ISBN: 978-93-91768-43-0

Diversity of Macrofungi

Dr. Nafeesa Begum

Bhumi Publishing

Diversity of Macrofungi

(ISBN: 978-93-91768-43-0)

Dr. Nafeesa Begum

Associate Professor,

Department of Botany,

Sahyadri Science College, Shimoga-577203, Karnataka, India

nafeesabegum30@gmail.com

Bhumi Publishing

2021

First Edition: 2021

ISBN: 978-93-91768-43-0

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Book Available online at:

https://www.bhumipublishing.com/books/

PREFACE

Macrofungi that produce spore containing structures called sporocarps that are large enough to be seen without the need of specialized optical instruments. This includes fungi in the phylum Basidiomycota that produce the familiar umbrella shaped sporocarps including the gill mushrooms and boletes, as well as Polypores, star fungi, tooth fungi, puffballs false-truffles, jelly and crust fungi whose sporocarps may have other shapes. Other macromycetes include morels, truffles, and cup fungi found in the phylum Ascomycota. The slime molds (Phylum Myxogastria) are often also included as well, even though they are not fungi. Of the estimated 1.5 million species of fungi in the world, only about 110,000 are macromycetes, and less than half of these are described. The fungal group becomes a significant component for reforestation programs. They are significant as nourishment source for human beings and animals.

This Book offers systematic approaches to the macrofungi diversity and was also used as a bioindicator of environmental quality. Most of the fleshy and gilled macrofungi were prevalent in the rainy times of the year as this time is favourable for their output, since there is ample moisture, favourable warmth, relative humidity, and sunshine, which furthermore aids the macrofungi in the decomposition of dead organic tissue. The early dry time of the year collection was predominated by the polypores since there is decline in rainfall and relative humidity, boost in warmth, and sunshine and most of the fleshy macrofungi will not withstand these conditions. During rainy season, there is abundant growth of several kinds of Basidiomycetes.

- ***Dr. Nafeesa Begum***

Acknowledgement

I am thankful to my Chairman, Department of Botany and Seed Technology, Sahyadri Science College, Kuvempu University, Shivamogga.

I profusely thankful to Prof. Vagdevi H. M. Principal, Sahyadri Science College, Kuvempu University, Shivamogga.

My Sincere thanks to my colleagues in the department and students for helping in the field visits.

About the Book

Biodiversity includes not only many species that exist, but also the diversity of populations that makeup a species, the genetic diversity among individual life forms, and the many different habitats and ecosystem around the globe. Macrofungi are economically important due to their use in food, medicine, biocontrol, chemical, biological and other industries. The macrofungi are an integral part of ecosystem, their diversity and types are poorly studied, with a particular knowledge gap in the tropical regions including India. Macro fungi are diverse in their uses as food and medicine and several species serve as decomposers and also form mycorrhizal associations. Macrofungal diversity in malnad region Shimoga district, Karnataka was studied. Abundance and diversity is more in rainy season than winter and summer. Mulching and moisture content of substratum play very important role in the growth of macrofungi. In our study more number of species belongs to fleshy gilled fungi as the same species may need less rain or moisture content for its development and they found in the entire substratum. Some species were edible (Termitomyces clypeatus) and many species found to be non-edible.

- ***Dr. Nafeesa Begum***

CONTENTS

1. Introduction:

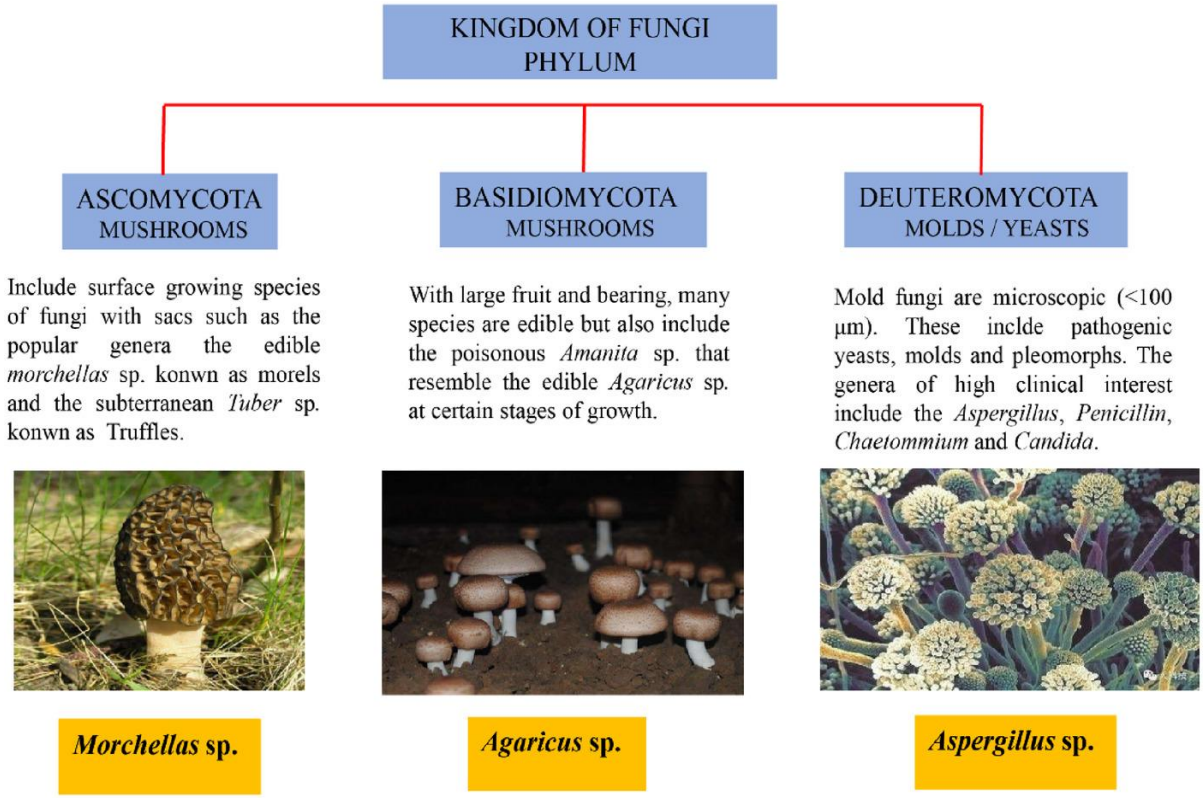
Fungi are key functional components of forest ecosystems and they have received less attention than animals and plants, although they are omnipresent and highly diverse in nature. Fungi play a vital role in ecosystem functions and have big influence on humans and human-related activities. Soil fungi play a central role in many ecological processes that are crucial to maintaining ecosystem stability, as influencing soil fertility, cycling of minerals and organic matter, as well as plant health and nutrition (Barrico *et al.,* 2010). Fungi are important in forest habitats and are involved in the decomposition of dead trees and forest litter into soil and deliver species-specific benefits to their host plants, which render their biodiversity of high importance to plant nutrition. Fungi play a significant role in the daily life of human beings besides their utilization in industry, agriculture, medicine food industry, textiles, bioremediation, natural cycling, as bio fertilizers and many other ways. The presence of extensive biodiversity available in tropical forests has been identified as the treasure box for the emerging field of biotechnology (Swapna *et al.,* 2008).

1.1 Macrofungi

Macrofungi belong to the kingdom fungi, which constitutes the most diverse group of organisms after insects on this biosphere. Fungi are the most diverse organisms on earth and are defined as a eukaryotic, heterotrophic which is devoid of chlorophyll and obtains its nutrients by absorption and reproduces by means of spores. Large fungi are those that form large fructifications visible without the aid of the microscope and include Basidiomycota and Ascomycota with large observable spore bearing structure. Ecologically, macrofungi can be classified into three groups: the saprophytes, the parasites, and the symbiotic (mycorrhizal) species. Most terrestrial fungi are saprobes or mycorrhizal symbionts, but some are pathogens of plants or fungi. Macrofungi fruiting on woody substrate are usually either saprobes or plant pathogens. Fungi of various taxonomic groups producing conspicuous sporocarps are collectively known as macrofungi which include “gilled fungi,” “jelly fungi,” “coral fungi,” “stink fungi,” “bracket fungi,” “puffballs,” “truffles,” and “birds nest’’. Macrofungal diversity is an important component of the global diversity, particularly community diversity, which is an essential part of fungal diversity.

Mushrooms are widespread in nature and they still remain the earliest form of fungi known to mankind.

Only about 6.7% of the 1.5 million species of fungi estimated in the world have been described and these are mostly in temperate regions. The tropical region which has the highest fungal diversity has not been fully exploited. Cameroon has a rich biodiversity but it remains poorly unexplored. Termitomyces spp. are widely distributed across the country and form an important source of income for the rural people of Baligham and Ndop plains of the Northwest Region of Cameroon as well as Mbouda in the Western part of the country. Checklist of macrofungi of Mount Cameroon consisted of 177 species.



Wild edible mushrooms are one of the most important natural resources on which the people of many nationalities rely and play a key role in nutrition. Ethnomycology investigates the indigenous knowledge of mushroom utilization and consumption patterns such as in nutrition, medicine, and other uses. It also investigates the ectomycorrhizal association and ecological benefits of macrofungi (mushrooms) to the forest. In Cameroon, mushrooms are known and consumed in many households, in the country sides and in forest areas. During the onset of the rainy season when mushrooms are abundant most

people in the rural areas collect them from the forest for consumption and sale. The current rate of bush burning, deforestation, and overexploitation of both timber and nontimber products are threatening mushroom diversity in Cameroon. The use of fungi for food and medicine goes back a long way in human history, but research and documentation of such knowledge are relatively new in Cameroon even though one hundred and seventy-seven species of mushroom were identified in the Mount Cameroon Region.

1.2 Hypogeous macrofungi

The hypogeous macrofungi can produce large fruiting bodies, which develop under the surface of soil or being covered by a thick layer of humus or leaf litter (Hawker, 1954). Most hypogeous fungi can form ectomycorrhiza with plants from which they obtain carbohydrates. In return, these macrofungi help plants by providing mineral nutrient and water and protecting them from root pathogens. These macrofungi are also important foods of small mammals. Some of the hypogeous macrofungi are also a significant source of income for humans. On their own, the hypogeous macrofungi have very limited ability to disperse, for example, by hyphal extension and shedding spores, which may be transported to a nearby location by soil-inhabiting invertebrates and small mammals (Hawker, 1954). The long-distance dispersal of these fungi is accomplished when the mycophagous mammals dug up and consume underground sporocarps and then defecate the spores at other places. Thus, the mycophagous mammals can have a significant influence on the reproduction, transmission, and genetic structure of hypogeous macrofungi. Hypogeous macrofungi are broadly distributed into three fungal phyla, the Basidiomycota, the Ascomycota, and the Zygomycota.

The economically important species are found mostly in Hymenogastrales (Basidiomycetes) and Tuberales (Ascomycetes). The black truffle belongs to Tuberales and is often referred to as the “black jewel” of European dining tables. As a result, the ascocarps of the genus Tuber (true truffle) have been studied extensively for their genetic structure and fungi–animal interactions. Tuber is the monophyletic truffle genus in Tuberaceae that includes truffle and non-truffle species. The genus evolved from an epigeous ancestor and dispersed with host plants’ migration (Bonito *et al.,* 2013). Currently, there are over 200 species in this genus (Murat *et al.,* 2013). Similar to other hypogeous macrofungi, Tuber truffles require and recruit mycetophagous mammals to disperse their spores. Generally,

mycetophagous animals are attracted by truffle volatiles, which then consume sporocarps and disseminate spores in their fecal pellets. In the case of truffles, the dispersing distance is determined by two factors: (i) the gut-retention time of spores in mycetophagous mammals, which generally might be more than 20 h; and (ii) the travel distance of the mammals within that time span, which may cover dozens of hectares. The mycetophagous mammals help Tuber species to disperse and by association increasing the health and productivity of host plants. Tuber melanosporum and Tuber magnatum are two highly prized truffles in Europe. They are the favorites of gastronomers and businessmen, and can be cultivated semi artificially by inoculation of young trees and plantations.

They form large fruiting bodies, visible without the aid of a microscope and include fruiting bodies, such as gilled fungi, cup fungi, jelly fungi, flask fungi, entomogenous fungi, tongue fungi, coral fungi, stinkhorns, bracket fungi, puffballs and bird's nest fungi (Bates, 2006). There are many thousands of species which are unique and each species beautiful in its own way. Since the dawn of civilizations, macrofungi have been fascinating to man due to their unusual characters like sudden appearance in isolated places in groups, rings and in different geometrical shapes. Macrofungi grow prolifically and are found in many parts of the world. They intermingle and participate or compete with other micro-organisms behavior and predators (Razaq *et al.,* 2014). A mushroom is a macrofungus with a distinct fruiting body which can be either epigeous or hypogeous and most macrofungi belongs to the Ascomycota or Basidiomycota, but a few are members of the Zygomycota (Parihar *et al.,* 2015). It is a saprophytic fungus that grows on dead and decaying organic matter. Due to the absence of chlorophyll, it is unable to synthesize its own food and hence depend upon the organic matter for food (Tiwari and Sharma, 2017). Mushrooms are seasonal fungi and occupy diverse niches in nature in the forest ecosystem (Abrar *et al.,* 2016). They predominantly occur during the rainy season particularly in forest, where the dense canopy shade from trees provide a moist atmosphere and decomposing organic material such as leaf litter and favors the germination and growth for mushrooms. Wild mushrooms have manifold impacts on the biology, ecology and economy in forest based areas and mushroom species are the indicator of the forest health (Singha *et al.,* 2017). Macrofungi have been fascinating man due to their usual character like sudden appearance in isolated places in groups, rings and in different geometrical shapes and becoming attractive as a functional food as a source for the development of drugs (Soni and Soni, 2017).

Classified Groups

Macrofungi include pathogens, saprophytes and the majority of ectomycorrhizal (ECM) species, are among the most important and widespread soil fungal groups (Barrico *et al.,* 2010). The two major groups which include macrofungi are Ascomycota and Basidiomycota. While most of the Ascomycota are microscopic species, these are also contains some "larger fungi" cup-fungi, morels and truffles. The Basidiomycota, is a larger group including mushrooms, toadstools, bracket fungi, polyporus and puffballs, although about 30% of its species are microscopic (Razaq *et al.,* 2014).

1.3 Fungi of Phallales

The Phallales is an order of Basidiomycota. Its members, the stinkhorn fungi, are well known for their morphologically unusual and brightly colored basidiomata as well as unpleasant odors associated with entomochory (Magnago *et al.,* 2013). The order used to include two families Clathraceae and Phallaceae, with the shared and diagnostic feature of the peridium breaking down at maturity. Based on a phylogenetic analysis using molecular data, a study by Hosaka *et al.* (2006) suggested that the order Phallales should include six families (Clathraceae, Claustulaceae, Lysuriaceae, Phallaceae, Protophallaceae, and Trappeaceae) including some species with peridium not breaking down at maturity. Economically, the order Phallales includes many edible and medicinal species, such as the "veiled lady mushroom," Phallus indusiatus (syn. Dictyophora indusiata). This cultivable mushroom is one of the most famous edible stinkhorn fungi with a high nutritive value and a delicious taste. Another mushroom of the genus, Phallus rubicundus, has been used as a traditional Chinese medicine.

Ecologically, the stinkhorn fungi are mainly saprophytic fungi, play important roles as decomposers in forest ecosystem. Because of their saprophytic nature, these fungi are found in many areas in southern Asia, Africa, the Americas, and Australia, where they grow in woodlands and gardens in rich soil and well-rotted woody material.

The formation of fruiting bodies of stinkhorn fungi starts underground, and basidiospores are formed within a glebe. Then a receptacle, bearing the gleba, emerges from the peridium and extends above ground at maturity. As the gleba breaks down, the basidiospores are exposed in a gelatinous mass at the top of the stinkhorn. Because the basidiospores cannot be dispersed in naturally due to the gelatinous matrix surrounding

them, the insects play an important role in their dispersal. The insects are attracted to these fruiting bodies by the volatile substances they emit and forage the top of the fungi, with the spores released as excrement. In this process, the insects consume the mucous matrix of the spores as nutrition while the spores remain intact and retain their germination ability in the digestive system until being excreted by the insects. This pattern of spore dispersal is similar to the fly pollinated angiosperm flowers. Consequently, the stinkhorn fungi are dispersed long distance through recruiting insects as spore dispersers with the insects benefiting from food of the mucilaginous.

1.4. Coprophilous Macrofungi

Coprophilous fungi (dung fungi) are a special group of fungi that grow on animal feces, particularly those of herbivores. They break down dung for recycling nutrients and are dispersed by animals. Several hundred fungal species are known to grow on dung but relatively few of them form macroscopic fruiting bodies. These fungi develop and grow through a typical succession pattern that begins with phycomycetes, followed by ascomycetes (-cup and flask fungi), and basidiomycetes (Richardson, 2002). Some of the ascomycete and basidiomycete dung fungi can fruit on dung, which are dispersed by animals. The cup and flask ascomycete spread spores in a typical pattern of most coprophilous fungi. The spores are produced in ascus and a high hydraulic pressure is built up, and upon reaching maturity, the spores are discharged, typically, toward light in the middle of the day, increasing their opportunity to reach new ecological niches (Richardson, 2003). The spores of dung fungi need assistance of digestive juice of animals to break their dormancy in order to germinate on dung. One of the best studied examples of dung macrofungi is the agaric genus coprinus (basidiomycetes), the inky caps, which also include some saprophytic species on grassland and dead wood. These organisms have autodigestive chitinases and digest themselves (Nagy *et al.,* 2013). Their basidiospores are black and released within a brown liquid to the dung during which the caps autolyze, typically within a few hours after basidiospores are formed (Kues, 2000). Because of the mucous liquid around them, these spores cannot be dispersed by wind and may be scattered to a limited extent by rain. However, they can be disseminated by coprophilous insects, which forage on dung and carry basidiospores on their feet and bodies from one place to another (Brodie, 1931). Because of the wide distributions of both dung materials and insects, the coprophilous fungi are also broadly distributed. Aside from their role as

decomposers associated with dung wastes, the coprophilous fungi have little other known functions.

1.5. Sporocarps

The macro fungi are differentiated by containing spore bearing structures "Sporocarps" that are seen by naked eye, it consist of mushrooms, puffballs, bracket fungi, false-truffles and cup fungi are common examples of macro fungi. It is usual for a particular fungus to produce a visible fruiting body only under a precise combination of conditions, including geographic location, elevation, temperature, humidity, light and surrounding flora. Sporocarps are ephemeral, may last only a few days before decomposing or being eaten. Macroscopic fungi with specific fruiting organs and size, big enough, to be visible, may either be epigeous or hypogenous (Karim *et al.,* 2013). Many macro fungal species are believed to fruit sporadically with no consistent pattern of occurrence from year to year. The distribution of macrofungal species is low in hot and dry seasons while they are abundant in spring and autumn due to the humid climate as well as the richness of the flora. In some species sporocarp is short-lived; in others they are persistent and may be perennial. Fruiting body of this group is extremely dependent on weather conditions and abundance of sporocarp may therefore vary by several orders of magnitude between the years. The basidiomycete sporocarps are among the first biotic groups to be affected by environmental disturbance, and as such, they can be considered as good indicators of ecosystem modification (Barrico *et al.,* 2010).

Challenges

The research conducted by professional mycologists a field observer over the globe in last few decades depicts our knowledge of fungi has been significantly increased and it is through now largely feasible to evaluate the present rank and future for fungal species (Razaq *et al.,* 2014). Only a fraction of total fungal wealth has been subjected to scientific scrutiny (Pala *et al.,* 2012) and mycologists continue to unravel the unexplored and hidden wealth (Swapna *et al.,* 2008). Some surveys have been dealt with composition and diversity of macrofungi assemblages in different vegetation types using different diversity indices and statistics (Rudolf *et al.,* 2012). Ecological consequences of shifts in temperature means, precipitation and drought spells have been widely reported at spatio-temporal scales,

including timing of the growing season. Unravelling these effects of climate variation on fungal distribution and fruiting is a major current challenge (Boddy *et al.,* 2014). The lack of knowledge of total fungal diversity and associations within any community is due in part to the lack of fungal diversity studies worldwide (Sheikh *et al.,* 2014).

1.6. Diversity

Although macrofungi have perhaps the longest history of diversity studies of any group of fungi, they are nevertheless understudied over most of the world (Mueller *et al.,* 2007). Of the 1.5 million species, there may be 1,40,000 species to be considered as macrofungi, but only 14,000 species are known to man, which would account for 10% of the estimated mushroom species (Pala *et al.,* 2011). Karim *et al.* (2013) estimated, 69,000 as discovered fungi, which include 46,124 Basidiomycetes and Ascomycetes. Seven thousand species are known to possess varying degrees of edibility and more than 3,000 species may be considered prime edible and 2,000 species have been suggested having medicinal importance (Pala *et al.,* 2012).

1.7. Ecology

Macrofungi is one of the most important organisms in the forest ecosystem. It provides invaluable information on the diversity of organism within this ecosystem (Bhattacharjee *et al.,* 2015). Climate is recognized to be a factor for fruiting body formation and seasonal changes have been linked to changes in the phenology, abundance and distribution of fungal species (Sutjaritvorakul *et al.,* 2017). Macrofungi is not only significant in the terrestrial ecosystem but also play an important role in the atmospheric biogeochemical cycles by acting as a potential source of bioaerosols, mainly as fungal spores (Priyamvada *et al.,* 2017). Only a fraction of total fungal wealth has been subjected to scientific scrutiny and mycologist continue to unravel the unexplored and hidden wealth, as many macrofungi are becoming extinct or facing threat of extinction because of habitat destruction and global climate change (Pala *et al.,* 2012).

Wood Decaying Macrofungi

Dead wood is an important substrate for a large number of forest-dwelling Basidiomycota: Aphyllophorales species viz., polypores (Junninen and Komonen, 2011). Wood-inhabiting fungi release the carbon fixed during photosynthesis and stored in the form of cellulose, hemicellulose and lignin, and return other nutrients from the woody

debris back to the soil. The bracket fungi are the main wood decayers (Robledo, 2004). Wood-decaying polypores play important roles in forest ecosystems. They decompose woody debris and provide microhabitats for other. In addition, they produce long-lasting fruiting bodies that are easily monitored in the field (Yamashita *et al.,* 2014).

1.8. Importance

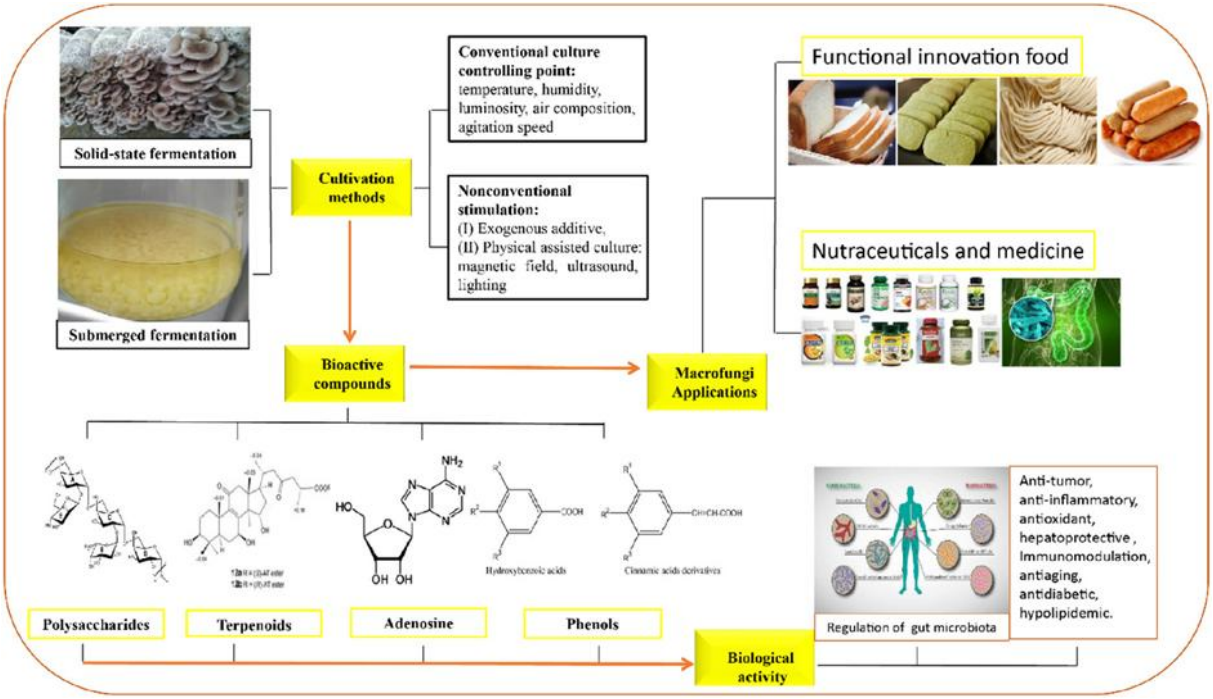
Saprotrophic macrofungi carry out the bulk of organic material decomposition and forest ecosystem has a strong effect on macrofungal diversity, species composition, and population structure (Tschen *et al.,* 2004). The socio-economic significance of wild fungi as food, medicinal source, ecosystem conservation, plant growth promotion, etc., has long been recognized in Europe, USA, China and other developed countries and this has attracted scientists to explore the potential macrofungi and their diversity (Sheikh *et al.,* 2014). Macrofungi studies have long been of interest to scientists as well as the public due to their important role in human welfare, in food industry, in medicinally effective products and in biodegradation (Ozturk *et al.,* 2003). Macrofungi were considered ideal for the purpose of evaluation as biosorbents, because it has been demonstrated that many fungal species exhibit high biosorptive potentials (Muraleedharan *et al.,* 1995). Work has been carried out on antimicrobial activities of lower fungi but edible mushrooms have not been adequately explored (Swapna *et al.,* 2008). The visible macroscopic fruit bodies have economic value as aesthetic components of the natural environment and as a food crop in the case of edible species (Buddy *et al.,* 2014). Studies on this subject, in fact, have been carried out in different countries (Stojchev, 1998) and new species for the world macrofungal flora have been recorded (Laferriare 1990). Macrofungi are also important components of the diet of many animals including soil invertebrates and small mammals (Buddy *et al.,* 2014).

Many saprophytic macrofungi play an important role as soil aggregators. Basidiomycetes are indeed the main decomposers of recalcitrant components of plant litter through the production of lignin modifying enzymes such as lignin peroxidases, manganese-dependent peroxidases and laccases (Barrico *et al.,* 2010). The majority (>95%) of boreal forest tree root tips are colonized by symbiotic ectomycorrhizal (EM) fungi. Macrofungi play an extraordinarily important role in the catalysis of the nutrient cycle of deciduous and coniferous forests, by which increase their fitness. They uptake of nutrients, these nutrients are very important for tree health by balancing the pH from

noxious natural resources. They produce a lot of pharmaceutically vigorous chemicals like hormones, pheromones, toxins, carcinogenic enzymes, antibiotics, anticarcinogens and pigment genetically (Razaq *et al.,* 2014). Macrofungi are not only beautiful but play a significant role in the daily life of human beings besides their utilization in industry, agriculture, medicine food industry, textiles, bioremediation, natural cycling, in recycling nutrients and decomposing the dead organic matter in soil and litter as biofertilizers and many other ways. Fungal biotechnology has become an integral part of the human welfare. The presence of extensive biodiversity available in tropical forests has been identified as the treasure box for the emerging field of biotechnology (Swapna *et al.,* 2008). Despite their great ecological significance, the community ecology, biogeography, and conservation status of macrofungi are poorly known (Krishnappa *et al.,* 2014).

Macrofungi are the centre of attraction as food, medicine and cosmetics throughout the world. Utilization of macrofungi as nutritional source against plant and animal products is one of the viable avenues to fulfil the protein energy demand. According to a rough estimate, although over 2000 species of mushrooms occur worldwide, only 25 species have been widely accepted as food and a few species are successfully cultivated commercially. The proteins, essential amino acids (EAAs), fibre, minerals, fatty acids, vitamins of edible mushrooms are favourable for human nutrition and health nutritional constituents of mushrooms are dependent on several factors like mushroom species, geographical region, substrate, stage of harvest and part of mushroom (Andrew *et al.,* 2015). Saprotrophic macrofungi carry out the bulk of organic material decomposition and forest ecosystem has a strong effect on macrofungal diversity, species composition, and population structure (Tschen *et al.,* 2004).

Macrofungi studies have long been of interest to scientists as well as the public due to their important role in human welfare, in food industry, in medicinally effective products and in biodegradation. Macrofungi were considered ideal for the purpose of evaluation as bio sorbents, because it has been demonstrated that many fungal species exhibit high biosorptive potentials. Work has been carried out on antimicrobial activities of lower fungi but edible mushrooms have not been adequately explored. The visible macroscopic fruit bodies have economic value as aesthetic components of the natural environment as food crop in the case of edible species. Studies on this subject, in fact, have been carried out in different countries and new species for the world macrofungal flora have been recorded. Macrofungi are also important components of the diet of many animals including soil invertebrates and small mammals (Boddy *et al.,* 2014).



Macrofungal Food Product Development

Macrofungal mycelia and fruiting bodies contain multiple nutrients and bioactive health components such as amino acids, proteins, dietary fibers, and active polysaccharides as well as functional components such as lovastatin, gamma-aminobutyric acid (GABA), and ergothioneine.

Thus, they are good sources of healthy food, nutraceuticals, and food-flavoring additives. At this time, novel applications for mycelia- and fruiting body-based macrofungal foods are being explored in the improvement of food flavor and nutrition. This approach might increase the industrial value of macrofungi without reducing product acceptability (Rathore *et al.,* 2019). Nowadays, macrofungi are used mainly in flourbased products such as breads and biscuits. They enhance the antioxidant and nutritional content of pasta, decrease the digestibility of its starch, and lower the glycemic response it induces (Lu *et al.,* 2018). A study conducted on Pleurotus sajor-caju powder disclosed that it could alter starch digestibility and granule structure in biscuits and improve postprandial glycemic response. When Agaricus bisporus polysaccharide was added to gluten-free flours, it had positive effects on the functional, pasting, rheological, and sensory properties of flour and biscuit doughs and made them fit for consumption by celiac patients (Sulieman *et al.,* 2019).

Macrofungus	Food products	Effect and result	References
Mycelia of *Antrodia camphorata, Agaricus blazei, Hericium erinaceus,* and *Phellinus linteus*	Bread	Higher umami intensity; maintenance of substantial amounts of GABA and ergothioneine	Ulziijargal *et al.,* 2013
Pleurotus sajor-caju fruiting body	Biscuit	Increased dietary fiber, β-glucan and protein content of biscuit and improve postprandial glycemic response	Ng *et al.,* 2017
Lentinus edodes	Rice noodle	Strengthen rice noodle extensibility and firmness	Heo, Jeon and Lee, 2014
Pleurotus sapidus	Vegan sausage	Alternative to commercial vegetable proteins	Stephan *et al.,* 2018
Grifola frondosa, Ganoderma lucidum	Fermented tea	Improve sensory flavor and therapeutic qualities of fermented tea	Terrien, 2017

Macrofungus-derived proteins may substitute for animal proteins in vegan sausage production) and serve as meat analogs. Macrofungal protein has higher acceptability than soybean protein. The use of macrofungi as meat substitutes has been investigated for the purpose of producing healthy functional foods and diminishing the environmental footprint of animal husbandry. Macrofungus powder may ameliorate the rheological and structural characteristics of meat emul sions and help formulate functional products with superior sensorial and other characteristics. Macrofungus powder might replace the phosphates used in emulsion-type sausages to minimize fat separation and lipid peroxidation and improve product flavor, taste, and acceptability. Macrofungi are also being exploited to develop novel tea beverages and fermented rice foods. In practice, however, there are comparatively few studies on the development of innovative macrofungus-based foods. Macrofungi are used in the production of kombucha, beer and health wine. Macrofungi are rich in numerous bioactive ingredients and metabolites.

Nevertheless, extracting these components from macrofungi for application in food ingredients requires further investigation.

The type of extraction method selected will affect the structure and yield of these bioactive ingredients, thereby influencing their biological activity. Therefore, it is necessary to establish practical and effective extraction methods that ensure the high yield of efficacious bioactive substances. Considerable attention has been directed toward the application of MPs in functional foods and health products. The most bioactive polysaccharides in macrofungi have complex structures and are indigestible in the host gastrointestinal tract. Hence, indigestible macromolecular MPs could serve as beneficial prebiotics for gut microbiota in the host intestine. Prebiotics modulate colonic microbiota composition, lower pH, increase SCFA production, and stimulate colonic immune responses in the colon. In certain cases, macrofungal prebiotics could function as costeffective substitutes for generally accepted and applied carbohydrate polymer and oligomer prebiotics such as fructooligosaccharides (FOS), galactooligosaccharides (GOS), and inulin. As a result of their particular physicochemical properties, MPs also serve as and gelation agents in aqueous media and form biofilms conducive to probiotic survival and antibiotic activity. Polysaccharides from the stipes of Lentinula edodes and the bases of Pleurotus eryngii and Flammulina velutipes prolonged probiotic survival during cold storage and in simulated gastric and bile juices. Hence, these materials could be used in yogurt. As macrofungi are rich in umami components, they have appealing flavors and are ideal foods flavoring agents. Non-volatile and volatile compounds in shiitake extract could enhance cooked minced meat flavour (Sknepnek *et al.,* 2018). The phenolic compounds in macrofungi have strong antioxidant and bacteriostatic activity and could, therefore, be applied in the food industry as natural antioxidants and antimicrobial agents (Bach *et al.,* 2019).

Artificial Macro fungus Cultivation

The bioactivity and structure–function relationships of the constituents in macrofungi have been clarified and reported. Nevertheless, only a few bioactive macrofungus derived components have been commercialized. Relatively few studies focused on high-quality macrofungi because the bioactive constituents were unstable and expensive and their yields were low or erratic (Giavasis, 2014). Hence, practical high-yield

macrofungus cultivation technology is urgently needed in order to meet market and consumer demands.

1.9. Conservation

Many macrofungi are becoming extinct or facing threat of extinction because of habitat destruction and global climate change (Pala *et al.,* 2012). Habitat degradation adversely influences the number of fruitbodies of macrofungi and diminishes the diversity of the fungal community (Rudolf *et al.,* 2012). Previous studies have shown that clear-cutting of old-growth forests affects the diversity and species composition of fruiting bodies (Osono and Trofymow, 2012). Macrofungi were long considered a strange group of organisms, poorly understood and difficult to study due to their mainly hidden nature and commonly sporadic and short-lived spore carps. Hence macrofungi have mainly been ignored and unnoticed in national and international nature conservation actions (Rang *et al.,* 2014).

1.10. Safety Concerns of Macrofungus Cultivation and Consumption

As they are rich in a multitude of bioactive components, macrofungi play important roles in food, health care products, as well as cosmetics. The potential toxicities, if any, are already known for most edible macrofungi. β-Glucan from G. lucidum has been used as a dietary supplement and food ingredient. It has not induced any significant subchronic toxicity in rodents and was not mutagenic (Chen *et al.,* 2011). These findings were consistent with those of subchronic toxicity and genotoxicity studies on β-glucan from Antrodia cinnamomea. The no observable adverse effects level (NOAEL) for mushroom β-glucan was 2,000 mg/kg BW/day. Though macrofungi abound in various active ingredients, only a few reports have indicated that edible macrofungi caused any negative effects in vivo (Rebolj *et al.,* 2007). A lethal protein in Agrocybe aegerita was linked to hepatotoxicity (Jin *et al.,* 2014). Sporadic intoxication events in humans and animals after the ingestion of large quantities of fresh macrofungi have been reported (Zuzek, Macek, Sepcic, Cestnik and Frangez, 2006). Thermo labile proteinaceous molecules in macrofungi may contaminate the culture environment as well as the edible macrofungal products themselves (Zuzek *et al.,* 2006).

The adverse effects of the toxins in certain edible macrofungi on human health remain controversial. It was reported that the ingestion of yellow knight mushrooms (Tricholoma equestre) could cause rhabdomyolysis (Bedry *et al.,* 2001). After extensive

and numerous human trials on T. equestre intake, however, no hematological or biochemical alterations and no other adverse effects were observed (Klimaszyk and Rzymski, 2018). Therefore, macrofungi toxicity and safety merit consideration. Systematic safety assessments should be conducted on macrofungi and the substances extracted from them. Concerns about food quality control and safety have increased along with the demand for macrofungi. To improve macrofungi acceptability, it is necessary to evaluate their safety and toxicity. Macrofungi growing in polluted areas accumulate heavy metals by absorbing them from the ambient environment (Melgar, Alonso and García, 2016).

Macrofungi may also accumulate radionuclides (Zou *et al.,* 2019; Chiocchetti *et al.,* 2020). In mycoremediation, macrofungi act as bio-sorbents and remove toxic metals from soil and wastewater. Macrofungi can also serve as biomarkers to assess environmental pollution levels. Pleurotus ostreatus decontaminated heavy metal pollution in colliery effluent (Vaseem, Singh and Singh, 2017). The secondary metabolites of macrofungi may also adsorb harmful materials. Alkali-soluble polysaccharides isolated from Boletus edulis have strong binding affinities for Cd and Pb (Choma *et al.,* 2018). Therefore, the endogenous toxins and environmental contaminants in edible macrofungi constitute serious food safety risks. Consequently, macrofungus cultivation on contaminated substrates and wildcrafted macrofungus harvest has constrained the development of the macrofungus industry. Cooking and digestion do not entirely eliminate heavy metal toxicity in macrofungi. As the bioactive constituents of macrofungi continue to be explored, the safety of macrofungi and their extracts must be carefully assessed. Heavy metal contamination in macrofungi raised in cultivation areas must be thoroughly investigated. Degradation of heavy metals by cooking and digestion should also be evaluated. Metabolite bioaccumulation in macrofungi in response to toxic and radioactive elements should be examined. Edible macrofungi may also be transmission routes of intracellular foodborne pathogens such as E. coli O157:H7, Listeria monocytogenes, Salmonella spp., Staphylococcus aureus, and Yersinia enterocolitica. For 402 samples of 22 species of cultivated and wild fresh mushrooms sold in retail markets, the microbial counts were in the range of 4.4 to 9.4 log CFU/g (Venturini, Reyes, Rivera, Oria and Blanco, 2011). Approximately 1.20% of 665 edible macrofungus samples tested positive for hypervirulent L. monocytogenes strains (Chen *et al.,* 2018). As a result, microbiological contamination and safety must be considered in macrofungus processing and consumption.

II. Materials and Methods

2.1 Study Area and Survey

Shimoga district is a part of the Malnad region of Karnataka and is also known as the 'Gateway to Malnad' or 'Malenaada Hebbagilu' in Kannada. The district is landlocked and bounded by Haveri, Davanagere, Chikkamagaluru, Udupi and Uttara Kannada districts. The district ranks 9th in the terms of the total area among the districts of Karnataka. It is spread over an area of 8465 km. Shimoga lies between the latitudes 13°27' and 14°39' N and between the longitudes 74°38' and 76°04' E at a mean altitude of 640 metres above sea level. The peak Kodachadri hill at an altitude of 1343 metres above sea level is the highest point in this district. Rivers Kalli, Gangavati, Sharavathi and Tadadi originate in this district. The two major rivers that flow through this district are Tunga and Bhadra which meet at Koodli near Shimoga city to gain the name of Thunga bhadra, which later joins River Krishna.

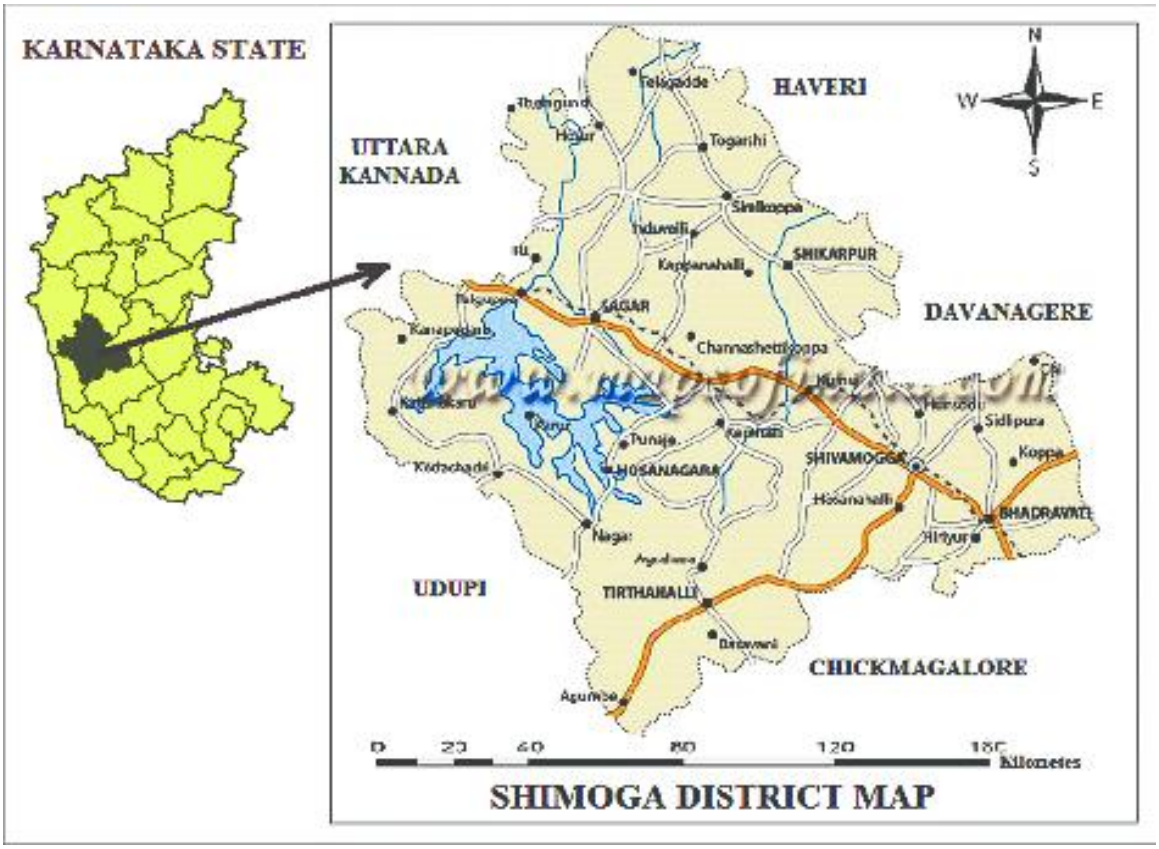


Figure 1: Shivamogga District map

As the district lies in the tropical region, rainy season occurs from June to October. Shimoga received an average annual rainfall of 1813.9 mm with an average of 86 days in

the year being rainy days. The average annual temperature of Shimoga district is around 26 °C. The average temperature has increased substantially over the years. In some regions of the district, the day temperature can reach 40 °C during summer. The major soil forms found in the Shimoga district are red gravelly clay soil; red clay soil lateritic gravelly clay soil; lateritic clay soil; medium deep black soil; non-saline and saline alluvo-colluvial soil; brown forest soil. The sporocarps encountered were collected and analysed for their identity. In the survey, macrofungi were identified by the presence-absence for sporomas. Surveys were done in 5 sampling plots of Shimoga district during June to August 2021.

Sampling

The study sites were plotted in 5 sampling plots of Shimoga district. A 50 X 20 m transect was measured out in each of the sampling plot. The study sites were selected randomly and macrofungi were collected within transects and characterized for further analysis.

2.2 Macrofungi Collection

The fungal survey depends on timing and location of observation. Necessary materials and equipments such as isolation kit, slants, petridishes containing medium, isolation chamber, typed data sheet, digital camera for photography, digging equipment, heat convector card board, chemical reagents for biochemical analysis were arranged and collection of samples were usually made during day time and field characteristics of mushrooms were recorded in the data sheet. Soft macrofungi were collected carefully by using forceps/free hand while the mushrooms growing on wood were collected along with small part of wood. The photograph was taken in their natural habitat. Each sample was wrapped in the paper envelop along with field notes, date of collection, habitat, locality and specimen number on tag.

2.3 Macrofungi Identification

The collected specimens were brought to the laboratory. The measurements of various parts of mushrooms were recorded and morphological features were observed. The taxonomy has been done on the basis of macro and microscopic characteristic according to the literatures. The morphological parameters used for the identification of

mushroom specimens such as- cap color, cap surface, cap margin, cap diameter, stipe length, gill attachment, gill spacing and spore dimension. Microscopic features were carried out using standard microscopic methods. The information of the various characters stated was used to identify each specimen by comparison with illustrations in color field guides and also by the use of descriptions and keys.

The specimens were dried in hot air at 40°-50°C and stored in air tight containers with some silica gel for further microscopic studies. The spores of collected mushrooms were mounted on slide by using glycerine and cotton blue for their size measurement. The spore diameter and the photograph of spores were calculated using the Motic Microscope (Motic images plus 2.0) with the magnification of 40x. Collected mushroom species have been categorized as edible, inedible and medicinal uses based on available world literature.

2.4 Diversity Analysis

A predesigned collection and data analysis procedures were used to collect the information in level of knowledge on biodiversity of mushroom. The density of different species has been determined by the following formula.

(%) Density = (Total number of individual of a particular species/ Total number of species) X 100

III. Results and Discussion

In the present study, macrofungal diversity in the Hosanagar taluk has been surveyed and documented. The classification is according to the Kirk et al. (2010) and also from Mycobank (http://www.mycobank.org/).

Taxonomy

1. *Agaricus augustus* (Fig. 2)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Agaricaceae, *Agaricus*

Pileus 18.0–45.0 mm diam, greyish brown, globose–campanulate to applanate, imbricate squamules, Lamellae 5.0 mm diam, brownish red to violet brown, free, thin,. Stipe 21.0–50.0×4.0–8.0 mm, brownish red to violet brown, equal, cylindric, solid to fistulose. Basidia 13.4–18.3×4.1–6.2 µm, Basidiospores 4.2– 6.5×3.2–4.7 µm.

2. *Aleuria aurantia* (Fig. 3)

Classification: Fungi, Ascomycota, Pezizomycotina, Pezizomycetes, Pezizomycetidae, Pezizales, Pyrenomataceae, *Aleuria*

Ascoma 5.0.0–25.0×5.0.0–25.0 mm, orange, solitary or clustered, leathery. Excipulum 2–layered. Subhymenium narrow. Asci 270.0–330.0×12.0–17.0 µm, cylindrical with rounded base, 8–spored, uniseriate. Paraphyses 1.2–2.5 µm, thick. Ascospores 22.2–30.3×11.3–13.6 µm.

3. *Auricularia auricula* (Fig. 4)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Auriculariomycetidae, Auriculariales, Auriculariaceae, *Auricularia*

Basidioma 5.0–10.0×30.0–120.0 mm, purplish grey to greyish magenta, thick, tough–gelatinous, gregarious or caespitose, convoluted at maturity, slightly ear– or shell–shaped, pruinose with fine short hairs, irregularly veined, sometimes appearing quilted. Basidia 5.4–8.3×65.2–80.5 µm, Basidiospores 11.2– 14.5×5.3–6.5 µm.

4. Bisporella sulfurina (Fig. 5)

Classification: Fungi, Ascomycota, Pezizomycotina, Leotiomycetes, Leotiomycetidae, Helotiales, Helotiaceae, *Bisporella*

Ascoma 5.0.0–25.0×5.0.0–25.0 mm, white, solitary or clustered, leathery. Excipulum 2–layered. Subhymenium narrow. Asci 270.0–330.0×12.0–17.0 µm, cylindrical with rounded base, 8–spored, uniseriate. Paraphyses 1.2–2.5 µm, thick, Ascospores 22.2–30.3×11.3–13.6 µm.

5. *Cantharellus formosus* (Fig. 6)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Cantharellales, Cantharellaceae, *Cantharellus*

Basidioma 25.0–65.0 mm diam, vivid yellow to yellow in margin, moist to dry, smooth. Lamellae dull yellow to greyish yellow, decurrent, narrow, distant, branched. Stipe 20.0–50.0×15.0–25.0 mm, yellowish white to pale yellow. Basidia 48.3–72.5×7.1–9.7 µm, Basidiospores 8.7–10.3×4.2–6.5 µm

6. *Clathrus delicatus* (Fig. 7)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Phallomycetidae, Phallales, Phallaceae, *Clathrus*

Immature Basidioma ('myco–eggs') 8.0–10.0 mm diam, arising from thick whitish mycelial strands, globose to ovoid, white to pale orange. Receptacle 15.0– 20.0×10.0–14.0 mm, hollow with latticed network, chalk white. Meshes 10.0-12.0 mm, polygonal, irregularly branched. Gleba olive brown, initially coralloid, mucilaginous, deliquescing. Volva pale white to light orange, thin. Basidiospores 1.0–2.2×3.6–4.8 µm.

7. *Clavaria miniata* (Fig. 8)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Clavariaceae, *Clavaria*

Basidioma 40.0–60.0×3.0–10.0 mm, red, solitary to gregorius to caespitose, erect, radial or cylindric, simple to forked, fleshy, acute to obtuse. Stipe 5.0–10.0×1.0–3.0 mm, cylindric, rarely solid. Basidia 35.5–43.2×4.0–6.1 µm, Basidiospores 4.3–6.2×2.5–4.1 µm.

8. *Clavulinopsis fuciformis* (Fig. 9)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Clavariaceae, *Clavulinopsis*

Basidioma 30.0–50.0×45.0–115.0 mm, white, broad, individual clubs 3.0–4.0 mm, solitary, caespitose, erect, medium–sized, radial, fleshy, smooth, glabrous. Stipe cylindrical, yellowish grey to greyish yellow, apices acute, concolorous. Basidia 5.8–6.4×11.4–13.5 µm, Basidiospores 4.1–7.4×6.2–9.5 µm.

9. *Clavulinopsis laeticolor* (Fig. 10)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Clavariaceae, *Clavulinopsis*

Basidioma 10.0–15.0×50.0–80.0 mm, vivid yellow to yellow, tall, caespitose, broad, gregarious, solitary. Stipe 3.0–12.0×1.0–2.0 mm, vivid yellow to yellow, once or twice forked. Branch cylindric, longitudinally furrowed, erect, hollow to solid. Basidia 22.5–35.6×3.8–5.6 µm, Basidiospores 5.2–6.5×4.2–4.9 µm

10. *Conocybe apala* (Fig. 11)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Bolbitiaceae, *Conocybe*

Pileus 12.0–18.0 mm diam, brown, hemispherical, light yellowish brown, smooth, dry, flesh thin, hygrophanous. Lamellae 4 mm, white to grey, crowded. Stipe 30.0–50.0×5.0–8.0 mm, white to grey, cylindrical, concolorous, hollow, whitish–pruinose above. Basidia 20.2–21.0×10.5–12.5 µm, Basidiospores 12.2– 16.4×6.5–8.0 µm.

11. *Conocybe lactea* (Fig. 12)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Bolbitiaceae, *Conocyb*.

Pileus 15.0–20.0 mm diam, orange brown, hemispherical, light yellowish brown, smooth, dry, flesh thin, hygrophanous. Lamellae 4 mm, white to grey, crowded. Stipe 35.0–50.0×5.0–8.0 mm, cylindrical, concolorous, hollow, whitish–pruinose above. Basidia 20.3–25.0×12.5–15.3 µm, Basidiospores 12.8–16.5×6.9–8.2 µm.

12. *Cookiena tricholoma* (Fig. 13)

Classification: Fungi, Ascomycota, Pezizomycotina, Pezizomycetes, Pezizomycetidae, Pezizales, Sarcoscyphaceae, *Cookeina*

Ascoma 5.0.0–25.0×5.0.0–25.0 mm, pale orange to light orange, solitary or clustered, leathery. Stipe 10.0–35.0×3.0–7.0 mm, pale orange to light orange. Hairs 2.0–5.0×70.0–135.0 µm. Excipulum 2–layered. Subhymenium narrow. Asci 270.0–330.0×12.0–17.0 µm, Ascospores 22.2–30.3×11.3–13.6 µm.

13. *Coprinopsis variegata* (Fig. 14)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Psathyrellaceae, *Coprinopsis*

Pileus 15.0–25.0 mm diam, brown, conical to expanded. Lamellae narrowly adnate, broad and distant, white to black. Stipe 25.0–45.0×10.0–20.0 mm, white, usually relatively short, pubescent. Basidia 15.2–32.0×8.5–10.5 µm, Basidiospores 7.2–10.5×6.2–7.5 µm

14. *Coprinus disseminatus* (Fig. 15)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Coprinaceae, *Coprinus*

Pileus 5.0–20.0 mm diam, bluish white, ovoid to campanulate, Lamellae white to grey, broadly adnate, narrow, crowded. Stipe 22.0–45.0×2.0–4.0 mm, grey to bluish grey, cylindric, glabrescent. Basidia 10.3–20.5×4.1–6.2 µm, Basidiospores 7.2–8.5×4.1–4.8 µm.

15. *Coprinus patouillardii* (Fig. 16)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Coprinaceae, *Coprinus*

Pileus 12.0–20.0 mm diam, brownish orange to brownish yellow, conical to expanded. Lamellae narrowly adnate, broad and distant, white to black. Stipe 20.0–40.0×12.0–25.0 mm, white, usually relatively short, pubescent. Basidia 15.5–30.5×8.4–9.5 µm, Basidiospores 7.0–9.5×6.2–7.8 µm

16. *Crepidotus variabilis* (Fig. 17)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Inocybaceae, *Crepidotus*

Pileus 5.0–20.0 mm diam, white, convex, reniform, minute, appressed margin thin, concolorous, undulate. Lamellae 4.0 mm diam, white, narrow to medium, crowded, Basidia 12.0–15.0×4.0–8.0 µm, Basidiospores 5.2–6.4 µm diam.

17. *Crepidotus sp.* (Fig. 18)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Inocybaceae, *Crepidotus*

Pileus 15.0–35.0 mm diam, white, convex, reniform, minute, appressed margin thin, concolorous, undulate, entire or lobed. Lamellae 4.0 mm diam, white, narrow to medium, crowded, Basidia 16.0–18.0×5.0–7.0 µm, Basidiospores 5.2–6.8 µm diam.

18. *Cyathus striatus* (Fig. 19)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Agaricaceae, *Cyathus*

Basidioma 15.0–25.0×5.0–10.0 mm, brown. obconic to variable with slender base and expanding outwards, covered with an irregular shaggy or wooly hairs. Epiphragm distinct, persistent. Peridioles 1.0–2.0 mm, dark brown, frequently roughly triangular and provided with a distinct pale tunica. Basidiospores 17.5– 20.6×7.6–11.2 µm

19. *Ganoderma applanatum* (Fig. 20)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Polyporales, Ganodermataceae, *Ganoderma*

Basidioma 270.0–450.0×90.0–180.0×25.0–40.0 mm, perennial, sessile. Dorsal surface orange white to light orange, crustose. Pore surface orange white. Pores 4.0–6.0 per mm, circular. Basidia broadly 17.5–24.5×8.7–10.2 µm, Basidiospores 6.4–8.5×4.5–6.3 µm

20. *Gloeophyllum odoratum* (Fig. 21)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Gloeophyllales, Gloeophyllaceae, *Gloeophyllum*

Basidioma 110.0–135.0×75.0–95.0×22.0–55.0 mm, perennial, pileate. Dorsal surface deep yellow to orange yellow, few strongly sulcate zones, margin round. Pore surface deep yellow to orange yellow, usually with a broad sterile margin. Pores regular 1.0–2.0 per mm, angular. Basidia 16.0–28.0×4.0–8.0 µm, Basidiospores 7.2–10.5×3.2–4.4 µm.

21. *Gymnopilus luteofolius* (Fig. 22)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Strophariaceae, *Gymnopilus*

Pileus 30.0–55.0 mm diam, white to reddish white at margin, surface greyish rose, plano–convex to umbilicate. Lamellae reddish grey, adnate, decurrent, crowded. Stipe 30.0–40.0×10.0–15.0 mm, white to reddish white, fibrous, concolorous with the pileus, fistulose. Basidia 17.1–23.4×3.4–5.6 µm, Basidiospores 3.4–4.6×2.1–3.3 µm.

22. *Gymnopilus sapineus* (Fig. 23)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Strophariaceae, *Gymnopilus*

Pileus 150.0–35.0 mm diam, brown, surface greyish rose, plano–convex to umbilicate. Lamellae reddish grey, adnate, decurrent, crowded. Stipe 20.0– 30.0×15.0–25.0 mm, white to reddish white, fibrous, concolorous with the pileus, fistulose. Basidia 15.5–22.5×3.5–5.5 µm, Basidiospores 3.4–4.5×2.0–3.5 µm

23. *Hygrocybe cantharellus* (Fig. 24)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Tricholomataceae, *Hygrocybe*

Pileus 15.0–30.0 mm diam, brownish red, subglobose to acutely conical, non–hygrophanous, viscid, drying at maturity, radially striate. Lamellae white to light orange, free. Stipe 32.0–58.0×5.0–9.0 mm, light brown, silky–fibrillose striate. Basidia 34.8–44.9×8.8–10.2 µm, Basidiospores 7.2–10.5×5.1–6.4 µm.

24. *Hygrocybe lanecovensis* (Fig. 25)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Tricholomataceae, *Hygrocybe*

Pileus 10.0–20.0 mm diam, vivid red, subglobose to acutely conical, non– hygrophanous, viscid, drying at maturity, radially striate. Lamellae light orange, free. Stipe 30.0–55.0×5.0–10.0 mm, light brown, equal, fistulose, silky–fibrillose striate. Basidia 35.5–42.5×8.0–10.5 µm, Basidiospores 7.5–10.5×5.2–6.6 µm.

25. *Hygrocybe miniata* (Fig. 26)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Tricholomataceae, *Hygrocybe*.

Pileus 15.0–25.0 mm diam, red to brownish red, subglobose to acutely conical, non–hygrophanous, viscid, drying at maturity, radially striate. Lamellae red, free. Stipe 30.0–60.0×5.0–10.0 mm, light brown, equal, fistulose, silky–fibrillose striate. Basidia 34.5–44.5×8.5–10.5 µm, Basidiospores 6.5–10.2×5.5–6.5 µm

26. *Hygrocybe psittacina* (Fig. 27)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Tricholomataceae, *Hygrocybe*.

Pileus 15.0–30.0 mm diam, greyish green, subglobose to acutely conical, non–hygrophanous, viscid, drying at maturity, radially striate. Lamellae greyish green, free. Stipe 30.0–45.0×5.0–8.0 mm, light brown, equal, fistulose, silky–fibrillose striate. Basidia 35.8–42.0×8.5–10.5 µm, Basidiospores 7.0–10.0×5.2–6.5 µm.

27. *Lepiota cristata* (Fig. 28)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Agaricaceae, *Lepiota*

Pileus 15.0–45.0 mm diam, white, convex to plano–convex, margin incurved to decurved to plane, fleshy, creamy white. Lamellae free, close, thin. Stipe 30.0– 40.0×5.0–8.0 mm, white, hollow at maturity. Annulus white, superior, thin. Basidia 20.5–20.0×4.5–10.0 µm, Basidiospores 5.0–7.0×3.0–4.5 µm

28. *Marasmius anomalus* (Fig. 29)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Marasmiaceae, *Marasmius*

Pileus 5.0–10.0 mm diam, brown to reddish brown, campanulate to convex, umbilicate, sulcate striate, glabrous. Lamellae 8.0–14.0 mm, greyish violet, distant. Stipe 12.0–60.0×1.0–3.0 mm, reddish brown, equal, glabrous. Basidia 24.1–28.3×6.2–7.5 µm, Basidiospores 16–20×3.0–4.5 µm

29. *Marasmius elegans* (Fig. 30)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Marasmiaceae, *Marasmius*

Pileus 5.0–15.0 mm diam, brown to orange brown, campanulate to convex, umbilicate, sometimes with a papillate umbo, sulcate striate, glabrous. Lamellae 6.0–12.0 mm, greyish violet, distant. Stipe 10.0–50.0×2.0–4.0 mm, brown to orange brown, equal, glabrous, smooth, shiny. Basidia 24.1–28.3×6.2–7.5 µm, Basidiospores 18–22×4.0–6.5 µm.

30. *Marasmius epidryas* (Fig. 31)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Marasmiaceae, *Marasmius*

Pileus 5.0–10.0 mm diam, orange brown to red brown, campanulate to convex, umbilicate, sometimes with a papillate umbo, sulcate striate, glabrous. Lamellae 8.0–14.0 mm, greyish violet, distant. Stipe 10.0–40.0×1.0–3.0 mm, dark violet, equal, glabrous, smooth, shiny. Basidia 20.5–25.0×5.5–7.5 µm, Basidiospores 15–20×3.0–4.5 µm.

31. *Marasmius epiphyllus* (Fig. 32)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Marasmiaceae, *Marasmius*

Pileus 5.0–10.0 mm diam, white to greyish white, campanulate to convex, umbilicate, sulcate striate, glabrous. Lamellae 8.0–14.0 mm, greyish violet, distant. Stipe 15.0–40.0×1.0–3.0 mm, dark violet, equal, glabrous, smooth, shiny. Basidia 22.0–25.0×6.0–7.0 µm, Basidiospores 15–18×3.0–4.5 µm.

32. *Marasmius haematocephalus* (Fig. 33)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Marasmiaceae, *Marasmius*

Pileus 8.0–15.0 mm diam, orange red to red, campanulate to convex, umbilicate, sulcate striate, glabrous. Lamellae 7.0–12.0 mm, greyish violet, distant. Stipe 10.0–50.0×1.0–3.0 mm, dark violet, equal, glabrous, smooth, shiny. Basidia 20.5–25.5×6.5–7.5 µm, Basidiospores 15–20×3.0–4.5 µm

33. *Micropus xanthopus* (Fig. 34)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Polyporales, Polyporaceae, *Microporus*

Basidioma 30.0–65.0 mm diam, stipitate, funnel shaped, corky, circular. Stipe 10.0–30.0×3.0–5.0 mm, light brown. Dorsal surface red to reddish brown, concentrically zoned, glabrous, shiny. Pores 6.0–8.0 per mm, regular, more or less round. Tubes 2.0 mm long, light pink. Basidia 9.2–13.4×2.7–4.1 µm, Basidiospores 4.1–6.1×1.4–2.4 µm.

34. *Parasola plicatilis* (Fig. 35)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Psathyrellaceae, *Parasola*

Pileus 15.0–35.0 mm diam, pale grey, ellipsoid or ovoid to campanulate or convex, sulcate–striate up to centre. Lamellae pale grey to dark grey free and remote from stipe.

Stipe 80.0–120.0×2.0–4.0 mm, white. Basidia 20.2–42.5×9.5–12.5 µm, Basidiospores 9.5–14.2×7.5–10.4 µm

35. *Phellinus igniarius* (Fig. 36)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Hymenochaetales, Hymenochaetaceae, *Phellinus*

Basidioma 40.0–70.0×25.0–40.0×15.0–20.0 mm, perennial, margin fertile or narrowly sterile, then yellowish—brown, tomentose. Dorsal surface dark brown, glabrous, rough. Pore surface white to orange white. Pores 6.0–7.0 per mm, circular, thick, entire dissepiments. Basidia 12.3–14.3×4.5–6.2 µm, Basidiospores 4.5–7.7×1.8–2.6 µm

36. *Pleurotus ostreatus* (Fig. 37)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Pleurotaceae, *Pleurotus*

Pileus 22.0–40.0×40.0–100.0 mm, white to orange white, subglobose to flabelliform. Lamellae white, decurrent, crowded. Stipe 12.0–15.0×5.0–8.0 mm, white, lateral, short, cylindric, solid, white, pubescent to glabrous. Basidia 20.5– 26.4×5.0–7.5 µm, Basidiospores 8.2–12.0×3.2–5.0 µm

37. *Polyporus tenuiculus* (Fig. 38)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Polyporales, Polyporaceae, *Polyporus*

Basidioma annual, laterally to centrally stipitate, solitary or clustered. Pileus 60.0–120.0×25–50.0×2.0–4.0 mm, circular or flabelliform. Dorsal surface white, glabrous, smooth, rugose on drying. Pores 5.0–8.0 per mm, circular to angular. Basidia 20.5–28.5×6.5–9.5 µm, Basidiospores 7.5–9.5×3.5–5.5 µm.

38. *Pycnoporus cinnabarinus* (Fig. 39)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Polyporales, Polyporaceae, *Pycnoporus*

Basidioma 55.0–70.0×105.0–130.0×27.0–40.0 mm, annual, sessile to effused–reflexed, leathery at young, dimidiate toelongate. Dorsal surface red glabrous, azonate. Pore surface red to high red. Pores 3.0–4.0 per mm, circular to angular, thick, tomentose dissepiments, thin. Basidiospores 5.7–7.2×2.5–3.3 µm.

39. *Ramaria botrytis* (Fig. 40)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Phallomycetidae, Gomphales, Gomphaceae, *Ramaria*

Basidioma 75.0–130.0×45.0–75.0 mm, greyish orange to golden yellow, broad, gregarious, solitary, erect, branched, fleshy, unequal, in alternate planes, primary branches

12.0–15.0 mm, broad, cylindrical, ultimate branchlets very small 3.0– 5.0 mm. Basidia 6.8–8.6×3.5–5.8 µm, Basidiospores 9.2–13.4×2.5–4.5 µm

40. *Ramaria rubella* (Fig. 41)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Phallomycetidae, Gomphales, Gomphaceae, *Ramaria*

Basidioma 50.0–100.0×25.0–55.0 mm, greyish pink, broad, gregarious, solitary, erect, branched, fleshy, unequal, in alternate planes, primary branches 10.0–15.0 mm, broad, cylindrical, ultimate branchlets very small 3.0–5.0 mm. Basidia 6.5– 8.5×3.0–5.5 µm, Basidiospores 9.5–12.5×2.5–4.0 µm

41. *Ramaria stricta* (Fig. 42)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Phallomycetidae, Gomphales, Gomphaceae, *Ramaria*

Basidioma 75.0–150.0×45.0–80.0 mm, greyish orange to golden yellow, broad, gregarious, solitary, erect, branched, fleshy, unequal, in alternate planes, primary branches 10.0–15.0 mm, broad, cylindrical, ultimate branchlets very small 3.0– 5.0 mm. Basidia 6.5–8.0×3.0–5.5 µm, Basidiospores 9.0–13.5×2.5–4.5 µm.

42. *Termitomyces clypeatus* (Fig. 43)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Lyophyllaceae, *Termitomyces*

Pileus 50.0–110.0 mm diam, white, cylindric–conical to convex, fibrillose silky, glabrous, margin irregularly lobed. Lamellae white, free, broad, crowded, lamellulae 2 lengths. Stipe 55.0–120.0×5.0–12.0 mm, white, solid, cylindric. Basidia 7.2–20.4×5.1–6.4 µm, clavate, Basidiospores 4.8–7.2×3.2–4.4 µm

43. *Tremella mesenterica* (Fig. 44)

Classification: Fungi, Basidiomycota, Agaricomycotina, Tremellomycetes, Tremellomycetidae, Tremellales, Tremellaceae, *Tremella*

Basidioma 30.0–60.0×20.0–40.0 mm, reddish yellow to deep yellow, firm–gelatinous. Basidia 42.4–50.6×6.3–12.4 µm ovate to globose, sterigmata often long and tortuous. Basidiospores 7.2–16.4×6.5–12.1 µm.

44. *Tremellodendron pallidum* (Fig. 45)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Auriculariomycetidae, Auriculariales, Exidiaceae, *Tremellodendron*

Basidioma 75.0–130.0×45.0–75.0 mm, white to greyish white, broad, gregarious, solitary, branched, fleshy, unequal, in alternate planes, primary branches 12.0–

15.0 mm, broad, cylindrical, ultimate branchlets very small 3.0–5.0 mm. Basidia 6.8–8.6×3.5–5.8 µm, Basidiospores 9.2–13.4×2.5–4.5 µm

45. *Trichoglossum hirsutum* (Fig. 46)

Classification: Fungi, Ascomycota, Pezizomycotina, Geoglossomycetes, Geoglossales, Geoglossaceae, *Trichoglossum*

Ascoma 50.0–150.0×10.0–30.0 mm, dark green to black, variable in shape, cylindric to cylindric-clavate to spathulate, usually unbranched, with rounded fertile apices. Perithecium 0.5–1.0 mm diam. Asci 160.0–230.0×6.0–14.0 µm, Ascospores 20.3–28.5×6.4–7.8 µm.

46. *Tricholoma album* (Fig. 47)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Tricholomataceae, *Tricholoma*

Pileus 20.0–70.0 mm diam, white, fleshy, convex to applanate, obtuse umbo, depressed, hygrophanous. Lamellae 6.0 mm diam, orange white, ventricose, crowded. Stipe 20.0–65.0×2.0–6.0 mm, pale orange to light orange, cylindric, firm. Basidia 33.2–37.5×8.2–11.8 µm, Basidiospores 8.3–10.7×4.5–6.2 µm.

47. *Tricholoma Sulphureum* (Fig. 48)

Classification: Fungi, Basidiomycota, Agaricomycotina, Agaricomycetes, Agaricomycetidae, Agaricales, Tricholomataceae, *Tricholoma*

Pileus 20.0–50.0 mm diam, orange grey to greyish orange, fleshy, convex to applanate, hygrophanous. Lamellae 6.0 mm diam, orange white, ventricose, crowded. Stipe 20.0–35.0×2.0–6.0 mm, pale orange to light orange, cylindric, firm. Basidia 30.0–35.5×8.5–11.5 µm, Basidiospores 8.5–10.5×4.0–6.5 µm

48. *Xylaria minuta* (Fig. 49)

Classification: Fungi, Ascomycota, Pezizomycotina, Sordariomycetes, Xylariomycetidae, Xylariales, Xylariaceae, *Xylaria*

Ascoma grey to dark brown, erect small, unbranched, clavate with pointed tip. Stipe 5.0–7.0×1.0–3.0 mm, short, Hymenial layer black zones of globose and angular. Perithecium 340.0–385.0×310.0–375.0 µm, globose to subglobose, ostiole papillate. Peridium 24.5–66.5 µm thick. Asci 67.5–71.8×5.5–7.2 µm, Ascospores 9.4–11.5×4.3–5.8 µm.

PLATE - I

Fig. 2. ***Agaricus augustus***

Fig. 3. ***Aleuria aurantia***

Fig. 4. ***Auricularia auricula***

Fig. 5. ***Bisporella sulfurina***

Fig. 6. ***Cantharellus formosus***

Fig. 7. ***Clathrus delicatus***

PLATE - II

Fig. 8. ***Clavaria miniata***

Fig. 9. ***Clavulinopsis fuciformis***

Fig. 10. ***Clavulinopsis laeticolor***

Fig. 11. ***Conocybe apala***

Fig. 12. ***Conocybe lactea***

Fig. 13. ***Cookiena tricholoma***

PLATE - III

Fig. 14. ***Coprinopsis variegata***

Fig. 15. ***Coprinus disseminatus***

Fig. 16. ***Coprinus patouillardii***

Fig. 17. ***Crepidotus*** **sp.**

Fig. 18. ***Crepidotus variabilis***

Fig. 19. ***Cyathus striatus***

PLATE - IV

Fig. 20. ***Ganoderma applanatum***

Fig. 21. ***Gloeophyllum odoratum***

Fig. 22. ***Gymnopilus luteofolius***

Fig. 23. ***Gymnopilus sapineus***

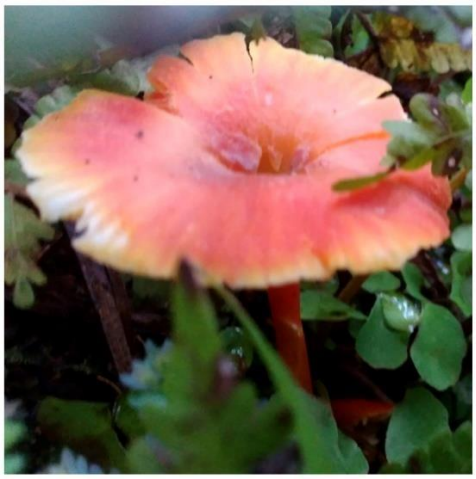


Fig. 24. ***Hygrocybe cantharellus***

Fig. 25. ***Hygrocybe lanecovensis***

PLATE - V

Fig. 26. ***Hygrocybe miniata***

Fig. 27. ***Hygrocybe psittacina***

Fig. 28. ***Lepiota cristata***

Fig. 29. ***Marasmius anomalus***

Fig. 30. ***Marasmius elegans***

Fig. 31. ***Marasmius epidryas***

PLATE - VI

Fig. 32. ***Marasmius epiphyllus***

Fig. 33. ***Marasmius haematocephalus***

Fig. 34. ***Micropus xanthopus***

Fig. 35. ***Parasola plicatilis***

Fig. 36. ***Phellinus igniarius***

Fig. 37. ***Pleurotus ostreatus***

PLATE - VII

Fig. 38. ***Polyporus tenuiculus***

Fig. 39. ***Pycnoporus cinnabarinus***

Fig. 40. ***Ramaria botrytis***

Fig. 41. ***Ramaria rubella***

Fig. 42. ***Ramaria stricta***

Fig. 43. ***Termitomyces clypeatus***

PLATE - VIII

Fig. 44. ***Tremella mesenterica***

Fig. 45. ***Tremellodendron pallidum***

Fig. 46. ***Trichoglossum hirsutum***

Fig. 47. ***Tricholoma album***

Fig. 48. ***Tricholoma Sulphureum***

Fig. 49. ***Xylaria minuta***

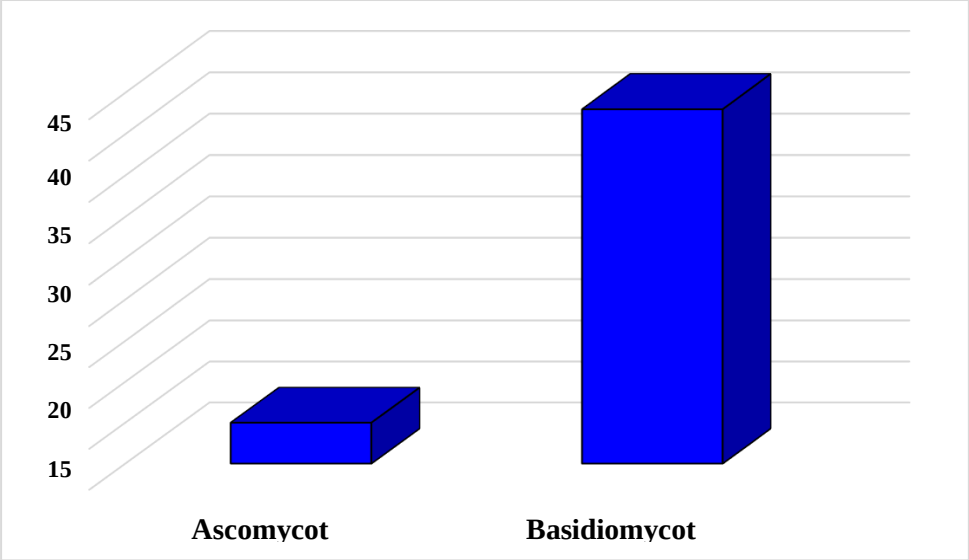


Figure 50: Total number of species occurred in Ascomycota and Basidiomycota of during 2021

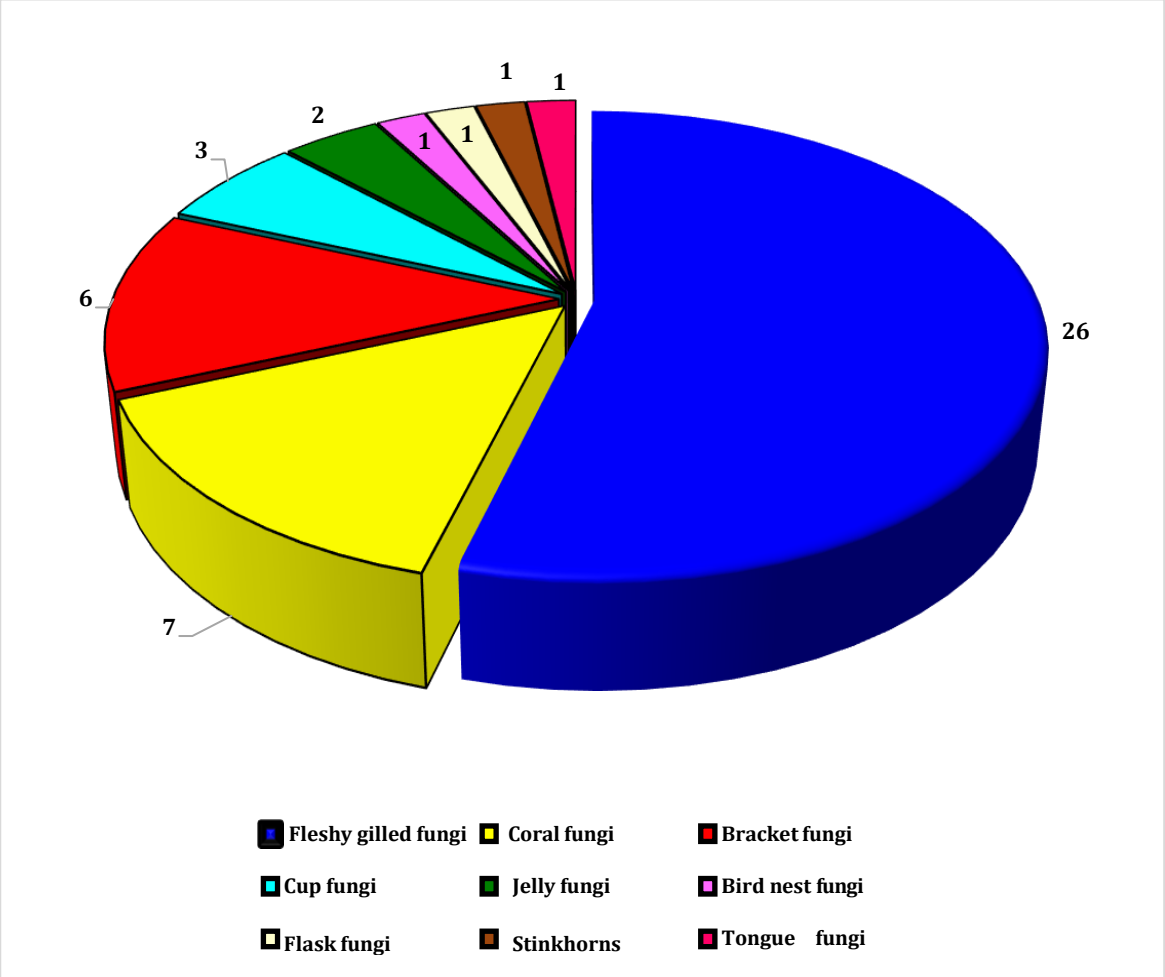


Figure 51: Total number of species occurring in different morpho-group

The survey was undertaken in five transects for documentation of macrofungi. The collected macrofungi belongs to 48 species, 33 genera, 26 families, two classes and nine morpho-groups. The collected species showed highest rate in basidiomycota with 43 species followed by five species in Ascomycetes (Fig.50).

Macrofungal studies were carried out in Hosanagar taluk according to their respective morphology during 2021 and encountered a total of nine different types of morpho-groups. The survey recorded 26 species in fleshy gilled fungi accounting for maximium species encountered during 2021 and second highest in coral fungi with seven species followed by six species (bracket fungi), three species (cup fungi), two species (Jelly fungi) and one each in birdnest fungi, flask fungi, stinkhorns and tongue fungi (Fig. 51). Families encountered in Hosanagar taluk during 2021 were enumerated. A total of 26 families were encountered. The highest species were found in Tricholomataceae and Marasmiaceae with six and five species respectively. Families with three species were found in Agaricaceae, Clavariaceae, Gomphaceae and Polyporaceae. Bolbitiaceae, Coprinaceae, Inocybaceae, Psathyrellaceae and Strophariaceae were associated with two species and the families with one species were Auriculariaceae, Cantharellaceae, Exidiaceae, Ganodermataceae, Geoglossaceae, Gloeophyllaceae, Helotiaceae, Hymenochaetaceae, Lyophyllaceae, Phallaceae, Pleurotaceae, Pyrenomataceae, Sarcoscyphaceae, Tremellaceae and Xylariaceae (Fig. 52). During three months study, species were recorded highest in *Marasmius* with five species followed by *Hygrocybe* (4 species), *Ramaria* (3 species) and *Clavulinopsis, Conocybe, Coprinus, Crepidotus, Gymnopilus, Tricholoma* (2 species) and *Aleuria, Auricularia, Bisporella, Cantharellus, Clathrus, Clavaria, Cookiena, Coprinopsis, Cyathus, Ganoderma, Gloeophyllum, Lepiota, Micropus, Parasola,, Phellinus, Pleurotus, Polyporus, Pycnoporus, Termitomyces, Tremella, Tremellodendron, Trichoglossum* and *Xylaria* possess only one species.

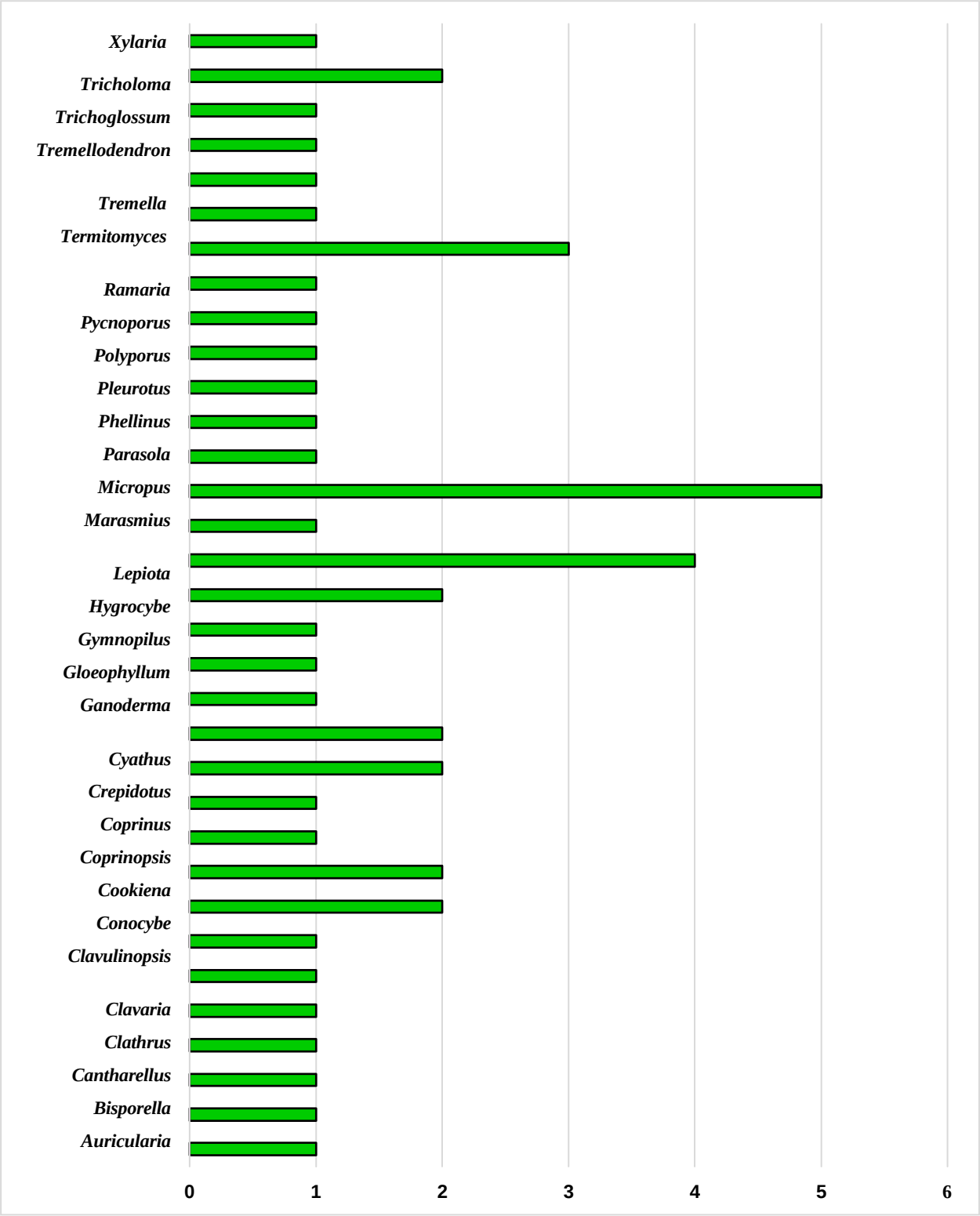


Figure 53: Total number of species in different genera

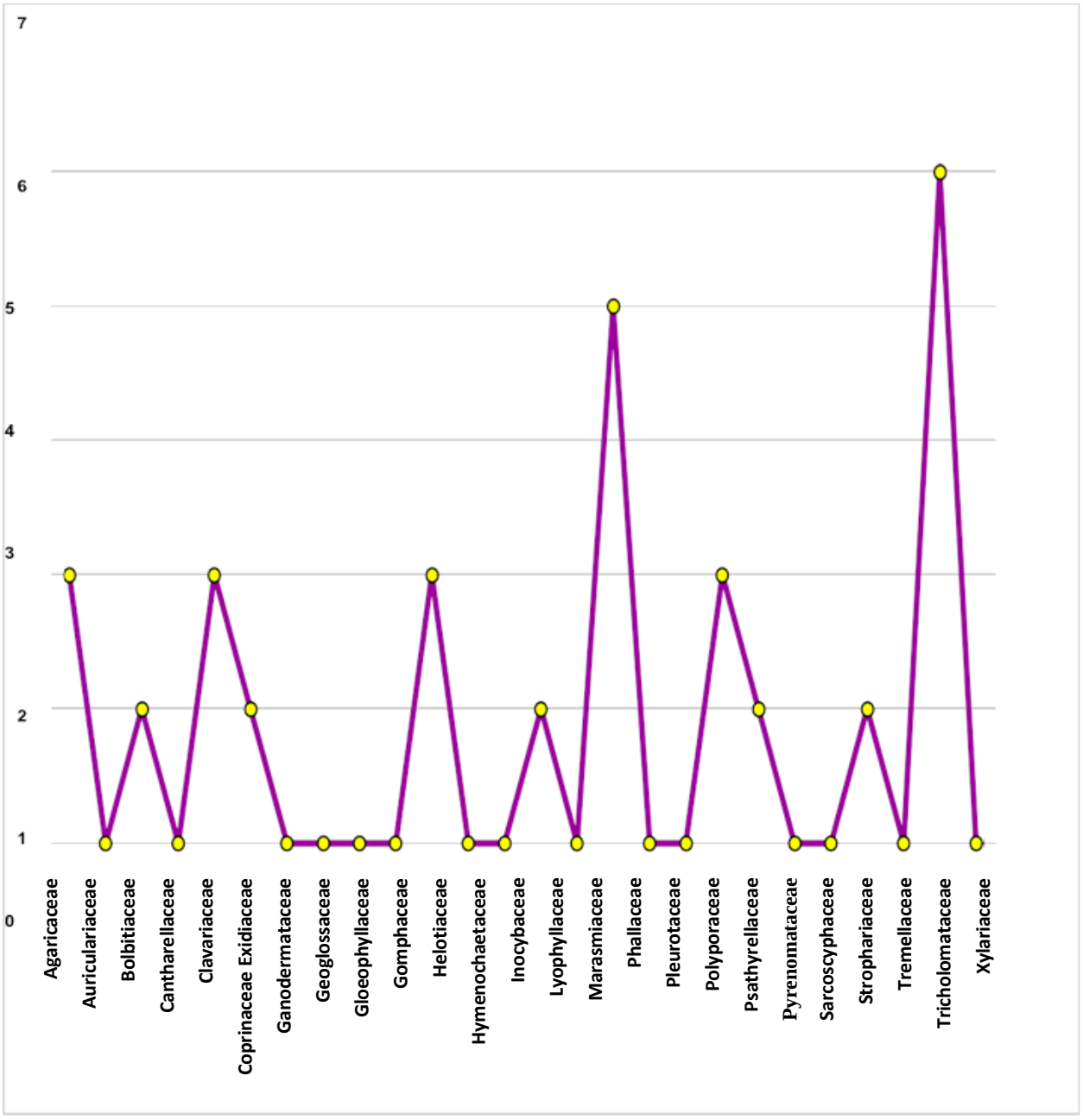


Figure 53: Total number of species

IV. Conclusion

The macro fungi are differentiated by containing spore bearing structures "Sporocarps" that are seen by naked eye, it consist of mushrooms, puffballs, bracket fungi, false-truffles and cup fungi are common examples of macro fungi. The study on macro fungal diversity in malnad region i.e. Shimoga district, Karnataka is conducted during the period of three months from June to August 2021 to identify and document the species which are present in the mentioned place. Abundance and diversity is more in rainy season than winter and summer. Mulching and moisture content of substratum play very important role in the growth of macrofungi. But the work usually needs more time because every time we wouldn't get the macrofungi in the study sites. The wood decaying fungi were usually present in all the seasons. In our study more number of species belongs to fleshy gilled fungi as the same species may need less rain or moisture content for its development and they found in the entire substratum. Some species were edible (Termitomyces clypeatus) and many species found to be non-edible. The same work has been dealt by researchers in the past, but our working duration is very short. However, the species collected were more in the short span of time.

V. References

Abrar S, Swapna S, Krishnappa M (2007). *Dictyophora cinnabarina*, Current Science, vol. 92, NO. 9, 10.

Abrar S, Swapna S, Krishnappa M (2008). *Bovista aestivalis* and *Calvatia craniiformis* – New records to India. Journal of Mycology and Plant Pathology 38: 504-506.

Abrar S, Swapna S, Krishnappa M (2012). Development and morphology of *Lysurus cruciatus* — an addition to the Indian mycobiota. Mycotaxon 122: 271-282.

Afyon A, Konuk M, Yagiz Helfer S (2005). A Study of wood decaying macrfungi of the western black sea region Turkey. MAycotaxon 93:319-322.

Ahmed S (1980). Gasteromycetes of West Pakistan. Bishen Singh Mahendra Pal Singh, Dehradun. Albatrellaceae from Mexico. Mycotaxon 37: 183-86.

Ali MBHB, Aschi-Smiti S (2013). Mycocoenologic study of the macrofungi on the forest of Jbel elbir (A€ın Draham, Jendouba, Tunisia). John Wiley and Sons Ltd, Afr. J. Ecol., 52: 1–9.

Baar, Jacqueline (1996). the ectomycorrhizal flora of primary and secondary stands of Pinus sylvestris in relation to soil conditions and ectomycorrhizal succession. Journal of Vegetation Science 7: 497-504.

Bach, F., Zielinski, A. A. F., Helm, C. V., Maciel, G. M., Pedro, A. C., Stafussa, A. P., .. Haminiuk, C. W. I. (2019). Bio compounds of edible mushrooms: In vitro antioxidant and antimicrobial activities. LWT, 107, 214–220.

Bai, J., Ren, Y., Li, Y., Fan, M., Qian, H., Wang, L., .. Rao, Z. (2019). Physiological functionalities and mechanisms of β-glucans. Trends in Food Science and Technology, 88, 57–66.

Bakshi BK (1971). Indian Polyporaceae. ICAR, New Delhi.

Baptista P, Martins A, Tavares RM, Lino-Neto T (2010). Diversity and fruiting pattern of macrofungi associated with chestnut (*Castanea sativa*). in the Tra´s-os-Montes region (Northeast Portugal). Fungal Ecology 3: 9-19.

Barrico L, Rodríguez-Echeverría S, Freitas H (2010). Diversity of soil basidiomycete communities associated with *Quercus suber* L. in Portuguese montados. European Journal of Soil Biology 46: 280-287.

Bates SC (2006). A Preliminary Checklist of Arizona Macrofungi. Canotia 2 (2).: 47-78.

Boddy L, Buntgen U, Egli S, Gange A C, Heegaard E, Kirk P M, Mohammad A, Kauserud H (2014). Climate variation effects on fungal fruiting. Fungal ecology I 0: 20-33.

Brown N, Bhagwat S, Watkinson S (2006). Macrofungal diversity in fragmented and disturbed forests of the Western Ghats of India. Journal of Applied Ecology 43: 11-17.

Chiang, S.-S., Liang, Z.-C., Wang, Y.-C., and Liang, C.-H. (2017). Effect of light-emitting diodes on the production of cordycepin, mannitol and adenosine in solid-state fermented rice by Cordyceps militaris. Journal of Food Composition and Analysis, 60, 51–56.

Cho, E. J., Oh, J. Y., Chang, H. Y., and Yun, J. W. (2006). Production of exopolysaccharides by submerged mycelial culture of a mushroom Tremella fuciformis. Journal of Biotechnology, 127(1)., 129– 140.

Dalby, M. J., Ross, A. W., Walker, A. W., and Morgan, P. J. (2017). Dietary uncoupling of gut microbiota and energy harvesting from obesity and glucose tolerance in mice. Cell Reports, 21(6)., 1521–1533.

Datta, H. K., Das, D., Koschella, A., Das, T., Heinze, T., Biswas, S., and Chaudhuri, S. (2019). Structural elucidation of a heteropolysaccharide from the wild mushroom Marasmiellus palmivorus and its immune-assisted anticancer activity. Carbohydrate Polymers, 211, 272–280.

De Silva, D. D., Rapior, S., Sudarman, E., Stadler, M., Xu, J. C., Alias, S. A., and Hyde, K. D. (2013). Bioactive metabolites from macrofungi: Ethnopharmacology, biological activities and chemistry. Fungal Diversity, 62(1)., 1–40.

Fadime Y, Mustafa I (2002). Macrofungi of degirmangobazy (Balikesir). Turk J Bot 26:161–164.

Giannaccini G, Betti L, Palego L, Mascia G, Schmid L, Lanza M, Mela A, Fabbrini L, Biondi L, Antonio Lucacchini A (2012). The trace element content of top-soil and wild edible mushroom samples collected in Tuscany, Italy. Environ Monit Assess 184: 7579–7595.

Gorbunova IA (2014). Biota of Agaricoid and Gasteriod Basidiomycetes of Dryad Tundras of the Altai_Sayan Mountain Area (Southern Siberia). Contemporary Problems of Ecology Vol.7: 39–44.

Gube M, Dörfelt H (2011). Gasteromycetation in Agaricaceae s. l. (Basidiomycota).: Morphological and ecological implementations. Feddes Repertorium 122: 5–6, 367–390.

Kabel, M. A., Jurak, E., Mäkelä, M. R., and de Vries, R. P. (2017). Occurrence and function of enzymes for lignocellulose degradation in commercial Agaricus bisporus cultivation. Applied Microbiology and Biotechnology, 101(11)., 4363–4369.

Karim M, Kavosi MR, Hajizadeh G (2013). Macrofungal communities in Hyrcanian forests, North of Iran: Relationships with season and forest types. Ecologia Balkanika vol.1, 1: 87-96.

Karlsson, F. H., Tremaroli, V., Nookaew, I., Bergström, G., Behre, C. J., Fagerberg, B.,Bäckhed, F. (2013). Gut metagenome in European women with normal, impaired and diabetic glucose control. Nature, 498, 99.

Kirk PM, Cannon PF, Minter DW, Stalpers JA (2010). Ainsworth and Bisby's dictionary of the fungi, 10th ed. CABI, UK.

Krishnappa M, Swapna S, Abrar S (2014). Diversity of macrofungal communities in Chikmagalur district of Western Ghats, India. Proceedings of the 8th International Conference on Mushroom Biology and Mushroom Products (ICMBMP8).

Liang, C.-H., Wu, C.-Y., Lu, P.-L., Kuo, Y.-C., and Liang, Z.-C. (2019). Biological efficiency and nutritional value of the culinarymedicinal mushroom Auricularia cultivated on a sawdust basal substrate supplement with different proportions of grass plants. Saudi Journal of Biological Sciences, 26(2)., 263–269.

Lin, S., Ching, L. T., Chen, J., and Cheung, P. C. K. (2015). Antioxidant and anti-angiogenic effects of mushroom phenolics-rich fractions. Journal of Functional Foods, 17, 802–815.

Liu, K., Wang, J., Zhao, L., and Wang, Q. (2013). Anticancer, antioxidant and antibiotic activities of mushroom Ramaria flava. Food and Chemical Toxicology, 58, 375–380.

Lu, X., Brennan, M. A., Serventi, L., Liu, J., Guan, W., and Brennan, C. S. (2018). Addition of mushroom powder to pasta enhances the antioxidant content and modulates the predictive glycaemic response of pasta. Food Chemistry, 264, 199–209.

Natarajan K, Senthilarasu G, Kumarasan V, Riviere T (2005). Diversity in ectomycorrhizal fungi of a dipterocarp forest in Western Ghats. Current Science 88: 1893-1895.

Niksic, M., Klaus, A., and Argyropoulos, D. (2016). Chapter 22 - safety of foods based on mushrooms. In V. Prakash, O. Martín-Belloso, L. Keener, S. Astley, S. Braun, H. McMahon, and H. Lelieveld (Eds.)., Regulating Safety of Traditional and Ethnic Foods (pp. 421–439). San Diego: Academic Press.

Ntougias, S., Baldrian, P., Ehaliotis, C., Nerud, F., Antoniou, T., Merhautová, V., and Zervakis, G. I. (2012). Biodegradation and detoxification of olive mill wastewater by selected strains of the mushroom genera Ganoderma and Pleurotus. Chemosphere, 88(5)., 620–626.

Pala SA, Wani AH, Bodha RH, Wani BA, Bhat MY, Mir RA, Taskeen-un-Nisa (2011). Two hitherto unreported macro-fungi from Kashmir; Himalaya. Bioresearch Bulletin 2: 130-134.

Pekşen A, Karaca G (2003). Macrofungi of Samsun province. Turk J Bot 27:173–184.

Penttilä R, Junninen K, Punttila P, Siitonen J (2013). Effects of forest restoration by fire on polypores depends strongly on time since disturbance – A case study from Finland based on a 23-year monitoring period. Forest Ecology and Management 310: 508–516.

Pushpa H, Purushothama KB (2012). Biodiversity of Mushrooms in and around Bangalore (Karnataka)., India. American-Eurasian J. Agric. and Environ. Sci., 12: 750-759.

Razaq A, Shahzad S and Ali H and Noor A (2014). New reported species of macro fungi from Pakistan. JAAS Journal. Vol. 2: 67-71.

Rebolj, K., Batista, U., Sepčić, K., Cestnik, V., Maček, P., and Frangež, R. (2007). Ostreolysin affects rat aorta ring tension and endothelial cell viability in vitro. Toxicon, 49(8)., 1211–1213.

Reis, F. S., Barros, L., Martins, A., and Ferreira, I. C. F. R. (2012). Chemical composition and nutritional value of the most widely appreciated cultivated mushrooms: An inter-species comparative study. Food and Chemical Toxicology, 50(2)., 191–197.

Reis, F. S., Martins, A., Vasconcelos, M. H., Morales, P., and Ferreira, I. C. F. R. (2017). Functional foods based on extracts or compounds derived from mushrooms. Trends in Food Science and Technology, 66, 48–62.

Reverchon F, Ortega-Larrocea MP, Pe´rez-Moreno J (2012). Soil factors influencing ectomycorrhizal sporome distribution in neotropical forests dominated by *Pinus montezumae*, Mexico. Mycoscience 53: 203–210.

Robledo GL, Renison D (2010). Wood-decaying polypores in the mountains of central Argentina in relation to Polylepis forest structure and altitude. Fungal Ecology 3: 178–184.

Sanchez, C. (2009). Lignocellulosic residues: Biodegradation and bioconversion by fungi. Biotechnology Advances, 27(2)., 185–194.

Sanchez, C. (2009). Lignocellulosic residues: Biodegradation and bioconversion by fungi. Biotechnology Advances, 27(2)., 185–194.

Senthilarasu G, Kumaresan V, Singh SK (2010). A new species of *Hygrocybe* in section firmae from Western Ghats, India, 111: 301-307.

Stojchev G, Asan A, Gucin F (1998). Some Macrofungi species of European part of Turkey. Turk J Bot 22: 341-346.

Swapna S, Abrar S, Krishnappa M (2008). Diversity of Macrofungi in Semi-Evergreen and Moist Deciduous Forest of Shimoga District-Karnataka, India. J Mycol Pl Pathol, Vol. 38, No. 1, 21-26.

Swapna S, Abrar S, Krishnappa M (2010). Development and morphology *of Clathrus delicatus* (Phallomycetidae, Phallaceae). from India. Mycotaxon 114: 319-328.

Tschen JS, Ho I, Hsu H, Tschen EF (2004). Distribution of macrofungi in the Quantaushi forest, a long-term ecological research site in Taiwan. Fung. Sci. 19: 1–19.

Upadhyay RC, Kaur A, Gulati A (2005). Dark spored agarics from North Himalaya, Journal of mycology and Plant Pathology 35(1).: 15-20

Usha N (2012). Diversity of Basidiomycetes in different regions of Karnataka (India). J Ecosyst Ecogr.

Yang, W., Guo, F., and Wan, Z. (2013). Yield and size of oyster mushroom grown on rice/wheat straw basal substrate supplemented with cotton seed hull. *Saudi J Biol Sci*, 20(4)., 333– 338.

Yoo, J. Y., and Kim, S. S. (2016). Probiotics and prebiotics: Present status and future perspectives on metabolic disorders. *Nutrients*, 8(3)., 20.

Zhang, K., Pu, Y.-Y., and Sun, D.-W. (2018). recent advances in quality preservation of postharvest mushrooms (*Agaricus bisporus*).: A review. *Trends in Food Science and Technology*, 78, 72– 82.

Zhang, Z., Lv, G., He, W., Shi, L., Pan, H., and Fan, L. (2013). Effects of extraction methods on the antioxidant activities of polysaccharides obtained from Flammulina velutipes. *Carbohydrate Polymers*, 98(2)., 1524– 1531.

Zhu, F. M., Du, B., and Xu, B. J. (2016). A critical review on production and industrial applications of beta-glucans. *Food Hydrocolloids*, 52, 275– 288.

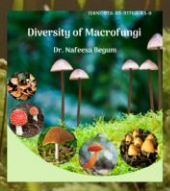
Diversity of Macrofungi

ISBN: 978-93-91768-43-0

About the Author

Dr. Nafeesa Begum studied her M.Sc. (1986) from Mysore University and Ph.D. (2008) in Environmental Science from Kuvempu University, Karnataka. She has 30 years of Teaching and 15 years of research experience. Presently, she has been working as Associate Professor in the Department of Botany, Sahyadri Science College, Shivamogga. She enjoys the distinction of authoring 01 book, 02 book articles and published more than 30 research papers in National and International Journals. She has attended various National/International conferences, Symposiums/Seminars and presented the research articles in various Universities, colleges and institutes of India. She has also participated in various workshops, Refresher courses, Orientation course, Faculty development and disaster management training programmes.

About the Book



Biodiversity includes not only many species that exist, but also the diversity of populations that makeup a species, the genetic diversity among individual life forms, and the many different habitats and ecosystem around the globe. Macrofungi are economically important due to their use in food, medicine, biocontrol, chemical, biological and other industries. The macrofungi are an integral part of ecosystem, their diversity and types are poorly studied, with a particular knowledge gap in the tropical regions including India. Macro fungi are diverse in their uses as food and medicine and several species serve as decomposers and also form mycorrhizal associations. Macrofungal diversity in malnad region Shimoga district, Karnataka was studied. Abundance and diversity is more in rainy season than winter and summer. Mulching and moisture content of substratum play very important role in the growth of macrofungi. In our study more number of species belongs to fleshy gilled fungi as the same species may need less rain or moisture content for its development and they found in the entire substratum. Some species were edible (Termitomyces clypeatus) and many species found to be non-edible.

Bhumi Publishing

ISBN 978-93-91768-43-0
9 789391 768430

Visit us:
https://www.bhumipublishing.com/