16 species. While describing a new dematiaceous hyphomycete. isolated from decaying leaves. producing a solitary conidium on partly verrucose conidiophores with non-cicatrized monotretic conidiogenous cells in the genus *Spadicoides*. as *S. goanensis* Bhat & Kendrick (1993). the authors wrote "*S. goanensis* differs from all other species of *Spadicoides* in (1) its partly verrucose conidiophores. (2) the presence of only one. monotretic conidiogenous cell on each conidiophore. and (3) the production of only a single conidium by the conidiogenous cell".

Cultures from a recent collection of *S. goanensis* gathered from the type locality in Goa. India. revealed a hitherto unknown feature of the fungus. namely production of several solitary. 3-distoseptate. conidia on non-cicatrized polytretic conidiogenous cells. This. along with recovery of a so far unknown fungus with similar conidiogenesis. 2-4-distoseptate conidia with a mucoid apical cap and otherwise similar characters warranted redescription of *S. goanensis*. its redisposition along with the new fungus in a new genus *Bharatheeya* and a detailed review of similar genera.

TAXONOMIC DESCRIPTION

Bharatheeya **anam. gen. nov.**

Ad fungos conidiales. hyphomycetes. pertinens. Coloniae effusae. olivaceae vel atro-brunneae. hypophyllae. Mycelium partim immersum et partim superficiale. ex hyphis laevis. septatis. ramosis. compositus. Conidiophora mononematica. discreta. aggregata. recta. curvata vel flexuousa. crassitunicata. septata. nonramosa. laevia vel verrucosa. ad basim lobata et inflata. atro-brunnea: versus apicem pallescentia. rotundata. Cellulae conidiogenae intercalares. intergratae. polytreticae. poro pluro. minuto. noncicatrizi. simplici. infra septum superius praeditae. Conidia sicca. solitaria. dry. cylindrico-ovoidea vel clavata. distoseptata. lumine reducto. crassitunicata. laevia vel verrucosa. brunnea vel atrobrunnea.

Conidial fungi. hyphomycetes. Colonies effuse. olivaceous to dark brown. hypophyllous. Mycelium partly immersed. partly superficial. composed of smooth. septate. branched. hyphae. Conidiophores mononematous. discrete. arising singly or in groups. erect. curved to flexuous. thick-walled. unbranched. septate. smooth or verrucose. dark brown. 3-4-lobed and slightly inflated at the base. rounded and slightly paler at the tip. Conidiogenous cells intercalary. integrated. polytretic. with several. simple. non-cicatrized pores below the septa. Conidia dry. solitary. cylindrical-ovoid to clavate. thick-walled. distoseptate. with reduced lumen. smooth to rough-walled. medium to moderately dark brown.

(Etymology: *Bharath* in Sanskrit ancient name for India) (Fig.1.3-5)

Type species: *B. goanensis* (Bhat & Kendrick) D'Souza & Bhat. **comb. nov.** .

= *Spadicoides goanensis* Bhat et Kendrick *Mycotaxon* **49**: 66-68.1993 (basionym).

Colonies on natural substrate gregarious. olivaceous to dark brown. hypophyllous. on MEA moderately fast growing. slightly floccose on the surface. white to slightly greenish. with circular margin. attaining 10 mm diam. in 7 days. Mycelium partly immersed. partly superficial. composed of smooth. septate. branched. hyaline hyphae 2.5-4 µm wide. Conidiophores mononematous arising in groups of 6-18. erect. curved in the middle. thick-walled. 3-5-septate. unbranched. 160-200µm long. 4-8-lobed and inflated at the up to 15 µm wide base. 6-8.5 µm wide above. lower half smooth to faintly verruculose. above half distinctly verrucose. dark brown and rounded at tips and slightly paler towards the apex. Conidiogenous cells intercalary. intergrated. polytretic. with several (1-5) minute. non cicatrized. simple pores just below the septum. 25-32 x 6-8.5 µm. smooth to verrucose. dark brown. Conidia dry. solitary. more than one. cylindrical-ovoid to clavate. 3-distoseptate. central two cells thick-walled with reduced lumen. verrucose. medium to moderately dark brown. darker at the base. 23-40 x 14-22 µm.

SPECIMEN EXAMINED: (i) On dead and decaying leaves. Morphirla. Goa. India. 28.7.1991. D.J. Bhat. Herb. DJB/GU/No. 514 (Part of Holotype No. DAOM 214612). (ii) On dead and decaying leaves of *Saraca asoca* (Roxb.) Dc Wilde.. Bondla Wildlife Sanctuary. Goa. India. 11-2-1998. Maria D'Souza. GUFCC No. 206. (iii) Dried culture mat of the fungus derived on endophytic isolation from fresh leaves of *S. asoca*. Bondla Wildlife Sanctuary. Goa. India. 11-2-1998. Maria D'Souza. GUFCC No. 210.

Bharatheeya mucoidea **anam.** D'Souza & Bhat **sp. nov.** (Fig. 2.6-8)

Coloniae effusae. gregariae. olivaceae vel brunneae. hypophyllae. Conidiophora mononematica. discreta. 6-15 aggregata. erecta. medio curvata vel cincinata. crassitunicata. atrobrunnea. 10-18-septata. non-ramosa. 240-370 µm alt.. ad inflatus basim 6-12 µm lat.. supra 7-10 µm lat.. verrucosa. versus apicem pallescentia. leviea vel verrucosa. rotundata. Cellulae conidiogenae intercalares. integratae. atrobrunneae. polytreticae. poro numero. indistincto. minuto. simplici. infra septum superius praeditae. Conidia sicca. solitaria. pyriforma vel clavata. 2-4-distoseptata. crassitunicatis. lumine reducto. leviea. brunnea vel atrobrunnea. 22-40 µm longa. medio 10-18 µm lat. crassa. 4-8 µm lat. basa. versus conspicuosa. crassa. hyalina. mucoidea ad apicem. usque ad 10 µm diam.

Colonies on natural substrate effuse to gregarious. greyish to brown. hypophyllous. on MEA moderately growing. attaining a diam. of 15 mm in 7 days. with rhizoidal margin. raised. grayish white. cottony. velvety. producing conidiophores in concentric rings. reverse of the colony off-white. Mycelium partly immersed. partly superficial. composed of smooth. septate. branched. hyaline hyphae 2.5-3.5 µm wide. Conidiophores mononematous. arising in groups of 6-15. erect. curved to curled in the middle. thick-walled. dark brown. 10-18-septate. unbranched. 240-370 µm long. 6-12 µm wide at the inflated base. 7-10 µm wide above. rounded and slightly paler at the tip. smooth to faintly verrucose in the lower half. distinctly verrucose in the upper half. Conidiogenous cells intercalary. intergrated. dark brown. verrucose. polytretic. with more than one. distinct. minute. non-cicatrized. simple. pores below the septum. Conidia dry. solitary. pyriform to clavate. 2-4-distoseptate. thick-walled. with reduced lumen. smooth. medium to dark brown. 22-40 µm long. 10-18 µm wide in the middle. 4-8 µm wide at the base. with a conspicuous. thick. hyaline. up to 10 µm diam. mucilaginous cap at the tip.

HOLOTYPE. On dry leaves of *Calamus thwaitesii* Becc. Bondla Wildlife Sanctuary. Goa. India. 8 June 1999. Maria D'Souza. GUFCC No. 209. Additional specimen examined: Dried culture mat of the fungus derived as endophytic isolate from fresh leaves of *C. thwaitesii* Becc.. Bondla Wildlife Sanctuary. Goa. India. 8.6.1999. Maria D'Souza. GUFCC No. 215

B. mucoidea differs from the type species. by its pyriform to clavate. smooth. conidia. each with a conspicuous. colourless. thick. mucilaginous cap at the tip. Both *B. goanensis* and *B. mucoidea* occur as endophytes in fresh leaves and as epiphytes on dead and decaying leaves.

DISCUSSION

Besides *Spadicoides* and *Diplococcium*. several genera such as *Hemicorynespora* M.B. Ellis (1972). *Monotretomyces* Morgan-Jones et al. (1987). *Polytretophora* Mercado (1983) and *Nusia* Subramanian (1997) were considered as possible repository for these fungi. In *Hemicorynespora*. typified by *H. deightonii* M.B. Ellis. limoniform. species produce solitary. 0-1-euseptate conidia are on percurrently proliferating conidiophores with cicatrized. apical monotretic condiogenous cells. In *Nusia*. typified by *N. scheeleae* Subramanian. species produce solitary. 9-14-euseptate. conidia on mononematous conidiophores with apical monotretic conidiogenous cells. In *Monotretomyces*. typified by

M. uniseptatum Morgan-Jones. Sinclair and Eiker. species produce 1-euseptate. catenate conidia on caespitose conidiophores with terminal. non-cicatrized. monotretic conidiogenous cells. In *Polytretophora*. typified by *P. calcarata* Mercado. species produce solitary. reniform to ellipsoidal. 1-euseptate. conidia on polytretic. non-cicatrized. terminal and intercalary conidiogenous cells on mononematous conidiophores. However. in species of the new genus *Bharatheeya*. 3-4-distoseptate conidia are produced on mononematous. partially verrucose conidiophores with non-cicatrized. polytretic and integrated conidiogenous cells.

The taxonomic significance of euseptate and distoseptate conidia and their usefulness for the delimitation of hyphomycete genera were emphasized by Holubova-Jechova (1990). The combination of characters such as production of distoseptate conidia on non-cicatrized. polytretic. integrated. intercalary conidiogenous cells on verrucose conidiophores exhibited in *Bharatheeya*. stand distinct from the *Spadicoides-Diplococcium* complex and other similar genera discussed above.

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