“STUDIES IN APHYLLOPHORALES OF RATNAGIRI DISTRICT (M.S.)”

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DOCTOR OF PHILOSOPHY (PH. D.) IN BOTANY
IN THE FACULTY OF SCIENCE AND TECHNOLOGY

SUBMITTED BY
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JULY, 2019

Certificate of the Guide

CERTIFIED that the work incorporated in the thesis "**Studies in Aphyllophorales of Ratnagiri District (M.S.)**" submitted by Mr. Yemul Nageshwar Bhikshapati was carried out by the candidate under my supervision/guidance. Such material has been obtained from other sources has been duly acknowledged in the thesis.

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CERTIFIED that the work incorporated in the thesis "**Studies in Aphyllophorales of Ratnagiri District (M.S.)**" submitted by Mr. Yemul Nageshwar Bhikshapati was carried out by the candidate under my supervision/guidance. Such material has been obtained from other sources has been duly acknowledged in the thesis.

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Declaration by the Candidate

I declare that the thesis entitled "**Studies in Aphyllophorales of Ratnagiri District (M.S.)**" submitted by me for the degree of Doctor of Philosophy is the record of work carried out by me during the period from 29/06/2015 to 27/03/2019 under the guidance of Dr. M. B. Kanade (Guide) and Prin. Dr. C. V. Murumkar (Co-Guide) and has not formed the basis for the award of any degree, diploma, associateship, fellowship, titles in this or any other University or other institution of Higher learning.

I further declare that the material obtained from other sources has been duly acknowledged in the thesis.

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CONTENT

ABBREVIATIONS

%	Percent
µm	Micrometers
^{0}C	Degree Celsius
E	East
e.g.	Exempli gratia (for example)
et al.	Et alia (and others)
g	Gram
ha	Hectares
i.e.	Id est. (in other words)
KCB	Konkan Coastal Belt
km	Kilometer
KOH	Potassium hydroxide
KI	Potassium iodide
m	Meter
min	Minutes
mm	Millimeters
MSL	Mean Sea Level
N	North
N. E.	North East
nm	Nanometers
PDB	Para dichloro benzene
S. W.	South-West
SNPs	Silver Nanoparticles
spp	Species
sq.	Square
Syn	Synonym
viz.	Namely
YKMNPO	Yemul Kanade Murumkar non-poroid
YKMPO	Yemul Kanade Murumkar poroid

GLOSSARY

Agarics:	Organisms belonging to order Agaricales of class Agaricomycetes. They are commonly known as mushrooms.
Agglutinate:	Fixed together as if with glue.
Aggregated:	Near together or crowded.
Allantoid:	Slightly curved with rounded ends, sausage-shaped.
Amyloid:	Stained blue with Melzer's reagent.
Animals:	These are eukaryotic, multicellular, heterotrophic organisms that show holozoic nutrition.
Aphyllophorales:	Order was proposed by Rea for Basidiomycetes in which the hymenophore is flattened (Thelephoraceae), club-like (Clavariaceae) and tooth-like (Hydnaceae) or has the tubes or lamellae (Polyporaceae), hymenophores rigid and non-fleshy. Traditionally the order has had a core of 4 families, (as indicated above) based on hymenophore shape but detailed microscopic studies of basidiocarp structure and molecular evidence has shown these groupings to be unnatural.
Applanate:	Having a flat surface.
Appressed:	Closely attached by the lower side.
Aseptate:	Having no cross walls.
Ballistospores:	Basidiospores getting discharged violently.
Basidiocarp:	A basidium producing organ.
Basidioma:	A basidium producing organ.
Basidiomycetes:	A group of fungi characterized by the production of basidiospores on a club-shaped basidium.
Basidiomycota:	Basidiomycota are filamentous fungi reproducing sexually by the development of basidia that undergo meiosis to form four basidiospores.
Basidiospore:	A propagative cell produced, after meiosis, on a basidium.
Basidium:	The cell or organ, in which Karyogamy and meiosis occur to produce basidiospores on an extension (sterigmata).
Binding hyphae:	Hyphae which are aseptate, thick-walled, much branched.
Blunt:	Not sharp or pointed.
Bracket:	Like a bracket.

Brown rot: A process in which cellulose and hemicelluloses are decayed, but lignin remains unaffected. It produces characteristic brick-shaped cracks in the wood.

Byssoid: Cotton-like delicate threads.

Cell: A structural and functional unit of the living organism.

Ceraccous: Wax like.

Clamp connection: A hyphal outgrowth which, at cell division, makes a connection between the resulting two cells by fusion with the lower; buckle; nodose septum; bypass hypha.

Clavate: Club-shaped.

Colony: A mass of individuals, belonging to one species, living together, a group of hyphae which, if from one spore or cell, may be one individual.

Conchate: Like a bivalve shell.

Concolorous: Of one color.

Conk: The basidiocarp of a wood-rotting bracket fungus.

Connate: Joined by growth.

Constricted: Make narrow or tight.

Context: The hyphal mass between the upper surface and the subhymenium or the trama of the basidiocarp.

Convex: bulged outwards.

Cordate: Heart shaped.

Coriaceous: Leather like texture.

Crust: A basidiocarp occupying substratum as a superficial layer.

Cuticle: A tough, impermeable, nonliving covering, secreted by epidermal cells.

Cyanophilous: Stains blue with cotton blue.

Cylindrical: Rod-shaped.

Cystidiole: A hymenial cell having the same diameter as the basidia but remaining sterile and protruding beyond the hymenial surface.

Cystidium: A sterile cell found in hymenium.

Daedaloid: Pores those are irregularly lobed and sinuous in outline, labyrinthiform.

Decay: The decomposition of wood caused by wood-rotting fungi. It results in softening of wood.

Decurrent: Running down the stipe.

Devrai: Protected forest around the temple.

Dikaryon: A cell having two genetically distinct haploid nuclei.

Dimidiate: Shield like.

Dimitic: Having hyphae of two kinds.

Dimixis: Fusion of two types of nuclei.

Dissepiments: A partition between the pores of a polypore.

Dolipore septum: A septum between neighboring cells of basidiomycete hypha having a barrel-shaped structure.

Duplex: In two layers, that adjacent to the lamellae or tubes being harder than the one over it.

Echinulate: Having spiny processes.

Effuse: Stretched out flat, especially as a film like growth.

Effused-reflexed: Stretched out over the substratum but turned up at the edge to make a pileus.

Ellipsoid: Elliptical in shape.

Encrusted: Covered to form a crust.

Endogenous: Living inside.

Entire: Having no teeth.

Extinction: The process of loss of species from the earth.

Filamentous: Thread-like.

Filiform: Thread-like.

Fimbriate: Edged; delicately toothed; fringed.

Flabelliform: Fan-shaped.

Fructification: A general term for spore-bearing body in macrofungi.

Fungi: These are achlorophyllous, eukaryotic, multicellular, filamentous, heterotrophic organisms showing absorptive mode of nutrition.

Generative hypha: Hyphae are branched, septate, with or without clamp-connections, thin to thick-walled and of unlimited length.

Glabrous: Smooth but not hairy.

Globose: Round shaped.

Gloeocystidia: a sterile body, frequently of distinctive shape occurring at any surface of Basidioma, particularly hymenium, thin-walled, usually irregular, contents hyaline or yellowish and highly refractive.

Gloeopleurous hyphae: Hyphae with very long cells with numerous oil drops in the

Glossy: Smooth and shiny.

Granular: Covered with very small particles.

Gymnocarpous basidiocarp: A basidiocarp with exposed hymenium as found in Aphyllophorales.

Habitat: A place where an organism lives.

Heartwood: Non-*conducting* xylem elements in the central portion of an old stem storing.

Hirsute: With hairs.

Hispid: having hairs or bristles.

Hollow: Having a cavity.

Holobasidia: Aseptate basidium.

Homogenous: Consisting of parts all of the same kind; uniform.

Host: A living organism affected by parasite.

Hyaline: Nearly transparent.

Hymenium: The spore-bearing layer of a basidiocarp.

Hymenophore: Pore surface of the fruiting body.

Hypha: The filamentous body of the fungus.

Imbricate: Attached to each other.

Incised: Lobes cut into.

Irregular: Uneven.

Karyogamy: The fusion of nuclei of the opposite sex.

Lamellate: Having lamellae.

Lateral: At the side.

Lignicolous: Growing on wood.

Lumen: The central cavity of the dead cell or other structure.

Marginate: Having a well-marked edge.

Membranaceous: Like a thin skin or parchment.

Microbes: These are prokaryotic or eukaryotic, uni or multicellular organisms which are not visible to the naked eye. They may be autotrophic or heterotrophic.

Monomitic: Having hyphae of one kind only.

Monophyletic: A group of organisms derived from a common ancestor.

Morphology: A branch of life science that deals with the study of structure and the function of living organisms.

Mucronate: with a sharp pointed tip.

Mycelium: A network of hyphae.

Mycologist: A person studying fungi.

Non-Poroid: Without pores.

Nutrition: The process of obtaining nutrients.

Oblong: Twice as long as wide and having somewhat truncated ends.

Obtuse: Rounded or blunt.

Ochraceous: Of a dull yellow colour.

Ornamented: Having the markings on the surface.

Ovate: Egg shaped.

Palisade: vertically elongated cells.

Papilla: A small rounded process.

Parasite: An organism dependant on another living organism (host) for nutrients.

Pathogen: Disease causing organism.

Pathogenic: Having the ability to cause disease.

Perennial: Surviving for a number of years.

Perfect state spores: Spores produced by the process of sexual reproduction.

Persistent: Still evident at maturity.

Pileate: Having a pileus.

Plants: These are eukaryotic, multicellular, chlorophyllous, autotrophic organisms that plasma.

Polyphyletic: A group of organisms derived from more than one common ancestor.

Polypore: A common name for members of order Aphyllophorales that has pores.

Poroid: With pores.

Primary mycelium: The haploid mycelium formed from a basidiospore.

Protuberant: forming a tube-like process. .

Reflexed: Turned down or curved backward.

Regular: Constant.

Reproduction: The process formation of new individuals of a species.

Resupinate: Flat on the substrate with hymenium on the outer side.

Rigid: Hard, unbendable.

Rimose: Cracked surface.

Rough: Uneven or not smooth.

Saprobic: An organism obtaining nutrients from dead organic matter.

Scaly: Having scales.

Secondary mycelium: The dikaryotic mycelium resulting from plasmogamy.

Semipileate: With a cap that is partially appressed to the substrate.

Septate: A hyphae with cross walls between neighboring cells.

Septum: A cross wall in a hypha.

Sessile: lacking stipe.

Setae: A stiff, thick-walled, dark coloured structure in the hymenium of Hymenochaetes.

Sinuate: A kind of gill attachment in which gills are notched at their point of attachment to the stipe.

Sinuous: Having rounded angles.

Skeletal hyphae: Thick walled, unbranched hyphae.

Soft rot: A decomposition of plant part by fungi or bacteria resulting in tissues becoming soft.

Solitary: Single.

Spathulate: Spoon shaped.

Spore: A unicellular reproductive structure of fungi.

Sporophore: A spore producing stalk or fruiting body.

Squamose: Having scales.

Sterigmata: The extension of the metabasidium which bears basidiospores terminally.

Stipitate: With stalk.

Stratified: Arranged in strata or layers.

Subiculum: A crust-like growth of mycelium under fruit bodies, which forms basidiocarp.

Substratum: The material on which an organism is growing or to which it is attached.

Subulate: Slender and tapering to a point; awl- shaped.

Sulcate: Having grooves.

Texture: Related to touch.

Thallus: Plant body which is not differentiated into root, stem and leaves.

Tomentose: Having covered with minute soft hairs.

Trama: The hyphae present in the central part of a lamella or a spine or the dissepiments between pores in the polypore.

Trimitic: Hyphal system in which three kinds of hyphae are involved to form a basidiocarp.

Ungulate: Horse-hoof shaped.

Velutinate: Thickly covered with soft hairs.

Ventricose: Swollen in the middle and pointed at apex.

Wart: A small hard round growth on the surface.

White rot: A kind of wood rot in which both cellulose and lignin is completely degraded leaving a white fibrous residue.

Xanthochroic reaction: The pileal surface darkens on treatment with KOH.

Zonate: Having concentric lines often forming alternating light and dark zones near the margin of basidiocarp.

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER – 1

INTRODUCTION

1.1 Introduction

The kind of diversity displayed by living organisms always fascinates and creates curiosity to know about them. Plants, animals, fungi and microbes are different forms of life that we usually come across in our daily routine. Among these, fungi are a diverse group showing great variation in habitat, colour, morphology, nutrition and reproduction (Mehrotra and Aneja, 1990). They may be large and macroscopic like mushrooms and bracket fungi and small, microscopic like yeast and many pathogenic forms (Dube, 2013).

Due to the presence of cell wall fungi are studied in Plant science. Cytochrome - C studies are important in determining the phylogeny of a particular group of organisms. Nolan and Margoliash (1968) found that fungi form phylogenetically a distinct group from plants and animals on the basis of Cytochrome - C studies. Therefore they proposed to assign a separate kingdom for fungi. According to Cooke (1977) as Botany is different from Zoology, in the same way mycology is different from plant science. This will lead to thorough extensive and comprehensive research in the field of mycology.

Fungi are beneficial to us in several ways. They play a vital role in providing Ecosystem services. The most important ecological service provided by fungi is decay and nutrient recycling. These processes are together responsible for decomposition of complex organic matter of plant and animal origin into simple compounds which are in turn added to the soil for reuse by plants. If this process is hampered then nutrient supply to plant will be affected; thereby primary productivity of the ecosystem gets affected. In the absence of these processes plants cannot survive for so long making the ecosystem unstable (Kuffer and Senn-Irlet, 2005). Many fungi live in reciprocal relation with higher plants to form the mycorrhizal association. It improves water, nutrition uptake and productivity of plants (Webster, 1980). The basic needs of human being are food, fiber and timber; they are spoiled by fungi. Deshpande (2003) studied live standing tree diseases caused by Aphyllophorales from Pune district. This provokes us to make their study in order to prevent their harmful effect on our basic needs.

Besides the negative value, fungi are exploited in industries for the synthesis of various organic acids, alcohol, enzymes, antibiotics, drugs, for brewing and baking

(Sharma, 1989). Fungi complete life cycle in short span and they can be easily cultured in artificial media this makes them excellent model organism for genetic studies. Lamrood (2004) studied medicinally important mushrooms from Pune district. Muraleedharan *et al*. (1995) used wood rotting fungi for bioremediation of polluted site. Besides this, fungi are rich in protein and fibers thus they form the excellent source of food for human consumption. Therefore mushrooms, truffles, bracket fungi and boletes are used as human food. There also much is left to learn about several biological aspects of fungi.

1.2 Diversity of Fungi

All fungi are kept in kingdom Fungi or Mycota (Alexopoulous *et al*., 2002). True fungi are divided into four phyla, *viz*. Chytridiomycota, Zygomycota, Ascomycota and Basidiomycota. Members of Chytridiomycota are commonly known as chytrids; they produce motile spores known as zoospores. Members of Zygomycota are commonly known as zygote fungi; they produce non-motile perfect state spores known as zygospores. Members of phylum Ascomycota are commonly known as sac fungi; their perfect spores known as ascospores. Phylum Basidiomycota includes diverse fungi like mushrooms, boletes, bracket fungi, rusts, smuts, etc. The wood rotting fungi are included in phyla Ascomycota and Basidiomycota.

The number of species of fungi, in the biological world, is estimated to be 1.5 million (Hawksworth, 2001). Recently an estimate of 2.2 to 3.8 million species of fungi is made by Hawksworth *et al*. (2017). Despite this, only a fraction of total fungal wealth has been documented by mycologists. As per Webster and Weber (2007) only 80,000 to 120,000 species of fungi have been identified and described till date. Mycologists continue to explore the hidden fungal wealth (Hawksworth, 2001). Manoharachary *et al*. (2005) made a conservative prediction about fungal diversity of India. Studies on diversity of fungi are gaining importance, as many fungi are facing the threat of extinction even before their discovery. Extinction of fungi is a grave problem due to habitat destruction, deforestation, loss of host etc. Therefore there is an urgency to explore and document maximum number of fungal species before their extinction.

1.3 Phylum Basidiomycota

The members of phylum Basidiomycota produce large and prominent fruiting bodies, they are known as basidiocarps and these fungi are commonly known as macrofungi (Bates, 2006). Fadime and Mustafa (2002), Peksen and Karaca (2003) and Stojchev *et al*. (1998) through a series of publication studied macrofungi of Turkey. The basidiocarps of macrofungi are of different size, shape, texture, beauty and colour (Swapna *et al*., 2007 and 2008). Therefore they draw the attention of most mycologists. Macrofungi are included in two major orders of class Agaricomycetes. They are Aphyllophorales and Agaricales. Order Agaricales includes saprobic macrofungi that are commonly known as Mushrooms. They have gills on the lower side of basidiocarp. While order Aphyllophorales (now known as Polyporales) mostly includes parasitic macrofungi that are commonly known as bracket fungi and are known to cause wood rot. The lower side of basidiocarp of Aphyllophorales is lined by conspicuous teeth, tubes or pores which constitute hymenophore. On the basis of the shape of hymenophore, Rea (1922) divided this order into families. The Aphyllophorales having pores in the hymenium are known as Polyporales.

1.4 Structure of Basidiocarp

The basidiocarps of Aphyllophorales produce basidiospores, the perfect state spores. Basidiospores are produced on a special structure known as Basidium. Aphyllophorales possesses holobasidia that are usually present inside the pores or tubes of the basidiocarp. Each holobasidium undergoes meiosis to produce four basidiospores on the sterigmata (Alexopoulous and Mims, 1979). These basidiospores are discharged violently from basidiocarp, therefore they are known as ballistospores. When basidiospores fall on moist woody substratum, they germinate by absorbing moisture and produce white cottony mycelium in the wood tissues. This ramifying network of mycelium is noticed during monsoon season on wood blocks.

1.5 A glance at the Aphyllophorales

Aphyllophorales is an important order of phylum Basidiomycota. It includes 1200 species distributed throughout the world both in tropical and temperate countries (Alexopoulos *et al*., 2002). The order was proposed by Rea (1922) for species showing flattened, club-shaped, toothed, poroid and lamellate hymenophore in the basidiocarp. Lamellate hymenophore is also found in order Agaricales but they differ from Aphyllophorales in having fleshy and putrescent basidiocarp. Traditionally the order has a core of 4 families on the basis of hymenophore *viz*. Clavariaceae (club-shaped hymenophore), Hydnaceae (toothed hymenophore), and Polyporaceae (poroid and lamellate hymenophore) and Thelephoraceae flattened hymenophore. Detailed microscopic studies of basidiocarp structure and molecular evidence have shown these groupings to be unnatural (Hibbett *et al.*, 2007). This group is polyphyletic in origin (Taylor and Berbee, 2001).

According to Alexopoulous *et al*. (2002), some species of the order are having basidiocarps as the appearance of paint. Without microscopic examination sometimes it is difficult to recognize a thin appressed basidiocarp. On the other hand, many species produce conspicuous, large, thick basidiocarps that can be visualized with unaided eyes. On the basis of the shape of hymenium and basidiocarps, these fungi are commonly known as bracket fungi, club fungi, coral fungi, pore fungi, shelf fungi or tooth fungi (Donk, 1964). There is even a beefsteak fungus. Hymenophore is a tissue directly supports the hymenium. Aphyllophorales are those hymenomycetes which possess holobasidia but lack gills. The hymenium of Aphyllophorales is borne on gymnocarpous basidiocarp (Alexopoulos *et al*., 2002). A gymnocarpous fruiting body has exposed hymenium is while the spores are still immature. In Aphyllophorales hymenium is either present on one side of the basidiocarp (unilateral) or all over the surface of basidiocarp (amphigenous). These large groups like Aphyllophorales pose a taxonomic challenge for the mycologists. There also much is left to learn about several biological aspects of these fungi.

The major importance of Aphyllophorales is their saprobiotic nature by virtue of which they act as natural scavengers and decomposers, particularly in the degradation of plant waste and wood components - cellulose, hemicelluloses, pectin and lignin. Although most species are saprobiotic on dead wood, in soil, litter, bark, of living trees, some species may be truly parasitic or pathogenic on shade-loving plants and forest trees.

Also, some Aphyllophorales are part of lichens. Many species form a mycorrhizal association with forest trees. Many Aphyllophorales cause decay of wood of trees that are already dead, but some species belonging to family Polyporaceae and

Hymenochaetaceae enter wounds in living trees and rot heartwood. The work of Hudson (1986) has shown that a number of microorganisms precede the secondary infection by wood-decaying Aphyllophorales. These microbes help to pave the way of Aphyllophorales by a series of physical and chemical changes to overcome defenses of the plant. Domestic furniture's are susceptible to decay by Aphyllophorales. Such rots are common in houses, utility poles, pilings and timbers. The dry rot fungus *Serpula lacrimans* is a dread of homeowners in Europe. A few wood rotting fungi form Ectomycorrhizal association with forest trees. Aphyllophorales are also important to animal life. Most cavity-nesting birds are dependent on wood rotting Aphyllophorales for softening of wood to facilitate the excavation of nest cavities. Certain Aphyllophorales provide feeding and breeding site for insects.

Many species of Aphyllophorales have medicinal applications. *Ganoderma lucidum* the fabled Ling Chi of Chinese herbal medicine is also known as 'reishi' (Stamets, 1993) yields products which are often used in natural herbal medicines of commercial importance. It is known to treat venereal diseases, lowering of cholesterol, purification of blood and cancer. Vaidya and Rabba (1993), pointed out 12 species of *Phellinus* have been used in Indian folk medicine. A species of *Phlebia* yields antibiotics (Quack et al., 1978), but has not been utilized commercially.

Few species of Aphyllophorales produce edible basidiocarps for e. g. *Lentinus edodes* (Shiitake mushroom), *Fistulina hepatica* (beefsteak fungus), *Sparassis crispa* (Cauliflower fungus), *Grifola frondosa* and *Hericium erinaceum* (the bear's head fungus).

1.6 Morphology of Aphyllophorales

Morphology is concerned with the structure and function of an organism. In the earlier part of the nineteenth century, all studies on basidiocarps of Aphyllophorales were based solely on external morphological features (Fries, 1821). The shift from external to internal morphological studies were initiated by Patouillard (1900). He introduced the use of microscopic characters for the taxonomic description of species. Aphyllophorales have two kinds of hymenium *viz.* poroid and non-poroid. Family Meruliaceae and Peniophoraceae have non-poroid hymenium, while Ganodermataceae and Polyporaceae have poroid hymenium. The morphological features of the basidiocarps of non-poroid and poroid Aphyllophorales differ significantly. Talbot (1951-1958) published a series of review papers on "Micromorphology of the lower Hymenomycetes" which contains non-poroid species while Teixeira (1962) described microstructures of poroid fungi. The detailed morphology of poroid members was studied by Ryvarden *et al*. (2010) in his publication "Poroid Fungi of Europe".

1.7 Substratum diversity of Aphyllophorales

Aphyllophorales are a cosmopolitan group. Many species grow parasitically on the roots, trunks and larger branches of trees. None of them are found on leaves. They also grow as saprophytes on dead or dying, standing or fallen tree trunks. Seldom they are found on grass and other herbaceous plants (Ranadive, 2012). They cause wood rot of various forest and shade-loving plants. Some attack and destroy timber trees like *Tectona grandis, Samanea saman*, *Dalbergia latifolia*, birch, oak, etc. Some species grow terrestrially on the underground organic matter.

1.8 Mycelium of Aphyllophorales

A basidiospore germinates and grows to produce mycelium. It is inconspicuous and grows subterranean. Initially, it grows in the soil near the host roots. In due course, it attacks the roots and starts to spread throughout the plant. Mycelial growth is found beneath the bark. It consists of several white, cottony, slender, branched and septate hyphae. The hypha produced from basidiospores is known as primary mycelium (Cunningham, 1945); it is multicellular. The cells of primary mycelium are uninucleate. Ultimately the cells become dikaryotic by fusion of hyphae. The dikaryotic cells form the dikaryotic secondary mycelium. The secondary mycelium is long-lived and of immense importance in the life cycle of Aphyllophorales. As the infection proceeds, the mycelium forms a thick layer of hyphae around the sap and heartwood of the trunk. The hyphae secrete lignocellulolytic enzymes which digest the wood cells.

From the secondary dikaryotic mycelium develop a rounded dense knot of hyphae. The knot grows through the bark; it gradually increases in size and comes out to form the basidiocarp.

1.9 Reproduction in Aphyllophorales

Aphyllophorales reproduce by two methods *viz.* asexual and sexual.

1. Asexual Reproduction

It is very rare in occurrence. Asexual reproduction takes place on secondary dikaryotic mycelium by formation of conidia or chlamydospores (Cunningham, 1964). Secondary mycelium forms erect conidiophores. Conidiophore produces a chain of conidia in a basipetal succession. During unfavorable condition secondary dikaryotic mycelium produces chlamydospores. Hyphal cells become rounded, thick walled and store reserve food to form chlamydospores. Asexual spores are also produced on sterile basidiocarps.

2. Sexual Reproduction

Aphyllophorales do not produce sex organs. They undergo sexual reproduction by somatogamy. The species of Aphyllophorales are heterothallic in nature (Alexopoulos *et al*., 2002). Somatogamy takes place by the fusion of two somatic primary monokaryotic mycelia of opposite strains. This results in the formation of secondary dikaryotic mycelium. The secondary dikaryotic mycelium is perennial; it may survive for several years. During favorable condition it forms basidiocarps.

1.10 Basidiocarp

The members of Aphyllophorales are mostly saprobic and others grow on host plants typically attacking only the dead cells of wood, but the enzymes they produce may kill living cells of host and ultimately contribute to the death of the plant (Gilbertson and Ryvarden, 1986). Often they cause serious damage to standing timber, kept in moist area. The visible portion of the Aphyllophorales is the fruiting body i.e. basidiocarp. It is produced by vegetative hyphae present just beneath the bark. The vegetative hyphae grow profusely in the substrate before it produces basidiocarp. Its manifestation indicates that considerable decay of host has already occurred. Even after removal of the basidiocarp from host, the left over portion of hyphae will continue to grow and will subsequently form new fruiting body. The basidiocarps are usually large bearing pores, teeth or lamellae. Sometimes pores are so small that cannot be seen with naked eye. Texture of basidiocarp may be fleshy, corky or woody. The vegetative mycelium is perennial in large tree trunks and substratum; it produces fruiting body every year. In *Ganoderma applanatum* and other species basidiocarp itself is perennial and new layers of hymenial tubes develop on the lower side of the fruiting body (Gilbertson and Ryvarden, 1987). The basidiocarp of Aphyllophorales varies in shape and size. Some species produce fan-shaped brackets lacking stipe, they are called pileate forms. Some forms have lateral stipe, e.g. *Microporus affinis* and others have centrally stalked fruiting body, e.g. *Lentinus velutinus* (Plate - 1).

In some wood-rotting Aphyllophorales basidiocarp is appressed to the surface of the wood such basidiocarps are called as resupinate. The hyphal construction system of basidiocarp varies and is unique identification feature of each species. In *Leucophellinus hobsonii*, construction of basidiocarp is monomitic; the basidiocarps are composed entirely of generative hyphae. The basidiocarp of Polyporus brumalis is dimitic, while *Microporus xanthopus* has trimitic basidiocarp. The type of hyphal system is related to the tenderness of basidiocarp. Trimitic basidiocarps are hard, rigid and difficult to tear while monomitic basidiocarps are sappy and flexible. The tissue between the pores is dissepiments; it may be thin or thick. The Aphyllophorales is a large group, probably containing about 70 genera and over 600 species (Kirk *et al*., 2008). There is a very extensive literature on this group.

Types and Shape of Basidiocarps

Following are different types of basidiocarps found in poroid Aphyllophorales.

- **Resupinate**: A flat, thin, crust-like basidiocarp appressed to the substratum (Plate - 1).
- **Effused-reflexed**: A resupinate basidiocarp partly turned up at the edge forming a small bracket-like projecting margin (Ranadive, 2012).
- **Pileate**: The basidiocarp possessing pileus but lacking stalk. It is also known as sessile. Pileate forms occur in various shapes such as applanate (Plate - 1), dimidiate, ungulate, flabelliform etc. Pileate forms occurring individually are called solitary. Sometimes many pilei grow and fuse together to form imbricate basidiocarp (Ryvarden *et al.*, 2010).

- **Stipitate**: The basidiocarp possessing a stipe of sterile tissue in addition to pileus is known as stipitate (Plate - 1). Depending on the position of the stipe, it may be lateral or centrally stipitate (Ranadive, 2012).

Mature basidiocarps are rigid; they may be in shape of funnels, clubs, coral-like or even umbrella like. A basidiocarp is differentiated into two parts as pileus and stipe. The cap like part is called pileus and stalk attached to it is called stipe. All basidiocarps have pileus however they may be stalked or sessile. The basidiocarps having pileus only and lacking stipe are called pileate and sessile for e.g. *Lenzites acuta*. Those basidioma having both pileus and stipe are called stipitate for e.g. *Lentinus velutinus*.

The other types of basidiocarps are resupinate, effused-reflexed, imbricate, ungulate, applanate, dimidiate, flabelliform, convex, etc (Sharma, 2013). The different types of basidiocarps may be broadly or narrowly attached to the substratum. Usually fleshy and gelatinous basidiocarps are fragile, they are prone to decomposition and short lived while leathery and rigid fruit bodies are perennial.

1.11 Parts of basidiocarps

The basidiocarp consists of following parts:

Pileus

It is differentiated into upper and lower surface. The upper surface of pileus may be glabrous or hirsute. Glabrous pileal surface may be dull, glossy or shiny (Ryvarden *et al*., 2010). In many species the pileus has a distinct colour which remains reasonably unchanged throughout the life span of the species as in *Ganoderma lucidum* (Leelavathy and Ganesh, 2000). White or light coloured basidiocarps frequently become darker with age as the upper layer of hyphae collapse and become darker in ochraceous to brownish shades, resulting in distinct zonation from base to the margin, where new hyphae are under active development. This is especially true in perennial basidiocarps. In some species with normal light coloured basidiocarps, a thin, black or deep reddish cuticle may develop from the base, making the pileus strikingly bi-coloured as in *Earliella scabrosa* (Gilbertson and Ryvarden, 1986).

When pileus is glabrous, it may be smooth and azonate. The type and consistency of the pileus cover plays an important role in taxonomy of species. Fruiting bodies of some species with hirsute projections on pileus are perennial and long lived. In some species there is a distinct dark cuticle below a tomentum and with age the hair may fall off zonately and expose the cuticle which then will contract strongly with the lighter coloured tomentum e.g. *Lenzites elegans* (Nunez and Ryvarden, 2000). In many perennial species the pileus may crack up with age, either in radial lines or into an irregular pattern of angular pieces, often so strongly and characteristically that the surface is called rimose e.g. *Phellinus* spp.

Margin

Especially for species with resupinate basidiocarp, the margin and its development is an important character. Most species have continuous margin several millimeters thick, frequently white or coloured. The hyphae grow at an equal rate and the margin becomes soft and finally tomentose (Ryvarden *et al*., 2010). For other species the margin can end abruptly with an almost vertical slope. Such basidiocarps often have a tendency to curl up and loosen along the margin after drying.

Stipe

The consistency and colour of the stipe is concolorous with that of the pileus. However in some species, the stipe may be differently coloured as in *Microporus xanthopus.* In case of applanate basidiocarp which is so strongly fan-shaped and tapering towards the base that it may appear sessile or with a short lateral stipe (Ranadive, 2012).

Plate – 1 : Types of Basidiocarps

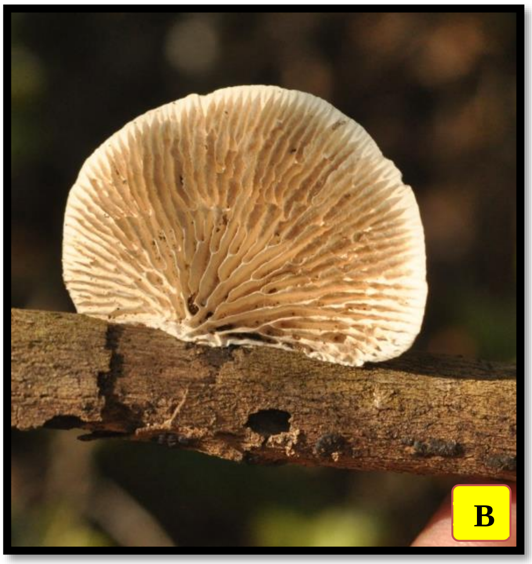
Applanate- *Ganoderma applanatum*

Stipitate- *Lentinus velutinus*

Pileate- *Lenzites elegans*

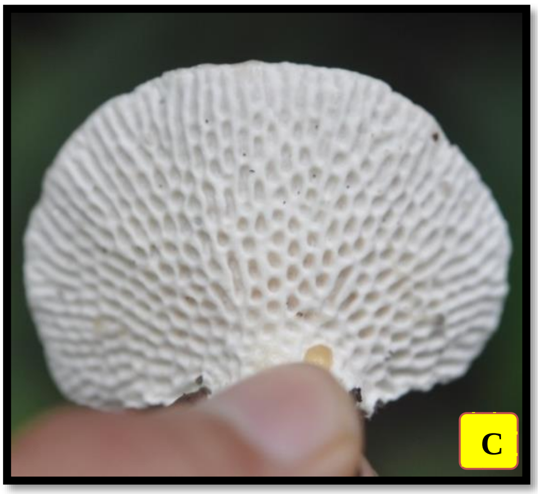
Resupinate- *Flavodon flavus*

Plate – 2 : Nature of hymenophore



Poroid- *Hexagonia nitida*

Lamellate- *Lenzites acuta*



Poroid and lamellate - *Lenzites elegans*

Flattened – *Hymenochaete* spp.

Pore surface

The colour of the pore surface is distinguishing feature for many species. With age, it has a tendency to become ochraceous and this has to be kept in mind while using keys. As compared to colour, the size and shape of the pores is an important taxonomical character though the pores tend to become larger in size with age. Some species have uniform poroid basidiocarp e. g. *Hexagonia nitida* (Plate - 2), there are a few species with complex hymenophore which changes with age and development e.g. *Lenzites elegans* and *Lenzites acuta* (Plate - 2). In these species, poroid specimens have been found along side with lamellate specimen. Even single basidiocarp may show variation in different parts of the hymenophore, indicating that the configuration of the hymenophore is not static as often assumed (Nunez and Ryvarden 2001). With age, the dissepiments in some species may becomes incised or become dentate as they develop at different rates. The pores may be round, radially elongated, irregular, sinuous, daedaloid, angular, hexagonal or lamellate (Ryvarden *et al*., 2010).

Tubes

In most species the tubes are more or less concolorous with the pore surface or with age they become paler than the pore surface (Sharma, 2013). In many species there is no apparent difference either in colour or consistency between the tubes and context e.g. *Microporus affinis*. However, in other species the tubes may have a different colour, consistency and even hyphal system than the context e.g. *Lenzites elegans*. These differences are important in describing taxonomy of a specimen.

Context

The context is the sterile part of a basidiome between the tubes and the pileus surface. In resupinate basidiocarps the sterile part between the tubes and the substrate is often called the subiculum although there is no standard difference between the two (Ryvarden *et al*., 2010). In most species the context is homogeneous with regard to both colour and consistency and will normally have radial structure as the hyphae grow from the base towards the margin e.g. *Leucophellinus hobsonii*. However in some species the context is distinctly duplex, the lower part being dense and without apparent and often intergrading with a pileus tomentum and the lower context may have different hyphal construction and binding hyphae will normally never be present in tomentum e.g. *Ganoderma lucidum*.

Hymenium

The lower surface of pileus is fertile; it is called hymenium which consists of reproductive hyphae. Hymenium may be flat non-poroid, poroid, teethed or lamellate. Irrespective of its nature hymenium consists of club shaped unicellular hyphal tips called basidia. Some times hymenial may contain sterile basidia called cystidia and sterile pointed structures called setae. In some genera, hyphal pegs, fascicles of sterile hyphae coming out from the hymenial surface are seen (Ryvarden *et al*., 2010). Each basidium undergoes meiosis to produce perfect state spores known as basidiospores. Basidiospores are unicellular, uninucleate, haploid structures. They get liberated from basidiocarp either violently or passively. On getting deposited upon suitable substratum they germinate and produce vegetative hyphae in the presence of moisture.

1.12 Non-Poroid Aphyllophorales

Peniophoraceae and Meruliaceae are families within the Aphyllophorales. They consist of an assemblage of species with non-poroid basidiocarp. Members of these families are also known as crust fungi and teeth fungi. Crust fungi have simple basidiocarps. They are more or less effused and have an even, merulioid, or warted to denticulate surface (Ranadive, 2012). A lot of non-poroid Aphyllophorales produces very delicate basidiocarp which is hardly visible to the naked eye. The colour is frequently in the shades of white, gray or yellow, sometimes more brightly coloured in red, brown or blue. The basidiome is usually soft to tough and seldom hard. A smaller group constituting of the soil-micro flora use only wood as support for their basidiome. Some species form mycorrhizal association with higher plants. Julich *et al*. (1976, 1980 and 1984) extensively studied the resupinate Non-poroid Aphyllophorales of the temperate Northern hemisphere and reported them in a book.

Basidiome

The fruit body of non-poroid aphyllophorales may vary considerably from one species to another, and it is frequently not easy in a small amount of words to cover the dissimilarity properly (Ranadive, 2012). The most commonly used terms are as follows:

a. Resupinate

The basidiocarps do not contain any sterile parts, except for the margin region. This is the general fruit body type among the members of family Meruliaceae, Peniophoraceae and Corticiaceae (Sarbhoy *et al*., 1996).

b. Effused-reflexed

In some species a pileus develops with age along the upper edge of the basidiocarp. Such basidiocarp is called effused-reflexed.

c. Cupulate

A few species have rounded basidiocarps with a raised margin so that it becomes discoid or cupulate. This condition should not be confused with raised margins found in effused-reflexed species.

d. Dimidiate

From the reflexed - pileate basidiocarp with a contracted or tapering base, some basidiocarps develop lateral stipe in which inferior face of the base is sterile and some genera have central stipe.

Construction of the fruit body

The fruit body in the non-poroid Aphyllophorales is rather simple and rarely complicated (Ranadive, 2012). It consists of the following layers:

a. The hymenium consists of the basidia and mostly intermingled with sterile organs such as cystidia and other structures.
b. Hymenium usually grows vertically downward and strongly branched. It is some times very compact so that the individual hypha is seen rarely.
c. Trama is a layer of hyphae supporting the hymenium. The tramal hyphae are often wide and loose than that of the sub-hymenium. Sub-hymenium is supporting layer of hymenophore when it is poroid or hydnoid.
d. Subiculum is the layer of hyphae next to the substrate (Nunez and Ryvarden, 2000). Its hyphal composition is like trama; its hyphae grow parallel to the substratum.

Hymenophore

The hymenophore is the fertile portion of the fruiting body. It consists of the subiculum, trama and sub- hymenium. The configuration of hymenophore varies from species to species (Ranadive, 2012). Following terms are used to describe the variations in configuration of hymenophore in non-poroid species:

- **Irpicoid:** with irregular and flattened teeth.
- **Merulioid:** with netlike or radial folds.
- **Hydnoid:** with prominent spines.
- **Tuberculate:** with (usually) spares and irregular warts.

Consistency

According to the structure, the fruit body can vary in consistency from very loose to almost horny hard when dry (Ranadive, 2012). The different types of consistencies encountered in the fruit bodies are as follows.

- **Athelioid:** has a thin, typically flexible membrane over subiculum.
- **Byssoid:** has cotton- like discontinuous surface.
- **Cereous:** is with a waxy, closely adnate appearance.
- **Membranaceous:** it is like athelioid but thicker.
- **Phlebioid:** is very dense and hard. Warty as fresh, horny when dry.

1.13 Recycling and Wood decomposition

The growing mycelium secretes extracellular enzymes that degrade cell wall components of wood. This degradation of wood components by fungi is termed as wood decomposition. The process of wood decomposition or rotting converts complex organic compounds into simple substances that are added to soil and absorbed by plants in the vicinity. Thus Aphyllophorales contribute towards recycling of waste, maintaining the fertility of the soil, replenishing soil nutrients and play a key role as environmental scavengers.

Aphyllophorales are known to cause three types of wood rot, *viz*. white rot, brown rot and soft rot (Mehrotra *et al*., 1983). During white rot, all the components of wood are completely degraded by fungi leaving a brittle, white fibrous spongy mass behind. While in case of brown rot all the components of wood except lignin are degraded leaving behind carbonaceous mass in varying shades of brown (Greig, 1995). This means brown rot fungi lack lignin degrading enzyme. Among two types of wood rot, most wood rotting Aphyllophorales are known to cause white rot predominantly.

1.14 Research on Aphyllophorales at International level

Wood rotting fungi have great economic importance in forestry and a lot of work is done on the wood rotting Aphyllophorales in developed countries like U. S. A., Britain and Australia (Ranadive, 2012). The work on Aphyllophorales had been carried out from the time of Linnaeus (1753). Persoon (1801) classified Aphyllophorales in his book “Synopsis Methodica Fungorum”. Fries (1821-1832) prepared book “Systema mycologicum” in which Aphyllophorales were kept in Hymenomycetes.

Persoon (1825) published two volumes of the book “Mycologia Europaea”. Berkeley (1839), Fries (1832), Karsten (1879), Cooke (1883) Saccardo (1899), did useful contribution to the knowledge of Aphyllophorales.

Patouillard (1900) a French mycologist used microscopic characters for classification and framed family Aphyllophoraces. Murrill (1907) also contributed to the work on Polyporaceae. Rea (1922) for the first time proposed the order Aphyllophorales. Bourdot and Galzin (1928) used microscopic analysis to study basidiocarp. Corner (1932) developed mitic system for classification of Aphyllophorales.

Bondartsev and Singer (1941) attempted to classify order Aphyllophorales into families and smaller groups. Donk (1964) divided Aphyllophorales into twenty-two families. Alexopoulos and Mims (1979) (1987) and Ryvarden (1991, 1993) analysed families proposed by Donk.

Ainsworth (1973) kept Aphyllophorales in order Polyporales of class Hymenomycetes. Hawksworth *et al*., (1983) accepted the classification proposed by Donk (1964) in the seventh edition of “Dictionary of the Fungi”.

Kirk *et al*. (2001 and 2008) in the ninth and tenth edition of “Dictionary of the Fungi” split Aphyllophorales into twelve different orders and fifty families under class Agaricomycetes. He considered Aphyllophorales to be an artificial assemblage of unrelated taxa. Therefore, treated them to be polyphyletic in origin.

1.15 Research on Aphyllophorales at National level in India

In developing countries like India, though work on wood rotting Aphyllophorales is undertaken, they are relatively less studied. The work on Aphyllophorales of India is mostly restricted to northern parts like Himalaya and Bengal and least is known from southern parts of the country (Ranadive, 2012). Studies on Aphyllophorales of India were initiated by British mycologist Koltzsch (1832). Hooker (1839) collected a number of specimens from North-East India in the mid-nineteenth century. Later Berkeley (1839) described several Aphyllophorales collected by Hooker and Cooke from Sikkim. Henning's (1901) prepared a manual of Aphyllophorales from India and published "Fungi India Orientalis". Massee (1901-1910), Butler (1905-1918), Lloyd (1898-1924) also worked on Indian Aphyllophorales and published several species. Sydow *et al*. (1906-1916) and Theissen (1913) reported few poroid species collected by Blatter (1911) from the Bombay presidency. Murrill (1903-24) had made significant contributions in the field of Aphyllophorales.

Bose (1919-1927) studied polypores from Bengal. Polyporaceae of Madras presidency was studied by Sundaramani and Madurajan (1925). Banerjee (1947) and Bagchee (1950) reported wood rotting Aphyllophorales from Bengal. Bakshi (1958), Puri (1956), Ramakrishan (1959), Bakshi *et al.* (1963), Rehill and Bakshi (1965), Welden (1965), Reeves *et al.* (1967), Thind (1971 and 1973), Sathe and Rahalker (1977), Rattan (1977), Thind and Dhanda (1978), Anjali Roy (1976-1996) and Harsh (1982) reported several species of Aphyllophorales from Northern parts of India.

Sharma (1995, 2000 and 2013) published manuals on "Hymenochaetaceae of India", "The Resupinate Aphyllophorales of the North Western Himalayas", "Genera of Polypores" and "Aphyllophorales of Himalaya". So most studies on Aphyllophorales are from the Northern side of the country. This caused negligence towards Aphyllofungal flora of Southern, Western and Eastern parts of the country, therefore rigorous studies are needed to document Aphyllophorales from these regions.

1.16 Research on Aphyllophorales in Maharashtra

Western Ghats pass through the North-South of Maharashtra and rich in fungal diversity but studied least. Considering the deteriorating ecosystem of this region there is an urgency to enlist, document and highlight the ecological and economic importance of this region. Therefore the current study has been undertaken at the Ratnagiri district of Maharashtra state lying in one of the hottest hotspots of biodiversity, the Western Ghats region a distinct phytogeographic zone of our country.

In Maharashtra studies on Aphyllophorales were initiated by Ranadive *et al.* (2011) from Pune district. They collected 126 specimens from Western Ghats of Pune of Maharashtra. They recorded 20 species of Aphyllophoraceous fungi from Pune district of Western Ghats of Maharashtra. Patil (2012) studied Aphyllophorales of Jalgaon district and reported 5 genera and 12 species. Mali and Raibole (2015) collected 500 specimens of Aphyllophorales from Parbhani and Nanded districts of Maharashtra. They identified 52 species of Aphyllophorales. Mali and Chouse (2016) studied Aphyllophorales from Latur and Osmanabad districts of Maharashtra. There are 36 districts in Maharashtra of which Aphyllofungal flora of only six districts is known. That means less than 20% of Aphyllofungal flora of Maharashtra has been studied so more than 80% area is still unexplored which necessitates rigorous studies in this region.

The Aphyllophoraceous mycobiota of Ratnagiri district is distinct due to long coastline, tropical evergreen forest and rich flora. The number of Aphyllophorales documented by earlier workers from Ratnagiri district of Maharashtra is meager 03 genera with 13 species belonging to 3 families (Ranadive *et al*., 2011). Of the three genera, *Ganoderma* is represented by 11 species, while *Rigidoporus* and *Wolfiporia* have one species each. So we assume that the Ratnagiri district being the part of Western Ghats must have a large number of species of Aphyllophorales. Thus we opted to study the diversity of Aphyllophorales in the forest of Ratnagiri district of Maharashtra.

1.17 Western Ghat range

The Western Ghats extend from the mouth of river Tapti in Surat (Gujarat) to the southern tip Kanniyakumari (Tamil Nadu) and run parallel to the west coast of India (Plate - 3). They form a 1600km long stretch on the west coast of the Indian Peninsula that traverses through the states of Gujarat, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. It is among the 34 biodiversity hot spots of the world and recognised as one of the 10 hottest hotspots of Biodiversity (Myers *et al.,* 2011). The Western Ghats are also known as Sahyadri in India and are rich in species diversity of flowering plant, fungi and amphibians (Wilson, 1988). Several thousand species of flowering plants are endemic to this region. This area has been threatened by deforestation, loss of habitat and developmental projects. There are several undescribed species reside in this area. These species will become extinct without getting a note of them if the present trend of destruction continues. Therefore the government has taken stringent steps to protect this area by forming national parks, wildlife sanctuaries and reserve forests. UNESCO has recognised it as "World Heritage Site".

1.18 Geology of Ratnagiri district

Geologically this area consists of the coastal belt on the Western side and Deccan Traps on the Eastern side. The land on the coastal belt has alluvial soil while that towards the Western Ghats has laterite. The igneous rock 'basalt' having columnar sheets forms the mountains peaks. Weathering and decomposition of basalt form lateritic soil. The hill slopes have loose trap boulders and soil cover.

1.19 Study Area

Maharashtra state is present in the Western part of India. It is roughly triangular in shape (Plate - 4). It has a vast coastline of 725km on the western side and large land area on north, east and south side covering Deccan peninsula. The state covers an area of 307,713.897km^2. It is surrounded by the Arabian Sea on the West side and the states of Gujarat, Madhya Pradesh, Telangana, Karnataka and Goa on other sides.

The coastal line of Maharashtra is also known as the Konkan region. Ratnagiri district is located at the midwestern part of the coastal region of Maharashtra state. It lies at 17.2478 N, 73.3709 E. The district has end to end extension of 174km in the North-South direction and average width of 62km in East-West direction, except in its extremities, which tapers to join the coastline. The area is surrounded by the Sahyadri hills on the Eastern side and the Arabian Sea on the Western side. The total land area is about 8,208 sq. km. Climate is tropical; altitude ranges about 11m-513m. The district has a share of 237km from the total 720km coastline of Maharashtra state.

1.20 Divisions of Ratnagiri district

On the basis of elevation Ratnagiri district is divided into three regions (Plate - 7). These are,

1. The Western Ghats region
2. The lateritic plateau
3. The river and estuarine areas

1. **The Western Ghats region**

The Eastern part of the district is covered with the Western Ghats which are locally known as Sahyadri hills. Its average height is above 500m. In the Western Ghats both above and below the main range, the tops are often crowned or gridded by large massive basaltic rocks. This region is extended North-South direction having steep slopes occupied by spurs and saddles.

2. **The lateritic plateau**

The middle portion of the district is formed by a narrow belt of low land, lying between the Arabian Sea and Sahyadri hills. This part is covered with small hills and ridges. The general slope of this zone is from East to West and it is formed by denudation of the parent rocks.

3. **The river and estuarine areas**

The coastal belt was often rocky and broken by small bays and creeks and fringed with islands. The elevation of the area is below 150m and it formed by alluvial soil. Due to the uneven and undulating topography, the agriculturally useful land is limited in the region.

1.21 Tahsils of Ratnagiri district

There are nine Tahsils in Ratnagiri District (Plate - 5). These are as follows

1. **Mandangad**

It is situated at the extreme north of Ratnagiri District. It is located at 17°58' N, 73°15' E and altitude is 268m above MSL. The average rainfall is 3996mm. It has hills with tropical forests and coastal belt with mangrove forest.

2. **Dapoli**

It is situated on the Arabian Sea at West (17°45' N latitude and 73°26' E longitude) with an altitude of 250m above MSL. The region is characterized by humid climate with average annual rainfall more than 3500mm with the moderate temperature ranges from as low as 7.5^0C to as high as 38.5^0C and average relative humidity ranging from 55% to 100%. The soil is lateritic and generally poor in organic content having poor water holding capacity. The vegetation predominantly consists of Tropical moist and mangrove forest. Dabhol creek is located within this tahsil.

3. **Khed**

It is an industrial non-coastal city with a municipal council in Ratnagiri district. Khed is located at 17.72°N 73.38°E. It has an average elevation of 25m.

4. **Guhagar**

It is a coastal tahsil located at 17.47°N 73.2°E. It has an average elevation of 10 meters above MSL. It is located in a scenic environment with the background of hilly terrains and dense evergreen vegetation. The vegetation predominantly consists of Tropical moist evergreen and mangrove forest.

Plate – 3 : Map of India showing Western Ghats Mountains passing through Maharashtra.

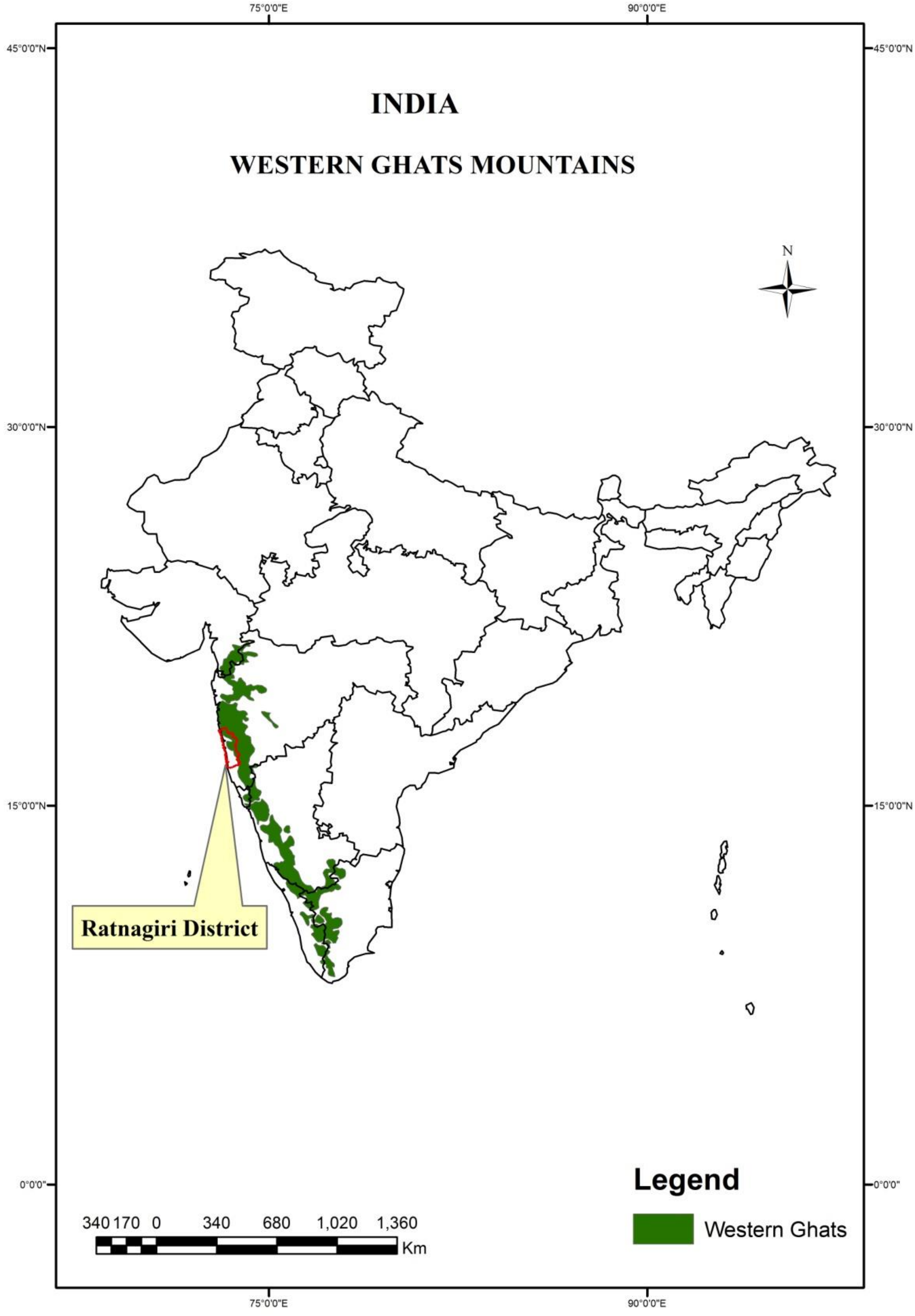


Plate – 4 : Location of Ratnagiri district in the map of Maharashtra state of India

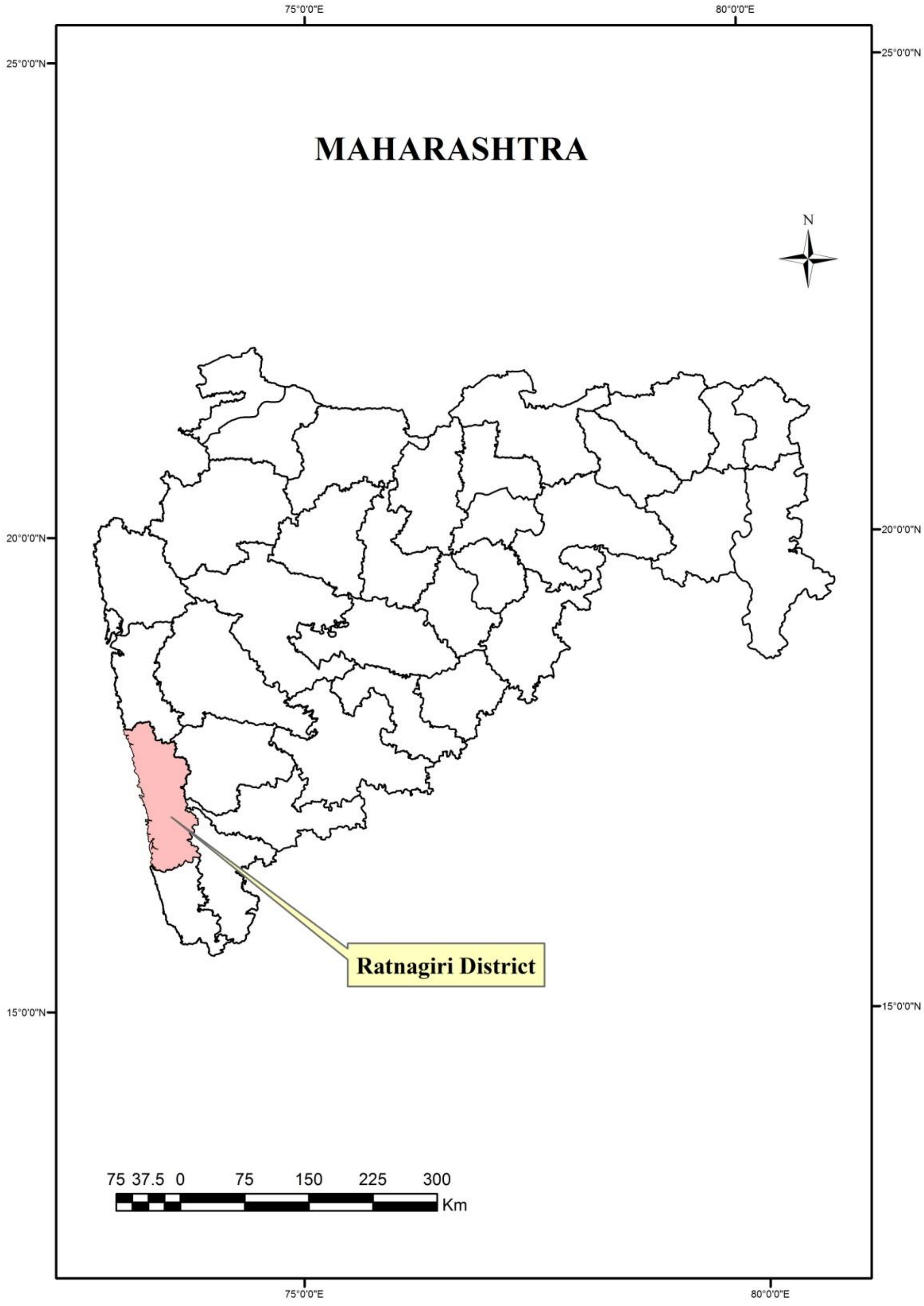


Plate – 5 : Map of Ratnagiri district showing tahsil places

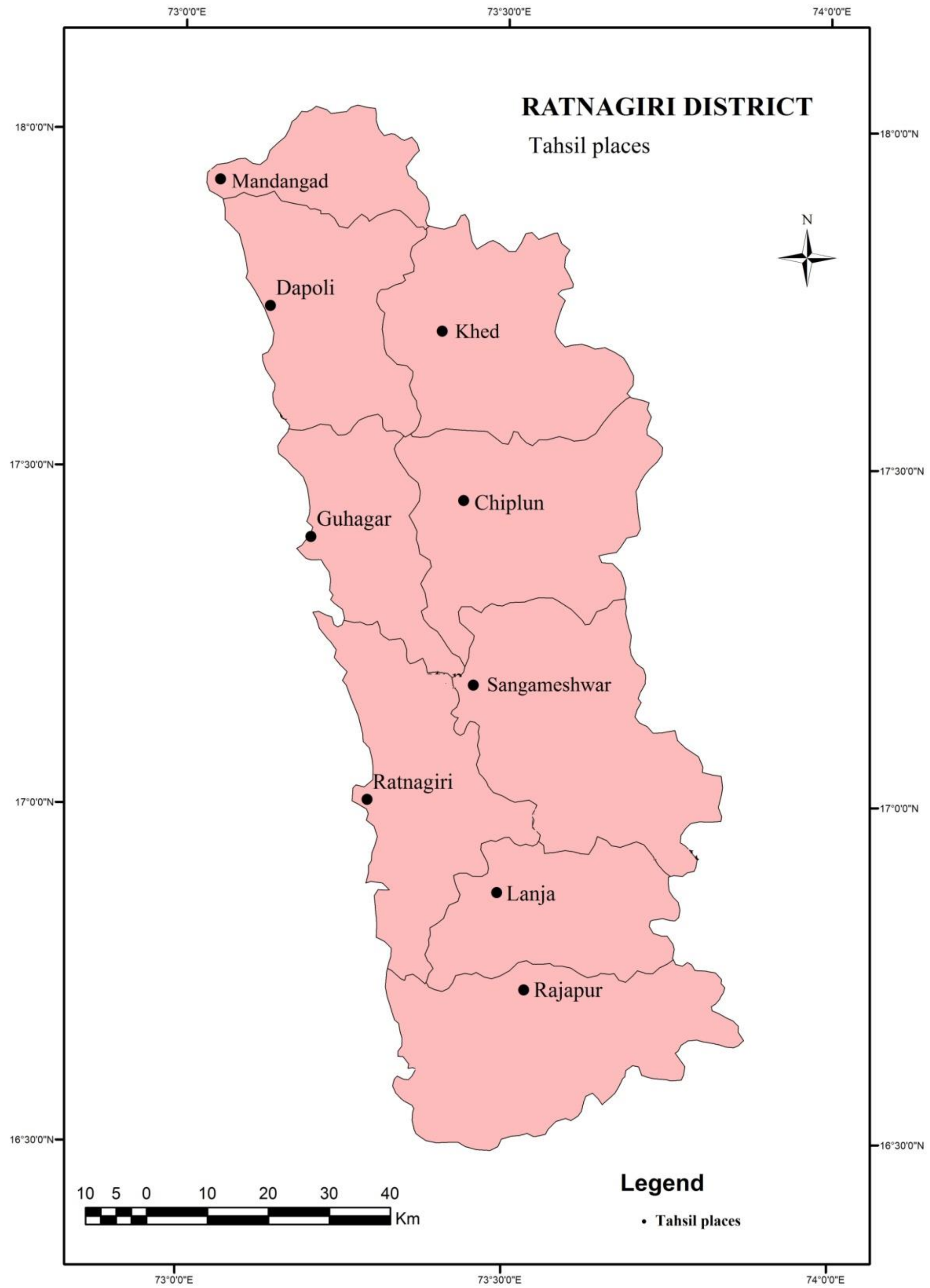


Plate – 6 : Geographic map of Ratnagiri district showing forest cover

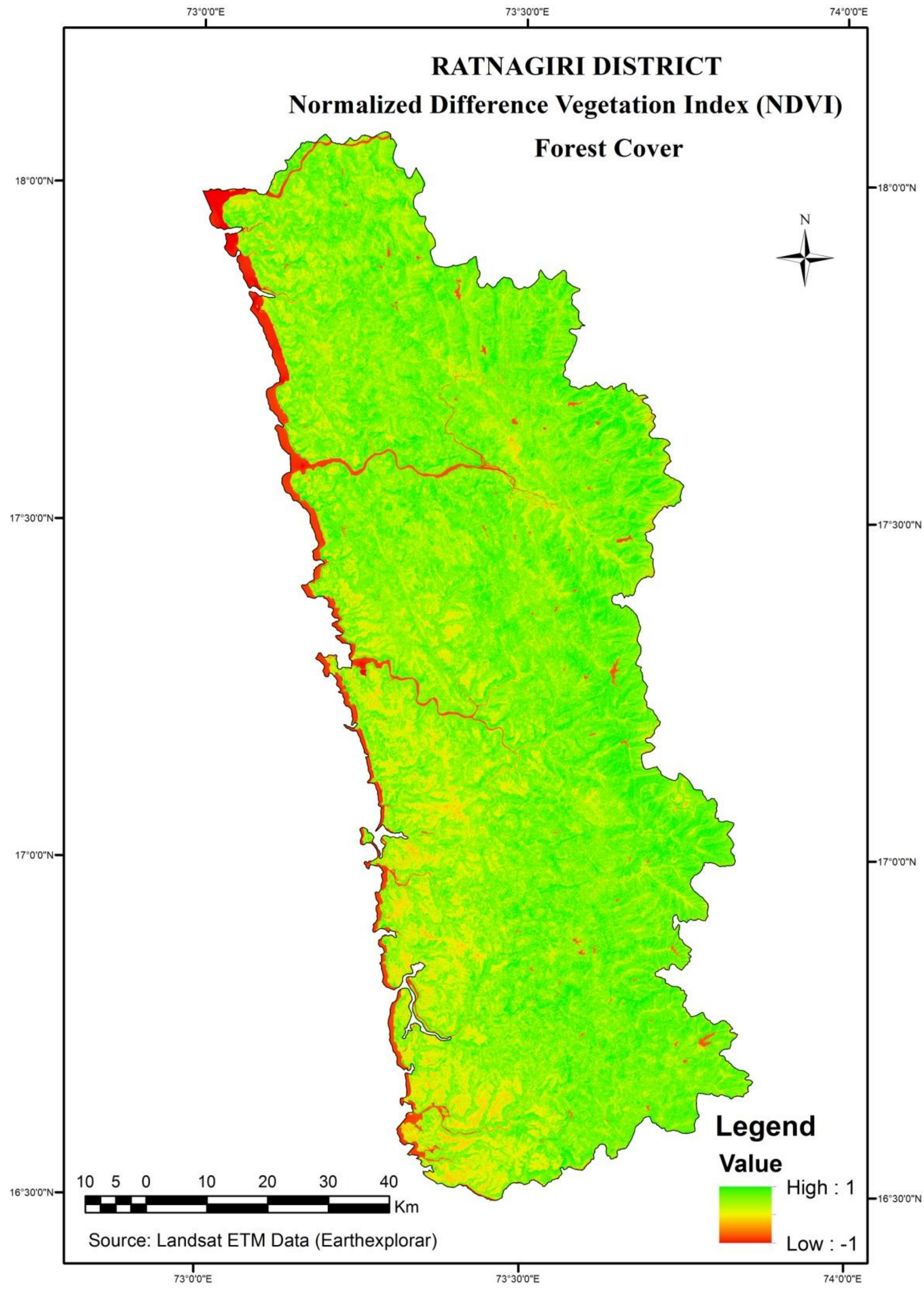


Plate – 7 : Satellite image of Ratnagiri district showing rivers, vegetation and mountains (Courtesy: Google Map)

5. **Chiplun**

It is an industrial city largely dominated by chemical and pharmaceutical industries. It is a beautiful town sandwiched in a valley between the Western Ghats on one side and the Arabian Sea on the other. The city serves as a link between the western coast and above Ghats region of Maharashtra. It is located at 17°31’ N, 73°31’ E with an average elevation of 12m above MSL.

6. **Ratnagiri**

It is the district headquarters and port city situated on the coast of Arabian Sea. It is located at 16.99°N 73.31°E and at an altitude of 11m above MSL. There are several places of interest for collection like Ganapati pule and Hathkhambha. The vegetation of the place consists of tropical evergreen forest and mangrove forest.

7. **Sangameshwar**

It is a non-coastal tahsil in Ratnagiri district. It is located at 17.11°N 73.33°E with an elevation of 187m above MSL. Devrukh city is part of this tahsil; it is rich in the tropical evergreen forest.

8. **Lanja**

Lanja is another non-coastal town in Ratnagiri district. Lanja is located at 16.85°N 73.55°E. It has an average elevation of 166m. Ringane village is located in this tahsil. The area has tropical mixed deciduous forest.

9. **Rajapur**

Rajapur is a city and municipal council in Ratnagiri district. Rajapur is located at 16.67°N 73.52°E. It has an average elevation of 72 meters. This tahsil consists of several collection sites. Jaitapur, Madban and Nate are coastal villages within this tahsil with rich mangrove vegetation. Unhale and Nanar are non-coastal villages with tropical vegetation.

Table – 1 : Tahsils of Ratnagiri district with their location and elevation

Sr. No.	Tahsil	Location	Elevation
1	Mandangad	17°58’ N, 73°15’ E	268 m
2	Dapoli	17°45’ N, 73°26’ E	250 m
3	Khed	17°72’ N, 73°38’ E	25 m
4	Guhagar	17°47’ N, 73°21’ E	10 m
5	Chiplun	17°31’ N, 73°31’ E	12 m
6	Ratnagiri	16°99’ N, 73°31’ E	11 m
7	Sangameshwar	17°11’ N, 73°33’ E	187 m
8	Lanja	16°85’ N, 73°55’ E	166 m
9	Rajapur	16°67’ N, 73°52’ E	72 m

1.22 Climate of Ratnagiri district

The climate of Ratnagiri is humid to sub-humid from June to January and warm from February to May (*https://ratnagiri.gov.in*). The region is characterized by the late rains received during November and December. The region has three seasons *viz*.

(i) Summer season from March to May
(ii) Rainy season from June to October
(iii) Winter season from November to February

Rainfall

Rainfall in the district is mainly due to the South-West monsoon; winter rains from the North-East monsoon are negligible or absent. Although the rainfall is spread over from middle or last of May to November, the important months of rainfall are from June to September and 97% of the rainfall is received during these months. The maximum rainfall (33.37%) and also the maximum intensity (49.4 mm/hr) are noticed in the month of July. The variability of the South-West monsoon is 25%. The total rainfall ranges from 3800 to 5,000mm. The maximum dry spells are observed in the month of September.

Temperature

The average maximum temperature of the district varies from 32.8^{0}C to 40.7^{0}C. While the average minimum percent temperature varies between 17.7^{0}C and 17.1^{0}C. The seasonal variation though not very high, is however, more pronounced in the Eastern parts of the zone on the hill land slopes.

The mean daily temperature is above 20^{0}C throughout the year. The month of May is generally the hottest, recording the mean maximum temperature around 39^{0}C. High humidity associated with warm temperatures from April to October which renders weather unfavorable in the absence of wind. The temperature begins to fall with the onset of the South-West monsoon in June. The day temperature drops by about 4^{0}C-5^{0}C after May till August.

The diurnal variation in temperature is usually small from April to October (less than 7^0C) due to marine influence. It, however, increases (10^0C to 11^0C) from November to March under the influence of the dry winds.

Humidity

During the rainy season, the relative humidity is as high as 90 to 98%. It is least during the winters.

Water

Rivers, streams, springs, ponds and wells are the main sources of surface water in the district. All the rivers of the district are short with varying length from 49Km. to 155Km. They originate from the Eastern side on hilly regions and run towards the west to meet the Arabian Sea. The catchment area of individual rivers is small. The notable rivers of the district are Arjuna, Bav, Jagbudi, Muchkundi, Ratnagiri, Savitri, Shastri and Vashishti. There are many streams and ponds in the district. In Rajapur tahsil hot water springs are there. These water bodies fulfill domestic, agricultural and industrial needs of the district.

Soil

The predominant parent material for soil formation is basalt, granites and gneisses in the area represented by the zone. The typical climate and topographic situation led to the formation of laterite from the basalt. The coastal soils are represented by coastal saline and coastal alluvial deposits. The soils in the hills of Western Ghats are represented by clay loam and coarse shallow soils.

1.23 Vegetational diversity

Vegetational diversity is important from the viewpoint of rainfall distribution, water availability and the fertility of the soil. It also checks soil erosion and keeps the natural balance. Forest products support to the forest-based industries. The proportion of the forested area is very uneven in the district (Plate - 6). Champion and Seth (1963 and 1968) had classified forest types of India. Forest contains many species of trees, shrubs, bamboos and grasses. *Terminalia tomentosa* (Ain), *T. paniculata*, *T. arjuna*, *Memecylon umbellatum* (Anjan), *Garcinia indica* (Kokam), *Bauhinia purpurea* (Kanchan), *Bombax malabaricum* (Kate savar), *B. insigne*, *Strychnos nux-vomica*, *Mangifera indica* (Amba), *Artocarpus integrifolia* (Phanas), *Eugenia jumbolana* (Jambhul), *Acacia catechu* (Khair), *Ficus religeosa* (Pimpal), *F. bengalensis* (Vad), *Tectonia grandis* (Sag), etc. are the important trees in the region. Bamboos include *Bambusa* sp. and *Dendrocalamus strictus*. During monsoon season lateritic platue is covered with mat of grasses. The dominant grasses are *Andropogon* sp. *Heteropogon* sp. *Cymbopogon citratum*, *Themeda* sp., *Glypocloa mysorensis*, *Dimeria woodrai*, and *Eragrostis uniloides*. Many plants of this region have medicinal value. The area of forest in the district was 20.13% in 2007. It is less than that mentioned in forest policy of India.

1.24 Locations of sample collection

Sample collection was carried out at selected localities of Ratnagiri district. Chiplun, Dapoli, Dabhol, Guhagar, Ganapati pule, Ratnagiri, Devrukh, Hathkhambha, Lanja, Ringane, Rajapur, Jaitapur, Nanar, Unhale, Madban and Nate were visited from 2015 to 2018 for sample collection. Every year sample collection was made during pre-monsoon and post-monsoon seasons. These areas have tropical moist, tropical deciduous and mangrove forests.

Aims and Objectives

The fundamental aim of the current study is to study Aphyllophoraceous mycoflora from the selected localities of Western Ghats of Ratnagiri District of Maharashtra. Being coastal area the area has a high level of humidity which favors the growth of fungi. Of the nine tahsils, frequent collections were done from five tahsils *viz.* Rajapur, Lanja, Ratnagiri, Sangameshwar and Chiplun. From remaining three tahsils *i. e.* Dapoli, Guhagar and Mandangad intermittent collections were carried out.

Objectives of the present work are as follows

1. To survey, collect and inventorisation of Aphyllophorales.
2. To identify and preserve the collected Aphyllophorales.
3. To study morphology (external and internal) of Aphyllophorales.
4. To investigate the potential of Aphyllophorales.

As the group Aphyllophorales is still unexplored in Western Ghats and Ratnagiri district in particular, the present research has been undertaken. The findings are submitted for post doctoral work. The present thesis comprises four chapters. The first one is introduction giving the onus of the present need of the hypothesis. Second chapter deals with the review of literature. The present work is completed with the standard protocol which is presented in the third chapter material and methods. The fourth chapter deals with results and discussion which comprises the findings in the present research, its relevance, taxonomy and justification in the form of discussion. The present work is supported by relevant literature which is presented in bibliography in chronological manner. At most care has been taken to incorporate all literature which is providing a strong backbone of sound follow-up. The species found are identified by competent authorities and confirmed. The present work is documented using graphs, tables, images and relevant insertion to advocate the positive relationship. The present work is based on original research and has not been presented anywhere.

CHAPTER – 2

REVIEW

OF

LITERATURE

2.1 Historical background

Studies on fungi began as early as in seventeenth century. Bauhin (1623) was the first to describe fungi in his book "Pinax Theatri Botanici". Micheli (1729) was considered to be the father of Mycology. He studied both micro and macrofungi and published them in a book "Nova Plantarum genera". Macrofungi belong to phylum Ascomycota and Basidiomycota (Kirk *et al*., 2008). Most macrofungi of phylum Ascomycota are leaf litter fungi while that of phylum Basidiomycota are either wood rotting or terrestrial species growing on humus (Srinivasan, 2016). Phylum Basidiomycota was formed by Moore (1980). It is a well-known group that includes mushrooms, boletes, bracket fungi, earth stars, puffballs, rust fungi and smut fungi. With the exception of rust and smut fungi, remaining members are macroscopic and characterised by large basidiome; these are known as macrofungi. Except for bracket fungi which are mostly wood rotting remaining members are terrestrial. Bracket fungi infect and rot living or dead trees. Bracket fungi show a wide range of diversity in the Konkan region and belong to order Aphyllophorales of phylum Basidiomycota (Alexopoulous *et al*., 1979). Order Aphyllophorales includes both parasitic and saprobic fungi which are distinguished by the presence of well developed, macroscopic basidiocarps (Alexopoulous *et al*., 1979). The basidiocarps of Aphyllophorales show diversity in shape, size, texture, beauty and colour (Swapna *et al*., 2008). Therefore they attract the attention of mycologists.

Traditionally Aphyllophorales were classified into two types on the basis of affinity of basidiocarp towards KOH as Polypores and Hymenochaetes (Cunningham, 1964). The basidiocarps producing black colour on reacting with KOH are considered as Hymenocheataceous fungi and others whose basidiocarp do not show any colour change are placed in group Polypores. This reaction was named as a xanthochroic reaction. Such a type of classification is artificial, as it is based on a single character and is being used to a limited extent in the taxonomy of these fungi.

2.2 Cytomorphology of Aphyllophorales

Thallus structure of Aphyllophorales is similar to any other fungal group in general. Thallus of Aphyllophorales is simple and made up of filamentous hyphae. The hyphae are of two type *viz.* vegetative hyphae and reproductive hyphae or hymenium. The importance of cytomorphology of vegetative hyphae in the basidiocarp of Aphyllophorales was introduced by Corner (1933 and 1953). The vegetative hyphae of Aphyllophorales is often well developed, septate, branched and may be uninucleate, binucleate or multinuclate. Hyphae shows characteristic dolipore septum and clamp connections. During favorable conditions hyphae forms basidiocarp.

Corner (1933) described involvement of three different kinds of hyphae in weaving basidiocarp. Corner gave emphasis on hyphal structure and introduced the concept of hyphal system which is also popularly known as mitic system. He recognised three types of hypha in Aphyllophorales *viz.*generative hyphae, skeletal hyphae and binding hyphae. Generative hypha is hyaline, well developed, thin walled, septate and branched. It is with or without clamps. The hyphae lacking clamps is said to be simple while the hyphae possessing clamps is called clamped. It contains nucleus and cytoplasmic structures. Generative hyphae give rise to skeletal and binding hyphae. Skeletal hyphae are thick walled, solid and unbranched. Its lumen is highly reduced due to deposition of substances. Binding hyphae is thick walled, solid and branched. These three types of hyphae construct basidiocarp of Aphyllophorales.

Corner (1932) described the anatomy of five species of Aphyllophoraceous fungi. He found variations in hyphal morphology of these species. Cunningham (1946, 1965) realized the significance of Corner's work and confirmed his results through a series of publications. Cunningham (1946-1965) further brought out the importance of the hyphal configuration in the understanding of the limits in the Aphyllophorales.

Corner (1932) discovered that the context of members of Aphyllophorales may consist of morphologically distinct hyphae which he classified into three basic groups *viz.* Generative, Skeletal and Binding hyphae. These three types of hyphae together form three kinds of hyphal systems needed for constructing the basidiocarp of Aphyllophorales. These are monomitic, dimitic and trimitic. In monomitic system basidiocarp is constructed by using one type of hyphae that is usually generative hyphae. In dimitic system basidiocarp is constructed by using two types of hyphae that are generative hyphae along with either skeletal or binding hyphae. In trimitic system, the basidiocarp is constructed by using all three types of hyphae that is generative hyphae, skeletal hyphae and binding hyphae.

2.3 Types of Hyphae

Hyphae are the basic structural units of basidiocarp (Alexopoulos *et al*., 2002). They are filamentous, hyaline or coloured, usually thin-walled or rarely thick walled, freely branched, and septate, might possess clamps or not. Generally they are tubes filled with cytoplasm and get stained with various agents.

Germination of basidiospore produces primary mycelium. It gives rise to secondary mycelium. The secondary mycelium produces hyphae involved in weaving of basidiocarp and is of limited growth. Secondary mycelium give rise to the skeletal hyphae, binding hyphae and other hyphal structure found in the basidiocarp (Corner, 1932).

1. Generative hyphae

It is usually filamentous; hyaline, thin walled, and branched, septate (Fig. - 1). The types of septa in the generative hyphae are an important character in the classification of Aphyllophorales (Corner, 1932). The septum between two neighboring hyphal cells can be simple or may have dolipore septum. The septa of the generative hyphae are fundamental and constant feature for a given species. The clamp connections may be present or absent and is again a constant feature for given species. Generative hyphae give rise to remaining two types of hyphae.

2. Skeletal hyphae

They are usually filamentous, unbranched and thick walled to solid, aseptate, without clamps, and mostly coloured (Fig. - 1). Skeletal hyphae often react with Melzer's reagent showing strong reddish brown colour. Cunningham (1965) distinguished two types of skeletal hyphae *viz.* bovista and long. The bovista type is broad and has a width of 4-11 µm, with several lateral branches, aseptate, hyaline or coloured. The long type is slender, 4-8 µm in diameter, septate or aseptate, typically unbranched, usually thick, coloured and loosely interwoven.

3. Binding hyphae

They are filamentous, branched, solid to very thick- walled, aseptate, which with random growth (Fig. - 1). It is found in trimitic genera *Microporus* and *Trametes* and in dimitic genus *Polyporus* (Corner, 1932).

Besides these three main types of hyphae some intermediate hyphal types are found. These are as follows:

4. Gloeoporus hyphae

In some Aphyllophorales there occurs rather wide and thin-walled hypha with a refractive content that differs from the normal hyaline generative hyphae. They are frequently yellowish with homogeneous or grainy content (Sharma, 2013). When the hyphae are mounted in phloxine it stains bright. This hypha has significance at species level.

5. Ampoule hyphae

In some Hymenomycetes, the hyphae swell into shape ampoules. They possess clamp connections (Ranadive, 2012).

6. Conducting hyphae

In some Hymenomycetes, in addition to the usual hyphal system, the context contains a network of special hyphae with dense contents, known as conducting hyphae (Sharma, 2013). They are much branched, anatomizing, of wide diameter, relatively thin-walled, at first non-septate and coenocytic but later becoming sparsely septate of intermediate lengths. They are stained with Melzer's reagent or phloxine.

7. Vesicles

Vesicles are pear shaped, hyaline, thin-walled swelling, usually borne terminally but occasionally in an intercalary position in the context hyphae. In cross section, they appear to be devoid of contents. They occur often, in the trama and are conspicuous objects (Ranadive, 2012).

Other structures

a) Paraphysoid structures

A number of sterile accessory structures are often found in hymenium are grouped for conveniently under the general name of paraphyses. They are a heterogeneous in nature (Ranadive, 2012).

b) Hyphal pegs

These are erect, papillate, tuberculate, wart like, spiny structure projecting from the hymenium as in *Hexagonia* spp. They consist of sterile hyphae arising in coherent fascicles from the subhymenial or deep tramal tissue. The term hyphal pegs have been used for the members of family Polyporaceae, where sterile hyphal masses project into the lumen of the tubes. Bose (1944) noted that hyphal pegs are formed due to altitudinal variations.

c) Cystidia

A Cystidium is a large, sterile cell found on hymenium of basidiocarp of Aphyllophorales. They are found between the clusters of basidia. They vary in shape and size and are characteristic for given genera. They are sterile, hyaline, thick walled, unicellular, cylindrical or clavate, blunt or pointed, smooth or ornamented and originating as the terminal cells of branched hyphae and projecting from the hymenium (Fig. - 1). Jenkinson *et al*. (2008) studied cytoplasmic organization of cystidia and classified them according to their position in the basidiocarp as Pilocystidia, on the surface of pileus; Cheilocystidia, on the edge of the gills; Pleurocystidia, on the sides of the gills; Caulocystidia, on the stipe; Dermatocystidia, on the cuticle. Cystidia are further divided into two groups according to their origin *viz*. Hymenial cystidia and tramal cystidia. Hymenial cystidia arise in the sub-hymenium and are of same size or slightly larger than the basidia. Tramal cystidia arises in the trama; may or may not bend into the hymenium and are often far beyond it. The exact function of cystidia is unknown but they are thought to function as excretory hydathodes. In some Aphyllophorales, the pointed, encrusted cystidia are present called Metuloides. They were supposed to protect basidiocarp from the attack of small animals. The cystidia are highly heterogeneous structures even in the single genus, like *Peniophora* they may be conical or cylindrical in shape. The walls are sometimes encrusted or smooth; they may be thick or thin walled. Gloeocystidia are sterile structures distinguished by their dense granular or refractive oily contents. The contents may be hyaline, yellow coloured. Gloeocystidia are involved in nutrition.

d) Cystidioles

A cystidiole is a hymenial cell of the same size and shape as an undeveloped basidium but remaining sterile and protruding beyond the hymenial surface. They are usually inconspicuous and colourless. They may be subulate, bottle-shaped, clavate or fusoid typically with a sharp pointed apex (Ranadive, 2012). They usually lack septa.

e) Setae

They are sterile, rigid, dark coloured, thick-walled, spiny processes, having more or less pointed apex and possessing the property of darkening in alkali. They are yellow or reddish brown in coloured, with pigment located in their walls. Their walls are thick while lumen narrow, simple, unbranched. Cunningham (1946) classified setae in to two type *viz.* hymenial setae and tramal setae. Hymenial setae usually develop below the hymenium and project beyond the basidium (Fig. - 1). Tramal setae are embedded in trama and may project obliquely into hymenium. They are typically conical and have acute apex and wide lumen. Its function is not understood well but thought to provide rigidity to the fructification and protect basidiocarp from damage by small animals. The setae have been used as a characteristic feature in raising new genera of family Hymenochaetaceae. They are abundant in genera like *Phellinus* and *Hymenochaete.*

f) Basidia

Basidia are the hymenial cells in which Karyogamy and meiosis occur. They bear basidiospores on terminal projections called sterigmata (Fig. - 1). Basidium is further divided into following parts *viz.*probasidium, metabasidium and sterigmata (Hudson, 1986).

1) Probasidium

A probasidium is a young basidium. It is that stage of the basidium where Karyogamy occurs. Two haploid nuclei of different genotype fuse to form a diploid nucleus (Hudson, 1986).

2) Metabasidium

It is second stage of the basidium in which meiosis occurs. Diploid nucleus undergoes reduction division to form haploid nuclei which ultimately develop into basidiospores (Hudson, 1986).

3) Sterigmata

The elongation of metabasidium into peripheral structures forms sterigmata. Haploid nuclei migrate from metabasidium to the tip of sterigmata to form terminal basidiospores. The sterigmata consist of a basal inflated part; prosterigmata and an apical point called the apiculum on which the spores are borne (Hudson, 1986).

Size and shape of basidia

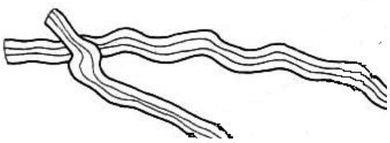
In Aphyllophorales the hymenium is compact and basidia are club shaped, clavate or cylindrical. The size of basidia ranges from 3-5µm x 10-12µm (Cunningham, 1954).

g) Basidiospores

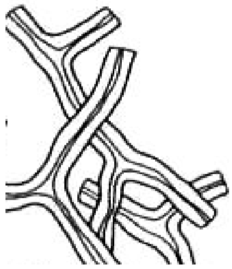
These are important structures for classification of Aphyllophorales. Basidiospores are produced by basidia on hymenium. They are borne singly at the apex of each sterigmata. There are usually one to four sterigmata per basidium. They are found in different shapes such as globose, subglobose, elongated, oblong, cylindrical, elliptical, navicular, reinform, alloantoid (Fig. -1). They often are hyaline or coloured or light brown or they are bright coloured in a mass. The spore wall may be thick or thin; it is made up of chitin. In many species spores are smooth walled but in some, they may be minutely sculptured as in *Ganoderma* (Nunez and Ryvarden, 2000). In others they may bear long spines, warts or reticulations. Sculpturing is frequently accompanied by a slight thickening of the spore wall and colouration. The spore size ranges from small to large in different species. The basidiospores are stained with cotton blue are called cyanophilous. They are called amyloid when get stained with Melzer's reagent; during this reaction they turn blue. Basidiospores are stained bright with Phloxin (Ryvarden *et al*., 2010).

Fig. – 1 : Types of hyphae, other structures and T. S. of Basidiocarp

Generative hyphae

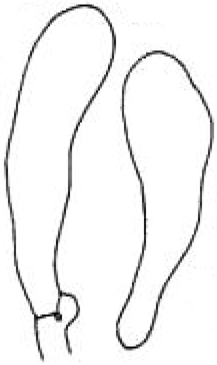


Skeletal hyphae

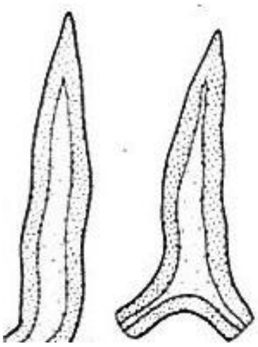


Binding hyphae

Basidia

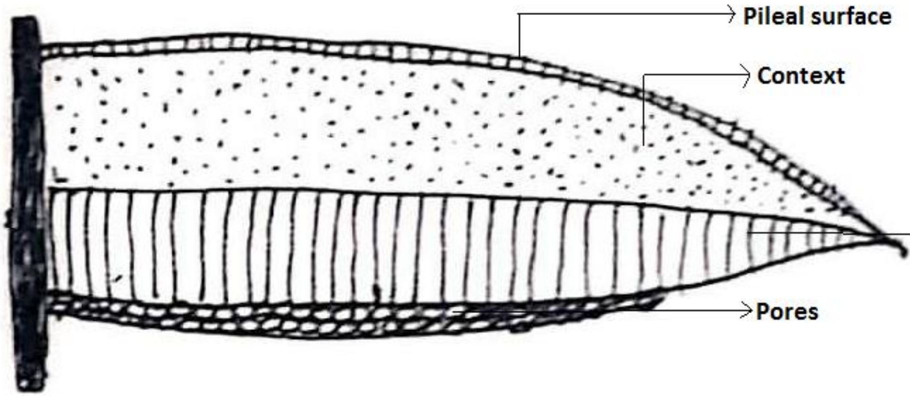


Cystidia



Setae

Basidiospores



T. S. of pileate basidiocarp (bracket form) showing different regions

2.4 Artificial culture of Aphyllophorales

Basidiocarp morphology has been used conventionally a fundamental character for the classification of Aphyllophorales. However, often morphological information is insufficient for the identification of species. Therefore cultural studies of fungal mycelia offer a new set of characters for taxonomy of Aphyllophorales. Cultural studies are useful in delimitation of taxa. Obligate parasites cannot be cultured on artificial medium as they grow on live host. Facultative parasites and saprophytes can be cultured on easily available artificial medium. Nobles (1948 and 1965) were the first to use cultural characteristics for identification of wood rotting Aphyllophorales. The most commonly used media are Malt extract Agar and Sabouraud's Agar (Roy and De, 1996). Cultural studies are used for diagnostic and pairing tests which are used for taxonomical purpose. Stalpers (1978) devised method for identification of Aphyllophorales in pure culture. Cultural methods are used for analytical purpose such as extraction of bioactive compounds, SNPs production, and antioxidant assay, DNA bar-coding and phylogenetic analysis.

2.5 Work on Aphyllophorales at International level

The literature on Aphyllophorales had been developed in the eighteenth century from the time of Linnaeus. He described some fungi in his book "Species Plantarum" written in 1753. Mycology was at neonatal stage during this century. Soon Persoon (1801) classified fungi in his book "Synopsis Methodica Fungorum". He was the first to separate the lamellate and poroid forms. He kept poroid fungi in class Gymnocarpii which was further divided into three orders *viz*. Lytothecii, Hymenothecii and Gymnothecii. The fungi currently classified within order Aphyllophorales were placed within the order Hymenothecii by Persoon (1801)**.**

Fries (1821-1832) a Swedish mycologist published three volumes of a book "Systema mycologicum" in which he provided a comprehensive classification of fungi. He kept Aphyllophorales in class Hymenomycetes. All studies from Linnaeus to Fries were mostly based on gross morphological features.

Later studies used anatomical characters in addition to morphology. Persoon (1822, 1825) published two volumes of a book "Mycologia Europaea". In this book he kept poroid fungi into group "Porodermei" with basidia lining the tubes on internal surface.

Berkeley (1839), a British mycologist described about five hundred and sixty species of polypores. He used hymenium structure of the basidiocarp as an important characteristic for classification of Basidiomycetes. Fries (1855) published another book “Novae Symbolae Mycologici” where he splited genus *Polyporus* into different subgenera. Later in 1874 Fries used hymenial configuration as an important character to classify Hymenomycetes into six different orders in another book “Hymenomycetes Europei”.

Karsten (1879), a Finnish mycologist used microscope to study Aphyllophorales and can be considered as pioneer of fungal microscopy. He used internal hymenial structure for classification of various genera of Hymenomycetes.

Cooke (1883) was a British botanist and mycologist who described and illustrated many genera of wood rotting Aphyllophorales in his book “Handbook of British Fungi”.

Saccardo (1899), in his book “Sylloge Fungorum”, divided fungi into six classes of which one is Basidiomycetes. He divided resupinate poroid and non-poroid fungi into families Polyporaceae and Thelephoraceae respectively.

Patouillard (1900) a French mycologist used microscopic characters and classified Hymenomycetes to give a revised system of classification in his book titled, “Essai Taxonomique surles families et les generes des Hymenomycetes”. He separated Basidiomycetes into “Heterobasidies” and “Homobasidies”. The Homobasidies was further divided into four families i.e. Exobasidiaces, Aphyllophoraces, Agaricaces and Gasteromycetes. So he was the first to use word “Aphyllophore” which means not bearing gills. He placed resupinate members in family Aphyllophoraces.

Murrill (1907) was an American mycologist known for his contribution to the work on Polyporaceae. He published a book “North American Flora (Polyporaceae)” in which he divided Polyporaceae into four tribes. He contributed a bundle of monographs to the studies on Aphyllophorales. Ames (1913) studied various structures occurring in the basidiocarps of Polyporaceae.

Rea (1922) was an English mycologist who for the first time proposed the order Aphyllophorales in his book “British Basidiomycetaceae”, for macroscopic Basidiomycetes having flattened, club like, tooth like, tube like poroid and some time gill like hymenophore. Though word “Aphyllophore” which means not bearing gills this order contains non fleshy gill bearing species such as *Lenzites*. He described number of species of Aphyllophorales which served as standard reference up to the middle of twentieth century.

Rea (1922) while proposing order Aphyllophorales had recognised eight core families on the basis of characteristic shape of basidiome and hymenium. These are Clavariaceae, Cyphellaceae, Fistulinaceae, Polyporaceae, Meruliaceae, Hydnaceae, Thelephoraceae and Polystictaceae. In Thelephoraceae hymenium is flattened, in Meruliaceae and Hydnaceae it is tooth-like and in Polyporaceae it has pores, in Fistulinaceae basidiome is liver shaped and in Clavariaceae it is club shaped. Thus there is ample diversity in basidiocarp shape.

Bourdot and Galzin (1928), French mycologists published “Hymenomycetes de France”, which was based on microscopic analysis of basidiocarp such as nature of hyphae in the different parts of basidiocarp, clamp connections, nature of basidia and type of spores. Overholts (1929) devised method to study taxonomy of Hymenochaetaceae.

Further details on microscopic characters were given by Corner (1932) who developed mitic system for classification of Aphyllophorales. Corner gave emphasis on hyphal structure and introduced the concept of hyphal system. He recognised three types of hypha in Aphyllophorales *viz.* generative hyphae, skeletal hyphae and binding hyphae which ultimately form three hyphal systems to construct basidiocarp in Aphyllophorales. These are monomitic, dimitic and trimitic. In monomitic system basidiocarp is constructed by using one type of hyphae that is generative hyphae. In dimitic system basidiocarp is constructed by using two types of hyphae that are generative hyphae and either skeletal or binding hyphae. In trimitic system basidiocarp is constructed by using three types of hyphae that is generative hyphae, skeletal hyphae and binding hyphae.

Bondartsev and Singer (1941) attempted to classify Aphyllophorales into families and sub-families. Cooke (1953) classified Homobasidiomycetes which included Aphyllophorales. Martin (1961) used macroscopic characters of basidiocarp to classify Aphyllophorales into four families. Lowe (1934) and Overholts (1953) studied Polyporaceae from tropical part of the world including New York State. Later in a series of publications (1957, 1963, 1966 and 1975) he reported several genera. Pelger (1966 and 1967) had published a series of monographs on Polyporaceae and Hymenochaetaceae. Stewart R. L. (1967 and 1972) studied *Ganoderma* and related genera from various Herbaria.

Donk a Dutch mycologist (1964, 1971) divided order Aphyllophorales into twenty two families in his paper, "A conspectus of the families of Aphyllophorales" published in Persoonia. This was a critical and comprehensive attempt for classification of this group and is followed by Alexopoulos and Mims (1979) and Ryvarden (1991). Ryvarden (1995) analysed families proposed by Donk and found that ten families had poroid hymenium and twelve families had hydnoid and other kind of hymenium. Mueller *et al*. (2004) devised method to study biodiversity of fungi.

Oberwinkler (1972) differentiated Tremellales and Aphyllophorales on the basis of softness of basidiocarp. Ainsworth (1973) a British mycologist, kept Aphyllophorales in order Polyporales of class Hymenomycetes. He divided order Polyporales into two families *viz.* Thelephoraceae and Polyporaceae. Gilbertson (1977, 1978, 1979 and 1980) in a series of publications gave synopsis for identification of genera of wood rotting Aphyllophorales. Rajchenberg (1987) described several taxa of South American Polypores.

Hawksworth *et al*. (1983) accepted the classification of Aphyllophorales into twenty one families proposed by Donk (1964) in their seventh edition of "Dictionary of the Fungi".

Kirk *et al*. (2001 and 2008) in the ninth and tenth edition of "Dictionary of the Fungi" splited Aphyllophorales in twelve different orders and fifty families under class Agaricomycetes.

Aime *et al*. (2014) divided the phylum Basidiomycota into four classes:

1. Homobasidiomycetes: Fungi with holobasidia e.g. Agarics and Aphyllophorales.
2. Heterobasidiomycetes: Fungi with Heterobasidia i.e. jelly fungi and their allies.
3. Urediniomycetes: Rust fungi.
4. Ustilaginomycetes: Smut fungi.

These taxonomic groups are supported by phylogenetic studies made by Swann and Taylor (1993). Due to arrangement basidia on hymenium, the Heterobasidiomycetes and Homobasidiomycetes are collectively known as Hymenomycetes. In some members of Basidiomycetes, hymenium is not freely exposed and discharges their spores slowly. These fungi together form a group called Gasteromycetes which includes earth stars.

Webster and Weber (2007) in the third edition of their book "Introduction to Fungi", followed molecular phylogenetic analysis of Berbee and Tailor (2001) to keep Aphyllophorales in Polyporoid clade of class Homobasidiomycetes and desisted from using family names.

Aphyllophoroid condition is found in nearly eight clades of Homobasidiomycetes. Of which Polyporoid clade encompasses one fourth of Aphyllophorales in which the hymenium is not borne on the gill surface with some exceptions. It comprises both poroid and non-poroid fungi which includes resupinate and pileate species. The clade includes bracket fungi, lamellate fungi, tooth fungi, coralloid fungi and crust fungi. Thorough study of this group have shown that Aphyllophorales form unnatural group, and is confirmed by phylogenetic molecular studies made by several workers like Hibbett *et al*. (2007), Tailor and Berbee (2001).

Hibbett *et al*. (2007) gave a higher-level phylogenetic classification of the fungi and included Aphyllophorales in phylum Basidiomycota with twelve orders, fifty families. Margulis and Chapman (2009) placed Aphyllophorales in Polyporoid clade of class Homobasidiomycetae in their book "Kingdoms and Domains".

Adl *et al.* (2013) in their publication "The revised classification of eukaryotes" considered Aphyllophorales as a group with uncertain affinity and kept them in Incertae sedis in class Agaricomycetes.

In the most recent classification proposed by Ruggiero *et al*. (2015) Aphyllophorales were placed in order Polyporales of class Agaricomycetes in their publication "A Higher Level Classification of All Living Organisms". So in the recent classification systems based on molecular phylogenetic analysis the order "Aphyllophorales" is no longer recognised and is being replaced by name "Polyporales". However we are using the word Aphyllophorales over the word Polyporales. As it includes all major clades of wood rotting Basidiomycetes. It is being used most frequently from a century ago and most publications on this group were made by using the name Aphyllophorales.

2.6 Work on Aphyllophorales at National level

Studies on Aphyllophorales of India were initiated by Europian mycologists in the beginning of nineteenth century. This was parallel to the world studies on Aphyllophorales. Pioneering studies on Indian Aphyllophorales were done by British mycologist Koltzsch (1832). He described Aphyllophorales found at that time in his paper on Indian Polyporaceae. Hooker (1839) collected number of specimens from North-East India in the mid nineteenth century.

Later the work on Aphyllophorales continued by Berkeley (1839). He described several Aphyllophorales collected during his field visits by Hooker and Cooke from Sikkim and Himalayas. It was succeeded by good contributions from Cooke (1886). Till the end of nineteenth century the studies on Aphyllophorales of India was under infant stage. An extensive study on this group was the need of the hour in twentieth century. It was rather difficult to survey the group as no comprehensive flora had been written for any country. In the beginning of twentieth century the studies on Aphyllophorales took pace with work of Hennings (1901) prepared a manual Aphyllophorales from India and published "Fungi India Orientalis". This is considered to be first myco-flora of Indian fungi.

Massee (1901-1910) published an account of Indian Polyporales based on collections made by Butler (1905-1918). Lloyd (1898-1924) also worked on Indian Aphyllophorales and published several species. Considerable work on this group was made by Sydow *et al*. (1906-1916). Theissen (1913) reported few poroid species collected by Blatter from the Bombay presidency region of India. Murrill (1924) had made significant contributions in the field of Aphyllophorales. So till now the work on Indian Aphyllophorales was being carried out by Europian scientist.

Bose (1919-1927) was the primary Indigenous mycologist to study and document Aphyllophorales from Bengal. His work served as starting point for study of Aphyllophorales of India. The work on Polyporaceae of Madras presidency was carried out by Sundaramani and Madurajan (1925). They reported more than 300 species of Aphyllophorales. By the time Butler and Bisby (1931) gave a comprehensive account of fungi from India in their standard publication “The Fungi of India”. This was an important landmark that motivated the studies on Indian Aphyllophorales. In the mid of twentieth century the work on Aphyllophorales took pace. Later the periodical work by a number of mycologists from various parts of country added to the knowledge of Aphyllophorales.

In the middle of twentieth century Banerjee (1935) studied Aphyllophorales of North-East India. He made useful contribution for identification and regeneration of basidiocarp of Aphyllophorales.

Bagchee (1950) reported Aphyllophorales causing wood rot in economically important trees from forests of North India. The work of Bagchee *et al.* (1954), Bakshi (1958), Puri (1956), Ramakrishan (1959), Vasudeva (1960), Bakshi *et al.* (1963), Rehill and Bakshi (1965), Reeves *et al.* (1967), Thind (1973, 1975), Sathe and Rahalker (1977), Rattan (1977), Thind and Dhanda (1978), Anjali Roy (1976-1996) and Harsh (1982) reported several species of Aphyllophorales from Northern parts of the country.

Bagchee along with Bakshi made several new reports of Aphyllophorales from Forest Research Institute Dehra Dun. Thind *et al*. (1957) extensively worked on Aphyllophorales of Mussoorie Hills of Western-Himalaya. He contributed a lot in this field and his team reported several species new to this area. Bakshi (1959) studied different types of rots found in forest trees. Singh *et al*. (1961) studied Aphyllophorales from Andaman and Nicobar Islands. Bakshi (1971) published a monograph on "Indian Polyporaceae" which described 15 genera and 355 species of Aphyllophorales. Reid (1975) made revision of some genera of Polyporaceae. He described new genus *Leucophellinus*.

Anjali Roy (1976) worked initially on Aphyllophorales of Bengal. She used anatomical and cultural characteristics in addition to morphology, for the study of Aphyllophorales. Her contribution in the field of wood rotting Aphyllophorales is significant. Going further she made exhaustive study of this group across the country. Roy and De (1996) published a handbook "Polyporaceae of India" based on exhaustive studies on members of family Polyporaceae collected from all over the India. Sharma (1993) reported new records of Polyporaceae. He (1995) came up with a couple of publications "Hymenochaetaceae of India" and "The Resupinate Aphyllophorales of the North Western Himalayas". By the end of twentieth century abundant literature on Aphyllophorales was available.

In twenty first century the knowledge continue to increase by several folds. Several standard floras of Aphyllophorales are now made available during this period. The important ones are "Genera of Polypores" by Sharma (2000), proved to be mile stone. This book covered all the genera of polypores known from India. Arya *et al*. (2008) reported Aphyllophorales of Gujarat state. Sharma (2013) came up with voluminous publication "Aphyllophorales of Himalaya". He described 30 families of Aphyllophorales from Auriscalpiaceae to Tremellodendraceae. The book provides taxonomic account and authors field observations.

These studies were mostly done on the poroid pileate, stipitate and resupinate Aphyllophorales. The work on non-poroid resupinate Aphyllophorales of India is being neglected due to lack of literature and complicated nature of hymenium. Therefore scanty information is available about this group. In fact, studies on this group of Aphyllophorales mainly remained neglected due to rare occurrence. Bagchee and Bakshi (1954) had done pioneering work on this group and contributed greatly towards the knowledge of non-poroid resupinate Aphyllophorales of India. Thind and Adalakha (1956) described many species of non-poroid resupinate Aphyllophorales from Punjab. Reid *et al*. (1959) and Rehill (1965) prepared generic monographs of *Peniophora*, *Corticium* and *Stereum.* Thind and Rattan (1971) described few species of non-poroid resupinate Aphyllophorales under Thelephoraceae. Natarajan and Kolandavelu (1985-1998) made valuable contribution on resupinate Aphyllophorales of Tamil Nadu. In Maharashtra, Naik-Vaidya (1990) reported wood rotting fungi from Karnala sanctuary. Rabba *et al*. (1994) worked on the resupinate species of genus *Phellinus* from Maharashtra state. Nanda (1996) studied wood rotting Aphyllophorales from Bhimashankar. Hakimi (2008) made bulk of the contribution towards the resupinate Aphyllophorales of Maharashtra. Bhosale *et al.* (2010) studied diversity and taxonomy of *Ganoderma* from Western Ghats of Maharashtra. This genus has abundant species in this part of the state. Ranadive *et al.* (2012) worked on host specificity of *Phellinus* from India. It was followed by another manual publication by Hakimi *et al.* (2013) entitled "Resupinate Aphyllophorales of India" which included both poroid and non poroid members. However, the work on largely remained neglected due to limited literature.

2.7 Work on Aphyllophorales of Western Ghats of India

Western Ghats are rich in floristic diversity (Nair and Danial, 1986). It is one of the hot spots of biodiversity (Nayar, 1996). The studies on Aphyllophorales of Western Ghats of India include the contributions from several researchers. Rangaswami (1970) studied Aphyllophorales of Southern India and reported 44 species. Thite *et al.* (1976) studied preliminary Aphyllophoraceous flora of Maharashtra. Patil and Thite (1978) studied polypores of Amboli Ghat, Maharashtra. Natarajan and Raman (1980), Natarajan and Kolandavelu (1985) studied resupinate Aphyllophorales of Tamil Nadu. Leelavathy and Ganesh (1986) reported new species of *Phellinus* from Western Ghats of Kerala, India. Leelavathy and Ganesh (2000) in their book "Polypores of Kerala" described nearly 80 species of Aphyllophorales belonging to 32 genera and three families *viz*. Ganodermataceae, Hymenochaetaceae and Polyporaceae.

Ranadive *et al.* (2011) had carried out extensive work on diversity of Aphyllophorales from Western Ghats of Maharashtra State. They explored various locations of Western Ghats of Maharashtra state and collected 126 specimens and reported 20 species belonging to 14 genera and 8 families of Aphyllophorales. Going a step further Ranadive *et al.* (2012) developed a website; www.fungifromindia.com which contains Indian Aphyllophorales database (IAD). This database provides detailed information of Indian fungi with their global links. It was an important landmark in the literature of Indian fungi.

2.8 Importance of Aphyllophorales

Aphyllophorales provide important ecological services by decaying wood in forest ecosystem. Thereby they help in recycling and replenishment of nutrients. These nutrients serve as raw materials for producers. In addition some species produce bioactive compounds which are used as medicines. To some extent they also contribute to pollution. The basidiocarps of *Lenzites betulinus* are used in the manufacture of charcoal crayons (Alexopoulous *et al*., 2002). In ancient times the upper tissue of the pileus was considered an efficient razor strop. A few soft, fleshy basidiocarps of *Lentinus* spp. are edible and sold in local markets.

Medicinal importance of Aphyllophorales

From the olden times Aphyllophorales have been used in the treatment of various diseases. Aphyllophorales have been used in the traditional medicine system by indigenous people in Asia. These fungi produce rigid and perennial basidiocarps which can be preserved for later use. *Ganoderma lucidum* have been used in traditional Chinese medicine as a tonic for promoting health, vitality and longevity. It is used to make toothpaste and tea powder (Tyagarajan-Sahu *et al.*, 2010). Studies have shown that extract isolated from *G. lucidum* has anti-cancerous, anti-diabetic and anti-inflammatory properties (Jong and Birmingham, 1992). Vaidya and Bhor (1990) studied medicinally important wood rotting fungi of Western Ghats. In Russia *Inonotus obliquus* is used since sixteenth century as a folk medicine to treat cancer, tuberculosis and gastro-intestinal diseases (Shashkina *et al.*, 2006). Recent studies by Zjawiony (2004) claimed it to be anti-AIDS, anti-aging, blood lipid lowering and immune enhancing effects.

2.9 Applied aspects of Aphyllophorales

Now at International level the work on Aphyllophorales is focused on antioxidant studies, enzyme assay, and bioprospecting and nanoparticles synthesis.

Silver Nanoparticle synthesis

Nanotechnology is new interdisciplinary branch of science dealing with design and synthesis particles ranging from 1-200nm in diameter. These particles have applications in various branches of Science. Nanotechnology has applications in many fields such as food, cosmetic, environmental conservation, health care, industries, electronics, drug delivery etc. (Kulkarni and Muddapur, 2014).

The term "nanoparticles" is used to describe a particle whose size ranges from 1nm to several nanometers, at least in one of the three possible dimensions. At this nano range dimensions, the biological, chemical and physical properties of the particles change from the properties of corresponding bulk material and also from individual atoms and molecules. The nanoparticles can be made from various chemical materials such as metals, metals oxide, silicates, polymers, and biomolecules (Kumar and Yadav, 2009). Shape of nanoparticles vary, they may be spherical, cylindrical, rod shaped or polygonal. Generally the nanoparticles are designed with tailored surface modifications to meet the needs of specific applications. The huge amount of variations in nanoparticles arises from their wide range of chemical nature, shape and size (Dahl *et al*., 2007).

Silver nanoparticles are of most sought after because of their unique properties, which can be used to get antimicrobial applications, cytogenetic superconducting materials, cosmetic products and electronic components. Several physical and chemical methods have been used for synthesizing and stabilizing silver nanoparticles (Senapati *et al.*, 2005). The most accepted chemical method for the synthesis of silver nanoparticles is chemical reduction by using a number of organic and inorganic reducing agents, physicochemical reduction and radiolysis.

Silver nanoparticles (SNPs) have attracted specific attention due to their potential applications, in electronics, biosensors, cloth manufacturing, food storage, paints, sunscreens, cosmetics and medical devices (Ahamed *et al*., 2010). SNPs have also a potent bactericidal and fungicidal activity and general anti-inflammatory effects. Further, can be used to improve wound healing, to develop dressings for wounds and antibacterial coatings (Ahamed *et al*., 2003). Although aerosol tools, laser technology, photochemical reduction and UV rays have been used fruitfully to make nanoparticles, they are quite expensive and rely on the use of unsafe chemicals (Narayanan and Sakthivel, 2010).

Recently, there is growing attention to produce nanoparticles using environmentally friendly methods. This move includes use of mixed valence polyoxometalates, irradiation, polysaccharides and biological method which provide advantages over traditional methods involving use of chemicals. Silver nanoparticles are the metal of choice as they hold the promise to kill microbe's effectively and effect on both extracellularly as well as intracellularly.

The microbial synthesis of nanoparticles is a unique approach as it combines nanotechnology and microbial biotechnology. Some microorganisms, including bacteria, filamentous fungi and yeast, plays important role in the remediation of toxic metals through the reduction of the metal ions; therefore, these microorganisms could be employed as a nanofactories for the production of nanoparticles (Kulkarni and Muddapur, 2014).

Biological method based on use of fungi to produce nanoparticles is based on the fact that fungi produce extra cellular enzymes, which can be used in the reduction of metal ions to synthesise nanoparticles. Wood rotting fungi are ideal candidates for this purpose. These fungi grow on easily available substrate and secrete large amount of extra cellular enzymes which can be used for synthesis of SNPs (Ahamed *et al*., 2010).

Bioprospecting of Aphyllophorales

Surprisingly the basidiocarps of large number of species of Aphyllophorales have been used in traditionally medicine system. A notable example is *Ganoderma lucidum*, the fabled Ling Chi of Chinese herbal medicine (Stamets, 1993). Vaidya and Rabba (1993) reported 12 species of *Phellinus* used in Indian folk medicine. Antibiotics have been isolated from several of the Aphyllophorales, including a species of *Phlebia* (Quack *et al*., 1978). These fungi are also known to produce antiviral, cytotoxic and antineoplastic compounds (Zjawiony, 2004).

Polysaccharides derived from cell wall of Aphyllophorales have shown antitumor effects. These substances are known as biological response modifiers (Zjawiony, 2004). They are also called immune-potentiators and prevent metastasis of tumor. Several compounds with antioxidant, anti-diabetic, phytotoxic, cardiovascular properties have been isolated from Aphyllophorales in recent times. Although several polypores are serious wood parasites, some of them are important in herbal medicine (Zjawiony, 2004). Because of their ability to degrade components of wood by secreting extracellular enzymes they play a vital role in maintaining balance of ecosystem (Elmqvist *et al*., 2010). Shah *et al*. (2018) reported enzymes produced by *Fomitopsis pinicola* a brown rot fungus responsible for degradation of wood. Several members of Aphyllophorales are used in preparation of food supplements and secondary metabolites.

Antioxidant studies

Many species of Aphyllophorales are having enormous importance in studies as a source of important biological compounds. The antioxidant compounds like indole compounds, phenolic acids and sterols in many species of Aphyllophorales have been isolated and identified. The reversed-phase high performance liquid chromatography (RP-HPLC) was used for analysis and estimation of these compounds.

Nowacka-Jechalke *et al.* (2014) revealed presence of eight phenolic compounds in Aphyllophorales like *Hydnum repandum* and *Sparassis crispa.* They also identified five indole compounds such as melatonin, serotonin, tryptamine, l-tryptophan and ergosterol. Therefore Aphyllophorales have immense potential of chemical components with recognized antioxidant activity. For this reason these fungi are used in traditional Chinese herbal medicine system.

Wood-decomposing enzymes

Aphyllophorales possess plant cell wall decomposing enzyme machinery. Glycoside hydrolase, exocellobiohydrolases and pectinases are enzymes associated with brown rot decay. Endoglucanase and xyloglucanase were also involved in wood decomposition (Blanchette, 1991). The levels of hydrogen peroxide-generating oxidoreductase enzymes such as Peroxidase, Mn-Peroxidase, and Lignin peroxidase are associated with white rot decay.

2.10 Wood rot by Aphyllophorales

Aphyllophorales occur in wide range of tropical forests of India. They contain both terrestrial and wood inhabiting forms. Some of them are serious parasites of forest and shade trees. Aphyllophorales play important role in ecosystem by rotting wood and recycling its components. These fungi digest moist wood and cause its rot. Parasitic species attack live wood while saprophytic species attack dead wood. The physical and chemical properties of wood make it extremely difficult to degradation by fungi due to low nitrogen content which are needed to produce enzymes that degrade the structural components of the wood. Hintikka and Laine (1970) described identification of various types of wood decay. Vaidya (1987) studied ecological characteristics of wood decay and cord forming fungi.

Afyon *et al*. (2005) studied wood decaying macrofungi of Turkey. They cause root rot, white rot, brown rot and heart rot of trees (Alba Zaremski *et al*., 2015). Of these two types of wood rots studied in detail *viz.* brown rot and white rot. In brown rot cellulose is destroyed and lignin component is left undisturbed, while in white-rot cellulose as well as lignin is destroyed. *Fomitopsis pinicola* causes brown-rot and *Microporus xanthopus* causes white-rot of hard wood trees.

White rot

Wood predominantly contains cellulose, hemicellulose and lignin. Some fungi degrade both cellulose and lignin component and cause complete degradation of wood, these are known as white rot fungi. Such wood is bleached fibrous in appearance. These are also known as lignicolous fungi because of their unique ability to degrade lignin. These fungi produce lignin degrading enzymes *viz.* Lignin peroxidases, Manganese peroxidases and laccases. All three lignin degrading enzymes are secreted as multiple isoforms which differ in their pH and catalytic properties (Kirk and Cullen, 1998). White rot fungi make wood brittle and weak therefore their oxidative enzymes are used in industries for the bleaching of wood pulp for paper production, or of textile dyes.

Brown rot

While other fungi degrade cellulose component only, leaving lignin unaffected, these are known as brown rot fungi. These fungi attack middle lamella by producing polygalacturonases (Green and Clausen, 1999, 2003). They produce oxalic acid which acidic condition for hydrolysis of pectin and cellulose (Green *et al*., 1991). They also produce cellulases and hemicellulases which breakdown cellulose and hemicelluloses respectively. Hydrogen peroxide is produced during breakdown of hemicelluloses. It rapidly diffuses into wood tissue leading to decay that causes wood to shrink and show brown discolouration. Such wood cracks into roughly cubical pieces called cubical fracture. Some members decay sap wood and others decay heart wood. Prolonged attack by Aphyllophorales causes hollowing of trunks as evident in many forest trees. Heartwood contains fungicidal substances stored in it which further makes it difficult to get degraded by fungi. Many brown rot fungi, produce enzymes for degradation of lignin (Mtui and Nakamura, 2004), but these enzymes are used for other functions, like detoxification of phenolics present in wood (Cho *et al*., 2009).

Contribution to green house effect

Some wood rotting Aphyllophorales like *Phellinus* produce chloromethane, a green house gas which is responsible for destruction of ozone layer in stratosphere. It is used by fungi for synthesis of some compounds needed for degradation of lignin. They produce large amount of chloromethane than required. According to Watling *et al*. (1998) of the total atmospheric chloromethane, 15-20% is produced by natural sources, and 80-85% is produced by fungi.

2.11 Trends in taxonomy of Aphyllophorales from past to present

Work before twentieth century

The pioneering work on Aphyllophorales was initiated in eighteenth century. During this period the work of Linnaeus (1753), Persoon (1801), Fries (1849) and Cooke (1886) laid the foundation for study of Aphyllophorales. Their work was mainly based on gross external characters. They also classified these fungi into different groups on the basis of morphological characters.

This period was characterised by invention of microscope (1881 to 1930). Workers like Karsten (1889), Patouillard (1900), Lloyd (1898-1925), and Murrill (1915); studied the microscopic characters of these fungi for the first time. They used these characters for classification of Aphyllophorales into family, genera and species.

Work in twentieth century

This period is characterised by exhaustive studies on this group. The major contributions by, Corner (1932-1953) and Cunningham (1945-1963) brought out the significance of the hyphal organization in the identification of the fungi.

This part consists of current works of Eriksson (1958); Donk (1964); Roy (1971-1987); Pegler (1973); Hjortstam (1973-1988); Eriksson and Ryvarden (1973, 1975, 1976); Gilbertson (1977-1978); Sharma (1989-1995) etc., which deals in detail with the external and internal characters, chemical reactions, hyphal structures of the basidiocarps under natural and culture conditions.

Aphyllophorales, is an order of phylum Basidiomycota, are distinguished by holobasidia, gymnocarpous and non-putrescent basidiocarp which typically lacks lamellate (Bourdot and Galzin, 1928; Donk, 1933; Rattan, 1977; Gilbertson, 1979 and Ryvarden *et al.,* 2010). The fruit bodies may be completely appressed either to the substratum or else to a reflexed edge. They may be club shaped, coralloid, cup-shaped, tube-like or pileate with central or lateral stalk. The basidium bearing structures may be variable like even, warted, toothed or poroid. The shape of basidium is another variable character which may be spherical, obovoid, clavate or cylindrical. The number of spore-bearing sterigmata is usually four, but may vary from one to eight in different genera (Donk, 1933). The separation of Aphyllophorales from Agaricales has not yet been established clearly (Bondartsev and Singer, 1941) and the position of genera such as *Pleurotus*, *Lentinus* and *Schizophyllum* is still a matter of debate (Roy, 1976).

Work in twenty first century

In the twenty first century the research on Aphyllophorales is mostly focused on DNA sequencing and Phylogenetic analysis (Taylor and Berbee, 2001). This has leads to the consideration of the natural and phylogenetic affinities among the species of Aphyllophorales (Hibbett *et al*., 2007).

2.12 Present status of work on Aphyllophorales

The taxonomic work on this group is progressing at a brisk pace from various corners of the world including India. Study on Aphyllophorales from Northern side of India has been done extensively by Bose, Bagchee, Bakshi, Roy, Thind and is being continued by faculties from various Universities of Jammu, Punjab, Himachal Pradesh, West Bengal, Assam, Meghalaya, Tamil Nadu and Kerala. The taxonomic work on this group in Maharashtra is incomplete. With the exception of Pune district (Ranadive *et al*., 2011) there is no Aphyllofungal flora of each district of Maharashtra state. Few faculties from University of Mumbai, Savitribai Phule Pune University, Pune, Dr. Baba Saheb Ambedkar Marathwada University, Aurangabad and Shivaji University, Kolhapur carried out work on this group. So studies on Aphyllophorales of Maharashtra initiated bit late and a lot of work is needed to document them before they get disappeared from the natural habitat due to deforestation and other unavoidable causes. Therefore, current study of documenting Aphyllophorales from Ratnagiri district of Western Ghats of Maharashtra has been undertaken.

The focus of studies on Aphyllophorales is to document morphological and anatomical characters of the collected species. Cultural methods were also used but they were not so helpful (Ryvarden *et al.,* 2010).

CHAPTER- 3

MATERIAL

AND

METHODS

3.1 Survey of study area

All the species described in the present work have been collected personally by the author through extensive field survey of the Western Ghats of the Ratnagiri District of Maharashtra State. The forest area of Ratnagiri district was surveyed from 2015 to 2018 for collection of fungi belonging to order Aphyllophorales of phylum Basidiomycota. The survey was carried out during different seasons of the year. The surveys were divided into pre-monsoon, monsoon and post-monsoon seasons. The pre-monsoon survey was conducted just before the onset of monsoon in the months from March to June when conditions were relatively dry. Second survey was conducted just in the mid of monsoon season from July to October when conditions were moist and humid. The third survey was conducted in the post-monsoon season from November to February when moisture content was relatively less. The survey was made in all tahsils of Ratnagiri district at selected places. The places covered during survey for collecting Aphyllophorales include Guhagar**,** Dabhol, Dapoli, Chiplun, Khed, Ratnagiri, Ganapati pule, Devrukh, Lanja, Rajapur, Jaitapur, Madban, Nate, Unhale, Hativale and Nanar (Plate - 8). Collection of fungal specimens was done from these areas from July, 2015 to June, 2018.

An account of Study areas

1. **Guhagar**

This town is located towards north of Ratnagiri district. It is situated on the west coast of Maharashtra. Climate of this place is warm and humid with average temperature of 27.0^{0}C. It receives heavy annual rainfall of 2605mm. Coastal area of the town is covered with littoral and swamp forest. The dominant mangrove species of this forest are *Rhizophora* spp., *Avicennia* spp., *Acanthus illicifolius* etc. It also has tropical moist broadleaf forest on the platue region. The dominant species of the forests are *Artocarpus integrifolia* (Phanas), *Terminalia tomentosa* (Ain), *Terminalia arjuna* (Arjun), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc.

Plate - 8 : Map of Ratnagiri district showing study localities

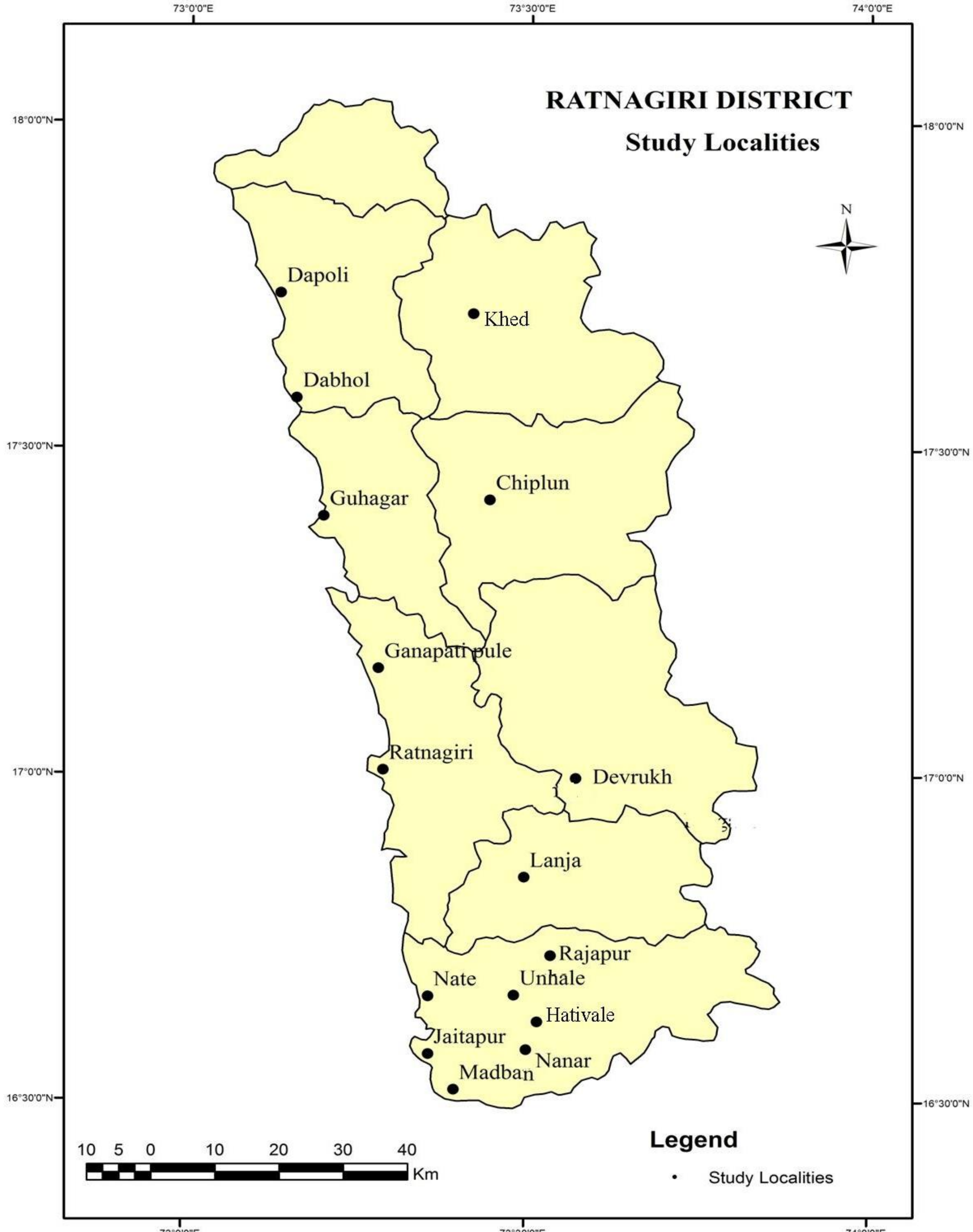


Plate - 9 : Tropical forest in the study localities of Ratnagiri district

Plate - 10 : Littoral and swamp forest in the study localities of Ratnagiri district

Table - 2 : Study areas of Ratnagiri district with their location and forest types

Sr. No.	Tahsil	Location	Forest types
1	Dapoli	17°45’ N, 73°26’ E	Tropical Semi-evergreen Forest
2	Dabhol	17°58’ N, 73°18’ E	Littoral and swamp Forest
3	Khed	17°72’ N, 73°38’ E	Sub-tropical Hill Forest
4	Guhagar	17°47’ N, 73°21’ E	Littoral and swamp Forest
5	Chiplun	17°31’ N, 73°31’ E	Tropical Moist Broadleaf Forest
6	Ratnagiri	16°99’ N, 73°31’ E	Littoral and swamp Forest
7	Ganapati pule	17°14’ N, 73°26’ E	Littoral and swamp Forest
8	Devrukh	17°11’ N, 73°33’ E	Tropical Semi-evergreen Forest
9	Lanja	16°85’ N, 73°55’ E	Tropical Semi-evergreen Forest
10	Rajapur	16°67’ N, 73°52’ E	Tropical Semi-evergreen Forest
11	Unhale	16°73’ N, 73°56’ E	Tropical Evergreen Forest
12	Hativale	16°59’ N, 73°54’ E	Tropical Evergreen Deciduous Forest
13	Nanar	16°50’ N, 73°23’ E	Tropical Semi-evergreen Forest
14	Jaitapur	16°35’ N, 73°20’ E	Littoral and swamp Forest
15	Madban	16°29’ N, 73°19’ E	Littoral and swamp Forest
16	Nate	16°45’ N, 73°21’ E	Littoral and swamp Forest

Table – 3 : Major forest types in Western Ghats of Ratnagiri district

Sr. No.	Forest type	Dominant species of the forest
1.	Tropical moist evergreen forest.	*Artocarpus integrifolia, Mangifera indica, Dioscorea batatas, Strychnos nux-vomica, Terminalia tomentosa* and *T. paniculata*
2.	Sub-Tropical broad leaved forest	*Bombax ceiba, Cinnamomum macrocarpus. Dalbergia lanceolaria, D. latifolia. Terminalia bellerica, T. chebula, Mallotus philippensis, Mangifera indica, Memecylon umbellatum* and *Bambusa arundinacea*
3.	Tropical Semi-evergreen forest.	*Terminalia paniculata, Memocylon umbellatum, Terminalia chebula, Syzigium cumini, Olea diocea* and *Mangifera indica* and *Actinodaphne hookeri*
4.	Littoral and Swamp forest	*Rhizophora mucronata, Avicennia apetala, Sonneratia spp., Kandelia spp., Bruguiera spp.* and *Acanthus illicifolius*

2. **Dabhol**

This town is located towards south of Dapoli town. It is situated on the West coast of Maharashtra. Climate of this place is warm and humid with average temperature of 26.8^{0}C. It receives heavy annual rainfall of 3300mm. It has tropical moist broadleaf forest. The forest trees are evergreen during rainy season and leafless in summer. The dominant species of the forests are *Terminalia tomentosa* (Ain), *Terminalia arjuna* (Arjun), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc. It also has littoral and swamp forests. These forests occur along the creeks and littoral regions. The dominant mangrove species of this forest are *Rhizophora* spp. and *Sonneratia* spp.

3. **Dapoli**

This town is located towards the North of district centre. It has an altitude of 240m. Climate of this place is cool and humid with average temperature of 27^{0}C. It receives annual rainfall of 3109mm. It has tropical semi-evergreen forest. This is one of the common types of forest in Konkan coastal belt. Such forests are confined to slopes of hill. These forests usually evergreen during monsoon season and become dry, leafless in summer (Plate - 9). The dominant species of such a type of forests are *Terminalia paniculata* (Kinjal), *Terminalia tomentosa* (Ain), *Terminalia chebula* (Hirda), *Memocylon umbellatum* (Anjan), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango), *Actinodaphne hookeri* (Pisa) etc. Being coastal area it also has littoral and swamp forests. These forests occur along the creeks and littoral regions. The typical mangrove species found in this area are *Rhizophora* spp. *Avicennia* spp. and *Kandelia* spp. These forests play important role in protection of marine and terrestrial life.

4. **Chiplun**

Chiplun town is located towards the Eastern side of the district with an average elevation of 80m above MSL. The city is situated on the bank of River Vashishti. Towards the east of the city lies the Western Ghats and on the west lies Guhagar tahsil. The place is known educational and medical facilities. Climate of this place is warm and humid with average annual temperature of 27.3^{0}C. It is a non-coastal town and the average annual rainfall is 3973mm. It has tropical moist broadleaf forest. The main species are *Pterocarpus marsupium* (Bija), *Salmalia malabaricum* (Semal), *Terminalaia bellarica* (Behada), *Dalbergia latifolia* (Shishum), *Syzigium cumini* (Jambul), *Terminalia tomentosa* (Ain), *Lagerstremia parviflora* (Bendara) etc.

5. **Khed**

Khed town is located at 17.72°N 73.38°E with an average elevation of 25m above MSL. This place is known for Alphonso variety of mangos which are grown in and around the town. It lies between Kashedi Ghat and Bhoste Ghat. Climate of this place is cool with average annual temperature of 24.8^{0}C. Being a non-coastal town the average annual rainfall is slightly less and is 2734mm. Among the 9 tahsils of Ratnagiri district Khed accounts for half of the total forest area of the district. It has sub-tropical hill forest. This type of forest occurs on the plateau at the ridge top of Sahyadri hills. The extent of this forest type is very small and in 3-4 patches in Khed tahsil. The dominant species of the forests are *Terminalia paniculata* (Kinjal), *Terminalia tomentosa* (Ain), *Bombax insigne* (Semal), *Memocylon umbellatum* (Anjan), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango), *Dendrocalamus strictus* (Bamboo) etc.

6. **Ratnagiri**

Ratnagiri district is situated on the West coast of India in Maharashtra state. The district is surrounded by the Raigad district to the North, Arabian Sea to the West, Sindhudurg district to the South, and Satara, Sangli and Kolhapur districts to the East. Climate of this place is warm and humid with average annual temperature of 27.0^{0}C. The Annual rainfall is heavy and is 3047mm. The geographical area of tahsil is 92796ha. It has littoral and swamp forest. The dominant mangrove species of this forest are *Rhizophora* spp. *Sonneratia* spp., *Avicennia* spp., *Bruguiera* spp. etc. The foot hills towards the Eastern side have tropical moist forest. The dominant species of the forests are *Terminalia tomentosa* (Ain), *Terminalia arjuna* (Arjun), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc.

7. **Ganapati pule**

This town is located 25km North of Ratnagiri city. Town is known for Ganesh temple and beach. Climate of this place is warm and humid with average temperature of 27.6^{0}C. It receives annual precipitation of 3207mm. It has littoral and swamp forest. This is one of the common types of forest in Konkan coastal belt. Near sea-shore trees of *Casuarina equisetifolia* (Suru), *Cocos nucifera* (Mad), *Pandanus* (Kevda) spp. acts as wind breakers. The main mangrove species of this forest are *Rhizophora* spp. and *Avicennia* spp. The forests on the side hills are usually evergreen during monsoon season and become dry, leafless in summer. Together with mangroves coconut palms are there at the seashore.

8. **Devrukh**

This town is located in Sangameshwar tahsil of Ratnagiri district. Climate of this place is cool and humid with average temperature of 26.5^{0}C. It receives annual rainfall of 3834mm. It has tropical semi-evergreen forest. This is one of the common types of forest on the slopes of Sahyadri. These forests usually evergreen during monsoon season and become dry in summer. The prominent species of these forests are *Terminalia paniculata* (Kinjal), *Terminalia tomentosa* (Ain), *Bombax ceiba* (Kate savar), *Memocylon umbellatum* (Anjan), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc.

9. **Lanja**

Lanja is located at 16.85°N 73.55°E. It has an average elevation of 166 meters. Climate of this place is cool and humid with average temperature of 27^{0}C. It receives annual rainfall of 2022mm. It has tropical semi-evergreen forest. This is one of the common types of forest in Konkan coastal belt. Such forests are confined to slopes of hill. These forests usually evergreen during monsoon season and become leafless in summer. The dominant species of these forests are *Terminalia paniculata* (Kinjal), *Terminalia tomentosa* (Ain), *Terminalia chebula* (Hirda), *Memocylon umbellatum* (Anjan), *Syzigium* cumini (Jambul), *Mangifera indica* (Mango), *Actinodaphne hookeri* (Pisa) etc. Being coastal area it also has littoral and swamp forests. These forests occur along the creeks and littoral regions. The typical mangrove species found in this area are *Rhizophora* spp. *Avicennia* spp. and *Kandelia* spp.

10. **Rajapur**

Rajapur has an average elevation of 72 meters. The place is famous for mangoes called Alphonso or locally called "Hapus". Climate of this place is cool and humid with average temperature of 26.5^{0}C. It receives annual rainfall of 798mm. It has tropical semi-evergreen forest. This is one of the common types of forest in Konkan coastal belt. Such forests are confined to slopes of hill. These forests usually evergreen during monsoon season and become dry, leafless in summer. The dominant species of these forests are *Terminalia paniculata* (Kinjal), *Terminalia tomentosa* (Ain), *Terminalia chebula* (Hirda), *Memocylon umbellatum* (Anjan), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango), *Actinodaphne hookeri* (Pisa) etc. Being coastal area it also has littoral and swamp forests. These forests occur along the creeks and littoral regions. The typical mangrove species found in this area are *Rhizophora* spp. *Avicennia* spp. and *Kandelia* spp. These forests are necessary for defense of seashore and marine life.

11. **Jaitapur**

Jaitapur is another village in the Rajapur tahsil of Ratnagiri district. It is located at 16.59°N 73.35°E. It has an average elevation of 80 meters. Climate of this place is cool and humid with average temperature of 27^{0}C. It receives annual rainfall of 2963mm. It has tropical littoral and swamp forest. The typical mangrove species found in this area are *Rhizophora* spp. *Avicennia* spp., *Sonneratia* spp. and *Acanthus illicifolius*. These forests are vital for protection of aquatic and terrestrial life. The plant species in the adjoining forest are *Caesalpinia bonducella* (Sagargota), *Crateva adensonii, Terminalia tomentosa* (Ain), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc.

12. **Madban**

Madban is a small village located North of the Jaitapur in the Rajapur tahsil of Ratnagiri at 16°29’ N, 73°19’E. It is a coastal village and average elevation is 81m. It has littoral and swamp forest. Coastal vegetation consists of *Cocos nucifera* (Naral), *Areca catechu* (Supari), *Pandanus* spp. (Kevda) and *Ipomea biloba*. Mangrove vegetation consists of *Rhizophora* spp. and *Avicennia* spp. Climate of this place is warm and humid with average temperature of 27^{0}C. It receives annual precipitation of

2963mm. Plants in surrounding forests are *Terminalia tomentosa* (Ain), *Terminalia arjuna* (Arjun), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc.

13. **Nate**

Nate Village is an important center of fishing in Rajapur tahsil of Ratnagiri District of Maharashtra state, India. It is situated on the Arabian seacoast at 16°45'N, 73°21'E. It has an average elevation of 70m. Climate of this place is warm and humid with average temperature of 26^0C. It receives annual rainfall of 3000mm. It has littoral and swamp forest (Plate - 10). The dominant species of Mangrove vegetation consists of *Rhizophora* spp. *Avicennia* spp., *Bruguiera* spp. etc. The forest contains species of *Terminalia tomentosa* (Ain), *Terminalia arjuna* (Arjun), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango) etc.

14. **Unhale**

It is a small village in the Rajapur tahsil located at 16°73'N, 73°56'E. This place is known for hot water spring and devrai. Climate of this place is cool with average annual temperature of 25.8^0C and average annual rainfall of 2374mm. It has tropical moist evergreen forest. The main dominant species are *Pterocarpus marsupium* (Bija), *Bombax ceiba* (Kate savar), *Terminalaia bellarica* (Behada), *Dalbergia latifolia* (Shisav), *Syzigium cumini* (Jambul), *Terminalia tomentosa* (Ain) and *Lagerstremia parviflora* (Tamhan).

15. **Hativale**

Hativale is a small village in the Rajapur tahsil located at 16°59' N, 73°54' E. Climate of this place is warm and humid with average annual temperature of 27^0C. The annual rainfall is 2175 mm. It has tropical moist evergreen deciduous forest. The dominant species of the forest is *Tectona grandis* (Teak), the associates are *Terminalia tomentosa* (Ain), *Dalbergia latifolia* (Shisham), *Adina cordifolia* (Haldu), *Madhuca indica* (Moha), *Pterocarpus marsupium* (Bija), *Mitragyna parviflora* (Kalam), *Bombax ceiba* (Kate savar) and *Dendrocalamus strictus* (Bamboo).

16. **Nanar**

Nanar is a small village situated in Rajapur town of Ratnagiri district of Maharashtra state of India Climate of this place is warm and humid with average temperature of 26^{0}C. It receives annual rainfall of 3047mm. It has tropical semi-evergreen forest. The dominant species of these forests are *Terminalia paniculata* (Kinjal), *Terminalia tomentosa* (Ain), *Terminalia chebula* (Hirda), *Terminalia bellarica* (Behda), *Memocylon umbellatum* (Anjan), *Syzigium cumini* (Jambul), *Mangifera indica* (Mango), *Actinodaphne hookeri* (Pisa) etc.

3.2 Collection of wood rotting aphyllophorales from study area

The basidiocarps of aphyllophorales were collected from different localities of the district. During the collection fungal specimens on tree trunks, dead twigs and fallen wood were observed by using a hand lens (10X) and basidiocarps were collected and kept in paper envelops. This was done throughout all seasons of the year. However the collections were plentiful only after rainy season. While collecting basidiocarps of Aphyllophorales host plant species was also collected and later identified using the standard floras (Singh *et al*., 2000). Some host plants were identified in consultation with taxonomy expert. This method though appears simple, needs extensive screening of maximum number of fallen twigs, bark and dead wood, dead roots of trees as well as the infected plants (Ranadive, 2012). The basidiocarps were collected along with parts of host attached to it. Morphological characters such as colour of basidiocarp, size, shape, texture, rot type and reaction with KOH were noted in the field itself (Ranadive *et al*., 2008). Colour of the basidiocarp noted by using colour codes of Konerup and Wanscher (1967). Shape is noted as per the illustrations given in fungi flora 23 by Ryvarden *et al.* (2010). Size is noted by using scale. Rot is noted by observing morphology of affected wood. Reaction with KOH was noted by adding a drop of 5% KOH on upper surface of pileus. Basidiocarp is then wrapped in news paper sheet and brought to the laboratory.

3.3 Spore print

Spore print of the basidiocarp was taken in the laboratory. Spore prints were taken by keeping hymenial surface of fresh basidiocarp on the glass slides. A moist blotting paper was kept on the upper surface of pileus while taking spore print. Basidiocarp was kept overnight on the glass slide (Ryvarden *et al.*, 2010). In the morning basidiocarp was removed and glass slide was covered with a black paper and sealed with cello tape. Such spore prints were preserved for further use.

3.4 Preservation of specimens

Specimens were allowed to dry completely on newspaper sheets for about a week period in the laboratory. Completely dried specimens were kept inside the paper bag for preservation and further use. Few crystals of para dichloro benzene were added in the paper bags. They prevent attack of insects on basidiocarp (Ryvarden *et al.*, 2010).

3.5 Morphology of Basidiocarp

Size of basidiocarp was noted by measuring its length, breadth and thickness. Colour of different parts of basidiocarp was noted by using standard colour chart (Kornerup and Wanscher, 1967). Specimens were photographed by using Moto G4 mobile phone. Best quality images were used for preparation of plates. Features of different parts of basidiocarp were noted by using standard technical terms (Ryvarden *et al*., 2010). Identification of aphyllophorales was done by using macro and micro morphological characters, reaction with KOH, reaction with Melzer's reagent and type of wood rot.

3.6 Anatomy of Basidiocarp

Microscopic characters were studied by mounting a thin longitudinal section of the basidiocarp on glass slide. Section was stained with Phloxin, and Congo red. 1% aqueous Phloxin was prepared in distilled water. 1% Congo-red was prepared in concentrated ammonia. 5% KOH was used to remove excess stain and also as mounting medium. Cover slip was kept and observed under low power, high power and oil immersion to study hyphae and sporulating structures. Section was also stained with cotton blue for 2 minutes prepared in lactophenol to study cyanophilic reaction. Amyloid reaction of spores was studied with Melzer's reagent. All cytological measurements of fungal hyphae and spores were done in KOH mounts by using Erma ocular and stage micrometer under Carl Zeiss Binocular microscope. The sections were photographed by using camera attached to the microscope.

Following stains and solutions were used for microscopic analysis of Aphyllophorales

i. Cotton blue

1% cotton blue stain was prepared by weighing 1g aniline blue on electronic weighing balance and dissolved it in 100ml of phenol and lactic acid (1:9). Stain was stored in dropping bottle. It serves dual purpose as stain and mounting medium. Cotton blue stains cytoplasm of fungal cell. The slide was observed for the cyanophilic reaction.

ii. Congo-red

1% Congo-red was prepared by weighing 1g Congo-red on electronic weighing balance and dissolved it in 100ml of concentrated ammonia. Stain is stored in dropping bottle. It stains cell wall of fungal cell. Excess stain was removed with treated with 3% aqueous KOH.

iii. Phloxine

1% aqueous Phloxine is prepared by weighing 1g Phloxin on electronic weighing balance and dissolved it in 100ml of distilled water. Stain was stored in dropping bottle. After staining a section with Congo-red, excess stain was removed with 3% aqueous KOH and slide was stained with 1% Phloxine simultaneously. Phloxine stains nuclei and cytoplasm of fungal cell (Ryvarden *et al.*, 2010).

iv. Melzer's regent

5g of KI (potassium iodide) was dissolved in 20ml of distilled water. Then 1.5g of iodine crystals were added to it and left it to dissolve for 24 hours. 100g of chloral hydrate is added to iodine until it dissolves completely. Mix thoroughly to make the volume 100ml with distilled water. It was used for determining the amyloid reaction in basidiospores. Also it act as clarifying agent and stains the fungal cell wall.

v. 5% KOH

5% aqueous KOH was prepared by weighing 5g of KOH on electronic weighing balance and dissolved it in 20ml of distilled water and volume was adjusted to 100ml in volumetric flask by using distilled water. Solution was stored in dropping bottle. 5% aqueous KOH was used as mounting medium and for measurement of hyphae and spores. It was also used as staining removing agent.

All cytological measurements were taken with ERMA Ocular and Stage micrometer.

3.7 Preparation of slide

A thin free hand section of basidiocarp was taken with a sharp blade. Basidiocarp was sectioned along the tube to study hyphal system, basidia, cystidia or setae and basidiospores. In poroid specimens, the pore mouths are usually sterile and a fertile hymenium was found at a certain distance beyond it. The section was transferred to a glass slide containing a drop of 5% KOH. For non-poroid specimens a small portion of basidiocarp was crushed and put on clean glass slide in a drop of KOH. The section was then stained with 1% Phloxin for 1 minute. Section was then washed with 5% KOH. Then section was stained with 1% Congo Red for 1 minute. Section was then washed with 5% KOH to remove excess stain. Finally section was mounted in 5% KOH and cover slip was applied over it. Section was observed under Carl Zeiss Binocular microscope. Initially sections were observed at low power objective (10X) of microscope. Then it was observed with high power (40X) and oil immersion (100X) objective to observe minute details. Sections were photographed by camera attached to microscope. Separate sections were used to study cyanophilic and amyloid reactions. For amyloid reaction section was stained with Melzer's reagent and for cyanophilic reaction section was stained with cotton blue. If spore remain yellow to colourless; they were said to be inamyloid or –ve in Melzer's reagent. When spores turn grey or blue the reaction is said to be amyloid. If they become reddish brown they were termed as dextrinoid. Semi-permanent slides were prepared by using nail paint.

3.8 Identification of the specimen

Both morphological and anatomical characters were used and compared with the standard references. Materials were identified up to species level with the help of standard literature namely Bakshi (1971), Gilbertson and Ryvarden (1993-1994), Leelavathy and Ganesh (2000), Ryvarden and Johansen (1980), Roy and De (1996), Sharma (1995, 2000 and 2013) and Ryvarden *et al*. (2010. Some specimens were compared with the herbarium specimens from national and mycological herbaria. Some specimens were sent to Prof. Leif Ryvarden, Inst. of Biosciences, University of Oslo, Norway; by post. He sent identity of specimens through email.

3.9 Data collection and its use for taxonomic analysis

Classifications of Donk (1964), Ainsworth and Sparrow (1973) and Alexopoulous *et al*. (2002) were used while studying the taxonomical characters of fungi. These systems are more natural and useful for classifying species on the basis of natural affinities and relations. It is easy to prepare keys for identification of species by using observable characters.

3.10 Preparation of key for identification of recorded species

In taxonomy key is routinely used as an aid for identification of fungi. They are based on similarities and dissimilarities. The keys are usually based on the contrasting characters generally considered in a pair called couplet. It represents the choice made between two opposite alternatives. This leads to acceptance of only one and rejection of the other option. Each statement of the key is called a lead. Separate taxonomic keys were prepared for each taxonomic category such as family, genus and species for identification purposes.

Key for identification of specimens up to species level was prepared by referring taxonomic keys proposed by Ryvarden *et al*. (2010) and standard online keys available on Mycobank (www.mycobank.org). A dichotomous key is prepared on the basis of easily observable morphological characters. Features like basidiocarp size, shape, colour, type of hymenophore, hyphal system were considered for preparation of key. The confirmation of identification was done through experts from authorities of Shivaji University, Kolhapur, Savitribai Phule Pune University, Pune and Botanical Survey of India.

CHAPTER – 4

RESULTS

AND

DISCUSSION

RESULTS

In order to study Aphyllophoraceous mycobiota of Ratnagiri district, a total of 102 specimens were collected from 16 localities of the district. A total of 35 species belonging to 22 genera and 07 families of order Aphyllophorales were identified from 102 collected specimens. These include *Coriolopsis polyzona, Dichomitus leucoplacus, Earliella scabrosa, Flavodon flavus, Fomes fomentarius, Ganoderma applanatum, G. australe, G. lucidum, Hexagonia apiaria, H. tenuis, H. nitida, Hymenochaete unicolor, Inonotus hispidus, Irpex lacteus, Lentinus connatus, L. sajor-caju, L. squarrosulus, L. velutinus, Lenzites acuta, L. betulina, L. elegans, Leucophellinus hobsonii, Microporus affinis, M. xanthopus, M. atrovillosus, Neofavolus alveolaris, Peniophora albobadia, Perenniporia ochroleuca, Phellinus ferruginosus, Podoscypha petalodes, Polyporus badius, P. brumalis, P. umbellatus, Schizophyllum commune* and *Trametes roseola.*

A KEY TO THE FAMILIES OF APHYLLOPHORALES

1a Basidiocarp stains permanently black with KOH……..….Hymenochaetaceae

1b Basidiocarp do not stains black with KOH………………………………....2

2a Basidiocarp poroid………………………....................................5

2b Basidiocarp non-poroid……………………………………….......3

3a Basidiocarp effused-reflexed to pileate, hymenophore irpicoid…..Meruliaceae

3b Hymenophore not irpicoid………………………………………………..4

4a Basidiocarp cup shaped, hymenophore split gills lamellate……………………………………………...Schizophyllaceae

4b Basidiocarp resupinate, hymenophore flattened…..….Peniophoraceae

5a Basidiospores with double wall, outer wall smooth, inner wall ornamented, brown to hyaline…………………………………………... Ganodermataceae

5b Basidiospores smooth; without ornamented inner wall………………........6

6a Basidiocarp pileate Hyphal system monomitic, spores globose, thick walled, smooth ……………………….……………………………Schizoporaceae

6b Basidiocarp pileate to stipitate, Hyphal system di or trimitic, spores globose, ellipsoidal to cylindrical………………………………………..Polyporaceae

Ganodermataceae, Donk

Family Ganodermataceae is distinguished from other families of Aphyllophorales by double-walled basidiospores. The inner walls of the spore are ornamented and coloured. The basidiocarps are large, leathery and tough; mostly in the shades of brown; they may be annual or perennial. The basidiocarps are poroid, may be pileate or stipitate. All the members have hymenium located inside the tubes on lower side of the pileus. Hyphal system is di or trimitic. Cystidia are absent; spore print brown. Basidiospores oval and non-amyloid. It contains 8 genera and 300 species. We have found three species belonging to genus *Ganoderma*. Key to identify these species is given below.

Ganoderma, P. Karst.

KEY TO SPECIES OF *GANODERMA*

1a Basidiocarp reddish brown, shiny, stipitate, margins yellowish white ………………………………………………………………………*G. lucidum*

1b Basidiocarp pileate, sessile, not shiny…………………………………………2

2a Basidiocarp applanate, upper surface grayish brown ……*G. applantum*

2b Basidiocarp dimidiate, upper surface with crustaceous Layer……………………………………………………..*G. australe*

1. ***Ganoderma applanatum*** (Pers.) Pat., 1889: (Plate - 11)

Syn. ***G. lipsiense*** (Batsch) G. F. Atk., 1908

Basidiocarp applanate, imbricate, nonlaccate, shortly stipitate, up to 8cm long, 12cm wide, and 5cm thick at the base, tough and coriaceous. Upper surface of pileus reddish brown, zonate, sulcate, margin smooth and white. Basidiocarp thick at base and thin at the margins. Pore surface white, pores small, round, mostly 4-6 per mm. Hyphal system trimitic. Basidia prominent and clavate shaped. Basidiospores oval, truncate at distal end, bitunicate, thick walled, outer wall thin, smooth, inner wall ornamented, spiny. Spore print brown, negative in Melzer's reagent.

Type of rot: White rot of standing trunk.

Remarks: It is identified in the field by its nonlaccate, applanate basidiocarp with sulcate surface.

2. ***Ganoderma australe*** (Fr.) Pat., 1889: (Plate - 12)

Basidiocarp solitary, nonlaccate, sessile, applanate up to 10cm long, 14cm wide and 1.5cm thick at the base, corky and coriaceous. Pileus applanate, upper surface reddish brown, radically cracked with black crust, pore surface white to grayish, often with sooty dust of spores, pores small, elongated to irregular, mostly 1-2 per mm. Hyphal system trimitic. Basidia prominent and club shaped. Basidiospores broadly ellipsoid, truncate at apex, thick walled, exospores thin, hyaline, smooth, endospore ornamented, echinulate. Spore print black, negative in Melzer's reagent.

Type of rot: White rot of dead tree trunk.

Remarks: It is identified in the field by its applanate, reddish brown basidiocarp with black crust and sooty powder of spores.

3. ***Ganoderma lucidum*** (Curtis) P. Karst., 1881: (Plate - 13)

Basidiocarp dimidiate, imbricate, bracket like, large, laccate, stipitate, up to 10cm long, 21cm wide, and 2.5cm thick at the base. Pilear surface laccate, reddish brown, zonate, sulcate, margin thin and brown. Pore surface white, pores small, round, mostly 3-5 per mm. Stipe 10cm long, purple red, cylindrical, solid, woody and prominently laccate. Hyphal system trimitic. Basidia prominent and clavate. Basidiospores oval, truncate at distal end, bitunicate, thick walled, outer wall thin, smooth, inner wall ornamented, spiny. Spore print brown, negative in Melzer's reagent.

Type of rot: White rot of standing trunk of *Nyctanthes arbor-tristis*.

Remarks: It is identified in the field by its dimidiate, imbricate, reddish brown, laccate, basidiocarp with cylindrical woody, laccate stipe.

Hymenochaetaceae, Imazeki & Toki

The family Hymenochaetaceae is chiefly identified by its distinguishing xanthochroic reaction. It contains several species that are responsible to cause diseases of soft and hard wood trees. Basidiocarps are annual to perennial, tough, leathery, poroid or nonporoid. Many species have pileate, dimidiate, ungulate and rimose basidiocarp. Basidiocarps are mostly dark in colour in the shades of brown and grey. Hyphal system may be dimitic or trimitic. Cystidia are absent; tramal or hymenial setae present; spore print white or brown. Basidiospores in various shapes and non-amyloid. There are 27 genera and 487 species recorded for this family. We have found 3 genera of this family and each genus is represented by 1 species each. Key to identify genera of Hymenochaetaceae is given below.

KEY TO GENERA OF FAMILY HYMENOCHAETACEAE

1a Basidiocarp pileate and sessile, pileal surface glabrous or hirsute……*Inonotus*

1b Basidiocarp resupinate ……………………………………………………..2

2a Basidiocarp woody, hard, hymenophore poroid …………….*Phellinus*

2b Basidiocarp non-poroid, hymenophore smooth ……….*Hymenochaete*

4. ***Hymenochaete unicolor*** Berk. & M. A. Curtis 1869: (Plate - 14)

Basidiocarp perennial, effused, sometimes with thickened, reflexed black densely sulcate upper margin, closely adnate, coriaceous to woody hard when dry, brittle, 1-3 mm thick; at first as numerous orbicular patches 2-15mm in diameter, then merging and up to 20 x 5cm; margin thin, later thick and abrupt. Hymenium smooth, azonate, irregularly cracked, sometimes lifting at the crevice edges and scaling off, cinnamon amber or yellowish brown, without olive or lilac tint; margin indeterminate, abrupt, concolorous or lighter coloured than hymenium.

Hyphal system monomitic; context hyphae compactly arranged, at base interwoven; setal hyphae absent; generative hyphae 2-4.5µm in diameter, yellowish, with thickened walls; in context and setal stratum crystalline matter absent, or present in dark bands between setal rows, in hymenium absent or present.

Type of rot: White rot of fallen woods.

Remarks: It is a resupinate hymenochaete that produces purple coloured paint like basidiocarp.

5. ***Inonotus hispidus*** **(**Bull.**)** P. Karst. 1879: (Plate - 15)

Basidiocarp annual, solitary or occasionally imbricate with broad basal attachment. Pileus 4-25 x 6-35 x 2-10cm, dimidiate, upper surface orange rust to fulvous, blackening on drying, strongly tomentose to pilose, changing to hispid and brittle with age; margin obtuse, straight. Context up to 7cm thick, fulvous, paler towards upper surface and margin, blackening with KOH, zoned, radially fleshy fibrous. Pore surface bright rusty; pores irregular, polygonal, 2-3 (-4) per mm, Basidia 12-17 x 7-9µm, broadly clavate, 4-spored. Setae typically present but often absent, 15-25 x 6-11µm, pointed ventricose to subulate, with a thick tawny brown wall. Hyphal system monomitic. Generative hyphae freely branching with a slightly thickened wall but broad lumen, simple septate.

Type of rot: White rot of hardwood

Remarks: It is a pileate hymenochaete identified in the field by heart rot of host.

6. ***Phellinus ferruginosus*** (Fr.) Pat. 1900: (Plate - 16)

Basidiocarp perennial, resupinate, measures 5 x 10 x 0.5cm, upper surface velvety brown, strongly tomentose and rigid with age; margin entire, obtuse. Context up to 2mm thick, blackening with KOH, azonate, tubes 5mm long. Pore surface brown; pores extremely minute and circular, 5-7 per mm, Basidia 14-16 x 8-10µm, broadly clavate. Setae typically present 12-15 x 5-8µm, pointed ventricose, with a thick tawny brown wall. Hyphal system dimitic. Generative hyphae freely branching with a slightly thickened wall but broad lumen, simple septate. Skeletal hyphae solid and unbranched.

Type of rot: White rot of hardwood

Remarks: It is a resupinate hymenochaete that produces dark brown thick basidiocarp on bark of host plant.

Meruliaceae, Rea

The family Meruliaceae has characteristic irpicoid or merulioid hymenophore. Basidiocarps are annual to perennial, rigid, nonporoid. Many species have resupinate, effused-reflexed basidiocarp with spines or folds. Basidiocarps are cream or light green or brown coloured. Hyphal system is dimitic with generative and skeletal hyphae. Cystidia are present; spore print white. Basidiospores allantoid and non-amyloid. There are 645 accepted species in the family. We have found 3 genera of this family and each genus is represented by 1 species each. Key to identify genera of Meruliaceae is given below.

7. ***Flavodon flavus***, (Klotzsch) Ryvarden, 1973: (Plate - 17)

Basidiocarp annual, resupinate, effused-reflexed, sometimes pileate, consistency tough, leathery, 4cm long, 9cm wide and 1-2mm thick. Basidiocarp initially cream, later grey to greenish yellow colour persists along the papery thin edge, changes to red when treated with KOH. Hymenophore first poroid soon becomes hydnoid with dentate lamellae, up to 5mm long, initially yellowish, then greenish brown. Hyphal system dimitic, generative hyphae thin walled, hyaline, branched, septate, septa simple, 3-4µm in diameter, skeletal hyphae unbranched, hyaline, thick-walled, up to 8µm wide, concentrated in the context and central part of the teeth. Cystidia abundant in the hymenium, thick-walled up to 20µm long and 5-6µm wide, apically encrusted, spores not seen.

Type of rot: White rot of fallen branch.

Remarks: It is easily identified in the field by its resupinate greenish yellow basidiocarp that turns red when treated with KOH.

8. ***Irpex lacteus*** (Fr.) Fr., 1828: (Plate - 18)

Basidiocarp annual, sessile, resupinate and effused-reflexed. Pileus irregular, up to 5cm wide, 14cm broad and 3mm thick; upper surface cream colored, hirsute, pore surface white to cream, the pores angular, 2-3 per mm at the margin, dissepiments thin and split to form an irpicoid hymenophore. Hyphal system dimitic, generative hyphae thin, hyaline, branched, septa simple, 2-3µm wide, skeletal hyphae thick-walled. Cystidia prominent, thick-walled and apically encrusted. Basidia clavate, basidiospores not seen.

Type of rot: White rot of fallen branch of angiosperms.

Remarks: It is identified in the field by its resupinate cream coloured basidiocarp.

9. ***Podoscypha petalodes*** (Berk.) Pat., 1903: (Plate - 19)

Basidiocarp spathulate, many, aggregated in loose cluster to form rosette on host surface; 3cm long, 4.5cm wide and 1 to 2mm thick. Pileus pale brown to golden-brown decorated with dark concentric zones. Hymenial surface concolourous with the pileus and covered by pallid hairs. Hyphal system dimitic, generative hyphae thin walled, hyaline, septate, branched, measuring 2-3µm in diameter, and possesses clamp-connections at the septa. Skeletal hyphae, thick-walled, unbranched, 3-5µm in diameter. Cystidia absent, but gloeocystidia present, basidia and basidiospores not seen.

Type of rot: white rot of *Mangifera indica*

Remarks: The species is easy to recognise by its spathulate, loosely aggregate rosette basidiocarps growing parasitically or occasionally on the humus rich ground.

Peniophoraceae, Lotsy

Family Peniophoraceae contains the members that produce crust like resupinate basidiocarps. Species of the family are cosmopolitan in distribution and are mostly saprophytes causing white rots of fallen wood. The basidiocarps are thin, papery with mostly the appearance of paint. They are in the shades of orange, brown, blue, violet or pink; they may be annual or perennial. The basidiocarps are resupinate, non-poroid with flattened hymenium. Hyphal system is dimitic. Cystidia are present; large and conical, spore print in various colours. Basidiospores oval to allantoids and non-amyloid. We have single species of this family.

10. ***Peniophora albobadia*** (Schwein.) Boidin, 1961: (Plate - 20)

Basidiocarps resupinate, effused in small patches or these confluent up to 6cm, adnate or peeling back at the margin; hymenial surface vinaceous to purplish brown or dark brown, fading to pinkish tan, smooth; margin white to cream colored, thinning out, minutely fimbriate; hyphal system dimitic; generative hyphae with clamps, thin- to firm-walled, with occasional branching, 2-4µm in diameter; skeletal hyphae firm- to thick-walled, aseptate, with rare branching, 1.5-3µm in diameter; dendrohyphidia abundant in hymenial region conical cystidia are present. They are heavily incrusted, 28-33 x 8-10µm in dimension. Basidia clavate and basidiospores cylindrical to allantoid, hyaline, smooth, negative in Melzer's reagent.

Type of rot: White rot

Remarks: It is a resupinate species and identified in the field by its irregular dark paint like basidiocarp with white margin on bark on dead branches.

Polyporaceae, Corda

The Polyporaceae family of poroid fungi belonging to the order Aphyllophorales of Basidiomycota. The nature of basidiocarp varies from soft to tough; it may be annual or perennial. Majority of the members have hymenium located inside the tubes on lower side of the pileus, but few may have gills or gill-like structures. Many species are pileate but others are stipitate. Basidiocarp colour varies from white, cream, orange, brown, grey and black. It may be dimitic or trimitic. Cystidia are absent; spore print mostly white. Basidiospores rounded, oval, cylindrical to allantoid, non-amyloid. It is one of the largest families in the order with 114 genera and 1621 species. We have found 12 genera and 23 species belonging to this family. Key to identify genera of Polyporaceae is given below.

KEY TO GENERA OF FAMILY POLYPORACEAE

1a Hymenophore poroid …………………………………………………….2

1b Hymenophore non-poroid, lamellate …………………………….. *Lentinus*

2a Hymenophore strictly poroid …………………………………….3

2b Hymenophore mixed type; poroid as well as lamellate…………………………………………………….*Lenzites*

3a Hyphal system dimitic……………………………………………*Polyporus*

3b Hyphal system trimitic ………………………………………………… 4

4a Basidiocarp pileate, sessile with distinct red cuticle…………………………………………………….*Earliella*

4b Basidiocarp without red cuticle …………………………………5

5a Basidiocarp resupinate ……………………………………………………6

5b Basidiocarp distinctly pileate……………………….............................7

6a Basidioma white, cream or ivory……………………….*Coriolopsis*

6b Basidioma orange yellow ………………………………*Dichomitus*

7a Basidiocarp ungulate and more than one tube layer (perennial)…….*Fomes*

7b Basidiocarp with single tube layer (annual)……………………………8

8a Basidioma ungulate ………………………………………*Trametes*

8b Basidioma shape other than ungulate …………………………*9*

9a Basidioma flabelliform …………………………………………*Neofavolus*

9b Basidioma other than flabelliform …………………..........................10

10a Basidiocarp ungulate and with single tube layer (annual)……………………………………………*Perenniporia*

10b Basidiocarp with single tube layer (annual) but not ungulate…11

11a Basidioma with large hexagonal pores ………………………….*Hexagonia*

11b Basidioma with small round pores ……………………………..*Microporus*

11. ***Coriolopsis polyzona*** (Pers.) Ryv., 1972: (Plate - 21)

Basidiocarp annual to perennial, pileate, sessile, dimidiate, flabelliform to reniform, sometimes reflexed with an effused and resupinate pore surface, commonly broadly attached, less often with a contracted base, solitary or in clusters, imbricate or fused laterally to elongated lobed fruit bodies, single pilei up to 10cm wide and 15cm long, 2-7mm thick at the base, coriaceous and flexible to corky. Pileus yellowish-ochraceous when fresh, soon darker, fulvous, ochraceous-brown or grayish-brown, in old specimens frequently with green tints due to algae in the tomentum, tomentose to slightly hispid in numerous sulcate to flat, concentric zones, margin thin, flat to undulating, often lobed and incised. Pore surface cream to beige when fresh, darkens to golden-brown or fulvous, pores angular to round, on average 2-3 per mm, on oblique substrates somewhat elongated radially and up to 1mm long, tubes concolorous with pore surface, in section often lighter than the trama, up to 4mm deep, sometimes stratified. Context duplex, lower part fibrous and subshiny in section, ochraceous to golden brown, darker towards the base, upper part loose and more faded, in old specimens it may become grayish-brown to dark brown, the two parts usually easy to distinguish in sections and sometimes with a separating thin black line, lower part' up to 3mm deep, tomentum 1-3mm thick in sulcate zones.

Hyphal system trimitic, generative hyphae with clamps, thin-walled and hyaline, slightly to strongly branched, 1.5-2.5µm wide. Skeletal hyphae dominating, thick-walled with a distinct lumen, hyaline to yellow, 3-8µm wide. Binding hyphae more sparingly present hyaline to slightly yellowish, with short branches, 3-6µm in diameter. The context is dominated by slightly thick-walled skeletal hyphae up to 10µm wide, but also a number of short-branched binding hyphae present. In the tomentum the skeletal hyphae are more thick-walled and agglutinated. Spores oblong to slightly ellipsoid, smooth and thin-walled, 5-8.5 x 2.5-3.5µm, the size varies considerably within one collection, non-amyloid.

Type of rot: White rot of dead hardwoods.

Remarks: It is a tropical polypore on dead angiosperms of all kinds, especially in areas with periodical dry seasons, where the fruiting bodies may persist from one rainy season to the next and identified in the field by appressed, irregular basidiocarp with poroid hymenophore and prominent zonation on pileus.

12. ***Dichomitus leucoplacus*** (Berk.) Ryvarden, 1977: (Plate - 22)

Basidiocarp annual, resupinate, adnate when young, in elder fruit bodies with a tendency to loosen along the margin, small to medium in size, up to 10cm long and 2cm wide, 0.5-2mm thick, coriaceous when fresh, woody hard when old, often forming elongated fruit bodies, margin distinct, white, darker in elder fruit bodies. Pore surface white to cream, in elder fruit bodies buff to ochraceous. Pores entire, round or more commonly somewhat elongated as fruit bodies seems to have a tendency to develop on standing oblique substrates, 4-5 per mm, tubes whitish to cream, 1mm deep. Context thin and white.

Hyphal system dimitic, generative hyphae with clamps, hyaline and 2-3µm wide, fruit bodies dominated by mostly dichotomous branched binding hyphae, branched, solid to thick-walled, up to 5µm wide in the trunks. Basidia and basidiospores not seen.

Type of rot: White rot of dead hardwoods.

Remarks: It is a tropical polypore identified in the field by its resupinate, yellowish orange basidiocarp with poroid hymenophore. The species is easy to recognize under the microscope because of the characteristic binding hyphae.

13. ***Earliella scabrosa*** (Pers.) Gilb. & Ryvarden, 1985: (Plate - 23)

Basidiocarp resupinate, effused-reflexed to pileate, sessile, dimidiate, imbricate, tough and coriaceous; 8cm in length 10cm wide and up to 5mm thick at the base. Pilear surface glabrous, concentrically zonate, first white to cream, soon covered by a reddish cuticle; pore surface white to cork-coloured, pores 2-3 per mm, sinuous to semidaedaloid, individual pores up to 5mm long, context white, tough. Hyphal system trimitic; generative hyphae with clamps, thin-walled; skeletal hyphae dominant, thick-walled, solid, hyaline, binding hyphae branched with tapering side-branches. Basidia clavate, Basidiospores cylindrical to oblong-ellipsoid, pointed at ends, 8-10 x 3-4µm. Spore print white, negative in Melzer's reagent.

Type of rot: White rot of dead hardwoods.

Remarks: It is a common tropical polypore identified in the field by its imbricate, dimidiate basidiocarp with semidaedaloid hymenophore and red cuticle.

14. ***Fomes fomentarius*** (L.) Fr., 1849: (Plate - 24)

Basidiocarp solitary, hoof shaped ungulate, 3cm long, 5cm wide and 1.2cm thick, coriaceous and flexible when young, hard at maturity. Upper surface of pileus glabrous, zonate, sulcate, initially yellowish brown later turns grey, concentrically grooved, margin thick white. Pore surface white, pores small, round, many, 1-2 per mm, dissepiments thick, entire, tubes up to 1cm long. Context brown, hyphal system trimitic, cystidia none. Spores large, cylindrical, oblong, oval, large and abundant. Spore print white, negative in Melzer's reagent.

Type of rot: White rot of standing trunk of *Strychnos nux-vomica*.

Remarks: It is identified in the field by its hoof shaped, ungulate basidiocarp with concentrically grooved surface and oblong cylindrical spores.

Hexagonia, Fr.

KEY TO SPECIES OF *HEXAGONIA*

1a Pileus reniform, cinnamon colored, pores honey comb-like……….*H. apiaria*

1b Pileus dimidiate, brown or snuff brown coloured…………………………...2

2a Pore surface snuff brown coloured, pores angular………….*H. tenuis*

2b Pore surface brown coloured, pores hexagonal…………….*H. nitida*

15. ***Hexagonia apiaria*** (Pers.) Fr. 1838: (Plate - 25)

Basidiocarp solitary, sessile, dimidiate up to 5.4cm long, 6.4cm wide and 0.5cm thick at the base, corky and coriaceous. Pileus reniform, applanate, zonate, glabrous and dark cinnamon coloured. Pore surface yellowish-brown to grayish-brown, pores angular, honey comb like, somewhat variable, mostly 2-3mm wide. Hyphal system trimitic. Basidia and basidiospores not seen.

Type of rot: White rot of standing tree trunk.

Remarks: It is identified in the field by its dimidiate basidiocarp with poroid hymenophore resembling honeycomb.

16. ***Hexagonia tenuis*** (Hook.) Fr., 1838: (Plate - 26)

Basidiocarp solitary or imbricate, sessile, 4cm long and 7cm wide, variable, papery thin, coriaceous. Pileus dimidiate, upper surface glabrous, zonate, brown to black. Margin thin, acute, wavy and entire. Pore surface snuff-brown, pores angular to hexagonal, variable, mostly 0.5-1 per mm, dissepiments thin, entire, tubes up to 1-2mm long. Context dark brown, blackening in KOH. Hyphal system trimitic, cystidia none, spores are not found.

Type of rot: White rot of fallen woods.

Remarks: It is easily identified in the field by its dimidiate, snuff-brown basidiocarp with hexagonal pores.

17. ***Hexagonia nitida*** Durieu & Mont., 1846: (Plate - 27)

Basidiocarp solitary, sessile, 3cm long and 5cm wide, variable, moderately thick, coriaceous. Pileus dimidiate, upper surface glabrous, zonate and brown. Margin thin, acute and entire. Pore surface brown, pores hexagonal, mostly 1-3 per mm, dissepiments thin, entire, tubes up to 2-4mm long. Context dark brown, blackening in KOH. Hyphal system trimitic, cystidia none, spores are not found.

Type of rot: White rot of fallen woods.

Remarks: It is easily identified in the field by its dimidiate, brown, moderately thick basidiocarp with hexagonal pores.

Lentinus, Fr.

KEY TO SPECIES OF *LENTINUS*

1a Basidiocarp stipitate, stipe velutinate…………………………*L. velutinus*

1b Basidiocarp stipitate, stipe not velutinate………………….…………..2

2a Basidiocarp larger than 15 cm in diameter……………*L. sajor-caju*

2b Basidiocarp smaller than 15 cm in diameter ……………………3

3a Pileus cone shaped brown coloured…………………………...*L. connatus*

3b Pileus not cone shaped lemon yellow coloured ………….*.L. squarrosulus*

18. ***Lentinus connatus*** Berk., 1842: (Plate - 28)

Basidiocarp stipitate; in cluster, pileus solitary, infundibuliform, up to 6cm in diameter; upper surface brown, azonate, margin concolorous, ciliate. Lower surface cream to brown coloured, lamellate, gill like thin, context brown, azonate, stipe central, dark coloured than the pileus, up to 3cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches. Basidia and Basidiospores not seen.

Type of rot: White rot of fallen wood.

Remarks: It is easily identified in the field by its stipitate basidiocarp with infundibuliform pileus and lamellate hymenophore.

19. ***Lentinus sajor-caju*** (Fr.) Fr., 1838: (Plate - 29)

Basidiocarp stipitate; in cluster, pileus solitary, infundibuliform, up to 15cm in diameter; upper surface cream coloured, azonate, margin concolorous, ciliate. Lower surface cream to white coloured, lamellate, gill like thin, context cream coloured, azonate, stipe central, dark coloured than the pileus, up to 20cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches. Basidia and Basidiospores not seen.

Type of rot: White rot of standing tree.

Remarks: It is easily identified in the field by its stipitate large ivory basidiocarp with infundibuliform pileus and lamellate hymenophore.

20. ***Lentinus squarrosulus*** Mont., 1842: (Plate - 30)

Basidiocarp stipitate; in cluster, pileus solitary, infundibuliform, up to 5cm in diameter; upper surface lemon yellow, azonate, margin concolorous, ciliate. Lower surface cream to yellow coloured, lamellate, gill like thin, context yellow, azonate, stipe central, pale than the pileus, up to 5cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches. Basidia and Basidiospores not seen.

Type of rot: White rot of fallen wood.

Remarks: It is easily identified in the field by its entirely white stipitate basidiocarp, becoming pale straw-colour to pale ochraceous, gills cream-coloured.

21. ***Lentinus velutinus*** Fr., 1830: (Plate - 31)

Basidiocarp stipitate; in cluster, pileus solitary, infundibuliform, varies 2-10cm in diameter; upper surface brown, azonate, margin concolorous, ciliate. Lower surface purple coloured, lamellate, gill like thin, context yellow, azonate, and stipe central, pale than the pileus, up to 15cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches. Basidia and Basidiospores not seen.

Type of rot: White rot of fallen wood.

Remarks: It is easily identified in the field by its stipitate, infundibuliform brown pileus with soft hairs all over the basidiocarp.

Lenzites, Fr.

KEY TO SPECIES OF *LENZITES*

1a Hymenophore lamellate, lamellae not dichotomously forked…….*L. betulina*

1b Hymenophore lamellate, lamellae dichotomously forked …………………2

2a Hymenophore strictly lamellate……………………..………*L. acuta*

2b Hymenophore partly lamellate, partly poroid…………….*L. elegans*

22. ***Lenzites acuta*** Berk., 1842: (Plate - 32)

Basidiocarps solitary to imbricate, pileate, dimidiate to semicircular and broadly attached, 16cm wide, 10cm long and 1cm thick. Margin concolorous, entire, corky and coriaceous. Upper surface zonate, tomentose, concentric, sulcate, cream coloured. Hymenophore lenzitoid with radial lamellae, new lamellae arise by dichotomous forking of old ones, context thin, 1-2mm thick, white. Hyphal system trimitic, generative hyphae thin, hyaline, with clamps; skeletal hyphae solid to thick-walled, hyaline; binding hyphae thick-walled to solid, tortuous, much branched; sword like branches. Cystidia none, Basidia clavate, Basidiospores not seen.

Type of rot: White rot of dead hardwoods and fallen branches.

Remarks: It is very common species in the tropical moist deciduous forest occurring on dead tree trunks and fallen logs and identified by its dimidiate basidiocarp with lamellate lenzitoid hymenophore.

23. ***Lenzites betulina*** (L) Fr., 1838: (Plate - 33)

Basidiocarps solitary to imbricate, pileate, dimidiate to semicircular and broadly attached, 13cm wide, 9cm long and 1cm thick. Margin concolorous, entire, corky and coriaceous. Upper surface white, zonate, tomentose, concentric, sulcate. Hymenophore lenzitoid with radial lamellae that do not show dichotomous forking. Context thick, 5mm, white. Hyphal system trimitic, generative hyphae thin, hyaline, with clamps; skeletal hyphae solid to thick-walled, hyaline; binding hyphae thick-walled to solid, tortuous, much branched; sword like branches. Cystidia none, Basidia clavate, basidiospores not seen.

Type of rot: White rot of dead hardwoods and fallen branches.

Remarks: It is very common species in the tropical moist deciduous forest occurring on dead tree trunks and fallen logs and identified by its large dimidiate basidiocarp with lamellate lenzitoid hymenophore that do not show dichotomous forking.

24. ***Lenzites elegans*** (Spreng.) Pat., 1900: (Plate - 34)

Basidiocarp perennial, sessile, attached centrally, pileus 13cm wide and 7cm long and 0.3-1cm thick, leathery, rigid. Pileus dimidiate to semi-circular, upper surface with dark black centre and grey brown periphery, covered with soft hairs, zonate and concentrically sulcate. Margin thin, white and often deflexed, even or lobed. Stipe absent, pore surface variable, partly poroid, partly sinuous-daedaloid and radially split, pores round, angular to elongated, 1-2mm in diameter. Pores or lamellae up to 5mm deep. Context white to pale cream, up to 5mm thick near the base, woody hard when dry. Hyphal system trimitic, generative hyphae hyaline, thin walled and clamped, 2-4µm wide, Skeletal hyphae dominating, thick-walled to solid, 3-7µm in diameter, binding hyphae hyaline to pale yellow thick-walled, up to 5µm wide, irregular branched. Cystidia absent, basidia and basidiospores not seen.

Type of rot: White rot of dead hardwoods

Remarks: The species is common in tropical moist deciduous forest and easy to recognize by its sinuous-daedaloid lamellae and round pores on the same specimens.

Microporus, P. Beauv.

KEY TO SPECIES OF *MICROPORUS*

1a Basidiocarp pileate, dimidiate……………………………………..*M. affinis*

1b Basidiocarp stipitate, infundibuliform…….…………………………………2

2a Pileal surface distinctly banded, zonate………………..*M. xanthopus*

2b Pileal surface dark coloured, azonate…………………*M. atrovillosus*

25. ***Microporus affinis*** (Blume & T. Nees) Kuntze, 1898: (Plate - 35)

Basidiocarp solitary or imbricate, sessile or laterally stipitate, semicircular, dimidiate, depressed in the area around the stipe, pileus up to 2.7cm long, 6cm wide and 0.4cm thick. Pileus glabrous, zonate, banded, colour variable from brown to black, usually darker at the center. Stipe lateral, up to 0.2cm long or absent, pore surface ochraceous, shiny, margin thin white, pores round and entire, minute 5-8 per mm, tubes 1-2mm deep, context white and dense. Hyphal system trimitic, generative hyphae hyaline and with clamps, skeletal hyphae thick-walled to almost solid, binding hyphae tortuous and spores spherical.

Type of rot: White rot of dead woods and fallen branches.

Remarks: It is identified in the field by laterally stipitate, dimidiate basidiocarp with poroid hymenophore.

26. ***Microporus xanthopus*** (Fr.) Kuntze, 1898: (Plate - 36)

Basidiocarp solitary or in groups, centrally stipitate and infundibuliform, margin white and deeply incised. Pileus up to 6cm in diameter and 1-2mm thick, zonate, tough, coriaceous, glabrous, shiny, banded. Stipe round, glabrous, covered with a thin, brown cuticle, up to 2cm high. Pore surface cream to pale buff, entire and very minute, almost invisible to the naked eye 7-9 per mm, tubes up to 0.5mm deep, context white, very thin and covered with a cuticle. Hyphal system trimitic, generative hyphae thin-walled and with clamps, moderately branched, skeletal hyphae dominating, hyaline and thick-walled, binding hyphae tortuous. Basidia club shaped, basidiospores not seen.

Type of rot: White rot of hardwoods and fallen branches.

Remarks: It is a commonly occurring polypore and identified in the field by its centrally stipitate basidiocarp with infundibuliform, dark, banded pileus and poroid hymenophore.

27. ***Microporus atrovillosus*** Ryvarden, 1975: (Plate - 37)

Basidiocarps in groups, centrally stipitate and infundibuliform to conical, margin thin, cream coloured and smooth. Pileus up to 5cm in diameter and 1-2mm thick, tough, coriaceous, glabrous, shiny, dark brown and non-banded. Stipe solid, round, glabrous, covered with brown cuticle, up to 3cm high. Pore surface grey to black coloured, banded, pores minute, almost invisible to the naked eye 8-10 per mm. Context brown, very thin and covered with a dark cuticle. Hyphal system trimitic, generative hyphae thin-walled and with clamps, moderately branched, skeletal hyphae dominating, hyaline and thick-walled, binding hyphae tortuous. Basidia clavate, basidiospores not seen.

Type of rot: White rot of *Terminalia paniculata*.

Remarks: It is an uncommon polypore identified in the field by its conical, dark, non banded stipitate basidiocarp with grey coloured hymenium.

28. ***Neofavolus alveolaris*** (DC.) Sotome & T. Hatt., 2012: (Plate - 38)

Basidiocarps annual, shortly stipitate, spathulate, 5.3cm in length, up to 6.4cm wide and 5mm thick; upper surface white, with age becoming ivory to pale buff, azonate, glabrous, smooth, margin concolorous; pore surface white to ochraceous, the pores rhombus-shaped, radially elongated, 1-2mm tangentially, dissepiments lacerate with age, context pale tan to ivory, azonate, corky, up to 1mm thick; stipe lateral, buff, glabrous, up to 0.8cm long and 5mm thick. Hyphal system dimitic; contextual generative hyphae hyaline, thin-walled, clamped, skeletal hyphae thick-walled and aseptate. Basidia and basidiospores not seen.

Type of rot: White rot of *Artocarpus integrifolia*.

Remarks: It is an uncommon polypore found during rainy season and identified in the field by its rhomboidal pores.

29. ***Perenniporia ochroleuca*** (Berk.) Ryvarden, 1972: (Plate - 39)

Basidiocarp solitary, stipitate 5cm in length, 6cm wide and 2cm thick, soft when fresh and woody hard when dry. Pileus glabrous, laterally stipitate, applanate, dimidiate, zonate, sulcate, cream coloured, dark brown at base, margin thick, round and entire. Pore surface white, cream to ochraceous, pores round, 2-4 per mm, dissepiments thick and entire, and tubes single-layered up to 5mm long. Hyphal system trimitic, generative hyphae thin walled, hyaline, 2-4µm in diameter. Skeletal hyphae thick walled, hyaline 4-7µm in diameter, binding hyphae thick walled, hyaline, sparingly branched, 3-6µm in diameter. Cystidia absent, basidia and basidiospores not seen.

Type of rot: white rot of *Mangifera indica*

Remarks: The species is identified in the field by its small, applanate, dimidiate, zonate, sulcate, cream coloured basidiocarp.

Polyporus, P. Micheli ex Adans

KEY TO SPECIES OF *POLYPORUS*

1a Basidiocarp laterally stipitate……………………………………..*P. badius*

1b Basidiocarp centrally stipitate ……………………………………………….2

2a Pores angular, white to cream coloured…………………*P. brumalis*

2b Pores elongated, ochraceous………………………… *P. umbellatus*

30. ***Polyporus badius*** (Pers.) Schwein., 1832: (Plate - 40)

Basidiocarp annual, laterally stipitate, pileus fan shaped 5-6 x 8-10 x 0.5cm, margin thin and entire, undulate, fleshy when fresh and brittle when dry. Upper surface of pileus glabrous yellow orange, fragile; pore surface ochraceous to straw coloured, pores circular, absent towards the stipe, 3-4 per mm. Hyphal system dimitic; generative hyphae hyaline, clamped, binding hyphae scattered, thick-walled to solid, branched, basidia clavate, basidiospores not seen.

Type of rot: White rot of fallen wood log.

Remarks: It is identified in the field by its laterally stipitate basidiocarp with poroid hymenophore.

31. ***Polyporus brumalis*** (Pers.) Fr., 1821: (Plate - 41)

Basidiocarp annual, centrally stipitate; in cluster, pileus solitary, up to 4cm in diameter; upper surface white, azonate, margin concolorous, ciliate; pore surface white to cream coloured, the pores angular, radially elongated, 1-2 per mm, dissepiments thin, context white, azonate, stipe central, pale pink, up to 2.5cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches, basidia, basidiospores not seen.

Type of rot: White rot of fallen woods.

Remarks: It is identified in the field by its centrally stipitate basidiocarp with poroid hymenophore.

32. ***Polyporus umbellatus*** (Pers.) Fr., 1821: (Plate - 42)

Basidiocarp annual, centrally stipitate, arising from sclerotia with numerous circular pilei. The individual pileus up to 4cm in diameter, flat to conical, margin thin and entire, deflexed, fleshy when fresh, hard and brittle when dry; upper surface glabrous ochraceous to brown, rough scaly; pore surface ochraceous to straw coloured, pores angular, elongated towards the stipe, 1-2 per mm. Hyphal system dimitic; generative hyphae hyaline, clamped, binding hyphae scattered, thick-walled to solid, hyaline, basidia club shaped bearing 4 elongated on pointed sterigmata.

Type of rot: White rot of fallen wood log.

Remarks: It is identified in the field by its centrally stipitate basidiocarps with poroid hymenophore arising from sclerotia.

33. ***Trametes roseola*** Pat & Har., 1900: (Plate - 43)

Basidiocarp annual to perennial, solitary, pileate, broadly attached to effused-reflexed, elongated to semicircular, up to 8cm wide and broad, 5-20mm thick near the base. Consistency soft corky when fresh, drying to tough and corky. Pileus convex, upper surface finely velvety tomentose, with age more glabrous and azonate. Colour first white-grayish to pale ochraceous buff, later darker buff or more pale dirty brown, margin obtuse, thick, even to slightly lobed. Pore surface pink to dirty brownish, cracking on drying, pores round to slightly angular, 5-8 per mm. Context pink to cork-coloured, brown in KOH, fading and leaving a pale grayish spot, 1-20mm thick, usually homogeneous, but sometimes with a few weak concentric zones. Hyphal system dimitic, generative hyphae clamped, hyaline and thin-walled, 1-4µm in diameter, moderately branched. Skeletal hyphae abundant, hyaline to pale brownish, thick-walled, usually with a distinct lumen, 2-4µm in diameter. Cystidia none.

Type of rot: White rot of wood log

Remarks: It is identified in the field by its dimidiate, pileate, zonate basidiocarp with small pinkish pores and poroid hymenophore.

Schizophyllaceae, Quel

The members of family Schizophyllaceae produce non-putrescent basidiocarp with lamellate hymenium. Species cause white rot of hardwoods. Hyphal system is dimitic with generative and skeletal hyphae. Cystidia are absent; spore print white. Basidiospores oval and non-amyloid. The family contains two genera and seven species distributed throughout the world. The most widely distributed species is *Schizophyllum commune*. It is described below.

34. ***Schizophyllum commune*** Fr. 1821: (Plate - 44)

Basidiocarps annual, shortly stipitate, spathulate to fan shaped, imbricate, 1.5cm in length, up to 1cm wide and 5mm in thickness; upper surface grey white, azonate, tomentose, smooth, margin entire; hymenophore lamellate, surface of lamellae brown hispid, context pale tan, azonate, corky, up to 1mm thick; stipe lateral, concolorous, tomentose, short. Hyphal system dimitic; contextual generative hyphae hyaline, thin-walled, simple septate, skeletal hyphae thick-walled and aseptate arranged loosely in trama. Basidia and basidiospores not seen.

Type of rot: White rot of wood log.

Remarks: It is identified in the field by presence of split lamellate hymenophore in the basidiocarp.

Schizoporaceae, Julich

The members of family Schizoporaceae produce poroid basidiocarp. Basidiocarp is white, cream to ochraceous, leathery, hirsute and with prominent pores. Hyphal system may be mono or dimitic. Cystidia are prominent, longer than basidia. Basidiospores oval, thick walled, abundant and non-amyloid; spore print white. We have found a rare, single species of this family. It is described below.

35. ***Leucophellinus hobsonii*** **(Berk. ex Cooke) Ryvarden, 1988**: (Plate - 45)

Basidiocarp effused-reflexed, sessile to imbricate, variable in size and thickness, up to 52 cm long, 16 cm in width and 2 cm thick at base, light in weight, consistency soft and watery when fresh, fibrous and loose. pileus white to cream coloured, straw-coloured, yellow-brown to ochraceous buff when dry, upper surface densely tomentose to hispid, azonate, cortex absent, pore surface concolorous with the pileus, pores angular, irregular to labyrinthine, 1–3mm in diameter, often varying in size within the same basidiocarp, dissepiments thin and papery, tubes indistinctly stratified, up to 7cm long.

Hyphal system monomitic, generative hyphae, hyaline and thin-walled, simple-septate, stains in cotton blue therefore cyanophilic. The hyphae are sparingly branched at acute angles, 3–4μm in diameter. Pileal hairs consist of almost unbranched simple-septate hyphae. The hyphae in the dissepiments are thick walled 3μm in diameter and have narrow lumen. The hyphae observed in the hymenium is thin walled and 4µm in diameter with wide lumen .Basidia clavate with swollen tips enclosing prominent nucleus and cytoplasm, stained with Congo red and Phloxin, length 15.2µm ± 1.9 (mean µm ±S.D) and its width 5.1µm ±0.9 (mean µm ±S.D). Fusing nuclei are seen in the basidium.

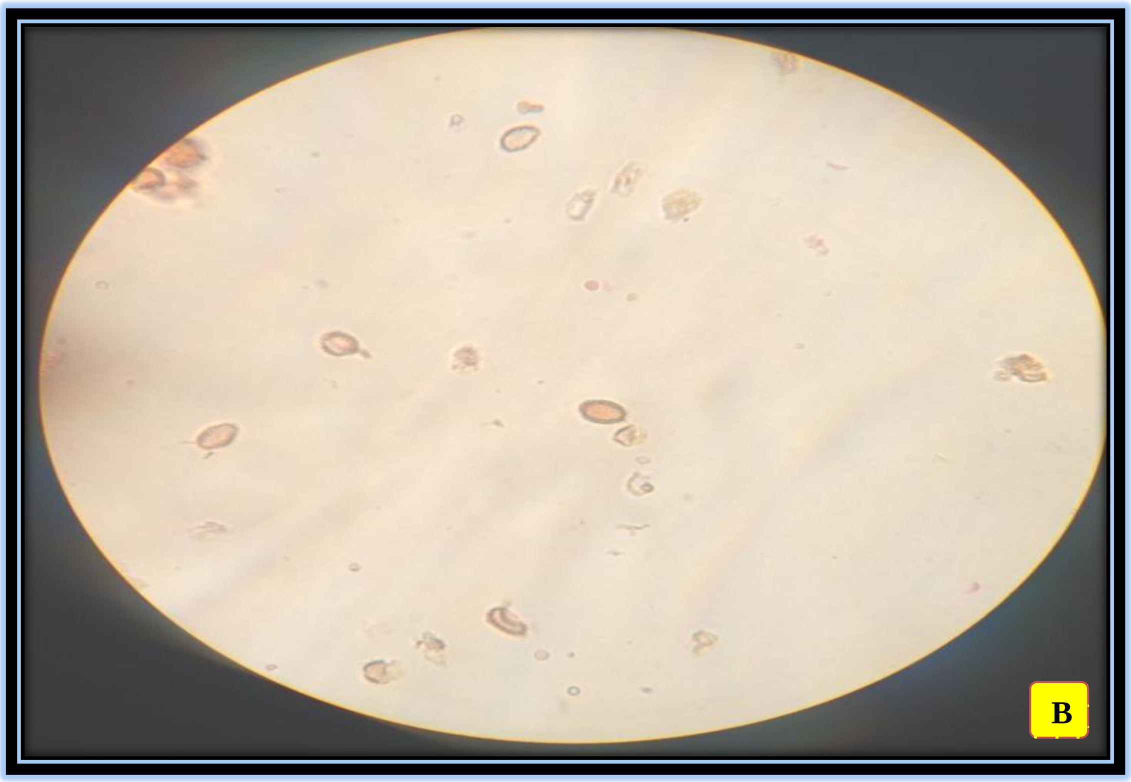
Cystidia oblong to cylindrical, projecting up to 30µm above the hymenium, stained with Hematoxylin and Phloxin, thin -walled, often with a swollen top 50 to 80µm long and 5–7µm wide.

Basidiospores are broadly ellipsoid to oval, thick-walled, abundant, and stained in phloxine. Basidiospores show prominent nucleus and cytoplasmic structures. They are negative in Melzer's reagent.

Type of rot: White rot of dead tree trunk.

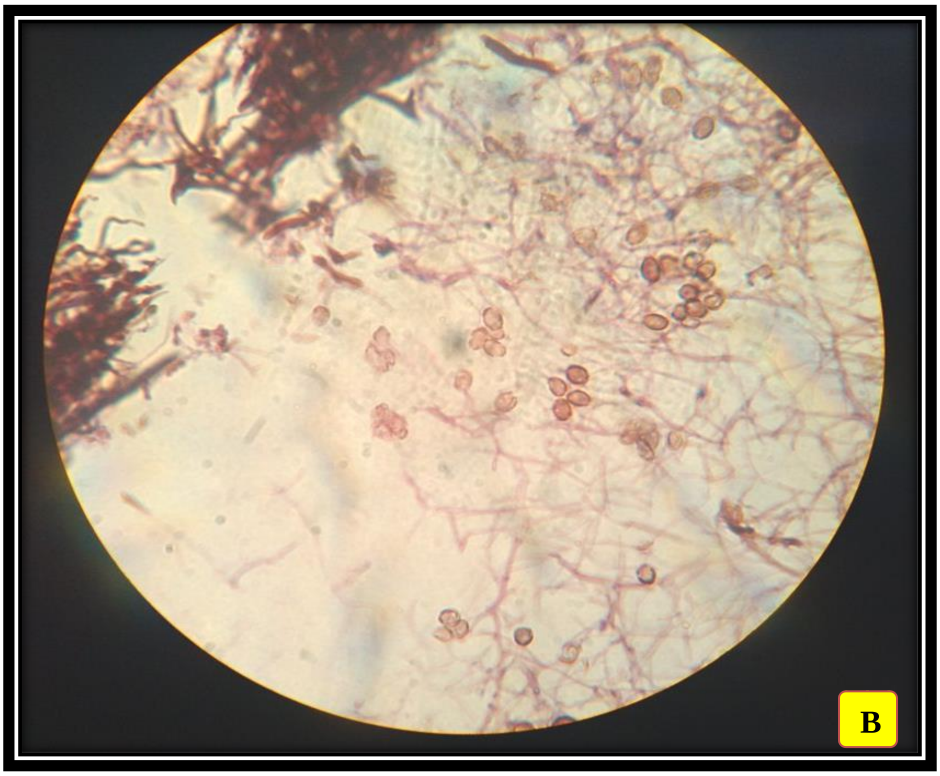
Remarks: This was a rare species identified in the field by its hirsute white to cream coloured basidiocarp with poroid hymenophore.

Plate - 11 : *Ganoderma applanatum* (Ganodermataceae)



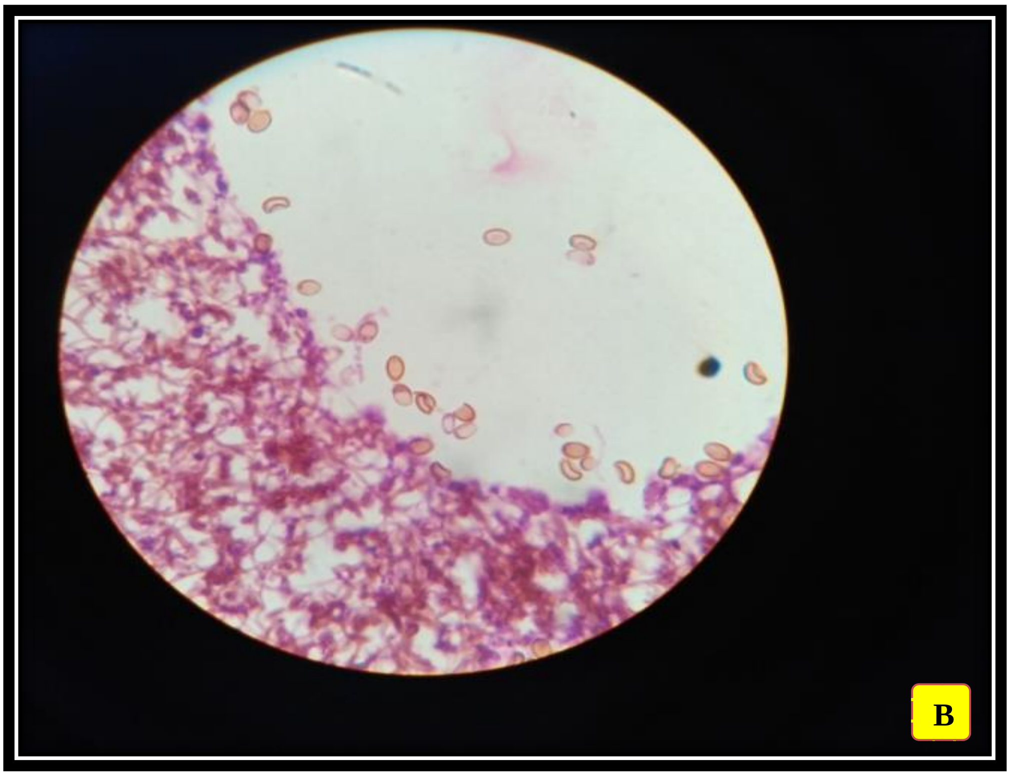
A. Habit **B.** Basidiospores

Plate - 12 : *Ganoderma australe (Ganodermataceae)*



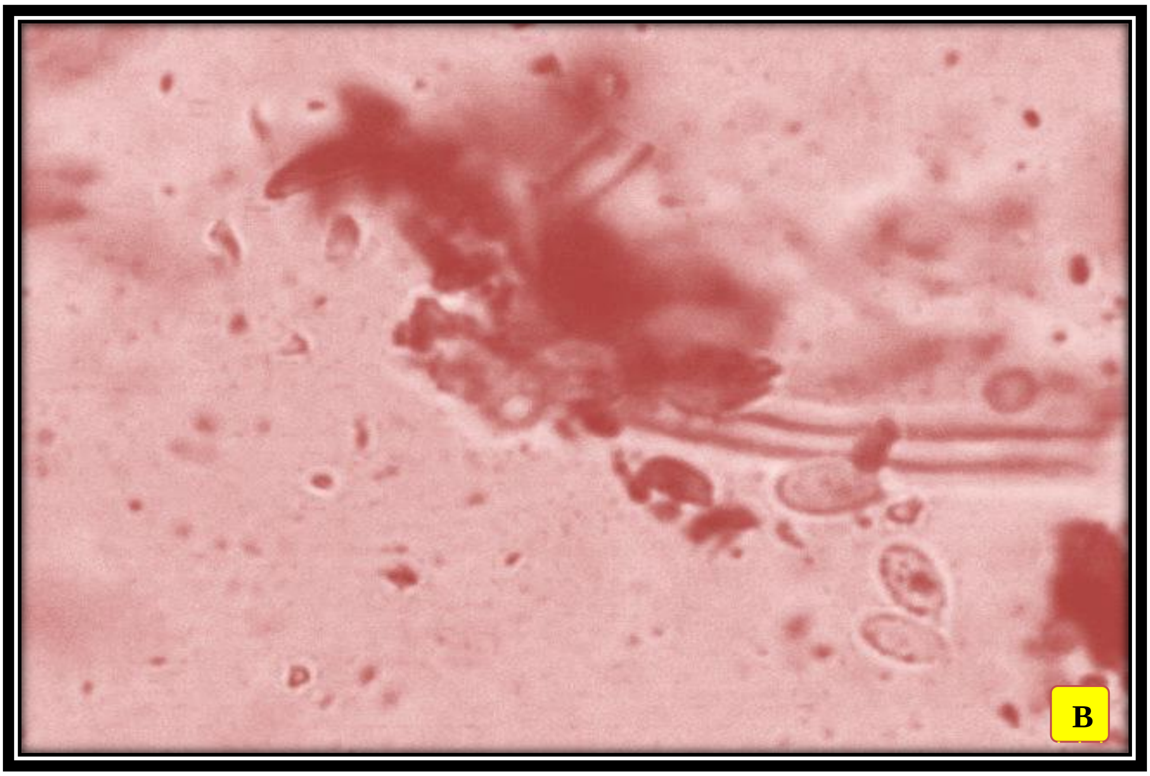
A. Basidiocarp **B.** Basidiospores with generative and skeletal hyphae

Plate - 13 : *Ganoderma lucidum* (Ganodermataceae)



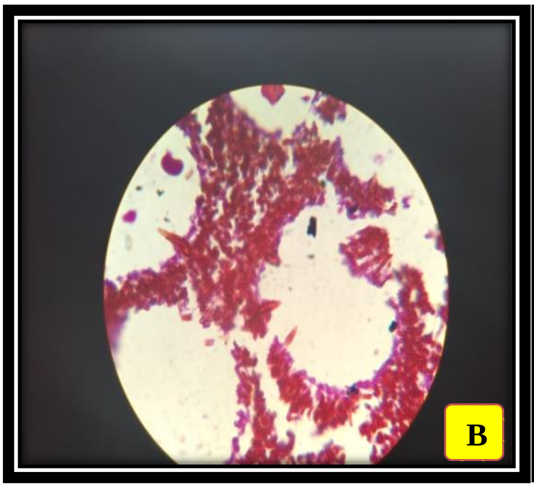
A. Habit **B.** T. S. of basidiocarp showing hymenium and spores

Plate - 14 : *Hymenochaete unicolor* (Hymenochaetaceae)



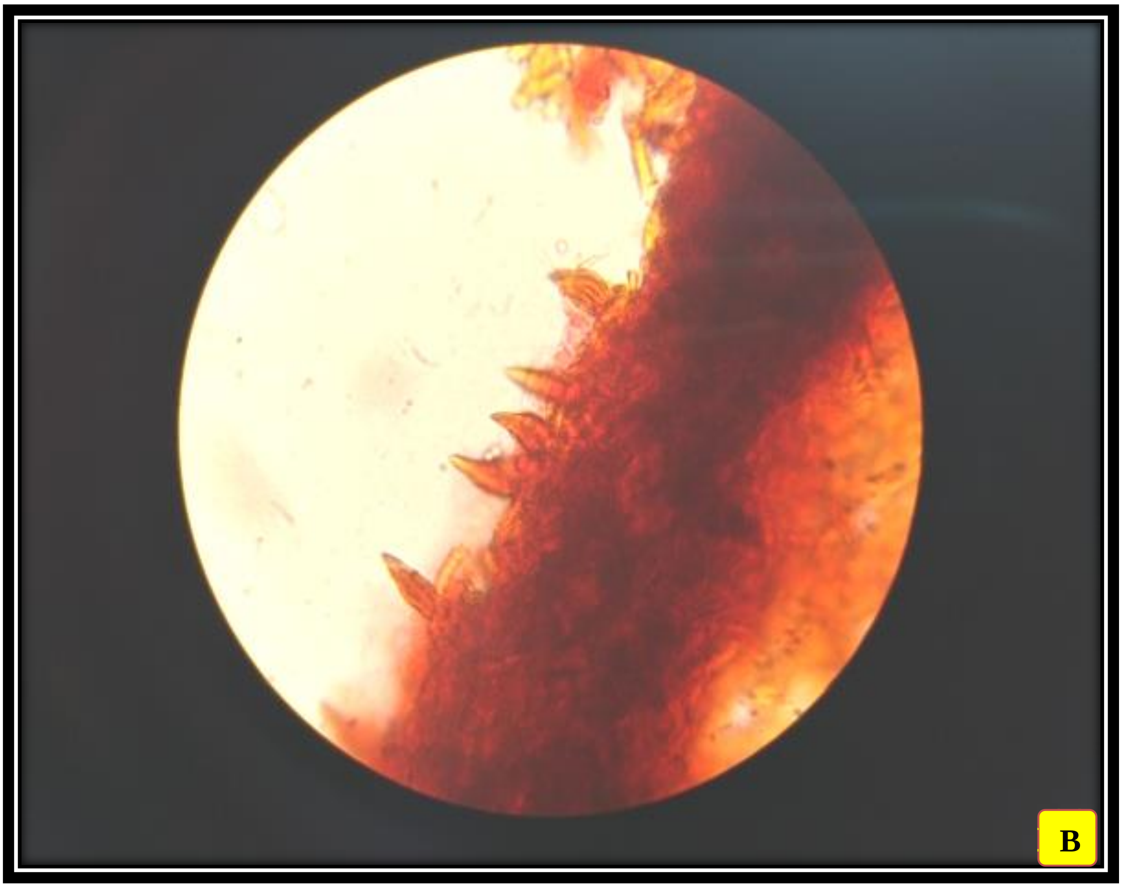
A. Habit **B.** Basidiospores

Plate - 15 : *Inonotus hispidus* (Hymenochaetaceae)



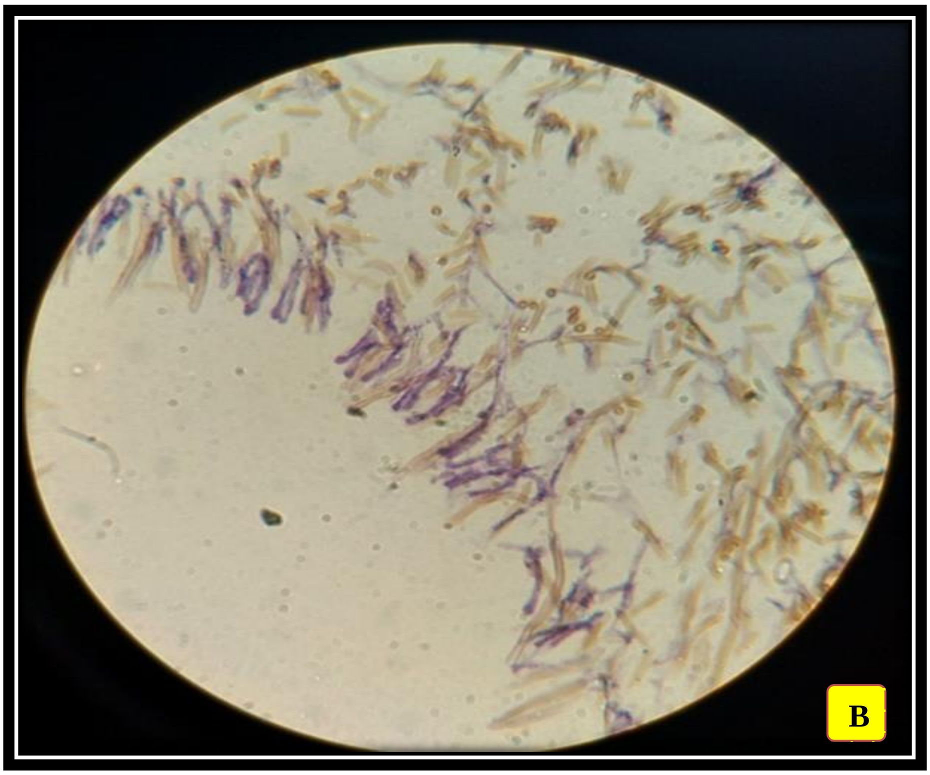
A. Habit **B**. T. S. of basidiocarp showing setae and spore **C**. Basidiocarp

Plate - 16 : *Phellinus ferruginosus* (Hymenochaetaceae)



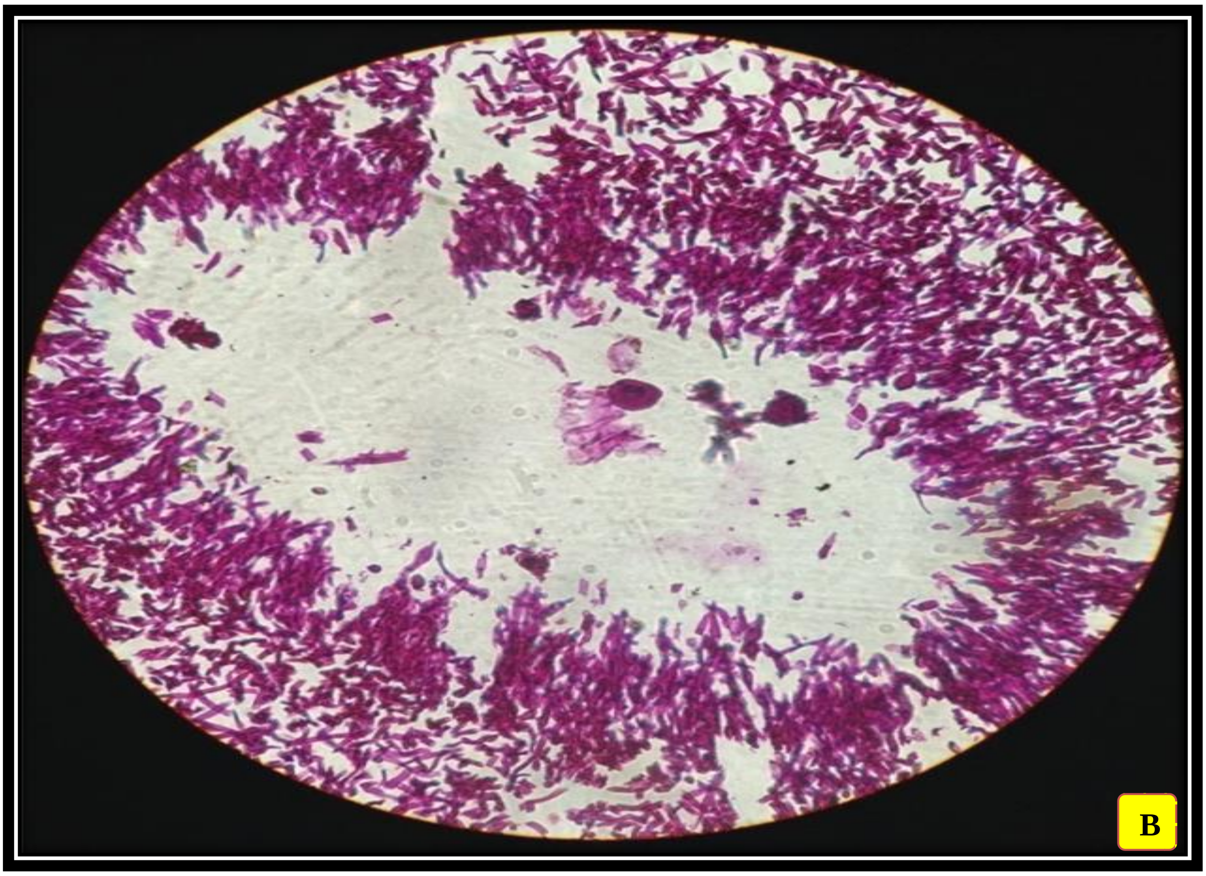
A. Habit **B.** T. S. of basidiocarp showing hymenial setae

Plate - 17 : *Flavodon flavus* (Meruliaceae)



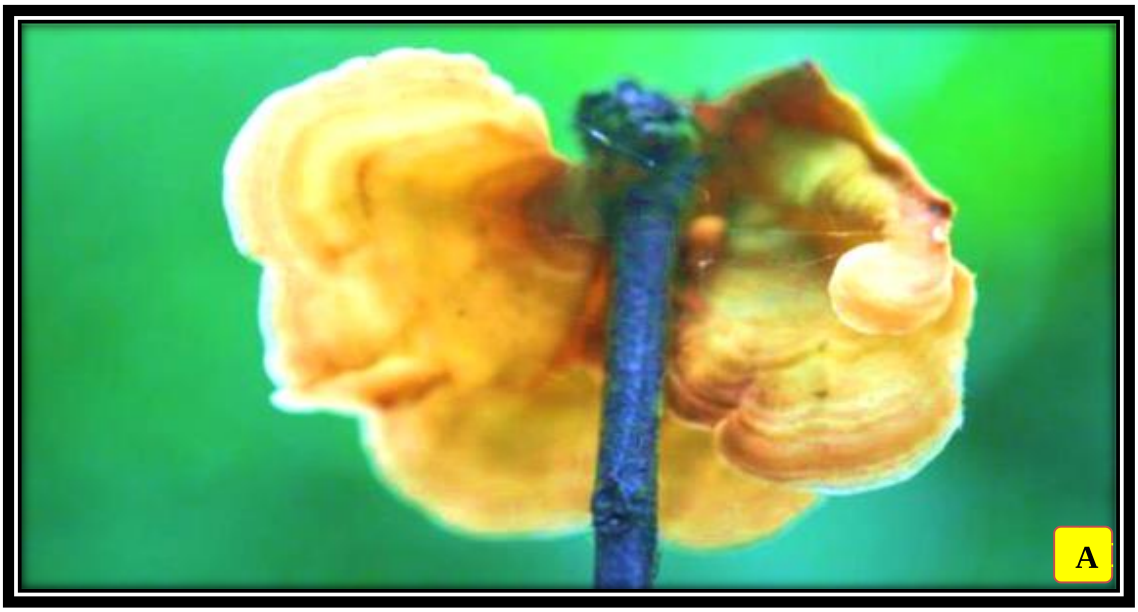
A. Habit **B**. T. S. of hymenium showing basidia and cystidia

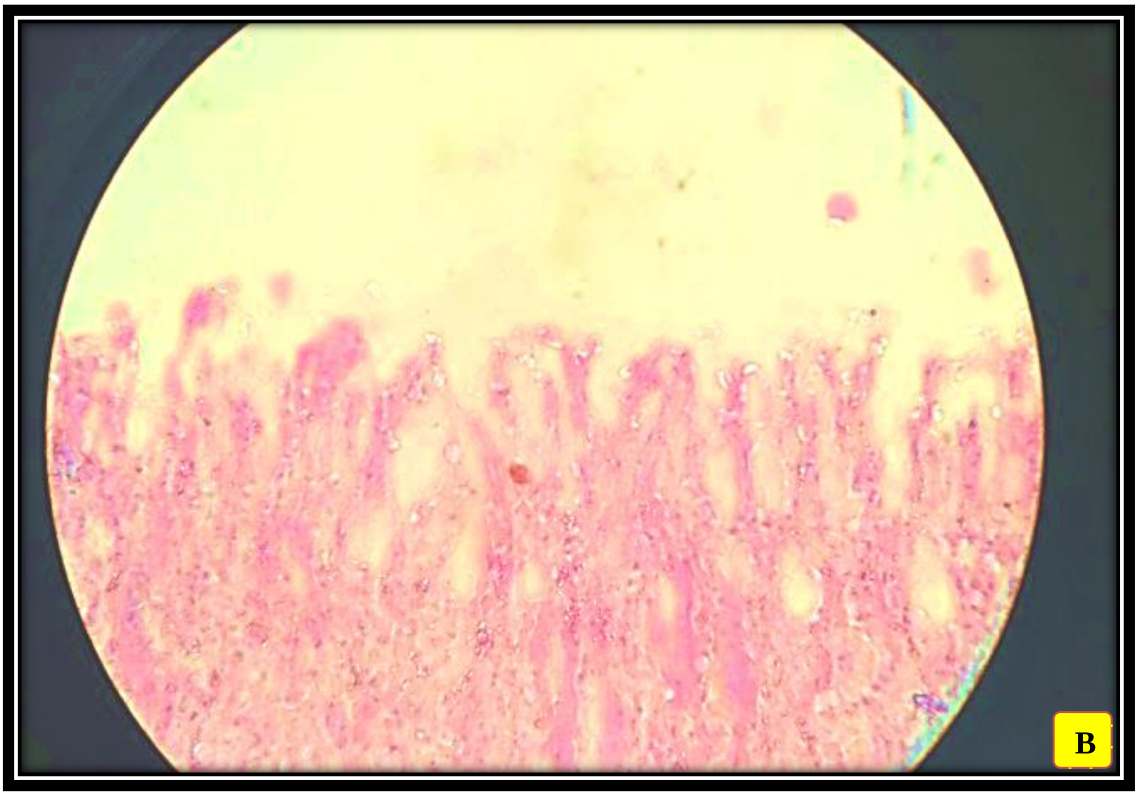
Plate - 18 : *Irpex lacteus* (Meruliaceae)



A. Habit **B.** T. S. of basidiocarp

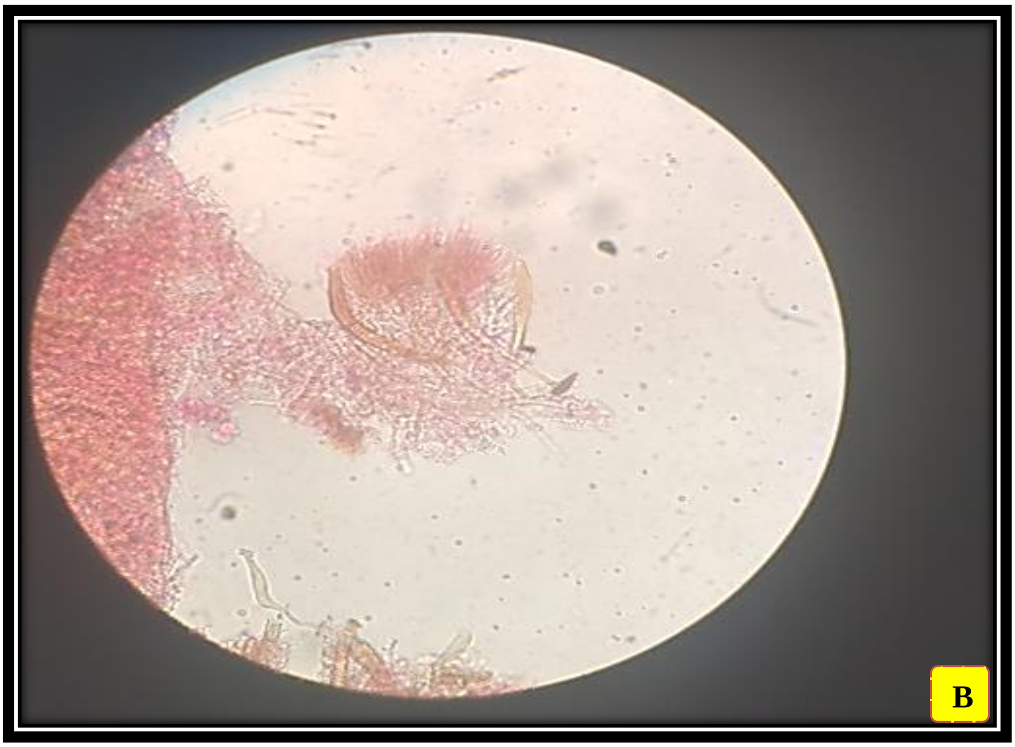
Plate - 19 : *Podoscypha petalodes* (Meruliaceae)





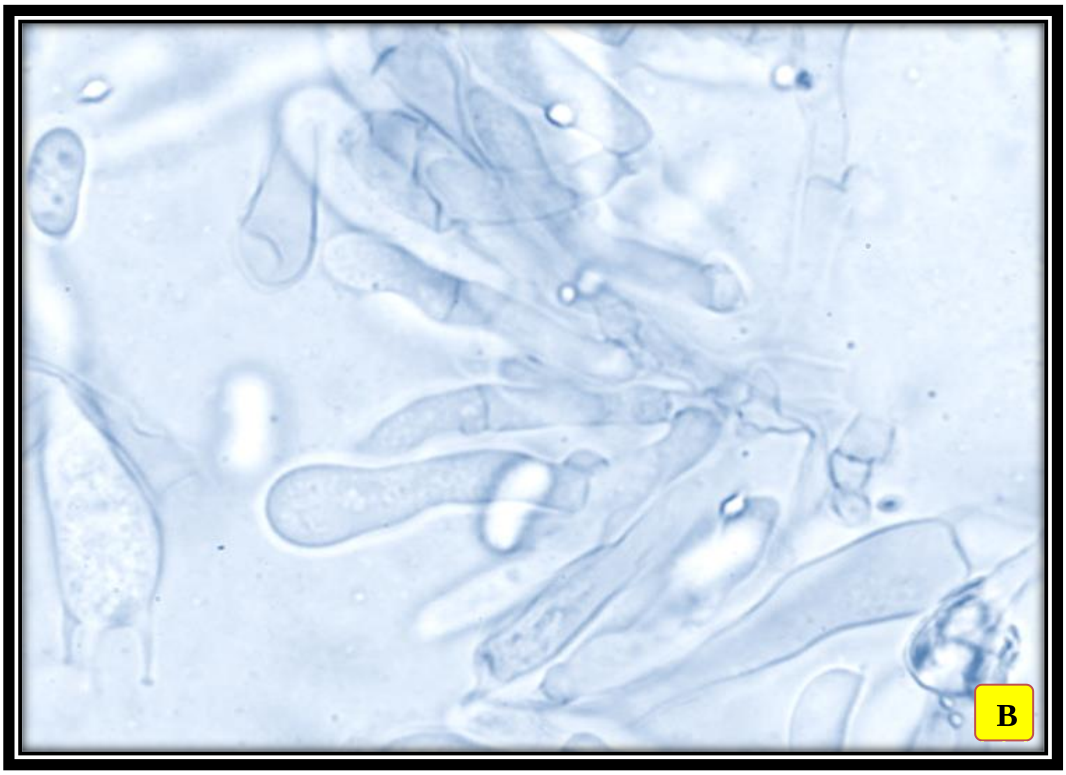
A. Habit **B.** T. S. of basidiocarp

Plate - 20 : *Peniophora albobadia* (Peniophoraceae)



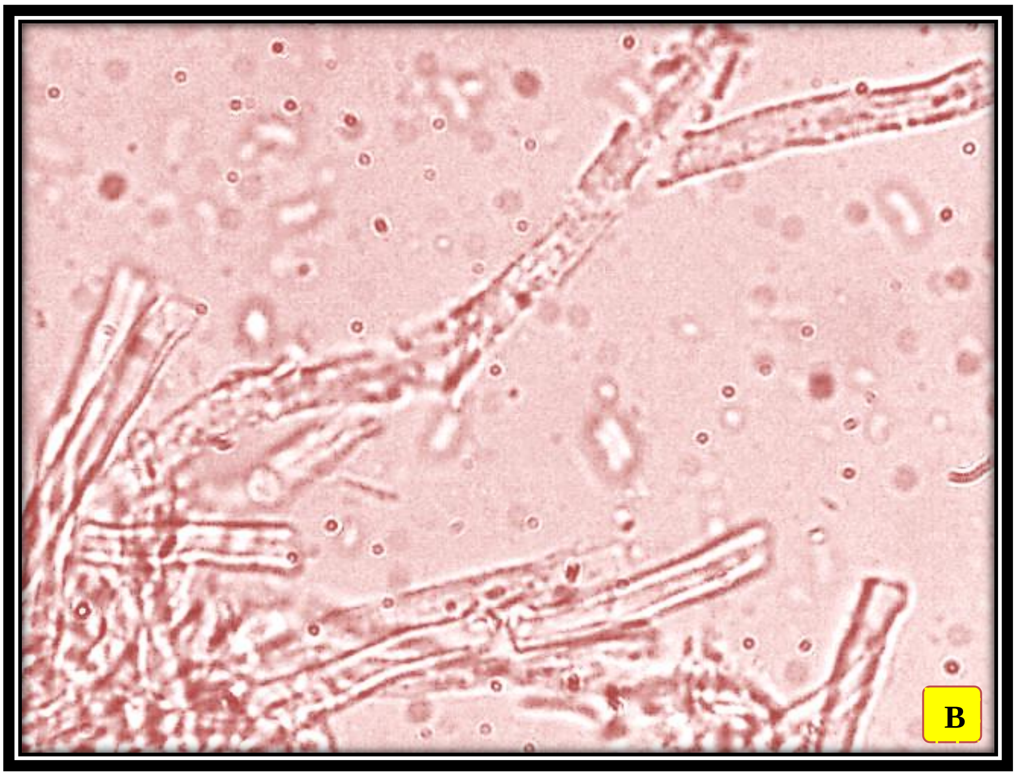
A. Resupinate basidiocarp on substratum **B.** T. S. of basidiocarp

Plate - 21 : *Coriolopsis polyzona* (Polyporaceae)



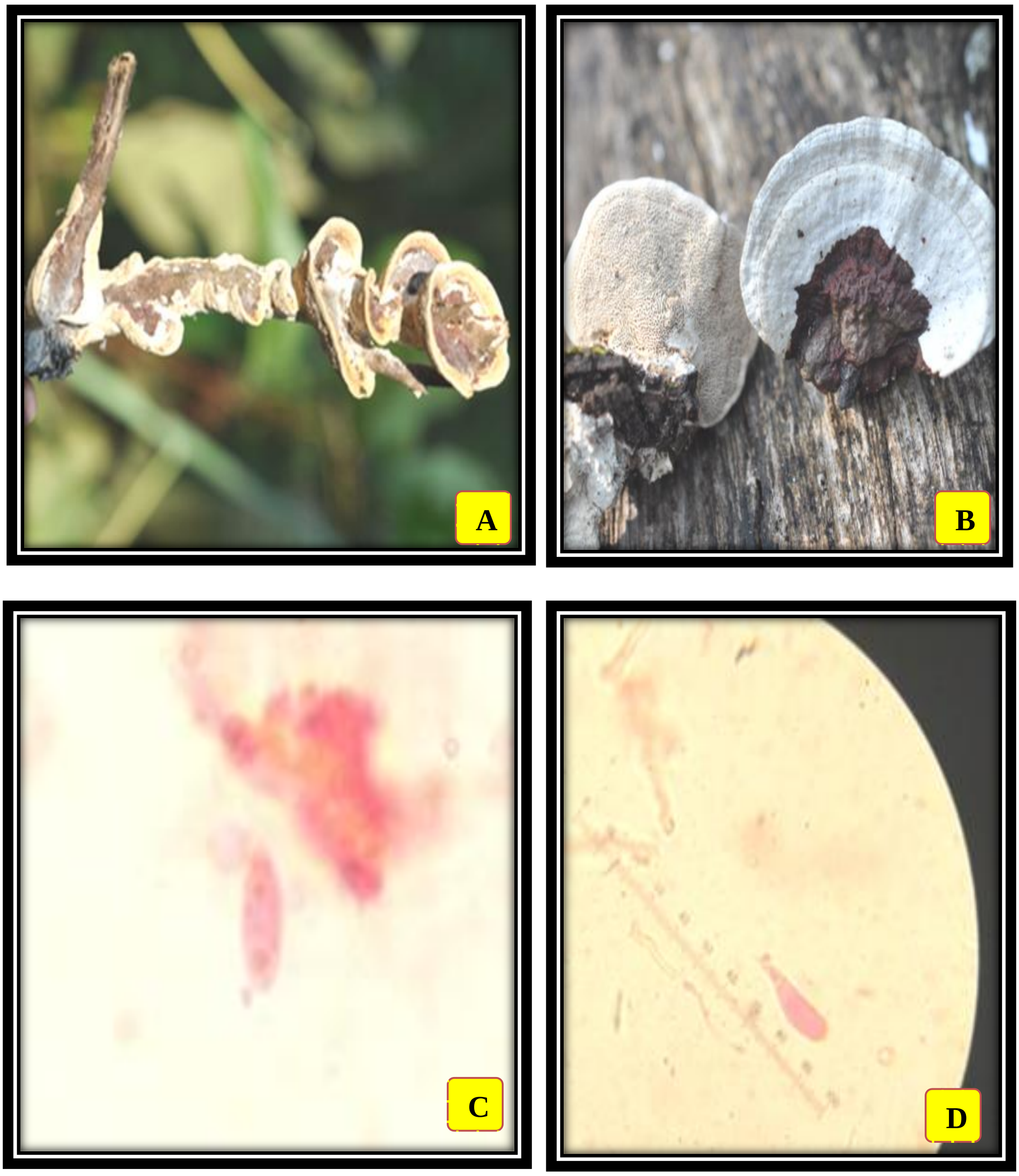
A. Habit **B**. T. S. of basidiocarp showing basidia and spores

Plate - 22 : *Dichomitus leucoplacus* (Polyporaceae)



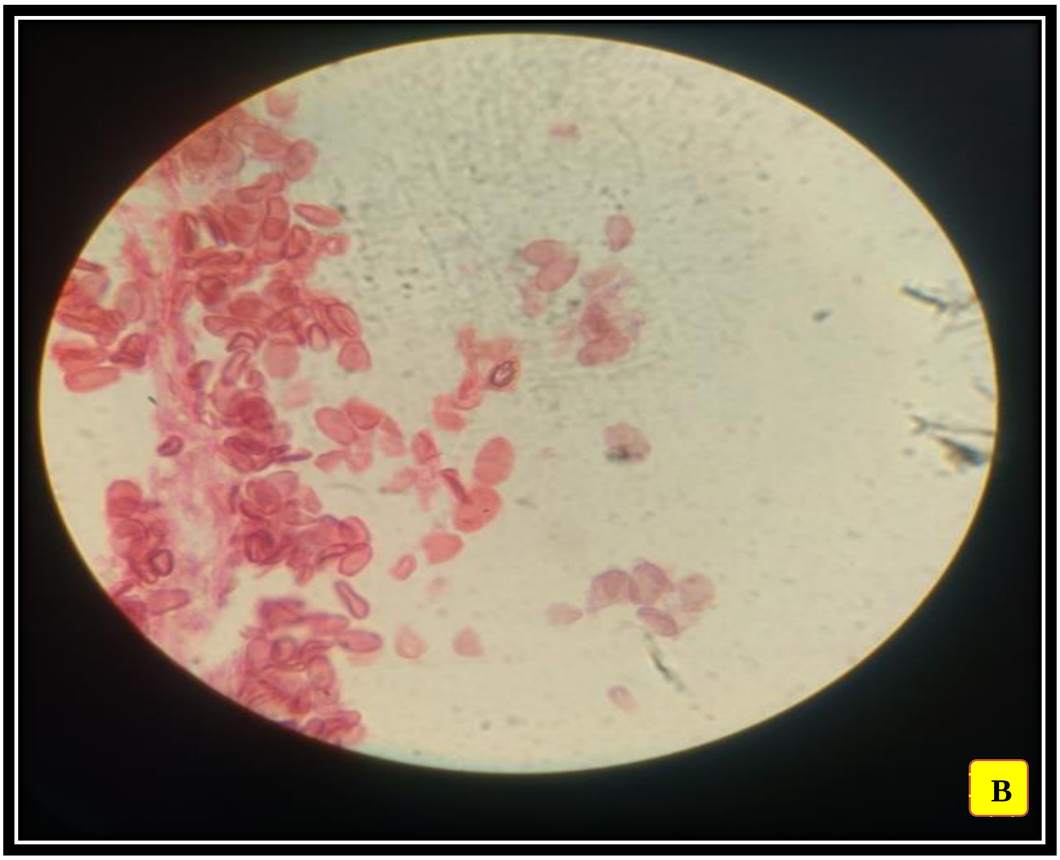
A. Habit **B**. Generative hyphae

Plate - 23 : *Earliella scabrosa* (Polyporaceae)



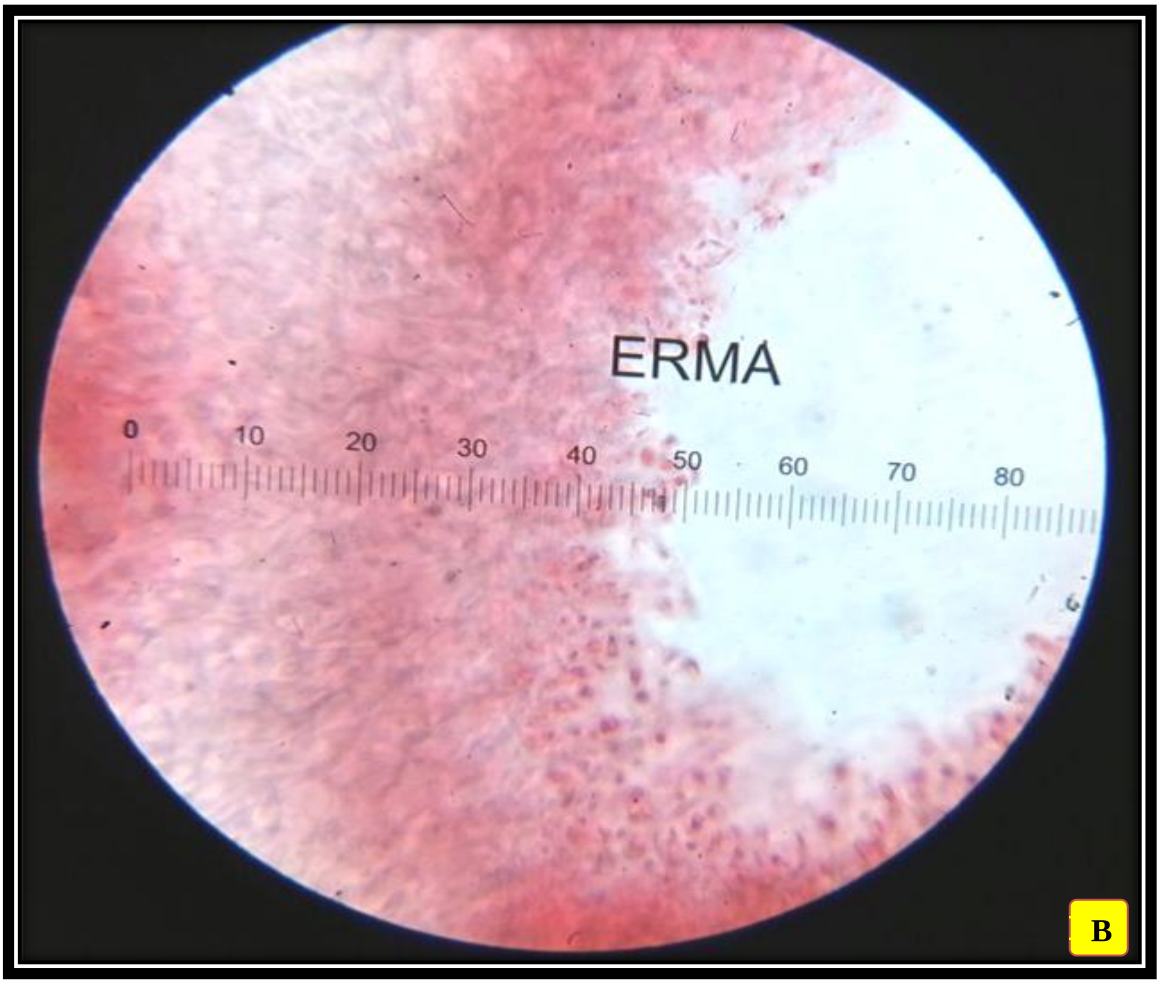
A. Habit **B**. Basidiocarp **C.** A basidiospore **D.** A basidium

Plate - 24 : *Fomes fomentarius* (Polyporaceae)



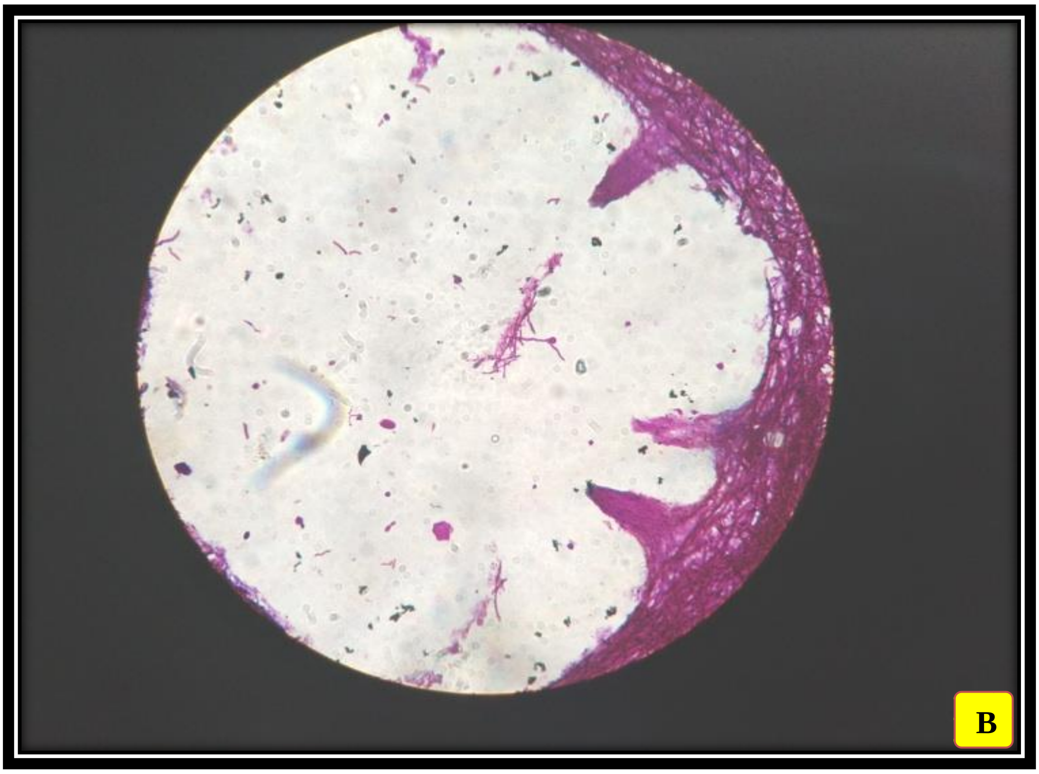
A. Habit **B.** Basidiospores

Plate - 25 : *Hexagonia apiaria* (Polyporaceae)



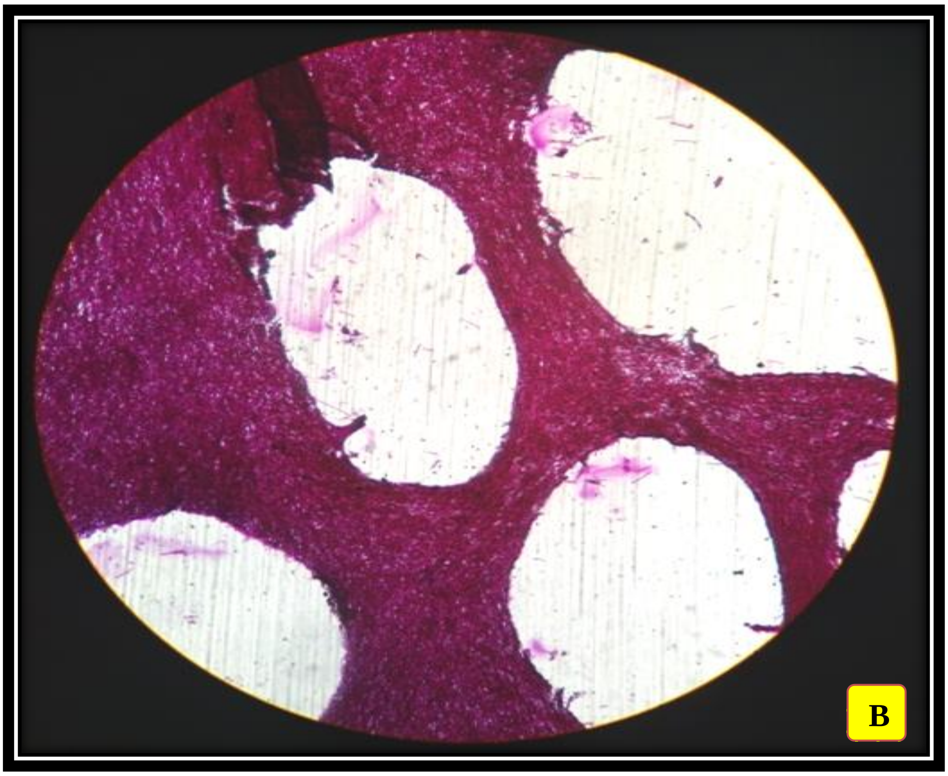
A. Habit **B.** T. S. of basidiocarp showing spores

Plate - 26 : *Hexagonia nitida* (Polyporaceae)



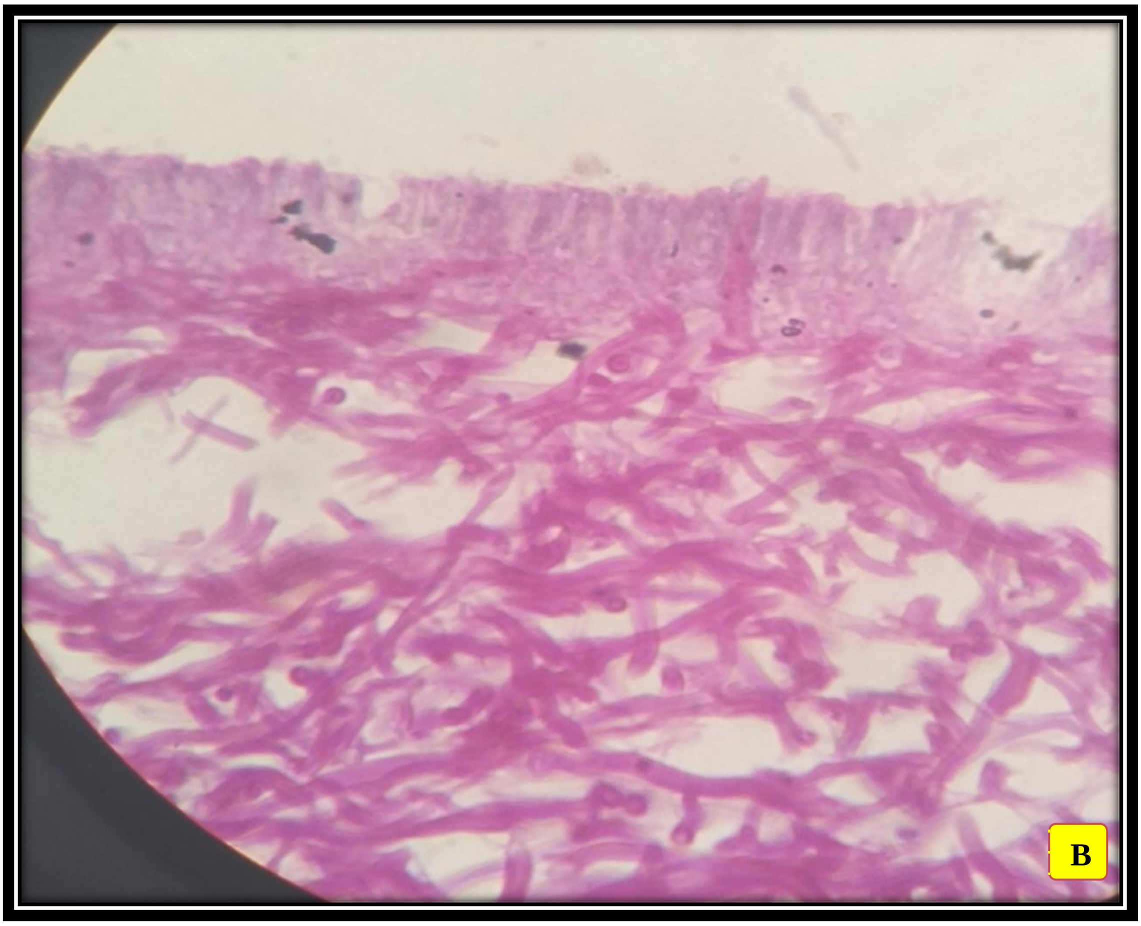
A. Habit **B.** T. S. of basidiocarp

Plate - 27 : *Hexagonia tenuis* (Polyporaceae)



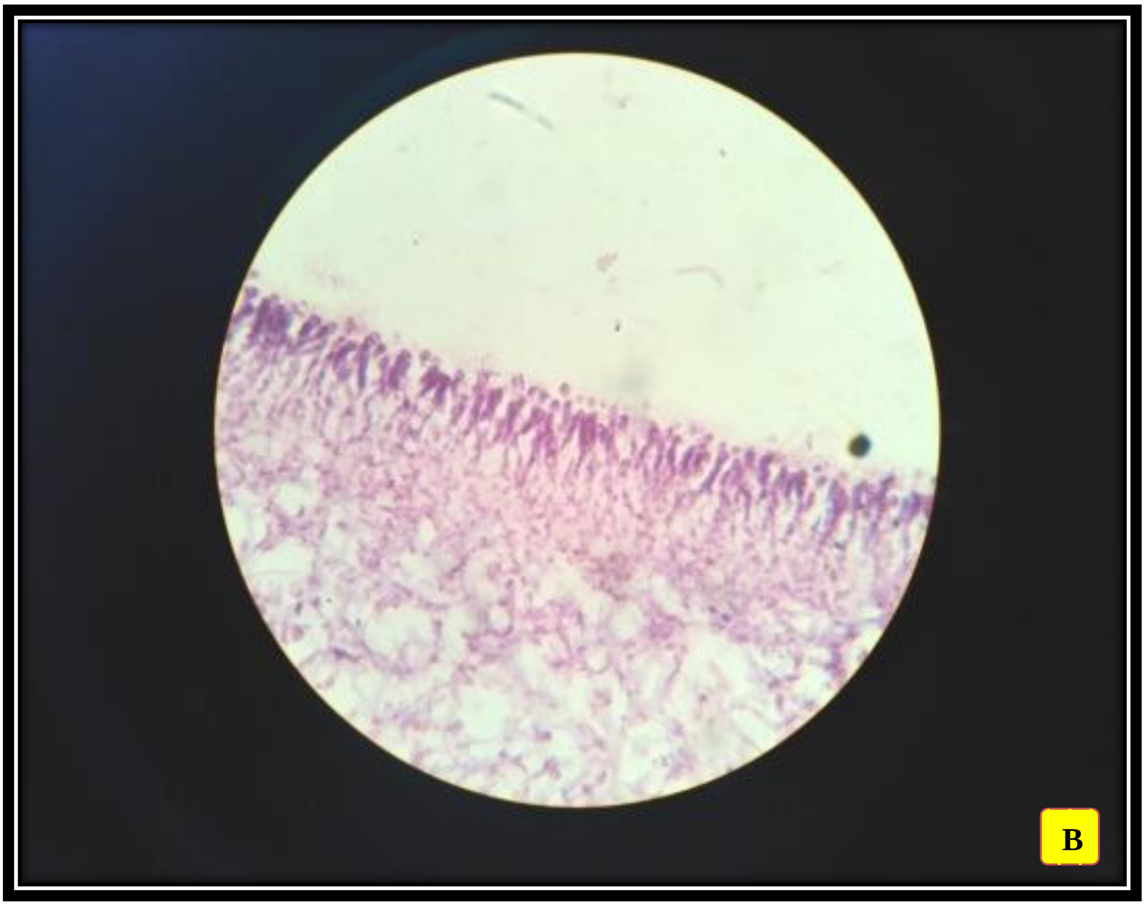
A. Habit **B.** T. S. of basidiocarp

Plate - 28 : ***Lentinus conatus*** **(Polyporaceae)**



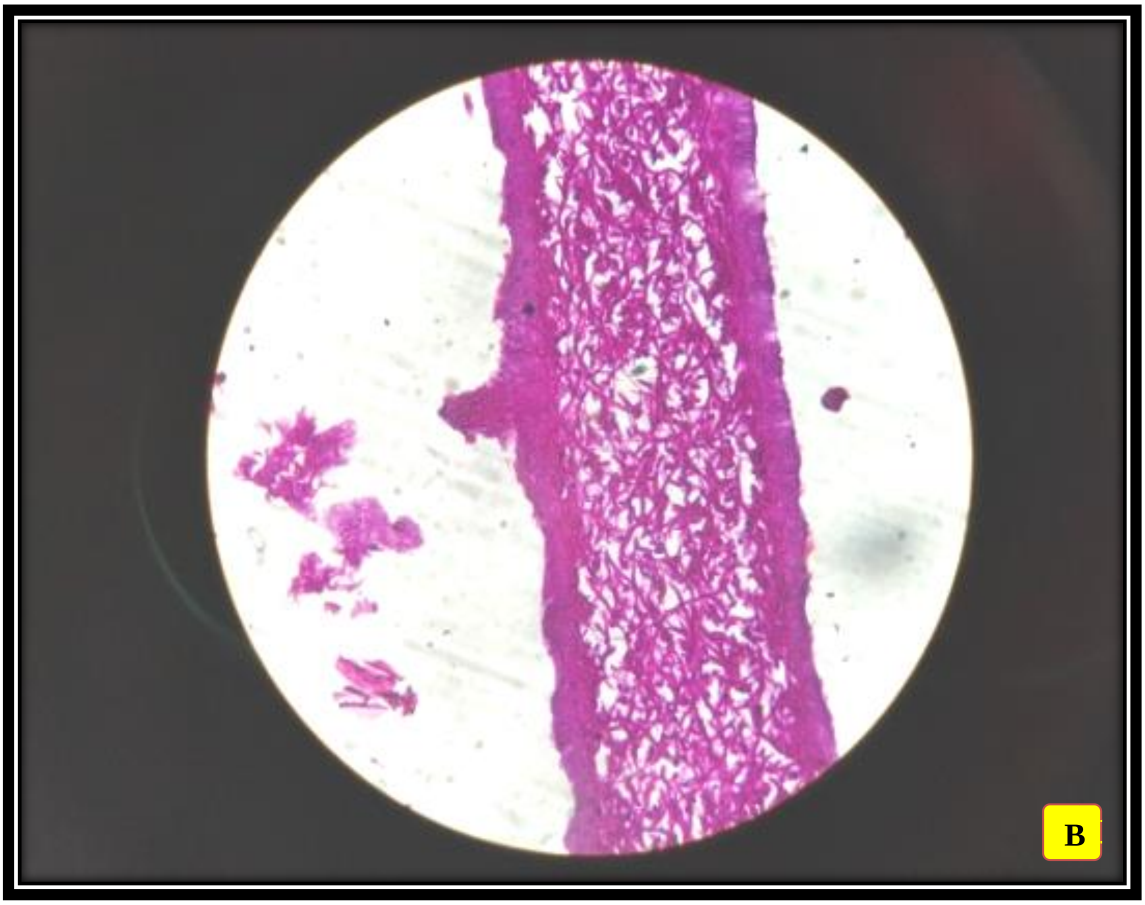
A. Habit **B.** T. S. of basidiocarp

Plate - 29 : *Lentinus sajor-caju* (Polyporaceae)



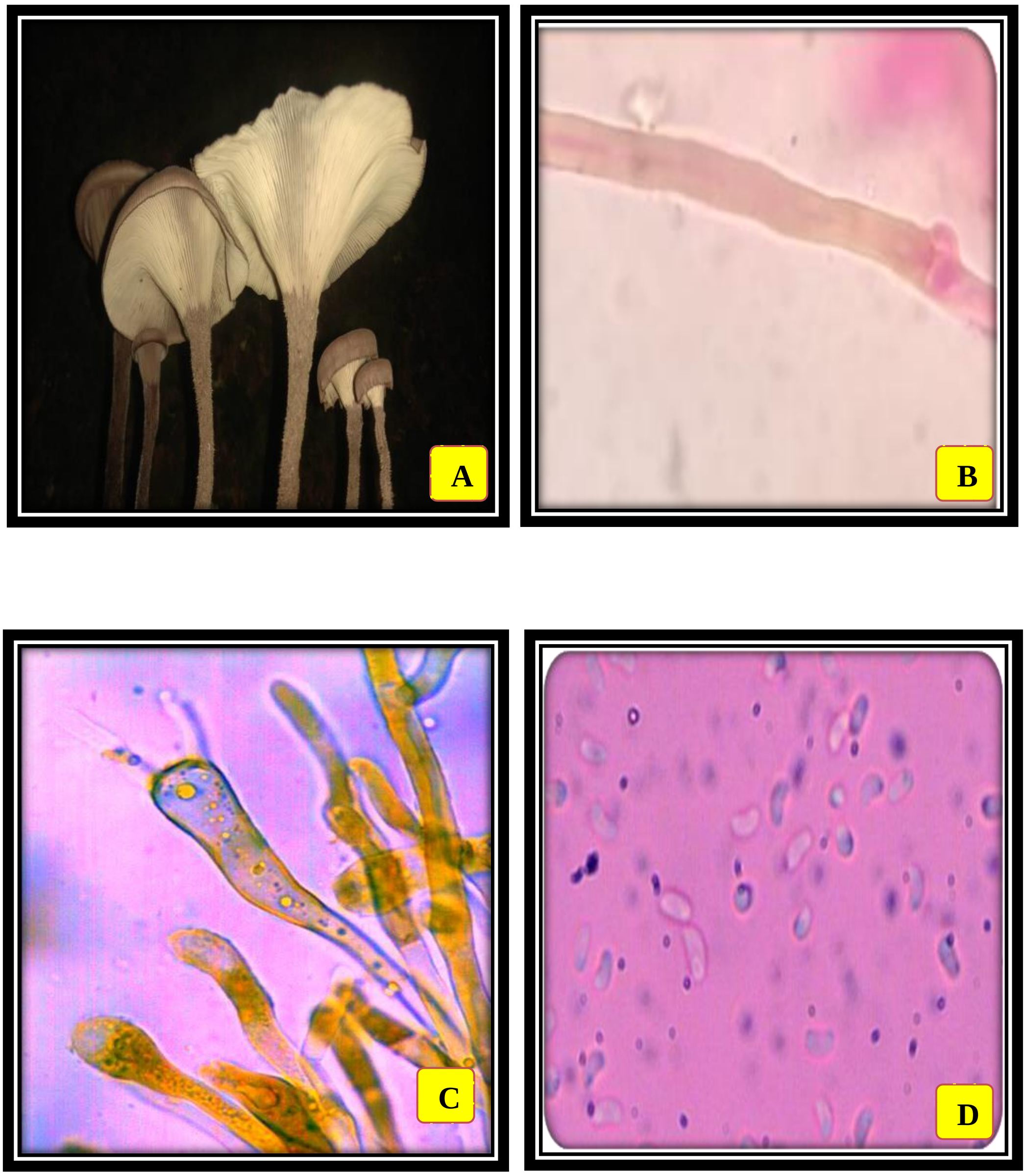
A. Habit **B.** T. S. of basidiocarp

Plate - 30 : *Lentinus squarrosulus* (Polyporaceae)



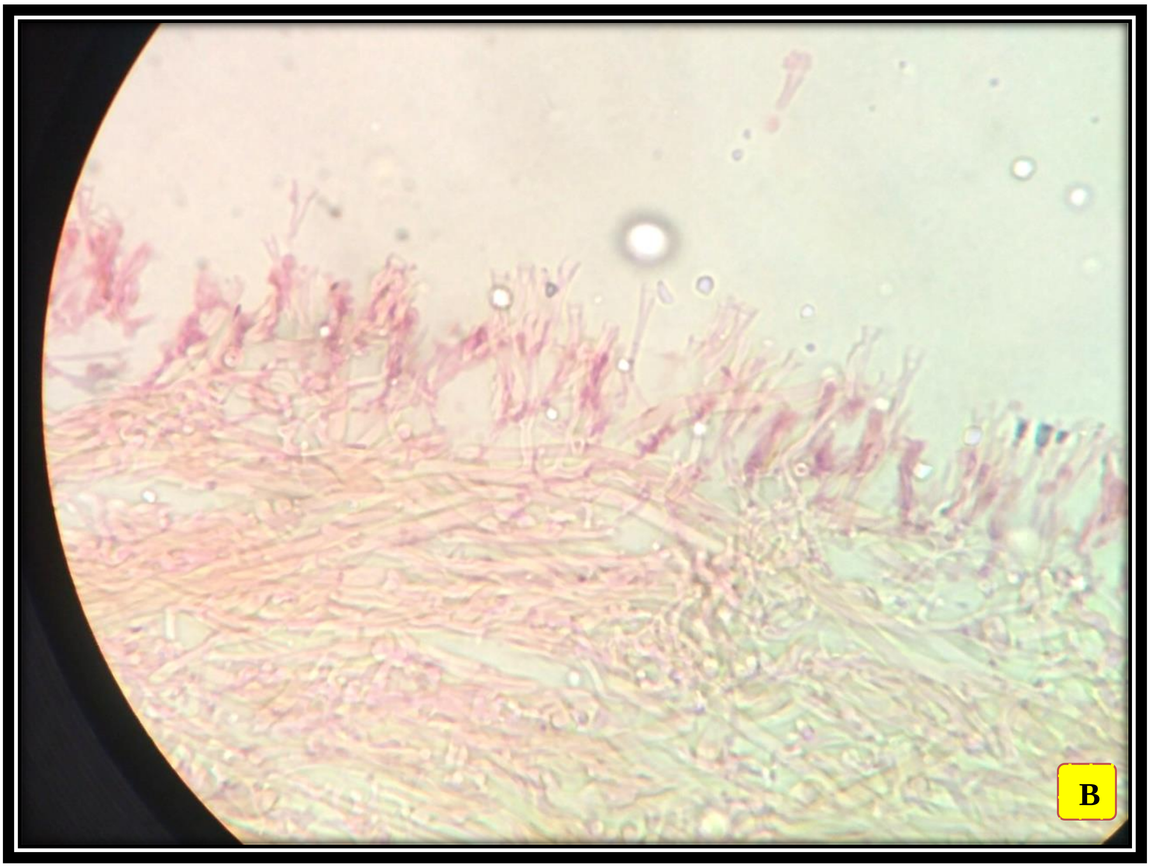
A. Habit **B.** T. S. of basidiocarp

Plate - 31 : *Lentinus velutinus* (Polyporaceae)



A. Basidiocarp **B**. Generative hyphae **C.** Basidia **D.** Basidiospores

Plate - 32 : *Lenzites acuta* (Polyporaceae)



A. Habit **B**. T. S. of basidiocarp

Plate - 33 : *Lenzites betulina* (Polyporaceae)

A. Habit **B.** Imbricate basidiocarps on substratum

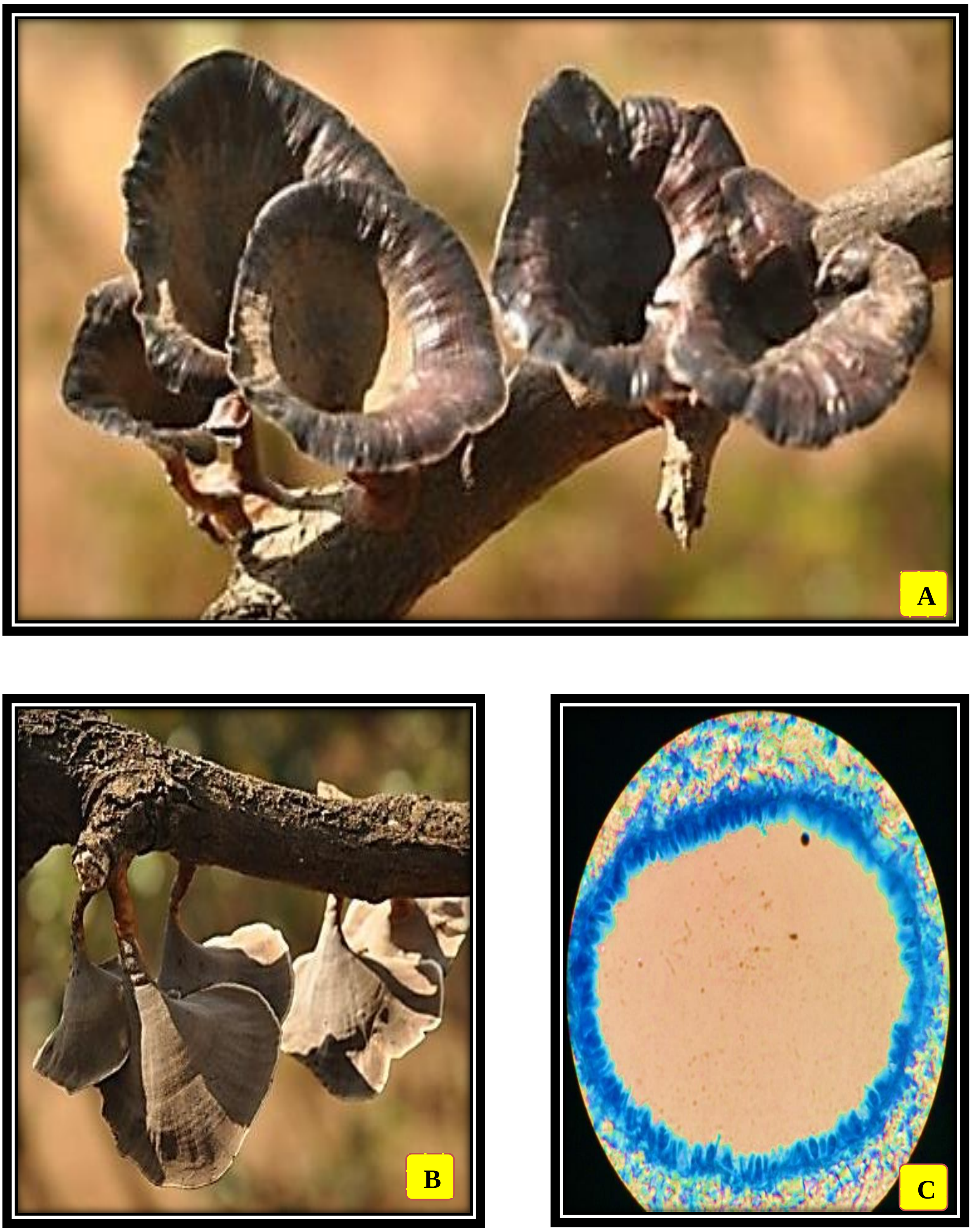
Plate - 34 : *Lenzites elegans* (Polyporaceae)

A. Habit **B.** Lower view of basidiocarp

Plate - 35 : *Microporus affinis* (Polyporaceae)

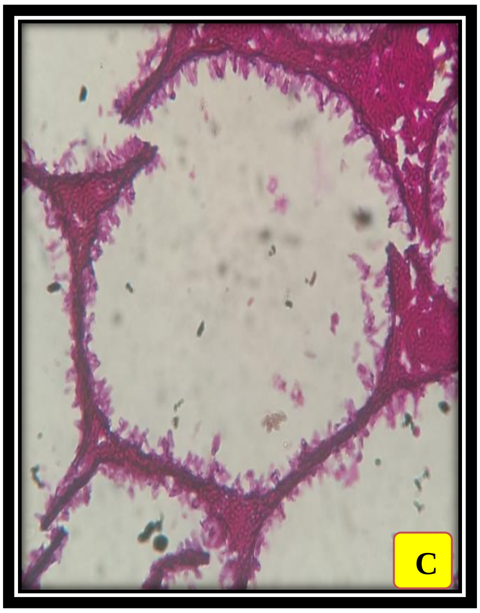
A. Habit **B**. Basidiocarp **C**. T. S. of basidiocarp **D**. Basidiospores

Plate - 36 : *Microporus atrovillosus* (Polyporaceae)



A. Habit **B**. Lower view of basidiocarp **C.** T. S. of basidiocarp

Plate - 37 : *Microporus xanthopus* (Polyporaceae)

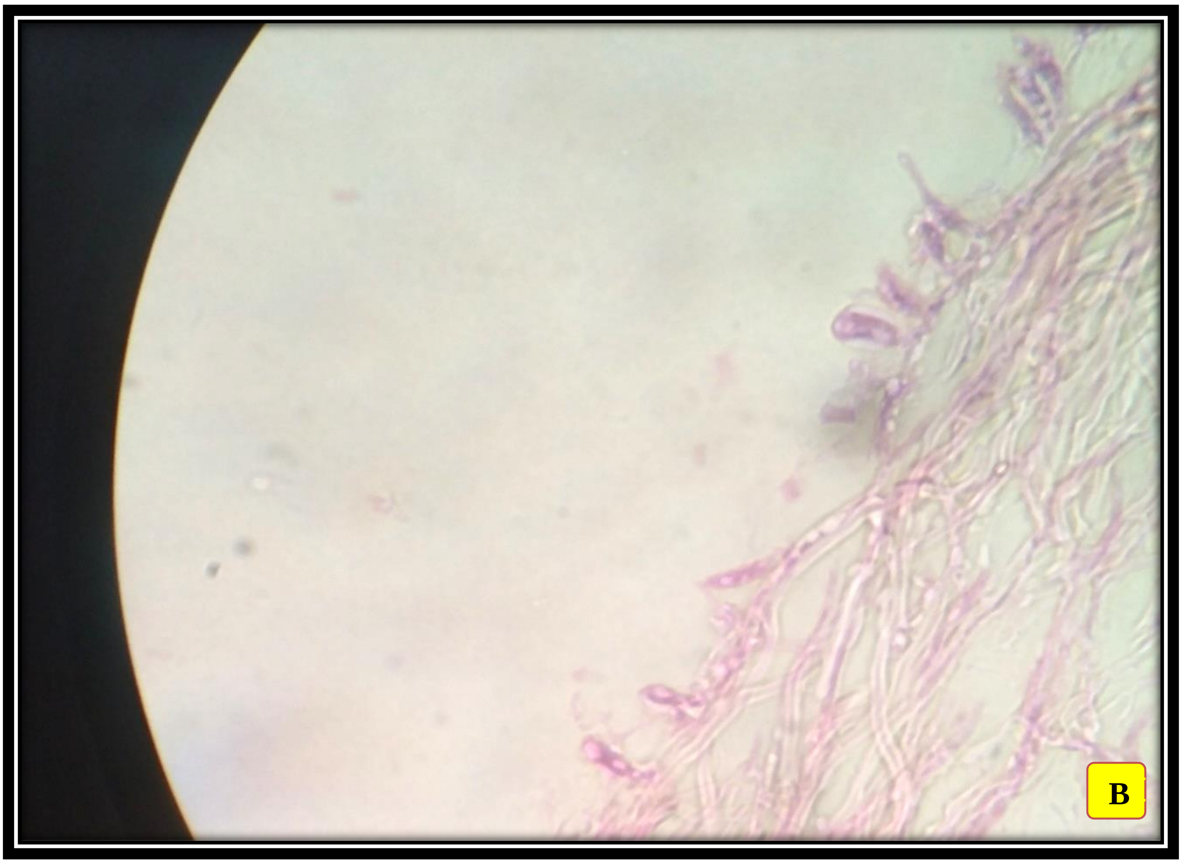


A. Habit **B.** Young basidiocarp **C.** T. S. of basidiocarp

Plate - 38 : *Neofavolus alveolaris* (Polyporaceae)

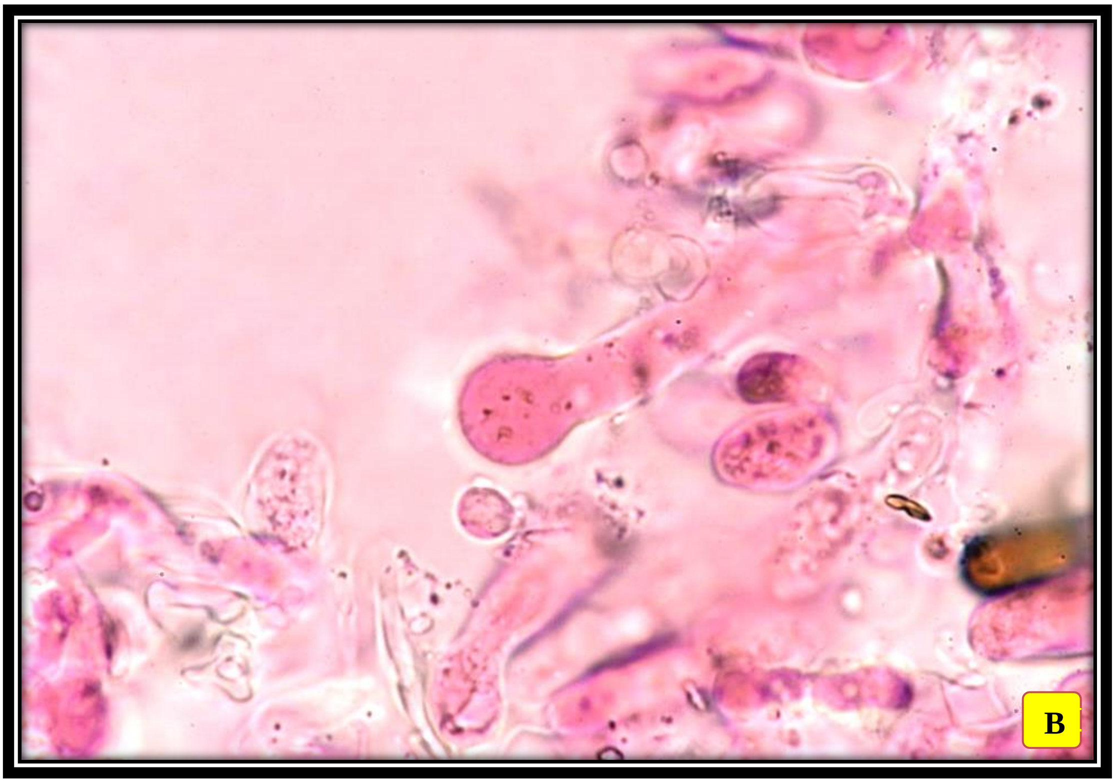
A. Upper view of basidiocarp **B**. Lower view of basidiocarp

Plate - 39 : *Perenniporia ochroleuca* (Polyporaceae)



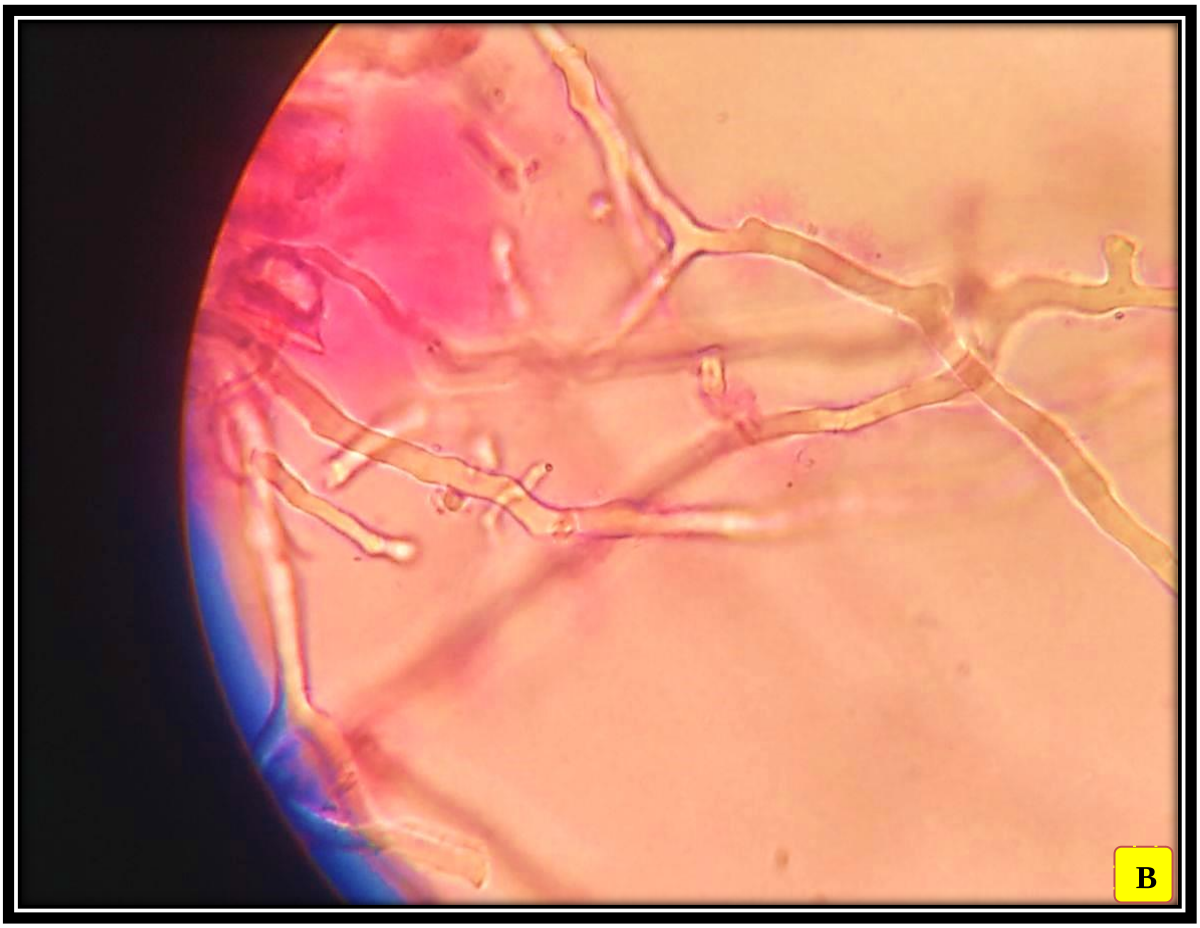
A. Upper view of basidiocarp **B.** T. S. of basidiocarp

Plate - 40 : *Polyporus badius* (Polyporaceae)



A. Habit **B.** T. S. of basidiocarp

Plate - 41 : *Polyporus brumalis* (Polyporaceae)



A. Habit **B**. Generative hyphae

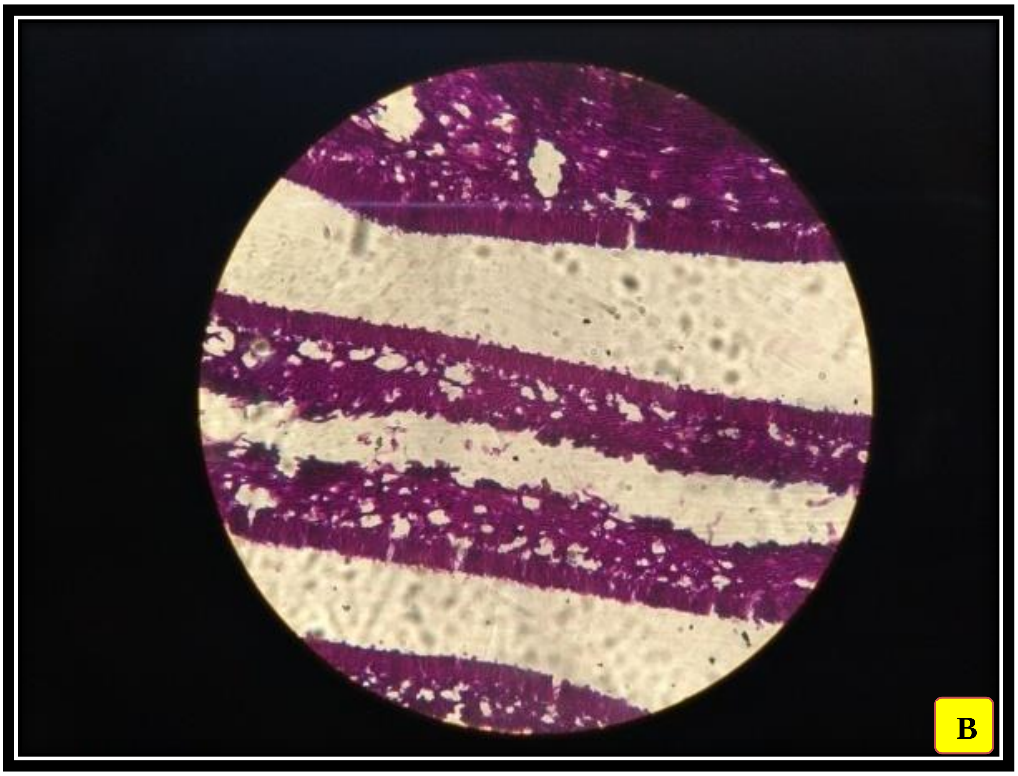
Plate - 42 : *Polyporus umbellatus* (Polyporaceae)

A. Habit **B.** T. S. of basidiocarp showing basidia and basidiospores on sterigmata.

Plate - 43 : *Trametes roseola* (Polyporaceae)

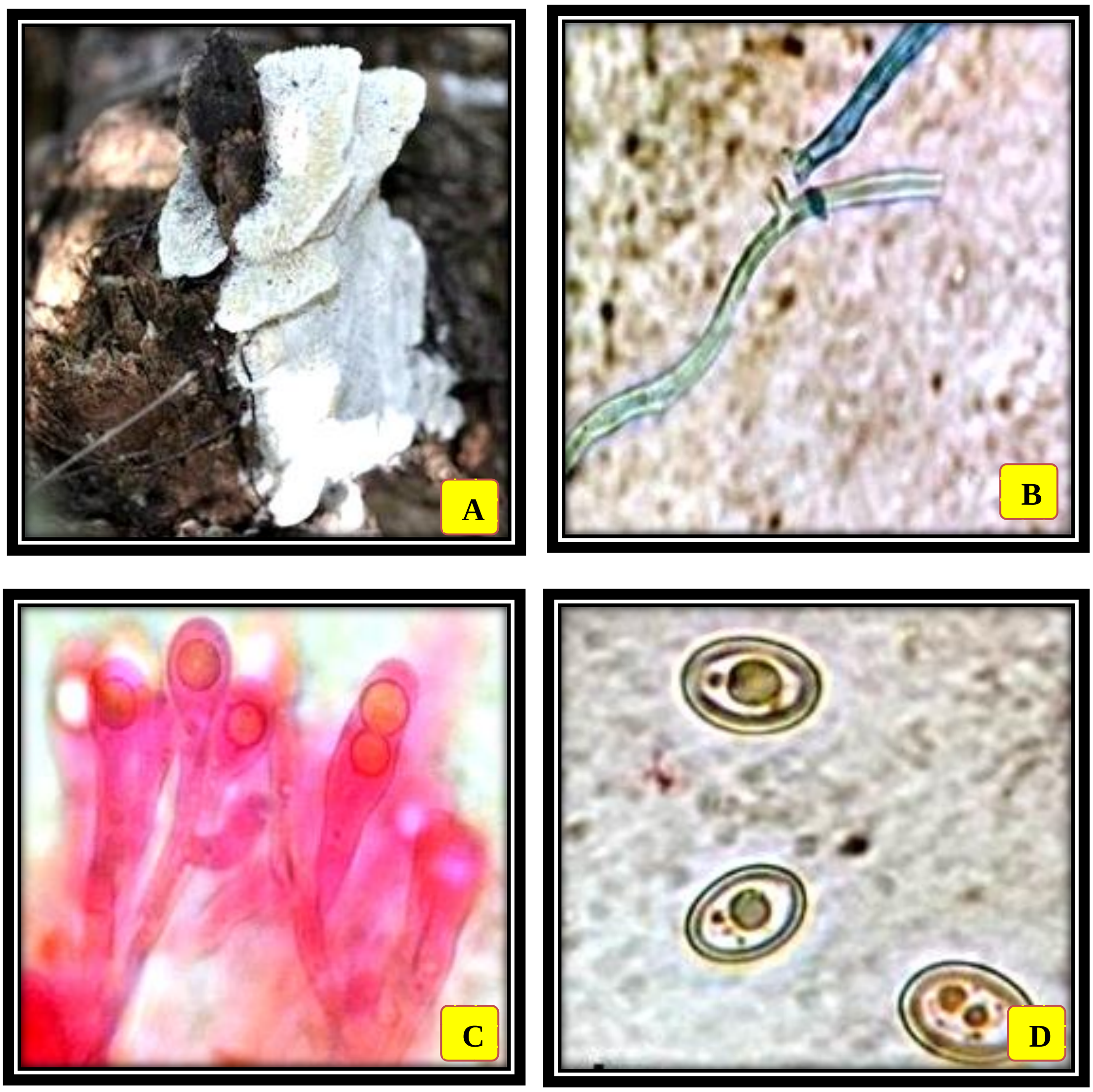
A. Habit **B.** Upper and lower view of basidiocarp

Plate - 44 : *Schizophyllum commune* (Schizophyllaceae)



A. Habit **B**. T. S. of basidiocarp

Plate - 45 : *Leucophellinus hobsonii* (Schizoporaceae)



A. Habit **B**. Generative hyphae **C**. Karyogamy in basidia **D.** Basidiospores

DISCUSSION

Ratnagiri district of Maharashtra is located in the Western Ghats biodiversity hotspots, it is rich in diversity of Aphyllophorales. The work on Aphyllophorales of Western Ghats of Maharashtra is initiated by Ranadive (2011). He visited several places in the Western Ghats especially Pune district and collected nearly 20 species. Western Ghats pass through 10 districts of Maharashtra; these are Mumbai, Thane, Palghar, Raigad, Ratnagiri, Satara, Pune, Sangli, Kolhapur and Sindhudurg. Aphyllophoraceous mycota has been studied for only one district and there is scanty work on this group in other districts of Maharashtra. So 10% area of Western Ghats of Maharashtra has been studied for Aphyllophorales and a large 90% area is yet to be explored. Therefore with the aim of exploring Aphyllophoraceous mycota from a fragment of Western Ghats the present investigation has been carried out to study diversity of Aphyllophorales from Ratnagiri district of Maharashtra. The studies on Aphyllophorales of Ratnagiri district are untouched before this study. During the investigation a total of 120 specimens were collected from 16 different localities of Ratnagiri district. This was the first attempt to study Aphyllophoraceous mycota of Ratnagiri district. From the collected specimens we have identified 35 species, belonging to 22 genera and 07 families of order Aphyllophorales from study area (Table - 6).

Collection localities had varied forest type like tropical moist broadleaved forest, tropical moist deciduous forest, sub-tropical hill forest and littoral and swamp forest. Of this large number of specimens were collected from tropical forests than littoral and swamp forest. This is due to the high moisture content and productivity of these areas. The study areas like Rajapur, Unhale, Hativale, Devrukh, Chiplun, and Khed yielded maximum number of specimens (Table - 6). The coastal areas yielded less specimen collection. This may be due to high salinity of substratum. Of the 16 study localities Rajapur was found to have rich in species diversity while Dapoli was found to be least in species diversity (Table - 6).

Out of 35 identified species of Aphyllophorales, genus *Coriolopsis* is represented by 1 species, *Dichomitus* by 1 species, *Earliella* by 1 species, *Flavodon* by 1 species, *Fomes* by 1 species, *Ganoderma* by 3 species, *Hexagonia* by 3 species, *Hymenochaete* by 1 species, *Inonotus* by 1 species, *Irpex* by 1 species, *Lentinus* by 4

Table - 4 : Genus wise species richness

Sr. No.	Name of the genus	Number of species
1.	*Coriolopsis Murrill*	1
2.	*Dichomitus* D. A. Reid	1
3.	*Earliella* Murrill	1
4.	*Fomes* (Fr.) Fr.	1
5.	*Neofavolus* Sotome & T. Hatt.	1
6.	*Perenniporia* Murrill	1
7.	*Podoscypha* Pat.	1
8.	*Trametes* Fr.	1
9.	*Phellinus* Quel.	1
10.	*Hymenochaete* Lev.	1
11.	*Inonotus* Karst.	1
12.	*Flavodon* Ryv.	1
13.	*Irpex* Fr.	1
14.	*Peniophora* Cooke	1
15.	*Schizophyllum* Fr.	1
16.	*Leucophellinus* Bondartsev & Singer ex Singer	1
17.	*Hexagonia* Fr.	3
18.	*Lenzites* Fr.	3
19.	*Microporus* Beauv. ex Kuntzeemend. Pat.	3
20.	*Polyporus* P. Micheli ex Adans.	3
21.	*Ganoderma* P. Karst.	3
22.	*Lentinus* Fr.	4

Table - 5 : Family wise list of species

Sr. No.	Name of the species	Family
1.	*Ganoderma applanatum* (Pers.) Pat.	Ganodermataceae
2.	*Ganoderma australe* (Fr.) Pat.	
3.	*Ganoderma lucidum* (Curtis) P. Karst.	
4.	*Phellinus ferruginosus* (Fr.) Pat.	Hymenochaetaceae
5.	*Hymenochaete unicolor* Berk. & M. A. Curtis	
6.	*Inonotus hispidus* **(**Bull.**)** P. Karst.	
7.	*Flavodon flavus* (KI.) Ryv.	Meruliaceae
8.	*Irpex lacteus* (Fr.) Fr.	
9.	*Podoscypha petalodes* (Berk.) Boidin	
10.	*Peniophora albobadia* (Schwein.) Boidin	Peniophoraceae
11.	*Coriolopsis polyzona* (Pers.) Ryv.	Polyporaceae
12.	*Dichomitus leucoplacus* (Berk.) Ryvarden	
13.	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	
14.	*Fomes fomentarius* (L.) Fr.	
15.	*Hexagonia apiaria* (Pers.) Fr.	
16.	*Hexagonia nitida* Durieu & Mont.	
17.	*Hexagonia tenuis* (Hook.) Fr.	
18.	*Lentinus connatus* Berk.	
19.	*Lentinus sajor-caju* (Fr.) Fr.	
20.	*Lentinus squarrosulus* Mont.	
21.	*Lentinus velutinus* Fr.	
22.	*Lenzites acuta* Berk.	

Sr. No.	Name of the species	Family
23.	*Lenzites betulina* (L) Fr.	Polyporaceae
24.	*Lenzites elegans* (Spreng.) Pat.	
25.	*Microporus affinis* (Blume & T. Nees) Kuntze	
26.	*Microporus atrovillosus* Ryvarden	
27.	*Microporus xanthopus* (Fr.) Kunt.	
28.	*Neofavolus alveolaris* (DC.) Sotome & T. Hatt.	
29.	*Perenniporia ochroleuca* (Berk.) Ryvarden	
30.	*Polyporus badius* (Pers.) Schwein.	
31.	*Polyporus brumalis* (Pers.) Fr.	
32.	*Polyporus umbellatus* (Pers.) Fr.	
33.	*Trametes roseola* Pat & Har.	
34.	*Schizophyllum commune* Fr.	Schizophyllaceae
35.	*Leucophellinus hobsonii* (Berk. ex Cook), Ryvarden	Schizoporaceae

species, *Lenzites* by 3 species, *Leucophellinus* by 1 species, *Microporus* by 3 species, *Neofavolus* by 1 species, *Peniophora* by 1 species, *Perenniporia* by 1 species, *Phellinus* by 1 species, *Podoscypha* by 1 species, *Polyporus* by 3 species, *Schizophyllum* by 1 species and *Trametes* by 1 species. Genus *Lentinus* appears to be dominant with 04 species recorded from study area followed by genus *Ganoderma, Hexagonia* and *Polyporus* with 03 species each (Table - 4). While other genera were represented by single species. Genus *Leucophellinus* was found to be rare in the study area as it was reported from single locality in the entire district.

There was also diversity in the shape and size of basidiocarps of different species. Basidiocarps of genera *Ganoderma* (*G. lucidum*), *Lentinus, Microporus* and *Polyporus* were stipitate, while remaining genera have pileate basidiocarps (Table- 9). In stipitate type except for *Ganoderma* (*G. lucidum*), others have circular pileus. In *Lentinus* and *Polyporus* was flat while in *Microporus* pileus was infundibuliform. In genera *Dichomitus, Flavodon, Hymenochaete, Irpex, Phellinus* and *Peniophora* basidiocarps were found to be resupinate type; they were attached on the surface of substratum. In pileate type most members had dimidiate basidiocarp while *G. applanatum* had applanate basidiocarp, *Fomes* had ungulate basidiocarp and *Schizophyllum* had spathulate basidiocarp. In most genera upper surface of pileus is glabrous and azonate. In *E. scabrosa* upper surface of pileus was covered with red cuticle; in *L. hobsonii* pileal surface was hirsute and in other it was zonate and sulcate. The size of basidiocarp in identified species varies from small basidiocarps with 10mm in diameter (*Lentinus* spp.) to large basidiocarps up to 250mm diameter (*Ganoderma* spp.).

Of the total 35 species identified 23 species had poroid hymenium, 12 species had non-poroid hymenium (Table - 4). *Hymenochaete* and *Peniophora* had flattened non-poroid hymenium. Amongst poroid species basidiocarp of *Ganoderma applanatum* had white fine round pores. By using needle beautiful figures can be carved on it and kept in houses as ornamental material. In *Hexagonia* pores were hexagonal, in *Polyporus* pores were large round or elongated and in *Leucophellinus* pores are large and angular. In non-poroid species genus *Lentinus* and *Lenzites* had lamellate non-poroid hymenium while genera *Irpex* and *Flavodon* had irpicoid hymenium. The type of hymenophore of basidiocarp i.e. whether poroid or non-poroid was used as a character to give codes to species (Table - 7).

The identified species belong to 07 families of Aphyllophorales (Table - 5). Among them family Polyporaceae was found to be dominant family during the study, containing 24 species. The family had both poroid and non-poroid species (Table - 10). Family Ganodermataceae, Meruliaceae and Hymenochaetaceae were represented with 03 species each. Family Ganodermataceae had poroid species (Table - 10) with ornamented spores. *G. lucidum* is a medicinal bracket fungus and used commercially for production of Gano Tea, Gano Toothpaste etc. Family Hymenochaetaceae had both poroid and non-poroid species (Table - 10); its species were parasites on hardwoods. Family Meruliaceae had non-poroid species; its species had irpicoid hymenium containing teeth (Table - 10). Family Peniophoraceae, Schizoporaceae and Schizophyllaceae were represented by 1 species each. The species of family Peniophoraceae, Schizophyllaceae were found to be very common while that of Schizoporaceae was rare at Ratnagiri district.

The basidiocarp colour of these species varied from the range of white to cream, brown, red and black. Hyphal system varies from monomitic in *Leucophellinus hobsonii* to dimitic in *Lentinus* and *Polyporus* while trimitic in rest of the members. Basidiocarps with trimitic hyphae were found to be tough, coriaceous and long lived while those with dimitic and monomitic hyphae were found to be soft and flexible. In most specimens, like *Hexagonia nitida*, we do not get spores; it was due to the fact that these fungi produce ballistospores.

All identified species of Aphyllophorales were wood rotting type and none of them occurred in terrestrial habitat; indicating that these fungi play important role in decay of dead wood in forest ecosystem. Out of 35 species recorded, 04 species were found to be obligate parasites, 25 species were saprophytic while remaining 06 species were facultative parasites (Table - 8). Obligate parasites grew on trunks of *Terminalia paniculata, Terminalia tomentosa, Mangifera indica* etc. While saprophytes grew on dead and fallen branches, roots and twigs. None of them were found on leaves. They play crucial role in decomposition of complex organic compounds in to simple one and help in nutrient recycling. These processes were necessary for ecosystem functioning.

In the present investigation all 35 identified species were reported for the first time. Of these 08 species were reported for the first time from the Maharashtra state

(Table - 11). These include *Coriolopsis polyzona*, *Hymenochaete unicolor*, *Lentinus velutinus*, *Lenzites elegans*, *Leucophellinus hobsonii*, *Microporus atrovillosus*, *Polyporus umbellatus* and *Trametes roseola*. None of them were new record for India.

We have successfully used a wood rotting fungus *Irpex lacteus* for synthesis of Silver Nanoparticles. SNPs produced by *Irpex lacteus* was found to have the size ranging from 95nm to 130nm. They were polygonal and irregular in shape. Thus aphyllophorales have the potential to be used for green synthesis of SNPs. These SNPs can be part of drug therapy which can be further used in pharmaceutical world for identifying new drugs even for cancer without major side effects. The characterization of SNPs and their biological, analytical and pharmaceutical impact can be another interesting area of research in the coming days.

Table – 6 : Distribution of Aphyllophorales in study localities of Ratnagiri district

Sr. No.	Name of the species	Name of localities															
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
1	*Coriolopsis polyzona* (Pers.) Ryv.	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-
2	*Dichomitus leucoplacus* (Berk.) Ryv.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
3	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
4	*Flavodon flavus* (Kl.) Ryv.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
5	*Fomes fomentarius* (L.) Fr.	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	*Ganoderma applanatum* (Pers.) Pat.	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
7	*Ganoderma australe* (Fr.) Pat.	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-
8	*Ganoderma lucidum* (Curtis) P. Karst.	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
9	*Hexagonia apiaria* (Pers.) Fr.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
10	*Hexagonia nitida* Durieu & Mont.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	*Hexagonia tenuis* (Hook.) Fr.	+	-	+	+	+	+	-	-	+	+	+	+	+	+	+	+
12	*Hymenochaete unicolor* Berk. & M. A. Curtis	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-
13	*Inonotus hispidus* **(**Bull.**)** Karst.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-

Sr. No.	Name of species	Name of the localities															
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
14	*Irpex lacteus* (Fr.) Fr.	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-
15	*Lentinus connatus* Berk.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
16	*Lentinus sajor-caju* (Fr.) Fr.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
17	*Lentinus squarrosulus* Mont.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
18	*Lentinus velutinus* Fr.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
19	*Lenzites acuta* Berk.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
20	*Lenzites betulina* (L) Fr.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
21	*Lenzites elegans* (Spreng.) Pat.	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-
22	*Leucophellinus hobsonii* (Berk. ex Cook) Ryv.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
23	*Microporus affinis* (Blume & T. Nees) Kuntze	-	-	+	-	-	-	-	+	+	-	-	+	-	-	-	-
24	*Microporus atrovillosus* Ryvarden	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
25	*Microporus xanthopus* (Fr.) Kunt.	-	-	+	+	+	-	-	+	+	-	+	+	+	+	+	+
26	*Neofavolus alveolaris* (DC.) Sotome & T. Hatt.	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
27	*Peniophora albobadia* (Schwein.) Boidin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
28	*Perenniporia ochroleuca* (Berk.) Ryv.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
29	*Phellinus ferruginosus* (Fr.) Pat.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-

Sr. No.	Name of the species	Name of localities															
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**
30	*Podoscypha petalodes* (Berk.) Boidin	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-
31	*Polyporus badius* (Pers.) Schwein.	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
32	*Polyporus brumalis* (Pers.) Fr.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
33	*Polyporus umbellatus* (Pers.) Fr.	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
34	*Schizophyllum commune* Fr.	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-
35	*Trametes roseola* Pat & Har.	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-

Symbol	**Name of localities**
A	Guhagar
B	Dapoli
C	Dabhol
D	Khed
E	Chiplun
F	Ratnagiri
G	Ganapati pule
H	Devrukh
I	Rajapur
J	Lanja
K	Unhale
L	Hativale
M	Madban
N	Nate
O	Jaitapur
P	Nanar

Table – 7 : Fungal species, collection locality and code.

Sr. No.	Name of the species	Locality	Code
1.	*Coriolopsis polyzona* (Pers.) Ryv.	Rajapur	YKMPO 1
2.	*Dichomitus leucoplacus* (Berk.) Ryv.	Hativale	YKMPO 2
3.	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	Rajapur	YKMPO 3
4.	*Flavodon flavus* (KI.) Ryv.	Jaitapur	YKMNPO 1
5.	*Fomes fomentarius* (L.) Fr.	Chiplun	YKMPO 4
6.	*Ganoderma applanatum* (Pers.) Pat.	Kodavali	YKMPO 5
7.	*Ganoderma australe* (Fr.) Pat.	Hativale	YKMPO 6
8.	*Ganoderma lucidum* (Curtis) P. Karst.	Dapoli	YKMPO 7
9.	*Hexagonia apiaria* (Pers.) Fr.	Juvathi	YKMPO 8
10.	*Hexagonia nitida* Durieu & Mont.	Ringane	YKMPO 9
11.	*Hexagonia tenuis* (Hook.) Fr.	Dapoli	YKMPO 10
12.	*Hymenochaete unicolor* Berk. & Curtis	Nanar	YKMNPO 2
13.	*Inonotus hispidus* **(**Bull.**)** Karst.	Jaitapur	YKMPO 11
14.	*Irpex lacteus* (Fr.) Fr.	Rajapur	YKMNPO 3
15.	*Lentinus connatus* Berk.	Hativale	YKMNPO 4
16.	*Lentinus sajor-caju* (Fr.) Fr.	Rajapur	YKMNPO 5
17.	*Lentinus squarrosulus* Mont.	Madban	YKMNPO 6
18.	*Lentinus velutinus* Fr.	Hardi	YKMNPO 7
19.	*Lenzites acuta* Berk.	Rajapur	YKMNPO 8
20.	*Lenzites betulina* (L) Fr.	Rajapur	YKMNPO 9
21.	*Lenzites elegans* (Spreng.) Pat.	Kodavali	YKMPO 12
22.	*Leucophellinus hobsonii* (Berk. ex Cook) Ryv.	Hativale	YKMPO 13
23.	*Microporus affinis* (Blume & T. Nees) Kuntze	Dapoli	YKMPO 14
24.	*Microporus atrovillosus* Ryvarden	Hativale	YKMPO 15
25.	*Microporus xanthopus* (Fr.) Kunt.	Rajapur	YKMPO 16
26.	*Neofavolus alveolaris* (DC.) Sotome & T. Hatt.	Ganapati pule	YKMPO 17
27.	*Peniophora albobadia* (Schwein.) Boidin	Jaitapur	YKMNPO 10
28.	*Perenniporia ochroleuca* (Berk.) Ryv.	Juvathi	YKMPO 18
29.	*Phellinus ferruginosus* (Fr.) Pat.	Jaitapur	YKMPO 19
30.	*Podoscypha petalodes* (Berk.) Boidin	Kodavali	YKMNPO 11
31.	*Polyporus badius* (Pers.) Schwein.	Hardi	YKMPO 20
32.	*Polyporus brumalis* (Pers.) Fr.	Juvathi	YKMPO 21
33.	*Polyporus umbellatus* (Pers.) Fr.	Hativale	YKMPO 22
34.	*Schizophyllum commune* Fr.	Rajapur	YKMNPO 12
35.	*Trametes roseola* Pat & Har.	Rajapur	YKMPO 23

- **YKMNPO:** Yemul, Kanade, Murumkar, [Non-Poroid]
- **YKMPO:** Yemul, Kanade, Murumkar, [Poroid]

Table – 8 : Host diversity of Aphyllophorales

Sr. No.	Name of the species	Host/Substratum
1.	*Coriolopsis polyzona* (Pers.) Ryv.	Dead wood log
2.	*Dichomitus leucoplacus* (Berk.) Ryv.	*Terminalia paniculata*
3.	*Earliella scabrosa* (Pers.) Gilb. & Ryv.	Dead wood log
4.	*Flavodon flavus* (KI.) Ryv.	Fallen wood log
5.	*Fomes fomentarius* (L.) Fr.	Dead standing trunk
6.	*Ganoderma applanatum* (Pers.) Pat.	Dead standing trunk
7.	*Ganoderma australe* (Fr.) Pat.	Dead standing trunk
8.	*Ganoderma lucidum* (Curtis) P. Karst.	*Nyctanthes arbor-tristis*
9.	*Hexagonia apiaria* (Pers.) Fr.	*Mangifera indica*
10.	*Hexagonia nitida* Durieu & Mont.	*Tectona grandis*
11.	*Hexagonia tenuis* (Hook.) Fr.	Fallen wood log
12.	*Hymenochaete unicolor* Berk. & Curtis	Fallen wood log
13.	*Inonotus hispidus* **(**Bull.**)** Karst.	Dead and Fallen wood log
14.	*Irpex lacteus* (Fr.) Fr.	Fallen wood log
15.	*Lentinus connatus* Berk.	Fallen wood log
16.	*Lentinus sajor-caju* (Fr.) Fr.	*Mangifera indica*
17.	*Lentinus squarrosulus* Mont.	Fallen wood log
18.	*Lentinus velutinus* Fr.	Fallen wood log
19.	*Lenzites acuta* Berk.	Fallen wood log
20.	*Lenzites betulina* (L) Fr.	Dead wood log
21.	*Lenzites elegans* (Spreng.) Pat.	Dead wood log
22.	*Leucophellinus hobsonii* (Berk. ex Cook) Ryv.	*Terminalia paniculata* and dead trunk
23.	*Microporus affinis* (Blume & T. Nees) Kuntze	Dead and Fallen wood log
24.	*Microporus atrovillosus* Ryvarden	*Terminalia paniculata*
25.	*Microporus xanthopus* (Fr.) Kunt.	*Mangifera indica*
26.	*Neofavolus alveolaris* (DC.) Sotome & T. Hatt.	*Terminalia paniculata*
27.	*Peniophora albobadia* (Schwein.) Boidin	Fallen wood log
28.	*Perenniporia ochroleuca* (Berk.) Ryv.	Dead tree trunk
29.	*Phellinus ferruginosus* (Fr.) Pat.	Fallen wood log
30.	*Podoscypha petalodes* (Berk.) Boidin	*Mangifera indica*
31.	*Polyporus badius* (Pers.) Schwein.	Fallen wood log
32.	*Polyporus brumalis* (Pers.) Fr.	Fallen wood log
33.	*Polyporus umbellatus* (Pers.) Fr.	Ply wood sheet
34.	*Schizophyllum commune* Fr.	Fallen wood log
35.	*Trametes roseola* Pat & Har.	on wood of washroom

Table – 9 : Types of basidioma of the species found in the investigation areas.

Sr. No.	Name of the species	Type of basidioma
1.	*Coriolopsis polyzona* (Pers.) Ryv.	Resupinate, effused reflexed
2.	*Dichomitus leucoplacus* (Berk.) Ryv.	Resupinate, effused reflexed
3.	*Earliella scabrosa* (Pers.) Gilb. & Ryv.	Semipileate
4.	*Flavodon flavus* (KI.) Ryv.	Resupinate, effused reflexed
5.	*Fomes fomentarius* (L.) Fr.	Ungulate
6.	*Ganoderma applanatum* (Pers.) Pat.	Applanate
7.	*Ganoderma australe* (Fr.) Pat.	Dimidiate
8.	*Ganoderma lucidum* (Curtis) P. Karst.	Dimidiate
9.	*Hexagonia apiaria* (Pers.) Fr.	Dimidiate
10.	*Hexagonia nitida* Durieu & Mont.	Dimidiate
11.	*Hexagonia tenuis* (Hook.) Fr.	Dimidiate
12.	*Hymenochaete unicolor* Berk. & Curtis	Resupinate
13.	*Inonotus hispidus* **(**Bull.**)** Karst.	Dimidiate
14.	*Irpex lacteus* (Fr.) Fr.	Resupinate, effused reflexed
15.	*Lentinus connatus* Berk.	Stipitate, infundibuliform
16.	*Lentinus sajor-caju* (Fr.) Fr.	Stipitate
17.	*Lentinus squarrosulus* Mont.	Stipitate
18.	*Lentinus velutinus* Fr.	Stipitate, infundibuliform
19.	*Lenzites acuta* Berk.	Dimidiate
20.	*Lenzites betulina* (L) Fr.	Dimidiate
21.	*Lenzites elegans* (Spreng.) Pat.	Dimidiate
22.	*Leucophellinus hobsonii* (Berk. ex Cook) Ryv.	Semipileate
23.	*Microporus affinis* (Blume & T. Nees) Kuntze	Dimidiate
24.	*Microporus atrovillosus* Ryvarden	Stipitate, infundibuliform
25.	*Microporus xanthopus* (Fr.) Kunt.	Stipitate, infundibuliform
26.	*Neofavolus alveolaris* (DC.) Sotome & T. Hatt.	Spathulate
27.	*Peniophora albobadia* (Schwein.) Boidin	Resupinate, effused reflexed
28.	*Perenniporia ochroleuca* (Berk.) Ryv.	Ungulate
29.	*Phellinus ferruginosus* (Fr.) Pat.	Resupinate, effused reflexed
30.	*Podoscypha petalodes* (Berk.) Boidin	Spathulate
31.	*Polyporus badius* (Pers.) Schwein.	Dimidiate
32.	*Polyporus brumalis* (Pers.) Fr.	Stipitate
33.	*Polyporus umbellatus* (Pers.) Fr.	Stipitate
34.	*Schizophyllum commune* Fr.	Spathulate
35.	*Trametes roseola* Pat & Har.	Ungulate

Table – 10 : Types of hymenophore of the species found in the investigation areas.

Sr. No.	Name of the species	Type of hymenophore
1.	*Coriolopsis polyzona* (Pers.) Ryv.	Poroid
2.	*Dichomitus leucoplacus* (Berk.) Ryv.	Poroid
3.	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	Poroid, Daedaloid, sinuate
4.	*Flavodon flavus* (KI.) Ryv.	Nonporoid Toothed
5.	*Fomes fomentarius* (L.) Fr.	Poroid
6.	*Ganoderma applanatum* (Pers.) Pat.	Poroid
7.	*Ganoderma australe* (Fr.) Pat.	Poroid
8.	*Ganoderma lucidum* (Curtis) P. Karst.	Poroid
9.	*Hexagonia apiaria* (Pers.) Fr.	Poroid
10.	*Hexagonia nitida* Durieu & Mont.	Poroid
11.	*Hexagonia tenuis* (Hook.) Fr.	Poroid
12.	*Hymenochaete unicolor* Berk. & Curtis	Nonporoid, smooth
13.	*Inonotus hispidus* **(**Bull.**)** Karst.	Poroid
14.	*Irpex lacteus* (Fr.) Fr.	Nonporoid Toothed
15.	*Lentinus connatus* Berk.	Lamellate
16.	*Lentinus sajor-caju* (Fr.) Fr.	Lamellate
17.	*Lentinus squarrosulus* Mont.	Lamellate
18.	*Lentinus velutinus* Fr.	Lamellate
19.	*Lenzites acuta* Berk.	Lamellate
20.	*Lenzites betulina* (L) Fr.	Lamellate
21.	*Lenzites elegans* (Spreng.) Pat.	Daedaloid, sinuate
22.	*Leucophellinus hobsonii* (Berk. ex Cook) Ryv.	Poroid
23.	*Microporus affinis* (Blume & T. Nees) Kuntze	Poroid
24.	*Microporus atrovillosus* Ryvarden	Poroid
25.	*Microporus xanthopus* (Fr.) Kunt.	Poroid
26.	*Neofavolus alveolaris* (DC.) Sotome & T. Hatt.	Poroid
27.	*Peniophora albobadia* (Schwein.) Boidin	Poroid
28.	*Perenniporia ochroleuca* (Berk.) Ryv.	Poroid
29.	*Phellinus ferruginosus* (Fr.) Pat.	Poroid
30.	*Podoscypha petalodes* (Berk.) Boidin	Poroid
31.	*Polyporus badius* (Pers.) Schwein.	Poroid
32.	*Polyporus brumalis* (Pers.) Fr.	Poroid
33.	*Polyporus umbellatus* (Pers.) Fr.	Poroid
34.	*Schizophyllum commune* Fr.	Nonporoid
35.	*Trametes roseola* Pat & Har.	Poroid

Table - 11 : List of new record for Maharashtra.

Sr. No.	Name of Species	Host/Substratum
1	*Coriolopsis polyzona* (Pers.) Ryv.	Dead wood log
2	*Hymenochaete unicolor* Berk. & Curtis	Fallen wood log
3	*Lentinus velutinus* Fr.	Fallen wood log
4	*Lenzites elegans* (Spreng.) Pat.	Dead wood log
5	*Leucophellinus hobsonii* (Berk. ex Cook), Ryvarden	*Terminalia paniculata* & dead trunk
6	*Microporus atrovillosus* Ryvarden	*Terminalia paniculata*
7	*Polyporus umbellatus* (Pers.) Fr.	Ply wood sheet
8	*Trametes roseola* Pat & Har.	on wood of washroom

CHAPTER- 5

SUMMARY

AND

CONCLUSION

SUMMARY

A total of 35 species belonging to 22 genera and 07 families of order Aphyllophorales have been identified from collected specimens. These include following species *viz. Coriolopsis polyzona, Dichomitus leucoplacus, Earliella scabrosa, Flavodon flavus, Fomes fomentarius, Ganoderma applanatum, G. australe, G. lucidum, Hexagonia apiaria, H. tenuis, H. nitida, Hymenochaete unicolor, Inonotus hispidus, Irpex lacteus, Lentinus connatus, L. sajor-caju, L. squarrosulus, L. velutinus, Lenzites acuta, L. betulina, L. elegans, Leucophellinus hobsonii, Microporus affinis, M. xanthopus, M. atrovillosus, Neofavolus alveolaris, Peniophora albobadia, Perenniporia ochroleuca, Phellinus ferruginosus, Podoscypha petalodes, Polyporus badius, P. brumalis, P. umbellatus, Schizophyllum commune and Trametes roseola.* A detailed account of these species is given below.

Distinguishing features of species

A. FAMILY: GANODERMATACEAE

1. ***Ganoderma applanatum*** (Pers.) Pat., 1889 (Family: Ganodermataceae): It is identified in the field by its nonlaccate, applanate basidiocarp with sulcate surface. It has white poroid hymenophore. It is also known as artist's conk used to draw figure on hymenium with a needle and used as ornamental article at home.
2. ***Ganoderma australe*** (Fr.) Pat., 1889 (Family: Ganodermataceae): It is identified in the field by its large, applanate, reddish brown basidiocarp with black crust and sooty powder of spores.
3. ***Ganoderma lucidum*** (Curtis) P. Karst., 1881 (Family: Ganodermataceae): It is identified in the field by its dimidiate, imbricate, reddish brown, laccate, basidiocarp with cylindrical woody, laccate stipe. It produces spores with ornamented inner wall.

B. FAMILY: HYMENOCHAETACEAE

4. ***Hymenochaete unicolor*** Berk. & M. A. Curtis 1869 (Family: Hymenochaetaceae): It is a resupinate hymenochaete that produces purple coloured paint like basidiocarp.
5. ***Inonotus hispidus*** **(**Bull.**)** P. Karst. 1879 (Family: Hymenochaetaceae): It is a pileate hymenochaete identified in the field by heart rot of host.

6. ***Phellinus ferruginosus*** (Fr.) Pat. 1900 (Family: Hymenochaetaceae): It is a resupinate hymenochaete that produces dark brown thick basidiocarp on bark of host plant.

C. FAMILY: MERULIACEAE

7. ***Flavodon flavus***, (Klotzsch) Ryvarden, 1973 (Family: Meruliaceae): It is easily identified in the field by its resupinate greenish yellow basidiocarp that turns red when treated with KOH.
8. ***Irpex lacteus*** (Fr.) Fr., 1828 (Family: Meruliaceae): It is identified in the field by its resupinate cream coloured basidiocarp.
9. ***Podoscypha petalodes*** (Berk.) Pat., 1903 (Family: Meruliaceae): The species is easy to recognise by its spathulate, loosely aggregate rosette basidiocarps growing parasitically or occasionally on the humus rich ground.

D. FAMILY: PENIOPHORACEAE

10. ***Peniophora albobadia*** (Schwein.) Boidin, 1961 (Family: Peniophoraceae): It is a resupinate species and identified in the field by its irregular dark paint like basidiocarp with white margin.

E. FAMILY: POLYPORACEAE

11. ***Coriolopsis polyzona*** (Pers.) Ryv., 1972 (Family: Polyporaceae): It is a tropical polypore identified in the field by appressed, irregular basidiocarp with poroid hymenophore.
12. ***Dichomitus leucoplacus*** (Berk.) Ryvarden, 1977 (Family: Polyporaceae): It is another tropical polypore identified in the field by its resupinate, yellowish orange basidiocarp with poroid hymenophore.
13. ***Earliella scabrosa*** (Pers.) Gilb. & Ryvarden, 1985 (Family: Polyporaceae): It is a common tropical polypore identified in the field by its imbricate, dimidiate basidiocarp with semidaedaloid hymenophore and red cuticle.
14. ***Fomes fomentarius*** (L.) Fr., 1849 (Family: Polyporaceae): It is identified its hoof shaped, ungulate basidiocarp with concentrically grooved surface and oblong cylindrical spores.

15. ***Hexagonia apiaria*** (Pers.) Fr. 1838 (Family: Polyporaceae): It is identified in the field by its dimidiate basidiocarp with poroid hymenophore resembling honeycomb.
16. ***Hexagonia tenuis*** (Hook.) Fr., 1838 (Family: Polyporaceae): It is easily identified by its dimidiate, snuff-brown basidiocarp with hexagonal pores.
17. ***Hexagonia nitida*** Durieu & Mont., 1846 (Family: Polyporaceae): It is easily identified in the field by its dimidiate, brown, thin basidiocarp with hexagonal pores, usually parasitic on hard woods.
18. ***Lentinus connatus*** Berk., 1842 (Family: Polyporaceae): It is easily identified in the field by its stipitate basidiocarp with infundibuliform pileus and lamellate hymenophore.
19. ***Lentinus sajor-caju*** (Fr.) Fr., 1838 (Family: Polyporaceae): It is easily identified in the field by its stipitate large ivory coloured basidiocarp with infundibuliform pileus and lamellate hymenophore. It is an edible species.
20. ***Lentinus squarrosulus*** Mont., 1842 (Family: Polyporaceae): It is identified in the field by its entirely white stipitate basidiocarp, becoming pale straw-colour to pale ochraceous on maturity.
21. ***Lentinus velutinus*** Fr., 1830 (Family: Polyporaceae): It is easily identified in the field by its stipitate, infundibuliform pileus with soft hairs all over basidiocarp.
22. ***Lenzites acuta*** Berk., 1842 (Family: Polyporaceae): It is very common species in the tropical moist deciduous forest occurring on dead tree trunks and fallen logs and identified by its dimidiate basidiocarp with lamellate lenzitoid hymenophore. Lamellae show dichotomous forking.
23. ***Lenzites betulina*** (L) Fr., 1838 (Family: Polyporaceae): Another very common species in the forest occurring on dead tree trunks and fallen logs and identified by its large dimidiate basidiocarp with lamellate lenzitoid hymenophore. Lamellae do not show dichotomous forking.
24. ***Lenzites elegans*** (Spreng.) Pat., 1900 (Family: Polyporaceae): The species is common in tropical moist deciduous forest and easy to recognize by its sinuous-daedaloid lamellae and round pores on the same specimen.
25. ***Microporus affinis*** (Blume & T. Nees) Kuntze, 1898 (Family: Polyporaceae): It is identified in the field by laterally stipitate, dimidiate basidiocarp with poroid hymenophore.

26. ***Microporus xanthopus*** (Fr.) Kuntze, 1898 (Family: Polyporaceae): It is a commonly occurring polypore and identified in the field by its centrally stipitate basidiocarp with infundibuliform, dark, banded pileus and poroid hymenophore.
27. ***Microporus atrovillosus*** Ryvarden, 1975 (Family: Polyporaceae): It is an uncommon polypore identified in the field by its conical, dark, non banded stipitate basidiocarp with grey coloured hymenium.
28. ***Neofavolus alveolaris*** (DC.) Sotome & T. Hatt., 2012 (Family: Polyporaceae): It is an uncommon polypore found during rainy season and identified in the field by its rhomboidal pores.
29. ***Perenniporia ochroleuca*** (Berk.) Ryvarden, 1972 (Family: Polyporaceae): The species is identified in the field by its small, applanate, dimidiate, zonate, sulcate, cream coloured basidiocarp.
30. ***Polyporus badius*** (Pers.) Schwein., 1832 (Family: Polyporaceae): It is identified in the field by its laterally stipitate basidiocarp with poroid hymenophore.
31. ***Polyporus brumalis*** (Pers.) Fr., 1821 (Family: Polyporaceae): It is identified in the field by its centrally stipitate basidiocarp with poroid hymenophore.
32. ***Polyporus umbellatus*** (Pers.) Fr., 1821 (Family: Polyporaceae): It is identified in the field by its centrally stipitate basidiocarps with poroid hymenophore arising from sclerotia.
33. ***Trametes roseola*** Pat & Har., 1900 (Family: Polyporaceae): It is identified in the field by its dimidiate, pileate, zonate basidiocarp with poroid hymenophore.

F. FAMILY: SCHIZOPHYLLACEAE

34. ***Schizophyllum commune*** Fr. 1821 (Family: Schizophyllaceae): It is identified in the field by presence of split lamellate hymenophore in the basidiocarp.

G. FAMILY: SCHIZOPORACEAE

35. ***Leucophellinus hobsonii*** (Berk. ex Cook) Ryvarden, 1988 (Family: Schizoporaceae)**:** It is a rare species identified in the field by its hirsute white to cream coloured basidiocarp with poroid hymenophore. It is reported from the state after 120 years.

CONCLUSION

As Ratnagiri district of Maharashtra is located in the Western Ghats biodiversity hotspots, it is rich in diversity of Aphyllophorales. In connection with this, the present investigation emphasizes on study of diversity of Aphyllophorales at Ratnagiri district of Maharashtra. During the investigation a total 35 species belonging to 22 genera and 07 families of order Aphyllophorales have been reported from study area. Here, the Polyporaceae is found to be dominant family containing 23 species followed by family Ganodermataceae, Hymenochaetaceae and Meruliaceae with 03 species each and family Peniophoraceae, Schizoporaceae and Schizophyllaceae with 01 species each. The species of family Peniophoraceae, Schizophyllaceae and Schizoporaceae are rare at Ratnagiri district.

Out of 35 species collected and identified, genus *Coriolopsis* is represented by 1 species, *Dichomitus* by 1 species, *Earliella* by 1 species, *Flavodon* by 1 species, *Fomes* by 1 species, *Ganoderma* by 3 species, *Hexagonia* by 3 species, *Hymenochaete* by 1 species, *Inonotus* by 1 species, *Irpex* by 1 species, *Lentinus* by 4 species, *Lenzites* by 3 species, *Leucophellinus* by 1 species, *Microporus* by 3 species, *Neofavolus* by 1 species, *Peniophora* by 1 species, *Perenniporia* by 1 species, *Phellinus* by 1 species, *Podoscypha* by 1 species, *Polyporus* by 3 species, *Schizophyllum* by 1 species and *Trametes* by 1 species.

Genus *Lentinus* appears to be dominant with 04 species recorded from study area, followed by genus *Ganoderma*, *Hexagonia* and *Polyporus* with 03 species each. While genus *Leucophellinus* was found to be rare in occurrence.

Basidiocarps of genera *Lentinus*, *Microporus* and *Polyporus* are stipitate, while remaining genera have pileate basidiocarps. In genera *Dichomitus*, *Flavodon*, *Hymenochaete*, *Irpex*, *Phellinus* and *Peniophora* basidiocarps are found to be resupinate type. In pileate type most members had dimidiate basidiocarp while *Fomes* has ungulate basidiocarp.

Basidiocarp of *Ganoderma applanatum* had white fine poroid hymenium. By using needle beautiful figures can be carved on it and kept in houses as ornamental material.

The basidiocarp colour of these species varied from the range of white to cream, brown, red and black. Hyphal system varies from monomitic in *Leucophellinus hobsonii* to dimitic in *Lentinus* and *Polyporus* while trimitic in rest of the members. Basidiocarps with trimitic hyphae are found to be tough, coriaceous and long lived while those with dimitic and monomitic hyphae are found to be soft and flexible. In most specimens, like *Hexagonia nitida*, we do not get spores; it is due to the fact that these fungi produce ballistospores. All identified species of Aphyllophorales are wood rotting type and none of them occurs in terrestrial habitat; indicating that these fungi play important role in decay of dead wood in forest ecosystem. Out of 35 species recorded, 04 species are found to be obligate parasites, 25 species are saprophytic while remaining 06 species are facultative parasites.

SNPs produced by *Irpex lacteus* was found to have the size ranging from 95nm to 130nm. They are polygonal and irregular in shape. Thus Aphyllophorales have the potential to be used for green synthesis of SNPs. These SNPs can be part of drug therapy which can be further used in pharmaceutical world for identifying new drugs even for cancer without major side effects. The characterization of SNPs and their biological, analytical and pharmaceutical impact can be another interesting area of research in the coming days.

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PUBLICATIONS

Sr. No.	Name of Author/s	Title of the Paper	Name of the journal and ISSN No.	Month and Year of publication, volume and page No.	Peer review
1	Yemul N. B., Kanade M. B. and Murumkar C. V.	The wood rotting fungi from Ratnagiri district of Western Ghats of Maharashtra	Proceeding of International Conference on “Plant Research and Resource Management” organized by T. C. college Baramati.	February, 2016, 96-97.	Peer reviewed
2	Yemul N. B., Kanade M. B. and Murumkar C. V.	Appraisal of family Polyporaceae (Aphyllophorales) from Ratnagiri district of Maharashtra	Contemporary Research in India. Special issue. ISSN 2231-2137	January, 2018, 248-252.	Peer reviewed
3	Yemul N. B., Kanade M. B. and Murumkar C. V.	Comprehensive Account of *Leucophellinus hobsonii* (Berk. ex Cooke) Ryvarden (Schizoporaceae) A Poroid species from Ratnagiri district of Western Ghats of India	Indian Forester, ISSN No. 0019-4816 (Print) 2321-094X (Online)	January, 2019, **145** (1): 48-51.	Peer reviewed

4	Yemul N. B., Kanade M. B. and Murumkar C. V.	*Lentinus velutinus* Fr. Linn (Polyporaceae) a new record for Maharashtra state of India	International journal of Life Sciences Research. ISSN 2348-313X (Print), ISSN 2348-3148 (Online)	June, 2019, **7** (2): 236-238.	Peer reviewed
5	Yemul N. B., Kanade M. B. and Murumkar C. V.	Synthesis of Silver Nanoparticles by using *Irpex lacteus* (Meruliaceae) a wood rotting Aphyllophore.	International journal of Scientific Research and Review. ISSN 2279-0543	June, 2019, **8** (2): 2347-2358.	Peer reviewed

The Wood Rotting Fungi from Ratnagiri District of Western Ghats of Maharashtra

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ABSTRACT

Ratnagiri district of Maharashtra is on the foot of Western Ghats. During present investigation a survey was conducted from July 2015 to October 2015 in monsoon season at the tropical forest of Ratnagiri district to collect wood rotting fungi. A total of 14 genera belonging to 11 families, 05 orders, 03 phyla and 02 kingdoms were collected, identified and enlisted. The dominant genera identified during investigation are *Lycogala, Xylaria, Ascobolus, Coprinus, Paxillus, Daedalia, Polyporus, Hexagonia, Irpex, Microporus, Fomes, Cantharellus, Stereum* and *Clavaria.* Further studies to mark their spread and dominance are in progress.

Keywords : *Ratnagiri district, Wood rotting fungi*

INTRODUCTION

Western Ghats extends in the north from mouth of river Tapti, in Surat (Gujarat) to Cape Comorin (Kerala) in South of India. It runs parallel to the west coast of India. Ratnagiri is one of the coastal district of Maharashtra and situated at the foot of Western Ghats. It is rich in flora and located in between 16^0 29' and 14^0 96' N and 73^0 33' and 16^0 45' E with a wide range of species diversity. The average rainfall is 275 cm, temperature is 27 ^{0}C and Relative Humidity is 70 to 100%.

The vegetation of Ratnagiri predominantly consists of tropical forest. Some of the dominant tree species of this forest are *viz., Memecylon umbellatum* Burm. f., *Terminalia* spp., *Artocarpus* spp., *Anacardium occidentale* L., *Mangifera indica* L., *Tectona grandis* L. f., *Bombax ceiba* L., *Garcinia* spp, *Acacia lognifolia* Willd, *Buchanania lanzans* Spreng. etc.

The Forest trees get infected by a variety of fungi. They damage plants to a great extent and cause death. Some fungi grow on dead wood logs and rot them. These wood rotting fungi belong to various categories of kingdom Fungi and Protista.

They primarily attack cellulose and lignin component of wood. Wood rotting fungi belongs to two phyla of kingdom Fungi *viz.*, Ascomycota and Basidiomycota and one phylum of kingdom Protista i.e. Myxomycota (Alexopoulous, Mims and Blackwell, 2002). The order Xylariales and Pezizales of phylum Ascomycota include wood rotting species. In phylum Basidiomycota order Agaricales and Aphyllophorales contain wood rotting fungi. In phylum Myxomycota order Stemonitales contain wood rotting fungal species. Wood rotting fungi are characterised by the presence of well developed, macroscopic fruiting bodies. These fruiting bodies were called as basidiocarps, ascocarps etc. depending upon the group to which they belong. The fruiting bodies of wood rotting fungi are of different shapes, sizes, texture, beauty and colour (Swapna, Syed Abrar and Krishnappa, 2008). Therefore they attract the attention of most mycologists. Hence attempt has been made to study wood rotting fungi from different locations of Ratnagiri district.

MATERIAL AND METHODS

Study area: Ratnagiri district of Maharashtra is the study area of the present paper. The study was made at selected villages of Rajapur tahsil of Ratnagiri district. The villages were Takewadi, Panhale, Kondye, Dongar, Unhale, Hativale, Vikhare-Gothane Juvathi, Kumbhavade, Taral, Jaitapur etc.

Survey : Wood rotting fungi exhibit diversity that is related largely to host availability (Natarajan *et al* 2005). Temperature plays important role either to stimulate or retard the growth of fruiting body. Surveys were particularly sensitive to season. Surveying is done just after the period of rains. Repeated surveys were conducted during July, 2015 to October, 2015 in selected villages of Ratnagiri. The fungal specimens found were collected and analyzed for identification.

Collection and Preservation : Different methods were used to collect specimens. Small fruiting bodies were collected with the help of forceps. Large fruiting bodies are collected from infected plants by using knife. The collected specimens were put into the polythene bag. Dry specimens were kept in brown paper envelopes. The fragile specimens were kept in containers containing 5% formalin. The collection was brought to the lab and soon preserved in a preservative liquid or as dried specimens.

Characterization of Wood Rotting Fungi : The collected specimens were described morphologically. The labels were attached to the specimens, which includes scientific name of the fungus, date of collection, location, and habitat. All collected specimens were identified up to genus level by using standard literature.

RESULTS

The Western Ghats region is rich in species diversity. It is also rich in mycobiota. The tropical forest of Ratnagiri district is home for several wood rotting fungi. In the present investigation, total of 14 genera belonging to 11 families, 05 orders, 03 phyla and 02 kingdoms were identified and enlisted during the study (Table - 1). These genera were identified as *Lycogala, Xylaria, Ascobolus, Coprinus, Paxillus, Daedalia, Polyporus, Hexagonia, Irpex, Microporus, Fomes, Cantharellus, Corticium* and *Clavaria*. *Daedalia* is the most dominant genera of wood rotting fungi in tropical forest of Ratnagiri. These fungi are ecologically important as they play important role in biodegradation of agricultural goods and waste. They are also involved in cycling of nutrients.

There are large numbers of wood rotting fungi in the tropical forest of Ratnagiri district of Western Ghats. But there is no documentation of them. The wood rotting fungi reported in this paper is probably first report for Ratnagiri district of Maharashtra.

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Table 1: List of wood rotting fungi in tropical forest of Western Ghats of Ratnagiri district of Maharashtra

Sr. No.	Genus	Family	Order	Phylum	Kingdom	Host
1	*Lycogala*	Liceaceae	Liceales	Myxomycota	Protista	wood log
2	*Xylaria*	Xylariaceae	Xylariales	Ascomycota	Fungi	*Mangifera indica* L.
3	*Ascobolus*	Ascobolaceae	Pezizales	Ascomycota	Fungi	wood log
4	*Coprinus*	Coprinaceae	Agaricales	Basidiomycota	Fungi	wood log
5	*Paxillus*	Paxillaceae	Agaricales	Basidiomycota	Fungi	wood log
6	*Irpex*	Meruliaceae	Aphyllophorales	Basidiomycota	Fungi	*Bombax ceiba* L.
7	*Daedalia*	Fomitopsidaceae	Aphyllophorales	Basidiomycota	Fungi	*Mangifera indica* L.
8	*Microporus*	Polyporaceae	Aphyllophorales	Basidiomycota	Fungi	wood log
9	*Clavaria*	Clavariaceae	Aphyllophorales	Basidiomycota	Fungi	Bamboo stick
10	*Polyporus*	Polyporaceae	Aphyllophorales	Basidiomycota	Fungi	*Mangifera indica* L.
11	*Hexagonia*	Polyporaceae	Aphyllophorales	Basidiomycota	Fungi	*Mangifera indica* L.
12	*Cantherellus*	Cantherellaceae	Aphyllophorales	Basidiomycota	Fungi	wood log
13	*Fomes*	Polyporaceae	Aphyllophorales	Basidiomycota	Fungi	wood log
14	*Corticium*	Corticiaceae	Aphyllophorales	Basidiomycota	Fungi	*Terminalia* spp.

APPRAISAL OF FAMILY POLYPORACEAE(Aphyllophorales) FROM RATNAGIRI DISTRICT OF MAHARASHTRA

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Abstract: *Family Polyporaceae Corda, 1839 belongs to order Polyporales (Aphyllophorales) of class Agaricomycetes and documented by 109 genera and 1574 species all over the world. Family Polyporaceae is characterized by lignicolous, white, cream, brown, orange or black coloured basidiocarps bearing pores. The family name Polyporaceae was initially used by Fries in 1838 to denote tube or pore bearing fungi excluding lamellate hymenophore. But later on it was used to include all types of fungi with pores as well as other type of hymenophores. Ratnagiri is a district in the Maharashtra state, situated on the west coast of India. Being a coastal district the rainfall is heavy. The district has tropical moist and deciduous forest which is rich in mycobiota. Frequent visit to these forest areas in selected localities of Ratnagiri district was arranged during July 2015 to October 2017 for collection of polypores (Aphyllophorales). Several specimens were collected from study site; they were brought to laboratory and studied for macro and micro morphology. They were identified by using standard references and total of 13 species belonging to family Polyporaceae were identified. These include Daedaleopsis confragosa, Dichomitus leucoplacus, Earliella scabrosa, Fomitopsis pinicola, Hexagonia tenuis, Lentinus brumalis, Lentinus connatus, Lenzites betulina, Microporus affinis, Microporus xanthopus, Oxyporus mollissimus, Polyporus umbellatus and Trametes apiaria.*

Keywords: *Polyporaceae, Ratnagiri, west coast, tropical moist forest.*

Introduction:

Ratnagiri district is a part of Konkan region of Maharashtra state of India. It is situated on the west coast of India on the Arabian Sea. It lies between 16^0 29' and 14^0 96' N and 73^0 33' and 16^0 45' E with a geographical area of 8208 Km^2. South West monsoon brings heavy rainfall to this region from June to September of every year. Due to this reason district has tropical moist evergreen and deciduous forest. The forests are rich in spermatophyte diversity. Dead, standing trunks and fallen branches of spermatophytes serve as substratum for wood rotting fungi; therefore this region is rich in mycobiota.

Most wood rotting fungi belong to order Polyporales (**Aphyllophorales)** of division Basidiomycota (Alexopoulous *et al*., 2002). The order was first proposed in 1922 by Carleton Rea. The order includes non gill bearing Macrofungi. Traditionally it includes families Clavariaceae, Hydnaceae, Polyporaceae, Cantharellaceae, Thelephoraceae etc. These fungi are commonly known as club fungi, tooth fungi, poroid fungi, lamellate fungi and crust fungi.Of these Polyporaceae is the largest family in this order.

Family Polyporaceae was proposed by Corda, in 1839. It contains 109 genera and 1574 species all over the world. Name of this family is derived from genus Polyporus P. Micheli ex Adans., 1763, meaning many pore bearing fungi. Family Polyporaceae is characterized by lignicolous, white, cream, brown, orange or black coloured basidiocarps bearing pores. Basidiocarps are usually stipitate, pileate or resupinate, they may be fleshy or woody. They are commonly known as bracket fungi and poroid fungi. Family name Polyporaceae was initially used by Fries in 1838 to denote tube or pore bearing fungi excluding lamellate hymenophore. But later on it was used to include all types of fungi with pores as well as other type of hymenophores (Leelawathy and Ganesh, 2000). The members of this family have a widespread distribution, especially in tropical and subtropical regions. Polyporaceae is distinguished by septate, hyaline generative hyphae which may be simple or with clamps. Along with generative hyphae basidiocarp also possesses skeletal and binding hyphae (Núñez and Ryvarden, 1995). Skeletal hyphae is solid, unbranched and binding hyphae is branched. Hymenial setae and cystidia are absent. In some genera, hyphal pegs, fascicles of sterile hyphae coming out from the hymenial surface, are some common features of Polyporaceae (Johansen and Ryvarden, 1980).

Material and Methods:

Field visits to the forest areas in selected localities of Ratnagiri district was arranged during July 2015 to October 2017. The localities visited during study are Jaitapur, Nate, Pavas, Ratnagiri, Hativale and Rajapur. The visits were focused on collecting basidiocarps of polypores (Aphyllophorales) both wood rotting and terrestrial. Several specimens were collected from study sites. Colour, rot type and host plant was analysed in the field itself. Then specimens were kept in paper bags and brought to the laboratory; where they are studied for macro and micro morphology as per Ryvarden (2010).

Results and Discussion:

A total of 13 species belonging to 11 genera of family Polyporaceae were identified from collected poroid specimens. These include *Daedaleopsis confragosa, Dichomitus leucoplacus, Earliella scabrosa, Fomitopsis pinicola, Hexagonia tenuis, Lentinus brumalis, Lentinus connatus, Lenzites betulina, Microporus affinis, Microporus xanthopus, Oxyporus mollissimus, Polyporus umbellatus* and *Trametes apiaria.* A detailed account of these species is given below.

Daedaleopsis confragosa (Bolton) J. Schröt., 1888

Basidiocarp annual, sessile. dimidiate. tough-corky, up to 18 cm wide; upper surface of pileus glabrous, dark to light brown, usually zonate and shallowly sulcate; pore surface white when young and cream coloured at maturity, the pores variable, circular at base and radially elongated above, daedaleoid, to radially lamellate hymenophore; context brown, azonate. Hyphal system trimitic; generative hyphae thin-walled, with clamps, hyaline, skeletal hyphae thick-walled, nonseptate, binding hyphae thickwalled, much-branched, dendrohyphidia present; Cystidia absent.Basidia clavate, basidiospores not seen.

Type of rot: White rot of fallen woods

Remarks: It is easily identified in the field by daedaleoid hymenophore and white rot

Dichomitus leucoplacus (Berk.) Ryvarden, 1977

Basidiocarps annual, resupinate, 8 cm long and 2.5 cm wide, 1-2 mm thick, coriaceous when young and woody at maturity, margin distinct, pore surface white to cream, pores entire, round elongated, 1 mm deep; context white. Hyphal system dimitic; generative hyphae with clamps, hyaline, skeletal hyphae arboriform solid to thick-walled, Cystidioles present. Basidia clavate, basidiospores not seen.

Type of rot: White rot of dead hardwoods.

Remarks: It is easily identified in the field by its resupinate poroid basidiocarp.

Earliella scabrosa (Pers.) Gilb. & Ryvarden, 1985

Basidiocarps resupinate, effused-reflexed to pileate, imbricate, tough and coriaceous; 5 cm length and 8 cm wide; pilear surface glabrous, concentrically zonate, first white to cream, soon covered by a reddish cuticle; pore surface white to cork-coloured, pores 2-3 per mm, sinuous to semidaedaloid, individual pores up to 5 mm long, context white, tough. Hyphal system trimitic; generative hyphae with clamps, thin-walled; skeletal hyphae dominant, thick-walled, solid, hyaline, binding hyphae branched with tapering side-branches. Basidia clavate, Basidiospores cylindrical to oblong-ellipsoid, 8-10 x 3-4 μm.

Type of rot: White rot of dead hardwoods.

Remarks: It is identified in the field by its imbricate, dimidiate basidiocarp with semidaedaloid hymenophore and red cuticle.

Fomitopsis pinicola(Sw) P. Karst., 1881

Basidiocarp solitary, hoof shaped, ungulate, 3 cm long and 4 cm wide, coriaceous and flexible when young, hard at maturity. Upper surface of pileus glabrous, zonate, yellowish brown, concentrically groved. Pore surface white, pores round to angular, mostly 1-2 per mm, dissepiments thick, entire, tubes up to 1cm long. Context brown. Hyphal system trimitic, cystidia none, spores cylindrical oblong abundant.

Type of rot: White rot of standing dead trunk.

Remarks: It is identified in the field by its hoof shaped, ungulate basidiocarp with concentrically groved surface and oblong cylindrical spores.

Hexagonia tenuis (Hook.) Fr., 1838

Basidiocarp solitary or imbricate, 3 cm long and 5 cm wide, variable, papery thin, coriaceous. Pileus dimidiate, upper surface glabrous, zonate, brown to black. Margin thin, acute, wavy, entire. Pore surface snuff-brown, pores angular to hexagonal, variable, mostly 0.5-1/mm but larger and smaller occur (5-25 per cm), dissepiments thin, entire, tubes up to 1-2 mm long. Context dark brown, blackening in KOH. Hyphal system trimitic, cystidia none, spores not found.

Type of rot: White rot of fallen woods.

Remarks: It is easily identified in the field by its dimidiate basidiocarp with hexagonal pores.

Lentinus brumalis (Pers.) Zmitr., 2010

Basidiocarps stipitate; in cluster, pileus solitary, up to 3 cm in diameter; upper surface white, azonate, margin concolorous, ciliate; pore surface white to cream coloured, the pores angular, 1-2 per mm, dissepiments thin, context white, azonate, stipe central, lighter coloured than the pileus, up to 4.5 cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches Basidia and Basidiospores not seen.

Type of rot: White rot of fallen woods.

Remarks: It is identified in the field by its stipitate basidiocarp with poroid hymenophore.

Lentinus connatus Berk., 1842

Basidiocarps stipitate; in cluster, pileus solitary, infundibuliform, up to 6 cm in diameter; upper surface brown, azonate, margin concolorous, ciliate. Lower surface cream to brown coloured, lamellate, gill like thin, context brown, azonate, stipe central, dark coloured than the pileus, up to 5 cm long. Hyphal system dimitic; generative hyphae thin-walled, hyaline, with clamps, binding hyphae hyaline, thick-walled with swellings and tapering branches Basidia and Basidiospores not seen.

Type of rot: White rot of fallen woods.

Remarks: It is easily identified in the field by its stipitate basidiocarp with infundibuliform pileus and lamellate hymenophore.

Lenzites betulina (L.) Fr., 1838

Basidiocarps solitary to imbricate, pileate, dimidiate to semicircular and broadly attached. 10x 8 x 0.5 cm. margin entire, corky and coriaceous; upper surface tomentose, concentric, sulcate, cream coloured. hymenophore lenzitoid with radial lamellae, new lamellae arise by dichotomous forking of old ones. context thin, 1-2 mm thick, white. Hyphal system trimitic, generative hyphae hyaline, with clamps; skeletal hyphae solid to thick-walled, hyaline; binding hyphae thick-walled to solid, tortuous, much branched; sword like branches. Cystidia none. Basidia clavate, Basidiospores not seen.

Type of rot: White rot of dead hardwoods and fallen branches.

Remarks: It is very common in the field on dead tree trunks and fallen logs and identified by its dimidiate basidiocarp with lamellate hymenophore.

Microporus affinis (Blume & T. Nees) Kuntze, 1898

Basidiocarps solitary or imbricate, sessile or laterally stipitate, semicircular dimidiate, depressed in the area around the stipe, pileus up to 5 cm long and 6 cm wide, PILEUS glabrous zonate, banded, colour variable from brown to black, usually darker at the center STIPE lateral, up to 2 cm long or absent, pore surface cream coloured, shiny, margin thin white, pores round and entire, minute 5-8 per mm, tubes 1-2 mm deep. Context white and dense. Hyphal system trimitic, generative hyphae hyaline and with clamps, skeletal hyphae thick-walled to almost solid, binding hyphae tortuous, spores not seen.

Type of rot: White rot of dead woods and fallen branches.

Remarks: It is identified in the field by laterally stipitate, dimidiate basidiocarp with poroid hymenophore.

Microporus xanthopus (Fr.) Kuntze, 1898

Basidiocarps solitary or in groups, centrally stipitate and infundibuliform, margin white and deeply incised. Pileus up to 6 cm in diameter and 1-2 mm thick, tough, coriaceous, glabrous, shiny, banded. Stipe round, glabrous, covered with a thin, brown cuticle, up to 2 cm high. PORE SURFACE cream to pale buff, entire and very minute, almost invisible to the naked eye 7-9 per mm, tubes up to 0.1 mm deep. Context white, very thin and covered with a cuticle. HYPHAL SYSTEM trimitic, generative hyphae thin-walled and with clamps, moderately branched, skeletal hyphae dominating, hyaline and thick-walled, binding hyphae tortuous. Basidia club shaped Basidiospores not seen.

Type of rot: White rot of hardwoods and fallen branches.

Remarks: It is another common polypore in the field identified by its centrally stipitate basidiocarp with infundibuliform, dark, banded pileus and poroid hymenophore.

Oxyporus mollissimus (Pat.) D.A. Reid, 1975

Basidiocarp effused-reflexed, sessile to imbricate, variable in size and thickness (15 cm long) and width (5 cm) and 2 cm thick at base. It is light in weight, consistency soft and fibrous. Pileus white to cream colour in appearance. Pores angular, irregular to labyrinthine. **Hyphal system** monomitic, generative hyphae, simple-septate. The hyphae are sparingly branched at acute angles. Basidia clavate with swollen tips enclosing nuclei and cytoplasm. **Cystidia** oblong to cylindrical, projecting above the hymenium. **Basidiospores**, broadly ellipsoid to oval.

Type of rot: White rot of dead tree trunk.

Remarks: It is a rare species identified in the field by its hirsute white to cream coloured basidiocarp with poroid hymenophore.

Polyporus umbellatus (Pers.) Fr., 1821

Basidiocarps stipitate, arising from a sclerotium with numerous, circular, centrally stipitate pilei arising from a common, branched stipe, the individual pilei partly imbricate, 3-4 cm in diameter, flat, margin thin and entire, deflexed, fleshy when fresh, hard and brittle when dry; upper surface glabrous ochraceous to greyish brown, smooth; pore surface cream to straw coloured, pores angular, elongated towards the stipe, 1-2 per mm. Hyphal system dimitic; generative hyphae hyaline, with clamps, binding hyphae scattered and restricted to the trama, thick-walled to solid, hyaline. Basidia clavate, Basidiospores not seen.

Type of rot: White rot of fallen wood log.

Remarks: It is identified in the field by its imbricate stipitate basidiocarp with poroid hymenophore arising from sclerotia.

Trametes apiaria (Pers.) Zmitr., Wasser & Ezhov, 2012

Basidiocarp solitary, sessile, dimidiate up to 8 cm long, 10 cm wide, and 2 cm thick at the base, corky and coriaceous. Pileus reniform, applante dark cinnamon. Pore surface yellowish-brown to greyish-brown, pores angular, somewhat variable, mostly 2-4 mm wide. Hyphal system trimitic. Basidia and basidiospores not seen.

Type of rot: White rot of standing tree trunk.

Remarks: It is identified in the field by its dimediate basidiocarp with poroid hymenophore resembling honeycomb.

Family Polyporaceae is rich in species diversity at Ratnagiri district of Maharashtra. In genera *Lentinus, Microporus* and *Polyporus* the basidiocarp is well developed with distinct stipe and pileus. Others have sessile pileate basidiocarp except in *Dichomitus leucoplacus* where it is resupinate type. In pileate type most members have dimidiate basidiocarp while *Fomitopsis pinicola* has ungulate basidiocarp. The colour of basidiocarp in species varies from White to cream, brown, red and black. Hyphal system varies from monomitic in *O. mollissimus* to dimitic in *Lentinus*, *Polyporus* and trimitic in rest of the members. Basidiocarps with trimitic hyphae are found to be tough, coriaceous and long lived while those with dimitic and monomitic hyphae are found to be soft and flexible. In most specimens we do not get spores; it is due to the fact that these fungi produce ballistospores. All reported species of Polyporaceae in this paper are wood rotting type and none of them occurs in terrestrial habitat, indicating that these fungi play important role in decay of wood in forest ecosystem.

Figure 1: Species of Polyporaceae from Ratnagiri Dist. (MS)
A:Daedaleopsis confragosa, B: Lenzites betulina C: Microporus affinis, D: Oxyporus mollissimus, E: Microporus xanthopus, F: Earliella scabrosa, G: Dichomitus leucoplacus, H: Lentinus brumalis. I: Hexagonia tenuis, J: Lentinus conatus, K: Trametes apiaria, L:Fomitopsis pinicola M:Polyporus umbellatus.

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Comprehensive Account of *Leucophellinus hobsonii* (Berk. ex Cooke) Ryvarden (Schizoporaceae) A Poroid species from Ratnagiri district of Western Ghats of India

Morphological and cytological details of Leucophellinus hobsonii studied from Ratnagiri District of Western Ghats of India.

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Western Ghats of India is one of the world's 35 biodiversity hotspots and is rich in mycobiota. The field surveys were conducted in the monsoon season of 2016 in the tropical moist deciduous forest of Ratnagiri district of India to collect wood rotting poroid fungi. Total 127 specimens collected, of which one specimen is identified as Leucophellinus hobsonii (Berk. ex Cooke). It was reported from Bombay, India in 1879 by Berkeley and named by M. C. Cooke as Polyporus hobsonii Berk. ex Cooke, 1886. This specimen was revaluated by Ryvarden in 1988 at Kew herbarium and renamed it as Leucophellinus hobsonii. As one of the specimens collected by us is also found to be L. hobsonii, we were curious to know its morphological and cytological details. Therefore we have carried out a comprehensive study on L. hobsonii from Ratnagiri district of Western Ghats of India. The basidiocarp of this species is pileate, sessile and imbricate. Pileal surface is cream coloured. Pores are angular to labyrinthine. Hyphal system is monomitic, basidia clavate, cystidia present and basidiospores broadly ellipsoid.

Key words: Biodiversity hotspot, Tropical moist deciduous forest, *Polyporus hobsonii.*

Introduction

Western Ghats of India is a UNESCO world heritage site and one of the 35 biodiversity hotspots of the world (Norman *et al.,* 2000). Western Ghats are one of the 8 hottest biodiversity hotspots of the world (Norman *et al.,* 2000). They are abundantly splendored in mycodiversity.

Ratnagiri is a western coastal district of Maharashtra state, India and situated on the foot of Western Ghats (FSI, 2011). It is ample in biodiversity including flora and fauna. The vegetation of Ratnagiri predominantly consists of tropical moist deciduous and tropical semi-evergreen forest (Champion and Seth, 1968). The forest canopies are variously associated with diverse fungi. The fungal infections damage plants to a greater extent and cause reduced floral vegetation. Some of the fungi are saprophytic and usually flourish on dead and disintegrating wood logs and further deteriorate or rot them. The common wood deteriorating species of Western Ghats belongs to genera *Microporus, Polyporus, Hexagonia* and *Fomes* (Yemul *et al*., 2016). *L. hobsonii* closely resembles the genus *Polyporus* morphologically in having large, visible pores in hymenium but differs from later due to lack of stipe. Cytologically *L. hobsonii* is widely different from Polyporus in having monomitic hyphae (Ryvarden, 1988) while Polyporus has trimitic hyphae (Ryvarden, 1980). *L. hobsonii* is a unique species among the mycobiota of Western Ghats due to pileate, effused reflexed, sessile and imbricate basidiocarp with distinct strigose pileal surface. Its hyphae is monomitic and simple-septate. Basidiospores are broadly ellipsoidal and thick walled. Hence the current study is carried out to investigate the detailed account of the *L. hobsonii* from Ratnagiri district of Western Ghats and explains about

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the morphology and cytological examination which makes this species a unique type in its wild habitat. *L. hobsonii* is exclusively found on *Terminalia paniculata* Roth (Combretaceae) as a facultative parasite which has a unique role in deteriorating the host plant.

Material and Methods

Collection of Leucophellinus hobsonii

The wood deteriorating poroid fungus, *L. hobsonii* was collected from Hativale village of Ratnagiri district of Maharashtra State India in southwest monsoon season of 2016. The fungal specimen was collected in a paper bag and brought to laboratory. It was dried and preserved in paper bags after taking the spore print. The macroscopic and microscopic characters were analysed as per Ryvarden and Melo, 2010.

Herbarium and morphological identification

The collected *L. hobsonii* was taxonomically identified by using the correct mycological key characters with preserved type specimen from Kew herbarium in the year 1879 (K (M) 234416). The most important taxonomical character were taken into consideration during the sample identification which are the Hyphal system, basidia, cystidia, basidiospore shape, size, thickness and colour of pileus and hymenial characters.

Cytology for Leucophellinus hobsonii

Following stains were used for analysis of *L. hobsonii*

1. Cotton blue was used to observe cyanophilic reaction.
2. Congo-red was used to observe staining of cell wall.
3. Phloxine was used to observe nuclei and cytoplasm.
4. Hematoxylin and Eosin (HE) were used as nuclear and cytoplasmic staining of hymenium and cystidia.

All cytological measurements were taken with ERMA Ocular and Stage micrometer. Statistical analysis was done by using Microsoft excel software (means ± SD) (Fig. 1)

Results

Morphological identification of *L. hobsonii*

Basidiocarp is pileate, effused-reflexed, sessile to imbricate, variable in size and thickness, 52 cm long, 16 cm in width and 2 cm thick at base, light in weight, consistency soft, fibrous and loose (Fig. 2A). Pileus white to cream coloured, straw-coloured as matures. Upper surface densely tomentose to hispid, azonate (Fig. 2A). Pore surface concolorous with the pileus, pores angular, irregular to labyrinthine, 1–3 mm in diameter, often varying in size within the same basidiocarp, dissepiments thin and papery, tubes indistinctly stratified, up to 7 cm long.

Cytological examination

Hyphal system monomitic, generative hyphae, hyaline and thin-walled, simple-septate, stains in cotton blue therefore cyanophilic (Fig. 2B). The hyphae are

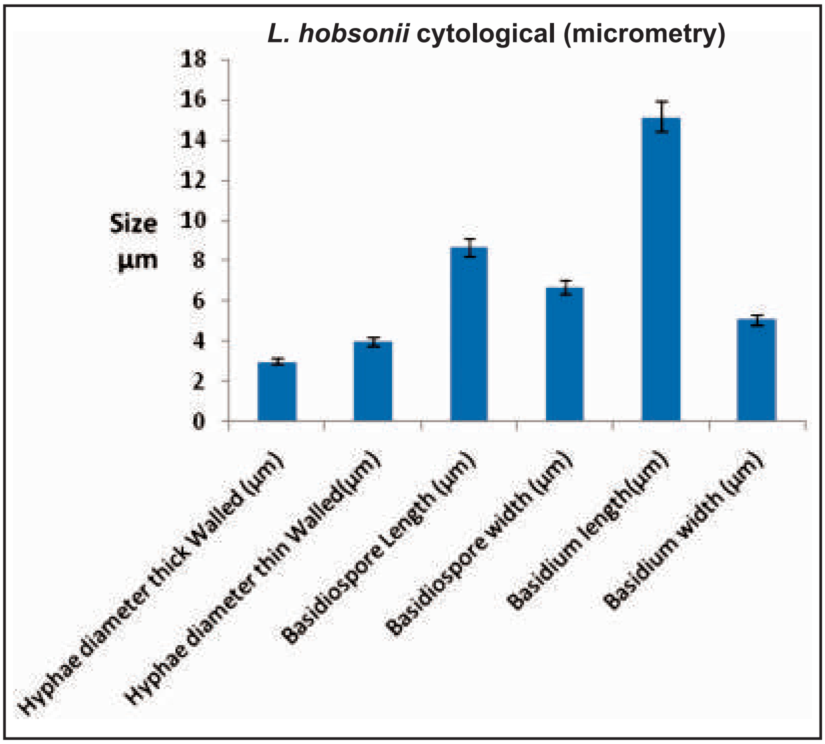

Fig. 1: *Leucophellinus hobsonii* cytological (micrometry). The variation in diameter of hyphae from dissepiments and hymenium. The dimensions of Basidia and Basidiospores.

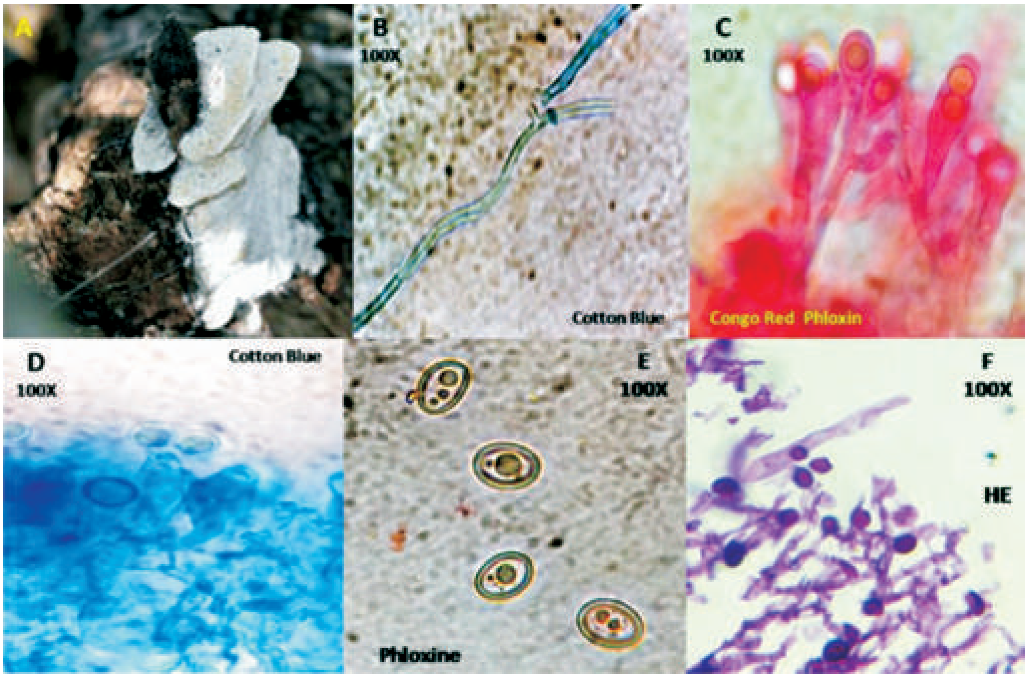

Fig. 2 (A): ***L. hobsonii*** in natural Habitat (B): Generative hyphae (C): Hymenium showing Basidia (D): Hymenium showing Basidia bearing basidiospores on sterigmata (E): Basidiospores (F): Hymenium showing Cystidium and Basidiospores.

sparingly branched at acute angles (Fig. 2B), 3–4 µm in diameter. The hyphae in the dissepiments are thick walled 3 µm in diameter and have narrow lumen. The hypha observed in the hymenium is thin walled with 4 µm diameter with wide lumen (Fig. 2B). Basidia clavate with swollen tips enclosing prominent nucleus and cytoplasm, stained with Congo red and Phloxine (Fig. 2C), length 15.2 µm ± 1.9 (mean µm ±S.D) and its width 5.1 µm ±0.9 (mean µm ±S.D). Fusing nuclei are seen in the basidium (Fig. 2C). Cystidia oblong to cylindrical, projecting up to 30 µm above the hymenium, stained with HE (Fig. 2F), thin -walled, often with a swollen top 50 to 80 µm long and 5–7 µm wide. Basidiospores are broadly ellipsoid to oval, thick-walled, abundant and stained in phloxine. Basidiospores show prominent nucleus and cytoplasmic structures (Fig. 2E), cyanophilic, born on sterigmata (Fig. 2D), negative in Melzer's reagent. The basidiospore length was about 8.7 µm ±0.8 (mean µm ±S.D) and its width was about 6.7 µm ±0.7 (mean µm ±S.D).

Discussion

Berkeley collected a poroid fungus from Bombay, India in 1879 and deposited it in Kew herbarium: K (M) 234416. It was later named by M. C. Cooke as *Polyporus hobsonii* (Polyporaceae) Berk. ex Cooke, 1886 (Cooke, 1886). At that time all poroid wood rotting fungi were kept in genus *Polyporus* P. Micheli ex Adanson, 1763. This species is later on renamed as *Oxyporus mollissimus* (Pat.) D. A. Reid, 1975. This species is described in the Polyporaceae of India by Prof. Anjali Roy 1996. She reported clamped hyphae and did not notice basidia in this species (Roy and De, 1996). In contrast *Leucophellinus hobsonii* has simple septate hyphae and abundant basidia with prominent nuclei. In 1988 Ryvarden revaluated this specimen deposited by Berkeley in 1879 at Kew herbarium with accession number, K (M) 234416 and changed its genus from *Polypours* P. Micheli ex Adanson, to *Leucophellinus* Bondartsev & Singer ex Singer, 1944 on the basis of broadly ellipsoidal thick walled spores and renamed it as *Leucophellinus hobsonii* (Berk. ex Cooke, 1886) Ryvarden, 1988, a basionym (Ryvarden 1988). *Leucophellinus hobsonii* belongs to family Schizoporaceae and order Hymenochaetales of Class Agaricomycetes (Kirk *et al.,* 2008).

We have collected 127 specimens from various localities of Ratnagiri district of Maharashtra, India, during monsoon season of 2016. From this collection we got only one specimen of *Leucophellinus hobsonii.* As this species is scarce, uncommon and infrequent in the Ratnagiri district of Maharashtra we are reporting *Leucophellinus hobsonii* as a rare species.

Authors collected this species on a dead standing tree from Hativale village of Rajapur Tahsil, Dist: Ratnagiri, Maharashtra India, on 11th Nov. 2016. We identified it initially as *Oxyporus mollissimus* (Sharma, 2000, 2012) on the basis of morphology and cytology. This species has been renamed by Leif Ryvarden as *Leucophellinus hobsonii* in 1988. After 1879 this species is being reported from Maharashtra state of India in 2016 from the tropical moist deciduous forest of Ratnagiri district. *L. hobsonii* is reported neither in the Polyporaceae of India nor in fungal flora of India. Although description of *L. hobsonii* is given in various books there are no images and illustrations of its basidiocarp, hyphae, basidia and spores. Therefore we have attempted to provide a detailed account of a poroid fungus *L. hobsonii* from Ratnagiri district of Western Ghats of India.

As the *L. hobsonii* is a rare, poroid species and this is the only available species from Genus *Leucophellinus* from Ratnagiri district of Western Ghats of India and is being critically reported from our study.

Conclusion

This study finally concludes that *Leucophellinus hobsonii* is a rare, poroid species from Ratnagiri district of Western Ghats of India and can be explained on basis of morphological as well as cytological parameters.

भारत के पश्चिमी घाटों के रत्नागिरी जिले से एक रन्ध्रिकाभ प्रजाति *ल्यूकोफीलीनस हॉबसोनाई* (वर्क, एक्स कूकी) रेवर्दन (स्कीजोपोरेसीया) का गहन विवरण

एन.बी. यमुल, एम.बी. कानाड़े एवं सी.वी. मुरूकुमार

सारांश

भारत का पश्चिमी घाट विश्व के 35 जैवविविधता हाटस्पॉटों में से एक है तथा यह कवक समजीवजात में समृद्ध है। भारत के रत्नागिरी जिले के उष्णकटिबंधीय आर्द्र पर्णपाती वन में 2016 के मानसून मौसम में क्षेत्र सर्वेक्षण किया गया ताकि काष्ठ विगलन रन्ध्रिकाभ कवक को एकत्र किया जा सके। कुल 127 नमूने एकत्र किए गए, जिसमें से एक नमूने की पहचान *ल्यूकोफीलीनस हॉबसोनाई* (बर्क. एक्स कुकी) रेवर्दन, 1988 के रूप में की गई। यह बर्कले द्वारा 1879 में बम्बई, भारत से सूचित किया गया था और इसका नाम *पॉलीपोरस हॉबसोनाई* बर्क एक्स कुकी, 1886 के रूप में एम.सी. कुक द्वारा किया गया था। इस नमूने को क्यू हर्बेरियम में 1988 में रेवर्दन द्वारा पूनरमूल्यांकित किया गया और इसे ल्यूकोफीलीनस हॉबसोनाई के रूप में पुनरनामित किया। चूँकि हमारे द्वारा एकत्रित नमूनों में से एक भी *ल्यूकोफीलीनस हॉबसोनाई* पाया गया हम इसकी आकारिकीय और कोशिकात्मक ब्योरों को जानने के इच्छुक थे। अतः हमने भारत के पश्चिमी घाटों के रत्नागिरी जिले से *ल्यूकोफीलीनस हॉबसोनाई* पर गहन अध्ययन किया गया है। इस प्रजाति का बेसिडियोकार्प कलँगीदार, अवृन्त और कोरछादी होता है। पिलीयल सतह क्रीम रंग की होती है। रन्ध्र कोणीय से जटिल होते हैं। कवक तन्तु प्रणाली मोनोमाइटिक, बेसिडिआ गदाकार, सिस्टिडिया उपस्थित तथा बेसिडियम बीजाणु स्थूल रूप से दीर्घवृत्तज हैं।

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LENTINUS VELUTINUS FR. LINN (POLYPORACEAE) A NEW RECORD FOR MAHARASHTRA STATE OF INDIA

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Abstract: **During the field survey of Ratnagiri district of Maharashtra, India on 01st September 2018 a polypore is found. It is identified as *Lentinus velutinus* Fr. Linn. (Polyporaceae). A thorough study of literature[8] revealed that this species is not reported from Maharashtra state of India. Therefore we are reporting *Lentinus velutinus* Fr. Linn (Polyporaceae) a new record for Western Ghats of Maharashtra state of India.**

***Keywords: Lentinus velutinus*, Ratnagiri, polypore, Western Ghats.**

I. INTRODUCTION

As a part of Ph. D. work authors visited Ratnagiri district of Maharashtra, India on 01st September 2018. During field survey authors came across a stipitate wood rotting aphyllophoraceous fungus. The morphological and cytological examination revealed its identity as *Lentinus velutinus* Fr. Linn. A careful review of literature had shown that this species is not yet reported from Maharashtra State of India[8]. Therefore we are reporting *L. velutinus* Fr. Linn. a new record for Western Ghats of Maharashtra state of India. *Lentinus velutinus* Fr. *Linn.* 5 : 510 (1830) was first documented by Berkeley from West Bengal[1]. He described it as *L. hookerianus* Berk. Later Hennings described it from Madhya Pradesh[3] and Pegler from Uttar Pradesh[5]. It's morphological and cytological characters are discussed in detail.

II. MATERIALS & METHODS

Specimen collection and analysis

The specimen was collected from Tropical moist deciduous forest of Dhopeshwar village in Rajapur Taluka of Ratnagiri district of Maharashtra, India (16°38'57"N 73°29'47"E), which is situated on the foot hills of Western Ghats. The specimen was studied for macro and micro morphology. For micro morphology basidiocarp was cut into thin sections and studied in 1% Phloxine, Melzer's reagent and 5% KOH under compound microscope.

III. RESULTS

Morphology of Basidiocarp

Basidiocarp stipitate, in cluster and brown coloured. Pileus 1.5-8 cm wide, convex with umbilicate centre, infundibuliform and dry. Upper surface brown, azonate, striated, short hispid, margin smooth or wavy, involute, rimose at maturity. Hymenial surface cream coloured, lamellate, gills purple. Gills radiating from apex of the stipe, decurrent, narrow, 0.5-1 mm wide. Stipe central, brown, 2-8 cm long x 4-10 mm thick, solid, attached firmly to the substratum. Stipe surface is velutinate with long thick hairs. Basidiocarp thin fleshy when young and tough, leathery at maturity. No specific smell. On a piece of wood in the forest area.

Cytology

Hyphal system dimitic, generative hyphae thin walled, hyaline, branched, septate, clamped, 3-4 µm in diameter, skeletal hyphae sparingly branched, dark brown, thick-walled, 5-7 µm wide, concentrated in the context and stipe. Hymenium with club shaped basidia. Some sterile, thin walled cheilocystidia and thick walled sclerocystidia intermingled with basidia in hymenium. Spores oblong, 8-9 µm x 3-4 µm, negative in Melzer's reagent. Abundant hyphal pegs are present on either side of gill. Hairs on pileus as well as stipe are one cell thick, multicellular, thick walled and clamped.

Type of rot: White rot of wood log.

Remarks: It is identified in the field by infundibuliform, stipitate brown basidiocarp with umbilicate centre and velutinate stipe.

IV. DISCUSSION

Ratnagiri district of Maharashtra state, India is situated on the foot hills of Western Ghats. Being a hot spot of biodiversity, it is rich in Mycobiota. Though studies on mycobiota of Western Ghats have been neglected initially, now research groups are extensively engaged in exploring it for new species. Natarajan K and Manjula M. studied diversity of Lentinus from Western Ghats of Tamilnadu state of India[4]. Senthilarasu G and Singh SK. discovered a new species L. alpacus from Western Ghats of Maharashtra[7]. G. Senthilarasu studied Lentinoid fungi from Western Ghats of Karnataka, Tamilnadu and Kerala of India. He collected seventeen species of lentinoid fungi[6]. L. velutinus is reported from northern and central parts of India by Singh S. K. and Atri, Bose, Henning and others[2]. But its presence from Western Ghats of Maharashtra, India is being reported for the first time in the present article.

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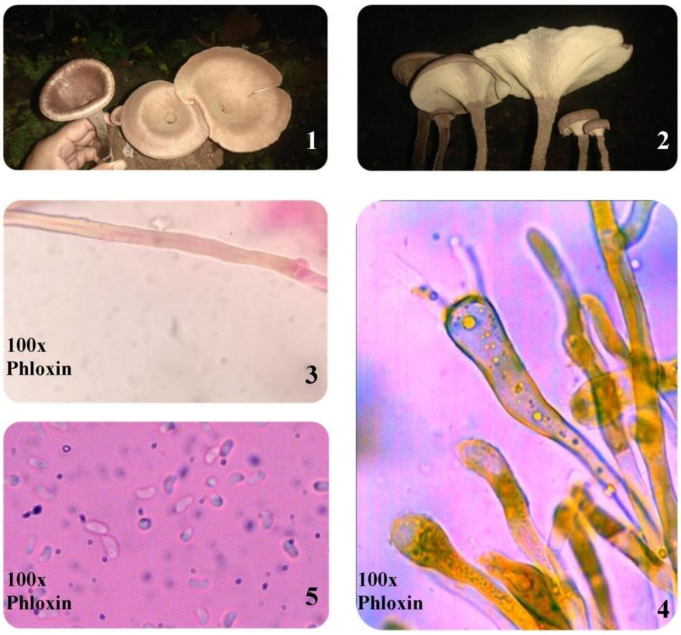

Fig. 1. *Lentinus velutinus* Habit and pileal surface view 2. Basidiocarp showing hymenium 3. Pileal hyphae showing clamp connection at 100x 4. Basidia and cystidia at 100x 5. spores at 100x.

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Synthesis of Silver Nanoparticles by using *Irpex lacteus* (Meruliaceae) a wood rotting Aphyllophore

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ABSTRACT:

Nanotechnology has immense applications in therapeutics of human diseases. Aphyllophoraceous fungi are known to cause wood rot of tree species. These pathogenic fungi produce extracellular enzymes which degrade wood and damage plant. These fungi can be used in productive way for producing silver nanoparticles. A common wood rotting fungus *Irpex lacteus* (Meruliaceae) was collected from tropical moist deciduous forest of Ratnagiri district. The fungus was cultured on Sabouraud Dextrose Agar medium. The mycelial mass was harvested and centrifused at 10000 rpm for 20 minutes to get cell free extract. The supernatant obtained was used for biosynthesis of silver nanoparticles. 0.1mM $AgNO_3$ solution is used as substrate. 40 ml of 0.1mM $AgNO_3$ solution is incubated with 10 ml of cell free extract of wood rotting fungus in a 100 ml conical flask at room temperature for 120 hours on orbital shaker. After 120 hours O. D. of reaction mixture was measured on UV-Visible spectrophotometer by taking 0.1mM $AgNO_3$ solution as a blank. SEM of reaction mixture was prepared. Both Spectroscopy and SEM analysis shown synthesis of Silver nanoparticles. Thus wood rotting aphyllophorales can be used in constructive way for biosynthesis of silver nanoparticles.

KEYWORDS: 0.1mM $AgNO_3$; *Irpex lacteus*; wood rotting aphyllophore; Silver Nanoparticles.

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INTRODUCTION:

Nanotechnology is new interdisciplinary branch of science dealing with design and synthesis particles ranging from 1-200nm in diameter. These particles have applications in various branches of Science. Nanotechnology has applications in many fields such as food, cosmetic, environmental conservation, health care, industries, electronics, drug delivery etc.[1].

The term "nanoparticles" is used to describe a particle whose size ranges from 1nm to several nanometers, at least in one of the three possible dimensions. In this size range, the physical, chemical, biological properties of the nanoparticles change from the properties of both individual atoms and molecules and from the corresponding bulk material. The nanoparticles can be made from various chemical materials such as metals, metals oxide, silicates, polymers, and biomolecules[2]. Shape of nanoparticles vary, they may be spherical, cylindrical, rod shaped or polygonal. Generally the nanoparticles are designed with tailored surface modifications to meet the needs of specific applications. The huge amount of variations in nanoparticles arises from their wide range of chemical nature, shape and size[3].

Silver nanoparticles are of most sought after because of their unique properties, which can be used to get antimicrobial applications, cytogenetic superconducting materials, cosmetic products and electronic components. Several physical and chemical methods have been used for synthesizing and stabilizing silver nanoparticles[4]. The most accepted chemical method for the synthesis of silver nanoparticles is chemical reduction by using a number of organic and inorganic reducing agents, physicochemical reduction, and radiolysis.

Silver nanoparticles (SNPs) have attracted specific attention due to their potential applications, in electronics, biosensors, cloth manufacturing, food storage, paints, sunscreens, cosmetics and medical devices[5]. SNPs have also a potent bactericidal and fungicidal activity and general anti-inflammatory effects. Further, can be used to improve wound healing, to develop dressings for wounds and antibacterial coatings[6]. Although ultraviolet rays, aerosol technology, laser ablation and photochemical reduction have been used successfully to produce nanoparticles, they remain expensive and involve the use of hazardous chemicals[7].

Recently, there is growing attention to produce nanoparticles using environmentally friendly methods. This approach includes mixed valence polyoxometalates, polysaccharides, biological and irradiation method which have advantages over conventional methods involving chemical agents associated with environmental toxicity. Silver nanoparticles are the metal of choice as they hold the promise to kill microbe's effectively and effect on both extracellularly as well as intracellularly.

The microbial synthesis of nanoparticles is a unique approach as it combines nanotechnology and microbial biotechnology[7]. Some microorganisms, including bacteria, filamentous fungi and yeast, plays important role in the remediation of toxic metals through the reduction of the metal ions; therefore, these microorganisms could be employed as a nanofactories for the production of nanoparticles[1].

Biological method based on use of fungi to produce nanoparticles is based on the fact that fungi produce extra cellular enzymes, which can be used in the reduction of metal ions to synthesise nanoparticles. Wood rotting fungi are ideal candidates for this purpose. These fungi grow on easily available substrate and secrete large amount of extra cellular enzymes which can be used for synthesis of SNPs[8].

Present paper discusses eco-friendly synthesis of silver nanoparticles by using wood rotting aphyllophoraceous fungus *Irpex lacteus* (Meruliaceae) (Figure 1) and their characterization by using UV-Vis spectroscopy, and SEM analysis.

MATERIALS AND METHODS:

Isolation and culture of Irpex lacteus

A segment of *Irpex lacteus* basidiocarp was surface sterilized by sequential rinsing into 70% ethanol for 30 seconds, 0.1% mercury chloride for 30 seconds, 0.5% sodium hypochlorite for 30 seconds, and 2-3 minutes with sterile distilled water. Then cut segment was placed on Petri dish containing Sabouraud Dextrose Agar (SDA). It is incubated at 28^0C for 3-4 days, and monitored every day for the growth of fungal colony (Figure 2). The pure fungal culture was obtained on PDA plates.

Mass culture of fungi

For synthesis of SNPs, the fungus was cultured on large scale by transferring pure inoculum of *Irpex lacteus* in to Sabouraud Dextrose broth in 250 ml conical flask. It is incubated at 28±0.5^{0}C, for 3 days on orbital shaker. After that, the mycelial biomass was removed by filtering media to obtain cell free extract (Figure 3). The filtrate that is cell free extract was centrifused at 10000 rpm for 20 minutes and supernatant was used further for the synthesis of SNPs.

Assay for SNPs synthesis

The reduction reaction for biosynthesis of silver nanoparticles was carried out by adding 0.5ml of 0.1M silver nitrate in 49.5 ml of distilled water so as to get the 1mM volume as the final concentration of silver nitrate in the reaction mixture. 40 ml of 1mM $AgNO_3$ solution is incubated with 10 ml of cell free extract of wood rotting fungus in a 100 ml conical flask at room temperature for 120 hours on orbital shaker. After 120 hours O. D. of reaction mixture was measured on UV-Visible spectrophotometer by taking 1mM $AgNO_3$ solution as a blank. The formation of silver nanoparticles was monitored visually by observing the change in colour of the reaction mixture (Figure 4).

Figure 1: ***Irpex lacteus*** **in natural habitat**

Figure 2: Irpex lacteus in culture

Figure 3: Cell free fungal extract

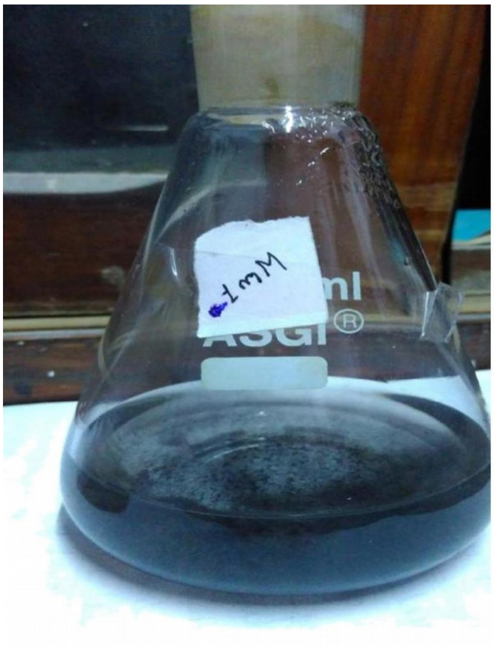

Figure 4: Synthesis of SNPs

RESULTS AND DISCUSSION:

Synthesis of SNPs is characterised by following way

Visual observations

The synthesis of nanoparticles was initiated once the fungal culture was introduced into 1mM aqueous AgNO3 solution. Sliver ions were reduced to silver nanoparticles. Reaction mixture develops dark colour in response to synthesis of SNPs. The intensity of colour change is due to rate of reduction reaction potential.

UV visible spectroscopy

The initial characterization of formation of silver nanoparticles was carried out by UV-Visible spectroscopy using a double beam spectrophotometer. Spectroscopy plays a very important role in the identification of different compounds and their qualitative and quantitative determination. Nothing can complement these characterizations now a days. The reduction of the Ag^{+} ions by the supernatant of the fungal culture in the solutions leads to formations of silver nanoparticles. The Optical Density (O. D.) was measured at 300nm-600nm wavelength. SNPs show maximum O. D. in between 400nm to 500nm wavelength.

Scanning electron microscopy

The morphological feature of synthesized silver nanoparticles from wood rotting fungal extract was studied by scanning electron microscopy. The shape and diameter of synthesized nanoparticles was identified using SEM analysis. SEM analysis done after drying the extract and dried powder was used for SEM images. Experimental result showed that the diameter of prepared nanoparticles was in between 90nm to 120 nm. The result showed that the particles were polygonal to irregular in morphology.

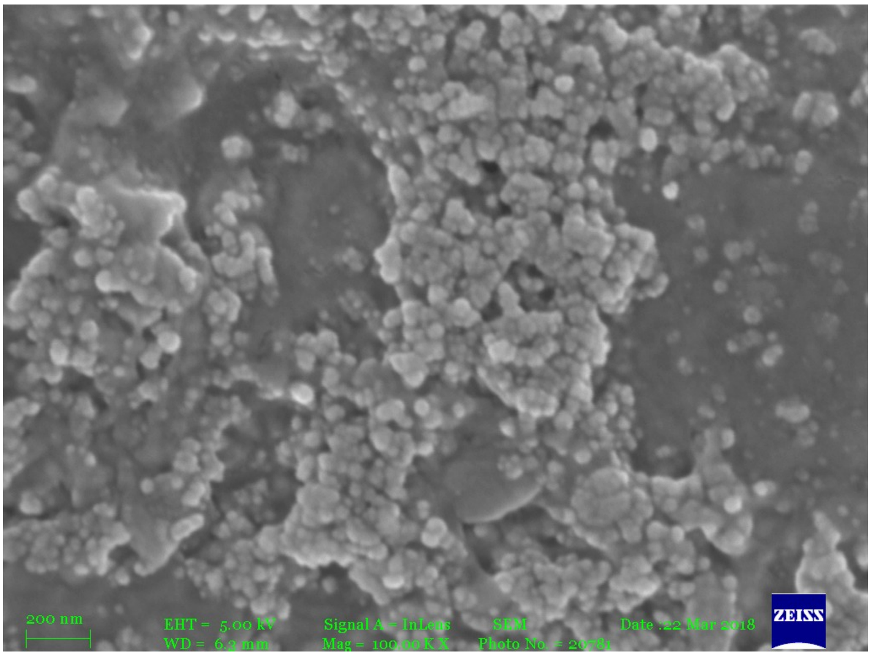

Figure 5: SNPs in SEM

CONCLUSIONS:

SNPs synthesized by *Irpex lacteus*, a wood rotting Aphyllophoraceous fungus have variable size and shape. SEM analysis shown that SNPs are mostly polygonal in shape. Their size ranges from 90nm-120nm in diameter. UV-Vis spectroscopy results had shown that SNPs show maximum O. D. in 400nm-500nm wavelength. Thus it is concluded that wood rotting aphyllophoraceous fungi can be potentially employed for synthesis of silver nanoparticles. Being an eco-friendly approach this method serves as a promising alternative to the traditional reduction routes to avoid usages of toxic chemicals. These nanoparticles have immense applications in pharmaceutical drug delivery systems and might be the future thrust in the field of medicines.

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