Studies on Diversity, Ecology and Activity of Coprophilous Fungi from Goa and Neighbouring Regions of Maharashtra and Karnataka, India

Thesis Submitted to
The Goa University
For the Award of The Degree of

DOCTOR OF PHILOSOPHY
IN
BOTANY

By

Ms. Sarita Kumari Yadav, M.Sc.

Department of Botany
Goa University
Taleigaon Plateau
Goa-403 206

July 2011

DECLARATION

I hereby declare that the Ph.D. thesis entitled "STUDIES ON DIVERSITY, ECOLOGY AND ACTIVITY OF COPROPHILOUS FUNGI FROM GOA AND NEIGHBOURING REGIONS OF MAHARASHTRA AND KARNATAKA, INDIA" submitted to Goa University, forms an independent and original work carried out by me in the Department of Botany, Goa University, under the supervision of Prof. D.J. Bhat, Department of Botany, Goa University, and the thesis has not formed previously the basis for the award of any degree, diploma, associateship or other similar titles.

Sarita

(Sarita K. Yadav)

Countersigned by

23.7.2011

Prof. D.J. Bhat
(Supervisor)

D. J. Bhat, M. Sc., Ph. D.
Professor
Department of Botany
GOA UNIVERSITY
GOA-403 203, INDIA

Certified that all corrections
are incorporated in the thesis and
this is the final hardbound copy

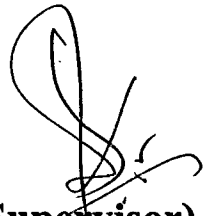
J. Mukherjee
4-10-2011
(External Examiner)

4/10/2011
(Prof. & Head)
Dept. of Botany
Goa University

CERTIFICATE

I certify that the thesis entitled "STUDIES ON DIVERSITY, ECOLOGY AND ACTIVITY OF COPROPHILOUS FUNGI FROM GOA AND NEIGHBOURING REGIONS OF MAHARASHTRA AND KARNATAKA, INDIA" submitted by Ms. Sarita K. Yadav, is a record of research work done by her during the period from 2007-2010 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. Sarita K. Yadav.

I affirm that the thesis submitted by Ms. Sarita K.Yadav incorporates the independent research work carried out by her under my supervision.



(Supervisor)

M.Sc., Ph.D.

Prof

Botany

ITY

GOA-403 206, INDIA

CONTENTS

ACKNOWLEDGEMENT

I owe my sincere gratitude to my guide, Prof. D.J. Bhat, Department of Botany, Goa University, for introducing me towards mycology and further giving support and encouragement throughout this study.

I am thankful to all my teachers, viz. Prof. P.K. Sharma, H.O.D., Prof. M.K. Janarthanam, Prof. B.F. Rodrigues, Dr. Vijaya Kerkar, Dr. S. Krishnan and Dr. Nandkumar Kamat, in the Department of Botany. I am also thankful to all the non-teaching staff in the Department for their cooperation.

I sincerely thank Prof. Arun Joshi, Goa College of Pharmacy, Panjim, for helping with Gas Chromatography-Mass Spectroscopy (GC-MS), carried out at the Karnatak University, Dharwad. I am thankful to Dr. J. Chakurkar, Scientist, and Mr. B. Dharmapal, Technical Officer, I.C.A.R., Old Goa, for providing permission and help to collect dung samples.

I place on records my grateful thanks to the Council for scientific and Industrial Research, New Delhi, for providing a Senior Research Fellowship during the tenure of this work. I am indebted to Goa University for providing all facilities.

I am thankful to my fellow research scholars, viz. Dr. Pratibha Jalmi, Dr. Puja Gawas, Nikita D'silva, Ashish Prabhugaonkar, M. Bhaskaran, Swapnaja Dhargalkar, Dhillan Velip, Sonia Faldessai and all other research scholars in the department for their continued help and assistance. I record my special thanks to Seema Dessai and Mr. Pai, Goa University Library. I also thank my friends, Freda, Sweta Naik, Videsh Naik, Sandesh Varik.

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

Sarita

INTRODUCTION

> *"The fungi are progressive, ever changing and evolving rapidly in their own way, so that they are capable of becoming adapted to every condition of life. We may be rest assured that as green plants and animals disappear one by one from the face of the globe, some of the fungi will always be present to dispose of the last remains."*
>
> - B.O. Dodge (1872–1960)

Fungi are achlorophyllous, eukaryotic microorganisms which grow as single cells or multicellular filaments, acquiring nutrition by absorption from the surrounding organic substrates. None of the biological matters can be free of fungal association (Maheshwari, 2005). There are fungi in soil, plant litter, decaying woods, submerged plant remains in stream or ponds, driftwoods in seawaters, on insects, with nematodes, on herbivore dung and so on (Dix and Webster, 1995). Based on their associations, fungi are considered with distinctive roles as saprophytes, parasites, endophytes or mutualists (Kendrick, 1992).

Fungi grow everywhere and in all sorts of habits and habitats. The necrotrophic and biotrophic fungi cause diseases in plants, insects, birds and animals. A small percentage of the fungi live in symbiotic association with plants or animals (Kendrick, 1992). The saprotrophic fungi are the primary agents responsible for decomposition of organic matter. These fungi bring about spoilage of food and damage fabrics, paper, leather and other consumer goods. They also grow on dung of all kinds of animals (Dix and Webster, 1995). The fungi are important industrially as they produce enzymes, organic acids, vitamins and antibiotics (Pointing and Hyde, 2001). There are fungi growing in extreme environments such as saltpans or Antarctic soils. The cold and harsh environmental conditions in the polar region aid the growth of psychrophilic and psychrotolerant fungi (Singh et al., 2006). These extremophillic fungi also have biotechnological potential (Puja and Singh, 2011).

Yet, very few fungi have so far been described from such environments (Gunde-Cimerman, 2003).

There have been numerous studies on the diversity, ecology and activities of fungi, around the world (Dix and Webster, 1995; Pointing and Hyde, 2001). Yet, the fungi haven't been explored all enough particularly in the tropical belt and much more remained to be studied. Over the last two decades, systematic efforts were made in this laboratory to explore the biology of saprophytic fungi found growing in different habitats such as decaying plant litter in soil (Jacob, 2000; D'Souza, 2002; Puja, 2008), submerged plant litter in freshwater streams (Nair, 2002), dead insects (Keshava Prasad, 2004), aerial region of plants (Jalmi, 2006) and internal plant parts (Jacob, 2000; D'Souza, 2002; Puja, 2008). With high humidity, warm temperature, varied vascular plants and dependent herbivore animals, numerous ecological niches and microhabitats, the tropical belt of the world is considered as major reservoir of majority of known and most of the unknown taxa of fungi (Bhat, 2010).

The number of fungi on earth surface has been projected as 1.5 million, roughly six times the estimated number of vascular plants (Hawksworth, 1991). Of these, a mere 5-7% of the fungi are presently described (Bhat, 2010; Hawksworth, 2004; Rossman, 1994). Using conventional microscopic methods and modern molecular techniques, many of the unknown fungi are now detected (Bhat, 2010; Pennisi, 2004; Horton and Bruns, 2001). Based on high-throughput sequencing methods, it has now been estimated that as many as 5 million species of fungi might be present on the earth's surface (Blackwell, 2011).

Succession of fungi

In order to achieve complete decomposition, one of the major events taking place in any habitat, is succession of microorganisms - be it fungi or bacteria (McIntosh, 1980; Morin, 1999; Dix and Webster, 1995). Most studies so far carried on fungal succession were based on the kind of substrata, viz. terrestrial wood (Lange, 1992), herbivore dung (Richardson, 2001; Kuthubutheen and Webster, 1986; Nagy and Harrower, 1979), hay (Breton and Zwaenepoel, 1991), aquatic wood (Fryar et al., 2002), pine cones (Kasai et al., 1995), wool (Ghawana et al., 1997), sugarcane (Sandhu and Sidhu, 1980), straw (Harper and Lynch, 1985) and living leaves (Wildman and Parkinson, 1979). Species that are lost during the course of succession are often assumed to be victims of competitive exclusion by later occupying species (Farrell, 1991). Analyzing the fungal succession on herbivore dung, Holmer and Stenlid (1997) suggested that the species producing fruiting bodies at later stages being much stronger than those fruiting at early stages, inhibition could be the mechanism driving the successional processes.

Activities:

Fungi elaborate a variety of enzymes and other metabolites which affect the humans, plants and other living forms, in different ways (Barnett & Hunter, 1999). The beneficial aspects of fungal activities have been well recognised (Gupta and Soni, 2000; Mehta and Gupta, 1991; 1992; Nevalainen and Te'o, 2003; Bergquist et al., 2003; Henriksson et al., 2000). All these studies illustrate the potential of fungi in industrial and food fermentation processes (Asan, 2004). With high nutrient value, fruiting bodies of macro-fungi, viz. *Lentinus edodes* (shiitake), *Pleurotus ostreatus*

(oyster mushroom), and *Agaricus bisporus* (button mushroom) are now considered as excellent culinary delicacies (Hintz, 1999).

Fungal amylases are used in food, brewing, textile, detergent and pharmaceutical industries. Although alternate sources of amylase (porcine pancreas, human saliva, rat pancreas, malted grains, etc.) exist, a large proportion of amylase production is from fungi (Ali et al., 1989). Fungi have also been attributed for the production of cellulases and the crude enzymes produced by species of *Trichoderma* and *Aspergillus* are commercially available for agricultural practices (Wainwright, 1992). Cellulases find their application in textile industries (Kotchoni et al., 2003) and bio-waste degradation (Mandels and Reese, 1985; Hoffman and wood, 1985).

Coprophilous fungi:

The literary meaning of 'coprophilous' is 'dung-loving'. The undigested carbohydrates, hemicelluloses and lignin, along with amino acids, vitamins, growth factors and minerals in the herbivore dung, aid colonization and growth of diverse fungi (Dix and Webster, 1995). They represent a diverse community of morphologically and physiologically specialised mycota which provide a biological force for the decomposition and recycling of animal faeces (Richardson, 2008). The varying fungal components of animal dung are difficult to relate to a specific cause; many fungal conidia or spores are ingested by herbivorous animals while grazing (Larsen, 1971). Some of the ingested propagules might be endophytic, geophilic or phylloplane fungi. The intake of vegetation from a common source, may lead to the occurrence of several common fungi in both ruminant and non-ruminant dung. The composition of dung's mycobiota is influenced by various factors, such as antagonism, exploitation, competition, nutritional factors, and environmental conditions (Caretta,

1998). Sometimes, coprophilous fungi act as indicators of habitat diversity (Richardson, 2001).

Succession of fungi on herbivore dung:

Rayner and Todd (1979) defined fungal succession on herbivore dung as "the sequential occupation of the dung by thalli (usually mycelia) either of different fungi or of different associations of fungi". The fungi replace one another as communities of mycelia get altered in space and time (Frankland, 1998). Generally, fungal succession is based on the sequence of sporulation on the substrate. The sequence of occurrance of fungi observed on dung after defecation has been, first by members of the zygomycetes, followed by ascomycetes and basidiomycetes. The zygomycetous fungi utilize simple sugars, starch, and protein (and subsequently sporulate); thereafter Ascomycetes use the hemicelluloses and celluloses (and sporulate), followed by the basidiomycetes using the lignin and cellulose (Fryar, 2002). The tenure required for fungi to fruit is independent of the nutritional status of the dung. Majority of coprophilous fungi start germinating within 6 h of defecation. Thereafter the mycelial growth starts, although the duration of fruiting varies. Thus, the fungal succession is said to be more of mycelial succession. Therefore, the sequence of fungal succession is more a succession of fungal fruiting bodies (Harper and Webster, 1964). The coprophilous fungi exhibit certain adaptive features for dung inhabitation. These included the following:

(i) Phototrophic nature and forcible discharge of spores towards light source. The spore-producing structures, viz. sporangiophore of mucorales, conidiophore of hyphomycetes and ascus or basidium of higher filamentous fungi, all get phototropically oriented and eject the spores to relatively long distances (Richardson,

2008; Dix and Webster, 1995). This is an ecological adaptation acquired by majority of dung inhabiting fungi, with which, the spore is thrown high in air which enables the latter to fall on any vegetation. In the next feeding course of herbivores, the dispersed spores along with forage get into the stomach of animals.

(ii) Adhesive projectiles: Ascospores are armoured with gelatinous appendages as extension of their spores or a partial sheath. These projectiles enable attachment of spores to the herbages without being washed off by wind or water and retaining viability (Richardson, 2008; Dix and Webster, 1995).

(iii) Pigmentation in exospores: The exospores are often pigmented and provide protection against UV exposure (Richardson, 2008).

(iv) Mucilaginous spores: The gelatinous ascospores of coprophilous fungi, e.g. *Sordaria* and *Podospora,* favour adherence of the propagules to adjacent vegetation. These are later consumed by herbivores along with the vegetation (Caretta, 1998).

(v) Resistance to digestive enzymes and acids in animal gut: Passage of spores through the gut of herbivore animal leads stimulation to germinate, resulting with a vegetative stage, followed by sporulation. The spores get triggered for germination following exposure to the chemical and physical environment of the animal gut (Kuthubutheen and Webster, 1986).

Significance of coprophilous fungi

Coprophilous fungi are known to produce antifungal peptides and amino acid-derived metabolites (Gloer and Truckenbrod, 1988; Webber, 1981). Zaragozic acids, a group of potent, broad-spectrum, antifungal metabolites that inhibit squalene synthase were originally obtained from a coprophilous fungus, *Sporormiella intermedia* (Bills, 1994). Novel bioactive metabolites, decipinin A and decipienolides A and B, were

obtained from coprophilous fungus, *Podospora decipiens* (Che et al., 2002). Caretta (1998) observed that studies on coprophilous fungi might lead to the discovery of many more novel bioactive fungal metabolites.

Zygomycetes are considered as good sources of polyunsaturated fatty acids (PUFAs) and a good percentage of Mucorales are coprophilous (Bajpai et al., 1992). These fungi are known to accumulate the lipids intracellularly. In microorganisms, including bacteria, lipid content is usually less than 10% of the dry biomass. However, the mucoraceous fungi have the potential to accumulate lipid in their bodies equivalent to about 50% of dry biomass (Ratledge, 1992). Among the known microbial lipids, PUFAs have attracted great interest because of their nutritive value, especially in child heath care. The first trial of PUFA production from mucoraceous fungi, with γ-linolenic acid as the target, was pioneered in the UK and Japan (Higashiyama et al., 2002).

Present Work:

While substantial work has been done on coprophilous fungi in other parts of the world, not much is known from India (Kirk et al. 2008) There is hardly any detailed study from the west-coast region of India (Bhat, 2010). Realizing this lacuna in our understanding of the diversity, ecology and prospecting of fungi in this part of the country, a modest beginning was initiated in this Department, on corpophilous fungi (Colgaonkar, 2001; Yadav, 2006). Encouraged with the preliminary results obtained, an elaborate plan was drawn on coprophilous fungi with following objectives:

- Isolation and culturing of fungi appearing on dung of various herbivore animals from different parts of Goa and neighbouring regions of Maharashtra and Karnataka.

- Taxonomic documentation of isolated coprophilous fungi.
- Analysis of pattern of appearance of fungi on cattle and rabbit dung over a period of time and their significance.
- Screening of some of the isolated coprophilous fungi for metabolites, significant from neutra- and pharma point of view.

Results of this study formed the subject matter of this thesis.

REVIEW OF LITERATURE

Herbivore dung is a partially digested, highly complex, organic matter. It is composed of the remains of ingested vegetation in the form of waste products, along with microbial population residing in the herbivore rumen. The dung contains nitrogen which is as high as 4%, a three to four-fold increase over the ingested material (Bell, 1983). The fungi which germinate, grow and sporulate on dung are termed 'coprophilous' (Ingold, 1953, 1971). On dung, especially after voided off, the nitrogenous compounds influence the growth and fruiting of coprophilous fungi (Bell, 1983). Herbivore dung generally has a higher pH, usually above 6.5. This has some selective effect on the fungi appearing on dung. The coprophilous fungi possess a wide variety of characteristics that assist their survival and reproduction on nutrient rich dung substrate. Although fungi are reported from all types of dung, herbivore dung is considered as rich repository of coprophilous mycota (Webster, 1983). In the decomposition of carnivore and omnivorous dung, bacteria play an important role (Bell, 1983).

Coprophilous Fungi

Dung inhabiting fungi are diverse. Members of all classes of the Kingdom Fungi, from Zygomycota, Ascomycota (and their anamorphs) to Basidiomycota, appear on herbivore dung (Richardson, 2001; Wicklow, 1981; Furuya and Udagawa, 1972; Valdoserra and Guarro, 1992). Coprophilous fungi play an important role in the decomposition and mineralization of herbivore dung (Angel and Wicklow, 1975). Besides, the dung provides a nutritional base for coprophilous and mycophagous arthropods (Malan and Gandini, 1966). Fungi also influence the microbial

composition and activity in the rumen and affect the digestive efficiencies of herbivores (Brewer and Taylor, 1969; Brewer et al., 1972).

First reference of a coprophilous fungus is known, in the form of record of a *Pilobolus* on horse dung in 'Historia Plantarum', by Johannes Bannister from Virginia in 1688. The same fungus was later referred and figured maas '*Fungus virginianus*' on horse dung from London (Petiver, 1696). The formal name, '*Pilobolus crystallinus*', was provided to the fungus much later (Tode, 1784). Thus, the knowledge on fungal association with dung was known to the botanists since the 17th century.

Systematic work on coprophilous fungi however began only towards the end of the 19th century. Several well known mycologists of the latter half of 19th and early 20th century took interest in this group of fungi. These included Zopf (1874, 1880, 1881) and in Germany; Crouan and Crouan (1857, 1858, 1867), Bainier (1882, 1909), Van Tieghem, 1875, 1876; Van Tieghem and Le Monnnier, 1873) in France; Saccardo (1877a,b; 1874-1880) and Cesati and De Notaris (1863) in Italy; Chalckowsky (1892) and Schroeter (1888, 1894) in Poland; Oudemans (1882) in Holland; Hansen (1876) in Denmark; Sterbäck (1889) in Sweden; Coemans (1861-1862), Marchal (1884a, b, c, 1885, 1889, 1891, 1894, 1895), Bommer and Rousseau (1884, 1886, 1887, 1890) and Monton (1886) in Belgium; Heimerl (1889) and Zukal (1886a, b, 1887, 1889, 1890) in Austria, Karsten (1870, 1885) in Finland; Woronin (1870) in Russia; Cooke (1864); Phillips and Plowright (1874, 1874, 1881, 1885), Massee and Salmon (1901, 1902) in England; Speggazini (1871, 1921) in South America; Griffiths (1901) and Griffiths and Seaver (1910) in North America.

The work of these pioneers, and those followed them subsequently, have enriched our knowledge not only on the types of fungi that occur on herbivore dung but also on the

physiology, spore discharge, germination and dissemination, ecology and cytology of these fungi.

Life cycle of coprophilous fungi

The germination, growth, and sporulation of a coprophilous fungus follow a definite cycle on freshly deposited dung after the fungal spore adhered on the herbage are apparently engulfed by the herbivore. The spore while moving, along with herbage, in the gut of the animal is treated by the acidic digestive juices present within. This mechanical and chemical digestion process benefited the germination of spores to many folds (Bell, 1983; Furuya, 1990; Larsen, 1971).

While grazing, herbivore animals ingest a variety of fungal spores, along with feed, which include both coprophilous and non-coprophilous. The slightly high temperature and a cocktail of gastric juices present in the gut of the animals evidently destroy most of non-coprophilous species, whereas the coprophilous fungi are protected due to certain adaptive features. Once the dung is voided off, viable fungal spores germinate, grow, fruit and discharge their spores onto surrounding herbage where by good fortune they are eaten by herbivores and thus the cycle continues. Schematic presentation of the cycle is given in Fig. 2.1 (Bell, 1983).

Adaptations of coprophilous fungi

Phototropism and violent spore-discharge: Although taxonomically quite unrelated, the coprophilous fungi in general show a number of adaptations to their habitat. Phototropism is the most common phenomenon demonstrated by the spore-bearing structures (Ingold, 1953). In most coprophilous fungi, the spore-producing structures such as the sporangiospore in Zygomycetes, condiophores of hyphomycetes, asci and basidia in higher fungi, all get phototropically oriented towards source of light and

Fig. 2.1 Life Cycle of Coprophilous Fungi

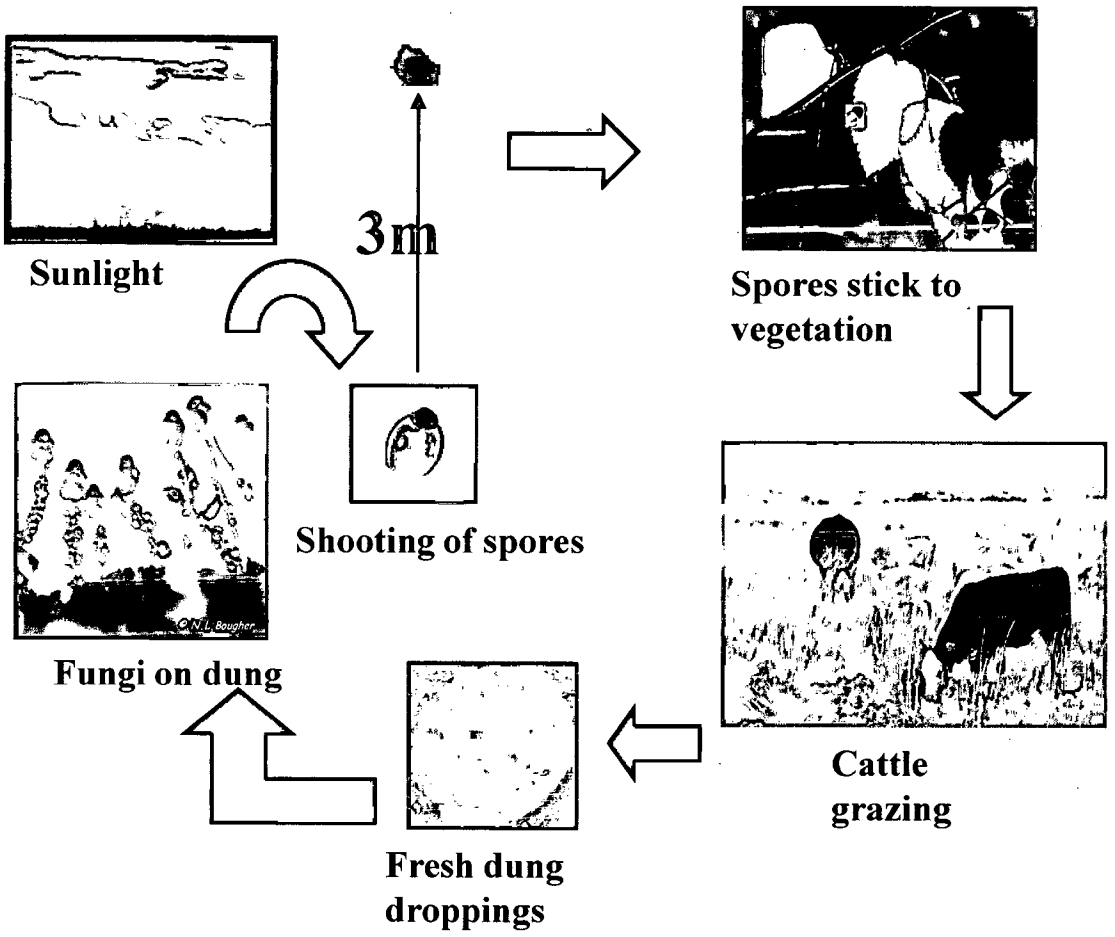
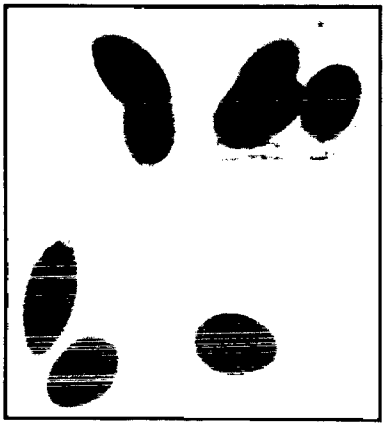


Fig. 2.2 Adaptations acquired by fungi for coprophilous habitat

Violent spore discharge:

Adhesive projectiles:



Mucilaginous spores:

Resistance to digestive enzymes and acids while in animal gut:

eject the spores to relatively long distances (Ingold, 1971). This is often supplemented by a mechanism of violent spore discharge, so as to get the spores dispersed towards the light, away from their staling substratum and onto the surrounding herbage (Richardson, 2008). The phenomenon of violent spore discharge is best demonstrated in *Pilobolus* (Webster, 1970). During spore dispersal, the mature sporangium is thrown more than 2m by dehiscence of mucilage found at the junction of columella with sporangium, by rupture of the subsporangial vesicle (Webster, 1983; Dix and Webster, 1995). The spore projectile often consists of many spores, sometimes the entire contents of asci or sporangia. The larger the projectile is the less limiting to dispersal. The projectile is often mucilaginous so that once impacted on an aerial substrate such as leaf blade or branches, the spore adheres there rather than falling to the soil. The spore walls are often pigmented and the protoplasm gets protected from excessive exposure to sunlight (Ingold, 1971). The spores are ingested with the herbage and survive passage through the alimentary canal of the animal. Majority of coprophilous fungi, but not all, require such treatment before they germinate (Webster, 1983). These are intricate ecological adaptations acquired by the dung inhabiting fungi, with which, the fungal spore is not only thrown high in air so as to enable the latter to fall on vegetation but also, in the next feeding of herbivores, the dispersed spores along with forage get into the stomach of animals (Dix and Webster, 1995).

Other than violent discharge, there are additional modes of spore dispersal which takes place by rain splash, insects, arthropods and even mammals. Amongst these, insects (Stevenson and Dindal, 1987) and mites (Malloch and Blackwell, 1992) play important role in the dispersal of fungal spores. Possession of modified appendages, in some cleistothecial ascomycetes, enables the attachment of fruiting

bodies to the fur of mammals, especially carnivorous mammals, and thereby dispersal of fungi to distant locations (Wicklow, 1981).

Adhesive projectiles: Coprophilous fungi have been well studied with respect to appendaged spores (Ingold, 1971; Jones, 1994, 1995; Lundqvist, 1972). Usually, ascospores are armoured with gelatinous appendages or sheaths, as extension of their spores. These projectiles enable attachment of spores to the herbage without being washed off by wind or water and losing viability and hence, the probability of being consumed by the grazing animals is large (Richardson, 2008; Dix and Webster, 1995). The elaboration or fragmentation of cell wall leads to the formation of primary appendages, whereas secondary appendages are formed by exudation through one or more pores in the spore wall (Read and Beckett, 1996). In *Zygopleurage zygospora*, each ascospore consists of two pigmented cells, linked by a hyaline intercalary cell and this can be seen within the ascus (Bell, 1983).

Pigmentation in spore-wall: It was an observation that the spore wall or exospores are often pigmented and provide protection against UV exposure while on discharge (Richardson, 2008; Krug et al., 2004).

Mucilaginous spores: Most of coprophilous ascomycetes have ascospores with brief or elaborate mucilaginous appendages which aid effective attachment of the spores to the substrata (Bell, 1983; 2005; Lorenzo and Havrylenko, 2001). The gelatinous ascospores of coprophilous fungi, as in species of *Sordaria* and *Podospora*, favour adherence of the propagules to adjacent vegetation. These, when consumed by herbivores along with the vegetation, the normal coprophilous fungal cycle gets continued (Caretta, 1998). In *Saccobolus citrinus,* the ascospores stick together to produce a contiguous projectile which enable the spore column to get fired to some

distance from the ascoma (Brummelen, 1967; Ingold, 1971). The gelatinous ascospore sheath swells in water, increasing in diameter and effecting greater adhesion to the surface (Jones, 2006). Spores of coprophilous fungi, as in *Graphium* sp. and *Mucor hiemalis,* are mucilaginous and these stick upon the vegetation for long periods without being washed off or losing viability even when the mucilage gets dried. These spores are apparently dispersed by arthropods or mites which are specialized inhabitants on dung (Kendrick, 1992).

Resistance to digestive enzymes and acids while in animal gut: Passage of spores through the gut of an animal is very often necessary to facilitate germination of spores of coprophilous fungi (Richardson, 2008). The passage through the animal gut leads to stimulation to germinate, leading to the vegetative stage followed by sporulation. Spores are triggered to germinate following exposure to the chemical and physical environment of the animal gut (Kuthubutheen and Webster, 1986). The fungi which have survived digestion and appear on dung have been termed 'true coprophilous' (Larsen, 1971).

The vegetation generally possesses certain amount of other fungal spores from the vicinity, which in turn is taken up by the grazing herbivores along with the spores of coprophilous fungi. However, the harsh conditions in the alimentary canal, to which these spores are subjected, provide no prospect of survival for fungi other than coprophilous (Richardson, 2008). These adaptations are diagrammatically represented in Fig. 2.2.

Significance of growth factors for coprophilous fungi: The species of *Pilobolus* require a growth factor, coprogen, present in the herbivore dung for growth and fruiting. The coprogen, an organo-iron compound, a precursor of protoporphyrinogen,

is apparently produced by various fungi and bacteria, in dung (Webster, 1983; Dix and Webster, 1995). Besides, fatty acids are present in herbivore dung and *Pilobolus* makes better growth on these as carbon source rather than it does on simple pentoses and hexoses.

Ecological succession

Among the ecological concepts, succession is well studied (Richardson, 2001). Although the fungal succession has been studied on many substrates (Dix and Webster, 1995), little is known about the mechanism which drives this phenomenon. The difference between succession in herbivore dung and other substrate such as plant litter is that decomposition of plant remains, viz. deciduous tree leaves, pine needles and dry grasses lack the initial Phycomycete phase. The low content of easily available sugar and nitrogen in plant litter led to the absence of mucoraceous members (Fryar, 2002).

Ecological succession is also the cause of sequential change in community composition (Morin, 1999). Various mechanisms such as facilitation, tolerance and inhibition drive the compositional change (Connell and Slatyer, 1977). Studies of fungal succession carried out on various substrates show certain uniformity in occurrence of fungi with time, i.e. early, intermediate or late colonisers. The time taken for fungal succession varied with each study and the examined substratum (Eaton and lones, 1971a; Sivichai et al., 2000; Tsui et al., 2000). The appearance of fungi on the substrate has been characterised as common, infrequent and rare, depending on the percentage frequency of occurrence (Jones, 1963;, 1999; Cai et al., 2002; Kane et al., 2002; Sivichai et al., 2000). Amongst all factors, succession of

fungi is more affected by temperature, light, and humidity (Wicklow, 1992; Kuthubutheen and Webster, 1986; Wicklow and Moore, 1974; Morinaga et al., 1980).

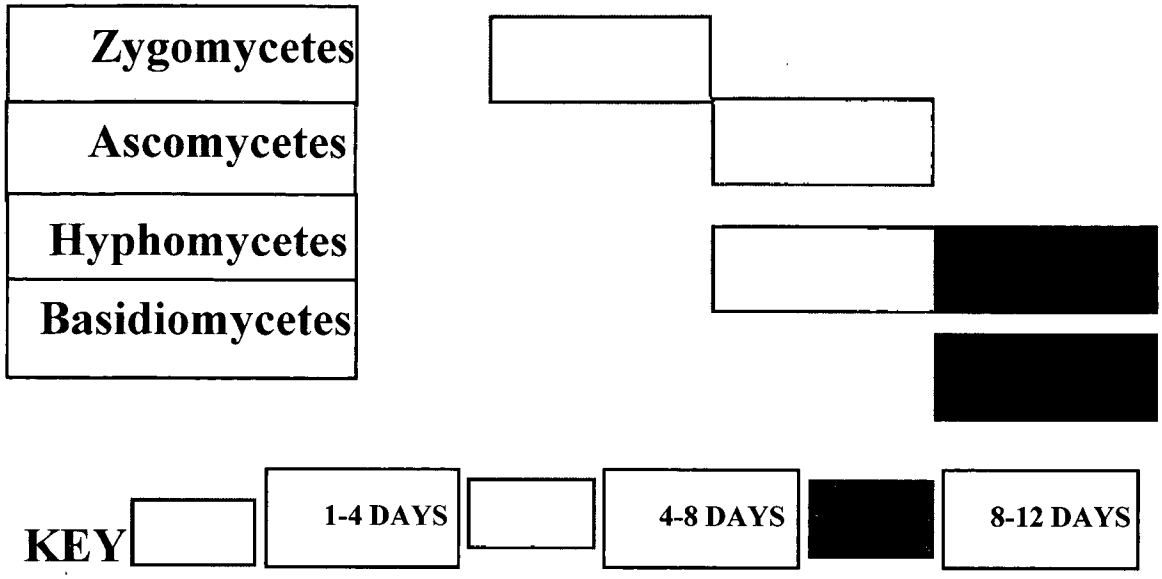
Fungal succession

Fungal succession is defined as the "sequential occupation of the same site by thalli (usually mycelia) of different fungi or of different associations of fungi" (Rayner and Todd, 1979). The fungal replacement is caused by communities of mycelia, both in space and time (Frankland, 1998). Fungal succession occurs at two levels: micro- and macro- (Suzuki, 2002). The association of different kinds of fungi with a plant community leads to the formation of macro-scale. Whereas, the fungal succession associated with plant succession at the patch level is micro-scale (Swift, 1982; Suzuki, 2002). Since the fungal growth is entirely dependent on plants' substrata, the succession of fungi is related to plant succession at different levels (Prentice, 1992). Theoretically, the saprobic fungal numbers reach zero value, once the substrate is exhausted. However, this value is hardly attained during fungal succession (Frankland, 1992). The pattern of succession is schematically presented with Fig. 2.3.

Fungal succession on herbivore dung

Freshly voided herbivore dung, on incubation in a damp chamber, showcases a host of fruiting fungi in succession, with the Phycomycete sporangiophores such as those of species of *Mucor*, *Pilaria* and *Pilobolus* dominating the first phase. This is followed by apothecial Ascomycetes including genera such as *Ascobolus*, *Coprobia* and *Rhyparobius*, after 6-7 days. By 9-10 days the perithecial asscomycetes, viz., *Sordaria*, *Podospora* and *Chaetomium*, appear. These persist for up to 3-4 weeks and

Fig. 2.3 Spectrum of fungi appearing in succession on incubated herbivore dung



finally leading to the appearance of basidiocarps of *Coprinus*, *Stropharia* and *Panaeolus* (Webster, 1983).

The exact succession pattern, timing and species list varies with the dung. The nutrient utility in dung is often considered as the reason for fungal succession (Webster, 1971). The sugars, starches and proteins are chiefly utlilized by the mucorales, also known as sugar fungi. Ascomycetes lead the consumption of the cellulose and the basidiomycetes exhaust both cellulose and lignin present in the substrate (Webster, 1983). The observation of succession sequence is based on the appearance of reproductive structures, (sporangiophores, ascocarps or basidiocarps), while the mycelial development sequence may not be the same. It is demonstrated that in the absence of any pre-treatment leads to the failure of a few coprophilous fungi to germinate, even on fresh dung. Whereas, when the spores are treated with pancreatin for 5 h at 37^0C, led to their successful germination within 6 h (Dix and Webster, 1995). Apart from this, succession is also explained based on the minimum time required to produce the fungal fruiting structures, when grown on sterile dung or standard culture medium. For example, *Mucor hiemalis* takes 2-3 days, *Sordaria fumicola* 9-10 days and *Coprinus heptemerus* 7-13 days in culture (Webster, 1970). Thus, the minimum time for fruiting provides an explanation for the succession. From an ecological stand-point, succession is influenced by competition (Krug et al., 2004). Basidiomycetes are not necessarily the last group of fungi appearing in the successional sequence. Certain ascomycete genera, notably *Coprotus*, *Podospora* and certain Gymnoascaceae develop theirs fruit-bodies after 35-50 days of incubation or plating (Bell, 1983).

Competition among fungi in herbivore dung

Being a nutrient rich substrate, competition amongst the resident micro-organisms exists in the dung. Apparently this has little effect on the actual time of appearance of fruit bodies (Webster, 1970). The duration of fungal fruiting on dung varies based on the various on-going activities in the substrate, viz., competition for nutrients, antibiotics production or antagonism among the existing micro-flora (Bell, 1983). The non-fungal competitors such as, arthropods and worms also influence the growth and survival of certain fungi. The diversity of mycobiota is influenced by the fragmentation of dung caused by these organisms. Certain arthropods and fly-larvae act as predators on certain fungi (Helsel and Wicklow, 1979). These activities encourage the growth of rarer fungal species, by reducing fungal competitors (Wicklow, 1981).

Factors influencing succession

Antagonism: Certain fungi are antagonistic in nature and suppress the fruiting of other fungi and this phenomenon is widespread among coprophilous fungi (Harper and Webster, 1964) Coprophilous basidiomycete such as *Coprinus* spp. are antagonistic to species of *Pilaria* and *Ascobolus* (Ikediugwu and Webster, 1970a, b). The phenomenon of antagonism is observed only after the hyphal interference. The hyphae of *Coprinus* when come in contact with cells of *Ascobolus,* it leads to cell vacuation, damage to permeability and loss of turgor. This might be the reason for dominance of Basidiomycetes, especially *Coprinus*, at the later stage of succession. Certain fungi such as *Chaetomium* sp., *Coniochaeta* sp. are equipped with perithecial hairs which perform as defence mechanisms (Wicklow, 1981).

Synergistic effects: Synergistic interactions lead to better fruiting in *Ascobolus furfuraceus*, in the presence of bacteria. Similarly, the release of ammonia by *Mucor plumbeus* gives an opportunity for *Pilobolus kleinii* to fruit better. It is thought that combination and interaction of all these factors determine the succession (Dix and Webster, 1995).

Dependency on the surroundings: To certain extent, the mycobiota appears to be specialized on particular kinds of dung. Some fungi appear on dung of certain animals. It was observed that *Perichaena corticalis* var. *liceoides* prefers the dung from domestic animals, whereas *Stemonitis fusca* prefers those from forest animals (Eliasson and Lundquist, 1979). The food preferences and habits and the type of digestive system of the different herbivorous animals, viz. *Connochaetes taurinus* (Blue wildebeest), *Equus burchelli* (Burchell's zebra), *Loxodonta africana* (African elephant) and *Giraffa camelopardalis* (Giraffe), had an effect on the coprophilous fungal species composition and diversity (Ebersohn and Eicker, 1991).

Optimal conditions for growth of coprophilous fungi: The pre-requisite for coprophilous fungi to grow is a narrow range of conditions. Diverse groups of fungi are recovered when the dung was subjected to various temporal conditions. Differences in humidity, temperature, decomposition stage and the pH of the substratum mattered. Majority of the coprophilous fungi find a pH of 7 optimal for growth (Krug et al., 2004). Some fungal taxa are ephemeral and observed only on fresh dung (Krug, 2004).

Effect of seasonal variation on the diversity of coprophilous fungi:

Composition of mycobiota is influenced by the environmental factors to which the dung is subjected. Under cold conditions, certain species of *Thelebolus* and *Preussia* are dominant on leporid dung, whereas during the warmer summer months, the above fungi are replaced by other dominant species such as *Sporormia* (Wicklow and Moore, 1974).

Species-substrate relationship

According to a study carried out in Egypt by Abdel-Azeem (2005), species richness varied tremendously from one type of dung to another. While diverse fungal species were observed on the donkey dung, the lowest value was seen on goat dung. A restricted occurrence of certain species was observed on certain types of dung, e.g. *Thielavia* appeared only on camel dung. Certain species such as *Chaetomium globosum*, *Podospora appendiculata* and *Saccobolus glaber* were present on all types of dung. In some studies, definite species-substrate relationship has been observed (Parker, 1979; Angel and Wicklow, 1975). The physical and chemical properties of the dung differed from animal to animal and consequently the colonization of fungi (Lundqvist, 1972; Richardson, 2001). Some coprophilous fungi have wide ecological adaptations and low preferences of particular herbivore dung (Richardson, 1972; Wicklow, 1975; Tisdall and Oades, 1982; Caretta et al., 1994). The fungi such as *Pilobolus crystallinus*, *Mucor* sp., *Kernia nitida*, *Mycoarachis inversa*, *Preussia isomera*, *Tripterospora erostrata*, *Arnium* sp., *Chaetomium cuniculorum*, *C. pulchellum*, *C. subspirale*, *Coniochaeta discospora*, *C. scatigena*, *Delitschia marchalii*, *D. patagonica*, *D. winteri*, *Hypocopra merdaria*, *Phomatospora hyalina*, *Podosordaria* sp., *P. anserina*, *P. decipiens*, *P. hyalopilosa*, *P. pectinata*, *P.*

tetraspora, *P. vesticola*, *Sordaria fimicola*, *S. macrospora*, *Sporormia fimataria*, *Sporormiella affinis*, *S. australis*, *S. cymatomera*, *S. intermedia*, *S. lageniformis*, *S. longisporopsis*, *S. mimima*, *Trichodelitschia bisporula*, *Zygopleurage zygospora*, *Ascobolus immerses*, *Coprotus disculus*, *C. glaucellus*, *C. sexdecimsporus*, *C. winteri*, *Iodophanus carneus*, *Lasiobolus* ciliatus, *Saccobolus globuliferellus*, *S. truncatus*, *Coprinus stercorarius*, *Psilocybe coprophia* and Sclerodermataceae (sterile) were widely distributed on different kinds of herbivore faeces (Ahmed and Cain, 1972; Brummelen, 1967; Cain, 1934, 1956;).

Comparative study: Ruminant vs non-ruminant dung

In a comparative study carried out on occurrence of fungi in the faeces of larger herbivore ruminants (antelopes, buffalo, zebu) and non-ruminants (hippopotamus, zebra) in Kenya, found 15 of 17 fungal species on prong-horn and cattle faeces. Richardson (2006) attributed this higher number of species of fungi in herbivore animals for their ruminant nature of feeding habits.

Diversity and taxonomic studies

Most of hitherto works carried on coprophilous fungi were from Europe, North America and southern South America (Richardson, 2001; 2006; Eliason and Lundqvist, 1979). Recent studies were from Central and East Africa; Japan and some parts of Asia, New Zealand, and Venezuela (Krug et al., 2004). Majority of the coprophilous fungi are cosmopolitan in distribution. Certain fungi however are restricted to specific areas (Richardson, 2001). In most instances, however, estimates of frequency and species richness are correlated with collecting intensity, geographic origin, and the expertise and interest of the mycologists. Therefore, hitherto

statements on distribution of coprophilous fungi may not be absolutely correct (Krug et al., 2004).

Analysis of species richness was possible to some extend in localities such as caves occupied by porcupines and certain wood rats in North America and by hyrax in Africa, wherein the dung was deposited in layers or pushed to the entrance of the cave for several generations. Although many fungi were isolated by moist chamber incubation method (Amann et al., 1995), complete estimation of mycobiota was possible only by usage of PCR-RFLP (polymerase chain reaction–restriction-fragment-length polymorphism) using the ITS region of ribosomal DNA. The application of molecular techniques significantly increased the knowledge on fungal diversity (Viaud et al., 2000).

A number of studies have been carried out around the world, aiming at estimation of coprophilous fungal diversity. Cain (1934) recorded 112 taxa of coprophilous Sphaeriales from Ontario, Canada. From Central African Republic, 91 taxa were recovered (Khan and Krug, 1989). From 50 dung samples, 153 taxa were recovered from the zone $0\text{-}30^0$ north and south of the equator. This figure substantially dropped, beyond 40^0 north or south. In contrast to this, 66 taxa of pyrenomycetes were recorded from New Zealand which supported latitudinal gradient (Bell, 1983).

Studies on coprophilous fungi were carried out in southern California and parts of Arizona and Mexico (Mueller et al., 2004). A five year study in Pakistan resulted in the compilation of 78 species belonging to 26 genera of fungi (Mirza et al., 1979). In Switzerland, 20 species belonging to 10 genera were encountered (Lendner, 1908). A number of studies have been carried out on zygomycetes fungi (Benjamin, 1958, 1959, 1960, 1961, 1962, 1963, 1965, 1966, 1979; Benjamin and Mehrotra,

1963; Benny, 1982; Humber, 1989;). Benjamin (1979) classified the Zygomycetes which was later emended by Humber (1989) and Cavalier-Smith (1998).

Attempt was made to isolate Myxomycetes from cattle dung samples. From 25 dung samples, 80 species belonging to 23 genera of Myxomycetes were recorded (Kowalski, 1969 a,b; Eliasson and Lundquist, 1979). Few of the coprophilous myxomycetes were recorded from Taiwan (Chung and Liu, 1996). Published records of Myxomycetes from dung of carnivorous and omnivorous vertebrates are however rare (Krug et al, 2004).

Abdel-Azeem (2005) examined dung samples of various animals, collected from different locations and incubated in moist chambers, for several weeks. From 3 types of dung, he reported 54 taxa of fungi, of which 26 were true ascosporic. Among these, 46 species were reported from donkey dung, followed by camel (37 spp.) and goat dung (32 spp.) In an earlier study, 12 ascosporic taxa were reported and these included both apothecial and perithecial (Bagy et al., 1986).

In a study carried out on coprophilous fungal communities on wild rabbit dung in Chile, during cold and warm seasons, in all 60 species belonging to 44 genera were isolated (Piontelli et al., 2006). These included Zygomycota (11.6%), Ascomycota (50%), associated mitosporic genera (36.8%) and Basidiomycota (1.6%). Several other workers have recovered a number of rare and new species from Chile (Lazo, 1979; Udagawa, 1980; Piontelli et al., 1981, 1997; Valdoserra and Guarro, 1988; 1994).

In Kenya, studies on coprophilous fungi were done on dung samples of antelope, buffalo, zebra and hippopotamus. A total of 143 fungi belonging to 40 genera and 59 species were isolated. These belonged to Ascomycetes (39%), Deuteromycetes (50.8%), Zygomycetes (8.5%) and Basidiomycete (1.7%). The

common species recovered were *Ascobolus immersus, Coprotus niveus, Iodophanus carneus, Lasiobolus lasioboloides, Podospora anserina, P. australis* and *Sporormiella minima*, whereas, *Kernia nitida, Saccobolus versicolor* and *Sordaria fimicola* were infrequent but interesting ascomycetes. *Sporormiella, Podospora, Iodophanus, Ascobolus* spp. were the most common ascomycetes. The highest number of different species was found in waterbuck faeces (17) followed by reedbuck (16), steenbok (15), impala and bushbuck (14), hippopotamus and zebu (131). On bushbuck, eland, buffalo, steenbok, zebra and dik-dik faeces collected in Savanna, the number of fungal species tended to be fewer (Caretta et al., 1998).

Many novel coprophilous species have been discovered. These included a new ascomycetous genus, *Pseudascozonus*, related to *Ascozonus* and *Thelebolus* of Pezizales (Brummelen, 1985). A novel pleoanamorphic coprophilous hyphomycete named *Basifimbria spinosa* characterized by sympodial conidiophores producing two intergrading types of successive blastoconidia, was described (Buffin and Hennebert, 1985).

Jeamjitt (2006) studied coprophilous hyphomycetes from Thailand. Dung samples of deer, barking deer, eld's deer, elephant, guar, rabbit, camel, goat, horse, buffalo, cow, mouse and toad were examined. The study resulted with recovery of 406 isolates of fungi. *Nodulisporium gregarium*, *Oidiodendron griseum* and *Pithomyces karoo* were recorded for the first time from Thailand. Two strains of *Mucor* sp. were recovered from canine dung Western Cape, South Africa (Jacobs and Botha, 2008). A new hetetothallic species of *Sordaria*, *S. sclerogenia,* was recovered, from Ceylon (Fields and Grear, 1966). The genus *Kernia*, with *K. nitida* and *K. pachypleura,* has been reported for the first time from Taiwan (Chang and Wang, 2008).

The genus *Podospora* was studied by several workers (Niessl, 1883; Winter, 1885; Cain, 1962; Cailleux, 1969; Garcia-Zorron, 1977; Lundqvist, 1972; Mouchacca, 1986; Mirza and Cain, 1969; Udagawa and Ueda, 1985; Krug and Khan, 1989). A species of *Mortierella*, *M. hypsicladia*, was isolated from bat dung (Degawa and Gams, 2004). On rhinoceros dung, Ávila et al. (2009) described *Coprotiella venezuelensis* from Venezuela. In a study carried out during the summer months in Orkney and Shetland, 64 species of coprophilous fungi were recorded wherein *Ascobolus brantophilus* was recorded for the first time from UK (Richardson, 2006). A novel species of the genus *Podosordaria*, *P. leporine,* a xylariaceous ascomycete, was identified from Thailand (Bangyeekhun, 2008). Richardson (1998, 2004) described 27 and 57 species of coprophilous fungi respectively from Scotland and southern Morocco. On the basis of studies carried out in Zulia, Venezuela, a novel species of *Mycotypha*, *M. indica*, was isolated from turkey dung (Ávila et al., 2007).

A number of coprophilous species of *Chaetomium* was recorded from countries such as Holland and South America, Chile, Germany, Buenos Ayres, North Carolina and New England which included *C. subspirale, C. quadrangulatum, C. convolutum, C. spinosum, C. ampullare* and *C. aureu,* respectively (Cooke, 1969; 1970). *Chaetomium deceptivum*, *Lasiobolidium orbiculoides* and *Thielavia cephalothecoides* were described and discussed from dung of wood-rat, mouse and deer, respectively (Malloch and Benny, 1973). *Pleuroascus nicholsonii* was reported from wood-rat dung from England (Massee and Salmon, 1901). *Podospora appendiculata* and *P fimiseda* were recorded from New Zealand (Bell and Mahoney, 1997). Novel species of the genus *Ascodesmis obristi* was described and illustrated from Coyote dung collected in Alberta (Currah, 1986). *Corynascella arabica* was isolated and described as a new species from donkey dung from Iraq (Guarrol, 1997).

Hapsidomyces venezuelensis, a new genus and species of the Pezizaceae with ornamented ascospores was isolated from Burro dung (Krug and Jeng, 1984). *Periamphisora* was included as a new genus of the Sordariaceae (Krug, 1989). Based on studies done with the aid of light and scanning electron microscopy on ascospores with unusual side view, *Gelasinospora hippopotama* was described as a novel species (Krug et al., 1994). A total of 25 species of coprophilous fungi, mostly of *Arnium* and *Podospora,* were recorded for the first time from Argentina (Lorenzo and Havrylenko, 2001). Lundqvist (1999) described *Podospora austrohemisphaerica* on dung of domesticated herbivores from England.

Meyer and Meyer (1949) described coprophilous ascomycetes from panama which included species belonging to the genera *Ascodesmis, Ascophanus, Bombardia, Chaetomium, Delitschia, Saccobolus, Sordaria,* and *Sporormia.* Spooner and Butterfill (1999) reported 31 species of ascomycetes belonging to Pezizales from Azores. *Leptokalpion*, a new genus with *L. albicans* as type species, was reported from Thailand (Brummelen, 1977). A new genus *Semidelitschia*, belonging to Sporormiaceae, was described from Canada by Cain and Allen (1969).

Studies on coprophilous fungi in India

Earliest work on coprophilous fungi in India was done by Manju (1933) on dung of six herbivores, viz. rabbit, sambar, horse, goat, buffalo and sheep, collected from various zoological gardens. This study resulted with isolation of 29 species belonging to 21 genera of mucorales, ascomycetes, basidiomycetes and hyphomycetes. Ginai (1936) contributed to the study of coprophilous fungi by isolating 48 species belonging to 27 genera (9 species in 3 genera of mucorales; 18 species in 12 genera of ascomycetes, 12 species in 3 genera of basidiomycetes and 9 species in 9 genera of

hyphomycetes) on the dung of cow, nilgai, camel, zebra, donkey and buffalo. Until 1957, only two species of *Coemansia, C. erecta* (Rugmini, 1956) and *C. reversa* (Agnihothrudu, 1957), were reported from India. *Coemansia ceylonensis* was later added to the list of Indian fungi (Prasad, 1965).

Detailed study on the taxonomy and ecology of coprophilous fungi in India was first done in Rajasthan in North India by Lodha (1964). He studied 67 dung samples, belonging to 17 different animals, both carnivorous and herbivorous. He used various isolation methods, viz. moist chamber incubation, serial dilution, particle-plating technique and Warcup's plating technique and recovered 160 species, belonging to 73 genera which included Mucorales 20 spp. in 10 genera; Hypocreales in 1 sp. in 1 genus; Sphaerales 49 spp. in 9 genera; Pezizales 21 spp. in 5 genera; Hyphomycetes 51 species in 38 genera. Of these, 7 genera and 32 species were new to India. Two new species of *Chaetomium, C. globisporum* Lodha and *C. rajasthanese* Lodha, were described from steamed rat dung and tiger excreta, respectively from Rajasthan (Lodha, 1964).

A few species of *Piptocephalis*, isolated from dung have been described from India. *Piptocephalis debaryana* was isolated from wild rat dung from Allahabad (Mehrotra, 1960). *P. indica* was recovered from rabbit dung collected from Lucknow zoo (Mehrotra and Baijal, 1963). A novel species of *Piptocephalis*, *P. brijmohanii*, was described from dung of Malayan squirrel, collected from Lucknow zoo (Mukerji, 1968). Several thermophilic fungi were isolated from dung of herbivores, compost and sewage manure. These included *Chaetomium thermophile*, *Humicola inslens*, *H. lanuginosa, H. Stellata*, *Malbranchea pulchella* and *Talaromyces thermophilus* (Maheshwari, 1968). A study carried out on various dung samples in and around Darjeeling district of Eastern Himalaya, lead to the discovery of six discomycetes

belonging to the genera *Cheilymenia, Ascophanus, Ascobolus* and *Thecotheus* (Kar and Pal, 1968). Kar and Pal (1970) described an operculate discomycete, *Iodophanus verrucosporus,* on cow dung from Hooghly, West Bengal. Mukerji (1970) carried out a taxonomic study of fungi in Delhi and isolated three coprophilous ascomycetes, viz. *Preussia isomera, Gelasinospora tetraspora* and *Podospora absimilis. Chaetomium warcupii* was reported as yet another novel coprophilous fungus from India (Saxena and Mukerji, 1972). Saxena and Mukerji (1973) described 4 new coprophilous hyphomycetes. *Sympodina coprophila* and *Adhogamina ruchira* were described on goat dung from Jaipur and pony dung from Rishikesh, respectively.

Bahupaathra samala and *Angulimaya sundara* were described from cow dung gathered from Dehradun (Subramanian and Lodha, 1964). *Beejasamuha samala* was isolated from goat and rabbit dung from Maduravoyal near Madras in Tamil Nadu (Subramanian and Chandrashekara, 1977). *Bahukalasa samala* was isolated from Hippotragus dung from Bannerughatta, Karnataka and *Candelabrella elegans* was isolated from cow dung collected from Madras, Tamil Nadu (Subramanian and Chandrashekara, 1978). *Chromocera marathwadi*, was isolated from unidentified herbivore dung in Maharashtra (Tilak, 1978). *Coniochaetidium coprophilum* was isolated from dung from Gwalior in Madhya Pradesh (Pathak and Agarwal, 1977). *Coprobia elaphorum*, and *C. flavus* were isolated from Chandanwari, Pahalgam, Jammu and Kashmir and Bisaran, Rajasthan, respectively (Thind and Kaushal, 1978). Another species of *C. striata*, was recovered from cow dung, Darjeeling, W.B. (Waraitch, 1977). *Coprotus argenteus*, was isolated from cow dung in coniferous forest, Narkanda, Mahusu, H.P. (Waraitch, 1977).

Dispira cornuata was isolated from mouse dung, Gorakhpur, U.P. (Misra and Gupta, 1978). *D. implicata* was isolated from dung of rodents and excreta of bird. *D.*

simplex was isolated from mouse dung, in Gorakhpur, U.P. (Misra and Gupta, 1978). *Faurelina indica* was another species of coprophilous fungus isolated from cow and goat dung, Nainital, U.P. (Von Arx, 1978). *Iodophanus carneus* and *I. kimboroughii* were isolated from the buffalo and goat dung respectively, from Dalhousie, H.P. (Thind and Kaushal, 1978). *Leucosphaeria indica* was isolated from Nilgai dung gathered from Delhi zoo in New Delhi (Von Arx, 1978). *Mycoarachis inversa*, was reported for the first time from Jaipur, Rajasthan, from buffalo dung (Sharma, 1977). *Paneolus indicus*, was isolated from cow dung from Kottayam, Kerala. *Pilaria anomala* was isolated from cat, cow and peacock dung from Allahabad, U.P. During the same study, several species of the genus *Pilobolus*, viz. *P. crystallinus*, *P. heterosporus*, *P. kleinii*, *P. longipes*, *P. nanus*, *P. roridus*, *P. sphaerosporus* and *P. umbonatus* were identified on dungs of cow, peacock, horse, donkey, goat and horse (Nand and Mehrotra, 1979). *P. ramosus*, was isolated from the dung of buffalo, Kolhapur, Maharashtra (Patil, 1978). *Pleurage glabra*, was isolated from cow dung from Darjeeling, W.B. (Kar and Maity, 1978). On rabbit dung collected from Lalbagh garden, Bangalore, *Sutravarana samala* was isolated by Subramanian and Chandrashekara (1977). *Thecotheus holmskjodii*, was isolated from cow dung, Jandhari Ghat, Dalhousie, H.P. by Waraitch (1977). *Tieghemiomyces parasiticus* was isolated from mouse dung in wheat field in Nagara village, Gorakhpur, U.P. (Misra and Gupta, 1978). Of the four species of genus *Lachnella* discovered, *L. albidofusca* and *L. fraxcinicola* were coprophilous (Bilgrami et al., 1979). *Achaetomium theilavioides* was isolated from Nilgai dung, collected from Delhi Zoo, New Delhi (Von Arx, 1978). *Ascobolus scatigenus* was isolated from dung heap in Mangiter, Sikkim (Waraitch, K.S., 1980) and on cow dung in Kerala (Leelavathy, 1981). *Cheilymenia aurantiaco-rubra* and *C. tandonii* were recovered from the heap of dung

from Sarangpur, Chandigarh and on cow dung from Narkanda, H.P., respectively (Thind and Kausal, 1980). *C. coprinaria* was isolated from cow dung from Darjeeling, W.B. (Waraitch, 1980). Ghadge and Patil (1988) described several species of *Ascobolus*, viz. *A. behnitziensis*, *A. crenulatus*, *A. foliicola*, *A. geophilus*, *A. hawaiiensis* and *A. sacchariferus* from dung of various herbivores. Species and varieties of coprophilous genus *Saccobolus* viz., *S. diffusus*, *S. humidicola*, *S. versicolor* var. *kasauliensis* and *S. verrucisporus* var. *longisporus* were described as new to science by Kaushal and Virdi (1986).

Manimohan (2007) described nineteen species of fungi belonging to 12 genera of 5 agaric families, from elephant dung in Kerala. These included *Agrocybe guruvayoorensis*, *Bolbitius coprophilus*, *Conocybe brunneoaurantiaca*, *C. pseudopubescens*, *C. volvata*, *Copelandia cyanescens*, *Entoloma anamikum*, *Macrocybe gigantea*, cf. *Panaeolina rhombisperma*, *Panaeolus antillarum*, *P. rickenii*, *Pholiotina indica*, *Psilocybe coprophila*, *Ps. pegleriana*, *Ps. subaeruginascens*, *Ps. subcubensis*, *Stropharia bicolor*, *S. rugosoannulata*, and *Volvariella volvacea*. Of these, *Agrocybe guruvayoorensis*, *Conocybe volvata*, *Conocybe pseudopubescens*, *Pholiotina indica* and *Stropharia bicolor* are known to be encountered only on elephant dung. *Panaeolina rhombisperma* was isolated from elephant dung in Wayanad district of Kerala (Noordeloos, 2007). During a study carried out in Satara, Maharastra, 65 species of fungi were isolated from dung samples. (Thoke and Kore, 2010).

Activities of coprophilous fungi

A good proportion of coprophilous fungi so far studied yielded a diverse array of novel and moderately potent antifungal compounds (Ridderbusch, 2004). Few of the

coprophilous taxa produce important chemical compounds that may inhibit competing and invading organisms or stimulate fungal growth (Harper and Webster, 1964).

Antifungal agents

Wicklow (1988) reviewed the role of such compounds in deterring predation. Coprophilous fungi, especially those slow-growing taxa developing in middle or late succession, offer a rich source of antifungal natural products (Gloer 1995; 1996; 1997). Many of these compounds possess novel ring systems, e.g., preussomerin A from *Preussia isomera* (Weber et al., 1990), a relatively rare occurrence in natural products chemistry (Gloer, 1995). Coprophilous fungi are thought of a good source of unknown compounds with diverse biogenetic origins and promising biological activity (Gloer, 1997). Chemical investigation of coprophilous fungus, *Apiospora montagnei*, led to the discovery of a novel antifungal metabolite called apiosporamide (Alfatafta and Gloer, 1994).

Polyphosphate

Inorganic polyphosphate (poly P) is a linear polymer of phosphoanhydride linked phosphate residues. Polyphosphates occur in all organelles of all organisms, including the fungal cell walls. Different species of Zygomycetes, mostly isolated from herbivore dung, possess polyphosphate molecules of different chain lengths. Depending on the cell growth phase cellular location, structure and distribution of polyphosphate differs. Polyphosphates with low molecular weights exist in free form or are bound to cytoplasmic compounds such as the ribonucleic acids. Extractions in high salt buffer reveal that larger polyphosphates were observed in Mucorales, when compared with other fungi. Presence of poly P in the cell walls of fungi was

investigated using techniques of poly P binding proteins. (PBPs) (Werner et al., 2007).

Rhizoferrin

Rhizoferrin is a novel polycarboxylate or complexone-type siderophore. This compound was originally isolated from *Rhizopus microsporus*, a coprophilous fungus. Rhizoferrin is known to be present in all Zygomycetes. Using high performance liquid chromatography (HPLC) rhizoferrin could be detected in various families of Zygomycetes. For instance, rhizoferin has been detected in *Rhizopus microsporus* var. *rhizopodiformis*, *Mucor mucedo* and *Phycomyces nitens* (Mucoraceae), *Chaetostylum fresenii* and *Cokeromyces recurvatus* (Thamnidiaceae), *Cunninghamella elegans* and *Mycotypha africana* (Choanephoraceae) and *Mortierella vinacea* (Mortierellaceae) and *Basidiobolus microsporus* (Entomophthorales).

Polyunsaturated fatty acid (PUFA)

As part of health knowledge, it is well known that the bad fats include saturated and trans fats, while the good fats include omega-3 (x-3) and omega-6 (x-6) fatty acids. The latter group of fatty acid includes arachidonic acid (ARA), α-linolenic acid (GLA) and linoleic acid (LA) which are essential fatty acids (EFAs) (Dyal and Narine, 2004). An increased intake of omega-3 fatty acids is generally recommended for a healthy life (Bajpai, 1992). Studies project that consumption of food products enriched with fish oil offers potential health benefits, especially protection against cardiovascular diseases (CVD), cancer and improvement of brain development and function (Dyal and Narine, 2004;). The group of fungi gaining maximum attention for the production of EFA is Zygomycetes, especially those belonging to the Class

Mucorales. Among the mucoraceous fungi *Mortierella* spp. Have gained a notable attraction due to their high content of lipids (Dyal and Narine, 2004).

Arachidonic acid (ARA)

A fungus containing more than 25% of its biomass in the form of lipids is known as oleaginous (Murphy, 1991). Arachidonic acid, 20:4(*n*-6), is one of the important PUFAs which helps development of brain in the infants and hence considered as an important constituent of the infant food (Wynn and Ratledge, 2000). ARA also acts as a precursor of prostaglandins, thromboxane, prostacyclin, and leucotrienes, and plays an important role in various physiological actions including uterine muscle contraction, relaxation, vasodilatation, and antihypertensive action in humans (Wynn and Ratledge, 2000). Of all the ARA producing fungi, 94% belonged to the genus *Mortierella,* the rest of the isolates belonged to *Mucor.* All the *Mortierella* isolates produce ARA (Higashiyama et al., 2002). *Mortierella alpina* is one of the major sources of arachidonic acid hence called as oil producing microorganism (Murphy, 1991). *M. alpina*, can accumulate up to 40% (w/w) lipid, of which up to 40% is arachidonic acid, when cultivated in submerged culture in a fermentor with glucose as a carbon source (Wynn and Ratledge, 2000). *Mortierella* sp. has a high potential to produce lipids, with a significant portion of EFAs. Due to this, *Mortierella* sp. has attracted notable attention.

Eicosapentaenoic acid (EPA)

Experiments with *Mortierella elongata* suggested that a maximum yield of EPA is obtained when linseed oil (2%) and yeast extract (0.5%) were used in the basal medium. Maximum EPA content as a percentage of lipids (15.12%) was observed when the latter medium was supplemented with 0.25% urea (Bajpai et al., 1992).

γ-linolenic acid (GLA)

γ-linolenic acid stands out tall among the fatty acids because of its numerous functions, including structural component of cellular membrane, formation of prostaglandin E1, control of the permeability of skin and possibly other membranes, and regulation of metabolism and cholesterol (Tauk-Tornisielo et al., 2007). As a precursor of prostaglandin, this acid is used in geriatrics treatment of premenstrual syndrome, prevention of osteoporosis, reduction of inflammatory processes and reduction of blood pressure. The subgenus *Micromucor* produces C-18 fatty acid γ-linolenic acid. Of the 28 Mucorales screened, *Mucor mucedo* and *Cunninghamella echinulata* were said to be the best yielders of γ-linolenic acid (Shinmen et al., 1989). With use of a basal growth medium consisting 5% dextrose and 1% yeast extract along with Mn^{2+}, the production of GLA increased significantly by *Mortierella ramanniana* var. *ramanniana* (Tauk-Tornisielo et al., 2007).

Food industry

Fungi are involved in the production of a wide range of blue-veined and white mould cheese and a number of fermented Asian food products including tempeh (Hudson, 1971). Amylase produced by *Rhizopus foetidus* are used to convert starchy substrates to sugars prior to alcoholic fermentation, chocolate production, syrups from cocoa and inverase (Hudson, 1971; Pointing and Hyde, 2001). Extraction of chitosan from *Absidia glauca* var. *paradoaxa* was done using 2% Acetic acid and the product is used as fining agents for apple juice (Rungsardthong et al., 2006). The chitosan obtained from fungus turned out to be much effective in reducing the turbidity and gave lighter juices than the sample treated with shrimp chitosan (Rungsardthong et al,

2006). *Rhizopus aarhizus* enriches the protein content, when inoculated in soaked barley. The derived product is used as feed of pigs (Jacela et al., 2010).

Chitosan is a natural polymer derived from chitin. It is a polysaccharide formed primarily by repeated units of β (1-4) 2-amino-2-deoxy-D-glucose or D-glucosamine (Yadav and Bhise, 2004). Chitosan is the deacetylated product formed by the treatment of chitin with concentrated (50%) caustic alkali. Traditionally, chitosan is obtained by chemical conversion of chitin, which is a constituent of the exoskeleton of annelids, coelenterates, crustacean, insects and molluscs (Chatterjee et al., 2005; Rungsardthong et al; 2006; Stamford et al., 2007). The unique properties of biodegradability, biocompatibility, bioactivity, selective permeability, polieletrolic action, chelation, ion exchange properties, antitumor and antimicrobial activity made chitosan very demanding in the fields of agriculture, medicine, biotechnology and pharmaceutical industries (Amorim et al., 2001; Stamford et al., 2007). Among coprophiolous fungi, *Mucor rouxii, Cunninghamella echinulata* and *C. elegans* are said to be the best strains producing chitosan at commercial scale (Amorim et al., 2001; Franco et al., 2004).

Ethanol

When screened, 9 members of the Zygomycetes were found to produce ethanol along with the capacity of fermenting pentoses. These included *Mucor corticolous*, *M. hiemalis*, *M. indicus*, *Rhizopus oryzae*, *Rhizomucor pusillus* and *R. miehe*. On fermentation, all the strains produced glycerol as by-product, while species of *Rhizopus* and *Rhizomucor* produced lactic acid in significant amount (Millati et al., 2004).

Bioremediation

Chitin and chitosan extracted from *Cunninghamella elegans* were subjected to biosorption in the aqueous solution for the metals, viz. copper (Cu), lead (Pb) and iron (Fe), using polysaccharide solutions (1% w/v). Chitosan and chitin showed high affinity for Cu and Fe adsorption (Franco et al., 2004). *Rhizopus arrhizus* helps in the removal of the Plutonium (Pu), Americium (Am) and Cerium (Ce) from nuclear fuel reprocessing plants (Pointing and Hyde, 2001).

β-Carotene

Although animals incorporate carotenoids, only plants, bacteria and algae can synthesize carotenoids. The carotenes produced by *Phycomyces blakesleeanus* and *Blakeslea trispora* are used as provitamins, pigments and antioxidants in the food and feed, pharmaceutical and cosmetics industries . Due to accumulation of β-Carotene in the mycelia and sporangia, the fungi attain yellow colour. Stimulation for accumulation of the pigment is mediated by the production of trisporic acid from the opposite mating strain (Mehta and Cerda′-Olmedo, 2001). It was reported that mutations in the genes lead to an increase in the β-carotene contents and other carotenes such as lycopene (Mehta and Cerda′-Olmedo, 2001; Kuzina and Cerda′-Olmedo, 2006). It has been studied that the biosynthesis of β-carotene is stimulated by H_2O_2. With the increase in the content of β-carotene, a decline in the superoxide dismutase and catalase activity was noticed. In *Blakeslea trispora*, β-carotene acts as a major antioxidant during inactivation of enzymes that detoxify reactive oxygen species (Gessler et al., 2002).

Organic acids

The members of Zygomycota have high ability of producing lactic acid. A significant commercial source of lactic acid is a bioprocess employing *Rhizopus oryzae* and *Rhizomucor* sp. Along with lactic acid these fungi produced significant amount of fumaric acid, L-malic acid. Species of *Rhizopus* and *Actinomucor* have resulted in the yield of 63-69% of lactic acid from a chemically defined medium containing 15% glucose. The production of lactic acid, along with ethanol, leads to the acidification of the environment and thereby discourages the competitors (Magnuson and Lasure, 2004). Lactic acid has found its non-food application as ethyl lactate (biodegradable solvent) along with the primary uses as preservative, flavor enhancer and acidulant in the food industry (Magnuson and Lasure, 2004).

Enzymes

The enzymes are essential proteins which mediate the metabolic processes of all living organisms. They also accomplish degradation of all organic matter on the face of this earth. Enzymes also cause perishable food, fruit and vegetable spoilage. Zygomycetous fungi generally degrade the easily available sugars such as glucose (Dix and Webster, 1995). Representatives of the genus *Mucor*, viz. *M. genevensis*, *M. circinelloides* f. *griseo-cyanus* and *M. circinelloides* f. *janssenii* show high lipase activity, whereas considerable less activity was observed in *M. circinelloides* f. *lusitanicus* (Alves et al., 2002). Although, *Mucor* isolates showed high lipase activity, the enzymatic activity does not establish standards for separation of the taxa at specific level since it varied in different isolates belonging to the same taxon. Protease activity of commercial value is exhibited by *Mucor hiemalis*, *M. racemosus*, *M. bacilliformis* and *M. miehei*. *M. miehei* has been studied most extensively for the

production of the lipase (Alves et al., 2002). *Rhizopus* along with *Aspergillus*, *Fusarium*, *Penicillium,* was reported to be a good producer of pectinase. The mycelial extracts of *Rhizopus nigricans* is used to purify the enzyme chitin-deacetylase (Jeraj et al., 2006). Species of *Chaetomium* commonly occur on dung. Species of *Chaetomium* are known to produce copious amount of cellulase (Ames, 1963).

Secondary metabolites

Secondary metabolites are not important for the basic metabolic growth of an organism but do possess basic survival functions in nature. They possess complex chemical structures. Secondary metabolites such as mycotoxins, antibiotics, pigments and pheromones are not produced by all organisms, but may be elaborated by some of the species of a genus (Demain, 1986). Decipinin A, with antifungal and antibacterial activity, has been isolated from liquid cultures of the coprophilous fungus, *Podospora decipiens*. Besides, two new compounds, tetracyclic sesquiterpenes lactones, decipienolides A and B, obtained from this isolate had showed antibacterial activity (Che, 2002). Australifungin, a novel inhibitor of Sphinganine N-Acyltransferase was discovered from *Sporormiella australis*. Another antifungal and antibacterial metabolite, Arugosin F, was isolated from the coprophilous fungus, *Ascodesmis sphaerospora* (Hein, 1998). A novel metabolite with strong antimicrobial activity and weaker cytotoxic and phytotoxic activity was isolated from a xylariaceous coprophilous fungus, *Podosordaria tulasnei* (Ridderbusch, 2004). Studies on *Cercosphora sordarioides*, a coporphilous isolate, has led to the isolation of arthrinone, a known fungal metabolite, along with three new related compounds 1-dehydroxyarthrinone, 3a,9a-deoxy-3a-hydroxy-1-dehydroxyarthrinone and cerdarin. Two of the compounds showed strong anti-*Candida* activity (Whyte, 1997).

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

Outline of the study

This thesis embodies report of a detailed study on floristics, ecology and activity of coprophilous fungi found growing on herbivore dung samples gathered from Goa and bordering regions of Karnataka and Maharashtra, along the west-coast of India. The study was carried out from January 2007 to December 2010. Dung samples of 13 herbivore animals were analysed. Several isolation techniques were used for the recovery of dung-inhabiting fungi (Bhat, 2010; Hawksworth, 1974). Of the fungi recovered in pure culture form, a few of the zygomycete isolates were screened for polyunsaturated fatty acids (PUFAs) and amylase activity. All the fungal cultures are maintained at the Goa University Fungus Culture Collection (GUFCC), as a fungus conservation effort.

Sample collection sites

The dung samples were sourced, keeping two objectives in mind: (i) Documentation and floristic assessment of coprophilous fungal diversity and (ii) seasonal occurrence of fungi on herbivore dung, in this part of the country.

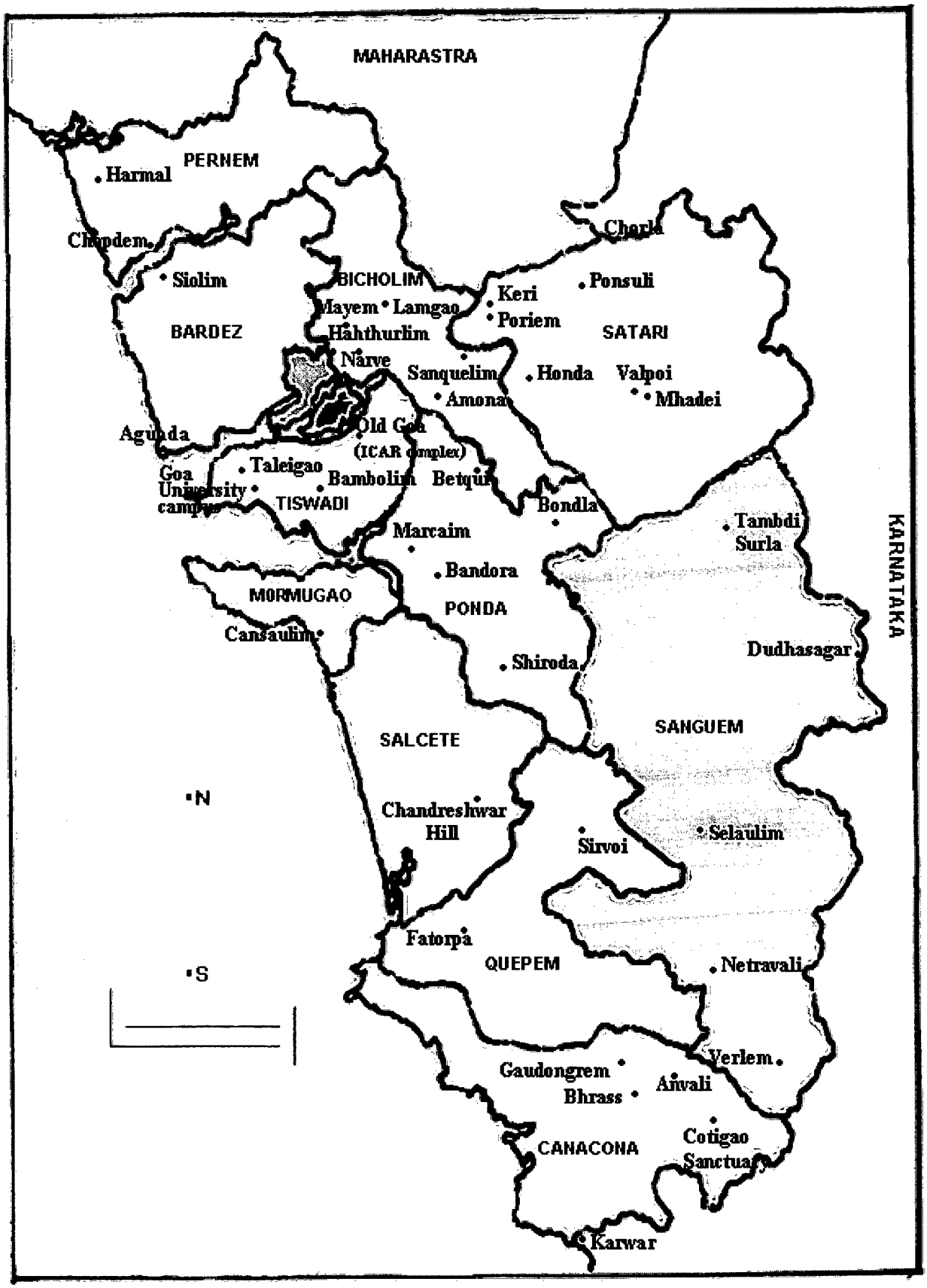
For floristic assessment, dung samples were collected from 49 different localities in Goa and neighbouring regions. Out of these 39 belonged to Goa, 8 and 2 belonged to Karnataka and Maharashtra respectively (Table 3.1, Fig. 3.1, 3.2).

Table 3.1 Table showing the collection sites

Goa:

1. Aguada
2. Amole
3. Amona
4. Anvali
5. Bambolim
6. Bandora
7. Becqui
8. Bhrass
9. Bondla
10. Cansaulim
11. Chandreshwar Hill
12. Chopdem
13. Chorla
14. Cotigao

Fig. 3.1: Map of Goa showing collection sites



15. Fatorpa
16. Gaundonguem
17. Goa University campus
18. Hahturlim
19. Harmal
20. Honda
21. ICAR station, Old Goa
22. Keri
23. Lamgao
24. Marcaim
25. Mayem
26. Mhadei
27. Narvem
28. Netravali
29. Ponsuli
30. Poriem
31. Selaulim
32. Sanquelim
33. Shiroda
34. Siolim
35. Sirvoi
36. Taleigao
37. Tambdi Surla
38. Valpoi
39. Verlem

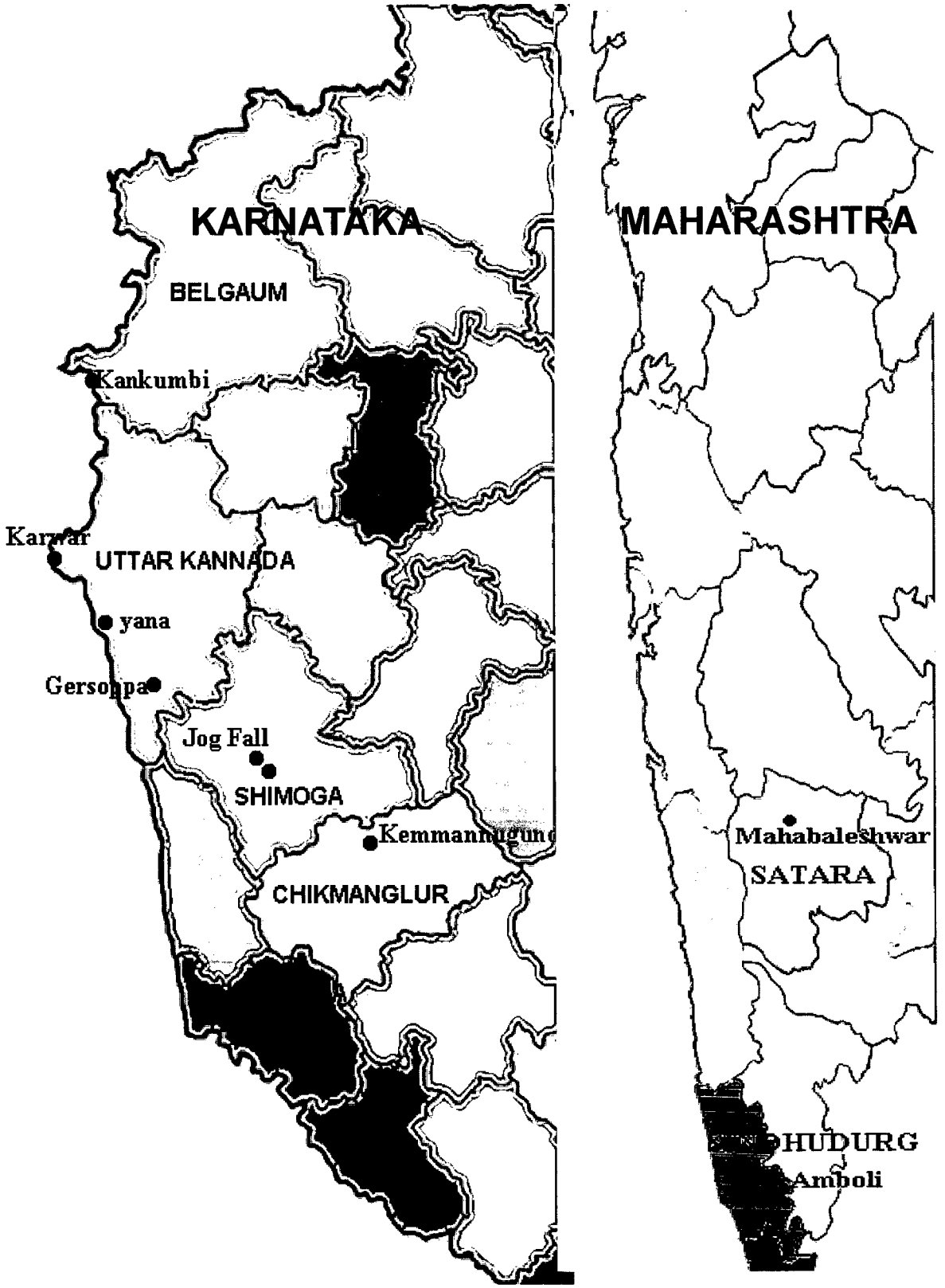
Karnataka

1. Gersoppa
2. Jog Falls
3. Kanbumbi
4. Karwar
5. Kemmangundi
6. Puttur
7. Shimoga
8. Yana

Maharashtra

1. Amboli
2. Mahabaleshwar

Fig 3.2 : Collection sites of Karnataka and Maharashtra



For seasonal studies of fungi, two pre-designated localities, viz. campus of Goa University (GU), Taleigao, and Indian Council of Agricultural Research (ICAR), Old Goa, were chosen (Fig. 3.1, 3.2).

The Goa University campus

The Goa University Campus, an area of 182 hectares, located at $73^0$50'N and $15^0$27'E, is an east-west extending table-top plateau, bordered on the southern side by the river Zauri, by undulating hilly terrains in the north and the Arabian Sea along the west. The plateau, about 60 m above the mean sea level (MSL), is mainly lateritic on the surface covered by a thin layer of soil and patchy scrub vegetation interspersed by several tall trees. The campus, in addition to the native plant species, has a number of planted fruit tree species. During monsoon, the campus exhibits luxuriant growth of karad grass (Gad, 2007).

Indian Council of Agricultural Research Station (ICAR)

The Indian Council of Agricultural Research Station, Old Goa, located at 15.50°N and 73.91°E and covering an area of 102 hectares, is about 15 km west of Goa University campus. The campus bears cultivated plantation crops of a variety of species which include coconut, oil and areca palms, mango, banana, guava, pomegranate and other fruit trees and numerous kinds of ornamental plants. Besides, the station cultivates cereal and vegetable crops (Personal communication).

Both the locations harbour several indigenous herbivore animal species and of which cattle (*Bos taurus*) and rabbits (*Oryctolagus cuniculus*) were common. The presence of rabbit and cattle in all seasons was the prime reason for selection of dung samples of these two animals for seasonal study, in these two localities.

Sampling material for fungal diversity study

In all, dung samples of 13 herbivore animals were sourced. While some of these were in captivity in zoos, many were of wild or stray type. The details are given in Table 3.2.

Table 3.2 Details of animal and dung samples collected

S. No.	Common Name	Scientific Name	Captivity/ Wild	Locations of collection of dung samples
1	Bison	*Bos gaurus*	Captivity	Bondla Wildlife Sanctuary (Goa)
2	Black Buck Deer	*Antilope cervicarpa*	Captivity	Bondla Wildlife Sanctuary (Goa)
3	Cattle	*Bos taurus*	Captivity	**Goa**: Aguada, Amole, Amona, Anvali, Bambolim, Bandora, Becqui, Bhrass, Bondla, Cansaulim, Chandreshwar Hill, Chopdem, Chorla, Cotigao, Fatorpa, Gaundonguem, Goa University campus, Hahturlim, Harmal, Honda, ICAR station, Keri, Lamgao, Marcaim, Mayem, Mhadei, Narvem, Netravali, Ponsuli, Poriem, Selaulim, Sanquelim, Shiroda, Siolim, Sirvoi, Taleigao, Tambdi Surla, Valpoi, Verlem **Karnataka**: Jog Falls, Kanbumbi, Karwar, Kemmangundi, Yana **Maharashtra**: Mahabaleshwar, Amboli
4	Cow	*Bos taurus*	Captivity/ Stray	**Goa**: Aguada, Amole, Amona, Anvali, Bambolim, Bandora, Becqui, Bhrass, Bondla, Cansaulim, Chandreshwar Hill, Chopdem, Chorla, Cotigao, Fatorpa, Gaundonguem, Goa University campus, Hahturlim, Harmal, Honda, ICAR station, Keri, Lamgao, Marcaim, Mayem, Mhadei, Narvem, Netravali, Ponsuli, Poriem, Selaulim, Sanquelim, Shiroda, Siolim, Sirvoi, Taleigao, Tambdi Surla, Valpoi, Verlem **Karnataka**: Jog Falls, Kanbumbi, Karwar,

				Kemmangundi, Yana **Maharastra**: Amboli, Mahabaleshwar
5	Elephant	*Elephas maximus*	Captivity	Bondla Wildlife Sanctuary
6	Four horned antelope (Causingha)	*Tetracerus quardricornis*	Captivity	Bondla Wildlife Sanctuary
7	Goat	*Capra hircus*	Captivity/ Wild	GU campus, ICAR, Taligao, Bambolim
8	Horse	*Equus ferus*	Captivity	Mahabaleshwar
9	Monkey	*Macaca mulatta*	Captivity/ Wild	Bondla Wildlife Sanctuary
10	Porcupine	*Hystrix indica*	Captivity	Bondla Wildlife Sanctuary
11	Rabbit	*Oryctolagus cuniculus*	Captivity/ Wild	GU campus, ICAR station, Siolim, Marcaim
12	Sambar	*Cervus unicolor*	Captivity	Bondla Wildlife Santuary
13	Spotted deer	*Axis axis*	Captivity	Bondla Wildlife Santuary

In diversity studies, sampling of several fresh and/or dried dung samples was done, so as to achieve a comprehensive picture of fungal diversity of the region. For seasonal studies, always fresh dung sample was collected. On incubation, with fresh or dried dung, the entire fungal spectrum over a period of time, from lower to higher fungi could be studied. The fungal succession pattern was studied using only fresh dung samples.

In both these studies, dung samples were collected in fresh polythene zip-bags and brought to the laboratory. The samples were systematically processed in the laboratory for recovery of fungi. In order to minimise the growth of extraneous organisms during incubation, a small piece of naphthalene pellet was introduced to the dung sample bags.

Sampling for seasonal studies

Dung samples of rabbit and cow, for seasonal studies of coprophilous fungi, were collected from Goa University campus and ICAR station, Old Goa. The samples were collected from these two localities at an interval of every four months from February

2007 to January 2009. The herbivores in the ICAR complex were maintained in captivity; whereas, those animals at Goa University campus were of stray or wild in nature. The animals at the ICAR station were fed at regular intervals and of defined feeds and fodder. The herbivores at Goa University campus fed on everything green, from wild grass to tree leaves. Accordingly, there has been a marked difference in the vegetation intake by the herbivores in these two localities. These differences made it interesting to document the various fungi emerging from the dung samples.

In this study, seasons were recognized as follows: summer: February-May; monsoon: June-September; winter: October-January. Pre- and post-monsoon seasons were recognised with reference to the preceding and proceeding months of the season.

Feed provided to the herbivores at ICAR Station: The rabbits were provided with freshly harvested grass as main feed, in all the seasons. Besides, pellets made of wheat husk and corn flour were provided. As per ICAR source, these feed pellets performed as tonic for better growth and weight gain. The cattle were provided with grass as main feed. Besides, corn, wheat and rarely groundnut cake were provided as staple food. In order to protect from infection, the animals were fed with dried grass in the rainy season. During the dry season, green vegetation is made available to herbivores.

Feed available to herbivores at Goa University campus: The cattle and rabbit at Goa University campus apparently fed on grass and other vegetations. The campus has been very rich with grass, shrubs and other vegetations. It was not possible to confirm the taxonomic identity of the consumed feed at Goa University campus.

Techniques used for recovery of fungi

The following 3 isolation techniques were used for the recovery of fungi:

- Moist-chamber incubation technique
- Particle-plating technique
- Single-spore isolation technique

(The techniques have been schematically presented in the Fig. 3.3)

Moist-chamber technique (Hawksworth, 1974):

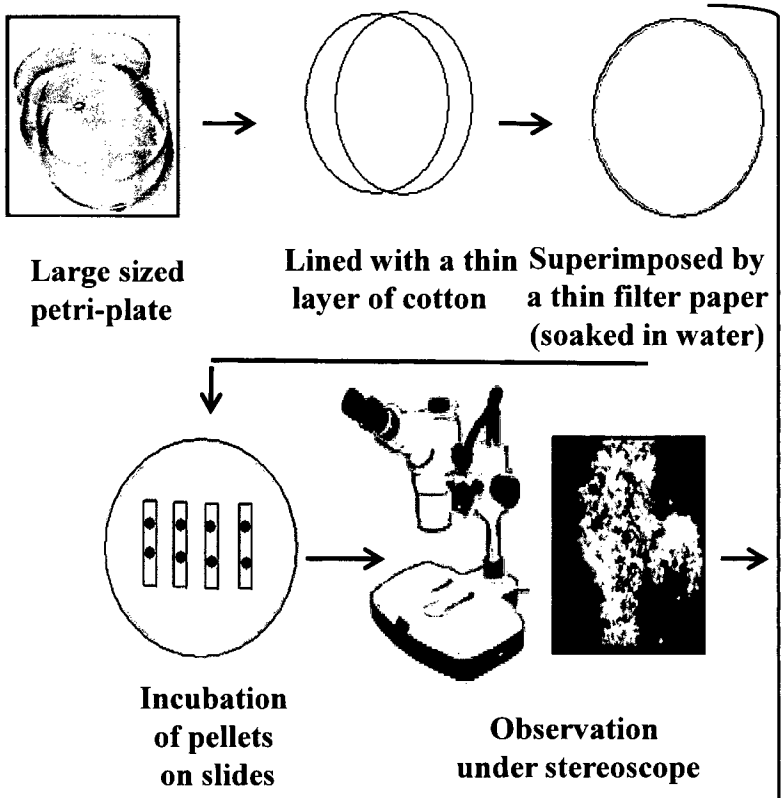
Large-sized (20 cm diam) petri-plates were used in this method. The basal lid, lined with a thin layer of absorbent cotton and superimposed by a blotting paper, was flooded with tap water. Excess water was drained off. The blotting paper was lined by 2-3 glass slides. The moist chamber was sterilized in an autoclave at 15 lb/psi and 121^0C temperature for 15 m. The dung sample was placed in the moist chamber and labelled appropriately. The plates were incubated at 23-25^0 C in the laboratory, near a day light illumination. The plates were examined at regular intervals from the second day onwards, for the fungi appearing from time to time. In this method, 100% moisture trapped inside the chamber and ambient temperature, provided optimal condition for growth of the resident fungi.

Particle-Plating technique (Bills and Polishook, 1994):

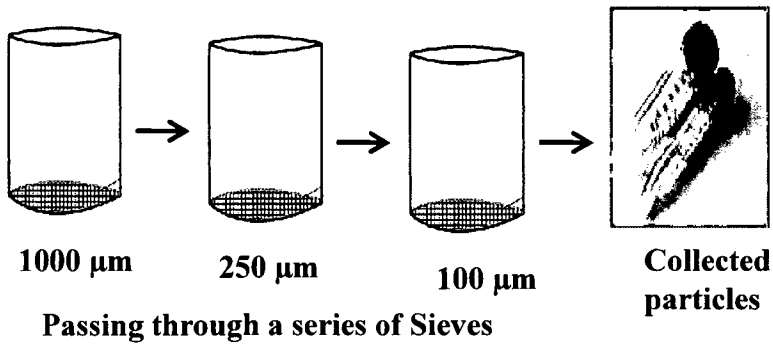
A small amount of dung sample was mixed with sterile distilled water and stirred well. The mixture was passed through 3 super-imposed alcohol-disinfected sieves of mesh size, 1000 µm, 250 µm to 100 µm respectively, from top to down. The particles trapped in the lower-most sieve, i.e. particles of size between 250 to 100 µm, were repeatedly and thoroughly washed in sterile distilled water. About 1g of particles were

Fig. 3.3. Fungal isolation techniques

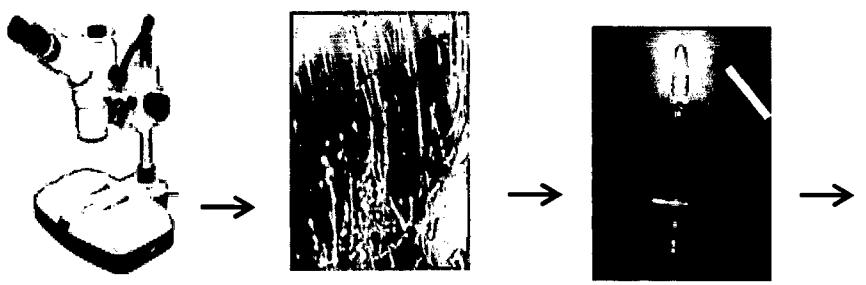
Moist Chamber Incubation method (Johnson and Booth, 1983)



Particle Plating Technique (Bills and Polishook , 1994)



Single Spore Isolation (Jacob, 2000)



re-suspended in 5 ml of sterile water. 0.05 ml of the dilution was plated into five petri-plates containing malt extract (MEA) medium mixed with a mixture of antibiotics. In this method, maximum number of cutlurable fungi could be recovered.

Single-spore isolation (Jacob, 2000):

Several of the fungi sporulated on dung were directly isolated in pure culture form, by single spore isolation method. Growing and sporulating fungus was located under a stereoscope. The spores were carefully picked up by a flame-sterilized needle and streaked onto a nutrient agar plate (e.g. MEA plate), incorporated with the antibiotic mixture. As the spore germinated, a small piece of the growing hypha was cut by a flame-sterilized needle and transferred to a fresh plate.

Culture media and various solutions used in the study

Malt Extract Agar: Malt extract agar (MEA) was the most often used medium for isolation, culturing and further maintenance of the fungal isolates in this study. The composition and making of MEA medium was as follows: Agar (20g) and malt extract (5g) were mixed in 1000 ml of distilled water and wet-sterilized in an autoclave under the conditions of high pressure and temperature (15 lb/psi and 121^0C) for 15 m. Glass Petri-plates were wet-sterilized in the autoclave. Besides, pre-sterilized plastic Petri plates were used in this study. About 10 ml of lukewarm molten medium (pre-sterilized) was poured into each Petri-plate in a laminar flow chamber. On solidification of the medium, the plates were used for further study.

Dung extract agar medium: This was the specific medium used in this study. About 10 pellets of rabbit dung were boiled in 100 ml of distilled water. The mixture was

filtered and 2g of agar was added to the filtrate. After autoclaving, the medium was poured into Petri plates and used for culturing of the fungi.

Specific media used for cultivation of Zygomycetes

MGYP Medium (Srinubabu et al., 2007)

This medium was used specifically for cultivation and growth enhancement of zygomycetous fungi. Composition of the medium was as follows: Malt Extract: 3g; Glucose: 10 g; Yeast Extract: 5 g; Peptone: 5 g; Agar: 20 g in 1000ml of distilled water.

M_2 Agar (Nair, 2002)

Glucose: 10g; Yeast Extract: 5g; Glycerol: 10ml; K_2HPO_4: 0.5g; $MgSO_4.7H_20$: 0.1g; Agar: 20g in 1000ml of distilled water.

Antibiotic solution (Jacob, 2000)

A mixture of antibiotics, in defined quantity (Bacitracin: 0.02g, Neomycin: 0.02g, Penicillin: 0.02g, Polymixin: 0.02g, Streptomycin: 0.02g and Terramycin: 0.04g) were dissolved in 10ml of distilled water. This was used, as a mixture of antibiotics, in the preparation of culture medium.

KOH solution for the germination of ascospores (Yu, 1954)

To enable germination of spores and culturing of the members of Ascobolaceae and Sordariaceae, the ascospores were treated with 0.5% KOH for 15 m, before placing on the surface of the medium.

Preparation of culture slants for preservation of fungi (Hawksworth, 1974)

About 4 ml of culture medium was poured in each 10ml glass tube and autoclaved. The tubes were maintained in slanting position until solidified. The slants were used for inoculation and preservation of fungal cultures.

Isolation of fungi from the sample

The growing fungus was located on the incubated dung sample, under a stereoscope (Leica Wild M10). The fungal mycelia or spore was carefully lifted using a flame sterilized fine-tipped needle and placed on a MEA plate. Simultaneously, a small portion of the fungus was placed on a slide containing lactophenol mountant, for further detailed microscopic study. The fungal culture on MEA plate was allowed to grow for a few days. Once the fungus attains considerable growth, the isolate was aseptically transferred to another plate for study of the cultural characters.

Composition of Lactophenol mountant (Booth, 1971)

Phenol (pure crystals) - 20g, Lactic acid - 20g, Glycerol - 40g and Water - 20ml were mixed and used. The slide so prepared was of semi-permanent nature and could be preserved for about 18 months.

Observation and identification of fungi

The fungal slide mounts were carefully observed under a transmitted-light binocular microscope and all diagnostic features were noted down. Further, the fungus was identified, down to species level, using standard taxonomic keys and monographs. Some of the monographs and taxonomic keys used were the following: Carmichael (1980); Ellis (1971, 1976) Lundquist (1971); Matsushima (1971, 1975); Richardson

and Walting (1996); Seifert et al. (1983). The slides were submitted at Goa University Botany Herbarium (GUBH) and pure cultures were maintained as reference material at Goa University Fungus Culture Collection (GUFCC) facility in the Department of Botany.

Isolation of PUFAs (O'Fallon et al., 2007)

The fungal culture obtained through single spore isolation was grown on a malt extract agar (MEA) plate. Seven day old culture was inoculated in a liquid medium in 250 ml conical flasks, each containing 50 ml aliquot. The composition of the liquid medium was as follows: 100 ml medium contained Gelatin Peptone (1.5%), Yeast Extract (0.1%), Glucose (1%) and Polyvinyl pyrrolidone (1%). The fungal biomass was harvested after a period of 72 h, grond for 10-15 sec, at room temperature, in a homogenizer. Five g of the sample was placed in a glass tube and treated with 0.5 ml of BF_3-MeOH, 0.7 ml of 10N KOH in water and 5.3 ml of methanol. The tube was incubated in a 55^0C water bath for 1.5 h, vigorously hand-shaking for 5 s every 20 min. The sample was cooled and brought to room temperature in a cold tap water bath. Thereafter, 0.58 ml of 24N H_2SO_4 was added to the sample tube, thoroughly mixed and precipitated with K_2SO_4 and again incubated in a 55^0C water bath for 1.5h with hand-shaking for 5s every 20 min. The tube was cooled in cold water bath. Three ml of solvent and n-hexane were added and the tube was vortex-mixed. The tube was further centrifuged for 5 min at 6000-7000 rpm. The tube was capped and placed at -20^0C until subjected to GC-MS.

Conditions maintained for GC-MS

Initial temp. = 60^0C; Raise in temp. = 20^0C per min. (Up to 280^0C); Column name = RtX-5MS; Thickness 0.2 micron: l = 30 m; Dia. = 0.2 mm; Injection Temperature = 250^0C

Detection of amylolytic activity (Hankin and Anagnostakis, 1975)

The fungal cultures were screened for amylase activity. The fungi were inoculated in 3 plated with appropriate medium the composition of which is given below. The fungi were allowed to grow for 7 days. The cultures were maintained at 24-25^0C. On the 8^{th} day the fungi were tested for the enzyme. The ability to degrade starch was used as a criterion to determine amylase enzyme production. Composition of the medium was as follows: Malt extract (5.5 g), agar (20 g) and soluble starch (0.2 %) per 1L medium. The mineral solution per litre contained, $(NH_4)_2SO_4$ (2 g), KH_2PO_4 (4 g), $NaHPO_4$ (6 g), $FeSO_4.7H_2O$ (0.2 g), $CaCl_2$ (1 mg), H_3BO_3 (10 µg), $MnSO_4$ (10 µg), $ZnSO_4$ (50 µg), $CuSO_4$ (50 µg) and MoO_3 (10 µg). The pH of the medium was maintained at 6. After 5-7 days of incubation, the plates were flooded with 1% Iodine solution. The yellow zone around the colony in an otherwise blue medium indicated amylolytic activity. The enzyme activity was calculated using the formula:

Enzyme activity = (Radius of colony + radius of clearance zone) – (Radius of colony).

Statistical Analysis:

The significance of the seasonal study carried out during this study was analysed using the 'Two sample T test' available in the online software of Web Agri Stat Package (WASP).

CHAPTER IV

RESULTS

RESULTS

In this thesis entitled 'studies on diversity, ecology and activity of coprophilous fungi of Goa and neighbouring regions of Karnataka and Maharastra', three major issues were addressed: First, taxonomic identity of the fungi appeared on dung of 48 different herbivorous animals sourced from Goa and neighbouring regions of Karnataka and Maharastra, over a period of nearly four years (2007-10); second, seasonal variation in quantity and quality of occurrence of coprophilous fungi on dung of two herbivore animals, viz. cow and rabbit, at two different localities, viz. GU campus and ICAR station, over a period of two years (2007-09); and third, the ability of mucoraceous coprophilius fung, isolated in culture during the study, to produce amylase enzyme and PUFAs.

As elaborated in Chapter III, standard mycological and analytical methods were followed in this study. For diversity studies, conventional moist chamber incubation, direct isolation and particle-plating techniques were followed. For sesonsl studies of fungal occurrence on two dung samples, sampling and isolations were done at 4 monthly intervals for two years and for activity analysis modern spectral analytical methods were followed. The results obtained were very interesting. A large number of and diverse fungi were encountered. Exiting results were obtained in investigations on amylase actitiy and PUFA production. Adequate care was taken, at all levels of the study, to reconfirm the results obtained. The results obtained are elaborated below under the following three headings:

1. Taxonomic diversity of coprophilous fungi
2. Seasonal variation of fungi on dung of cattle and rabbit
3. Amylase activity and PUFA productivity

PART I TAXONOMIC DIVERSITY OF COPROPHILOUS FUNGI

In all, 2600 isolates of fungi belonging to 212 species in 102 genera were recovered.

The fungi recovered are listed below:

Zygomycetes

Absidia corymbifera
Absidia coerulea
Actinomucor elegans
Circinella muscae
Circinella umbellata
Circinella sp.
Coemansia erecta
Helicostylum piriforme
Helicostylum sp. 1
Helicostylum sp. 2
Helicostylum sp. 3
Mucor hiemalis
Mycotypha microspora
Pilobolus crystallinus
Piptocephalis freseniana
Piptocephalis
Rhizopus stolonifer
Rhizopus sp. 1
Rhizopus sp. 2.
Rhopalomyces elegans
Mortierella bainiereri
Syncephalis reflexa

Ascomycetes

Arnium sp.
Arnium sp.
Ascobolus elegans
Ascobolus furfuraceus
Ascobolus lignatilis
Ascobolus stictoideus
Ascobolus
Ascodesmis nana
Ascodesmis macrospora
Ascodesmis microscopica
Ascodesmis nigricans
Ascodesmis porcina
Ascotricha chartarum
Byssochlamys nivea
Cercophora anisura
Cercophora coprophila
Cercophora mirabilis
Chaetomium atrobrunncu
Chaetomium brasiliense
Chaetomium crispatum
Chaetomium funicola
Chaetomium globosum
Chaetomium sp. 1
Chaetomium sp. 2
Cheilymenia sp.
Delitschia araneosa
Delitschia chaetomioides
Delitschia gigaspora
Delitschia patagonica
Delitschia timagamensis
Delitschia sp.
Dennisiopsis multispora
Dennisiopsis octaspora
Dennisiopsis tax. sp.nov.
Emericella nidulans
Lophotrichus bartlettii
Lophotrichus sp.
Podospora mendax
Saccobolus citrinus
Saccobolus glaber
Saccobolus saccoboloides
Saccobolus sp. 1
Saccobolus sp. 2
Schizothecium nanum
Schizothecium sp.
Sordaria fimicola
Sordaria humana
Sporormiella minima
Sporormiella pulchella
Sporormiella sp. 1
Trichodelitschia bisporula
Zygopleurage zygospora

Anamorphic fungi

Hyphomycetes

Acremonium fusidioides
Acremonium strictum
Acremonium murorum
Agarwalomyces sp.
Alternaria longipes
Alternaria porri
Amblyosporium sp.
Angulimaya tax. sp. nov.
Antromyces tax. sp. nov.
Arthrobotrys superb
Arthrographis kalrae
Aspergillus fumigatus
Aspergillus flavus
Aspergillus ochraceus
Aspergillus sydowii
Aspergillus terreus
Aspergillus sp. 1
Aspergillus sp. 2
Aspergillus sp. 3
Aspergillus sp. 4
Bahupaathra samala
Botryotrichum piluliferum
Catenularia sp.
Cephaliophora tropica
Cephaliophora irregularis
Cephaliophora sp.
Chlamydomyces palmarum
Chlamydomyces tax. sp. nov.
Chrysosporium sp.
Ciliciopodium sanguineum
Cladorrhinum foecundissimum
Cladorrhinum sp.1
*Cladorrhinum*sp.2
*Cladorrhinum*sp.3
Cladosporium cucumerinum
Cladosporium spongiosum
Cladosporium sp.
Curvularia clavata
Curvularia eragrostidis
Curvularia fallax
Curvularia sp. 1
Curvularia tax. nov. sp.
Curvularia sp.
Curvularia tax. sp. nov.
Custingophora olivacea
Cylindrocarpon didymum
Didymostilbe sp.
Doratomyces purpureofuscus
Doratomyces columnaris
Doratomyces stemonitis
Doratomyces sp.
Drechslera hawaiiensis
Fusarium semitectum
Fusarium chlamydosporum
Fusarium sp.
Geomyces tax. sp. nov.
Geotrichum candium
Geotrichum sp. 1
Geotrichum sp. 2
Geniculosporium sp.
Gilmaniella humicola
Gliocephalis sp.
Goidenichiella sp.
Gonatobotryum sp.
Graphilbum sp.
Graphium putredinis
Graphium sp. 1
Graphium sp. 2
Harposporium anguillulae
Haplographium sp.
Lomachashaka gomaya sp. nov.
Memnoniella echinata
Microsporum appendiculata
Microsporum sp.
Myrothecium advena
Myrothecium gramineum
Myrothecium indicum
Myrothecium roridum
Myrothecium sp. 1
Myrothecium sp. 2
Myrothecium sp. 3
Myrothecium sp. 4
Myrothecium sp. 5
Oedocephalum elegans
Ovularia sp.
Paecilomyces dahlia
Paecilomyces variotii
Papulaspora immersa
Penicillium atrovenetum
Penicillium decumbens
Penicillium sp. 1
Penicillium sp. 2
Periconia byssoides
Phialophora cyclaminis

Phialophora phaeophora
Phialophora richardsiae
Phialophora sp. 1
Phialophora sp. 2
Phialophora sp. 3
Phialophora sp. 4
Phialophora sp. 5
Rhinotrichum sp.
Sarocladium sp.
Scolecobasidium constrictum
Scopulariopsis brevicaulis
Scopulariopsis brumptii
Sesquicillium sp.
Shanomyces indica
Stachybotrys chartarum
Trichocladium sp.
Trichothecium roseum
Trichothecium sp. 1
Tricothecium sp. 2
Tritirachium tax. sp. nov.
Verticillium lecanii
Wiesneriomyces javanicus
Zygosporium masonii

Coelomycetes
Colletotrichum sp.
Dimastigosporium yanese. sp. nov.
Pestalotiopsis sp.
Pullospora tetrachaeta
Pycnidiella sp.
Sarcophoma sp.

Basidiomycetes
Coprinus sp.

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

GLOMEROMYCOTA (= ZYGOMYCETES)

Absidia corymbifera (Cohn) SGUBH & Trotter, 1912. Saccardo, *Syll. fung.* (Abellini) 21: 825. **(Fig. 65)**

Fungus Zygomycete. *Sporangiophores* plentiful, arising from stolons in whorls, simple or occasionally branched, hyaline to sub-hyaline, smooth, elongated, erect, up to 300-450 x 4-12 µm. *Sporangia* hyaline to sub-hyaline, pear-shaped, smooth, closed structure, numerous spores, the largest sporangia terminating the stolons, deliquescing

after release of the spores, 20-40 diam. *Columellae* with definite apophysis, globose to oval. *Sporangiospores* smooth, aseptate, spherical to ellipsoidal, 3-6 x 2-3 µm.

Specimen examined: (i) On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15500, Coll. by Sarita Yadav, 16.05.2007. (ii) On rabbit dung, Siolim, Goa, India, GUFCC No. 14921, Coll. by Sarita Yadav, 23.09.2011.

The fungus was isolated by moist chamber incubation technique. The fungus was earlier reported from the dungs of Kangaroo, Spotted deer, Eland Deer and Nil Gai from Allahabad, U.P. India (Saxena et al., 1969).

Absidia coerulea Bainier, 1889. *Bull. Soc. bot. Fr.* 36: 184 **(Fig. 66)**

Fungus Zygomycete. *Sporangiophores* arising from stolons in whorls of 2-5, hyaline to sub-hyaline. *Sporangium* hyaline to sub-hyaline, pyriform, 21-23 x 10-20 µm. *Columella* hyaline, hemi-spherical above the apophysis, with a single apical projection. *Apophysis* conical, separated from sporangiophore by a septum. *Sporangiospores* hyaline, smooth-walled, spherical, 3-5 µm diam.

Specimen Examined: (i) On cattle dung, Gaundongrem, Goa, India, GUFCC No. 15495, Coll by Sarita Yadav, 26.02.2007. (ii) On black buck deeer dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15456, Coll. by sarita Yadav, 22.03.2011.

The fungus was isolated by moist chamber incubation technique and not cultured. This is the first report of the fungus from India.

***Actinomucor* sp.** Peyronel, 1913. *I germi astmosferici dei fungi con micelio*, Diss.(Padova): 17 **(Fig. 1, 67)**

Fungus Zygomycete. *Sporangiophores* simple, erect, hyaline, arising from a point, aseptate, broader at the base, narrower towards the apex, with a widened and often irregulaty swollen base. *Sporangia* spherical, soon gets ruptured. *Sporangiospores* hyaline, smooth, aseptate, ellipsoidal, 3-5 x 2 µm.

Specimen Examined: On cattle dung, Kemmangudi, Karnataka, GUBH No. SY222, Coll. by Sarita Yadav, 15.06.2009

Circinella muscae (Sorokīn) Berl. & De Toni, 1888. Berlese, De Toni & Fischer, *Syll. fung.* (Abellini) 7: 216. **(Fig. 68a-b)**

Fungus Zygomycete. *Sporangiophores* branched, sympodially branched, indefinite in length, branches with many sporangia, along with the sterile spines. *Sporangia* borne circinately at the ends of branches, globose, with a persistent and incrusted sporangial wall, many-spored. *Columella* sub-hyaline, elongated, hyaline, smooth, elongated, broader at the base, with a well-defined collar. *Sporangiospores* spherical, smooth, sub-hyaline, greenish in mass, 6-8 µm diam.

Specimen Examined: (i) On cattle dung, Khandola, Goa, India, GUFCC No. 15495, Coll by Sarita Yadav, 26.02.2007. (ii) On elephant dung, Sirvoi, Goa, India, GUFCC No. 15368, Coll. by Sarita Yadav, 31.09.2009

Circinella umbellata Tiegh. & G. Le Monn., *Annls Sci. Nat.*, Bot., sér. 5 17: 300 (1873) **(Fig.69a-b)**

Fungus Zygomycete. *Sporangiophores* sub-hyaline, smooth, short, circinate, with 5-6 branches of sporangia at the tip. *Sporangia* produced in umbels, up to 6 at each node. These umbels produced from successive branches along with sporangiophores and terminating with sporangia. *Columella* 21-35 x 17-21 µm. *Sporangiospores* numerous, smooth, olivaceous, sub-globose, 6-10 x 3-8 µm.

Specimen Examined: (i) On cattle dung, Khandola, Goa, India; GUFCC No. 15495, Coll by Sarita Yadav, 26.02.2007. (ii) On goat dung, ICAR station, Goa, India; GUFCC No. 15433, Coll. by Sarita Yadav, 12.03.2010.

***Circinella* sp.** **(Fig. 70)**

Fungus Zygomycete. *Sproangiophores* branched, sympodially branched, indefinite in length, 2424 x16 µm long. Branches with two sporangia at each junction, along with the sterile spines. *Sporangia* borne circinately, olivaceous, bearing many

sporangiospores, 65-70 µm. *Sporangiospores* spherical, smooth, aseptate, numerous, 5-8 µm diam. *Columella* greenish, smooth.

Specimen Examined: (i) On cattle dung, Khandola, Goa, India, GUFCC No. 15209, Coll by Sarita Yadav, 26.02.2007. (ii) On cattle dung, Mahabaleshwar, Maharashtra, India, GUFCC No. 15438, Coll. by Sarita Yadav

Coemansia erecta Bainier, 1906, *Bull. Soc. mycol. Fr.* 22: 220 **(Fig. 2, 71a-c)**

Fungus Zygomycete. *Colonies* on MEA sulphur yellow. *Sporangiophores* erect or ascending, septate, branched, branches forming a sporodochia-like bundle, 610-730 x 24-32 µm, branches of sporangiophores 21-28 x 3-5 µm. *Sporododia* becoming laterally disposed by the continued growth of the fertile axes and appearing pleurogenous, stalked, elongate, nearly straight, slightly sigmoid, septate, producing pseudophialides arranged in more or less transverse rows on their lower surfaces. *Pseudophialides* ellipsoidal to elongate-obovoid, bearing single sporangiola terminally. *Sporangiospores* elongate-ellipsoidal to fusiform, smooth, immersed, 10-13 x 2-3 µm.

Specimen Examined: On deer dung, Bondla Wildlife Sanctuary, Goa; 16.05.2007. Sarita Yadav, GUFCC No. 15210.

The fungus was isolated by moist chamber incubation and particle-plating techniques. The fungus is recovered from mouse-dung, Allahabad (Mehrotra, et al., 1968).

Helicostylum piriforme Bainier, 1880. *Bull. Soc. bot. Fr.* 27: 227. **(Fig. 73 a-c)**

Fungus Zygomycete. *Sporangiophores* erect, sub-hyaline, smooth, aseptate, 1 mm or more long, 10-30 µm wide. At the apex bearing a single, many-spored, *Mucor*-type sporangium and having laterally a number of sporangia with fewer spores. Short, thick, lateral branches are formed in one or more verticils from swollen parts of the main axis, and these each bear a number of slender, hamate branches at their recurved

tips called sporangia. *Sporangia* 50-x 42 µm. *Sporangiospores* 4-6 x 3-4 µm, smooth, sub-hyaline, aseptate, ellipsoidal.

Specimen Examined: On goat dung, Chimbel, Goa, India, GUFCC No. 15211, Sarita Yadav, 16.05.2007

***Helicostylum* sp. 1** **(Fig. 73a-b)**

Fungus zygomycete. *Sporangiophores* pale brown, tapering towards the apex, aseptate, smooth, with small projection for the attachment of sporangia, 2323 x 20 µm. *Sporangia* attached at 3 points (3 intercalary zones), spherical, smooth, numerous sporangiospores, a hyaline hook like to be connected to the conidiophores, 21-23 x 19-21 µm. *Sporangiospores* sub-hyaline, smooth, elliptical, 8-10 x 4-6 µm.

Specimen Examined: On rabbit dung, Siolim, Goa, India, GUFCC No. 15243, Coll. by Sarita Yadav, 16.05.2007.

***Helicostylum* sp. 2** **(Fig. 74)**

Fungus Zygomycete. *Sprorangiophores* erect, sub-hyaline, smooth, aseptate, long, 0.5-1 mm long. Apex of the sporangiophore tapered, hyaline, sterile without bearing any sporangia, Lateral branches arise in whorls just below the sterile region to which bear sporangia. *Sporangia* sub-hyaline, the stalk cuved for the attachment to the conidiophore, bearing numerous sporangiospores, 19-23 x 17-20 µm. *Sporangiospores* elliptical, olivaceous, smooth, 6-8 x 6 µm.

Specimen Examined: On rabbit dung, Siolim, Goa, India, GUFCC No. 15213. Coll. by Sarita Yadav, 16.05.2007.

***Helicostylum* sp. 3** **(Fig. 75)**

Fungus Zygomycete. *Sprorangiophores* erect, sub-hyaline, smooth, aseptate, long, 0.5-0.7 mm long. Apex of the sporangiophore bearing any sporangia, Lateral branches arise in whorls just below the sterile region to which bear sporangia. *Sporangia* sub-

hyaline, the stalk cuved for the attachment to the conidiophore, bearing numerous sporangiospores, 25-30 µm. *Sporangiospores* ellipsoidal, olivaceous, smooth, numerous, dry, thin layered, 4-7x 3-5 µm.

Specimen Examined: (i) On deer dung, Bondla Wildlife Santuary, Goa, India, GUFCC No. 15214, Coll. by Sarita Yadav, 16.05.2007. (ii) On cattle dung, Ponsuli, Goa, India, GUFCC No. 15512, Coll. by Sarita Yadav, 15.09.2009.

Mortierella bainieri Costantin, 1889. *Bull. Soc. mycol. Fr.* **4**: 152 **(Fig. 76a-b)**

Fungus Zygomycete. *Sporangiophores*, erect, aseptate, smooth, branched, wider at the base, narrower towards the apex, 870-1000 x 40 µm. Sporangia bears numerous sporangiospores, spherical, easily ruptures. *Sporangiospores* aseptate, ellipsoidal, numerous, sub-hyaline, egluttalate, rounded at the sides, 8-10 x 3-4 µm.

Specimen Examined: (i) On cattle dung, Narvem, Goa, India, GUFCC No. 15342, Coll. by Sarita Yadav, 26.11.2009. (ii) On horse dung, Mahabaleshwar, Maharashtra, GUFCC No. 15328, Coll. by Sarita Yadav, 01.12.2009.

Mucor hiemalis Wehmer, 1903. *Annls mycol.* 1(1): 39. **(Fig. 77a-b)**

Fungus Zygomycete. *Sporangiophores* simple, up to 15-20 mm in height. *Sporangia* creamish-yellow becoming dark brown, up to 70-85 µm in diam. With deliquescent walls. *Columella* elliptical, truncate at base, globular when young, hyaline, 30-38 µm long. *Sporangiospores* ellipsoidal, varying in size, smooth, aseptate, numerous, 5-9 x 2-5 µm.

Specimen Examined: On rabbit dung, Chandranath hill, Goa, India, GUFCC No. 14954, Coll. by Sarita Yadav, 16.05.2007.

Mycotypha microspora Fenner, 1932. *Mycologia* 24(2): 196 **(Fig. 78a-c)**

Fungus Zygomycete. *Sporangiophores* simple, erect, up to 3-4 mm high, hyaline at first, becoming light brown, aseptate, hyaline, 3838-42622 x 32-40 µm, wider at the

base of the sporangium, narrower at the tip of the sporangium, increase in length, towards down, tip is sterile. Fertile vesicle variable in length, ovoid to clavate, but mostly short to long-cylindrical, without sporangiola, rounded at the apex, beaing sporangiola over the entire surface except at the extreme tip. *Sporangiola* over the entire surface except at the extreme tip. *Sporongiola* dimorphic, forming two distinct layers over the surface of the fertile vesicle.

Sporangiola comprising the outer layer broadly ellipsoidal to obovoid, 4-7 x 3-5 μm.

Specimen Examined: On bison dung, Bondla Wildlife Santuary, Goa, India, 16.05.2007, GUBH No. SY182, Coll. by Sarita Yadav.

Pilobolus crystallinus sensu Coemans; fide Saccardo (1888) **(Fig. 79a-b)**

Fungus Zygomycete. *Sporangiophores* hyaline, glistening, often becoming yellowish, arising from a swollen cell immersed in dung, and terminating in a large vesicle. *Vesicle* swollen, pear shaped, 600-1200 x 300-800 μm. On the top of the vesicle is a black, shining, flattened, though-walled sporangium which dehisces by a transverse crack around the base, and through this is excluded a mucilaginous ring or pad which comes to separate the sporangium form its conical columella. *Sporangia* 100-400 x 100-150 μm. Sporangiospores ellipsoidal, hyaline to pale yellow, 6-12 x 4-7 μm.

Specimen Examined: On cattle dung, Bicholim, Goa, India, GUFCC No. 15319, Coll. by Sarita Yadav, GUBH No. SY7. 22.08.2007

The fungus was isolated by moist chamber incubation technique. The fungus is reported from the Nil Gai dung, Delhi (Iyer et al, 1973). The fungus was repeatedly recovered from fresh dung samples. The conidiophores are phototrophic and bend over towards the light. The vesicle itself is full of liquid under pressure and acts as a little gun. Projecting its sporangium up to 2-2.5 m. The mucilage enable enables the sporangium to become firmly attached to a grass leaf or vegetation. This facilitates the

chances sporangium being engulfed by herbivore and thus increasing the chances of its survival.

Piptocephalis freseniana de Bary, 1865. *Abh. senckenb. naturforsch. Ges.* 5: 356. **(Fig. 3)**

Fungus Zygomycete. *Sporangiophores* brownish-green, smooth, dichotomously branched, delicate, repeatedly and regularly dichotomously branched, with the tips of the ends branches slightly swollen and bearing several cylindrical, dichotomously branched, 2020 x 6.3 µm. *Sporangia* which contain spores in a single row and eventually break up into one-spored pieces. Sporangiospores smooth, olivaceous green, one end tapered at one point, other side flattened 4-5 x 2-3 µm.

Specimen Examined: On cattle dung, Bicholim, Goa, India, GUBH No. SY97, Coll. by Sarita Yadav, 22.08.2007.

***Piptocephalis* sp.** **(Fig. 80)**

Fungus Zygomycete. *Sporangiospores* greenish-brown, smooth, profusely dichotomously branched, delicate, repeatedly and regularly dichotomously branched, with the tips of the ends branches slightly swollen and bearing several cylindrical. *Sporangia* which contain spores in a single row and eventually break up into one-spored pieces. *Sporangiospores* smooth, rectangular, greenish-brown, 7-11 x 4 µm.

Specimen Examined: On Goat dung, Taleigao Plataeu, Goa, India, GUBH No. SY191, Coll. by Sarita Yadav, 27.09.2009.

Rhizopus stolonifer (Ehrenb.) Vuill., 1902. *Revue mycol.*, Toulouse 24: 54. **(Fig. 81)**

Fungus Zygomycete. *Colonies* fast growing, circular, fibrous with lots of aerial mycelium, off white, margin rhizoidal. *Stolons* clearly differentiated, arising from and terminating in strong tufts, margin rhizoidal. *Sporangiophores* erect, smooth, aseptate, rhizoids well developed, profusely branched, in groups, brown at the base later

becomes pale brown towards the apex, 2-3 mm long. *Sporangia* globose, ruptures on the relaease of the sporangiospores, 160-260 µm. *Sporangiospores* rough walled, aseptate, striations, irregular shaped ovoid, polyangular, light brown, round, 8-14 x 7-10 µm.

Specimen Examined: On goat dung, GU campus, Goa, India, GUBH SY197, Coll. by Sarita Yadav, 27.09.2009.

From India, the fungus has been reported earlier from dung of Nil Gai (Iyer et al., 1973).

***Rhizopus* sp. 1.** **(Fig. 82)**

Fungus Zygomycete. *Colonies* circular, with lots of aerial mycelia. *Stolons* clearly differentiated, arising from and terminating in strong tufts of brown rhizoids. *Sporangiophores* erect, smooth, aseptate, unbranched, 580-650 x 8-12 µm. *Sporangia* sub-globoase to conical, pale brown to dark brown, 55-115 µm. *Sporangiospores* ellipsoidal to spherical, 10-12 µm.

Specimen Examined: (i) On goat dung, Goa, India, GUFCC No. 15217, Coll. by Sarita Yadav, 27.09.2009

***Rhizopus* sp. 2** **(Fig. 83)**

Fungus Zygomycete. *Sporangiophores* erect, smooth, pale brown, aseptate, branched frequently at both the sides, 6055-730 x 8-17 µm. *Sporangia* sub-globose to conical, pale brown, 55-85 µm. *Sporangiospores* mostly ellipsoidal and circular, occasionally polygonal, pale brown, 4-7 µm.

Specimen Examined: (i) On cattle dung, Kemmangudi, Karnataka, India, GUFCC. No. 15218, Coll. by Sarita Yadav, 22.11.2009.

Rhopalomyces elegans Corda, 1839. *Prachtflora*: 3 **(Fig. 84a-b)**

Fungus Zygomycete. *Sporangiophores* yellowish brown, smooth, aseptate, erect, swollen at the apex to form a large vesicle over the surface of which are scattererd

taperered spicules each bearing at its tip a single sporangiospore, aseptate, erect, 400-600 x 25-40 µm. *Sporangiophores* base rhizoidal with numerous branches, hyaline filaments. *Vesicles* globose, easily collapsing, finely granular, yellowish-brown, 30-45 µm diam. *Sporangiospores* olivaceous brown, smooth, fusiform, ellipsoidal, aseptate, 9-11 x 4-6 µm.

Specimen Examined: (i) On cattle dung, Karwar, Karnataka, India, GUFCC No. 15102, Coll. by Sarita Yadav, 12.10.2009. (ii) On cattle dung, Poriem, Goa, Indai, GUFCC No, 15205, Coll. by Sarita Yadav, 13.10.2010.

Syncephalis reflexa Tiegh., 1875. *Annls Sci. Nat.*, Bot., sér. 6 1: 134. **(Fig. 85a)**

Fungus Zygomycete. *Sporangiophores* originating from rhizoids, at first straight, simple, 150-190 µm high (rhizoids excluded), 4-6 µm wide at the narrowest point near the base, enlarging gradually upward to 10-15 µm wide near the fertile vesicle, bent at this region, then narrowing down to 5.0-6.3 µm wide just below the fertile head, usually single, attached to the host hyphae by stout, dichotomously branching rhizoids. Fertile heads globose, 25-40 µm, bearing over 40 unbranched merosporangia on its upper hemisphere. *Merosporangia* cylindrical, slightly curved, each mature merosporangium containing 4-5 spores. *Sporangiospores* ellipsoidal, 4-7 x 2-4 µm. Head collapsed after the spores released. Conspicuous warts left on the upper surface of the head after detachment of the merosporangia.

Specimen examined: On deer dung, Bondla Wildlife Sanctuary, GUFCC No. 15481, Coll. by Sarita Yadav, 16.08.2010

ASCOMYCETES

***Arnium* sp.** **(Fig. 86 a-c)**

Fungus Ascomycete. *Perithecia* scattered, semi-immersed, obpyriform, dark brown, neck black, short, ostiolate, 646 x 505 µm; perithecial neck tapering, short, dark brown, swollen part light brown, hairs all over the ascocarp. *Asci* clavate, biseriate,

unitunicate, 90-320 x 110-160 µm. *Ascospores* aseptate, gluttalate, ellipsoidal, appendaged at both ends, 27-39 x 15-19 µm. Appendages hyaline, with multiappendages.

Specimen examined: (i) On cattle dung, Tambdi Surla, Goa, India, GUBH No. SY253, Coll. by Sarita Yadav, 19.07.2009. (ii) On elephant dung, Bondla Wildlife Sanctuary, Goa, India, GUBH No. SY10, Coll. by Sarita Yadav, 28.09.2010.

Arnium sp. **(Fig. 4)**

Fungus Ascomycete. *Perithecia* scattered, semi-immersed, obpyriform, dark brown, neck black, short, ostiolate, 455 x 650 µm; perithecial neck tapering, short, dark brown, swollen part light brown, hairs all over the ascocarp. *Asci* clavate, biseriate, unitunicate, 90-320 x 110-160 µm. *Ascospores* aseptate, gluttalate, ellipsoidal, pedicled, multi appendaged at both ends, 37-43 x 12-15. Appendages hyaline, with multiappendages.

Ascobolus elegans J. Klein, *Verh. zool.-bot. Ges. Wien* 20: 566 (1870) **(Fig. 87a-e)**

Fungus Ascomycete. *Apothecia* solitary to closely crowded, superficial, sessile, 400-550 x 402-500 µm. Hymenium 200-240 µm thick, isodiametric cells 7-15 µm. *Asci* unitunicate, cylindrical-clavate, operculate, tapering downwards into a short stalk, 170-260 x 40-50 µm. *Ascospores* hyaline when immature, then pale purple, finally dark purple, extremely fine granular, mucilaginous substance surrounded by the layer surrounded 37-39 x 20-24 µm. *Paraphyses* simple, septate, cylindrical, hyaline, simple, septated, 3 µm.

Specimen examined: On cattle dung, Amboli, Maharashtra, India, GUFCC. No. 15219, Coll. by Sarita Yadav, 09.12.2007.

Ascobolus furfuraceus Pers., *Neues Mag. Bot.* **1**: 115 (1794) **(Fig. 88a-b)**

Fungus Ascomycete. *Apothecia* up to 5mm diam., margin sometimes furfuraceous or toothed, disc yellowish-brown later becomes brownish on maturity, mostly solitary,

sessile, receptacle closed and sub-globular later opens. Hymenium 120-200 µm, Hypothecium 25-45 µm thick, of isodiametric, rounded cells. Excipulum near the margin 20-50 µm thick, near the base still thicker. *Asci* unitunicate, uniseriate to biseriate, operculate, clavate, tapering downwards into a short stalk, rounded above, 121-145 x 16-24 µm. *Ascospores* Brown when mature, hyaline when young, thick outer wall, reticulate, 23-25 x 12 µm. *Paraphyses* simple, hyaline, septate, filiform, 2-4 µm thick, usually thickened above.

Specimen examined: On cattle dung, Tambdi Surla, GUFCC. No. 15220, Coll. by Sarita Yadav, 19.07.2009.

Ascobolus lignatilis Alb. & Schwein., *Consp. fung.* (Leipzig): 347 (1805)**(Fig. 89a-b)**

Fungus Ascomycete. *Apothecia* up to 5mm high, scattered, superficial, distinct stalk present, receptacle at present closed, then opens up later, yellowish, disk flat, with the protruding tips of the mature asci. Hypothecium about 30 µm thick, of closely compacted, isodiametric cells, 7-11 µm diam. Excipulum 24-50 µm thick, of subglobular cells, 12-20 µm diam., hyaline. *Asci* clavate, gradually tapering downwards, rounded above, unitunicate, biseriate, thin-walled, operculate, circular at the tip, tapering towards the base, cylindrical-clavate, 8-spored; 138-219 x 12-25 µm. *Ascospores* ellipsoidal, with blunt ends, hyaline when young, later purplish on maturity, sub-parallel longitudinal striations, surrounded by thick mucilaginous layer, 17-25 x 10-13 µm. *Paraphyses* simple, hyaline, many, cylindrical.

Specimen Examined: (i) On Elephant dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC. No. 15223, Coll. by Sarita Yadav, 05.02.2007. (ii) On Cattle dung, Jog Falls, Karnataka, India, GUBH No. SY12, Coll. by Sarita Yadav, 12.09.2009.

The fungus was isolated by moist chamber incubation technique. Earlier the fungus is recovered by Kar and Pal, 1968 from dung in the Eastern Himalayas region of India.

Ascobolus stictoideus Speg., 1879. *Michelia* 1(no. 5): 474. **(Fig. 90a-b)**

Fungus Ascomycete. *Apothecia* solitary, disc very pale olivaceous. *Asci* hyaline, cylindrical, tapering at the bottom, operculate, uniseriate, unitunicate, 259-280 x 20-24 µm. *Ascospores* brown at the surroundings, greenish at the centre, deep striations (ornamental), 23-30 x 12-17 µm.

Specimen Examined: On elephant dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC. No. 15012, Coll. by Sarita Yadav, 03.02.2007.

The fungus was isolated by moist chamber incubation technique.

***Ascobolus* sp. 1** **(Fig. 91a-c)**

Fungus Ascomycete. *Apothecia* solitary, disc very pale olivaceous. *Asci* hyaline, cylindrical, tapering at the bottom, operculate, uniseriate, unitunicate, 240-350 x 19-35 µm. *Ascospores* hyaline, smooth, elliptical, obtuse, 23-30 x 12-17 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC. No. 15376, Coll. by Sarita Yadav, 03.02.2007.

***Ascobolus* sp. 2 (Fig. 5)**

Fungus Ascomycete. *Apothecia* solitary, disc very pale olivaceous. *Asci* hyaline when young, later mature into purple, cylindrical, tapering at the bottom, operculate, uniseriate, unitunicate, 270-550 x 17-40 µm. *Ascospores* hyaline, smooth, elliptical, obtuse, 23-30 x 12-17 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC. No. 15276, Coll. by Sarita Yadav, 03.02.2007.

***Ascobolus* sp. 3** **(Fig. 6)**

Fungus Ascomycete. *Apothecia* solitary, disc very pale olivaceous. *Asci* hyaline when young, later mature into purple, cylindrical, tapering at the bottom, operculate,

uniseriate, unitunicate, 270-550 x 17-40 µm. *Ascospores* hyaline when young, later turns into pale purple and than dark purple, elliptical, obtuse, 23-30 x 12-17 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC. No. 15276, Coll. by Sarita Yadav, 03.02.2007.

***Ascobolus* sp. 3** **(Fig. 6)**

Fungus Ascomycete. *Apothecia* solitary, disc very pale olivaceous. *Asci* hyaline when young, later mature into purple, cylindrical, tapering at the bottom, operculate, uniseriate, unitunicate, 270-550 x 17-40 µm. *Ascospores* hyaline when young, later turns into pale purple and than dark purple, elliptical, obtuse, 23-30 x 12-17 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUFCC. No. 15101, Coll. by Sarita Yadav, 03.02.2007.

Ascodesmis nana Brumm., 1981. *Persoonia* 11(3): 343. **(Fig. 95a-b)**

Fungus Ascomycete. *Apothecia* solitary or gregarious, pale brown, often from globose structures, without an excipulum, just in groups of protuberant asci surrounded by paraphyses and arising a group of basal cells, 150-200 x 16-20 µm. *Asci* broadly clavate, operculate, unitunicate, biseriate, 8-spored, thin-walled, 45-50 x 12-14 µm. *Ascospores* ellipsoidal, ornamented, olivaceous, hyaline and smooth when young, later brown and rough walled, egluttalate, 8-12 x 8-10 µm.

Specimen Examined: On Elephant dung, Bondla Wildlife Sanctuary, 03.02.2007, Coll. by Sarita Yadav, GUFCC. No. 15289.

Ascodesmis macrospora W. Obrist, 1961. *Can. J. Bot.* 39: 951. **(Fig. 93)**

Fungus Ascomycete. Apothecium solitary or gregarious, pale brown, often from globose structures, without an excipulum, just in groups of protuberant asci surrounded by plenty of paraphyses and arising a group of basal cells, 90-150 x 25-40 µm. *Asci* broadly clavate, operculate, unitunicate, sub-hyaline, biseriate, 8-spored, thin-walled, 50-70 x 25-35 µm. *Ascospores* ellipsoidal, ornamented, echinate, dark

brown, hyaline and smooth when young, later brown and rough walled, egluttalate, 16-18 x 12-14 µm.

Specimen Examined: (i) On cattle dung, Amole ghat, Goa, India, GUBH No. SY295, Coll. by Sarita Yadav, 12.12.2009. (ii) On elephant dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15413, Sarita Yadav, 16.10.2010.

Ascodesmis microscopica (P. Crouan & H. Crouan) Le Gal, 1949. *Revue Mycol.*, Paris 14(2): 85. **(Fig. 93)**

Fungus Ascomycete. *Apothecium* solitary or gregarious, pale brown, often form globose structures, without an excipulum, just in groups of protuberant asci surrounded by plenty of paraphyses and arising a group of basal cells, 90-150 x 25-40 µm. *Asci* broadly clavate, operculate, unitunicate, sub-hyaline, biseriate, 8-spored, thin-walled, 50-70 x 25-35 µm. *Ascospores* ellipsoidal, ornamented, echinate, hyaline and smooth when young, later brown and rough walled, egluttalate, 16-28 x 10-14 µm.

Specimen Examined: (i) On cattle dung, Amole ghat, Goa, India, GUBH No. SY332, Coll. by Sarita Yadav, 12.12.2009. (ii) On cattle dung, Valpoi, Goa, India, GUFCC No. 15200, Coll. by Sarita Yadav, 11.01.2010.

Ascodesmis nigricans Tiegh., 1876. *Bull. Soc. bot. Fr.* 23: 271. **(Fig. 93)**

Fungus Ascomycete. *Apothecia* solitary or gregarious, pale brown, often from globose structures, without an excipulum, just in groups of protuberant asci surrounded by plenty of paraphyses and arising a group of basal cells, 150-220 x 20-25 µm. *Asci* broadly clavate, operculate, unitunicate, biseriate, 8-spored, thin-walled, 40-55 x 15-21 µm. *Ascospores* ellipsoidal, ornamented, olivaceous, hyaline and smooth when young, later brown and rough walled, egluttalate, 10-14 x 7-11 µm.

Specimen Examined: (i) On cattle dung, Fatropa, Goa, India, GUFCC No. 15224, Coll. by Sarita Yadav, 26.03.2007. (ii) On cattle dung, Chopdem, Goa, India, GUFCC No. 15221, Coll. by Sarita Yadav, 06.03.2008.

Ascodesmis porcina Seaver, 1916. *Mycologia* 8(1): 3. **(Fig. 8)**

Fungus Ascomycete. *Apothecia* solitary or gregarious, pale brown, often from globose structures, without an excipulum, just in groups of protuberant asci surrounded by plenty of paraphyses and arising a group of basal cells, 150-200 x 250-300 µm. *Asci* broadly clavate, operculate, unitunicate, biseriate, 8-spored, thin-walled, 70-95 x 32-40 µm. *Ascospores* ellipsoidal, ornamented, olivaceous, hyaline and smooth when young, later brown and rough walled, egluttalate, 10-14 x 12-16 µm.

Specimen Examined: On cattle dung, Fatropa, Goa, India, GUBH No. SY225, Coll. by Sarita Yadav, 06.03.2008.

Ascotricha chartarum Berk., 1838. *Ann. Mag. nat. Hist.*, Ser. 1 1: 257 **(Fig. 9)**

Fungus Ascomycete. *Perithecia* solitary, globose to sub-globose, always with a distinct neck, olivaceous brown to black, 80-97 x 55-64 µm. Terminal hair arising from the neck simple or branched, geniculate to curved, hyaline to sub-hyaline, clavate, sterile branches, 84-190 x 2-4 µm. Similar lateral hairs sometimes not arising from the wall of the perithecium below the neck. *Asci* cylindrical, 8-spored, walls diffluent. *Ascospores* uniseriate, pale to dark brown, simple, ellipsoid, sometimes laterally discoid, with equatorial germ-slit, issuing through the ostiole in a long tendril.

Specimen Examined: (i) On cattle dung, Anvali, Goa, India, GUBH No. SY215, Coll. by Sarita Yadav, 26.03.2007.

Byssochlamys nivea Westling, 1909. *Svensk bot. Tidskr.* 3: 134. **(Fig. 241)**

Fungus Ascomycete. *Ascomata* white, up to 350 µm in diam. *Asci* globose to subglose, 8-11 µm in diam. *Ascospores* ellipsoidal, 4-6 x 2-3 µm, smooth, thick-walled.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUFCC No. 15401, Coll. by Sarita Yadav, 10.07.2007.

Cercophora anisura N. Lundq., 1972. *Symb. bot. upsal.* 20(1): 91. **(Fig. 75)**

Fungus Ascomycete. *Perithecia* scattered or aggregated in small groups, semi-immersed, obpryiform, covered with flexous, sparingly ramified hair, 703-808 x 343-424 µm. Neck conical, black, opaque, 90-250 µm, provided with tufts of short, agglutinated, swollen, obtuse, septate, thick walled, 15-35 x 5-7 µm. Peridium membranous, subopaque, brown, 3-layered, outer peridial cells angular, swollen, moderately thick-walled, 6-10 µm in diam. Paraphyses filiform. *Asci* 8-spored, clavate, thick-walled, simple, sub-globose, 190-300 x 20-25 µm. *Ascospores* biseriate, unitunicate, 170-250 x 10-15 µm, vermiform and filled with oil droplets at the young stage, undergoing transverse septation, upper cell becomes darker, 15-30-35 x 10-15 µm. *Pedicel* cylindrical, geniculate below, solid gelationous cauda present at the both the ends of the spore, apical cauda 10-20 x 2-4 µm, basal one, 20-35 x 2-3 µm.

Specimen Examined: On cattle dung, Amboli, Maharashtra, India, GUBH No. SY219, Coll. by Sarita Yadav, 16.02.2009.

Cercophora coprophila (Fr.) N. Lundq., 1972. *Symb. bot. upsal.* 20(no. 1): 95. **(Fig. 98a-b)**

Fungus Ascomycete. *Perithecia* scattered or aggregated in small groups, semi-immersed, obpryiform, covered with flexous, sparingly ramified hair, 650-950 x 330-450 µm. Neck conical, black, opaque, 90-250 µm, provided with tufts of short, agglutinated, swollen, obtuse, septate, thick walled, 15-35 x 5-7 µm. Peridium membranous, subopaque, brown, 3-layered, outer peridial cells angular, swollen, moderately thick-walled, 8-15 µm in diam. Paraphyses filiform. *Asci* 8-spored, clavate, thick-walled, simple, sub-globose, 190-300 x 20-25 µm. *Ascospores* biseriate, unitunicate, 200-320 x 15-20 µm, vermiform and filled with oil droplets at the young stage, undergoing transverse septation, upper cell becomes darker, 17-25 x 8-13 µm, truncate at the base. *Pedicel* cylindrical, geniculate below, solid gelationous cauda

present at the both the ends of the spore, apical cauda 30-60 x 2-4 µm, basal one, 20-35 x 2-3 µm.

Specimen Examined: (i) On cattle dung, Kemmangundi, Karnataka, GUBH No. SY320, Coll. by Sarita Yadav, 16.12.2008. (ii) On cattle dung, Netravali, Goa, India, GUFCC No. 14889, Coll. by Sarita Yadav, 12.09.2010

Cercophora mirabilis Fuckel, 1870. *Jb. nassau. Ver. Naturk.* 23-24: 245 **(Fig.10, 99a-b)**

Fungus Ascomycete. *Perithecia* scattered or aggregated in small groups, semi-immersed, obpryiform, covered with flexous, sparingly ramified hair, 545-606 µm. Neck cylindrical, black, opaque, 90-250 µm. Peridium membranous, subopaque, brown, 3-layered, outer peridial cells angular, swollen, moderately thick-walled, 6-15 µm in diam. *Paraphyses* filiform. *Asci* 8-spored, clavate, thick-walled, simple, sub-globose, 225-290 x 14-20 µm. *Ascospores* biseriate, unitunicate, 56-63 x 8.4-12.5 µm, vermiform and filled with oil droplets at the young stage, undergoing transverse septation, upper cell becomes darker, 15-25 x 10-12 µm. *Pedicel* cylindrical, geniculate below, solid gelationous cauda present at the both the ends of the spore, apical cauda narrower than the basal one, 15-50 x 2-3 µm.

Specimen Examined: On cattle dung, Hahturlim, Goa, India, GUBH No. SY111, Coll. by Sarita Yadav, 13.12.2009.

Chaetomium atrobrunncu L.M. Ames, *Mycologia* 41(4): 441 (1949). **(Fig. 100)**

Fungus Ascomycete. *Perithecia* ovate up to 0.2-0.4 mm, brownish, terminal hairs pale brown to dark brown, slightly curved, slightly verrucose, attached to the peridium. *Asci* clavate, limoniform, unitunicate, biseriate, seen with mature ascospores, later the ascus breaks off for the release of the ascospores, 8-10 x 4-8 µm. *Ascospores* brown when mature, hyaline when young, smooth, limoniform, 12-15 x 4-5 µm.

Specimen Examined: On elephant dung, Bondla Wildlife Sanctuary, Goa, GUBH No. SY356, Goa, Coll. by Sarita Yadav, 18.07.2009

Chaetomium brasiliense Bat. & Pontual, 1948. *Bol. Secr. Agric. (Pernambuco)* 15: 70. **(Fig. 101a-b)**

Fungus Ascomycete. *Perithecium* dark brown, solitary, ostiolate, 345 x 410 µm. *Asci* unitunicate, hyaline, clavate, 6-7 x 3-4 µm. Setae coiled, dark brown to black, unbranched. *Ascospores* brown when hyaline, later on turn brown.

Specimen Examined: On cattle dung, Valpoi, Goa, India, GUFCC No. 15312, Coll. by Sarita Yadav, 10.03.2008. The fungus is isolated by the moist incubation isolation technique.

The fungus is earlier recorded from the dungs of buffalo in Rajasthan (Lodha, 1963) and from Kangaroo dung, Delhi zoo (Satyanarayana and Rao, 1965).

Chaetomium crispatum (Fuckel) Fuckel, 1870. *Jb. nassau. Ver. Naturk.* 23-24: 90. **(Fig. 102a, b)**

Fungus Ascomycete. *Perithecia* spherical, dark brown, 330-360 x 210-240 µm, hairs verrucose, darker at the point of attachment, becomes hyaline to sub-hyaline towards the apex, flexous, coiled at the apex, septated, 200-240 x 240-400 µm. *Asci* cylindrical, rather persistent with spores in a row. *Ascospores* smooth, broadly ellipsoidal to limoniform, broader in the middle, 8-10 x 6-8 µm.

Specimen examined: On cattle dung, Valpoi, Goa, India, GUBH No. SY108, Coll. by Sarita Yadav, 10.03.2008

Chaetomium funicola Kunze, 1818. *Deutsche Schwämme* 8: 3, no.184 **(Fig. 103 a, b)**

Fungus Ascomycete. *Perithecia* ovoid up to 0.2mm, brownish, terminal hairs dark brown, turns lighter and later hyaline towards the tip, often dichotomously branched, verrucose, attached to the peridium. *Asci* clavate, limoniform, unitunicate, biseriate, seen with mature ascospores, later the ascus breaks off for the release of the ascospores, 8-10 x 4-7 µm. *Ascospores* brown when mature, hyaline when young, smooth, elliptical, 12-15 x 4-5 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, GUBH No. SY224, Coll. by Sarita Yadav, 10.03.2008.

Chaetomium globosum Kunze, 1817. Kunze & Schmidt, *Mykologische Hefte* (Leipzig) 1: 16. **(Fig. 104)**

Fungus Ascomycete. *Perithecia* ostiolate, to be held by the terminal hairs in large, dark masses, dark brown setiform hairs Setae rough, many margin wavy, dematiaceous at the base, hyaline towards the tip, septated, hyaline when young, thin-walled, 58-87 x 3-6 µm. *Ascospores* smooth, sub-hyaline, solitary to in groups, ellipsoidal to circular, 7-10 x 7-8 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, India, GUFCC No. 15227, 10.03.2008, Coll. by Sarita Yadav.

***Chaetomium* sp. 1** **(Fig. 105a)**

Fungus Ascomycete. *Perithecia* superficial, ostiolate, dark brown setiform hairs, coiled, smooth. *Ascospores* limoniform, sub-hyaline to brown, margins of ascospores dark brown, 9-10 x 7-8 µm. *Asci* smooth, obovoid; setae light brown, wavy, dissolve on maturity.

Specimen Examined: (i) On cattle dung, Valpoi, Goa, India, GUBH No. SY224, Coll. by Sarita Yadav 10.03.2008. (ii) On elephant dung, Bondla Wildlife sanctuary, Goa, India, GUFCC No. 15443, Coll. by Sarita Yadav, 12.04.2010.

***Chaetomium* sp. 2** **(Fig. 105b)**

Fungus Ascomycete. *Perithecia* ovoid, brownish, 200-120 x 120-135 µm. Terminal hairs dark brown, turns lighter and later hyaline towards the tip, often dichotomously branched, verrucose, attached to the peridium. *Asci* clavate, unitunicate, biseriate, seen with mature ascospores, later the ascus breaks off for the release of the ascospores. *Ascospores* brown when mature, hyaline when young, smooth, elliptical, 12-15 x 4-5 µm.

Specimen Examined: On cattle dung, Gaundongrem, Goa, India, GUFCC No. 15228, Coll. by Sarita Yadav, 26.02.2007.

***Cheilymenia* sp.** **(Fig. 106 a-c)**

Fungus Ascomycete. *Apothecia* superficial, disk orange in colour, surrounded by a series of setae. Setae hyaline to sub-hyaline, aseptate, thick walled, sub-hyaline, slightly verrucose, base swollen, aculeate, 160-360 x 12-16 µm. Excipulum present, well differentiated into a medullary wall in containing globose to sub-globose cell. *Asci* smooth, hyaline, cylindrical, 8-spored, unitunicate, inoperculate, uniseriate, 97-130 x 8 µm. *Ascospores* hyaline to sub-hyaline, smooth, obovoid, aseptate, 8-12 x 6-9 µm.

Specimen Examined: On cattle dung, Betqui, Goa, India, GUFCC No. 15229, Coll. by Sarita Yadav, 10.03.2008.

Delitschia araneosa Cain, 1934. *Coproph. Sphaeriales Ontario*: 8 **(Fig. 12, 107a-c)**

Fungus Ascomycete. *Perithecia* scattered, immersed, subglobose to pyriform, thin, membranous to slightly coriaceous, very dark brown, opaque, smooth; neck stout, short, clylindrical, sometimes enlarged and roughened at the apex, 600-700 x 300-400 µm; covered densely with moderately short, fine, flexous, brown hair measuring up to 70-100 x 2 µm. *Asci* 8-spored, cylindrical, bitunicate, hyaline, broadly rounded above, narrow below into a short slender stipe. *Ascospores* uniseptate, oblong-ellipsoid, acutely rounded at the ends, transversely uniseptate, constriction broad and shallow, hyaline when young, ranges through yellowish-brown to dark brown and later opaque, surrounded by a narrow hyaline gelatinous sheath, 25-35 x 10-15 µm. Germ slit lateral, extending nearly the entire length of the cell. *Paraphyses* filiform, septate, abundant, slightly longer than the asci and mixed with them.

Specimen Examined: On cattle dung, Betqui, Goa, India, GUBH No. SY248, Coll. by Sarita Yadav 10.03.2008.

Delitschia chaetomioides P. Karst., *Bidr. Känn. Finl. Nat. Folk* 23: 60 (1873)
(Fig. 108a-b)

Fungus Ascomycete. *Perithecia* scattered, immersed, subglobose to pyriform, thin, membranous to slightly coriaceous, very dark brown, opaque, smooth; neck stout, short, clylindrical, sometimes enlarged and roughened at the apex, 750-600 µm long; covered densely with moderately short, fine, flexous, brownish-green hair. *Asci* 8-spored, cylindrical, bitunicate, uniseriate, hyaline, broadly rounded above, narrow below into a short slender stipe, 200-300x 20-25 µm. *Ascospores* uniseptate, oblong-ellipsoid, acutely rounded at the ends, transversely uniseptate, constriction broad and shallow, hyaline when young, ranges through yellowish-brown to dark brown and later opaque, surrounded by a narrow hyaline gelatinous sheath, 35-45 x 10-15 µm. Germ slit lateral, extending nearly the entire length of the cell. *Paraphyses* filiform, septate, abundant, slightly longer than the asci and mixed with them, numerous.

Specimen Examined: On cattle dung, Betqui, Goa, India, GUBH No. SY90, Coll. by Sarita Yadav, 02.08.2007.

Delitschia gigaspora Cain, 1934. *Coproph. Sphaeriales Ontario*: 86.**(Fig. 13, 109a-b)**

Fungus Ascomycete. *Perithecia*, scattered, immerse, subglobose to pyriform, thin, slightly coriaceous, very dark brown to nearly black and opaque, upper part and the neck covered by a short hairs; neck short, stout, clavate, papilliform to short cylindrical green, 88-1000 x 500-750 µm. *Asci* 8-spored, clavate, bitunicate, biseriate, narrow below into a short, stout, curved stipe, 200-300 x 50-60 µm. *Ascospores* biseriate, oblong-ellipsoid, broadly to acutely rounded at the ends, transversely uniseptate, constriction broad and fairly deep, hyaline at first, surrounded by a broad hyaline gelatinous sheath which swells greatly in water, germ slit lateral, extending

length of cell, 85-95 x 20-25 µm. *Paraphyses* filiform, septate, longer than that of asci and mixed with them, abundant.

Specimen Examined: On cattle dung, Aguada fort, Goa, India, GUBH No. SY102, Coll. by Sarita Yadav, 02.08.2007.

Delitschia patagonica Speg., 1887. *Boln Acad. nac. Cienc. Córdoba* 11(1): 44. **(Fig. 110a-b)**

Fungus Ascomycete. *Perithecia* scattered, immersed, subglobose to pyriform, thin, membranous to slightly coriaceous, very dark brown, opaque, smooth; neck stout, short, clylindrical, sometimes enlarged and roughened at the apex, 750-600 µm long; covered densely with moderately short, fine, flexous, brownish-green hair measuring up to 70-100 x 2 µm. *Asci* 8-spored, cylindrical, bitunicate, uniseriate, hyaline, broadly rounded above, narrow below into a short slender stipe, 170-190 x 20-25 µm. *Ascospores* uniseptate, oblong-ellipsoid, acutely rounded at the ends, transversely uniseptate, constriction broad and shallow, hyaline when young, ranges through yellowish-brown to dark brown and later opaque, surrounded by a narrow hyaline gelatinous sheath, 25-35 x 10-15 µm. Germ slit lateral, extending nearly the entire length of the cell. *Paraphyses* filiform, septate, abundant, slightly longer than the asci and mixed with them, numerous, 29-37 x 12-14 µm.

Specimen Examined: On cattle dung, Salaeulim, Goa, India, GUBH No. SY268, Coll. by Sarita Yadav, 02.08.2007.

Delitschia timagamensis Cain, 1934. *University of Toronto Studies*, Biological Series 38: 79. **(Fig. 111a-b)**

Fungus Ascomycete. *Perithecia* scattered, immerse, subglobose to pyriform, thin, dark brown, upper part and neck dark brown to black, cylindrical, elongated, covered by a short hairs; neck , papilliform to short, 350-450 x 200-250 µm. *Asci* 8-spored, cylindrical, rounded above, tapering below into a short slender stipe, bitunicate,

uniseriate, 105-170-15x 88 µm. *Ascospores* uniseptate, uniseriate, oblong-ellipsoid, narrow and acutely rounded at the ends, with a broad deep constriction, hyaline when young, ranges through yellowish to dark brown and turns out to be fully opaque, 21-25 x 6-8 µm. Germ slit lateral, extending entire length of the cell. *Paraphyses* filiform, septate, slightly longer than the asci.

Specimen Examined: On cattle dung, Salaeulim, Goa, India, GUBH No. SY11, Coll. by Sarita Yadav, 10.07.2007.

***Delitschia* sp.** **(Fig. 112)**

Fungus Ascomycete. *Perithecia* scattered, immersed, subglobose to pyriform, thin, membranous to slightly coriaceous, very dark brown, opaque, smooth; neck stout, short, clylindrical, sometimes enlarged and roughened at the apex, 450-550 µm long; covered densely with moderately short, fine, flexous, brownish hair. *Asci* 8-spored, cylindrical, bitunicate, uniseriate, hyaline, broadly rounded above, narrow below into a short slender stipe, 200-300 x 20-25 µm. *Ascospores* uniseptate, oblong-ellipsoid, acutely rounded at the ends, transversely uniseptate, constriction broad and shallow, hyaline when young, ranges through yellowish-brown to dark brown and later opaque, surrounded by a narrow hyaline gelatinous sheath, 30-45 x 10-14 µm. Germ slit lateral, extending nearly the entire length of the cell. *Paraphyses* filiform, septate, abundant, slightly longer than the asci and mixed with them, numerous.

Specimen Examined: On cattle dung, Salaeulim, Goa, 10.07.2007, Coll. by Sarita Yadav, GUBH No. SY11.

Dennisiopsis multispora Subram. & Chandrash., 1977. *Kew Bull.* 31(3): 640 (1977) **(Fig. 113a-c)**

Fungus Ascomycete. *Apothecia* scattered, solitary, superficial, sessile, creamish in colour when young, 220-400 x 150-250µm. Ectal excipulum absent. Structure

consists only of the basal tissue. *Asci* 164-spored, unitunicate, biseriate, operculate, broadly clavate, thin-walled, with a short stipe, a rounded apex and a terminal operculum, 70-140 x 30-40 µm. *Ascospores* sub-hyaline, smooth, ellipsoidal, thin-walled, aseptate, prominent de Bary bubble lactophenol mount, 10-15 x 7-10 µm. *Paraphyses* long filiform, smooth, slightly curved at the tip, sub-hyaline, branched at the base, uniform width except at the tip.

Specimen Examined: On cattle dung, Verler, Goa, India, GUBH No. SY170, Coll. by Sarita Yadav, 12.11.2007.

Dennisiopsis octaspora Subram. & Chandrash., 1977. *Kew Bull.* 31(3): 639. **(Fig. 14, 114)**

Fungus Ascomycete. *Apothecia* scattered, solitary, superficial, sessile, creamish in colour when young, 160-435 µm long and 150-250 µm in height. Ectal excipulum absent. Structure consists only of the basal tissue. *Asci* 8-spored, unitunicate, biseriate, operculate, cylindric-clavate, with a short stipe, a rounded apex and a terminal operculum, 53-95 x 17-30 µm. *Ascospores* sub-hyaline, smooth, ellipsoidal, thin-walled, prominent de Bary bubble lactophenol mount, 10-15 x 7-10 µm. *Paraphyses* long, filiform, smooth, slightly curved at the tip, sub-hyaline, branched at the base, uniform width except at the tip.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUBH No. SY83, Coll. by Sarita Yadav, 31.07.2007.

***Dennisiopsis* tax. sp. nov.** **(Fig. 115a-b)**

Fungus Ascomycete. *Apothecia* scattered, solitary, superficial, sessile, creamish in colour when young, 120-234 µm long and 100-250 µm in height. Ectal excipulum absent. Structure consists only of the basal tissue. *Asci* 8-spored, unitunicate, biseriate, operculate, cylindric-clavate, with a short stipe, a rounded apex and a terminal operculum, 53-95 x 17-30 µm. *Ascospores* sub-hyaline, smooth, ellipsoidal, thin-

walled, prominent de Bary bubble lactophenol mount, 10-15 x 7-10 µm. *Paraphyses* long, filiform, smooth, slightly curved at the tip, sub-hyaline, branched at the base, uniform width except at the tip.

Specimen Examined: On cattle dung, Mhadei, Goa, India, GUBH No. SY18, Coll. by Sarita Yadav, 12.02.2007.

Emericella nidulans (Eidam) Vuill., 1927. *C. r. hebd. Séanc. Acad. Sci., Paris* 184: 137. **(Fig. 116)**

Fungus Ascomycete. *Ascomata* abundant, globose to subglobose, solitary, ranging from 100-300 µm in diam. Ascoma wall composed of one layer. *Asci* 8-spored, globose to subglobose, 8-12 µm in diam. *Ascospores* lenticular, 2-4 x 3-4 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUBH. No. SY7, Coll. by Sarita Yadav, 31.07.2007.

Lophotrichus bartlettii (Massee & E.S. Salmon) Malloch & Cain, 1971. *Can. J. Bot.* 49(6): 866. **(Fig. 117)**

Fungus Ascomycete. *Perithecium* black, spherical, with short neck, hairy, 290 x 120 µm. Terminal hairs up to 1.5 mm long, emerging from the tip of the perithecia, 240-1270 µm, darker at the base, pale brown towards the tip, curled by the base and the tip. *Conidia* smooth, limoniform, greenish-brown, 8-10 x 6-8 µm.

Specimen Examined: On cattle dung, Chopdem, Goa, India, GUFCC No. 15230, Coll. by Sarita Yadav, 17.04.2007.

***Lophotrichus* sp. 1** **(Fig. 118)**

Fungus Ascomycete. *Perithecia* smooth, brown. Setae long, slender, straight, greenish-brown, septate, smooth, originating from the tip of the perithecium, 243-810 x 16-24 µm. *Asci* unitunicate, biseriate, 8-spored, asci dissolves on maturity, 14-21 x 10-12 µm. *Ascospores* smooth, lemon-shaped, olivaceous, aseptate, 7-8 x 8 µm.

Specimen Examined: On cattle dung, Keri, Goa, India, GUBH No. SY234, Coll. by Sarita Yadav, 29.12.2007.

Podospora appendiculata (Auersw. ex Niessl) Niessl, *Hedwigia* 22: 156 (1883) **(Fig. 16)**

Fungus Ascomycete. *Perithecia* scattered, semi-immersed, non-stromatic, obpyriform, ostiolate, covered with flexous hair, 250-600 x 110-230 µm. Neck tapering, short, black, swollen part light brown, hairs all over the ascocarp; 120-180 x 140-290 µm. *Asci* clavate, biseriate, unitunicate, fairly long stipulate, 250-330 x 40-55 µm. *Ascospores* biseriate, one-celled, at first hyaline, ellipsoidal, pale brown to dark brown, smooth, 17-36 x 30-55 µm bicelled, lower cell hyaline, upper cell darker, with pdeicle and hyaline appendages.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India, GUBH No. SY189, Coll. by Sarita Yadav, 24.10.2007.

***Podospora* sp.** **(Fig. 119)**

Fungus Ascomycete. *Perithecia* scattered, semi-immersed, non-stromatic, obpyriform, ostiolate, covered with flexous hair, 600-900 x 430-550 µm. Neck tapering, short, black, swollen part light brown, hairs all over the ascocarp; 150-330 x 150-220 µm. *Asci* clavate, biseriate, unitunicate, fairly long stipulate, 250-330 x 40-55 µm. *Ascospores* biseriate, one-celled, at first hyaline, ellipsoidal, pale brown to dark brown, smooth, 35-45 x 20-25 µm equilateral, with somewhat pointed ends, provided at each end with a germ pore and a lash-like gelationous cauda.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India, GUBH No. SY206, Coll. by Sarita Yadav, 30.11.2007.

Saccobolus citrinus Boud. & Torrend, 1911. *Bull. Soc. mycol. Fr.* 27(2): 131.

(Fig. 120a-b)

Fungus Ascomycete. *Apothecia* solitary, superficial, sessile, 0.1-0.3 mm diam., all ochraceous yellow or with disc lemon yellow. Hynemium 90-100 thick. Hypothecium not clearly differentiated. Flesh thin, of small isodiametric cells, 8-12 µm. Spore clusters 40-50 x 12-15 µm. Spore clusters 40-55 x 10-20 µm. *Asci* cylindrical-clavate, elongated, rather compact, 8-spored, 135-160 x 19-25 µm. *Ascospore mass* 63-65 x 17-21 µm, ornamented. *Ascospores* ellipsoidal-fusiform, hyaline turning to brown, with truncate ends, slightly verruculose, 16-24 x 7-10 µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India, GUFCC No. 15231, Coll. by Sarita Yadav, GUFCC No. 05.02.2007.

Saccobolus glaber (Pers.) Lambotte, 1887. *Fl. myc. Belg.*, Suppl. 1 1: 284.
(Fig. 121a-b)

Fungus Ascomycete. *Apothecia* solitary, superficial, sessile, 0.2-1.0 m diam. Receptacle at first globular, then globular, then pulvinate, golden-yellow. Hymenium 120-200 µm thick. Hypothecium not clearly differentiated. Flesh thin, of small, isodiametric cells, 8-12 µm diam., hyaline. Excipulum very thin and rather fugitive, in the lower part of subglobular or ellipsoidal cells, 10-22 x 10-15 µm. *Asci* cylindric-clavate, elongated, rather compact, 8-spored, 145-174 x 25-40 µm. Spore-clusters elongated, rather compact, with thick gelatinous envelope. *Ascospores* fusiform, ellipsoidal, hyaline later turning to brown, smooth, attached in groups (8-ascospore), surrounded by the mucilaginous sheath. *Paraphyses* simple, sub-hyaline, smooth, unbranched.

Specimen Examined: (i) On cattle dung, Chandreshwar hill, Goa, India, GUFCC No. 15232, Coll. by Sarita Yadav, 05.02.2007. (ii) On rabbit dung, Siolim, Goa, India, GUFCC No. 15323, Coll. by Sarita Yadav, 13.09.2009.

The fungus is isolated by Moist chamber incubation technique. The fungus was earlier isolated from cow dung, in Howrah, W.B. (Kar and Pal, 1970).

Saccobolus saccoboloides (Seaver) Brumm., 1967. *Persoonia*, Suppl. 1: 168.
(Fig. 122)

Fungus Ascomycete. *Apothecia* scattered, superficial, sessile, up to 1 mm across. Disk convex, dull yellow, dotted with the protruding tips of ripe asci. Hymenium and flesh not fully differentiated. Excipulum rather thin and fugitive, parallel and cylindrical hyphae present. *Asci* broadly clavate, gradually tapering towards the base, unitunicate, biseriate, yellowish-brown when young, later becoming pale brown, 8-spored (in cluster). *Spore-clusters* very loose, at first free then clinging together, not cemented together by gelatinous sheath. *Ascospores* in clumps, rhombus shaped, light brown, smooth, 21-23 x 10.5-12 µm. *Paraphyses* filiform, septate, simple, not enlarged at tip, yellowish, 2-3 µm.

Specimen Examined: On cattle dung, Gaundongrem, Goa, India, GUFCC No. 15335, Coll. by Sarita Yadav, 26.02.2007.

***Saccobolus* sp. 1**
(Fig. 123)

Fungus Ascomycete. *Apothecia* solitary, superficial sessile, 0.1-1 mm. Receptacle at first globular, then pulvinate, smooth, margin not differentiated. Hymenium 150-200 µm. Excipulum very thin and rather fugitive, in the lower part of subglobular or ellipsoid cells, 10-20 x 9-20 µm. *Asci* cylindric-clavate, with short stalk, clavate, tip ends up into a small point or sometimes into elongated neck. Spore-clusters elongated, rather compact, with thick gelatinous envelope. *Ascospores* fusiform, ellipsoidal, at first hyaline, then purplish, surrounded by mucilaginous sheath, in groups of 8, no ornamentation, young spores hyaline with a germ slit like, 19-22 x 9-15 µm. *Paraphyses* simple, septate, irregularly cylindrical, plenty.

Specimen Examined: On cattle dung, Pansuli, Chorla, Goa, India, GUFCC No. 15233, Coll. by Sarita Yadav, 11.06.2007.

***Saccobolus* sp. 2** **(Fig. 7)**

Fungus Ascomycete. *Apothecia* solitary, superficial sessile, up to 1 mm. *Asci* cylindric-clavate, with short stalk, clavate, tip ends up into a small point or sometimes into elongated neck. Spore-clusters elongated, rather compact, with thick gelatinous envelope. *Ascospores* fusiform, ellipsoidal, at first hyaline, then purplish, surrounded by mucilaginous sheath, in groups of 8, no ornamentation, young spores hyaline with a germ slit like, 10-15 x 9-15 µm. *Paraphyses* simple, septate, irregularly cylindrical, plenty.

Specimen Examined: On cattle dung, Puttur, Karnataka, India, GUFCC No. 15233, Coll. by Sarita Yadav, 11.10.2009.

Schizothecium nanum N. Lundq., *Symb. bot. upsal.* 20(no. 1): 255 (1972).... **(Fig. 124)**

Fungus Ascomycete. *Perithecia* non-stromatic, ostiolate, brownish-green, dark brown, 400-550 µm. Peridium pseudo-parenchymatous, membraneous, covered with hair, 3-layered, upper part of perithecia clad with tufts of agglutinated, swollen hairs or protruding, inflated cells. *Asci* clavate, rarely cylindrical, without apical ring, almost invariably dehiscing below the apex, 150-180 x 14-20 µm. *Ascospores* at first hyaline, later becoming dark, greenish-brown, fusiform-obovoid, tapering at the tip, smooth, with a germ pore, 16-21 x 8-10 µm. Pedicel hyaline, 3-4 x 1-2 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, Coll. by Sarita Yadav, 16.05.2007. GUBH No. SY348. Isolated by Moist chamber incubation.

Schizothecium sp.
(Fig. 18)

Fungus Ascomycete. *Perithecia* non-stromatic, ostiolate, brownish-green, dark brown, 560-650 µm. Peridium pseudo-parenchymatous, membraneous, covered with hair, 3-layered, upper part of perithecia clad with tufts of agglutinated, swollen hairs or protruding, inflated cells. *Asci* clavate, rarely cylindrical, without apical ring, almost invariably dehiscing below the apex, 200-250 x 29-35 µm. *Ascospores* at first hyaline, later becoming dark, greenish-brown, fusiform-obovoid, tapering at the tip, smooth, with a germ pore, 16-21 x 8-10 µm. Pedicel hyaline, 5-7 x 2-4 µm.

Specimen Examined: On cattle dung, Bambolim, Goa, India, Coll. by Sarita Yadav, 16.05.2007. GUBH No. SY212. Isolated by Moist chamber incubation.

Sordaria fimicola (Roberge ex Desm.) Ces. & De Not., 1983. *Comm. Soc. crittog. Ital.* 1(4): 226. **(Fig. 20, 125a-b)**

Fungus Ascomycete. *Perithecia* mostly aggregated, superficial, obpyriform, sparsely covered with flexous, hyaline hairs, 350-450 x 200-350 µm. Neck cylindrical, papillose, 90-200 x 70-100 µm. *Perdium* membranous, subopaque, brown below, brownish at the base, *Asci* 8-spored, cylindrical, short-stipitate, with a truncate, wide apex, unitunicate, uniseriate. *Ascospores* one-celled, germ pore present, dark brown, hyaline when young, later dark, 18-25 x 10-13 µm. Gelatinous sheath present.

Specimen Examined: On cattle dung, Ugem, Salaeulim, Goa, India, GUBH No. SY267, Coll. by Sarita Yadav, 07.01.2008.

The fungus was isolated by moist chamber isolation technique. The fungus was isolated from the excreta of *Naja tripudians*.

Sordaria humana (Fuckel) G. Winter, 1885. *Rabenh. Krypt.-Fl.*, Edn 2 (Leipzig) 1.2: 166. **(Fig. 126)**

Fungus Ascomycete. *Perithecia* mostly aggregated, semi-immersed, subglobose to broadly obovoid, often soft haired, 400-700 µm. Peridium membranous, subopaque,

brown, blackish in the short, papillose neck, slightly swollen. *Asci* 8-spored, 100-200x 15-15 µm, cylindrical, short-stipitate with truncate, apical ring 6-7 µm present. *Ascospores* uniseriate, one-celled, black-brown at maturity, 17-20 x 12-18 µm. Gelatinous sheath lacking.

Specimen Examined: On cattle dung, Ugem, Salaeulim, Goa, 07.01.2008, Coll. by Sarita Yadav, SY270.
The fungus is reported from the dungs of spotted and eland deer, Delhi zoo (Iyer et al., 1973).

***Sporormia* sp.** **(Fig. 21)**

Fungus Ascomycete. *Pseudothecia* small, mostly immersed, only neck visible, apex dark brown, *Asci* short, clavate, arounded at the apex, later tapering down, smooth, 70-178 x 12.6-14 µm. *Ascospores* 16-celled, smooth, dark brown, in bundle in ascus and even after the discharge, lower and upper cell elongated, blunt at the apex, other middle cells ellipsoidal, 44-48 x 2-3 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUBH No. SY352. Coll. by Sarita Yadav, 10.07.2007.

Sporormiella minima (Auersw.) S.I. Ahmed & Cain, 1970. Ahmed & Asad, *Pakist. J. scient. ind. Res.* 12(3): 241. **(Fig. 127)**

Fungus Ascomycete. *Pseudothecia* small, mostly immersed, only neck visible, 0.1-0.15 mm. *Ascocarp* setae absent. *Asci* cylindrical, abruptly contracted, below to a short stalk, elongated, bitunicate, biseriate, 110-220 x 8.4-16 µm. *Ascospores* dark brown, 4-celled, smooth, germ slit present, end cells longer than the edge cells, 27-38 x 4-8 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUFCC No. 15234, Coll. by Sarita Yadav, 10.07.2007.

Sporormiella pulchella (E.C. Hansen) S.I. Ahmed & Cain, 1972. *Can. J. Bot.* 50(3): 456. **(Fig. 128a-b)**

Fungus Ascomycete. Ascomal wall membranous, composed of pseudoparenchymatous cells, outer-wall thick, inner cells thin and hyaline, filamentous pseudoparaphyses present. *Asci* bitunicate, cylindrical-fusiform, blunt at the apex later tapering at the tip, with elongated stalk, 8-spored, 165-445 x 16 µm. *Ascospores* 4-celled, middle cells rectangular, end cells tapered, dark brown, diagonal germ slit present, spore surrounded by a gelatinous sheath, 25-27 x 4-6 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUBH No. SY27, Coll. by Sarita Yadav, 10.07.2007.

***Sporormiella* sp. 1** **(Fig. 129)**

Fungus Ascomycete. *Ascocarp* sub-immerse, neck with fine hair, 600-615 x 12-16 µm. Ascomal wall membranous, composed of pseudoparenchymatous cells, outer-wall thick, inner cells thin and hyaline, filamentous pseudoparaphyses present. Ascomal wall membranous, composed of pseudoparenchymatous cells, outer-wall thick, inner cells thin and hyaline, filamentous pseudoparaphyses present. *Asci* smooth, bitunicate, biseriate, cylindrical-fusiform, blunt at the apex later tapering at the tip, with elongated stalk, 8-spored, 125-146 x 8-10 µm. *Ascospores* 4-celled, middle cells rectangular, end cells tapered, dark brown, diagonal germ slit present, spore surrounded by a gelatinous sheath, diagonal germ slit, 25-27 x 4-6 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUBH No. SY86, Coll. by Sarita Yadav, 10.07.2007

***Sporomiella* sp. 2** **(Fig.129b)**

Fungus Ascomycete. *Ascocarp* sub-immerse, neck with fine hair, 450-515 x 10-15 µm. Ascomal wall membranous, composed of pseudoparenchymatous cells, outer-

wall thick, inner cells thin and hyaline, filamentous pseudoparaphyses present. Ascomal wall membranous, composed of pseudoparenchymatous cells, outer-wall thick, inner cells thin and hyaline, filamentous pseudoparaphyses present. *Asci* smooth, bitunicate, biseriate, cylindrical-fusiform, blunt at the apex later tapering at the tip, with elongated stalk, 8-spored, 100-125 x 8-10 µm. *Ascospores* 4-celled, middle cells rectangular, end cells tapered, dark brown, diagonal germ slit present, spore surrounded by a gelatinous sheath, diagonal germ slit, 15-26 x 8-10 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India, GUBH No. SY86, Coll. by Sarita Yadav, 10.07.2007

Trichodelitschia bisporula (P. Crouan & H. Crouan) Munk. 1953, *Dansk bot. Ark.* 15(2): 109. **(Fig. 130a-b)**

Fungus Ascomycete. *Pseudothecia* scattered, mostly immersed, pyriform, 0.25 mm diam., blackish brown, with rigid neck, black, setiform hairs, 100-150 long, around their short necks. Setae attached at the neck, short, tapering towards the apex. *Asci* cylindrical, 8-spored, bitunicate, 85-95 x 8 µm. *Ascospores* ellipsoidal, dark brown, 1-septate, deeply constricted at the septum, smooth, bicelled, hyaline, gelatinous cell at one end, constrictum, dark band, smooth, sub-hyaline when young later dark brown, 12-19 x 6-8 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, 10.07.2007, Coll. by Sarita Yadav, GUFCC No. 15235.

Zygopleurage zygospora **(Speg.) Boedijn**, 1962. *Persoonia* 2(3): 316 (1962). **(Fig. 23, 130a-d)**

Fungus Ascomycete. *Ascocarp* the tip is dark brown, rest of the ascocarp light brown coloured, 606-808 x 505-606 µm. *Asci* broadly-clavate, mostly 8-spored, with round apices but without apical structures. *Ascospores* three-celled, two apical dark broad-fusiform cells, sub-hyaline when young, later becomes dark coloured, 15-42 x 14-23

μm, connecting cells hyaline, non-septate, strongly coiled with each other, without gelatinous sheath. Apical dark cells with four gelatinous caudae on the distant surface and four others at the junction with connecting hyphae.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India, GUBH No. SY177, Sarita Yadav, 16.05.2007.

The fungus was isolated by Moist chamber incubation.

ANAMORPHIC ASCOMYCOTA

HYPHOMYCETES

Acremonium fusidioides (Nicot) W. Gams, 1971. *Cephalosporium-artige Schimmelpilze* (Stuttgart): 70 **(Fig. 26)**

Fungus Hyphomycete. *Colonies* reaching 8-10 mm in ten days on MEA, ochraceous-brown, powdery. *Conidiophores* erect, smooth, 48-75 x 2 μm. *Conidiogenous cells* monophialiadic, single, integrated, terminal, arising directly from vegetative hyphae. *Conidia* aseptate, hyaline, in groups, smooth, ellipsoidal, 2-9 x 2-4 μm.

Specimen Examined: (i) On cattle dung, Tambdi Surla, Goa, India, GUBH No. SY360; GUFCC No. 14895; Coll. by Sarita Yadav, 07.07.2009. (ii) On cattle dung, Netravali, Goa, India; GUFCC No. 14900; Coll. by Sarita Yadav, 06.09.2007. (iii) On rabbit dung, Chopdem, Goa, India; GUFCC No. 14910; Coll. by Sarita Yadav, 07.10.2007.

The fungus was isolated by the particle-plating method. This species has been encountered several times during the study period. Earlier the fungus was reported on monkey dung (Tubaki, 1954).

Acremonium strictum W. Gams, 1971. *Cephalosporium-artige Schimmelpilze* (Stuttgart): 42. **(Fig. 26)**

Fungus Hyphomycete. *Colonies* off white, chlamydospores absent in culture. *Conidiophores* erect, sub-hyaline, smooth, base wide later tapering towards the apex, 25-42 x 2-3 μm. *Conidiogenous cells* monophialiadic, single, integrated, terminal,

arising from the vegetative hyphae. *Conidia* elliptical, hyaline, smooth, solitary to accumulated at the apex, 3-5 x 2 µm.

Specimen Examined: On Bison dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 14912; Coll. by Sarita Yadav, 07.07.2009.

Acremonium murorum (Corda) W. Gams, *Cephalosporium-artige Schimmelpilze* (Stuttgart): 84 (1971) **(Fig. 133)**

Fungus Hyphomycete. Colonies reaching 8-10 mm in ten days on MEA, ochraceous-brown, powdery. *Conidiophores* 15-20 x 1-2 µm, erect, smooth, without collarette. *Conidiogenous cells* monophialiadic, single, integrated, terminal, arising directly from vegetative hyphae. *Conidia* 2-4 x 1-3µm, aseptate, hyaline, in groups, smooth, ellipsoidal.

Specimen Examined: (i) On cattle dung, Tambdi Surla, Goa, India, GUFCC No. 14899, Coll. by Sarita Yadav, 07.07.2009. (ii) On spotted deer dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 14851, Coll. by Sarita yadav, 02.06.2009.
The fungus was isolated by particle-plating technique. The fungus is a known saprophyte with a worldwide distribution and an extremely wide range of substrates. Frequent records have been reported from both temperate and tropical habitats.

Agarwalomyces sp. **(Fig. 134)**

Fungus Hyphomycete. *Colonies* elliptical, fringed, flat, thin, aerial mycelia, powdery. *Synnema* up to 745 µm .*Conidiophores* macronematous, synnematous, hyaline, arsing, light green, branched, smooth. Individual hyphae fused and parallel, the stipe ends with a rounded head. *Conidiogenous cells* integrated, cylindrical, polybalstic. *Conidia* acropleurogenous, globose to elliptical, 2-5 µm in diam.

Specimen Examined: (i) On cattle dung, Netravali, Goa, India; GUFCC No. 14992, Coll. by Sarita Yadav, 27.08.2009. (ii) On rabbit dung, Marcaim, Goa; India, GUFCC No. 15041, Coll. by Sarita Yadav, 28.06.2009. (iii) On cattle dung, Cansaulim, Goa, India; GUFCC No. 14854, Coll. by Seema Dessai, 19.09.2008.
The fungus was isolated by moist chamber technique.

Alternaria longipes (Ellis & Everh.) E.W. Mason, 1928. *Mycol. Pap.* 2: 19. **(Fig. 135)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononematous, arising in groups, erect, simple, cylindrical, septate, pale olivaceous brown, with conidial scars, 60-80 x 2-5 µm. *Conidiogenous cells* integrated, terminal becoming intercalary, polytretic. *Conidia* solitary to catenate, dry, typically obclavate, pale brown, smooth to verruculose, septated, long elongated stout 46-110 x 8-12 µm, body of conidium, thickest in the broadest part, tapering gradually into the pale brown, 1-several longitudinal septa.

Specimen Examined: On cattle dung, Shiroda, Goa, India, GUFCC No. 14869, Coll. by Sarita Yadav, 16.02.2007.

The fungus was isolated by Moist chamber incubation. The fungus has been recorded from many countries Bolivia, China, Colombia, Germany, Hungary, India and many other countries, especially on tobacco (Ellis, 1971).

Alternaria porri (Ellis) Cif., 1930. *J. Dept. Agric. Porto Rico* 14: 3 **(Fig. 136)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononematous, arising in groups, erect, simple, cylindrical, septate, pale brown, solitary, with conidial scars, up to 100-12 µm x 5-10 µm. *Conidiogenous cells* integrated, terminal becoming intercalary, polytretic. *Conidia* solitary to catenate, dry, typically ovoid or obclavate, greenish to pale or mid olivaceous brown, brown, smooth, transverse septa, 6-septated, 40-90 x 6-9 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 14901, Coll. by Sarita Yadav, 16.05.2007.

Isolated by Moist chamber incubation technique. Reported from various countries, including both tropical and temperate countries (Ellis, 1971).

Amblyosporium **sp.** **(Fig. 137)**

Fungus Hyphomycete. *Conidiophores* septate, hyaline, branched, smooth, aggregated, 10-15 x 1-2.5 µm. *Conidia* hyaline, solitary to aggregated, apex, spherical to elliptical, smooth, 3.5-6 x 2.5-3.5 µm.
Specimen Examined: On cattle dung, Karwar, Karnataka, India; GUFCC No. 14891, Coll. by Sarita Yadav, 25.08.2008.

Isolated by Moist chamber incubation technique. The fungus is isolated from various substrates wood, litter, dung and soil (Carmichael et al., 1980).

Angulimaya **tax. sp. nov.** **(Fig. 29)**

Fungus Hyphomycete. *Conidiophores* short, hyaline, smooth. *Conidiogenous cells Phialides* squat, borne laterally along the branches of the connidiophore, collarettes dark, *Conidia* smooth, catenate, spherical, unbranched, 4-5 µm in diam.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUBH No. SY121, Coll. by Sarita Yadav,

Isolated by moist chamber technique. Based on the larger size of the conidia this fungus was distinguished as new.

Antromyces **tax. sp. nov.** **(Fig. 138a-b)**

Fungus Hyphomycete. In habit Synnemata solitary or in group of 2-3, peach colored on dung substrate, stroma none, setae and hyphopodia absent, mostly curved, amphideterminate. *Conidiophores* mononematous, length varies from 105-285 µm, maximum thickness at top 56-137 µm, which narrows down to 32-81 µm and 32-121 µm thickness at the bottom, smooth. *Conidiogenous* cells size Polyblastic, integrated, clavate, denticles absent. *Conidia* 14-23 x 2-4 µm in breadth, catenate, dry, acropleurogenous, simple, cylindrical, hyaline, 1-2 septate.

Specimen Examined: On cow dung, Yana, Karnataka, India, 27.07.2008. Coll. by Ashish Prabhugaonkar, GUFCC No. 14991.

Isolated by Moist Chamber Incubation Technique. The various species of *Antromyces* have been reported from different dung substrates. Thus this genus grows commonly from dung.

Arthrobotrys superba Corda, 1839. *Pracht-Fl. Eur. Schimmelbild.*: 43. **(Fig. 139a-b)**

Fungus Hyphomycete. *Colonies* white, cottony. *Conidiophores* simple, erect, septate, sub-hyaline, bulbous at the tip (ampullate), tapering at the apex then swelling again and bearing conidia on denticles, producing conidia asynchronously on short denticles at swollen conidiogenous cells or on clusters of denticles, 280-360 x 4-5 µm. *Conidia* 1-septate, sub-hyaline, thin-walled, smooth-walled, clavate-shaped, broad at the behind part, narrow at the attachment point, septate, 21-30 x 6-12 µm.

Specimen Examined: (i) On cattle dung, Keri, Goa, india, 13.03.2007. Coll. by Sarita yadav, GUFCC No. 14892 (ii) On cattle dung, Bondla Wildlife Sanctuary, Goa, India, 16.05.2007, Coll. by Sarita Yadav, GUFCC No. 14821.

The fungus was isolated by by Moist chamber incubation technique. The fungus is known as Nematode destroying fungus and is reported during various earlier studies; on horse and goat dung (Massee and Salmon, 1902); on rabbit dung (Mahju, 1933); on dung (Bisby, 1938, Lindau, 1910).

Arthrographis kalrae (R.P. Tewari & Macph.) Sigler & J.W. Carmich., *Mycotaxon* 4(2): 360 (1976) **(Fig. 140)**

Fungus Hyphomycete. *Colonies* cream colours to dark later. *Conidiophores* sub-hyaline, smooth, often indistinguishable from the vegetative hyphae, narrow, branched. No differentiation between the vegetative hyphae. *Conidiogenous cells* thallic. *Conidia* sub-hyaline, smooth, 1-celled, 4-8 x 2.µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India, 10.10.2008, Coll. by Sarita Yadav, GUFCC No. 14882.

The fungus was isolated by Moist chamber incubation technique.

Aspergillus fumigatus Fresen., 1863. *Beitr. Mykol.* 3: 81. **(Fig. 141)**

Fungus Hyphomycete. *Colonies* dark green, with aerial hyphae. *Conidiophores* short, smooth-walled, green, straight, erect, smooth, pale brown, 420-640 x 20-25 µm. *Conidiogenous cells* phialidic. *Phialides* directly borne on the vesicles, 6-8 x 2-3 µm. *Vesicles* up to 20-30 µm in diam., often coloured as the conidiophore, usually fertile on the upper portion. *Conidia* greenish, round, spherical, catenate, accumulated, minutely verrucose, 2-5 µm diam.

Specimen Examined: On Bison dung, Bondla Wildlife Sanctuary, Goa, India; GUFCC No. 14993, Coll. by. Sarita Yadav, 16.05.2007.

The fungus was isolated by Moist chamber incubation technique. The fungus is earlier reported on horse dung (Piontelli at al, 1991) on dung (Ellis, 1971).

Aspergillus flavus Link, *Mag. Gesell. naturf. Freunde,* 1809. *Berlin* 3(1-2): 16. **(Fig. 142)**

Fungus Hyphomycete. *Colonies* effuse, variously coloured, often brownish-green. *Conidiophores* hyaline to sub-hyaline, minutely verrucose, up to 1 mm long. Vesicles globose to sub-globose, 25-45 µm in diam. Phialides borne directly on the vesicle or on the metulae, 6-10 x 4-5 µm. Metulae 6-10 x 3-5 µm. *Conidia* globose to sub-globose, sub-hyaline to pale brown, spherical, verrucose, globose, catenate, 3-5 µm.

Specimen Examined: (i) On Goat dung, Taliegao Plataeu, Goa, India; GUFCC No. 14870, Coll. by Sarita Yadav, 12.02.2007. (ii) On cattle dung, Mhadei, Goa, India, GUFCC No. 15502, Coll. by Sarita Yadav, 15.09.2010.

The fungus was isolated by Moist chamber and Particle-Plating Techniques. The fungus was reported on dung Manju on sheep dung in 1933, on deer, bird, elephant and kangaroo dung (Iyer et al., 1973); on horse dung (Pointelli et al., 1981). Also the fungus was reported from various substrates from India, temperate areas, extreme dry areas as soils in southeast Alaska, from various other substrates.

Aspergillus ochraceus G. Wilh., 1877. *Inaugural Dissertation* (Strassburg): 66 (1877) **(Fig. 143a, b)**

Fungus Hyphomycete. *Colonies* effuse, whitish when young, later yellowish-brown. Conidial heads yellow when young. *Conidiophores* stipe erect, hyaline to sub-hyaline, minutely verrucose, up to 1.5 mm in length. Vesicles globose, hyaline, 35-35 µm in diam., *Conidiogenous cells* phialidic. Phialides borne on metulae, 7-11 x 2-4 µm. Metuale 15-20 x 5-6 µm. *Conidia* globose to sub-globose, hyaline, smooth, 2-3 µm in diam.

Specimen Examined: (i) On cattle dung, Quepem, Goa, India, GUFCC No. 15121, Coll. by Sarita Yadav, 03.02.2007. (ii) On cattle dung, Jog Falls, Karnataka, India, GUFCC No. 15491, Coll. by Sarita Yadav, 31.10.2008. (iii) On goat dung, Marcaim, Goa, India, GUFCC No. 15431.

The fungus was isolated from by moist chamber and particle –plating techniques

Aspergillus sydowii (Bainier & Sartory) Thom & Church, 1926. *The Aspergilli*: 147. **(Fig. 144)**

Fungus Hyphomycete. *Colonies* on MEA, spreading, blue-green. *Conidiophores* erect, septate, smooth, unbranched, sub-hyaline, smooth- walled, up to 500 µm in length. Heads biseriate, vesicles globose, sub-hyaline up to 20 µm in diam. Phialides borne on metulae, up to 20 µm in diam. *Conidiogenous cells* phialides, borne on metulae, 5-10 x 2-4 µm. *Conidia* globose, verrucose, greenish brown to dark brown, round, catenate, 6-8 µm.

Specimen Examined: (i) On sambhar dung, Bondla Wildlife Sanctuary, Goa, India; GUFCC No. 15211, Coll. by Sarita Yadav, 15.07. 2009. (ii) On cattle dung, Sanquelim, Goa, India, GUFCC No. 14852, Coll. by Sarita Yadav, 22.11.2010. (iii) On goat dung, Siolim, Goa, India, GUFCC No. 14901, Coll. by sarita Yadav, 26.11.2011.

The fungus was isolated from by moist chamber and particle –plating techniques.

Aspergillus terreus Thom, Thom & Church, 1918. *Am. J. Bot.* 5: 85-6. **(Fig. 145)**

Fungus Hyphomycete. *Colonies* of MEA, effuse, brownish-yellow. *Conidiophores* hyaline to sub-hyaline, smooth, hyaline, erect, foot cell present, head spherical, diam. 40-55 µm. Vesicles subglobose, 10-20 µm in diam. Phialides borne on metuale, 5-7 x 2-3 µm. *Conidia* globose, hyaline to olivaceous green, aseptate, smooth, catenate, 1 µm diam.

Specimen Examined: On Black Buck Pellets, Bondla Wildlife Sanctuary, Goa, India; GUFCC No. 15221, Coll. by Sarita Yadav, 16.05.2007.

The fungus was isolated by moist chamber incubation and particle-plating techniques. The fungus was earlier reported on horse dung (Subramanian and Lodha, 1975); dung (Lodha, 1974); dungs of Kangaroo, Spotted deer, Eland Dear and Nil Gai from Allahabad, U.P. India.

Aspergillus wentii Wehmer, Zentbl. 1896. *Bakt. ParasitKde*, Abt. II 2: 150. **(Fig. 146)**

Fungus Hyphomycete. *Colonies* on MEA, whitish to yellowish later brown. Conidial heads yellow when young. *Conidiophores* stipe erect, hyaline to sub-hyaline, brownish, smooth, single, unbranched, integrated, 560-640 x 6 µm. Medullae present, 14-20 x 19-23 µm. *Conidiogenous cells* phialidic. *Phialides* on meduallae. *Conidia* smooth, greenish, round, spherical, diam. 2.52 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 14994, Sarita Yadav, 16.05.2007.

The fungus was isolated by moist chamber incubation and particle-plating techniques. The fungus is commonly found in the warmer countries, frequenly recovered from dung.

Aspergillus **sp. 1** **(Fig. 147)**

Fungus Hyphomycete. Colonies on MEA, effuse, brownish-black. *Conidiophores* erect, elongated, hyaline, sub-hyaline, smooth, 500-600 x 5-6 µm. *Vesicle* brownish, smooth, spherical. *Conidiogenous cells* phialidic. Phialides on medullae. *Conidia* smooth, globose, sub-hyaline, 1-2 µm diam.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa; 16.05.2007. Sarita Yadav, GUFCC No. 14496.

The fungus was isolated from isolated by moist chamber incubation technique and single-spore isolation technique.

Aspergillus **sp. 2** **(148a-b)**

Fungus Hyphomycete. Colonies on MEA effuse, greenish-brown. *Conidiophores* macronematous, mononematous, solitary, straight to slightly flexuous, smooth, olive brown, aseptate, bearing a greenish-broan vesicle at the tip and phialides in uniseries. *Conidiogenous cells* phialidic, discrete, hyaline. *Conidia* globose, brownish-green, smooth, 2-5 µm diam.

Specimen Examined: On goat dung, Mahabaleshwar, Maharashtra, 21.02.2007. Sarita Yadav, GUFCC No. 15116.

The fungus is isolated from by moist chamber incubation and particle-plating technique.

Aspergillus **sp. 3** **(149a-b)**

Fungus Hyphomycete. *Colonies* fast growing on MEA. *Conidiophores* hyaline to sub-hyaline, smooth, aseptate, erect, often septate, 1290-1470 x 10.5 µm. *Vesicles* globose to sub-globose. Metulae covering the entire vesicle, 10-20 x 5-8 µm. *Conidiogenous*

cells phialiadic. *Phialides* 5-10 x 2-4 µm. *Conidia* globose to sub-globose, hyaline to sub-hyaline, smooth-walled, smooth, 4-5 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa; 16.05.2007. Sarita Yadav, GUFCC No. 15108.

The fungus is isolated by the method of moist chamber incubation and particle-plating technique.

***Aspergillus* sp. 4** **(Fig. 150a-b)**

Fungus Hyphomycete. *Colonies* on MEA, *Conidiophores* smooth, erect, sub-hyaline, smooth, aseptate, vesicles globose, 125-280 x 6 µm. *Conidiogenous cells* phialidic. *Conidia* catenate, greenish to greenish brown, brown, minutely verrucose, diam. 3-5 µm.

Specimen Examined: (i) On cattle dung, Cotigao Wildlife Sanctuary, Goa, India; GUFCC No. 15111, Coll. by Sarita Yadav, 10.07.2007. (ii) On Chausingha dung, Bondla Wildlife Sanctuary, Goa, India; GUFCC No. 15210, Coll. by Sarita Yadav.

The fungus was isolated by moist chamber incubation and Particle-plating technique.

***Aspergillus* sp. 5** **(Fig. 151)**

Fungus Hyphomycete. *Conidiophores* smooth, erect, sub-hyaline, smooth, aseptate, vesicles globose, 100-250 x 4-6 µm. *Conidiogenous cells* phialidic. Head spherical, black, 55-105 x 65-110 µm. *Conidia* sub-hyaline, minutely verrucose, round, 485-760 x 12 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India; Coll. by Sarita Yadav, GUFCC No. 15111, 10.07.2007.

The fungus was isolated by moist chamber incubation and particle-plating technique

Bahupaathra samala Subram. & Lodha, 1964. *Antonie van Leeuwenhoek* 30: 329. **(Fig. 30, 152)**

Fungus Hyphomycete. Mycelium dark brown, smooth, forming network, 1-2 µm in breadth. *Conidiophores* semi-macronematous, mononematous, hyaline to sub-hyaline forming pale brown colour in group, smooth, 0-1 septate, 50-60 x 15 µm. *Conidiogenous cells* globose, hyaline, monophialiadic, proliferating, smooth with flared collarette from which spores are successively produced, 5-10 µm. *Conidia* hyaline, smooth, globose, aseptate, solitary to in groups, 1-2 µm

Specimen Examined: On elephant dung, Bondla Wildlife Sanctuary, Goa, India; Coll. by Sarita Yadav, GUBH No. SY181, 16.05.2007.

The fungus is isolated by Moist chamber incubation technique. This fungus was reported by Ellis, 1971 on dung; Subramanian and Lodha in 1975 on horse and cow dung.

Botryotrichum piluliferum SGUBH & Marchal, 1885. *Bull. Soc. R. Bot. Belg.* 24(1): 66. **(Fig. 31,153a-b)**

Fungus Hyphomycete. *Conidiophores* greenish, sub-hyaline, smooth, branched, branching almost at right angles, swelling at the point of attachment. *Conidiogenous cells* blastic, integrated, terminal. *Conidia* globose, thick-walled, formed singly at ends of branches of conidiophores, sub-hyaline, greenish, smooth, aggregated with detached, 8-15 µm.

Specimen Examined: On cattle dung, Verlem, Goa, India; GUBH No. SY162, Coll. by Sarita Yadav 16.05.2007.

Fungus was recovered by moist chamber incubation technique. The fungus was reported by Downing in 1953; on cow dung by Dominik and Majchrowicz in 1970 and on horse dung by Piontelli et al., 1981.

Catenularia sp. **(Fig. 154)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononematous, straight, greenish-brown smooth, erect, straight, olivaceous, green to brown, 250-300 x 4-6 µm. *Conidiogenous cells* integrated, terminal, monophialidic, percurrent, calyciform, whorls, 10-11 µm long. *Conidia* greenish-brown, smooth, endogenous, simple, aspeptate, catenate in short chains, 2.5-5 x 2.5-3.5 µm.

Specimen Examined: On cattle dung, Chandranath Hill, Goa, India, GUFCC No. 15207; Coll. by Sarita Yadav, 14.12.2007.

The fungus was recovered by the techniques of moist chamber incubation and particle-plating.

Cephaliophora tropica Thaxt., 1903. *Bot. Gaz.* 35: 153-7. **(Fig. 32, 155a-b)**

Fungus Hyphomycete. *Conidiophores* semi-maccronematous, mononematous, short, smooth, sub-hyaline, 0-1 septate, broad and rounded at the apex to form vesicle, 8-10 x 2-3 µm. *Conidiogenous cells* polyblatic, integrated, terminal. *Conidia* 4-5 septate, clavate-shaped, sub-hyaline, smooth, 47-63 x 23-25 µm.

Specimen Examined: (i) On rabbit dung, Siolim, Goa, India; GUBH No. SY199, GUFCC No. 15211, Coll. by Sarita Yadav, 27.11.2007. (ii) On rabbit dung, Taleigao, Goa, India, GUFCC No, 15321, Coll. by Sarita Yadav, 15.09.2008.

The fungus is isolated by moist chamber incubation technique. The earlier reports were on ass dung (Saccardo, 1906); on mouse and monkey dung (Iyer at al., 1973) and on dung (Barron, 1968; Ellis, 1971).

Cephaliophora irregularis Thaxt., 1903. *Bot. Gaz.* 35: 158 **(Fig. 152)**

Fungus Hyphomycete. *Colonies* fast growing, floccose, white to creamish. *Conidiophores* semi-macronematous, mononematous, short, smooth, sub-hyaline, 0-1 septate, broad and rounded at the apex to form vesicle, 8-10 x 2-3 µm. *Conidiogenous*

cells polyblatic, integrated, terminal. *Conidia* 1-septate, clavate-shaped, sub-hyaline, smooth, 27-30 x 16-21 µm.

Specimen Examined: On rabbit dung, Bambolim, Goa, India, GUFCC No. 15322, Coll. by Sarita Yadav, 07.07.2007.

The fungus is isolated by moist chamber incubation technique. The earlier reports were by Iyer et al. (monkey dung); on rat dung (Subramanian and Lodha, 1975); on sheep, monkey and sparrow dung (Narendra and Rao, 1976); on dung (Barron, 1968; Ellis, 1971; Lodha, 1974).

***Cephaliophora* sp.** **(Fig. 157a-b)**

Fungus Hyphomycete. *Conidiophores* semi-macronematous, mononematous, short, smooth, sub-hyaline, 3-septate, bulbous at the tip, short, smooth, broad and rounded at the apex to form vesicle, 8-10 x 2-3 µm. *Conidiogenous cells* polyblastic, integrated, terminal. *Conidia* clavate, tipped at the apex, septated, smooth, egluttalate, solitary, 31-42 x 14-19 µm.

Specimen Examined: On goat dung, Sirvari, Goa, India, GUBH No. SY305; Coll. by Sarita Yadav, 15.07.2009.
Isolated by moist chamber incubation.

Chlamydomyces palmarum (Cooke) E.W. Mason, 1928. *Mycol. Pap.* 2: 37
(Fig. 33, 158)

Fungus Hyphomycete. *Conidiophores* semi-macronematous, mononematous, simple hyaline, septated, smooth, cylindrical. *Conidiogenous Cells* monoblastic, integrated, terminal. *Conidia* solitary, dry, acrogenous, obovoid to pyriform, divided by a septum, 2-celled, single celled when young, later develops into distal and basal cell, basal cell distinctly smaller, basal cell hyaline ending with a hilum, young spores hyaline later changing to golden brown, upper cell verrucose and yellowish-brown, lower cell smooth and hyaline, 25-38 x 19-27 µm.

Specimen Examined: (i) On goat dung, Sirvari, Goa, India, GUBH No. SY302; Coll. by Sarita Yadav, 26.07.2010. (ii) On cattle dung, Poriem, Goa, India, GUFCC No. 15415; Coll. by Sarita Yadav, 31.02.2009.

Isolated by moist chamber incubation and single-spore isolation techniques. The fungus was reported earlier form various studies. The fungus was earlier recovered from rat dung (Subramanian and Lodha, 1975); on cow dung (Saccardo, 1913) and horse dung (Piontelli et al, 1991).

***Chlamydomyces* tax. sp. nov.** **(Fig. 159)**

Fungus Hyphomycete. *Conidiophores* semi-macronematous, mononematous, simple, hyaline, septated, smooth, cylindrical, equally broad throughout, simple, unbranched, 3-4 x 46 µm. *Conidiogenous Cells* monoblastic, integrated, terminal. *Conidia* solitary, dry, acrogenous, obovoid to pyriform, divided by a septum, 2-celled, obovate, lower part hyaline, upper part pale brown, lower part hyaline, 23-42 x 18-31 µm.

Specimen Examined: On cattle dung, Fatorpa, Goa, India; GUBH No. SY311, Coll. by Sarita Yadav 26.07.2010. (ii) On the sambar dung, Bondla Wildlife sanctuary, Goa, India; GUFCC No. 15231, Coll. by Sarita Yadav, 15.09.2009.

Isolated by the moist chamber incubation technique.

***Chrysosporium* sp.** **(Fig. 160)**

Fungus Hyphomycete. *Colonies* white coloured, later turning pale brown. *Conidia* are typically formed on the lateral branches as alternate arthroconidia, globose, smoothed wall, Terminal and lateral thallic conidia borne all over the hyphae, sessile or on short protrusions or side branches, subhyaline, obovoid, 1-celled, truncate.

Specimen Examined: On cattle dung, Sirvoi, Goa, India; GUBH. No. SY359; Coll. by Sandesh Varik, 22.08.2010

Isolated by moist chamber incubation technique.

Ciliciopodium sanguineum Corda, 1840. *Icon. fung.* (Prague) 4: 30 **(Fig. 161)**

Fungus Hyphomycete. *Conidiophores* erect, solitary, macronematous, synnematous, unbranched, paler at the apex, smooth, dark brown, broader at the base, minutely narrow at the apex, 98-258 x 12-16 µm. *Conidiogenous cells* blastic, integrated, terminal. *Conidia* sub-hyaline, smooth, gluttalate, aseptate, narrower at the attachment point, 6-8 x 3-5 µm.

Specimen Examined: (i) On cattle dung, Sirvoi, Goa, India; GUBH No. SY292; Coll. by Sarita Yadav, 18.07.2009. (ii) On cattle dung, Ponsuli, Goa, India, GUFCC No. 15212; Coll. by Sarita Yadav, 20.09.2010.

Isolated by moist chamber incubation technique.

Cladorrhinum foecundissimum **(Fig. 162)**

Fungus Hyphomycete. *Colonies* slow, whitish to creamish. *Conidiophores* sub-hyaline, smooth, flexous, micronematous. Short, pale brown at the base, hyaline towards the apex. *Conidiogenous cells* phialiadic, collarette present, sub-hyaline, smooth, 2.5-3.5 µm. *Conidia* spherical, sub-hyaline, olivaceous green, smooth, aseptate, 2.5 x 3.5 µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India; GUFCC No. 15435; Coll. by Sarita Yadav, 25.11.2009.

Isolated by moist chamber incubation technique.

***Cladorrhinum* sp. 1** **(Fig. 163)**

Fungus Hyphomycete. *Conidiophores* sub-hyaline, smooth, flexous, micronematous. Short, pale brown at the base, hyaline towards the apex. *Conidiogenous cells* phialiadic, collarette present, sub-hyaline, smooth, 2.5-3.5 µm. *Conidia* spherical, sub-hyaline, olivaceous green, smooth, aseptate, 3-18 x 2-3 µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India; GUBH No. SY17; Coll. by Sarita Yadav, 13.11.2009.

Isolated by moist chamber incubation technique.

***Cladorrhinum*msp. 2** **(Fig. 164)**

Fungus Hyphomycete. *Colonies* effuse, pale white. *Conidiophores* hyaline, collarette, 4.2-6.3 x 2.1 µm. *Conidiogenous* cells hyaline, integrated. *Conidia* hyaline, numerous, solitary to aggregated at times, irregular to spherical, 1.7-2.5 µm.

Specimen Examined: On cattle dung, Gaundonguem, Goa, India; GUFCC No. 15321; Coll. by Dhillan Velip, 27.12.2007. (ii) On cattle dung, Karwar, Goa, India, GUFCC No. 15432; Coll. by Sarita Yadav, 22.09.2009. (iii) On Cattle dung, Harmal, Goa, India, GUFCC No. 15421; Coll. by Sarita Yadav, 28.01.2008.

Isolated by moist chamber incubation technique.

***Cladorrhinum* sp. 3** **(Fig. 34)**

Fungus Hyphomycete. *Conidiophores* sub-hyaline, smooth, flexous, micronematous. Short, pale brown at the base, hyaline towards the apex. *Conidiogenous cells* phialiadic, collarette present, sub-hyaline, smooth, 2.5-3.5 µm. *Conidia* ellipsoidal, sub-hyaline, olivaceous green, smooth, aseptate, 2-10 x 2-3 µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India; GUFCC No. 15334, Coll. by Sarita Yadav, 13.11.2009. (ii) On elephant dung, Bondla Wildlife Sanctuary, Goa, India; GUFCC No. 15332, Coll. by Sarita Yadav, 15.11.2009. (iii) On cattle cattle dung, Lamgao, Goa, India; GUFCC No. 15390, Coll. by Sarita Yadav, 30.09.2010.

Isolated by moist chamber incubation technique.

Cladosporium cucumerinum Ellis & Arthur, 1889. *Bull. Indiana Agric. Stat.* 19: 9. **(Fig. 165a-b)**

Fungus Hyphomycete. *Colonies* effuse, olivaceous. *Conidiophores* macronematous, straight, sub-hyaline, smooth. *Conidiogenous cells* polybalstic, integrated, terminal, discrete, cylindrical, cicatrized scars are prominent. *Conidia* catenate, acropleurogenous, simple, ellipsoidal, ovoid, aseptate, protuberant scar at each end, sub-hyaline, smooth, ellipsoidal, 5-8 x 1.5-2.5 µm.

Specimen Examined: (i) On cattle dung, Chandreshwar hill, Goa, India; GUFCC No. 15236, Coll. by Sarita Yadav, 16.05.2007. (ii) On rabbit dung, cattle dung, Narvem, Goa, India, Coll. by Sarita Yadav, 12.09.2009.

Cladosporium spongiosum Berk. & M.A. Curtis, 1868. Berkeley, *J. Linn. Soc.*, Bot. 10(46): 362. **(Fig. 36)**

Fungus Hyphomycete. *Colonies* dark olivaceous brown, brown. *Conidiophores* short, semi-macronematous, simple, sub-hyaline, smooth, flexous, olivaceous, *Ramo-conidia* present, up to 60 µm. *Conidiogenous cells* cylindrical, smooth, olive green, straight, polyblastic, 25-50 x 2-4 µm. *Conidia* smooth, sub-hyaline, broadest in the middle, scar at the tips, at bottom varying sizes, fusiform-elliptical to cylindrical, 10-30 x 3-7 µm.

Specimen Examined: (i) On cattle dung, Karwar, Karnataka; GUFCC No. 15237, Coll. by Sarita Yadav, 20.10.2009. (ii) On Cattle dung, Chorla, Goa, India; GUFCC No. 15240, Coll. by Sarita Yadav, 15.09.2010. (iii) On cattle dung, Selaulim, Goa, India; 20.09.2010, Coll. by Sarita Yadav, GUFCC No. 15252.

***Cladosporium* sp.** **(Fig. 166)**

Fungus Hyphomycete. *Conidiophores* straight, macronematous, branched, septate, usually with groups of 2-3 scars at the apex, sub-hyaline, minutely verrucose, 250-300 x 3-5 µm. *Ramo-conidia* 25-30 µm long. *Conidiogenous cells* cylindrical, smooth, sub-hyaline, polybalstic, 10-15 x 2-4 µm. *Conidia* spherical, fusiform, ellipsoidal or oblong, very pale olive, smooth, septate.

Specimen Examined: (i) On cattle dung, Karwar, Karnataka, India, GUFCC No. 15448, Coll. by Sarita Yadav, 31.10.2007. (ii) On cattle dung, Aguada, Goa, India, GUFCC No. 15410, Coll. by Ashish Prabhugoankar, 15.11.2008.

Isolated by single spore isolation technique.

Curvularia clavata B.L. Jain, 1962. *Trans. Br. mycol. Soc.* 45(4): 542. **(Fig. 167)**

Fungus Hyphomycete. *Colonies* effuse, brown, grey. *Conidiophores* semi-macronematous, mononematous, straight, geniculate, 75-120 x 3-5 µm. *Conidiogenous cells* polytretic, integrated, terminal, later becoming intercalary, swollen, smooth, pale brown. *Conidia* dark brown, septate, smooth, ellipsoidal, three transverse septa, cells at the ends paler than those in the middle, 21-31 x 2-4.5 µm.

Specimen Examined: (i) On cattle dung, Netravali, Goa, India, GUFCC No. 15238, Coll. by Sarita Yadav, 10.10.2009. (ii) On goat dung, Siolim, Goa, India, GUFCC No. 15330, Coll. by Sarita Yadav, 21.03.2007.
Isolated by moist chamber incubation and particle-plating techniques.

Curvularia eragrostidis (Henn.) J.A. Mey., 1959. *Publ. Inst. nat. Étude agron. Congo belge*, Sér. sci. 75: 183. **(Fig. 168)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononemaotus, erect, straight, dark brown, unbranched, septate, smooth, 280-567 x 4-9 µm. *Conidiogenous cells* polytretic, terminal or intercalary, sympodial, integrated. *Conidia* 3-4 septate, phragmosprous, 20-25 x 12-20 µm.

Specimen Examined: (i) On cattle dung, Hahturlim, Goa, India; GUFCC No. 15250; Coll. by Sarita Yadav, 04.02.2008. (ii) On cattle dung, Verlem, Goa, India, GUFCC No. 15324; Coll. by Sarita Yadav, 17.09.2009.

Isolated by moist chamber incubation and particle plating techniques.

Curvularia fallax Boedijn, 1933. *Bull. Jard. bot. Buitenz*, 3 Sér. 13(1): 129. **(Fig. 169)**

Fungus Hyphomycete. Mycelium dark brown, smooth, septate. *Conidiophores* macronematous, mononematou,s erect, smooth, unbranched, septate, nodous, dark brown to blackish, 250-400 x 4-8 µm. *Conidiogenous cells* polytretic, intregated, terminal. Cicatrized. *Conidia* solitary, simple, slightly curved, smooth, with three transverse septa, pale brown to brown, central cells dark brown, 15-20 x 10-15 µm.

Specimen Examined: (i) On cattle dung, Jog falls, Karnataka, India; GUFCC No. 15122; Coll. by Sarita Yadav, 21.05.2010 (ii) On horse dung, Mahabaleshwar, Maharashtra, India; GUFCC No. 15310; Coll. by Sarita Yadav. (iii) On spotted dung, Bondla Wildlife Sanctuary, Goa, India; GUFCC No. 15225, Coll. by Sarita Yadav.

Isolated by moist chamber incubation and particle plating techniques.

Curvularia oryzae Bugnic., 1959. *Catalogue des Cryptogames*: 54. **(Fig. 40, 170)**

Fungus Hyphomycete. *Colonies* effuse, brown, grey. *Conidiophores* macronematous, mononematous, straight, geniculate, 102-120 x 4.5-5.5 µm. *Conidiogenous cells* polytretic, integrated, terminal, later becoming intercalary, swollen, smooth, pale brown. *Conidia* dark brown, septate, smooth, ellipsoidal, cells at the ends paler than those in the middle, 19-25 x 10.5-15 µm.

Specimen Examined: On cattle dung, Solye, Goa, India; GUFCC No. 15301, Coll. by Sarita Yadav, 26.09.2009. (ii) On rabbit dung, Siolim, India; GUFCC No. 15226. Coll. by Sarita Yadav.

***Curvularia* sp. 1** **(Fig. 171)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononematous, erect, denticulate, brown, two transverse septa present, 303-505 x 40-60 µm. *Conidiogenous cells* polytretic, integrated, terminal, brown, smooth, *Conidia* smooth, ellipsoidal, 4-septated, terminal cells paler than the middle cells, with a hilum, 15-30 x 2-4 µm.

Specimen Examined: On cattle dung, Anvali, Goa, India, GUFCC No. 15302, Coll. by Sarita Yadav. 19.03.2008, Coll. by Sarita Yadav, GUBH No. SY256.

***Curvularia* tax. sp. nov.** **(Fig. 172)**

Fungus Hyphomycete. *Colonies* effuse, dark brown. *Conidiophores* mononematous, macronematous, erect, pale brown, septate, unbranched, smooth, simple, 72-396 x 2-6 µm. *Conidiogenous cells* polytretic, integrated, terminal, smooth, sympodial, swollen, cicatrized, 8-31 x 4-6 µm. *Conidia* ellipsoidal, broader at the tip, pale to dark brown,

top and bottom cells, pale brown in colour, 3-4 septate, broad dark band at each septa, smooth, simple, solitary, acropleurogenous, solitary, 10-25 x 3-4 µm.

Specimen Examined: On cattle dung, Karwar, Karnataka, India, GUFCC No. 15303; Coll. by Sarita Yadav 26.11.2009.

Custingophora olivacea olivacea Stolk, Hennebert & Klopotek, in Stolk & Hennebert, *Persoonia* 5(2): 197 (1968) **(Fig. 173)**

Fungus Hyphomycete. *Colonies* effuse, olivaceous brown. *Conidiophores* macronematous, mononematous, flexous, unbranched, brown, smooth, swollen over the surfaceof which are borne numerous phialides, 175-250 x 2-5 µm. *Conidiogenous cells* monophialidic, discrete, determinate, 6-10 µm. *Conidia* aggregated in slimy heads, simple, oblong rounded at the ends or ovoid, hyaline or sub-hyaline, smooth, aseptate, 2-3 x 1-2 µm.

Specimen Examined: On Chausingha dung, Bondla wildlife sanctuary, Goa, India; GUFCC No. 15304; Coll. by Sarita Yadav.

Cylindrocarpon didymum (Harting) Wollenw., *Fusaria autographica delineata* 2: no. 650 (1924) **(Fig. 174)**

Fungus Hyphomycete. *Colonies* whitish, later brownish. *Conidiophores* erect, smooth, sub-hyaline, broader at the base, narrower towards the apex, 73-81 x 4 µm. *Conidiogenous cells* phialidic, cylindrical, integrated, terminal, 10-25 x 2-3 µm. *Conidia* fusiform, sub-hyaline, septate, egluttalate, macro and micro conidia, oval to ellipsoidal or cylindrical, slightly curved, 14-27 x 4-6 µm.

Specimen Examined: (i) On Cattle dung, Bhrass, Goa, India; GUFCC No. 15305, Coll. by Sarita Yadav, 11.11.2007. (ii) On Cattle dung, Poriem, Goa, India, GUFCC No. 15239, Coll. by Sarita Yadav, 122.09.2011.

Cylindrotrichum triseptatum Matsush., 1975. *Icon. microfung. Matsush. lect.* (Kobe): 48. **(Fig. 175)**

Fungus Hyphomycete. *Colonies* off-white, effuse, immersed. *Conidiophores* solitary, erect, simple, hyaline, thick-walled, septate, cylindrical, branched, elongated, 86-136 x 2-5 µm. *Conidiogenous* cells phialides, integrated, hyaline, 5-7 µm. *Conidia* cylindrical-ellipsoidal, smooth, rounded at the ends, triseptate, elliptical, gluttalate, aggregated, base truncate, 10-26 x 4.2-6.3 µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, India, 20.12.2007, GUFCC No. 15240. Coll. by Sarita Yadav.

***Didymostilbe* sp.** **(176 a-b)**

Fungus Hyphomycete. *Synnema* whole, 460-560 x 60 µm, broad at the base and apex, narrower at the middle of the conidiophores; stipe 440-460 x 40-60 µm. *Conidiogenous cells* blastic, hyaline; conidiopore hyaline, septate. *Conidia* elliptical, single septated, thick-walled, edges blunt, hyaline, smooth, mostly single, 12-21 x 4.2 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, 12.12.2008, Coll. by Sarita Yadav, GUFCC No. 15241.

Doratomyces purpureofuscus (Schwein.) F.J. Morton & G. Sm., 1963. *Mycol. Pap.* 86: 74. **(Fig. 177)**

Fungus Hyphomycete. Synnnema brownish, solitary to sometimes in a group of two, up to 700-950 µm long. *Colonies* effuse, grey, brown, brownish-black. *Conidiophores* macronematous, synnematous, dark brown to black, threads straight to flexous, smooth, branched towards the apex with branches forming a head. *Conidiogenous cells* annellidic, integrated, terminal on branches, penicillately arranged, percurrent. *Conidia* catenate, dry, acrogenous, simple, ellipsoidal, ovoid, sub-spherical, truncate at the base, aseptate, 5-7 x 3-4 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, 12.12.2008, Coll. by Sarita Yadav, GUFCC No. 15241.

Doratomyces columnaris H.J. Swart, 1967. *Acta bot. neerl.* 15(3): 521.
(Fig. 42, 178 a-b)

Fungus Hyphomycete. *Colonies* effuse, grey, brown, brownish-black. Synnema brownish, solitary to sometimes in a group of two, 63-99 µm long. *Conidiophores* macronematous, synnematous, dark brown to black, threads straight to flexous, smooth, branched towards the apex with branches forming a head. *Conidiogenous cells* annellidic, integrated, terminal on branches, penicillately arranged, percurrent, 10-17 x 2-3 µm. *Conidia* catenate, dry, acrogenous, simple, ellipsoidal, ovoid, sub-spherical, truncate at the base, aseptate, 4-7 x 3-4 µm.

Specimen Examined: On cattle dung, Pansuli, Goa, 07.07.2009, Coll. by Sarita Yadav, GUBH No. SY201.

Doratomyces stemonitis (Pers.) F.J. Morton & G. Sm., 1963. *Mycol. Pap.* 86: 70. **(Fig. 179)**

Fungus Hyphomycete. *Colonies* effuse, grey, brown, brownish-black. Synnema brownish, solitary to sometimes in a group, 900-1200 µm long. *Conidiophores* macronematous, synnematous, dark brown to black, threads straight to flexous, smooth, branched towards the apex with branches forming a head. *Conidiogenous cells* annellidic, integrated, terminal on branches, penicillately arranged, percurrent, 8-25 x 3-4 µm. *Conidia* catenate, dry, acrogenous, simple, ellipsoidal, ovoid, sub-spherical, truncate at the base, aseptate, 6-8 x 4-5 µm.

Specimen Examined: On cattle dung, Verler, Goa, India, GUFCC No. 15241, Coll. by Sarita Yadav, 29.11.2007.

***Doratomyces* sp.** **(Fig. 180)**

Fungus Hyphomycete. *Colonies* effuse, grey, brown, brownish-black. Synnema brownish, solitary to sometimes in a group, 100-130 µm long. *Conidiophores* macronematous, synnematous, dark brown to black, threads straight to flexous,

smooth, branched towards the apex with branches forming a head. *Conidiogenous cells* annellidic, integrated, terminal on branches, penicillately arranged, percurrent, 8-25 x 3-4 µm. *Conidia* catenate, dry, acrogenous, simple, ellipsoidal, ovoid, sub-spherical, truncate at the base, aseptate, 4-8 x 4-5 µm.

Specimen Examined: On cattle dung, Siolim, Goa, 17.04.2007, Coll. by Sarita Yadav, GUBH No. 15242.

Drechslera hawaiiensis Bugnic. ex Subram. & B.L. Jain, 1966. *Curr. Sci.* 35: 354. **(Fig. 181)**

Fungus Hyphomycete. *Colonies* effuse, blackish black to brown. *Conidiophores* macronematous, mononematous, solitary, unbranched, brown. flexous, denticulate, septate, tip hyaline at the edges, 170-600 x 42 µm. *Conidiogenous cells* polytretic, integrated, terminal, sympodial, cylindrical. *Conidia* straight, ellipsoidal, oblong, rounded at the ends, brownish-green, smooth, 2-4 pseudoseptate, 12-22 x 8-15 µm.

Specimen Examined: On cattle dung, Bondla Wildlife Sanctuary, Goa, India, Coll. by Sarita Yadav, GUFCC No. 22.05.2007.

Fusarium semitectum Berk. & Ravenel, 1875. in Berkeley, *Grevillea* 3(27): 98. **(Fig. 182)**

Fungus Hyphomycete. *Conidiophores* short, branched, sub-hyaline, septated. *Conidiogenous cells* at first produce conidia from single apical pores, later becoming polyblastic sympodial, polyphialide cells. *Conidia* 3-7 septate, fusiform, straight or somewhat curved, borne on loosely branched conidiophores, 17-28 x 2-4 µm. Macroconidia borne from loosely branched conidiophores or from short lateral phialides in young aerial mycelium.

Specimen Examined: On cattle dung, Tambdi Surla, Goa, 18.07.2009, Sarita Yadav, GUBH No. SY352.

Isolated by moist chamber incubation technique.

Fusarium chlamydosporum Wollenw. & Reinking, 1925. *Phytopathology* 15: 156. **(Fig. 183)**

Fungus Hyphomycete. Conidiophores scattered over the aerial mycelium, branched. Conidiogenous cells phialides with numerous sympodial proliferations (denticles) bearing one micro-conidium on each opening. Micro-conidia accumulating in dry heads, fusiform or elongate, 8-10 x 3-5 µm. Macro-conidia 3-5 septate, slightly septate, slightly curved, 30-38 x 3-5 µm.

Specimen Examined: On goat dung, Taliegao, Goa, 02.01.2009, Sarita Yadav, GUBH No. SY263.

Fusarium sp. **(Fig. 43)**

Fungus Hyphomycete. Conidiophores scattered over the aerial mycelium, branched. Conidiogenous cells phialides with numerous sympodial proliferations (denticles) bearing one micro-conidium on each opening. Micro-conidia accumulating in dry heads, fusiform or elongate, 6-10 x 4-6 µm. Macro-conidia 3-5 septate, slightly septate, slightly curved, 30-38 x 3-5 µm.

Geomyces **tax. sp. nov.** **(Fig. 186)**

Fungus Hyphomycete. Colonies white, later pale brown. *Conidiophores Conidia* hyaline, spherical, aseptate, 3-4 µm. Thallic conidia borne terminally on verticillate branches, intergrading with intercalary conidia or borne laterally. Intercalary conidia borne on the outer branches of the verticillate hyphae, alternate, separated by short, mostly broad than long sterile hyphal segments, in series, olivaceous green, smooth-walled, thin walled.

Specimen Examined: On cattle dung, Kankumbi, Karnataka, 10.06.2007, Sarita Yadav, GUBH No. 15244.

Geotrichum candium Link, 1809. *Mag. Gesell. naturf. Freunde, Berlin* 3(1-2): 17 **(Fig. 187)**

Fungus Hyphomycete. Colonies white, smooth. *Conidiophores* hyaline, smooth, often indistinguishable from the vegetative stage, integrated, micronematous. *Conidiogenous cells* thallic. *Conidia* catenate, unbranched, sub-hyaline, smooth, catenate, arthroconidia, 6.3-12.5 x 3-6.5 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, 20.10.2009, Sarita Yadav, GUBH No. 15245.

***Geotrichum* sp. 1** **(Fig. 188a)**

Fungus Hyphomycete. *Colonies* white, smooth. *Conidiophores* hyaline to sub-hyaline, smooth, indistinguishable from the vegetative stage, integrated, micronematous. *Conidiogenous cells* thallic. *Conidia* elliptical, smooth, sub-hyaline, arthroconidia, 5-10 x 3-4 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, 20.10.2009, Sarita Yadav, GUBH No. 15246.

***Geotrichum* sp. 2** **(Fig. 188)**

Fungus Hyphomycete. *Conidiophores* hyaline, smooth, cylindrical, septate, indistinguishable from the vegetative stage, integrated, micronematous. *Conidia* hyaline, cylindrical, an attachment point like at the tip, smooth, egluttalate, unbranched, sometimes catenate to solitary, aseptate, arthroconidia, 6-19 x 1-3 µm.

Specimen Examined: On cattle dung, Valpoi, Goa, 20.10.2009, Sarita Yadav, GUBH No. 15247.

***Geniculosporium* sp.** **(Fig. 189)**

Fungus Hyphomycete. *Colonies* effuse, grey, brown. *Conidiophores* macronemaotus, mononematous, branched, hyaline to sub-hyaline, smooth. *Conidiogenous cells*

polyblastic, integrated and terminal on branches or discrete, geniculate, short denticulate. *Conidia* solitary, dry, simple, ellipsoidal, hyaline to sub-hyaline, aseptate, 7-8 x 4-12 µm.

Specimen Examined: On cattle dung, Quepem, Goa, 03.02.2007, Sarita Yadav, GUFCC No. 15248.

Gilmaniella humicola G.L. Barron, 1964. *Mycologia* 56(4): 514. **(Fig. 190)**

Fungus Hyphomycete. *Hyphae* hyaline, smooth, septated, short. *Conidia* acropleurogenous, solitary, dry, spherical to little obvate, smooth, light brown, outer wall thick, young spores hyaline, later sub-hyaline turns to light brown, germ pore present, 9-12.5 µm.

Specimen Examined: On cattle dung, Quepem, Goa, 03.02.2007, Sarita Yadav, GUFCC No. 15249.

Isolated by the moist chamber incubation technique.

***Gliocephalis* sp.** **(Fig. 191a-b)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononematous, solitary, erect, straight to slightly flexous, smooth, usually erect, smooth, aseptate, light brown. *Conidiogenous cells* monophialidic, discrete, uniseriate, light green, smooth, hyaline. Vesicle globose, brown, 15-20 µm in diam. *Conidia* catenate, simple, globose, pale green, 20-25 µm in diam.

Specimen Examined: On cattle dung, Siolim, Goa, 10.12.2008, Sarita Yadav, GUFCC No. 15250.

***Goidenichiella* sp.** **(Fig. 192)**

Fungus Hyphomycete. *Conidiophores* pale brown, smooth, erect, later bend just above the base, solitary, sometimes branched, bulbous point at the conidiophore.

Conidiogenous cells phialidic, hyaline, aggregated, 8-12 x 2.1 µm. *Conidia* hyaline, smooth, solitary, 2.1-6.3 µm diam.

Specimen Examined: On cattle dung, Siolim, Goa, 10.12.2008, Sarita Yadav, GUFCC No. 15251.

***Gonatobotryum* sp.** **(Fig. 193)**

Fungus Hyphomycete. *Conidiophores* up to 300-500 x 9-10 µm, macronematous, mononematous, unbranched, flexous, intercalary conidiogenous ampullae, often swollen at the base, pale to dark brown. *Conidiogenous cells* polytretis, integrated, terminal becoming intercalary, percurrent. *Conidia* catenate, dry, acronematous, simple, ellipsoidal, limoniform, smooth, aseptate, sub-hyaline to brown, smooth, elliptical, aseptate, 3-4 x 2-3 µm.

Specimen Examined: On cattle dung, Chandranath hill, Goa, 07.01.2008, Sarita Yadav, GUBH No. SY241.

***Graphilbum* sp.** **(Fig. 194)**

Fungus Hyphomycete. *Colonies* effuse, olivaceous brown. *Synnemata* up to 700 µm long. *Conidiophores* macronematous, synnematous, each synnema capped by a slimy head, straight to flexuous, pale brown, smooth. *Conidiogenous cells* annelidic, percurrent, integrated or discrete, cylindrical. *Conidia* simple, straight, cylindrical, rounded at the apex, ellipsoidal, usually with a flat base, colourless or pale olivaceous brown, smooth, 0-septate, 9-14 x 2-4 µm.

Specimen Examined: On cattle dung, Chandranath hill, Goa, 07.01.2008, Sarita Yadav, GUFCC No. 15253.

Graphium putredinis (Corda) S. Hughes, 1958. *Can. J. Bot.* 36: 770. **(Fig. 195)**

Fungus Hyphomycete. *Colonies* effuse, olivaceous brown. Synnemata up to 700 µm long. *Conidiophores* macronematous, synnematous, each synnema capped by a slimy

head, straight to flexuous, pale brown, smooth, branches penicillate. *Conidiogenous cells* monoblastic, percurrent, integrated or discrete, cylindrical. *Conidia* simple, straight, cylindrical, rounded at the apex, ellipsoidal, usually with a flat base, colourless or pale olivaceous brown, smooth, aseptate, 5-8 x 2 µm.

Specimen Examined: On cattle dung, Chimbel, Goa, 20.02.2007, Sarita Yadav, GUFCC No. 15254.

***Graphium* sp. 1** **(Fig. 196)**

Fungus Hyphomycete. Synnemata up to 1000-1100 µm long. *Conidiophores* macronematous, synnematous, each synnema capped by a slimy head, straight to flexuous, pale brown, smooth, branches penicillate. *Conidiogenous cells* monoblastic, percurrent, integrated or discrete, cylindrical. *Conidia* simple, straight, cylindrical, rounded at the apex, ellipsoidal, usually with a flat base, colourless or pale olivaceous brown, smooth, aseptate, 4-5 x 2-3 µm.

Specimen Examined: On cattle dung, Chopdem, Goa, 17.04.2007, Sarita Yadav, GUFCC No. 15255.

***Graphium* sp. 2** **(Fig. 196b)**

Fungus Hyphomycete. Synnemata up to 680-800 x 21 µm long. *Conidiophores* macronematous, synnematous, each synnema capped by a slimy head, straight to flexuous, pale brown, smooth, branches penicillate. *Conidiogenous cells* monoblastic, percurrent, integrated or discrete, cylindrical. *Conidia* simple, straight, cylindrical, rounded at the apex, ellipsoidal, usually with a flat base, colourless or pale olivaceous brown, smooth, aseptate, 8-18 x 4-6 µm.

Specimen Examined: On cattle dung, Tambdi Surla, Goa, India, GUBH No. 337, Coll. by Sarita Yadav, 18.06.2009GUBH No. SY337.

Harposporium anguillulae Lohde, 1874. *Tageblatt der 47 Versammlung deutscher Naturhüscher und Artze in Breslau* 47: 203-206. **(Fig. 197)**

Fungus Hyphomycete. *Conidiophores* integrated, hyaline, smooth. *Conidiogenous Cells* phialiadic, integrated, vase-shaped, broad at the centre, narrow towards at the apex, smooth. *Conidia* sickle-shaped, hyaline, aseptate, 5-6 x 1 µm.

Specimen Examined: On cattle dung, Chandreshwar hill, Goa, 15.07.2007, Coll. by Sarita Yadav, GUFCC No. 15256.

***Haplographium* sp.** **(Fig. 198)**

Fungus Hyphomycete. *Conidiophores* synnematous, smooth, unbranched, erect, straight, light brown. Synnema about 785 µm long. *Conidiogenous cells* sub-hyaline, blastic. *Conidia* catenate, smooth, 0-3 septate, cylindrical, hyaline, 2-6 x 12-28 µm.

Specimen Examined: On cattle dung, Jog falls, Karnataka, 23.04.2009, Coll. by Sarita Yadav, GUFCC No. 15257.

***Lomachashaka gomaya* sp. nov.** S.K. Yadav & Bhat, 2009. *Mycotaxon* 110: 358 **(Fig. 199a-b)**

Colonies slow growing, attaining a diam. of 4mm in 20 d in 2% malt extract agar (HiMedia, India), mycelium white, floccose, becoming cottony after 12 days in diurnal light at 22–24°C. As on the natural substrate, sporodochia in culture are superficial, scattered or in groups of 2–3, dark green to greenish black, 200–235 diam. × 150–160 µm high. *Setae* numerous, unbranched, hyaline, smooth, thick-walled, verrucose at the swollen base, blunt to rounded at the tip, septate, cells with reduced lumen, 110–190 µm long, 6–6.5 µm wide. *Conidiophores* integrated, subhyaline, verrucose, septate, penicillately branched, 75–95 × 2.0–8.5 µm. *Conidiogenous cells* integrated, monophialidic, verruculose, subhyaline, 8–14.5 × 2 µm, with conspicuous collarette and moderate periclinal thickening at the tip. *Conidia*

fusiform-ellipsoidal with an acute apex, unicellular, subhyaline (in mass olivaceous-green), smooth, 6.5–8.5 × 2.5–3.5 µm, with a funnel-shaped, cupulate, mucoid, hyaline, 2–3 µm wide

Holotype: On cow dung, Yana, Uttara Kannada District, Karnataka State, India, Coll. by Ashish Prabhugaonkar 27.07.2008, Herb. No. HCIO 49196

Memnoniella echinata (Rivolta) Galloway, 1933. *Trans. Br. mycol. Soc.* 18(2): 165. **(Fig. 200)**

Fungus Hyphomycete. *Conidiophores* macronematous, mononematous, unbranched, sometimes swollen at the apex, olivaceous or brown, minutely verrucose, hyaline, smooth, lower portion light whereas upper portion dark, greenish-black, minutely verruculose, curved bended, 20-55 x 2-4 µm. *Conidiogenous cells* monophialiadic, discrete, no collarette, pale brown, pale brown, clavate-shaped, 7.3-12 x 6 µm. *Conidia* catenate, acrogenous, simple, sub-spherical to spherical, dark brown to black, verrucose, spherical, solitary to in groups, sometimes aggregated, 5.3-7.5 µm.

Specimen Examined: On cattle dung, Keri, Goa, 07.01.2008, Coll. by Sarita Yadav, GUFCC No. 15258.

Microsporum appendiculata Bhat & Miriam, 1998. Miriam & Bhat, *Kavaka* 25: 93 (1998) **(Fig. 46)**

Fungus Hyphomycete. *Conidiophores* micronematous, hyaline, integrated, determined. *Conidiogenous cells* blastic, hyaline, integrated. *Conidia* elliptical, verrucose, septated with an appendiculate, 3-5 sepated, 35-45 x 8.5-12 µm. Appendiculates thin, erect, aseptate, hyaline, straight to curved, 17-30 µm.

Specimen Examined: On goat dung, Siolim, Goa, 27.11.2007, Coll. by Sarita Yadav, GUFCC No. 15259.

Microsporum sp. **(Fig. 201)**

Fungus Hyphomycete. *Conidiophores* micronematous, hyaline, integrated, determined. *Conidiogenous cells* blastic, hyaline, integrated. *Conidia* elliptical, verrucose, septated with an appendiculate, 3-5 sepated, 20-35 x 9-12 µm.

Specimen Examined: On goat dung, Siolim, Goa, India, Coll. by Sarita Yadav, GUFCC No. 15259, 27.11.2007

Myrothecium advena SGUBH, 1908. *Annls mycol.* 6(6): 560. **(Fig. 202)**

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia surrounded by a zone of white, flocculent, 330-550 long. *Setae* absent. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight, hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, smooth, 5-6 x 1-3 µm. *Conidia* aggregated in dark green, slimy masses, ellipsoidal, olivaceous green, 5-7 x 1-3 µm.

Specimen Examined: On goat dung, Siolim, Goa, 13.09.2008, Coll. by Sarita Yadav, GUFCC No. 15260.

Myrothecium gramineum Lib., 1837. *Pl. crypt. Arduenna*, fasc. (Liège) 4: no. 380. **(Fig. 203)**

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia surrounded by a zone of white, flocculent, 120-137 x 50-97 µm. *Setae* thick-walled, sub-hyaline, smooth, broad at the base, pointed towards the apex, no swelling in between, 162-364 x 2-4 µm. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight, hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, smooth, 5-6 x 1-3 µm. *Conidia* aggregated in dark

green, slimy masses, ellipsoidal, olivaceous green, little blunt at the apex, aseptate, 7-10 x 1-2 µm.

Specimen Examined: On goat dung, Siolim, Goa, 20.10.2009, Coll. by Sarita Yadav, GUFCC No. 15261.

Myrothecium indicum P.Rama Rao, 1963. *Antonie van Leeuwenhoek* 29: 180.
(Fig. 204)

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia surrounded by a zone of white, flocculent, 747-1010 x 404-505 µm. *Setae* present, unbranched, colourless, 250 x 2-4 µm. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight, hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, clavate. *Conidia* aggregated in dark green, slimy masses, ellipsoidal, olivaceous green, 8-11 x 4 µm.

Specimen Examined: On cattle dung, Karwar, Karnataka, 15.10.2007, Coll. by Sarita Yadav, GUFCC No. 15262.

Myrothecium roridum Tode, 1790. *Fung. mecklenb. sel.* (Lüneburg) 1: 25
(Fig. 205)

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia surrounded by a zone of white, flocculent, 150-650 long. Setae absent. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight, hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, smooth, 9-10 x 3-4 µm. *Conidia* aggregated in dark green, slimy masses, ellipsoidal, olivaceous green, 8-10 x 2-4 µm.

Specimen Examined: On cattle dung, Karwar, Karnataka, 15.10.2007, Coll. by Sarita Yadav, GUFCC No. 15263.

Myrothecium **sp. 1** **(Fig. 206)**

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia, *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight, hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, clavate. *Conidia* aggregated, in dark green, slimy masses, ellipsoidal, sub-hyaline, smooth, 4-6 x 2-3 µm.

Specimen Examined: On cattle dung, Cansaulim, Goa, 27.04.2009, Coll. by Sarita Yadav, GUFCC No. 15264.

Myrothecium **sp. 2** **(Fig. 207)**

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia surrounded by a zone of white, flocculent, 747-1010 x 404-505 µm. *Setae* present, unbranched, colourless, 250 x 2-4 µm. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight, hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, clavate. *Conidia* aggregated in dark green, slimy masses, ellipsoidal, olivaceous green, 5-6 x 2-3 µm.

Specimen Examined: On goat dung, Taligao Plateau, Goa, 19.08.2007, Coll. by Sarita Yadav, GUFCC No. 15265.

Myrothecium **sp. 3** **(Fig. 208)**

Fungus Hyphomycete. *Sporodochia* sessile, green mass of conidia surrounded by a zone of white, flocculent, 80-95 x 94 µm. *Setae* thick-walled, sub-hyaline, smooth, broad at the base, pointed towards the apex, no swelling in between, 162-364 x 2-4 µm. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochia, branched, with the branches apical and arranged penicillately, straight,

hyaline, smooth, broad at the base, taperimg at the tip. *Conidiogenous cells* phialiadic, discrete, cylindrical, smooth, 5-6 x 1-3 µm. *Conidia* aggregated in dark green, slimy masses, ellipsoidal, olivaceous green, little blunt at the apex, aseptate, 5-7 x 1-3 µm.

Specimen Examined: On horse dung, Mahabaleshwar, Maharashtra, 22.09.2009, Coll. by Sarita Yadav, GUFCC No. 15266.

***Myrothecium* sp. 4** **(Fig. 209)**

Fungus Hyphomycete. *Colonies* on MEA slow growing, attaining a diam. of 3 cm in 7 days, irregular, convex colony, aerial mycelium present, white. *Conidiophores* macronematous, mononematous, closely packed together to form sporodochium. *Sporodochia* sessile 75-90 x 5-7 µm. *Conidiogenous cells* monophialidic, discrete, cylindrical. Sub-hyaline to green. *Conidia* ellipsoidal to cylindrical, rounded at the apex, 2-5 x 2-3 µm.

Specimen Examined: On cattle dung, Dudh Sagar, Goa, 16.07.2008, Coll. by Sarita Yadav, GUFCC No. 15267.

***Myrothecium* sp. 5** **(Fig. 210)**

Fungus Hyphomycete. *Conidiomata* sporodochia. *Sporodochia* sessile. Superficial, olivaceous green. *Setae* hyaline, smooth, aseptate, 205-243 x 3-5 µm. *Conidia* ellipsoidal, tapering at the ends, aseptate, hyaline to pale green, 4-8 x 1-2 µm.

Specimen Examined: On cattle dung, Sanquelim, Goa, 25.05.2009, Coll. by Sarita Yadav, GUFCC No. 15268.

Oedocephalum elegans Preuss, 1851. *Linnaea* 24:-131. **(Fig. 48, 211)**

Fungus Hyphomycete. *Colonies*, hyaline, whitish, later turns into pinkish. *Conidiophores* erect, usually solitary, unbranched, hyaline, septate, smooth, terminating into a swollen, obovoid vesicle which is often cut by a septa, 90-280 x 6-8

µm. *Vesicle* covered with vesicle, minute denticles seen after conidium detachment, 12-25 µm. *Conidia* aseptate, hyaline, oblong-elliptical, solitary, eguttalate, minutely verrucose, 7-10 x 6-7 µm.

Specimen Examined: On cattle dung, Sirvari, Goa, 28.09.2009, Coll. by Sarita Yadav, GUBH No. SY293.

***Ovularia* sp.** **(Fig. 211)**

Fungus Hyphomycete. *Conidiophores* hyaline to sub-hyaline, septated, smooth, erect, 33-3.µm. *Conidia* obovoid, apexed at the tip, grown in groups, attached to conidiophores, hyaline, aseptate, egluttalate, smooth, 4-7 x 3 µm.

Specimen Examined: On cattle dung, Poryem, Goa, 20.07.2008, Coll. by Sarita Yadav, GUBH No. SY218.

Paecilomyces dahlia **(Fig. 49, 212)**

Fungus Hyphomycete. *Conidiophores* erect, hyaline throughout, with several whorls of phialides, smooth, elongated, septate, 46-105 x 2 µm. *Conidiogenous cells* phialiadic, hyaline, smooth, broad at the base-tapered towards the apex, 19-33 x 2-4 µm. *Conidia* hyaline, smooth, aseptate, coming from conidiogenous cells, 3-5 x 2 µm.

Specimen Examined: On cattle dung, Diggiwado, Goa, 20.07.2008, Coll. by Sarita Yadav, GUBH No. SY218.

Paecilomyces variotii Bainier, 1907. *Bull. Soc. mycol. Fr.* 23(1): 27. **(Fig. 213)**

Fungus Hyphomycete. *Conidiophores* erect, long, repeatedly verticillate, greenish-brown, septate, sub-hyaline, olivaceous green, smooth, 607 x 2 µm. *Conidiogenous cells* in whorls, phialides, smooth, sub-hyaline, apexed at tip, 10-17 x 2 µm. *Conidia* sub-hyaline, ellipsoidal, sub-hyaline, smooth, 3-5 x 2-4 µm.

Specimen Examined: On cattle dung, Fatropa, Goa, 16.06.2008, Coll. by Sarita Yadav, GUFCC. No.

Papulaspora immersa Hotson, 1912. *Proc. Amer. Acad. Arts & Sci.* 48: 173 **(Fig. 214)**

Fungus Hyphomycete. *Papulaspores* originating from intercalary cells, pale brown, irregular in outline, 80-105 µm in diam., central cells present, comparatively large, 25-55 µm diam., darker than the peripheral cells.

Specimen Examined: On cattle dung, Amboli, Maharashta, 20.04.2009, Coll. by Sarita Yadav, GUFCC No. 15277.

Penicillium atrovenetum G. Sm., 1956. *Trans. Br. mycol. Soc.* 39(1): 112. **(Fig. 215)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight, branched, septate, greenish, smooth, branched, 78-115 x 4 µm. *Conidiogenous cells* phialiadic, 6-10 x 4 µm. *Conidia* globose, greenish, hyaline, catenate, numerous, dry, diam. 3-4 µm.

Specimen Examined: On cattle dung, Gaundongrem, Goa, 17.11.2007, Coll. by Sarita Yadav, GUFCC No. 15276.

Penicillium decumbens Thom, 1910. *Bull. U.S. Department of Agriculture, Bureau Animal Industry* 181: 71. **(Fig. 216)**

Fungus Hyphomycete. *Conidiophores* mononematous, smooth, unbranched, septate, greenish erect, sub-hyaline, olivaceous, 50-100 µm. catenate. *Conidiogenous cells* phialidic. *Conidia* sub-hyaline, olive-green, smooth, catenate, diam. 2-3 µm.

Specimen Examined: On goat dung, Karwar, Karnataka, 17.11.2007, Coll. by Sarita Yadav, GUFCC No. 15275.

***Penicillium* sp. 1** **(Fig. 217)**

Fungus Hyphomycete. *Conidiophores* mononematous, erect, smooth, branched, septate, greenish, 135-200 x 4 µm. *Conidiogenous cells* phialidic, penicillus, discrete, terminal, cylindrical, ampullate. *Conidia* greenish brown, ellipsoidal, smooth walled, catenate, 3 x 2-3 µm.

Specimen Examined: (i) On goat dung, Karwar, Karnataka, India, 06.12.2009, Coll. by Sarita Yadav, 06.12.2009. (ii) On spotted deer, Bondla Wildlife sanctuary, Goa, India, 09.08.2007, Coll. by Sarita yadav, 04.02.2010.

***Penicillium* sp. 2** **(Fig. 218)**

Fungus Hyphomycete. *Conidiophores* mononematous, erect, smooth, unbranched. *Conidiogenous cells* phialidic. *Conidia* sub-hyaline, pale green, smooth, ellipsoidal to circular, catenate, 2.5-4 x 2.5-3.5 µm.

Specimen Examined: On cattle dung, Amboli, Maharashtra, India, GUFCC No. 15273, Coll. by Sarita Yadav, 28.10.2008.

Periconia byssoides Pers., 1801. *Syn. meth. fung.* (Göttingen) 1: 18. **(Fig.219)**

Fungus Hyphomycete. *Conidiophores* solitary, macronematous, mononematous, with a stipe and a head, branches absent, septated, brown, dark brown at the base, 880 x 10 µm. *Conidiogenous cells* blastic, discrete, determinate, ellipsoidal. *Conidia* catenate, arising from one of the points on the curved surface of the conidiogenous cells, spherical, brown, verrucose, aseptate, 10-15 µm.

Specimen Examined: (i) On cattle dung, Netravali, Goa, India, GUFCC No. 15317, Coll. by Sarita Yadav, 27.11.2008.

Phialophora cyclaminis J.F.H. Beyma, 1942. *Antonie van Leeuwenhoek* 8: 115. **(Fig. 220)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight to flexous, branched, smooth, olivaceous green. *Conidiogenous cells* phialidic, terminal, discrete, ampulliform, hyaline, smooth, 15-30 x 3-4.5 µm, broader at the base, narrow thereafter; collarette darker than the conidiogenous cells. *Conidia* spherical, smooth, round, sub-hyaline, 1-2.5 µm diam.

Specimen Examined: (i) On cattle dung, Bicholim, Goa, GUFCC No. 15268, Coll. by Sarita Yadav, 16.02.2007. (ii) On spotted deer dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15467, Coll. by Sarita Yadav, 12.02.2009.

Isolated by moist chamber incubation and particle plating technique.

Phialophora phaeophora W. Gams, Gams & Holubová-Jechová, 1976. *Stud. Mycol.* 13: 65. **(Fig. 51)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight, greenish-brown smooth, erect, straight, olivaceous, green to brown, 150-250 x 3-4 µm. *Conidiogenous cells* Phialidic, integrated, terminal, percurrent, calyciforms, whorls. *Conidia* pale brown, simple, aseptate, catenate, 3-4 x 2-3 µm.

Specimen Examined: On cattle dung, Ugem, Sanguem, Goa; India, GUFCC No. 15208, Coll. by Sarita Yadav, 14.12.2007

Isolated by moist chamber incubation and particle-plating technique.

Phialophora richardsiae (Nannf.) Conant, 1937. *Mycologia* 29(5): 598. **(Fig. 221)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight to flexous, branched, smooth, sub-hyaline, pale brown, wide collarette, borders darker than inside, smooth. Conidiogenous cells phialidic, terminal, discrete, ampulliform, sub-hyaline, collerette present, two kinds of phialides present: primary and secondary phialides. Primary phialides pale brown with inconspicuous, dark brown, ellipsoidal, sub-hyaline, 2-4 x 1-3 µm. Secondary phialide globose or sub-globose. *Conidia* globose to sub-globose, sub-hyaline, aseptate, smooth, in groups to solitary, 2-5 x 1-3 µm.

Specimen Examined: (i) On cattle dung, Netravali, Goa, India, GUFCC No. 15315, Coll. by Sarita Yadav, 18.05.2007. (ii) On Sambar dung, Yana, Karnataka, India; GUFCC No. 14900, Coll. by Sarita yadav, 12.10.2009.

***Phialophora* sp. 1** **(Fig.51, 222)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight to flexous, branched, smooth, olivaceous green. *Conidiogenous cells* phialidic, terminal, discrete, ampulliform, hyaline, smooth, present on both the sides of the conidiophores, 10-13 x

2-3.5 µm, broader at the base, narrow thereafter; collarette darker than the conidiogenous cells. *Conidia* spherical, smooth, round, sub-hyaline, 1-2.5 µm diam.

Specimen Examined: (i) On horse dung, Mahabaleshwar, Maharashtra, India, GUFCC No. 15269, Coll. by sarita Yadav, 12.05.2008. (ii) On cattle dung, Valpoi, Goa, India, GUFCC No. 15216; Coll. by Sarita Yadav, 14.09.2010.

Isolated by moist chamber technique.

***Phialophora* sp. 2** **(Fig. 223)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight to flexous, branched, smooth, sub-hyaline. *Conidiogenous cells* phialidic, terminal, discrete, ampulliform, sub-hyaline, collerette present 10-15 x 4.5 µm. Conidia globose to sub-globose, sub-hyaline, aseptate, smooth, in groups to solitary, 2-3 x 3 µm.

Specimen Examined: (i) On elephant dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15267, Coll. by Sarita Yadav, 13.06.2009. (ii) On rabbit dung, Sanquelim, Goa, India, GUFCC No. 15421; Coll. by Sarita Yadav, 12.03.2009.

Isolated by moist chamber technique.

***Phialophora* sp. 3** **(Fig. 224)**

Fungus Hyphomycete. *Conidiophores* mononematous, straight to flexous, branched, smooth, hyaline to sub-hyaline. *Conidiogenous cells* phialidic, terminal, discrete, ampulliform, hyaline, smooth, present on both the sides of the conidiophores, 20-27 x 2-4 µm, broader at the base, narrow thereafter; collarette darker than the conidiogenous cells. *Conidia* spherical, smooth, round, hyaline, aseptate, in clumps 1.5-2.5 µm diam.

Specimen Examined: On cattle dung, Jog falls, Karnataka, India; GUFCC No. 15270; Coll. by Sarita Yadav, 22.07.2009.

Isolated by moist chamber technique.

***Phialophora* sp. 4** **(Fig. 52**

Fungus Hyphomycete. *Conidiophores* mononematous, straight to flexous, branched, smooth, pale brown, 12-20 x 3.5 µm. *Conidiogenous cells* phialidic, terminal, discrete, ampulliform, hyaline, smooth 12-19 x 3.5 µm. *Conidia* globose, sub-hyaline, smooth, in group (accumulated), diam. 2.5-3.5 µm.

Specimen Examined: (i) On cattle dung, Siolim, Goa, India; GUFCC No. 15267, Coll. by Sarita Yadav, 08.08.2009. (ii) On goat dung, Siolim, Goa, India, GUFCC No. 15333, Coll. by Sarita Yadav, 18.03.2008.

Isolated by Moist chamber incubation.

***Rhinotrichum* sp.** **(Fig. 225a-b)**

Fungus Hyphomycete. *Colonies* white to creamish. Sterile mycelium hyaline, branched, anastomosing, septate. *Conidiophores* simple, erect, hyaline, septate, terminal cells apiculate, flat-topped pegs to bear conidia, 4-6 x 1-2 µm. *Conidia* hyaline, smooth, aseptate, solitary to hyaline, ellipsoidal to pyriform, 3-5 x 2-3 µm.

Specimen Examined: (i) On cattle dung, Marcaim, Goa, India, GUFCC No. 15367, Coll. by Sarita Yadav, 12.05.2008. (ii) On Black Buck deer, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15412, Coll. by Sarita Yadav, 12.09.2009.

Isolated by particle plating technique.

***Sarocladium* sp.** **(Fig. 226)**

Fungus Hyphomycete. *Conidiophores* short, branched, sub-hyaline, septated, 6-10 x 4 µm. *Conidiogenous cells* at first produce conidia from single apical pores, later becoming polyblastic sympodial, polyphialide cells, 52-60 x 4 µm. *Macroconidia* borne from loosely branched conidiophores or from short lateral phialides in young aerial mycelium. *Conidia* 3-7 septate, fusiform, straight or somewhat curved, borne on loosely branched, 8-21 x 4-6 µm.

Specimen Examined: On cattle dung, Tambdi Surla, Goa, India, GUFCC No. 15446, coll. by Sarita Yadav, 18.06.2009

Scolecobasidium constrictum E.V. Abbott, 1927. *Mycologia* 19(1): 30. **(Fig. 227)**

Fungus Hyphomycete. *Colonies* effuse, grey to brownish. *Conidiophores* macronematous, mononematous, often short, unbranched, straight, olivaceous, smooth, 18-30 x 2 µm. *Conidiogenous cells* polyblastic, integrated, sympodial, sub-hyaline, cylindrical, clavate, denticulate. *Conidia* solitary, dry, acropleurogenous, simple, ellipsoidal, oblong, cylindrical rounded at the ends, fusiform, sub-hyaline, uniseptate, verriculose, 8-10 x 3-4 µm.

Specimen Examined: On Cattle dung, Amole, Goa, India; GUFCC No. 15432, Coll. by Sarita Yadav, 18.04.2009.
The fungus was earlier reported on rabbit dung (Tubaki, 1954).

Scopulariopsis brevicaulis (SGUBH) Bainier, 1907. *Bull. Soc. mycol. Fr.* 23: 99. **(Fig. 228)**

Fungus Hyphomycete. *Colonies* whitish, later brownish. *Conidiophores* macronematous, mononematous, branched with branches mostly restricted to the apical region, smooth, septate, sub-hyaline, arranged penicillately. *Conidiogenous cells*, monoblastic, integrated, terminal, percurrent, closely annellate, arranged penicillately, ampulliform, smooth, 5-7 x 3.5 µm. *Conidia* smooth, hyaline, brownish when in group, catenate, subspherical or obovoid, truncate at the base, 4-9 x 4-5 µm.

Specimen Examined: (i) On cattle dung, Chopdem, Goa, India; GUFCC No. 15445, Coll. by Sarita Yadav 22.04.2008. (ii) On goat dung, Taligao, Goa, India; GUFCC No. 15431, Coll. by Sarita Yadav, 31.09.2009.

Isolated by moist chamber technique.

Scopulariopsis brumptii Salv.-Duval, 1935. *Thèse Fac. Pharm. Paris* 23: 58. **(Fig. 229)**

Fungus Hyphomycete. *Colonies* white later turning to brownish-balck. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, branched with branches mostly restricted to the apical region, smooth, septate, olivaceous-green, 13-

22 x 2-4 µm. *Conidiogenous cells* monoblastic, integrated, terminal, percurrent, closely annellate, arranged penicillately, ampulliform, smooth, 8.5-12.5 x 2.5-4.5 µm. *Conidia* catenate, dry, acrogenous, simple, sub-hyaline, sub-spherical, truncate at the base, 5-6 x 3-4 µm.

Specimen Examined: (i) On Chausingha dung, Bondla Wildlife Sactuary, Goa, India; GUFCC No. 15364, Coll. by Sarita Yadav, 21.01.2009. (ii) On cattle dung, Narvem, Goa, India, GUFCC No. 15451, Coll. by Sarita Yadav, 23.09.2008.

***Sesquicillium* sp.** **(Fig. 230)**

Fungus Hyphomycete. *Colonies* white powdery. *Conidiophores* monomorphic, penicillate, primary branches, terminal branches, hyaline, thin walled, smooth, septate, branched, aggregated, short, whole conidiophores 150-210 x 2-4 µm. *Conidiogenous cells* phialiadic, terminal phialides flask shaped, but narrowing on the upper part, hyaline, smooth, 10-15 x 3-4 µm at widest point. *Conidia* hyaline, smooth, spherical to sub-globose, aseptate, smooth, 3-5 x 2-4 µm.

Specimen Examined: On cattle dung, Chopdem, Goa, 21.01.2009, Coll. by Sarita Yadav, GUFCC No. 15263.

Shanomyces indica gen. et sp. nov. **(Fig. 58, 231)**

Fungus Hyphomycete. *Conidiophores* short, spirally erect, hyaline, upper minutely verrucose, 105-154 x 8-15 µm. *Conidia* hyaline, smooth, ellipsoidal, 3-17 x 1-2 µm. Conidiogeneous cells blastic, denticulate, hyaline.

Specimen examined: On cattle dung, Tambdi Surla, Goa, India, GUBH No. SY 259, Coll. by Sarita Yadav, 22.7.2009.

Stachybotrys chartarum (Ehrenb.) S. Hughes, 1958. *Can. J. Bot.* 36: 812 **(Fig. 232)**

Fungus Hyphomycete. *Colonies* slow growing, brownish. Setae and hyphopodia absent. *Conidiophores* macronematous, mononematous, unbranched, sub-hyaline, smooth, bearing at its apex a crown of phialides, verrucose at the tip. *Conidiogenous*

cells monophialic, discrete, in groups at the apex of each stipe or branch, determinate, clavate, ellipsoidal, 4.2-5 µm. *Conidia* aggregated, slimy, dark brown to black, acrogenous, simple, verrucose, spherical, dark brown, aseptate, 9-12 x 5-7 µm.

Specimen Examined: (i) On cattle dung, Chopdem, Goa, India; GUFCC No. 15341, Coll. by Sarita Yadav, 24.10.2009. (ii) On sambar dung, Bondla Wildlife sanctuary, Goa, India, GUFCC No., 15434, Coll. by Sarita Yadav, 11.03.2007.

Earlier the fungus was recorded on hawk dung (Watlig, 1963); on rabbit dung (Tubaki, 1954); on sheep dung (Lodha, 1974).

***Trichocladium* sp.** **(Fig. 233)**

Fungus Hyphomycete. Setae and hyphopodia absent. *Conidiophores* micronematous, mononematous, scattered, unbranched, straight to flexous, septated, hyaline, smooth. *Conidia* solitary, dry, simple, clavate, cylindrical, rounded at the apex, pyriform, verrucose, usually thick-walled, 1-transverse septa, hyaline, verrucose, 1-septate, 8-10.5 x 6-8.5 µm.

Specimen Examined: On cattle dung, Bandora, Goa, India; GUFCC No. 15261, Coll. by Sarita Yadav, 16.03.2008

Isolated by particle plating technique.

Trichothecium roseum (Pers.) Link, 1809. *Mag. Gesell. naturf. Freunde, Berlin* 3(1-2): 18. **(Fig. 59, 234)**

Fungus Hyphomycete. *Conidiophores* simple, erect, sub-hyaline, septate, smooth, 25-84 x 2-8 µm. *Conidiogenous cells* polyblastic, integrated, terminal, cylindrical. *Conidia* hyaline, cylindrical, ellipsoidal, with an obliquely prominent truncate basal scar, 2-celled, tapered at the point of attachment, uniseptate, smooth, 1-septate, aseptate when young, 10-17 x 4-8 µm.

Specimen Examined: (i) On cattle dung, Bandora, Goa, India; GUFCC No. 15260, Coll. by Sarita Yadav,
16.03.2008.

Isolated by moist chamber incubation and particleplating technique. The fungus was earlier recorded on hawk dung (Waling, 1963); on sheep and monkey dung (Tubaki, 1954; on cow dung (Subramanian and Lodha, 1975; on dung (Lindau, 1910; Lodha, 1974).

***Trichothecium* sp. 1** **(Fig. 235)**

Fungus Hyphomycete. *Conidiophores* simple, erect, sub-hyaline, septate, smooth, 42-90 x 2-5.5 µm. *Conidiogenous cells* polyblastic, integrated, terminal, cylindrical, 42-63 x 2-3.5 µm. *Conidia* smooth, cylindrical-ellipsoidal, in groups, 1-7 septated, sub-hyaline, 15-32 x 6-7 µm.

Specimen Examined: On cattle dung, Fatropa, Goa, India; GUFCC No. 15392, Coll. by Sarita Yadav, 08.02.2007.

Isolated by moist chamber incubation technique.

***Tricothecium* sp. 2** **(Fig. 236a-b)**

Fungus Hyphomycete. *Conidiophores* sub-hyaline, septated, breadth narrows from base to apex, 70-90 x 2-3 µm. *Conidiogenous cells* polyblastic, integrated, terminal, cylindrical, 25-37 x 2-3 µm. *Conidia* smooth, sub-hyaline, cylindrical-ellipsoidal, 2-3 septated, smooth.

Specimen Examined: On Chausingha dung, Cotigao Wildlife Sanctuary, Goa, India; GUFCC No. 15389, Coll. by Sarita Yadav, 15.06.2009.

Isolated by moist chamber incubation technique.

Tritirachium **tax. sp. nov.** **(Fig. 60, 237 a-b)**

Fungus Hyphomycete. *Conidiophores* brownish, lighter towards the base, smooth-walled, merging into the vegetative mycelium, bearing in the upper part several whorls of conidiogenous cells, 178-750 x 2-4 µm. *Conidiogenous cells* hyaline, consisting of an elongate basal part, slightly swollen at the base and tapering towards the tip, regularly geniculate, cicatrized rachis, 32-129 µm. *Conidia* aseptate, hyaline, smooth, thin-walled, spherical, diam. 2-3 µm.

Specimen Examined: On cattle dung, Cotigao Wildlife Sanctuary, Goa, India; GUFCC No. 15409, Coll. by Sarita Yadav, 10.07.2007.

Isolated by moist chamber technique.

Verticillium lecanii (Zimm.) Viégas, 1939. *Revista Inst. Café Sao Paulo* 14: 754. **(Fig. 238)**

Fungus Hyphomycete. *Conidiophores* erect, hyaline, branched, verticillately branched all over its length. *Conidiogenous cells* phialidic, bearing whorls of slender flask-shaped divergent phialides with inconspicuous collarettes, 14-17 x 2 µm. *Conidia* hyaline, aseptate, ellipsoidal, curved, borne in slimy heads, smooth, 4-5 x 1-2 µm.

Specimen Examined: (i) On cattle dung, Tambdi Surla, Goa, India; GUFCC No. 15239, Coll. by Sarita Yadav, 06.11.2009. (ii) On monkey dung, Bondla Wildlife Sanctuary, Goa, India, GUFCC No. 15444, Coll. by Sarita Yadav, 19.04.2009.

Isolated by moist chamber incubation and particle-particle plating technique.

Wiesneriomyces javanicus Koord., 1907. *Verh. K. ned. Akad. Wet.*, 2 Sectie 13(4): 246. **(Fig. 62, 239)**

Fungus Hyphomycete. *Stroma* superficial, brown. *Sporodochia* conidia in mass, 262-303 x 200-300 µm. *Setae* simple, long, inwardly curved, swollen at the base, acutely pointed at the apex, septate, brown, smooth. *Conidiophores* macronematous, accumulate to form sporodochia, narrow, branched at the apex, straight, 35-50 x 2-3

µm. *Conidiogenous cells* formed usually in threes at the end of short branches, polyblastic, discrete, determinate, clavate, 9-13 x 2-4 µm. *Conidia* formed in acropetal chains, yellow when seen in aggregation, hyaline when single, curved, isthmus-connection, tapering towards the ends, 46-50 x 4-5 µm.

Specimen Examined: On Bison dung, Bondla Wildlife Sanctuary, Goa, India, Coll. by Sarita Yadav, GUFCC No. 15339, 12.10.2009.

Zygosporium masonii S. Hughes, 1951. *Mycol. Pap.* 44: 15. **(Fig. 63, 240)**

Fungus Hyphomycete. *Conidiophores* terminates into sterile and hyaline setae, a bulbuous at theapex of seta, separated setae absent, dematicaeous smooth, branched, septate, solitary, branched into short lateral branches. *Conidiogenous cells* monoblastic, discrete, determinate, hyaline, curved, ampulliform, tapering at a point, 5-8 x 1-2 µm. *Conidia* solitary, acrogenous, simple, ellipsoidal, hyaline, smooth, 1-2 in groups, 7-10 x 3-5 µm.

Specimen Examined: (i) On goat dung, Shiroda, Goa, India, GUFCC No. 15538, Coll. by Sarita Yadav, 20.09.2009. (ii) On cattle dung, Yana, Karnataka, GUFCC No. 15540, Coll. by Sarita Yadav, 21.01. 2008.
Isolated by moist chamber incubation technique.

COELOMYCETES

Colletotrichum sp. **(Fig. 242)**

Fungus Coelomycete. *Conidiomata* acervular, epidermal, subbepidermal, textural angularis present, 210 x 168 µm. *Setae* in conidiomata dark brown, septate, broad at the base, tapered at the apex, thick walled, 102-140 x 4 µm. *Conidiophores* hyaline to brown, septate, branched only at the base, smooth, formed from the upper cells of the conidiomata. *Conidiogenous cells* enteroblastic, phialiadic, hyaline, smooth,

determinate, cylindrical, integrated. *Conidia* hyaline, aseptate, elliosoidal, guttalate, 21-29 x 8 µm.

Specimen Examined: (i) On cattle dung, Valpoi, Goa, India; GUBH No. SY319; Coll. by.Sarita Yadav, 16.12.2008.

Isolated by moist chamber incubation technique.

Dimastigosporium yanese. sp. nov. **(Fig. 247)**

Colonies slow growing on malt extract agar, slimy, pale orange, circular, 3.5 mm diam. after 20 days of incubation in diurnal light at 22–24°C. *Conidiomata* cupulate, initially closed, eventually opening, sessile, superficial, scattered, solitary, rarely in aggregates of 2–3, 250–450 µm diam., 500–750 µm high, greenish brown; basal tissue pseudoparenchymatous; conidiomal wall with discernible, straight or curved, thick-walled, smooth, septate, rarely branched, up to 220 µm long and up to 7 µm wide setae. *Conidiophores* developing in a hymenium, hyaline, smooth, septate, branched once or twice below mid point, 6–23 × 2–3.5 µm. *Conidiogenous cells* 6.5–20 × 1–5 µm, holoblastic, cylindrical, narrower at the tip, smooth, integrated, determinate. *Conidia* 6.5–10 × 1.5–2.5 µm, subcylindrical, hyaline, aseptate, solitary, numerous, pale orange in mass, thin-walled, smooth, with one appendage at apex and three at the base, developing through one of the basal appendages; appendages acellular, hyaline, unbranched, cylindrical, smooth, 10–16 µm long, up to 1 µm wide.

Holotype: On cattle dung, Yana, Karnataka, India, Coll. by Ashish Prabhugaonkar, 28.07.08. Herb No. HCIO 48658

Pestalotiopsis sp. **(Fig. 244)**

Fungus Coelomycete. Conidiomata acervular, epidermal to subepidermal, separate to confluent thin-walled textura angularis, 400-500 µm. Conidiophores hyaline,

branched, septate at the base and above, cylindrical, formed from the upper part of the pseudoparenchyma. Conidiogenous cells blastic, annelidic, indeterminate, integrated, cylindrical, hyaline, smooth, with several purcurrent proliferations. Conidia fusiform, slightly curved, truncate, numerous, basal cell hyaline, median cells sub-hyaline to brown, with appendages, 10-15 x 3-4 µm. Appendages thin, hyaline, 3 at the apex, 1 at the base.

Specimen Examined: (i) On cattle dung, Ugem, Goa, India; GUFCC No. 15313; Coll. by Sarita Yadav, 12.12.2009. (ii) On cattle dung, Becqui, Goa, India, GUFCC No. 15320; Coll. by Sarita Yadav, 14.09.2009. (iii) On cattle dung, Kanbumbi, Karnataka, India, GUFCC No. 15329; Coll. by Sarita Yadav, 23.04.2009.

Isolated by moist chamber incubation method.

Pullospora tetrachaeta Faurel & Schotter, 1965. *Revue Mycol.*, Paris 29(4): 280. **(Fig. 244)**

Fungus Coelomycete. *Conidiomata* pycnidial, scattered to gregarious, immersed with only the short neck visible in surface voew, venter globose to subglobose, 160-240 µm wide, 190-330 µm deep. Unilocular, glabrous, brown to dark brown, neck cylindrical to somewhat obconic, 25-35 µm wide, 30-80 µm long. *Ostiole* circular or oval, 15-20 µm diam. wall 15-20 µm thick of textura angularis cells thick-walled, brown to dark brown in the outer layers, thin-walled and paler in the inner layers, cells of the neck region often much darker than those of the vener. *Conidiophores* lining of pycnidial cavity, unbranched or irregularly branched, septate, colourless, thin-walled, smooth, 20-50 µm long, invested in mucus. *Conidiogenous cells* discrete or integrated, sub-cylindrical to lageniform, colourless, thin-walled, smooth, 5-20 x 2-5 µm. *Conidia* smooth, lemon-shaped, appendaged at both the ends, hyaline, ornamented, thin fibrous appendages, 8-15 x 6-7.5 µm.

Specimen Examined: (i) On cattle dung, Siolim, Goa, India; GUFCC No. 15416, Coll. by Sarita Yadav, 13.06.2009. (ii) On cattle dung, Amboli, Maharashtra, India; GUFCC No. 15417, Coll. by Sarita Yadav (iii) On goat dung, cattle dung, Lamgao, Karnataka, India, GUFCC No. 15311, Coll. by Sarita Yadav, 16.02.2010. (iv) On horse dung, Mahabaleshwar, Maharashtra, India, GUFCC No. 15427, Coll. by Sarita Yadav.

Isolated by moist chamber incubation.

Pycnidiella **sp.** **(Fig. 245a-b)**

Fungus Coelomycete. *Conidiomata* superficial, separate or aggregated, thin-walled textura intricate. *Conidiophores* cells septate, branched at the base and above, irregular, hyaline, smooth, with acropleurogenous conidia. *Conidiogenous cells* phialidic, determinate, discrete, cylindrical or tapered towards the apices, hyaline, smooth, collarette minute but apical periclinal wall thickened. *Conidia* globose, smooth, thin-walled, hyaline, aseptate.

Specimen Examined: (i) On cattle dung, Marcaim, Goa, India; GUFCC No. 15410; Coll. by Sarita Yadav, 12.05.2008. (ii) On cattle dung, Keri, Goa, India; GUFCC No. 15411; Coll. by Sarita Yadav, 13.04.2007.

Isolated by moist chamber incubation.

Sarcophoma **sp.** **(Fig. 246a-b)**

Fungus Coelomycete. *Conidiomata* dark brown, globose, separate, unilocular, wall composed of pale brown, thin-walled textura angularis, somewhat thicker at the base than the upper and the side walls, 250-300 µm high. *Conidiophores* absent. *Conidiogenous cells* enteroblastic, discrete, determinate, hyaline, smooth, collarette, 7-10 x 5-9 µm. *Conidia* hyaline, aseptate, smooth, eguttulate, thin-walled, ellipsoid to obpyriform, apex obtuse, base truncate, 9-11 x 4-5 µm.

Specimen Examined: (i) On cattle dung, Jogs Falls, Karnataka, India; GUFCC No. 15409, Coll. by Sarita Yadav, 20.08.2009. (ii) On cow dung, Bhrass, Goa, India; GUFCC No. 15499; Coll. by Sarita Yadav, 09.08.2008.

Isolated by moist chamber incubation technique.

BASIDIOMYCETES

***Coprinus* sp.**

Fungus Basidiomycete. The fruit appeared initially as buttons and later fully opened muchrooms only after 12 days of incubation. Basdiocarp stalked, erect, initially white amd later becoming blackish white, with a convex pileus; stalk thin, white with apowdery surface, up to 10 cm long; piles blackish white, slimy, odourless, up to 12 cm diam., slowly delinquishing. Gills on the under-surface of the pileus, repeadly branched and radiating from the center. Basidia lining the hymenium, clavate to elongate, smooth, colourless, 20-24 x 4-7 μm, with terminal 2-4 sterigmata terminally bearing 2-4 basidiospores. Basidiospores oval to rounded, dark brown, smooth, 2-3 x 1.5 μm.

Specimen examined: (i) On catte dung, Bhrass, Goa, India, GUBH No. SY69, Coll. by Sarita Yadav, 29.04.2010 (ii) On cattle dung, Chorla, Goa, India, GUBH No. SY90, Coll by sarita Yadav, 12.09.2009.

Camera Lucida Diagrams

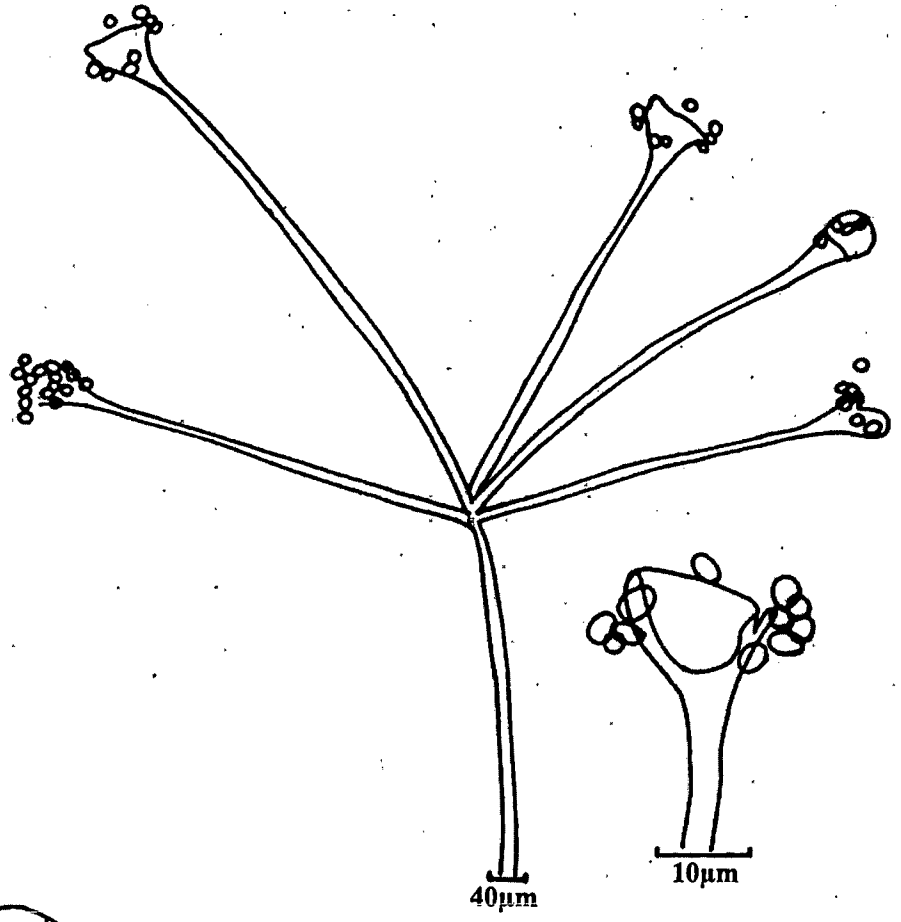


Fig. 1 *Actinomucor* sp.

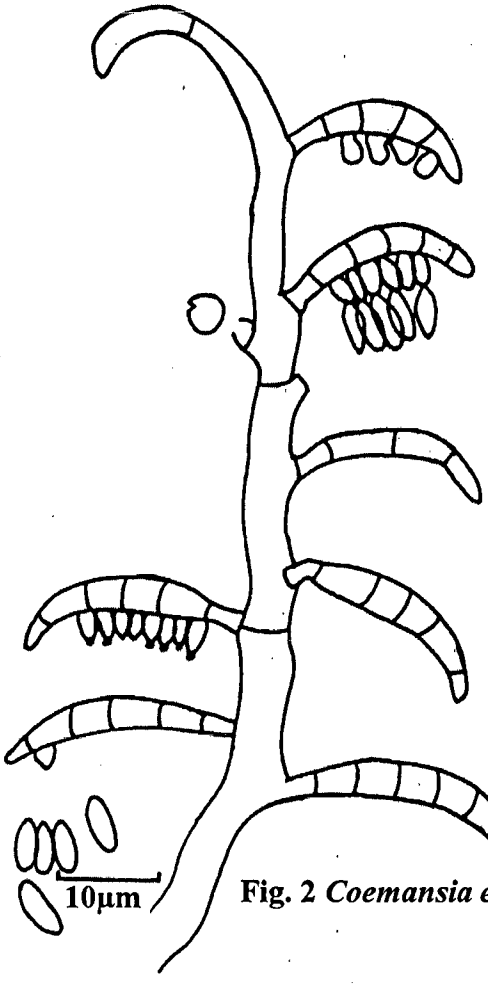


Fig. 2 *Coemansia erecta*

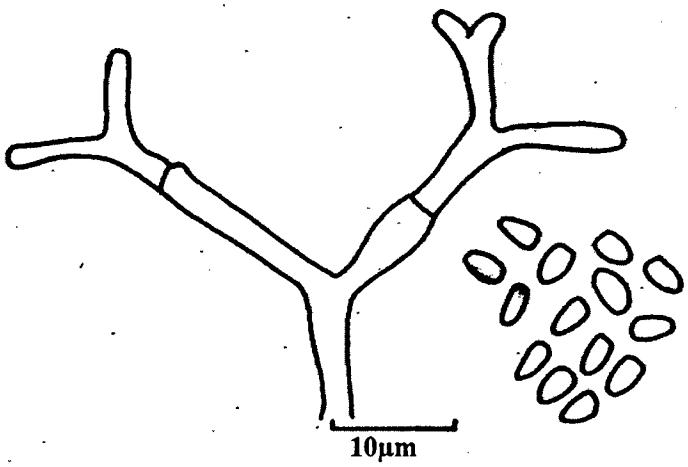


Fig. 3 *Piptocephelis freseniana*

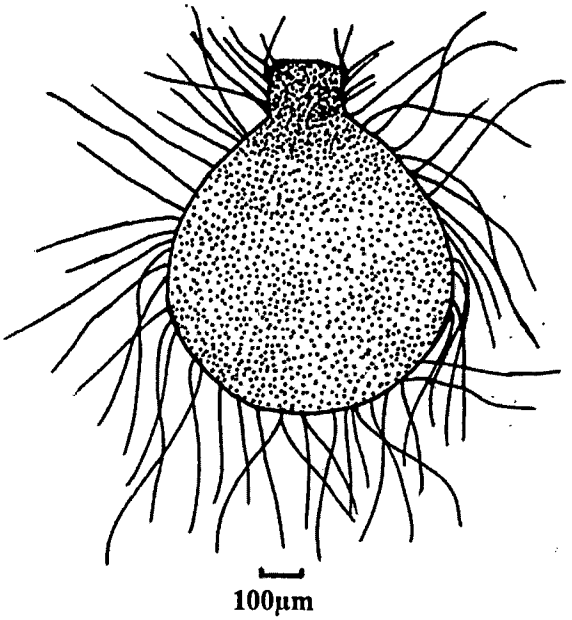
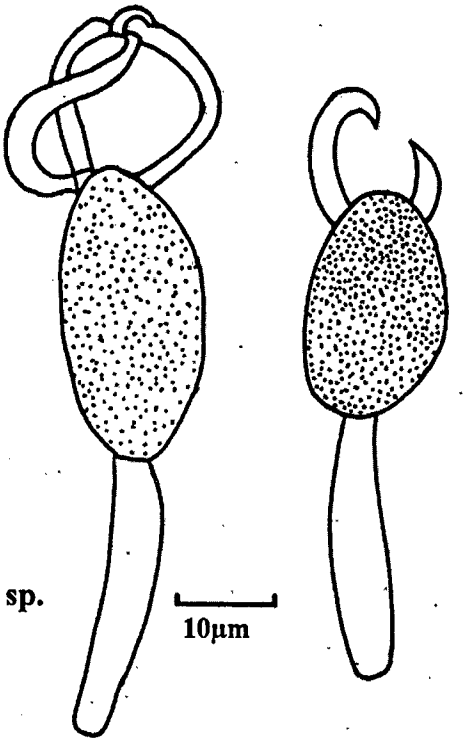


Fig. 4 *Arium* sp.



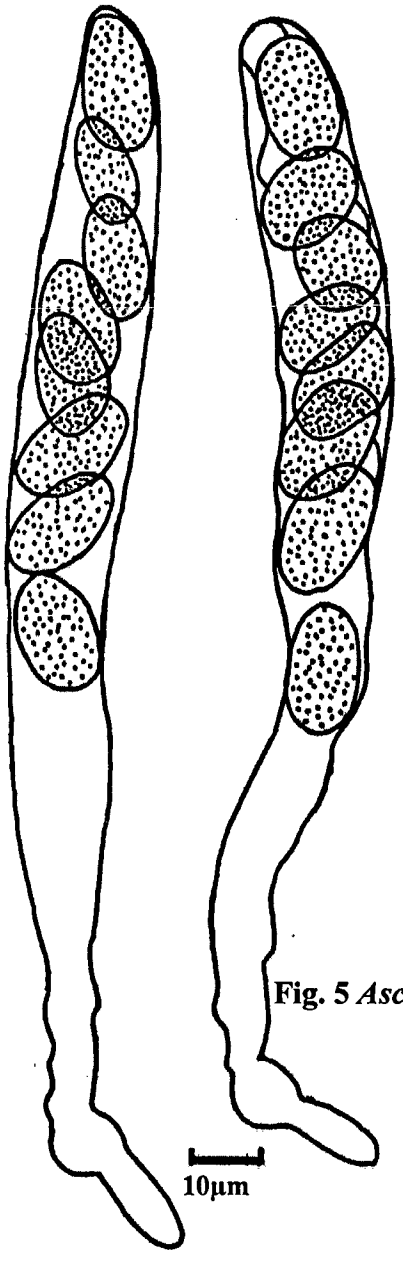


Fig. 5 *Ascobolus* sp. 2

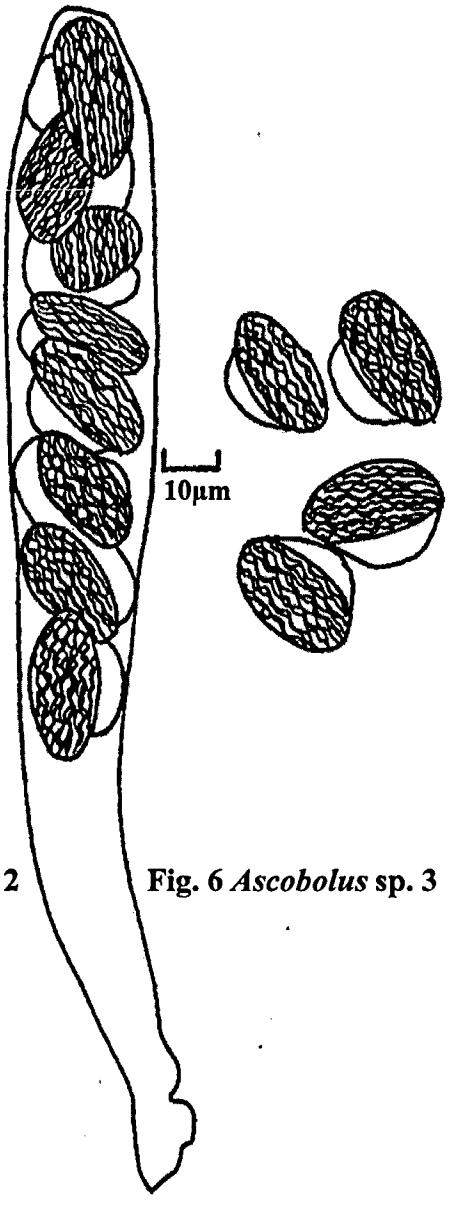


Fig. 6 *Ascobolus* sp. 3

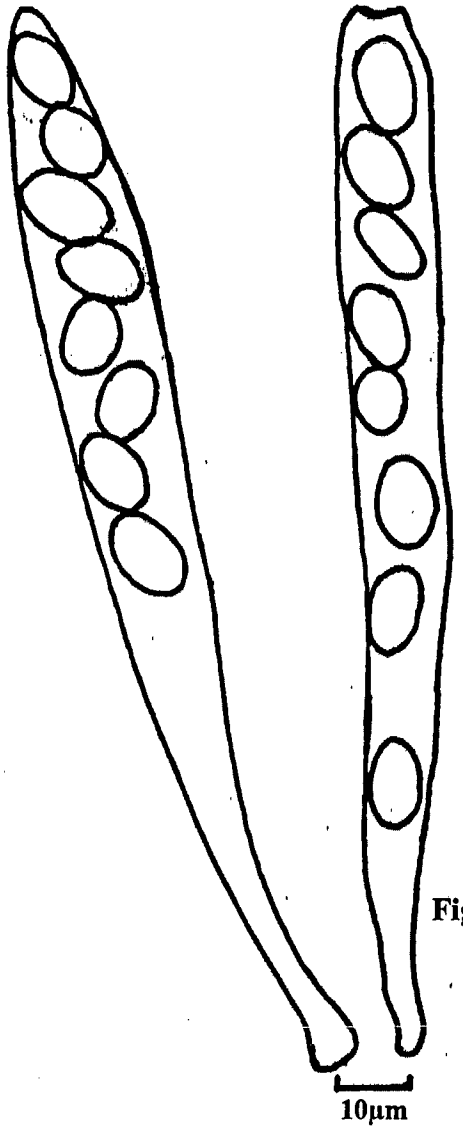


Fig. 7 *Ascobolus* sp. 4

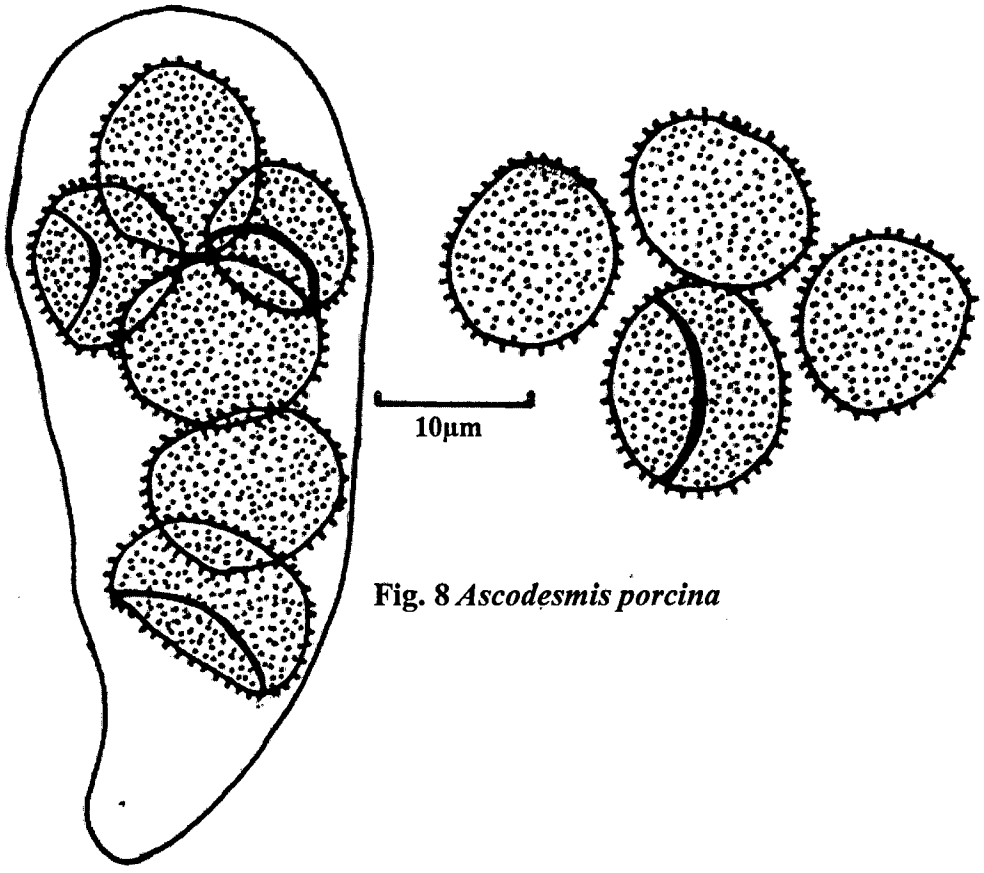


Fig. 8 *Ascodesmis porcina*

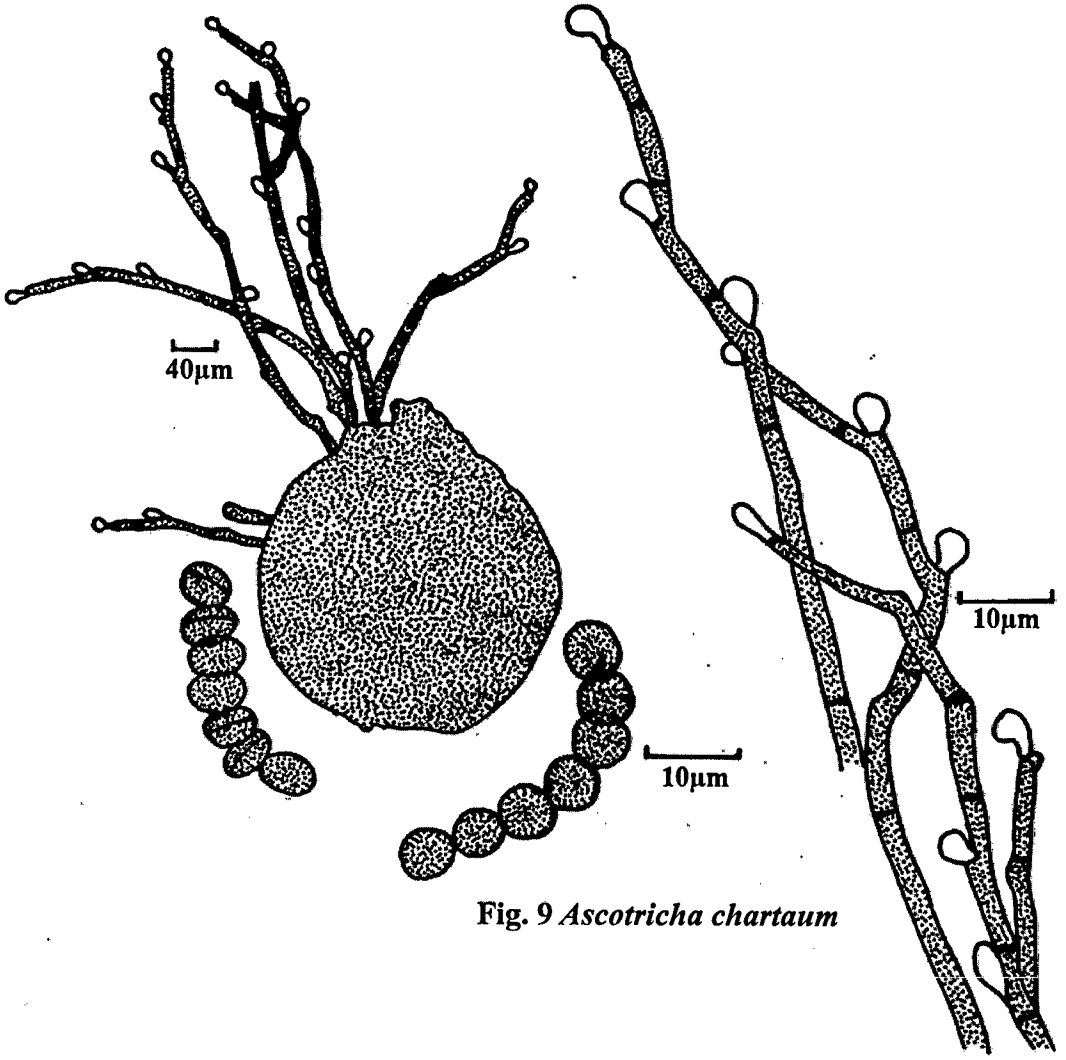


Fig. 9 *Ascotricha chartaum*

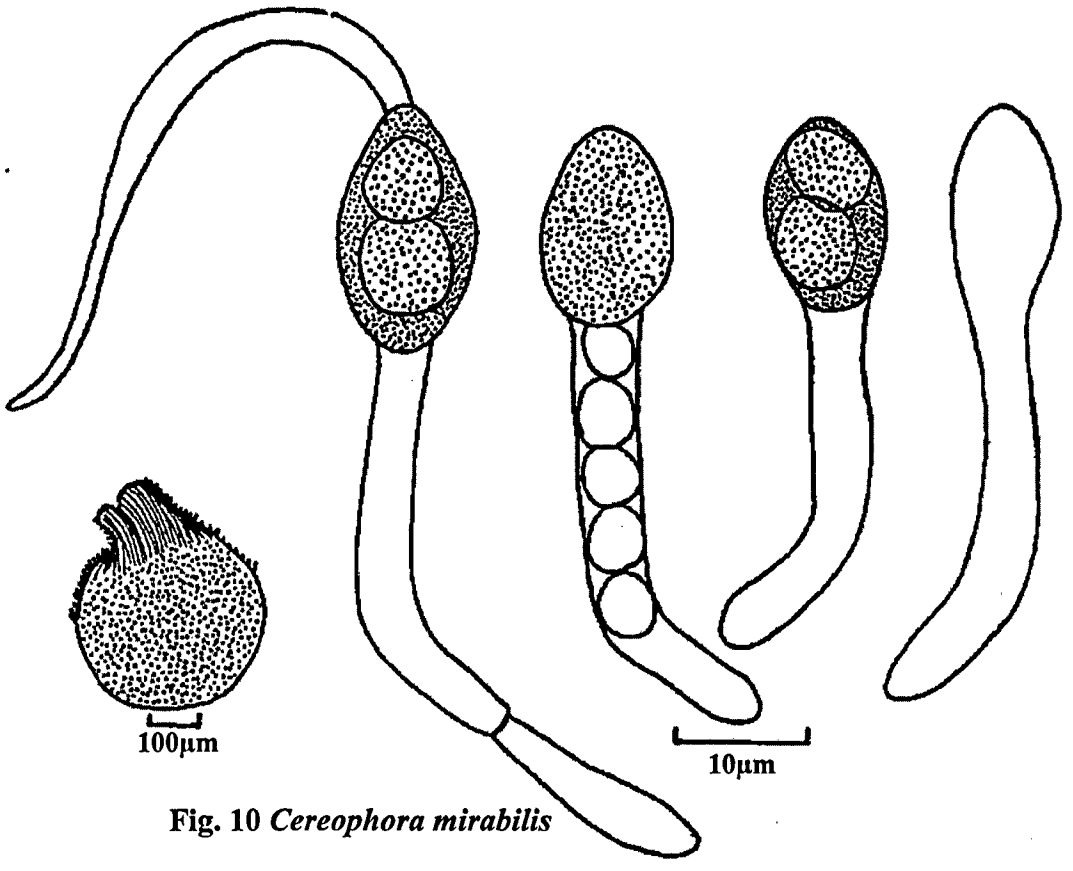


Fig. 10 *Cereophora mirabilis*

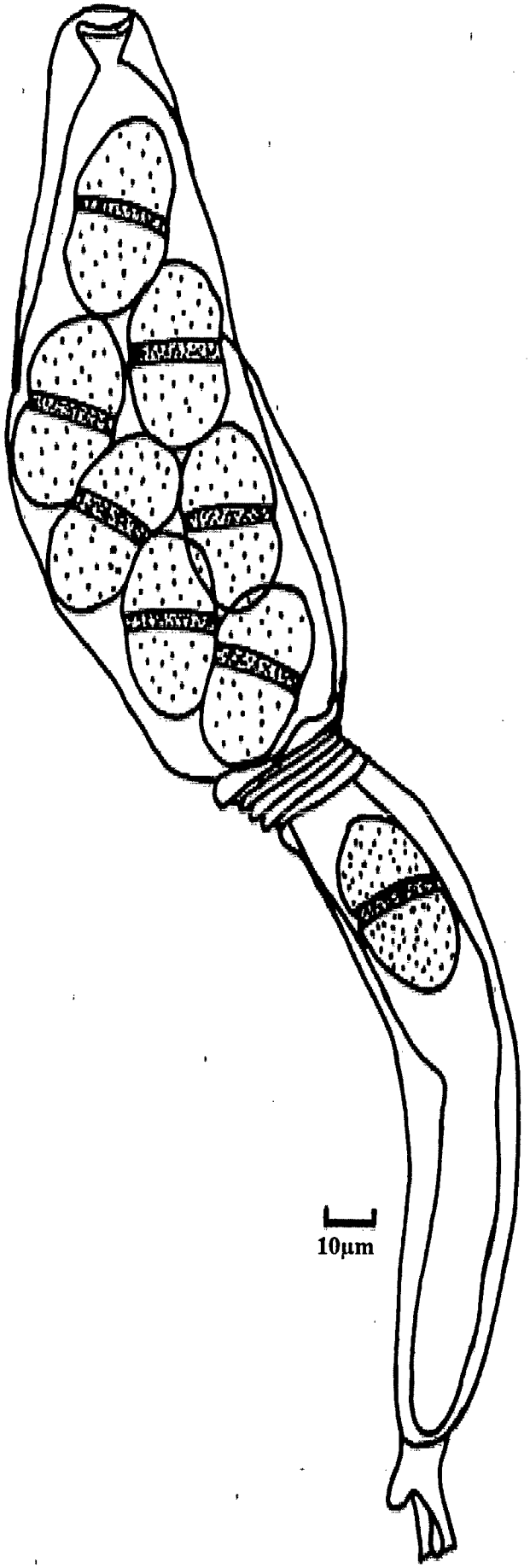


Fig. 11 *Delischia* sp

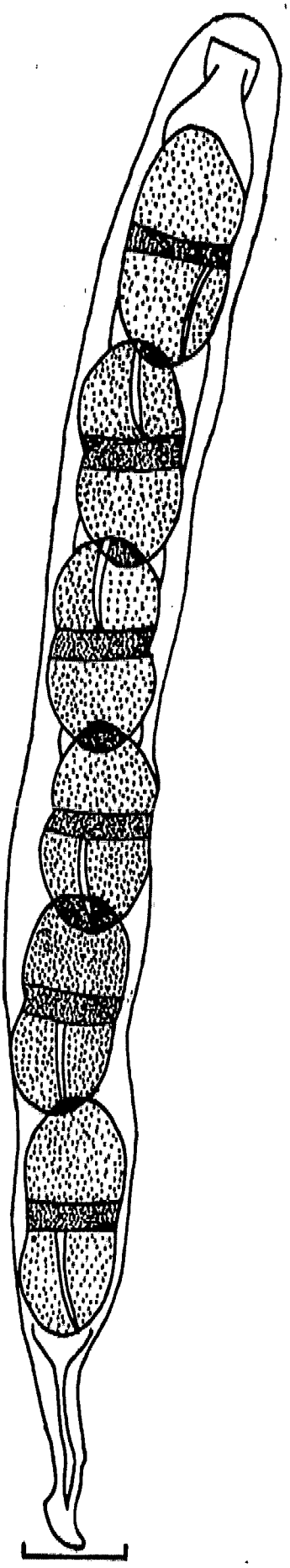


Fig. 12 *Delischia araneosa*

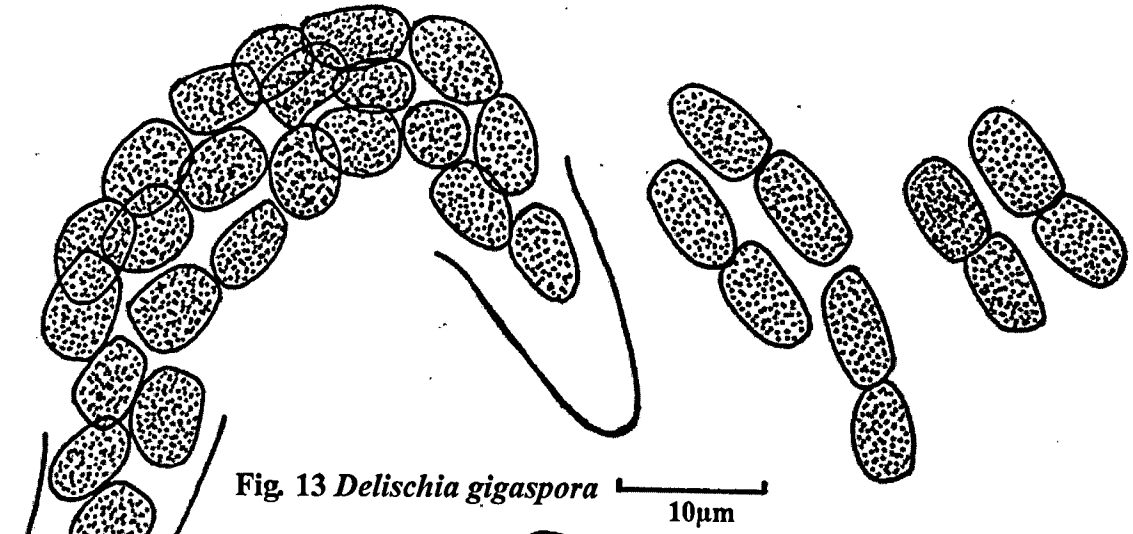


Fig. 13 *Delischia gigaspora*

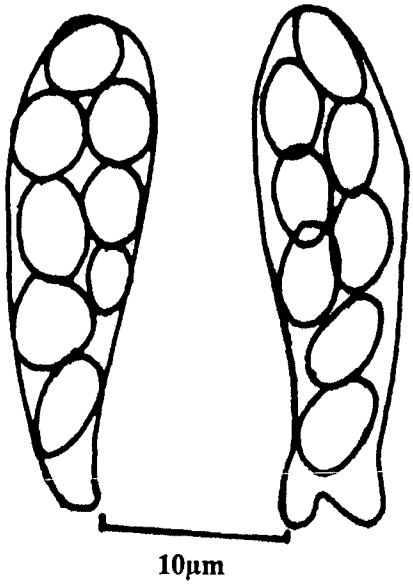


Fig. 14 *Dennisiopsis octospora*

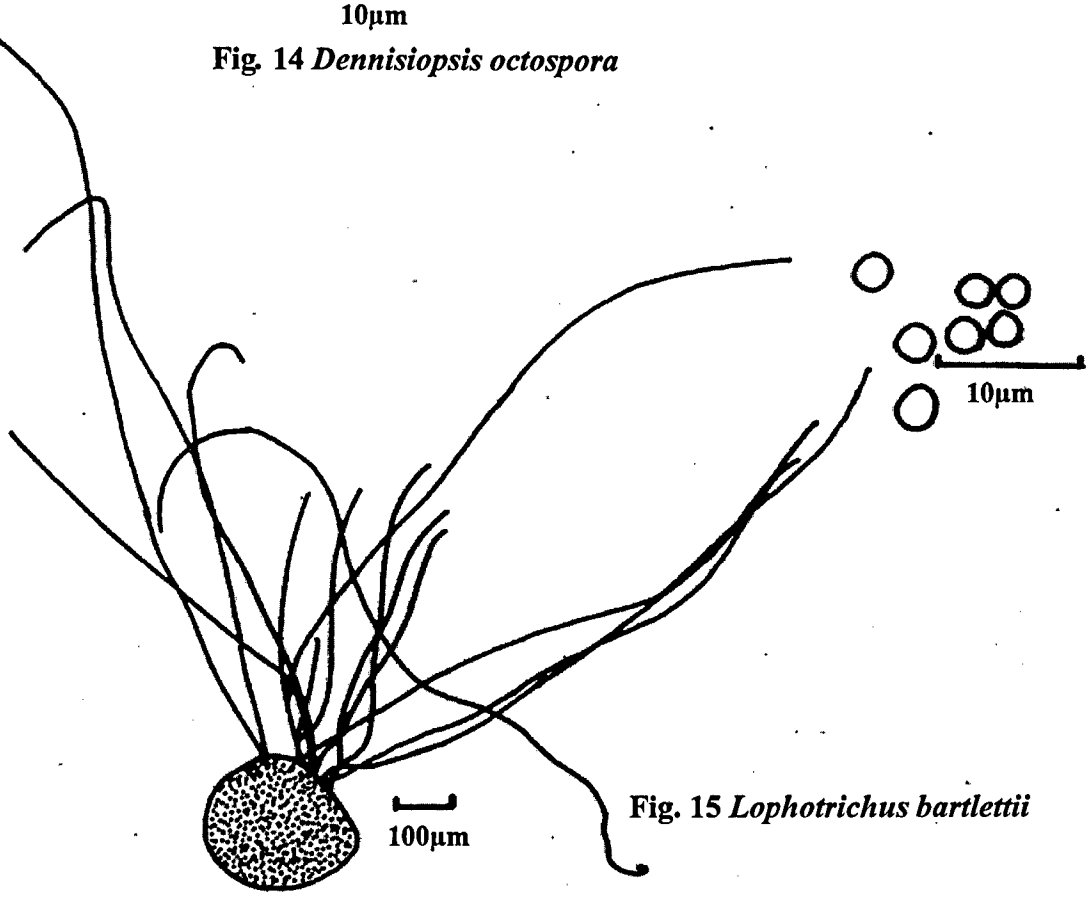


Fig. 15 *Lophotrichus bartlettii*

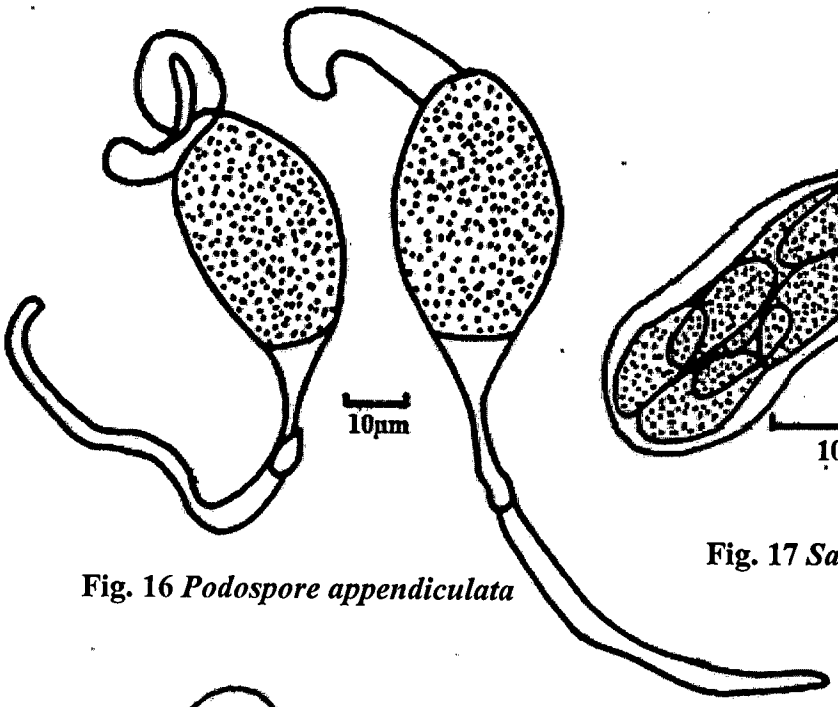


Fig. 16 *Podospore appendiculata*

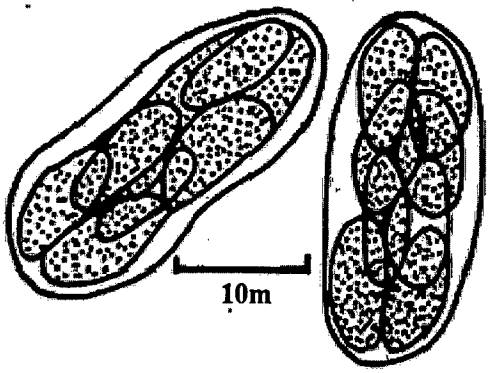


Fig. 17 *Saccobolus* sp.

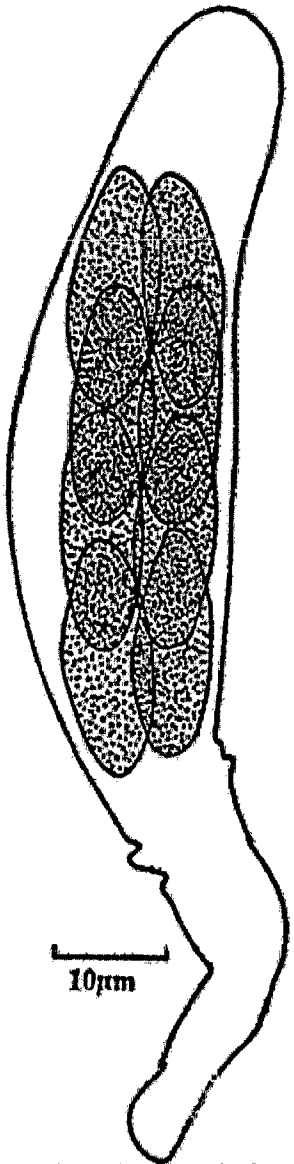


Fig. 18 *Saccobolus* sp.

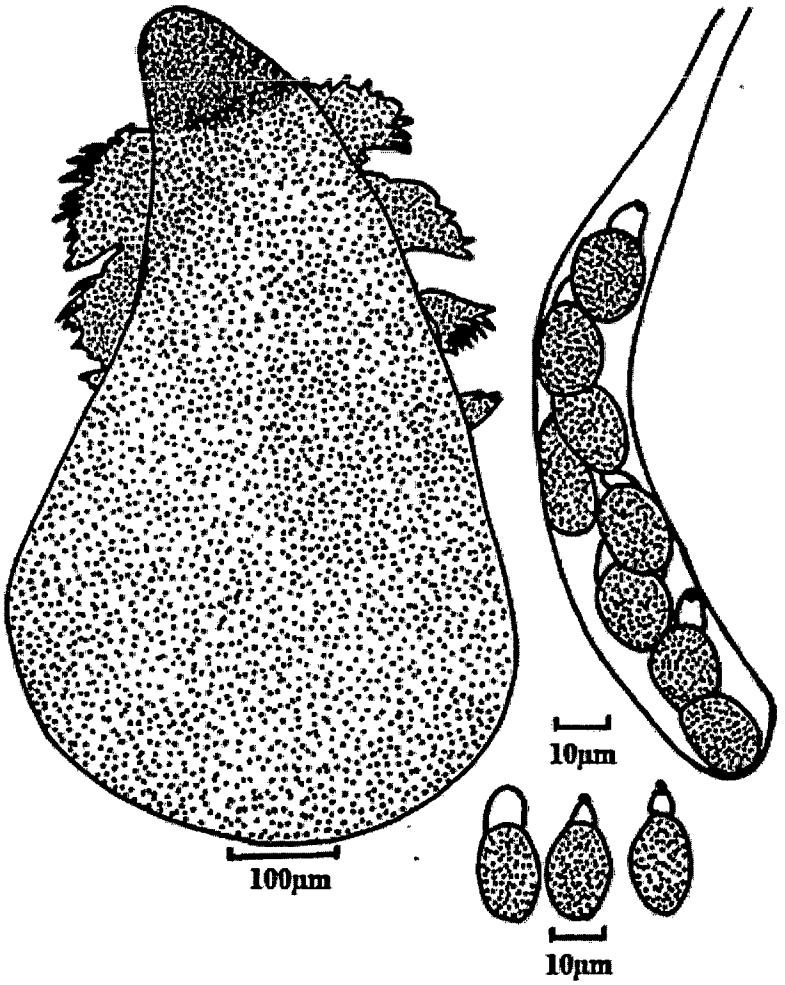


Fig. 19 *Schizothecium* sp.

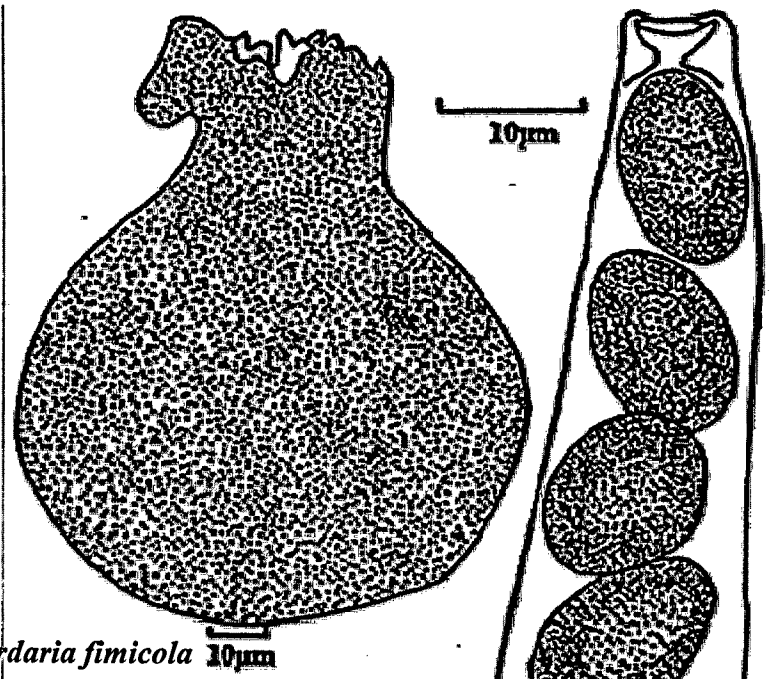


Fig. 20 *Sordaria fimicola*

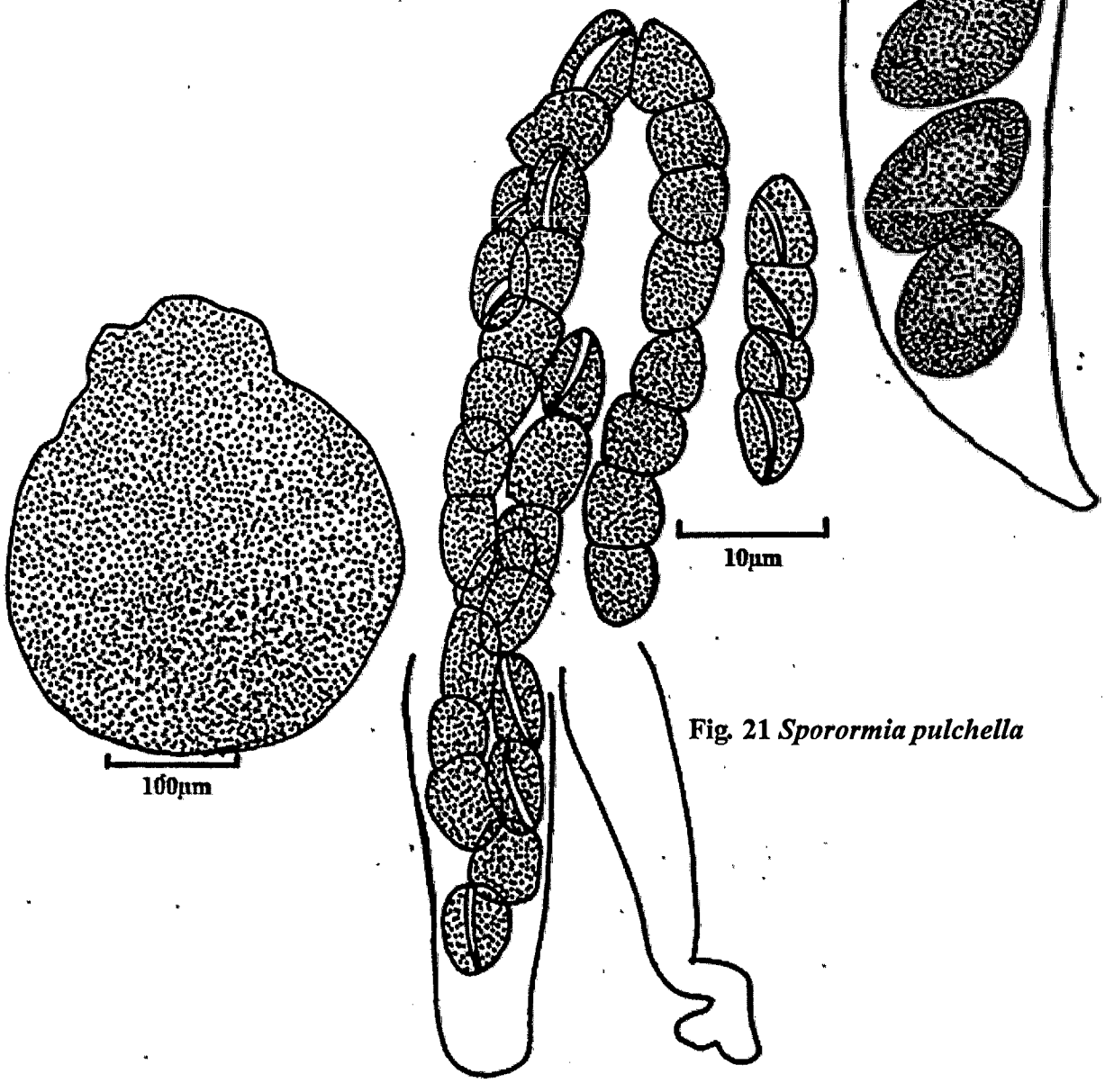


Fig. 21 *Sporormia pulchella*

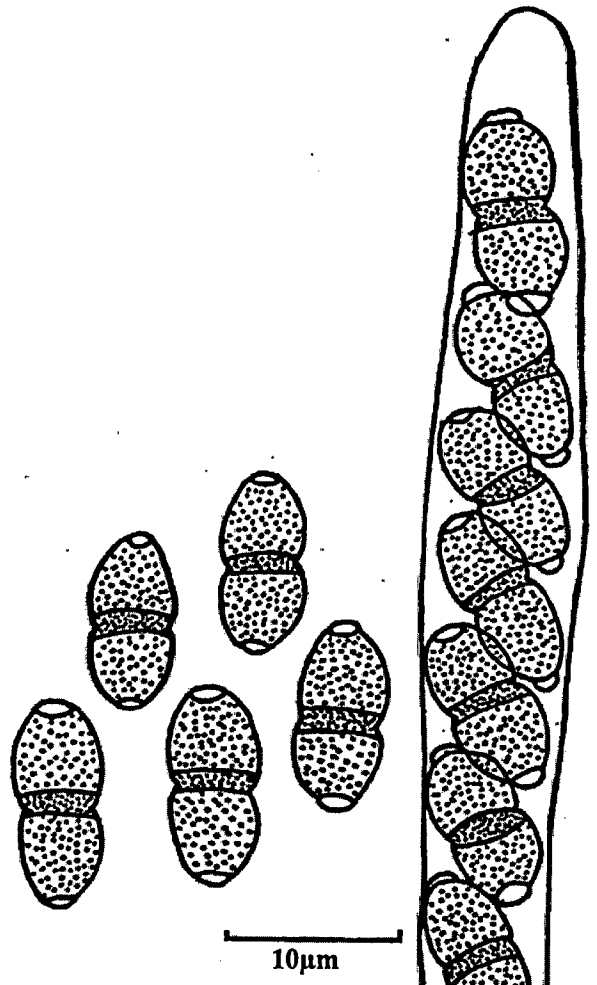


Fig. 22 *Trichodetischia bisporula*

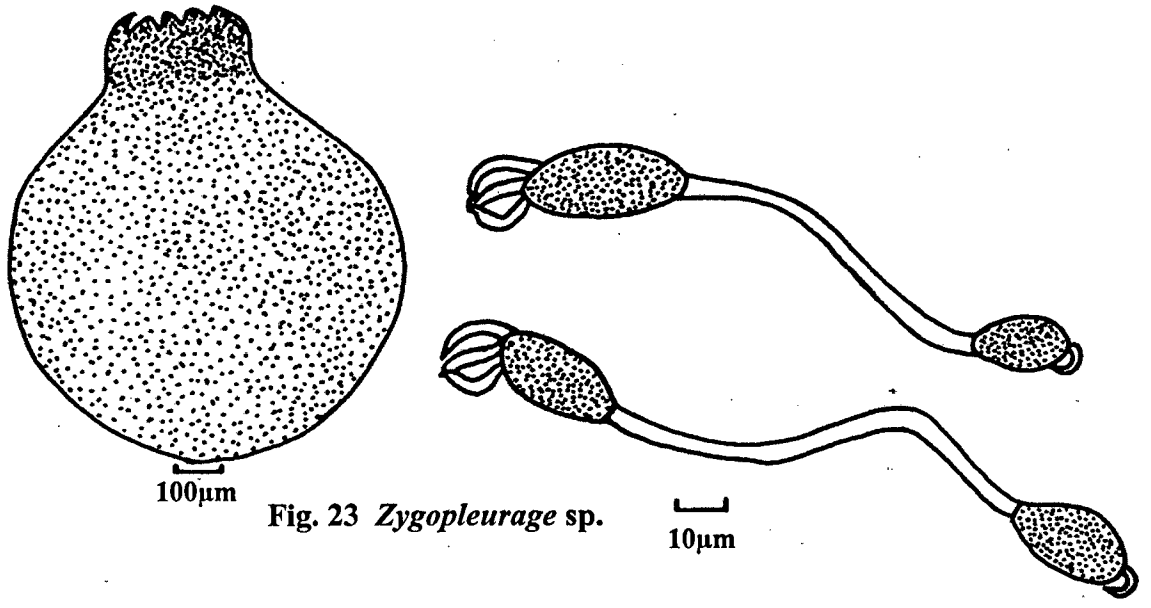


Fig. 23 *Zygopleurage* sp.

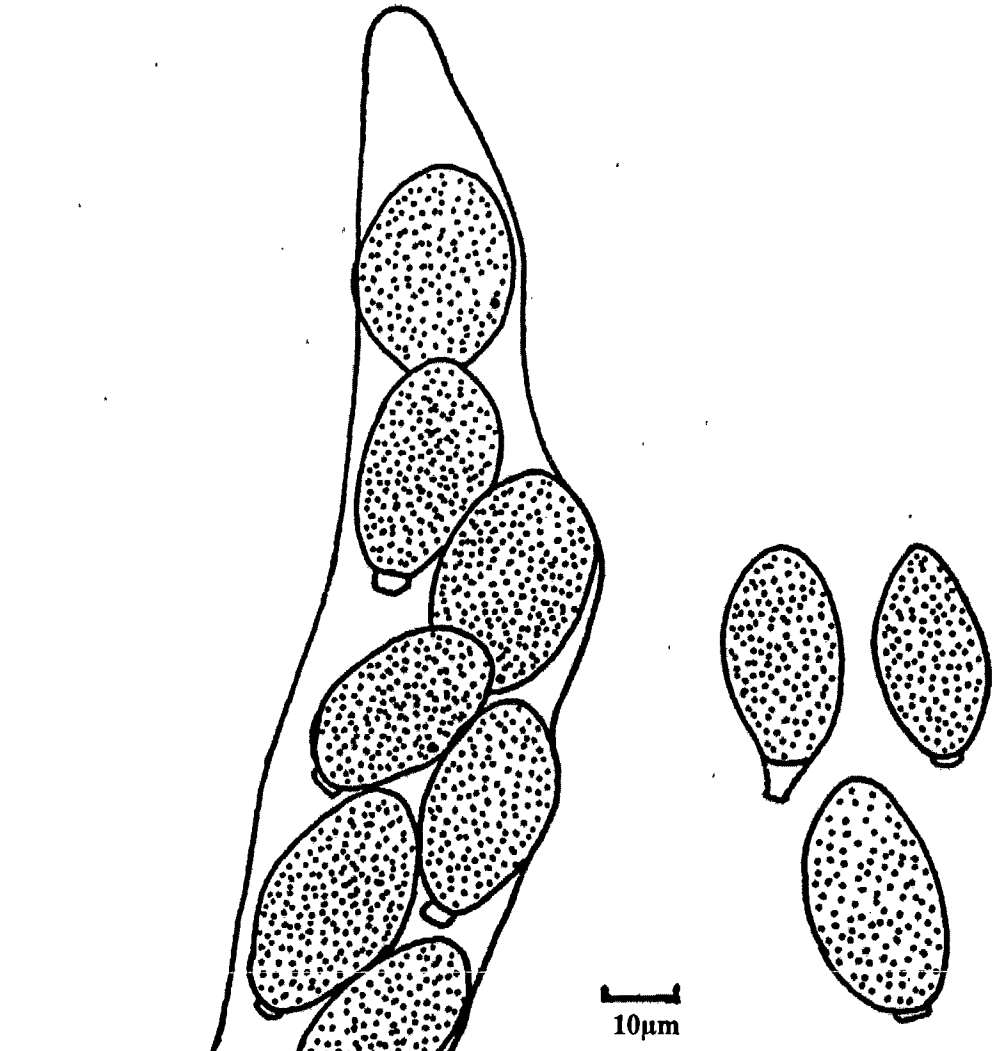


Fig. 24 *Unidentified Ascomycetes* sp. 1

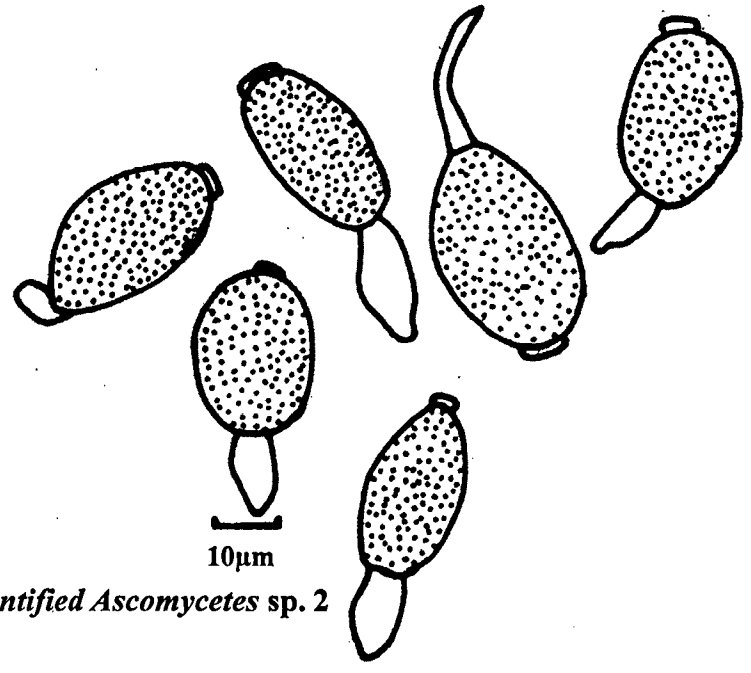


Fig. 25 *Unidentified Ascomycetes* sp. 2

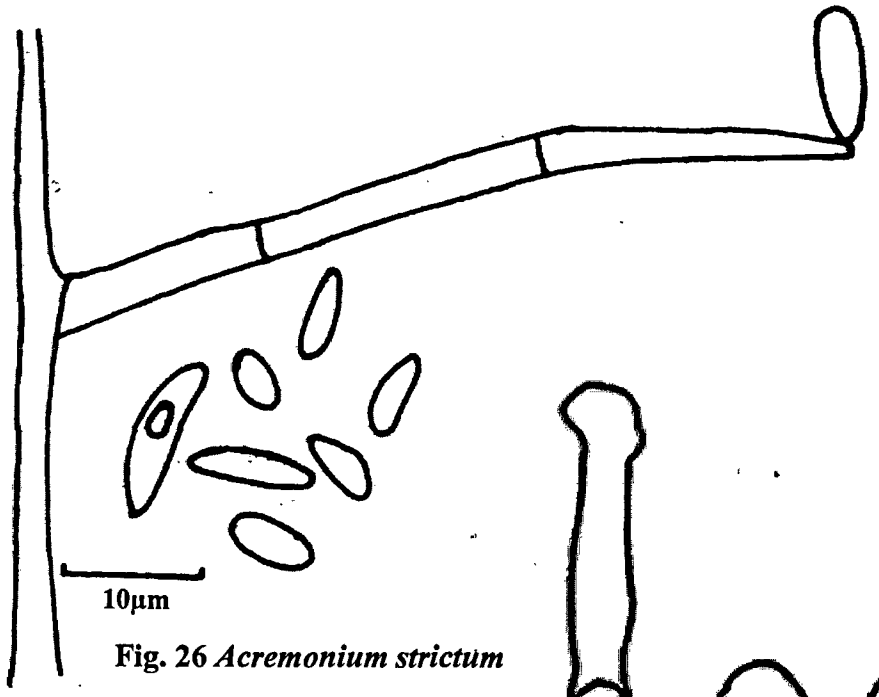


Fig. 26 *Acremonium strictum*

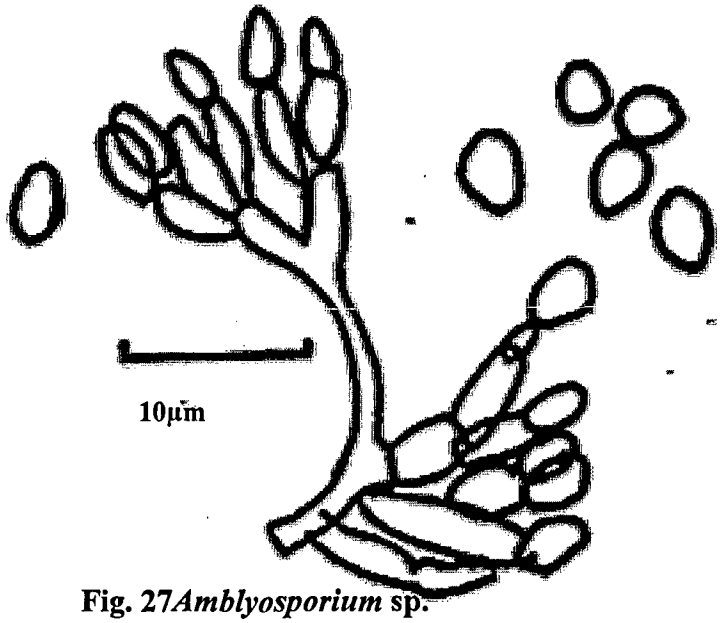


Fig. 27*Amblyosporium* sp.

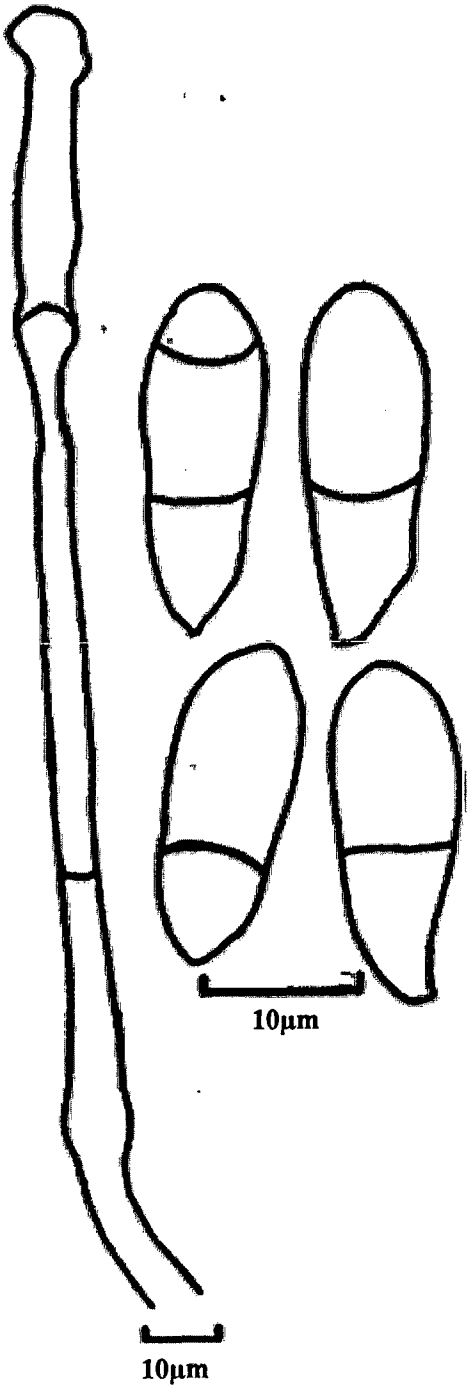


Fig. 28 *Arthrobotrys superba*

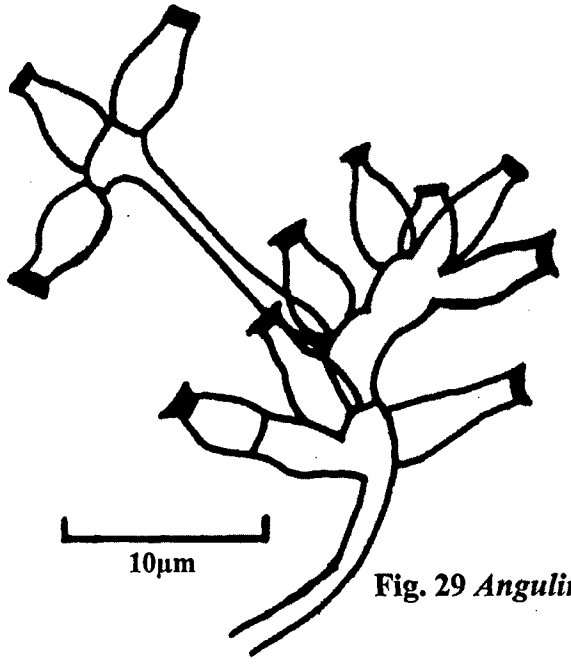


Fig. 29 *Angulimaya* sp.

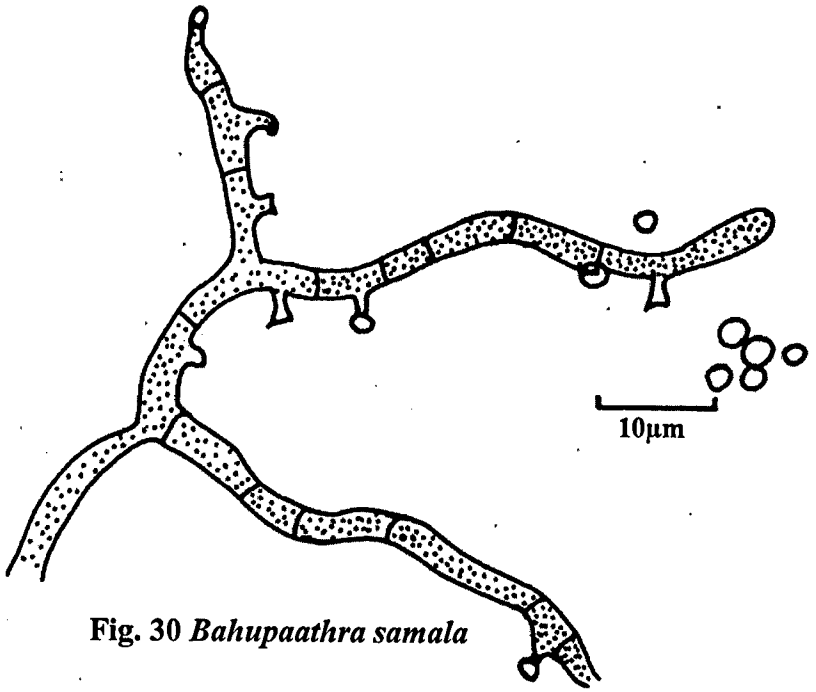


Fig. 30 *Bahupaathra samala*

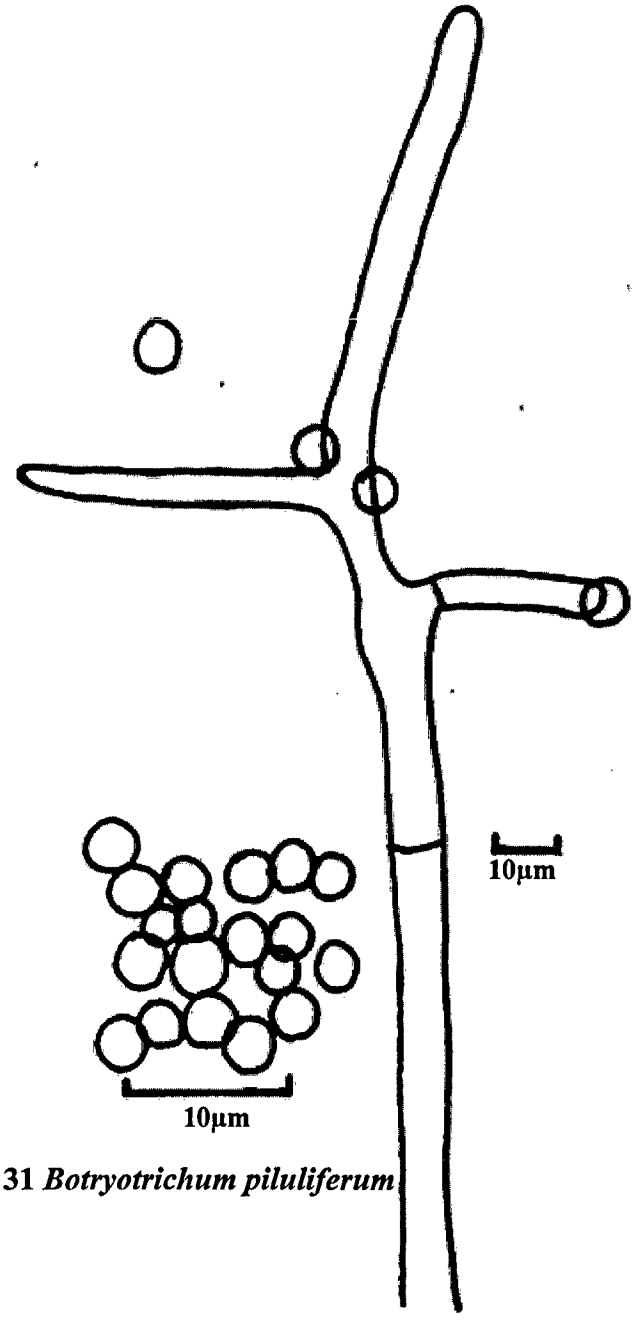


Fig. 31 *Botryotrichum piluliferum*

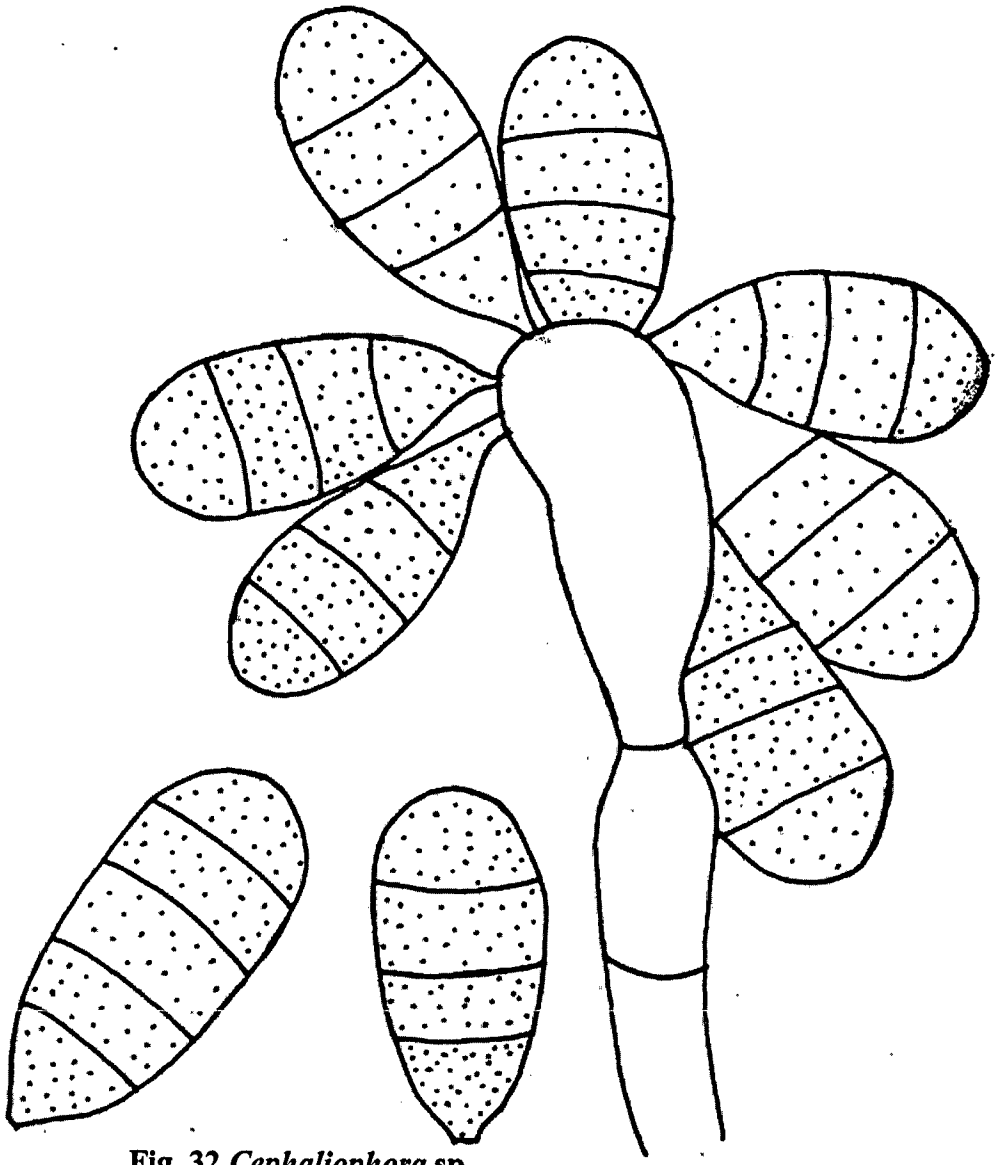


Fig. 32 *Cephaliophora* sp.

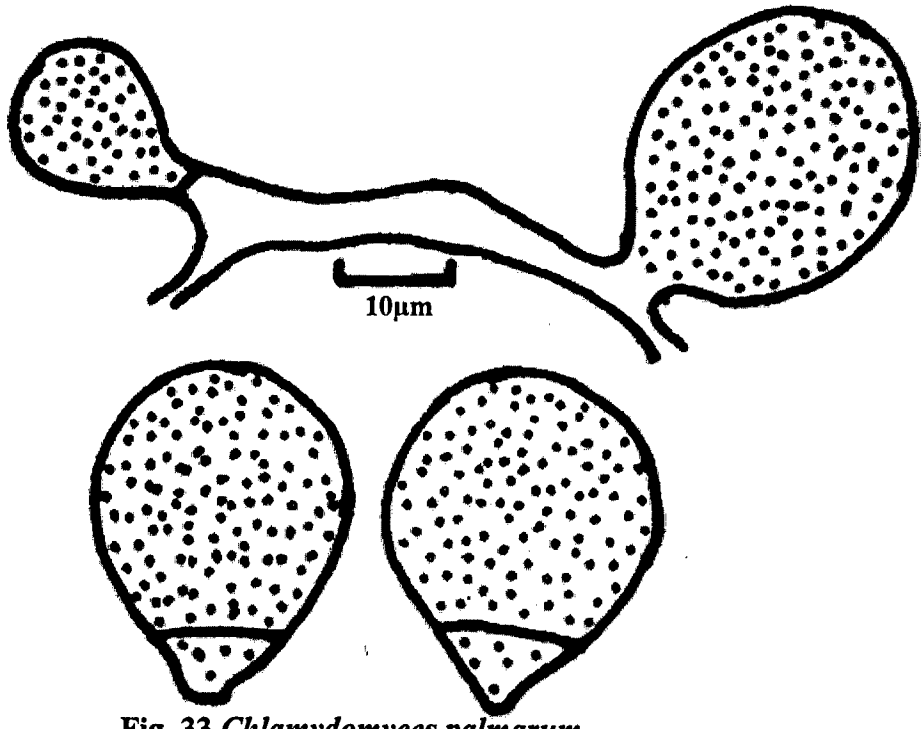


Fig. 33 *Chlamydomyces palmarum*

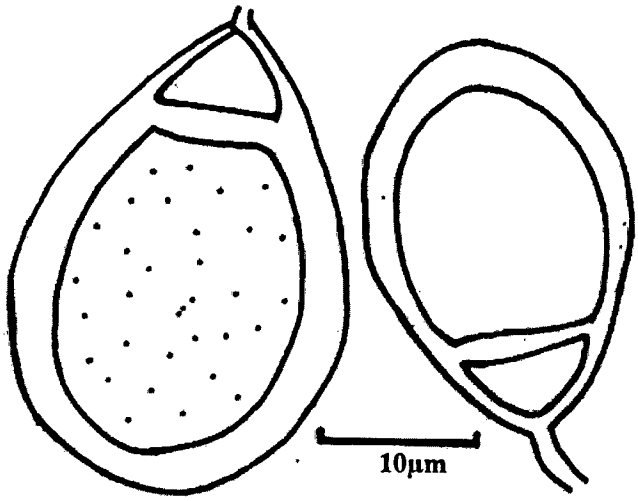


Fig. 34 *Chlamydomyces* sp.

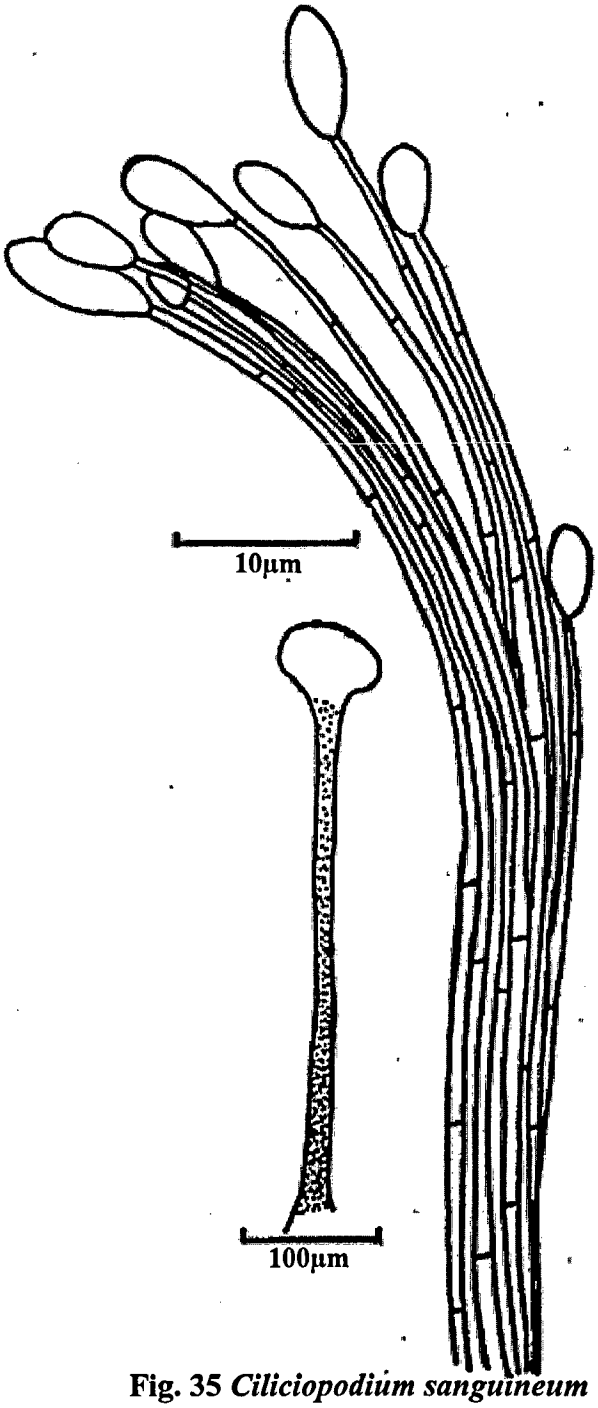


Fig. 35 *Ciliciopodium sanguineum*

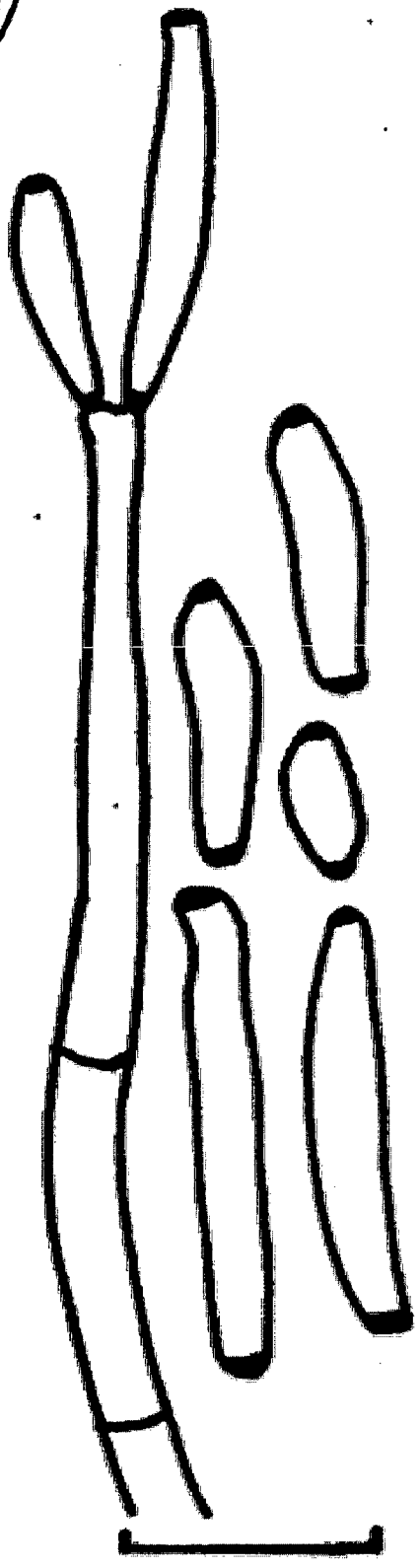


Fig. 36 *Cladosporium spongiosum*

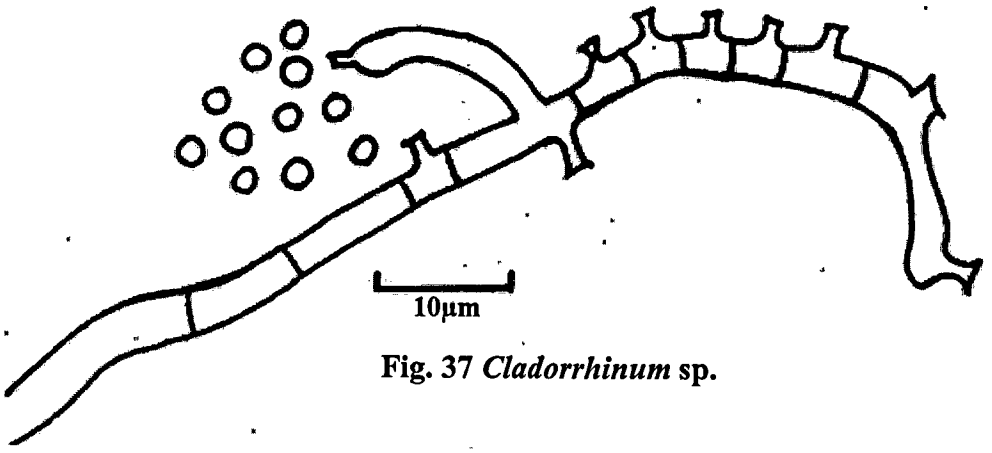


Fig. 37 *Cladorrhinum* sp.

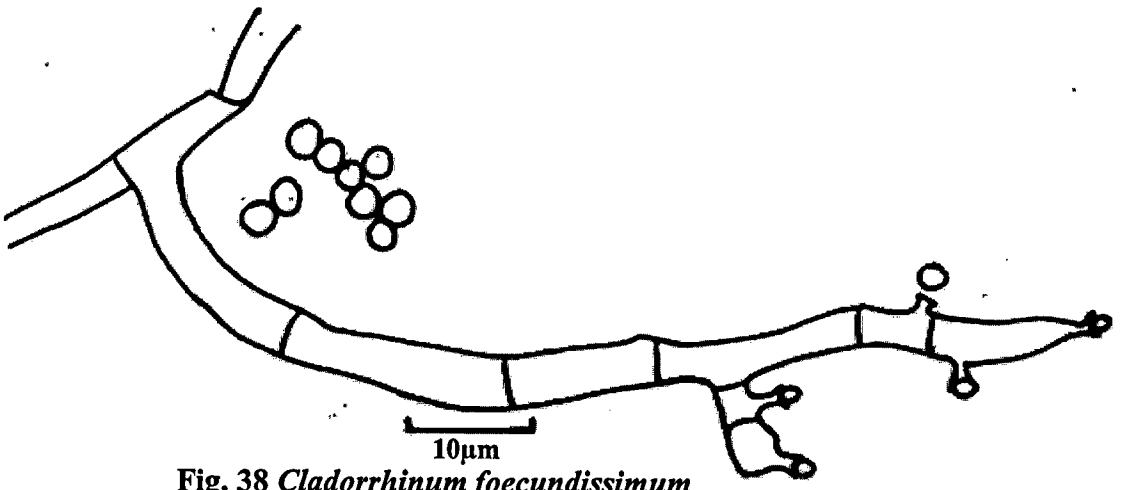


Fig. 38 *Cladorrhinum foecundissimum*

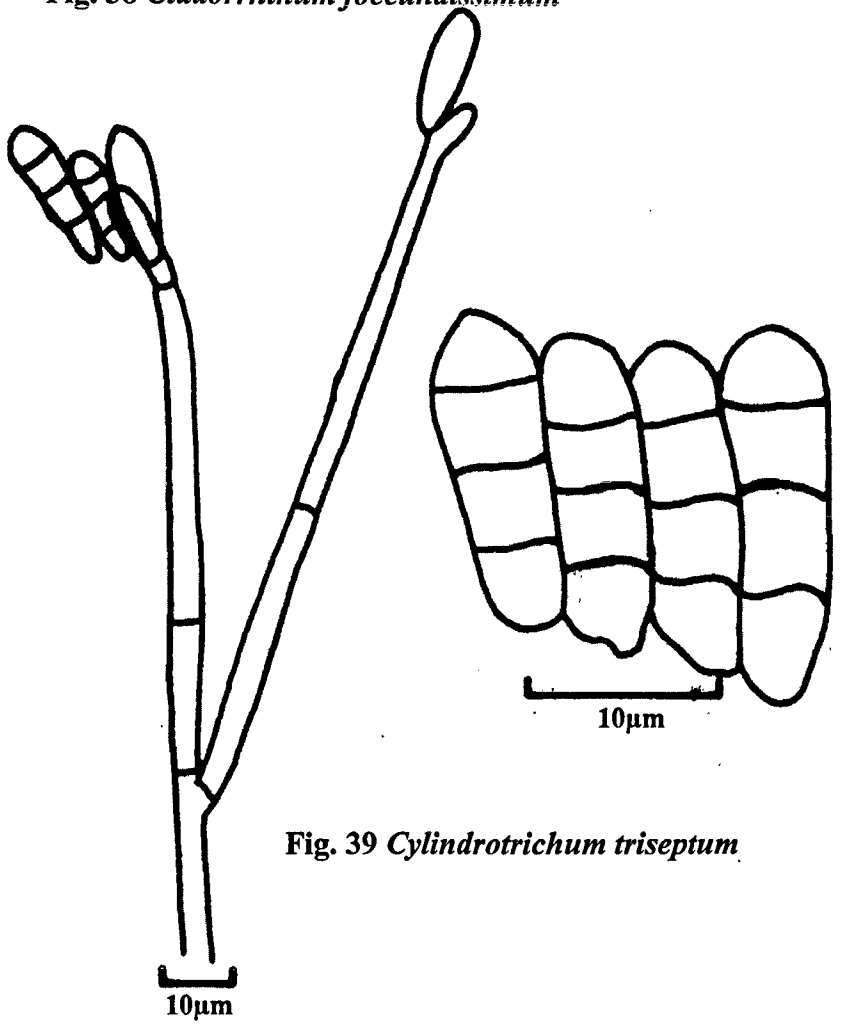


Fig. 39 *Cylindrotrichum triseptum*

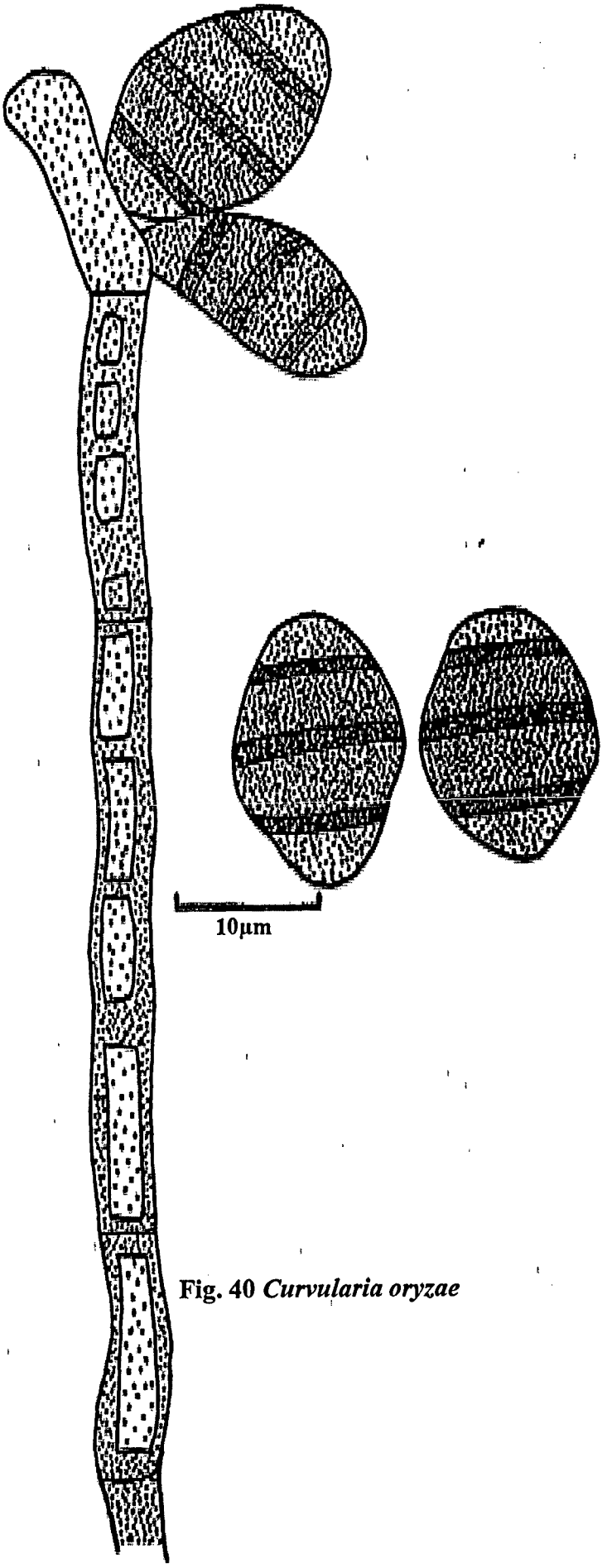


Fig. 40 *Curvularia oryzae*

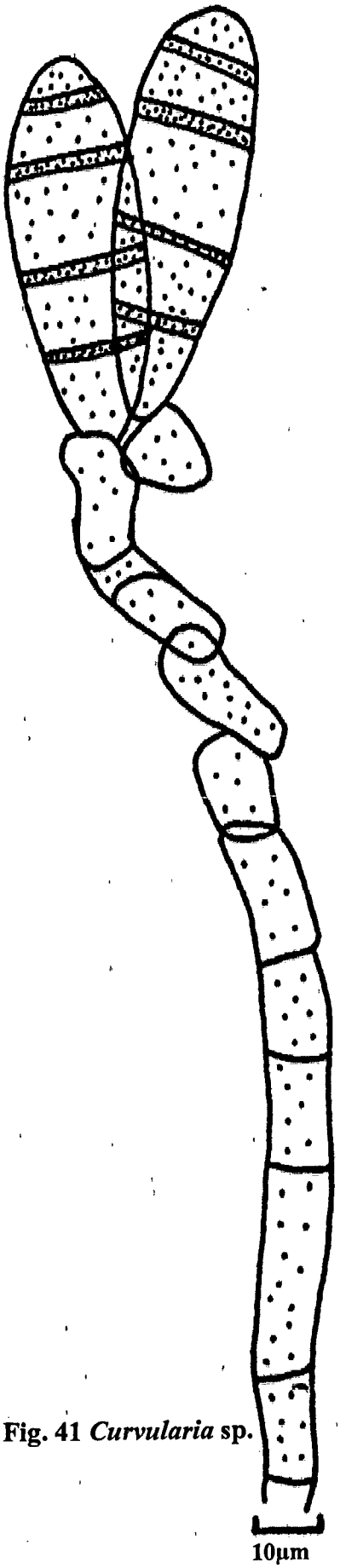


Fig. 41 *Curvularia* sp.

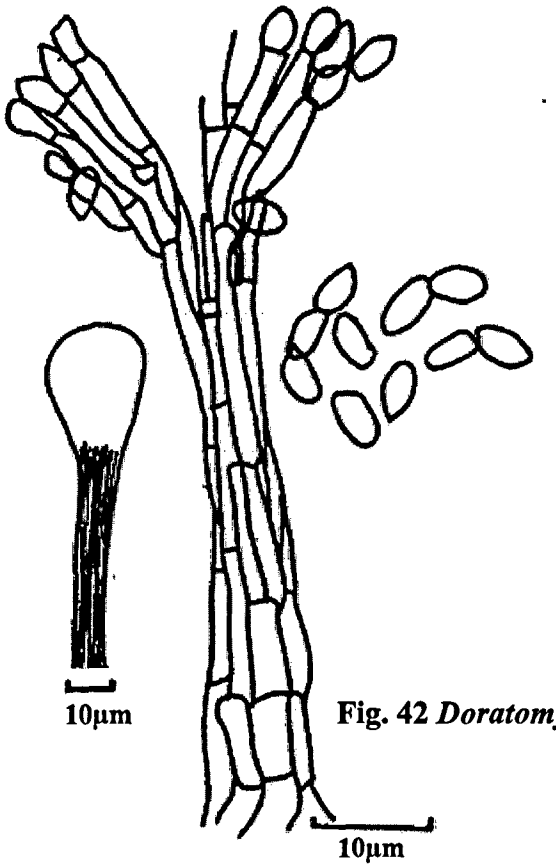


Fig. 42 *Doratomyces columnaris*

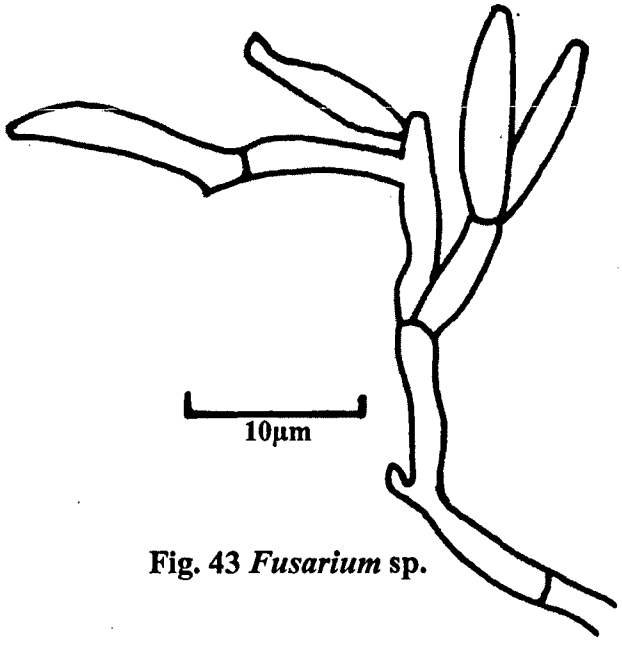


Fig. 43 *Fusarium* sp.

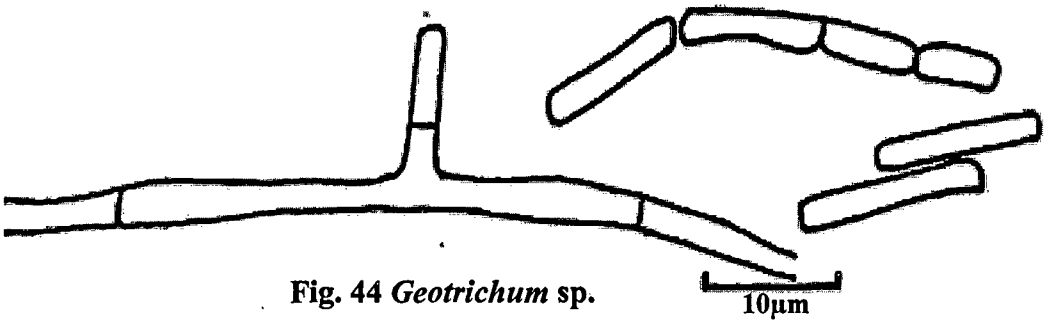


Fig. 44 *Geotrichum* sp.

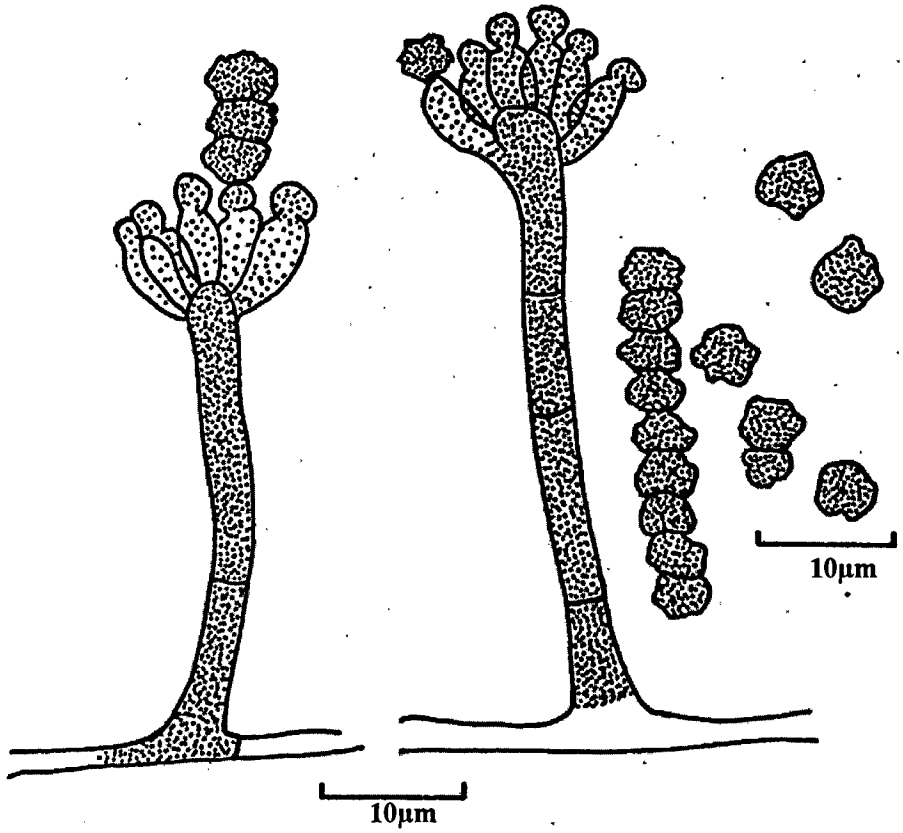


Fig. 45 *Memnoniella echinate*

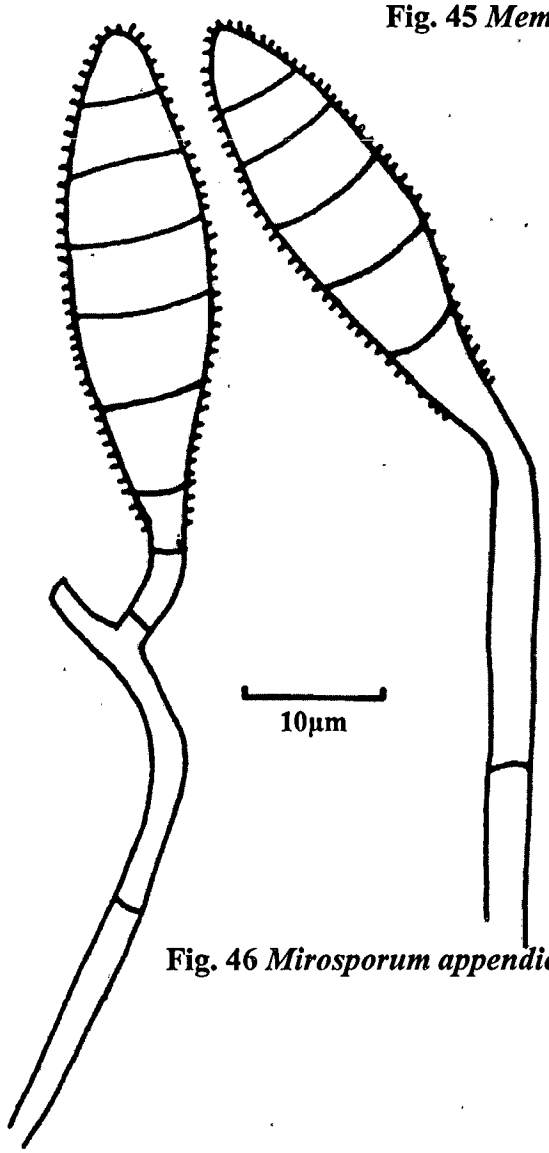


Fig. 46 *Mirosporum appendiculata*

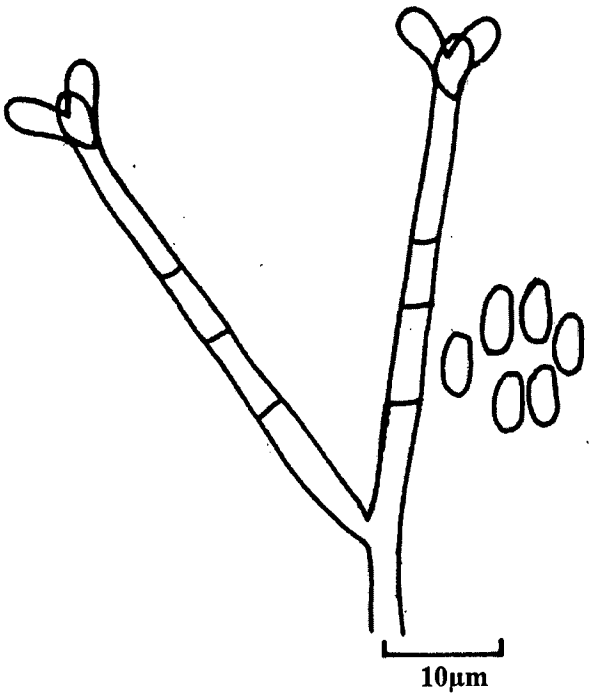


Fig. 47 *Ovularia* sp.

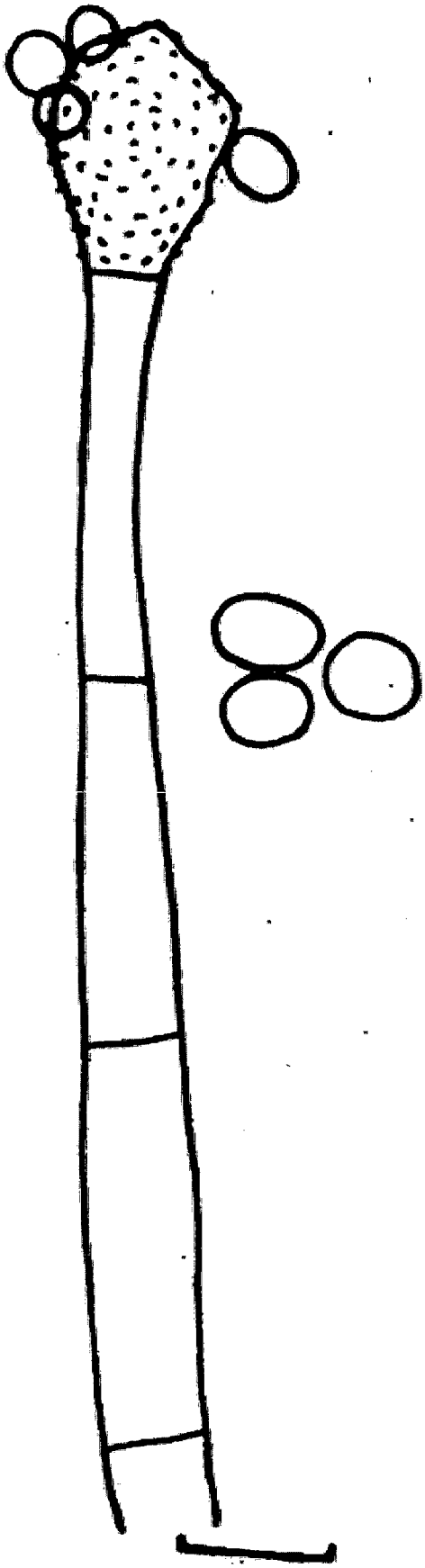


Fig. 48 *Oedocephalum elegans*

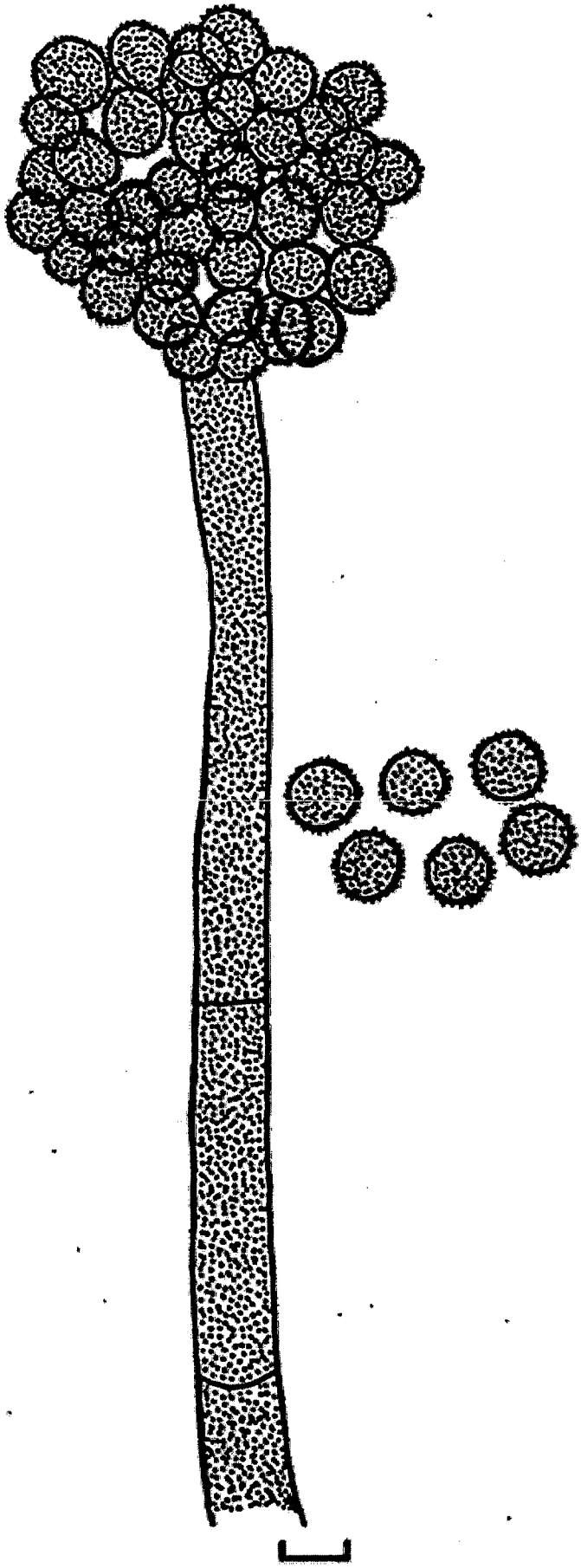


Fig. 49 *Periconia byssoides*

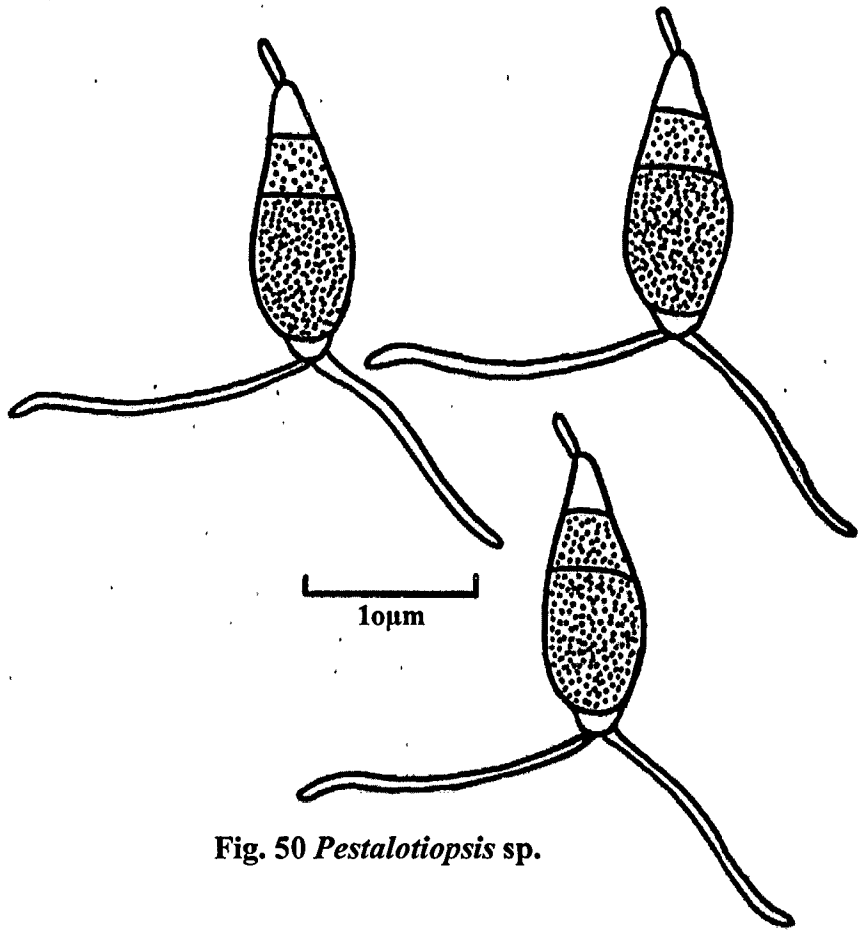


Fig. 50 *Pestalotiopsis* sp.

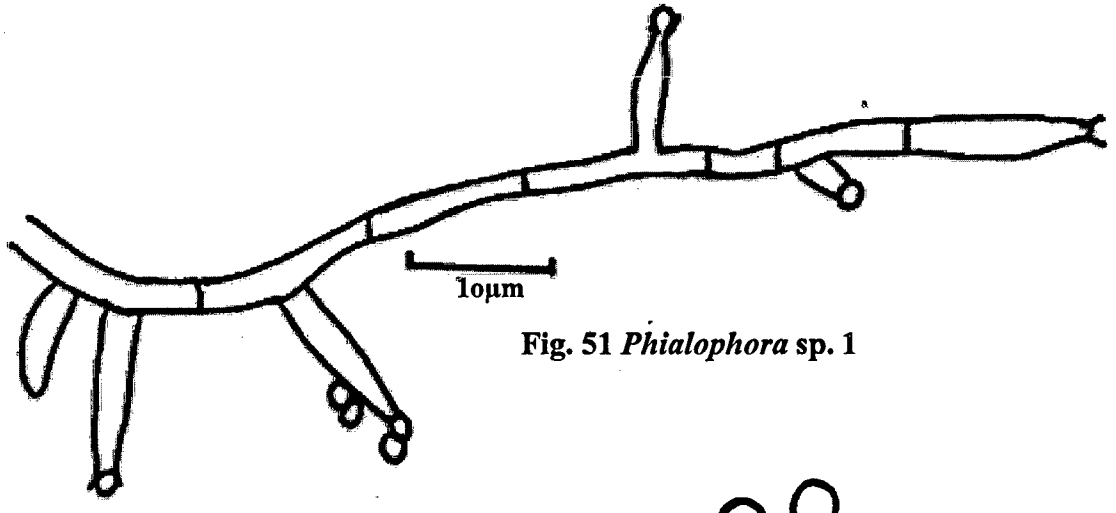


Fig. 51 *Phialophora* sp. 1

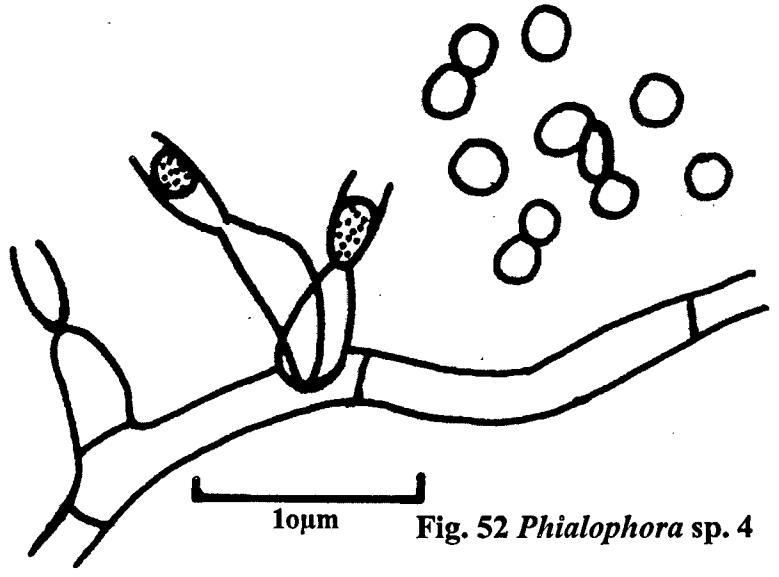


Fig. 52 *Phialophora* sp. 4

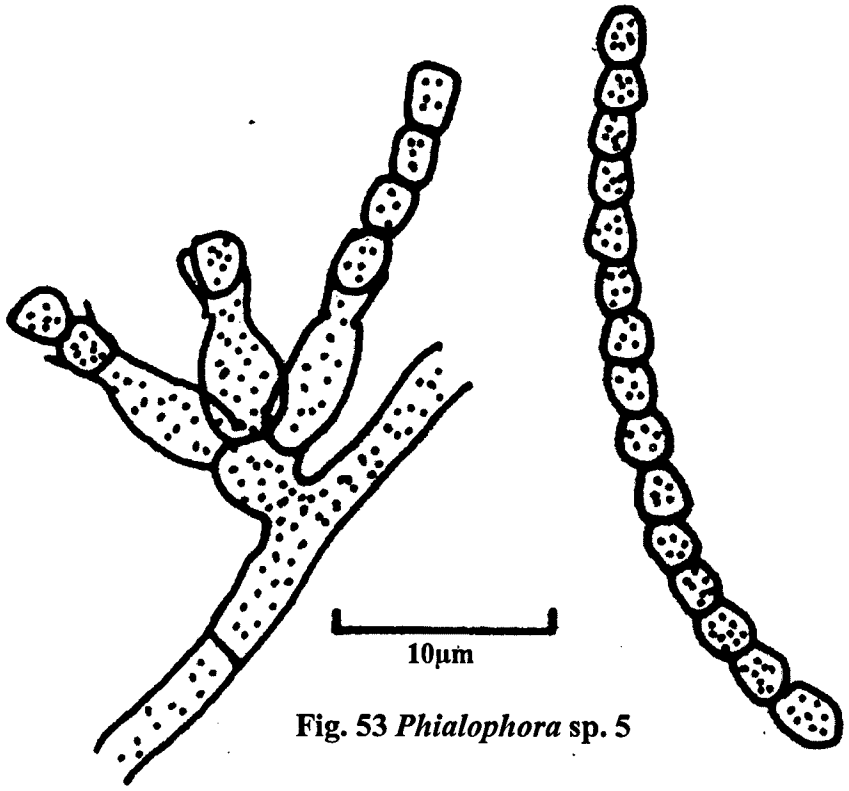


Fig. 53 *Phialophora* sp. 5

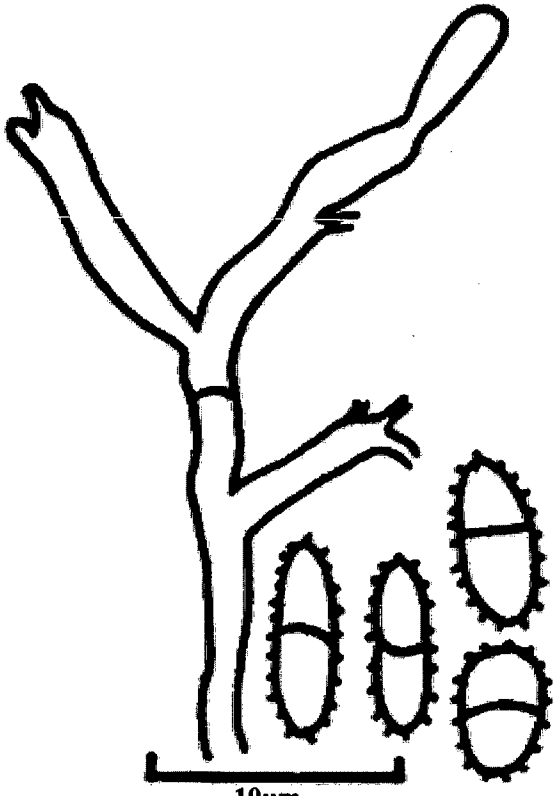


Fig. 54 *Scolecobasidium constrictum*

Fig. 55 *Sesquicillium* sp.

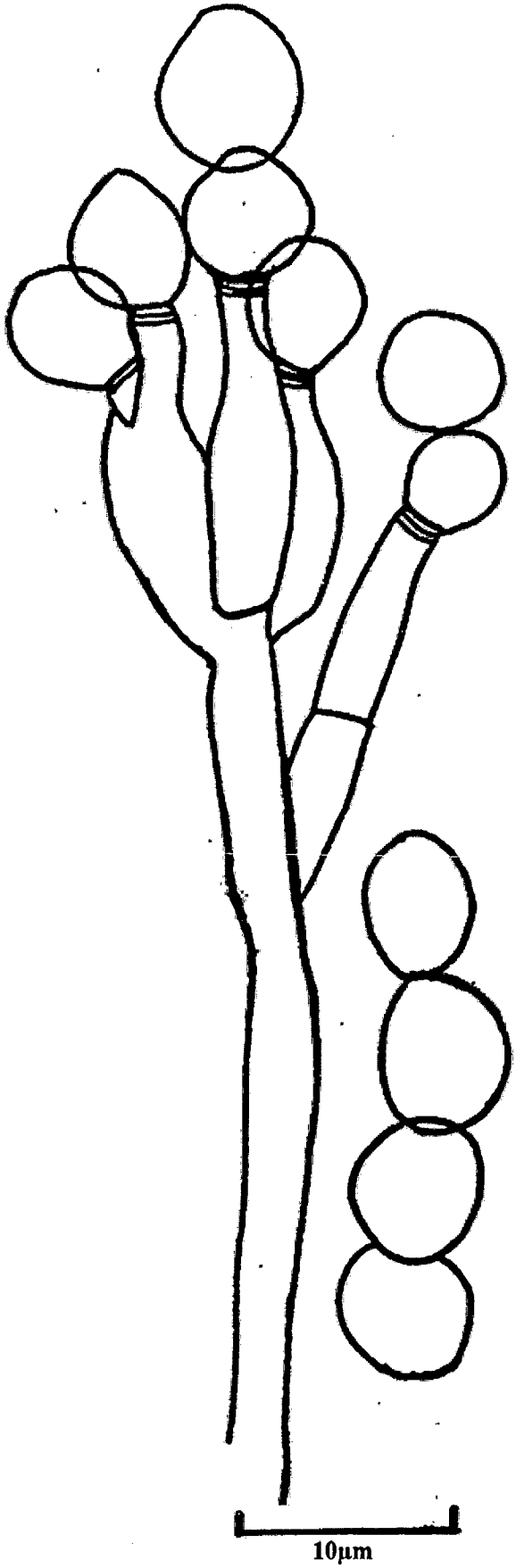


Fig. 57 *Scopldlariopsis brumptri*

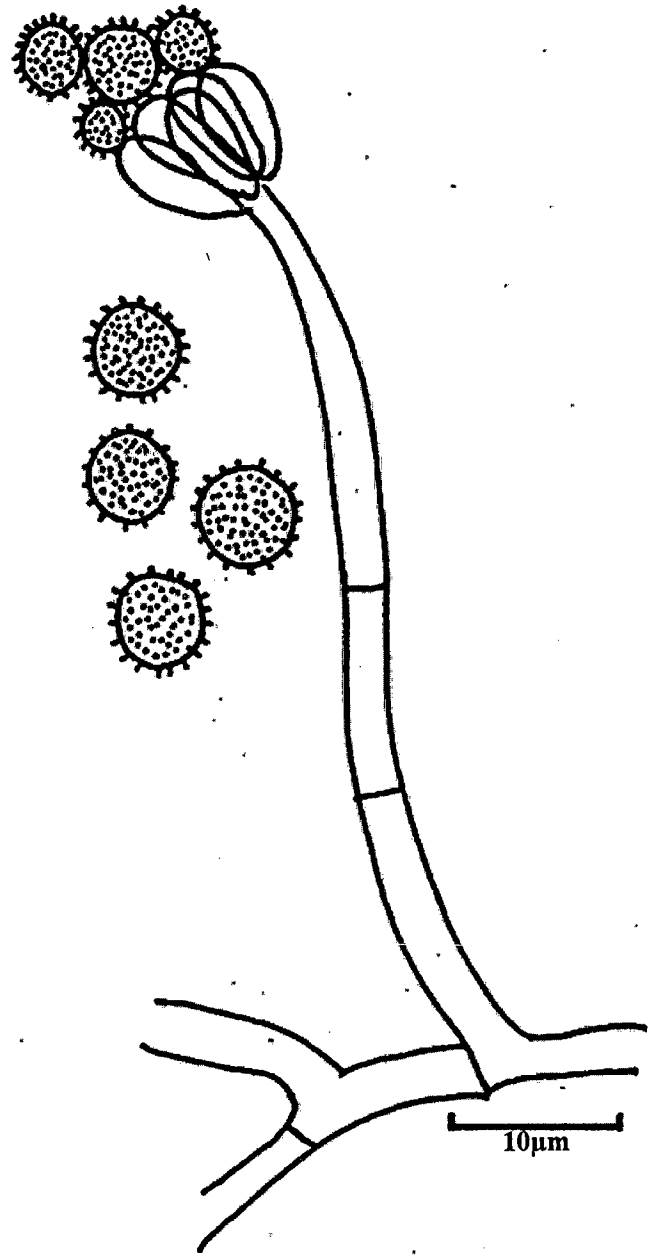


Fig. 56 *Stachybotrys* sp.

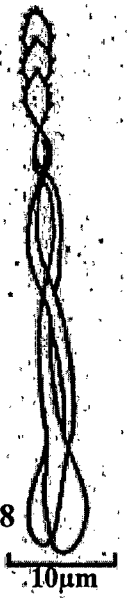


Fig. 58

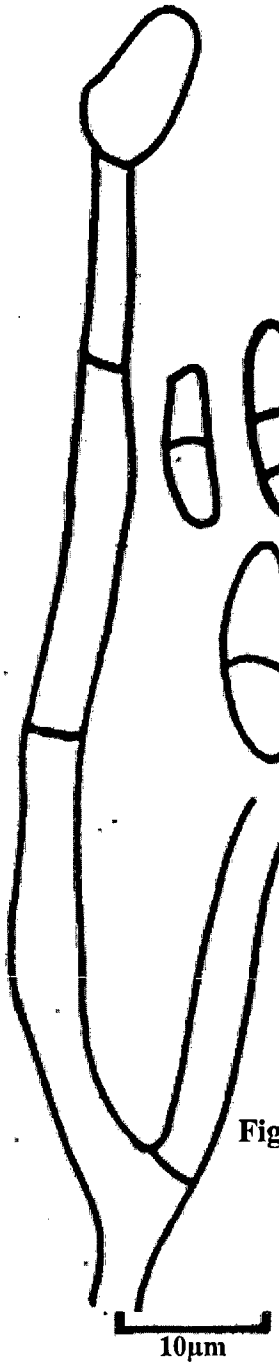


Fig 59. *Trichothecium roseum*

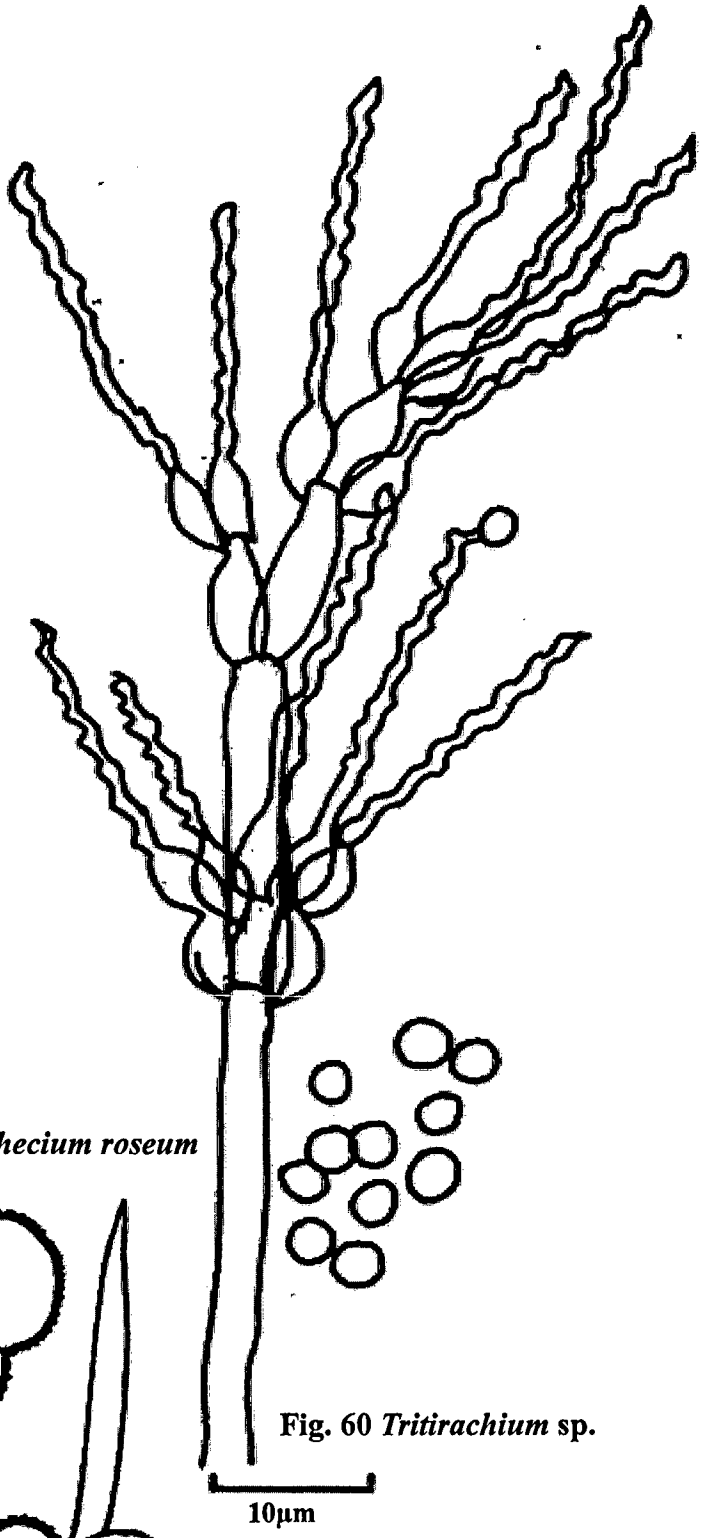


Fig. 60 *Tritirachium* sp.

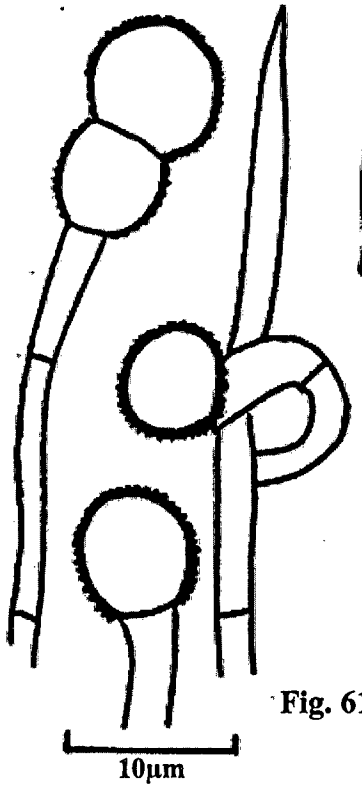


Fig. 61 *Trichocladium* sp.

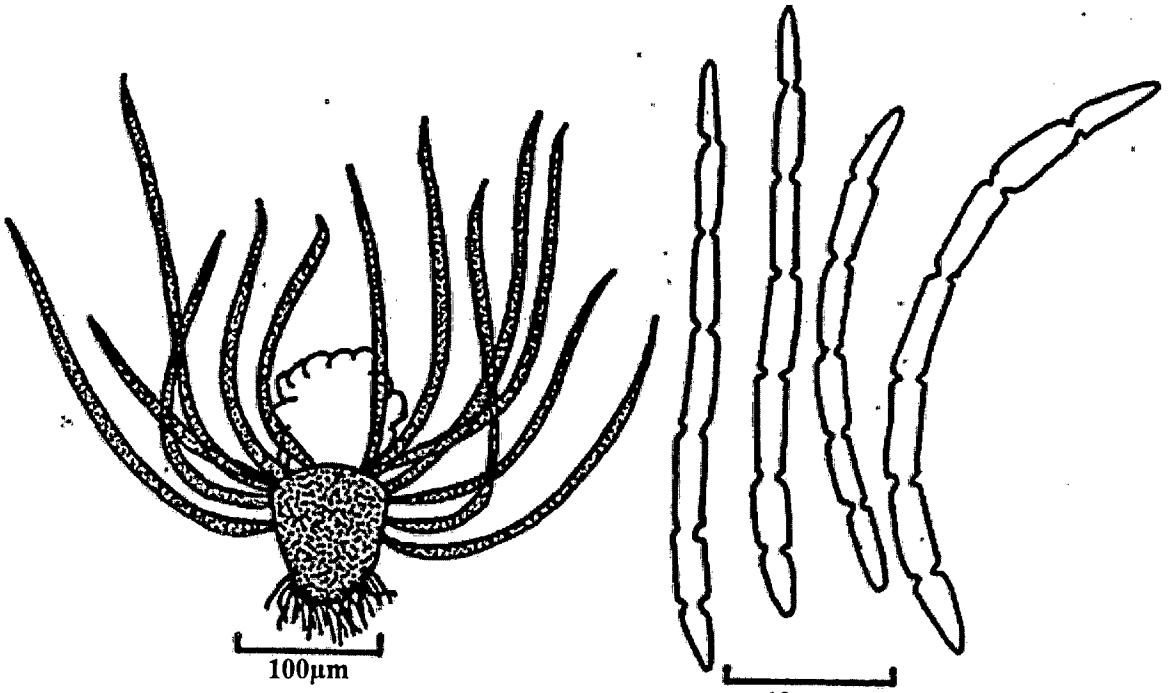


Fig. 62 *Wiesenariomyces* sp.

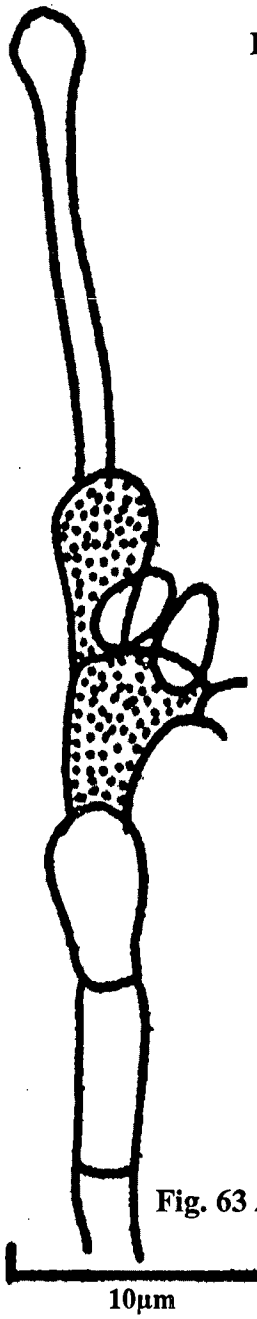


Fig. 63 *Zygosporium masonii*

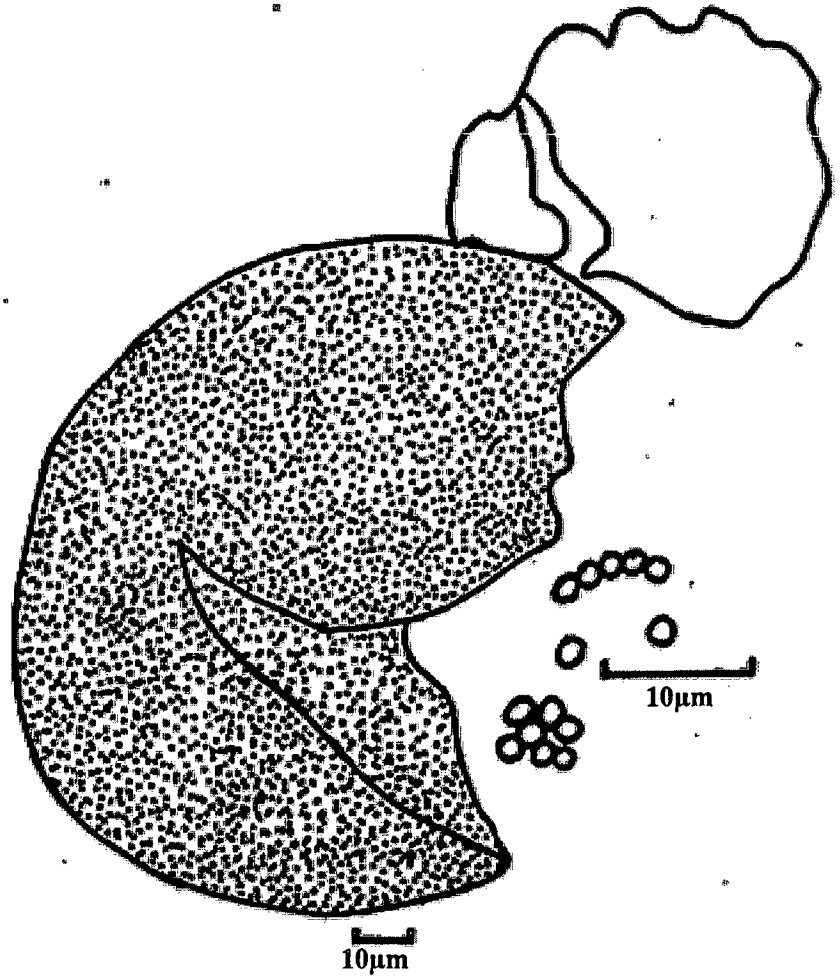


Fig. 64 Unidentified Coelomycetes

ZYGOMYCETES

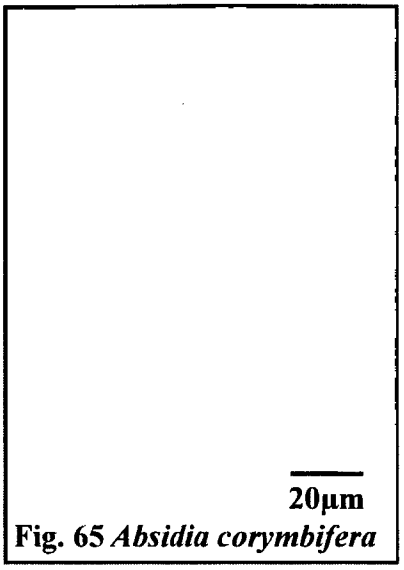


Fig. 65 *Absidia corymbifera*

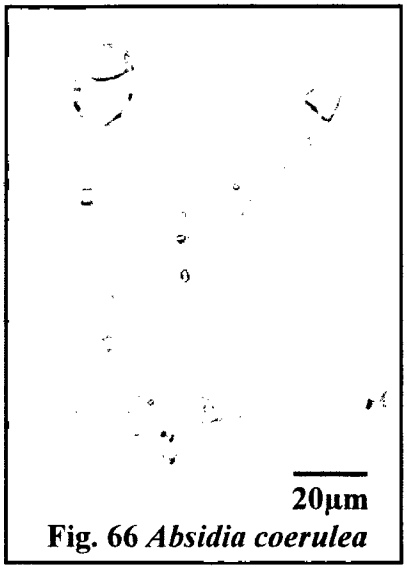


Fig. 66 *Absidia coerulea*

Fig. 67 *Actinomucor elegans*

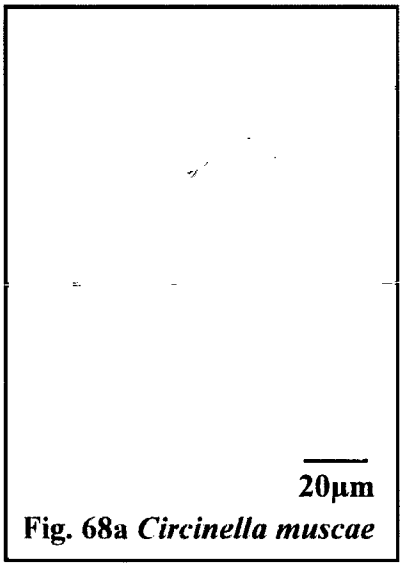


Fig. 68a *Circinella muscae*

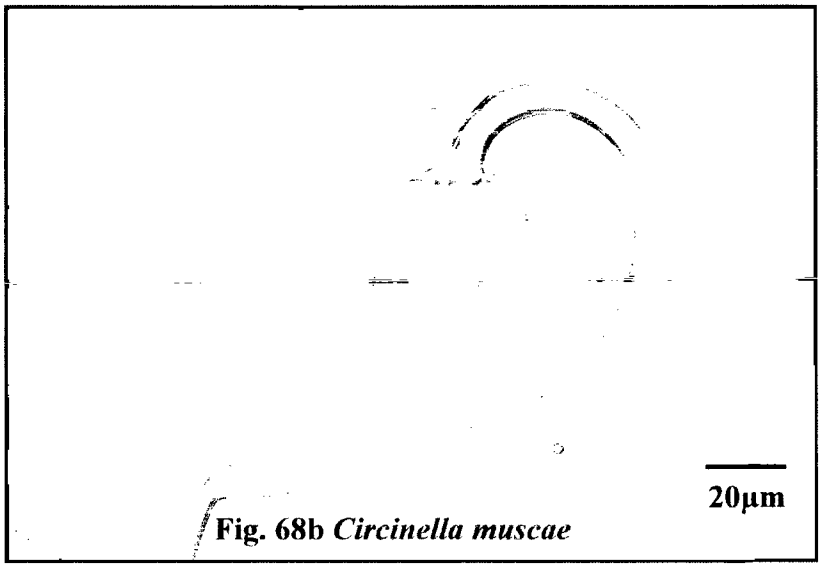


Fig. 68b *Circinella muscae*

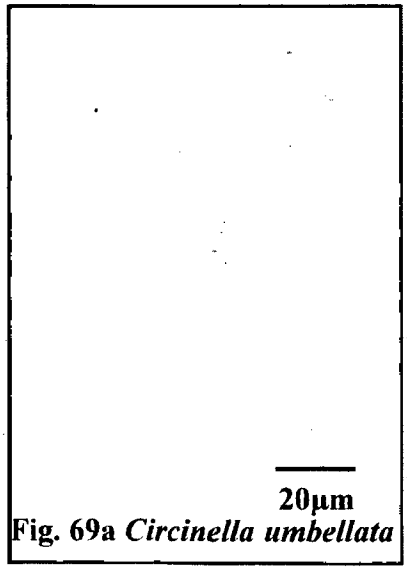


Fig. 69a *Circinella umbellata*

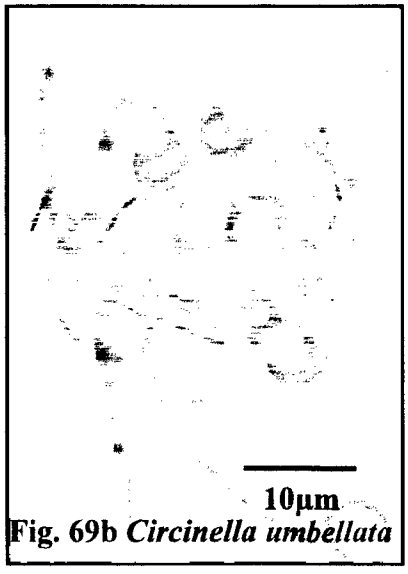


Fig. 69b *Circinella umbellata*

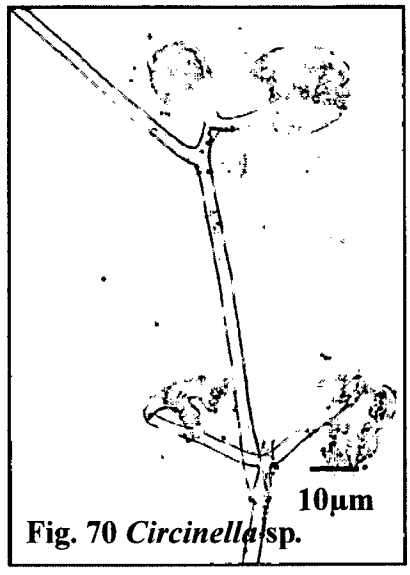


Fig. 70 *Circinella* sp.

Fig. 71a *Coemansia erecta*

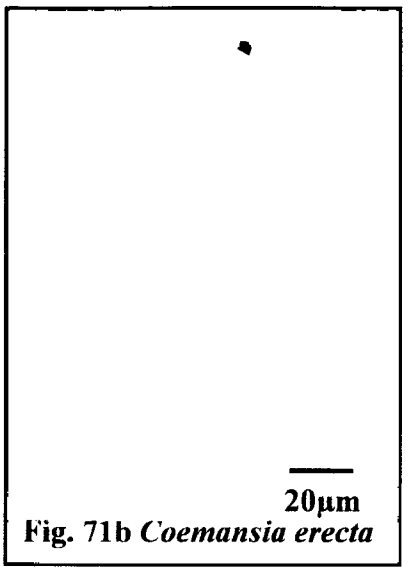


Fig. 71b *Coemansia erecta*

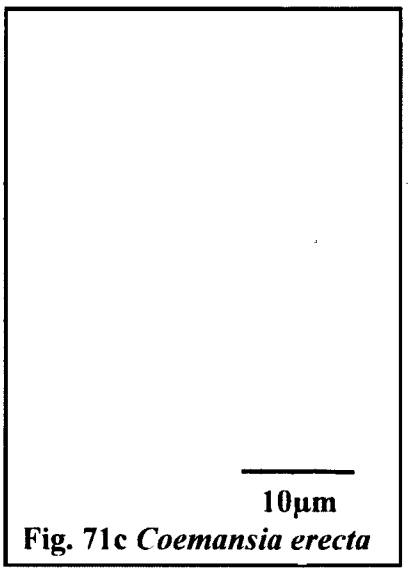


Fig. 71c *Coemansia erecta*

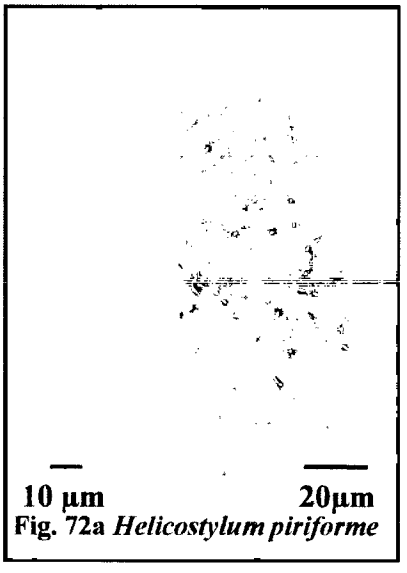


Fig. 72a *Helicostylum piriforme*

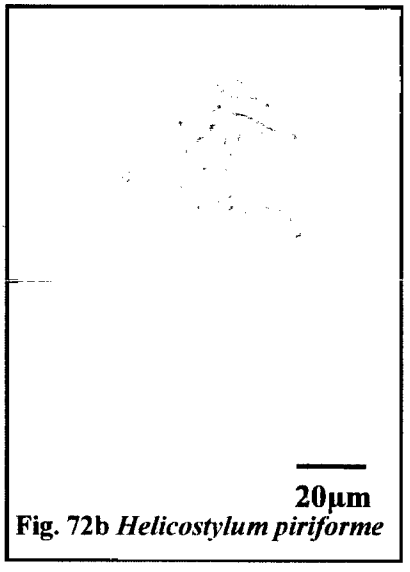


Fig. 72b *Helicostylum piriforme*

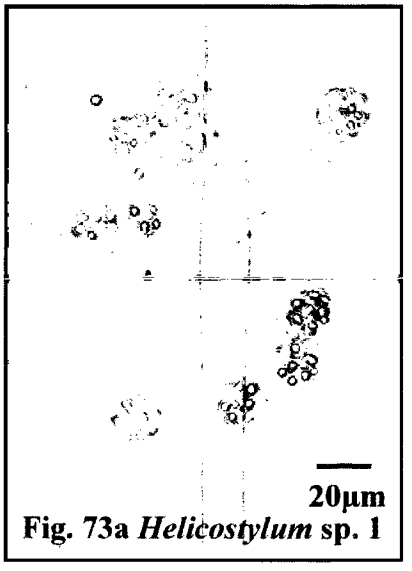


Fig. 73a *Helicostylum* sp. 1

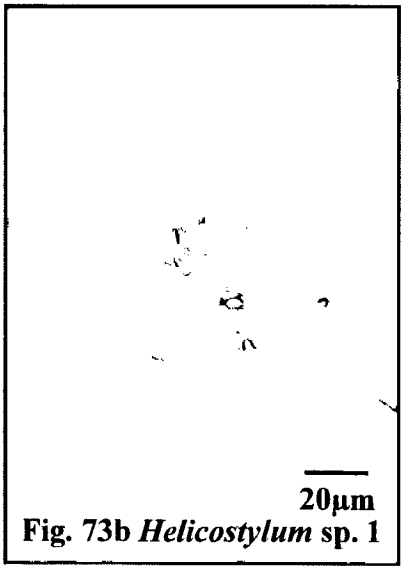


Fig. 73b *Helicostylum* sp. 1

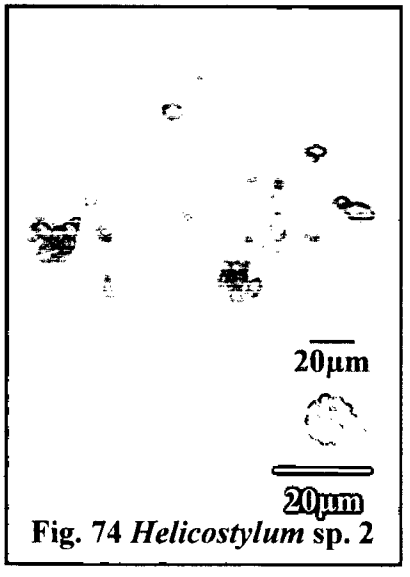


Fig. 74 *Helicostylum* sp. 2

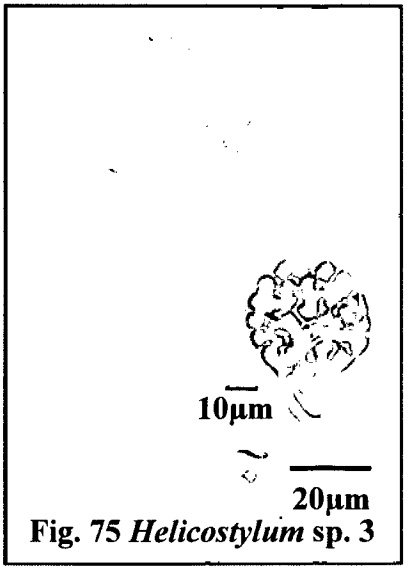


Fig. 75 *Helicostylum* sp. 3

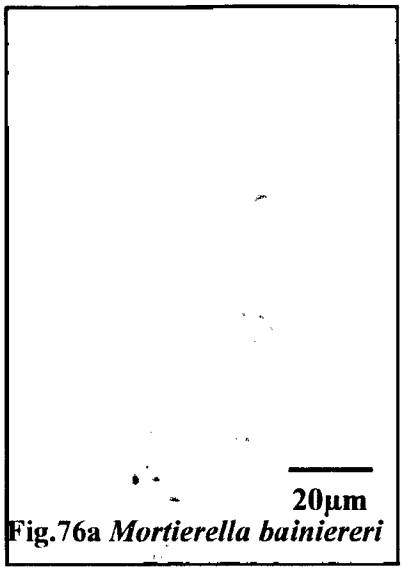


Fig.76a *Mortierella bainiereri*

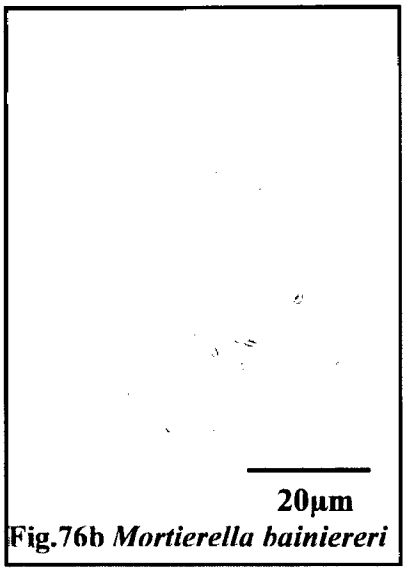


Fig.76b *Mortierella bainiereri*

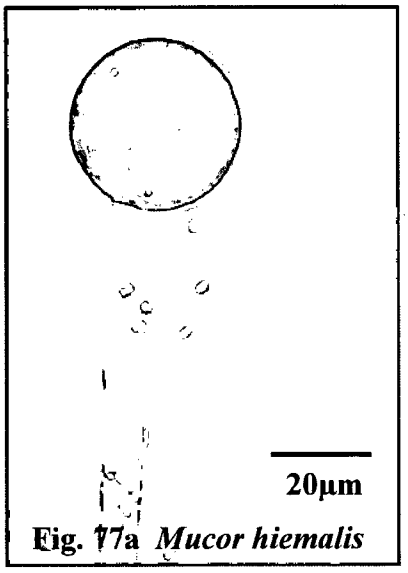


Fig. 77a *Mucor hiemalis*

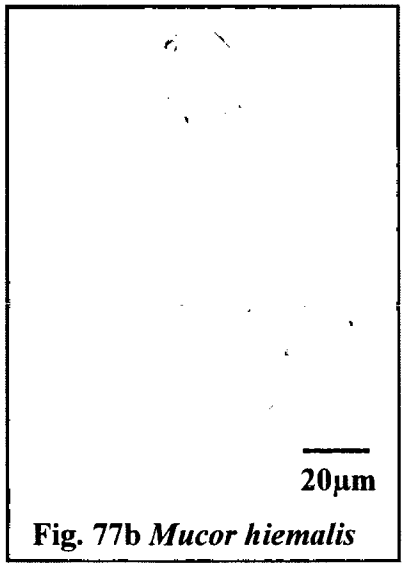


Fig. 77b *Mucor hiemalis*

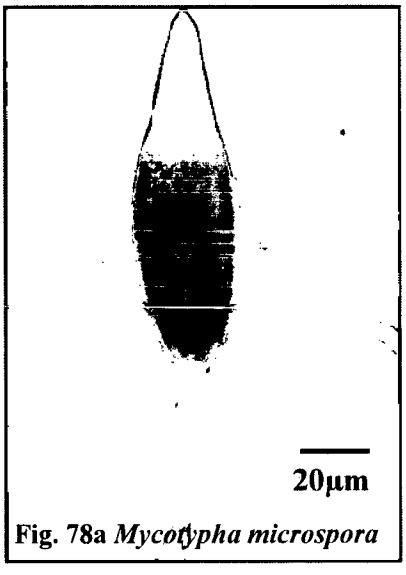


Fig. 78a *Mycotypha microspora*

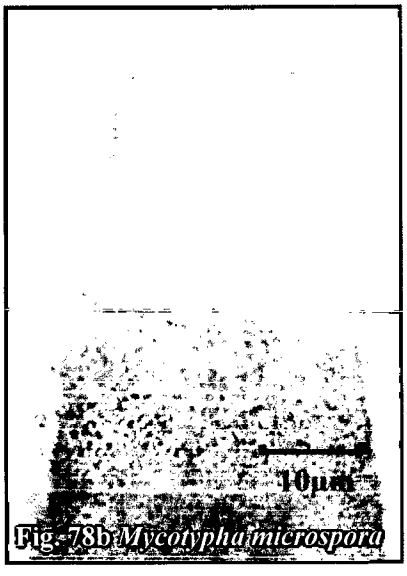


Fig. 78b *Mycotypha microspora*

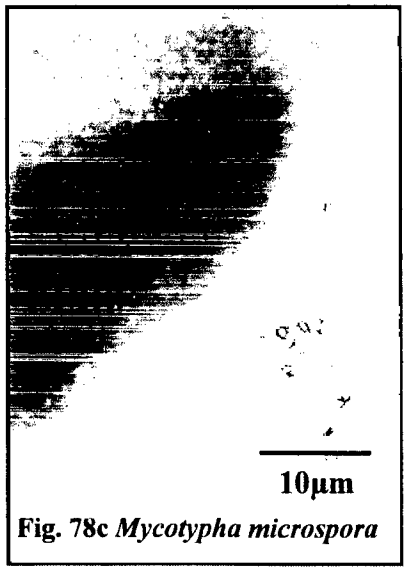


Fig. 78c *Mycotypha microspora*

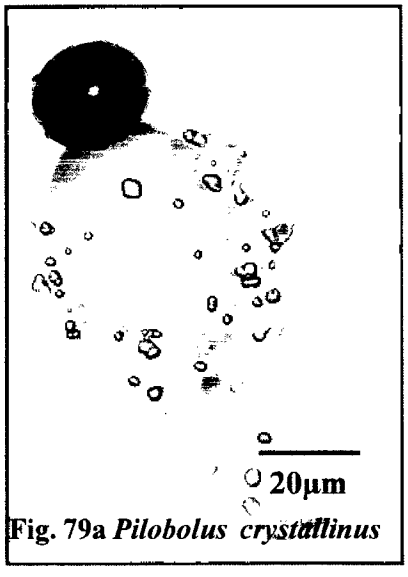


Fig. 79a *Pilobolus crystallinus*

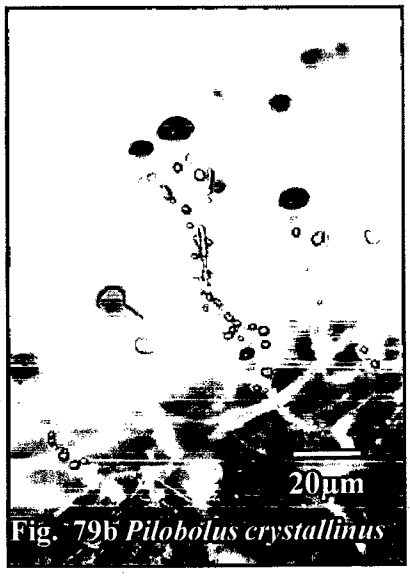


Fig. 79b *Pilobolus crystallinus*

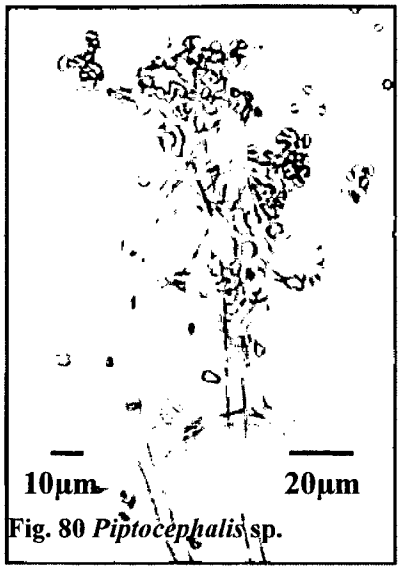


Fig. 80 *Piptocephalis* sp.

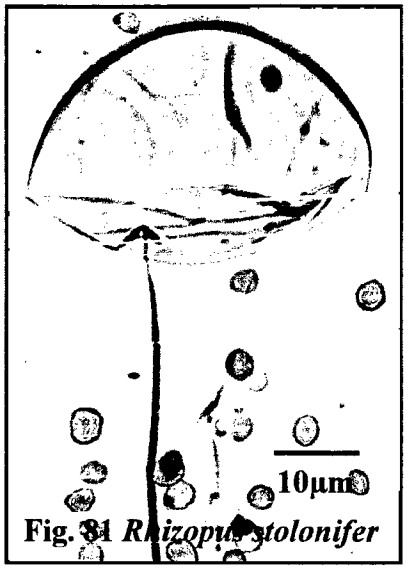


Fig. 81 *Rhizopus stolonifer*

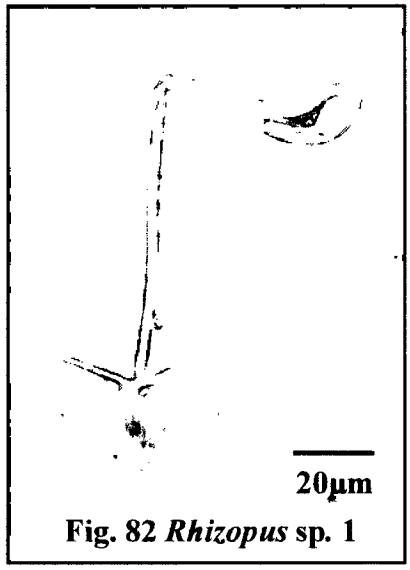


Fig. 82 *Rhizopus* sp. 1

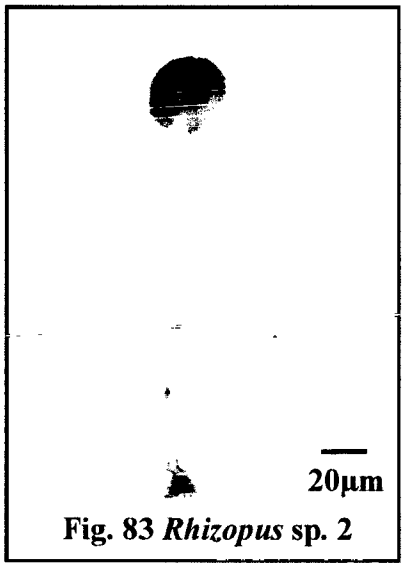


Fig. 83 *Rhizopus* sp. 2

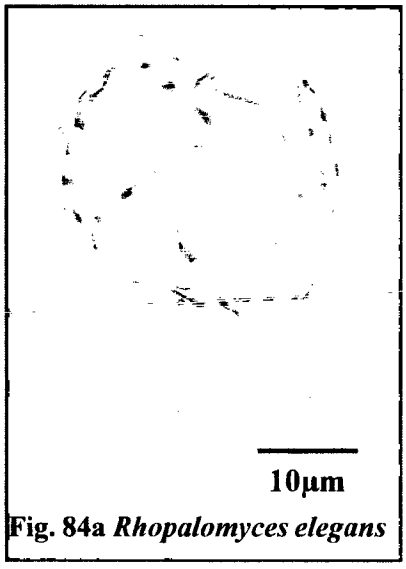


Fig. 84a *Rhopalomyces elegans*

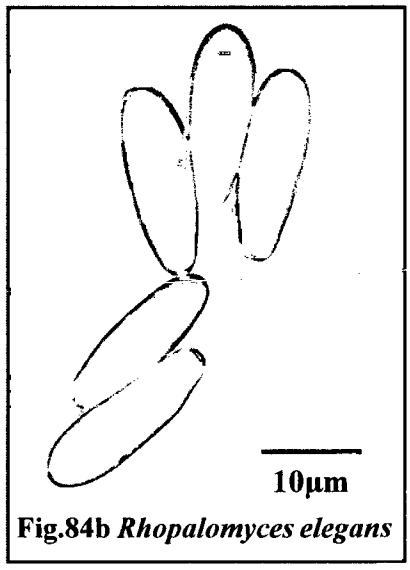


Fig.84b *Rhopalomyces elegans*

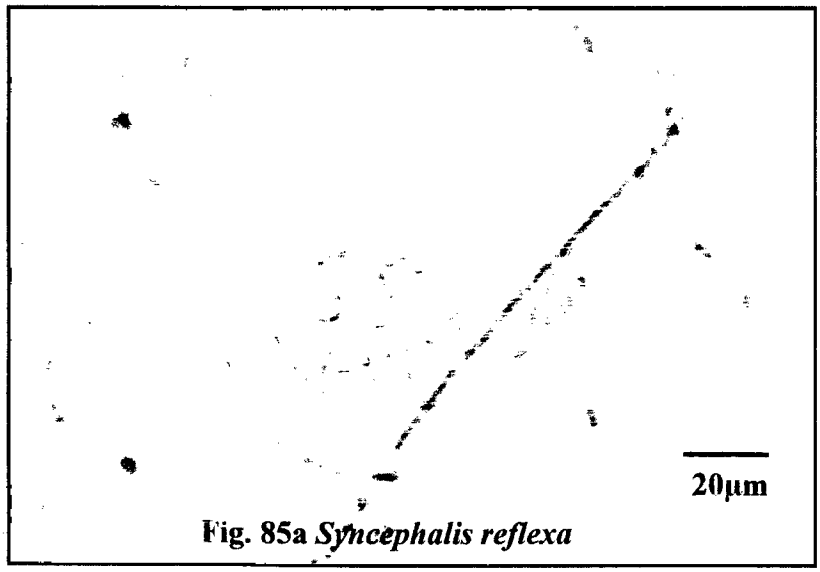


Fig. 85a *Syncephalis reflexa*

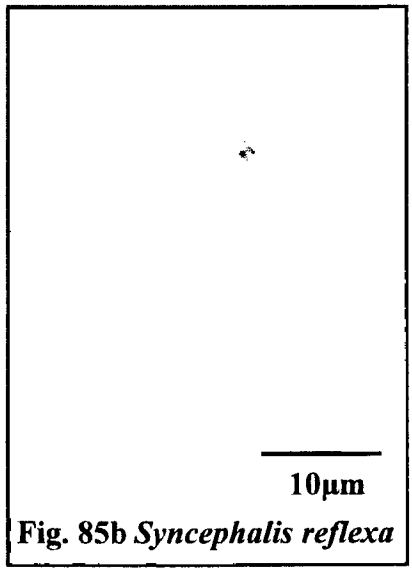


Fig. 85b *Syncephalis reflexa*

Ascomycetes (Fig. 86-131)

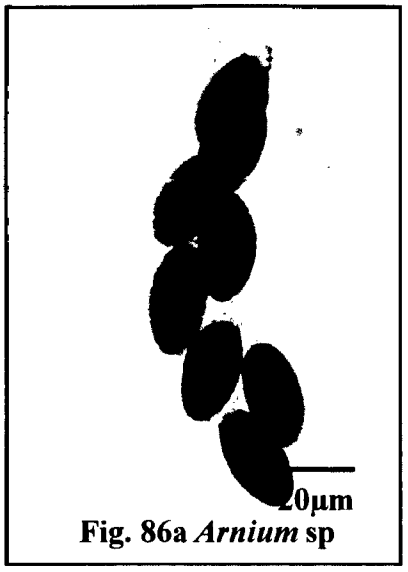


Fig. 86a *Arnium* sp

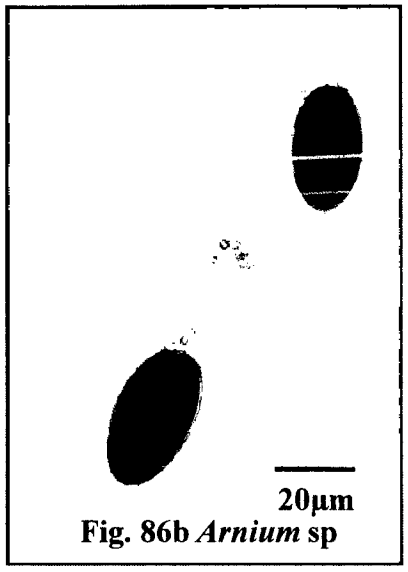


Fig. 86b *Arnium* sp

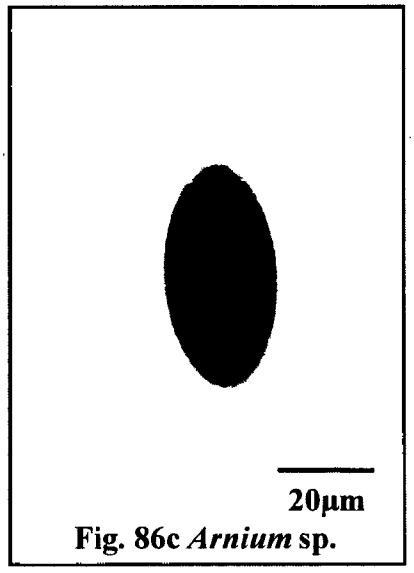


Fig. 86c *Arnium* sp.

Fig. 87a *Ascobolus elegans*

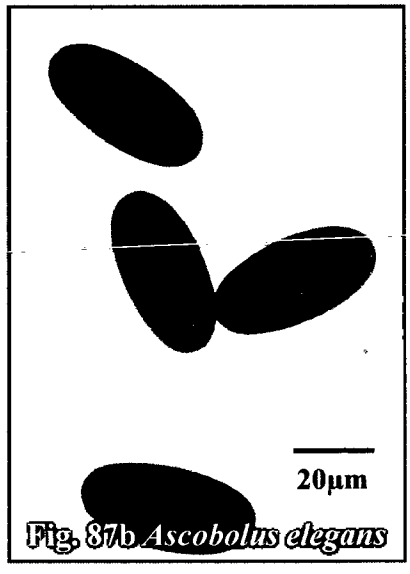


Fig. 87b *Ascobolus elegans*

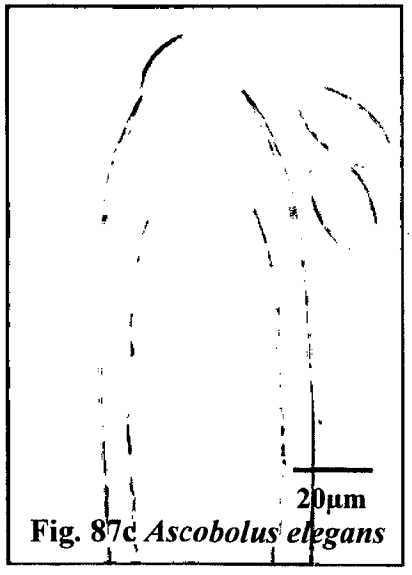


Fig. 87c *Ascobolus elegans*

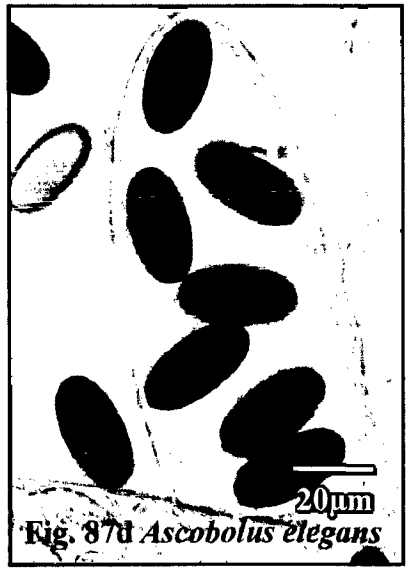


Fig. 87d *Ascobolus elegans*

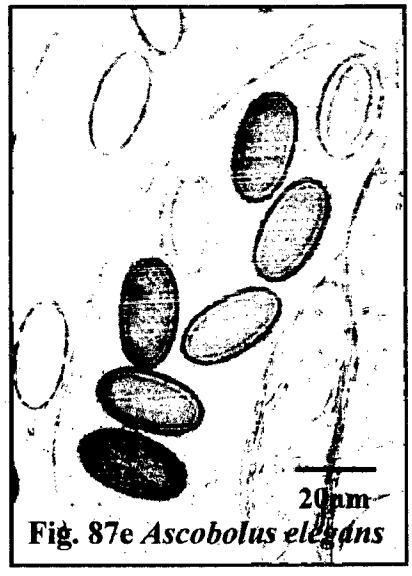


Fig. 87e *Ascobolus elegans*

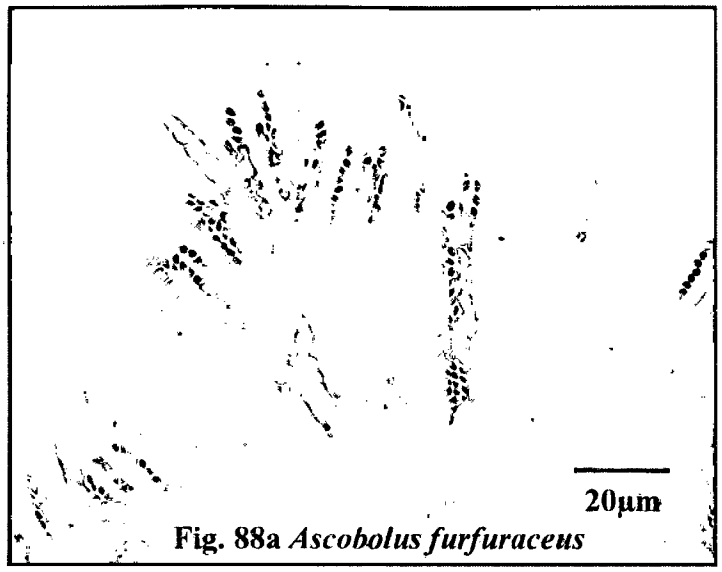


Fig. 88a *Ascobolus furfuraceus*

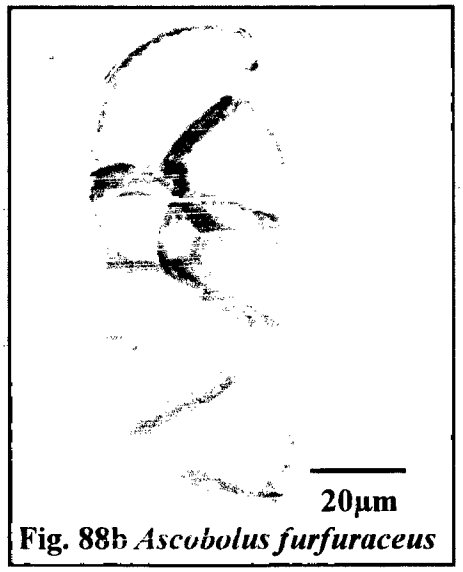


Fig. 88b *Ascobolus furfuraceus*

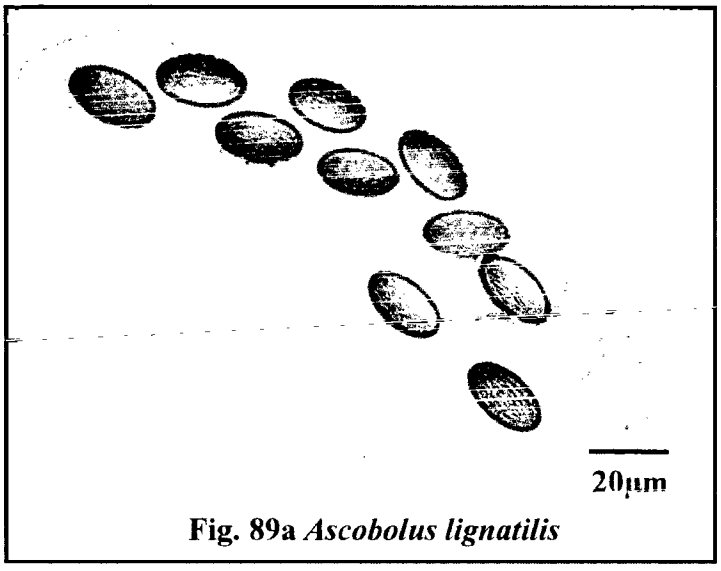


Fig. 89a *Ascobolus lignatilis*

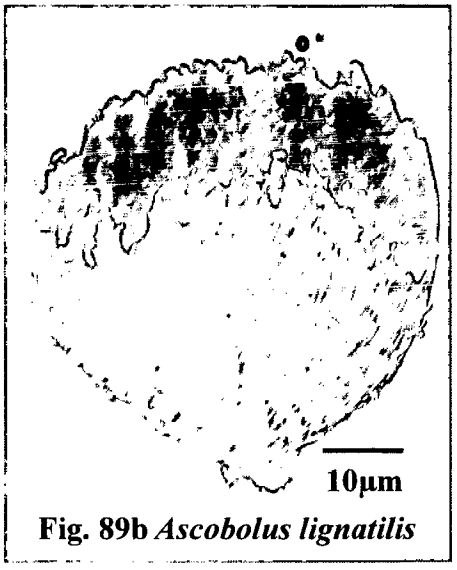


Fig. 89b *Ascobolus lignatilis*

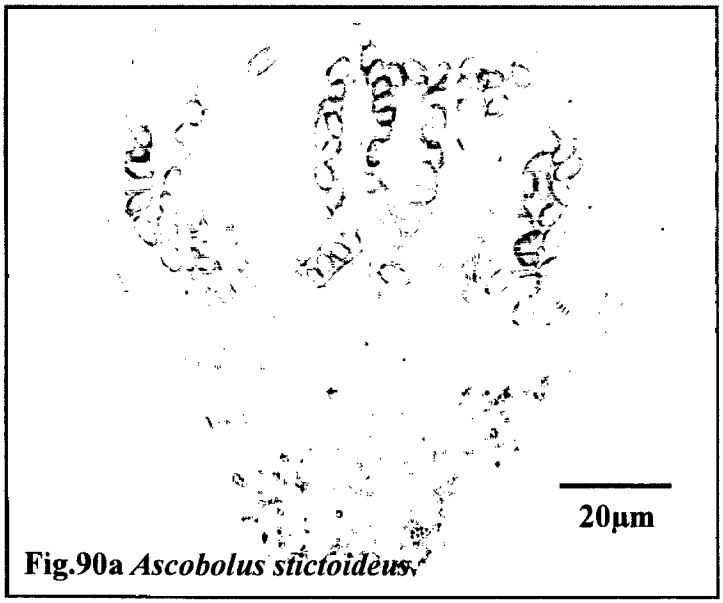


Fig.90a *Ascobolus stictoideus*

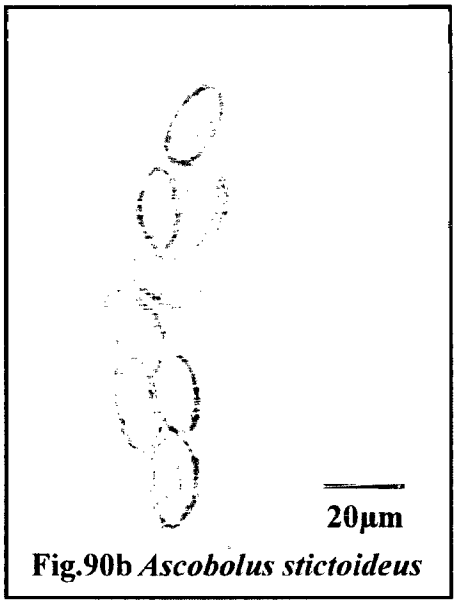


Fig.90b *Ascobolus stictoideus*

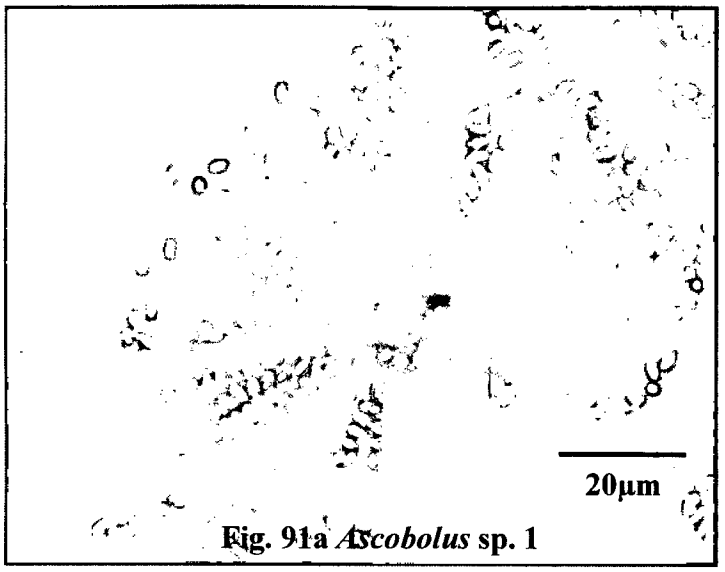


Fig. 91a *Ascobolus* sp. 1

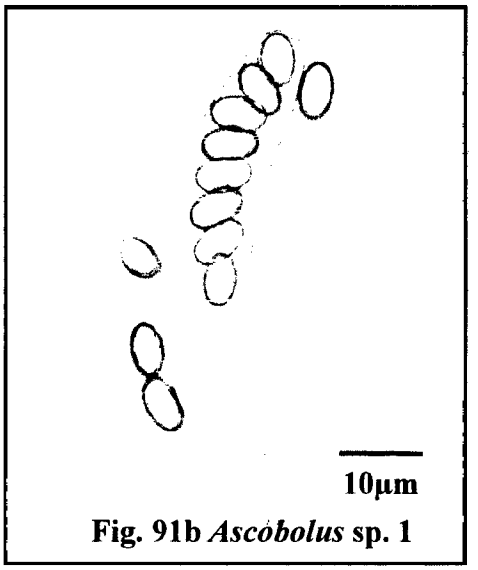


Fig. 91b *Ascobolus* sp. 1

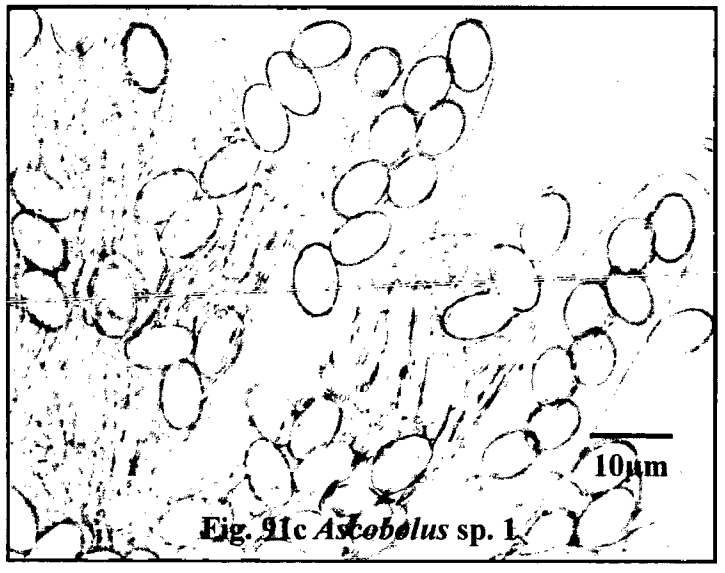


Fig. 91c *Ascobolus* sp. 1

Fig. 92 *Ascodesmis macrospora*

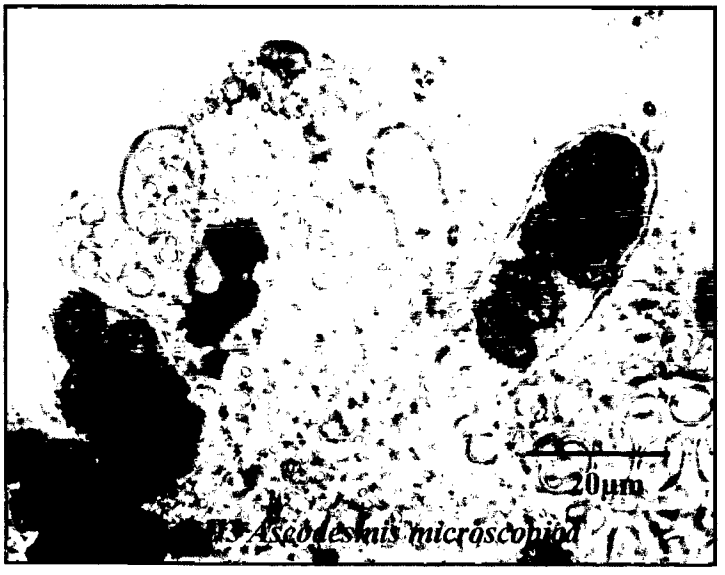


Fig. 93 *Ascodesmis microscopica*

Fig. 94 *Ascodesmis nigricans*

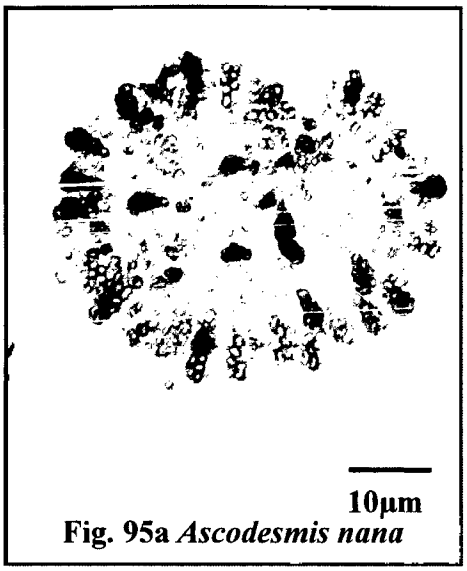


Fig. 95a *Ascodesmis nana*

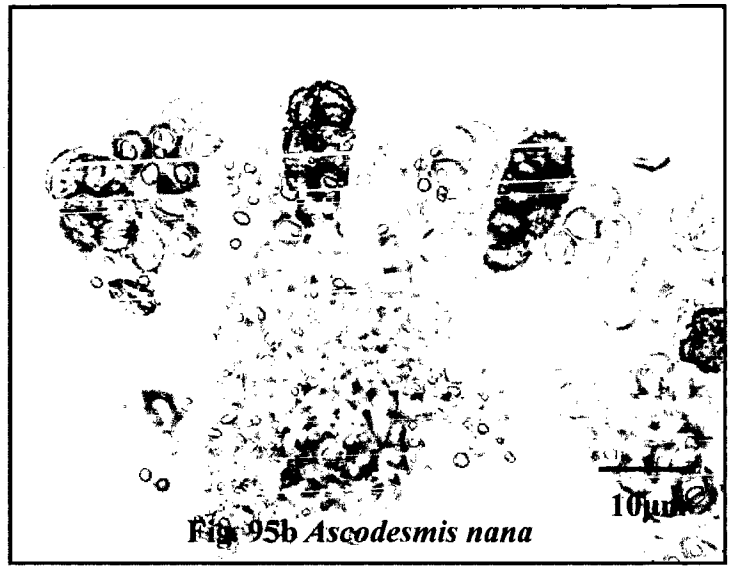


Fig. 95b *Ascodesmis nana*

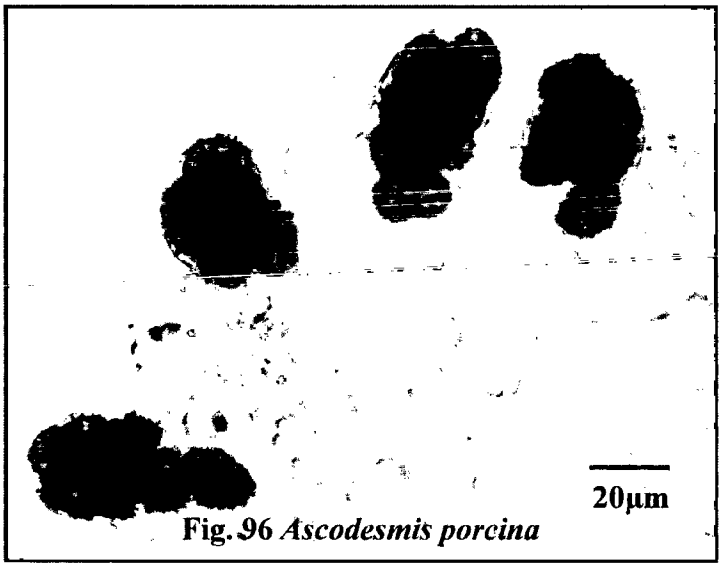


Fig. 96 *Ascodesmis porcina*

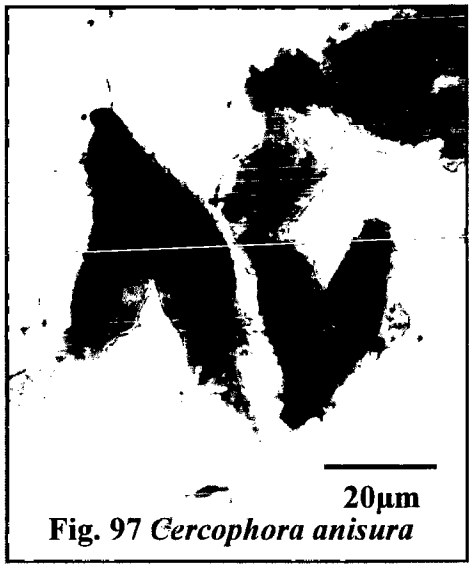


Fig. 97 *Cercophora anisura*

Fig. 98a *Cercophora coprophila*

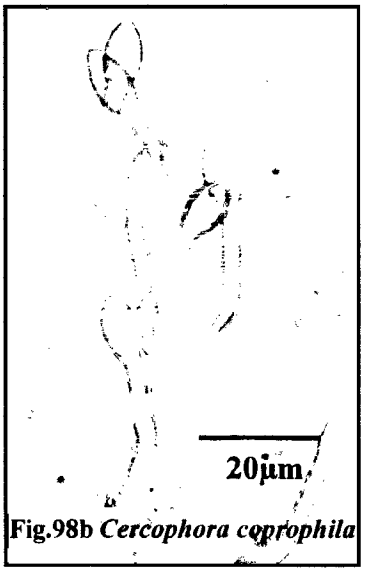


Fig.98b *Cercophora coprophila*

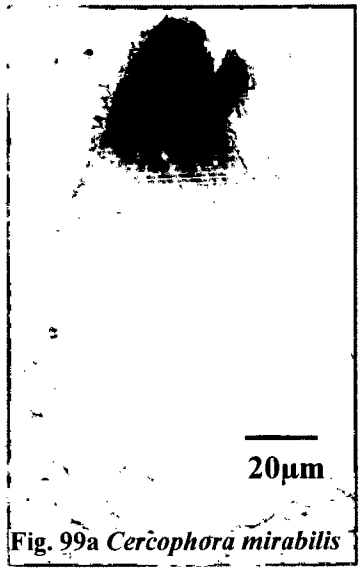


Fig. 99a *Cercophora mirabilis*

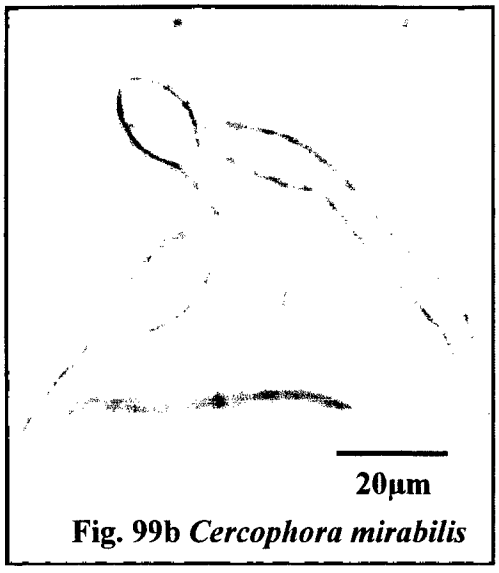


Fig. 99b *Cercophora mirabilis*

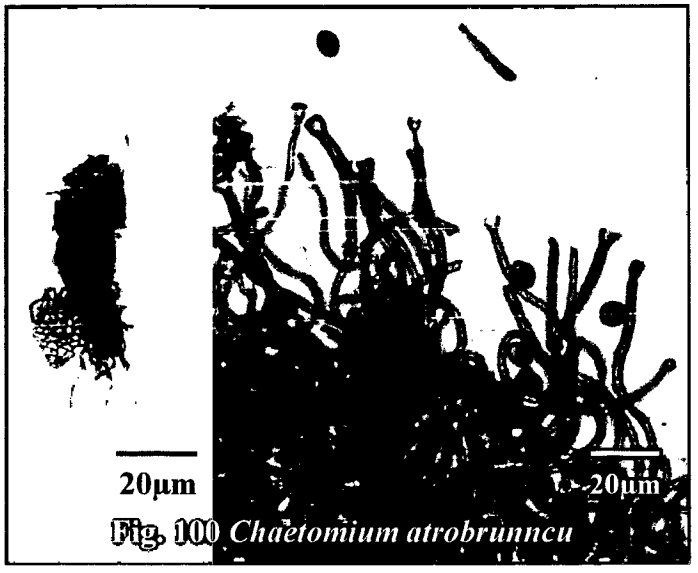


Fig. 100 *Chaetomium atrobrunncu*

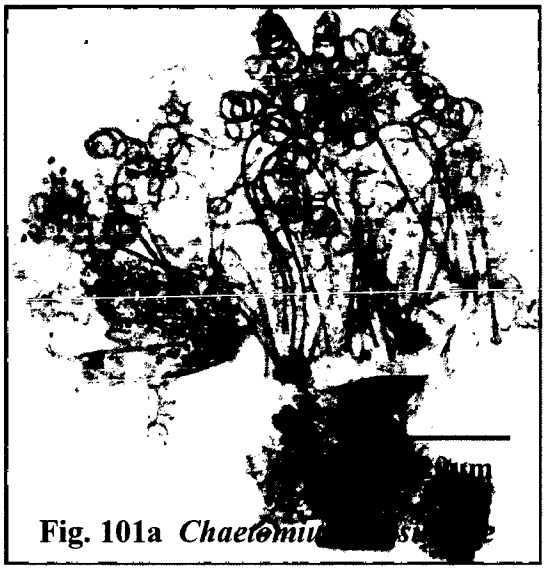


Fig. 101a *Chaetomiu*

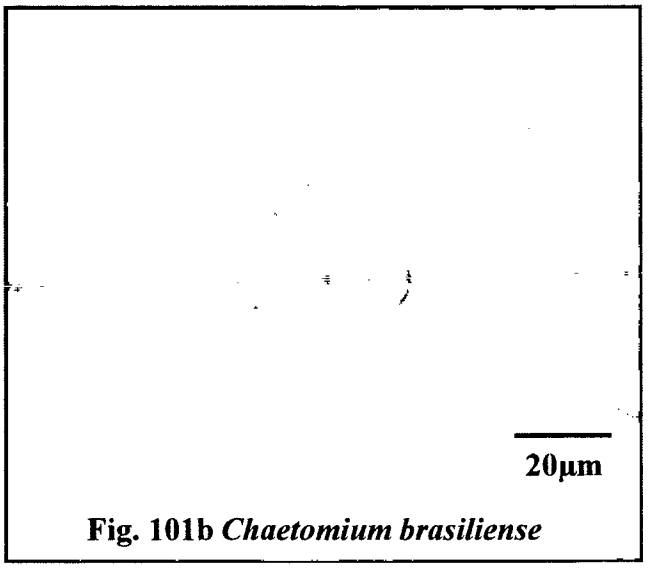
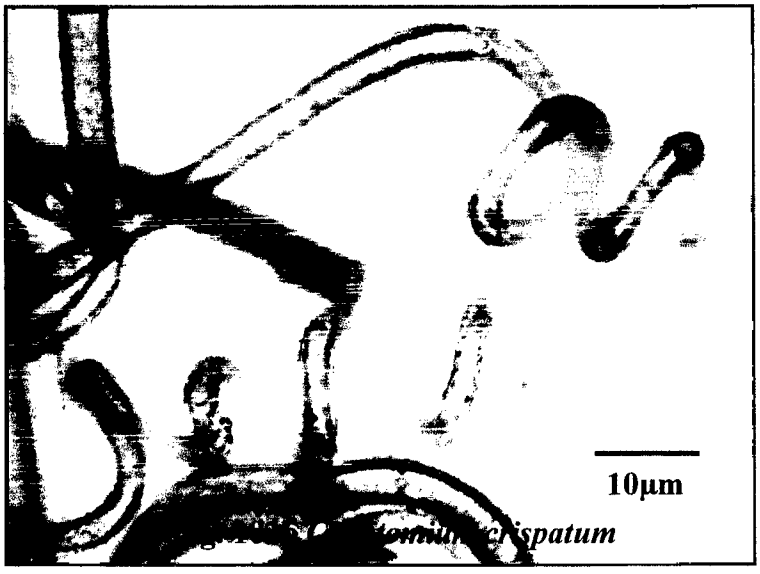


Fig. 101b *Chaetomium brasiliense*

Fig. 102a *Chaet crispatum*



crispatum

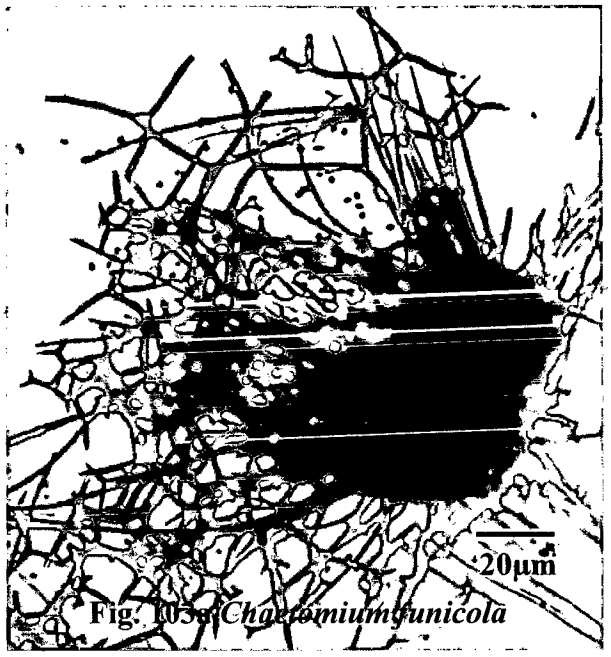


Fig. 103a *Chaetomium funicola*

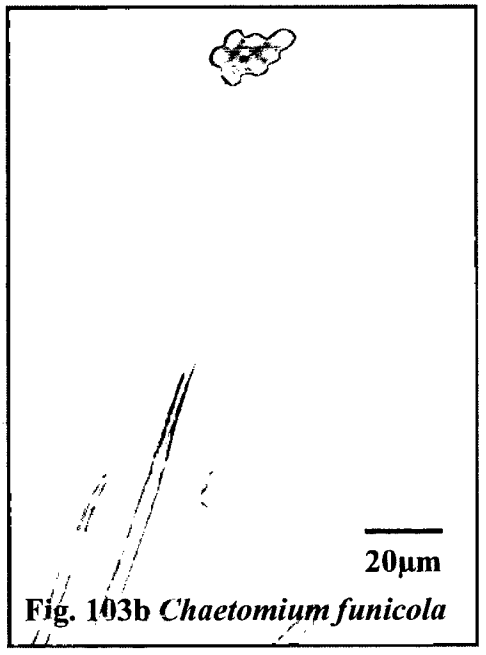


Fig. 103b *Chaetomium funicola*

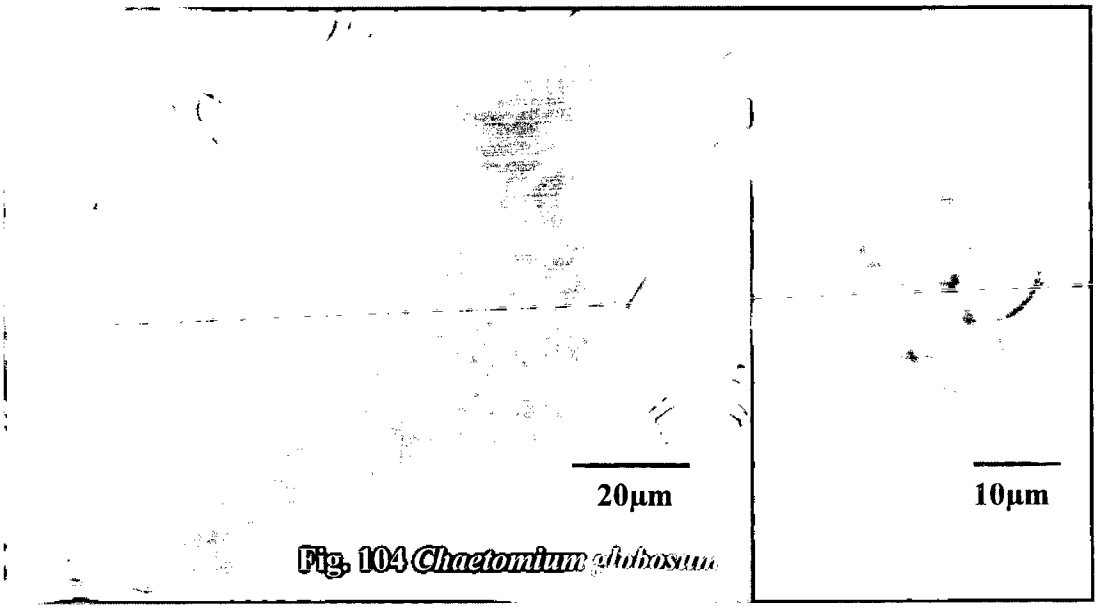


Fig. 104 *Chaetomium globosum*

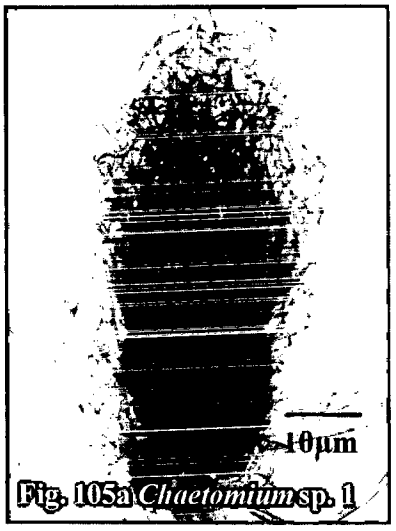


Fig. 105a *Chaetomium* sp. 1

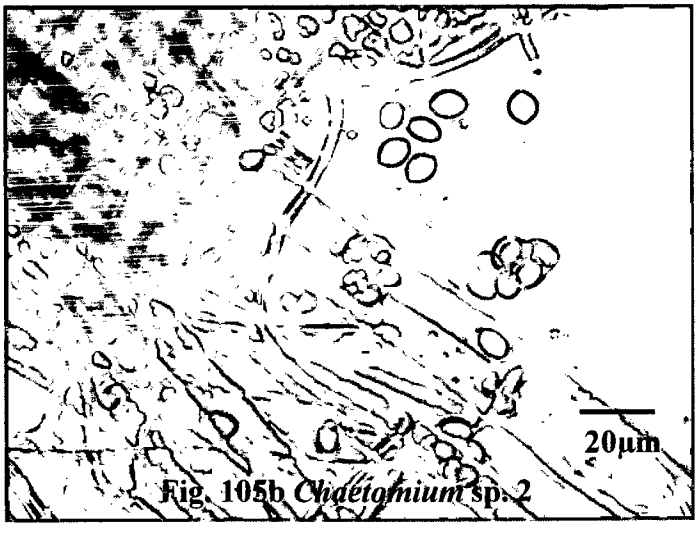


Fig. 105b *Chaetomium* sp. 2

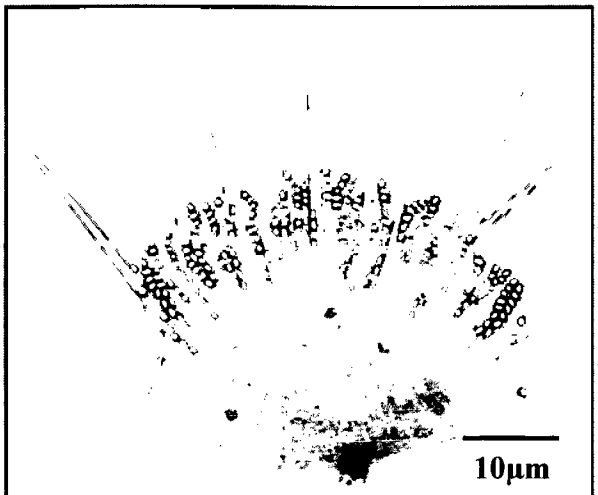


Fig. 106a *Cheilymenia*

Fig. 106b *Cheilymenia*

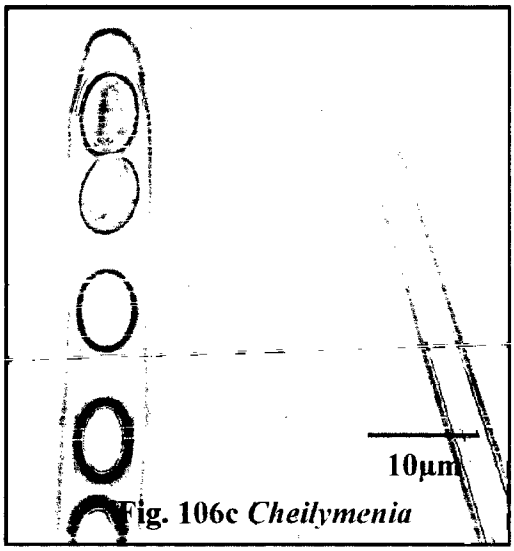


Fig. 106c *Cheilymenia*

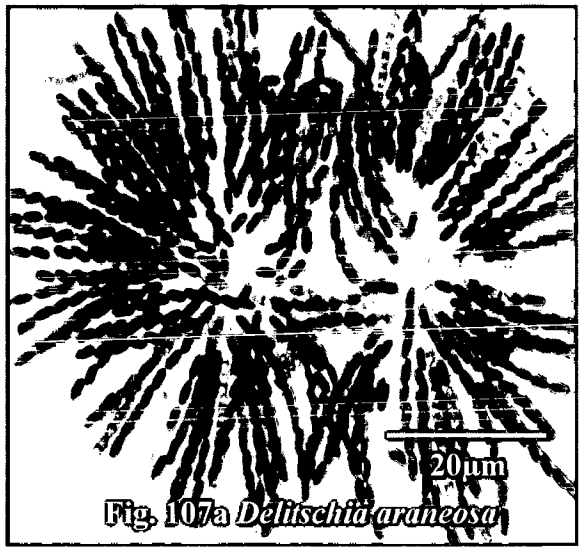


Fig. 107a *Delitschia araneosa*

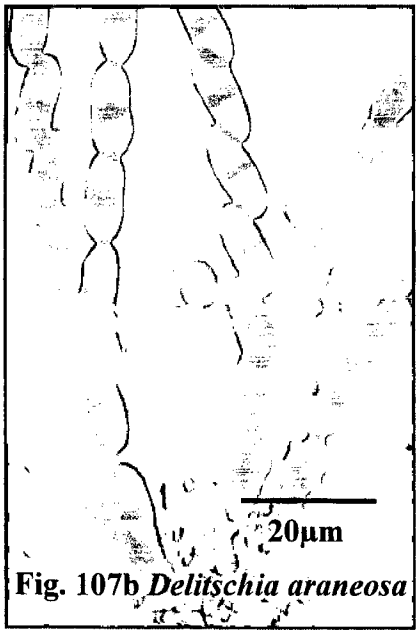


Fig. 107b *Delitschia araneosa*

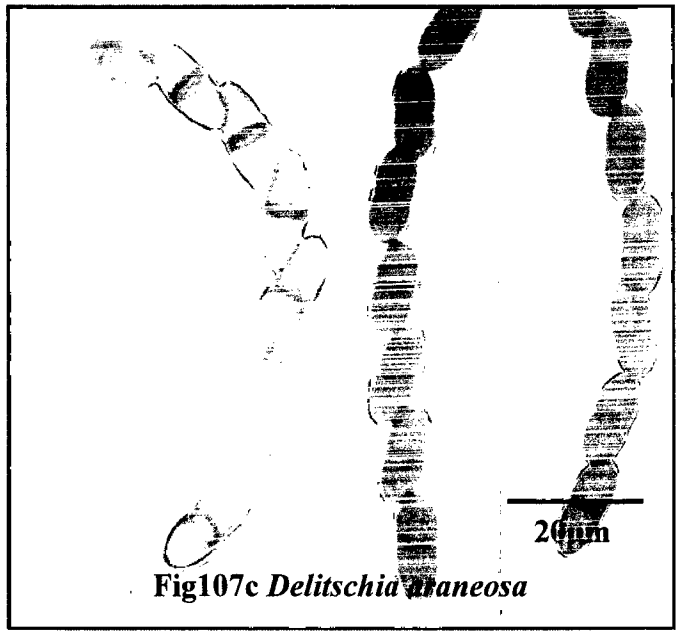


Fig107c *Delitschia araneosa*

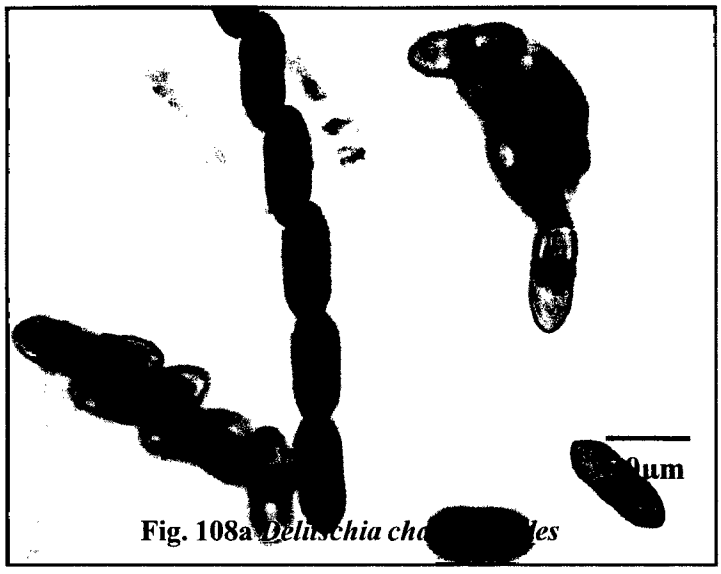


Fig. 108a *Delitschia cha[illegible]des*

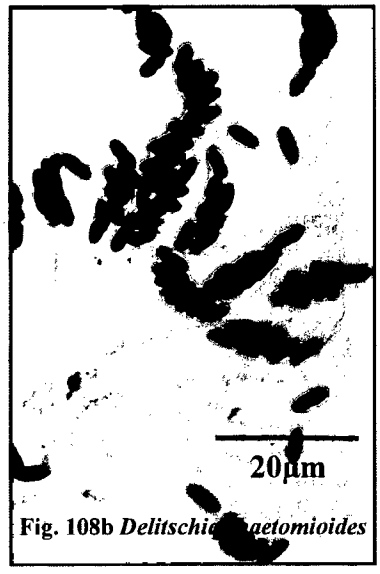
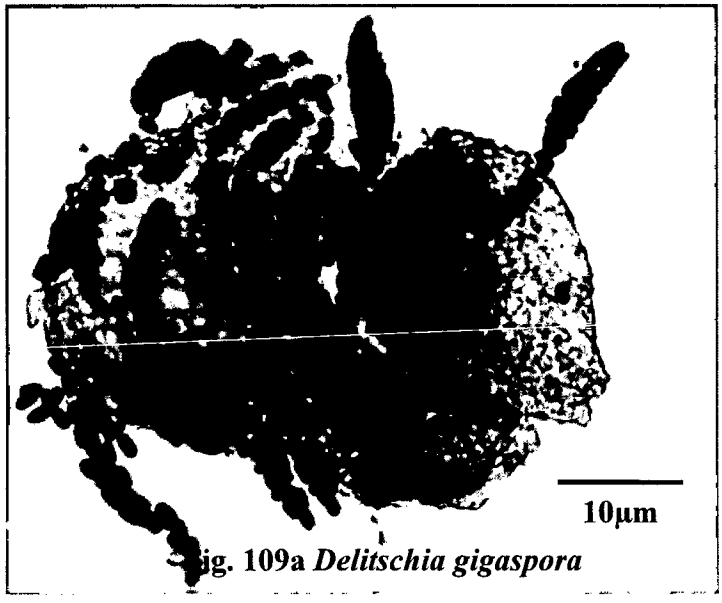


Fig. 108b *Delitschi[illegible]aetomioides*



[illegible]ig. 109a *Delitschia gigaspora*

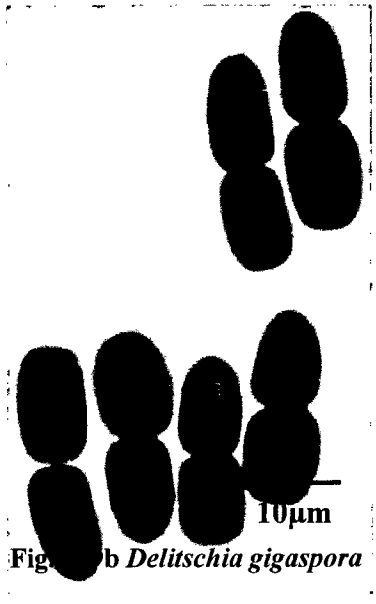


Fig. [illegible]b *Delitschia gigaspora*

Fig. 110a *Delitschia patagonica*

Fig. 110b *Delitschia patagonica*

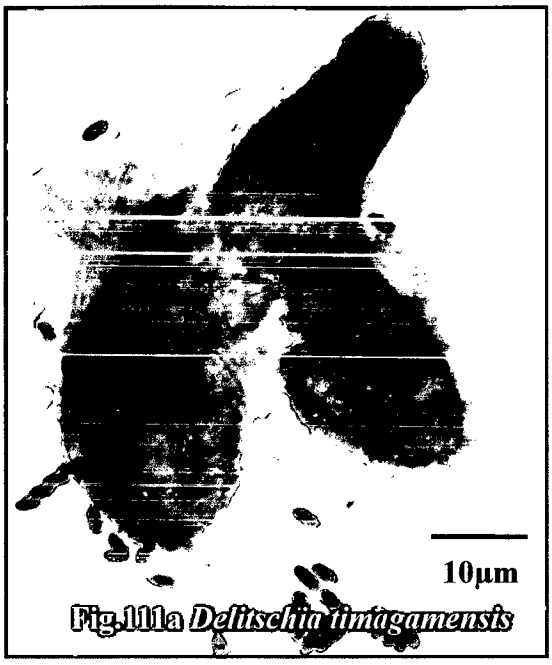


Fig.111a *Delitschia timagamensis*

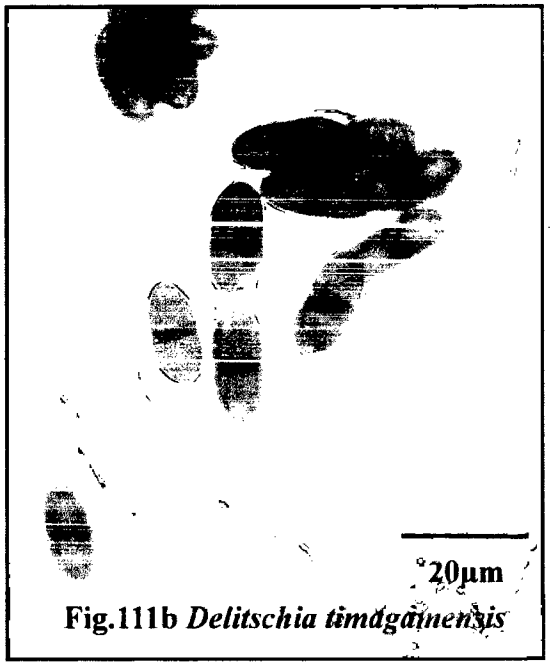


Fig.111b *Delitschia timagamensis*

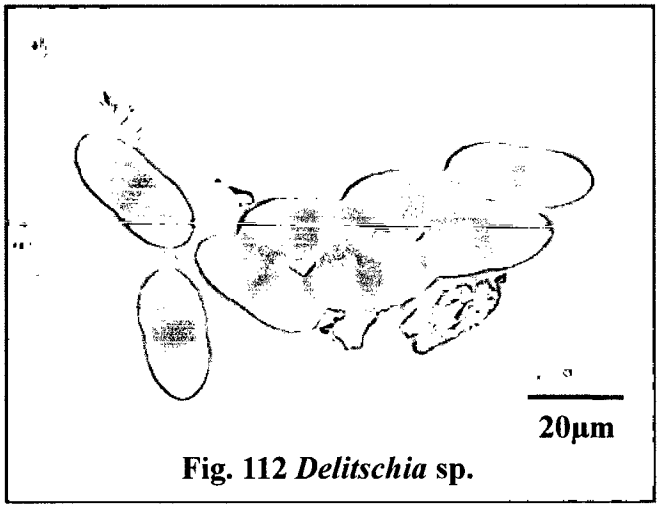


Fig. 112 *Delitschia* sp.

Fig. 113a *Dennisiopsis multispora*

Fig. 113b *Dennisiopsis multispora*

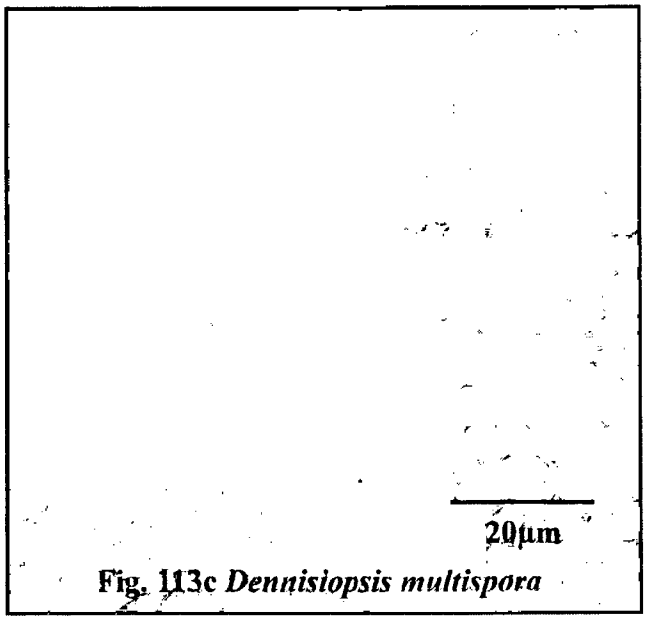
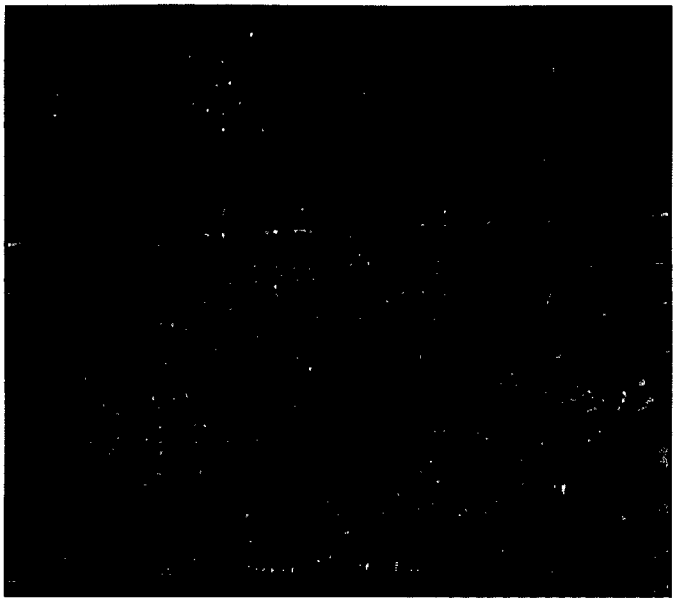


Fig. 113c *Dennisiopsis multispora*



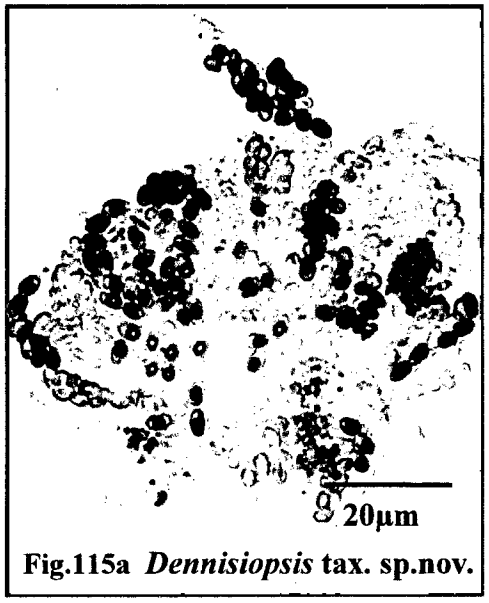


Fig.115a *Dennisiopsis* tax. sp.nov.

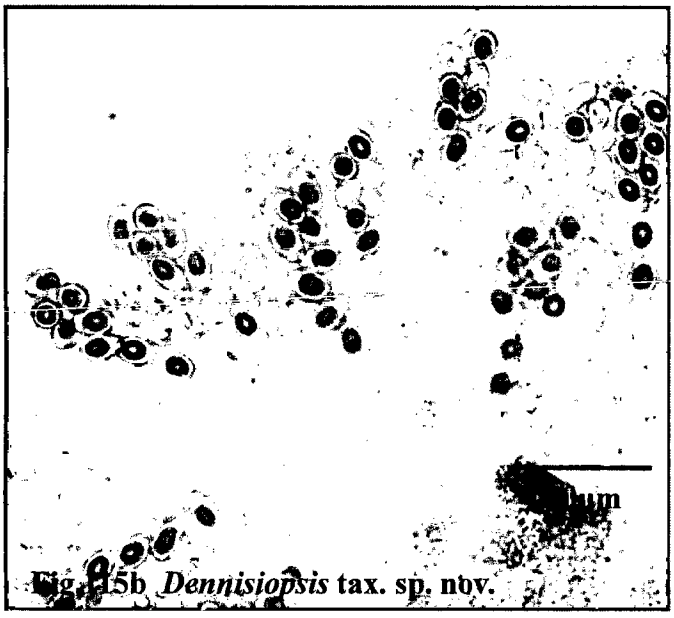


Fig.115b *Dennisiopsis* tax. sp. nov.

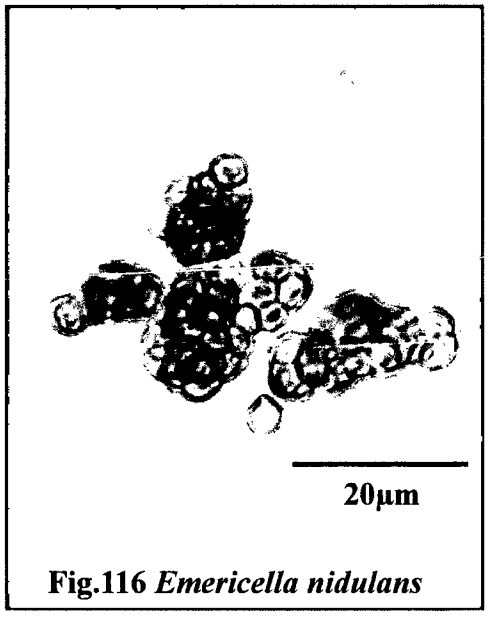


Fig.116 *Emericella nidulans*

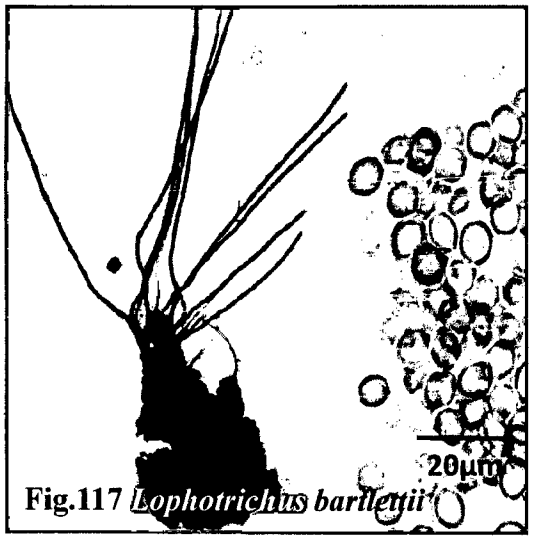


Fig.117 *Lophotrichus barllettii*

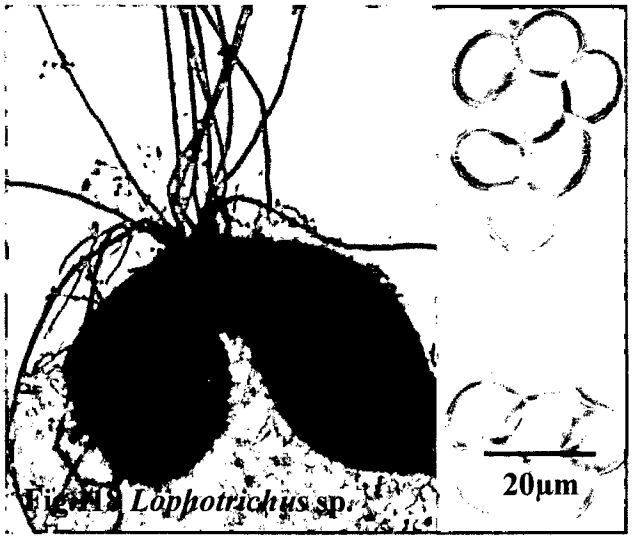


Fig.118 *Lophotrichus* sp.

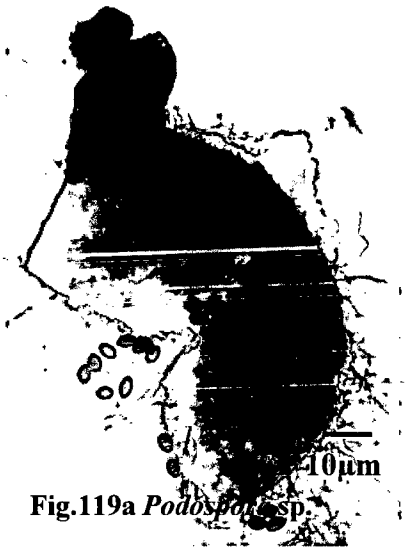


Fig.119a *Podospora* sp.

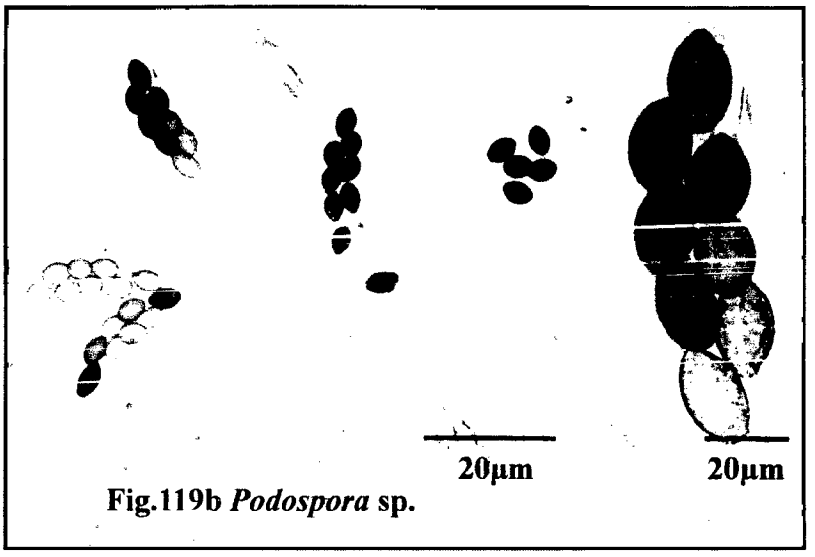


Fig.119b *Podospora* sp.

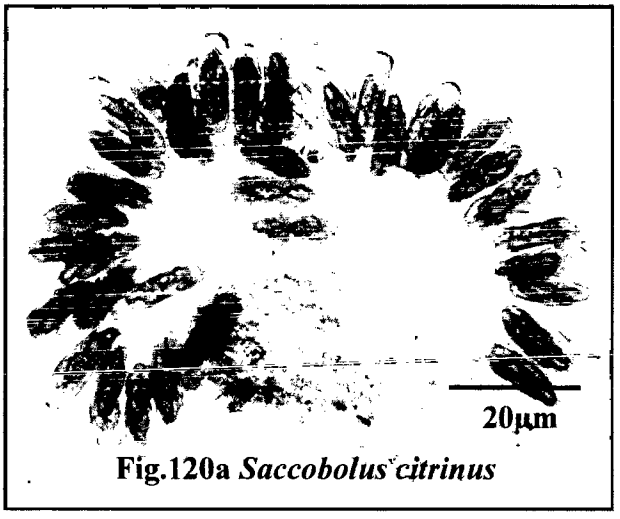


Fig.120a *Saccobolus citrinus*

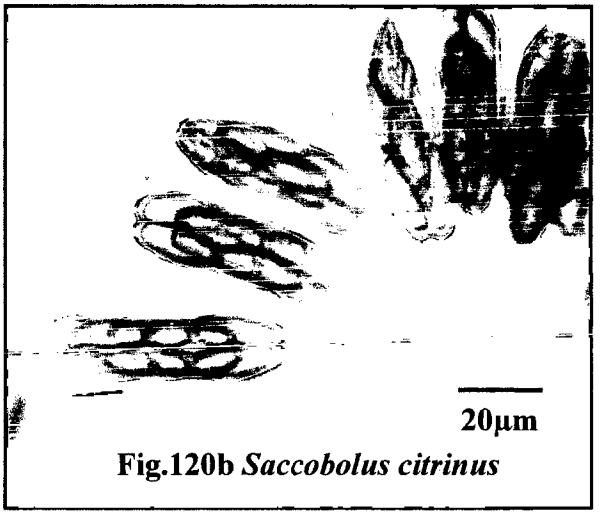


Fig.120b *Saccobolus citrinus*

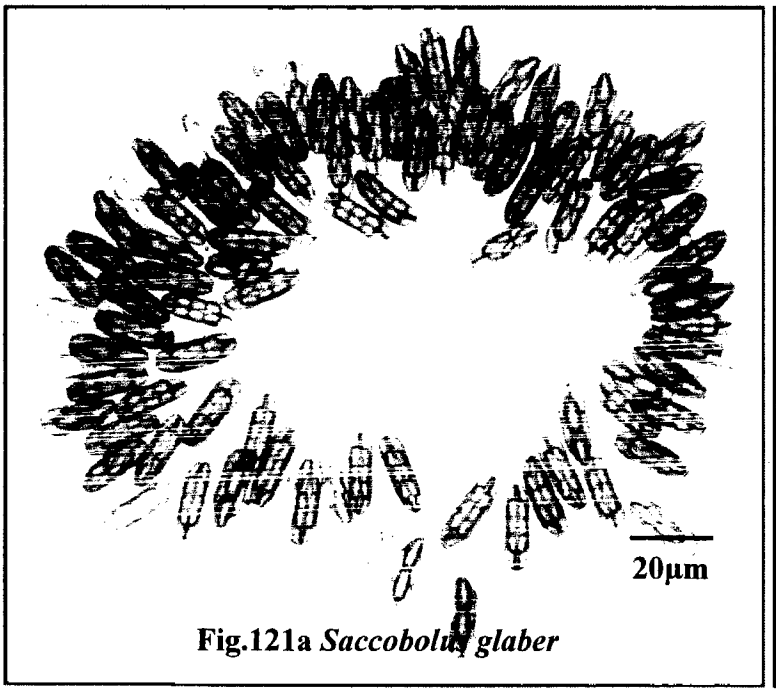


Fig.121a *Saccobolus glaber*

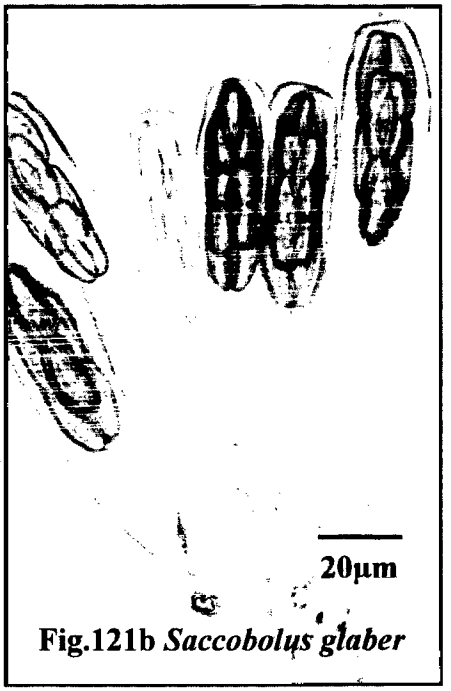


Fig.121b *Saccobolus glaber*

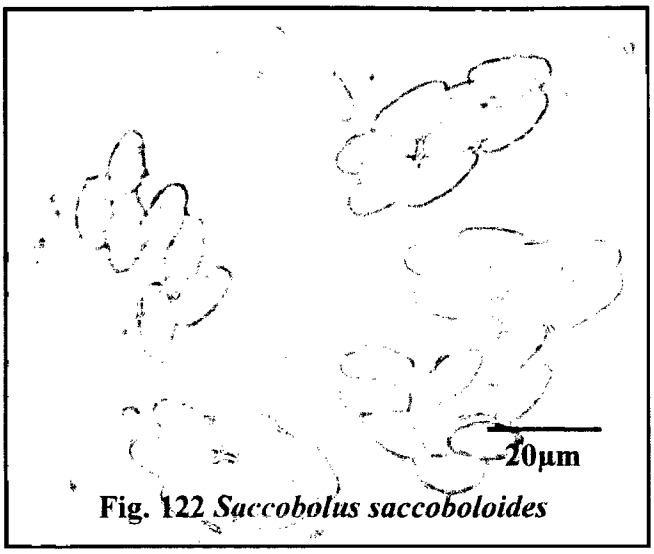


Fig. 122 *Saccobolus saccoboloides*

Fig. 123 *Saccobolus* sp.

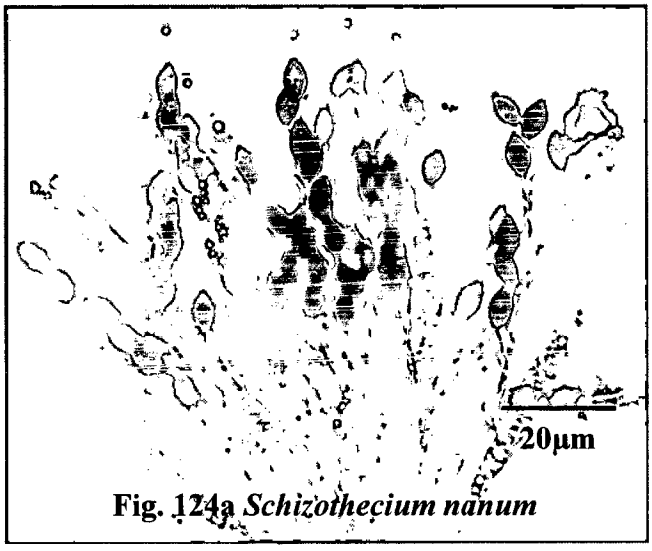


Fig. 124a *Schizothecium nanum*

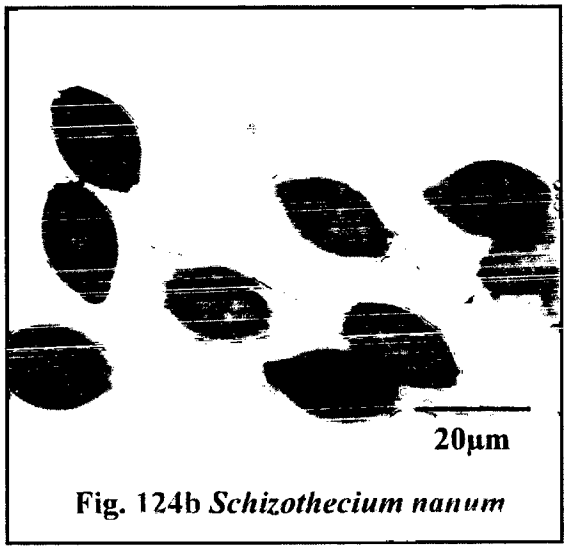


Fig. 124b *Schizothecium nanum*

Fig. 125a *Sordaria fimicola*

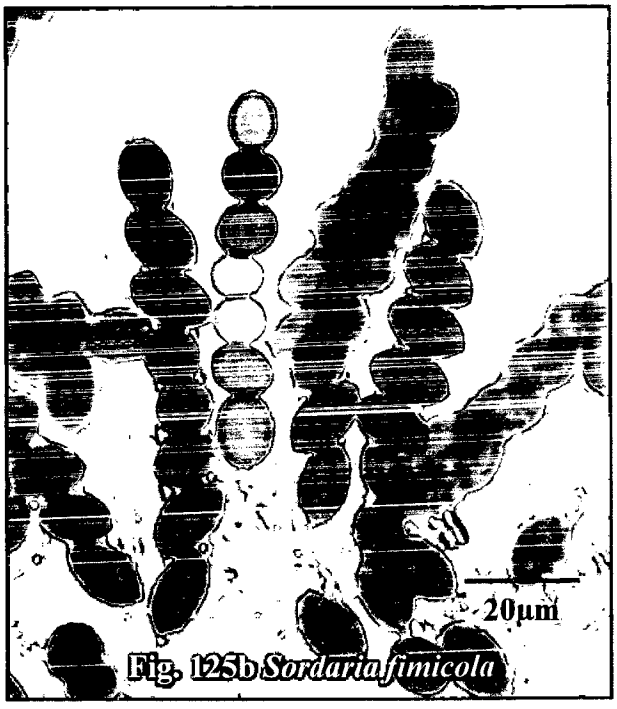
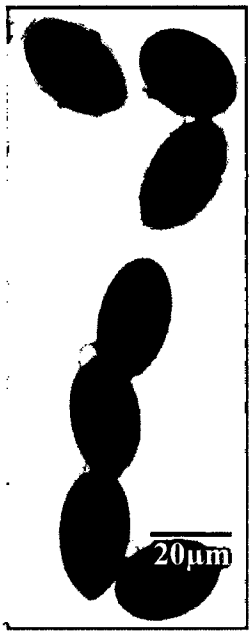


Fig. 125b *Sordaria fimicola*

Fig. 126 *Sporormiella minima*



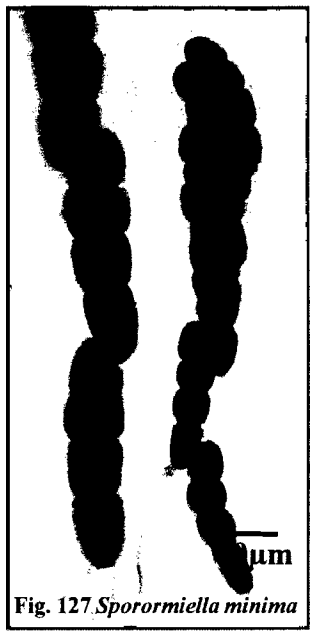


Fig. 127 *Sporormiella minima*

Fig. 128a *Sporormiella pulchella*

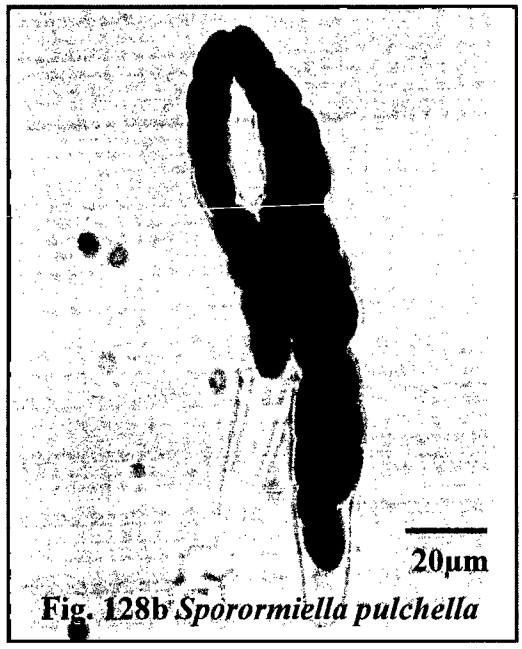


Fig. 128b *Sporormiella pulchella*

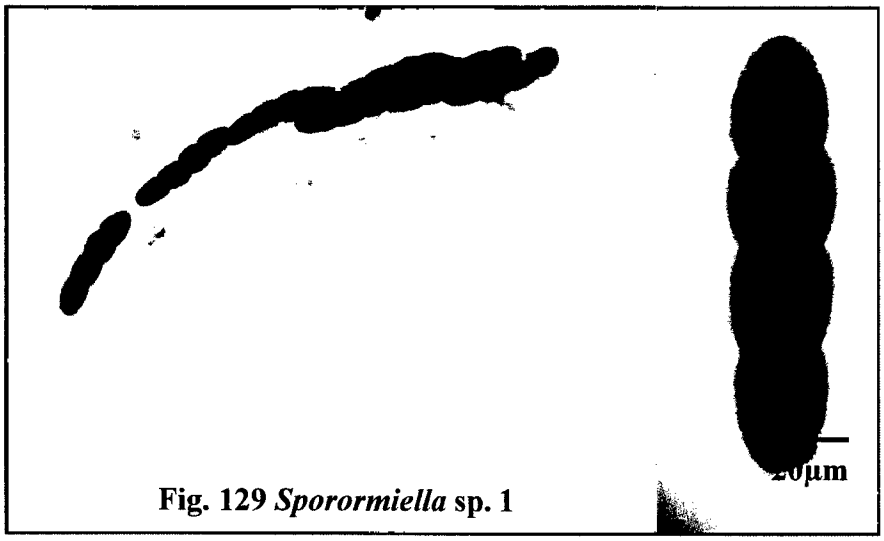


Fig. 129 *Sporormiella* sp. 1

Fig. 129b *Sporormiella* sp. 2

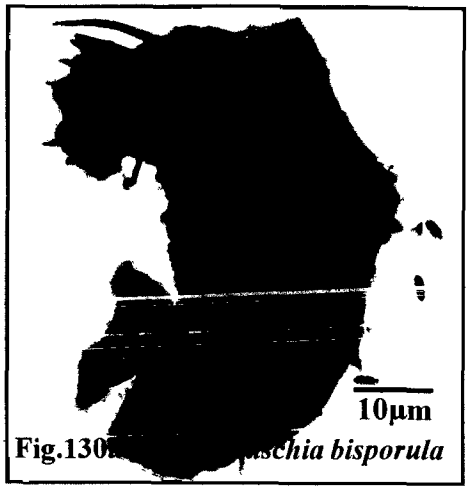


Fig.130 *schia bisporula*

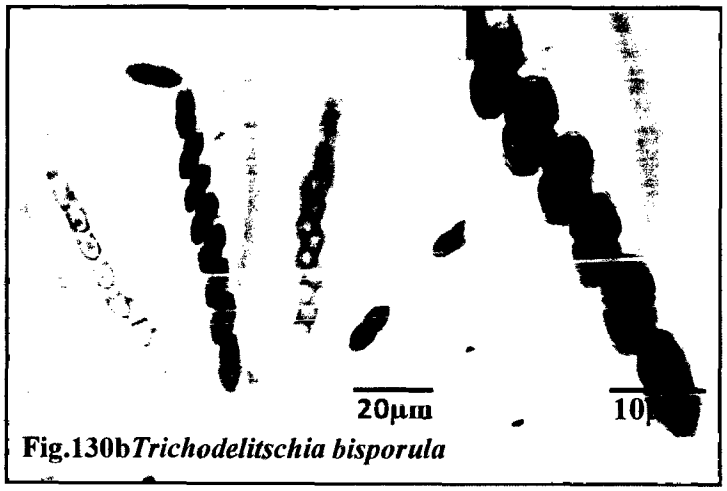


Fig.130b *Trichodelitschia bisporula*

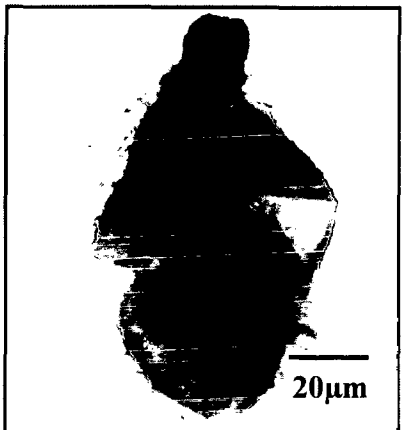


Fig. 131a *Zygopleurage zygospora*

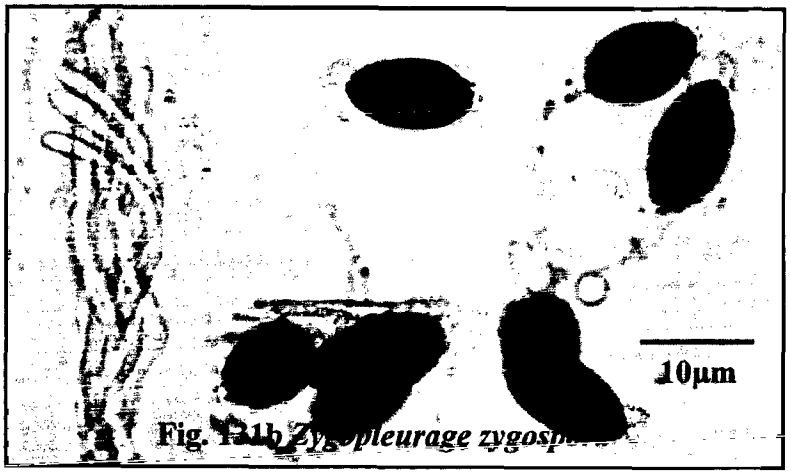


Fig. 131b *Zygopleurage zygospora*

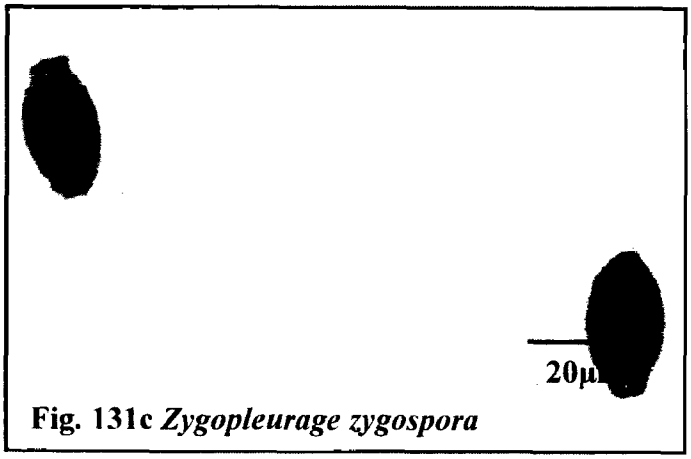


Fig. 131c *Zygopleurage zygospora*

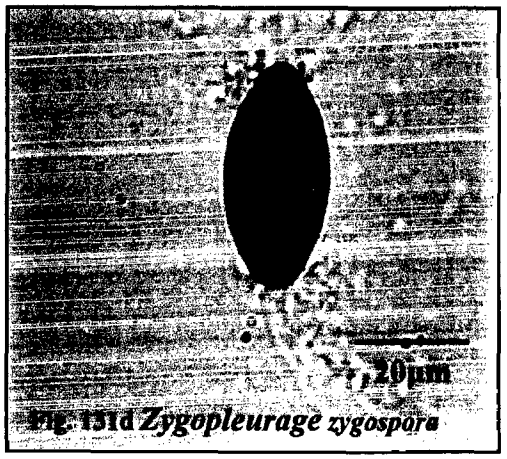


Fig. 131d *Zygopleurage zygospora*

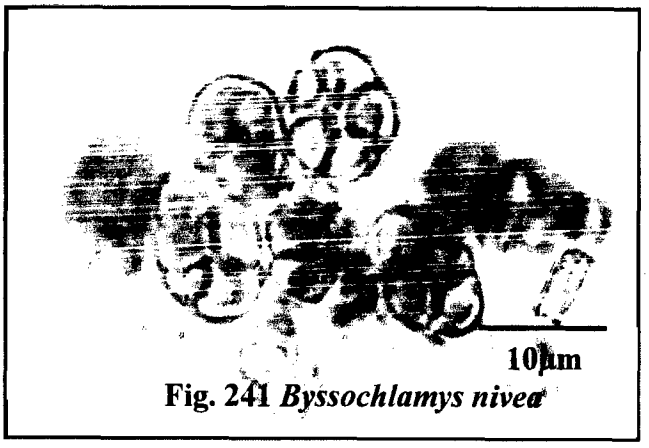


Fig. 241 *Byssochlamys nivea*

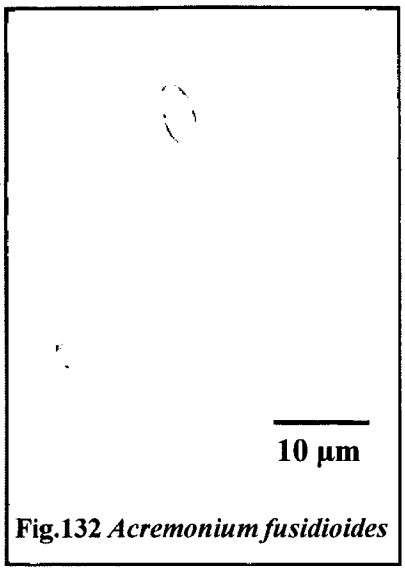


Fig.132 *Acremonium fusidioides*

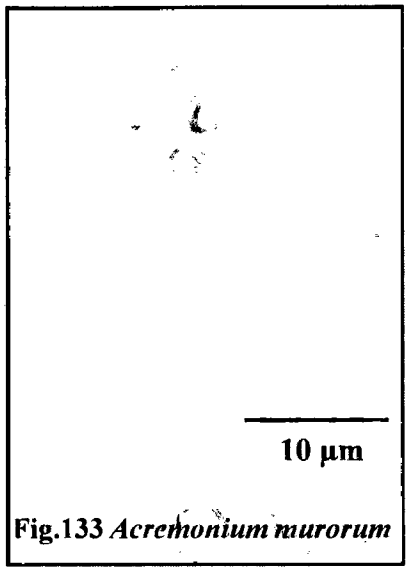


Fig.133 *Acremonium murorum*

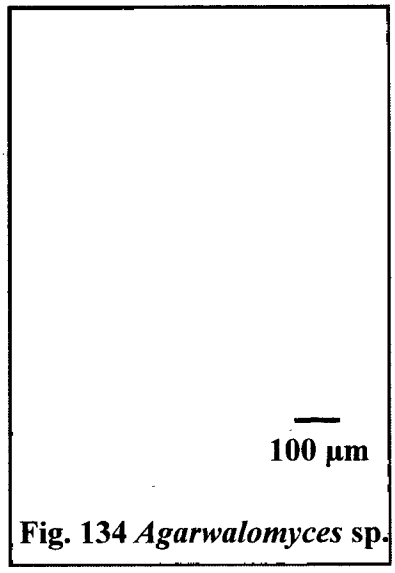


Fig. 134 *Agarwalomyces* sp.

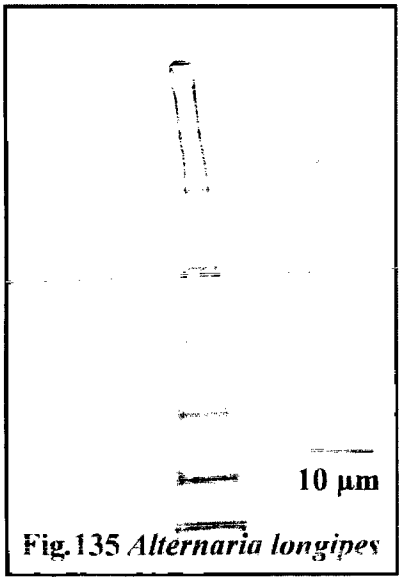


Fig.135 *Alternaria longipes*

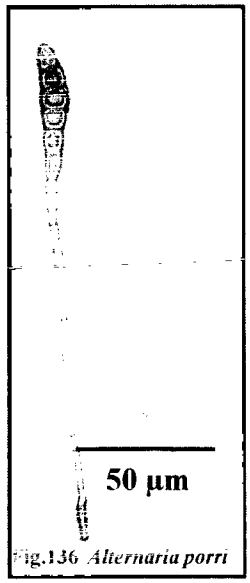


Fig.136 *Alternaria porri*

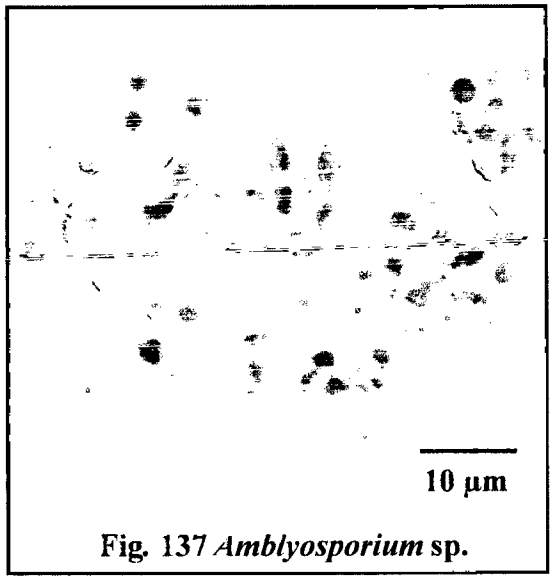


Fig. 137 *Amblyosporium* sp.

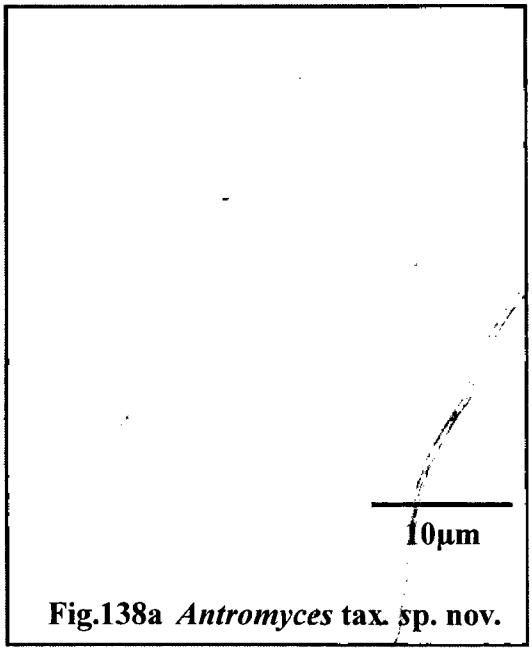


Fig.138a *Antromyces* tax. sp. nov.

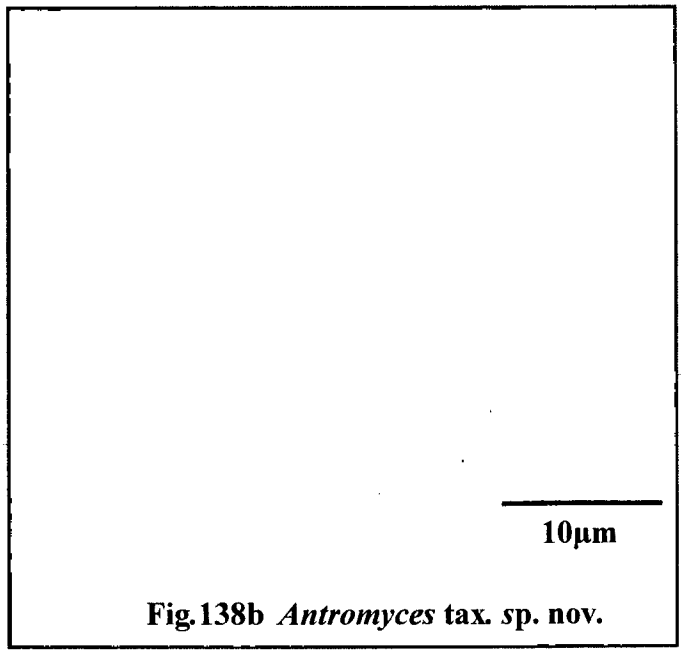


Fig.138b *Antromyces* tax. sp. nov.

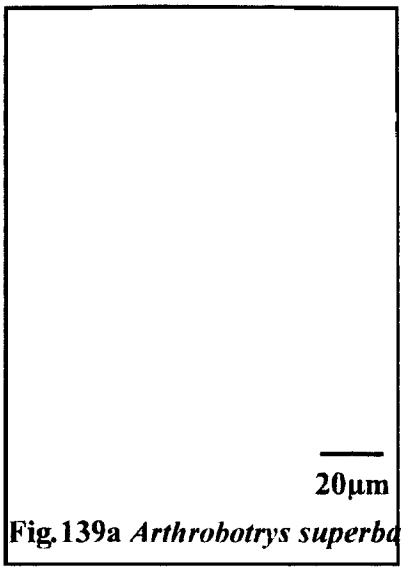


Fig.139a *Arthrobotrys superba*

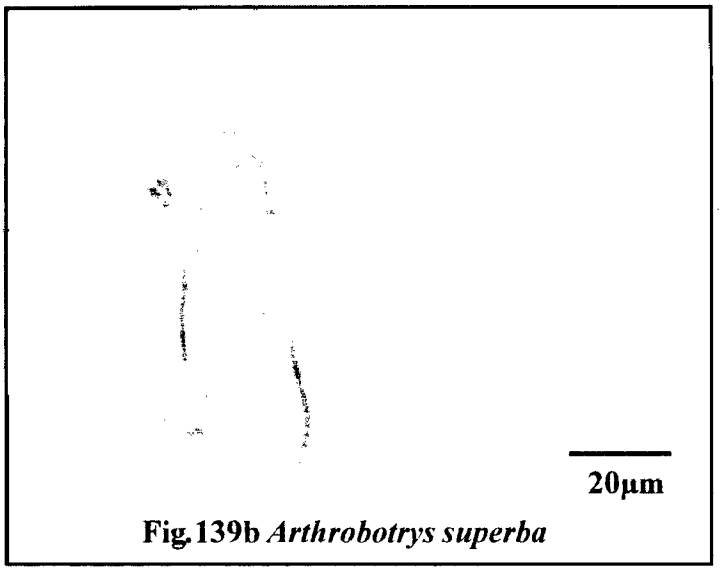


Fig.139b *Arthrobotrys superba*

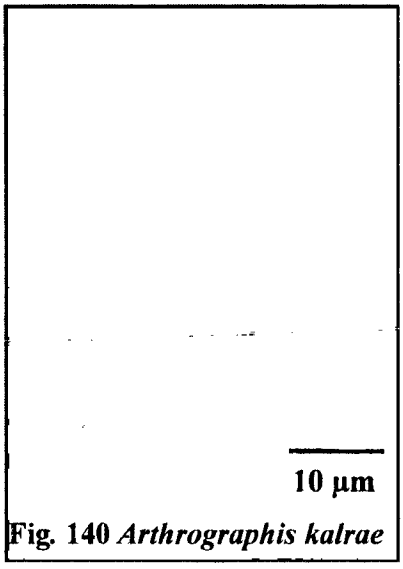


Fig. 140 *Arthrographis kalrae*

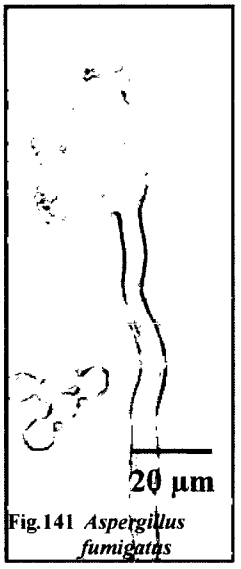


Fig.141 *Aspergillus fumigatus*

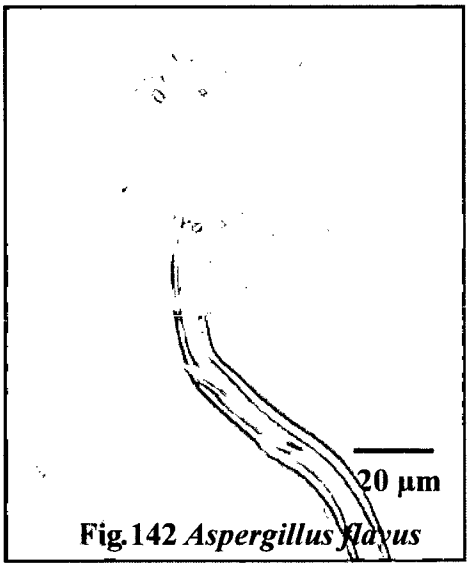


Fig.142 *Aspergillus flavus*

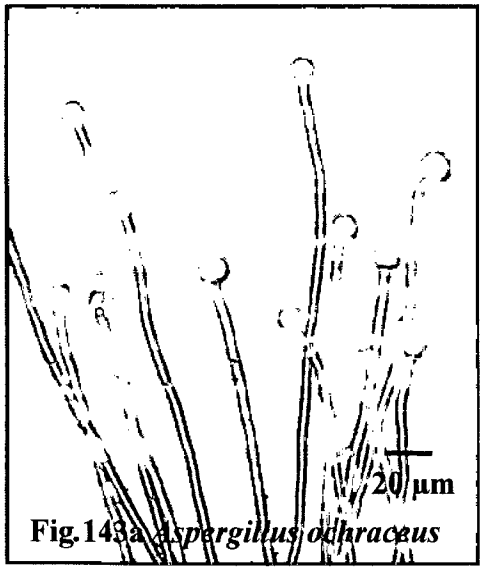


Fig.143a *Aspergillus ochraceus*

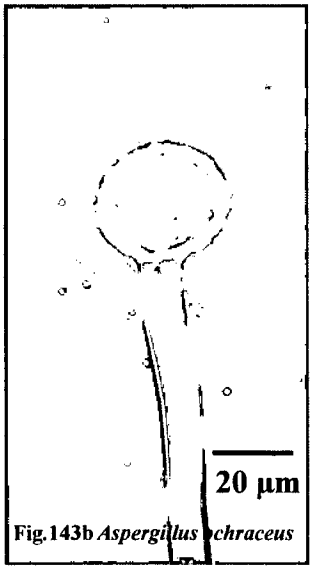


Fig.143b *Aspergillus ochraceus*

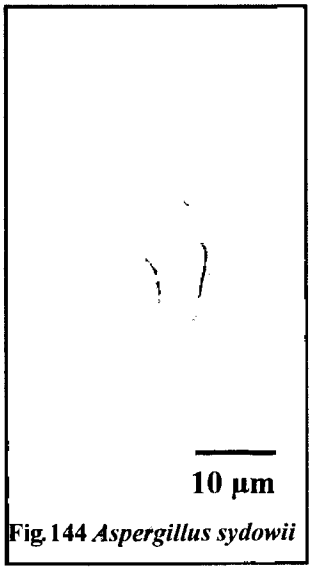


Fig.144 *Aspergillus sydowii*

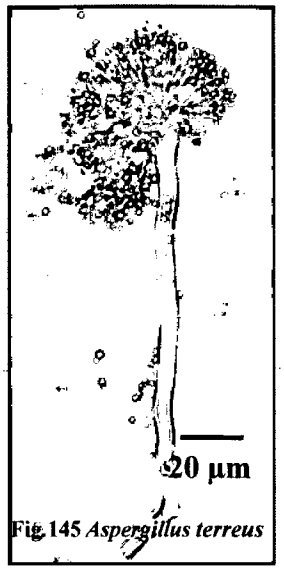


Fig.145 *Aspergillus terreus*

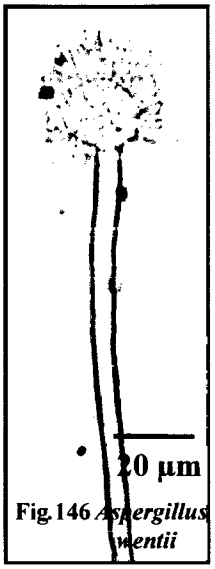


Fig.146 *Aspergillus wentii*

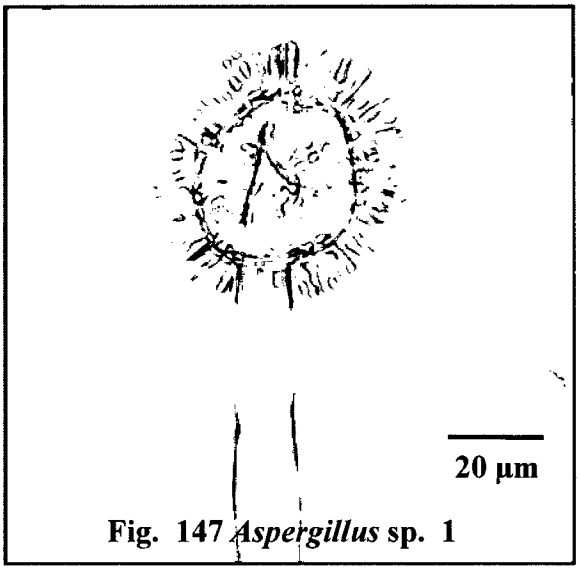


Fig. 147 *Aspergillus* sp. 1

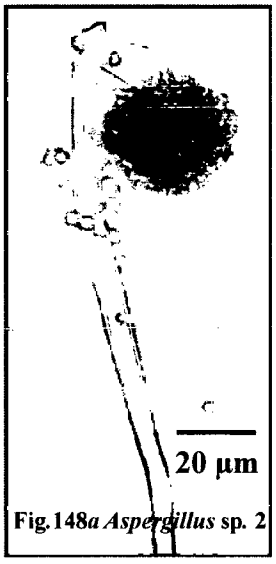


Fig.148*a Aspergillus* sp. 2

Fig. 148b *Aspergillus* sp. 2

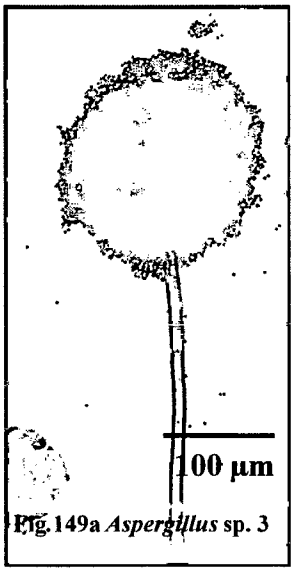


Fig.149a *Aspergillus* sp. 3

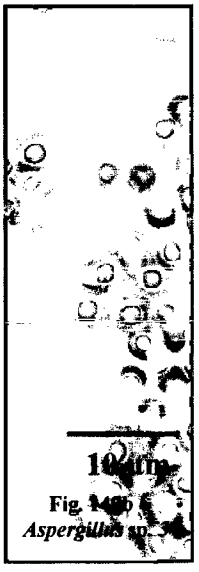


Fig. 149b *Aspergillus* sp. 3

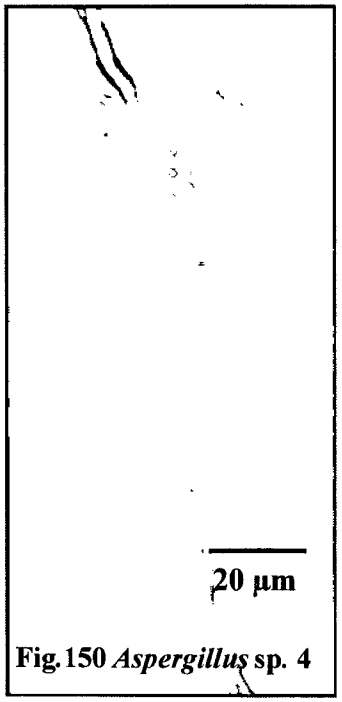


Fig.150 *Aspergillus* sp. 4

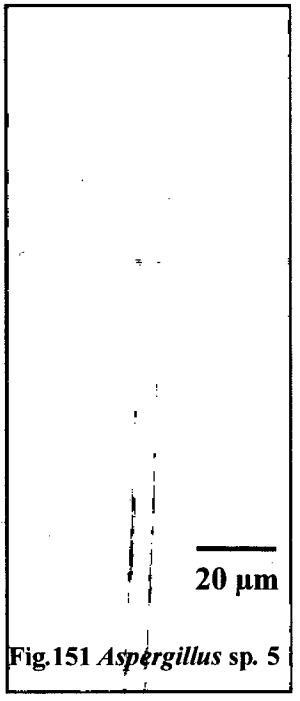


Fig.151 *Aspergillus* sp. 5

Fig.152 *Bahupaathrasamala*

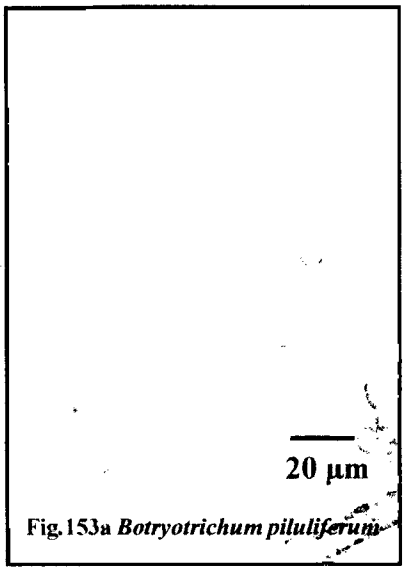


Fig.153a *Botryotrichum piluliferum*

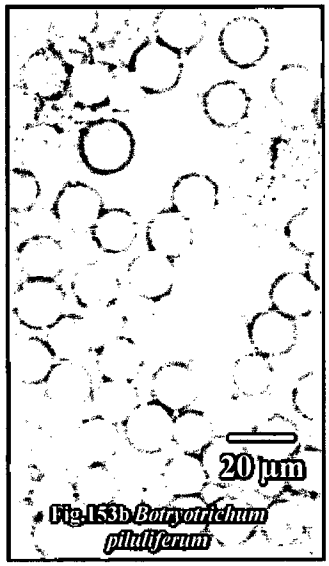


Fig.153b *Botryotrichum piluliferum*

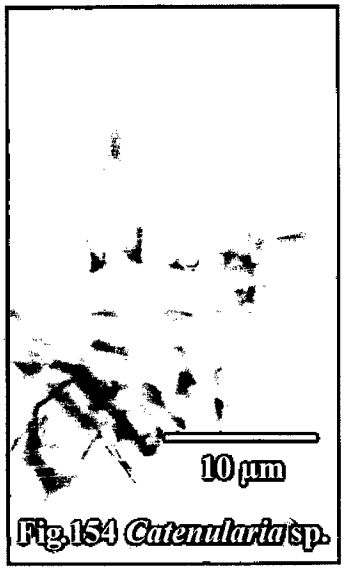


Fig.154 *Catenularia* sp.

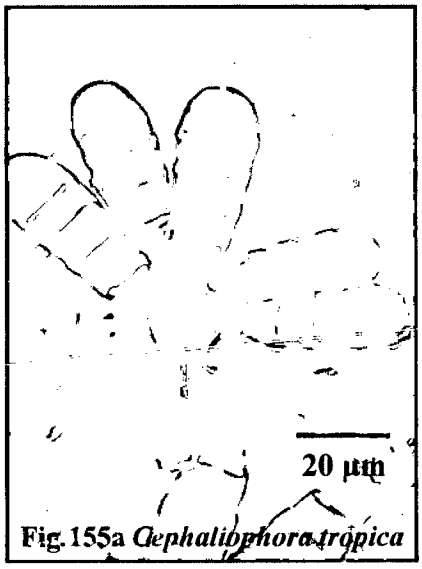


Fig.155a *Cephaliophora tropica*

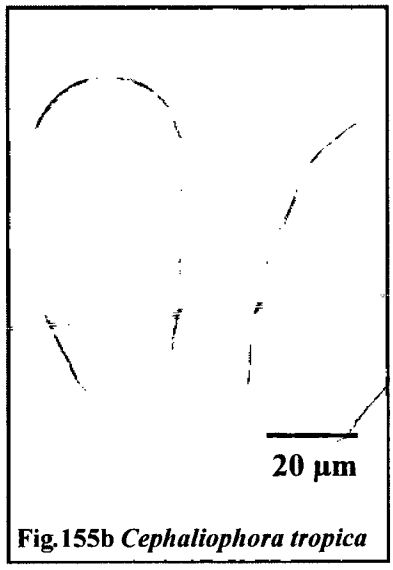


Fig.155b *Cephaliophora tropica*

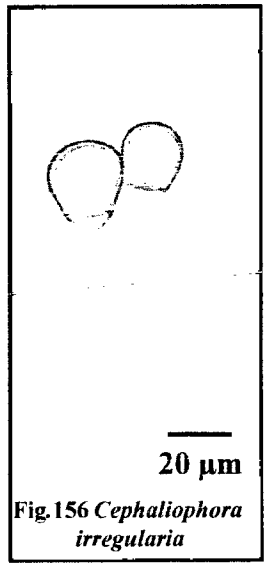


Fig.156 *Cephaliophora irregularia*

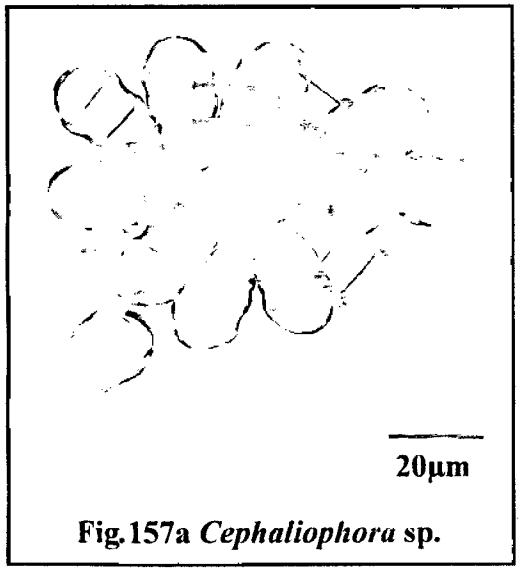


Fig.157a *Cephaliophora* sp.

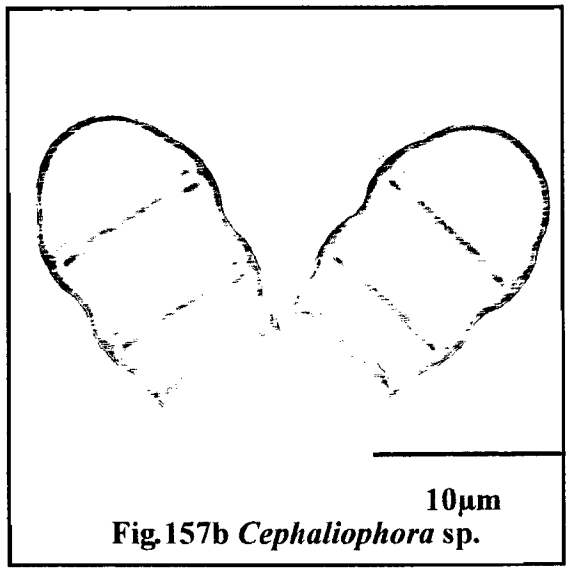


Fig.157b *Cephaliophora* sp.

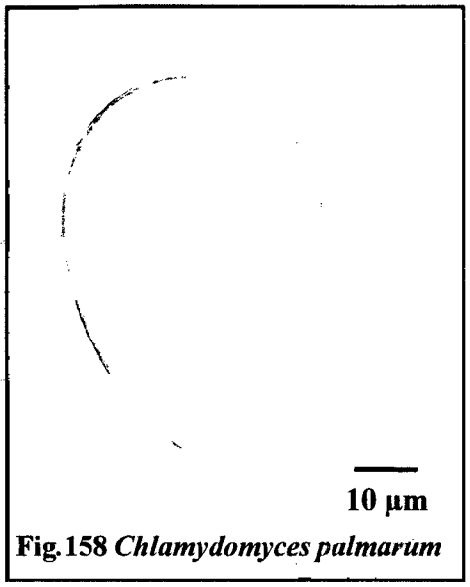


Fig.158 *Chlamydomyces palmarum*

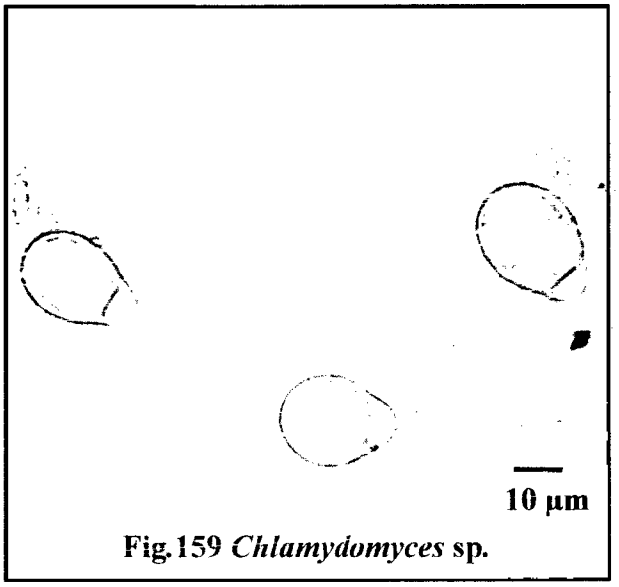


Fig.159 *Chlamydomyces* sp.

Fig.160 *Chrysosporium* sp.

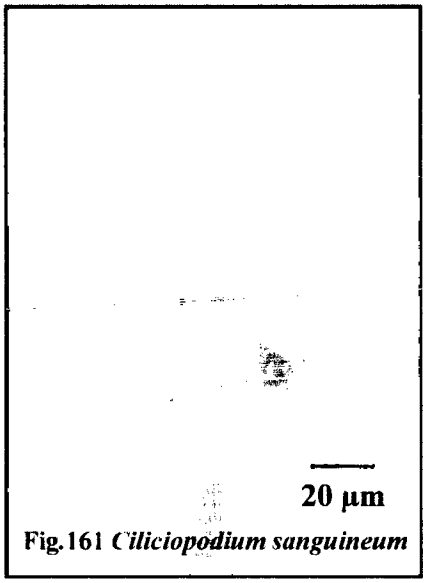


Fig.161 *Ciliciopodium sanguineum*

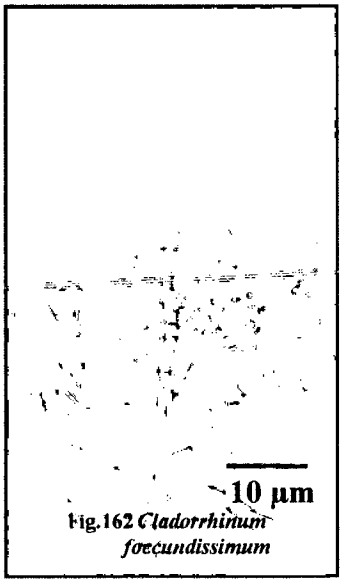


Fig.162 *Cladorrhinum foecundissimum*

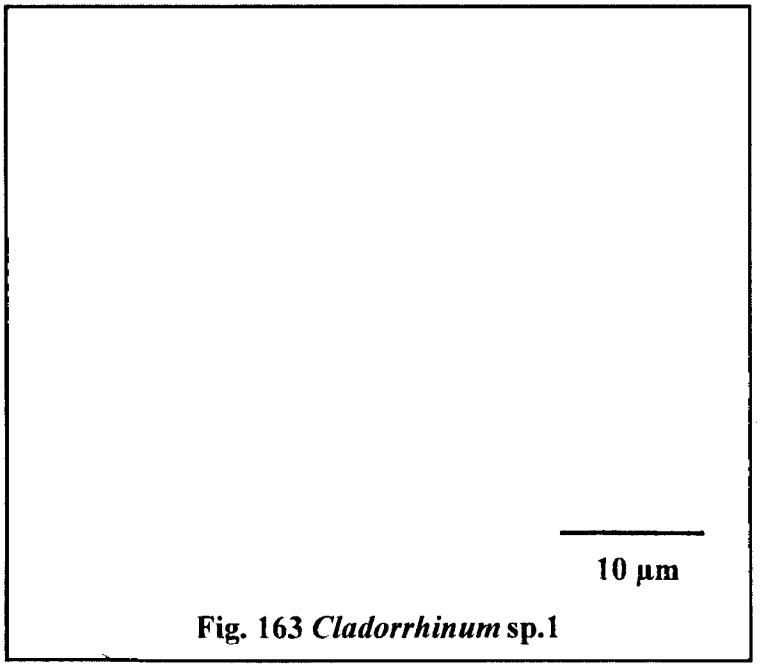


Fig. 163 *Cladorrhinum* sp.1

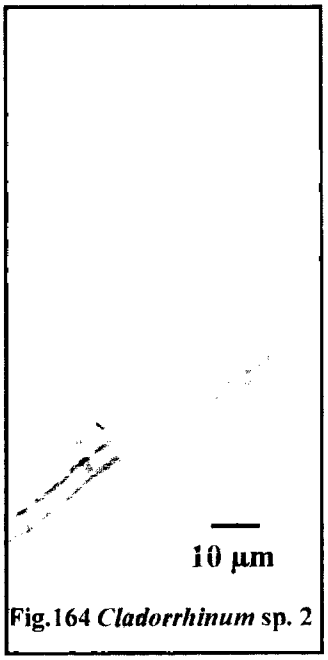


Fig.164 *Cladorrhinum* sp. 2

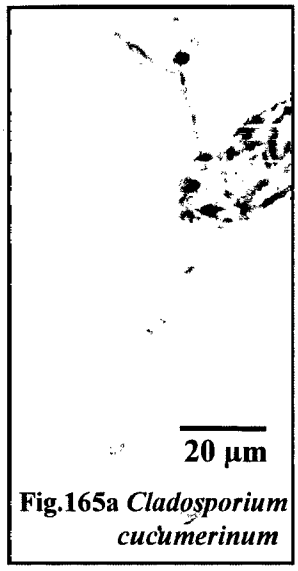


Fig.165a *Cladosporium cucumerinum*

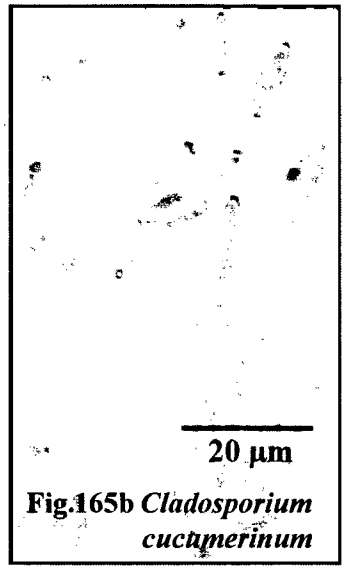


Fig.165b *Cladosporium cucumerinum*

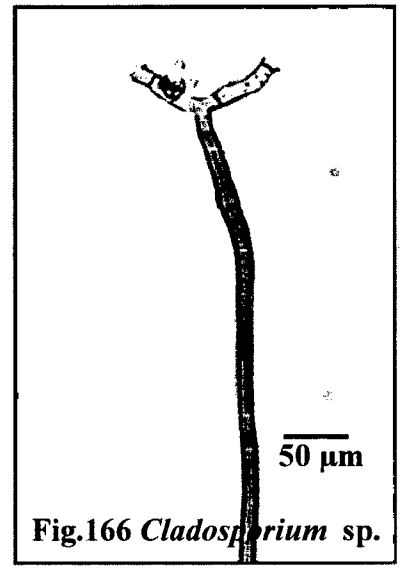


Fig.166 *Cladosporium* sp.

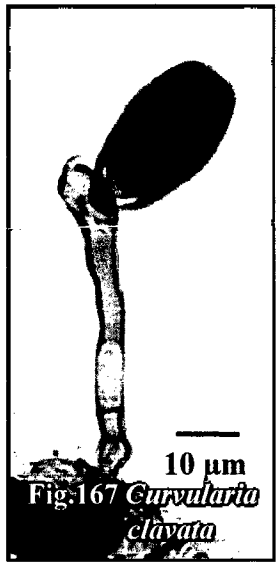


Fig.167 *Curvularia clavata*

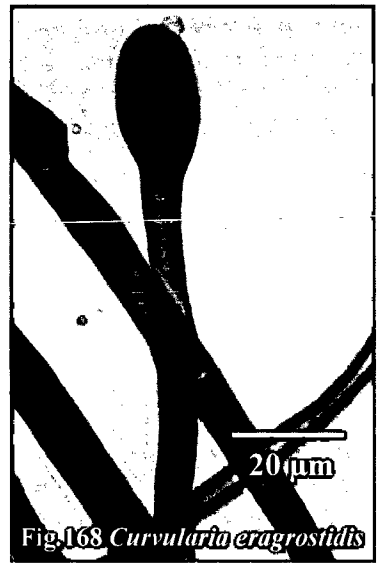


Fig.168 *Curvularia eragrostidis*

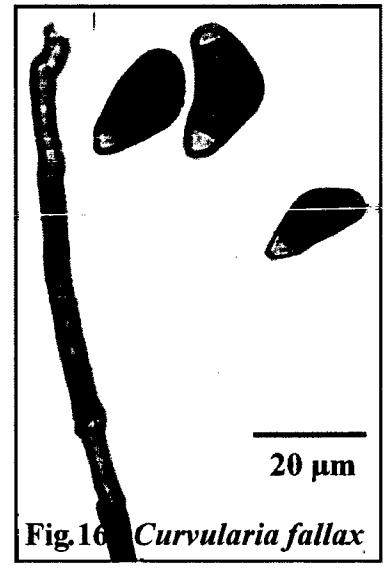


Fig.16 *Curvularia fallax*

Fig.170 *Curvularia oryzae*

Fig.171 *Curvularia* sp.

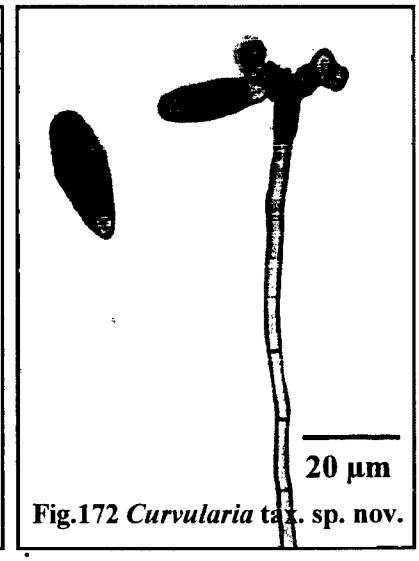


Fig.172 *Curvularia* tax. sp. nov.

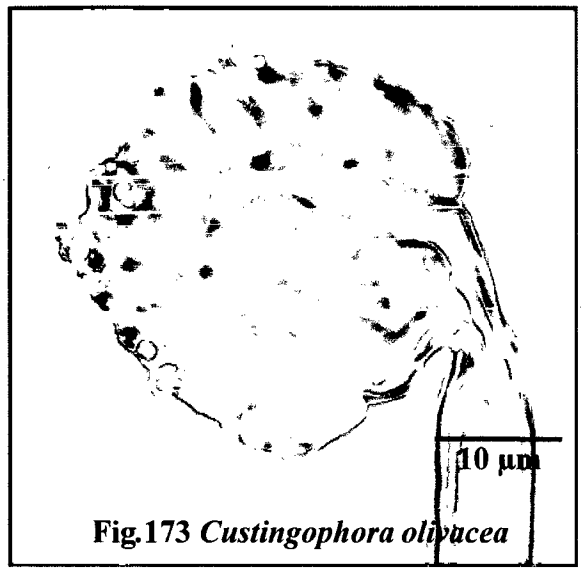


Fig.173 *Custingophora olivacea*

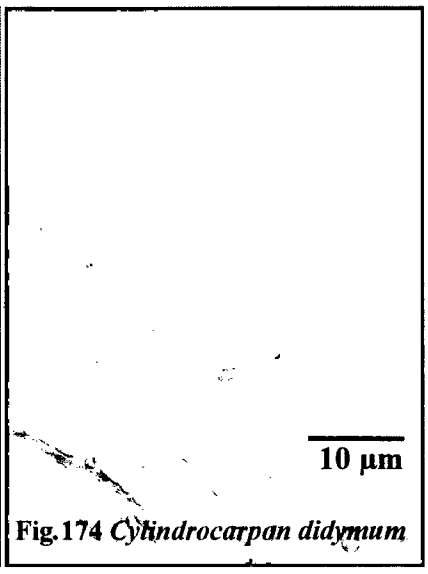


Fig.174 *Cylindrocarpan didymum*

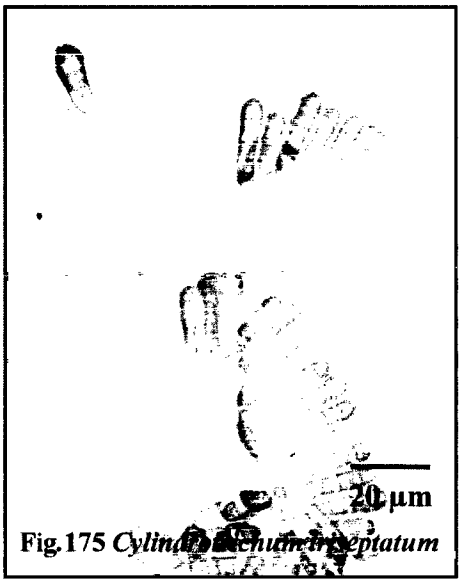


Fig.175 *Cylindrocladiella septatum*

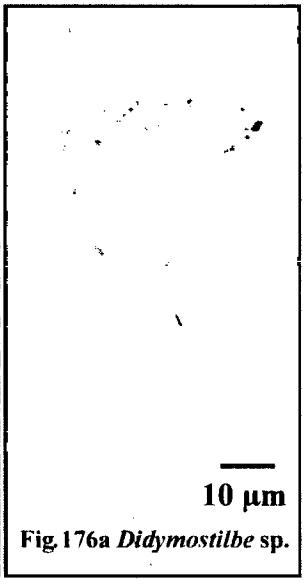


Fig.176a *Didymostilbe* sp.

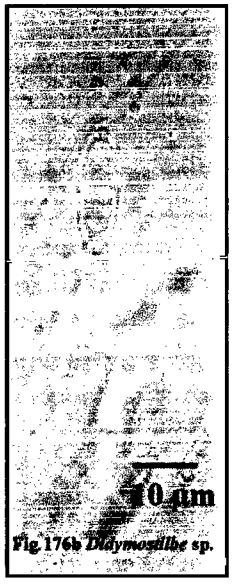


Fig.176b *Didymostilbe* sp.

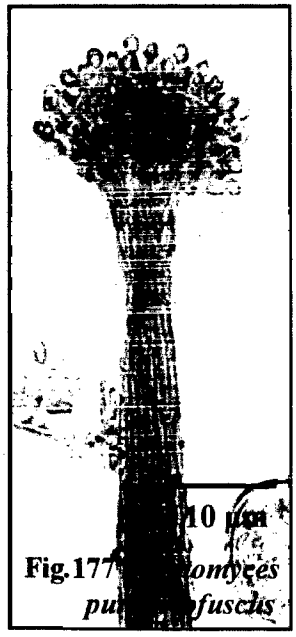


Fig.177 *Doratomyces pu fusclus*

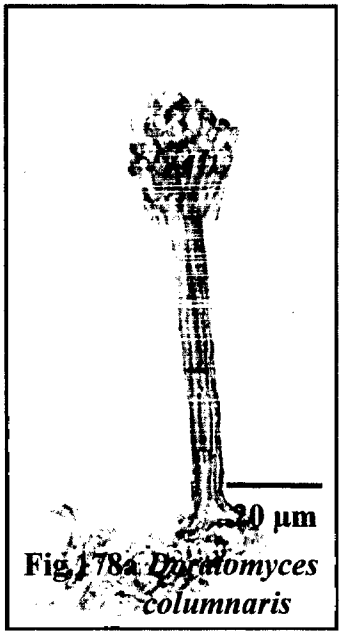


Fig.178a *Doratomyces columnaris*

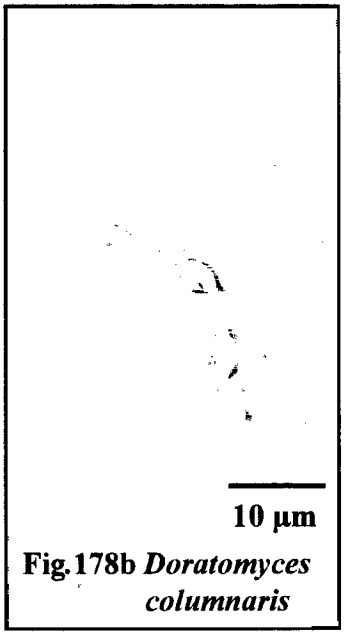


Fig.178b *Doratomyces columnaris*

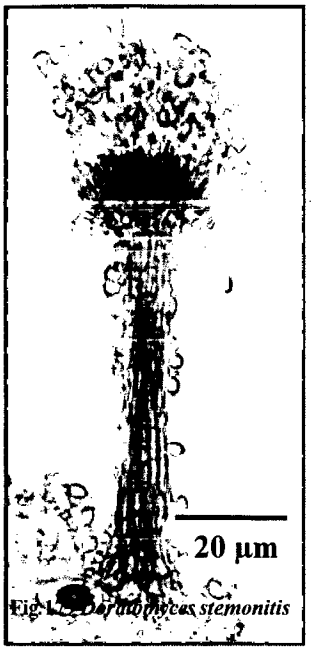


Fig.1 *Lycogala stemonitis*

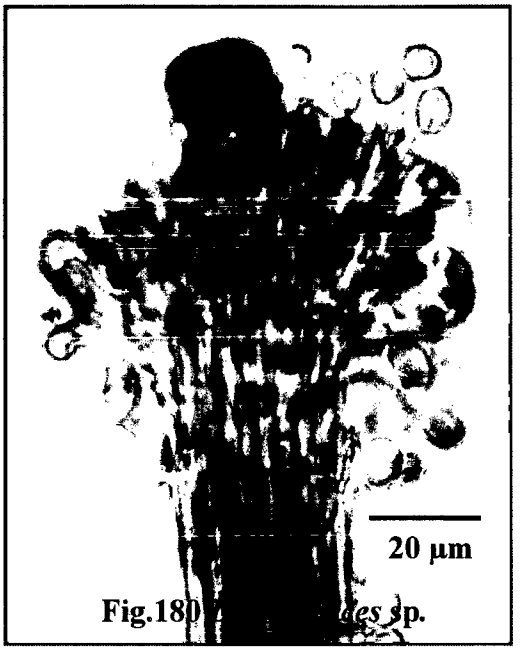


Fig.180 *Geomyces* sp.

Fig.181 *Echslera hawaiiensis*

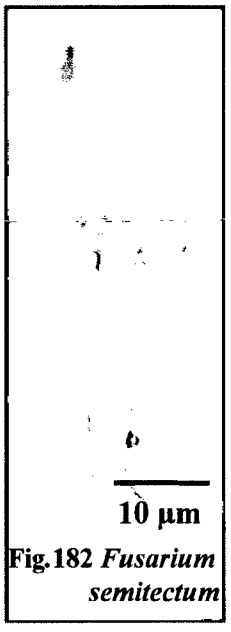
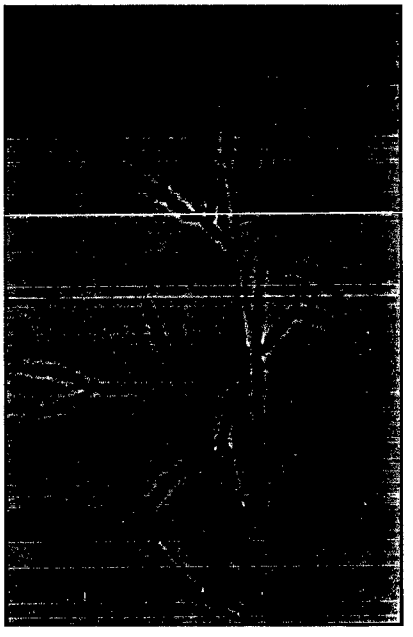


Fig.182 *Fusarium semitectum*

Fig.183 *Fusarium chlamydosporum*



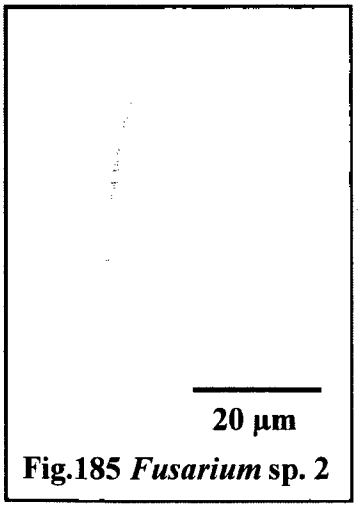


Fig.185 *Fusarium* sp. 2

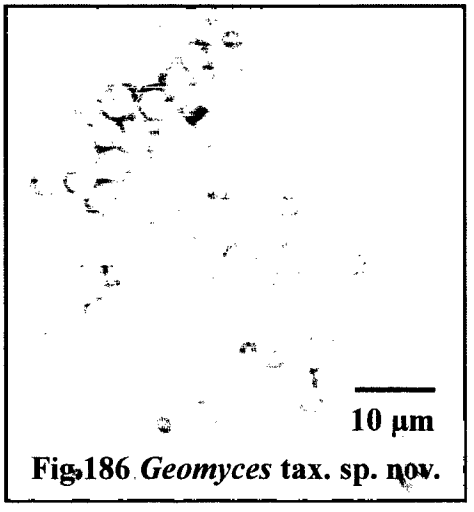


Fig.186 *Geomyces* tax. sp. nov.

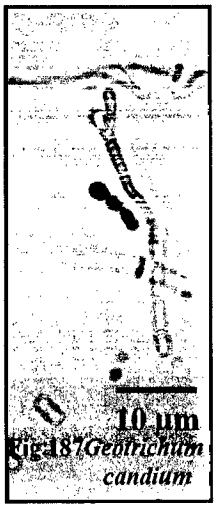
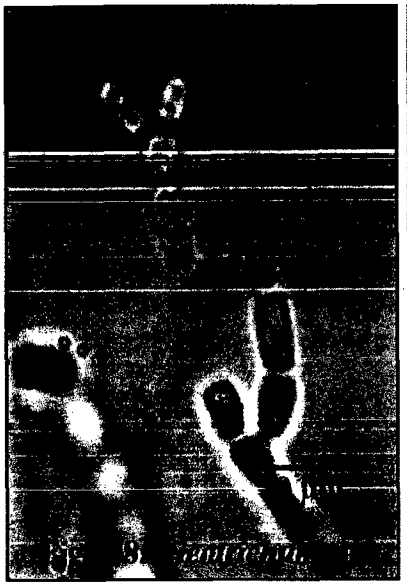


Fig.187 *Geotrichum candium*



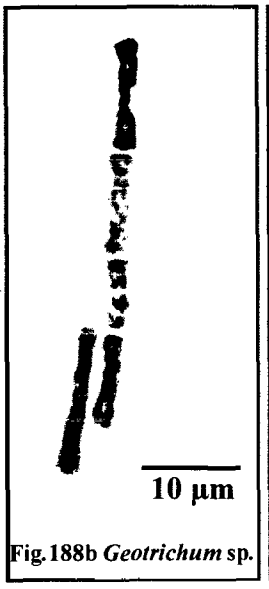


Fig.188b *Geotrichum* sp.

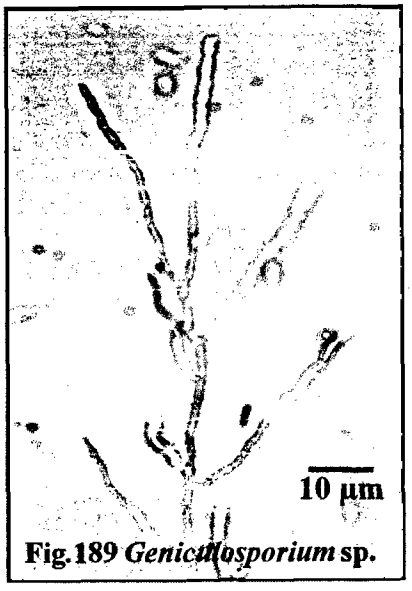


Fig.189 *Geniculosporium* sp.

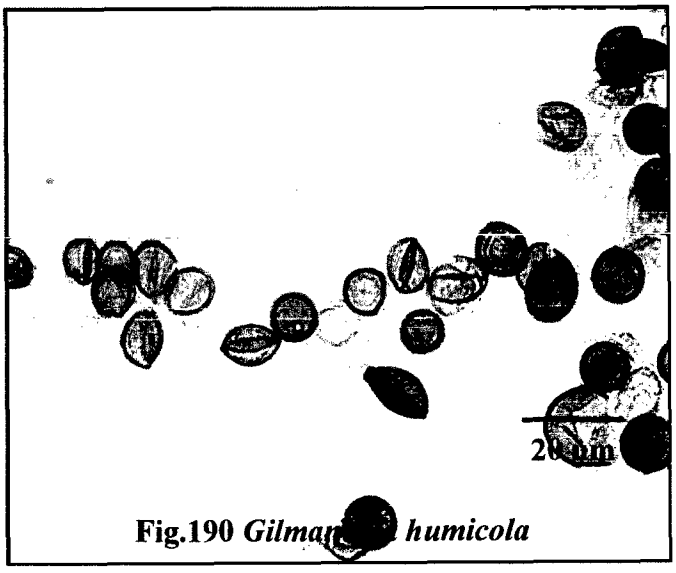


Fig.190 *Gilman[illegible] humicola*

phalis sp.

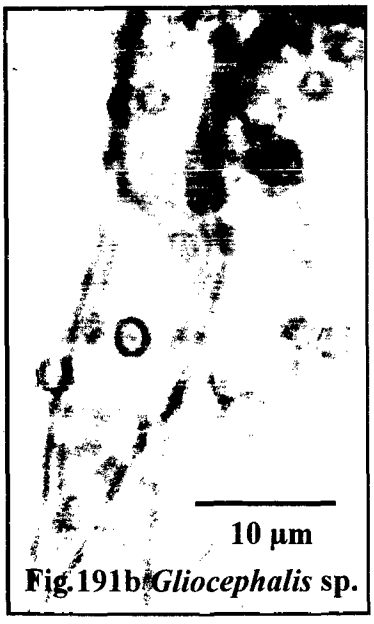


Fig.191b *Gliocephalis* sp.

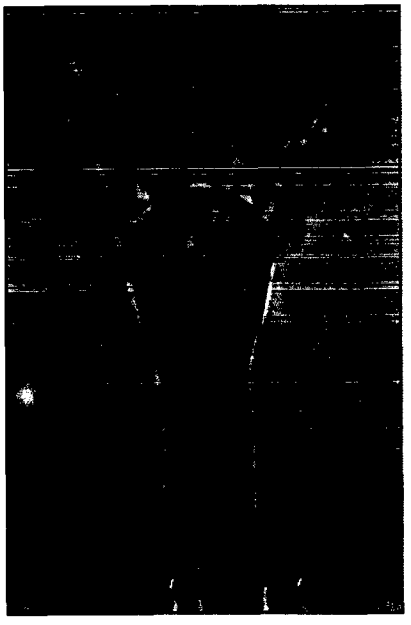


Fig.193 *Gonat[illegible]botrytum* sp.

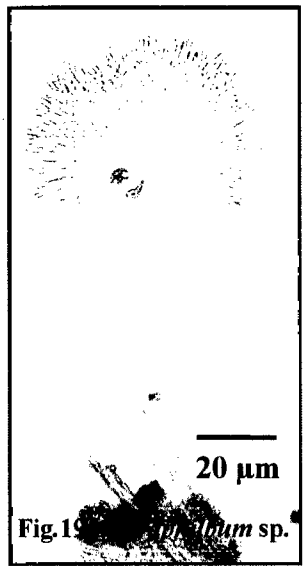


Fig.19 *Graphilbum* sp.

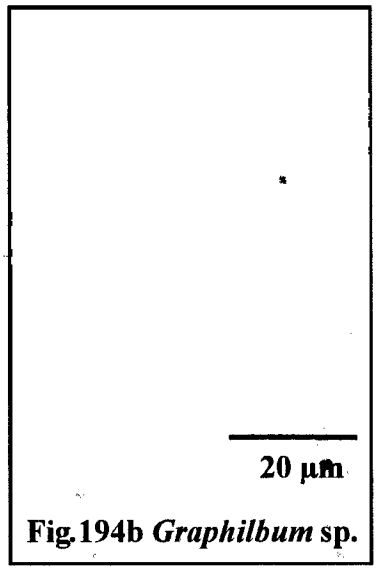


Fig.194b *Graphilbum* sp.

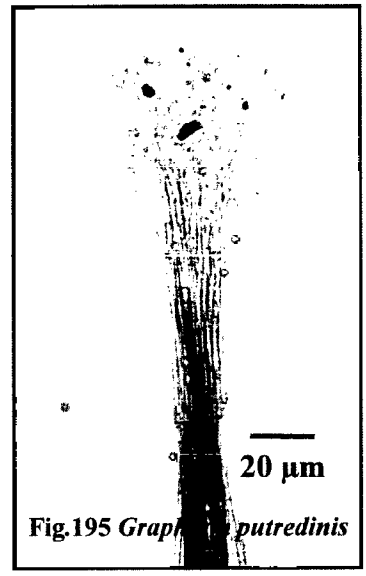
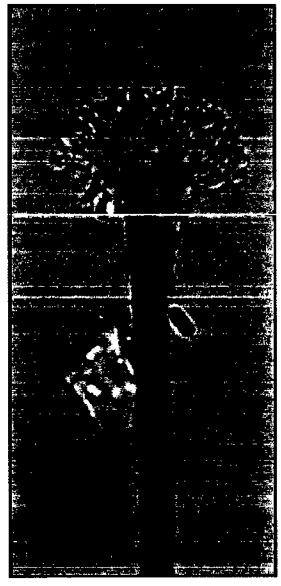


Fig.195 *Graph putredinis*



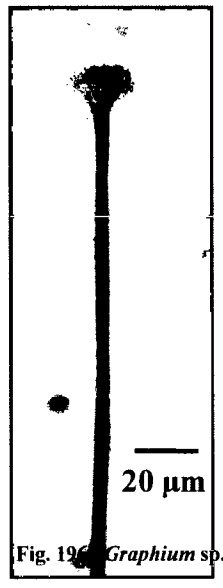


Fig. 19 *Graphium* sp.

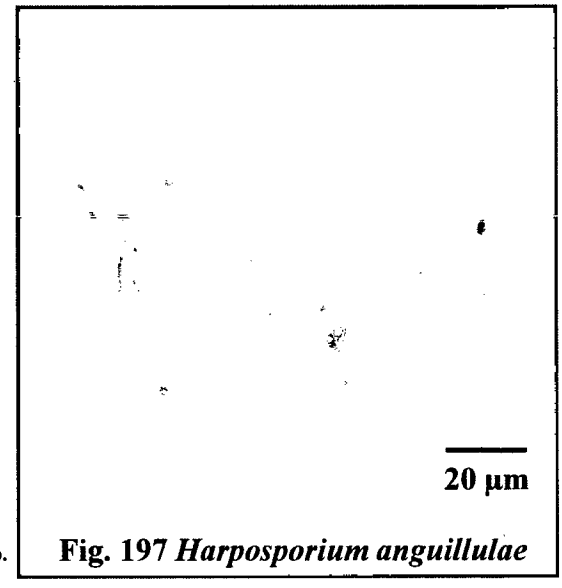


Fig. 197 *Harposporium anguillulae*

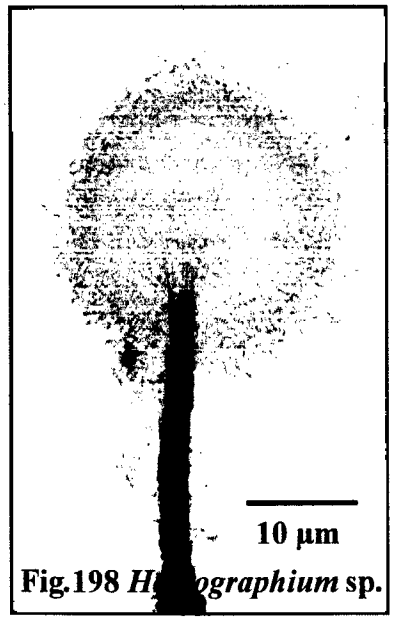


Fig.198 *H graphium* sp.

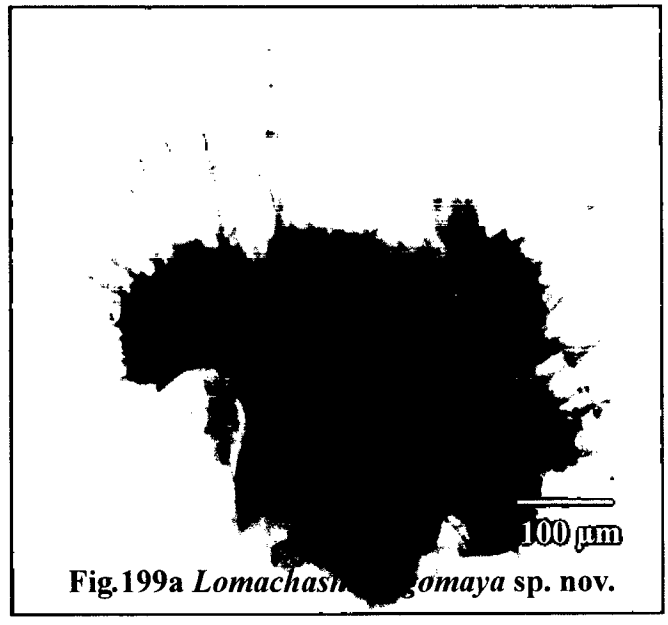


Fig.199a *Lomachash omaya* sp. nov.

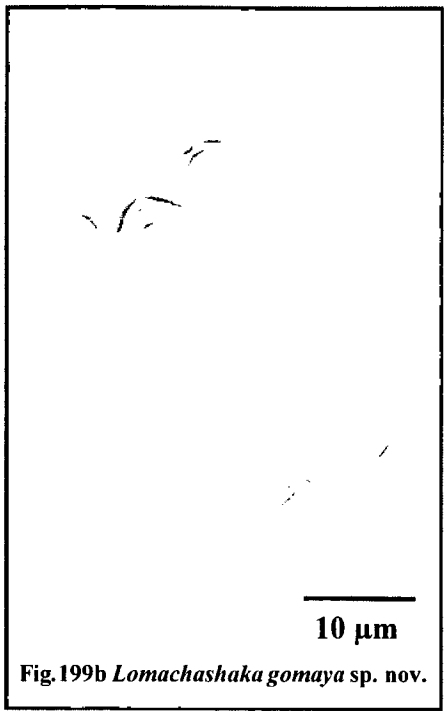


Fig.199b *Lomachashaka gomaya* sp. nov.

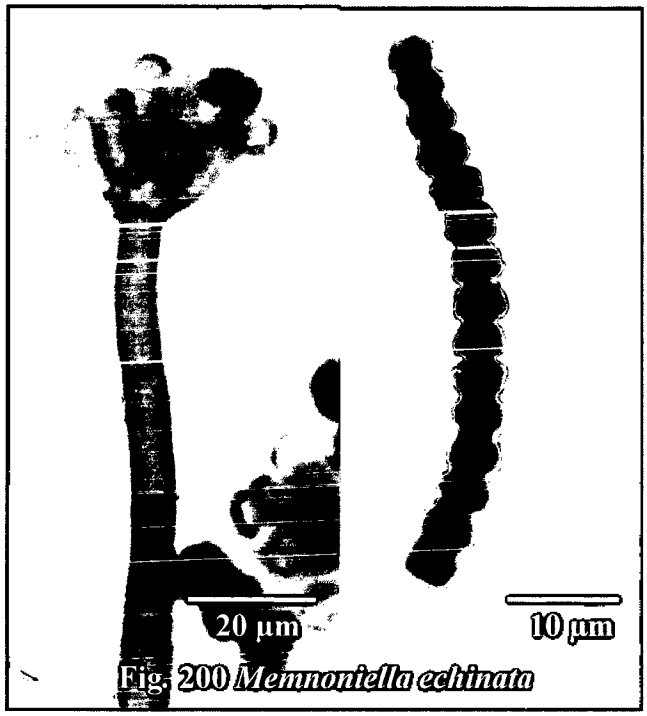


Fig. 200 *Memnoniella echinata*

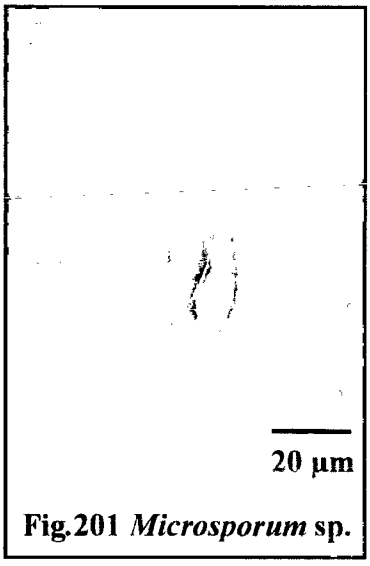


Fig.201 *Microsporum* sp.

Fig.202 *Myrothecium advena*

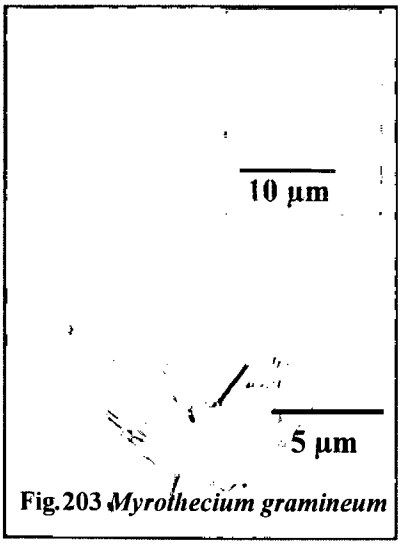


Fig.203 *Myrothecium gramineum*

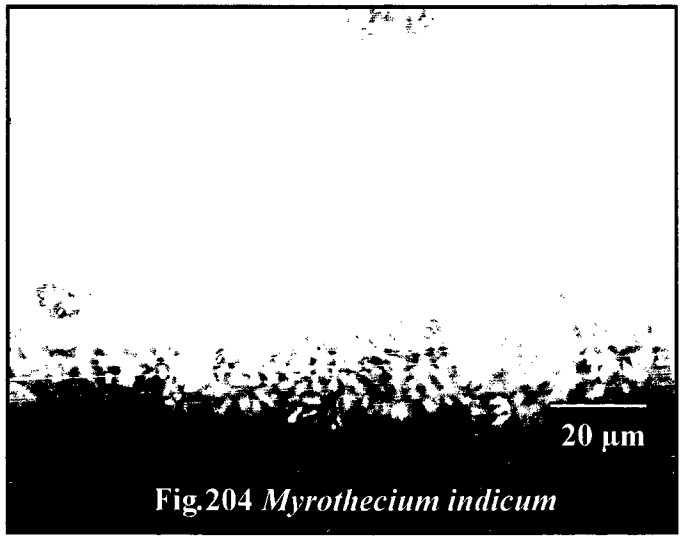


Fig.204 *Myrothecium indicum*

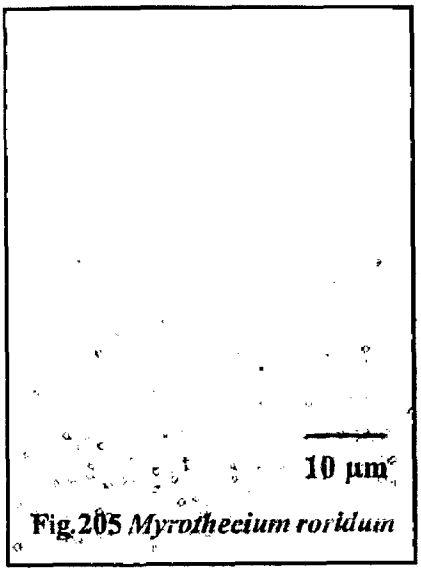


Fig.205 *Myrothecium roridum*

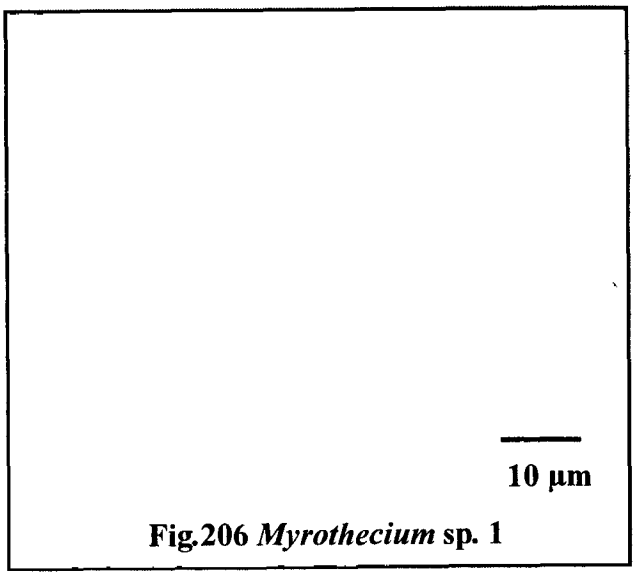


Fig.206 *Myrothecium* sp. 1

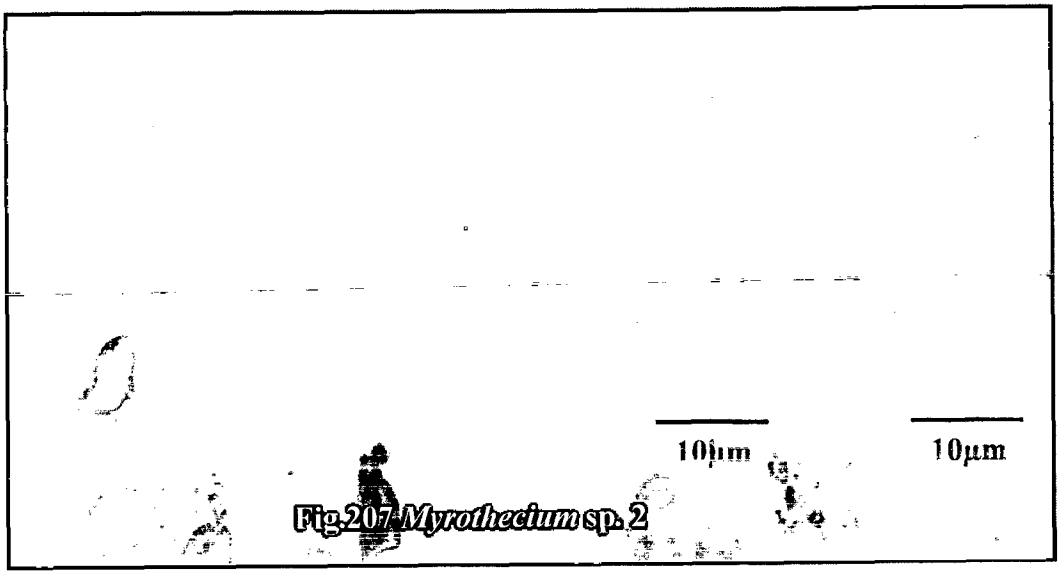


Fig.207 *Myrothecium* sp. 2

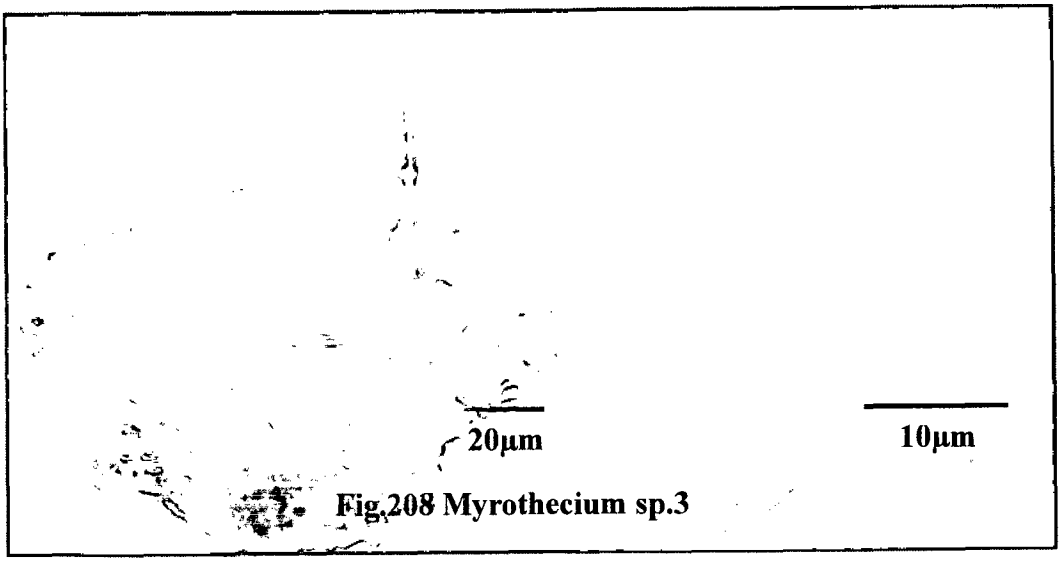


Fig.208 Myrothecium sp.3

Fig. 209 Myrothecium sp. 4

Fig. 210 Myrothecium sp. 5

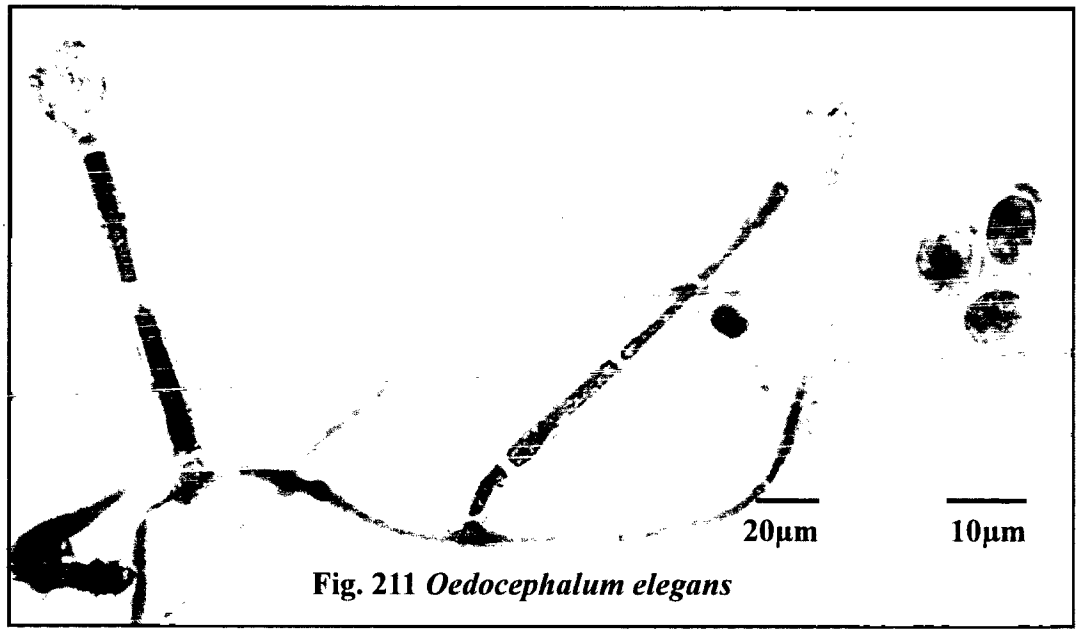


Fig. 211 *Oedocephalum elegans*

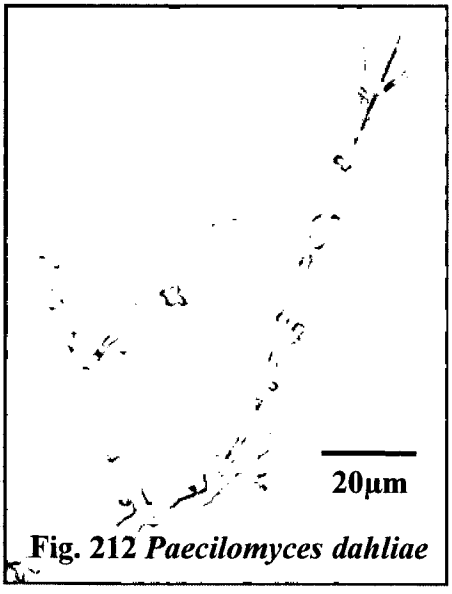


Fig. 212 *Paecilomyces dahliae*

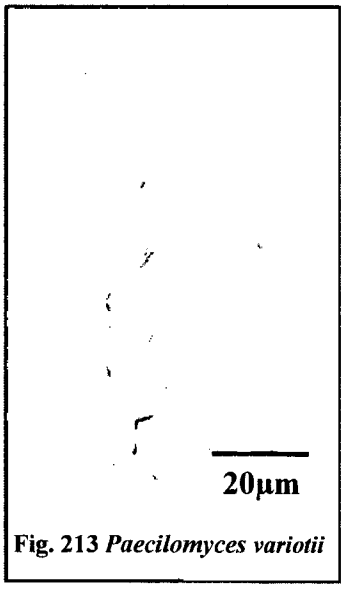


Fig. 213 *Paecilomyces variotii*

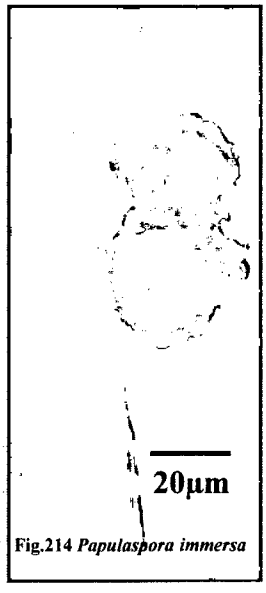


Fig.214 *Papulaspora immersa*

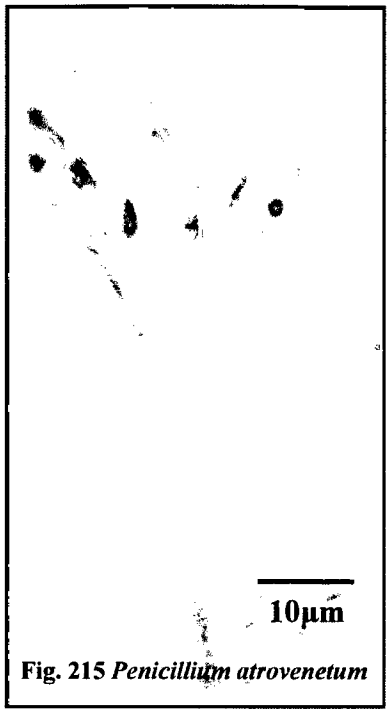
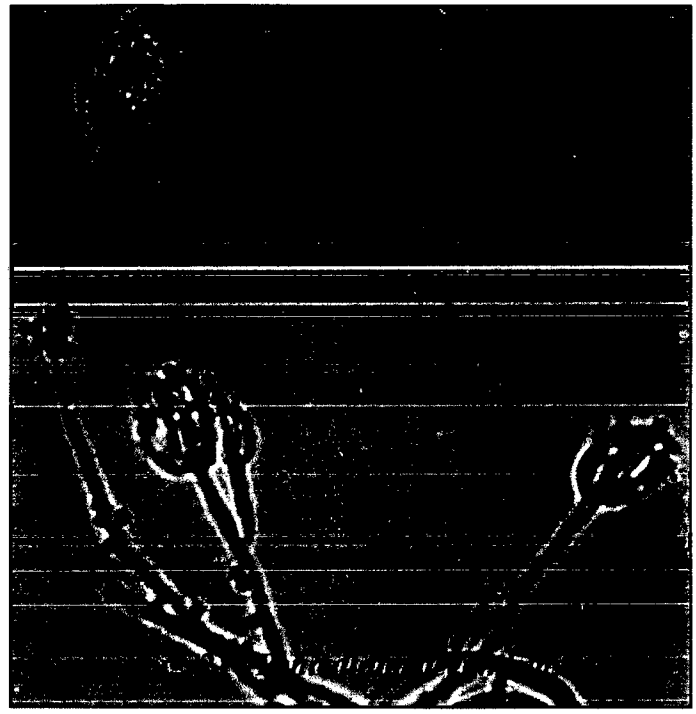


Fig. 215 *Penicillium atrovenetum*



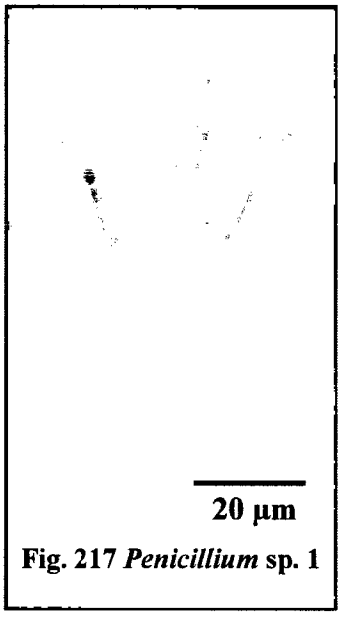


Fig. 217 *Penicillium* sp. 1

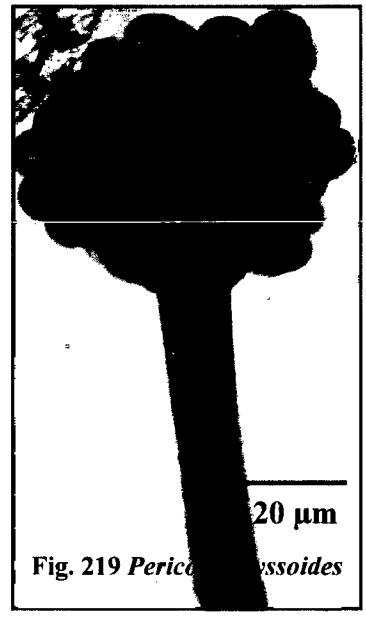


Fig. 219 *Perice ssoides*

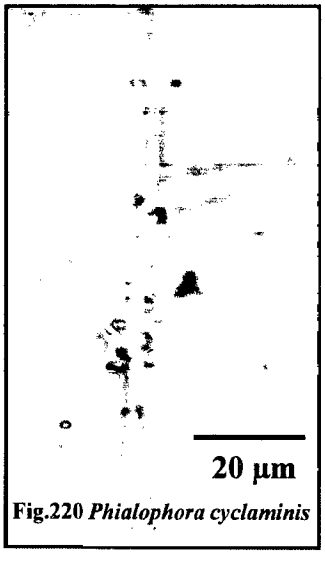


Fig.220 *Phialophora cyclaminis*

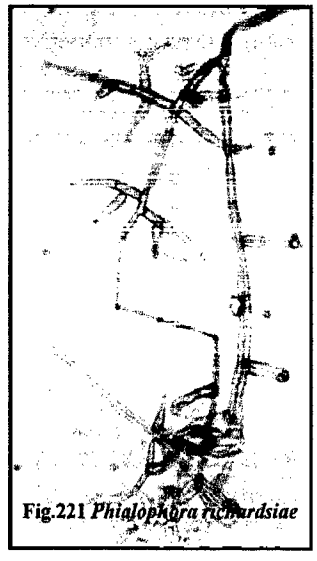


Fig.221 *Phialophora richardsiae*

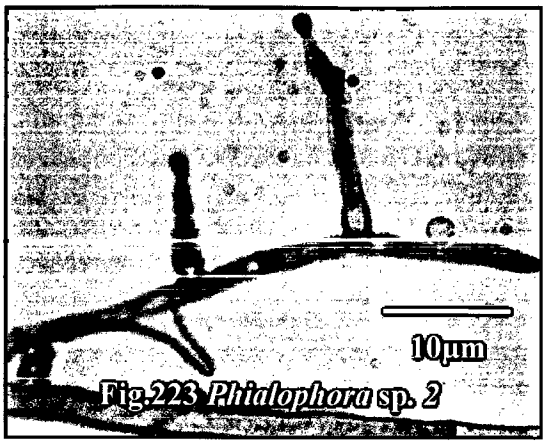


Fig.223 *Phialophora* sp. 2

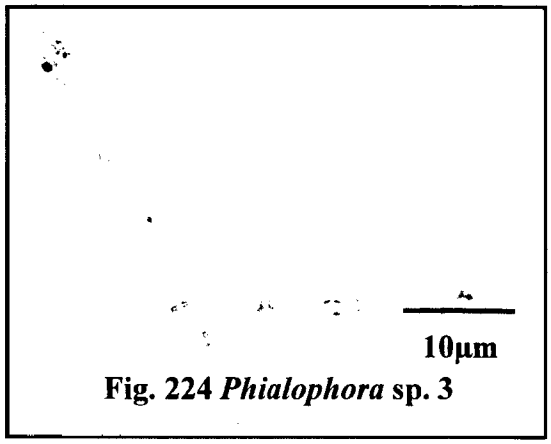


Fig. 224 *Phialophora* sp. 3

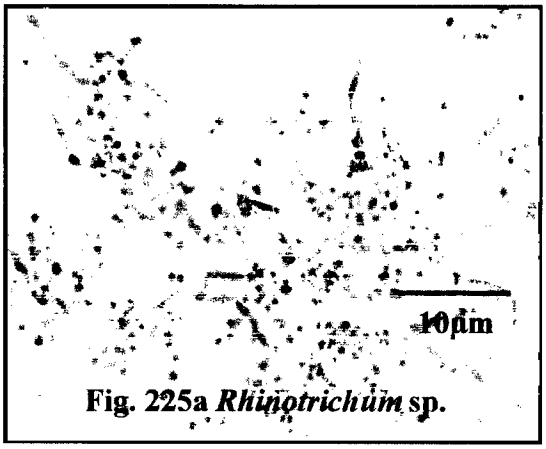


Fig. 225a *Rhinotrichum* sp.

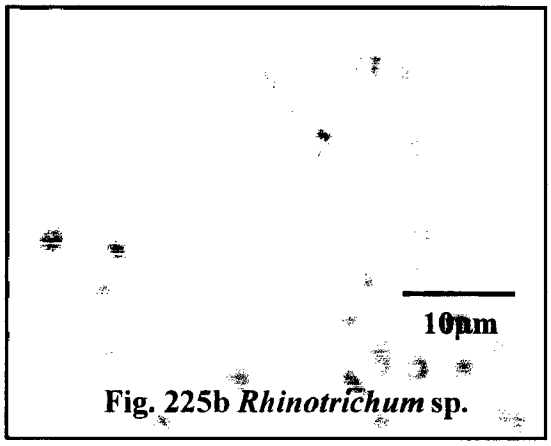


Fig. 225b *Rhinotrichum* sp.

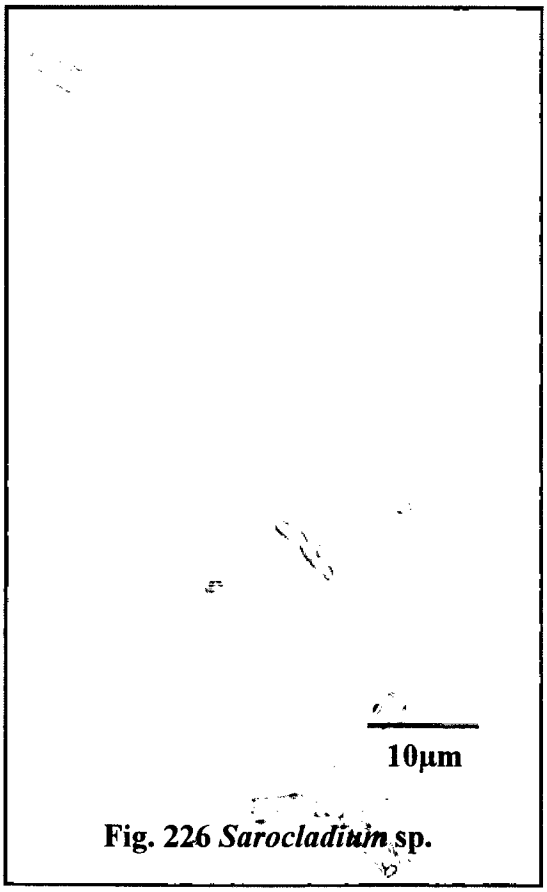


Fig. 226 *Sarocladium* sp.

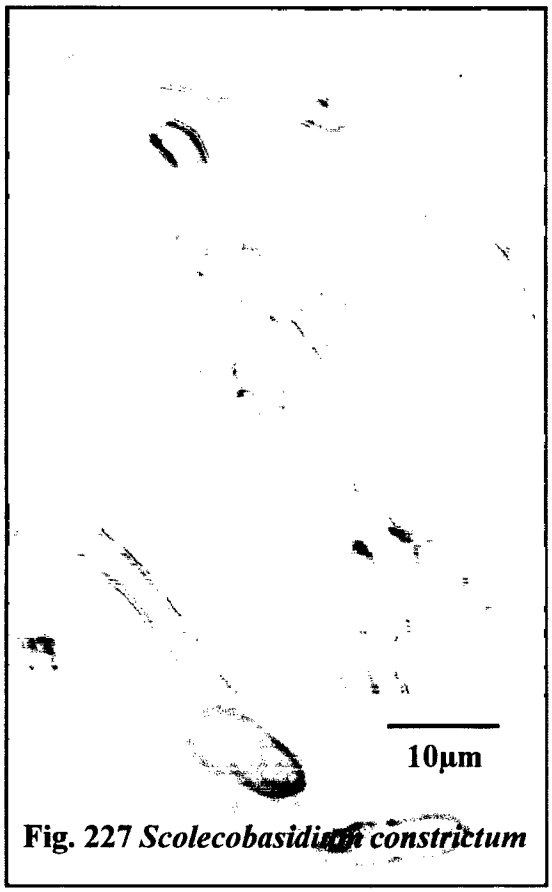


Fig. 227 *Scolecobasidium constrictum*

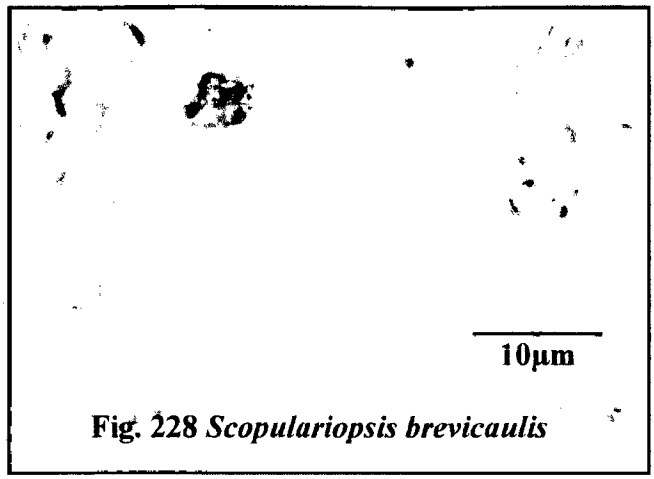


Fig. 228 *Scopulariopsis brevicaulis*

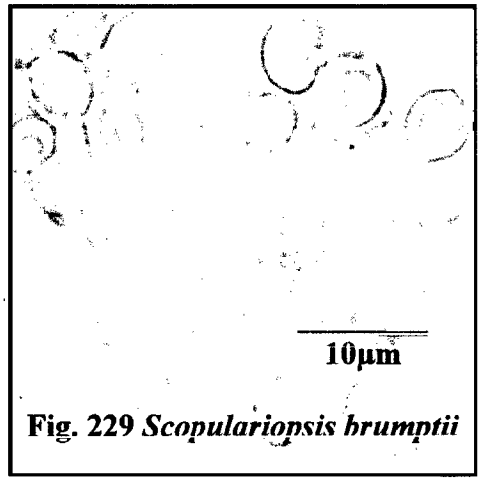


Fig. 229 *Scopulariopsis brumptii*

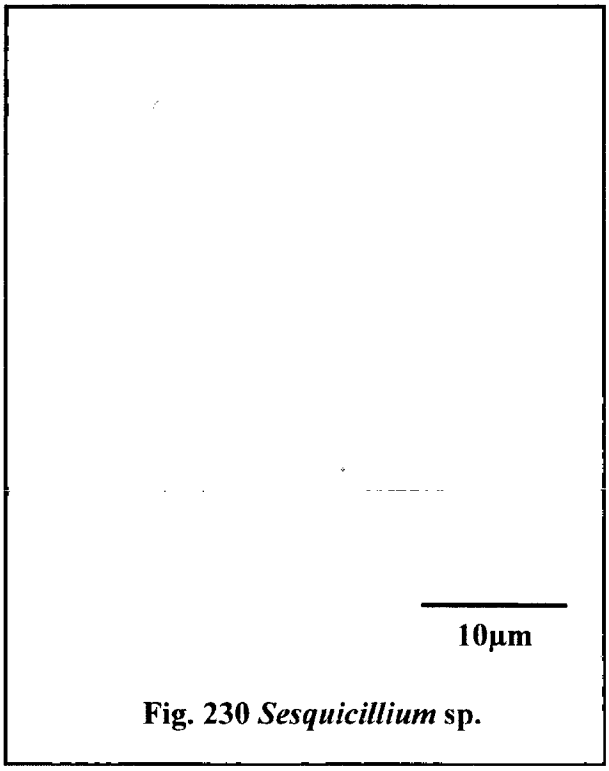


Fig. 230 *Sesquicillium* sp.

Fig. 231 *Shanonmyces* gen. et sp. nov.

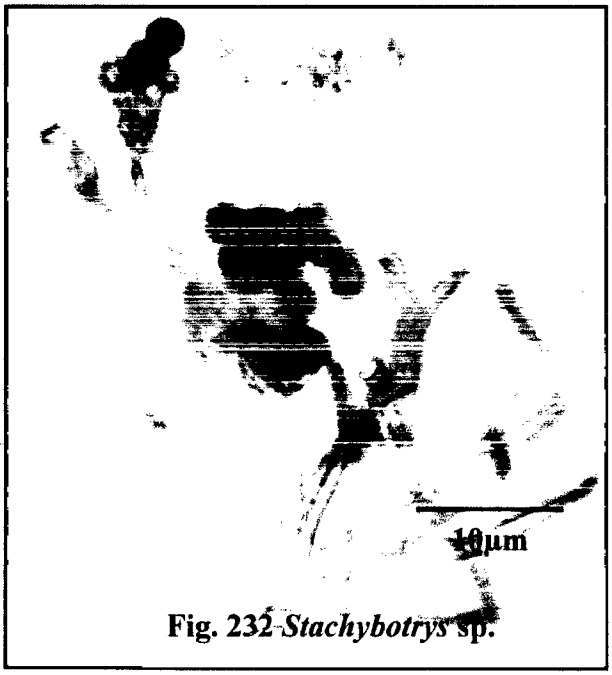


Fig. 232 *Stachybotrys* sp.

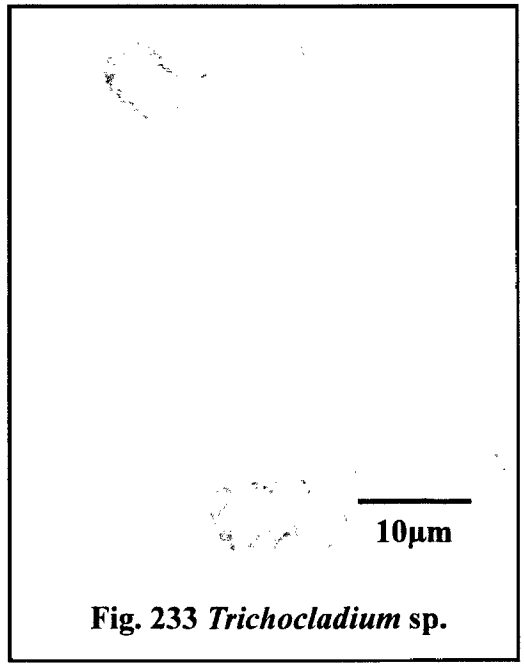


Fig. 233 *Trichocladium* sp.

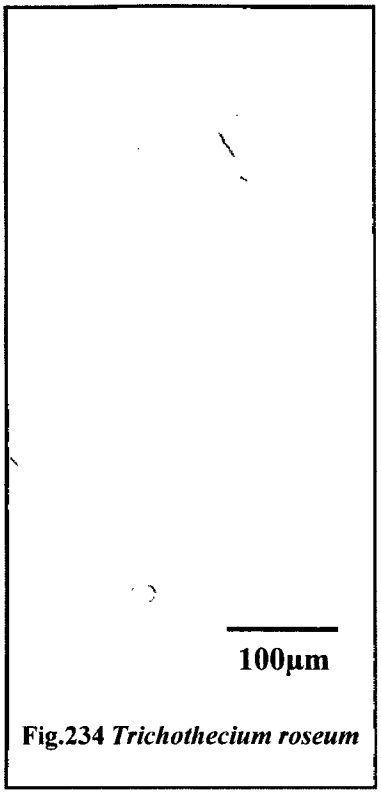


Fig.234 *Trichothecium roseum*

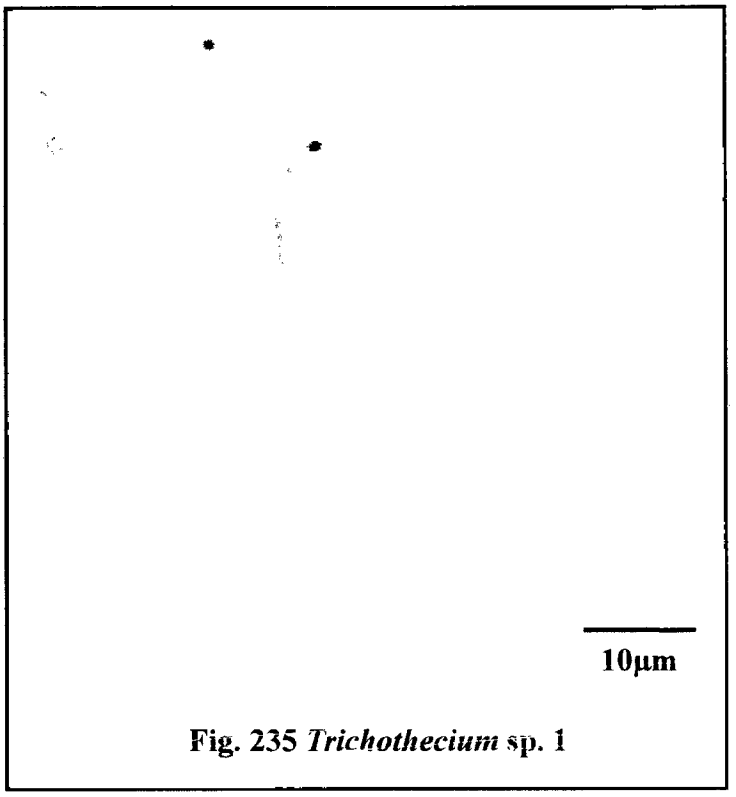


Fig. 235 *Trichothecium* sp. 1

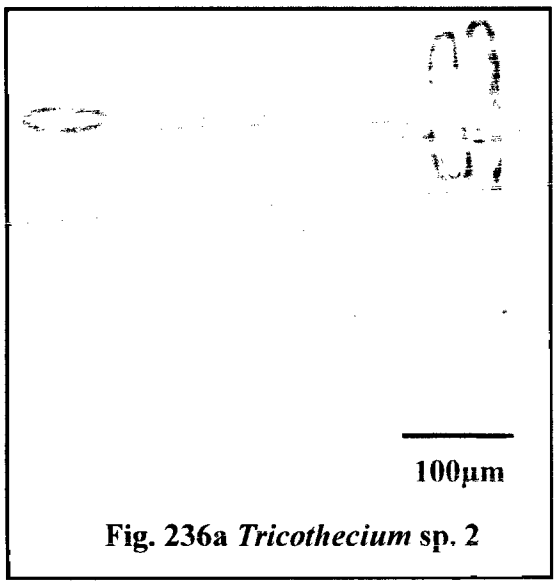


Fig. 236a *Tricothecium* sp. 2

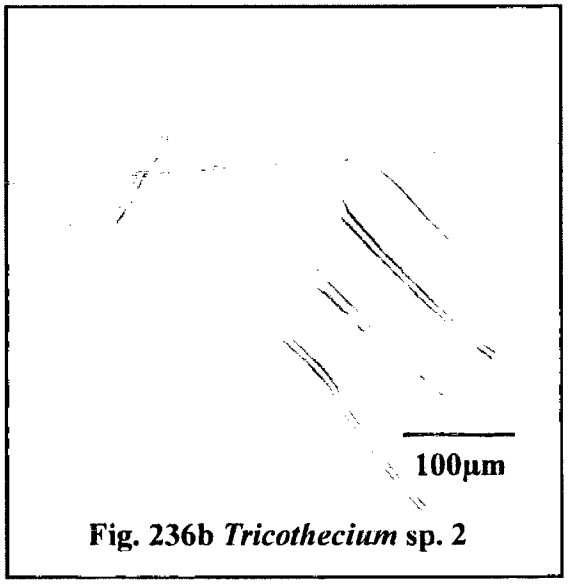


Fig. 236b *Tricothecium* sp. 2

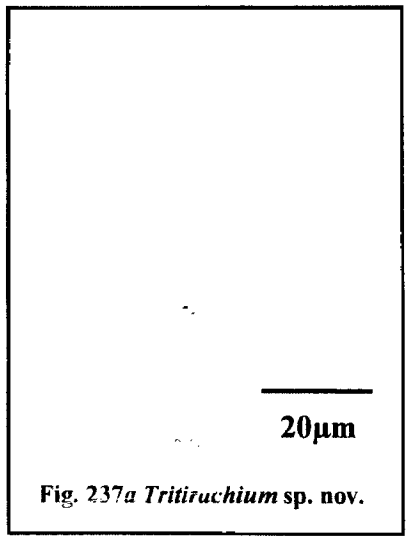


Fig. 237*a Tritirachium* sp. nov.

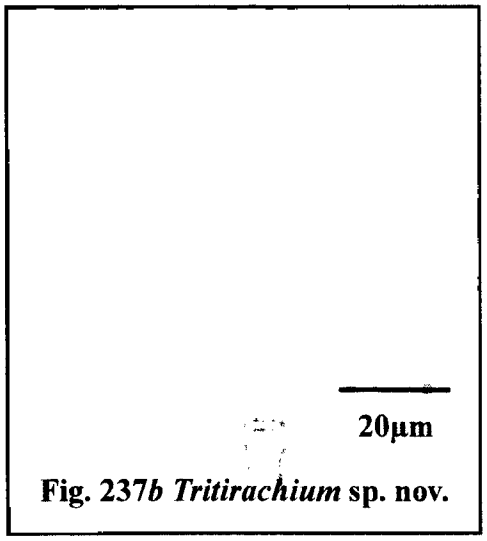


Fig. 237*b Tritirachium* sp. nov.

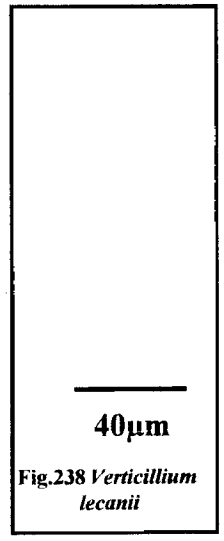


Fig.238 *Verticillium lecanii*

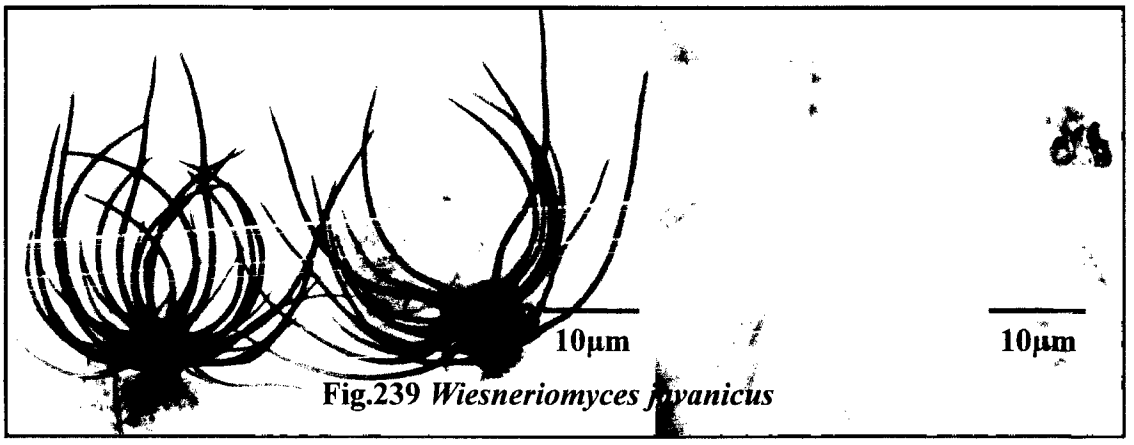


Fig.239 *Wiesneriomyces javanicus*

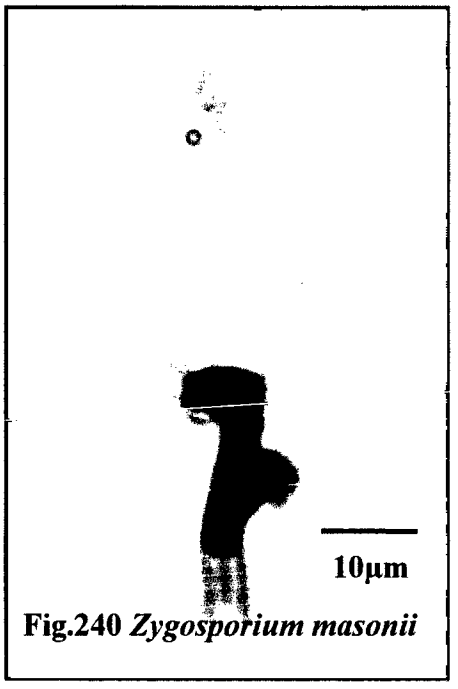


Fig.240 *Zygosporium masonii*

COELOMYCETES

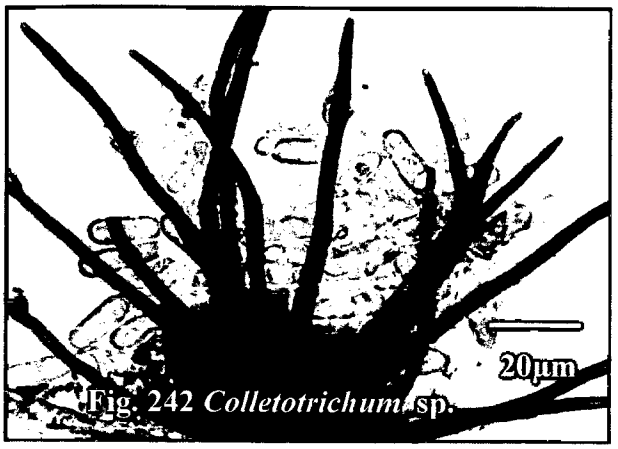
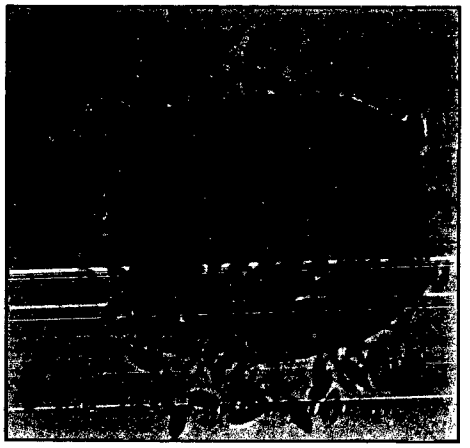


Fig. 242 *Colletotrichum* sp.



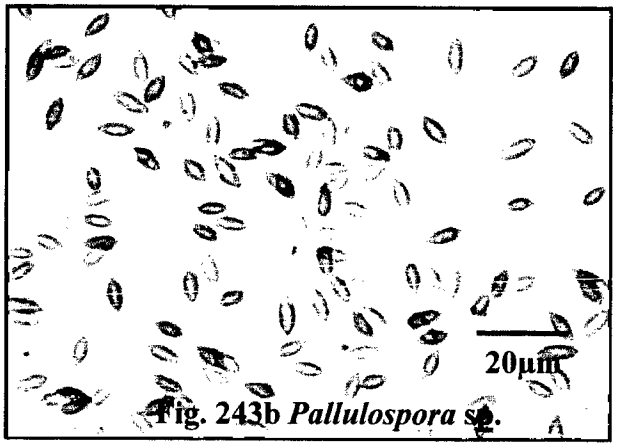


Fig. 243b *Pallulospora* sp.

Fig. 244 *Pestalotiopsis*

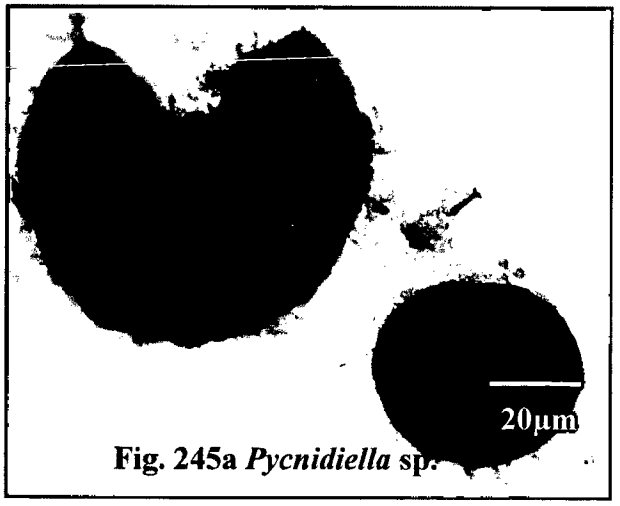


Fig. 245a *Pycnidiella* sp.

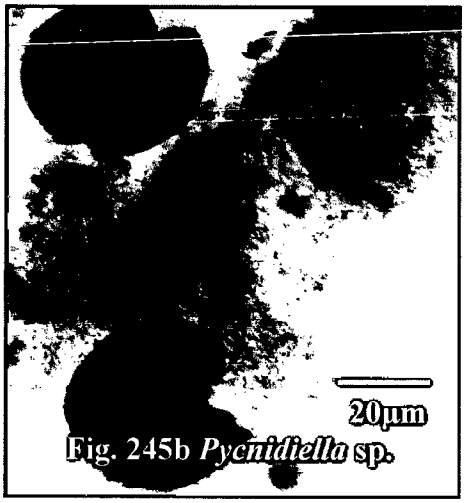


Fig. 245b *Pycnidiella* sp.

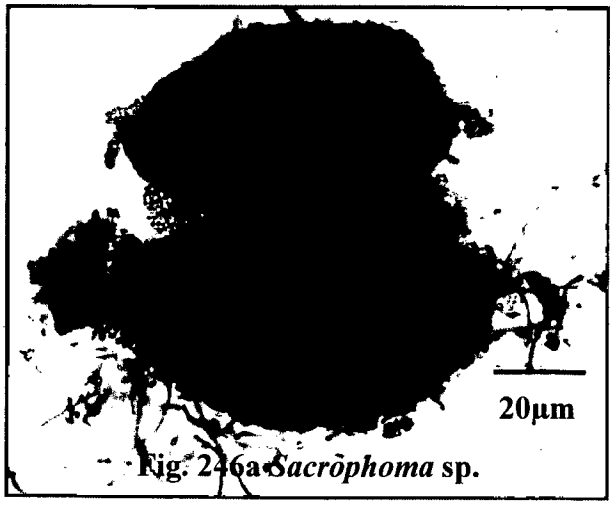


Fig. 246a *Sacrophoma* sp.

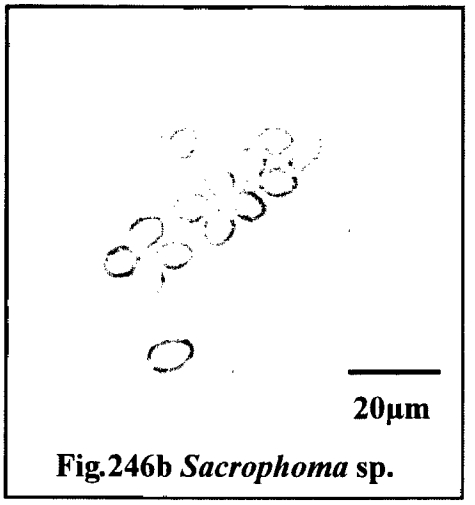


Fig.246b *Sacrophoma* sp.

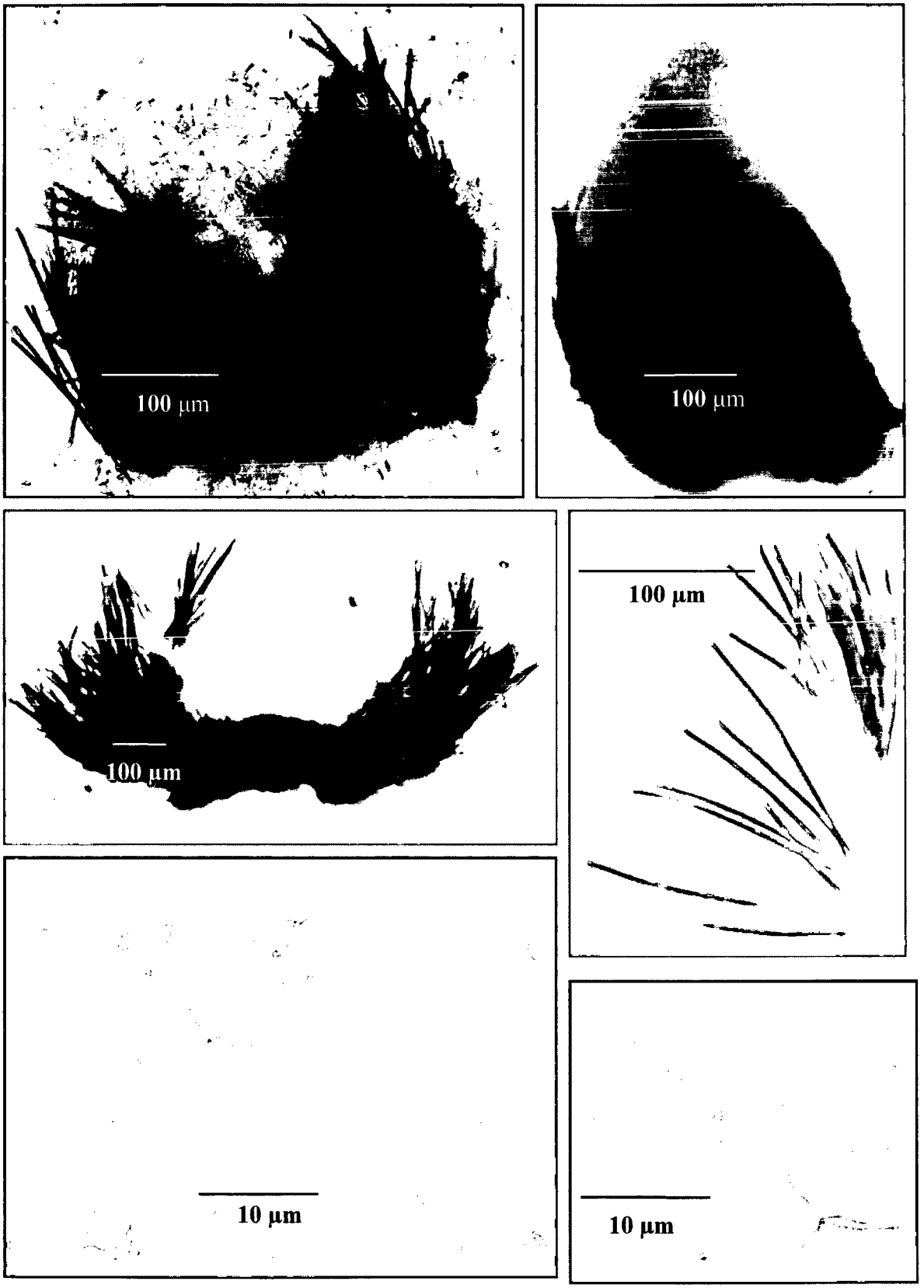


Fig. 247 *Dimastigosporium* yanese sp. nov.

Part II: Studies on pattern of appearance of fungi on cattle and rabbit dung over a period of time and their significance

Fungi exhibit a variety of ecological patterns on their own and/or in association with other organisms. These associations, saprophytic, parasitic and mutulistic, have been topics of considerable significance in mycological discourses and recognised since long. As saprophytes, the fungi along with other decomposing organisms such as bacteria, viruses and nematodes, ensure complete decomposition of the herbivore dung which contains sufficiently large amount of undigested plant material (Kendrick, 2002).

The saprophytic association of micro-fungi with herbivore dung has been the subject of several investigations and this aspect is reviewed in detail in Chapter II. The studies so far carried out have revealed that there are fungi exhibiting specificity at substrate, host and habitat level, besides in relation to season and other environmental factors. In the decomposition of herbivore dung, participatory examples are available from different taxonomic entities in Zygomycetes, Ascomycetes, Hyphomycetes and Basidiomycetes (Dix and Webster, 1995).

In the present study, the two localities selected for analysis of dung samples were (i) Goa University (GU) campus and (ii) Indian Council of Agriculture Research (ICAR) station at Old Goa. Cow and rabbit were the two herbivores considered for dung samples, for study. The occurrence of dung of these two herbivores throughout the year in these two sites and in view of the fact that rabbit is a non-ruminant and cow a ruminant, dung of these animals were selected for the study. For recovery of the fungi from dung, three techniques, viz. moist chamber incubation, particle-plating and single-spore isolation, were employed. The fungal isolation details are given in Chapter III.

The fungi recovered from the dung of rabbit and cow, seasons and year-wise (2007-08 and 2008-09), are given in Tables 4.2.1 and 4.2.2. During the study tenure, 86 taxa of identifiable fungi and 227 distinct isolates which could not be identified due to their non-sporulating nature, were recovered. Looking at the entire duration of study, maximum number of fungi recovered, from both the locations under study, was during the post monsoon season. In terms of fungal load, between the two locations, the Goa University campus was richer in the post monsoon season, both for rabbit and cow dung. Whereas, in the summer months, maximum number of fungi recovered from rabbit and cattle dung was from the ICAR station.

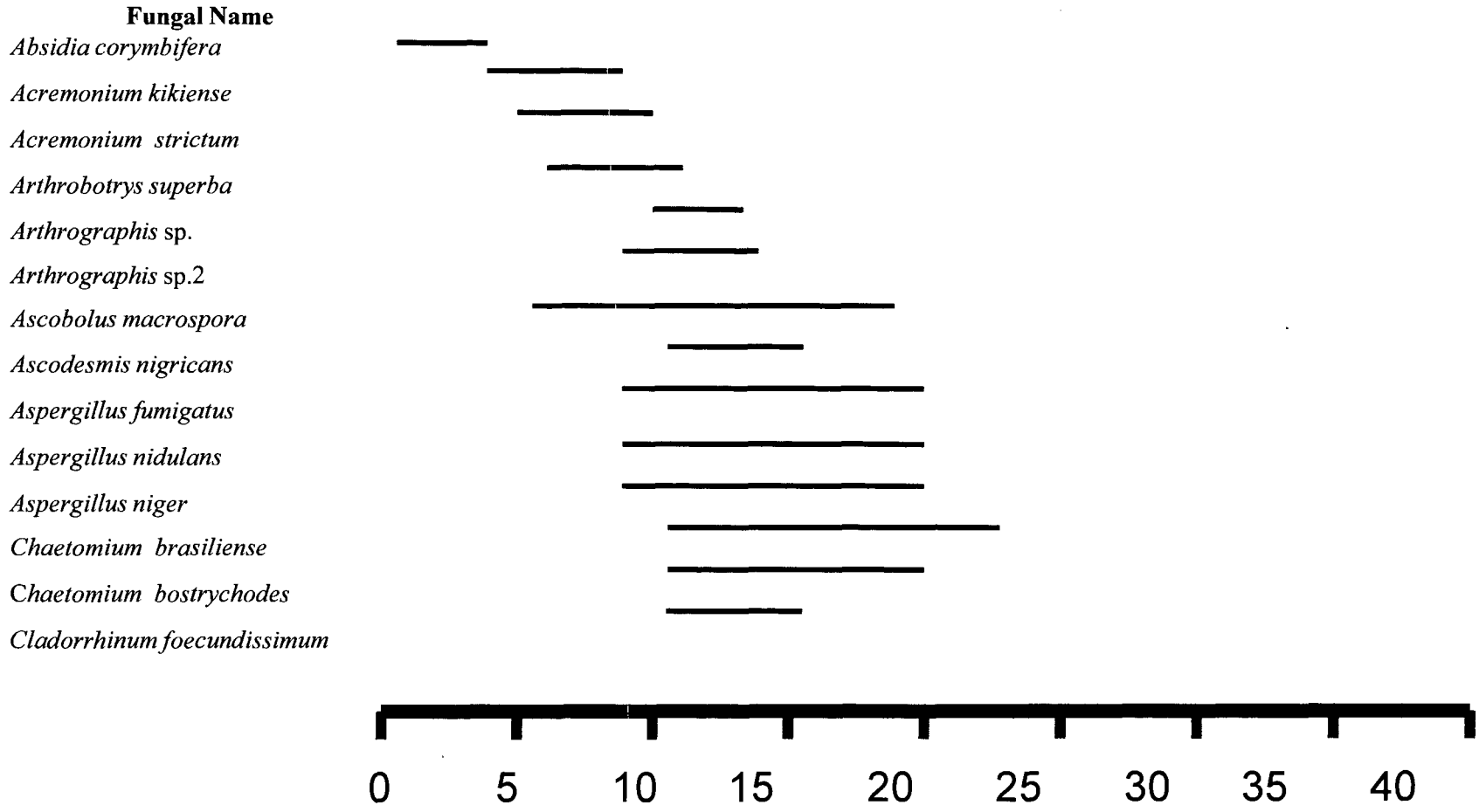
It was found that certain species showed substrate specificity. *Cladorrhinum foecundissimum* was specifically observed on cattle dung during all the three seasons for the entire period of two years. *Cephaliophora irregularis* and *Circinella umbellata* were recovered, in all the seasons, specifically on rabbit dung. These were absent on cow dung. Species belonging to the genera *Ascobolus*, *Saccobolus* and *Pilobobus* were common to both the herbivores in both locations. *Pilobolus crystallinus* was observed in both the samples in all the seasons during the entire study period.

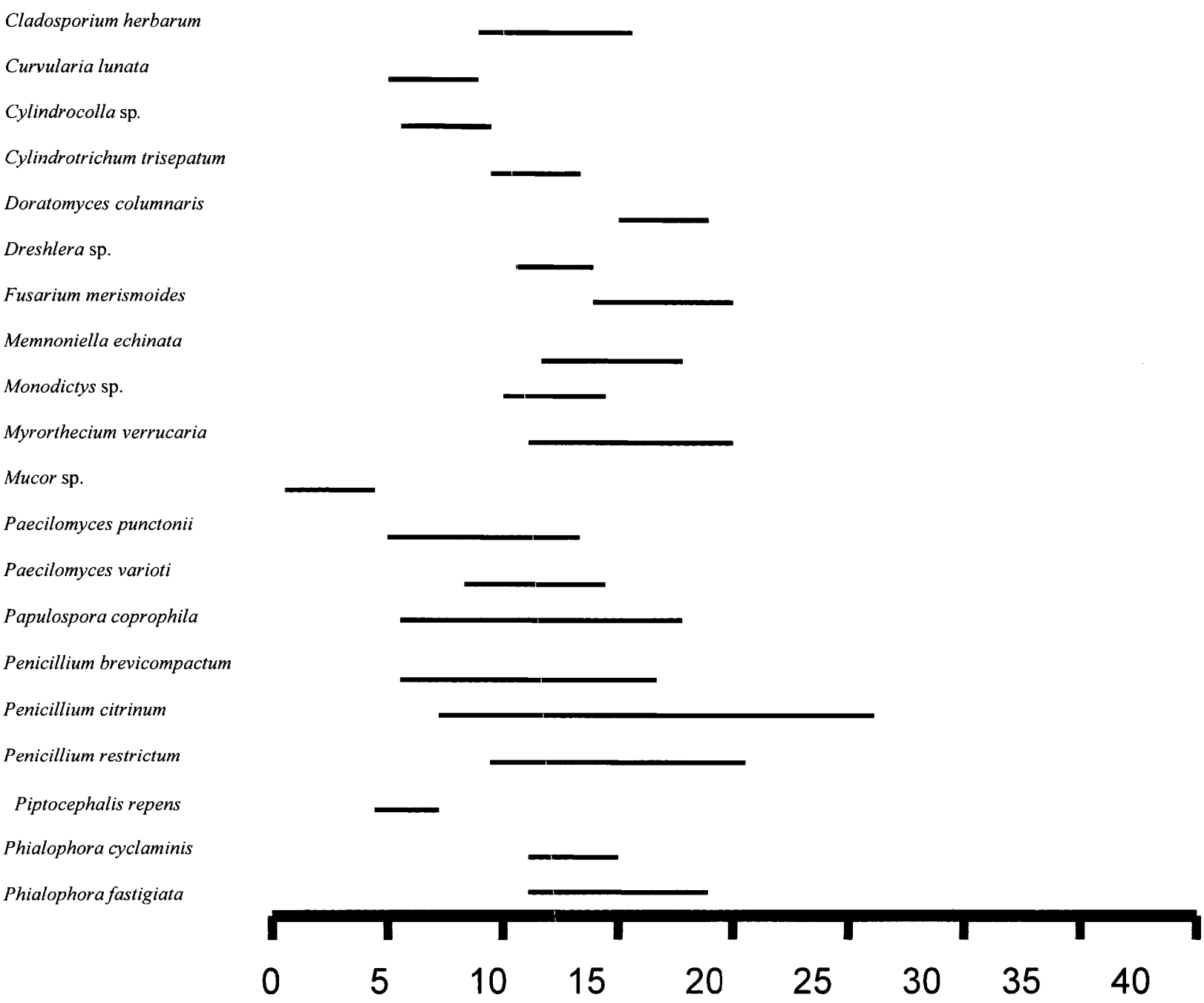
It was observed that the fungi isolated from the two study sites, i.e. Goa University campus and ICAR station, in rabbit and cow dung samples, didn't show much variation in number. In the first year of study (2007-08), the fungi recovered during the summer in the ICAR station samples of rabbit and cow dung were more than those isolated from the rabbit and cow dung samples of Goa University campus. This may be due to the fact that in the summer season, the availability of natural forage feed to the herbivores was less at Goa University campus, whereas at the ICAR station, regular green feed was provided to the herbivores. Perhaps, this lead to the increased number of fungi in the dung of animals at ICAR in the summer months.

In the post-monsoon season, it was observed that the number of fungi was more in rabbit and cow dung, at the Goa University campus, compared to the samples of ICAR Station. Consideration can be given to the fact that in the post-monsoon season good amount of vegetation was present at Goa University campus for the herbivores to graze upon. (Fig. 4.2.1. a-b)

As it is known (Richardson, 2001), fungi growing on herbivore dung follow a specific pattern of succession, i.e. from members of Zygomycetes to Ascomycetes and Basidiomycetes. The results obtained from studies carried out in this work are presented in Fig. 4.2.2, 4.2.3. The pattern of succession of fruiting bodies of fungi was found to be broadly similar in both rabbit and cow dung. Initially, the colonisation was by members of Zygomycetes, followed the Ascomycetes and their anamorphic forms. These were finally replaced by the members of Basidiomycetes. For example, from the study carried out it was observed that, amongst the zygomycetes, the species belonging to *Pilobolus*, *Absidia* were the earliest ones to occupy the herbivore dung, later on other anamorphic fungal forms such as species of *Acremonium* and *Fusarium* started to colonize the dung. Simultaneously, occurrence of certain members of the Discomycetes (viz. *Ascobolus*, *Saccobolus*) was seen. At the later stages of succession, various other Ascomycetes such as species of *Sordaria*, *Podospora*, *Schizothecium* and *Sporormia* were observed. The fungal succession thread came to an end with the appearance of Basidiomycetes.

Fig. 4.2.2 Succession of fungi on Cow dung




Cladosporium herbarum
Curvularia lunata
Cylindrocolla sp.
Cylindrotrichum trisepatum
Doratomyces columnaris
Dreshlera sp.
Fusarium merismoides
Memnoniella echinata
Monodictys sp.
Myrorthecium verrucaria
Mucor sp.
Paecilomyces punctonii
Paecilomyces varioti
Papulospora coprophila
Penicillium brevicompactum
Penicillium citrinum
Penicillium restrictum
Piptocephalis repens
Phialophora cyclaminis
Phialophora fastigiata
0
5
10
15
20
25
30
35
40

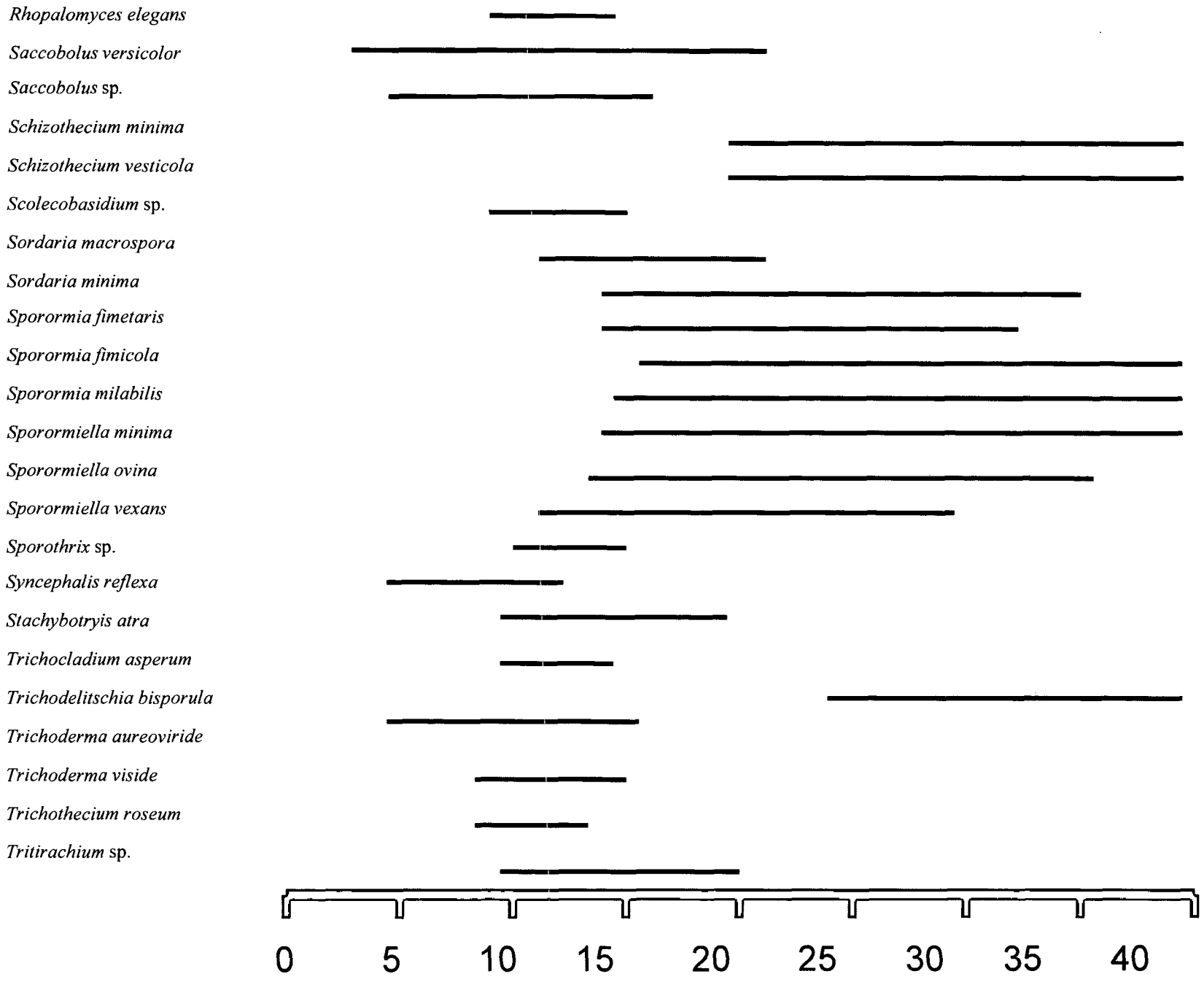
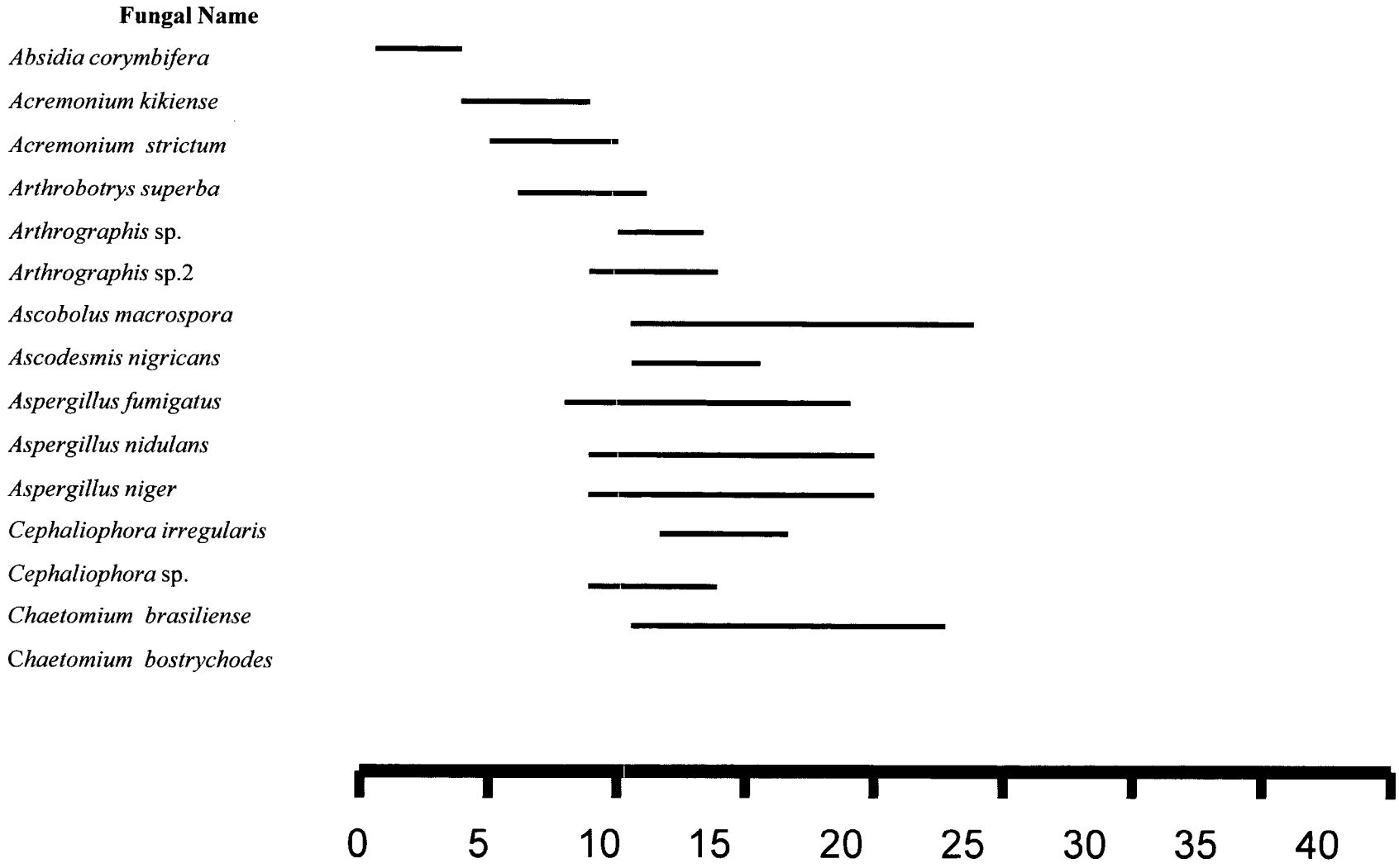
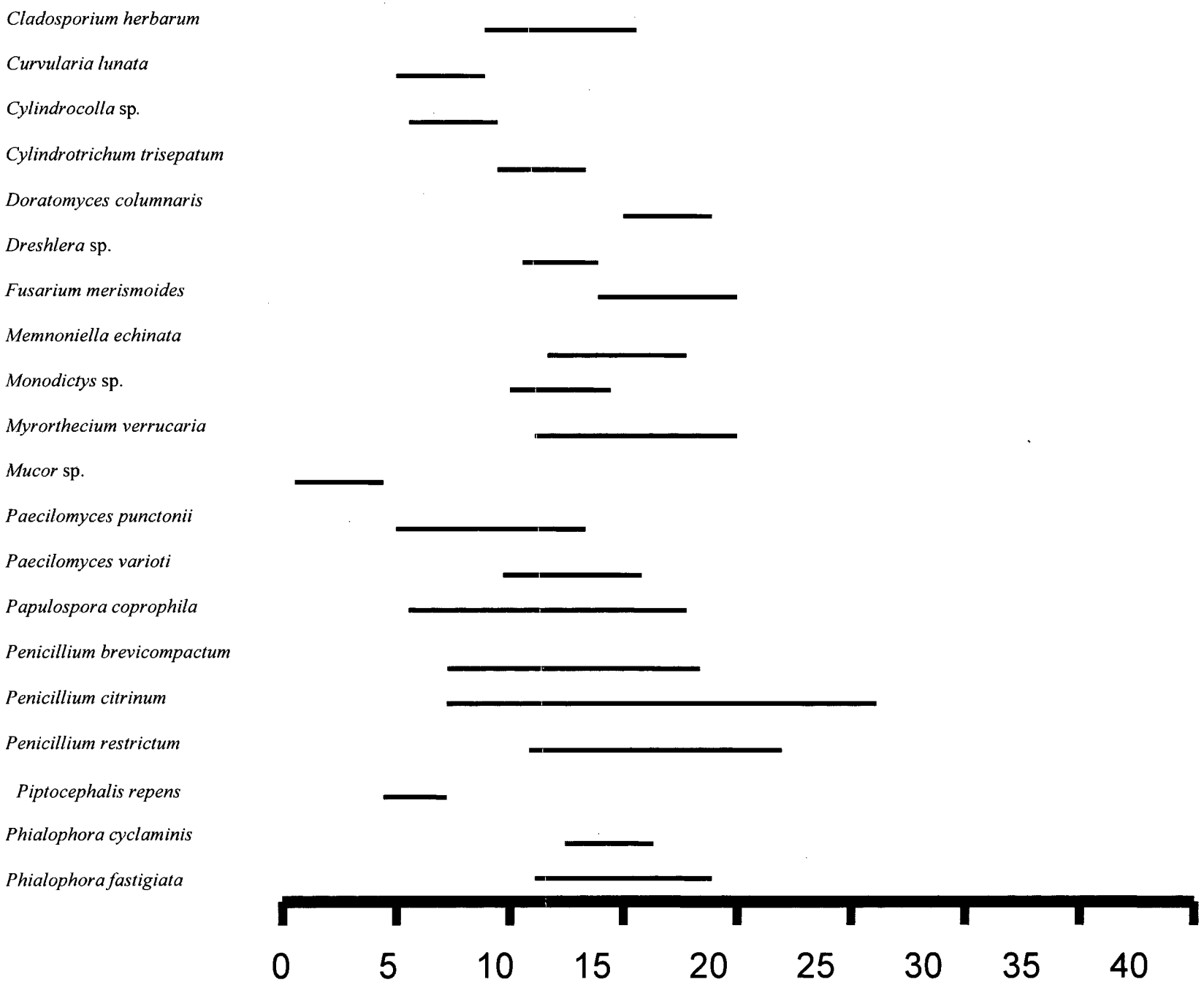

Rhopalomyces elegans
Saccobolus versicolor
Saccobolus sp.
Schizothecium minima
Schizothecium vesticola
Scolecobasidium sp.
Sordaria macrospora
Sordaria minima
Sporormia fimetaris
Sporormia fimicola
Sporormia milabilis
Sporormiella minima
Sporormiella ovina
Sporormiella vexans
Sporothrix sp.
Syncephalis reflexa
Stachybotryis atra
Trichocladium asperum
Trichodelitschia bisporula
Trichoderma aureoviride
Trichoderma viside
Trichothecium roseum
Tritirachium sp.
0
5
10
15
20
25
30
35
40

Fig. 4.2.3 Succession of fungi on Rabbit pellets




Cladosporium herbarum
Curvularia lunata
Cylindrocolla sp.
Cylindrotrichum trisepatum
Doratomyces columnaris
Dreshlera sp.
Fusarium merismoides
Memnoniella echinata
Monodictys sp.
Myrorthecium verrucaria
Mucor sp.
Paecilomyces punctonii
Paecilomyces varioti
Papulospora coprophila
Penicillium brevicompactum
Penicillium citrinum
Penicillium restrictum
Piptocephalis repens
Phialophora cyclaminis
Phialophora fastigiata
0
5
10
15
20
25
30
35
40

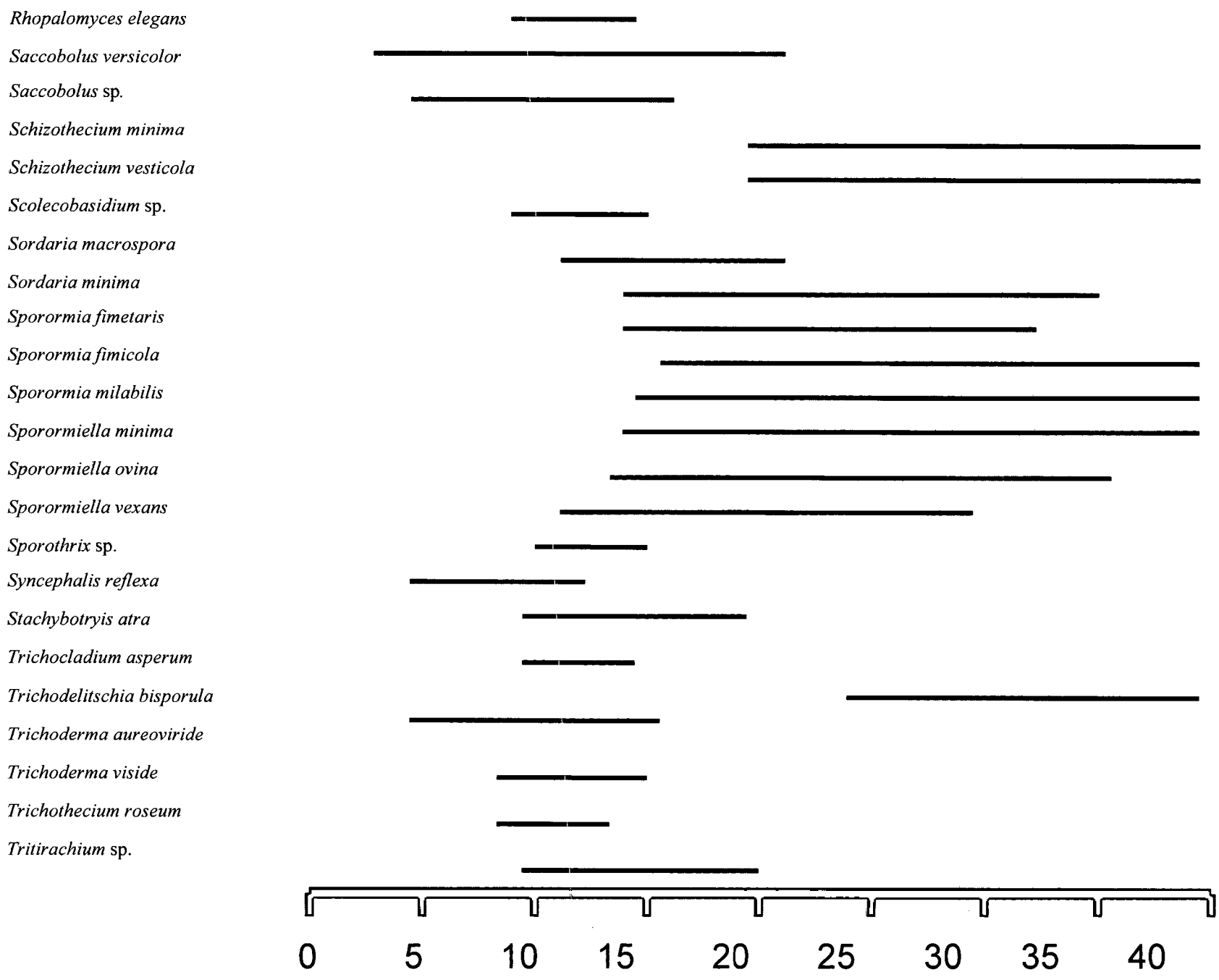
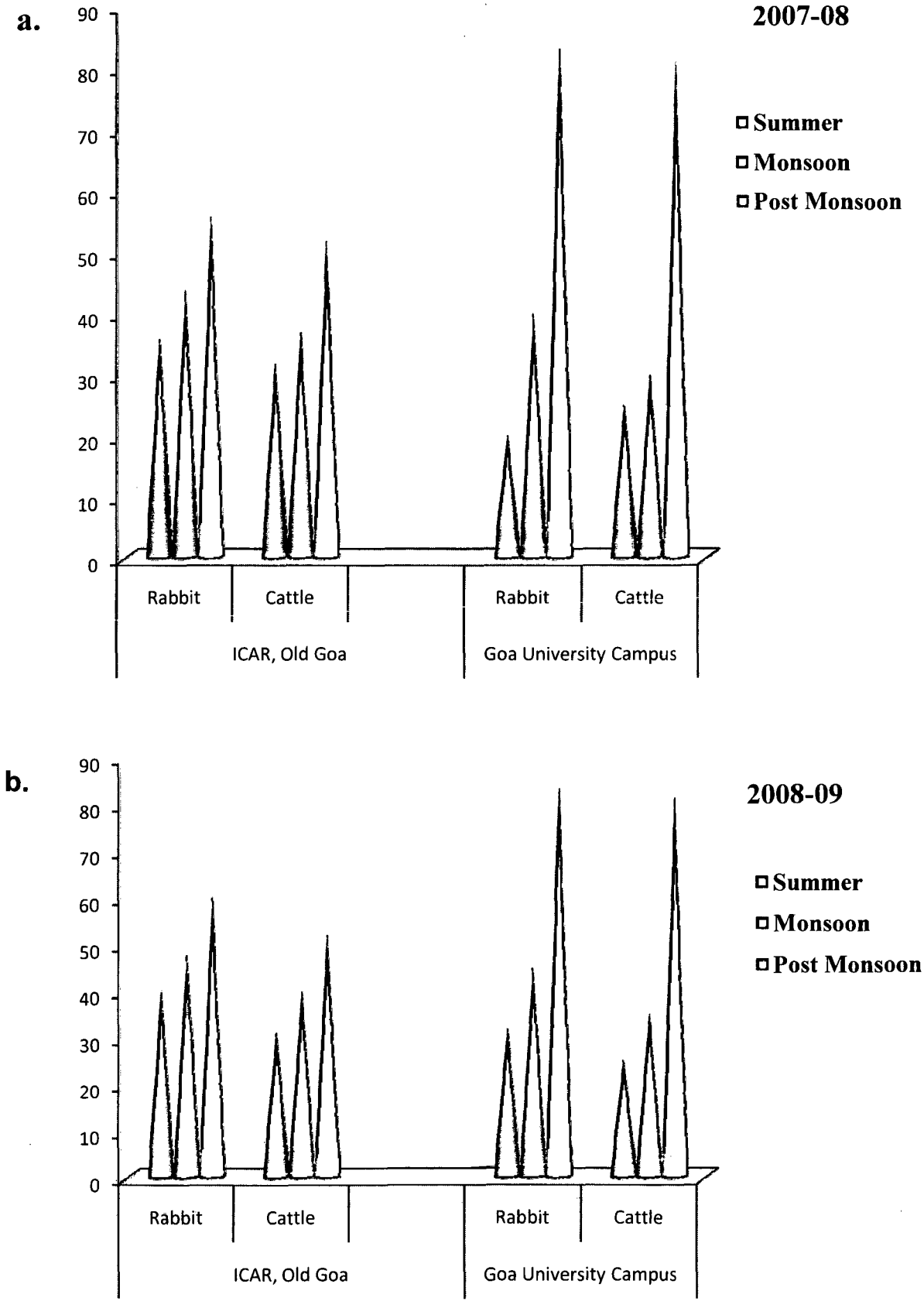

Rhopalomyces elegans
Saccobolus versicolor
Saccobolus sp.
Schizothecium minima
Schizothecium vesticola
Scolecobasidium sp.
Sordaria macrospora
Sordaria minima
Sporormia fimetaris
Sporormia fimicola
Sporormia milabilis
Sporormiella minima
Sporormiella ovina
Sporormiella vexans
Sporothrix sp.
Syncephalis reflexa
Stachybotryis atra
Trichocladium asperum
Trichodelitschia bisporula
Trichoderma aureoviride
Trichoderma viside
Trichothecium roseum
Tritirachium sp.
0
5
10
15
20
25
30
35
40

Fig. 4.2.1a-b Recovery of fungal species based on seasons and locations



In this study, the values of appearance of fungi on cattle and rabbit dung at the two locations, i.e. Goa University campus and ICAR station, Old Goa, were analysed using the online software 'Web Agri Stat Package' (WASP) in order to understand the statistical significance. Comparative study was done on the fungi appeared on cattle dung and rabbit pellets, and hence 'Two sample T test' was used.

Comparison of significance of samples studied within same sites

The seasonal study done for fungi on cattle and rabbit dung showed statistically that they were significantly different. The comparative analysis done in ICAR, between rabbit and cattle dung during the summer season i.e., Feb to May 2007, showed they were significantly different. Similarly, the studies carried out during June to Sept., 2007, (Monsoon Season); Oct. to Jan., 2008, (Post-Monsoon); Sept. to Dec., 2008 (Post-Monsoon) were significantly GU, 2007, Jan. to Apr. (summer); GU, 2007, May to Aug. (Monsoon); GU, 2008, Jan. to Apr. (Summer); GU, 2008, May to Aug. (Monsoon) were found to be significantly different.

Comparison of significance of the two samples when compared between the two study sites

The significance of two samples was compared between the two study areas, viz., Goa University campus and ICAR station and, in the three seasons. Rabbit pellets of ICAR and GU campus during monsoon (June to Sept.), post-monsoon (Sept. to Dec.) and summer (Jan. to Apr.) for the year 2007-08 and 2008-09 were found to be significantly different.

Comparison of Significance of samples within the same study area

ICAR, 2007, Summer Season)

Sample 1 = Rabbit Dung

Number of Observations	3
Average	39.667
Standard Deviation	4.509
Variance	20.333

Sample 2 = Cattle dung

Number of Observations	3
Average	21.333
Standard Deviation	2.309
Variance	5.333

Test results

T - Statistic	:	**6.268**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

ICAR, 2007, Monsoon Season

Sample 1

Number of Observations	3
Average	20.333
Standard Deviation	4.509
Variance	20.333

Sample 2

Number of Observations	3
Average	32.333
Standard Deviation	2.517
Variance	6.333

Test results

T - Statistic	:	**-4.025**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Sample are significantly different at 5% level of significance

ICAR, 2007, Oct. to Jan (Post-Monsoon)

Sample 1

Number of Observations	3
Average	50.333
Standard Deviation	5.508
Variance	30.333

Sample 2

Number of Observations	3
Average	52.333
Standard Deviation	2.517
Variance	6.333

Test results

T - Statistic	:	**-0.572**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different

ICAR, 2008, Summer

Sample 1

Number of Observations	3
Average	43.333
Standard Deviation	4.933
Variance	24.333

Sample 2

Number of Observations	3
Average	26.667
Standard Deviation	2.887
Variance	8.333

Test results

T - Statistic	:	**5.051**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

ICAR, 2008, Monsoon

Sample 1

Number of Observations	3
Average	23.000
Standard Deviation	2.646
Variance	7.000

Sample 2

Number of Observations	3
Average	28.333
Standard Deviation	2.887
Variance	8.333

Test results

T - Statistic	:	**-2.359**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different

ICAR, 2008, Post-Monsoon

Sample 1

Number of Observations	3
Average	61.000
Standard Deviation	7.211
Variance	52.000

Sample 2

Number of Observations	3
Average	45.000
Standard Deviation	5.000
Variance	25.000

Test results

T - Statistic	:	**3.158**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Sample are significantly different at 5% level of significance

GU, 2007, summer

Sample 1

Number of Observations	3
Average	36.667
Standard Deviation	2.887
Variance	8.333

Sample 2

Number of Observations	3
Average	20.333
Standard Deviation	4.509
Variance	20.333

Test results

T - Statistic	:	**5.284**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

GU, 2007, Monsoon

Sample 1

Number of Observations	3
Average	32.667
Standard Deviation	3.055
Variance	9.333

Sample 2

Number of Observations	3
Average	24.333
Standard Deviation	4.041
Variance	16.333

Test results

T - Statistic	:	**2.849**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Sample are significantly different at 5% level of significance

GU, 2007, Post-Monsoon

Sample 1

Number of Observations	3
Average	79.667
Standard Deviation	4.509
Variance	20.333

Sample 2

Number of Observations	3
Average	72.333
Standard Deviation	8.737
Variance	76.333

Test results

T - Statistic	:	**1.292**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different

GU, 2008, Summer

Sample 1

Number of Observations	3
Average	39.667
Standard Deviation	8.083
Variance	65.333

Sample 2

Number of Observations	3
Average	20.333
Standard Deviation	4.509
Variance	20.333

Test results

T - Statistic	:	**3.618**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Sample are significantly different at 5% level of significance

GU, 2008, Monsoon

Sample 1

Number of Observations	3
Average	35.333
Standard Deviation	3.512
Variance	12.333

Sample 2

Number of Observations	3
Average	22.667
Standard Deviation	3.055
Variance	9.333

Test results

T - Statistic	:	**4.713**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

GU, 2008, Post-Monsoon

Sample 1

Number of Observations	3
Average	84.000
Standard Deviation	3.606
Variance	13.000

Sample 2

Number of Observations	3
Average	79.667
Standard Deviation	2.082
Variance	4.333

Test results

T - Statistic	:	**1.803**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different.

Comparison of Significance of the two samples when compared between the two study sites

Rabbit pellets of ICAR and GU Campus (Summer)

Sample 1

Number of Observations	3
Average	39.667
Standard Deviation	4.509
Variance	20.333

Sample 2

Number of Observations	3
Average	36.667
Standard Deviation	2.887
Variance	8.333

Test results

T - Statistic	:	**0.970**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different.

Rabbit pellets of ICAR and GU Campus (Monsoon)

Sample 1

Number of Observations	3
Average	20.333
Standard Deviation	4.509
Variance	20.333

Sample 2

Number of Observations	3
Average	32.667
Standard Deviation	3.055
Variance	9.333

Test results

T - Statistic	:	**-3.922**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at 5% level of significance

Rabbit pellets of ICAR and GU Campus, Post-Monsoon

Sample 1

Number of Observations	3
Average	50.333
Standard Deviation	5.508
Variance	30.333

Sample 2

Number of Observations	3
Average	79.667
Standard Deviation	4.509
Variance	20.333

Test results

T - Statistic	:	**-7.138**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

Cattle dung of ICAR and GU Campus, Summer

Sample 1

Number of Observations	3
Average	21.333
Standard Deviation	2.309
Variance	5.333

Sample 2

Number of Observations	3
Average	20.333
Standard Deviation	4.509
Variance	20.333

Test results

T - Statistic	:	**0.342**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different

Sample 1

Number of Observations	3
Average	32.333
Standard Deviation	2.517
Variance	6.333

Sample 2

Number of Observations	3
Average	24.333
Standard Deviation	4.041
Variance	16.333

Test results

T - Statistic	:	**2.910**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Sample are significantly different at 5% level of significance

Sample 1

Number of Observations	3
Average	45.333
Standard Deviation	4.163
Variance	17.333

Sample 2

Number of Observations	3
Average	72.333
Standard Deviation	8.737
Variance	76.333

Test results

T - Statistic	:	**-4.832**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

2008-09

Rabbit pellets of ICAR and GU Campus, Summer

Sample 1

Number of Observations	3
Average	43.333
Standard Deviation	4.933
Variance	24.333

Sample 2

Number of Observations	3
Average	31.667
Standard Deviation	4.726
Variance	22.333

Test results

T - Statistic	:	**2.958**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Sample are significantly different at 5% level of significance

Rabbit pellets of ICAR and GU Campus, Monsoon

Sample 1

Number of Observations	3
Average	23.000
Standard Deviation	2.646
Variance	7.000

Sample 2

Number of Observations	3
Average	35.333
Standard Deviation	3.512
Variance	12.333

Test results

T - Statistic	:	**-4.858**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

Rabbit pellets of ICAR and GU Campus, Post-Monsoon

Sample 1

Number of Observations	3
Average	61.000
Standard Deviation	7.211
Variance	52.000

Sample 2

Number of Observations	3
Average	84.000
Standard Deviation	3.606
Variance	13.000

Test results

T - Statistic	:	**-4.941**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance.

Cattle dung of ICAR and GU Campus, Summer

Sample 1

Number of Observations	3
Average	30.000
Standard Deviation	5.000
Variance	25.000

Sample 2

Number of Observations	3
Average	23.000
Standard Deviation	2.646
Variance	7.000

Test results

T - Statistic	:	**2.143**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different.

Cattle dung of ICAR and GU Campus, Monsoon

Sample 1

Number of Observations	3
Average	28.333
Standard Deviation	2.887
Variance	8.333

Sample 2

Number of Observations	3
Average	22.667
Standard Deviation	3.055
Variance	9.333

Test results

T - Statistic	:	**2.335**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are not Significantly different

Cattle dung of ICAR and GU Campus, Post-Monsoon

Sample 1

Number of Observations	3
Average	45.000
Standard Deviation	5.000
Variance	25.000

Sample 2

Number of Observations	3
Average	79.667
Standard Deviation	2.082
Variance	4.333

Test results

T - Statistic	:	**-11.086**
T - Table (0.05)	:	**2.776**
T - Table (0.01)	:	**4.604**

Samples are significantly different at both 5% and 1% level of significance

Part III: Screening coprophilous fungi for amylase activity and PUFA productivity

Although, Zygomycetes form a small group in the Kingdom Mycota, herbivore dung harbours a decent number of them (Dix and Webster, 1995). It is known that majority of these fungi exhibit amylase activity and some of them even show the ability to produce Polyunsaturated Fatty Acids (Bajpai et al, 2002). An attempt was made to carry out screening of isolated zygomycetous fungi for amylase activity and PUFA productivity.

In this study, qualitative analysis of the fungi for amylase activity was done following the method of Hankin and Anagnostakis (1975) and screening for PUFA was done following O'Fallon (2007). The methods followed are elaborated in Chapter III. The results obtained form this part of the Chapter IV.

The details, i.e. name and source, of the zygomycetous fungi tested for amylase activity and PUFA productivity are given below in Table 4.3.1

Table 4.3.1 List of fungi screened for amylase activity and PUFA productivity

S. No.	Name	Dung/Pellet substrate
1.	*Absidia corymbifera*	Rabbit
2.	*A. coerulea*	Cattle, Rabbit
3.	*Actinomucor elegans*	Rabbit
4.	*Circinella muscae*	Rabbit
5.	*C. umbellata*	Rabbit
6.	*Coemansia erecta*	Deer
7.	*Helicostylum piriforme*	Rabbit
8.	*Piptocephalis repens*	Rabbit
9.	*Rhizopus stolonifer*	Cattle, Rabbit
10.	*Rhizopus* sp.	Rabbit

Fig.4.3.1 Plates showing the positive amylase activity

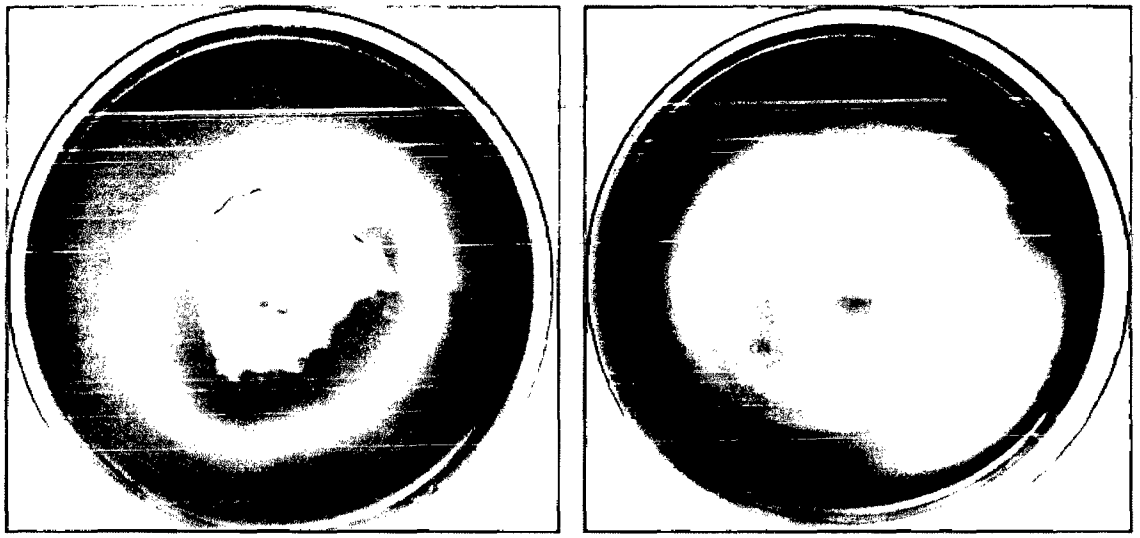
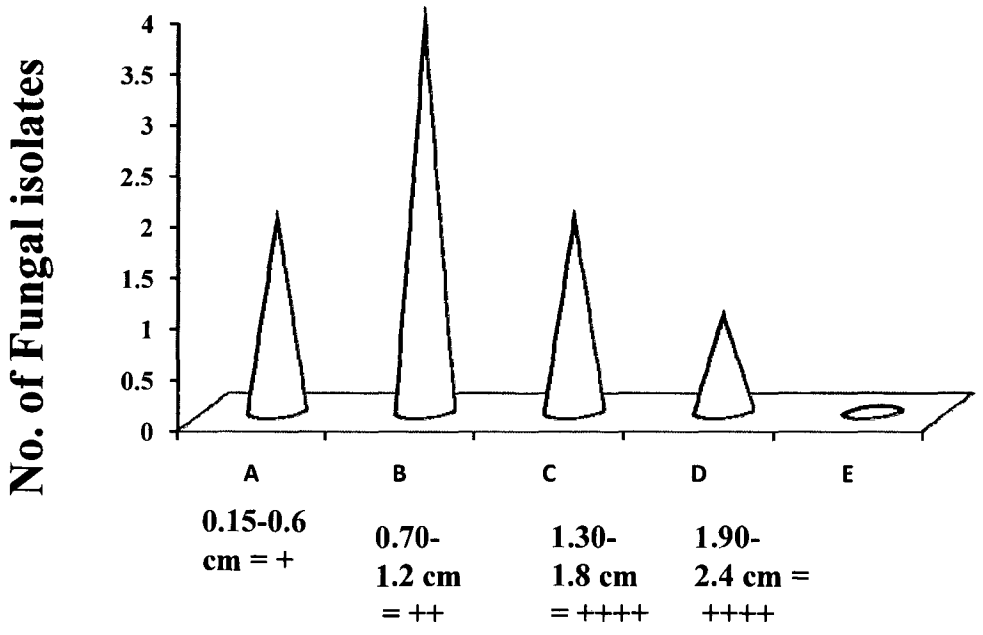


Fig. 4.3.1a Fungal isolates showing radius of clearance zone for Amylase activity



Screening of zygomycetous (Mucorales) fungi for amylase profile

Some of the zygomycetous isolates brought into pure culture were subjected to screening of amylase activity.

Results showed that out of the 10 zygomycetous fungi investigated, 8 showed positive activity. The amylase activity in culture plates was visible as a 'clearance zone', as in Fig 4.3.1 and Table 4.3.2 The extent of clearance zone size from the edge of fungal colony represented the activity, in the following way:

Clearance zone	Activity represented	Description
0.05-0.50 cm	+	Nil or very less activity
0.50-1.25 cm	++	Moderate activity
1.25-2.00 cm	+++	Good activity
2.00-2.50 cm	++++	Very good activity

Table 4.3.1. Amylase activity exhibited by the zygomycetous fungi

S. No.	Fungal Name	Amylase Activity
1.	*Absidia corymbifera*	+
2.	*A. coerulea*	++
3.	*Actinomucor elegans*	+++
4.	*Circinella muscae*	+
5.	*C. umbellata*	++
6.	*Coemansia erecta*	-
7.	*Helicostylum piriforme*	++
8.	*Piptocephalis repens*	-
9.	*Rhizopus stolonifer*	+++
10.	*Rhizopus* sp.	++

The radius of clearance zone is represented in a pictorial form in Fig. 4.3.2. While *Coemansia erecta* and *Piptocephalis repens* showed no activity, rest of the studied fungi showed moderate to very good amylase activity. *Absidia corymbifera* and *Circinella muscae* exhibited very less activity, *Absidia coerulea, C. umbellata, Helicostylum piriforme* and *Rhizopus* sp. showed moderate activity and *Actinomucor elegans* and *Rhizopus stolonifer* exuded very good activity.

The results also indicate that the sampled dung had sufficient easily available sugar which has been utilized by these fungi.

Screening of cultures for the production of PUFAs

The same set of zygomycetous fungal cultures, analysed for amylase activity, were screened for the presence of PUFA (Table 4.3.1) The methods followed were as described by O'Fallon (2007).

From the ten zygomycetous fungi screened, 13 fatty acids were detected. Amongst these, five turned out to be the group belonging to polyunsaturated fatty acids. The identification was carried out with the help of GC-MS profiles obtained. The various PUFAs detected were Eicosapentanoic acid (EPA), Eranthic Acid, Linolenic Acid (LA), γ- Calendic Acid and γ-Linolenic Acid (GLA). At some instances, a single fungus produced more than one PUFA, whereas not even a single PUFA could be detected from certain fungi. Along with these PUFAs, certain interesting fatty acids viz., 2,4- Decadiyonic Acid, Arachidic Acid, Heptanoic Acid, Margaric Acid (Heptadecanoic Acid), Methyl Octadecanoic Acid, Nondecanoic (Nonadecyclic), Palmitic acid, Sterculic Acid, were also obtained.

Eicosapentanoic acid, Eranthic Acid, Linolenic acid and γ-Linolenic Acid (GLA) were detected in *Circinella umbellata*. Other than *Circinella umbellata,* Linolenic Acid (LA) was also detected in *Helicostylum piriforme, Rhizopus stolonifer* and *Rhizopus* sp.; whereas, γ- Calendic Acid was detected exclusively in *Actinomucor elegans*. The GC-MS graphs, representing the fatty acids detected are given in Fig. 4.3.3 to 4.3.23.

The list of the fatty acids, including both polyunsaturated fatty acids and other fatty acids are presented in Table 4.3.2.

Table 4.3.3. List of Fatty Acids detected, based on the GC-MS profiles:

S.No.	Fungal names	Fatty Acids	Fatty Acids (FAs)/ Polyunsaturated Fatty Acids (PUFAs)
1.	*Circinella muscae, Actinomucor elegans*	2,4- Decadiyonic Acid	FA
2.	*Rhizopus* sp.	Arachidic Acid	FA
3.	*Circinella umbellata*	Eicosapentanoic acid (EPA)	**PUFA**
4.	*Circinella umbellata*	Eranthic Acid	**PUFA**
5.	*Absidia corymbifera*	Heptanoic Acid	FA
6.	*Circinella umbellata, Helicostylum piriforme, Rhizopus stolonifer, Rhizopus* sp.	Linolenic Acid (LA)	**PUFA**
7.	*Absidia coerulea, Helicostylum piriforme, Circinella muscae, Rhizopus* sp.	Margaric Acid (Heptadecanoic Acid)	FA
8.	*Helicostylum piriforme*	Methyl Octadecanoic Acid	FA
9.	*Helicostylum piriforme, Coemansia erecta,*	Nondecanoic (Nonadecyclic)	FA
10.	*Helicostylum piriforme, Piptocephalis repens, Circinella muscae, Rhizopus stolonifer, Rhizopus* sp.	Palmitic acid	FA
11.	*Rhizopus stolonifer, Rhizopus* sp.	Sterculic Acid	FA
12.	*Actinomucor elegans*	γ- Calendic Acid	**PUFA**
13.	*Circinella umbellata*	γ-Linolenic Acid (GLA)	**PUFA**

There are many PUFAs, which have been recognised to be important from the pharma- and neutral- point of view (Bajpai et al., 2002). The utility of PUFAs, recorded during the study, is provided in the Table 4.3.3. Of the recorded PUFAs, two are turned out to be omega-3-fatty acids and rest of five belonged to the omega-6-fatty acids.

Table No. 4.3.3. Importance of the detected PUFAs

S. No.	PUFA	Types of Fatty Acids	Significance (Higashiyama et al., 2002)
1	Eicosapentanoic acid 20:5 (n-3).	ω-3	Brain development in children, prevention of night blindness, neurological disorders, anti-cancerous
2	Eranthic Acid 22: 2 (n-6)	ω-6	Anti- cancerous, anti-inflammation
3	Linoleic Acid 18:2 (n-6)	ω-6	Lower risk of cardiovascular diseases, faster wound healing, anti-inflammatory
4	γ- Calendic Acid 18:3 (n-6)	ω-6	anti-cancer activity, anti inflammation, wound healing and is antiseptic
5	γ-Linolenic Acid 18:3 (n–3)	ω-3	Lower risk of cardiovascular diseases

Based on the GC-MS profile obtained, % relative abundance was derived. The percentage of relative abundance of the detected Polyunsaturated Fatty Acids is presented in the Table 4.3.4. The relative abundance of all the obtained fatty acids is in Table 4.3.5.

Table 4.3.4. Relative abundance of the Polyunsaturated Fatty Acids

S.No.	PUFAs	% Relative abundance
1.	Eicosapentanoic Acid (EPA)	72
2.	Eranthic Acid	17
3.	Linolenic Acid	2 1 5 2
4.	γ-Linolenic Acid	1.7
5.	γ- Calendic Acid	0.1

The GC-MS graphs, representing the various fatty acids detected (Fig.4.3.3to4.3.23)

Absidia corymbifera

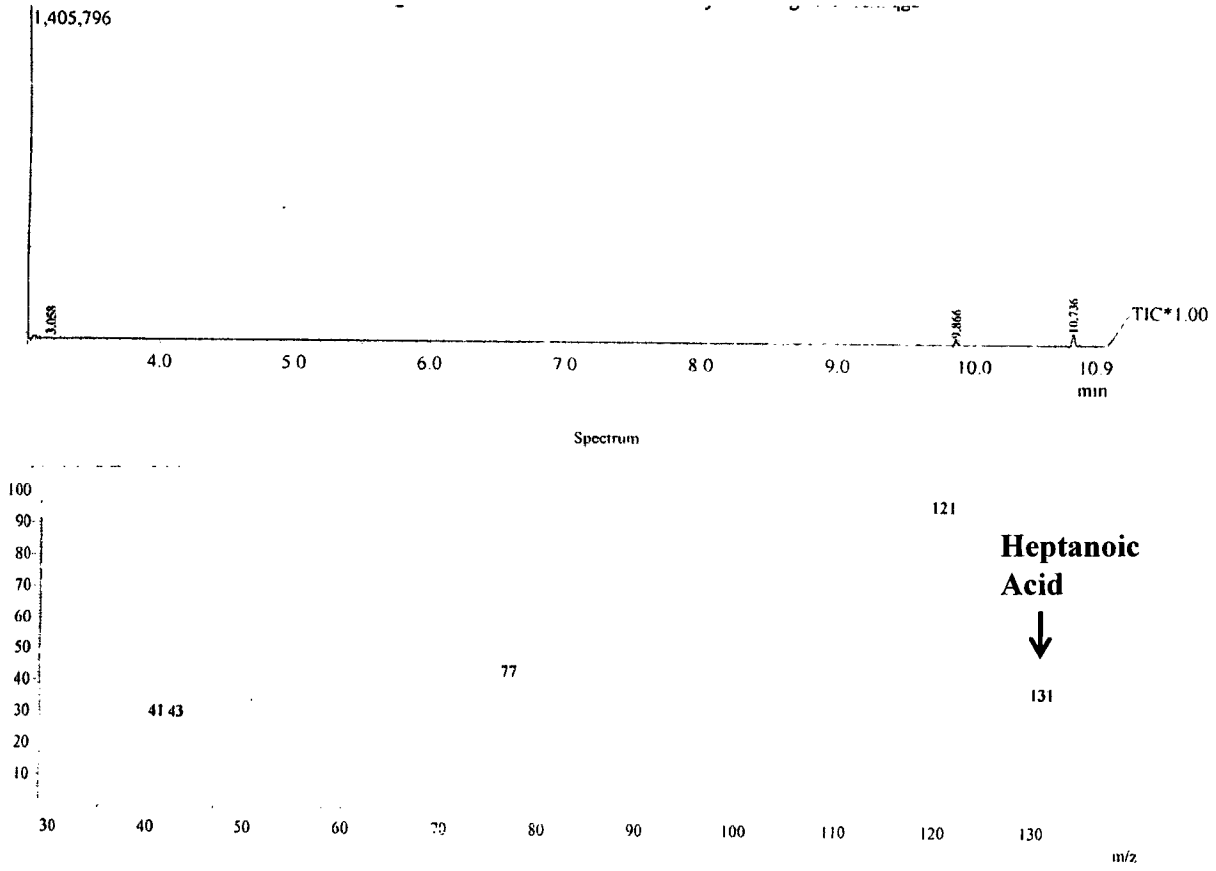
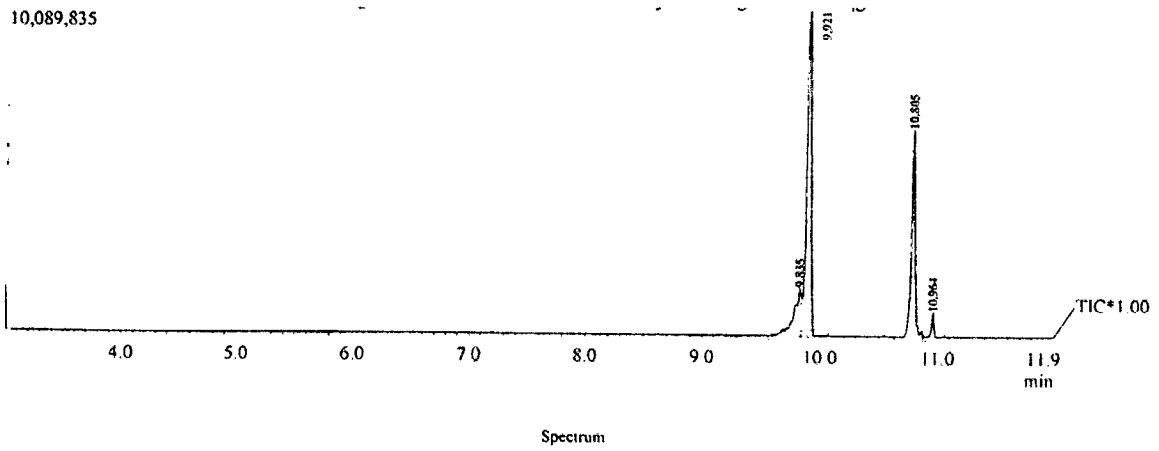


Fig. 4.3.3 GC-MS graph showing the presence of Heptonoic acid in *Absidia corymbifera*

***Circinella umbellata* (Fig. 4.3.4)**



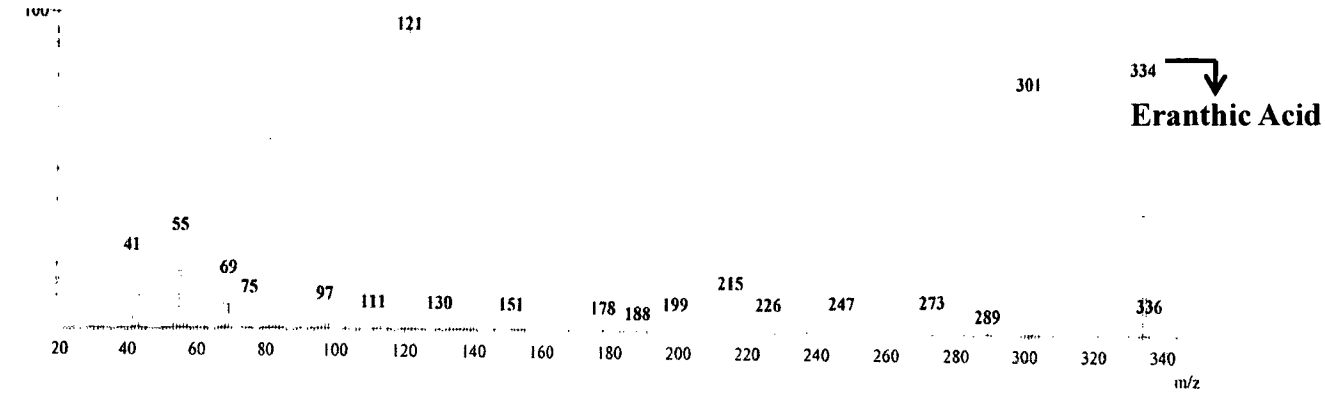


Fig. 4.3.4 GC-MS graph showing the presence of Eranthic acid in ***Circinella umbellata***

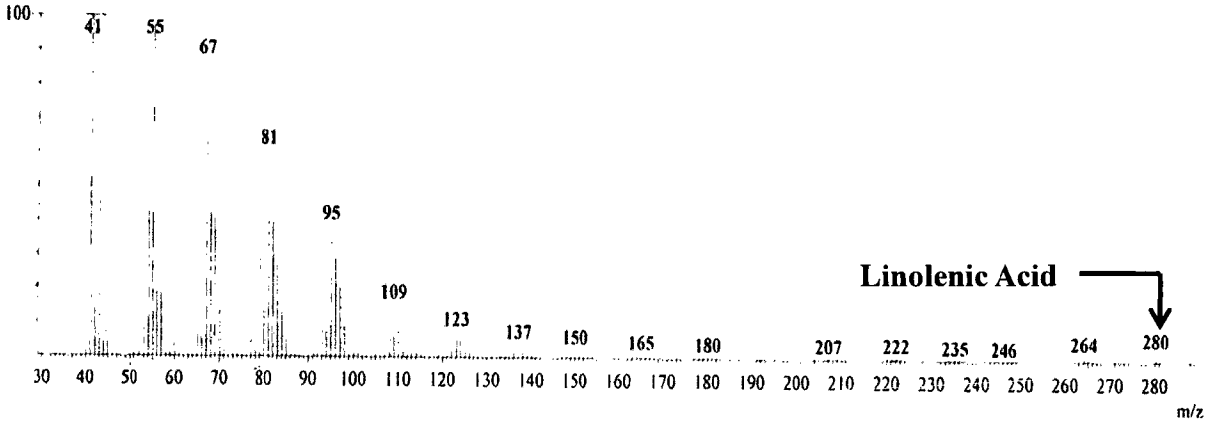


Fig. 4.3.5 GC-MS graph showing the presence of Linolenic acid in ***Circinella umbellata***

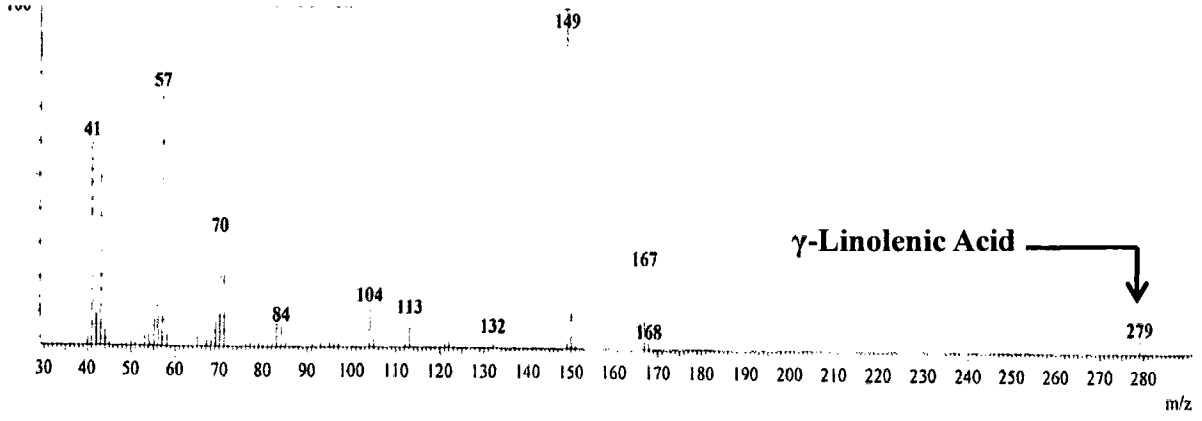


Fig. 4.3.6. GC-MS graph showing the presence of γ-Linolenic Acid in ***Circinella umbellata***

Helicostylum piriforme

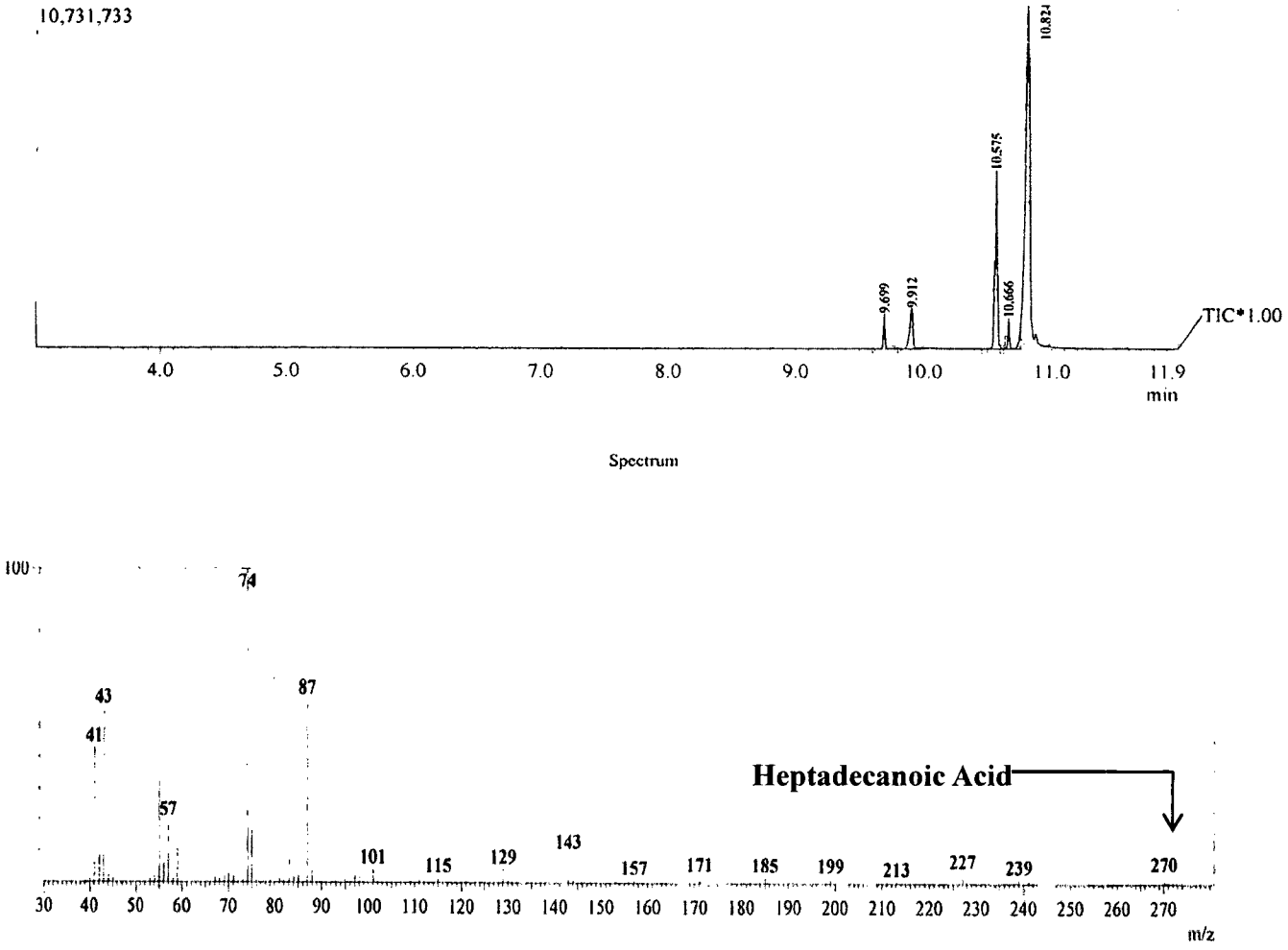


Fig. 4.3.7. GC-MS graph showing the presence of Heptadecanoic acid in *Helicostylum piriforme*

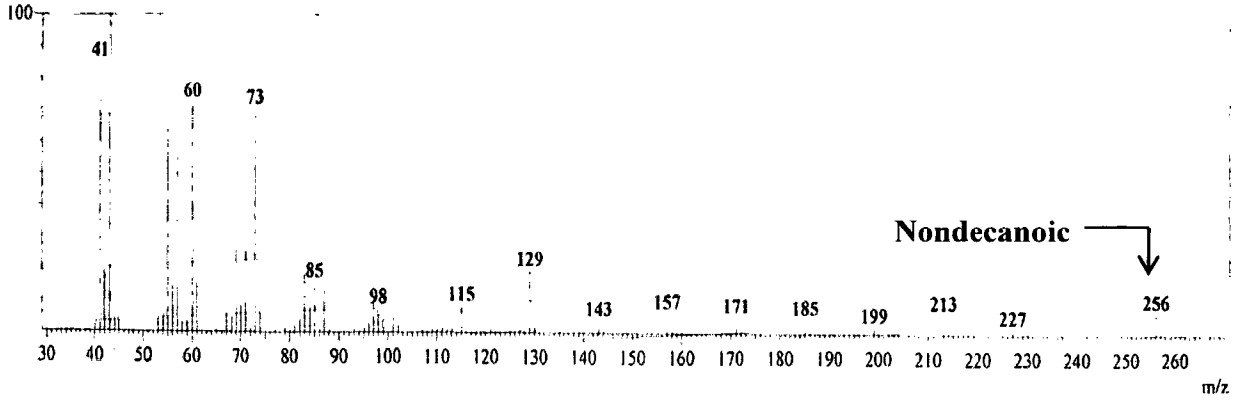


Fig. 4.3.8. GC-MS graph showing the presence of Nondecanoic in *Helicostylum piriforme*

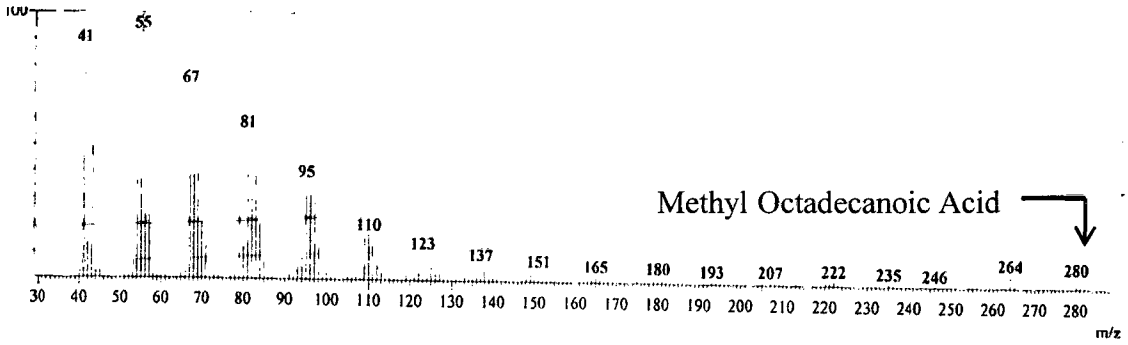


Fig. 4.3.9 GC-MS graph showing the presence of Methyl Octadecanoic Acid in *Helicostylum piriforme*

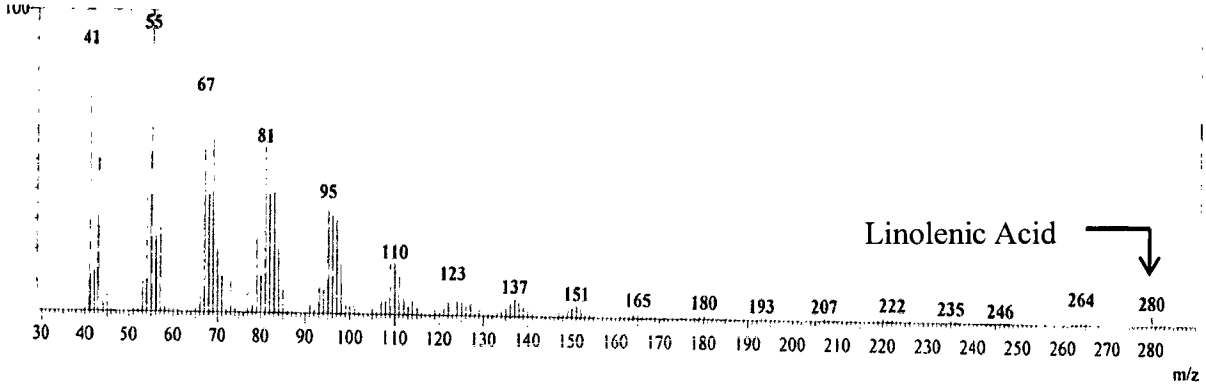
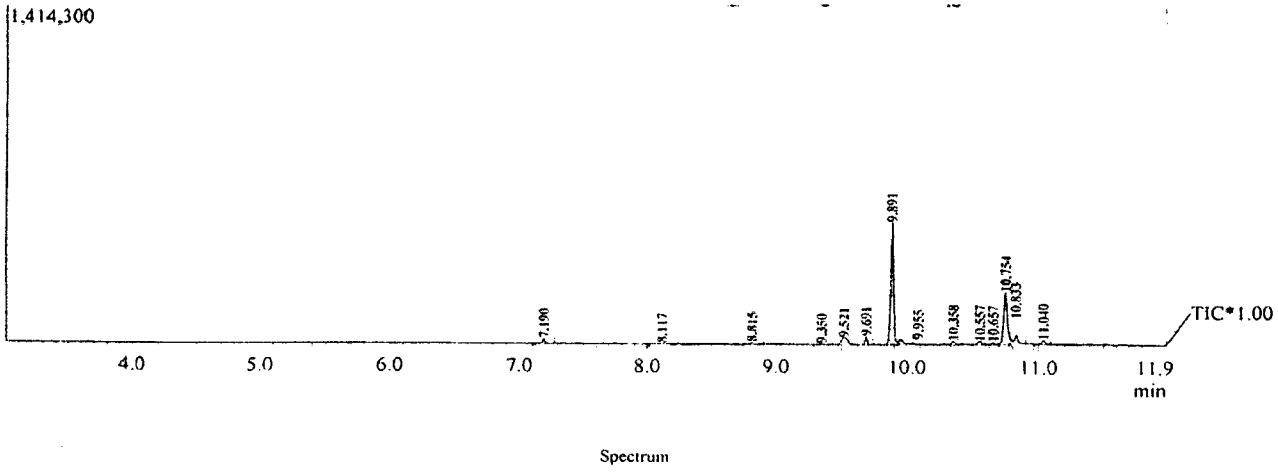


Fig. 4.3.10. GC-MS graph showing the presence of Linolenic Acid in *Helicostylum piriforme*



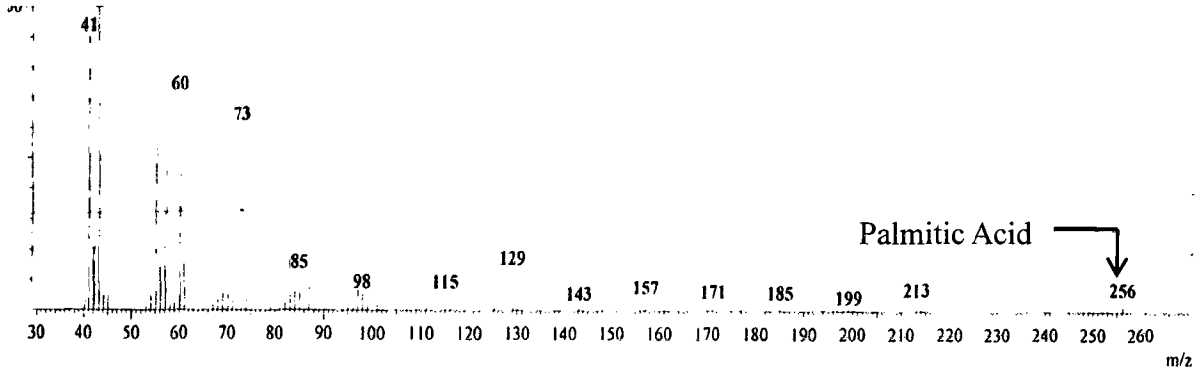
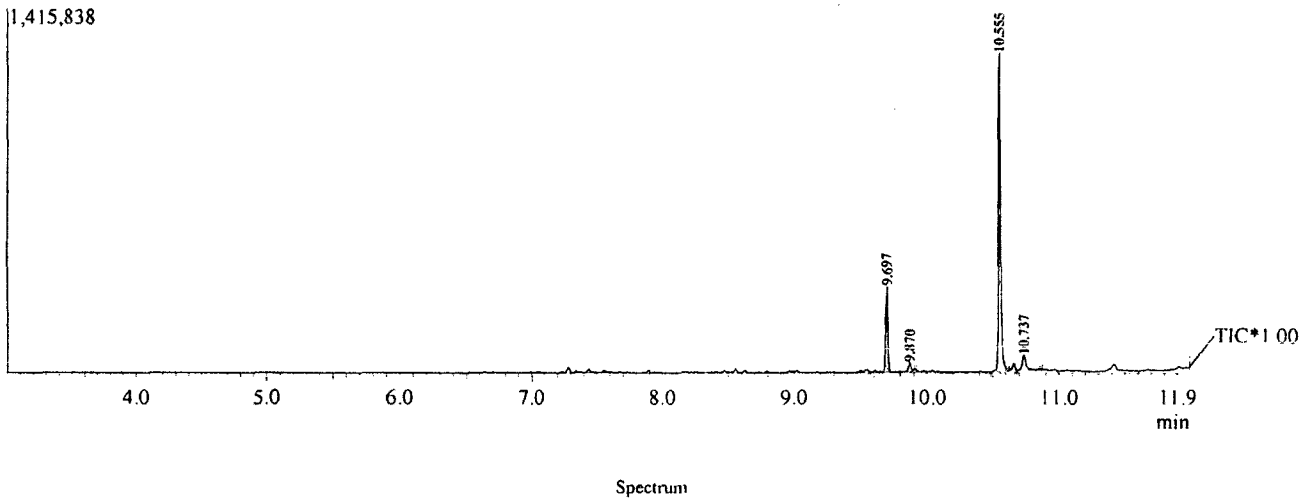


Fig. 4.3.11 GC-MS graph showing the presence of Palmitic Acid in *Piptocephalis repens*



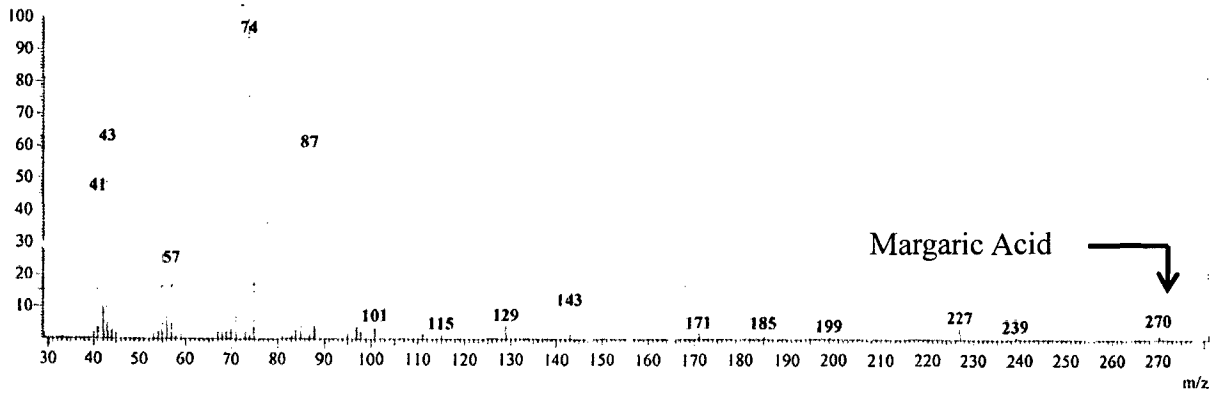


Fig. 4.3.12. GC-MS graph showing the presence of Margaric Acid in *Circinella muscae*

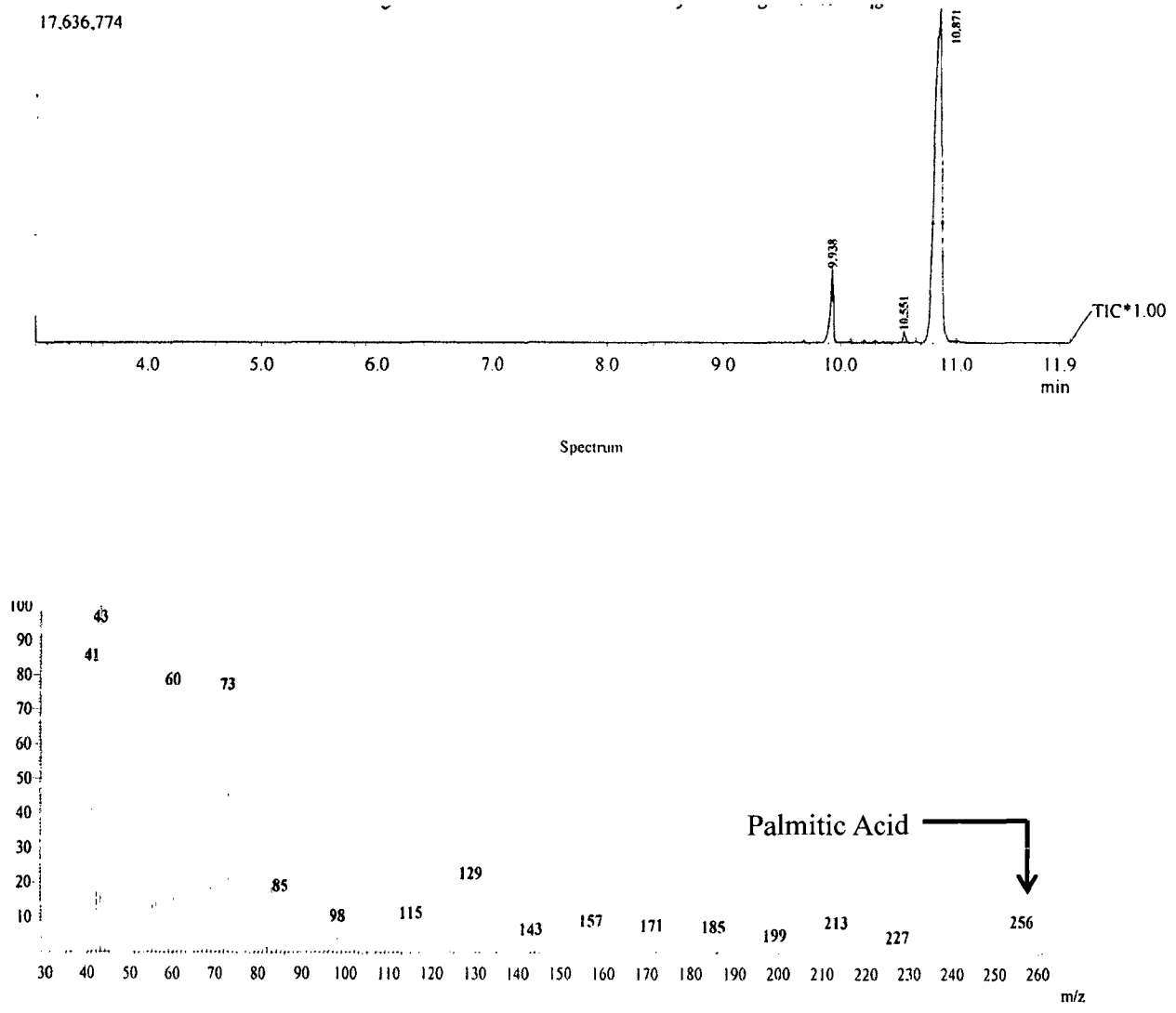


Fig. 4.3.13. GC-MS graph showing the presence of Palmitic Acid in *Actinomucor elegans*

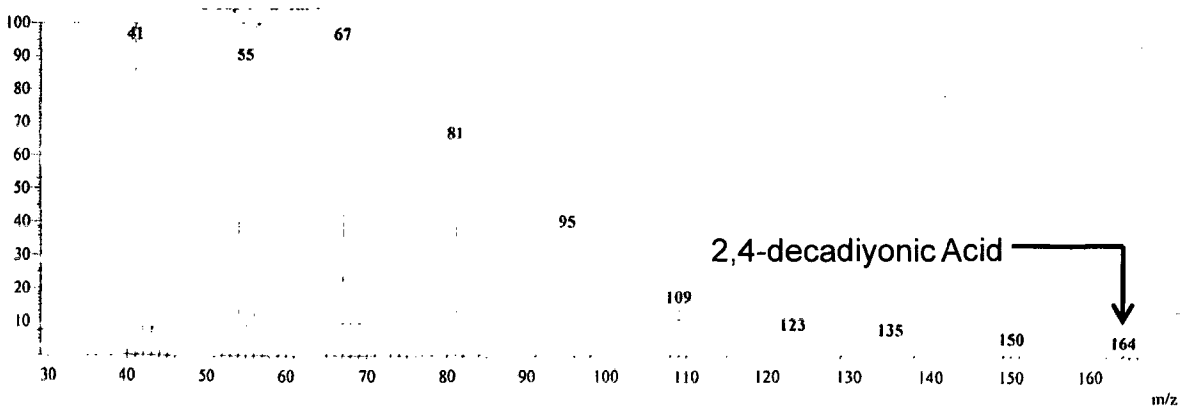


Fig. 4.3.14. GC-MS graph showing the presence of 2,4-decadiyonic Acid in *Actinomucor elegans*

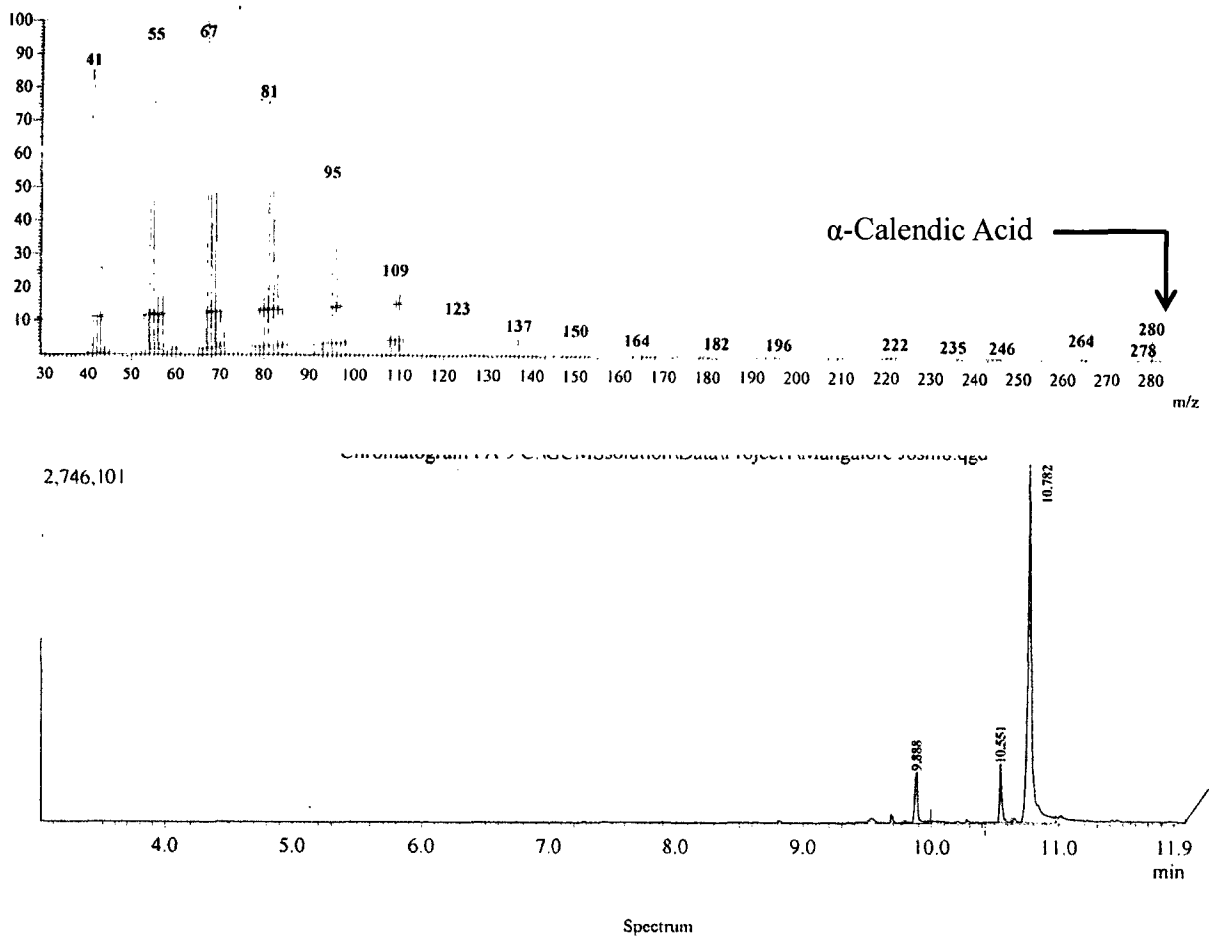


Fig. 4.3.15. GC-MS graph showing the presence of α-Calendic Acid in *Actinomucor elegans*

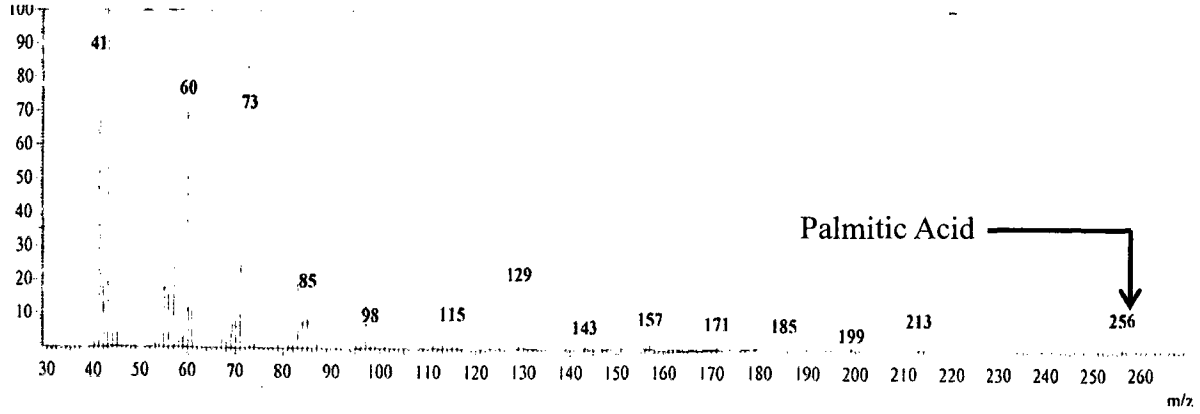


Fig. 4.3.16 GC-MS graph showing the presence of Palmitic Acid in *Rhizopus stolonifer*

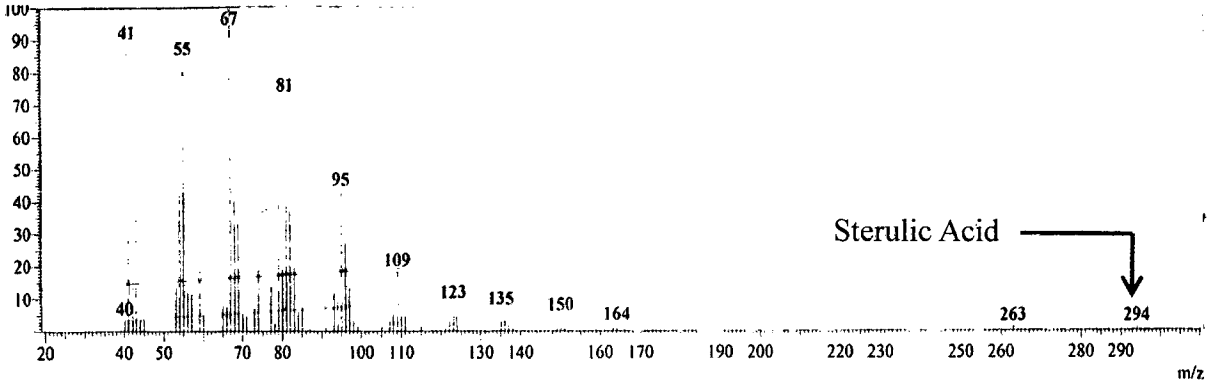


Fig. 4.3.17. GC-MS graph showing the presence of Sterulic Acid in *Rhizopus stolonifer*

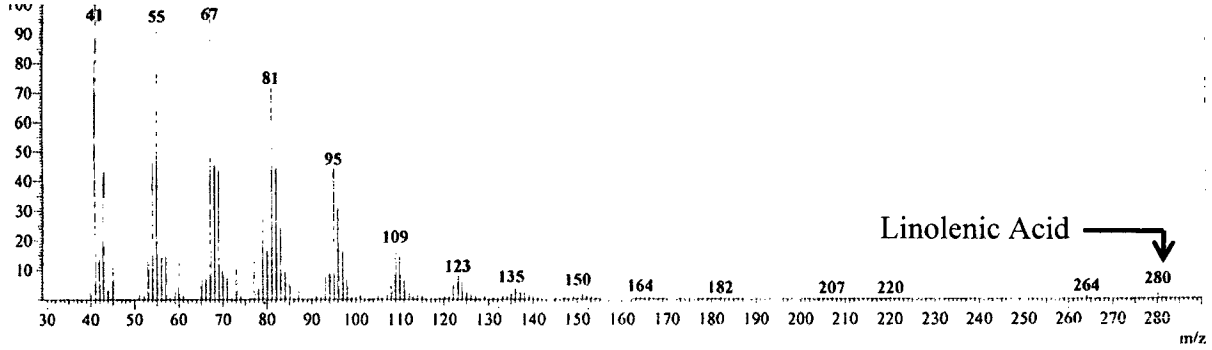
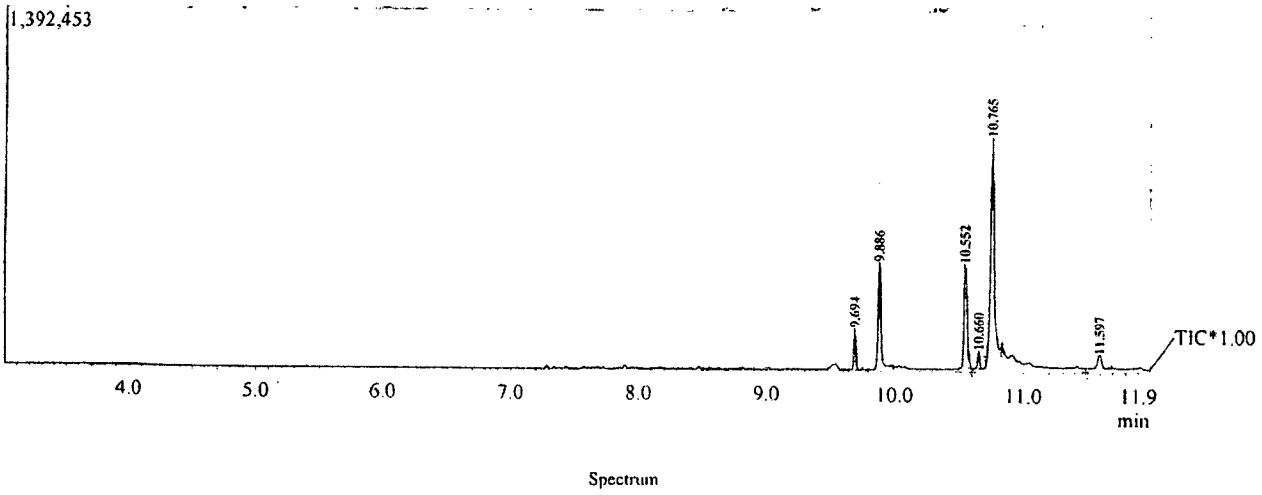


Fig. 4.3.18. GC-MS graph showing the presence of Linolenic Acid in *Rhizopus stolonifer*



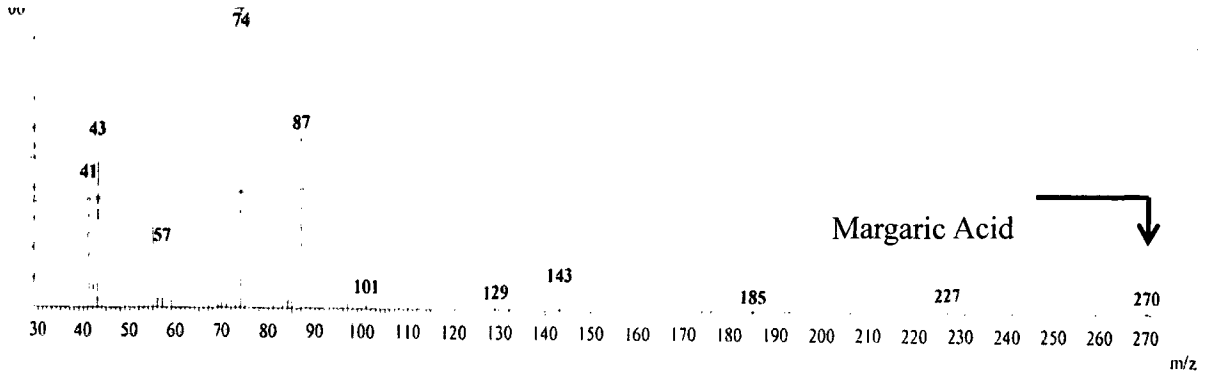


Fig. 4.3.19 GC-MS graph showing the presence of Margaric Acid in *Rhizopus stolonifer*

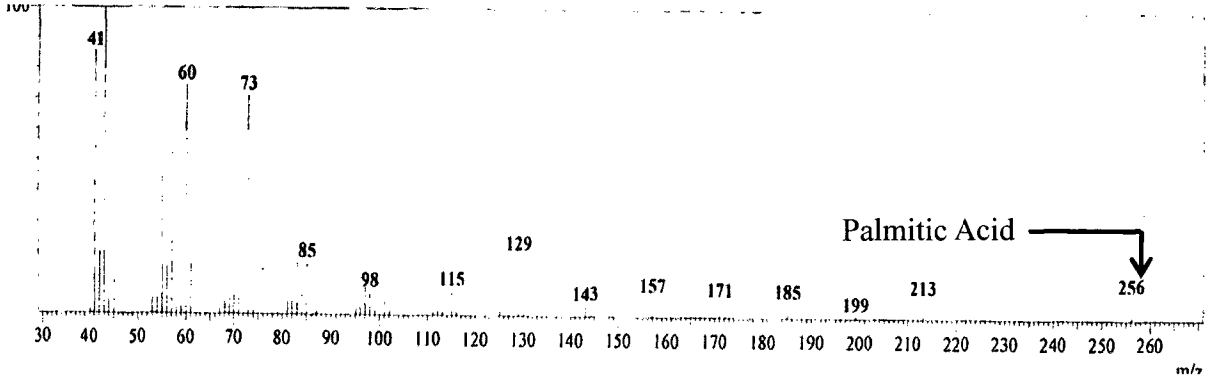


Fig. 4.3.20 GC-MS graph showing the presence of Palmitic Acid in *Rhizopus* sp.

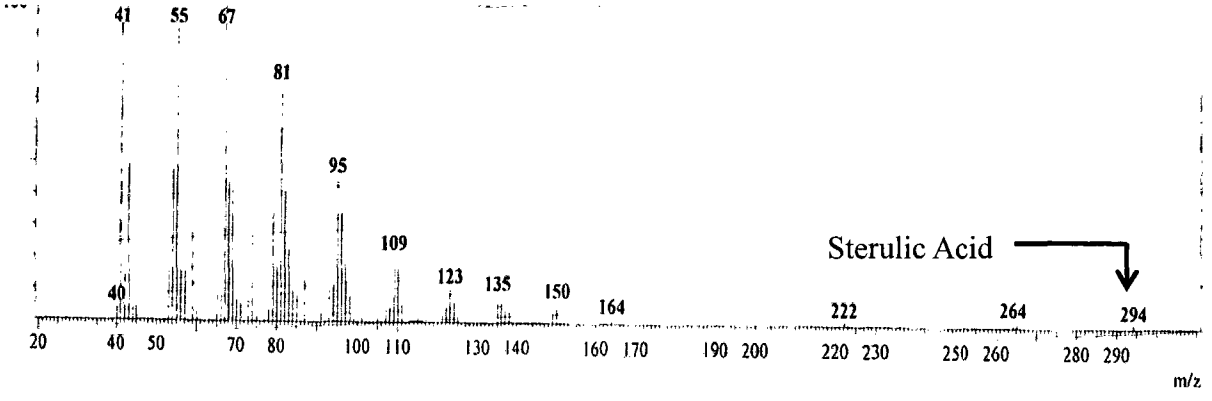


Fig. **Fig. 4.3.21** GC-MS graph showing the presence of Sterulic Acid in *Rhizopus* sp.

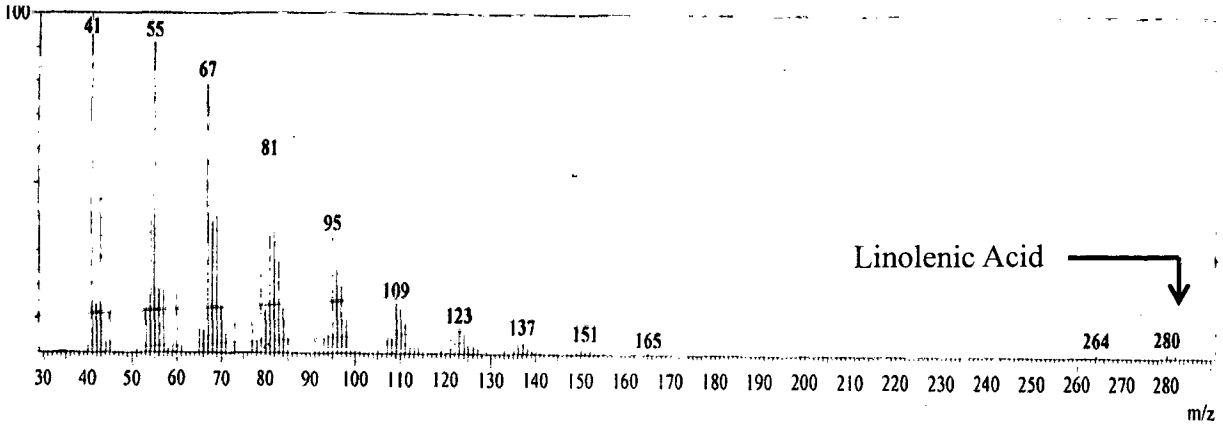


Fig. 4.3.22. GC-MS graph showing the presence of Linolenic Acid in *Rhizopus* sp.

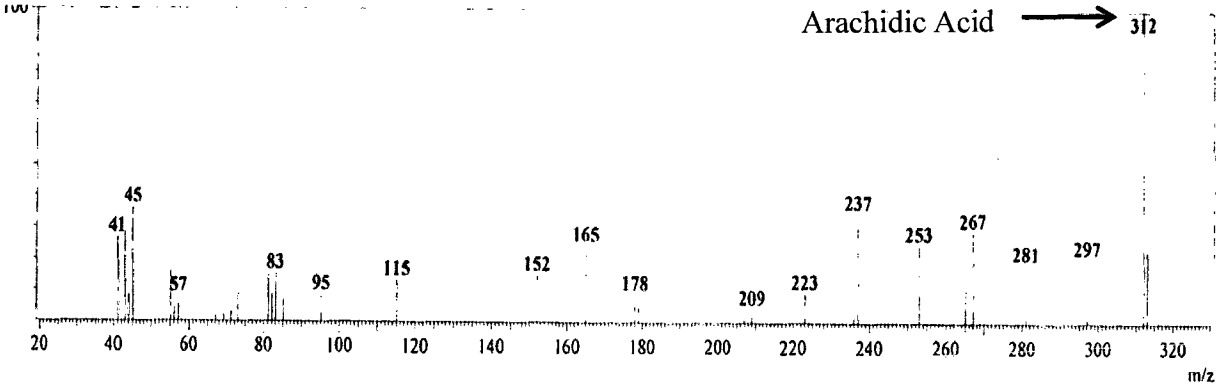


Fig. 4.3.23. GC-MS graph showing the presence of Arachidic Acid in *Rhizopus* sp.

The highest percentage of relative abundance of PUFA was observed in *Circinella umbelleta*, with 72% relative abundance for EPA, whereas the minimum was seen in *Actinomucor elegans* in the production of γ- calendic acid at 0.1%. With the relative abundance of Eranthic Acid at 17%, it can be considered as intermediate of the studied fungi. The most commonly detected PUFA was γ-linolenic acid. It was detected in four different fungi. However, the percentage of relative abundance remained very low.

Relative Abundance percentage of Fatty Acids obtained

	Hep tano ic Acid	Eicosap ent-anoic acid (EPA)	Erant hic Acid	Linole nic Acid (LA)	γ-Linole nic Acid (GLA)	Margaric Acid (Heptadeca noic Acid)	Palmi tic Acid	Nondeca-noic (Nonadecy clic)	Methyl Octade ca-noic Acid	2,4-Decadi yo-nic Acid	γ-Calen dic Acid	Sterc ulic Acid	Arach idic Acid
FA1	30	--	--	--	--	--	--	--	--	--	--	--	--
FA2	--	--	--	--	--	0.5	--	--	--	--	--	--	--
FA3	--	72	17	2	1.7	--	--	--	--	--	--	--	--
FA4	--	--	--	1	-	1	2	0.2	0.9	--	--	--	--
FA5	--	--	--	--	--	--	--	0.6	--	--	--	--	--
FA6	--	--	--	--	--	--	1	--	--	--	--	--	--
FA7	--	--	--	--	--	0.4	--	--	--	0.3	--	--	--
FA8	--	--	--	--	--	--	0.8	--	--	0.1	0.1	--	--
FA9	--	--	--	5	--	--	9	--	--	--	--	2	--
FA 10	--	--	--	2	--	0.1	8	--	--	--	--	0.1	100

CHAPTER V

DISCUSSION

DISCUSSION

The results presented in this thesis, based on an investigation carried out over a time-period from Jan. 2007 to Dec. 2010, on floristic diversity, ecology and activity of coprophilous fungi from Goa and the neighbouring regions of Karnataka and Maharashtra, are discussed in this Chapter.

In Part I of this study, fungal diversity appearing on herbivore dung samples was investigated. Both fresh and old dung samples of 13 herbivore animals were collected and processed for recovery of the coprophilous fungi. The methods used for isolation of fungi included the moist-chamber incubation, particle plating and single-spore isolation techniques. This multi-pronged effort resulted in the recovery of numerous isolates which were assignable to 212 taxa of identifiable fungi. These included, 22 species belonging to Glomeromycota (Zygomycetes), 55 species of Ascomycota, 128 species of anamorphic Ascomycota [Hyphomycetes (121) and Coelomycetes (6)] and 1 species of Basidiomycota. Besides, two isolates belonging to Myxomycetes were recovered.

The diagnosed 212 taxa belonged to 102 genera of fungi. These were assignable Zygomycetes (12), Ascomycetes (20), Hyphomycetes (64), Coelomycetes (5) and Basidiomycetes (1). Amongst the Zygomycetes recovered from the dung samples, the most common genus encountered was *Helicostylum* with 4 species, viz. *Helicostylum piriforme*, *Helicostylum* sp. 1, *Helicostylum* sp. 2 and *Helicostylum* sp. 3. Species belonging to *Ascobolus* (5), *Ascodesmis* (6), *Delitschia* (6) and *Saccobolus* (5) were the most common genera met with amongst the Ascomycetes. Of the Hyphomycetes, *Aspergillus* (11), *Curvularia* (6) *Doratomyces* (4) and *Phialophora* (7) were the most common genera recovered.

For a number of genera, only one species was recovered during the entire duration of the study period and these included *Coemansia* erecta, *Mucor hiemalis*, *Mycotypha microspora*, *Pilobolus crystallinus*, *Rhopalomyces elegans*, *Syncephalis reflexa* in Zygomycetes, *Byssochlamys nivea*, *Cheilymenia* sp., *Emericella nidulans*, Peziza sp., *Trichodelitschia bisporula*, *Zygopleurage zygospora* in Ascomycetes, *Agarwalomyces* sp., *Amblyosporium* sp., *Angulimaya* sp. nov., *Antromyces* sp. nov., *Arthrobotrys superba*, *Arthrographis kalrae*, *Bahupaathra samala*, Beltraniella sp., *Botryotrichum piluliferum*, *Catenularia* state of *Chaetosphaeria myriocarpa*, Chrysosporium sp., *Ciliciopodium sanguineum*, *Custingophora olivacea*, *Cylindrocarpon didymium*, *Didymostilbe* sp., *Dimastigosporium* yanese. Sp. nov., *Doratomyces purpureofuscus*, *Drechslera hawaiiensis*, *Geomyces* sp. nov., *Geniculosporium* sp., *Gilmaniella humicola*, *Gliocephalis* sp., *Goidenichiella* sp., *Graphilbum* sp., *Harposporium anguillulae*, *Haplographium* sp., *Lomachashaka gomaya* sp. nov., *Memnoniella echinata*, *Oedocephalum elegans*, *Ovularia* sp., *Papulaspora immersa*, *Periconia byssoides*, *Rhinotrichum* sp., *Sarocladium* sp., *Scolecobasidium constrictum*, *Sesquicillium* sp., *Stachybotrys chartarum*, *Trichocladium* sp., *Tritirachium* sp. nov., *Verticillium lecanii*, *Wiesneriomyces javanicus*, *Zygosporium masonii*, coelomycetes included *Colletotrichum* sp., *Pestalotiopsis* sp., *Pullospora tetrachaeta*, *Pycnidiella* sp., *Sarcophoma* sp. and *Coprinus* sp. in Basidiomycetes.

During this study, eleven species of coprophilous fungi (Ascomycetes – 4; Hyphomycetes – 7) were found to be new to science and described accordingly in Chapter IV. These included Ascomycetes - *Ascobolus* sp. nov., *Dennisiopsis* sp. nov., *Saccobolus* sp. nov., *Schizothecium* sp. nov. and Hyphomycetes - *Angulimaya* tax. sp. nov., *Antromyces* tax. sp. nov., *Ovularia* tax. sp. nov., *Curvularia* tax. sp. nov., *Tritirachium* tax. sp. nov., *Chlamydomyces* tax. sp. nov., *Geomyces* tax. sp. nov. In

view of its unique morphological features *Shanomyces indica* is introduced as a new genus in this thesis.

Perusal of literature indicates that no detailed taxonomic investigation has so far done on coprophious fungi of west-coast region of India. This is the first ever detailed study of fungi found growing on herbivore dung from this region. Western Ghats belt is one of the mega-biodiversity zones of the world and therefore understanding the composition of mycoflora of the region has become considerable interest (Bhat, 2010.) In the light of this, though modest, 35 species of coprophilous fungi recorded for the first time from this part of southern India through this study is of great floristic value and an invaluable contribution.

As can be seen, by moist chamber incubation and single-spore isolation method, 216 species of fungi were recovered in pure culture form. Whereas, by particle-plating method, 532 species of fungi were isolated in pure culture. From the results, it is evident that particle-plating method lead to the isolation of maximum number of fungi in pure form, although many of the isolates remained non-sporulating. As many of these remained nonsporulating for a much longer period, identification remained only half-done. Based on cultural characters these isolates were recognised as distinct morphotypes. There is no doubt that by combined application of many techniques as done in this study, a large number of fungi could be recovered.

In general, of all the fungal isolates recovered, maximum number was from cattle dung (143). Of the wild or stray type of animals, dung of cattle (143) yielded maximum number followed by rabbit (98) and goat (65). Beyond this, the distribution was like this: bison (51), sambar (43), chausingha (32), elephant (29), black buck deer

(28), spotted deer(15), monkey (5) and porcupine (3). Many of these fungi were common to these herbivores in their appearance. The dung of animals in captivity, in general, showed lesser fungal association compared to those on move. As reviewed elsewhere, the association of fungi on dung is attributed the feeding of herbivore animals, i.e. wider the kind of feed, richer the fungal diversity and this is in conformity with earlier studies (Richardson, 2001).

Of the 212 fungi recovered in this study, 79 were known so far only from herbivore dung whereas the remaining were earlier recorded from other substrates also. Therefore the former can be recognised as strict coprophilous and the latter treated as casual settlers on dung.

As detailed out in Part II of the results, for the seasonal studies, comparison was done between the fungi appeared on cow and rabbit dung, from the two localities, i.e. Goa University campus and ICAR station, for the three seasons, viz. summer, monsoon and post-monsoon. It was observed that certain species of fungi showed substrate specificity. *Cladorrhinum foecundissimum* was specifically observed on cattle dung during all the three seasons for the entire period of two years. *Cephaliophora irregularis* and *Circinella umbellata* were recovered, in all the seasons, specifically on rabbit dung. This may be due to the difference in the food habits of herbivore animals investigated and the fact that cow is a ruminant animal and rabbit a non-ruminant. Certain species of fungi did not exhibit dung specificity at all. Species belonging to the genera *Ascobolus*, *Saccobolus* and *Pilobobus* were common to both the herbivores in both locations. *Pilobolus crystallinus* was observed in both the samples in all the seasons during the entire study period.

It was also observed that during the post-monsoon season, the dung of herbivores from Goa University campus showed higher number of fungi than those of ICAR, Old Goa. This could be due to the fact that the herbivores at Goa University campus had access to a variety of green vegetation in the post-monsoon season. On the contrary, although herbivores at ICAR station were fed regularly of green forage, it was devoid of a variety of forage.

At the same time, the fungal diversity on herbivore dung at the Goa University campus was less, may be due to the fact that in the summer season, very scanty vegetation was available for the herbivores to feed upon. At ICAR station, green vegetation is made available to herbivores in the dry season. Hence it can be considered that the availability of vegetation does effect the number of fungi appearing on herbivore dung.

As elaborated in Part III of the results, for the study of fungal activities, two aspects were considered, viz., amylase activity and PUFA productivity. As herbivore dung harbours a good number of Zygomycetes, it was felt prudent to screen these fungi for amylase activity and productivity of PUFAs. Ten zygomycetes namely, *Absidia corymbifera*, *A. coerulea*, *Actinomucor elegans, Circinella muscae, C. umbellata, Coemansia erecta, Helicostylum piriforme, Piptocephalis repens, Rhizopus stolonifer, Rhizopus* sp. were screened. Of these, barring *Coemansia erecta* and *Piptocephalis repens,* rest of the fungi showed positive amylase activity. Though modest, this high value (80%) result indicates that coprophilous fungi can be the dependable source for production of amylase in future biotechnological adventures.

For the study of the Polyunsaturated fatty acids, the same set of fungi were screened. In all, 13 kinds of fatty acids were recovered, of which 5 belonged to PUFA. These included Eicosapentanoic acid (EPA), Eranthic Acid, Linolenic Acid

(LA), γ- Calendic Acid and γ-Linolenic Acid (GLA). In some instances, a single fungus produced more than one PUFA as in the case of *Circinella umbellata*, whereas Linolenic acid was detected in *Helicostylum piriforme, Rhizopus stolonifer* and *Rhizopus* sp. Besides these PUFAs, certain interesting fatty acids such as 2,4-Decadiyonic Acid, Arachidic Acid, Heptanoic Acid, Margaric Acid (Heptadecanoic Acid), Methyl Octadecanoic Acid, Nondecanoic (Nonadecyclic), Palmitic acid, Sterculic Acid, were found in the fungi screened.

Eicosapentanoic acid, Eranthic Acid, Linolenic acid and γ-Linolenic Acid (GLA) were detected in *Circinella umbellata*. Other than *Circinella umbellata,* Linolenic Acid (LA) was also detected in *Helicostylum piriforme, Rhizopus stolonifer* and *Rhizopus* sp.; whereas, γ- Calendic Acid was detected exclusively in *Actinomucor elegans*. The highest percentage of relative abundance was observed in Eicosapentanoic acid (EPA) whereas the lowest was shown in γ- Calendic Acid.

Epilogue

With their unique ecological and substrate adaptations in spores such as adhesive projectiles, pigmentation in exospores, mucilaginous spore-sheaths and rresistance to digestive enzymes and acids in the animal gut, coprophilous fungi are very unique and unlike the general mycoflora. Perusal of the lists of Indian fungi (Mukerji and Juneja, 1962-72; Sarbhoy et al., 1977-81; Sarbhoy et al., 1982-92; Jamaluddin, et al., 1989-2001) reveals that not many coprophilous fungi are known from the subcontinent especially from this part of the country. From this angle, though modest, the study carried out and the results presented in this thesis are not only interesting but also very rewarding.

Most fungal floristic researches have so far been done following morphology-based identifications. Similar methods have been used in the present study. The results obtained are undoubtedly interesting. About 8% of the fungi described here in this thesis were turned out to be new to science. This is yet another proof that intensive search for fungi in more and more substrates results with unforeseen novel excitements. Some of the new fungi encountered during the study were already published and copies of the papers are appended to the thesis (see Appendix).

The ecological investigations of dung substrate carried out in this thesis revealed that the succession of fungi on dung followed the already known patterns. This confirmed the earlier thinking that besides the nutrient driven force, enduring life cycle of different fungi mattered much for appearance of one group after another. Further, the dung of wild/stray animals was more productive than those in captivity.

In the present work, of the 10 species of lower fungi investigated, 8 showed amylase activity. This is certainly not a small success but proves beyond doubt that coprophilous zygomycetous fungi are the major sources of amylase. Amylase being an important digestive enzyme and used widely in food industry, the basic results obtained in this study offers opportunities to explore this group of fungi for further biotechnological applications. Similarly, the PUFA. While some of the screened fungi yielded more that one PUFA two produced the same PUFA. Besides, presence of some interesting fatty acids were also recorded.

In sum, it can be said that intensive fungal floristic, ecological and screening studies, done as in this case, yield exiting results. This is the essence of this work.

SUMMARY

This thesis embodies results of an investigation carried out over a period of 4 years from Jan. 2007 to Dec. 2010, on floristics, diversity, ecology and activity of coprophilous fungi collected from Goa and neighbouring regions of Karnataka and Maharashtra.

The topic of study and objectives addressed in the work were introduced in Chapter I. The hitherto known information on coprophilous fungi was reviewed in Chapter II. Material used and methods followed in this study were elaborated in Chapter III. Results obtained and discussions followed were given in the subsequent Chapters.

Moist chamber incubation, particle-plating and single spore isolation techniques were used for the recovery of fungi found inhabiting the herbivore dung. By moist chamber incubation and single spore isolation 216 fungi were recovered and by particle-plating method 532 species of fungi were isolated in pure culture. In all, 212 species in 102 genera of fungi were documented. These were assignable to Zygomycetes (12), Ascomycetes (20), Anamorphic Ascomycetes [Hyphomycetes (64), Coelomycetes (6)] and Basidiomycetes (1). All the 212 fungi have been described in detail with camera lucida illustrations and/or microphotographs.

In this study, in view of its unique morphological features, *Shanomyces indica* gen. et sp. nov. was introduced as a new species in a new genus. Besides, 11 coprophilous fungi were described as novel taxonomic species (Ascomycetes – 4 and Hyphomycetes – 7). These included: *Ascobolus* tax. sp. nov., *Dennisiopsis* tax. sp. nov., *Saccobolus* tax. sp. nov., *Schizothecium* tax. sp. nov. (Ascomycetes) and *Angulimaya* tax. sp. nov., *Antromyces* tax. sp. nov., *Ovularia* tax. sp. nov., *Curvularia*

tax. sp. nov., *Tritirachium* tax. sp. nov., *Chlamydomyces* tax. sp. nov., *Geomyces* tax. sp. nov. (Hyphomycetes).

The diversity of saprophytic fungi found growing on various other substrates has been studied earlier, from this part of the country, in this laboratory (Bhat, 2010; Bhat et al. 2009). However, information on coprophilous fungi of this region was not available. With the present study, not only a large number of known fungi were recognised as coprophilous but also 35 species of fungi came to light for the first time on herbivore dung. These are new additions to Indian fungi.

In the seasonal studies of coprophilous fungi carried out, it was observed that certain fungi showed substrate specificity, for example, *Cephaliophora irregularis* and *Circinella umbellata* were recovered, in all the seasons, specifically on rabbit dung. On the other hand, *Cladorrhinum foecundissimum* was observed only on cattle dung during all the three seasons during the entire period of study. It was also revealed in this study that during post-monsoon, fungal productivity was much more in Goa University campus, on both cattle and rabbit dung as compared to the samples studied from ICAR station. This study indicated that fungal diversity on a substrate probably depends on the food intake of the herbivores. The study also revealed that the succession of fungi on dung followed the conventional known path, i.e. members of Zygomycetes followed by the Ascomycetes and anamorphic Ascomycetes and last the Basidiomycetes.

From the bioactivity point of view, amylase activity and PUFA productivity were analysed of pure cultures of 10 species of Zygomycetes, using GC-MS. Of the 10 fungi studied for amylase activity, 8 were positive. With regard to PUFA productivity, it was seen that out of the 13 fatty acids produced, 5 were

polyunsaturated fatty acids, viz. Eicosapentanoic acid, Eranthic Acid, Linolenic acid and γ-Linolenic Acid (GLA) and γ- Calendic Acid. These fatty acids have application value in neutra- industries.

In the Appendix, three papers published during the study were appended.

Abdel-Azeem, A.M. 2005. Mycobiota survey of Wadi El-Arbae'en, Saint Katherine Protectorate. Final Report. British Council.

Abdel-Hafez, S.I.I. 1982a. Cellulose-decomposing fungi of desert soils in Saudi Arabia. *Mycopathologia*. 78: 73-78.

Abdel-Hafez, S.I.I. 1982b. Survey of the mycoflora of desert soils in Saudi Arabia. *Mycopathologia*. 80: 3-8.

Abdel-Kader, M.I.A.; Abdel-Hafez, A.I.I. and Abdel-Hafez, S.I.I. 1983. Composition of the fungal flora of Syrian Soils. I. Cellulose-decomposing fungi. *Mycopathologia*. 81: 167-171.

Agnihothrudu, V. 1957. Fungi isolated from rhizosphere-III. *J. Indian Bot. Soc.* 36: 486-490.

Ahmed, S.I. and Cain, R.F. 1972. Revision of the genera *Sporormia* and *Sporormiella*. *Can. J. Bot.* 50: 419-477.

Ali, A.I., Ogbonna, C.I.C. and Rahman, A.T.M.F. 1989. Hydrolysis of certain Nigerian starches using crude fungal amylase. *Niger. J. Biotechnol.* 9(1): 24-35.

Alfatafta, A.A. and Gloer, J.B. 1994. Apiosporamide, a new antifungal agent from the coprophilous fungus *Apiospora montagnei*. *Journal of Natural Products*. 57(12): 1696-1702.

Alexopoulos, C.J. and Mims, C.W. 1979. *Introductory Mycology*. 3rd Ed. John Wiley and Sons, New York, Chichester, Brisbane, Toronto.

Alexopoulos, C.J.; Mims, C.W. and Blackwell, M. 2002. *Introductory Micrology*. 4th Edn. John Wiley and Sons (Asia) Pvt. Ltd.

Alves, M.H.; Campos-Takaki, G.M; Porto, A.L.M. and Ivo, A. 2002. Searching of *Mucor* spp. for the production of amylase, lipase, polygalacturonase and protease. *Brazilian Journal of Micrology*. 33: 325-330.

Amann, R.I., Ludwig, W. and Schleifer, K.H. 1995. Phylogenetic identification and in situ detection of individual microbial cells without cultivation. *Microbiology Reviews*. 59: 143–169.

Ames, L.M. 1963. A monograph of the Chaetomiaceae. U.S. Army Res. Dev., Ser. 2.

Ander, P.; Daniel, G.; Pettersson, B. and Westermark, V. 1996. Possible applications of cellobiose oxidizing and other flavine dinucleotide enzymes in the pulp and paper industry. *ACS Symp. Ser.* 655: 297-307.

Angel, K. and Wicklow, D.T. 1975. Relationships between coprophilous fungi and fecal substrates in a Colorado grassland. *Mycologia*. 67: 63-74.

Asan, A. 2004. *Aspergillus*, *Penicillium* and related species reported from Turkey. *Mycotaxon*. 89: 155-157.

Ávila, A.E.D., García, L.M.U. and Chávez, A.J.P. 2009. *Coprotiella venezuelensis*, A new record of cleistothecia genus of the ascomycetes in the world. *Revista Científica*. XIX(1): 22-24.

Ávila, A.E.D.; García, L.M.U. and Chávez, A.J.P. 2007. *Mycotypha indica* P.M. Kirk & Benny, in turkey dung, a new record for Venezuela. *Multiciencias*. 7(2): 176-180.

Bagy, M. M. K.; Moharram, A.M. and Abdel-Mallek, A. 1986. Coprophilous fungi of the camel. *Bull. Fac. Sci. Assiut Univ.* 15(1): 1-10.

Bajpai, P.K.; Bajpai, P. and Ward, O.W. 1992. Optimisation of culture conditions for production of eisosapentanoic acid by *Mortierella elongata* NRRL 5513. *Journal of Industrial Microbiology and Biotechnology*. 9: 11-17.

Barnett, H.L. and Hunter, B.B. 1999. Illustrated genera of imperfect fungi. *The Amer. Phytopathol. Soc.* St. Paul, Minnesota (USA): Aps Pres.

Bangyeekhun, E. 2008. *Podosordaria leporina* (Ell. & Ev.) Dennis (Ascomyceta: Xylariaceae): A new record for Thailand. *The Natural History Journal of Chulalongkorn University*. 8(1): 23-25.

Beckett, A.; Barton, R. and Wilson, I.M. 1968. Fine structure of the wall and appendage formation in ascospores of *Podospora anserina*. *J. Gen. Microbiol.* 53: 89–94.

Bell, A. 2005. An illustrated guide to the coprophilous Ascomycetes of Australia. *CBS Biodivers Ser.* 3:1–178.

Bell, A. 2006. *Podospora obclavata* (Lasiosphaeriaceae), A new species from Australia. *Australasian Mycologist*. 25(2): 41-44.

Bell, A. 1983. Dung Fungi: An illustrated guide to coprophilous fungi in New Zealand. Victoria University Press, Wellington, New Zealand.

Bell, A. and Mahoney, D.P. 1997. Coprophilous fungi in New Zealand. II. *Podospora* species with coriaceous perithecia. *Mycologia*. 89(6): 908-915.

Benjamin, R.K. 1958. Sexuality in the Kickxellaceae. *Aliso*. 4: 149–169.

Benjamin, R.K. 1959. The merosporangiferous Mucorales. *Aliso*. 4: 321–433.

Benjamin, R.K. 1960. Two new members of the Mucorales. *Aliso*. 4: 523–530.

Benjamin, R.K. 1961. Addenda to "the merosporangiferous Mucorales." *Aliso*. 5: 11–19.

Benjamin, R.K. 1962. A new *Basidiobolus* that forms microspores. *Aliso*. 5: 223–233.

Benjamin, R.K. 1963. Addenda to "the merosporangiferous Mucorales." II. *Aliso*. 5: 273–288.

Benjamin, R.K. 1965. Addenda to "the merosporangiferous Mucorales." III. *Dimargaris*. *Aliso*. 6: 1–10.

Benjamin, R.K. 1966. The merosporangium. *Mycologia*. 58:1–42.

Benjamin, R.K. 1979. Zygomycetes and their spores. In Kendrick, W.B. (Ed.). *The whole fungus, the sexual-asexual synthesis*. Vol. 1. National Museum of Natural Sciences, Ottawa, Canada.

Benjamin, R.K. and Mehrotra, B.S. 1963. Obligate azygospore formation in two species of *Mucor* (Mucorales). *Aliso*. 5: 235–245.

Benny, G.L. 1982. Zygomycetes. In *Synopsis and Classification of Living Organisms*. Vol. I. S.P. Parker Ed. McGraw-Hill, New York. 184–195.

Bergquist, P.; Te'o, V.; Gibbs, M.; Curach, N. and Nevalainen, K. 2003. Recombinant bleaching enzymes from thermophiles expressed in fungal hosts. In: Mansfield, S.D., Saddler, J.N. Eds. Applications of enzymes to lignocellulosics. *Amer. Chem. Soc. Symposium Series*. 855: 435-445.

Bettucci, L.; Rodriguez, C. and Indarte, R. 1993. Studies on fungal communities of two Grazing-land Soils in Uruguay. *Pedobiologia*. 37: 72-82.

Bhat, D.J. 2010. Fasinating hyphomycetes from Western Ghats. Broadway Publishers.

Bills, G.F.; Pelaez, F.; Polishook, J.D.; Diez-Matas, M.T.; Harris, G.H.; Clapp, W.H.; Dufresne, C.; Byrnr, K.M.; Nallin-Omstead, M.; Jenkins, R.G. Mojena, M.; Huang, L. and Bergstrom, J.D. 1994. Distribution of zaragozic acids (squalestatins) among filamentous ascomycetes. *Mycol. Res*. 98: 733-739.

Bilgrami, K.S.; Jamaluddin, K.S. and Rizwi, M.A. 1979. Fungi of India Part I, list and references. Today and Tomorrow's Printers and Publishers, New Delhi.

Bills, G.F.; Pelaez, F.; Polishook, J.D.; Diez-Matas, M.T.; Harris, G.H.; Clapp, W.H.; Dufresne, C.; Byrne, K.M.; Nallin-Omstead, M.; Jenkins, R.G.; Mojena, M.; Huang, L. and Bergstrom, J.D. 1994. Distribution of zaragozic acids (squalestatins) among filamentous ascomycetes. *Mycol. Res*. 98: 733-739.

Bisby, G.R. and Ainsworth, G.C. 1943. The numbers of fungi. *Trans. Br. Mycol. Soc*. 26: 16-19.

Blackwell, M. 2011. The Fungi: 1, 2, 3... 5.1 million species? *American*

Journal of Botany. 98(3): 426-438.

Blanchette, R.A. and Shaw, G.C. 1978. Associations among bacteria, yeasts and basidiomycetes during wood decay. *Phytopathology*. 68: 631-637.

Bogan, B.W. and Lamar, R.T. 1999. Surfactant enhancement of white rot fungal PAH soil remediation. In *Bioremediation Technologies for Polycyclic Aromatic Hydrocarbon Compounds.* Leeson, A. and Alleman, B.C. Eds. Columbus, OH: Battelle Press. 81-86.

Bokhary, H.A. 1986 Coprophilous fungi of Saudi Arabia. 2. Occurrence of coprophilous fungi on camel, sheep and goat dung. 9: 3-11.

Booth, C. 1971. Introduction of general methods. In methods of microbiology. Vol.4 Academic Press, London.

Breton, A. and Zwaenepoel, P. 1991. Succession of moist hay mycoflora during storage. *Canadian Journal of Microbiology*. 37: 248-251.

Brewer, D. and Taylor, A. 1969. *Aspergillus funigatus* and *Sporormia minima* isolated from the rumen of sheep. *J. Gen. Microbiol.* 59: 137-139.

Brewer, D.; Duncan, J.M.; Safe, S. and Taylor, A. 1972. Olive ill-thrift in Nova Scotia. 4. The survival at low oxygen partial pressure of fungi isolated from the contents of the ovine rumen. *Can. J. Microbiol.* 18: 1119-1128.

Brown, J.L. 1964. The evolution of diversity in avian territorial systems. *Wilson Bulletin.* 76: 160-169.

Bruehl, G.W., Millar, R.L. and Cunfer, B. 1969. Significance of antibiotic production by *Cephalosporium gramineum* to its saprophytic survival. *Canadian Journal of Plant Science.* 49: 235-246.

Brummelen, J.V. 1967. A world-monograph of the genera *Ascobolus* and *Saccobolus*. (Ascomycetes, Pezizales). *Persoonia.* Suppl. 1.

Brummelen, J.V. 1977. A New Genus of Pezizales from Thailand. *Kew Bulletin*. 31(3): 617-620.

Brummelen, J.V. 1985. *Pseudascozonus*, a new genus of Pezizales. *Proc. Indian Acad. Sci.* 363-367.

Buffin, N. and Hennebert, G.L. 1985. *Basifimbria spinosa*, a new pleoanamorphic hyphomycete. *Proc. Indian Acad. Sci. (Plant Sci.).* 94(2, 3): 259-267.

Cailleux, R. 1971. Recherches sur la Mycoflore coprohilie Centrafricaine. Les genres *Sordaria*, *Gelasinospora, Bombaria* (Biologie-Morphologie-Systématique-Ecologie). *Bulletin de la Société Mycologique de la France.* 87:

461-626.

Cain, R.F. 1934. *Studies of coprophilous Sphaeriales of Ontario.* University of Toronto Studies, Biological Series. 38: 1–126.

Cain, R.F. 1956. Studies of Coprophilous ascomycetes. II. *Phaeotrichum*, a new cleistocarpous genus in a new family, and its relationships. *Can. J. Bot.* 34: 675-687.

Cain, R.F. and Luck-Allen, E.R. 1969. *Semidelitschia*, a new genus of the Sporormiaceae. *Mycologia.* 61(3): 580-585.

Cai, L.; Tsui, C.K.M.; Zhang, K and Hyde, K.D. 2002. Aquatic fungi from Lake Fuxian, Yunnan, China. *Fungal Diversity.* 9: 57-70.

Calviello, B. O. 1979. Contribucion al estudio de Ascomycetes argentinos. II. Una nueva especie de "*Kernia* (Microascales)". *Revta Mus. Argent. Ciencias Nat. Bernardino Rivadavia Bot.* 5: 239-243.

Caretta, G; Piontelli, E; Savino, E. and Bulgheroni, A. 1998. Some coprophilous fungi from Kenya. *Mycopathologia.*142: 125–134.

Caretta, G.; Mangiarotti, A.M. and Piontelli, E. 1994. Coprophilous fungi on horse, goat and sheep dung from Lombardia (Italy). *Micologia Italiana.* 23:11-20.

Carmichael, J.W.; Kendrick, W.B.; Conners, I.L. and Sigler, L. 1980. *Genera of Hyphomycetes.* University of Alberta Press, Edmonton.

Caporale, L.H. 1995. Chemical ecology: a view from the pharmaceutical industry. *Proc. Natl. Acad. Sci.* USA. 92: 75–82.

Cavalier-Smith, T. 1986. The Kingdom Chromista: origin and systematics. In, Progress in Phycological Research. Round, F.E. and Chapman,D.J. Eds. Biopress, Bristol, England. 309–347.

Cavalier-Smith, T. 1998. A revised six-kingdom system of life. *Biol. Rev.* 73: 203-266.

Chang, Jong-How and Wang, Yei-Zeng. 2008. Two Species of *Kernia* (Plectomycetes) in Taiwan. *Taiwania.* 53(4): 414-416.

Che, Y; Gloer, J.B.; Koster, B. and Malloch, D. 2002. Decipinin A and Decipienolides A and B: New bioactive metabolites from the coprophilous fungus *Podospora decipiens. J. Nat. Prod.* 65: 916-919.

Clare, Chaun-Chang Yu. 1954. The Culture and spore germination of *Ascobolus* with emphasis on *A. magnificus. American Journal of Botany.* 41(1): 21-30.

Clivers, A.H. 1912. Preliminary diagnoses of new species of *Chaetomium*. *Proceedings of the American Academy of Arts and Sciences.* 48(4): 83-88.

Colgaonkar, P. 2001. *Studies on Coprophilous Fungi from Goa.* Dissertation Thesis. Goa University.

Cooke, J.C. 1969. Morphology of *Chaetomium funicolum. Mycologia.* 61(6): 1060-1065.

Cooke, J.C. 1970. Morphology of *Chaetomium trilaerale. Mycologia.* 62(2): 282-288.

Connell, J.H. and Slatyer, R.O. 1977. Mechanisms of succession in natural communities and their role in community stability and organization. *American Naturalist.* 111: 1119-1144.

Crous, P.W.; Rong I.H.; Wood, A.; Lee, S.; Glen, H.; Botha, W.; Slippers, B.; Beer, W.Z. de; Wingfield, M.J. and Hawksworth, D.L. 2006. How many species of fungi are there at the tip of Africa? *Studies in Mycology.* 55: 13-33.

Currah, R. 1986. A new species of *Ascodesmis* from Alberta. *Mycologia.* 78(2): 198-201.

Degawa, Y. and Gams, W. 2004. A new species of *Mortierella*, and an associated sporangiiferous mycoparasite in a new genus, *Nothadelphia. Studies in Mycology.* 50: 567–572.

D'souza, M. 2002. Studies on diversity, ecology and biology of microfungi associated with a few dicot and monocot plant species of Western Ghats in Goa state, India. Ph.D. thesis. Goa University, Goa.

Dix, N.J. and Webster, J.W. 1955. *Fungal Ecology.* Capman and Hall. London, U.K.

Dixon, R.A. and Postgate, J.R. 1972. Genetic transfer of nitrogen fixation from *K. pneumoniae* to *E. coli. Nature London.* 237: 102-103.

Dreyfuss, M.M. and Chapela, I.H. 1994. Potential of fungi in the discovery of novel, low-molecular weight pharmaceuticals. In: *The discovery of natural products with therapeutic potential.* Gullo, V.P., Ed. Butterworth-Heinemann, London: 49-80.

Dyal, S.D. and Narine, S.S. 2004. Implications for the use of *Mortierella* fungi in the industrial production of essential fatty acids. *Food Research International.* 38: 445-467.

Eaton, R.A. and Jones, E.B.G. 1971a. The biodeterioration of timber in water-cooling towers. I. Fungal ecology and the decay of wood at Connah's Quay and Ince. *Material und Organismen.* 6: 51-80.

Ebersohn, C. and Eicker, A. 1991. Coprophilous fungal species composition and species diversity on various dung substrates of African game animals. *Bot. Bull. Academia Sinica.* 33: 85-95.

Eliasson, U. and Lundqvist, N. 1979. Fimicolous myxomycetes. *Botaniska Notiser.* 132:551-568.

Ellis, M.B. 1971. Dematiatious Hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England.

Ellis, M.B. 1976. More Dematiatious Hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey, England.

El-Nagdy, M.A. and Abdel-Hafez, S.I. 1990. Occurrence of zoosporic and terrestrial fungi in some ponds of Kharga Oases, Egypt. *J. Basic Microbiol.* 30: 2333-240.

Evans, C.S. and Hedger, J.N. 2001. *Degradation of plant cell wall polymers. In Fungi in Bioremediation.* Gadd, G.M. Ed. British Mycological Society, Cambridge University Press. 1-26.

Farrell, T.M. 1991. Models and mechanisms of succession: An example from a rocky intertidal community. *Ecological Monographs.* 61: 91-113.

Fields, W.G. and Grear, J.W. Jr. 1966. A new heterothallic species of *Sordaria* from Ceylon. *Mycologia.* 58(4): 524-528.

Frankland, J.C. 1992. Mechanisms in fungal succession. In: *The Fungal Community: Its Organization and Role in the Ecosystem.* Carroll, G.E. and Wicklow, D.T. Eds. 2nd. edn. Mercel Dekker, New York: 383-401.

Frankland, J.C. 1998. Fungal succession - Unraveling the unpredictable. *Mycological Research.* 102: 1-15.

Fries, E.M. 1825. Systema Orbis Vegetabilis. Vol. 1. *Typographia Academica.* Lund.

Fröhlich, J. and Hyde, K.D. 1999. Biodiversity of palm fungi in the tropics: are global fungal diversity estimates realistic? *Biodiversity and Conservation.* 8: 977-1004.

Fryar, S.C. 2002. Fungal succession or sequence of fruit bodies? In: *Fungal Succession.* Hyde, K.D. and Jones, E.B.G. Eds. *Fungal Diversity.* 10: 5-10.

Furuya, K. and Udagawa, S-I. 1972. Coprophilous Pyrenomycetes from Japan I. *J.Gen. Microbiol.* 18: 433-454.

Gad, H.S. 2007. A Taxonomic study of Family Poaceae in Goa. Ph.D. thesis. Goa University, Goa.

Jacob, M. 2000. Studies on diversity, ecology and activity of the microfungi associated with *Ficus bengalensis* Linn. and *Carissa congesta* Wight from Goa State. Ph.D. Thesis. Goa University, Goa.

Jacobs, K. and Botha, A. 2008. *Mucor renisporus* sp. nov., a new coprophilous species from Southern Africa. *Fungal Diversity* 29: 27-35.

Jacela, J.Y.; Joel, M.D.; Tokach, M.D.; Goodband, R.D; Nelssen, J.L.; Renter, D.G. and Dritz, S.S. 2010. Feed additives for swine: Fact sheets - flavours and mold inhibitors, mycotoxin binders and antioxidants. *Journal of Swine Health and Production.* 18(1): 27-32.

Jalmi, P. 2006. *Studies on Foliicolous Fungi from Goa and neighbouring areas of Maharashtra and Karnataka.* Ph.D. Thesis. Goa University.

Jamluddin, M.G., Joswami and Ohja, B.M. 2004. Fungi of India. 1989-2004.

Janczewski, E. von G. 1871. Morphologische Untersuchungen über *Ascobolus furfuraceus. Botanische Zeitung.* 29:257–262.

Jeamjitt, O.; Manoch, L.; Visarathanonth, N. and Chamswarng, C. 2006. Diversity and Distribution of Hyphomycetes from Dung in Thailand. Kasetsart. *J. Nat. Sci.* 40: 890-901.

Jeraj, N.; Kumin, B. and Lenasi, H. 2006. Purification and molecular characterization of chitindeactylase from *Rhizopus nigricans. Enzyme and Microbial Technology.* 39(6): 1294-1299.

Jones, E.B.G., 1963. Marine fungi II. Ascomycetes and Deuteromycetes from submerged wood and drift *Spartina.* Transactions of the British *Mycological Society.* 40: 135-144.

Jones, E.B.G. 1994. Fungal adhesion. Presidential address 1992. *Mycol. Res.* 98: 961-981.

Jones, E.B.G. 1995. Ultrastructure and taxonomy of the aquatic ascomycetous order Halosphaeriales. *Can J Bot.* 73 (suppl 1):S790–S801.

Kar, A.K. and Pal, K.P. 1968. Some Coprophilous Discomycetes of Eastern Himalaya (India). *Mycologia.* 60(5): 1086-1092.

Kar, A.K. and Pal, K.P. 1970. Some Operculate Discomycetes from West Bengal. *Mycologia.* 62(4): 690-698.

Kar, A.K. and Maity, M.K. 1978. The Pyrenomycetes of West Bengal. India – VI. *Indian Phytopath.* 31: 189-195.

Kasai, K.; Morinaga, T. and Horikoshi, T. 1995. Fungal succession in the early decomposition process of pine cones on the floor of *Pinus denisflora* forests.

Mycoscience. 36: 325-334.

Kaushal, S.C. and Virdi, S.S. 1986. Himalaya species of *Saccobolus*, a coprophilous genus of Pezizales. *Willdenowia*. 16: 269-277.

Kendrick, W.B. and Carmichael, J.W. 1973. Hyphomycetes. In "The Fungi" Ainsworth, G.C.; Sparrow, F.K. and Sussman, A.S. Eds. Vol.4. Academic Press, New York. 323-509.

Keshavaprasad, T.S. 2003. *Studies on diversity, ecology and activity of microfungi in relation to mosquito developmental stages.* Ph.D. Thesis. Goa University.

Khan, R.S. and Krug, J.C. 1991. *Podospora fibrinocaudata*, a New Species from California. *Mycologia*. 83(6): 817-821.

Kirk, P.M., Cannon, P.F., David, J.C. and Stalpers, J.A. 2008. *Ainsworth and Bisby's Dictionary of Fungi.* 10th edition CAB International, Walling Ford.

Kotchoni, O.S.; Shonukan, O.O. and Gachomu, W.E. 2003. *Bacillus pumillus*, BPCR16, a promising candidate for cellulase production under conditions of catabolic prepression. *Afr. J. Biotechnol.* 2: 140-146.

Kowalski, D.T. 1969a. A new coprophilous species of *Calonema* (Myxomycetes). *Madrona*. 20: 229-231.

Kowalski, D.T. 1969b. A new coprophilous species of *Didymium*. *Mycologia*. 61:635–639.

Krug, J.C. and Jeng, R.S. 1984. *Hapsidomyces*, a New Genus of the Pezizaceae with Ornamented Ascospores. *Mycologia*. 76(4): 748-751.

Krug, J.C. 1989. *Periamphispora*, A new genus of the Sordariaceae. *Mycologia*. 81(3): 475-479.

Krug, J. C.; Khan, R.S. and Jeng, R. S. 1994. A New Species of *Gelasinospora* with Multiple Germ Pores. *Mycologia*. 86(2): 250-253.

Krug, J.C.; Benny, G.L. and Keller, H.W. 2004. Coprophilous fungi. *In Biodiversity of fungi: inventory and monitoring methods*. Mueller, G. M.; Bills, G.F.; and Foster, M.S. (Eds.) Elsevier Academic Press.

Kuthubutheen, A.J. and Webster, J. 1986. Water availability and the coprophilous fungus succession. *Transactions of the British Mycological Society*. 86: 63-76.

Lange, M. 1992. Sequence of macromycetes on decaying beech logs. *Persoonia* 14: 449 -456.

Larsen, K. 1971. Danish endocoprophilous fungi and their sequence of

occurrence. *Botanisk Tidsskrift.* 66: 1–32.

Lazo, W. 1979. Hongos coprófilos de Chile. *Archivos de Biol. Y Med. Exper.* 12: 637.

Lendner, A. 1908. Les Mucorinées de la Suisse. Matériaux pour la Flore Cryptogamique. *Suisse.* 3: 1–182.

Leelavathy, K.H.; Zachariah, Z. And Sankaran, K.V. 1981. Additions to Indian fungi. *Acta Bot. Indica.* 9: 144-145.

Locquin-Linard, M. 1977. A propos des genres non ostiolés placés dans la famille des Microascaceae (Ascomycètes). Création d'un nouveau genre: *Enterocarpus. Rev. de Mycol.* 41: 509-523.

Locquin-Linard, M. 1980. *Kernia setadispersa*, nouvelle espèce de la famille des Microascaceae (Ascomycètes). *Cryptog. Mycol.* 1: 29-32.

Lodha, B.C. 1964. Studies on coprophilous fungi. II *Chaetomium. Antonie van Leeuwenhoek.* 30: 163-167.

Lorenzo, L.E. and Havrylenko, M. 2001. The genera *Arnium* and *Podospora* from Argentina. *Mycologia.* 93(6): 1221-1230.

Lundqvist, N. 1972. Nordic Sordariaceae. *Symb Bot Ups.* 20:1–374.

Lundqvist, N.; Mahoney D.P.; Bell, A. and Lorenzo, L.E. 1999. *Podospora austrohemisphaerica*, a New Heterothallic Ascomycete from Dung. *Mycologia.* 91(2): 405-415.

Maheshwari, R. 1968. Occurrence and isolation of thermophilic fungi. *Current Science.* 37: 277-279.

Maheshwari, R. 2005. Fungal biology in the 21st century. *Current Science.* 88(9): 20-34.

Mahju, N.A. 1933. A contribution to our knowledge of Indian coprophilous fungi. *Jour. Indian Bot. Soc.* 12: 153-164.

Maheshwari, R., Kamalam, P.T. and Balasubramanyam, D.V. 1987. The biogeography of thermophilic fungi. *Current Science.* 56: 151-155.

Malloch, D. and R. F. Cain. 1971. The genus *Kernia. Can. J. Bot.* 49: 855-867.

Malloch, D. and R. F. Cain. 1973. The genus *Thielavia. Mycologia.* 65: 1055-1077.

Malloch, D. and Benny, G.L. 1973. California Ascomycetes: Four New Species and a New Record. *Mycologia.* 65(3): 648-660.

Malloch, D., and Blackwell, M. 1992. Dispersal of fungal diaspores. In The Fungal Community: Its Organization and Role in the Ecosystem. Carroll, G.C and Wicklow, D.T. Eds. 2nd Ed. Marcel Dekker, New York. 147–171.

Malan, C.E. and Gandini, A. 1966. Blastomiceti della fonti alimentazione, del nido pedotrofico e dell apparato digerente di larvae de Scarabei coprofagi (Coleoptera; Scarabaeidae). *Atti. Acad. Sci. Torino.* 100: 97-118.

Mandels, M. and Reese, M.T. 1985. Fungal cellulase and microbial decomposition of cellulosic fibres. *Dev. Ind. Microbiol.* 5: 5-20.

Manimohan, P., K. Agretious Thomas and V. S. Nisha. 2007. Agarics on elephant dung in Kerala State, India. *Mycotaxon.* 99: 147–157.

Manoch, L.; Chana, C. and Athipunyakom, P. 1999. Diversity of coprophilous fungi in Thailand. In Proceedings of the International Conference on Asian Network on Microbial Research. Chiang Mai, Thailand. November 29-December 1, 1999. 675-688.

Mandala, S.M.; Thornton, R.A.; Frommer, B.R.; Curotto, J.E; Rozdilsky, W.; Kurtz, M.B.; Giacobbe, R.A.; Bills. G.F.; Cabello, M.A.; Martin, I. and Pelaez, F. and Harris, G.H. 1995. The Discovery of Australifungin, a novel inhibitor of Sphinganine N-Acyltransferase from *Sporormiella australis* producing organism, fermentation, isolation, and biological activity. 48(5): 349-356.

Massee, G. and Salmon, E.S. 1901. Researches on coprophilous fungi. I. *Jour. Tenn. Acad. Sci.* 16: 401-405.

Massee, G. and Salmon, E.S. 1902. Researches on coprophilous fungi. II. *Annals of Botany.* 16:57–93.

Matsushima, T. 1971. *Microfungi of Solomon Islands and Papua Islands, New Guinea.* Matsushima, Kobe, Japan.

Matsushima, T. 1975. *Icones Microfungorum.* A Matsushima Lectorum. Matsushima, Kobe, Japan.

McIntosh, R.P. 1980. The relationship between succession and the recovery process in ecosystems. In: *The Recovery Process in Damaged Ecosystems.* J. Cairns (Ed.). Ann Arbor Science, Ann Arbor, Michigan. 22: 11-62.

Mehrotra, B.S. 1960. Studies on Mucorales III. *Piptocephalis debaryana* sp. nov. *Proc. Nat. Acad. Sci. India.* 30B: 370-372.

Mehrotra, B.S. and Baijal, U. 1964. *Piptocephalis indica* sp. nov. and *Piptocephalis* sp. from India. *Sydowia.* 17: 171-174.

Mehta, V. and Gupta, J.K. 1991. Biotechnology in the pulp and paper industry. *Research and Industry.* 36:161-167.

Mehta, V. and Gupta, J.K. 1992. Biobleaching of Eucalyptus Kraft Pulp with Phaenero Chaete *Chrysosporium* and its Effect on Paper Properties. Tappi, USA, pp.151-152.

Mehrotra, B.M. and Baijal, U. 1963. Species of *Mortierella* from India – III. *Mycopathologia Mycologia applicata.* **20**: 49–54.

Meyer, S.L. and Meyer, V.G. 1949. Some Coprophilous Ascomycetes from Panama. *Mycologia.* 41 (5): 594-600.

Mirza, J.H. and Cain, R.F. 1969. Revision of the genus *Podospora. Canadian Journal of Botany.* 47: 1999-2048.

Mirza, J.H.; Khan, S.M., S. Begum, and Shagufta, S. 1979. Mucorales of Pakistan. University of Agriculture, Faisalabad, Pakistan.

Miller, R.S. 1967. Pattern and process in competition. *Advances in Ecological Research.* 4: 1-74.

Misra, P.C. and Gupta, N.N. 1979. Studies on Dimargaritaceae-II. A new *Dispira parasitic* on Ascomycetous hosts. *Mycotaxon.* 8: 372-376.

Misra, P.C. and Gupta, N.N. 1979. Studies on Dimargaritaceae-II. A new *Dispira parasitic* on Ascomycetous hosts. *Mycotaxon.* 8: 372-376.

Morin, P.J. 1999. Succession. In: *Community Ecology* Morin, P.J. (Ed.) Blackwell, Massachussetts. 339-365.

Morinaga, T.; Ito, S. and Minoura, K. 1980. Fungal succession on deer dung. The effects of light on the development of certain fungi. *Transactions of the Mycological Society of Japan.* 21:351–357.

Morton, J.B., and Benny, G.L. 1990. Revised classification of arbuscular mycorrhizal fungi (Zygomycetes): a new order, Glomales, two new suborders, Glomineae and Gigasporineae, and two new families, Acaulosporaceae and Gigasporaceae, with an emendation of Glomaceae. *Mycotaxon* 37: 471–491.

Mueller, G.M; Bills, G.F. and Foster, M.S. 2004. *Biodiversity of fungi: inventory and monitoring methods.* Elsevier Academic Press.

Mukerji, K.G. 1968. Fungi of Delhi: IV. A New Species of *Piptocephalis* from India. *Mycologia.* 60(2): 326-330.

Mukerji, K.G. 1968. Fungi of India: a new species of *Piptocephalis* from India. *Mycologia.* 326-330.

Mukerji, K. G. 1970. Fungi of Delhi: III. Some interesting ascomycetes. *Mycopathologia et Mycologia applicata.* 42(3-4): 277-280.

Muller, C.H. 1966. The role of chemical inhibition (allelopathy) in vegetational composition. *Bulletin of the Torrey Botanical Club.* 93: 332-351.

Nagy, L.A. and Harrower, K.M. 1979. Analysis of two southern hemisphere coprophilous fungus successions. *Transactions of the British Mycological Society.* 72: 69-74.

Nair, S.K. 2002. Studies on diversity, ecology and biology of aquatic fungi of some freshwater streams of Western Ghat forests in Goa state, India. Ph.D. Thesis, Goa University.

Singh; N.; Wasini, A. A. Effect of Nutrition on Growth and Sporulation of a Tropical Isolate of *Pilobolus crystallinus. Mycologia.* 72(3): 558-563.

Nair, M.C. and Balakrishnan, S. (Eds.) 1984. *Beneficial fungi and their utilization. Sci.* Ratanada Road, Jodhpur, India.

Nand, K. and Mehrotra, B.S. 1979. Species of *Pilobolus* and *Pilaria* from India. *Sydowia.* 40: 243-289.

Nevalainen, H. and Te'o, V.S.J. 2003. Enzyme Production in Industrial Fungi—Role of Molecular Genetics. *In*: Arora, D.K. (Ed.) *Applied Mycology and Biotechnology.* Vol. 3, Fungal Genomics. Elsevier Science.

Niessl, G. von. 1883. Ueber der Theilung der Gattung *Sordaria. Hedwigia* 22: 153-156.

Noordeloos, M.E., Vrinda, K.B. and Manimohan, P. 2007. On two remarkable brown-spored agarics from Kerala State, India. *Fungal Diversity.* 27: 145-155.

O'Donnell, K.L. 1979. Zygomycetes in Culture. Palfrey Contributions in Botany. No. 2. Department of Botany, University of Georgia, Athens, Georgia.

O' Fallon, J.V.; Busboom, J.R. and Nelson, M.L. and Gaskins, C.T. 2007. A direct method for fatty acid methyl ester synthesis: Application to wet meat tissues. *Journal of Animal Science.* 85: 1511-1521.

Parker, A. D. 1979. Associations between coprophilous ascomycetes and fecal substrates in Illinois. *Mycologia* 71: 1206-1214.

Patil, M.S. 1978. Two Phycomycetous fungi from Maharashtra. *J. Shivaji Univ.* (Sci). 17: 187-189.

Pascoe, I.G. 1990. History of systematic mycology in Australia. In: *History of systematic botany in Australia.* Short, P.S. Ed. Australian Systematic Botany Society, South Yarra: 259-264.

Pathak, R.K. and Agarwal, S.C. 1977. A new species of *Coniochaetidium* from India. Curr. Sci. 46: 393-395.

Pennisi, E. 2004. The secret life of fungi. *Science.* 304: 1620–1622.

Petiver, J. 1696. *John Ray's synopsis methodical stirpium britannicarum,* London.

Piontelli, E.; Toro SantaMaria, M.A. and Caretta, G. 1981. Coprophilous fungi of the horse. *Mycopathologia.* 74:89-105.

Piontelli, E. and Grixolli, A. 1997. Microhongos de la Patagonia Chilena. Algunos Ascomycetes coprófilos. *Boletín. Micológico.* 12:13-24.

Piontelli, E.L.; Cruz, R.C. and Toro, M.A. 2006. Coprophilous fungal community of wild rabbit in a park of a hospital (Chile): A taxonomic approach. (Comunidades fúngicas coprófilas de conejos silvestres en un parquet de un Hospital (Chile): un enfoque taxonómico). *Boletín Micológico.* 21: 1-17.

Pirozynski, K.A. 1972. Microfungi of Tanzania. *Mycological Papers.* 129: 1-64.

Prentice, I.C. 1992. Climate change and long-term vegetation dynamics. In: *Plant Succession- Theory and Prediction, Population and Community Biology Series 11.* Glenn-Lewin, D.C.; Peet, R.K. and Veblen, T.T. Eds. Chapman & Hall, London. 293-339.

Pointing, S.B. and Hyde, K.D. 2001. Bio-exploitation of filamentous fungi. Fungal Diversity Press, Hong Kong.

Prieta, J.M.A.; Moreno, S.; Diaz, S.; Suarez, G. and Dominguez, L. 1994. Survey of patulin cider and children's apple food by the diphasic dialysis membrane procedure. *J Agric Food Chem.* 42:1701–1703.

Plukenet, L. 1691. Phytographic. Pl. 116. f. F.-London.

Puja, G-S. and Singh, S.M. 2011. Fungal community assicated with Arctic moss, Tetraplodon mimodes and its rhizosphere: bioprospecting for production of industrially useful enzymes. *Current Science.* 100(11): 1701-1705.

Puja, G. 2008. Studies on endophytic fungi from Goa and neighbouring regions of Maharashtra and Karnataka associated with medicinal plants. Ph.D Thesis, Goa University.

Ratledge, C. 1992. Microbial lipids: Commercial realities or academic curiosities. In: Industrial applications of single cell oils. Kyle, D.J. and Ratledge, C. Eds. AOCS Press II, USA. 1-15.

Ray, J. 1688. *Historic Plantarum.* vol. II. p. 1928.

Rayner, A.D.M. and Todd, N.K. 1979. Population and community structure and dynamics of fungi in decaying wood. *Advances in Botanical Research.* 7: 334-

420.

Read, N.D. and Beckett, A. 1996. Ascus and ascospore morphogenesis. *Mycol. Res.* 100:1281–1314

Reddy, C.A. 1995. The potential for white-rot fungi in the treatment of pollutants. *Current Opinion in Biotechnology.* 6: 320-328.

Rice, E.L. 1974. *Allelopathy.* New York: Academic Press.

Richardson, M.J. 1972. Coprophilous ascomycetes on different dung types. *Brit. Mycol. Soc. Trans.* 58: 37-48.

Richardson, M.J. 1998. New and interesting records of coprophilous fungi. *Botanical Journal of Scotland.* 50(2):161-175.

Richardson, M.J. 2001. Coprophilous Fungi from Brazil. *Brazilian archives of biology and technology.* 44 (3):283-289.

Richardson, M.J. 2001. Diversity and occurrence of coprophilous fungi. *Mycological Research.* 105:387-402.

Richardson, M.J. 2004. Coprophilous fungi from Morocco. *Botanical Journal of Scotland.* 56: 2, 147-162.

Richardson, M.J. 2008. Records of Coprophilous Fungi from the Lesser Antilles and Puerto Rico. *Caribbean Journal of Science.* 44(2): 206-214.

Richardson, M.J. 2006. New records of fungi from Orkney and Shetland. *Botanical Journal of Scotland.* 58(1): 93-104.

Richardson, M.J. and Walting, R. 1996. *Keys to fungi on dung.* Royal Botanic Garden, Edinburgh.

Ridderbusch, D.C.; Weber, R.W.S.; Anke, T. and Sterner, Olov. 2004. Tulasnein and Podospirone from the Coprophilous Xylariaceous Fungus *Podosordaria tulasnei.* Z. *Naturforsch.* 59c: 379-383.

Rigby, P.W.J; Burleigh, B.D. and Hartley, B.S. 1974. Gene duplication in experimental enzyme evolution. *Nature.* London. 251: 220-224.

Root, R.B. 1969. The behaviour and reproductive success of the blue-grey gnat catcher. *Condor.* 71: 16-31.

Rossman, A.Y. 1994. A strategy for an all-taxa inventory of fungal diversity. In: *Biodiversity and terrestrial ecosystems.* Peng, C.I. and Chen C.H. Eds. Institute of Botany, Academia Sinica, Taipei. 169-194.

Rossman, A.Y. and Miller, D.R. 1996. Systematics solves problems in

agriculture and forestry. *Ann Mo Bot Gar.* 83: 17–28.

Rugmini, K. 1956. *Soil Fungi of Sagar.* M. Sc. Thesis. Sagar University.

Ruisi, S.A.; Barreca, D.; Selbman, L.; Zucconi, L. and Onofri, S. 2007. paper name missing, not in the referred paper. *Rev Environ Sci Biotechnol.* 6: 127-141.

Rungsardthong, V.; Wongvuttanakul, N.; Kongpien, N. and Chotiwaranon, P. 2006. Application of fungal chitosan for clarification of apple juice. *Process Biochemistry.* 41:589-593.

Sandhu, D.K. and Sidhu, M.S. 1980. The fungal succession on decomposing sugar cane bagasse. *Transactions of the British Mycological Society.* 75: 281-286.

Saxena, A. S. and Mukerji, K. G. 1972. Fungi of Delhi. XVIII. A New Species of *Chaetomium. Mycologia.* 64(6): 1328-1330.

Saxena, A.S. and Mukerji, K.G. 1973. Fungi of Delhi. XIX. *Bahupaathra minuta* sp. n. *Mycopathologia et Mycologia applicata.* 49 (2-3): 201-203.

Seaver, F.J. 1925. Studies in Tropical Ascomycetes: III Porto Rican Cup-Fungi. *Mycologia.* 17(2): 45-50.

Seifert, K.A. and Samuels, G.J. 2000. How should we look at anamorphs? *Studies in Mycology.* 45: 5-18.

Seifert, K.A.; Kendrick, B. and Murase, G. 1983. A key to hyphomycetes on dung. University of Waterloo Biology Series.

Sharma, M. 1977. A new report on the coprophilous ascomycetes from India – I. *M. inversa. Curr. Sci.* 46: 759-780.

Shortle, W.C. and cowling, E.B. 1978. Interaction of live sapwood and fungi commonly found in discoloured and decayed wood. *Phytopathology.* 68: 617-623.

Singh, S.M. and Puja, G. and Bhat, D.J. 2006. Psychrophilic fungi from schirmacher Oasis East Antarctica. *Current Science.* 90(10): 1388-1392.

Sivichai, S.; Hywel-Jones, N. and Jones, E.B.G. 2000. Fungal colonization of wood in a freshwater stream at Khao Yai National Park, Thailand. *Fungal Diversity.* 5: 71-88.

Somrithipol, S. 2004. Coprophilous fungi. In Fungal Diversity. Jones, E.B.G.; Tanticharoen, M. and Hyde, K.D. Eds. Thai Biotec, Thailand. 119-128.

Srinubabu, G.; Lokeshwari, N. and Jayaraju, K. 2007. Screening of Nutritional

Parameters for the Production of Protease from *Aspergillus oryzae*. 4(2): 208-215.

Stevenson, B.G., and Dindal, D.L. 1987. Functional ecology of coprophagous insects: a review. *Pedobiologia* 30: 285–298.

Spooner, B.M. and Butterfill, G.B. 1999. Coprophilous Discomycetes from the Azores Source. *Kew Bulletin.* 54(3): 541-560.

Subramanian, C.V. and Lodha, B.C. 1964. Four new coprophilous hyphomycetes. *Antonie van Leeuwenhoek.* 30: 317-330.

Subramanian, C.V. and Chandrashekara, K.V. 1977. *Beejasamuha* and *Sutravarana* – Two genera of coprophilous hyphomycetes. *Can. J. Bot.* 55: 245-253.

Subramanian, C.V. and Chandrashekara, K.V. 1978. Two interesting coprophilous hyphomycetes. *Bahukalasa samala* gen. et nov. and *Candelabrella* elegans sp. nov. *Kavaka.* 6: 41-48.

Sundaram, B.M. 1977. Fungal Flora of Rice Field Soils. *Proc. indian Acad. Sci.* 87: 90-99.

Sussman, A.S. 1968. Longevity and survivability of fungi. In: The fungi. Vol. III., Ainsworth, G.C. and Sussman, A.S. Eds. Academic Press, New York. pp. 447-486.

Suzuki, A. 2002. Fungal succession at different scales. In: Fungal Succession. Hyde, K.D. and Jones, E.B.G. Eds. *Fungal Diversity.* 10: 11-20.

Swift, M.J. 1982. Microbial succession during the decomposition of organic matter. In: *Experimental Microbial Ecology*. Bums, R.G. and Slater, J.H. Eds. Blackwell Scientific Publications, Oxford: 164-177.

Thind, K.S. and Kaushal, S.C. 1978. The genus *Coprobia* in India. *Kavaka.* 6: 25-29.

Thind, K.S. and Kaushal, S.C. 1978. Three species of *Iodophanus* from Western Himalayas. *Indian Phytopath.* 33: 380-387.

Thind, K.S. and Kaushal, S.C. 1980. Two new species of *Cheilymenia* from India. *Indian Phytopath.* 33: 427-432.

Thoke, R.B. and Kore B.A. 2010. Diversity in coprophilous fungi-II. *A Quarterly Journal of Life Sciences.* 7(4): 56-67.

Tilak, S.T. and Gaikwad, Y.B. 1978. Contribution to our knowledge of Ascomycetes of India- XXXV. *Rev. de Mycol.* 42: 41-48.

Tisdall, J.M. and Oades, J.M 1982. Organic matter and waterstable aggregates

in soils. *Journal of Soil Science.* 33: 141-163.

Tode, H.J. 1784. Beschreibung des Hutwerfers (*Pilobolus*) schrift. *Berlin Ges. Naturf. Freunde.* 5: 46-52.

Tsui, K.M.; Hyde, K.D. and Hodgkiss, I.J. 2000. Biodiversity of fungi on submerged wood in Hong Kong streams. *Aquatic Microbial Ecology.* 21: 289-298.

Udagawa, S. and T. Muroi. 1981. Notes on some Japanese Ascomycetes XVI. *Trans. Mycol. Soc. Japan.* 22: 11-26.

Udagawa, S. and Ueda, S. 1985. A new species of *Podospora* from marine sediment. *Mycotaxon.* 22: 399-406.

Udagawa, S. and K. Furuya. 1988. *Emericellopsis sphaerospora* and *Kernia peruviana*, Two new soil-borne cleistothecial Ascomycetes. *Mycotaxon.* 33: 291-301.

Valdoserra, M. and Guarro, J. 1992. Estudios sobre hongos coprófilos aislados en España.XVII. Recopilación de la bibliografía existente y relación de todos los ascomicetos citados. *Bol. Soc. Micol. Madrid.* 17:39-55.

Valldosera M. and Guarro J. 1988. Some coprophilous ascomycetes from Chile. *Tran. Br. Mycol. Soc.* 90:601-605.

Van Brummelen, J. 1967. A world-monograph of the genera *Ascobolus* and *Saccobolus* (Ascomycetes, Pezizales). *Persoonia*, Suppl. I. 260p.

Van, G. 1885. Die Pilze II. Ascomyceten: Gymnoasceen und Pyrenomyceten. In: Rabenhorst, Krypt.-Fl. *Deutschl. Österr. Schweiz.*1(1): 65-528.

Viaud, M.; Pasquier, A. and Brygoo, Y. 2000. Diversity of soil fungi studied by PCR-RFLP of ITS. *Mycological Research.* 104:1027–1032.

Viriato, A. 2008. *Pilobolus* species found on herbivore dung from the São Paulo Zoological Park, Brazil. *Acta Bot. Bras.* 22(3): 614-620.

Von Arx, J.A; Mukerji, K.G. and Singh, N. 1978. A new coprophilous ascomycetes from India. *Persoonia.* 10: 144-146.

Von Arx, J.A.; Mukerji, K.G. and Singh, N. 1978. *Leucosphaeria*- A new genus of the Pseudoeurotiaceae. *Persoonia.* 10: 141-143.

Von Arx, J.A.; Mukerji, K.G. and Singh, N. 1981. *Faurelina indica* sp. nov. *Sydowia.* 34: 39-41.

Wainwright, M. 1992. An introduction to fungal biotechnology. Wiley Biotechnolgy Series. John Wiley and sons, Toronto, NY. 280-284.\

Wainwright, M. 1995. An Introduction to Fungal Biotechnology. Wiley, Chichester.

Waksman, S.A. and Cordon, T.C. 1939. Thermophilic decomposition of plant residues in composts by pure and mixed cultures of microorganisms. *Soil Science.* 47: 217-224.

Walker, J.C. 1969. Plant pathology, 3rd Ed. McGraw-Hill, New York. 819.

Waraitch, K.S. 1977. New combination in the operculate Discomycetes. *Trans. Br. Mycol. Soc.* 68: 303-304.

Waraitch, K.S. 1977. A contribution to the knowledge of coprophilous Pezizales of India. Sydoeia. 29: 1-9.

Waraitch, K.S. 1980. Operculate Discomycetes from Eastern Himalayas. *Indian Phytopath.* 33: 423-426.

Wang, Y.Z.; Wu, S.H.; Chou, W.N.; Chang, T.T.; Chen, G.Y.; Chen, S.F.; Chen, J.L.; Tzean, S.S.; Liu, C.H.; Hsieh,W.H.; Hsieh, H.J.; Chung, C.H. and C.-Y. Chien. 1999. *List of the fungi in Taiwan. Agricultural Committee Administrative Government.* Taipei, Taiwan.

Webster, J. 1983. *Introduction to Fungi.* Second Edition. Cambridge University Press.

Weber, H.A. and Gloer, J.B. 1998. Interference competition among natural fungal competitors: an antifungal metabolite from coprophilous fungus *Preussia fleishhakii* (Auerswald). Cain. *J. Nat Prod.* 51: 879–883.

Werner, T.P.; Amrhein, N. and Freimoser, F.M.2007. Specific localization of inorganic polyphosphate (poly P) in fungal cell walls by selective extraction and immunohistochemistry. *Fungal genetics and biology FG B.* 44 (9): 845-852.

Whyte, A.C.; Gloer, K.B.; Gloer, J.B.; Koster, B. and Malloch, D. 1997. New antifungal metabolites from the coprophilous fungus *Cercophora sordarioides. Can. J. Chem.* 768-772.

Wicklow, D.T. and Malloch, V. 1971. Effect of incubation temperature on the coprophilous fungus succession. *Trans. Br. Mycol. Soc.* 86: 263-276.

Wicklow, D.T. 1975. Relationships between coprophilous fungi and fecal substrates in a Colorado grassland. *Mycologia.* 67:63-74.

Wicklow, D.T. 1981. *Biogeography and conidial fungi.* In The Biology of Conidial Fungi. Cole, G.T. and Kendrick, B. Eds. Vol. 1. Academic Press, New York. 417–447.

Wicklow, D.T. 1981. The coprophilous fungal community: A mycological system for examining ecological ideas. In: The fungal community its organization a role in the ecosystem Wicklow, D.T. and Carrol, G.C. Eds. Marcel Dekker, New York. 47-70

Wicklow, D.T. 1992. The coprophilous fungal community: an experimental system. In The Fungal Community: Its Organization and Role in the Ecosystem. 2nd Ed. G.C. Carroll and D.T. Wicklow Eds. Marcel Dekker, New York. 715-728.

Wicklow, D.T. and Moore, V. 1974. Effect of incubation temperature on the coprophilous fungal succession. *Trans. Br. Mycol. Soc.* 62: 411–415.

Wicklow, D.T. and Angel, K. Sr. 1983. Some Reproductive Characteristics of Coprophilous Ascomycetes in Three Prairie Ecosystems. *Mycologia.* 75(6): 1070-1073.

Wildman, H.G. and Parkinson, D. 1979. Microfungal succession on living leaves of *Populus tremuloides. Can. J. of Bot.* 57: 2800-2811.

Wildman, H.G. 1997 3. Potential of tropical microfungi within the pharmaceutical industry. In: *Biodiversity of tropical microfungi.* Hyde, K.D. Ed. Hong Kong University Press, Hong Kong, 29–46.

Wolf, L.L. and Hainsworth, F.R. 1971. Time and energy budgets of territorial hummingbirds. Ecology.

Wynn, J.P. and Ratledge, C. 2000. Evidence that the rate-limiting step for the biosynthesis of arachidonic acid in *Mortierella alpina* is the level of the 18:3 to 20:2 elongase. *Microbiology.* 146: 2325-2331.

Yadav, S. 2006. *Studies on diversity and activity of the coprophilous fungi from Goa.* M.Sc. Dissertation, Goa University.

Yadav, A.V. and Bhise, B.B. 2004. Chitosan a potential biomedical effective against typhoid. *Curr. Sci.* 187(9): 1176-1178.

Yu, C. 1954. The culture and spore germination of *Ascobolus* with emphasis on *A. magnificus. American Journal of Botany.* 41(1): 21-30.

Zopf, W. 1874. Fungi fimicoli der Berliner Flora. Verh. *Bot. Ver. Prov. Brand.* 16: Sher p. 125.

Zopf, W. 1874-1881. Zur Entwickelungagesch der Ascomyceten-Chaetomium. *Nova Acta Acad. Gaesar. Leop. Carol.* 42: 197-292.

LIST OF PUBLICATIONS

1. **Yadav, S.** and Bhat D.J. 2009. *Lomachashaka gomaya*, a new sporodochial hyphomycete from India. *Mycotaxon* **110:** 357–362.

2. **Yadav, S.** and D. J. Bhat. 2009. *Dimastigosporium yanense,* a new coprophilous fungus from the forests of Western Ghats in Karnataka State, India. *Mycotaxon* **107**: 397–403

3. Bhat D.J., Prtatibha, J., Gawas, P., **Sarita K.Y.,** and D. Swapnaja. 2009. Diversity of Microfungi in the forests of Western Ghats in Goa and surrounding regions. In: *Plant and Fungal Biodiversity and Bioprospecting* (Eds. S. Krishnan & D.J. Bhat). Broadway Publications, Panaji, Goa. pp 117-133

Taxonomic description

Lomachashaka gomaya S.K.Yadav & Bhat, sp. nov. FIGURES 1–7

MYCOBANK MB 513542

Coloniae lente crescentes in agaro extracto malti, albae, mycelium floccosum, hyalinum lanatum, 4mm diam. post 20 dies 22–24°C. Sporodochia superficialia, dispersa vel 2–3 aggregata, viridia vel viridulo-atra, 200–235 µm alta, 150–160 µm diametro Setae numerosae hyalinae, laeves, crassitunicatae, verrucosae ad basim, sursum obtusae vel rotundatae, septatae, cellulis lumine reducto, non ramosae, 110–190 µm longae, 6–6.3 µm latae Conidiophora aggregata, integrata, subhyalina, verrucosa, septata, ramosa, 75–95 × 2.0–8.5 µm. Cellulae conidiogenae monophialidicae, verrucosae, subhyalinae, 8–14.5 × 2 µm, collare conspicuum formantes. Conidia fusiformi-ellipsoidea, sursum acuta, unicellularia, subhyalina, laevia, 6.5–8.5 × 2.5–3.5 µm, appendice funiculari, cupulari, mucido, hyaline, 2–3 µm lato praedita.

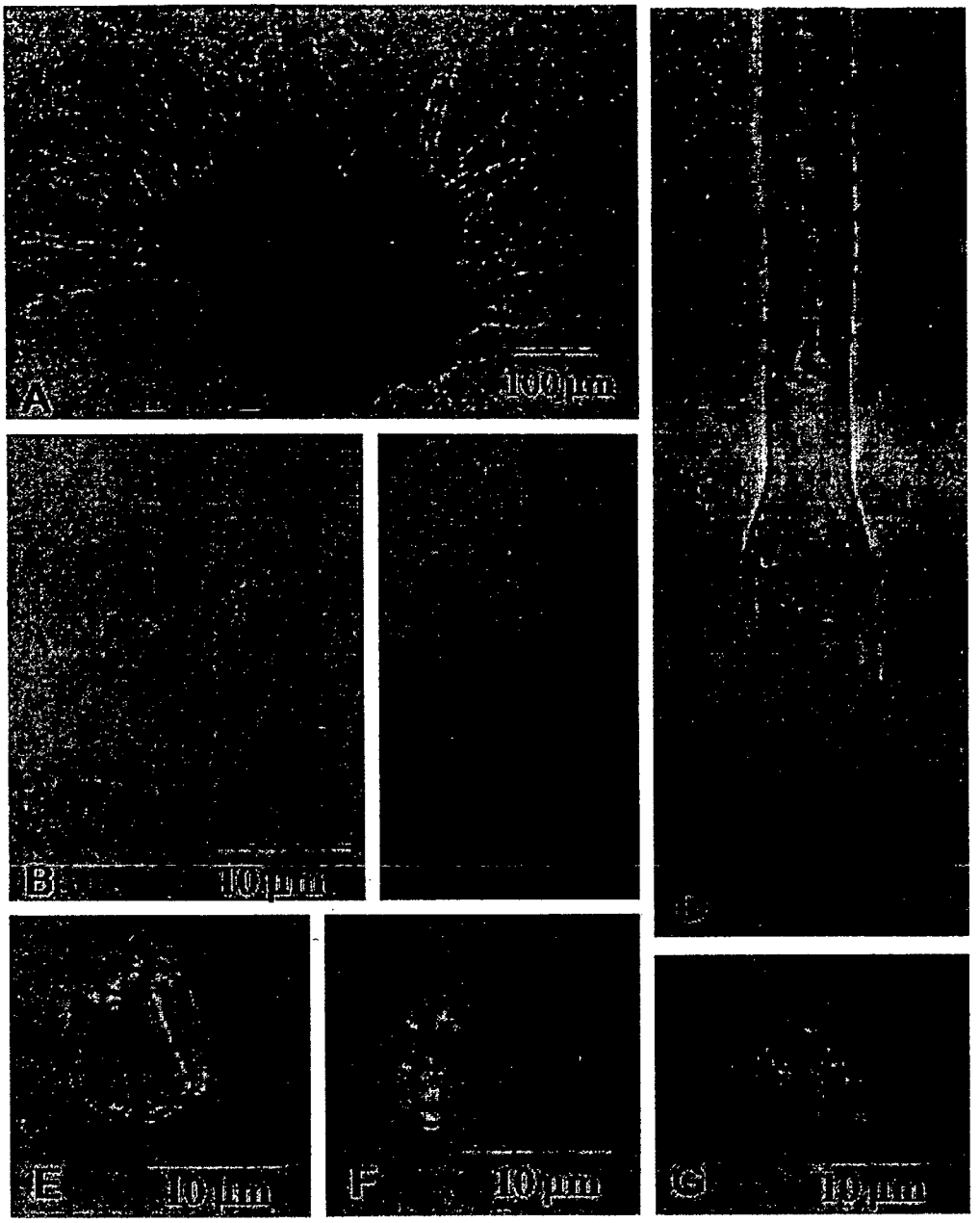
HOLOTYPE: On cow dung, Yana, Uttara Kannada District, Karnataka State, India. 27.07.2008 col. Ashish Prabhugaonkar Herb. No. HCIO 49196

ETYMOLOGY: *gomaya* (Sanskrit), referring to the substrate, cattle dung.

Colonies slow growing, attaining a diam. of 4mm in 20 d in 2% malt extract agar (HiMedia, India), mycelium white, floccose, becoming cottony after 12 days in diurnal light at 22–24°C. As on the natural substrate, sporodochia in culture are superficial, scattered or in groups of 2–3, dark green to greenish black, 200–235 diam. × 150–160 µm high. Setae numerous, unbranched, hyaline, smooth, thick-walled, verrucose at the swollen base, blunt to rounded at the tip, septate, cells with reduced lumen, 110–190 µm long, 6–6.5 µm wide. Conidiophores integrated, subhyaline, verrucose, septate, penicillately branched, 75–95 × 2.0–8.5 µm. Conidiogenous cells integrated, monophialidic, verruculose, subhyaline, 8–14.5 × 2 µm, with conspicuous collarette and moderate periclinal thickening at the tip. Conidia fusiform-ellipsoidal with an acute apex, unicellular, subhyaline (in mass olivaceous-green), smooth, 6.5–8.5 × 2.5–3.5 µm, with a funnel-shaped, cupulate, mucoid, hyaline, 2–3 µm wide appendage.

Discussion

The genus *Lomachashaka* Subram., typified by *L. kera* (Subramanian 1956), is characterized by sporodochial, setose conidiomata, smooth or verrucose conidiophores, phialidic conidiogenesis and fusiform-ellipsoidal conidia with an apical, cupulate, mucoid appendage. Our new species *L. gomaya* is compared with the four hitherto known species in the genus (TABLE 1). The new species is characterized by long setae with a verrucose bulbous base, verrucose conidiophores, and small conidia. The conidial size of the novel species overlaps with that *L. africana*, but the species are distinctly different in their others characters. The coprophilous habit of *L. gomaya* also distinguishes it from the plant substrates, especially monocots, colonized by the other species.



FIGURES 1–7. *Lomachashaka gomaya*.
1. Conidiomata. 2. Conidiogenous cells. 3. Conidiophores. 4. Seta. 5–7. Conidia.

Acknowledgements

The authors are thankful to Dr. Walter Gams, formerly of Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands, Dr. Keith Seifert, Agriculture and Agri-Food Canada, Ontario, Canada, and Dr. Eric McKenzie Landcare Research, New Zealand for kindly reviewing the manuscript. DJB thanks Council of Scientific & Industrial Research, Ministry of Environment & Forests and the University Grants Commission, New Delhi, for provision of research grants. SY thanks C.S.I.R., New Delhi, for a student fellowship.

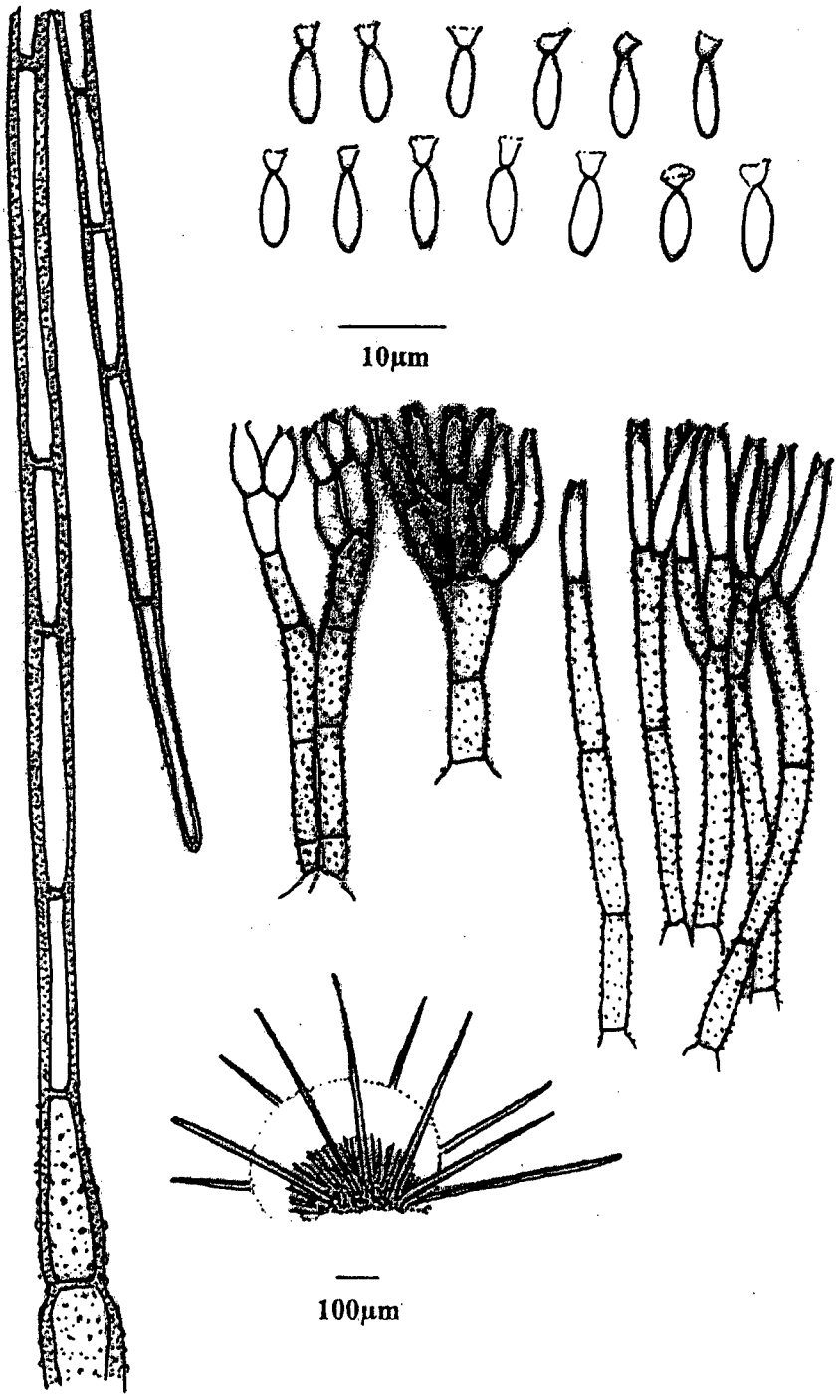


FIGURE 8. *Lomachashaka gomaya.*
Seta, Conidia, Conidiophores and conidiogenous cells, Conidioma.

References

Nag Raj TR. 1995. *Lomachashaka* revisited. Mycotaxon. 53: 311–324.
Subramanian CV. 1956. Hyphomycetes I. J. Indian Bot. Soc. 35(1): 53–91.

TABLE 1: Comparison of *Lomachashaka gomaya* with four known species

CHARACTERS / SPECIES / (REFERENCE)	SUBSTRATE (LOCALITY)	CONIDIOMATA	SETAE	CONIDIOPHORES [all branched]	CONIDIOGENOUS CELLS	CONIDIA [apices funnel-shaped & mucoid]
L. africana Nag Raj (Nag Raj 1995)	Leaves of *Pennisetum purpureum* (Togoland)	Applanate to discoid; 140–200 × 30–40 µm	Filiform, flexuous; base bulbous, thick-walled, smooth; apex 70–160 µm long	Compact, smooth, hyaline to pale olivaceous	Subcylindrical to lageniform, flared collarette & mod. periclinal thickenings, pale olivaceous, 7–11 × 2–3 µm, twice percurrently proliferating, smooth	Fusiform, 6–9.5 × 2–2.5 µm
L. cynodontis Nag Raj (Nag Raj 1995)	Leaves of *Cynodon dactylon* (Ghana)	Aplanate to discoid; orbicular to oval, 160–220 × 40–80 µm	Base ampulliform to conical, smooth, 7–12 × 3.5–4.5 µm, separate from irreg. nodulose part; apex thick-walled, smooth, 50–140 µm long	Compact, smooth, hyaline to pale olivaceous	Vase-shaped with walls invaginated near median, with flared collarette & mod. periclinal thickenings, percurrently proliferating 1–2 times, smooth	Fusiform, pale olivaceous, smooth, 7–12.5 × 0.5–3.5 µm
L. gomaya (Present study)	Cattle dung (India)	Cupulate; 200–235 × 150–160 µm	Erect, unbranched, hyaline, smooth, with swollen, verrucose base, blunt at the tip, septate, 110–190 × 6–6.5 µm	Compact, verrucose, septate, sub hyaline to olivaceous	Mostly smooth, occ. minutely verrucose, subhyaline, phialidic, conspicuous collarette & mod. periclinal thickenings at the tip, 8–14.5 × 2 µm	Fusiform, smooth, hyaline, unicellular, olivaceous, 6.5–8.5 × 2.5–3.5 µm
L. kera Subram. (Subramanian 1956)	Dead leaves of *Cocos nucifera* (India)	Cupulate; 210–350 × 80–100 µm	Erect, thin-walled, hyaline, erect or flexuous, ≤ 200 × 1.5–2.5 µm	Compact, smooth, hyaline	Subcylindrical to lageniform, colourless, 13–19 × ≤ 3 µm	Fusiform, colourless, 9–14 × 2–4 µm
L. sundara Nag Raj (Nag Raj 1995)	Grass blades (India)	Pulvinate to discoid, cupulate, orbic. to oval; 100–180 × 60–100 µm	Base septate, verruculose, swollen, 15–20 × 2.5–3.5 µm; apex slender, thick-walled, irreg. nodulose, smooth, 120–300 µm	Smooth, hyaline	Subcylindrical to lageniform with flared collarette & marked periclinal thickenings, pale olivaceous, smooth, 9–15 × 2.5–3 µm	Fusiform or fus.-elliptic, pale olivaceous, smooth, 7–12.5 × 2.5–3.5 µm

MYCOTAXON

~~*Mycotaxon Styles 2008* 107: 397–403 *August 18, 2008, revision*~~ 2009

Dimastigosporium yanense, a new coprophilous fungus from the forests of Western Ghats in Karnataka State, India

S. YADAV[1] & D.J. BHAT[2]

[1]*yadavsarita24@rediffmail.com*; [2]*bhatdj@rediffmail.com*

Department of Botany, Goa University

Goa- 403 206, India

Abstract – *Dimastigosporium yanense* sp. nov., isolated from cattle dung collected from the forests of Western Ghats, Karnataka State, India, is described and illustrated. *D. yanense* differs from the type species genus, *D. musimonum*, by the production of subcylindrical, smaller conidia with an apical and three basal appendages. The conidia develop holoblastically through one of the basal appendages.

Key words – biodiversity, anamorphic, coelomycete, pure culture.

Introduction

During studies on the biodiversity and taxonomy of microfungi of the forests of Western Ghats in southern India, an interesting coelomycete fungus was collected and isolated from partially decomposed cow dung. It was collected at Yana, a tiny hamlet amidst dense and pristine tropical forests, 30 km from Kumta, Uttara Kannada District, Karnataka State, India. Description and taxonomy of the fungus form the subject matter of this communication.

Materials and Methods

The dung sample was air-dried and taken to the laboratory in paper bags. A small lump was soaked in sterile distilled water and incubated for several days in a sterile plastic box lined with moist filter paper. The dung was examined under a stereoscope at periodic intervals. Fungal fructifications appeared after 10 days of incubation. A pure culture of the fungus was established by streaking a sterile needle tip-full of conidia on malt extract agar (HiMedia, India) containing antibiotics (bacitracin, 0.02 g; neomycin, 0.02 g; penicillin, 0.02 g; streptomycin, 0.02 g; tetramycin, 0.02 g; dissolved in 10 ml of distilled water) and then purified by transferring germinated individual conidia onto malt extract agar slants.

Taxonomic description

Dimastigosporium yanense S.K. Yadav & Bhat, sp. nov. Figs. 1–7

MYCOBANK MB 512676

Coloniae lente crescentes in agaro extracto malti, mucosae, pallide aurantiae, 3.5 mm diam. post 20 dies 22–24°C. Conidiomata primum clausa, deinde dehiscentia et cupularia, 250–450 µm diam., 500–750 µm alta, viridi-brunnea; stratum basilare pseudoparenchymatosum; paries pycnidiorum plectenchymatosus, setis conspicuis, rectis vel curvatis, crassitunicatis, laevibus, septatis, raro ramosis, usque 220 µm longis et 7 µm latis praeditus. Conidiophora in hymenio aggregated, hyalina, laevia, septata, in parte inferiore ramosa, 6–23 × 2–3.5 µm. Cellulae conidiogenae holoblasticae, cylindricae, sursum angustatae, laeves, integratae, determinatae, 6.5–20 × 1–5 µm. Conidia subcylindrica, hyalina, aseptata, solitaria, numerosa, aggregata pallide aurantia, tenuitunicata, laevia, 6.5–10 × 1.5–2.5 µm, una appendice apicali et tribus basilaribus praedita; appendices non-cellulares, hyalinae, non ramosae, laeves, 10–16 µm longae, ad 1 µm latae.

HOLOTYPE: On cattle dung, Yana, Karnataka, India, coll. Ashish Prabhugaonkar, 28.07.08. Herb. No. HCIO 48658
ETYMOLOGY: *yanense* = referring to the collection site.

Colonies slow growing on malt extract agar, slimy, pale orange, circular, 3.5 mm diam. after 20 days of incubation in diurnal light at 22–24°C. Conidiomata cupulate, initially closed, eventually opening, sessile, superficial, scattered, solitary, rarely in aggregates of 2–3, 250–450 µm diam., 500–750 µm high, greenish brown; basal tissue pseudoparenchymatous; conidiomal wall with discernible, straight or curved, thick-walled, smooth, septate, rarely branched, up to 220 µm long and up to 7 µm wide setae. Conidiophores developing in a hymenium, hyaline, smooth, septate, branched once or twice below mid point, 6–23 × 2–3.5 µm. Conidiogenous cells 6.5–20 × 1–5 µm, holoblastic, cylindrical, narrower at the tip, smooth, integrated, determinate, Conidia 6.5–10 × 1.5–2.5 µm, subcylindrical, hyaline, aseptate, solitary, numerous, pale orange in mass, thin-walled, smooth, with one appendage at apex and three at the base, developing through one of the basal appendages; appendages acellular, hyaline, unbranched, cylindrical, smooth, 10–16 µm long, up to 1 µm wide.

Discussion

The genus *Dimastigosporium* Faurel & Schotter, typified by *D. musimonum* Faurel & Schotter (Faurel & Schotter 1965, Nag Raj 1993), is characterized by superficial, cupulate conidiomata, smooth, branched, conidiophores, integrated, hyaline, cylindrical conidiogenous cells and appendaged conidia. Conidia in *D. musimonum* are hyaline, pyriform, 10–16 × 2.5–3 µm, with the primary appendage 16–23 µm long and 2–3 secondary appendages 12–21 µm long. *D. yanense* differs from the type species by smaller, subcylindrical, conidia (6.5–10 × 1.5–2.5 µm) with three basal and one apical appendage of 10–16 µm long. The two species are compared in Table 1.

Table 1: Comparison of *D. musimonum* with *D. yanense*

Characters	***D. musimonum***	***D. yanense***
Habit and habitat	Wild sheep (*Ammotragus lervia*) dung	Cow (*Bos taurus*) dung
Conidiomata	Superficial, cupulate, black or blackish green, 350 µm diam., up to 200 µm high	Superficial, cupulate, greenish brown, 250–450 µm diam., 500–750 µm high
Conidiomal wall type	Pseudoparenchymatous	Textura porrecta
Conidiophores	Cylindrical, septate, sparingly branched at the base, smooth, hyaline.	Septate, branched below mid point, hyaline, smooth, 6–23 × 2–3.5 µm
Conidiogenous cells	Holoblastic, integrated, subcylindrical to obclavate, hyaline, 11–15 × 1.5–2 µm	Holoblastic, integrated, cylindrical, narrower at the tip, hyaline, 6.5–20 × 1–5 µm
Conidia	Pyriform, unicellular, hyaline, thin-walled, smooth, 10–16 × 2.5–3 µm	Subcylindrical, unicellular, hyaline, smooth, rounded at the base, 6.5–10 × 1.5–2.5 µm
Conidial appendages	Primary appendage 16–23 µm long, 2–3 secondary appendages 12–21 µm	Four; one at the tip, 3 at the base, 10–16 µm long, up to 1 µm wide.

Sutton (1980: 470) describing the genus *Dimastigosporium* wrote: "... during conidiogenesis the body of the conidium is formed first and is attached to the conidiogenous cell by one of the appendages." Nag Raj (1993) examining the only slide available in the voucher material of *D. musimonum* could not diagnose the exact nature of conidiogenesis, though he suspected it to be of the phialidic category. Careful examination of the conidiogenesis in *D. yanense* revealed that conidium ontogeny is holoblastic and the body of the conidium is developed through one of the basal appendages (Fig. 7c).

Coelomycetous genera such as *Eleutheromyces* Fuckel, *Monodia* Breton & Faurel and *Strasseria* Bres. & Sacc. (Nag Raj 1993, Sutton 1980) also exhibit similar conidial development wherein conidiogenesis is initiated through an appendage within a compact, ostiolate, pycnidium. The conidia develop at the tip of filiform appendages emerging from the conidiogenous cells. In *Eleutheromyces* and *Strasseria*, typified by *E. subulatus* (Fuckel 1870) and *S. carpophila* (Strasser 1902), respectively, the conidia are enteroblastic and phialidic whereas in *Monodia* they are holoblastic. With holoblastic conidiogenesis, appendaged conidia and coprophilous habitat, *Dimastigosporium* is more similar to *Monodia*, typified by *M. elegans*

(Breton & Faurel 1970), though the former is distinct by absence of discernible pycnidium. In *Dimastigosporium* species, the fructification is a closed structure to begin with; it later attains an open, cupulate shape. The salient features of these genera are summarized in Table 2.

Table 2. Comparison of *Eleutheromyces, Dimastigosporium, Monodia* and *Strasseria*

Characters	*Eleutheromyces*	*Dimastigosporium*	*Monodia*	*Strasseria*
Habit and habitat	On *Polyporus picipes* and hymenomycetes	Cow (*Bos taurus*) dung	Herbivorous animal dung	On trees (*Picea excelsa*, *Pinus strobus*, *P. nigra*)
Conidiomata	Pycnidial, gregarious, unilocular, ostiolate, pale brown, 130–350 µm diam. up to 3300 µm high	Superficial, cupulate, black or blackish green, 350 µm diam., up to 200 µm high	Pyriform, immersed to semi-immersed, dark brown, ostiolate, 240–350 µm diam.	Pyriform, immersed, black to dark brown, ostiolate, 100–350 µm diam.
Conidiomata wall type	Textura angularis	Pseudoparenchym-atous	Textura angularis	Textura angularis
Conidiophores	Cylindrical, septate, branched at base, hyaline, smooth, 60 × 2.5–3.5 µm	Cylindrical, septate, sparingly branched at the base, smooth, hyaline.	Septate, branched, hyaline, smooth, 70 µm long	Cylindrical to lageniform, septate, branched, hyaline, 6–14 × 2–2.5 µm

Conidiogenous cells	Enteroblastic, phialidic, integrated, determinate	Holoblastic, integrated, subcylindrical to obclavate, hyaline, 11–15 × 1.5–2 µm	Holoblastic, integrated, terminal, 8–18 × 1–3 µm	Enteroblastic, phialidic
Conidia	Lenticulate, hyaline, unicellular, 4–5.5 × 1.5–2 µm	Pyriform, unicellular, hyaline, thin-walled, smooth, 10–16 × 2.5–3 µm	Subcylindrical, unicellular, smooth-walled, truncate at the base, 16–24 × 5.5–7 µm	Botuliform, hyaline, unicellular, smooth, 8–15 × 2–3 µm
Conidial appendages	Unbranched, cellular, smooth, thin-walled, eguttulate, 2–7 µm long	Primary appendage 16–23 µm long, 2–3 secondary appendages 12–21 µm	4; filiform, two at either end, unequal in length,16–23 µm long	1; filiform, flexuous, smooth, unbranched, 12–15 µm long

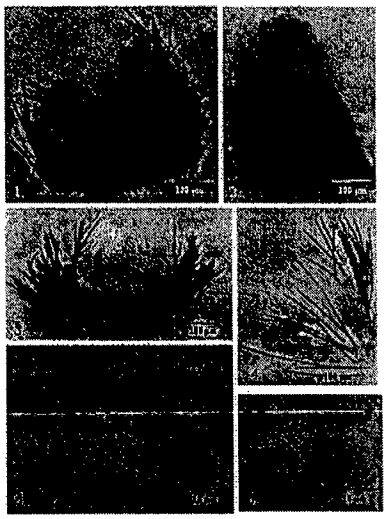


Fig. 1–6 *Dimastigosporium yanense.* 1–2 Conidiomata; 3 Section through a conidioma; 4 Setiferous hyphae; 5 Conidiogenous cells; 6 Conidia

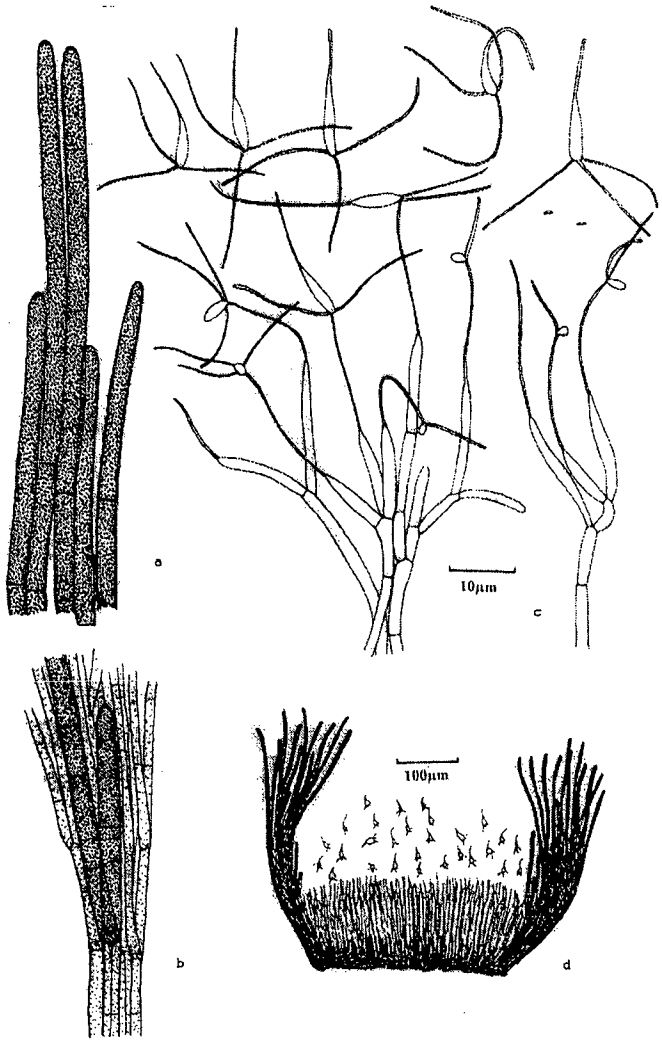


Fig.7. *Dimastigosporium yanense.* a–b, Setiferous hyphae; c, Conidiogenous cells & Conidia; d, Section of a conidioma.

Acknowledgements

The authors are thankful to Dr. Keith Seifert, Agriculture and Agri-Food Canada, Ontario, Canada, and Dr. Eric McKenzie, Landcare Research, New Zealand, for kindly reviewing the manuscript. Dr. Walter Gams, formerly of Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands, is thanked for correcting the Latin diagnosis. SY is thankful to the C.S.I.R., New Delhi, for a student fellowship. DJB is thankful the Council of Scientific & Industrial Research, Ministry of Environment & Forests and the University Grants Commission, New Delhi, for provision of research grants.

References

Breton A, Faurel L. 1970. Etude comparative des *Monodia elegans* nov. gen. sp. et *Pullospora tetrachaeta* Faur. et Schott., Sphaeropsidales coprophiles. Rev. Mycol. 35: 22–40.

Faurel L, Schotter G. 1965. Notes mycologiques. IV. Champignons coprophiles du Sahara central et notamment de la Tefedest. Rev.Mycol. 30: 141–165.

Fuckel L. 1870. Symbolae mycologicae. Jahrb. Nassauischen Vereins Naturk. 23–24: 1–459.

Kendrick B. 1992. The fifth kingdom. 2nd edition. Mycologue Publications, Victoria, BC, Canada. 324 pp.

Nag Raj TR. 1993. Coelomycetous anamorphs with appendage-bearing conidia. Mycologue Publication, Waterloo, Ontario, Canada. 1101 pp.

Strasser PP. 1902. Zweiter Nachtrag zur Pilzflora des Sonntagberges (N.-Österreich). Verh. K.K. Zool.-Bot.Ges. Wien 52:429-437.

Sutton BC. 1980. The Coelomycetes. Commonwealth Mycological Institute. UK. 696 pp.

Plant and Fungal Biodiversity and Bioprospecting, 117-133, 2009
Editors: S. Krishnan & D. J. Bhat, Goa University

Diversity of microfungi in the forests of Western Ghats in Goa and surrounding regions

D. J. Bhat [+], J. Pratibha [*], P. Gawas [*], K. Y. Sarita and D. Swapnaja
Department of Botany, Goa University, Goa-403 206, India
[+]E-mail: *bhatdj@rediffmail.com*
[*]Present Address: Myco Tech Pvt. Ltd., Mapusa Industrial Estate, Mapusa, Goa 403 507, India

Abstract
This paper presents a concise picture of the diversity of microfungi, largely of Hyphomycetes, in the forests of Western Ghats in Goa and neighbouring regions in Maharastra and Karnataka, India. Commenced in 1993-94, various habitats of and substrates from the Western Ghats, viz., aquatic and terrestrial leaf litter, dead insects, endophytes, extremophiles, phylloplanes, herbivore dung, salt pans, soil, wood bark and logs, perishable foods, etc. have been surveyed for microfungi. Several isolation techniques, viz. direct isolation, isolation following moist-chamber incubation, aquatic spore induction and endophytes through 3-step sterilization and litter particle-plating methods, were used to recover the fungi from the substrates. In all, 556 species in 312 genera of fungi have been documented. A sizable number of these are available in live culture form at the Goa University culture collection facility. With this 1½ decade-long mycological survey, it can now be noted that Goa is one of the fairly well-documented provinces in India for microfungi.

Key words: Biodiversity; Endophytes; Entomogenous; Foliicolous; Hyphomycetes; Isolation techniques; Tropical forests.

Introduction
Moist deciduous, wet-evergreen and shola forests of the Western Ghats in southern India are known to harbour a vast variety of flowering plants, ferns, mosses, algae, fungi and lichens (Pascal, 1989). Several distinct endemic elements have been reported from the region. The state of Goa accommodates a sizable portion of the central Western Ghats.

Aquatic, arboreal and terrestrial fungi largely depend on fallen and decaying plant substrates for sustenance (Kendrick, 1992; Hawksworth, 2001). Initiated in 1992-93, systematic survey of the fungi found growing on varied plant substrates such as fallen, decaying leaf litter, endophytes, phylloplane, freshwater aquatics, air, insects and herbivore dung, etc. was made in the forests of Western Ghats in Goa and surrounding areas with an aim to document the microfungal diversity of the region (Bhat, 2000). Besides, substrates in the saltpans and mangroves of the coastal belts of Goa have also been surveyed for

fungi. The results obtained so far were amazing. Besides the common, an exceedingly large number of rare, interesting and new fungi were recovered. Several of these were brought into culture and maintained in a sustainable manner in an *ex situ* culture repository established in the Department of Botany, Goa University, since 1998. The fungi were diagnosed down to species level based on conventional morphological parameters and this paper gives an overview of the microfungal generic diversity in the region.

Methods

Substrates of different kinds, gathered from aquatic, arboreal and terrestrial habitats, were considered as source material or samples for isolation of fungi. The samples from aquatic habitats included freshwater foam containing fungal propagules, submerged decaying leaf litter and live roots extended into stream water. Arboreal habitat offered interesting substrates such as litter from bird nests, rain water from stem flow, fresh leaves and phylloplane surfaces. Fallen, dead and decaying leaves, twigs, wood bark, nuts, fruits, dead insects, herbivore dung and soil constituted the substrates from terrestrial habitat. The substrates used for isolation of fungi are listed in the Table 1.

Table 1. Habitats surveyed and substrates screened for fungi.

Substrates / Habitat	Herbivor dung	Plant litter	Ins-ects	Fresh plant parts	Infected plant parts	Soil	Freshwater
Aquatic	-	+	-	+ (roots)	-	-	+
Arboreal	-	+	-	+ (leaves, stem)	+	-	-
Terrestrial	+	+	+	+ (roots)	-	+	-

In most cases, the samples brought to the laboratory were immediately processed for isolation of fungi. Sometimes, when too many samples were accumulated, part of them was maintained in cold store until processed. The methods used for isolation of fungi were mainly based on the kind of substrates considered for investigation (Table 2).

Table 2. Isolation techniques followed for recovery of fungi.

Substrates / Isolation methods	Herbivore dung	Plant litter	Insects	Fresh plant parts	Infected plant parts	Soil	Aquatic foam
Direct isolation	+	+	+	-	+	-	+
Moist	+	+	-	-	+	-	-

chamber incubation							
Particle plating	+	+	+	-	-	-	-
3-step sterilization	-	-	-	+	-	-	-
Foam plating technique	-	-	-	-	-	-	+
Soil dilution technique	-	-	-	-	-	+	-

The methods are briefly explained and illustrated below:

1. Direct isolation from plant litter:
The sample, say a decaying leaf, nut or bark, was scanned under a stereomicroscope to locate a fungal colony. A small portion of the fungal material was picked by a fine-tipped needle and placed in distilled water or lactophenol mountant and examined under a microscope. The detailed study of morpho-taxonomic characteristics of the fungus was done using a light-transmitted microscope.

2. Recovery following moist chamber incubation (Fig. 1):

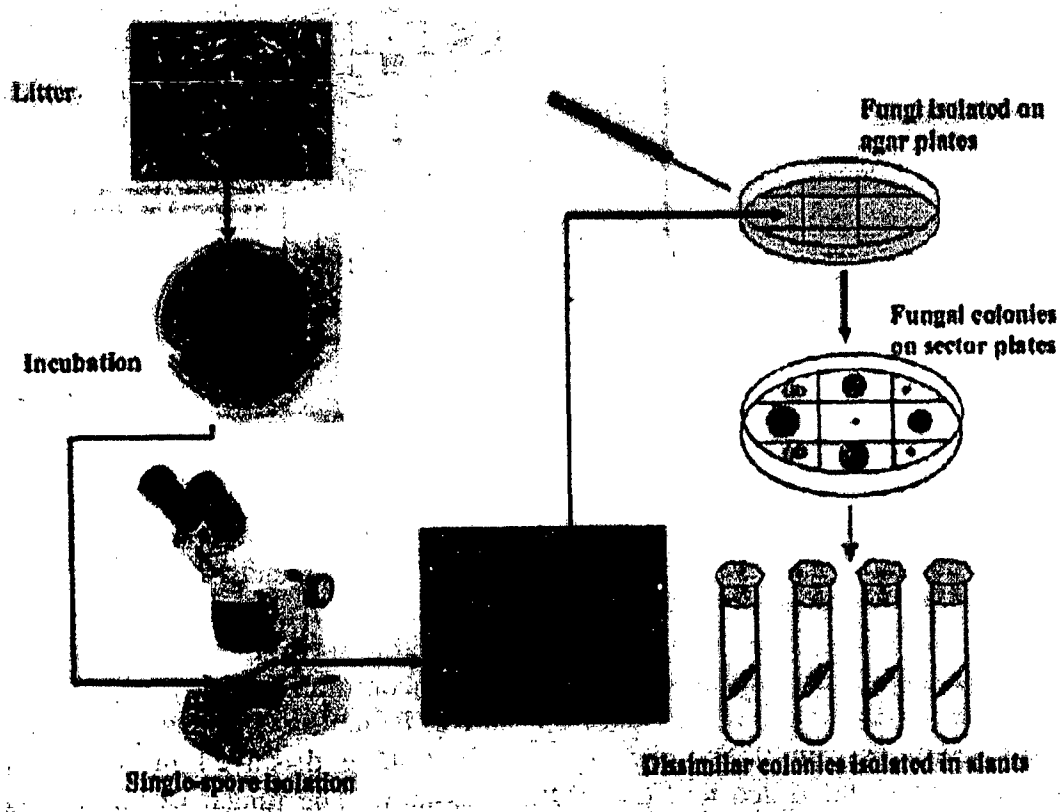


Fig 1. Moist chamber incubation technique

A thin layer of absorbent cotton superimposed by a circular piece of blotting paper was placed in a Petri plate (20 cm diam) and drenched with distilled water. Four micro-slides were placed on the filter paper. The plates were sterilized at 121°C and 15lbs/cm^3 pressure in an autoclave for 20 min. The sample was thoroughly washed in sterile distilled water, placed in the sterile moist plates and incubated at room temperature. Beginning on the 3rd day, the incubated samples were scanned daily under a stereomicroscope for growth of the fungi. The fungal colony was picked up and mounted on a slide containing a drop of distilled water or lactophenol for microscopic examination.

3. Isolation by particle-plating (Fig 2):

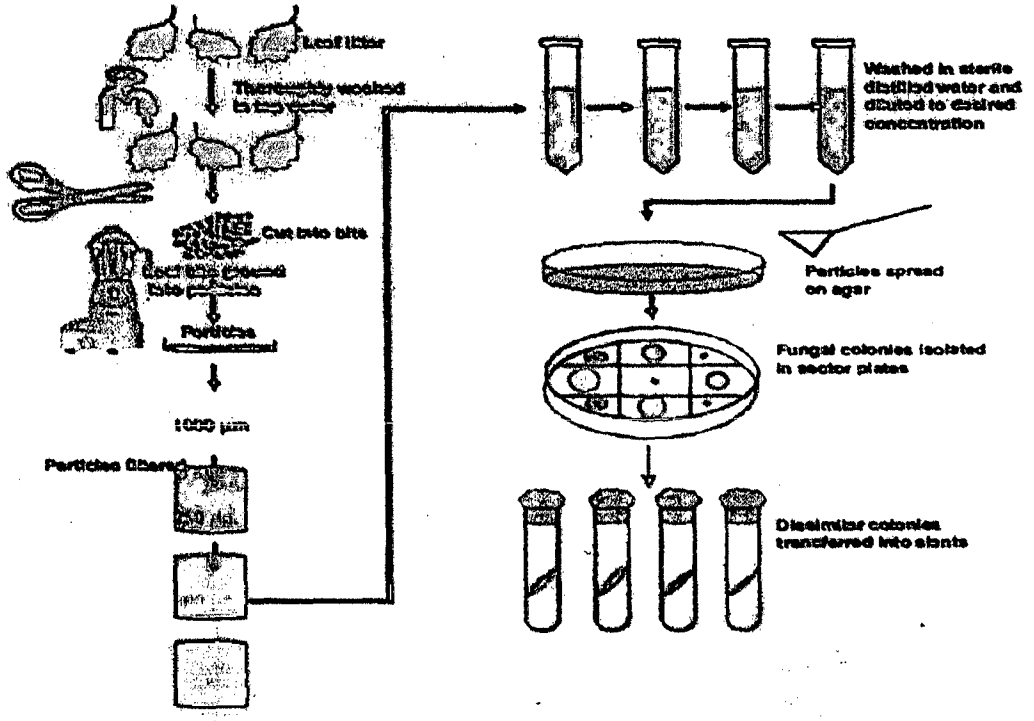


Fig 2. Particle plating technique

Decaying leaves, twigs or bark was cut into small pieces and ground to fine particles in an electric blender. The particles were filtered through three super-imposed metal sieves with mesh size of 1000 µm, 250 µm and 100 µm. The fine particles of size between 100 and 250 µm trapped in the lower sieve were repeatedly washed in sterile distilled water, diluted to suitable concentration and plated on malt extract agar (MEA) medium incorporated with a mixture of antibiotics (Bacitracin 0.02 g, Neomycin 0.02 g, Penicillin G 0.02 g, Polymixin 0.02 g, Streptomycin 0.02 g and Tetramycin 0.04 g dissolved in 10 ml of distilled water and added to 1 L of MEA medium). The fungal hypha arising

from the particles was aseptically and individually transferred into fresh MEA slants (Bills and Polishook, 1994).
Not all but some of the fungi sporulated in culture on several days/weeks of incubation. These were examined under the microscope and identified.

4. Isolation of aquatic fungi by foam plating technique (Fig. 3):

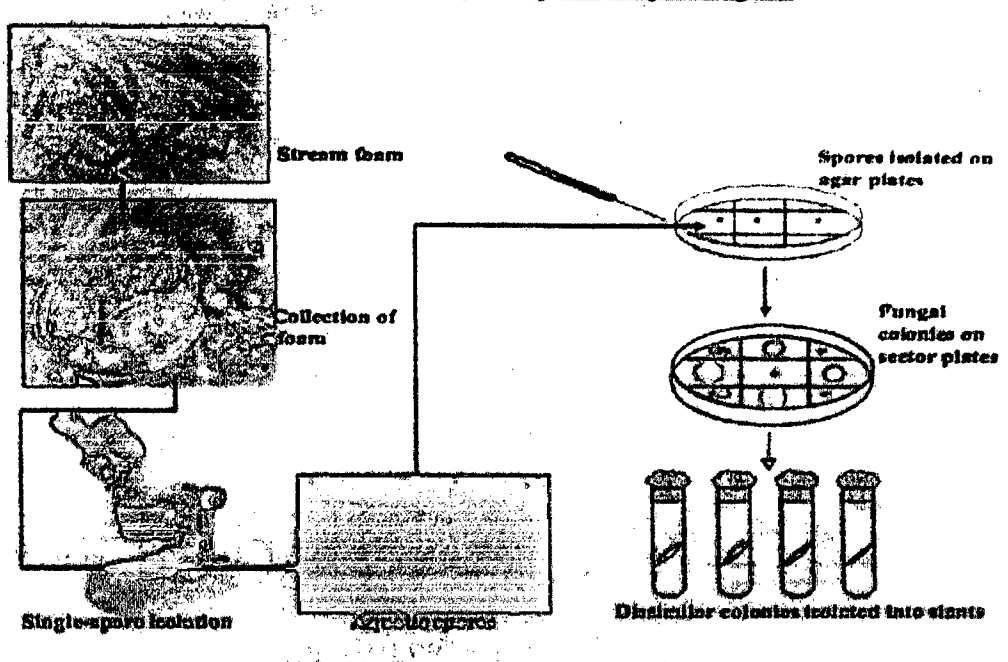


Fig. 3. Foam plating technique

Naturally occurring surface foam, presumably laden with a heavy load of aquatic fungal spores, from clean running freshwater stream was scooped out into a glass jar and thinly spread over antibiotic-incorporated malt extract agar (MEA) plates. After a few hours of incubation spores germinate. The germinating spores/conidia were singularly and aseptically picked up and transferred into fresh MEA slants.
When natural foam was not available, a few decaying leaves were gathered from the stream-bed and placed in glass jars, containing each 1 leaf in 500 ml distilled water. A constant flow of air was introduced into the jar using a fish-aerator. The agitation of water column induced fungal sporulation. Foam bubbles accumulated on the surface contained conidia and these were scooped and used for single-spore isolation. A sizeable collection of microfungi were brought into pure culture using this technique (Ingold, 1975).

5. Three-step sterilization for endophytes (Fig. 4):
The sample, fresh leaf or twig, after washing with sterile distilled water, was surface sterilized, first with 70% ethanol (1 min), followed by 4% Sodium hypochlorite (3 mins) and finally with 70% ethanol (30 secs) again. The plant tissue was than thoroughly washed thrice in sterile distilled water. The surface

sterilized leaf tissue was cut into pieces of 0.5 cm^2, plated on 2% MEA medium and incubated at 25°C up to 14 days. The fungal colonies emerging out of the tissue bits were transferred onto fresh plates. The plates were maintained until the cultures sporulated in the medium (Petrini, 1986).

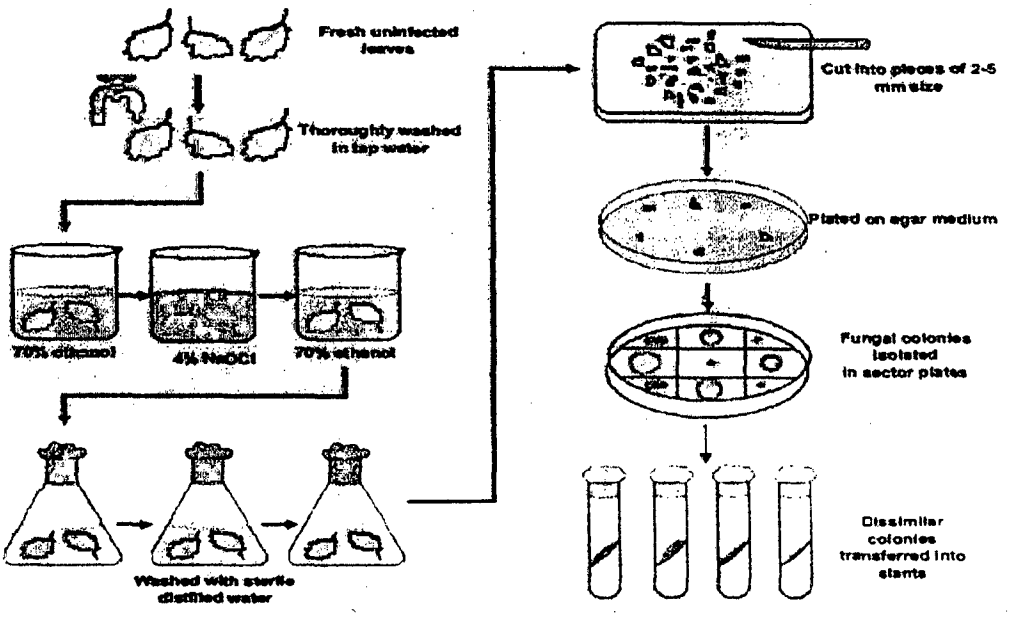


Fig 4. 3-step sterilization technique

6. Recovery of entomogenous fungi:
The dead or moribund insects of any kind found adhering to the leaf surface were carefully picked up from the substrate and plated on antibiotic-embedded agar medium. The fungal colonies emerging out of the insect tissue were isolated aseptically and transferred onto fresh plates. The plates were maintained until the cultures sporulated well in the medium.

7. Isolation of phylloplane or foliicolous fungi:
The infected leaves, directly or after incubation in a moist chamber, were scanned under stereomicroscope and a sterile needle was allowed to touch the spore-producing part, conidiophore, ascocarp or pycnidium, of the growing fungus. Several spores get attached to the loop due to tenacity. A drop of sterile distilled water was taken on a clean flame-sterilized slide and a loop load of spore mass was placed in it. The soaked spores were spread on a Petri plate containing 2% MEA medium. On subsequent days, as and when individual spores germinate, a small block of agar with mycelium was cut and transferred on to an agar slant to maintain a pure culture of the fungus.

Results

The data presented here (Table 3) is based on the results obtained from systematic studies on fungi carried out by a number of students who did these as part of their masterate or doctoral programme under the guidance of the senior author since 1993 (Coelho, 1998; Colgaonkar, 2001; Divkar, 1993; D'souza, 2002; D'souza & Bhat, 2001a, 2001b, 2002a, 2002b; Gawas, 2004; Gawas & Bhat, 2005; Jacob, 1996, 2000; Jacob & Bhat, 1997, 2000, 2000a; Jalmi, 2006; Kalekar, 2003; Keshava Prasad, 2003; Keshavaprasad & Bhat, 2002a, 2002b; Keshavaprasad *et al.*, 2004; Nair, 1998; 2002; Nair & Bhat, 2001; 2002; Pednekar, 2003; Prabhugaonkar, 2005; Pratibha and Bhat, 2006; Pratibha *et al.*, 2005; Ramaswamy, 2006; Rodrigues, 1993; Sawal, 1996; Soosamma *et al.*, 2001; Vengurlekar, 1997; Yadav, 2006).

In all, 556 species in 312 genera of microfungi have been documented. Of these, 62% are available in live form in the culture collection facility at Department of Botany, Goa University. The following are the new genera of hyphomycetes described during this floristic study: *Bharatheeya* D'Souza & Bhat (2002), *Ceeveesubramaniomyces* Pratibha & Bhat (2004), *Kumbhamaya* M. Jacob & D. J. Bhat (2000), *Natarajania* Pratibha & Bhat (2005) and *Vamsapriya* Gawas & Bhat (2005). Twenty-one new species of fungi were described. With this 1½ decade-long mycological survey, Goa can be considered as one of the fairly well-documented provinces in India, for microfungi.

Table 3. Genera of fungi encountered on different substrates, during the study:

Genera of Fungi	Substrates scanned						
	A	B	C	D	E	F	G
Absidia Tiegh.	1	1	-	-	-	-	-
Acremoniula G. Arnaud ex Cif.	-	1	-	-	-	1	-
Acremonium Link	-	4	3	-	2	2	-
Acroconidiellina M.B. Ellis	-	-	-	-	1	-	-
Acrodictys M.B. Ellis	-	4	-	-	-	-	-
Acrogenospora M.B. Ellis	-	2	-	-	-	-	-
Acrophialophora Edward	-	-	-	-	1	-	-
Actinocladium Ehrenb.	-	1	-	-	-	-	-
Actinomucor Schostak.	2	-	-	-	-	-	-
Agarwalomyces R.K. Verma & Kamal	1	-	-	-	-	-	-
Aigialus Kohlm. & S. Schatz	-	1	-	-	-	-	-
Alatospora Ingold	-	-	-	-	-	-	3
Alternaria Nees	-	5	-	3	5	3	-
Ambrosiella Brader	-	1	-	-	-	-	-
Anguillospora Ingold	-	-	-	-	-	-	6
Anulosporium Sherb.	-	-	-	-	-	-	1
Aquaphila Goh, K.D.Hyde & W.H. Ho	-	2	-	-	-	-	-
Ardhachandra Subram. & Sudha	-	2	-	-	1	-	1

Arenariomyces Höhnk	-	2	-	-	-	-	-
Arthrinium Kunze	-	1	-	-	-	-	-
Arthrobotrys Corda	-	2	-	-	-	-	-
Arthrobotryum Ces.	-	1	-	-	-	-	-
Articulospora Ingold	-	-	-	-	-	-	1
Arxiella Papendorf	-	1	-	1	-	-	-
Aschersonia Mont.	-	-	5	-	-	-	-
Ascobolus Pers.	2	-	-	-	-	-	-
Aspergillus P. Micheli ex Link	4	9	10	3	2	12	-
Asterina Lév.	-	-	-	-	1	-	-
Bacillispora Sv. Nilsson	-	1	-	-	-	-	-
Bahupaathra Subram. & Lodha	1	-	-	-	-	-	-
Bahusakala Subram.	-	1	-	-	-	-	-
Bahusutrabeeja Subram. & Bhat	-	4	-	-	2	-	-
Beltrania Penz.	-	6	1	1	1	1	2
Beltraniella Subram.	-	4	-	2	1	1	1
Bharatheeya D'Souza & Bhat	-	2	-	-	-	-	-
Botryosporium Corda	-	1	-	-	-	-	-
Botrysphaeria Ces. & De Not.	-	-	-	-	1	-	-
Brachysporiella Bat.	-	1	-	-	-	-	-
Camposporium Harkn.	-	2	-	-	-	-	2
Campylospora Ranzoni	-	2	-	-	-	-	1
Canalisporium Nawawi & Kuthub.	-	2	-	-	-	-	-
Candelabrum Beverw.	-	1	-	-	-	-	-
Catenularia Grove	-	1	-	-	-	-	-
Ceeveesubramaniomyces Pratibha & Bhat	-	-	-	-	1	-	-
Centrospora Neerg.	-	1		-	-	-	-
Cephaliophora Thaxt.	3	-	-	-	-	-	-
Ceratosporella Höhn.	-	-	-	-	1	-	-
Ceratosporium Schwein.	-	1	-	-	-	-	-
Cercophora Fuckel	2	-	-	-	-	-	-
Cercospora Fresen.	-	2	-	2	20	1	-
Chaetendophraginia Matsush.	-	2	-	-	-	-	1
Chaetomella Fuckel	-	-	1	-	1	-	1
Chaetomium Kunze	5	1	-	1	-	1	1
Chaetopsina Rambelli	-	-	-	-	1	-	-
Chaetospermum Sacc.	-	-	-	-	-	-	1
Chalara (Corda) Rabenh.	-	1	-	-	3	-	-
Chlamydomyces Bainier	-	2	-	-	-	1	-
Chloridium Link	-	1	-	-	-	-	-
Choanephora Curr.	-	-	-	-	1	-	-
Chrysosporium Corda	-	1	-	-	-	-	-
Circinella Tiegh. & G. Le Monn.	4	-	-	-	-	-	-
Circinotrichum Nees	-	2	-	-	-	-	-

Cirrenalia Meyers & R.T. Moore	-	1	-	-	-	-	-
Cladosporium Link	1	4	5	2	2	2	-
Clavariopsis De Wild.	-	-	-	-	-	-	1
Clavatospora Sv. Nilsson ex Marvanová & Sv. Nilsson	-	-	-	-	-	-	2
Codinaea Maire	-	-	-	-	-	-	2
Coemansia Tiegh. & G. Le Monn.	1	-	-	-	-	-	-
Colletotrichum Corda	-	-	-	2	5	-	1
Condylospora Nawawi	-	1	-	-	-	-	1
Conidiobolus Bref.	-	-	2	-	-	-	-
Conioscypha Höhn.	-	1	-	-	-	-	-
Coniothyrium Corda	-	1	-	-	-	-	-
Cordana Preuss	-	1	-	-	1	-	-
Corynespora Güssow	-	3	-	-	11	-	2
Craspedodidymum Hol.-Jech.	-	2	-	-	-	-	-
Cunninghamella Matr.	-	1	-	-	-	-	-
Curvularia Boedijn	4	9	2	1	5	3	1
Cylindrocarpon Wollenw.	-	4	-	-	1	1	2
Cylindrocladiopsis J.M. Yen	-	1	-	-	-	-	-
Cylindrocladium Morgan	-	2	2	2	1	1	2
Cylindrotrichum Bonord.	-	5	-	-	2	-	-
Dactylaria Sacc.	-	2	-	1	-	-	-
Dactylella Grove	-	1	-	-	1	-	-
Deightoniella S. Hughes	-	1	-	-	1	-	-
Dematophora R. Hartig	-	1	-	-	1	-	-
Dendrospora Ingold	-	-	-	-	-	-	2
Dendrosporium Plakidas & Edgerton ex J.L. Crane	-	1	-	1	-	-	1
Dendrostilbella Höhn.	-	1	-	-	-	-	-
Dendryphiopsis S. Hughes	-	1	-	-	-	-	-
Denticularia Deighton	-	-	-	-	1	-	-
Dichotomophthoropsis M.B. Ellis	-	-	-	1	-	-	-
Dictyoarthrinium S. Hughes	-	1	-	-	-	-	-
Dictyochaeta Speg.	-	4	-	1	-	-	1
Dictyosporium Corda	-	2	-	1	1	-	-
Dicyma Boulanger	-	1	-	-	-	-	-
Didymella Sacc.	-	1	-	-	-	-	-
Didymobotryum Sacc.	-	2	-	-	-	-	-
Didymosphaeria Fuckel	-	1	-	-	-	-	-
Diplocladiella G. Arnaud ex M.B. Ellis	-	1	-	-	-	-	2
Diplococcium Grove	-	-	-	-	1	-	-
Diploospora Grove	-	1	-	-	-	-	-
Dischloridium B. Sutton	-	1	-	-	1	-	-
Doratomyces Corda	4	1	-	-	1	-	-

Drechslera S. Ito	-	4	-	-	3	-	-
Echinopodospora B.M. Robison	-	-	-	-	-	1	-
Echinosphaeria A.N. Mill. & Huhndorf	-	-	-	1	-	-	-
Edmundmasonia Subram.	-	1	-	-	-	-	-
Eladia G. Sm.	-	1	-	-	-	2	-
Elegantimyces Goh, K.M. Tsui & K.D. Hyde	-	1	-	-	-	-	-
Emericella Berk.	-	-	-	-	-	1	1
Emericellopsis J.F.H. Beyma	-	-	-	-	-	1	-
Endophragmia Duvernoy & Maire	-	3	-	-	-	-	-
Epicoccum Link	-	2	-	-	-	-	-
Esdipatilia Phadke	-	1	-	-	-	-	-
Eupenicillium F. Ludw.	-	-	-	-	-	1	-
Excipularia Sacc.	-	-	-	-	1	-	-
Exosporium Link	-	1	-	-	-	-	-
Exserticlava S. Hughes	-	1	-	-	-	-	-
Flabellospora Alas	-	1	-	-	-	-	2
Flagellospora Ingold,	-	-	-	-	-	-	2
Fulvia Cif.	-	1	-	-	-	-	-
Fusariella Sacc.	-	4	-	-	1	-	-
Fusarium Link	3	8	10	3	9	11	-
Fusichalara S. Hughes & Nag Raj	-	1	-	-	-	-	-
Gangliostilbe Subram. & Vittal	-	1	-	-	-	-	-
Geotrichum Link	-	-	-	-	1	-	-
Gibberella Sacc.	-	1	-	-	1	-	-
Gibelluia Cavara	-	-	1	-	-	-	-
Gilmaniella G.L. Barron	-	1	-	-	-	1	-
Gliocephalis Matr.	1	-	-	-	-	-	-
Gliocladiopsis S.B. Saksena	-	-	2	-	-	-	-
Gliocladium Corda	-	2	3	-	-	-	-
Gliomastix Guég.	-	3	-	1	-	-	-
Glomerella Spauld. & H. Schrenk	-	4	-	-	-	-	-
Gonatobotryum Sacc.	-	2	-	2	2	-	-
Gonatophragmium Deighton	-	-	-	-	1	-	-
Gonytrichum Nees & T. Nees	-	2	-	1	-	-	-
Graphium Corda	2	1	-	-	-	-	-
Guignardia Viala & Ravaz	-	1	-	-	1	-	-
Hansfordia S. Hughes	-	1	-	-	1	-	-
Haplographium Berk. & Broome	1	-	-	-	-	-	-
Helicoma Corda	-	2	-	-	-	-	-
Helicomyces Link	-	3	-	-	-	-	2
Helicosporium Nees	-	3	-	-	-	-	3
Helicostylum Corda	2	-	-	-	-	-	-
Helminthosporium Link	-	4	-	-	-	-	-

Hemicorynespora M.B. Ellis	-	1	-	-	-	-	-
Hermatomyces Speg.	-	1	-	-	1	-	-
Heteroconium Petr.	-	2	-	-	-	-	-
Hirsutella Pat.	-	-	2	-	-	-	-
Humicola Traaen	-	2	-	-	-	-	-
Hymenoscyphus Gray	-	-	-	-	-	-	1
Hyphodiscosia Lodha & K.R.C. Reddy	-	1	-	-	-	-	-
Hypocrella Sacc.	-	-	1	-	-	-	-
Hypoxylon Bull.	-	2	-	-	-	-	-
Idriella P.E. Nelson & S. Wilh.	-	13	-	4	-	5	1
Ingoldiella D.E. Shaw	-	1	-	-	-	-	2
Isaria Fr.	1	-	-	-	1	-	-
Isthmotricladia Matsush.	-	2	-	-	-	-	2
Iyengarina Subram.	-	1	-	-	-	-	-
Janetia M.B. Ellis	-	-	-	-	1	-	-
Kramasamuha Subram. & Vittal	-	1	-	-	1	-	-
Kumbhamaya M. Jacob & D.J. Bhat	-	3	-	3	-	-	-
Kylindria DiCosmo, S.M. Berch & W.B. Kendr.	-	2	-	1	-	-	-
Lacellinopsis Subram.	-	1	-	-	-	-	-
Lasiodiplodia Ellis & Everh.	-	3	-	-	1	-	-
Lateriramulosa Matsush.	-	1	-	-	-	-	-
Lemonniera De Wild.	-	1	-	-	-	-	2
Leptosphaeria Ces. & De Not.	-	2	-	-	-	-	-
Lunulospora Ingold	-	1	-	-	-	-	2
Mariannaea G. Arnaud ex Samson	-	1	-	-	-	-	-
Melanocephala S. Hughes	-	1	-	-	-	-	-
Melanographium Sacc.	-	1	-	-	-	-	-
Melanospora Corda	1	-	-	-	-	-	-
Meliola Fr.	-	-	-	-	2	-	-
Memnoniella S. Hughes	2	3	-	-	1	2	-
Menisporopsis S. Hughes	-	-	-	-	1	-	1
Microascus Zukal	-	1	-	-	-	-	-
Microsporum Gruby	1	-	-	-	-	-	-
Miladina Svrček	-	-	-	-	-	-	2
Mirandina G. Arnaud ex Matsush.	-	1	-	-	-	-	-
Monodictys S. Hughes	-	6	-	-	2	-	-
Moorella P. Rag. Rao & D. Rao	-	1	-	-	-	-	-
Morrisographium M. Morelet	-	2	-	-	-	-	-
Mortierella Coem.	-	1	-	-	-	1	-
Mucor Fresen.	5	4	-	-	-	3	-
Mycoleptodiscus Ostaz.	-	2	-	-	-	-	3
Mycovellosiella Rangel	-	1	-	-	1	-	-
Myrothecium Tode	3	-	-	1	3	-	-

Nakataea Hara	-	1	-	-	-	-	-
Natarajenia Pratibha & Bhat	-	1	-	-	-	-	-
Nawawia Marvanová,	-	1	-	-	-	-	1
Nectria (Fr.) Fr.	-	3	-	-	-	-	1
Neottiosporella Höhn. ex Falck	-	1	-	-	-	-	-
Nigrospora Zimm.	-	3	-	2	2	2	-
Nodulisporium Preuss	-	5	-	1	-	-	-
Ophionectria Sacc.	-	1	-	-	-	-	-
Paecilomyces Bainier	-	3	8	-	-	2	-
Parahelminthosporium Subram. & Bhat	-	1	-	-	-	-	-
Parodiella Speg.	-	-	-	-	1	-	-
Passalora Fr.	-	-	-	-	5	-	-
Penicillium Link	6	3	10	2	4	7	-
Periconia Tode	1	4	-	-	3	-	1
Periconiella Sacc.	-	2	-	-	2	-	-
Pestalotiopsis Steyaert	-	3	-	1	2	1	2
Phaeoisaria Höhn.	2	2	-	-	1	-	-
Phaeoramularia Munt.-Cvetk.	-	-	-	-	1	-	-
Phaeotrichoconis Subram.	-	1	-	-	1	-	-
Phalangispora Nawawi & J. Webster	-	2	-	-	1	-	2
Phialocephala W.B. Kendr.	-	2	-	-	-	-	-
Phialomyces P.C. Misra & P.H.B. Talbot	-	1	-	-	-	-	-
Phialophorophoma Linder	-	1	-	-	-	-	-
Phoma Sacc.	-	2	-	-	2	-	-
Phyllachora Nitschke ex Fuckel	-	-	-	-	2	-	-
Pilobolus Tode	2	-	-	-	-	-	-
Piptocephalis de Bary	3	-	-	-	-	-	-
Piricauda Bubák	-	1	-	-	-	-	-
Pithomyces Berk. & Broome	1	3	-	1	3	1	1
Pleurophragmium Costantin	-	2	-	-	-	-	-
Pleurothecium Höhn.	-	2	1	-	-	-	-
Podonectria Petch	-	-	1	-	-	-	-
Podospora Ces.	4	-	-	-	-	-	-
Podosporium Schwein.	-	2	-	-	-	-	-
Poltrasia P.M. Kirk	-	-	-	-	-	-	1
Polychaeton (Pers.) Lév.	-	-	-	-	2	-	-
Polyschema H.P. Upadhyay	-	2	-	-	-	-	-
Pseudobotrytis Krzemien. & Badura	-	2	-	-	-	1	-
Pseudocercospora Speg.	-	-	-	-	18	-	-
Pseudocercosporella Deighton	-	-	-	-	2	-	-
Pseudophaeoramularia U. Braun	-	-	-	-	1	-	-
Pseudospiropes M.B. Ellis	-	-	-	-	1	-	-
Pteroconium Sacc. ex Grove	-	1	-	-	-	-	-
Pyricularia Sacc.	-	2	-	-	1	-	-

Pyriculariopsis M.B. Ellis	-	-	-	-	1	-	-
Ramaraomyces N.K. Rao, Manohar. & Goos	-	1	-	-	-	-	-
Ramichloridium Stahel ex de Hoog	-	1	-	-	-	-	-
Raperia Subram. & Rajendran	-	1	-	-	-	-	-
Rhinocladiella Nannf.	-	1	-	-	-	-	-
Rhizopus Ehrenb.	3	-	-	-	2	1	-
Robillarda Sacc.	-	-	-	1	-	-	2
Saccardaea Cavara	-	1	-	-	-	-	-
Saccobolus Boud.	2	-	-	-	-	-	-
Sarcinella Sacc.	-	-	-	-	1	-	-
Savoryella E.B.G. Jones & R.A. Eaton	-	1	-	-	-	-	-
Sclerographium Berk.	-	1	-	-	-	-	-
Scolecobasidium E.V. Abbott	-	4	-	3	1	-	-
Scutisporus K. Ando & Tubaki	-	-	-	-	-	-	1
Scytalidium Pesante	-	1	-	-	-	-	-
Seimatosporium Corda	-	1	-	1	1	-	2
Selenodriella R.F. Castañeda & W.B. Kendr.	-	1	-	-	-	-	-
Selenosporium Corda	-	1	-	-	-	-	-
Septonema Corda	-	1	-	-	-	-	-
Septoria Sacc.	-	-	-	-	1	-	-
Sesquicillium W. Gams	-	-	-	1	1	-	-
Sirosporium Bubák & Serebrian.	-	-	-	-	1	-	-
Solosympodiella Matsush.	-	1	-	-	-	-	-
Sopagraha Subram. & Sudha	-	1	-	-	-	-	-
Sordaria Ces. & De Not.	1	-	-	-	-	-	-
Sorocybe Fr.	-	2	-	-	-	-	-
Spadicoides S. Hughes	-	2	-	-	-	-	-
Spegazzinia Sacc.	-	1	-	-	-	-	1
Speiropsis Tubaki	-	2	-	-	-	-	2
Spiralum J.L. Mulder	-	-	-	-	1	-	-
Spiropes Cif.	-	-	-	-	2	-	-
Sporidesmiopsis Subram. & Bhat	-	1	-	-	-	-	-
Sporidesmium Link	-	7	-	-	4	-	-
Sporormiella Ellis & Everh.	2	-	-	-	-	-	-
Sporoschisma Berk. & Broome	-	4	-	-	-	-	-
Stachybotrys Corda	2	3	-	2	2	-	-
Stachylidium Link	-	1	-	-	-	-	-
Stellomyces Morgan-Jones, R.C. Sinclair & Eicker	-	1	-	-	-	-	-
Stemonitis Gled.	-	2	-	-	-	-	-
Stemphylium Wallr.	-	-	-	-	1	-	-
Stenella Syd.	-	-	-	-	4	-	-

Stigmina Sacc.	-	-	-	-	1	-	-
Stilbella Lindau	-	1	-	-	-	-	-
Stilbum Tode	-	-	-	-	1	-	-
Subulispora Tubaki	-	1	-	-	-	-	1
Sympodiella W.B. Kendr.	-	1	-	-	-	-	-
Syncephalastrum J. Schröt.	-	-	-	-	1	-	-
Tetrachaetum Ingold	-	1	-	-	-	-	-
Tetraploa Berk. & Broome	1	1	-	-	-	-	1
Tetraposporium S. Hughes	-	1	-	-	-	-	-
Thamnidium Link,	1	-	-	-	-	-	-
Thozetella Kuntze	-	3	-	-	-	-	-
Tomenticola Deighton	-	-	-	-	1	-	-
Torula Pers.	-	3	-	-	1	-	-
Trematostoma (Sacc.) Shear,	-	1	-	-	-	-	-
Trichobotrys Penz. & Sacc.	-	4	-	-	-	-	-
Trichoderma Pers.	2	2	1	-	1	2	-
Trichotheclum Link	2	2	-	-	2	-	-
Tricladium Ingold	-	2	-	1	-	1	4
Trinacrium Riess	-	3	-	-	-	-	-
Tripospermum Speg.	-	2	-	-	-	-	1
Triscelophorus Ingold	-	1	-	-	-	-	3
Tritirachium Limber	-	2	-	-	-	-	-
Tubercularia Tode	-	2	-	-	1	-	-
Vamsapriya Gawas & Bhat	-	1	-	-	-	-	-
Vanakripa Bhat, W.B. Kendr. & Nag Raj	-	2	-	-	-	-	-
Varicosporium W. Kegel	-	-	-	-	-	-	2
Vermiculariopsiella Bender,	-	5	-	7	5	-	1
Vermispora Deighton & Piroz.	-	1	-	-	-	-	-
Veronaea Cif. & Montemart.	-	3	-	-	-	-	-
Verticillium Nees	-	1	-	-	1	-	1
Virgaria Nees	-	-	-	-	-	-	1
Virgatospora Finley	-	2	-	1	-	-	-
Volutella Fr.	1	1	-	-	-	-	-
Wardomyces F.T. Brooks & Hansf.	-	1	-	-	1	-	-
Wiesneriomyces Koord.	-	1	-	1	-	1	1
Xylaria Hill ex Schrank,	-	1	-	-	-	-	1
Zalerion R.T. Moore & Meyers	-	1	-	-	-	-	-
Zygosporium Mont.	-	4	-	-	3	-	-

A=Dung, B=Plant litter, C=insects, D=fresh plant parts (Endophytes), E=infected plant parts (Foliicolous), F= soil, G=freshwater

Acknowledgements

We are thankful to the DST, ICMR, MOENF and CSIR, New Delhi, for research grant support and the UGC, New Delhi, for a DRS level Special Assistance Programme to the Department of Botany, Goa University.

References

Bhat, D. J. 2000. Planning for Biodiversity Study of Fungi of India. In: Aneja, K. R., Charaya MU, Aggarwal A, Hans DK, Khan SK. eds. *Glimpses in Plant Sciences* - Professor R. S. Mehrotra Felicitation Volume. Meerut: Pragati Prakashan, 59-62.

Bills, G. F. and J. D. Polishook. 1994. Abundance and diversity of microfungi in leaf litter of a lowland rainforest in Costa Rica. *Mycologia* **86**:187-198.

Coelho, M. 1998. *Observations on association of fungi with plant parts of* Artocarpus heterophyllus *Lamark. Unpublished Dissertation Thesis, Goa University.*

Colgaonkar, P. 2001. Studies on coprophilous fungi from Goa. Unpublished Dissertation Thesis, Goa University.

Divkar, R. 1993. Studies on some aspects of fungal association on the growth of rice plant. Unpublished Dissertation Thesis, Goa University.

D'Souza, M. and D. J. Bhat. 2001a. Two new hyphomycetes form India. In: Sinha A, ed. *Microbes and plants* - Professor R. Dayal Festschrift.. New Delhi: Campus Books International, 1-7.

D'Souza, M. and D. J. Bhat. 2001b. A new species of *Trichobotrys* from the Western Ghat forests, India. *Mycotaxon* **80**: 104-108.

D'Souza, M. and D. J. Bhat. 2002a. *Bharatheeya*, a new hyphomycete genus from India. *Mycotaxon* **83**: 397-403.

D'Souza, M. and D. J. Bhat. 2002b. *Didymobotryum spirillum*, a new synnematous hyphomycete from India. *Mycologia* **94**: 535-538.

D'Souza, M. 2002. Studies on diversity, ecology and biology of microfungi associated with a few dicot and monocot plant species of Western Ghats in Goa state, India. Unpublished Ph.D. Thesis, Goa University.

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

Gawas, P. 2004. Studies on diversity, ecology and activity of arboricolous microfungi. Unpublished Dissertation Thesis, Goa University.

Ingold, C. T. 1975. *An illustrated guide to aquatic and water-borne Hyphomycetes (Fungi imperfectii) with notes on their biology.* England: Freshwater biological association scientific publication No. 30.

Jacob, M. and D. J. Bhat. 1997. *Microsporum appendiculatum* sp.nov. on goat dung from India. *Kavaka* **25**: 93-94.

Jacob, M. and D. J. Bhat. 2000a. Two new endophytic conidial fungi from India. *Cryptogamie mycologie* **21**: 81-88.

Jacob, M. and D. J. Bhat 2000b. Diversity and abundance of microfungi on decaying leaf litter of *Ficus bengalensis* Linn. In: Bhat, D.J., Raghukumar S, eds. *Ecology of fungi.* Goa: Goa University Publication, 33-39.

Jacob, M. 1996. *Study of diversity in coprophilous fungi. Unpublished Dissertation Thesis, Goa University.*

Jacob, M. 2000. Studies on diversity, ecology and activity of the microfungi associated with *Ficus benghalensis* Linn. and *Carissa congesta* Wight from Goa state. Unpublished Ph.D. Thesis, Goa University.

Jalmi, P. 2006. Studies on Foliicolous Fungi from Goa and neighbouring areas of Maharashtra & Karnataka. Unpublished Ph.D. Thesis, Goa University.

Hawksworth, D. L. 2001. The magnitude of fungal diversity: the 1.5 million species estimate revisited. *Mycological Research* **105**: 1422-1433.

Kalekar, S. 2003. Wood-inhabiting fungi from the forests of Western Ghats, Goa. Unpublished Dissertation Thesis, Goa University.

Kendrick, B. 1992. *The Fifth Kingdom.* Waterloo: Mycologue Publications.

Keshavaprasad, T. S., Kumar, A. and D. J. Bhat. 2004. New records of *Aschersonia* from forests of Western Ghats, India. *Indian Journal of Mycology and Plant Pathology* 34: 7-14.

Keshavaprasad, T. S. 2003. Studies on diversity, ecology and activity of microfungi in relation to mosquito developmental stages. Unpublished Ph.D. Thesis, Goa University.

Keshavaprasad, T. S. and D. J. Bhat. 2002a. *Stellomyces kendrickii*, a new hyphomycete from India. *Mycotaxon* 84: 61-63.

Keshavaprasad, T. S. and D. J. Bhat. 2002b. A new species of *Phalangispora* from India. *Mycotaxon* 83: 403-407.

Nair, S. K. 1998. Aquatic hyphomycetes from a few freshwater streams in Goa: as revealed from a monsoon seasonal study. Unpublished Dissertation Thesis, Goa University.

Nair, S. K. 2002. Studies on diversity, ecology and biology of aquatic fungi of some freshwater streams of Western Ghat forests in Goa state, India. Unpublished Ph.D. Thesis, Goa University.

Nair, S. K. and D. J. Bhat. 2001. *Diploospora indica*, a new species of Hyphomycetes. *Mycotaxon* 80: 101-104.

Nair, S. K. and D. J. Bhat. 2002. *Kumbhamaya jalapriya*, a new endophytic hyphomycete from India. *Mycotaxon* 84: 65-68.

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

Pednekar, S. 2003. Diversity of aquatic fungi in streams of Goa. Unpublished Dissertation Thesis, Goa University.

Petrini, O. 1986. Taxonomy of endophytic fungi of aerial plant tissues. In: Fokkema NJ, Van den Heuvel J, eds. *Microbiology of the phyllosphere.* London: Cambridge University Press, 175-187.

Prabhugaonkar, A. 2005. Fungi associated with ornamental plants of Goa. Unpublished Dissertation Thesis, Goa University.

Pratibha, J. and D. J. Bhat. 2006. *Bahusutrabeeja manoharacharii* sp. nov. a foliicolous hyphomycete from the forests of Western Ghats, India. In: Bagyanarayana G, Bhandariah B, Kumar IK, eds. *Emerging Trends in Mycology plant pathology and microbial biotechnology*. Hyderabad: BS Publications, 1-5.

Pratibha, J., Hyde, K. D. and D. J. Bhat. 2004. *Ceeveesubramaniomyces*. a new dematiaceous hyphomycetous genus from India. *Kavaka* **32**: 21-26.

Pratibha, S. J., Puja, G., Shenoy, B. D., Hyde, K. D. and D. J. Bhat. 2005. *Chalara indica* sp nov. and *Sorocybe indicus* sp. nov. from India. *Cryptogamie Mycologie* **26**(2): 97-103.

Puja, G., Shenoy, B. D., Hyde, K. D. and D. J. Bhat. 2005. *Echinosphaeria macrospora* sp. nov., teleomorph of *Vermiculariopsiella* endophytica sp. nov. *Cryptogamie Mycologie* **27**(1): 1-11.

Ramaswamy, L. 2006. Diversity and activity of fungi isolated from some extreme environments. Unpublished Dissertation Thesis, Goa University.

Rodrigues, J. 1993. A study of the mycoflora associated with some fresh vegetables in a Goan market. Unpublished Dissertation Thesis, Goa University.

Sawal, U. 1996. Microfungal diversity on leaf litter of Teak (*Tectona grandis*) and kokum (*Garcinia indica*) in Goa. Unpublished Dissertation Thesis, Goa University.

Soosamma, M., Lekha, G., Sreekala, K. N. and D. J. Bhat. 2001. A new species of *Trinacrium* from submerged leaves from India. *Mycologia* **93**: 1200-1202.

Vengurlekar, K. 1997. Studies on diversity of micro-fungi on leaf litter of wild and cultivated banana in Goa. Unpublished Dissertation Thesis, Goa University.

Yadav, S. 2006. Studies on diversity and activity of the Coprophilous fungi from Goa. Unpublished Dissertation Thesis, Goa University.