CERTIFICATE

This is to certify that Ms. H. Lalrinawmi has submitted the Ph.D Thesis entitled "**Study on Soil Mushroom in Aizawl District of Mizoram, India"** under my supervision, for the requirement of the award of the Degree of Doctor of Philosophy in the Department of Environmental Science, Mizoram University, Aizawl. The work is authentic, the content of the thesis is the original work of the Research Scholar and the nature and presentation of the work are the first of its kind in Mizoram. It is further certified that no portion(s) or parts of the content of the thesis has been submitted for any degree in Mizoram University or any other University or Institute. She is allowed to submit the thesis for examination and for the award of the Doctor of Philosophy in Environmental Science.

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03.05. 2019

DECLARATION

I, Ms. H. Lalrinawmi, hereby declare that the subject matter of this thesis entitled "**Study of Soil Mushroom in Aizawl District of Mizoram, India**" is the record of the work done by me, that the contents of this thesis did not form basis of award of any previous degree to me or to the best of my knowledge, to anybody else, and that the thesis has not been submitted by me for any research degree to any other University or Institute.

This is being submitted to the Mizoram University for the award of the degree of Doctor of Philosophy in the Department of Environmental Science.

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TABLE OF CONTENTS

Contents **Page No.**

List of Figures

List of Tables

CHAPTER – I

GENERAL INTRODUCTION

I.1. INTRODUCTION

Fungi are regarded as one of the most important components and diverse group of organisms in the ecosystem, comprising the largest biotic community after insects and include thousands of lineages, from the mushroom-forming fungi to yeasts, rusts, smuts, mold, and other symbionts with differing phenotypic and genotypic features (Hasan and Gupta, 2012). They are among the most important organisms in the world because of their vital role in ecosystem functions (Mueller and Bills, 2004). They make up one of the six kingdoms of the Linnaean Taxonomy System. They are neither plants nor animals. They do not contain chlorophyll like green plants and as a result they are a group of heterotrophic organisms that consist of a thallus, an assemblage of vegetative cells not forming tissue in the functional sense, and therefore not having differentiated organs. They reproduce by means of reproductive units called spores. The spores are dispersed into the environment and germinate and grow into a new mycelium with suitable moisture, temperature, and nutrient. Fungi normally inhabit the different parts of a plant body. A number of fungi produce large and conspicuous fruiting bodies and are often also called as macrofungi (Arnolds, 1992; Hawksworth *et al.*, 1995; Richards and Murray, 2002; Bates, 2006). They are broadly divided under the classes Chytridiomycetes, Zygomyces, Ascomycetes, Basidiomycetes and Mitosporic fungi.

They play one of the most essential components in decomposition processes, symbiosis and parasitism.

The term "mushroom" and its variations may have been derived from the French word *mousseron* in reference to moss (*mousse*). In ancient times, mushrooms have been treated as special kind of nutritious food. Greek warriors regarded them as “strength food”, Romans considered them as “food of Gods” whereas Chinese regarded mushrooms as “elixir of life”. The Aztecs of South America referred mushrooms as “teo- nonacte” (God’s flesh) and worshipped a group of mushrooms as being divine. In the Indian Rigveda and other ancient literature much referred “somrus” was actually a decoction of mushroom that is known by different names as Ksumpa in Sanskrit, Kukurmutta, Kavaka, Chhatra, Khumbi, Bhoomi kavak and Bhustrna in Hindi (Wasson, 1969). The history of the use of wild mushrooms as food and in medicine is well documented for many countries, and India is just one example (Kaul and Kachroo, 1975; Sagar *et al.*, 2005; Sharma *et al*., 2009; Karwa *et al*., 2010 and Giri *et al*., 2012).

Mushroom is a general term used for the fruiting body of macro fungi (Ascomycota & Basidiomycota) and represents only a short reproductive stage in their lifecycle (Das, 2010). They are seasonal fungi, occupying a diverse niche in nature in the forest ecosystem. They are the fruiting bodies of fungi especially of Class Ascomycetes or Basidiomycetes. Wild mushroom species also grow during different times of the year. Their habitats vary with species, but mostly they prefer damp areas especially those mushrooms that are growing in the soil. Some mushrooms grow only in summer and fall (poisonous jack-o'-lanterns) while others prefer spring to early summer (edible morels). Most mushrooms grow during the warm rains of spring, summer and fall; however, they predominantly occur during the rainy seasons. The most advanced group of fungi are the club fungi or phylum Basidiomycota, containing about 30,000 described species, or 37% of the described species of true fungi (Kirk *et al*., 2001).

The Mushrooms (macrofungi) have been defined by several authors. They are defined as the fleshy, spore-bearing fruiting bodies of fungi, which typically appear above ground after rain (Ainsworth et al., 1950). They are fungi that form macroscopic fruiting bodies, such as gilled fungi, jelly fungi, coral fungi, stinkhorns, bracket fungi, puffballs, and bird’s nest fungi (Hawksworth *et al*., 1995; Richard and Murray, 2002; Bates, 2006). They are macrofungi with distinctive fruiting body, which can either be hypogeous or epigeous, large enough to be seen with the naked eye & can be picked by hand. (Chang and Miles, 1992). They are forming macroscopic fruiting bodies (Dix and Webster, 1995). They maybe fleshy, sub-fleshy, leathery or woody and bear their fertile surface either on lamellae or lining the tubes, opening out by means of pores. Agarics are the lamellate members and the tube bearing poroid members are the boletes and polypores (Deshmukh, 2004).

Mushrooms are associated with almost all parts of living plants in terrestrial ecosystems. They are mostly common in soil, dead organic matters and on animal droppings, nectar and sap flows. Some mushrooms are either aggressive plant pathogen for wood decaying in nature. It is also found that all major timber trees and many ornamentals are symbiotically dependent on ectomycorrhizal symbionts, but some are pathogen of plant or fungi. Mushrooms fruiting on woody substrata are usually either saprobes or plant pathogens (Mueller *et al.,* 2007). Ecologically, they can be classified into three groups as the saprophytes, the parasites and the symbiotic (mycorrhizal) species.

Mushrooms as a whole are considered as the indicators of the forest life support system. The presence or absence of fungal species is a useful indicator to assess the damage or the maturity of an ecosystem (Stamets, 2000). The presence of visible fruiting bodies allows more easy access to information and their ecology is therefore better known than that of microfungi (Pollanen *et al*., 2001). Mushrooms are responsible for recycling of both natural and industrial forest waste. They can degrade complex polymers like lignin and cellulose. They also decompose the dead organic matter (Molina *et al*., 1993; Keizer, 1998; Pilz and Molina, 2001). In the biological world, diversity, economic value and environmental importance of mushrooms occupy a prominent place (Sarma *et al.*, 2010). They are extremely important beneficial organisms for several reasons. Fungi hold key roles in the maintenance of forest ecosystem including nutrient cycling, retention and formation of soil structure; food in detritivore food webs in forests and forest streams; micro- habitat creation in forests by fungal pathogens and mycorrhizal mutualisms (Moore *et al.,* 2001).

Soil mushroom are those that are growing in the soil. Soil is composed of both biotic and abiotic components. The biotic components like algae, fungi, bacteria, actinomycetes, nematodes and bacteria play a crucial role in decomposition of organic matter and release various kinds of nutrients present in organic matter. Fungi or macro fungi play an important role in the formation of soil and their fertility therefore richness of soil depends upon variation of fungal population increase in different kinds of soil (Nagmani and Kunwar, 2005).

Study of mushrooms have long been of interest to scientists due to their significant role in human life. They are used significantly in the daily life of agriculture, medicine (Cowan, 2001; Chang and Miles, 2004), food industry, textiles, bioremediation, natural cycling, in recycling nutrients and decomposing the dead organic matter (Molina *et al*., 1993; Keizer, 1998; Pilz and Monila, 2001, Lindequist *et al*., 2005; De Boer *et al*., 2005) in soil and litter (Hunt, 1999; Gates *et al.*, 2005), as bio fertilizers and many other ways.

Mushrooms have the longest history of studies of any mycota but are understudied all over the world. Mycologists continue to unravel the unexplored, hidden and fascinating fungal biodiversity as many mushrooms are becoming extinct or facing threat of extinction because of habitat destruction and global climate change (Swapana *et al.*, 2008). Besides their beauty, mushrooms play a significant role in the daily life of human beings in industry, agriculture, medicine, food industry, textiles, bioremediation, natural cycling, as biofertilizers and many other ways.

To date, there is no systematic reports of soil mushrooms in Mizoram. Thus, the present study was undertaken with the aim to generate a baseline data on taxonomy and diversity of the soil mushrooms in Mizoram.

I.2. OBJECTIVES

1. Taxonomical study of the specimens.
2. To study diversity of soil mushroom from forests sites.
3. To determine the physico-chemical characteristics of the soil.

CHAPTER – II

TAXONOMICAL STUDY OF THE SPECIMENS

II.1. INTRODUCTION

Mushrooms can be epigeous or hypogeous, large enough to be seen with the naked eyes and can be picked by hand (Chang and Miles, 1992). They are usually either saprobes or plant pathogens (Mueller *et al.,* 2007). Ecologically, they can be classified into three groups as the saprophytes, the parasites and the symbiotic (mycorrhizal) species. Macromycetes arranged in the phylum Basidiomycota and some of them in the Ascomycota are known as the higher fungi (Moradali, 2007; Sicoli, 2005). They mostly belong to different groups such as agarics, boletus, jelly fungi, coral fungi, stinkhorns, bracket fungi, puffballs and bird's nest fungi. They have a fertile surface either on lamellae or lining the tubes, opening out by means of pores. The lamellate members are often called agarics or gilled mushrooms and the tube bearing are called poroid mushrooms (Gogoi and Parkash, 2015).

The Ascomycetes and Basidiomycetes consist most of the mushroom species and are known as Higher fungi. The spores and spore bearing structures of mushrooms are large and are included in the class Ascomycotina and Basidiomycotina. They are borne on the gills or pores below the cap and the stipe raises the fruit body above the ground for the spore to dispersed by air currents. The spores are borne on specialized cells termed basidia in the Basidiomycetes or in sac like structures called ascus in Ascomycetes (Carlilie *et al*., 2001). The Ascomycota is the largest phylum of the

Kingdom Fungi, with approximately 32,000 species (Hawksworth *et al*., 1995). Three major groups or classes of Ascomycota, including Euascomycetes (mostly filamentous, sporocarp producing as well as mitosporic or conidial forms), Saccharomycetes (the true yeasts), and Archiascomycetes (a paraphyletic assemblage of basal taxa) generally are recognized (Taylor *et al*., 1994).

The most advanced group of fungi are the club fungi or phylum Basidiomycota, containing about 30,000 described species, or 37% of the described species of true fungi (Kirk *et al*., 2001).

In this chapter, the taxonomy of mushrooms in selected sites of Aizawl districts, Mizoram was studied with an effort to compile a taxonomical description of the species of the region.

II.2. REVIEW OF LITERATURE

The study of taxonomy of mushrooms started with Species Plantarum (1753), in which Linnaeus recognized one mushroom of the genus, *Agaricus* among 10 fungal genera, which include all the gilled bearing fungi. Persoon (1796, 1797) established the first classification of mushrooms which stands as a starting point for fungal nomenclature and was considered as the founder of modern mycology. Fries (1821-1832) further elaborated the classification of fungi, including various microscopic characteristics and color of the spore color, the methods which are still in use by taxonomists today. Leveille (1846) and Berkeley (1856) were considered as the first to recognize that the basidia and basidiospores are different from asci and ascospores. Saccardo (1882-1931) also laid emphasis on the importance of spore color in the mushroom taxonomy and thus recognized four sub–divisions of agarics based on their spore color. Singer (1986) also emphasized the spore color in the taxonomy of mushroom in his monograph and recognized 17 families, 230 genera and 5658 species under order Agaricales.

Studies on mushrooms and their various aspects have been carried out in different part of the world (Laferriare, 1990; Peck, 1873; Stojchev, 1995). Ahmed (1941, 1952, 1978) published excellent information about taxonomy and distribution of various fungal groups from Pakistan. Khan *et al*., (1980) also described edible mushrooms from Pakistan. Batra (1983) collected edible discomycetes from Pakistan, North Eastern India and Afghanistan. Zoberi (1972) described systematically a range of tropical mushrooms belonging to 25 families. Huang (1993) had studied and documented the mushrooms in China and Japan. Moser (1983) worked on the Agarics and Boletes in England, and Pegler (1977) in Africa. Arora (1986) had done a systematic and comprehensive study of fleshy fungi on mushrooms. Zhang *et al.* (2004) studied the genus *Amanita* and found that *Amanita* contains about 500 species, including some of the most toxic known mushrooms distributed worldwide. Gates *et al.* (2005) had a comparative study on the mushrooms in southern Tasmania Tas forest. Miller *et al. (*2006) reported that there are around 750 worldwide species of mycorrhizal mushrooms. According to Mueller *et al.* (2007), a total of 21,679 names of mushrooms were compiled. An additional approximately 35,000 macrofungal species were estimated. This would give an estimated total of 56,679 mushrooms in the world. Kirk *et al*. (2008) recognized 85 genera in the family Agaricaceae.

The list of fungi in India was first reported and published by Butler & Bisby (1931) and was revised by Vasudeva (1960). Later, Bilgrami *et al*. (1979, 1981, 1991) published many additional lists of Indian fungal species. The systematic study of Indian Agaricology seems to have occurred in three phases (Sathe and Sasangan, 1977). Phase I (1825- 1899), Phase II (1900-1969) and Phase III (1970-onwards). The main contributors in the first phase was Berkeley (1851, 1852a,1852b, 1867, 1876) dealing collection of 159 species of mushrooms from Assam, Darjeeling, Sikkim, Calcutta, Masulipatnam and Madhya Pradesh. Cooke (1880) reported nine mushroom species mostly collected from Bombay, Andaman, Island, Saharanpur, Madras and Nepal. Henning (1990, 1991) described 72 species, Bose and associates (1920) recorded about 34 species, Ginai (1936) recorded two species of *Coprinus* from Punjab, Banerji (1947) reported 42 agarics belonging to 14 genera from Calcutta. Ghosh and Pathak (1962) described three species of *Macrolepiota* from Lucknow. In the second phase Massee (1898) recorded 32 species of mushrooms. There are a number of significant contributors in the third phase. Saccardo (1882-1931); Kirtikar and Basu (1918) have reported some Indian mushrooms in their books. Sathe and Sasangan (1974, 1977) and his team work on the manographs and taxonomic studies on mushrooms of the order Agaricales in India. Sathe and Rahalkar (1975) were the first to review the status of Indian Agaricales which was followed by Manjula (1983), providing list of Agaricoid and Boletoid fungi from Nepal and India which was updated by Natarajan *et al.* (2005). Natarajan (1979) described a new species *Termitomyces heimii* from India. Manjula (1980) also carried out taxonomic studies of mushrooms in South India. Watling and Gregory (1980) recorded 119 taxa of mushrooms from Kashmir which was later extended to 145 species (Beigh *et al.*, 2008), 150 (Dar *et al*., 2009a) from Kashmir and 250 from whole Jammu and Kashmir (Dar *et al.*, 2009b). Sathe & Kulkarni (1987) published a checklist of 44 species of wild edible mushrooms from southwestern India. Atri and Saini (1989, 1994) published the checklist of Indian Russulaceous species wherein 48 species of *Lactarius* and 67 taxa of *Russula* have been listed. Kumar *et al.* (1990) studied mushrooms from Dheradun, India. Sheikh and Banaras (1991) described morels (*Morchella*) hybrid from Jammu and Kashmir. Arnolds, (1992), Brown *et al.* (2006) studied mushrooms in the Western Ghats of India. Gupta *et al.* (1994) reviewed Agaric systematically on Indian work with 261 collections falling in 66 taxa, which include 4 new species. Saini and Atri (1995) reviewed exploratory work on mushrooms from Punjab and listed 94 taxa spread over 24 genera. Natarajan (1995) reported 457 species of agarics spread over 76 genera from South Indian region, excluding Kerala. Bhavani Devi (1995) reviewed on mushrooms from Kerala. Patil *et al.* (1995) listed 212 species of Agarics spreading over 63 genera from Maharashtra. Lakhanpal (1996, 1997); Atri *et al.* (2000) has recorded many species of *Russula* and *Amanita* from conifer forests of Kashmir, Gardezil and Ayoub (2003) also described eight species of *Russula* from Azad Kashmir. Besides these contributions and reports, many researchers have also contributed to the study of mushroom flora of Himalayas and have reported more than 250 species like Abrahim and Kaul (1985, 1988); Abrahim and Kachroo (1989). Lakhanpal, (1996) compiled the family Boletaceae into a monograph: Mushrooms of India-Boletaceae recording 7 genera and 57 species which include 5 new species and an equal number of new varieties. Rahi, (2001), Upadhyay (2004) had reported and described several mushrooms on their morphological basis from Amarkantak region, Madhya Pradesh. Hyde (2003) concluded that the taxonomic studies of Indian macro fungi have recently been reported to be in due line and this is a rising cause of concern among mushrooms conservationists especially when, so little is known, and much is waiting to be explored. Natarajan *et al.* (2005a, 2005b) published a checklist of Indian agarics and boletes and the taxonomy of Agarics has been carried out in Western Ghat region. Semwal *et al.,* (2006) illustrated a section of *Amidella* of the genus Amanita namely *Amanita avellaneosquamosa* for the first time in India. Dar *et al*. (2010) described four new species of *Russula* from India. Mohanan (2011) illustrated the monographs of mushrooms upto 550 species in 166 genera and 51 families from Kerala. Tanti *et al.* (2011) identified 13 fleshy fungi species under 9 genera and 6 families of wild edible fungi from Kohima district of Nagaland. Pushpa and Purushothama (2012) reported 90 species in 48 genera belonging to 19 families in 5 orders, out of which 28 species were reported for the first time in India. Farook *et al.* (2013) compiled a literature-based checklist of agarics with 616 species occurring in Kerala State. Amandeep *et al.* (2015) deals with the taxonomy of nine species belonging to the family Agaricaceae of Punjab. Borkar *et al.* (2015) reported 29 mushroom species from Konkan region of Maharashtra.

The North Eastern hills of India being the transitional zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions makes the gate way for many of India's flora and fauna. It is one of the biodiversity hotspots of the world (Myers *et al.*, 2000). Northeast India is also very rich in mushroom flora (Verma *et al.*, 1995). Very few works on mushroom diversity has been carried out in North Eastern region of India. Bhattacharrya and Barua (1953) studied the distribution and description mushrooms found in Assam. Baruah, (1971); Barua, (1998); Agrahar-Murugkar, (2005); Sarma *et al*., 2010; Srivastava and Soreng (2014) reported wild edible mushrooms from Assam, Arunachal Pradesh, Meghalaya, Manipur, Jharkhand. Verma *et al.* (1995) listed 95 species of mushrooms from North Eastern hills of India. Das, (2009) reported 126 wild mushrooms from Barsey Rhododendron Sanctuary, Sikkim. Tanti *et al.*, 2011; Ao *et al.*, 2016 also reported a few collected of mushrooms from Nagaland. Work on Wood rotting fungi of Meghalaya was done for the first time by Zothanzama (2011a) and recorded 53 species of mushrooms from the State. Khaund and Joshi (2013) recorded 11 different species belonging to 9 genera and 8 families of edible mushrooms from Meghalaya. Gogoi & Parkash (2015a, 2015b, 2014), Khaund & Joshi (2014), Tanti *et. al.* (2011), Boruah *et al.* (1997), and Sing & Sing (1993) reported a few numbers of wild mushrooms from Assam and NE India. Gogoi and Parkash, (2015) reported 138 species of gilled mushrooms belonging to 48 genera, 23 families, five orders of the class Agaricomycetes, division Basidiomycota from Assam. Ao *et al.* (2016) reported 87 species of wild mushrooms from Nagaland. Kalita *et al.* (2016)

recorded 22 mushrooms species representing 16 genera, 14 families and 6 orders from Meghalaya.

In Mizoram, macro fungal or study of mushroom especially with regard to their taxonomy has not yet been done much except for those that are wood decaying (Bisht, 2011; Zothanzama, 2011b). Little information about the soil mushrooms of Mizoram were reported by Bisht (2011). An investigation has been done on mushrooms and only few mushrooms have so far been known and named (Zothanzama, 2011a; Zothanzama, 2011b; Bisht, 2011; Zothanzama and Lalrinawmi, 2015; Lalrinawmi and Zothanzama, 2016a; Lalrinawmi and Zothanzama, 2016b; Zothanzama *et al.,*2016 and Lalrinawmi *et al.*, 2018).

II.3. MATERIALS AND METHODS

II.3.1. Study Area, Climate and Vegetation

Collection of the soil mushroom was carried out from two different forests in Aizawl District i.e., Hmuifang and Mizoram University Campus.

Hmuifang forest

Hmuifang is situated in the southern part of Aizawl. It is a village in Aibawk Tehsil, Aizawl District, Mizoram State. It is about 50 km from Aizawl with an elevation of 1619 meters above sea level. The area lies between the coordinates 92°45'19"E - 92°45'24"E longitudes and 23°27'22"N - 23°27'31"N latitudes. Hmuifang is also the source of Tuirial River. The mountain is still covered with virgin forests reserve. The mountain has beautiful cliffs and offers great views of the surrounding hills. The texture of the soil falls under the loamy sand. The forest falls under tropical semi-evergreen forests (Champion and Seth, 1968).

Under the Koppen Climate Classification, the study site comes under the Humid subtropical climate (Cwa). The average annual rainfall during the study period May, June, July, August, September and October 2014, 2015 and 2016 is 472.5, 454.38, 475 (Figure 3). The average annual temperature in May, June, July, August, September and October 2014, 2015 and 2016 19.56 20.62 ºC, 19.81 ºC, 19.56ºC respectively during the study period (Figure 4, Thermometer).

The common tree species were *Dipterocarpus retusus, Helicia excelsa, Lithocarpus xylocarpus, Symplocos racemosa, Dryptes indica, Elaeocarpus rugosus,* etc.

Figure 1. Forest floor of study site-1

Mizoram University Campus

Mizoram University is in the Western side at a distance of about 19 kms away from the state capital, Aizawl, just below Tanhril Village. The Mizoram University Campus is about 980 acres in area and lies between 23^{o}45’25” N - 23^{o}43’37” N latitudes and 92^{o}38’39” E - 92^{o}40’23’E longitudes. The elevation ranges from 330m to 880m above mean sea level (msl). Soils under forest cover are porous, sandy loam and humus whereas the open areas are covered with coarse sandy, friable and lateritic and the top soils have been washed away by run-off.

The climate of Mizoram University is humid and tropical, characterized by short winter and long summer. The average annual rainfall during the study period May, June, July, August, September and October 2014, 2015 and 2016 is 306.95, 361.87, 405.57

(Figure 3). The average annual temperature in May, June, July, August, September and October 2014, 2015 and 2016 is 24.01 ºC, 24.32 ºC, 24.54 ºC respectively during the study period (Figure 4).

The common tree species were *Castanopsis tribuloides*, *Schima wallichii, Aporusa octandra, Alseo daphne petiolaris, Styrax serrulatum, Michelia champaca; Rhus semialata; Saurauia punduana, Lithocarpus xylocarpa, Macaranga indica, Callicarpa arborea,* etc.

Figure 2. Forest floor of study site-2

II.3.2. Mushroom taxonomy studies

Morphology and terminology

This section deals with the macroscopic and microscopic characters and various scientific terms used in the text for describing taxonomic details of mushrooms in the ongoing account. The morphological and microscopic observations such as pileus, lamellae, stipe, basidiospores, basidia were studied by following the method of Bas (1969), Singer (1986), Arora (1986), Surcek (1988), Ainsworth *et al*., (2001) and Mohanan (2013).

Macroscopic characters

The macroscopic features of mushroom which play an important role in taxonomical study of mushrooms has been discussed along with their taxonomic importance.

The Pileus

The pileus or cap is an important structure that supports the spore-producing surface (gills or lamellae, pores, etc.). It is described by various features such as size, shape, margin, moisture or viscidity, texture, scales or warts, color, change in color on exposure or sliced and other surface features play an important role in immediate identification and broad categorization of mushrooms in the field during collection and in the future.

Size and Shape

Size is an important feature for comparison. The size and shape of the pileus of most fruiting body of mushroom varies with age. The shape includes flat, convex, concave, parabolic, conical, cylindrical, bell shaped (campanulate), infundibuliform (funnel-shaped), at the center of the pileus there may be a depression (centrally depressed), or a protrusion (umbonate), vase-shaped.

Margin

Smooth and entire, wavy-undulating, crenate, striate or non- striate, zoned concentrically and plane, incurved, inrolled, straight, or upturned.

Moisture content

The cap surface may be dry or moist. If the cap is gelatinized it may be glutinous (slimy) or viscid (sticky).

Color

One of the most noticeable features of a mushroom is the color of the pileus. However, if not noted carefully it can often lead to misidentification as it undergoes variable color or discolor with age or when cut, bruised or mishandling. Mushrooms color are highly sensitive to environmental factors. Color varies from white, whitish cream, creamy, pale yellowish, yellowish, orange, orange-yellowish, reddish, dingy orange, grayish, brownish, pinkish, maroon, and many more or mixture of these colors.

Surface

The surface of the pileus may be smooth, wrinkled, striate, regular, slimy, viscid, striate, fragile, brittle, dry, moist, shiny, glabrous, dull, hydrophanous. It may also be atomate (minute shining particles), pulvurulent, scurfy, granulous, silky, fibrillose, floccose, tomentose, scaly, leathery, hairy, corrugated or cracked.

Flesh

The color of the flesh may change on exposure or sliced or bruised. The texture, thickness, odor when crushed and the taste of the flesh play a significant character for distinguishing species. It may be either mild or sour, acrid, spicy or peppery.

The Lamellae

The lamellae or gills of a mushroom are the thin, radiating blades or plate like structures that are found on the underside of the pileus, they radiate out from the stipe and produce the spores. It is described by various features such as mode of attachment to the stipe, width, spacing, thickness, forking pattern (if any), color, margin or edges, bruising when sliced, presence or absence of lamellulae.

Attachment

The easiest way to observe lamellae attachment is to slice or cut a mushroom in half longitudinally. The attachment of the lamellae to the stipe may be recurrent, adnate, free, sinuate or adnexed. This character plays an important key character for supporting character at generic level and also in broad groupings while preparing the taxonomic keys.

Shape and width

The shape and width of the lamelllae may be variously spaced or narrow, moderately broad, broad, or sometimes ventricose in the middle and gradually tapering towards the ends.

Margin or edges

Most lamellae have thin edges that may be minutely fringed or toothed, smooth, wavy, serrate, crenate, eroded, dentate, fimbriate or glistening. This is an additional character which helps in easier identification of such species.

Color

The color of the lamellae may be white, yellowish white, pale, pale yellow, pinkish, purple greenish, yellow to ochraceous or even light brown. The color may be changing on exposure or cut. Color variation of the lamellae during the developmental stages provides an important key character in taxonomy for segregation of closely allied taxa.

Lamellulae

Lamellulae are short gills which extend only part of the way from the margin of the pileus to the stipe i.e. these are short lamellae. Lamellulae may be absent or abundant with one set or series may be present between adjacent lamellae and may extend approximately one half to one third the length of the complete lamellae. They are important characters for taxonomic segregation.

The Stipe

A stipe or stalk is a stem like structure supporting the cap of a mushroom which elevates the pileus to a sufficient height so that most of the spores can be discharged from the lamellae into the air. Some features of the stipe include size, shape, colour, color changes, position or attachment, texture, surface characteristics, viscidity, presence or absence of volva, veil or annulus.

Shape, size

The shape and size of the stipe can be extremely variable, they may be equal or cylindrical, tapering toward the base or apex, clavate, ventricose. The base may be bulbous, abruptly bulbous, unswollen or tapering to a rootlike growth or may have mycelium at the base or may be absent.

Attachment and position

The stipe is usually located at the center of the pileus, eccentric or lateral attachment to the pileus.

Color

The stipe color varies from white to cream, pale yellow, grey, yellowish, range-yellowish, orange-brownish, pink, maroon, brown to reddish or more or less like the pileus, etc. Any color change when cut or bruised is important for taxonomic segregation.

Texture

The texture of the stipe may be smooth, dotted, ridged or wrinkled, striate, veined, lined, netted, scaly, polished, fibrillose, powdery, hairy. It may also be viscid to slimy when moist.

Consistency

The stipe may be fragile, robust, cartilaginous, fibrous, leathery, woody, corky, chalky or even fleshy. They may also be hollow, solid, stuffed or chambered.

Veil

The veil is a layer of specialized tissue that initially protects the developing mushroom and then breaks up or collapses so that the spores can be released. There are two basic types, partial or universal. The partial veil extends from the margin of the pileus to the stalk and covers the lamellae or pores when young and frequently forms an annulus on the stipe while a universal veil surrounds or envelops the young fruiting body and sometimes form a volva after breaking. Veil is a key character for segregation at generic level.

Annulus

Annulus is a ring formed by the veil after breaking. Some mushrooms have more than one veil or contain layer of veil, others have only one veil or are absent in many mushrooms. They play an important key character in identification.

Volva

Volva is a cup-shaped structure at the base of the stipe formed from the universal veil. The volva may occur as a separate tissue or may be attached to a bulbous base. They may be thin, powdery, friable or ragged bands etc.

Mycelium

The mycelium is a loosely organized mass of threadlike cells or hyphae which are invisible to the naked eye except when they are bundle together to form thicker strand called rhizomorphs.

Spore color and spore print

Spore color is an extremely useful character, particularly in the gilled mushrooms. Unlike, the color of the fruit body, it is relatively constant for each species and is not as susceptible to the environmental influence. The color of the spores can be noted only in mass by taking the spore prints.

Chemical color reaction

Chemical color reactions are performed by placing a drop of chemical directly on the pileus surface, flesh, stipe surface, context and spores with variety of chemical reagents and stains and observing immediate and longer color changes. Chemical reaction of Meltzer's reagent (for observing amyloid, inamyloid or dextrinoid) and aqueous KOH (15% w/v) are commonly used.

Habitat

Growth habit refers to the manner in which mushrooms grow in a particular area. This is considered as an important feature. It gives the information about habit whether solitary, scattered, in clusters or forming fairy rings, etc. and in association with plants or insects in termitaria (*Termitomyces*), which must be recorded.

Microscopic characters

The microscopic details include the internal texture and arrangement of mushroom mycelium in different carpophore parts including variation in size, structure and distribution of basidia, cystidia and other associated cuticular elements, etc. which are of immense importance in the taxonomic segregation of mushrooms. The pioneers to work out these details include Hook (1665), Fayod (1889), Beck (1923) and Singer (1939). Microscopic features have been discussed in the ongoing account with a view to introduce the terminology associated with the microscopic description of agarics and to emphasize the relevance of internal details in mushroom systematics.

Basidiospores

The basidiospore characteristics is one of the most important keys in identifying and segregation of the taxonomy of mushrooms. Their shape, size, thickness and ornamentation are fairly constant characters. These are unicellular, single or double walled, may be small or gigantic, smooth or ornamented. They exhibit variety of shapes such as globose, sub globose, broadly ellipsoid, ellipsoid, elongated, cylindric and bacilliform. The size and shape of the spore is another stable character, which needs accurate recording.

The spore shapes are described and calculated according to the definitions of Bas (1969): A spore is ‘globose’ if its length/width ratio (Q) falls between 1 and 1.05; ‘sub-globose’ if its Q falls between 1.05 and 1.15; ‘broadly ellipsoid’ if its Q falls between 1.15 and 1.3; ellipsoid’ if its Q falls between 1.30 and 1.6; ‘elongate’ if its Q falls between 1.6 and 2; ‘cylindric’ if its Q falls between 2 and 3; and bacilliform’ if its Q falls above 3.

Basidia

Basidia is the spore-producing cell. They are relatively large, chiastic, clavate and thin walled with terminal sterigmata on which basidiospores are borne. They may be as broad as spores or about 2-5 times as long as the longer axis of the spore. Their shape, size is an important key in identifying mushroom. This type of variation is important taxonomically.

Clamp connection

It is well known that the dikaryotic mycelium of higher basidiomycetes is provided with a special structure at the septa of the hyphae, known as clamp connection. The presence or absence of clamp connections showed a great taxonomic variation within families.

Collection of specimens

The best collecting season is rainy season where the fruiting bodies are produced. A survey of fungal fruiting bodies was carried out in the selected sites and the fruiting body of mushrooms were photographed in their natural habitat before collection is done. All-important morphological characters were noted down in a notebook. Color and size were taken from the fresh specimens and the morphology of the fructification was studied with a hand lens.

Identification of specimens

Collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Bas, 1969; Singer, 1986; Arora, 1986; Surcek, 1988; Ainsworth and Bisby, 2000; Mohanan, 2013). Spore print of the collected specimens were taken by cutting off the cap and placing it in a piece of white paper for about 20 minutes to overnight, then, the color of the spore print was noted (Surcek, 1988). For microscopic study, thin sections of dried specimens were taken with the help of a sharp razor blade and were mounted in 3% KOH solution and stained in 2% aqueous phloxine. Sections are also mounted in Lactophenol or 60% lactic acid + cotton blue.

Reagents for staining:

Melzer's reagent	:	Iodine - 0.5g, Potassium Iodide (KI) - 1.5g
	Chloral hydrate - 20g, Distilled water - 20ml.	
Eosin and Phloxine (1 or 2%)	:	1 or 2g Eosine or Phloxine in 100ml water.
Cotton blue	:	Cotton blue in 60% lactic acid.
Lactophenol	:	5g lactic acid, 5g phenol, 10g glycerin and
5ml		water
KOH	:	2 - 5% KOH in water

Nomenclature, taxonomic position and author names follow the databases: Index Fungorum- IFS (http://www.indexfungorum.org), the International Plant Names Index – IPNI (http://www.ipni.org) and MycoBank (http://www.mycobank.com). Voucher specimens were maintained at the Department of Environmental Science.

Preservation of herbarium specimens

Specimens collected were air dried in sunlight or with a blower and packed in polythene bags for herbarium specimens. They are also preserved in FAA solution and kept in specimen bottles or containers. They were then labeled with appropriate voucher numbers.

FAA : Formaldehyde + Glacial Acetic acid + Alcohol (Ethanol) in appropriate proportion.

II.4. RESULTS AND DISCUSSION

Species description

1. ***Agaricus silvaticus* Schaeff. (1774)** **Photo plate-01**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Agaricus*
Species	-	*silvaticus*

Synonyms - *Agaricus sylvaticus* Schaeff. (1774), *Agaricus laceratus* Batsch (1783), *Psalliota sylvatica* (Schaeff.) P. Kumm. (1871), *Psalliota silvatica* (Schaeff.) P. Kumm. (1871), *Pratella sylvatica* (Schaeff.) Gillet (1878), *Pratella silvatica* (Schaeff.) Gillet (1878), *Fungus silvaticus* (Schaeff.) Kuntze (1898), *Fungus sylvaticus* (Schaeff.) Kuntze (1898), *Agaricus haemorrhoidarius* Schulzer (1874), *Agaricus sanguinarius* P. Karst. (1882), *Fungus haemorhodarius* (Schulzer) Kuntze (1898), *Psalliota silvatica* var. *saturata* F.H. Møller (1950), *Agaricus vinosobrunneus* P.D. Orton (1960)

Description of the specimen

Pileus: Small to medium, 2-8 cm in diam., convex, fibrillose, scaly, somewhat spiny or hairy, crenate or toothed margin, distinctively bright yellow to orange-yellow. Lamellae- free, pale pinkish at first, then becoming brownish to dark brown in age, crowded. Lamellulae- of several length. Flesh – pale pinkish to brown, thick. **Stipe:** 4-5 cm long, 1-1.5 cm wide, colored more or less like the pileus bright yellow to orange-yellow, equal, solid, scaly or hairy, hollow. Annulus- present. Volva–absent. **Basidiospores:** 3-6 x 2.3-4 μm [Q=1.30, 1.50], broadly ellipsoid to ellipsoid, smooth, amyloid. Spore print–dark brown. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0034, July and September 2014; EVS/SF/00115, June, July, August, October 2015 and EVS/SF/00217, June, July, August, September 2016 respectively and Mizoram University Campus EVS/SF/0101, June, July 2015 and EVS/SF/0214, June, July 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. *Agaricus silvaticus* is being reported by several worker from different region of India. Known distribution include Maharashtra (Karwa and Rai, 2010); Nagaland (Tanti *et al*., 2011); Similipal Biosphere Reserve, Odisha (Sachan *et al*., 2013); Assam (Gogoi and Parkash, 2015). This species is commonly known as Blushing wood mushroom. Krieger (1967) and Phillips (1981) recorded *A. silvaticus* as a good edible fungus. Local name (Mizo) - unknown.

2. *Agaricus trisulphuratus* Berk. (1885) **Photo plate-02**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae

Order - Agaricales
Family - Agaricaceae
Genus - *Agaricus*
Species - *trisulphuratus*

Synonyms - *Fungus trisulfuratus* (Berk.) Kuntze, *Cystoagaricus trisulphuratus* (Berk.)

Description of the specimen

Pileus: Small, 2-4 cm in diam., convex, fibrillose, scaly, somewhat spiny or hairy, crenate or toothed margin, distinctively bright yellow to orange-yellow. Lamellae - free. Pale pinkish at first, then becoming brownish to dark brown in age, crowded. Lamellulae-of several length. Flesh - pale pinkish to brown, thick. **Stipe:** 4-5 cm long, 1-1.5 cm wide, colored more or less like the pileus bright yellow to orange-yellow, equal, solid, scaly or hairy, hollow. Annulus – present. Volva-absent. **Basidiospores:** 3.1-6 x 2.5-4 μm [Q=1.24, 1.50], broadly ellipsoid to ellipsoid, smooth, amyloid. Spore print-dark brown. Basidia- clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0106, May 2015 and EVS/SF/0205, May 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. *Agaricus trisulphuratus* is being reported by several worker from different region of India. Known distribution include West Bengal, Calcutta (Massee 1907) as *Psalliota burkillff*; Uttar Pradesh, Dehra Dun (Bakshi 1974); Tamil Nadu, Madras, (Manjula 1980; Natarajan and Manjula 1981). Kerala (Saini *et al.*, 1991); Jammu and Kashmir (Kumar and Manimohan, 2009a); Konkan (Pramod *et al.*, 2014) Western Ghats of Karnataka (Senthilarasu G. and Kumaresa, 2016, as *Cystoagaricus* *trisulphuratus*). *Agaricus trisulphuratus* is also reported by Massee 1912 as *Lepiota punicea* and as *Stropharia aurivella*. Edibility is not known. Local name (Mizo) - unknown.

3. *Amanita crocea* (Quel.) Singer (1951) **Photo plate-03**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*crocea*

Synonyms - *Amanita vaginata* var. *crocea* Quel. 1898, *Amanitopsis crocea* (Quel.) E.-J. Gilbert (1928)

Description of the specimen

Pileus: Medium, sometimes large, 3-10 cm in diam., convex, expanding to plano-convex or flat, typically with a central bump or umbonate at maturity, pale, dull orange to dark orange, developing a brownish at the centre and paler at the margin, margin distinctly striated. Lamellae-free, close or crowded, smooth, white to cream or sometimes with a slight pink, lamellulae- of several length with one or two series. **Stipe:** 6-16 cm long, 0.5-1.5 cm wide, slightly tapering toward apex, cream to pale yellowish orange with pale orange fibres or scales arranged in chevron or v-shaped pattern, without a basal bulb but a saclike volva up to 1.5 cm long, 1-3 cm thick is present at the base, white to cream or pale peach or brownish orange stains or spots.

Annulus-absent. Flesh-white to pale yellow, soft, thin and unchanging or staining when sliced or exposed. **Basidiospores:** 8-17.5 x 7.5-16 µm [Q=1.06, 1.09], globose or sub-globose, smooth, inamyloid. Spore print-white to pale cream. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0027, May 2014, EVS/SF/0122, May, June 2015 and EVS/SF/0215, May, 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. *Amanita crocea* is commonly known as Saffron ringless *Amanita*, *Orange Grisette*. It is inedible. Local name (Mizo) - unknown.

4. *Amanita griseofolia* Zhu L. Yang (2004) **Photo plate-04**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*griseofolia*
Synonyms	-	NA

Description of the specimen

Pileus: Small to medium, 3-8 cm in diam., campanulate to hemispherical at first, then, becoming convex to plano-convex, without an umbo, brownish gray to gray-brown, darker over disc, becoming somewhat paler towards the margin, and with a tuberculate-striate margin. expanding to plano-convex or flat, typically with a central bump or umbonate at maturity, pale, dull orange to dark orange, developing a brownish at the centre and paler at the margin, margin distinctly striated. Lamellae – free, close or crowded, smooth, white to cream or sometimes with a slight pink, lamellulae- of several length with one or two series. **Stipe:** 6-15 cm long, 0.5-1.5 cm wide, slightly tapering toward apex, cream to pale yellowish orange with pale orange fibres or scales arranged in chevron or v - shaped pattern, without a basal bulb but a saclike volva up to 1.5 cm long, 1-3 cm thick is present at the base, white to cream or pale peach or brownish orange stains or spots. Annulus-absent. Flesh-white to pale yellow, soft, thin and unchanging or staining when sliced or exposed. Spore print-white to pale cream. **Basidiospores:** 8 – 17.5 x 7.8 - 16 μm [Q=1.02, 1.09], globose or subglobose, smooth, hyaline, thin-walled, inamyloid. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus No.EVS/SF/0032, May 2014; EVS/SF/0116, June 2015 and EVS/SF/0216 May, June 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. *Amanita griseofolia* is first reported from India by Bhatt *et.al.,* 2017. *Amanita griseofolia* is commonly known as Chinese Sister Ringless *Amanita*. This species is closely related to *A. ceciliae*. It is inedible. Local name (Mizo) - unknown.

5. *Amanita jacksonii* Pomerl. (1984) **Photo plate–05**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*jacksonii*
Synonym	-	*Amanita umbonata* Pomerl. Non (Sumst) Sartory & L. Maire; *Amanita tullossii* Guzman & Ram. – Gull.

Description of the specimen

Pileus: Medium, sometimes large, 5-12 cm in diam., oval at first becoming convex, typically with a central bump, slightly sticky when fresh, brilliant red or orange, fading to orange to pale orange or yellow on the margin, margin striated for almost half of the pileus radius, bald, without warts or patches. Lamellae – free, smooth, yellow to orange-yellow, close or crowded, lamellulae- of several length with one or two series. **Stipe:** 9-15 cm long, 1-1.5 cm wide, slightly tapering toward apex, yellow with orange to reddish scales or fibres, often in zones, not bruising, without a basal bulb but a saclike volva up to 1.5 cm long, 1-3 cm thick is present at the base, white. Annulus – present, yellow to orange, skirt like ring. Volva - present. Flesh – white to pale yellow, soft, thin and unchanging or staining when sliced or exposed. **Basidiospores:** 7.9-11 x 5.5-7 µm [Q=1.43, 1.57], ellipsoid, smooth, inamyloid, hyaline, thin-walled. Spore print – light yellow. Basidia- clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus No.EVS/SF/0031, May 2014, EVS/SF/0120, June 2015 and EVS/SF/0215, May 2016.

Comments: Solitary to scattered or gregarious on ground broad-leaved forest. *Amanita jacksonii* is commonly known as Jackson's Slender Caesar. It is inedible. Local name (Mizo) - unknown.

6. *Amanita pachycolea* Stuntz *In* Thiers & Ammirati (1982) Photo plate–06

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*pachycolea*
Synonyms	-	NA

Description of the specimen

Pileus: Small to medium. 4-9cm in diam., convex to plano-convex, grayish brown in color, volva remnants on pileus as scattered felted to crust like patches, margin non-striated, non-appendiculate, incurved. Lamellae-sometimes forked, lamellulae- of several length. **Stipe:** 10-25 cm long, 0.5-3 cm wide, equal or tapering slightly toward apex, covered with finely hairy or fairly smooth, whitish, sometimes grayish or brownish in age, without a basal bulb but a sack like volva up to 1.5 cm long, 1-3 cm thick is present at the base, white, sometimes discolor rusty or brownish with age. Annulus-absent. Flesh-white unchanging or staining when sliced or exposed.

Basidiospores: 9-14 x 9-12.5 µm [Q=1, 1.12], globose to sub globose, smooth, inamyloid. Spore print-white. Basidia- clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0030, June, July, August, September 2014; EVS/SF/110, May, June, August, September 2015; EVS/SF/0203, May, June, July, August, September, October 2016.

Comments: Solitary to scattered or gregarious on ground broad-leaved forest. *Amanita pachycolea* is reported from India by Bhatt *et al.,* 1999. This species is commonly known as Stunt'z Great Ringless *Amanita.* It is inedible. Local name (Mizo) - unknown.

7. *Amanita pantherina* (DC.) Krombh (1846) **Photo plate – 07**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*pantherina*

Synonyms - *Agaricus pantherinus* D.C., (1815), *Amanitatia pantherina* (D.C.) E.-J. Gilbert, (1940), *Agaricus maculatus* Schaeff., (1774), *Agaricus pustulatas* Schumach., (1803).

Description of the specimen

Pileus: Small to medium, 4-13cm in diam., convex to plano-convex then becoming planar or flat, brown to tan or yellowish brown, bald, adorned with numerous cottony whitish warts, viscid and shiny when wet, margin striated slightly, non-appendeculate, inflexed at first, then decurved. Lamellae-free, close to crowded, white to cream in age, lamellulae- of several length. **Stipe:** 4-15 cm long, 1-2.5 cm wide, equal or tapering slightly toward apex, ending in slightly swollen basal bulb, covered with finely hairy or fairly smooth, whitish with a skirt like, whitish ring above, and a roll of tissue from the universal veil forming the upper margin of the bulb or occasionally, with concentric rings of volval material. The volva is white, becoming grey with age, easily broken, and forming at least one ring on the joint of the stem and bulb which is sometimes described as like a rolled sock. Annulus-present. Flesh-white unchanging or staining when sliced or exposed. **Basidiospores:** 8.5 - 14 x 6.6 – 10.3 μm [Q=1.28, 1.35], broadly ellipsoid to ellipsoid, smooth, inamyloid. Spore print-white. Basidia- clavate, four spored. Clamp connection absent but sometimes rarely present.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0159, August, September 2015; EVS/SF/0242 July, August, September 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Amanita pantherina* reported from India by Sathe and Sasangan (1977), Watling and Gregory (1980), Kumar *et al*. (1990), Shajahan *et al.* (1988), Verma and Pandro (2018). It is inedible. Local name (Mizo) - unknown.

8. *Amanita phalloides (Fr.) (1833)* **Photo plate – 08**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*phalloides*

Synonyms - *Agaricus phalloides* Fr. (1821), *Venenarius phalloides* (Fr.) Murrill (1912), *Amanitina phalloides* (Fr.) E.-J. Gilbert, (1940), *Agaricus vernalis* Bolton (1788), *Agaricus bulbosus* Bull. (1793), *Agaricus virosus* Vittad (1835).

Description of the specimen

Pileus: Medium to large, 4-18 cm in diam., nearly round or oval at first then becoming convex, expanding to broadly convex to flat in age, bald, viscid and shiny when wet, shiny when dry, yellowish white to brownish at the centre, the margin usually not lined but sometimes striated slightly. Lamellae-free, close or crowded, smooth, white to cream lamellulae- of several length with one or two series. **Stipe:** 6-9 cm long, 1-2.5 cm wide, more or less equal or slightly tapering toward apex and flaring to a swollen base, white to cream with tints of the cap color, bald or finely hairy with a white, skirt like ring that typically persists but is sometimes lost, with a sack like white volva encasing the base (sometimes underground or broken up Annulus-present with skirt like ring that typically persists but is sometimes lost. Flesh-white throughout and unchanging or staining when sliced or exposed. **Basidiospores**: 7–12 x 5–9 µm

[Q=1.4, 1.33], ellipsoid, smooth, amyloid. Spore print–white. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0058, August, September 2014; EVS/SF/00139, July, August, September 2015; EVS/SF/0237 July, August, September 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. *Amanita phalloides* is reported from India by Vrinda *et al.* (2005); Pradeep and Vrinda (2007). It is deadly poisonous. Local name (Mizo) - unknown.

9. *Amanita spissacea* S. Imai (1933) — Photo plate – 09

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*spissacea*
Synonyms	-	*Amplariella spissacea* (S.Imai) E.-J. Gilbert (1940).

Description of the specimen

Pileus: Small to medium, 4 - 9cm in diam., convex to plano-convex, grayish brown in color, volva remnants on pileus as scattered felted to crust like patches, margin non-striated, non-appendeculate, incurved. Lamellae - sometimes forked, lamellulae- of several length. **Stipe:** 8-14 cm long, 0.5-1cm wide, tapering toward apex, stuffed, white to grayish brown with brown scales. Annulus membranous, grayish brown, apical. Bulbous base up to 1.5 cm long, 1-3 cm thick, glabrous with dark brown spots. The upper part of the bulbous base of the stipe is covered with dark grey volval remnants in 2 to 5 dotted rings. Context – white and thin. **Basidiospores:** 7-9.8 x 6.8-8.5 µm [Q=1.02, 1.15] and are globose to subglobose, sometimes rarely broadly ellipsoid, amyloid, colorless, hyaline, thin walled and smooth. Spore print-white. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0012, May 2014. INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0222, June. 2016.

Comments: Solitary to scattered or gregarious on ground broad-leaved forest. *Amanita spissacea* is first reported from India by Lalrinawmi *et al*., 2018. *This species* is closely related to *A. fritillaria* and *A. griseofolia.* It is poisonous. Local name (Mizo) - unknown.

10. *Amanita vaginata* (Bull.) Lam. (1783) **Photo plate-10**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Amanitaceae
Genus	-	*Amanita*
Species	-	*vaginata*

Synonyms - *Amanita vaginata* var. *vaginata*, *Agaricus vaginatus* Bull. (1783), *Vaginata livida* Gray (1821), *Amanitopsis vaginata* (Bull.) Roze, (1876), *Amanitopsis vaginatus* (Bull.) Roze (1876), *Amanitopsis vaginata* subsp. *vaginata* (Bull.) (1876)

Description of the specimen

Pileus: Small to medium. 3-11 cm in diam., oval at first, becoming convex or nearly flat, with a central bump, viscid at first or when wet, gray to grayish brown, sometimes with a few scattered whites to grayish patches, margin prominently lined or grooved for up to 1 cm or more. Lamellae-free or slightly attached to it, white, close or crowded, lamellulae-of several length. **Stipe:** 7-16 cm long, 0.5-2.5 cm wide, equal or tapering slightly toward apex, bald, or with a few grayish scales, whitish to sometimes grayish or brownish in age, without a basal bulb but a sack like volva up to 1.5 cm long, 1-3 cm thick is present at the base, white, sometimes discolour rusty or grayish or reddish brownish with age. Annulus-absent. Flesh-white unchanging or staining when sliced or exposed. **Basidiospores:** 8-12.8 x 8-12 µm [Q=1, 1.06], globose to sub globose, smooth, inamyloid. Spore print- white. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0039 July, August, September, October 2014; EVS/SF/0138 July, August, September 2015; EVS/SF/0209 May, June, July, August, September 2016

Comments: Solitary to scattered or gregarious on ground broad-leaved forest. *Amanita vaginata* is reported from India by Shajahan and Samajpati (1995); Ghosh *et al.* (1974); Berkeley (1852); Shajahan *et al.* (1988); Singh and Mehrotra (1974); Sohi *et al.* (1964);

Semwal *et al.* (2014a); Abraham and Kachroo (1989); Walting and Gregory (1980). This species is commonly known as Grisette. It is inedible. Local name (Mizo) - unknown.

11. *Aureoboletus auriflammeus* (Peck) Manfr. (2002) Photoplate-11

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Boletaceae
Genus	-	*Aureoboletus*
Species	-	*auriflammeus*

Synonyms - *Boletus auriflammeus* Berk. & M.A. Curtis (1872), *Suillus auriflammeus* (Berk. & M.A. Curtis) Kuntze (1898*), Ceriomyces auriflammeus* (Berk. & M.A. Curtis) Murrill (1909), *Pulveroboletus auriflammeus* (Berk. & M.A. Curtis) Singer (1947)

Description of the specimen

Pileus: Small to medium, 3–11 cm in diam., becoming broadly convex, dry, finely velvety when young, becoming more or less bald, sulphur yellow or medium brown when young, usually becoming brown to medium brown or tan with age, often with a paler, yellower margin, the margin slightly inrolled when young. Hymenophore – pores small, round, bright yellow, becoming orangish yellow to olive yellow with age; not bruising, or bruising slowly orangish brown. Flesh –yellow to bright golden yellow, not staining when sliced or exposed. **Stipe:** 5 - 8 cm long, 0.5 – 2.5 cm wide, thick, more or less equal, or tapered toward base, reticulate, yellow that becomes brownish with age or on handling, bright yellow, discoloring brownish in age, solid, basal mycelium yellow. **Basidiospores:** 9-11 x 7.5-8.5 µm [Q=1.2, 1.29], broadly ellipsoid, smooth. amyloid. Spore print- bright orangish yellow with a very slight hint of olive. Basidia- clavate, four spored. Clamp connection absent**.**

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0117 May, June, July, August, September 2015; EVS/SF/0207 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0027, June, July, August, September 2014; EVS/SF/0109, May, June, July, August, September 2015 and EVS/SF/0228, May, June, July, August, September 2016.

Comments: Mycorrhizal, solitary or in small groups on ground broad-leaved forest. *Aureoboletus auriflammeus* is reported from India (Das *et al.*, 2013). It is edible. Local name (Mizo) - unknown.

12. *Aureoboletus moravicus f. luteus* Nonis & Ponzi (2014) Photo plate – 11

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Russulaceae
Genus	-	*Aureoboletus*
Species	-	*moravicus*
Synonyms	-	NA

Description of the specimen

Pileus: Medium, 5-15 cm in diam., convex when young becoming flat with a shallow depression, dry or slightly greasy, smooth or radially wrinkled, streaked or cracked, extremely variable in color, yellow-ochre, tan, brownish yellow to copper-brown, the cuticle peeling about halfway to the centre, margin slightly projecting. Hymenophore - tubes and pores pale ochre-yellow, buff-yellow, dark yellow. Flesh - whitish to pale ochraceous yellow, thick. **Stipe:** 3-11 cm long, 1-3 cm wide, dry, smooth, pale yellow, ochraceous yellow, brownish-fibrillose or veined ornamented, basal mycelium pale yellowish. **Basidiospores:** 8-12 x 6.3-9.2 µm [Q=1.26, 1.2], broadly ellipsoidal with isolated warts, amyloid. colourless, hyaline, thin walled and smooth. Spore print - ochraceous. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0124 May, June, July, August, September, October 2015; EVS/SF/0229 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. It is edible. Local name (Mizo) - unknown.

13. *Boletus carpinaceus Velen.* (1939) **Photo plate – 13**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales

Family	-	Boletaceae
Genus	-	*Boletus*
Species	-	*carpinaceus*
Synonyms	-	*Boletus reticulatus* subsp. *carpinaceus* (Velen.) (1994)

Description of the specimen

Pileus: Medium, 6 – 18 cm in diam., convex when young expanding to broadly convex in age with some wrinkled or finely cracked surface, slightly velvety, dry, whitish to pale brown, or yellow-brown in age, margin inrolled when young, splitting with age, typically without a sterile projection. Hymenophore - tubes and pores white, tubes depressed, pores small and round, dirty gray when young; becoming pale buff, then olive, then brownish; young pore surface bruising ochraceous to brownish Flesh - white unchanging or staining when sliced or exposed. **Stipe:** 7-17 cm long, 2.5-5 cm wide, stout, swollen, thick, club-shaped when young, becoming more or less equal, finely reticulate, white with brown or black scales on surface, solid, sometimes appearing to stain brownish when handled. **Basidiospores:** 12-16 x 10-12.5 µm [Q=1.2, 1.28], broadly ellipsoid, smooth. amyloid. colorless, hyaline, thin walled and smooth. Basidia- clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0016 May, June, July, August 2014; EVS/SF/00104 May, June, August 2015; EVS/SF/0233 May, June, September, October 2016.

Comments: Mycorrhizal, solitary or in small groups on ground broad-leaved forest. It is edible. Local name (Mizo) - unknown.

14. *Boletus mirabilis* (Murrill) Murrill (1912) **Photo plate-14**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Boletaceae
Genus	-	*Boletus*
Species	-	*mirabilis*

Synonyms - *Ceriomyces mirabilis* Murrill (1912), *Xerocomus mirabilis* (Murrill) Singer (1940), *Boletellus mirabilis* (Murrill) Singer (1945), *Heimioporus mirabilis* (Murrill) E. Horak (2004), *Aureoboletus mirabilis* (Murrill) Halling (2015).

Description of the specimen

Pileus: Medium to large, 5 – 23 cm in diam., convex to plane or flattened, margin inrolled when young, often hung with fragments of tissue, deep reddish brown to maroon brown, liver colored, bay-brown or chocolate-brown, surface moist to sticky, becoming dry, woolly and fibrous scaly, sometimes granular-scaly, with a shallow depression, dry or slightly greasy, smooth or radially wrinkled, streaked or cracked, extremely variable in color. Hymenophore Pores - 1-2mm in diam., round or angular, fairly large, pale yellow, with age to greenish yellow, not blueing when bruised, tubes also yellow. Flesh – white to dingy pinkish or yellowish, rarely blueing when bruised. **Stipe:** 7-20 cm long, 2-5 cm wide, thick, club-shaped, thicker toward base, moist to dry, smooth, typically webbed at top, dark brown to maroon brown or reddish-brown, with occasional yellow, buff or beige streaks, firm, base frequently with yellow mycelium. **Basidiospores:** 18-24 x 15-18.6 µm [Q=1.2, 1.29], broadly ellipsoid, smooth. amyloid. colourless, hyaline, thin walled and smooth. Spore print - olive-brown. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0006 May, June, July, August 2014; EVS/SF/00113 May, June, July, August 2015; EVS/SF/0230 May, June, July, September, October 2016.

Comments: Mycorrhizal, Solitary or in small groups on ground broad-leaved forest. *Boletus mirabilis* is commonly known as Admirable Bolete. It is edible and delicious. Local name (Mizo) - unknown.

15. *Boletus quercinus* Hongo (1967) or Schrad. (1794) (Pilát) Hlavácek (1990)

Photo plate -15

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Boletaceae
Genus	-	*Boletus*
Species	-	*quercinus*

Synonyms - *Leccinum aurantiacum* var. *quercinum* Pilát (1961), *Leccinum quercinum* (Pilát) E.E. Green & Watling (1969), *Krombholziella quercina* (Pilát) Šutara (1982), *Polyporus quercinus* (Schrad.) Fr. (1838), *Piptoporus quercinus* (Schrad.) P. Karst. (1881), *Placodes quercinus* (Schrad.) Quél. (1886), *Fomes* *quercinus* (Schrad.) Gillot & Lucand (1890), *Ungulina quercina* (Schrad.) Pat. (1900), *Buglossoporus quercinus* (Schrad.) Kotlába & Pouzar (1966), *Antrodia quercina* (Schrad.) Teixeira (1992), *Boletus pulvinus* Pers. (1799), *Polyporus paradoxus* Fr. (1873), *Polyporus cadaverinus* Schulzer (1874), *Caloporus fuscopellis* Quél. (1892), *Polyporus quercicola* Velen. (1922)

Description of the specimen

Pileus: Medium, 4-15 cm in diam., globular when young then becoming convex, dry, finely velvety felt, brownish, yellow brown. Hymenophore - pores small, round, fine, separable, brick red or red bright yellow, not bruising, or bruising slowly orangish brown. Flesh - white to creamy or gray then bluish or blackening when cut or sliced. **Stipe:** 9-15 cm long, 2-3 cm wide, thick, more or less equal, or tapered or swollen toward centre, covered slightly with pale scales but quickly turns to brown or black on a whitish base. **Basidiospores:** 13-16 x 10.2-12.3 µm [Q=1.27, 1.3], broadly ellipsoid, smooth. amyloid. Sporeprint - Bright orangish yellow with a very slight hint of olive. Basidia - clavate, four spored. Clamp connection absent**.**

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0005 May, June, July, August 2014; EVS/SF/00103 May, June 2015; EVS/SF/0238 May, June, July, September, October 2016.

Comments: Mycorrhizal, solitary or in small groups on ground broad-leaved forest. It is edible. Local name (Mizo) - unknown.

16. *Boletus stramineum* (Murrill) Singer (1944) **Photo plate-16**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Boletaceae
Genus	-	*Boletus*
Species	-	*stramineum*

Synonyms - *Boletus stramineus* (Murrill) Murrill (1940), *Gyroporus stramineus* Murrill (1940), *Leucogyroporus stramineus* (Murrill) Snell (1942)

Description of the specimen

Pileus: Small to medium, 4.5-8.5 cm in diam., convex with an incurved margin at first, becoming expanded and somewhat irregularly shaped in age, white becoming straw colored, then grayish or brownish, smooth or with a very slight bloom on the margin when young, shining when dry, cracked. Tubes - adnate and sometimes with a slightly decurrent tooth, white at first, then becoming dirty cream to brownish. Pores - small, round to angular, concolorous with the tubes or sometimes slightly bruising brown. **Stipe:** 2-6 long, 1-3.5cm thick, solid, somewhat swollen in the middle, white to slightly bruising brown in age, smooth, vein like structure, white basal mycelium. Flesh - thick, firm, mild. **Basidiospores:** 10-15x5-5 µm [Q=2, 3], cylindrical, smooth, thin-walled, amyloid. Sporeprint - whitish to brown Basidia- clavate, four spored. Clamp connection absent**.**

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/00134 May, June 2015; EVS/SF/0231 May, June, July, September, October 2016.

Comments: Mycorrhizal, solitary or in small groups on ground broad-leaved forest. The edibility is not known. Local name (Mizo) - unknown.

17. *Boletus subtomentosus* L. (1753) **Photo plate -17**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Boletaceae
Genus	-	*Boletus*
Species	-	*subtomentosus*

Synonyms - *Leccinum subtomentosum* (L.) Gray (1821), *Rostkovites subtomentosus* (L.) P. Karst. (1881), *Versipellis subtomentosus* (L.) Quél.(1886), *Xerocomus subtomentosus* (L.) Quél.(1887), *Suillus subtomentosus* (L.) Kuntze (1898), *Ceriomyces subtomentosus* (L.) Murrill (1909), *Xerocomopsis subtomentosus* (L.) Reichert (1940), *Xerocomus subtomentosus f. xanthus* E.-J. Gilbert (1931), *Xerocomus flavus* Singer & Kuthan (1976).

Description of the specimen

Pileus: Medium, 3-15 cm in diam., convex, becoming broadly convex, dry, finely velvety, brownish yellow to brown, yellowish brown, or olive brown, often becoming cracked in age. Pore surface - yellow, becoming olive yellow with maturity, often bruising blue, or not bruising. Flesh - white, usually turning pale blue in the cap when sliced. **Stipe:** 4-10 cm long, 1-2 cm wide, thick, more or less equal, or tapered or swollen toward base, dry, solid and tough, sometimes ribbed near the apex or over the upper half, but not reticulate, usually featuring tiny reddish granules on a whitish to yellowish surface. **Basidiospores:** 10-14 x 3.5–5 µm [Q=1.27, 1.3], broadly ellipsoid to ellipsoid, smooth, hyaline; thin-walled, smooth, amyloid. Sporeprint - Olive to olive brown. Basidia - clavate, four spored. Clamp connection absent**.**

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0251 June, July 2016 and Mizoram University Campus EVS/SF/0045 June, August, September, October 2014; EVS/SF/0133 May, June, July, August, September, October 2015; EVS/SF/0201 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, growing **s**olitary or in small groups on ground broad-leaved forest. *Boletus subtomentosus* is commonly known as suede bolete. It is edible. Local name (Mizo) - unknown.

18. *Cantharellus cibarius* Fr. (1821) **Photo plate -18**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Cantharellales
Family	-	Cantharellaceae
Genus	-	*Cantharellus*
Species	-	*cibarius*

Synonyms - *Agaricus cantharellus* L. (1753), *Agaricus chantarellus* L. (1753), *Merulius cantharellus* (L.) Scop. (1772), *Merulius chantarellus* (L.) Scop. (1772), *Cantharellus vulgaris* Gray (1821), *Merulius cibarius* (Fr.) Westend. (1857), *Craterellus cibarius* (Fr.) Quél. (1888), *Alectorolophoides cibarius* (Fr.) Earle (1909), *Chanterel cantharellus* (L.) Murrill (1910), *Chanterel chantarellus* (L.) Murrill (1910), *Cantharellus rufipes* Gillet (1878), *Cantharellus cibarius* var. *amethysteus* Quél. (1883), *Cantharellus edulis* Sacc. (1916), *Cantharellus cibarius f. pallidus* R. Schulz (1924), *Cantharellus cibarius* var. *salmoneus* L. Corb. (1929), *Cantharellus cibarius* var. *inodorus* Velen. (1939), *Cantharellus pallens* Pilát, Omagiu lui (1959).

Description of the specimen

Pileus: Small to medium, 3 – 12 cm in diam., funnel-shaped, margin irregular, wavy, light yellow to deep egg-yolk yellow, dry. oval or nearly round, then becoming convex to broadly cone-shaped, plane with a shallow umbo, dry, white, at first smooth but soon breaking into many small flat or curled scales of light brown to brown or pinkish-brown scales, concentrated toward the centre. Lamellae - veins, wrinkled on the underside of the cap, close, thick, decurrent, forked and more sinuous towards the edge of the cap. Flesh - white, thick. **Stipe:** 1-2 cm long, 0.5-1 cm wide, concolorous with the cap or sometimes paler, thick, equal or when growing in clumps, the stipe is often curved and occasionally joined together near the base. Annulus - absent. **Basidiospores:** 7-11 x 5-7.2 μm [Q=1.4, 1.52], ellipsoid, smooth, hyaline inamyloid. Spore print - pale yellow to creamy white, sometimes with a slight pinkish tinge. Basidia - clavate, Four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0008 May, June, July, August, September, October 2014; EVS/SF/0107 May, June, July, August, September, October 2015; EVS/SF/0231 May, June, July, August, 2016 and Mizoram University Campus EVS/SF/0023 May, June, July, August, September, 2014; EVS/SF/0126 June, July, August, September 2015; EVS/SF/0243 May, June, July, September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or in clusters or gregarious on ground broad-leaved forest at Mizoram University Campus and Hmuifang forest. *Cantharellus cibarius* is reported from Northwestern Himalaya (Semwal *et al*., 2014b). This species is commonly known as Chanterelle. It is edible and is collected worldwide for food. Local name (Mizo) - unknown.

19. *Chlorophyllum molybdites var. molybdites* (G. Mey. Massee, Bull. (1898)

Photo plate -19

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Chlorophyllum*
Species	-	*molybdites*

Synonyms - *Lepiota morgani, Agaricus molybdites, Lepiota molybdites, Leucocoprinus molybdites, Macrolepiota molybdites.*

Description of the specimen

Pileus: Medium to large, 5-35 cm in diam., oval or nearly round, then becoming convex to broadly cone-shaped, plane with a shallow umbo, dry, white, at first smooth but soon breaking into many small flat or curled scales of light brown to brown or pinkish-brown scales, concentrated toward the centre. Lamellae - free, close, broad, white to dingy yellowish, then slowly becoming grayish to greenish in age. Lamellulae - of several length. Flesh - white, thick. **Stipe:** 5-25 cm long, 1-2.5 cm wide, thick, equal or thicker at base, smooth, white to brownish-stained, discoloring on handling. Annulus - present, white becoming brownish on underside, double-edged, often movable in age. **Basidiospores:** 7- 13 x 5.2 – 8.4 µm [Q=1.34, 1.54], ellipsoid, smooth, thick-walled with an apical pore, dextrinoid. Spore print - grayish-olive to green. Basidia - clavate, Four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0046 June, July 2015; EVS/SF/0252 June, July 2016 and Mizoram University Campus EVS/SF/0055 June, July 2014; EVS/SF/0151 June, July, August, September 2015; EVS/SF/0258 June, July, September, October 2016.

Comments: Saprobic, growing solitary to scattered or gregarious on ground broad-leaved forest. *Chlorophyllum molybdites* is being reported from Allahabad (Singh & Mehrotra,1974); Lucknow (Ghosh *et al*., 1976); Kolhapur (Patil & Thite, 1978); Chennai, Madras (Natarajan & Manjula, 1981); Chennai, Madras; Pune (Sathe & Rahalkar, 1976; Sathe & Deshpande, 1980; Sathe & Deshpande, 1982); Ernakulam, Thrissur, Idukki, Thiruvananthapuram, Kerela (Sankaran & Florence, 1995; Florence & Yesodharan, 1997, 2000; Mohanan, 2003; Florence, 2004; Pradeep & Vrinda, 2007;

Mohanan, 2011; Vrinda & Pradeep, 2011); Amravathi (Hedawoo, 2010); Bangalore (Pushpa & Purushothama, 2012); Mangalore (Greeshma *et al.*, 2015). This species is commonly known as Green-spored Parasol. It is poisonous. Local name (Mizo) - unknown.

20. *Clavulinopsis corallinorosacea* (Cleland) Corner (1950) **Photoplate-20**

Classification:

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Clavariaceae
Genus	-	*Clavulinopsis*
Species	-	*corallinorosacea*
Synonyms	-	*Clavaria corallinorosacea* Cleland (1931)

Description of the specimen

Fruiting body: Small to medium, 1.5-10 cm high, 0.1-0.6 cm wide, thin, clubs, simple, stems cylindrical becoming flattened, red. Flesh - yellow, firm, fragile, brittle. **Basidiospores:** 5-9 x 4.5-8 µm [Q=1.11, 1.13], sub-globose, smooth. Spore print - white. Basidia - clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0267, July, August, September 2016.

Comments: Terrestrial, apparently saprobic on decaying organic matter, found under hardwoods or less commonly, conifers, solitary or in small groups on ground broad-leaved forest. The edibility is not known. Local name (Mizo) - unknown.

21. *Clavulinopsis laeticolor* (Berk. & M.A. Curtis) R.H. Petersen (1965)

Photoplate-21

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Clavariaceae/ Sparassidiaceae
Genus	-	*Clavulinopsis*
Species	-	*laeticolor*

Synonyms - *Clavaria laeticolor* Berk. & M.A. Curtis (1869), *Ramariopsis laeticolor* (Berk. & M.A. Curtis) R.H. Petersen (1978), *Donkella laeticolor* (Berk. & M.A. Curtis) Malysheva & Zmitr. (2006), *Donkella laeticolor* (Berk. & M.A. Curtis) Malysheva (2008), *Clavaria pulchra* Peck *(1876).*

Description of the specimen

Fruiting body: Small to medium, 1.5–7 cm high, 0.1-0.5 cm wide, thin, clubs, simple, tips pointed or discolors somewhat reddish to orange, stems cylindrical and unbranched becoming flattened, dry, bright yellow to yellow. Flesh - pale yellow, firm, fragile, brittle, thin. **Basidiospores:** 4 - 7 x 3.5 – 5.8 µ [Q=1.14, 1.21], sub-globose to broadly ellipsoid, irregularly shaped, smooth with apiculus. Spore print - white. Basidia - clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0160 July, August, September 2015; EVS/SF/0268 July, August, September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest at Hmuifang forest. *Clavulinopsis laeticolor* is reported from Uttar Pradesh (Vishwakarma *et al*., 2012). Edibility is not known. Local name (Mizo) - unknown.

22. *Cortinarius croceous* (Schaeff.) Gray (1821) **Photo plate-22**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Cortinariaceae
Genus	-	*Cortinarius*
Species	-	*croceous*

Synonyms - *Agaricus croceus* Schaeff. (1774), *Agaricus subcorneus* Batsch (1783), *Agaricus cinnamomeus δ croceus* (Schaeff.) Fr. (1821), *Agaricus cinnamomeus d. croceus* (Schaeff.) Fr. (1821), *Agaricus cinnamomeus d croceus* (Schaeff.) Fr. (1821), *Cortinarius cinnamomeus var. croceus* (Schaeff.) Fr. (1838), *Flammula cinnamomea var. crocea* (Schaeff.) P. Kumm. (1871), *Cortinarius cinnamomeus subsp. croceus* (Schaeff.) Sacc. (1887), *Cortinarius croceus* (Schaeff.) Bigeard & H. Guill. (1909), *Dermocybe crocea* (Schaeff.) M.M. Moser (1974), *Cortinarius croceus* (Schaeff.) Høil. (1984).

Description of the specimen

Pileus: Small, 1.5-8 cm, convex or nearly conical at first, becoming broadly convex, flat, or broadly bell-shaped, sometimes with a sharp central bump, dry, silky, yellowish brown to olive brown, often aging to dark brown, especially over the center, the margin often more yellowish. Lamellae - adnate or attached to the stem but often pulling away from it in age, close or crowded, yellow at first (orangish in some varieties), becoming cinnamon to rusty, covered by a yellowish cortina when young, sometimes spotting and discoloring reddish brown. Flesh - yellowish. **Stipe:** 3-7 cm long, up to 1 cm thick at the apex, more or less equal, dry, silky with brownish fibers, yellowish above, sometimes olive brown to reddish brown below, sometimes with a rusty ring zone, basal mycelium pale yellow. Annulus - absent. **Basidiospores**: 6.5-9 x 4.5-6 µm [Q=1.44, 1.5], ellipsoid, slightly to moderately roughened amyloid. Spore print - rusty brown. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0131 May, June, July, August, September, October 2015; EVS/SF/0232 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0074 July, August, September, October 2014; EVS/SF/0182 August, September, October 2015, EVS/SF/0234 May, June, July, September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. It is inedible. Local name (Mizo) - unknown.

23. *Cortinarius helvolus f. helvolus* (Bull.) Fr. (1838) Photo plate-23

Classification

Domain	- Eukaryota
Kingdom	- Fungi
Division	- Basidiomycota
Sub Division	- Agaricomycotina
Class	- Agaricomycetes
Sub Class	- Agaricomycetidae
Order	- Agaricales
Family	- Cortinariaceae
Genus	- *Cortinarius*
Species	- *helvolus*

Synonyms - *Agaricus aranaeolus* var. *helvolus* Bull., (1792), *Agaricus helvolus* (Bull.) Pers., (1801), *Cortinarius helvolus* f. *helvolus* (Bull.) Fr., (1838), *Cortinarius helvolus* f. *media* Fr., *Cortinarius helvolus* var. *bresadolae* Rob.Henry & Ramm, 1989, *Cortinarius helvolus* var. *helvolus* (Bull.) Fr., 1838, *Cortinarius helvolus* var. *maximus* (Fr.) Rob.Henry & Ramm, 1989, *Cortinarius helvolus* var. *medius* (Fr.) Rob.Henry & Ramm, 1989, *Hydrocybe helvola* (Bull.) M.M. Moser, 1953, *Telamonia helvola* (Bull.).

Description of the specimen

Pileus: Medium, 5cm - 10cm in diam., conical then a convex and strongly bulging, truncate, the edge is in rolled, with a sharp central bump or umbo, dry, finely velvety or fibrillose, varies from reddish brown to ocher yellow color, stem of varies from dirty white to ocher brown color. Lamellae - adnate or attached to the stem, distant, reddish brown to rust, ochre. Lamellulae- of several length. Flesh - ochre, rusty brown. **Stipe:** 5-10cm long, 1.5-3 cm wide, tapering towards the apex, reddish brown to ocher. Annulus - absent. **Basidiospores**: 7-10 x 4.5-7.5 µm [Q=1.55, 1.33], ellipsoid or ovate, amyloid. Spore print - ochre or rusty brown. Basidia - clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0152 May, June, July, August, October 2015; EVS/SF/0235 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0047 June, July, August, September, October 2014; EVS/SF/0165 July, August, September, October 2015; EVS/SF/0253 June, July, August, September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. It is inedible. Local name (Mizo) - unknown.

24. *Cortinarius phoeniceus* var. *occidentalis* (Bull.) R. Marie Bull. (1911)

Photo plate-24

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Cortinariaceae
Genus	-	*Cortinarius*
Species	-	*phoeniceus*

Synonyms - *Agaricus purpureus* Bull., (1792), *Agaricus purpureus* Bull. ex Pers., (1801), *Agaricus phoeniceus* Bull., (1812), *Dermocybe phoenicea* (Bull.) M.M. Moser, (1974), *Cortinarius purpureus* (Bull. ex Pers.), (1994).

Description of the specimen

Pileus: Small to medium, 3-8 cm, broadly convex, becoming broadly bell-shaped or nearly flat, dry, silky, deep red to maroon, the margin usually somewhat inrolled. Lamellae - adnate or attached to the stem, distant or nearly so, dark red to purplish red, becoming rusty red, covered by a cortina when young. Lamellulae - of several length. Flesh - ochre, rusty brown. **Stipe:** 4-7 cm long, 0.5-1 cm thick, more or less equal, dry or sticky, silky with yellowish or reddish fibers, yellowish, or discoloring reddish with age. Flesh - yellowish to olive or brownish. **Basidiospores:** 6-8 x 4-5 µm, [Q=1.5, 1.6], ellipsoid, moderately roughened. Spore print – rusty brown. Basidia - clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0064 July, August, September, October 2014; EVS/SF/0167 July, August, September, October 2015; EVS/SF/0239 May, June, August, September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. It is inedible. Local name (Mizo) - unknown.

25. *Craterellus cornucopioides* (L.) Pers., (1825) **Photo plate-25**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Cantharellales
Family	-	Cantharellaceae
Genus	-	*Craterellus*

species - *cornucopioides*

Synonyms - *Strebeeckia cornucopoides* (L.) Dumort., *Peziza cornucopoides* L., (1753), *Helvella cornucopoides* (L.) Scop., (1772), *Elvela cornucopoides* Schaeff., (1774), *Helvella pinctata* Schaeff., (1774), *Elvela cornucopiae* Schaeff., (1774), *Elvela punctata* Schaeff., (1774), *Agaricus cinereus* Batsch, (1783), *Octospora cornucopoides* (L.) Timm, (1788), *Helvella cornucopoides* (l.) Bull., (1791), *Pezicula cornucopoides* (L.) Paulet, (1791), *Craterella nigrescens* Pers., (1794), *Craterella cornucopoides* (L.) Pers., (1797), *Merulius cornucopoides* (L.) Pers., (1801), *Cantharellus cornucopoides* (L.) Fr., (1821), *Cantharellus cornucopiae* Wallr., (1833), *Dendrosarcus cornucopoides* (Pers.), Kuntze, (1898), *Dendrosarcus cornucopoides* (Pers.) Kuntze, (1898), *Dendrosarcus cornucopoides* (L.) Kuntze, (1898).

Description of the specimen

Pileus: Small, 2-8 cm in diam., funnel-shaped or vase-shaped, without a clearly defined cap and stem, hollow at the center with the margin decurved at first, then spreading out and becoming wavy and split, the upper edge rolled under when young and often partly rolled under in maturity. The inner surface - black to dark gray, finely roughened or finely scaly with dark fibers and scales over a paler, grayish or grayish brown base color. The outer Surface - smooth to uneven or very shallowly wrinkled, deeply decurrent wrinkles but not gills, grey, dark gray to black, with a whitish bloom. Lamellae - absent. Flesh - thin, brittle but tough, colored like cap or paler blackish. **Stipe:** 5-10 cm long, without a clearly defined pileus and stipe, finely wrinkled, hollow right down the base, tapering slightly towards the base. **Basidiospores:** 11-16 x 8.9-12.4 µm [Q=1.23, 1.29], broadly ellipsoid, smooth, hyaline. Spore print - white. Basidia - clavate, four spored. Clamp connections absent.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0132 May, June, July, August 2015; EVS/SF/0236 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0065 July, August, September, October 2014; EVS/SF/0161 July, August, September, October 2015; EVS/SF/0254 June, July, August, September, October 2016.

Comments: Mycorrhizal, growing solitary or in tightly packed clusters on ground broad-leaved forest. *Craterellus cornucopioides* is reported from India by Banerjee, 1947, Rea, 1922 and Bilgrami *et al.*,1991. This species is commonly known as Horn of plenty. It is edible. Local name (Mizo) - unknown.

26. *Entoloma hainanense* T.H. Li & Xiao Lan He (2012) Photo plate-26

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Entolomataceae
Genus	-	*Entoloma*
species	-	*hainanense*

Description of the specimen

Pileus: Medium, 6-7 cm in diam., plane becoming convex, slightly depressed at the centre, margin slightly inrolled, creamy to white. Lamellae - adnate or attached to the stem, distant, creamy to white. Lamellulae - of several length. Flesh - white, brittle but tough. **Stipe:** 8-10 cm long, 0.7-1cm thick, hollow right down the base, tapering slightly towards the base. **Basidiospores:** 9-11.5 x 8-10 µm [Q=1.13, 1.15], angular, irregular, hyaline. Spore print-white. Basidia - clavate, four spored. Clamp connections present occasionally.

Specimens examined: INDIA, Mizoram, Mizoram University Campus EVS/SF/0153 June, July, August 2015; EVS/SF/0255 June, July, August 2016.

Comments: Mycorrhizal, growing solitary or in tightly packed clusters on ground broad-leaved forest. It is inedible. Local name (Mizo) – unknown.

27. *Geastrum morganii* Lloyd (1902) **Photo plate-27**

Classification:

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Phallomycetidae
Order	-	Gastrales
Family	-	Geastraceae
Genus	-	*Geastrum*
species	-	*morganii*
Synonyms	-	*Geaster morganii Lloyd (1901)*

Description of the specimen

Fruiting Body: 1-3 cm wide, smooth at first, bulb-shaped ball partially submerged in the substrate, with a prominent pointed beak, with maturity the outer skin peeling back to form 4-8 more or less triangular, buff colored, non-hygroscopic arms that are thick and usually develop fissures and cracks, frequently splitting to form a saucer, spore case more or less round, smooth, brownish, with a fuzzy conical beak that is often surrounded by a pale area, 5-10 cm across when arms are opened, interior of spore case initially solid and white but soon powdery and brown. A pointed hole known as a perisome on the top of the sac releases spores via wind or rain. The sides of the perisome are fibrous and appear rather ragged but not regularly striate, surrounded by a fuzzy ring slightly paler fawn-brown than the rest of the spore-sac outer surface. **Basidiospores:** 3.5-5 x 3.5-5 µm, [Q=1.30, 1.50], globose, ornamented with small spiny or warts spiny, inamyloid. Sporemass - olive brown. Basidia - clavate, four spored. Clamp connection present ocassionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0162 July, August, September, October 2015; EVS/SF/0260 June, July, August, September 2016.

Comments: Saprobic, growing solitary to scattered or gregarious on ground broad-leaved forest. *Geastrum morganii* is commonly known as Collared Earthstar. It is inedible. Local name (Mizo) - unknown.

28. *Hebeloma victoriense* A.A. Holland & Pegler (1983) Photo plate-28

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Hymenogastraceae
Genus	-	*Hebeloma*
Species	-	*victoriense*

Description of the specimen

Pileus: Medium, 4-11 cm in diam., convex becoming plano-convex, slightly viscid, light brown to grayish orange, margin inrolled at first, appendiculate, with velar remnants attached. Lamellae - sinuate, crowded, pinkish buff at first, darkening as the spores mature, with distinctive moisture drops forming along the gill edge in which spores accumulate giving a dark brown appearance. Lamellulae - of several length. Flesh - thick, firm, white, not changing on exposure to air. **Stipe:** 4-8 cm long, 0.5-2 mm thick, fibrillose below, white to pale buff, white, becoming stained purplish brown by spores, annulus present. **Basidiospores:** 9.4 – 11.5 × 5.1 – 6.3 µm [Q=1.84, 1.82], elongate, inamyloid. Spore print - purplish brown, dark reddish-brown. Basidia -clavate, four spored.

Specimens examined: INDIA, Mizoram, Aizawl Mizoram University Campus EVS/SF/0051 June, July, August 2014; EVS/SF/0157 June, July, August 2015; EVS/SF/0265 June, July, August 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest It is inedible. Local name (Mizo) - unknown.

29. *Helvella ephippium* (Lév.) Boud. (1907) Lev. (1841) **Photo plate-29**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Ascomycota
Sub Division	-	Pezizomycotina
Class	-	Pezizimycetes
Sub Class	-	Pezizomycetidae
Order	-	Pezizales

Family - Helvellaceae
Genus - *Helvella*
Species - *ephippium*

Synonyms - *Leptopodia ephippium* Lev. Boud, (1907), *Helvella atra* var. *murina* (Boud.) Keissl., (1922), *Helvella murina* (Boud.) Sacc. & Traverso, (1910), *Helvella murina* var. *huyoti* (Boud.) Sacc. & Traverso, (1910), *Leptopodia murina* Boud., (1907), *Leptopodia murina* var. *huyoti* Boud., (1907).

Description of the specimen

Ascomata: Small, 2.5-3cm in diam., typically saddle-shaped, usually with two lobes, mostly gray-brown on the top fertile side and slightly lighter and mostly frosted on the underside. Thin, slightly sinuous, smooth. Flesh - white fragile. **Stipe:** 4-5 cm long, 0.5-2 cm thick, cylindrical, sometimes laterally compressed, smooth, white to greyish brown or slightly grayish yellowish. Annulus - absent. Volva - absent. **Ascospores:** 18-20 x 11.5-12.5 μm, [Q=1.56, 1.6], ellipsoid, hyaline, smooth, inamyloid. Spore print - white to gray.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0256 May, June, July 2016 and Mizoram University Campus EVS/SF/0135 May, June, July, August 2015; EVS/SF/0240 May, June, August, September 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. It is inedible. Local name (Mizo) - unknown.

30. *Helvella macropus* (Pers.) P. Karst (1871) **Photo plate-30**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Ascomycota
Sub Division	-	pezizomycotina
Class	-	Pezizimycetes
Sub Class	-	Pezizomycetidae
Order	-	Pezizales
Family	-	Helvellaceae
Genus	-	*Helvella*
Species	-	*macropus*

Synonyms - *Peziza macropus* Pers., (1795), *Peziza macropus* var. *macropus* Pers. (1975), *Peziza macropus* var. *hirta* Gray, (1821), *Macropodia macropus* (Per.) Fuckel, (1870), *Aleuria macropus* (Persoon) Gillet, (1879), *Lachnea macropus* (Pers.) W. Phillips, (1887), *Cowlesia macropus* (Pers.) Nieuwl, (1916), *Cyathipodia macropus* (Pers.) Dennis, (1960), *Helvella hispida* Schaeff., (1774), *Peziza hypocrateriformis* Berg., (1783), *Paxina hispida* (Schaeff.) Seaver, (1928), *Macropodia macropus* var. *hispida* (Schaeffer) Killerm, (1929).

Description of the specimen

Ascomata: Small, 1-6 cm in diam., cup-shaped or disc-shaped or occasionally nearly flat or folding towards more of a saddle shaped, upper surface medium to dark grayish brown, bald, under surface light to medium grayish brown, finely to prominently pustulate-hairy (especially near the margin). Flesh - insubstantial. **Stipe:** 1-7 cm long, 0.1-0.5 cm thick, more or less equal, sometimes with clefts near the base, medium brown (usually colored like the under surface of the cap), whitish near the base, finely hairy or nearly bald with age. **Ascospores:** 18-25 x 10-11.5 µm, [Q=1.8, 2.1], elongate to cylindric (but occasional ellipsoid spores are often present, especially when still in asci), smooth or roughened, hyaline, inamyloid. Spore print – white. Asci - typically, 300 x 15 µm, each ascus contains eight spores.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0152 May, June, July, August, October 2015; EVS/SF/0235 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0047 June, July, August, September, October 2014; EVS/SF/0165 July, August, September, October 2015; EVS/SF/0253 June, July, August, September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest. *Helvella macropus* is reported from Eastern and North Western Himalayas by K. S. Waraitch in 1976; Konchok Dorjey *et al*., in 2013 reported from Jammu and Kashmir. This species is commonly known as Felt saddle fungus. Edibility is not known. Local name (Mizo) - unknown.

31. *Laccaria vinaceoavellanea* Hongo (1971) **Photo plate-31**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Hydnangiaceae
Genus	-	*Laccaria*
Species	-	*vinaceoavellanea*
Synonyms	-	NA

Description of the specimen

Pileus: Small, 1-4 cm in diam., becoming flat and sometimes depressed, faintly to moderately lined, bald or very finely hairy, pinkish to buff, margin striated. Lamellae - decurrent, distant, pinkish flesh color, lamellulae- of several length. Flesh - pale brownish. **Stipe:** 2-7 cm long, 3-5 mm thick, more or less equal, finely hairy and often longitudinally lined, colored like the cap, or a little darker, with white basal mycelium. Annulus-absent. **Basidiospores:** 8.5-11 x 7.5-10.5 µm [Q=1.04, 1.13], globose to sub globose, ornamented with spines, inamyloid. Spore print - white. Basidia - two spored.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0025 May, June, July, August, October 2014; EVS/SF/0141 May, June, July, August, September, October 2015; EVS/SF/0245 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0066 July, August, September, October 2014; EVS/SF/0150 May, June, July, August, September, October 2015; EVS/SF/0248 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Laccaria vinaceoavellanea* is reported from Meghalaya in the North-East region of India by Khaund and Joshi in 2014. It is edible. Local name (Mizo) - unknown.

32. ***Laccaria yunnanensis*** **Popa, Rexer, Donges, Zhu L.Yang & G.Kost, (2014)**

Photo plate-32

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota

Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Hydnangiaceae
Genus	-	*Laccaria*
Species	-	*yunnanensis*
Synonyms	-	NA

Description of the specimen

Pileus: Small, 1-4 cm in diam., becoming flat and sometimes depressed, faintly to moderately lined, bald or very finely hairy, pinkish to buff, margin striated. Lamellae - adnate to decurrent, distant or nearly so, pinkish flesh color, lamellulae - of several length. Flesh - pale brownish. **Stipe:** 2-7 cm long, 3-5 mm thick, more or less equal, finely hairy and often longitudinally lined, colored like the cap, or a little darker, with white basal mycelium, hairy or spiny at the base. Annulus - absent. **Basidiospores:** 8-10 x 7.8-9 µm [Q=1.02, 1.11], globose to sub globose, ornamented with warts, inamyloid. Spore print - white. **Basidia:** Clavate, four spored, some two spored, hyaline. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0026 May, June, July, August, October 2014; EVS/SF/0148 May, June, July, August, October 2015; EVS/SF/0247 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0067 May, June, July, August, September, October 2014; EVS/SF/0147 July, August, September, October 2015; EVS/SF/0246 May, June, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. It is inedible. Local name (Mizo) - unknown.

33. *Lactarius piperatus* (L.) Pers. (1797) **Photo plate-33**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Lactarius*
species	-	*piperatus*

Synonyms - *Agaricus lactifluus* var. *piperatus* (L.) Pers., *Agaricus piperatus* L. (1753), *Agaricus acris* Bull. (1785), *Lactaria piperata* (L.) Pers. (1797), *Lactifluus piperatus* (L.) Roussel (1806), *Lactifluus piperatus* (L.) Kuntze (1891).

Description of the specimen

Pileus: Small to medium, 6-16 cm in diam., convex at first becoming sunken to vase-shaped or funnel shaped, white to cream staining dingy tan or pinky-tan with age, dry, unzoned, smooth to sometimes wrinkled, margin non-striated. Lamellae - adnate, crowded, narrow, white pale to cream, often forked, lamellulae - of several length. Flesh - white, unchanging. Latex - white, unchanging, or sometimes slowly drying yellow or staining gills yellowish, abundant. **Stipe:** 2-8 cm long, 1-2.5 cm wide, firm, solid, thick, dry with white bloom, white, concolorous with the pileus, Annulus - absent. **Basidiospores:** 5.5-7 x 4.2-5µm [Q=1.3, 1.4], ellipsoid, amyloid, ornamented with fine lines. Spore print - white. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0024 May, June, July, August, September, October 2014; EVS/SF/0137 May, June, July, August, October 2015; EVS/SF/0244 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0038 May, June, July, August, October 2014; EVS/SF/0146 May, June, July, August, October 2015; EVS/SF/0249 May, June, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Lactarius piperatus* is reported from Garhwal Himalaya (Joshi *et al*., 2013); Nagaland (Ao *et al*., 2016). This species is commonly known as Peppery milkcap. It is edible. Local name (Mizo) - unknown.

34. *Lactifluus corrugis* (Peck) Kuntze, (1891) **Photo plate-34**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Lactifluus*
Species	-	*corrugis*
Synonyms	-	*Lactarius corrugis* Peck (1879)

Description of the specimen

Pileus: Small to medium, 4-15 cm in diam., convex at first becoming plane or shallowly depressed then somewhat vase shaped, minutely velvety to nearly smooth, dry, usually dark brownish red to dark brick red but sometimes purplish brown or dark brown. margin non-striated. Lamellae - adnate to slightly decurrent, close, pale buff when young but soon orangish to yellowish or brownish, discolouring brown when sliced or injured. lamellulae- of several length. Flesh - whitish to yellowish, thick, firm but brittle, staining slowly brown when sliced. Latex-white, copious, slowly staining brown or staining tissues brown. **Stipe:** 2-11 cm long, 1.5-3 cm wide, concolorous with the pileus, brown to reddish brown or paler equal, solid, smooth. Annulus - absent. **Basidiospores:** 9-12.1 x 8.7-11 µm [Q=1.03, 1.1], globose to sub globose, ornamented, amyloid. Spore print - white. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0074 July, August, September, October 2014; EVS/SF/0140 June, July, August, September 2015; EVS/SF/0269, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Lactifluus corrugis* is reported from Assam by Borah *et al.*, in 2017. *T*his species is formerly known as *Lactarius corrugis*. It is commonly known as Corrugated Milky. It is edible and delicious. Local name (Mizo) – Pa uithin.

35. *Lepiota echinella* Quel. & G.E. Bernard, Bull. (1888) Photo plate-35

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae

Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Lepiota*
Species	-	*echinella*

Synonyms - *Cystoderma echinellum* (Quel. & G.E. Bernard), Singer (1936), *Lepiota minuta* (J.E. Lange) (1923)

Description of the specimen

Pileus: Small, 1.5-3cm in diam., convex then becoming flattened, pinkish-brown, ornamented at the centre with small, punctuate scales of a brownish-fawn or red-brown tint. Lamellae - free, close, broad, white to creamy, Lamellulae - of several length. Flesh - whitish with pinkish tint. **Stipe:** 2-5 cm long, 0.2-0.4 cm wide, whitish at first, then becoming pinkish-ochre, rhizoids sometimes bright red, ornamented with fine scales, ring zone indistinct. Annulus - present. **Basidiospores:** 5 -7 x 4.5-6.4 µm [Q=1.11, 1.09], sub globose or ovate smooth, thick-walled with an apical pore, dextrinoid. Spore print - white. Basidia - clavate, Four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0019 May, June, July, August, September, October 2014; EVS/SF/0136 May, June, July, August, September, October 2015; EVS/SF/0241 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0043 May, June, July, August, September, October 2014; EVS/SF/0149 May, June, July, August, September, October 2015; EVS/SF/0250 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Lepiota echinella* is reported from the Botanical garden of Konaje, Mangalore, Karnataka (Pavithra *et al*., 2017). It is edible. Local name (Mizo) - unknown.

36. *Leucocoprinus birnbaumii* (Corda) Singer (1962) **Photoplate-36**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Leucocoprinus*
Species	-	*birnbaumii*

Synoymns - *Agaricus birnbaumii* Corda (1839), *Agaricus luteus* Bolton (1788), *Agaricus flos-sulphuris* Schnizl. (1851), Bolbitius *birnbaumii* (Corda) Sacc. & Traverso (1910), *Lepiota aurea* Massee (1912), *Lepiota pseudolicmorphora* Rea (1922), *Lepiota coprinoides* Beeli (1936).

Description of the specimen

Pileus: Small, 2.5-5 cm in diam., oval to egg-shaped when young, then becoming conical to campanulate with a blunt umbo becoming convex in age membranous, bright to pale yellow, dry, powdery to finely scaly, the margin striate or grooved nearly to the center by maturity often with a darker (but not brown) center. Lamellae - free, close or crowded, concolorous with pileus, bright yellow to pale yellow. Lamellulae - of several length. Flesh - white to pale yellow, very thin. **Stipe:** 3-9 cm long and 0.2-0.5 cm wide, more or less equal, slightly swollen at the base, hollow, dry, bald or powdery, fragile, concolorous with pileus. Annulus - present, moving freely all along the stipe length or sometimes disappears, volva absent. **Basidiospores:** 7-11 x 5-7 μm [Q=1.4, 1.57], ellipsoid, truncated at the apex by a small but distinct germ pore, hyaline, smooth, thick walled, dextrinoid. Spore print - white. Basidia - clavate, two or four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0028 May, June, July, August 2014; EVS/SF/0155 June, July, August, September 2015; EVS/SF/0273 June, July, August, September 2016.

Comments: Sapotrophic, solitary to scattered or gregarious on ground broad-leaved forest, in flower pots, greenhouse. *Leucocoprinus birnbaumii* is reported from Karnataka State (Pushpa and Purushothama, 2012); Kerala (Mohanan, 2011). It is poisonous. Local name (Mizo) – unknown.

37. *Lycoperdon excipuliforme* (Scop.) Schaeff. (1774) **Photoplate-37**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Lycoperdon*
Species	-	*excipuliforme*

Synonyms - *Lycoperdon polymorphum var. excipuliforme* Scop. (1772), *Lycoperdon bovista* var. *excipuliforme* (Scop.) Huds. (1778), *Lycoperdon boletiforme* Batsch (1783), *Lycoperdon gemmatum var. excipuliforme* (Scop.) Fr. (1829), *Utraria excipuliformis* (Scop.) Quél. (1873).

Description of the specimen

Fruiting body: Small, 10-20 cm wide, 5-12 cm high, shaped like an inverted pear, with a fairly prominent stem-like area and a roundish to flattened top, dry, white at first and turns ochre in age, covered with whitish spines when young and fresh, but the spines often falling away by maturity and leaving scars on the surface or wrinkled. **Sporemass:** Spongy, spores develop inside the rounded head filled with brownish to olive granular spore dust and ruptured releasing the spores. **Stipe:** Parallel or slightly tapering in at the base; spongy; surface soon becoming wrinkled, initially white with pointed warts, but later turning ochre and becoming smooth and leathery. **Basidiospores:** 3.5-5.5 x 3.4-5.2 µm [Q=1.02, 1.05], globose, minutely minutely ornamented with warts, thick-walled, flexuous.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0033 May, June, July 2014; EVS/SF/0097 May, June, July, August, September 2015; EVS/SF/021 June, July, August, September 2016.

Comments: Saprobic, solitary to scattered or gregarious on ground broad-leaved forest, in flower pots, greenhouse. *Lycoperdon excipuliforme* is commonly known as pestle puffball. It is edible but not recommended as they could be confused with the poisonous *Amanitas* at young stage. Local name (Mizo) – unknown.

38. *Lycoperdon perlatum Pers. (1796)* **Photoplate-38**

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae

Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Lycoperdon*
Species	-	*perlatum*
Synonyms	-	*Lycoperdon gemmatum var. perlatum* (Pers.) Fr. (1829)

Description of the specimen

Fruiting body: Small, 2.5-7 cm wide, 3-7.5 cm high, shaped like an inverted pear, with a fairly prominent stem-like area and a roundish to flattened top, dry, covered with whitish spines when young and fresh, but the spines often falling away by maturity and leaving scars on the surface, by maturity developing a central perforation through which spores are liberated by rain drops and wind currents, white, becoming discolored and eventually sometimes brownish with a white, fleshy interior at first, later with yellowish to olive granular flesh and eventually filled with brownish spore dust. **Basidiospores:** 3.2-5.3 x 3.2-5.3 µm [Q=1,1], globose, minutely spiny, thick-walled, flexuous.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0017 May, June, July, August, September, October 2014; EVS/SF/0096 May, June, July, August, September 2015; EVS/SF/0194 May, June, July, August, September, October 2016.

Comments: Saprobic, growing solitary to scattered or gregarious on ground broad-leaved forest. *Lycoperdon perlatum* is reported from Uttar Pradesh (Vishwakarma *et al.*, 2012). This species is commonly known as Gem-studded puffball, Devil's snuffbox. It is edible. It is edible only when the internal spore tissue (gleba) is completely white and uniform in appearance. Local name (Mizo) – unknown.

39. *Macrolepiota dolichaula* (Berk. & Broome) Pegler & R.W. Rayner (1969)

Photoplate-39

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Macrolepiota*
Species	-	*dolichaula*

Synonyms - *Agaricus dolichaulus* Berk. & Broome (1870), *Lepiota dolichaula* (Berk. & Broome) Sacc. (1887), *Leucocoprinus dolichaulus* (Berk. & Broome) Boedijn (1951).

Description of the specimen

Pileus: Medium to large. 6-16 cm in diam., fleshy, campanulate when young, become convex to plano-convex with age, with a low umbo at disc, white to whitish, covered with yellow brownish to brownish granular squamules, which become minute and sparse toward margin, disc smooth, yellow brown to brown, margin down-reflexed, appendiculate, sometimes inconspicuously short striate. Lamellae - free, crowded, lamellulae - of several length, white when young, white to cream colored when mature, off white to cream when dried, at times hay colored after years of deposit. **Stipe:** white to whitish, subcylindrical, 7-24 cm long, 0.8–2.5 cm wide, attenuating upwards, with minute farinose granules; base slightly enlarged, hollow. Annulus - present, ascending, simple, whitish, membranous. Flesh - white, sometimes becoming orange at the base of the stipe when cut. **Basidiospores**: 10–16 × 9.3–12.2 µm [Q = 1.07, 1.3], subg lobose to ellipsoid, thick-walled smooth, hyaline, dextrinoid, with a germ pore. Spore print - white. Basidia - clavate, thin-walled, hyaline, four-spored. Clamp connections present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0062 June, July, August 2014; EVS/SF/0164 June, July, August, September 2015; EVS/SF/0270 June, July, August 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest or in mixed forests at Hmuifang forest and Mizoram University Campus. *Macrolepiota dolichaula* is reported from Kerela (Manjula, 1980; Natarajan and Manjula, 1981). Macroscopically, *M. dolichaula* differs from the other species of *Macrolepiota* by its relatively big, umbonate pileus with minute, pallid squamules and long slender stipe which sometimes becomes orange at the base when cut. Microscopically, it differs from other species by its clavate to broadly clavate cheilocystidia, and squamules made up of a palisade of short, more branched, subcylindric, clampless hyphae. It is considered an edible mushroom in China. Massee in 1898 reported as *Lepiota altissima.*It is commonly known as white parasol. It is edible. Local name is Pa se-ek.

40. *Macrolepiota procera* (Scop.) Singer (1948) **Photoplate-40**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina

Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Agaricaceae
Genus	-	*Macrolepiota*
Species	-	*procera*

Synonyms - *Agaricus procerus* Scop. (1772), *Agaricus annulatus* Lightf. (1777), *Agaricus colubrinus* Bull. (1782), *Agaricus antiquatus* Batsch (1783), *Lepiota procera* (Scop.) Gray (1821), *Amanita procera* (Scop.) Fr. (1836), *Mastocephalus procerus* (Scop.) Kuntze (1891), *Leucocoprinus procerus* (Scop.) Pat. (1900), *Lepiotophyllum procerum* (Scop.) Locq. (1942).

Description of the specimen

Pileus : Medium to large, 7–25 cm in diam., ovoid to drum stick shaped when young, becoming convex to plano-convex with age, with an obtuse umbo at disc, white to whitish, covered with brown, dark brown to grayish brown plate-like squamules; disc smooth, brown; covering disrupting into small plate-like squamules which are irregularly arranged toward margin on the dirty white background. Lamellae - free, densely crowded, thin, white when young, white to cream colored when mature. Lamellulae - of several length, in 2-3 lengths. **Stipe:** whitish, subcylindrical, 18.0-34 cm long, 1-2 cm wide, attenuating upwards, at base enlarged, covered with brown to dark brown velvet squamules sometimes in irregular bands, hollow or fibrous-stuffed. Annulus - present, superior, about 5 cm below stipe apex, dirty white above, underside brownish, membranous, complex, moveable. Flesh - spongy, white to cream at the pileus, grayish red to purplish brown at the stipe, not changing color. **Basidiospores**: 12.0–19.0 × 8.0–12.0 µm, [Q = 1.5, 1.58], ellipsoid to ovoid thick-walled, smooth, hyaline, dextrinoid, apiculus not distinctive. Sporeprint - white. Basidia - clavate, thin-walled, hyaline, 4-spored. Clamp connections present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0070 July, August 2014; EVS/SF/0171 June, July, August, September 2015; EVS/SF/0277 June, July, August, September 2016 and Mizoram University Campus EVS/SF/0087 September, October 2014; EVS/SF/0158 May, September, October 2015; EVS/SF/0291 September, October 2016.

Comments: Mycorrhizal, growing solitary to scattered or gregarious on ground broad-leaved forest or in mixed forests. *Macrolepiota fuliginosa* (Barla) M. Bon and *M. permixta* (Barla) Pacioni are two closely related species. *Macrolepiota procera* is commonly known as Parasol mushroom. *It is edible.* Local name (Mizo)- unknown.

41. *Mutinus caninus* (Huds.) Fr. (1849) **Photoplate- 41**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Phallomycetidae
Order	-	Phallales
Family	-	Phallaceae
Genus	-	*Mutinus*
Species	-	*caninus*

Synonyms - *Phallus caninus* Schaeff. (1774), *Phallus caninus* Huds. (1778), *Ithyphallus inodorus* Gray (1821), *Cynophallus caninus* (Huds.) Fr. (1860), *Aedycia canina* (Huds.) Kuntze (1898).

Description of the specimen

Fruiting body: Small to medium, 4-12 cm high and 0.5-2 cm wide. Immature fruiting body-white to pinkish egg- like stage at first, resembling a puffball, revealing the stinkhorn-to-be encased in a gelatinous substance when sliced, attached to the substrate by white mycelial strands (rhizomorphs). Mature fruiting body- spike like, white to orangish-red stalk expands toward the tip and paler to whitish toward the base, with an olive brown to brown slime towards the apex, the slime quickly becoming foul and odorous, and often quickly removed by insects, hollow, spongy with a whitish, sack like volva at the base. **Basidiospores:** 3.5-5 x 1.5-2 µm [Q=2.3, 2.5], elliptical or oblong, smooth.

Comments: Saprobic, growing solitary to scattered or in groups or clumps on ground and wood debris usually in forests but sometimes also in gardens or in sandy or disturbed soil. *Mutinus caninus* is reported from India by (Ameri *et.al.*, 2011). This species is commonly known as dog stinkhorn. The status of edibility is edible at the egg stages but is poisonous. Local name (Mizo) - unknown. Flies are attracted to the fetid slimy mass and serve to disperse the spores. European and North American concepts of *Mutinus elegans, Mutinus caninus,* and *Mutinus ravenelii* appear to differ somewhat, and some authors (e.g. McNeil, 2006) suggest that *Mutinus caninus* and *Mutinus ravenelii* are synonyms.

42. *Hymenopellis furfuracea* (Peck) R.H. Petersen (2010) **Photoplate-42**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Physalacriaceae
Genus	-	*Hymenopellis*
Species	-	*furfuracea*

Synonyms - *Collybia radicata var. furfuracea* Peck (1893), *Oudemansiella radicata var. furfuracea* (Peck) Pegler & T.W.K. Young (1987), *Xerula furfuracea* (Peck) Redhead, Ginns & Shoemaker (1987), *Oudemansiella furfuracea* (Peck) Zhu L. Yang, G.M. Muell., G. Kost & Rexer (2009) *Hymenopellis furfuracea* (Peck) R.H. Petersen (2010).

Description of the specimen

Pileus: Medium, 1.5-12 cm in diam., bell-shaped or occasionally convex at first, then becoming broadly convex to broadly bell-shaped or nearly flat in age, bald, smooth or moderately to prominently radially wrinkled and puckered (over the center when young and later nearly overall), sticky to greasy when fresh or wet, dark brown to grayish brown or yellow-brown, margin incurved when young, sometimes uplifted in maturity, not striated. Lamellae - adnate, sometimes with a tiny tooth runs down the stem, close or almost distant, white to creamy, thick. Lamellulae - of several length. **Stipe:** 4-16 cm long, 0.5-2 cm wide, tapering a little to apex, white and nearly bald near the apex, brownish gray to brownish or brown and fibrillose to hairy below, with the brown scales or fibres, sometimes developing a stretched into snakeskin patterns by maturity, with a long, tapered tap root extending underground, the tap root sometimes bruising rusty brown. Flesh - white, unchanging when sliced. Annulus - absent. **Basidiospores**: 11-17 x 9.5-13 µm [Q=1.15, 1.30], broadly ellipsoid to ellipsoid, smooth, hyaline, inamyloid. Spore print - white. Basidia - clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0095 May, June, June, July, August, September, October 2015; EVS/SF/0200 May, June, June, July, August, September, October 2016.

Comments: Saprobic, growing solitary to scattered or in groups or clumps on ground and directly from well-rotted wood, or around the bases of stumps. *Hymenopellis furfuracea* is reported from Kerala (Mohanan, 2011) as *Xerula furfuracea* (Peck); Karnataka (Senthilarasu and Kumaresan, 2016) as *Oudemansiella furfuracea* (Peck). *Hymenopellis furfuracea* is commonly known as Rooted Collybia, Rooted Agaric or Rooted *Oudemansiella*. It is edible. Local name (Mizo) – unknown.

43. *Phallus indusiatus* Vent. (1798) **Photoplate-43**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Phallomycetidae
Order	-	Phallales
Family	-	Phallaceae
Genus	-	*Phallus*
Species	-	*indusiatus*

Synonyms - *Dictyophora indusiata* (Vent.) Desv. (1809), *Hymenophallus indusiatus* (Vent.) Nees (1817)

Description of the specimen

Fruiting body: Medium to large, 4-25 cm high and 1-5 cm wide. Immature fruiting body-white to brownish egg-like stage at first, resembling a puffball, revealing the stinkhorn-to-be encased in a gelatinous substance when sliced, attached to the substrate by white mycelial strands (rhizomorphs). Mature fruiting body – spike like, white, smooth at first but pitted and ridged by maturity stalk expands toward the tip and becoming slimy olive-brown substance toward the apex, the slime quickly becoming foul and odorous, and often quickly removed by insects, hollow, spongy with a whitish, sack like volva at the base, a laced, white to slightly pinkish "skirt" hanging up to 15 cm from the bottom edge of the cap. **Basidiospores:** 2.5-3.5 x 1-1.5 µm [Q=2.5, 2.3], elliptical or oblong, smooth.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0086 July, August, September, October 2014; EVS/SF/0181 July, August, September, October 2015; EVS/SF/0282 July, August, September 2016.

Comments: Mycorrhizal, saprobic, growing solitary to scattered or in groups or clumps on ground. *Phallus indusiatus* is reported from Eastern Ghats (Dash *et al*., 2010). This species is commonly known as Stinkhorn. It is edible at the egg stages but is poisonous. Flies are attracted to the fetid slimy mass and serve to disperse the spores. This species is unpleasant odor or strongly sweet. Local name (Mizo) – Phungsahmim.

44. *Pisolithus albus* (Cooke & Massee) Priest, (1998) **Photoplate-44**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Sclerodermataceae
Genus	-	*Pisolithus*
Species	-	*albus*
Synonyms	-	*Polysaccum album* Cooke & Massee, (1891)

Description of the specimen

Pileus: Small, 3-12 cm in diam., 3-6 cm high, irregular shape, rounded to pear-shaped, becoming elongated and club-shaped. Peridium - singled layered, thin, membranous, smooth, white to cream at first, then becoming brownish in age, at maturity the outer skin on the top cracks and flakes away exposing the spore mass which is then dispersed via wind. The lower portion of the pileus typically consists of a fibrous, stalk like, sterile, attached to ground by numerous cordlike, persisting strands. **Spore mass:** Tightly packed cellular structure of vary shades or egglike spore sacs embedded in blackish jelly from yellow to orange-brown or ochre, usually develops into a powdery brown spore mass in age. **Basidiospores:** 9 - 12 x 9 – 12 µm [Q=1, 1], globose, ornamented with warts or spines upto 1 µm tall. Sporeprint - bright yellow-brown. Basidia - clavate, four spored. Clamp connection present.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0082 July, August, September 2014; EVS/SF/0174 June, July, August, September 2015; EVS/SF/0272 June, July, August, September, October 2016.

Comments: Mychorrhizal, solitary to scattered or in groups or clumps on ground and wood debris usually in forests but sometimes also in gardens or in sandy or disturbed soil. *Pisolithus albus* is reported from India by (Ameri *et.al.,* 2011). This species is commonly known as Dead man's foot. It is inedible. Local name (Mizo) – unknown.

45. *Ramaria cystidiophora* (Kauffman) Corner (1950) **Photoplate-45**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Phallomycetidae
Order	-	Gomphales
Family	-	Gomphaceae
Genus	-	*Ramaria*
Species	-	*cystidiophora*
Synonyms	-	*Clavaria cystidiophora* Kauffman (1928)

Description of the specimen

Fruiting Body: Medium, 2-10 cm high, up to 10 cm wide, usually numerously branched, yellow, lemon yellow tips, fuzzy white stipe base, tips bluntly pointed. Flesh – white, brittle and fragile or in some collections pliable. **Basidiospores:** 4-5x3.9-10 µm [Q=1.03, 1.09], globose to subglobose, or broadly elliptical, minutely ornamented warts, inamyloid. Spore print - yellowish orchre. Basidia - clavate, four spored. Clamp connections present and easily demonstrated.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0173 June, July, August 2015; EVS/SF/0275 June, July, August, September, 2016.

Comments: Probably saprobic, growing terrestrially or rarely from well decayed wood, growing solitary to scattered or gregarious on ground broad-leaved forest. *Ramaria cystidiophora* is commonly known as Fuzzy-footed coral. It is edible. Local name (Mizo) – Far Pa eng.

46. *Ramaria kunzei* (Fr.) Quel. (1888) **Photoplate-46**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Phallomycetidae
Order	-	Gomphales
Family	-	Gomphaceae
Genus	-	*Ramaria*
Species	-	*kunzei*

Synonyms - *Clavaria dubia* Pers. (1797), *Clavaria kunzei* Fr., (1821), *Clavaria kunzei* (Fr.) J. Schrot (1888), *Ramariopsia kunzei* (Fr.) Corner (1950), *Clavulinopsis kunzei* (Fr.) Julich, (1985), *Clavaria chionea* Pers.,(1822), *Clavaria subcorticalis* Schwein., (1832), *Clavaria krombholzii* Fr., (1838), *Lachnocladium subsimile* Berk. & M.A Curtis, (1873), *Clavaria velutina* Ellis & Everh., (1888), *Ramaria favreae* Quél., (1894), *Clavaria asperula* G.F. Atk., (1908), *Clavaria* *asperulans* G.F. Atk., (1908), *Clavaria lentofragilis* G.F. Atk., (1908), *Clavaria favreae* (Quél.) Sacc. & Traverso, (1912), *Clavaria subcaespitosa* Peck, (1913).

Description of the specimen

Fruiting Body: 2-10 cm high, up to 10 cm wide, usually numerously branched, compound, snow-white at first, often developing a tinged with pink at maturity, scurfy, tips bluntly pointed, colored like the sides. Flesh - White; brittle and fragile or in some collections pliable. **Basidiospores:** 3.2-6x3.1-5.5 µm [Q=1.03, 1.09], globose, sub globose, or broadly elliptical, minutely spiny, with a fairly prominent apiculus, inamyloid. Spore print - white. Basidia - clavate, four spored. Clamp connections present and easily demonstrated.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0013 May, June, July, August, September 2014; EVS/SF/0178 July, August, September, October 2015; EVS/SF/0278 July, August, September, October 2016 and Mizoram University Campus EVS/SF/0036 May, June, July, August 2014; EVS/SF/0094 May, June, September 2015; EVS/SF/0274 June, July, August, September 2016.

Comments: Probably saprobic, growing terrestrially or rarely from well decayed wood, growing solitary to scattered or gregarious on ground broad-leaved forest. *Ramaria kunzei* is commonly known as White coral. It is edible. Local name (Mizo) – Far Pa var.

47. *Russula aurora* Krombh. (1845) **Photoplate-47**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*aurora*

Synonyms - *Russula lepida* var. *aurora* (Krombh.) Rea (1932), *Russula rosea* var. *aurora* (Krombh.) R.W. Rayner (1985)

Description of the specimen

Pileus: Small to medium, 4-14 cm in diam., convex at first becoming slightly sunken or depressed at the center, pink to creamy pink, often darker at the center, the cuticle of the pileus peels about halfway to the center, dry or slightly pruinose, smooth to sometimes wrinkled, margin slightly striated. Lamellae - adnate, crowded, narrow, white pale to cream, often forked, lamellulae- of several length. Flesh - white, brittle. **Stipe:** 4-8 cm long, 1-2 cm wide, firm, solid, thick, brittle, white. Annulus - absent. **Basidiospores:** 6.5-9 x 5.5-7.5µm [Q=1.3, 1.4], ovoid, ellipsoid, amyloid, ornamented with fine lines. Spore print - white. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0002 May, June, July, August, September, October 2014; EVS/SF/0093 May, July, August, September, October 2015; EVS/SF/0262 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Russula aurora* is commonly known as Dawn Brittle. It is edible. Local name (Mizo) – Pa Leng var.

48. *Russula compacta* Frost, (1879) Photoplate-48

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*compacta*
Synonyms	-	NA

Pileus: Small to medium. 3-16 cm in diam., convex at first or broadly convex becoming slightly sunken at the center, white to whitish cream when young but soon becoming yellowish to reddish or orange brown and tawny brown in age, sticky, more or less smooth, the cuticle of the pileus peels about halfway to the center, sometimes braking up in age, brittle, bruising reddish brown, margin non-striated. Lamellae - adnate, crowded, close or almost distant, white pale to cream, bruising and discoloring reddish brown, lamellulae - of several length. Flesh - discoloring yellowish to yellowish brown or reddish brown on exposure, thick. **Stipe:**2-9 cm long, 1-3 cm wide, firm, solid, thick, more or less equal; dry; smooth; whitish, but soon flushed reddish brown, bruising reddish brown. Annulus - absent. **Basidiospores:** 6.5-9 x 5.5-7.5µm [Q=1.3, 1.4], ellipsoid, amyloid, ornamented with warts. Spore print - white. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0029 May, June, July, August, September, October 2014; EVS/SF/0143 May, June, July, August, September, October 2015; EVS/SF/0259 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0156 May, June, September, October 2015; EVS/SF/0264 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Russula compacta* is commonly known as Firm *Russula*. It is edible. Local name (Mizo) – Pa Leng.

49. *Russula cyanoxantha* (Schaeff.) Fr. **Photoplate-49**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*cyanoxantha*

Synonyms - *Agaricus cyanoxanthus* Schaeff. (1774), *Agaricus cynoxanthus* Pers. (1801), *Agaricus lividus* var. *angustatus* Pers. (1801), *Agaricus linnaei* var. *vagus* Fr. (1815), *Agaricus virescens* Krombh. (1845), *Russula cutifracta* Cooke (1881), *Russula cutefracta* Cooke (1881)

Description of the specimen

Pileus: Medium. 5 – 15 cm in diam., convex when young becoming flat with a shallow depression, dry or slightly greasy, smooth or radially wrinkled, streaked or cracked, extremely variable in color, usually shades of lilac to pinkish purple to green or olive green, the cuticle peeling about halfway to the center. Lamellae - white to pale cream, narrow, crowded, attached or slightly running down the stem, sometimes forking occasionally, flexible and greasy to touch, lamellulae - of several length. Flesh - white, brittle, thick. **Stipe:** 3-11 cm long, 1-3 cm wide, dry, smooth, white to yellowish white but occasionally flushed with lilac, solid, becoming hollow, brittle. **Basidiospores:** 7-10 x 5.6 – 7.8 µm [Q=1.25, 1.28], broadly ellipsoid with isolated warts, amyloid. hyaline, thin walled and smooth. Spore print – white. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0035 May, June, July, August, September, October 2014; EVS/SF/0142 May, June, July, August, September, October 2015; EVS/SF/0257 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0049 May, June, July, August, September, October 2014; EVS/SF/0144 May, June, July, September, October 2015; EVS/SF/0261 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. It is edible. Local name (Mizo) – Pa Leng var.

50. *Russula earlei* Peck (1903) **Photoplate-50**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*earlei*
Synonyms	-	NA

Description of the specimen

Pileus: Small to medium. 3-12 cm in diam., convex when young becoming broadly convex to flat, with a shallow depression, dry or slightly greasy or sticky when wet, finely rugged, waxy-feel, smooth or radially wrinkled, streaked or cracked with age, yellow to dirty orangish yellow, the cuticle peeling about halfway to the centre, margin non-striated. Lamellae - adnate, white to pale cream becoming dull yellow, sometimes spotting and discoloring reddish brown, distant. Lamellulae - of several length. Flesh - white to yellowish, brittle. **Stipe:** 2-7 cm long, 0.5-2.5 cm wide, dry, smooth, but with waxy feel, white to yellowish white but a water-soaked appearance, brittle. **Basidiospores:** 5.5-7.5 x 5-6.5 μm [Q=1.1, 1.5], broadly ellipsoid with isolated warts, amyloid. Spore print - white. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0014 May, June, July, August, September, October 2014; EVS/SF/0129 May, June, July, August, September, October 2015; EVS/SF/0227 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Russula earlei* is commonly known as Beewax *Russula*. It is edible. Local name (Mizo) – Pa Leng var.

51. *Russula rosea* Pers. (1796) **Photoplate-51**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*rosea*

Synonyms - *Agaricus roseus* Schaeff. (1774), *Agaricus sanguineus* Batsch (1783), *Agaricus rosaceus* Pers. (1801), *Agaricus purus var. roseus* (Schaeff.) Pers. (1801), *Russula rosacea* (Pers.) Gray (1821), *Agaricus opiparus* Fr. (1838), *Clitocybe opipara* (Fr.) P. Kumm. (1871), *Omphalia opipara* (Fr.) Quél.(1886), *Hygrophorus nemoreus f. opiparus* (Fr.) Quél.(1890), *Hygrophorus opiparus* (Fr.) Quél. (1896), *Tricholoma opiparum* (Fr.) Bigeard & H. Guill. (1909), *Russula luteotacta var. rosacea* (Pers.) Singer (1929), *Russula lepida* Fr. (1836).

Description of the specimen

Pileus: Small to medium. 3-13 cm in diam., convex when young becoming broadly convex to flat, with a shallow depression, dry either shiny or matte, red or pink, the cuticle peeling or not at all, margin non-striated. Lamellae - adnate, white to pale cream, distant, forked, brittle. Lamellulae - of several length. Flesh - white. **Stipe:** 4-12 cm long, 1-2.5 cm wide, dry, smooth, white to reddish or pinkish, brittle. **Basidiospores:** 7-9.5 x 6.8-9 µm [Q=1.02, 1.05], subglobose, isolated warts, amyloid. Spore print - white to pale cream. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0015 May, June, July, August, September, October 2014; EVS/SF/0130 May, June, July, August, September, October 2015; EVS/SF/0226 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Russula rosea* is reported from Odisha (Tripathy, 2015). This species is commonly known as Rosy Brittle. It is edible. Local name (Mizo) – Pa Lengsen.

52. *Russula mutabilis* Murrill (1940) **Photoplate-52**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*mutabilis*
Synonyms	-	NA

Description of the specimen

Pileus: Small. 3-8 cm in diam., convex when young becoming broadly convex to flat, with a shallow depression, dry or slightly greasy or sticky when wet, dull, orange-brownish to tawny, sometimes bruising deep red, the cuticle peeling about halfway to the centre, margin striated. Lamellae - adnate, close or slightly distant, sometimes forked, cream, often spotting or discoloring reddish brown to brownish. Lamellulae - of several length. Flesh - white. **Stipe:** 2-5 cm long, 1-2.5 cm wide, whitish above the stem, becoming bright yellow to orange yellow, bruising deep red with age, dry, smooth. Annulus - absent. **Basidiospores:** 5.4-9.5 x 5-8.3 μm [Q=1.08, 1.14], broadly elliptical, amyloid, ornamented with warts. Spore print – white to cream. Basidia - clavate, four spored. Clamp connection present ocassionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0059 July, August, September, October 2014; EVS/SF/0225 May, June, July, August, September, October 2015; EVS/SF/0208 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. It is edible. Local name (Mizo) – unknown.

53. *Russula nigricans* Fr (1838) Photoplate-53

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*nigricans*

Synonyms - *Lactarelis nigricans* (Fr.), *Agaricus nigrescens* Bull., *Agaricus nigricans* Bull. (1785), *Agaricus adustus var. crassus* Alb. & Schwein (1805), *Agaricus nigrescens* Krombh. (1845)

Description of the specimen

Pileus: Medium to large, 5-20 cm in diam., broadly convex when young becoming flat, with a shallow depression, dry, smooth with a waxy feel, white at first but soon discolouring slowly greyish brown to blackish with age, dull, orange-brownish to tawny, sometimes bruising deep red, the cuticle not peeling easily, margin striated. Lamellae - adnate or slightly running down the stem, thick, distant, sometimes forked, white to cream, bruising and discolouring slowly greyish to blackish, lamellulae - of several length. Flesh - white, brittle, bruising and discolouring slowly greyish brown to blackish. **Stipe:** 3-9 cm long, 1-4 cm wide, whitish at first, becoming, bruising and discolouring slowly greyish brown to blackish, dry, smooth. Annulus - absent. **Basidiospores:** 5.5-9.5 x 5.3-8.3 µm [Q=1.03, 1.14], sub globose to broadly ellipsoid, amyloid, ornamented with warts. Spore print - white to cream. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0004 May, June, July, August, September, October 2014; EVS/SF/0112 May, June, July, August, September, October 2015; EVS/SF/0208 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Russula nigricans* is reported from Uttar Pradesh (Saini and Atri, 1988);

Uttarakhand (Verma *et al.,* 2018). This species is commonly known as blackening brittlegill or blackening *russula*. It is edible. Local name (Mizo) – unknown.

54. *Russula queletii* Fr (1872) **Photoplate-54**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Russulales
Family	-	Russulaceae
Genus	-	*Russula*
Species	-	*queletii*

Synonyms - *Russula drimeia var. queletii* (Fr.) Rea (1922), *Russula sardonia f. queletii* (Fr.) Singer (1923), *Russula flavovirens* J. Bommer & M. Rousseau (1884)

Description of the specimen

Pileus: Small to medium, 3-8 cm in diam., convex when young becoming broadly convex or flat, with a shallow depression, sticky or wet when wet, smooth, pinkish purple to deep purple, the cuticle peeling easily half way to the center, margin striated. Lamellae - adnate or slightly running down the stem, thick, close, sometimes forked, white to cream. Lamellulae - of several length. Flesh - white, unchanging when sliced, brittle. **Stipe:** 3-9 cm long, 1-2 cm wide, pale to dark or pinkish purple, dry, smooth or slightly hairy, sometimes staining yellow at the base. Annulus - absent. **Basidiospores:** 7-9.5 x 6.5-8.3 μm [Q=1.07, 1.14], broadly elliptical, amyloid, ornamented with warts. Spore print – white to cream. Basidia - clavate, four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0009 May, June, July, August, September, October 2014; EVS/SF/0127 June, July, August, October 2015; EVS/SF/0210 May, June, July, August, September, October 2016.

Comments: Mycorrhizal, solitary to scattered or gregarious on ground broad-leaved forest. *Russula queletii* is commonly known as Fruity Brittlegill. It is edible. Local name (Mizo) – Pa Leng sen.

55. *Scleroderma citrinum* Pers. (1801) **Photoplate-55**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Sclerodermataceae
Genus	-	*Scleroderma*
Species	-	*citrinum*

Synonyms - *Lycoperdon tessellatum* Schumach. (1803), *Scleroderma vulgare* Hornem. (1829)

Description of the specimen

Fruiting body: Small to medium, 2.5-10 cm in diam., 2-6 cm high, round to somewhat flattened. Peridium - covered with rough warts, hard and rigid or rindlike, 1-3 mm thick, white when cut or sliced but usually staining pinkish, surface yellow brown to dingy yellow to ochre or tan and cracked or arranged into prominent, inherent scales which often have a smaller, central wart. **Sporemass:** white when very young, soon becoming gray to purplish gray with whitish veins often running through it, then becoming dark purple-gray to purple-black to black, solid and firm, eventually becoming powdery. **Basidiospores:** 8 - 12 x 8 – 12 μm [Q=1], globose, ornamented, amyloid, ornamented with fine lines. Basidia - clavate four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang EVS/SF/0001 May, June, July, August, September, October 2014; EVS/SF/0102 May, June, July, August, September, October 2015; EVS/SF/0206 May, June, July, August, September, October 2016 and Mizoram University Campus EVS/SF/0010 May, June, July, August, September, October 2014; EVS/SF/0111 May, June, July, August, September, October 2015; EVS/SF/0211 May, June, July, August, September, October 2016.

Comments: Mychorrhizal, solitary to scattered or in groups or clumps on ground and wood debris usually in forests but sometimes also in gardens or in sandy or disturbed soil. *Scleroderma citrinum* was reported from India (Natarajan and Kanan, 1979; Thind *et al.*,1982 and Bilgrami *et al.*, 1991); Jammu & Kashmir (Anand and Chowdhry, 2013). *Scleroderma citrinum* is commonly known as Common Earthball Fungus. A look-alike species to *Scleroderma citrinum* is *Scleroderma areolatum* but *S. areolatum* generally has a thinner peridium and is covered by minute, dark brown scales. It is poisonous. Local name (Mizo) – unknown.

56. *Scleroderma verrucosum* (Bull.) Pers. (1801) **Photoplate-56**

Classification:

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Sclerodermataceae
Genus	-	*Scleroderma*
Species	-	*verrucosum*
Synonyms	-	*Lycoperdon verrucosum* Bull. (1791)

Description of the specimen

Fruiting body: Small to medium, 3-8 cm in diam., 3-6 cm high, rounded, attached to a longitudinally grooved pseudostype (a stem-like structure of infertile material), a white mycelia cords 1-4 cm long spread out from the base. Peridium - covered with small isolated angular scales, 0.5-1 mm thick, reddish brown or yellowish brown becoming more ochraceous with age, as the fruiting body matures, the peridium tends to shed its scales. The peridium then raptures at the apex leaving an irregular opening where the spores are dispersed via wind or rain. **Spore mass:** cream at first but soon becoming purplish brown with fine white marbling, then becoming brown to dark brown and powdery. **Basidiospores:** 8-13 x 8-13 µm [Q=1, 1], globose, ornamented. Basidia - clavate four spored. Clamp connection present occasionally.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang EVS/SF/0003 May, June, July, August, September, October 2014; EVS/SF/0105 May, June, July, August, September, October 2015; EVS/SF/0202 May, June, July, August, September 2016.

Comments: Mychorrhizal, solitary to scattered or in groups or clumps on ground and wood debris usually in forests but sometimes also in gardens or in sandy or disturbed soil. *Scleroderma verrucosum* is reported from Southwest coast of Karnataka (Karun and Sridhar, 2014). This species is commonly known as Scaly Earthball. It is inedible or poisonous. Local name (Mizo) – unknown.

57. *Strobilomyces verruculosus* Hirot. Sato (2009) **Photoplate-57**

Classification:

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Boletales
Family	-	Boletaceae
Genus	-	*Strobilomyces*
Species	-	*verruculosus*
Synonyms	-	NA

Description of the specimen

Pileus: Small to medium. 3-12 cm in diam., convex at first then becoming broadly convex to plane, surface dry, blackish, or purple-black when young, becoming dark brown or almost black when matured, densely verruculose, with minute scales which are fibrous, warty or sub pyramidal, blackish. **Tubes and Pores:** sub decurrent, whitish at first then dark grayish to blacking at maturity, pores up to 1 mm wide, distinctly turning reddish then black on bruising. Flesh-whitish, the color changing like the tubes and pores when injured**. Stipe:** 6-12 cm long, 0.8-3.5 cm wide, equal or narrowing to the base, straight or curved concolorous with the pileus**. Basidiospores:** 7.8-9.5x7.4-8.4 µm (Q=1.05, 1.13) including ornamentation, globose to sub globose, amyloid. Spore print- fuscous-brown. Basidia - clavate, four-spored, ornamented with warts. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0011May, June, July 2014; EVS/SF/0108 May, June 2015; EVS/SF/0204 May, June, July 2016.

Comments: Mycorrhizal, solitary on ground of Greenhouse at broad-leaved evergreen forest. Edibility is not known. Local name (Mizo) – unknown.

58. *Termitomyces clypeatus* R. Heim (1951) **Photoplate-58**

Classification:

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Lyophyllaceae
Genus	-	*Termitomyces*
Species	-	*clypeatus*

Synonyms - *Sinotermitomyces taiwanensis* M. Zang & C.M. Chen, (1998)

Description of the specimen

Pileus: Small, 4-6 cm in diam., conical becoming flat with strongly pointed umbo to acutely umbo, irregular margin, greyish brown cap at the center or umbo, fading lighter towards the margin, smooth, fibrillose, silky, sticky when wet. Lamellae -white to pinkish cream, free, crowded. Lamellulae - of several length. Flesh - white, thin. **Stipe:**

5–11 cm long, 0.5–1 cm wide, whitish, solid, central, cylindrical and with a slightly bulbous base, with tapering pseudorrhiza. Annulus absent. **Basidiospores**: 5.5–7.0 × 5.1-6.2 µm [Q= 1.07 – 1.1] broadly ellipsoidal, hyaline and smooth. Spore print - white to pinkish cream. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0044, July, August, September 2014; EVS/SF/0145, July, August, September 2015; EVS/SF/0212 May, June, July 2016.

Comments: Solitary on ground of broad-leaved evergreen forest. *Termitomyces* clypeatus is reported from Kerala (Karun and Sridhar, 2013); Assam (Gogoi & Parkash 2015). Local name (mizo) – unknown.

59. *Termitomyces robustus* (Beeli) R. Heim (1951) Photoplate-59

Classification:

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Lyophyllaceae
Genus	-	*Termitomyces*
Species	-	*robustus*

Synonyms - *Schulzeria robusta* Beeli *(1927)*, *Termitomyces fuliginosus* Pegler (1977).

Description of the specimen

Pileus: Medium to large, 7-15 cm in diam., conical at first becoming convex to flat with strongly pointed umbo to acutely umbo, irregular margin, white to brown or grayish brown, darker at the center or umbo, fading lighter towards the margin, fibrillose, scaly, somewhat spiny or hairy, crenate or toothed margin. Lamellae - free, crowded, white to pale yellow or pinkish cream. Pale pinkish at first, then becoming brownish to dark brown in age, crowded. Lamellulae - of several length. Flesh – white to pale yellow or pinkish cream, thick. **Stipe:** 6-11cm long, 1-2.5 cm wide, concolorous with the pileus white to brown or grayish brown, equal, solid, scaly or hairy, hollow, attenuating as an elongate pseudorrhiza. Annulus – present. Volva – absent. **Basidiospores:** 4-8×3-4.5 µm [Q = 1.3 –1.7], ovoid to ellipsoid, thin-walled, inamyloid, hyaline. Spore print– white to pinkish cream. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Mizoram University Campus EVS/SF/0022, June, July, August 2014; EVS/SF/0122 June, July, August, 2015; EVS/SF/0224, June, July, August 2016.

Comments: Mycorrhizal, growing solitary to scattered to gregarious on termite mounds or on soil on ground of broad-leaved forest. *Termitomyces robustus* is reported from Kerala (Karun and Sridhar, 2013); Uttar Pradesh (Vishwakarma *et al.*, 2017). This species is readily recognized by its large, tough pileus with brown cap surface conical umbo and a swollen stipe and long pseudorrhiza. It is edible and delicious. Local name (mizo) – Pasawntlung.

60. *Thelephora ganbajun* M. Zang (1987) **Photoplate-61**

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Thelephorales
Family	-	Thelephoraceae/Clavariaceae
Genus	-	*Thelelophora*
Species	-	*ganbajun*
Synonyms	-	NA

Description of the specimen

Fruiting Body: 2.5-10 cm high, 2.5 to 15 cm wide, spoon or fan-shaped folds arising from a common base to form a vase-like or cuplike mushroom, dirty-white or yellowish to brownish grey, radially lined, slightly hairy towards th base, becoming smooth. Fertile surface pale yellow to greyish brown, smooth becoming slightly wrinkled with tiny projections. **Stipe:** 0.5-5cm long, whitish to grey, slightly hairy. Flesh - whitish to grey, thick, leathery. **Basidiospores:** 4.5-8 x 4.2-6.5 µ [Q=1.07, 1.23], angular and lobed, slightly spiny. Spore print – buff. Basidia - clavate, four spored. Clamp connections present and easily demonstrated.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0041. July, August, September, October 2014; EVS/SF/0123 June, July, August, September 2015; EVS/SF/0221 June, July, August, September 2016 and Mizoram University Campus EVS/SF/0021 June, July, August 2014; EVS/SF/0223 June, July, August 2015; EVS/SF/0220 June, July, August 2016.

Comments: Mycorrhizal, growing terrestrially or rarely from well decayed wood, growing solitary to scattered or gregarious on ground broad-leaved forest. Edibility is not known. Local name (mizo) – unknown.

61. *Trichoglossum hirsutum* Pers. Boud (1907) **Photoplate-62**

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Ascomycota
Sub Division	-	Pezizomycotina
Class	-	Geoglossomycetes
Sub Class	-	Geoglossomycetidae
Order	-	Geoglossales
Family	-	Geoglossaceae
Genus	-	*Trichoglossum*
Species	-	*hirsutum*

Synonyms - *Clavaria atra* J.F. Gmel (1792), *Geoglossum hirsutum* Pers., (1797).

Description of the specimen

Ascomata: Small, 0.5-2 cm in diam., 0.8-2 cm high, clavate to capitate or spathulate, club-shaped, flattened, spearhead-shaped to ellipsoid, often strongly laterally compressed, not viscid, the entire surface fuliginous to black, finely velvety or hairy, black, tough. Fertile part clearly differentiated from the stipe, occupying the upper part of the ascoma and extending to around one third of its length. The flesh is thin, tough and brownish. **Ascospores:** 10.5 - 19 x 5.5 - 7 µm, [Q=1.91, 2.7], cylindric-clavate to bacilliform, broadest in the middle and tapering to the blunt ends, with 15 septa, inamyloid. Spore print - black. Asci - typically, 300 x 18 µm, each ascus contains eight spores.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest EVS/SF/0007. May, June, July, August, September, October 2014; EVS/SF/0119 June, July, August, September, October 2015; EVS/SF/0219 June, July 2016 and Mizoram University Campus EVS/SF/0220 June, July, August 2016.

Comments: Saprobic, growing solitary to scattered or gregarious on ground broad-leaved forest. *Trichoglossum hirsutum* is commonly known as Hairy-earth tongue. It is inedible. Local name (Mizo) – unknown.

62. *Volvariella taylorii* (Berk. & Broome) Singer (1951) (Photoplate-63)

Classification

Domain	-	Eukaryota
Kingdom	-	Fungi
Division	-	Basidiomycota
Sub Division	-	Agaricomycotina
Class	-	Agaricomycetes
Sub Class	-	Agaricomycetidae
Order	-	Agaricales
Family	-	Plutaceae
Genus	-	*Volvariella*
Species	-	*taylorii*

Synonyms - *Agaricus taylorii* Berk. (1854), *Volvaria taylorii* (Berk.) Gillet (1876), *Volvariella taylori* (Berk. & Broome) Singer (1951), *Volvariella pusilla var. taylorii* (Berk.) Boekhout (1986).

Descrition of the specimen

Pileus: Medium, 3-10 cm in diam., at first oval, then broadly convex to plane or flat with broadly umbonate, finely hairy, sometimes with patches in age, viscid when moist, dull white to gray or grayish brown, margin slightly lined. Lamellae - free, close or crowded, broad, whitish becoming pink or sordid reddish. Lamellulae - of several length. Flesh - white. **Stipe:** 4-9 cm long, 1-2 cm wide, colored more or less like the pileus dull white to gray or grayish brown, tapering gradually to apex, with a slightly swollen base, smooth or finely hairy, forming a sack-like volva at the base of the stipe, often buried in soil. Annulus – absent. Volva – present. **Basidiospores:** 5.5-9 x 4-6 μm [Q=1.37, 1.5], elongate, smooth, amyloid. Spore print - salmon pink or pinkish brown. Basidia - clavate, four spored. Clamp connection absent.

Specimens examined: INDIA, Mizoram, Aizawl, Hmuifang forest, EVS/SF/0018, June, July 2014; EVS/SF/0118 June, July 2015; EVS/SF/0218 June, July 2016.

Comments: Saprobic, growing alone or scattered gregariously on ground of broad-leaved evergreen forest. *Volvariella taylorii* is reported from India as *V. taylori* (Berk.) Singer (Pradeep *et al.*, 1998), Kerala (Mohanan, 2011). This species is commonly known as Rose-gilled Grisette**.** It is edible and delicious. Local name (Mizo) - Changel-Pa.

CHAPTER – III

DIVERSITY OF SOIL MUSHROOMS FROM TWO FOREST SITES

III.1. INTRODUCTION

Mushrooms are seasonal macro fungi occurring predominantly during rainy season in various habitats all over the world. They are one of the most diverse niches and constitute a significant part of ecosystems. They form a large share of the species richness and are key-players in ecosystem processes (Keizer, 1998; Seen-Irlet *et al*., 2007). They are also an indicator of the forest life support system (Stamets, 2000). Mushrooms are economically important since they serve as food, medicine, biocontrol agents, chemical producers of bioactive compounds used in the pharmaceuticals and many other industries (Duarte *et al*., 2006). Data on their diversity in different vegetation types is important for planning and managing ecosystem biodiversity (Engola *et al*., 2007). The knowledge of biodiversity at the community and species level is very important for monitoring the effectiveness and effects of natural and artificial disturbances (Packham *et al*., 2002). Mushrooms have the longest history of diversity studies of any mycota but are understudied over the world; however, mycologists continue to unravel the unexplored, hidden and fascinating fungal biodiversity as many macro fungi are becoming extinct or facing threat of extinction because of habitat destruction and global climate change (Swapana *et al*., 2008). In this chapter, the purpose and objective of this three years study was to generate base line information and inventorying species of soil mushrooms from two forest sites and to evaluate diversity between the two forests so that this database can be used as a reference for further studies in the future.

III.2. REVIEW OF LITERATURE

Defining the exact number of fungi on the earth has always been a point of discussion and several studies have been focused on enumerating the world's fungal diversity (Crous, 2006). Studies estimate that out of 1.5 million species of fungi existing on this biosphere, 140,000 species may be considered as mushrooms, but only 14,000 species are known to man, which accounts for 10% of the estimated mushroom species (Chang and Miles, 2004). Only a fraction of total fungal biodiversity has been subjected to scientific scrutiny and mycologists continue to unravel the unexplored, hidden and fascinating fungal biodiversity as many macro-fungi are becoming extinct or facing threat of extinction because of habitat destruction and global climate change (Swapana *et al.,* 2008).

Villeneuve *et al*. (1989) observed that the macrofungal flora of deciduous forests composed mainly of many infrequent species, whereas coniferous forests had a few but very frequent macro fungi. Further, the species composition in coniferous forests differed from that of deciduous forests, and in conifer forests the dominance of ectomycorrhizal fungi was obvious. Tolgor (1999) reported 286 species of mushrooms from Daqinggou Nature Reserve (China) belonging to 135 genera, 55 families and 23 orders and 30 species were new reports from China. Similarly, Chen-Ying *et al*. (2004) reported 40 species of Basidiomycota from Liuxihe National Forest Park, Guangzhou, China belonging to 21 genera in 15 families. More than half of the species collected were edible and of these 10 species exhibited medicinal properties. Moreover, about 60 per cent species, spread in 26 taxa, were ectomycorrhizal involving 12 edible fungi. Devkota (2005a) reported 76 species from Lumle (Kaski) and 9 Clavariales from

Kathmandu valley in Nepal. Kharel and Rajbhandary (2005) documented ethnomycological knowledge among local people about some wild mushrooms from Lumle (Kaski) Nepal. Turkoglu *et al*. (2007) reported 130 taxa of macrofungi from Babadag district in province Denizli of Turkey and 5 species were new records for Turkey. Egbe *et al*., (2013) studied diversity and distribution of mushrooms in the Mount Cameroon Region. These were assessed at low and high altitudinal ranges in the four flanks of the mountain during the rainy and early dry seasons. Species richness was higher in the rainy seasons than in the early dry seasons and tended to decrease with altitude.

India is one of the top 10 mega biodiversity nations of the world fortunate to have a varied agro climate, abundance of agro wastes, relatively low-cost labor and a rich fungal diversity (Borkar *et al.*, 2015). In India, about 2000 species of fungi are used as food by tribes and various communities. Climatic conditions in India are favorable for natural occurrence of mushrooms and some of them are regularly collected and used as food by the natives particularly those belonging to the tribes, the common edible mushrooms collected from nature are species of *Astraeus, Auricularia, Calvatia, Cantharellus, Lycoperdon, Morchella, Schizophyllum, Termitomyces, Tuber* etc. (Harsh and Joshi, 2009). One third of fungal diversity of the globe exists in India. Out of 1.5 million of fungi, only 50% are characterized until now. Though the occurrence of mushrooms is of diverse nature in India, they are not well known. Out of 2000 edible species available in the world, about 283 are reported from India. Nearly 6,500 collections of mushroom flora belonging to 223 species, 59 genera and 15 families of Agaricales have been reported from North West Himalayas by Lakhan Pal and his students since 1976 (Sarbhoy, 1997). According to Sarbhoy *et al.*, (1996) the number of fungi species recorded in India were over 27,000.

Atri and Saini (1989) reported several mushrooms from the North-western Himalayas reviewing work on the Russulaceae worldwide including the Indian components. To date only 81 taxa (55 of *Russula* and 26 of *Lactarius*) have been recorded from India. Bhatt, *et al*. (1989, 1990, 1995, 1999, 2000, 2007a, 2007b, 2003); Das, *et al*. (2005); Prasad, *et al*. (2000); Moncalvo, *et al*. (2004) studied the diversity of macrofungal flora of the Garhwal Himalaya, Uttarakhand. Kumar and Sharma (2011) reported wild edible mushrooms from various locations of the northwest Himalayas of Jammu and Kashmir. Vishwakarma *et al*. (2011) reported 40 macrofungal taxa belonging to 11 families from different moist temperate forests of Garhwal Himalaya within the elevation range of 550–2500 msl in the districts. Pushpa and Purushothama (2012) reported 90 species in 46 genera belonging to 19 families in 05 orders of Basidiomycotina from 8 collection sites from Bangalore where mushroom diversity and species richness was found to be higher in restricted areas than that of urban places. Farook (2013) reported 616 species of gilled mushrooms belonging in 112 genera and 5 orders from Kerala. Vyas *et al*. (2014) reported 18 genera belonging to 12 families of mushrooms where the species richness and abundance was much higher in the thick forest rather than thining and destruction of forest in Patharia Forest of Sagar at Madhya Pradesh. Singha (2017) reported a total of 71 mushroom species of 41 genera belonging to 24 families from West Bengal, India. The genus *Russula* exhibited the maximum number of species and the family Tricholomataceae represented the maximum number of individuals. According to Simpson's index of diversity, the calculated value of species richness was 0.92 and as to Shannon's diversity index, the relative abundance of species was found to be 2.206.

The North Eastern hills of India being the transitional zone between the Indian, Indo-Malayan and Indo-Chinese bio-geographical regions makes the gate way for many of India's flora and fauna. It is one of the biodiversity hotspots of the world (Myers *et. al.,* 2000). Northeast India is also very rich in mushroom flora (Verma *et al.,* 1995). Very few works on mushroom diversity has been carried out in North Eastern region of India.

Bhattacharrya and Barua (1953) studied the distribution and description mushrooms found in Assam. Baruah (1969) also studied various members of basidiomycetes mushrooms in Assam. Baruah (1971); Barua (1998, 2002); Agrahar-Murugkar (2005); Sarma *et al*., 2010; Srivastava and Soreng (2014) reported wild edible mushrooms from Assam, Arunachal Pradesh, Meghalaya, Manipur, Jharkhand. Verma *et al.* (1995) listed 95 species of mushrooms from North Eastern hills of India. Zothanzama (2011) studied the diversity of wood rotting fungi from two forests of Meghalaya where it was reported that the forests having more tree species was having a greater number of fungal species. Khaund & Joshi (2013) recorded 11 different species belonging to 9 genera and 8 families of edible mushrooms from Meghalaya. Gogoi & Parkash (2015a, 2015b, 2014), Tanti *et. al.* (2011), Boruah *et al.* (1997), and Sing & Sing (1993) reported a few numbers of wild mushrooms from Assam and Manipur. Das (2009) reported 126 wild mushrooms from Barsey Rhododendron Sanctuary of the state Sikkim. Tanti *et al. (*2011) reported a few collected of mushrooms from Nagaland. Gogoi and Parkash (2015a and 2015b) reported 138 species of gilled mushrooms belonging to 48 genera, 23 families, five orders of the class Agaricomycetes, division Basidiomycota from Assam. Ao *et al.* (2016) reported 87 species of wild mushrooms from Nagaland. Kalita *et al.* (2016) recorded 22 mushrooms species representing 16 genera, 14 families and 6 orders from Meghalaya.

In Mizoram, macro fungal or study of mushroom especially regarding their diversity has not yet been done much except for some report of wood decaying (Bisht, 2011; Zothanzama, 2011). Little information about the soil mushrooms of Mizoram were reported by Bisht, 2011. An investigation has been done on mushrooms and only few mushrooms have so far been known and named (Zothanzama, 2011a; Zothanzama, 2011b; Bisht, 2011; Zothanzama and Lalrinawmi, 2015; Lalrinawmi and Zothanzama, 2016a; Lalrinawmi and Zothanzama, 2016b; Zothanzama *et al.*,2016 and Lalrinawmi *et al.*, 2018).

III.3. MATERIALS AND METHODS

Study sites, Climate and Vegetation-

Collection of the soil mushroom was carried out from two different forests in Aizawl District i.e., Mizoram University Campus and Hmuifang.

Hmuifang forest

Hmuifang is situated in the southern part of Aizawl. It is a village in Aibawk Tehsil, Aizawl District, Mizoram State. It is about 50 km from Aizawl with an elevation of 1619 meters above sea level. The area lies between the coordinates 92°45'19"E - 92°45'24"E longitudes and 23°27'22"N - 23°27'31"N latitudes. Hmuifang is also the source of Tuirial River. The mountain is still covered with virgin forests reserve. The mountain has beautiful cliffs and offers great views of the surrounding hills. The texture of the soil falls under the loamy sand. The forest falls under tropical semi-evergreen forests (Champion and Seth, 1968).

Under the Koppen Climate Classification, the study site comes under the Humid subtropical climate (Cwa). The average annual rainfall during the study period May, June, July, August, September and October 2014, 2015 and 2016 is 472.5, 454.38, 475 (Figure 3). The average annual temperature in May, June, July, August, September and October 2014, 2015 and 2016 is 20.62 ºC, 19.81 ºC, 19.56ºC respectively during the study period (Figure 4, Thermometer).

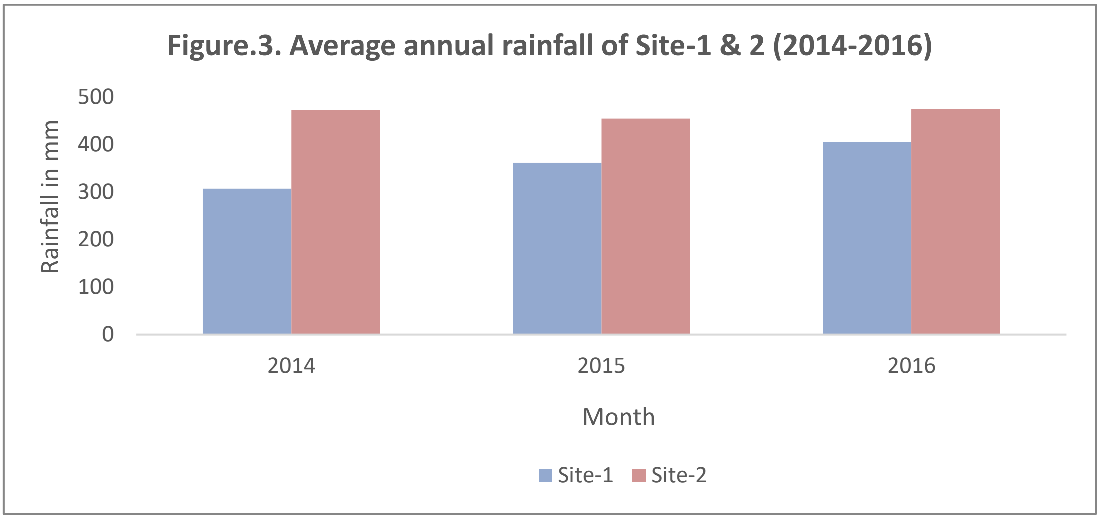
The common tree species were *Dipterocarpus retusus, Helicia excelsa, Lithocarpus xylocarpus, Symplocos racemosa, Dryptes indica, Elaeocarpus rugosus,* etc.

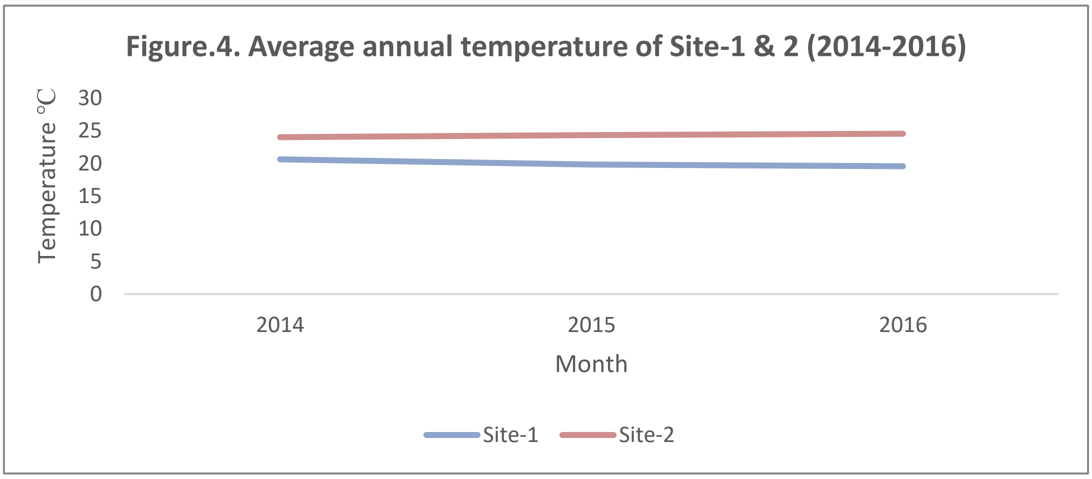
Mizoram University Campus

Mizoram University is in the Western side at a distance of about 19 kms away from the state capital, Aizawl, just below Tanhril Village. The Mizoram University Campus is about 980 acres in area and lies between 23º45’25” N - 23º43’37” N latitudes and 92º38’39” E - 92º40’23’E longitudes. The elevation ranges from 330m to 880m above mean sea level (msl). Soils under forest cover are porous, sandy loam and humus whereas the open areas are covered with coarse sandy, friable and lateritic and the top soils have been washed away by run-off.

The climate of Mizoram University is humid and tropical, characterized by short winter and long summer. The average annual rainfall during the study period May, June, July, August, September and October 2014, 2015 and 2016 is 306.95, 361.87, 405.57 (Figure 3). The temperature in May, June, July, August, September and October 2014, 2015 and 2016 is 24.01 ºC, 24.32 ºC, 24.54 ºC respectively during the study period (Figure 4).

The common tree species were *Castanopsis tribuloides, Schima wallichii, Aporusa octandra, Alseo daphne petiolaris, Styrax serrulatum, Michelia champaca; Rhus semialata; Saurauia punduana, Lithocarpus xylocarpa, Macaranga indica, Callicarpa arborea,* etc.





Species Diversity-

The following method were employed for studying the diversity of soil mushroom from two forests:

Sampling Methodology

The macro fungal fruiting bodies was sampled monthly from May to October from the two sites during 2014-2016. Sampling of the mushrooms were not showing any results during the dry season (November to April) and hence were not represented throughout the study. Sampling were taken from five plots of 20m X 20m square plots.

In case of small macro fungi occurring in groups/clusters, a frame of 20cm X 20cm was put on top of the fruit body clusters and those fruit bodies inside the frame was treated as a single individual of the species (Mani and Kumaresan, 2009).

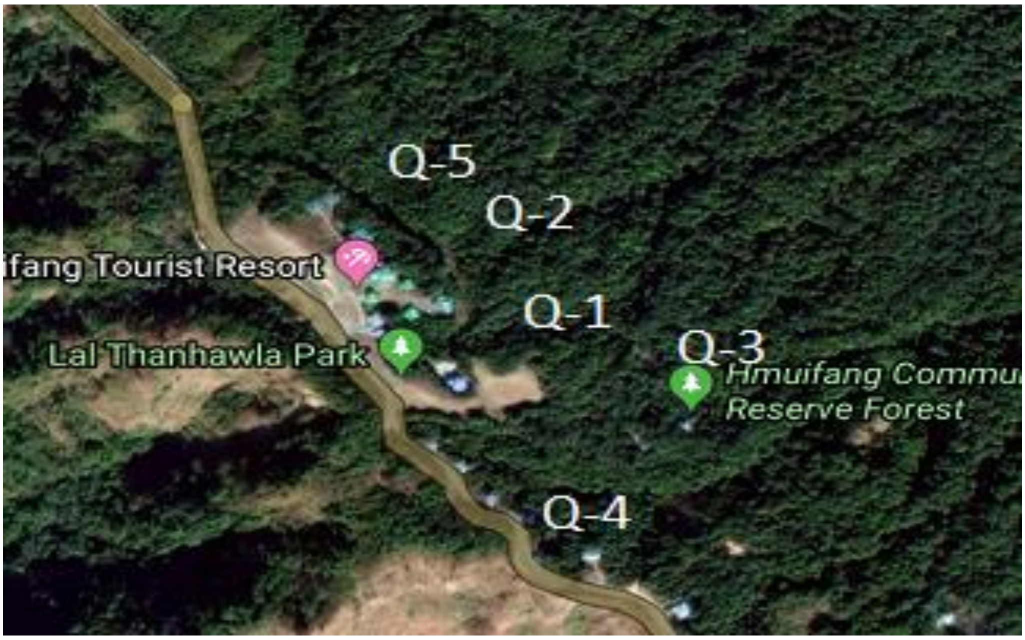


Figure 5. Quadrats of study site-1 (Aerial view)

Figure 6. Quadrats of study site -2 (Aerial view)

The following indices were then calculated:

Cumulative species richness

Cumulative species number was calculated following the method of Zothanzama (2011). The species accumulated at each sampling was noted and the cumulative species richness of mushrooms in both the sites were calculated from the collecting seasons May to October for three year of the study periods 2014-2016. The species accumulation graph was then plotted as number of species accumulated within each sampling time.

Shannon's diversity Index (H_s)

The index assumes that individuals are randomly sampled from an infinitely large community (Pielou,1975) and that all species are represented in the sample. The Shannon Index is calculated from the equation-

$$H_s = -\sum piLnpi$$

Where p_i = the proportion of individuals found in the i^{th} species

Or $pi = \frac{ni}{N}$

Where, n_i =the abundance of the individual in the i^{th} species.

N = the abundance of all the species.

Simpson Index of Dominance (Ds)

Simpson (1949) gave the probability of any two individuals drawn at random from an infinitely large community belonging to the same species.

The form of the index appropriate for a finite community is represented by

$$Ds = \sum\left[\frac{[\{ni(ni-1)\}]}{[\{N(N-1)\}]}\right]$$

Where, ni = No. of individuals of the i^{th} species

N= total no. of individual

As the Simpson's index values increases, diversity decreases. Simpson index is therefore usually expressed as "1- D" or "1/D". The Index was written as Ds for 1-D throughout the study.

Pielou's Evenness Index (J')

For calculating the evenness of species, the Pielou's Evenness Index (J') was used (Pielou, 1966).

$$J' = \frac{H}{LnS}$$

Where, H = Shannon–Wiener's diversity index

S = total number of species in the sample

Ln = Natural Logarithm

Margalef's Diversity Index (D_{Mg})

Given by Clifford and Stephenson (1975), it is indicated by

$$\mathbf{DMg} = \frac{(S-1)}{LnN}$$

Where, S = number of species recorded

N = total number of individuals

Ln = Natural Logarithm

III.4. RESULTS AND DISCUSSION

Species Richness-

Cummulative species

A total of 62 mushroom species belonging to 18 families with 34 genera were identified from both the sites during the collecting period of May to October 2014 to 2016. 35 species were recorded from Site-1 (Hmuifang) (Table 1) and 48 species were recorded from the Site-2 (Mizoram University Campus) (Table 2). It was observed that the species continue to increase with each year as shown in the species accumulation curve (Fig. 7).

Species diversity

The diversity indices of soil mushrooms are presented in Appendix I. Species diversity of soil mushrooms was found to be higher in Mizoram University Campus than in Hmuifang forest. The diversity indices were calculated from the collections made during the mushroom growing season i.e., May to October for each of the years 2014-2016.

It was observed that the Shannon diversity index (H_s) in Site-1 shows highest value of 3.38 (± 0.27 SE) and lowest value of 1.28 (± 0.22 SE) during July 2015 and October_2014 respectively. (Appendix I, Figure 8). The Shannon diversity index (H_s) in Site-2 shows highest value of 3.62 (± 0.25 SE) and lowest value of 2.84 (± 0.17 SE) during June 2016 and October 2014 respectively. (Appendix I, Figure 9). The annual average Shannon diversity index (H_s) in Site-1 were 2.6, 2.8 and 3.12 for the year 2014, 2015 and 2016 respectively and 3.13, 3.27 and 3.25 for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix I, Figure 10).

It was observed that the Simpson index of Dominance (D_s) in Site-1 shows highest value of 0.97 (± 0.18 SE), 0.97 (± 0.18 SE), 0.97 (± 0.1 SE); 0.97 (± 0.27 SE), 0.97 (± 0.12 SE); and 0.97 (± 0.13 SE), 0.97 (± 0.2 SE), 0.97 (± 0.18 SE), during June, July, August 2014; July, September 2015; and June, July, August 2016 respectively and lowest value of 0.94 (± 0.17 SE) in May 2015. (Appendix I, Figure 11). The Simpson index of Dominance (D_s) in Site-2 shows highest value of 0.97 (± 0.21 SE), 0.97 (± 0.1 SE); 0.97 (± 0.22 SE), 0.97 (± 0.26 SE) during July, September 2015; and July, September 2016 respectively and lowest value of 0.54 (± 0.07 SE) in September 2014. (Appendix I, Figure 12). The annual average Simpson index of Dominance (D_s) in Site-1 was 0.96 for the year 2014, 2015 and 2016 respectively, and 0.88, 0.96 and 0.96 for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix I, Figure 13).

It was observed that the Pielou's Evenness index (J') in Site-1 shows highest value of 0.63 (± 0.13 SE), 0.63 (± 0.21 SE) during June and September 2016 and lowest value of 0.28 (± 0.22 SE) in October 2014. (Appendix I, Figure 14). The Pielou's Evenness index (J') in Site-2 shows highest value of 0.64 (± 0.2 SE) and 0.64 (± 0.22 SE) during August 2015 and July 2016 respectively and lowest value of 0.54 (± 0.1 SE) in October 2016. (Appendix I, Figure 15). The annual average Pielou's Evenness index (J') in Site-1 were 0.51, 0.54 and 0.59 for the year 2014, 2015 and 2016 respectively, and 0.58, 0.6 and 0.6 for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix I, Figure 16).

It was observed that the Margalef's Diversity Index of Species Richness (D_{Mg}) in Site-1 shows highest value of 5.61 (± 0.27 SE) in July 2015 and lowest value of 2.55 (± 0.17 SE) in May 2014 (Appendix I, Figure 17). The Margalef's Diversity Index of Species Richness (D_{Mg}) in Site-2 shows highest value of 7.21 (± 0.18 SE) in June 2015 and lowest value of 2.55 (± 0.23 SE) in May 2016 (Appendix I, Figure 18). The annual average Margalef's Diversity Index of Species Richness (D_{Mg}) were 3.83, 4.65, 4.45 for the year 2014, 2015 and 2016 respectively in Site-1 and 4.55, 5.66 and 3.83 for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix I, Figure 19).

The average Shannon diversity index (Hs), Simpson index of Dominance (D_s), Evenness index (J'), Margalef's Diversity Index of Species Richness (D_{Mg}) during the study period 2014-2016 were 2.84, 0.96, 0.55 and 4.32 respectively in Site-1. The average H_s, D_s, J' and D_{Mg} during the study period 2014-2016 were 3.22, 0.93, 0.59, 4.68 respectively from Site-2. The average mushroom diversity from Site-1 were lower than that of Site-2 for all the indices except for Simpson's index of dominance D_S (Appendix I, Figure 20).

Fig.7. Cummulative no. of species from 2014-2016

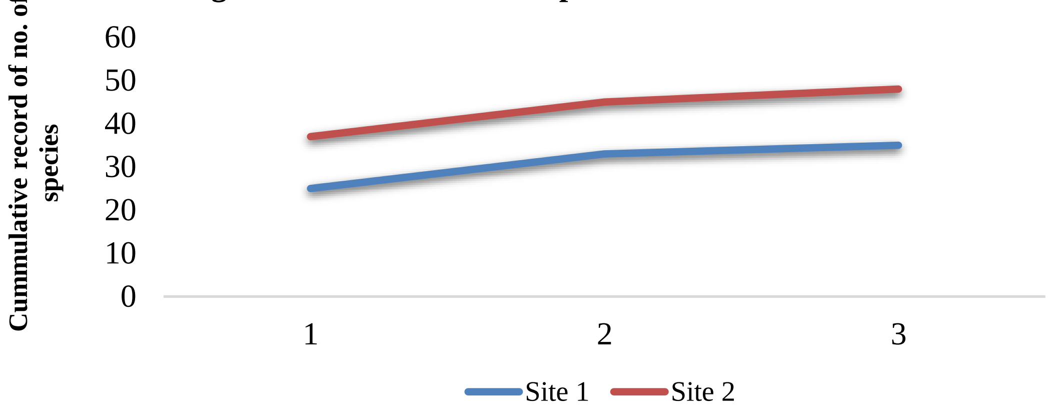


Fig.8. Shannon Wiener's Diversity Index (H_s) of Site-1 during 2014-2016

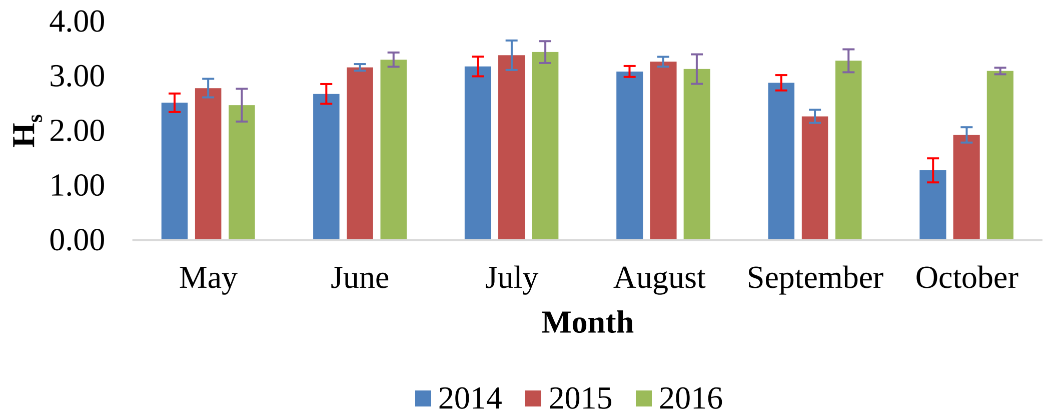


Fig.9. Shannon-Wiener's Diversity Index (H_s) of Site-2 during 2014- 2016

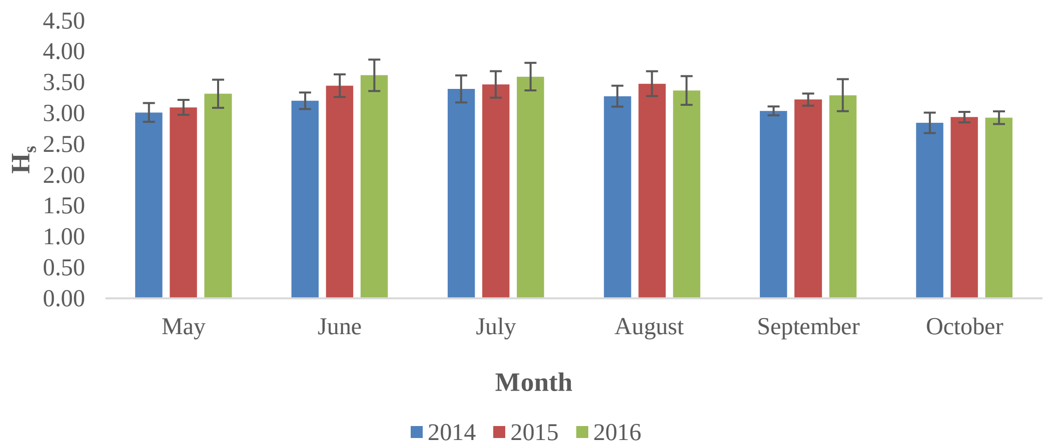
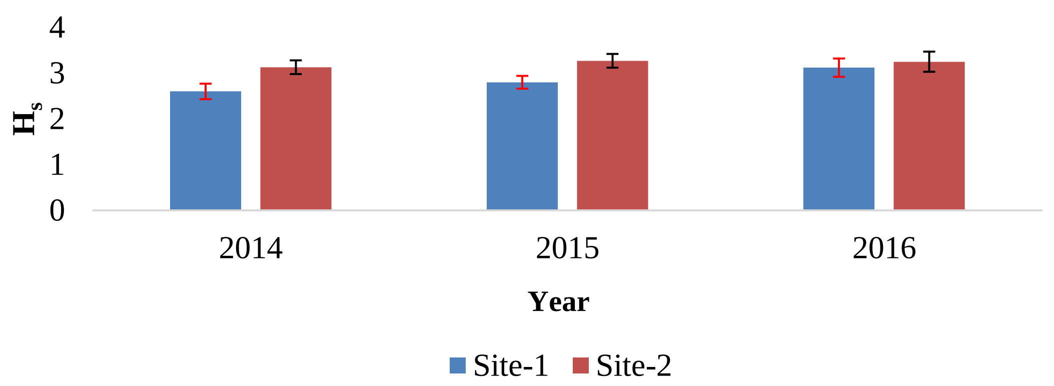


Fig.10. Annual Average Shannon-Weiner's Diversity Index (H_s) of Site-1 and Site-2 during 2014-2016



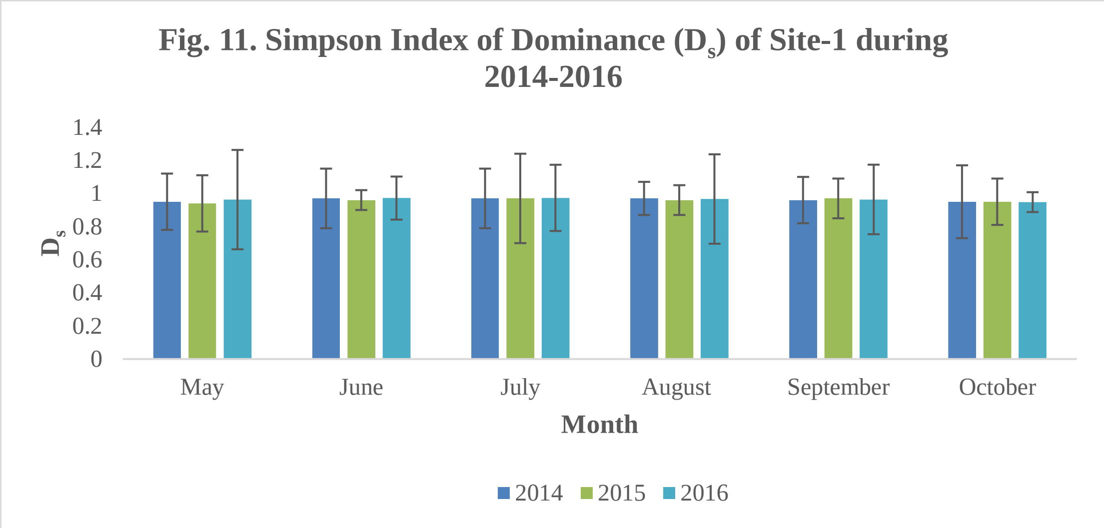


Fig. 11. Simpson Index of Dominance (D_s) of Site-1 during 2014-2016
1.4
1.2
1
0.8
0.6
0.4
0.2
0
D_s
May
June
July
August
September
October
Month
2014
2015
2016

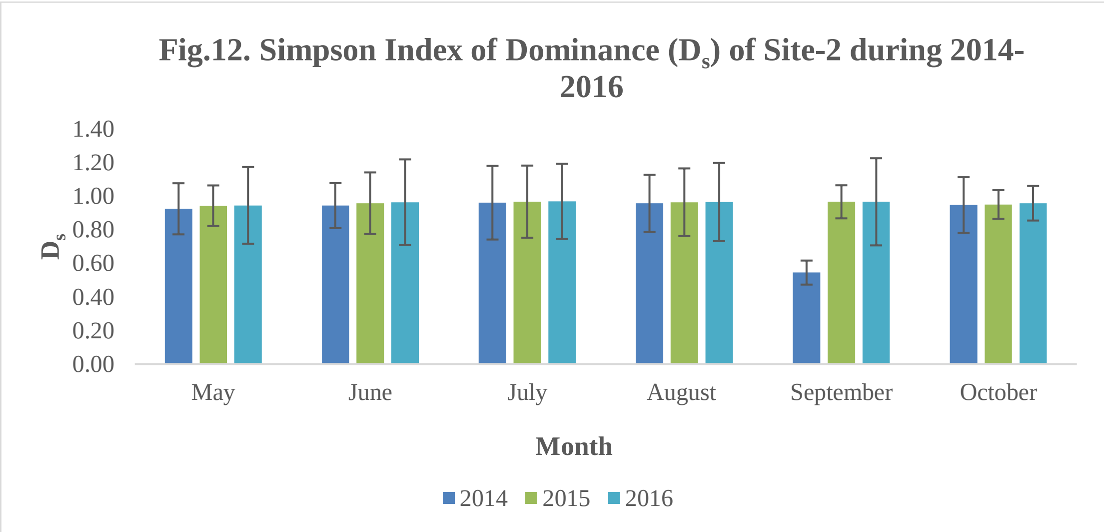


Fig.12. Simpson Index of Dominance (D_s) of Site-2 during 2014-2016
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
D_s
May
June
July
August
September
October
Month
2014
2015
2016

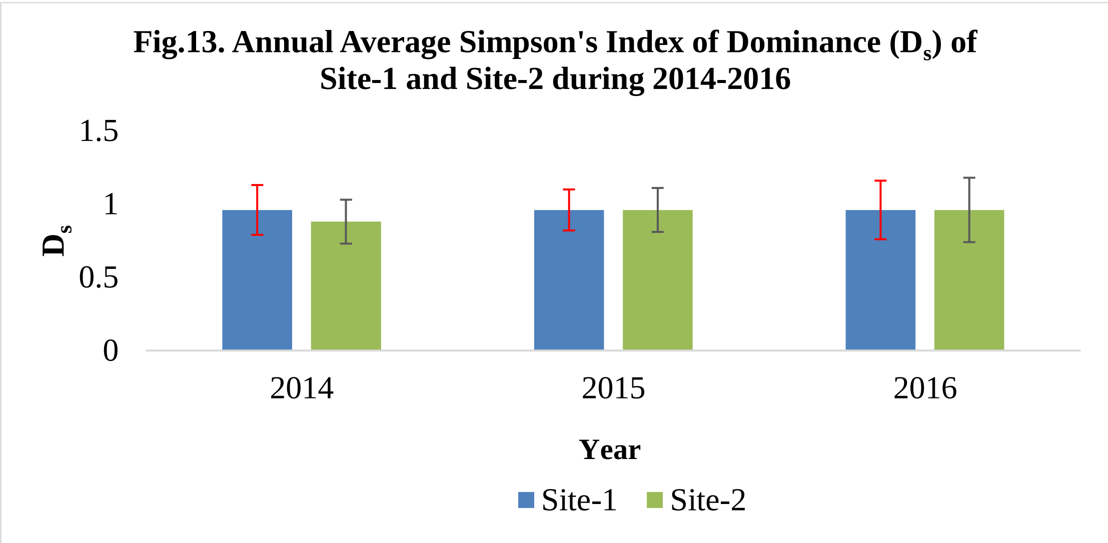


Fig.13. Annual Average Simpson's Index of Dominance (D_s) of Site-1 and Site-2 during 2014-2016
1.5
1
0.5
0
D_s
2014
2015
2016
Year
Site-1
Site-2

Fig.14. Pielou's Evenness Index (J') of Site-1 during 2014-2016

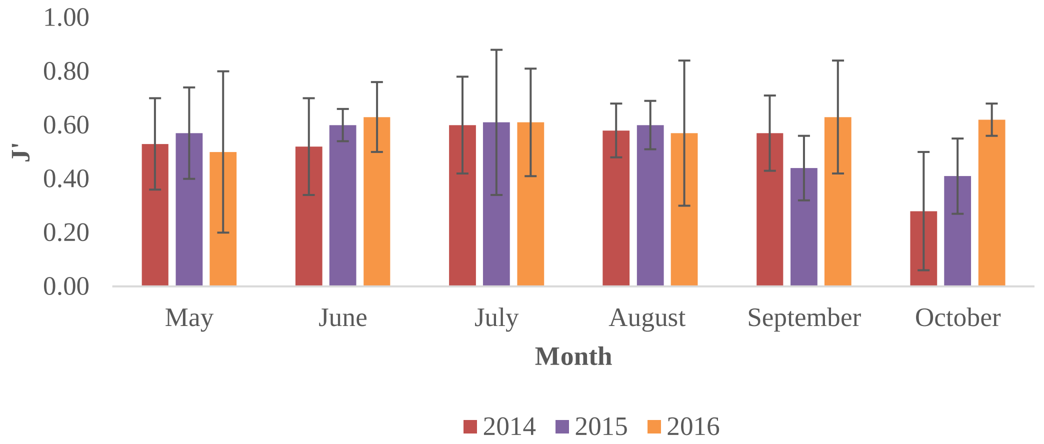


Fig.15. Pielou's Eveness Index (J') of Site-2 during 2014-2016

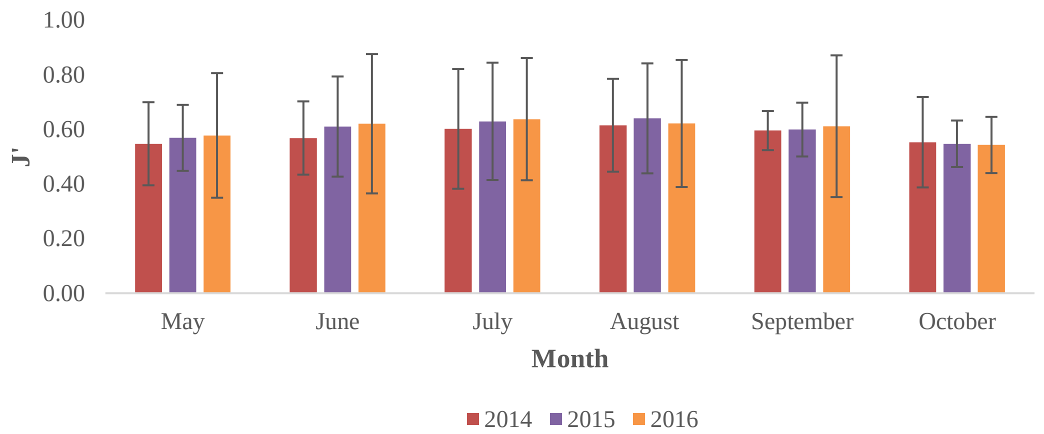


Fig.16. Annual Average Pielou's Evenness (J') Index of Site-1 and Site-2 during 2014-2016

Fig.17. Margalef's Species Richness (D_{Mg}) of Site-1 during 2014-2016

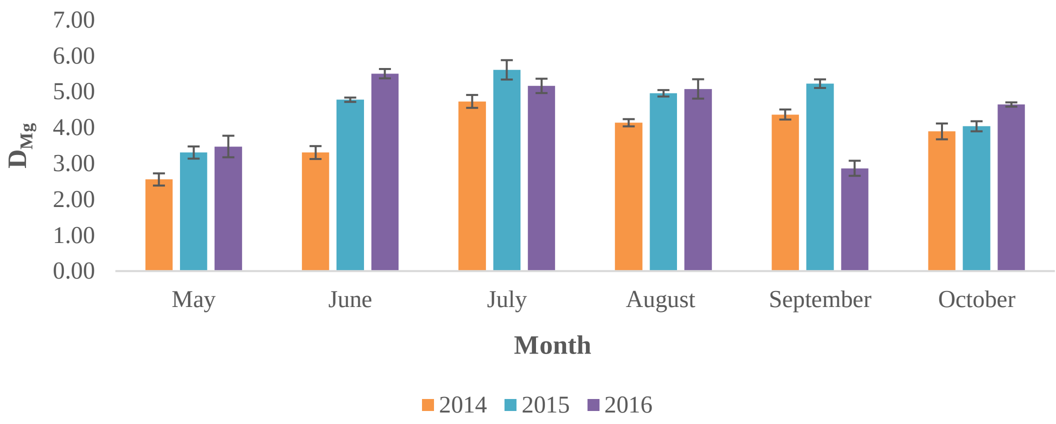


Fig.18. Margalef's Species Richness (D_{Mg}) of Site-2 during 2014-2016

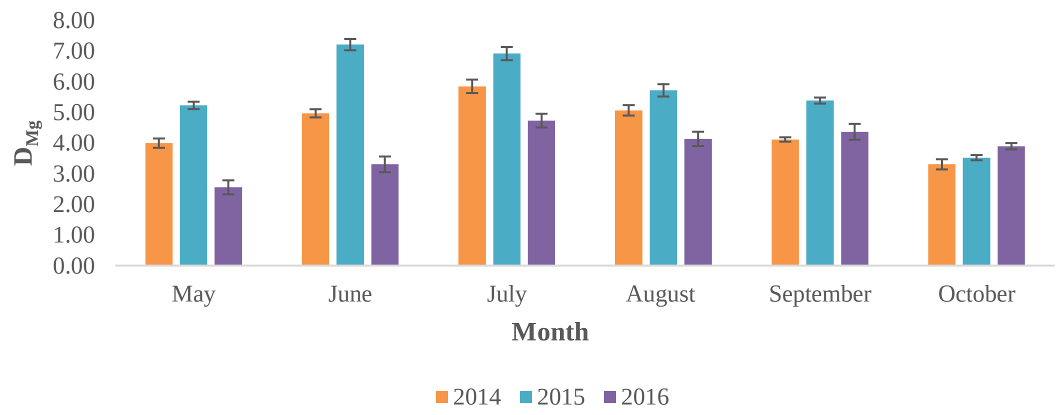
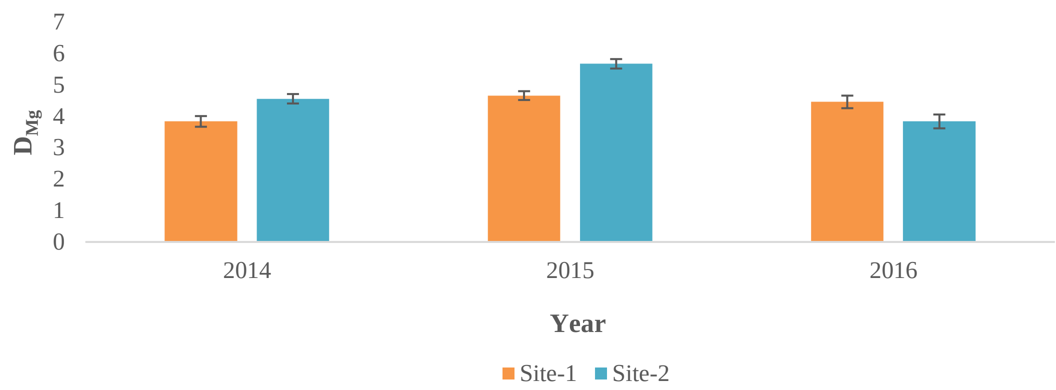


Fig.19. Annual Average Margalef's Species Richness (D_{Mg}) of Site-1 and Site-2 during 2014-2016



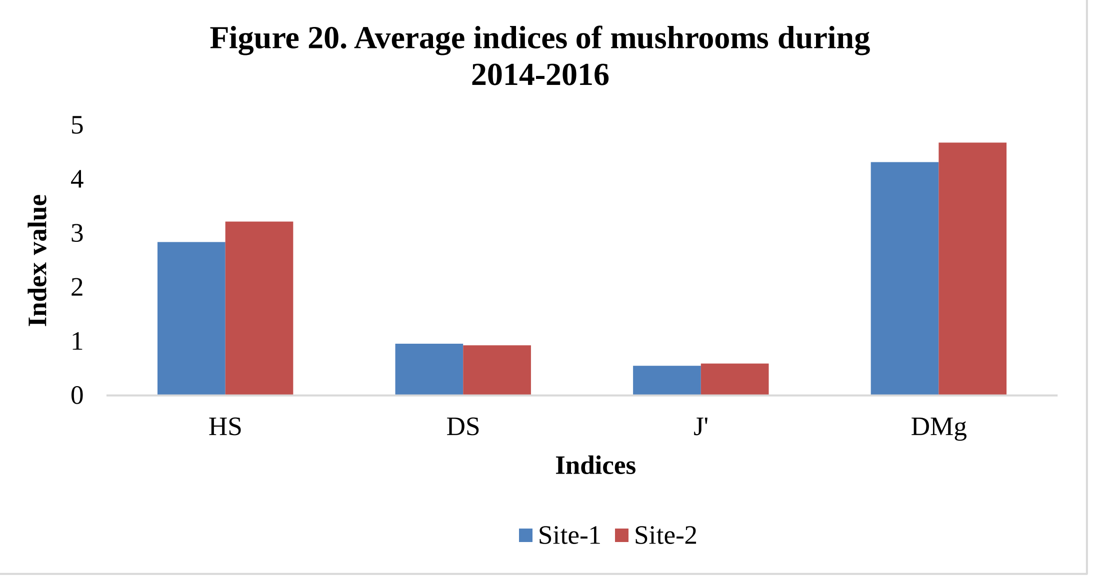


Figure 20. Average indices of mushrooms during 2014-2016
Index value
5
4
3
2
1
0
HS
DS
J'
DMg
Indices
Site-1
Site-2

Table 1. List of Species collection from Site-1 during 2014-2016

Sl.No.	Species Name	2014	2015	2016
1	*Agaricus silvaticus*	+	+	+
2	*Amanita vaginata*	+	+	+
3	*Aureoboletus moravicus f. luteus*	+		
4	*Aureoboletus auriflammeus*		+	+
5	*Boletus subtomentosus*			+
6	*Cantharellus cibarius*	+	+	+
7	*Chlorophyllum molybdites*		+	+
8	*Clavulinopsis laeticolor*		+	+
9	*Cortinarius croceous*		+	+
10	*Cortinarius helvolus*		+	+
11	*Craterellus cornucopioides*		+	+
12	*Geastrum morganii*		+	+
13	*Helvella ephippium*			+
14	*Laccaria vinaceoavellanea*	+	+	+
15	*Laccaria yunnanensis*	+	+	+
16	*Lactarius piperatus*	+	+	+
17	*Lactifluus corrugis*	+	+	+
18	*Lepiota echinella*	+	+	+
19	*Lycoperdon perlatum*	+	+	+
20	*Macrolepiota dolichaula*	+	+	+
21	*Macrolepiota procera*	+	+	+

22	*Mutinus caninus*	+	+	+
23	*Hymenopellis furfuracea*		+	+
24	*Phallus indusiatus*	+	+	+
25	*Pisolithus albus*	+	+	+
26	*Ramaria kunzei*	+	+	+
27	*Russula aurora*	+	+	+
28	*Russula compacta*	+	+	+
29	*Russula cyanoxantha*	+	+	+
30	*Russula mutabilis*	+	+	+
31	*Scleroderma citrinum*	+	+	+
32	*Scleroderma verrucosum*	+	+	+
33	*Thelephora ganbajun*	+	+	+
34	*Trichoglossum hirsutum*	+	+	+
35	*Volvariella taylorii*	+	+	+
	Number of Species	25	32	34
	Cummulative number of species	25	33	35

Table 2. List of Species collection from Site-2, during 2014-2016

Sl.No.	Species Name	2014	2015	2016
1	*Agaricus silvaticus*		+	+
2	*Agaricus trisulphuratus*		+	+
3	*Amanita crocea*	+	+	+

4	*Amanita griseofolia*	+	+	+
5	*Amanita jacksonii*	+	+	+
6	*Amanita pachycolea*	+	+	+
7	*Amanita pantherina*		+	+
8	*Amanita phalloides*	+	+	+
9	*Amanita spissacea*	+		+
10	*Boletus carpinaceus*	+	+	+
11	*Boletus mirabilis*	+	+	+
12	*Aureoboletus auriflammeus*	+	+	+
13	*Boletus quercinus*	+	+	+
14	*Boletus stramineum*		+	+
15	*Boletus subtomentosus*	+	+	+
16	*Cantharellus cibarius*	+	+	+
17	*Chlorophyllum molybdites*	+	+	+
18	*Clavulinopsis corallinorosacea*			+
19	*Cortinarius croceous*	+	+	+
20	*Cortinarius helvolus*	+	+	+
21	*Cortinarius phoeniceus*	+	+	+
22	*Craterellus cornucopioides*	+	+	+

23	*Entoloma hainanense*		+	+
24	*Hebeloma victoriense*	+	+	+
25	*Helvella ephippium*		+	+
26	*Helvella macropus*	+	+	+
27	*Laccaria vinaceoavellanea*	+	+	+
28	*Laccaria yunnanensis*	+	+	+
29	*Lactarius piperatus*	+	+	+
30	*Lepiota echinella*	+	+	+
31	*Leucocoprinus birnbaumii*	+	+	+
32	*Lycoperdon excipuliforme*	+	+	+
33	*Macrolepiota procera*	+	+	+
34	*Hymenopellis furfuracea*		+	+
35	*Ramaria cystidiophora*		+	+
36	*Ramaria kunzei*	+	+	+
37	*Russula compacta*		+	+
38	*Russula cyanoxantha*	+	+	+
39	*Russula earlei*	+	+	+
40	*Russula lepida*	+	+	+
41	*Russula nicrigans*	+	+	+

42	*Russula queletii*	+	+	+
43	*Scleroderma citrinum*	+	+	+
44	*Strobylomyces verruculosus*	+	+	+
45	*Termitomyces clypeatus*	+	+	+
46	*Termitomyces robustus*	+	+	+
47	*Thelephora ganbajun*	+	+	+
48	*Trichoglossum hirsutum*			+
	Number of Species	37	45	48
	Cummulative number of species	37	45	48

Discussion:

35 species of mushrooms were identified from Site-1 and 48 species from Site-2. A total of 83 species were collected from the two sites of which 24 species were found to be present in both the sites. The species accumulation curve (Figure-1) and Table-1 & 2 and showed that the number of species collected increased year to year. The species accumulation curve shows a gradual rise which may be due to the absence of the mushrooms at the time of collection in the previous years. It has been noted that timing of collection of mushrooms is vital as the mushroom especially those growing in the soil has a brief period of existence. Moreover, there is also a chance of missing on the mushrooms due to interference from animals or humans (Bhattacharjee *et al*., 2015; Sheikh, 2013). Straatsma *et al.* (2001) also monitored a plot area of 1500m in western Switzerland for agarics for over a period of 21D-years with sampling frequency of 7 days and recorded 408 species but concluded that the number of species would increase if the survey continued.

All the diversity indices i.e., Shannon-Weiner's Diversity Index, Simpson Index of Dominance, Evenness Index and Margalef's Species Richness were found to be higher in Site-2 than Site-1. The greater species number in Site-2 may be due to higher plant diversity. Vyas *et al*. (2014) found that the number of mushrooms were directly correlated with the number and diversity of the vegetation. Vyas *et al*. (2014) reported 18 genera belonging to 12 families of mushrooms where the species richness and abundance was much higher in the thick forest rather than thinning and destruction of forest in Patharia Forest of Sagar at Madhya Pradesh. It has also been stated that mushroom diversity indicates the quality of ecosystem (Stamets, 2000). This is in conformity with the present study sites. The diversity indices of trees at Site-1 has been reported by Sharma, S.B. *et al.*, (2018) wherein the Shannon Wiener's Diversity Index (H_s), Simpson Index of Diversity (D_s or 1-D), Pielou's Evenness Index (J') and Margalef's Species Richness (D_{Mg}) were 3.22, 0.94, 0.82 and 8 respectively. Also, the diversity indices of the trees at Site-2 according to Lalchhuanawma (2008) for the Shannon Wiener's Diversity Index (H_s), Simpson Index of Diversity (D_s or 1-D), Pielou's Evenness Index (J') and Margalef's Species Richness (D_{Mg}) were 3.78, 0.97, 0.92 and 10.12 respectively. Vyas *et al*. (2014) have also reported that mushrooms are comparable to plants in requiring site and condition to thrive. Pushpa and Purushothama (2012) also concluded that occurrence of ectomycorrhizal fungal species decreased where tree species diversity decreased. It may be also due to more availability of degradable organic matters, or may be due to varied latitude, vegetation, topography, etc. and their effects on temperature and precipitation across the wide geographic distances or along the elevational gradients. Bhattacharjee (2015) also reported that mushroom diversity and species richness decreases due to increased human activities, air pollution caused by vehicles and dumping of non-biodegradable wastes especially plastics. Singha (2017) has also reported that richness and abundance of mushrooms are higher in thick forest areas, whereas fewer species are observed in thin forest areas.

Evenness of the mushrooms was 0.55 and 0.59 from site-1 and Site-2 respectively. This result showed that all the 62 mushroom species belonging to 19 families were not fairly distributed in the community. This may be probably due to the habitats in the ecosystem which favours the occurrence and abundance of some mushroom species while other species seldom appears only during particular time of the season as reported by Pushpa and Purushothama, 2012.

The various ecological factors also play an important role for the growth and abundance of the mushroom species. The annual average rainfall was higher in Site-1 than Site-2. However, though the rainfall was higher in Site-1 than Site-2, there was also abundant or enough rainfall for mushrooms to thrive well therefore the diversity indices was higher in Site-2. The finding is in conformity with Yang *et al.* (2012) who reported that high temperature and abundant rain resulted in good productivity and mushrooms may sometimes appear later in the season by rising temperatures and reduced rain. The annual average temperature was lower in Site-1 than in Site-2 (Figure 5&6) during the study period. This finding is in conformity with Jang and Hur (2012) who reported that most fungi, including ectomycorrhizal mushrooms, wood-rotting fungi, and ground fungi were prevalent at mean temperatures of 23.0~24.9℃. Holm (2012) also reported that warmer climate prolongs mushroom season. Salerni *et al*., (2002) have reported a strong correlation of rainfall and temperature on mushroom growth and diversity.

CHAPTER – IV

PHYSICO-CHEMICAL CHARACTERISTICS OF SOIL

IV. 1. INTRODUCTION

Unlike plants, mushrooms have no chlorophyll to make their own food from the sun's energy and therefore they rely or attach to a nutritious source of a plant's roots, a dead plant, or a dead animal for their survival or reproduction. They develop special methods of living through symbiotic relationship with the plants, saprophytic or parasitic with both dead plants or animals. Most of the mushrooms growing in soil are linked to trees through mychorrhizal activities by exchanging nutrients between the root ends of the tree and the vegetative system of a mushroom.

Soils play an important role for mycorrhizal activities between the trees and mushrooms. They are biogeochemically dynamic bodies, formed by the combined effects of environmental and biological factors over geological expanses of time (Amundson and Jenny, 1997). Soil have many different properties, including texture, structure or architecture, water holding capacity and pH. Soil structure can change as a result of either time or management. Soil structure is of extreme importance to plant growth (Baver, 1949; Russell, 1950).

The physico-chemical properties of soil can influence the structure, spatial distribution, level of biomass and the activity of microorganisms in soil, which are early indicators of soil health and quality (Schnurer *et al.*, 1985; Dick, 1994). Physical disturbance of soil alters the amount of soil organic matter (Mattson and Smith, 1993), soil temperature, soil moisture and pH (Bormann and Likens, 1979) all of which affect the microbial activity (Harvey *et al.,* 1980; Hendrickson *et al.,* 1985; Entry *et al*., 1986; Pettersson and Baath, 2003). Physical conditions determine the environments in which biological processes take place (De Vos *et al.*, 1994) while chemical characteristics determine the maximum quality of a particular soil (Hassink, 1997). Abiotic factors such as climate, heat, water, pH, sunlight, soil and minerals are of great importance for the growth of mushrooms. Of particular importance for the distribution and variety of mushrooms are climate and soil characteristics. Mushrooms generally prefer humid and cool climates. In addition, such pedological characteristics as the ability of the soil to hold air and water, salinity, osmotic potential and pH may affect the growth of fungal mycelia (Noble *et al.,* 1999). Among the essential nutrient demands of fungi are water and oxygen. In addition, macro elements such as carbon, nitrogen, phosphorus, potassium, and magnesium are need in large quantities, while necessary microelements include iron, zinc, copper, manganese and molybdenum (Sumer, 2006). The properties of some nutrients such as N, P and K depend upon the interaction between soils, plants, microbes and animals Wen *et al.* (2004).

The pH of the soil is the measure of the acidity or alkalinity. pH is the negative logarithm (base10) of the activity of hydrogen ions (H^+ or more precisely, H_3O^+ aq) in a solution. The soil pH also influences plant growth by its effect on activity of beneficial microorganisms. Soils are referred to as being acidic, neutral, or alkaline (or basic) depending on their pH values on a scale from approximately 0 to 14 (McCauley, *et al.*, 2009).

The moisture content of soil is an indicator of the amount of water present in the soil. Soil moisture levels can be expressed in terms of soil water content or soil water potential (Werner, 1992). Moisture content even has a very important influence on the microbial activity greater than the temperature (Liang *et al.*, 2003). Fungal community is likely to be more sensitive to temperature fluctuations and moisture content adjustment than bacterial community (Zhang *et al.*, 2011).

Water holding capacity is the total amount of water a soil can hold at field capacity. Soils that hold generous amount of water are less subject to leaching losses of nutrients. It is an indicator of a soil ability to retain water and make it sufficiently available for plant use (U.S.D.A., 2005).

Soil organic matter is important in maintaining soil fertility, but its dynamics and composition are influenced by land-use changes and management practices. It is well known to maintain several functions. Being the major component of soil organic matter (SOM), it is a determinant of soil physical and chemical properties, an important representative of soil productivity (Batjes and Sombroek, 1997; Rossi *et al.*, 2009). It also plays an important role in climate change processes by acting either as source or sink of atmospheric CO_2 (Jiménez *et al*., 2008).

Nitrogen is an essential plant nutrient and is available to the plant in the ammonium or nitrate form, it affects the growth of a plant and the quantity and quality of produce. In soil, nitrogen is present in many forms which can be transformed to ammonium or nitrate.

In this chapter, the physico-chemical properties of soil in selected sites of Aizawl districts, Mizoram was studied with an effort to compile the correlation of mushroom diversity with the soil properties of the region.

IV. 2. REVIEW OF LITERATURE

Erlanson *et al.* (2015) studied the influences of soil environment and willow host species on ectomycorrhizal fungi communities across hydrologic gradient in temperate North America. He reported that soil moisture, organic matter and pH strongly predicted changes in fungal community composition, however, he also reported that in contrast, increased fungal richness strongly correlated with higher plant especially available phosphorus. Gezer and Kaygusz (2015) reported that non-saline soils are suitable for mushroom development as the osmotic pressure of these soils is low, the ion balance of the soil solutions is stable, and soil biological activity is high. Physical conditions which are favorable for a mushroom to grow are determined by the sand, silt and clay levels in the soil, the materials which these consist of, and accumulated organic matter. The movement of water and air is easy in light soils. It is thought that growth and productivity increase in such locations because the mushroom mycelia can penetrate clayey or clayey-loamy soils more easily. They also concluded that the soils rich in humus provide a suitable environment for the growth of mushrooms and suitable vegetation, elevation and temperature is needed in order to grow plentifully in a given area. They also established that mushroom variety was high in areas where plant variety was also high. It is thought that areas where mushrooms grow plentifully in the wild will be effective in protecting or bringing under cultivation various edible mushrooms which have their own characteristic habitat, climatic and soil conditions, and which are used as economic, food or medical resources, whether locally or more generally. Also, some mushroom species could be indicators of the environment where they are found or of the soils in which they grow.

Haktanir and Arcak, (1997) reported that organic matter is a source of essential nutrients and energy for mushrooms as it is for all other living things in the soil and gives the soil a spongy structure by linking its separate particles and improving the physical properties of the soil.

Boddy *et al.* (2013) reported that fruiting phenology of fungi is changing in many European countries; on average, the fruiting season is extending, though for some species it is contracting; different species and ecological groups behave differently; time of fruiting depends on geographical location; some fungi now fruit early in the year as well as in autumn, and spring fruiting is getting earlier; some fungi appear to be changing hosts; fruit body yields vary dramatically from year to year; the amount, duration and frequency of fruiting are influenced by numerous environmental factors.

Jinhong He *et al.* (2017) reported that the vegetational properties such as plant diversity and forest age were the dominant factors affecting soil fungal community composition in the subtropical evergreen forests while edaphic properties were the dominant ones in the temperate deciduous forests.

Chandra *et al*. (2016) studied impact of forest vegetation on soil characteristics and correlating between soil biological and physico-chemical properties in temperate and dry deciduous forest types. The results displayed that the soil microbial characters and soil physico-chemical uniqueness are interrelated and were significantly influenced by specific forest type and climatic variables. Karavani *et al.* (2017) reported that mushroom yield was primarily dependent on weather and soil moisture conditions.

IV. 3. MATERIALS AND METHODS

IV.3.1. Soil sampling and analysis

Five random samples of soil were collected monthly from each site located at least 10 m apart from the two sites during the study period of 2014-2016. The physical soil analyses were done immediately after collection for Soil Moisture Content (%) and Water Holding Capacity. The chemical analysis, pH was done immediately after collection; Soil Organic Carbon and Total Nitrogen were carried out after the soil was dried. The collected soil samples were then oven-dried at 104˚C for 24 hours, ground with a mortar and pestle, sieved through 0.2 mm sieve and were kept in air-tight plastic bags for further analysis (Ghosh *et al.*, 1983). Soil analysis were done as under:

Soil moisture content

The moisture content was calculated by using the method given by Anderson and Ingram (1993). In this method, 10g of fresh soil sample was taken and kept in the hot air oven at 105˚C for 24 hours. It was weighed again, and dry weight of the sample was recorded. The moisture content was calculated by the formula:

$$\text{Moisture content (\%)} = \frac{W1-W2}{W2} \times 100$$

Where,

W1= Weight of moist soil (g).

W2= Weight of Oven dried soil (g).

Water holding capacity

The water holding capacity was calculated by using the method given by Anderson and Ingram (1993). In this method, weighed of box and filter paper kept inside the box was recorded and soil added to the box was weighed and weight of the soil was recorded again and kept overnight. Then, the weight of keen box after overnight was weighed to measure the water absorption. The formula for calculating water holding capacity was:

$$\text{WHC (\%)} = \frac{(W3-W2)}{(W2-W1)} \text{ X } 100$$

Where,

Weight of box + filter paper = W1

Weight of box + filter paper + soil = W2

Weight of the soil = (W2 – W1)

Weight of keen box after overnight water absorbed = W3

Soil pH

The pH of the collected soil samples was measured following the method by Anderson and Ingram, 1993. In this method, 10g of air-dried soil sample and 25 ml of deionised water was added in a beaker. It was stirred for 10 minutes and allowed to stand for 30 minutes. The Benchtop pH meter (BT-86502) electrode was immersed into the soil suspension and the pH value obtained was recorded when equilibrium is reached.

Soil organic carbon

Organic Carbon (C) was estimated by following Walkley and Black's Rapid Dichromate Oxidation Method given in Anderson and Ingram, (1993). In this method, 0.5g of the oven dried soil was taken to which 10ml of 1N potassium dichromate was added. Then, 20ml of conc. Sulphuric acid was added, swirled 2-3 times and was allowed to stand for 30 minutes. To this, 200ml of distilled water was added and 10ml of orthophosphoric acid was added to get a sharper end point of titration. Then 1ml of diphenylamine indicator was added which was titrated against ferrous ammonium sulphate solution till the colour flashes from blue-violet to green. The percentage Organic Carbon content was calculated by the following formula:

$$\text{Organic Carbon (\%)} = \frac{10(B-T)}{B} 100 \times 0.003 \times \frac{100}{S}$$

Where,

B= Volume of Ferrous Ammonium Sulphate solution for blank titration in ml.

T= Volume of Ferrous Ammonium Sulphate solution needed for soil sample in ml

S= Weight of soil in gram.

Total Nitrogen

The Total Nitrogen was estimated by following Kjeldahl's Digestion Method in Anderson and Ingram, (1993). The percentage of Nitrogen is calculated by the following formula:

Total Nitrogen (%) = $\frac{14\ X\ Normality\ of\ acid\ X\ titrant\ Value}{Sample\ weight\ X\ 1000}\ X\ 100$

IV.3.2. Statistical analysis

The soil physico-chemical characteristics were calculated using Microsoft Office Excel. The data were analysed statistically for correlation coefficient or significance level of soil characteristics and diversity of the soil mushrooms using the Statistical Package SPSS 16.0.

IV.4. RESULTS AND DISCUSSION

IV.4.1. Soil sampling and analysis

Appendix II represents the various physico-chemical properties of soil analysed.

It was observed that monthly Soil Moisture Content in Site-1 shows highest value of 52.67 % (± 0.94 SE) and lowest value of 21.50 % (± 0.96 SE) during in June 2014 and January 2014 respectively (Appendix II, Figure 21). The monthly Soil Moisture Content in Site-2 shows highest value of 36.24 % (± 0.86 SE) and lowest value of 16.90 % (± 0.77 SE) during in May 2014 and March 2014 respectively (Appendix II, Figure 22). The annual average Soil Moisture Content in Site-1 were 29.85 % (± 0.67 SE), 32.50 % (± 0.66 SE) and 32.66 % (± 0.73 SE) for the year 2014, 2015 and 2016 respectively and 26.72 % (± 0.68 SE), 26.97 % (± 0.66 SE) and 28.88 % (± 0.62 SE) for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix II, Figure 23).

It was observed that monthly Water holding Capacity in Site-1 shows highest value of 90.5 % (± 0.57 SE) and lowest value of 68.30 % (± 0.43 SE) during in December 2014 and August 2014 respectively (Appendix II, Figure 24). The monthly Water holding Capacity in Site-2 shows highest value of 91.40 % (± 0.64 SE) and lowest value of 57.50 % (± 0.50 SE) during in November 2014 and August 2014 respectively (Appendix II, Figure 25). The annual average Water holding Capacity in Site-1 were 78.05 % (± 0.59 SE), 77.78 % (± 0.48 SE) and 79.99 % (± 0.51 SE) for the year 2014, 2015 and 2016 respectively and 70.33 % (± 0.63 SE), 75.25 % (± 0.48 SE) and 75.91 % (± 0.48 SE) for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix II, Figure 26).

It was observed that monthly pH of soil in Site-1 shows highest value of 6.20 (± 0.13 SE), and lowest value of 4.67 (± 0.14 SE), in October 2015 and September 2015 respectively (Appendix II, Figure 27). The monthly pH of soil in Site-2 shows highest value of 5.67 (± 0.15 SE), and lowest value of 4.77 (± 0.24 SE), in February 2015 and August 2015 respectively (Appendix II, Figure 28). The annual average pH of soil in Site-1 were 5.32(± 0.15 SE), 5.34 (± 0.14 SE) and 5.46 (± 0.12 SE),for the year 2014, 2015 and 2016 respectively and 5.11 (± 0.16 SE), 5.19 (± 0.14 SE) and 5.23 (± 0.12 SE) for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix II, Figure 29).

It was observed that monthly Organic Carbon in Site-1 shows highest value of 3.74 % (± 0.14 SE) and lowest value of 1.18 % (± 0.09 SE) during in May 2014 and February 2015 respectively (Appendix II, Figure 30). The monthly Organic Carbon in Site-2 shows highest value of 3.97 % (± 0.13 SE) and lowest value of 1.30 (± 0.13 SE) % during in June 2016 and December 2014 respectively (Appendix II, Figure 31). The annual average Organic Carbon in Site-1 were 2.41 % (± 0.13 SE), 2.23 % (± 0.14 SE) and 2.41 % (± 0.35 SE) for the year 2014, 2015 and 2016 respectively and 2.31 % (± 0.12 SE), 2.26 % (± 0.15 SE) and 2.3 % (± 0.15 SE) for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix II, Figure 32).

It was observed that monthly Total Nitrogen in Site-1 shows highest value of 0.82 % (± 0.11 SE) and lowest value of 0.19 % (± 0.03 SE), 0.19 % (± 0.06 SE) during in August 2015 and February 2014, 2016 respectively (Appendix II, Figure 33). The monthly Total Nitrogen in Site-2 shows highest value of 0.77 % (± 0.13 SE) and lowest value of 0.16 % (± 0.07 SE) during in June 2016 and January 2015 respectively (Appendix II, Figure 34). The annual average Total Nitrogen in Site-1 were 0.47 % (± 0.08 SE), 0.43 % (± 0.09 SE) and 0.43 % (± 0.1 SE) for the year 2014, 2015 and 2016 respectively and 0.42 % (± 0.11 SE), 0.42 % (± 0.1 SE) and 0.45 % (± 0.11 SE) for the year 2014, 2015 and 2016 respectively in Site-2 (Appendix II, Figure 35).

Figure. 21. Monthly Soil Moisture Content (%) of soil during collection period January to December 2014- 2016 of Site-1

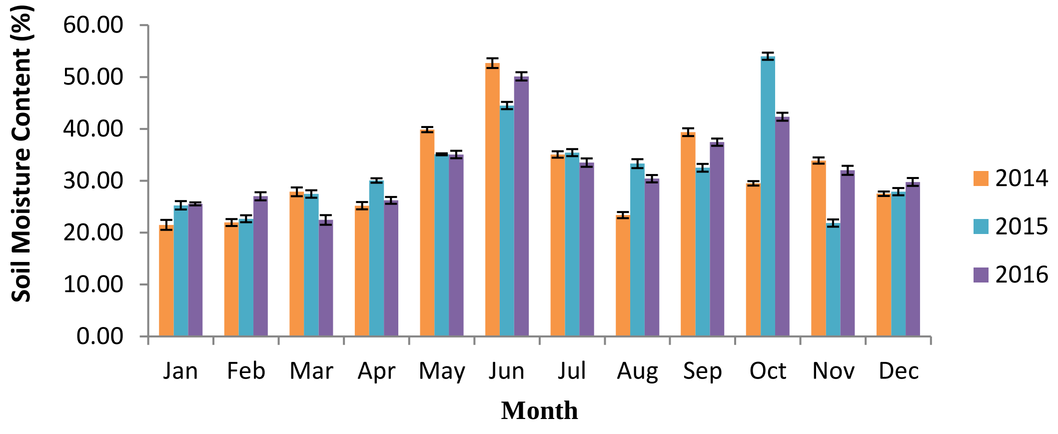


Figure. 22. Monthly Soil Moisture Content (%) of soil during collection period January to December 2014- 2016 of Site-2

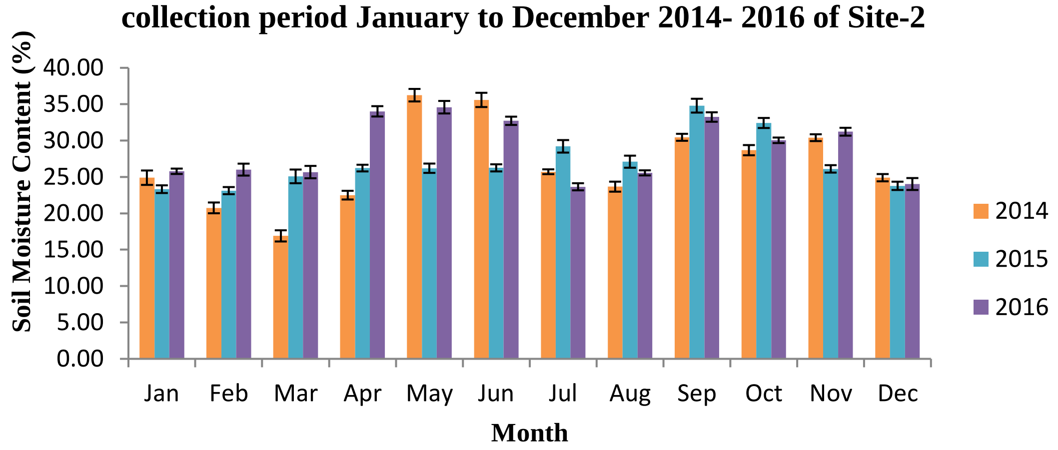


Figure. 23. Average annual Soil Moisture Content (%) of soil during collection period January to December 2014 - 2016 of Site-1 and Site-2

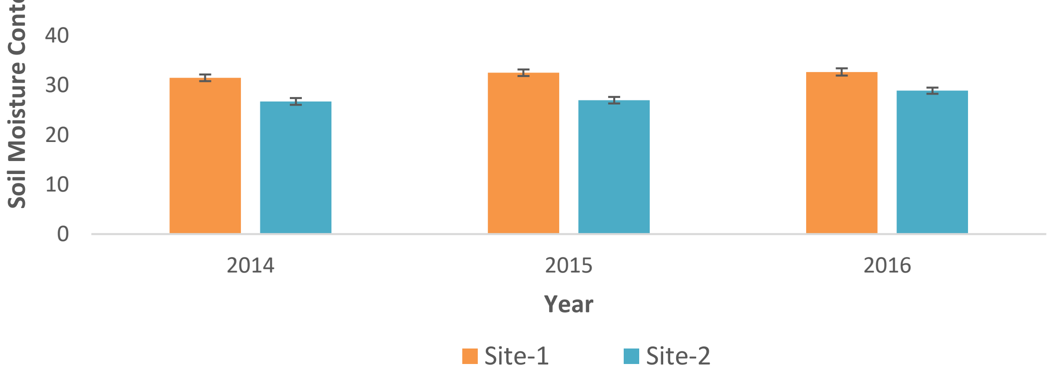


Figure. 24. Monthly Water Holding Capacity of soil during collection period January to December 2014- 2016 of Site-1

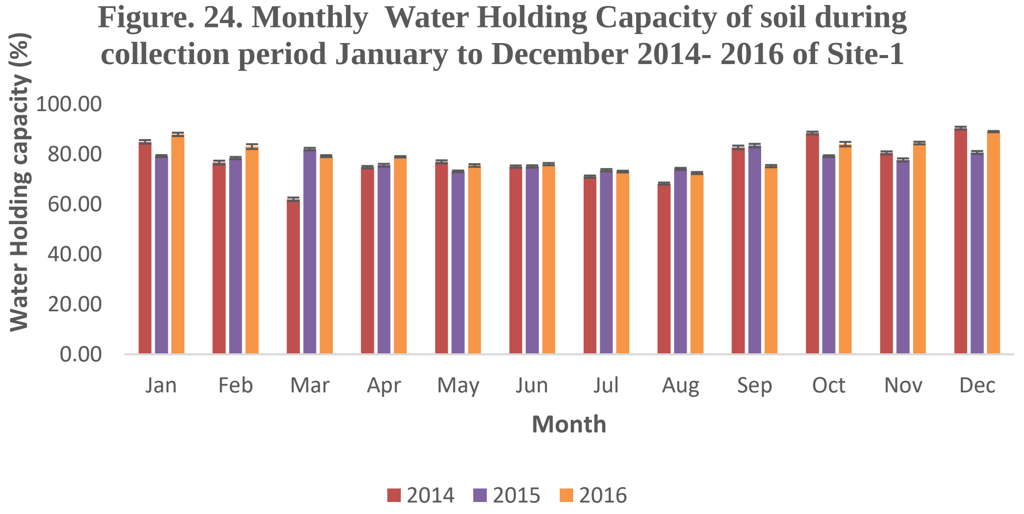


Figure. 25. Monthly Water Holding Capacity (%) of soil during collection period January to December 2014- 2016 of Site-2

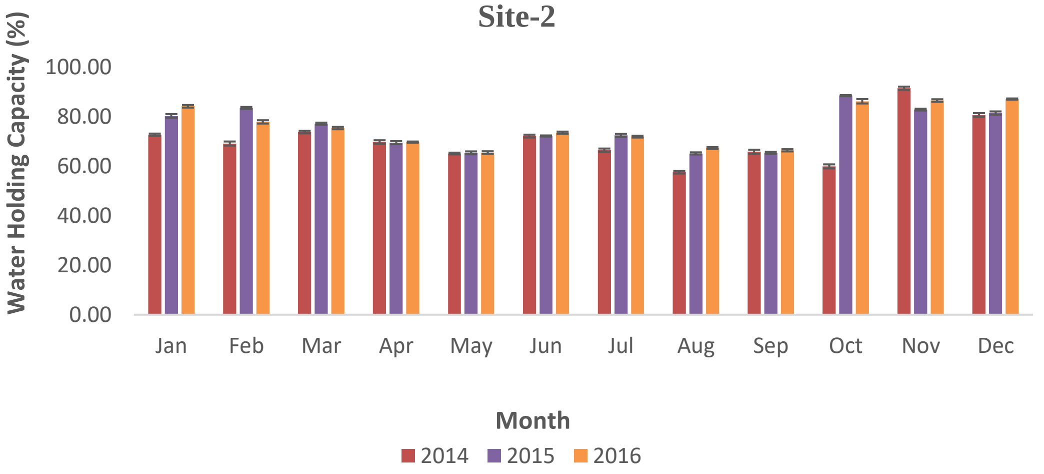


Figure. 26. Average annual Water Holding Capacity (%) of soil during collection period January to December 2014 - 2016 of Site-1 and Site-2

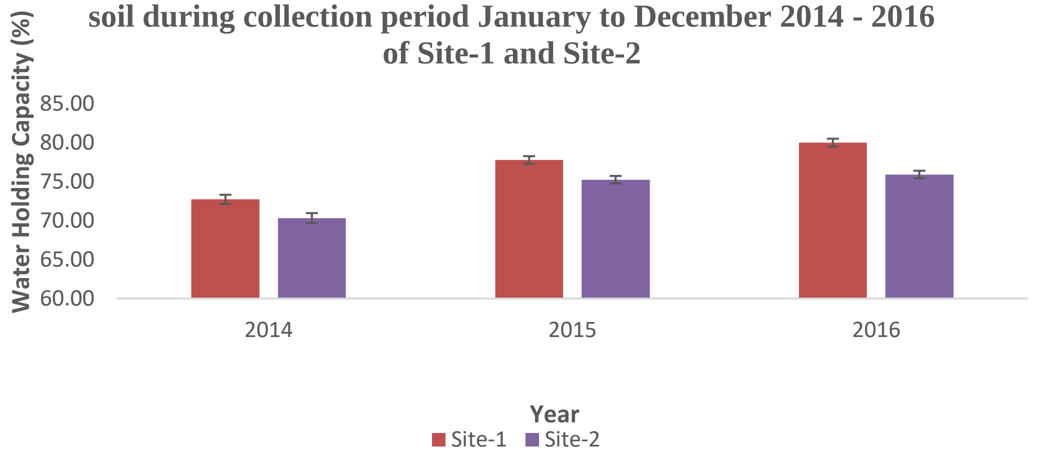


Figure. 27. Monthly pH of soil during collection period January to December 2014- 2016 of Site-1

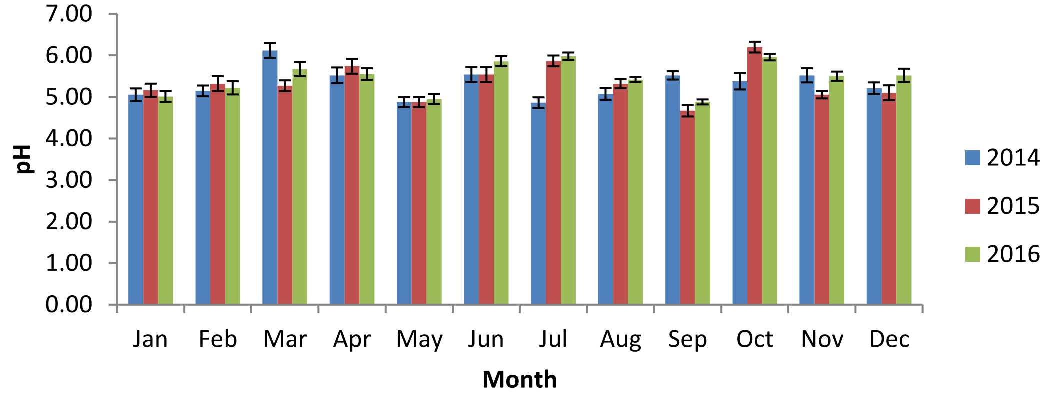


Figure. 28. Monthly pH of soil during collection period January to December 2014- 2016 of Site-2

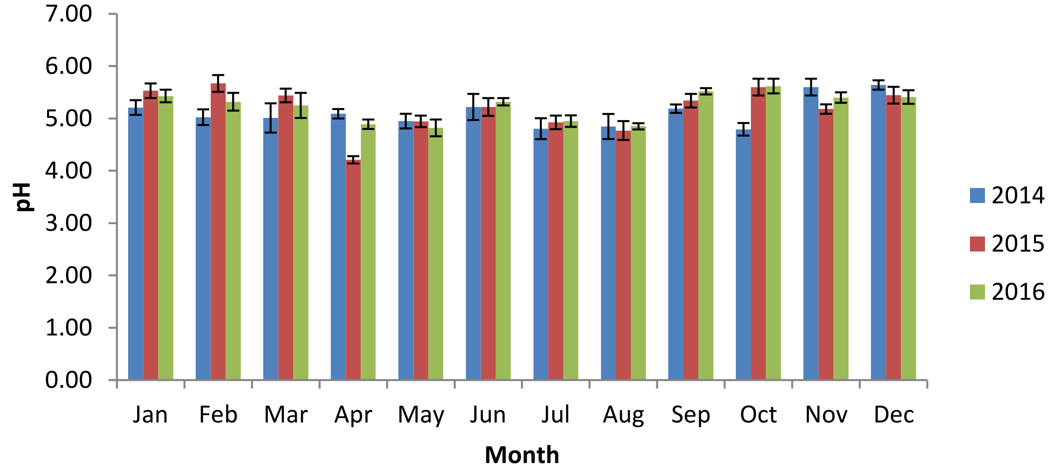
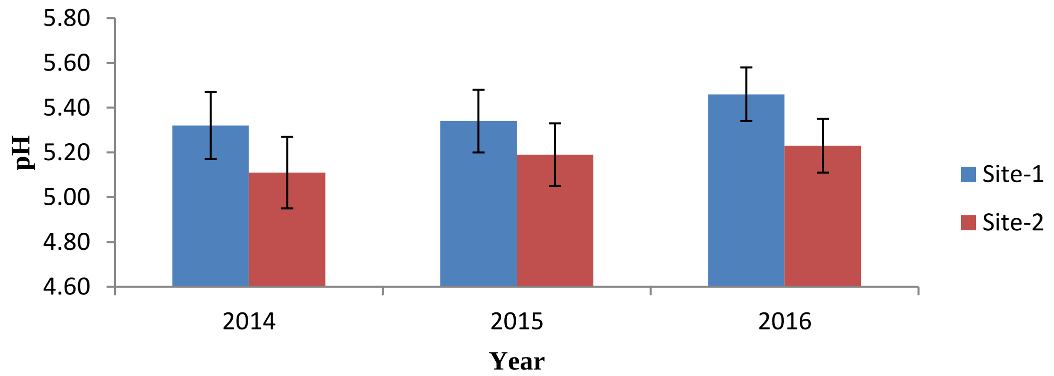


Figure. 29. Average annual pH of soil during collection period January to December 2014 - 2016 of Site-1 and Site-2



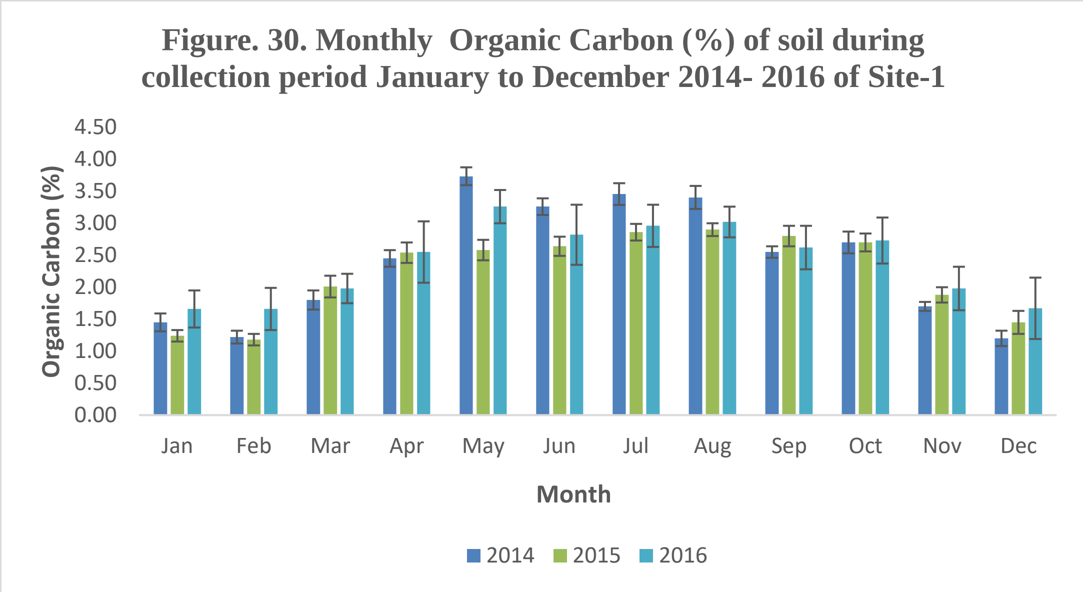


Figure. 30. Monthly Organic Carbon (%) of soil during collection period January to December 2014- 2016 of Site-1
Organic Carbon (%)
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
2014
2015
2016

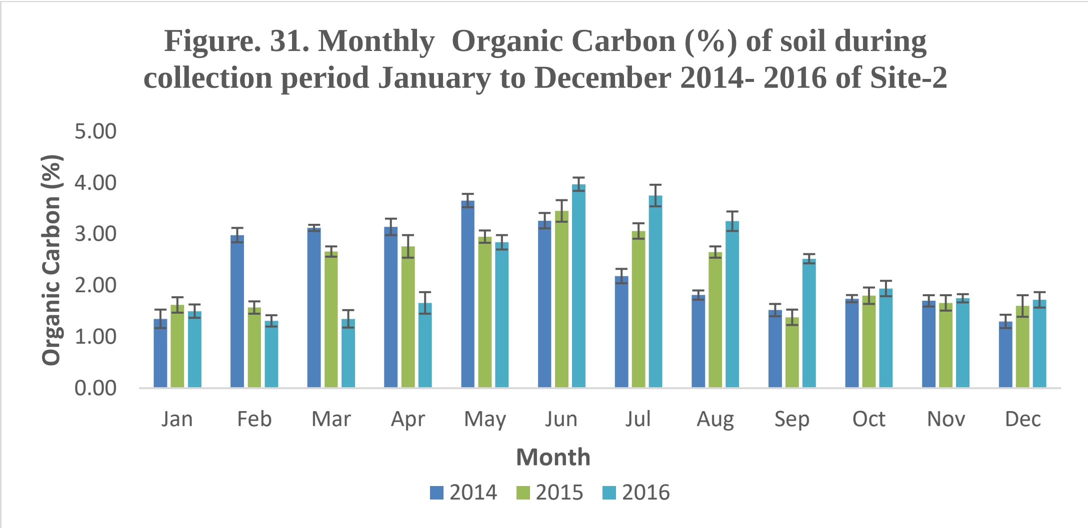


Figure. 31. Monthly Organic Carbon (%) of soil during collection period January to December 2014- 2016 of Site-2
Organic Carbon (%)
5.00
4.00
3.00
2.00
1.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
2014
2015
2016

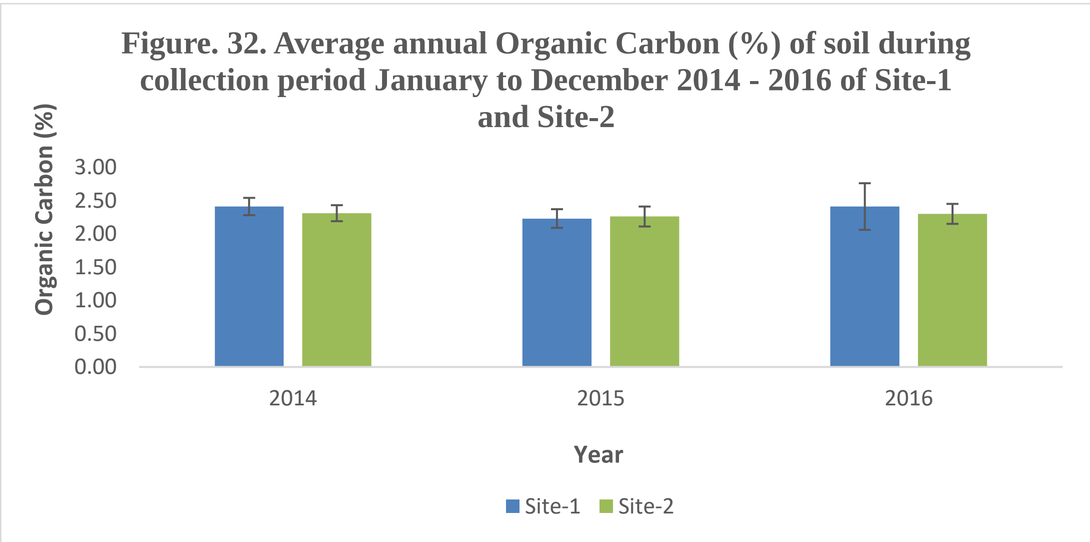


Figure. 32. Average annual Organic Carbon (%) of soil during collection period January to December 2014 - 2016 of Site-1 and Site-2
Organic Carbon (%)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2014
2015
2016
Year
Site-1
Site-2

Figure. 33. Monthly Total Nitrogen (%) of soil during collection period January to December 2014- 2016 of Site-1

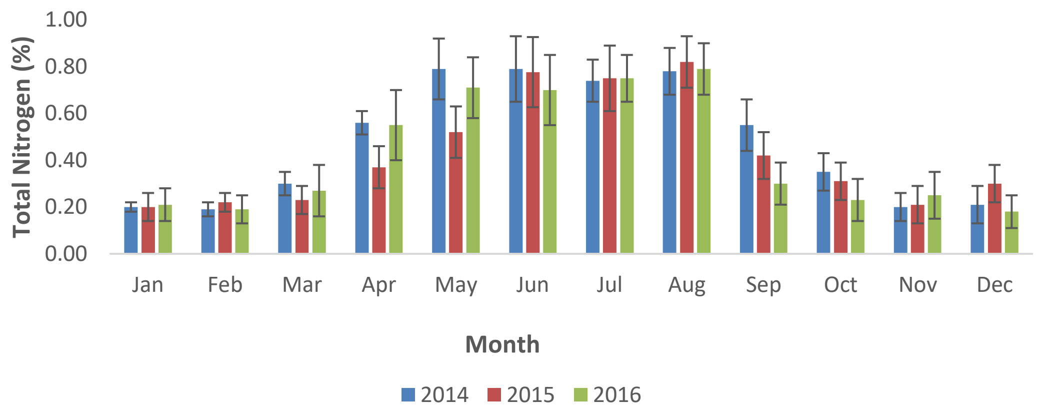


Figure. 34. Monthly Total Nitrogen (%) of soil during collection period January to December 2014- 2016 of Site-2

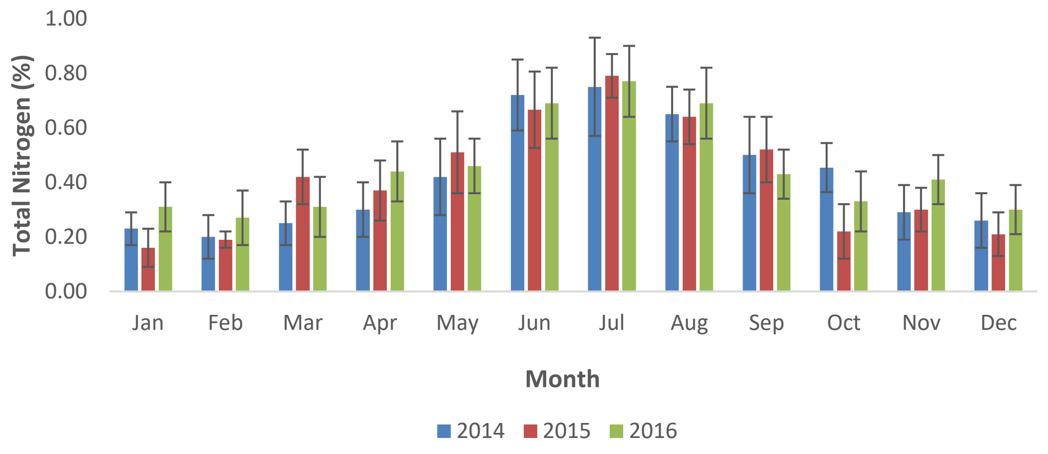


Figure. 35. Chart showing average annual Total Nitrogen (%) of soil during collection period January to December 2014 - 2016 of Site-1 and Site-2

IV.4.2. Statistical analysis

Pearson correlation co-efficient (r) analysis indicated that there was positive correlation between Total Nitrogen of Site-2 with Shannon Wiener's Diversity Index of Site-2 and Margalef's Species Richness of Site-2 in 2014 (Table 3).

Pearson correlation co-efficient (r) showed positive correlation between Organic Carbon of Site-2 with Margalef's Species Richness of Site-2 and Total Nitrogen of Site-2 with Margalef's Species Richness of Site-2 in 2015 (Table 4).

Pearson correlation co-efficient (r) also showed positive correlation between Total Nitrogen of Site-2 with Margalef's Species Richness of Site-2 in 2016 (Table 5).

Table 3: Pearson correlation coefficient (*r*) between diversity indices with respect to various soil parameters of Site-1 and Site-2 (2014)

Parameters	H_s_1	H_s_2	D_s_1	D_s_2	J'_1	J'_2	D_{Mg}_1	D_{Mg}_2
SMC_1	0.108		0.104		0.162		-0.430	
SMC_2		-0.405		-0.12		-0.686		-0.363
WHC_1	-0.855		-0.765		-0.82		-0.096	
WHC_2		0.219		-0.161		-0.144		0.295
pH_1	-0.326		0.001		-0.353		0.053	
pH_2		-0.038		-0.6		0.043		-0.028
OC_1	0.147		0.169		0.145		-0.426	
OC_2		0.293		0.239		-0.246		0.306
N_1	0.714		0.564		0.723		-0.288	
N_2		.947**		0.233		0.64		.960**

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

H_s= Shannon Wiener's Diversity Index, D_s= Simpson Index of Diversity, J'= Pielou's Evenness Index, D_{Mg}= Margalef's Species Richness, SMC= Soil Moisture Content, WHC= Water Holding Capacity, pH= negative logarithm (base10) of the activity of hydrogen ions, OC= Organic Carbon, N= Total Nitrogen; 1 indicates Site-1 and 2 indicates Site-2 for all the parameters.

Table 4: Pearson correlation coefficient (*r*) between diversity indices with respect to various soil parameters of Site-1 and Site-2 (2015)

Parameters	H_s_1	H_s_2	D_s_1	D_s_2	J'_1	J'_2	D_{Mg}_1	D_{Mg}_2
SMC_1	-0.769		-0.350		-0.742		-0.383	
SMC_2		-0.459		0.265		-0.320		-0.534
WHC_1	0.276		-0.550		0.382		-0.413	
WHC_2		-0.548		-0.211		-0.589		-0.571
pH_1	0.022		-0.035		0.000		0.069	
pH_2		-0.672		-0.053		-0.704		-0.715
OC_1	0.309		0.737		0.114		0.796	
OC_2		0.789		0.231		0.607		.835*
N_1	0.984		0.198		0.975		0.330	
N_2		0.955		0.603		0.889		.946**

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

H_s= Shannon Wiener's Diversity Index, D_s= Simpson Index of Diversity, J'= Pielou's Evenness Index, D_{Mg}= Margalef's Species Richness, SMC= Soil Moisture Content, WHC= Water Holding Capacity, pH= negative logarithm (base10) of the activity of hydrogen ions, OC= Organic Carbon, N= Total Nitrogen; 1 indicates Site-1 and 2 indicates Site-2 for all the parameters.

Table 5: Pearson correlation coefficient (*r*) between diversity indices with respect to various soil parameters of Site-1 and Site-2 (2016)

Parameters	**H_s_1**	**H_s_2**	**D_s_1**	**D_s_2**	**J'_1**	**J'_2**	**D_{Mg}_1**	**D_{Mg}_2**
SMC_1	0.181		-0.279		0.519		0.252	
SMC_2		-0.221		-0.504		-0.437		-0.235
WHC_1	-0.130		-0.858		0.254		-0.045	
WHC_2		-0.532		0.173		-0.605		-0.466
pH_1	0.543		0.138		0.500		0.864	
pH_2		-0.361		0.419		-0.382		-0.27
OC_1	-0.690		0.286		-0.914		0.078	
OC_2		0.738		-0.500		0.432		0.682
N_1	-0.097		0.858		-0.462		0.450	
N_2		0.882		0.288		0.878		.885*

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

H_s= Shannon Wiener's Diversity Index, D_s= Simpson Index of Diversity, J'= Pielou's Evenness Index, D_{Mg}= Margalef's Species Richness, SMC= Soil Moisture Content, WHC= Water Holding Capacity, pH= negative logarithm (base10) of the activity of hydrogen ions, OC= Organic Carbon, N= Total Nitrogen; 1 indicates Site-1 and 2 indicates Site-2 for all the parameters.

Discussion:

The higher soil moisture content at Site-1 may be due to higher altitude forest stand which can be attributed to a combination of the higher infiltration rate allowing more water into the profile in the high-altitude soil, as well as the water extraction by the plants. The lower soil moisture content at Site-2 may be due to the low altitude forest soil resulting in quick run-off from the slopes and low water retention capacity of the soil. This is in conformity with the findings of Elliott *et al*. (1998), Palviainen *et al*. (2004) and Tejedor *et al*. (2004). Soil moisture content tend to be lower in lower altitude (Laurance *et al*., 1999; Aerts, 2006). Soil moisture availability is an important determinant of fruiting. If the water potential is too low, fungi are unable to obtain sufficient water for fruit body development (Barroetavena *et al*., 2008). But in contrast to saprotrophs, mycorrhizal fungi can receive water from the host tree or from the plant's roots end through hydraulic lift (nocturnal water transfer from the tree to the associated mycorrhizal symbiont) (Querejeta *et al*., 2003), and transfer this water to the sporocarps (Lilleskov *et al*., 2009). Moisture inhibits activity when there is both too little and too much; low water potential causes difficulties in taking up and retaining water, and of enzyme function; high water content exerts effects by decreasing rate of diffusion of O_2 to hyphae and of CO_2 away from hyphae (Boddy, 1986). However, although the soil moisture content of Site-1 is higher, Pearson correlation (r) revealed that it is not statistically significant between soil moisture content and diversity indices in both Site-1 and Site-2 because $P>0.05$.

The higher water holding capacity at Site-1 may be due to soil type of the higher altitude forest stand. Similarly, the lower water holding capacity at Site-2 may be due to the low altitude forest soil type resulting in quick run-off and low water retention capacity of the soil. This is in conformity with the findings of Elliott *et al*. (1998), Palviainen *et al*. (2004) and Tejedor *et al*. (2004). The effect of high-water content is less at cold temperatures than at warmer temperatures, because metabolism is slower at lower temperatures. (Boddy *et al.*, 2013). Even though, the water holding capacity of Site-1 is higher Pearson correlation (r) revealed no significant value was observed between water holding capacity and diversity indices of Site-1. This may be due to adequate presence of moisture for mushroom in both the study sites.

The soil pH of both the study sites was found to be acidic and there was not much variations in pH at both the sites. The slightly higher soil pH of Site-1 than Site-2 may be due to the accumulation of leaf litters or organic matter on the forest floor. Soil bacteria respond strongly to pH changes (Lauber *et al*., 2009; Rousk *et al*., 2010). Even though, the pH of Site-1 is higher, Pearson correlation (r) revealed that it is not statistically significant between pH and diversity indices of both Site-1 and Site-2 because $P>0.05$. This may be due to adequate presence of moisture for mushroom in both the study sites (Ayodele *et al.*, 2011; Tibuhwa *et al*., 2011; Bellettini *et al*., 2016).

The soil organic carbon of both the study sites revealed that there was not much variations at both the sites. Although, Site-1 shows slightly higher values than Site-2, but Pearson correlation (r) revealed that there was positive significant value between organic carbon and Margalef's Species Richness of Site-2 because $p<0.05$. With increase in organic carbon of the soil, diversity of soil mushroom increases. This may be due to the higher plant diversity in Site-2 as most mushrooms collected are mycorrhizal with plants. Amount and quality of plant residues can also influence the composition of the soil microbial community as well as the dynamics of carbon and nutrient release in soil (Nelson and Mele, 2006).

The Total Nitrogen of soil of both the study sites revealed that there was not much variations at both the sites. Although, Site-1 shows slightly higher values than Site-2, but Pearson correlation (r) revealed that there was statistically positive significant between total nitrogen of Site-2 with Shannon Wiener's Diversity Index because $p>0.01$ and Margalef's Species Richness of Site-2 because $p>0.05$. With increase in Total Nitrogen of the soil, diversity of mushroom increases. This may be due to the higher plant diversity in Site-2 as most mushrooms collected are mycorrhizal with plants. It is in conformity with Gezer and Kaygusz (2015) who reported that mushroom variety was high in areas where plant variety was also high. Moreover, amount and quality of plant residues can also influence the composition of the soil microbial community and nutrient release in soil (Nelson and Mele, 2006).

Gezer and Kaygusz (2015) also concluded that mushrooms needed suitable vegetation, elevation and temperature in order to grow plentifully in a given area. Nantel and Neumann (1992) also found a high correlation between ectomycorrhizal fungi and host trees in a mixed forest, regardless of soil characteristics. Hansen (1988), however, suggests that the distributions of mycorrhizal fungi, even those specific to a particular host plant species, are further attenuated by edaphic factors.

Fungal distribution and activity are hard to predict because they are mediated in many different ways, including fungal physiology, reproduction and survival, host physiology, spatial and temporal distribution of hosts and resource availability, and outcome of competitive interspecific interactions. Moreover, the effects of temperature, water and CO_2 and a combination of these are complex, e.g. moisture content effects may differ depending on temperature, and affect different physiological processes and life-style traits differently (Boddy, 1984). The amount, duration and frequency of fruiting are influenced by numerous environmental factors both biotic and abiotic, as well as complex interactions among them.

A wide range of environmental factors influence the timing and development of fruit bodies, including nutritional factors, gaseous regime, pH, light, microclimate, disturbance, and inter- and intra-specific mycelial interaction (Moore *et al.*, 2008). If water content is too high, aeration is reduced, which can also be inhibitory.

From this finding, diversity of mushrooms is dramatically from influenced by numerous environmental factors both biotic and abiotic, as well as complex interactions among them.

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SUMMARY AND CONCLUSION

The present study was carried out from two different forests of Aizawl District, Mizoram i.e., Hmuifang (Site-1) and Mizoram University Campus (Site-2). Hmuifang is situated in the southern part of Aizawl with an elevation of 1619 meters above sea level. The area lies between the coordinates 92°45'19"E - 92°45'24"E longitudes and 23°27'22"N - 23°27'31"N latitudes. Mizoram University is in the Western part of Aizawl with an elevation range from 330m to 880m above mean sea level (msl). The area lies between the coordinates 23º45’25” N - 23º43’37” N latitudes and 92º38’39” E - 92º40’23’E longitudes.

Mushrooms as a whole are considered as the indicators of the forest life support system. To date, there is no systematic reports of soil mushrooms in Mizoram. Therefore, considering the lack of systematic studies on soil mushrooms, the present study was undertaken with the aim to generate a baseline data on taxonomy and diversity of the soil mushrooms in Mizoram. The present study entitled “Study on soil mushroom in Aizawl District of Mizoram, India” with the following objectives.

1. Taxonomical study of the specimens.
2. To study diversity of soil mushroom from two forests sites.
3. To determine the physico-chemical characteristics of the soil.

Collection of soil mushrooms was carried out during January 2014 to December 2016. The best collecting season is rainy season. A survey of fungal fruiting bodies was carried out in the selected sites and the fruiting body of mushrooms were photographed in their natural habitat before collection is done. All-important morphological characters were noted down in a notebook. Color and size were taken from the fresh specimens and the morphology of the fructification was studied with a hand lens.

For taxonomical study, mushrooms were photographed in their natural habitat before collection is done. All-important morphological characters were noted down in a notebook. Color and size were taken from the fresh specimens and the morphology of the fructification was studied with a hand lens. Collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Bas, 1969; Singer, 1986; Arora, 1986; Surcek, 1988; Ainsworth and Bisby, 2000; Mohanan, 2013). Spore print of the collected specimens were taken then, the color of the spore print was noted (Surcek, 1988). For microscopic study, thin sections of dried specimens were taken with the help of a sharp razor blade and were mounted in 3% KOH solution and stained in 2% aqueous phloxine. Sections are also mounted in Lactophenol or 60% lactic acid + cotton blue. Nomenclature, taxonomic position and author names follow the databases: Index Fungorum- IFS (http://www.indexfungorum.org), the International Plant Names Index – IPNI (http://www.ipni.org) and MycoBank (http://www.mycobank.com). Specimens collected were air dried in sunlight or with a blower and packed in polythene bags for herbarium specimens. They are also preserved in FAA solution and kept in specimen bottles or containers. They were then labeled with appropriate voucher numbers. During the period altogether 62 specimens could be identified according to standard macroscopic and microscopic characteristics from the collection sites.

For the diversity study, mushrooms were sampled monthly from May to October from the two sites during 2014-2016. Sampling of the mushrooms were not showing any results during the dry season (November to April) and hence were not represented throughout the study. Sampling were taken from five plots of 20m X 20m square plots. In case of small macro fungi occurring in groups/clusters, a frame of 20cm X 20cm was put on top of the fruit body clusters and those fruit bodies inside the frame was treated as a single individual of the species (Mani and Kumaresan, 2009).

The following indices were then calculated:

Cumulative species number was calculated following the method of Zothanzama (2011). The species accumulated at each sampling was noted and the cumulative species richness of mushrooms in both the sites were calculated from the collecting seasons May to October for three year of the study periods 2014-2016. The species accumulation graph was then plotted as number of species accumulated within each sampling time.

Index of species diversity of the mushrooms were calculated using the Shannon's diversity Index (H_s), Simpson Index of Dominance (D_S), Margalef's Diversity Index (D_{Mg}) and Pielou's Evenness Index (J') as suggested by Pielou,1975, Simpson (1949), Clifford and Stephenson (1975) and Pielou, 1966 respectively.

Shannon's diversity Index (H_s): $H_s = -\sum piLnpi$

Where p_i = the proportion of individuals found in the i^{th} species or $pi = \frac{ni}{N}$

Where, n_i =the abundance of the individual in the i^{th} species; N = the abundance of all the species.

Simpson Index of Dominance (D_S): $Ds = \sum[\frac{[\{ni(ni-1)\}]}{[\{N(N-1)\}]}]$

Where, ni = No. of individuals of the i^{th} species; N= total no. of individual

As the Simpson's index values increases, diversity decreases. Simpson index is therefore usually expressed as "1- D" or "1/D".

Margalef's Diversity Index (D_{Mg}): $DMg = \frac{(S-1)}{LnN}$

Where, S = number of species recorded; N = total number of individuals; Ln = Natural Logarithm

Pielou's Evenness Index (J'): $J' = \frac{H}{LnS}$

Where, H = Shannon–Wiener's diversity index; S = total number of species in the sample; Ln = Natural Logarithm

A total of 62 mushroom species belonging to 18 families with 34 genera were identified from both the sites during the collecting period of May to October 2014 to 2016. 35 species were recorded from Site-1 (Hmuifang) and 48 species were recorded from the Site-2 (Mizoram University Campus). From the collected specimens, *Amanita spissacea* was recorded for the first time in India. It was observed that the species continue to increase with each year as shown in the species accumulation curve.

The diversity indices were calculated from the collections made during the mushroom growing season i.e., May to October for each of the years 2014-2016. Species diversity of soil mushrooms was found to be higher in Mizoram University Campus than in Hmuifang forest.

The annual average Shannon diversity index (H_s) in Site-1 were 2.6, 2.8 and 3.12 for the year 2014, 2015 and 2016 respectively and 3.13, 3.27 and 3.25 for the year

2014, 2015 and 2016 respectively in Site-2. The Shannon diversity index (H_s) in Site-2 shows higher value than Site-1.

The annual average Simpson index of Dominance (D_s) in Site-1 was 0.96 for the year 2014, 2015 and 2016 respectively, and 0.88, 0.96 and 0.96 for the year 2014, 2015 and 2016 respectively in Site-2. The Simpson index of Dominance (D_s) in Site-1 shows higher value than Site-2.

The annual average Pielou's Evenness index (J') in Site-1 were 0.51, 0.54 and 0.59 for the year 2014, 2015 and 2016 respectively, and 0.58, 0.6 and 0.6 for the year 2014, 2015 and 2016 respectively in Site-2. The Pielou's Evenness index (J') in Site-2 shows higher value than Site-1.

The annual average Margalef's Diversity Index of Species Richness (D_{Mg}) were 3.83, 4.65, 4.45 for the year 2014, 2015 and 2016 respectively in Site-1 and 4.55, 5.66 and 3.83 for the year 2014, 2015 and 2016 respectively in Site-2. The Margalef's Diversity Index of Species Richness (D_{Mg}) in Site-2 shows higher value than Site-1

The average Shannon diversity index (Hs), Simpson index of Dominance (D_s), Evenness index (J'), Margalef's Diversity Index of Species Richness (D_{Mg}) during the study period 2014-2016 were 2.84, 0.96, 0.55 and 4.32 respectively in Site-1. The average H_s, D_s, J' and D_{Mg} during the study period 2014-2016 were 3.22, 0.93, 0.59, 4.68 respectively from Site-2. The average mushroom diversity from Site-1 were lower than that of Site-2 for all the indices except for Simpson's index of dominance $D_{S.}$

All the diversity indices i.e., Shannon-Weiner's Diversity Index, Simpson Index of Dominance, Evenness Index and Margalef's Species Richness were found to be higher in Site-2 than Site-1. The greater species number in Site-2 may be due to higher plant diversity.

For soil physico-chemical characteristic study, pH of soil samples was measured by 1:2.5 (soil: water suspension) (Anderson and Ingram, 1993), Soil moisture was measured by Oven drying method (Anderson and Ingram, 1993), Soil organic carbon is estimated by Rapid dichromate oxidation method (Walkley and Black, 1934), total nitrogen estimation was done by Kjeldahl method following (Anderson and Ingram, 1993), using Kel plus nitrogen Auto-analyser (KES 04l, DISTYL-EM). The statistica analysis of soil physico-chemical characteristics were calculated using Microsoft Office Excel. The data were analysed statistically for correlation coefficient or significance level of soil characteristics and diversity of the soil mushrooms using the Statistical Package SPSS 16.0.

The annual average Soil Moisture Content in Site-1 were 29.85 %, 32.50 % and 32.66 % for the year 2014, 2015 and 2016 respectively and 26.72 %, 26.97 % and 28.88 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Soil Moisture Content of Site-1 shows higher value than Site-2 during study period of 2014-2016.

The annual average Water holding Capacity in Site-1 were 78.05 %, 77.78 % and 79.99 % for the year 2014, 2015 and 2016 respectively and 70.33 %, 75.25 % and 75.91 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Water holding Capacity in Site-1 shows higher value than Site-2 during study period of 2014-2016.

The annual average pH of soil in Site-1 were 5.32, 5.34 and 5.46 for the year 2014, 2015 and 2016 respectively and 5.11, 5.19 and 5.23 for the year 2014, 2015 and 2016 respectively in Site-2. The average pH of soil in Site-1 shows highest value shows higher value than Site-2 during study period of 2014-2016.

The annual average Organic Carbon in Site-1 were 2.41 %, 2.23 % and 2.41 % for the year 2014, 2015 and 2016 respectively and 2.31 %, 2.26 % and 2.3 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Organic Carbon in Site-1 shows higher value than Site-2 during study period of 2014-2016.

The annual average Total Nitrogen in Site-1 were 0.47 %, 0.43 % and 0.43 % for the year 2014, 2015 and 2016 respectively and 0.42 %, 0.42 % and 0.45 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Total Nitrogen in Site-1 shows higher value than Site-2 during study period of 2014-2016.

Pearson correlation (r) indicated that there was positive correlation between total nitrogen of Site-2 with Shannon Wiener's Diversity Index of Site-2 and Margalef's Species Richness of Site-2 in 2014.

Pearson correlation co-efficient (r) analysis indicated that there was positive correlation between total nitrogen of Site-2 with Shannon Wiener's Diversity Index of Site-2 and Margalef's Species Richness of Site-2 in 2014.

Pearson correlation co-efficient (r) showed positive correlation between Organic Carbon of Site-2 with Margalef's Species Richness of Site-2 and Total Nitrogen of Site-2 with Margalef's Species Richness of Site-2 in 2015.

Pearson correlation co-efficient (r) also positive correlation between Total Nitrogen of Site-2 with Margalef's Species Richness of Site-2 in 2016.

The present work on soil mushrooms of Mizoram from two selected forests sites is only a preliminary work on the species of the region. Evidently such coverage is by no means complete for the entire area and many forests still remain almost completely unexplored. However, an effort was made on the taxonomy, general diversity and its physico-chemical characteristics of the soil of the state.

From the current findings and other works mentioned, it is observed that the diversity of the mushrooms is dramatically influenced by numerous environmental factors both biotic and abiotic, as well as complex interactions among them.

This work highlighted the species composition, diversity and soil characteristics and its relation to soil mushrooms. It provides the first baseline data on soil mushroom composition, density and diversity and their correlation with soil physico-chemical parameters of the State, which is expected to be important for future references. However, it would be valuable to continue and maintain a long-term monitoring of the mushrooms to understand the nature of diversity and succession in the region. At the same time, a more detailed and specific study is required to explore and identify soil mushrooms as they are one of the indicators of forest health.

PHOTO PLATES

Plate 1.A

Plate 1.B

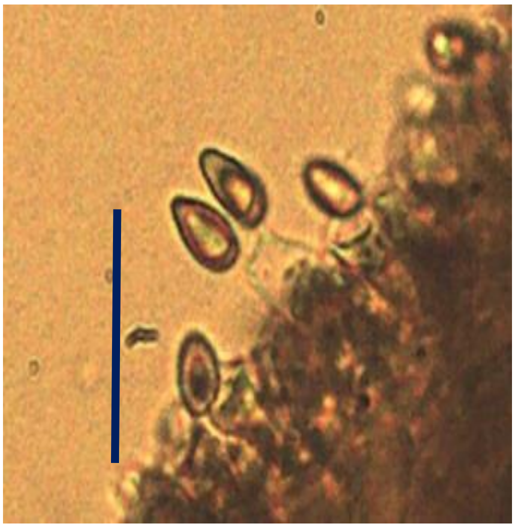


Plate 1.C

Plate 1.D

Plate 1.A. Field photo of *Agaricus silvaticus*
Plate 1.B. Laboratory photo *Agaricus silvaticus* (scale bar = 1 cm)
Plate 1.C. Basidia of *Agaricus silvaticus* (scale bar = 20 µm)
Plate 1.D. Spores of *Agaricus silvaticus* (scale bar = 5 µm)

Plate 2.A

Plate 2.B

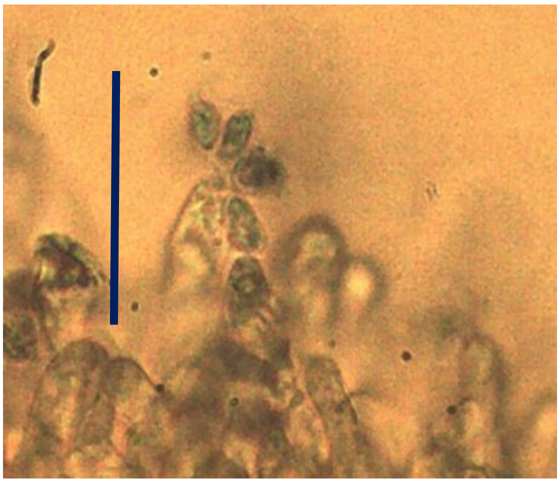


Plate 2.C

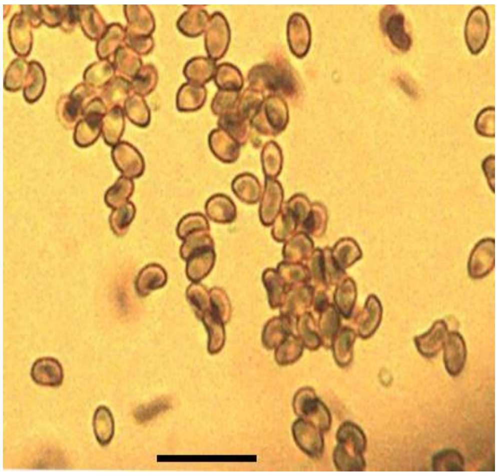


Plate 2.D

Plate 2.A. Field photo *Agaricus trisulphuratus*
Plate 2.B. Laboratory photo of *Agaricus trisulphuratus* (scale bar = 1 cm)
Plate 2.C. Basidia of *Agaricus trisulphuratus* (scale bar = 30 µm)
Plate 2.D. Spores of *Agaricus trisulphuratus* (scale bar = 10 µm)

Plate 3.A

Plate 3.B

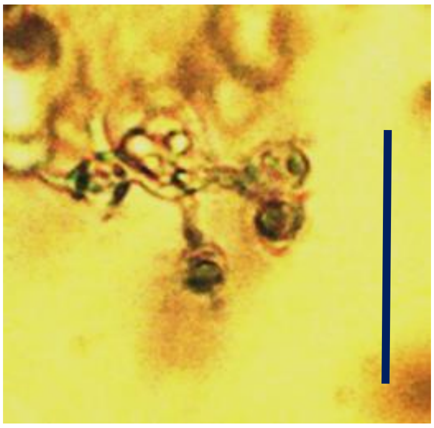


Plate 3.C

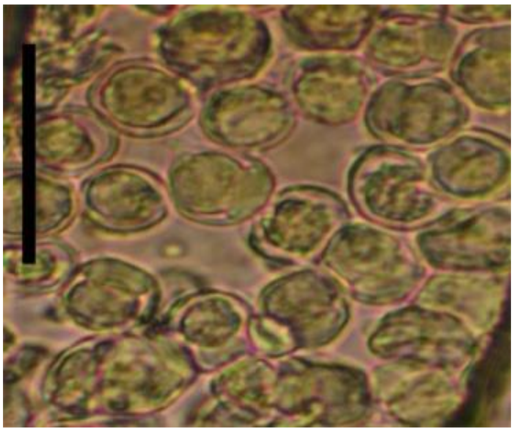


Plate 3.D

Plate 3.A. Field photo *Amanita crocea*

Plate 3.B. Laboratory photo of *Amanita crocea* (scale bar = 2 cm)

Plate 3.C. Basidia of *Amanita crocea* (scale bar = 20 µm)

Plate 3.D. Spores of *Amanita crocea* (scale bar = 30 µm)

Plate 4.A

Plate 4.B

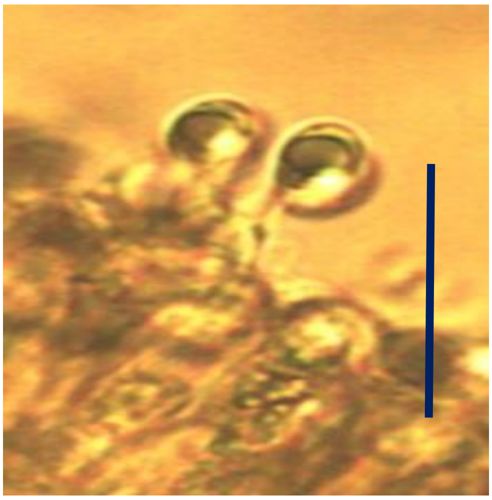


Plate 4.C

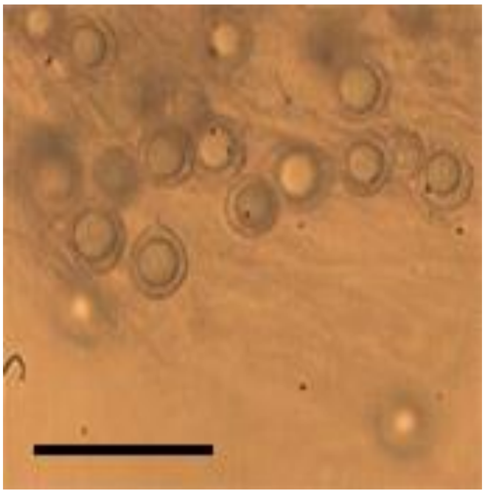


Plate 4.D

Plate 4.A. Field photo *Amanita griseofolia*
Plate 4.B. Laboratory photo of *Amanita griseofolia* (scale bar = 5 cm)
Plate 4.C. Basidia of *Amanita griseofolia* (scale bar = 20 µm)
Plate 4.D. Spores of *Amanita griseofolia* (scale bar = 30 µm)

Plate 5.A

Plate 5.B

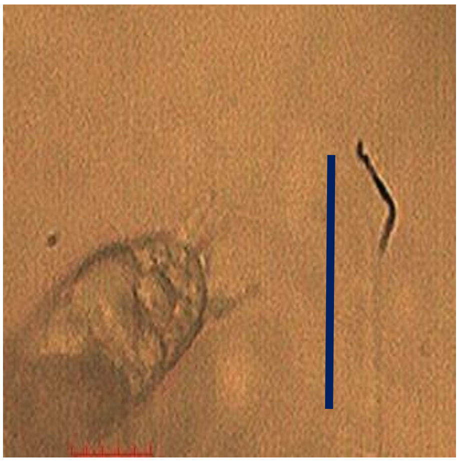


Plate 5.C

Plate 5.D

Plate 5.A. Field photo *Amanita jacksonii*
Plate 5.B. Laboratory photo of *Amanita jacksonii* (scale bar = 2 cm)
Plate 5.C. Basidia of *Amanita jacksonii* (scale bar = 20 μm)
Plate 5.D. Spores of *Amanita jacksonii* (scale bar = 10 μm)

Plate 6. A

Plate 6.B

Plate 6.C

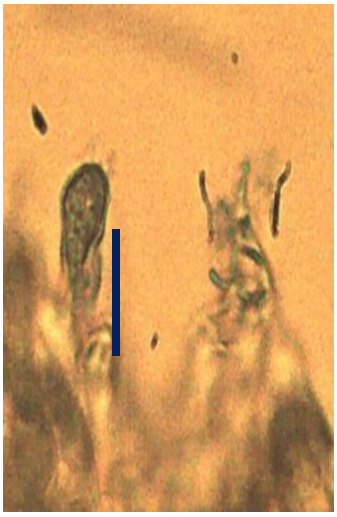


Plate 6. D

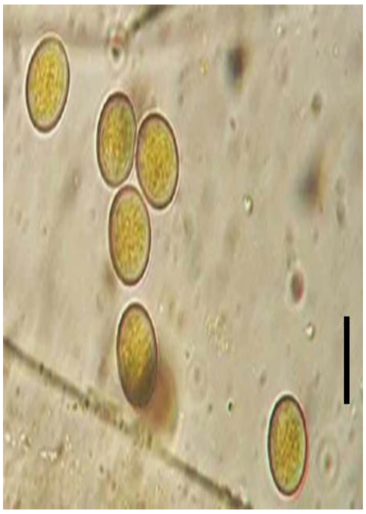
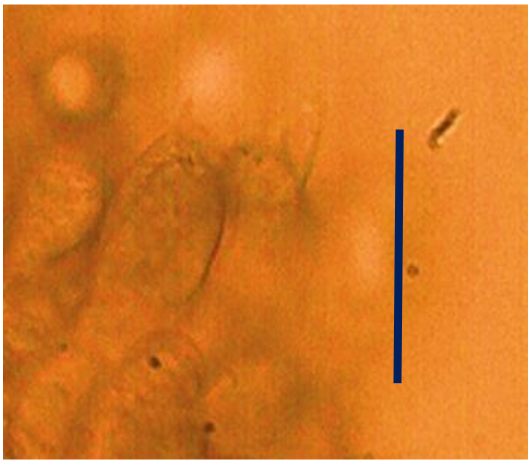


Plate 6.E

Plate 6.A & B. Field photo *Amanita pachycolea*
Plate 6.C. Laboratory photo of *Amanita pachycolea* (scale bar = 2 cm)
Plate 6.D. Basidia of *Amanita pachycolea* (scale bar = 20 µm)
Plate 6.E. Spores of *Amanita pachycolea* (scale bar = 10 µm)

Plate 7.A

Plate 7.B



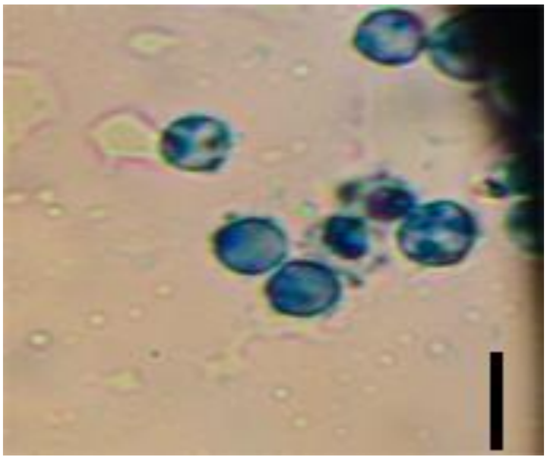


Plate 7.C

Plate 7.D

Plate 7.A. Field photo *Amanita pantherina*
Plate 7.B. Laboratory photo of *Amanita pantherine* (scale bar = 2 cm)
Plate 7.C. Basidia of *Amanita pantherina* (scale bar = 20 µm)
Plate 7.D. Spores of *Amanita pantherina* (scale bar = 10 µm)

Plate 8.A

Plate 8. B

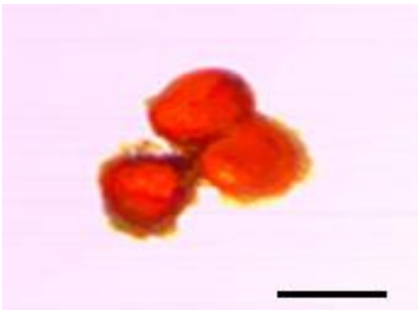


Plate 8.C

Plate 8.A. Field photo of *Amanita phalloides*
Plate 8.B. Laboratory photo of *Amanita phalloides* (scale bar = 2 cm)
Plate 8.C. Spores of *Amanita phalloides* (scale bar = 10 µm)

Plate 9.A

Plate 9.B

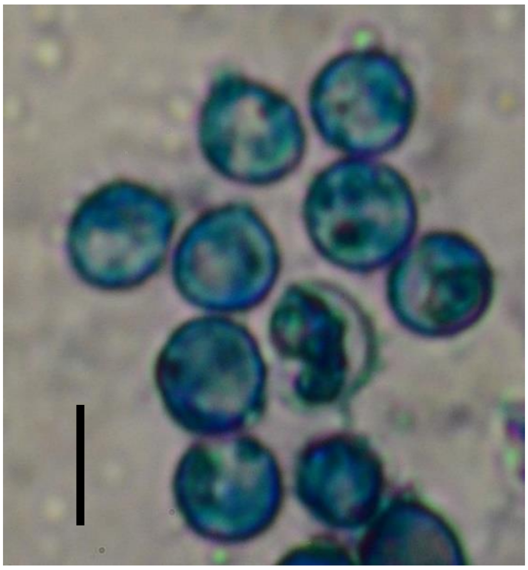


Plate 9.C

Plate 9.A. Field photo of *Amanita spissacea*
Plate 9.B. Laboratory photo of *Amanita spissacea* (scale bar = 2 cm)
Plate 9.C. Spores of *Amanita spissacea* (scale bar = 10 µm)

Plate 10.A

Plate 10.B

Plate 10.C

Plate 10.D

Plate 10.A. Field photo of *Amanita vaginata*

Plate 10.B. Laboratory photo of *Amanita vaginata* (scale bar = 2 cm)

Plate 10.C. Basidia of *Amanita vaginata* (scale bar = 30 µm)

Plate 10.D. Spores of *Amanita vaginata* (scale bar = 10 µm)

Plate 11.A

Plate 11.B

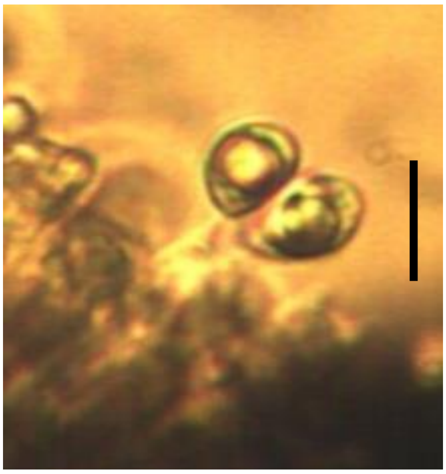


Plate 11.C

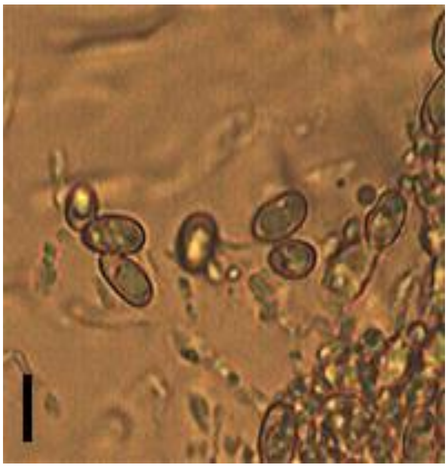


Plate 11.D

Plate 11.A. Field photo of *Aureoboletus auriflammeus*

Plate 11.B. Laboratory photo of *Aureoboletus auriflammeus* (scale bar = 2 cm)

Plate 11.C. Basidia of *Aureoboletus auriflammeus* (scale bar = 10 µm)

Plate 11.D. Spores of *Aureoboletus auriflammeus* (scale bar = 10 µm)

Plate 12.A

Plate 12.B

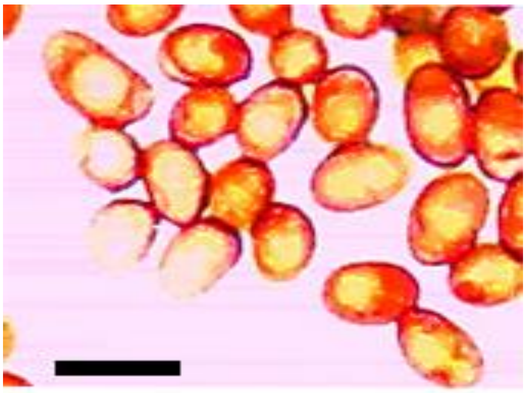


Plate 12.C

Plate 12.A. Field photo of *Aureoboletus moravicus f. luteus*
Plate 12.B. Laboratory photo of *Aureoboletus moravicus f. luteus* (scale bar = 2 cm)
Plate 12.C. Spores of *Aureoboletus moravicus f. luteus* (scale bar = 10 µm)

Plate 13.A

Plate 13.B

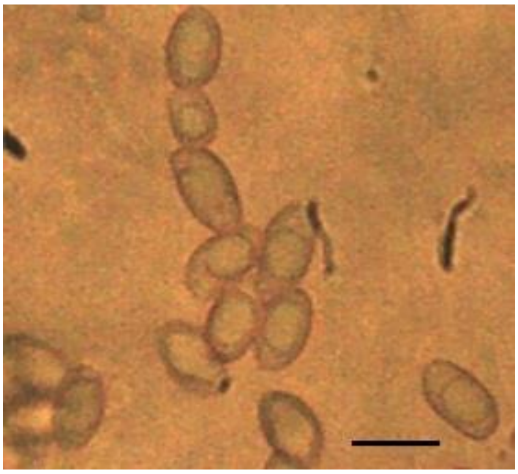


Plate 13.C

Plate 13.A. Field photo of *Boletus carpinaceus*

Plate 13.B. Laboratory photo of *Boletus carpinaceus* (scale bar = 2 cm)

Plate 13.C. Spores of *Boletus carpinaceus* (scale bar = 10 µm)

Plate 14.A

Plate 14.B

Plate 14.C

Plate 14.A. Field photo of *Boletus mirabilis*
Plate 14.B. Laboratory photo of *Boletus mirabilis* (scale bar = 1 cm)
Plate 14.C. Spores of *Boletus mirabilis* (scale bar = 20 µm)

Plate 15.A

Plate 15.B

Plate 15.C

Plate 15.A. Field photo of *Boletus quercinus*
Plate 15.B. Laboratory photo of *Boletus quercinus* (scale bar = 3 cm)
Plate 15.C. Spores of *Boletus quercinus* (scale bar = 15 µm)

Plate 16.A

Plate 16.B Plate 16.C

Plate 16.A. Field photo of *Boletus stramineum*

Plate 16.B. Laboratory photo of *Boletus stramineum* (scale bar = 3 cm)

Plate 16.C. Spores of *Boletus stramineum* (scale bar = 10 µm)

Plate 17.A

Plate 17.B

Plate 17.C

Plate 17.A. Field photo of *Boletus subtomentosus*

Plate 17.B. Laboratory photo of *Boletus subtomentosus* (scale bar = 2 cm)

Plate 17.C. Spores of *Boletus subtomentosus* (scale bar = 15 µm)

Plate 18.A

Plate 18.B

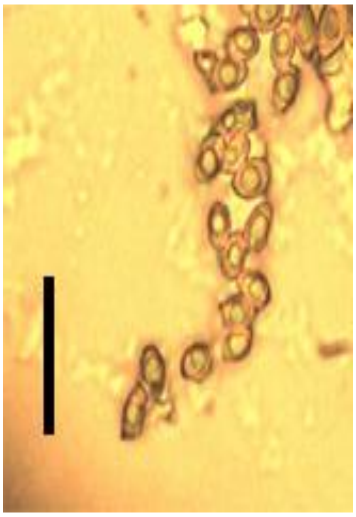


Plate 18.C

Plate 18.A. Field photo of *Cantharellus cibarius*
Plate 18.B. Laboratory photo of *Cantharellus cibarius* (scale bar = 1 cm)
Plate 18.C. Spores of *Cantharellus cibarius* (scale bar = 40 µm)

Plate 19.A

Plate 19.B

Plate 19.C

Plate 19.A & B. Laboratory photo of *Chlorophyllum molybdites var. molybdites* (scale bar = 5 cm)

Plate 19.C. Spores of *Chlorophyllum molybdites var. molybdites* (scale bar = 10 µm)

Plate 20.A

Plate 20.B

Plate 20.C

Plate 20.A. Field photo of *Clavulinopsis corallinorosacea*

Plate 20.B. Laboratory photo of *Clavulinopsis corallinorosacea* (scale bar = 2 cm)

Plate 20.C. Spores of *Clavulinopsis corallinorosacea* (scale bar = 50 µm)

Plate 21.A

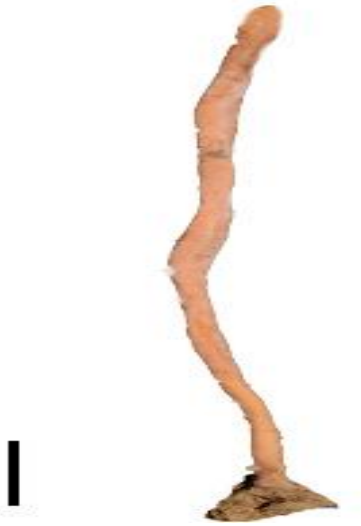


Plate 21.B

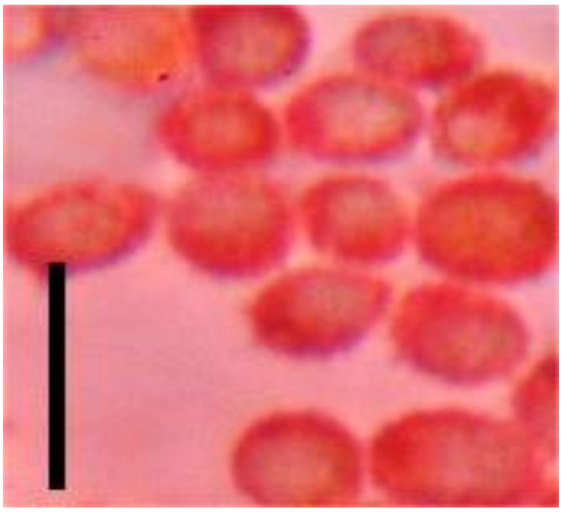


Plate 21.C

Plate 21.A. Field photo of *Clavulinopsis laeticolor*
Plate 21.B. Laboratory photo of *Clavulinopsis laeticolor* (scale bar = 1 cm)
Plate 21.C. Spores of *Clavulinopsis laeticolor* (scale bar = 10 µm)

Plate 22.A

Plate 22.B

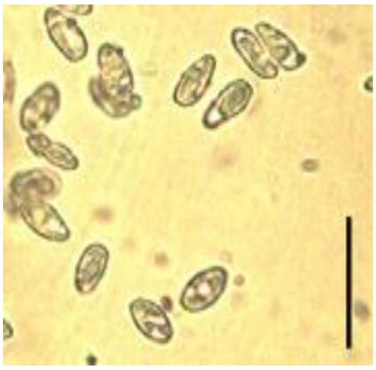


Plate 22.C

Plate 22.A. Field photo of *Cortinarius croceous*
Plate 22.B. Laboratory photo of *Cortinarius croceous* (scale bar = 1 cm)
Plate 22.C. Spores of *Cortinarius croceous* (scale bar = 30 µm)

Plate 23.A

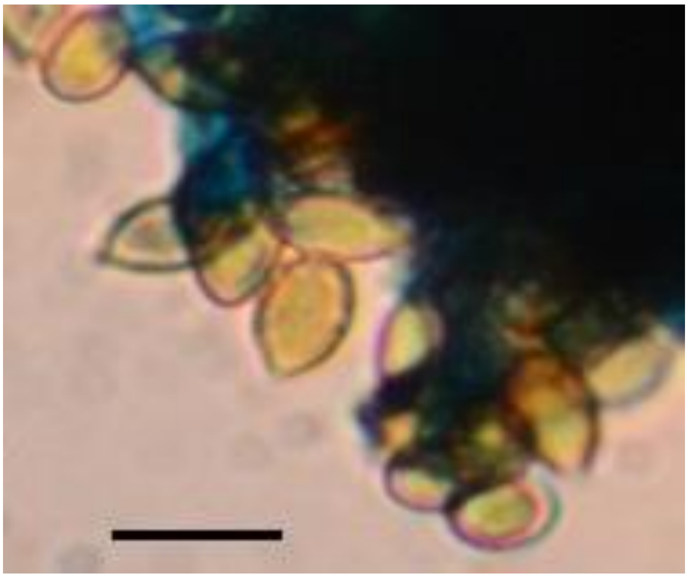


Plate 23.B

Plate 23.A. Laboratory photo of *Cortinarius helvolus f. helvolus* (scale bar = 2 cm)
Plate 23.B. Spores of *Cortinarius helvolus f. helvolus* (scale bar = 20 µm)

Plate 24.A

Plate 24.B

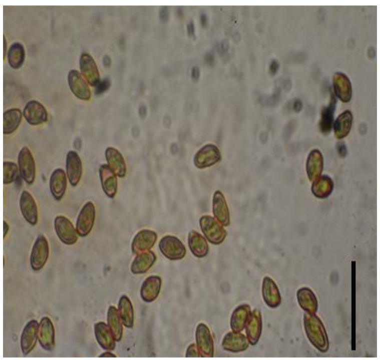


Plate 24.C

Plate 24.A. Field photo of *Cortinarius phoeniceus* var. *occidentalis*
Plate 24.B. Laboratory photo of *Cortinarius phoeniceus* var. *occidentalis* (scale bar = 1 cm)
Plate 24.C. Spores of *Cortinarius phoeniceus* var. *occidentalis* (scale bar = 20 µm)

Plate 25.A

Plate 25.B

Plate 25.C

Plate 25.A. Field photo of *Craterellus cornucopioides*
Plate 25.B. Laboratory photo of *Craterellus cornucopioides* (scale bar = 2 cm)
Plate 25.C. Spores of *Craterellus cornucopioides* (scale bar = 20 µm)

Plate 26.A

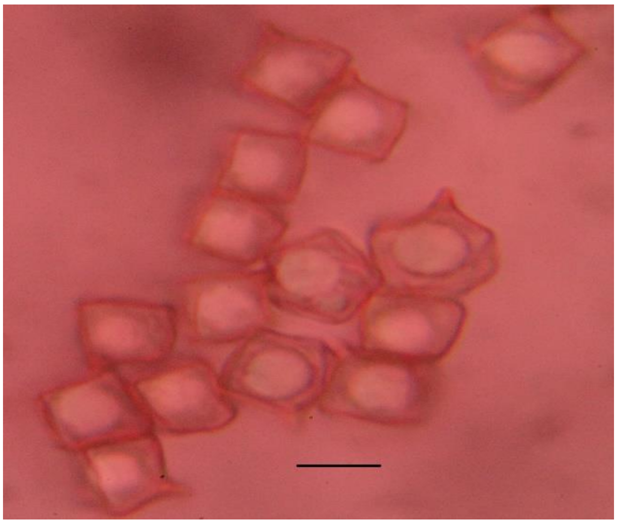


Plate 26.B

Plate 26.A. Laboratory photo of *Entoloma hainanense* (scale bar = 1 cm)
Plate 26.B. Spores of *Entoloma hainanense* (scale bar = 10 µm)

Plate 27.A

Plate 27.B

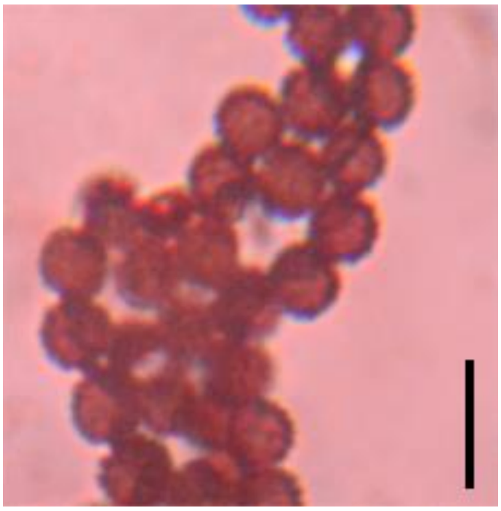


Plate 27.C

Plate 27.A. Field photo of *Geastrum morganii*
Plate 27.B. Laboratory photo of *Geastrum morganii* (scale bar = 1 cm)
Plate 27.C. Spores of *Geastrum morganii* (scale bar = 10 µm)

Plate 28.A

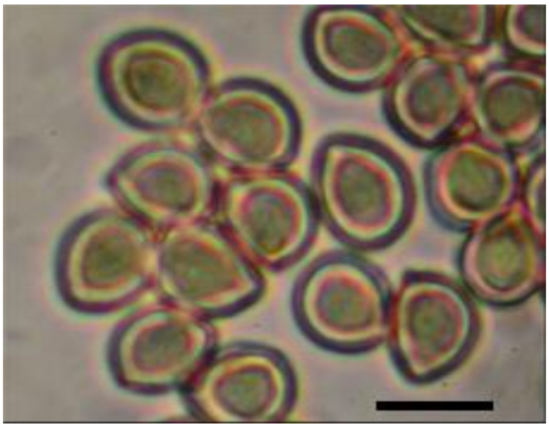


Plate 28.B

Plate 28.A. Laboratory photo of *Hebeloma victoriense* (scale bar = 5 cm)
Plate 28.B. Spores of *Hebeloma victoriense* (scale bar = 10 µm

Plate 29.A

Plate 29.B

Plate 29.A. Laboratory photo of *Helvella ephippium* (scale bar = 2 cm)
Plate 29.B. Spores of *Helvella ephippium* (scale bar = 15 µm)

Plate 30.A

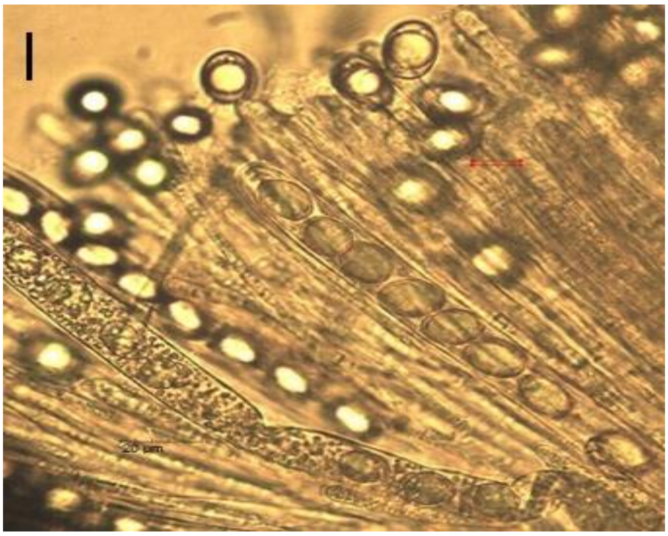


Plate 30.B

Plate 30.A. Laboratory photo of *Helvella Macropus* (scale bar = 2 cm)
Plate 30.B. Spores of *Helvella macropus* (scale bar = 15 µm)

Plate 31.A

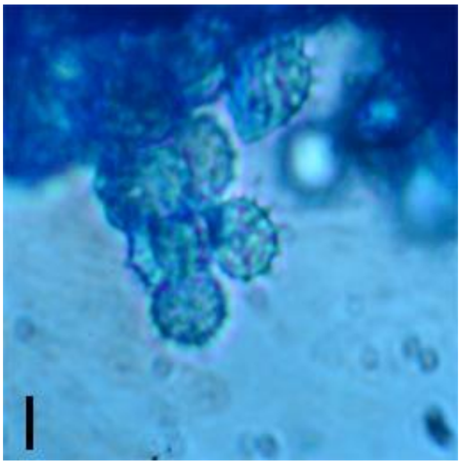


Plate 31.B

Plate 31.A. Laboratory photo of *Laccaria vinaceoavellanea* (scale bar = 2 cm)
Plate 31.B. Spores of *Laccaria vinaceoavellanea* (scale bar = 5 µm)

Plate 32.A

Plate 32.B

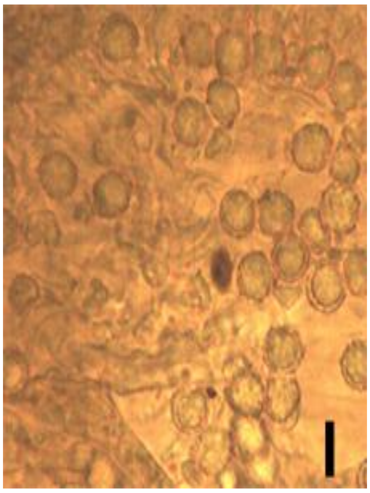


Plate 32.C

Plate 32.D

Plate 32.A. Field photo of *Laccaria yunnanensis*

Plate 32.B & C. Laboratory photo of *Laccaria yunnanensis* (scale bar = 1 cm)

Plate 32.D. Spores of *Laccaria yunnanensis* (scale bar = 10 µm)

Plate 33.A

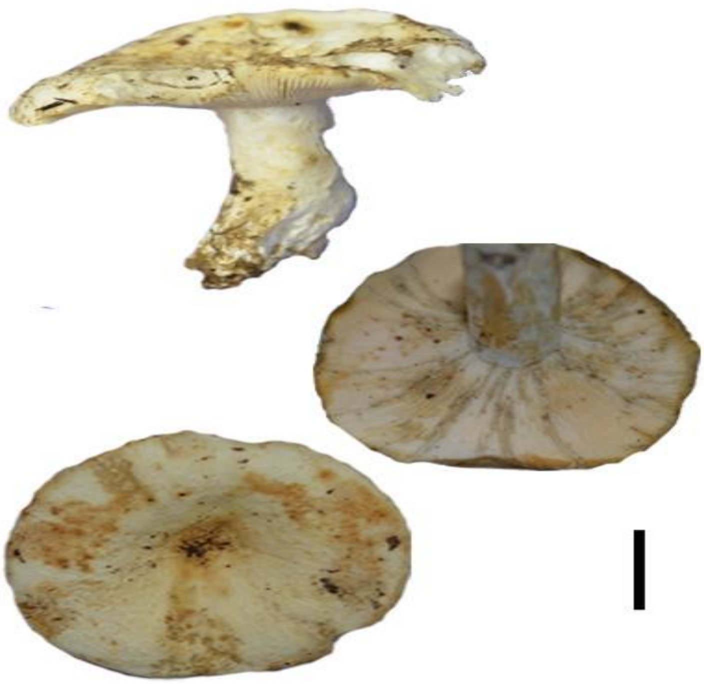


Plate 33.B

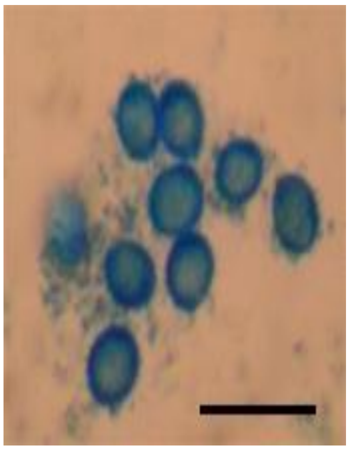


Plate 33.C

Plate 33.A. Field photo of *Lactarius piperatus*

Plate 33.B. Laboratory photo of *Lactarius piperatus* (scale bar = 2 cm)

Plate 33.C. Spores of *Lactarius piperatus* (scale bar = 10 µm)

Plate 34.A

Plate 34.B

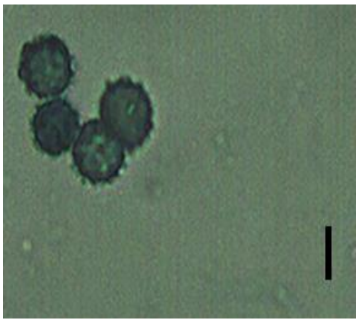


Plate 34.C

Plate 34.A. Field photo of *Lactifluus corrugis*
Plate 34.B. Laboratory photo of *Lactifluus corrugis* (scale bar = 2 cm)
Plate 34.C. Spores of *Lactifluus corrugis* (scale bar = 10 µm)

Plate 35.A

Plate 35.B

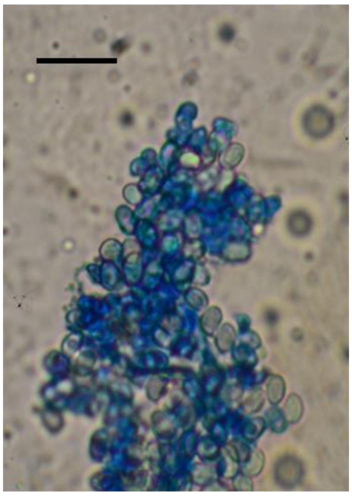


Plate 35.C

Plate 35.A. Field photo of *Lepiota echinella*
Plate 35.B. Laboratory photo of *Lepiota echinella* (scale bar = 0.5 cm)
Plate 35.C. Spores of *Lepiota echinella* (scale bar = 30 µm)

Plate 36.A

Plate 36.B

Plate 36.C

Plate 36.A. Field photo of *Leucocoprinus birnbaumii*
Plate 36.B. Laboratory photo of *Leucocoprinus birnbaumii* (scale bar = 1 cm)
Plate 36.C. Spores of *Leucocoprinus birnbaumii* (scale bar = 10 µm)

Plate 37.A

Plate 37.B

Plate 37.C

Plate 37.D

Plate 37.A. Field photo of *Lycoperdon excipuliforme*
Plate 37.B & C. Laboratory photo of *Lycoperdon excipuliforme* (scale bar = 2 cm)
Plate 47.D. Spores of *Lycoperdon excipuliforme* (scale bar = 10 µm)

Plate 38.A

Plate 38.B

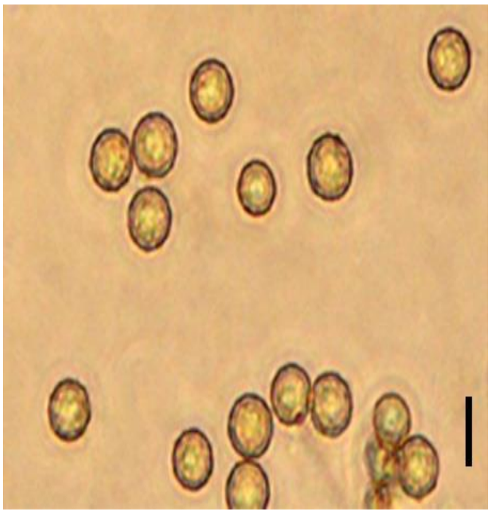


Plate 38.C

Plate 38.A. Field photo of *Lycoperdon perlatum*
Plate 38.B. Laboratory photo of *Lycoperdon perlatum* (scale bar = 1 cm)
Plate 38.C. Spores of *Lycoperdon perlatum* (scale bar = 5 µm)

Plate 39.A

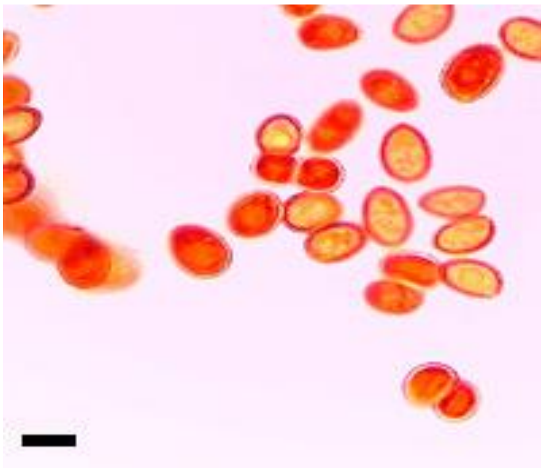


Plate 39.B

Plate 39.C

Plate 39.A. Field photo of *Macrolepiota dolichaula*

Plate 39.B. Laboratory photo of *Macrolepiota dolichaula* (scale bar = 2 cm)

Plate 39.C. Spores of *Macrolepiota dolichaula* (scale bar = 10 µm)

Plate 40.A

Plate 40.B

Plate 40.C

Plate 40.A. Field photo of *Macrolepiota procera*
Plate 40.B. Laboratory photo of *Macrolepiota procera* (scale bar = 2 cm)
Plate 40.C. Spores of *Macrolepiota procera* (scale bar = 10 µm)

Plate 41.A

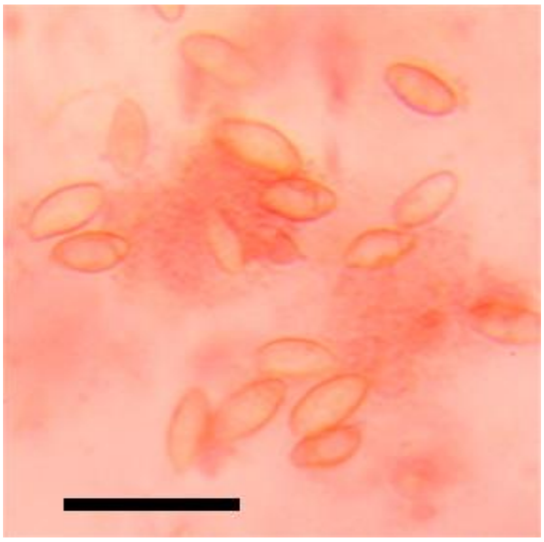


Plate 41.B

Plate 41.C

Plate 41.A. Field photo of *Mutinus caninus*
Plate 41.B. Laboratory photo of *Mutinus caninus* (scale bar = 2 cm)
Plate 41.C. Spores of *Mutinus caninus* (scale bar = 10 µm)

Plate 42.A

Plate 42.B

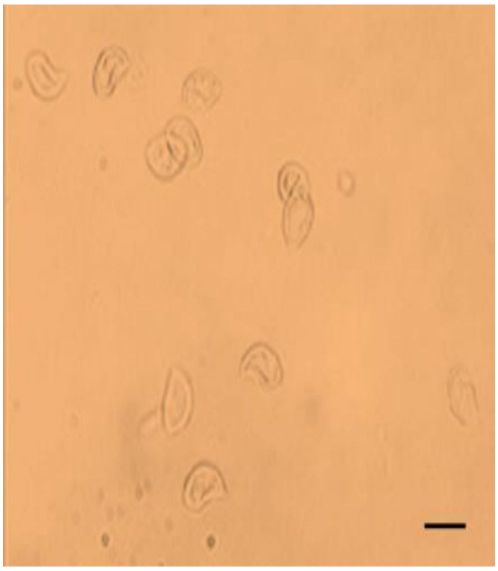


Plate 42.C

Plate 42.A & B. Laboratory photo of *Hymenopellis furfuracea* (scale bar = 2 cm)
Plate 42.C. Spores of *Hymenopellis furfuracea* (scale bar = 10 µm)

Plate 43.A

Plate 43.B

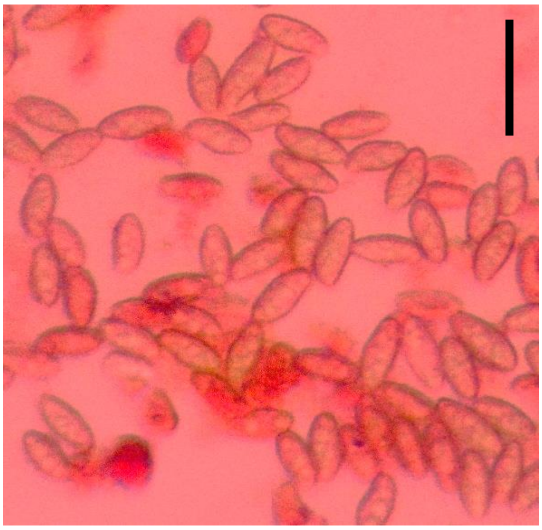


Plate 43.C

Plate 43.D

Plate 43.A & B.	Field photo of *Phallus indusiatus*
Plate 43. C.	Laboratory photo of *Phallus indusiatus* (scale bar = 4 cm)
Plate 43.D.	Spores of *Phallus indusiatus* (scale bar = 10 µm)

Plate 44.A

Plate 44.B

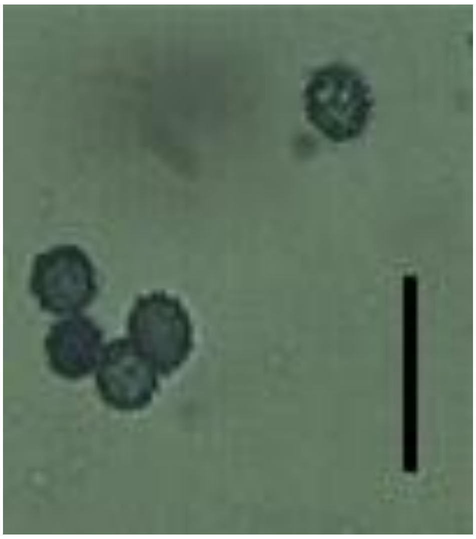


Plate 44.C

Plate 44.A & B. Laboratory photo of *Pisolithus albus* (scale bar = 2 cm)
Plate 44.C. Spores of *Pisolithus albus* (scale bar = 15 μm)

Plate 45.A

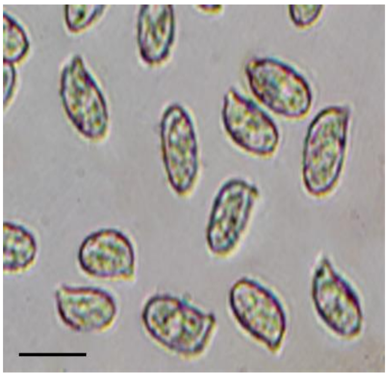


Plate 45.B

Plate 45.A. Laboratory photo of *Ramaria cystidiophora* (scale bar = 2 cm)
Plate 45.B. Spores of *Ramaria cystidiophora* (scale bar = 10 µm)

Plate 46.A

Plate 46.B

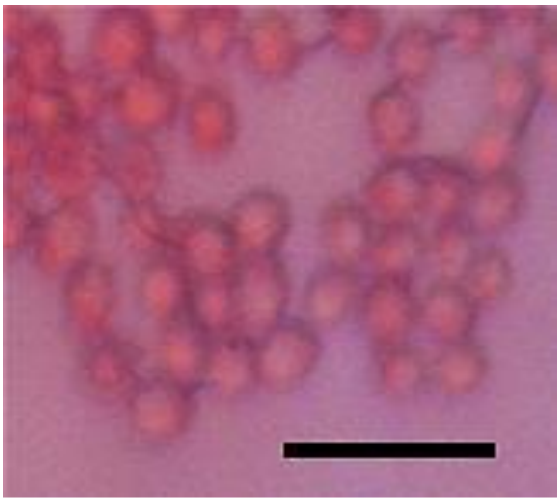


Plate 46.C

Plate 46.A. Field photo of *Ramaria kunzei*

Plate 46.B. Laboratory photo of *Ramaria kunzei* (scale bar = 1 cm)

Plate 46.C. Spores of *Ramaria kunzei* (scale bar = 20 µm)

Plate 47.A

Plate 47.B

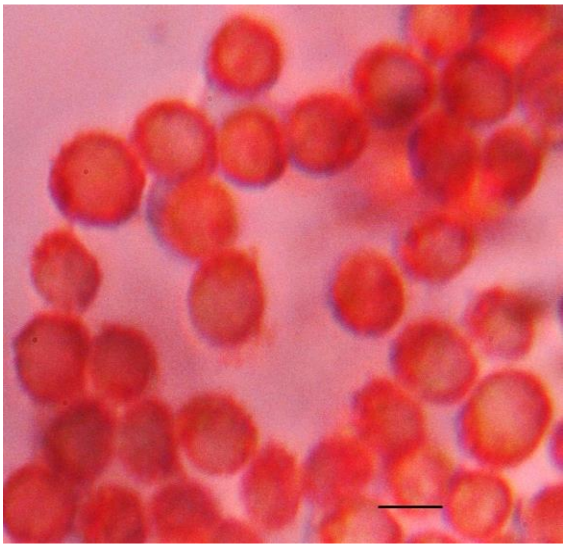


Plate 47.C

Plate 47.A. Field photo of *Russula aurora*
Plate 47.B. Laboratory photo of *Russula aurora* (scale bar = 1 cm)
Plate 47.C. Spores of *Russula aurora* (scale bar = 10 µm)

Plate 48.A

Plate 48.B

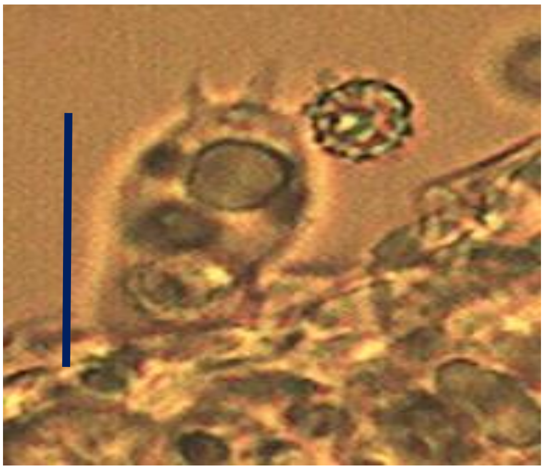


Plate 48.C

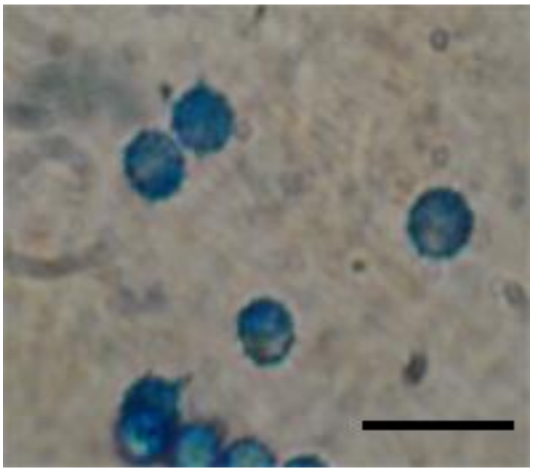


Plate 48.D

Plate 48.A. Field photo of *Russula compacta*
Plate 48.B. Laboratory photo of *Russula compacta* (scale bar = 2 cm)
Plate 48.C. Basidia of *Russula compacta* (scale bar = 40 µm)
Plate 48.D. Spores of *Russula compacta* (scale bar = 10 µm)

Plate 49.A

Plate 49.B

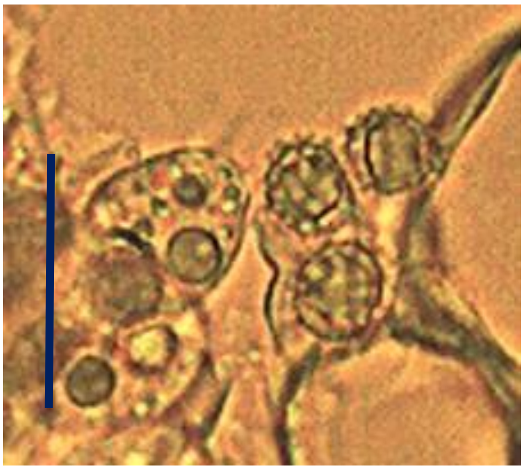


Plate 49.C

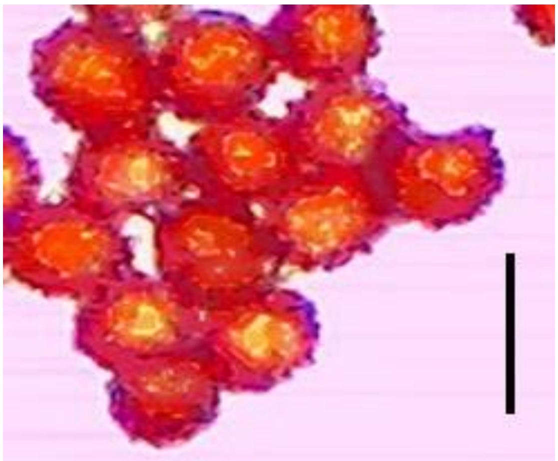


Plate 49.D

Plate 49.A. Field photo of *Russula cyanoxantha*
Plate 49.B. Laboratory photo of *Russula cyanoxantha* (scale bar = 2 cm)
Plate 49.C. Basidia of *Russula cyanoxantha* (scale bar = 20 µm)
Plate 49.D. Spores of *Russula cyanoxantha* (scale bar = 15 µm)

Plate 50.A

Plate 50.B

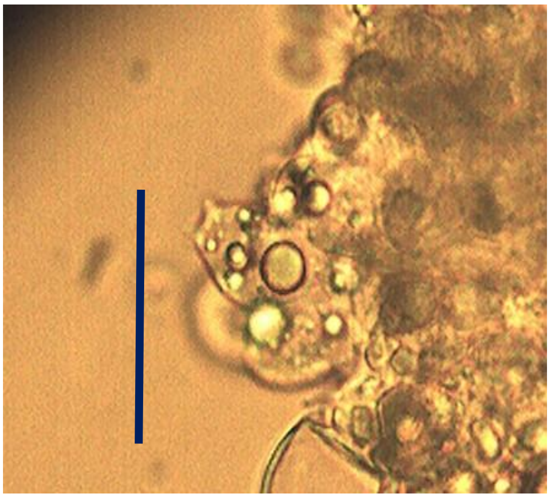


Plate 50.C

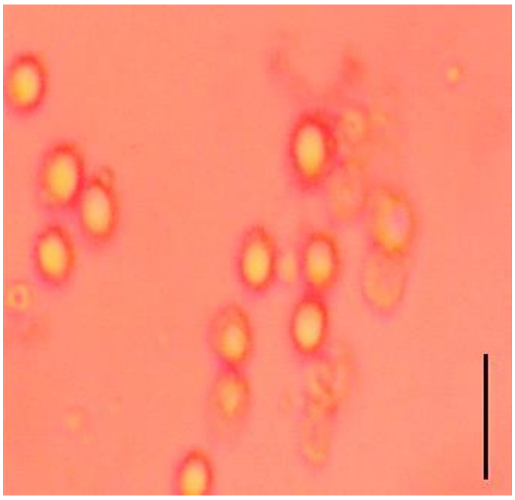


Plate 50.D

Plate 50.A. Field photo of *Russula earlei*

Plate 50.B. Laboratory photo of *Russula earlei* (scale bar = 1 cm)

Plate 50.C. Basidia of *Russula earlei* (scale bar = 20 µm)

Plate 50.D. Spores of *Russula earlei* (scale bar = 10 µm)

Plate 51.A

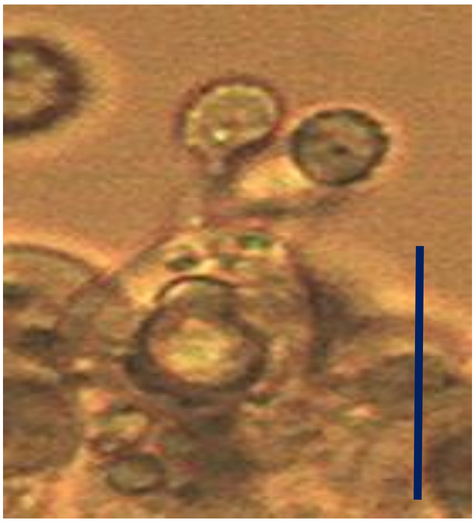


Plate 51.B

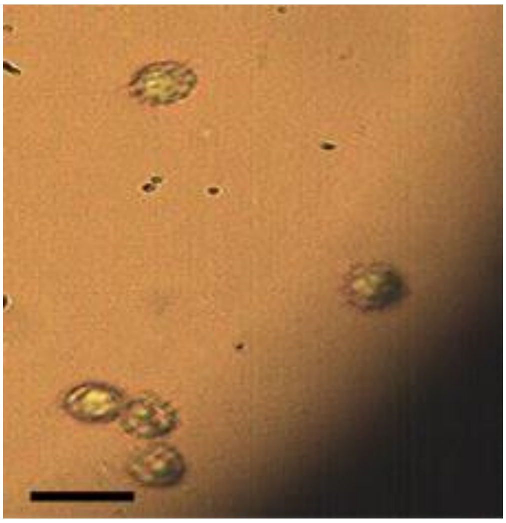


Plate 51.C

Plate 51.A. Laboratory photo of *Russula rosea* (scale bar = 2 cm)
Plate 51.B. Basidia of *Russula rosea* (scale bar = 20 µm)
Plate 51.C. Spores of *Russula rosea* (scale bar = 10 µm)

Plate 52.A

Plate 52.B

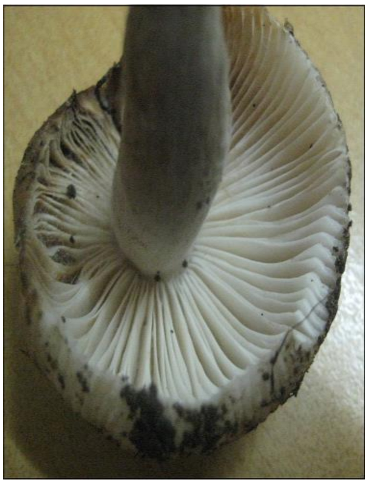


Plate 52.C

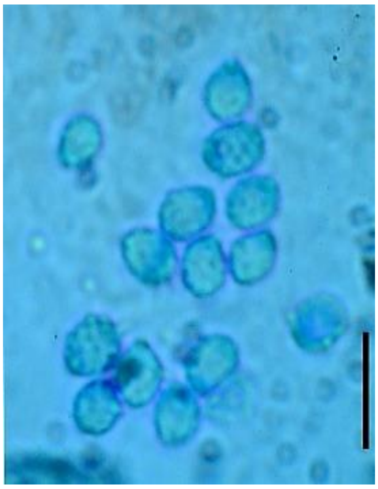


Plate 52.D

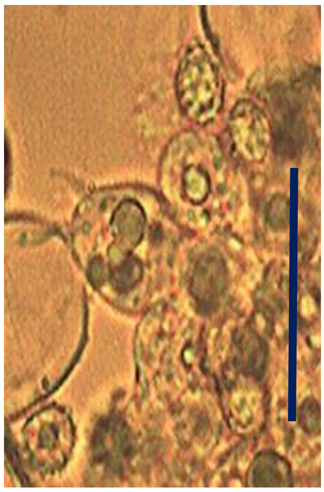
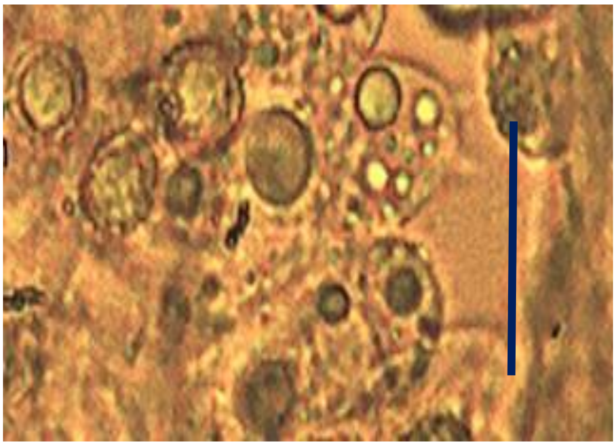


Plate 52.E

Plate 52.A, B & C. Laboratory photo of *Russula mutabilis*
(scale bar A= 1 cm, B=2 cm)
Plate 52.D. Spores of *Russula mutabilis* (scale bar = 20 µm)
Plate 52.E. Basidia of *Russula mutabilis* (scale bar = 40 µm)

Plate 53.A

Plate 53.B



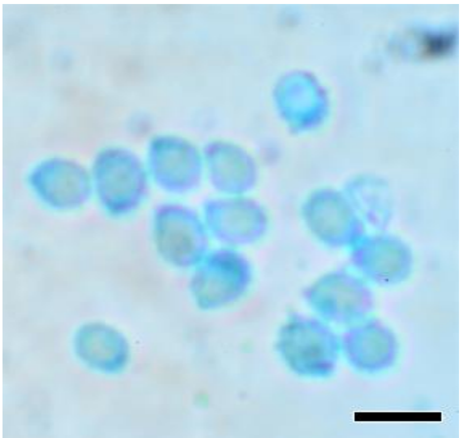


Plate 53.C

Plate 53.D

Plate 53.A. Field photo of *Russula nigricans*
Plate 53.B. Laboratory photo of *Russula nigricans* (scale bar = 1 cm)
Plate 53.C. Basidia of *Russula nigricans* (scale bar = 30 µm)
Plate 53.D. Spores of *Russula nigricans* (scale bar = 15 µm)

Plate 54.A

Plate 54.B

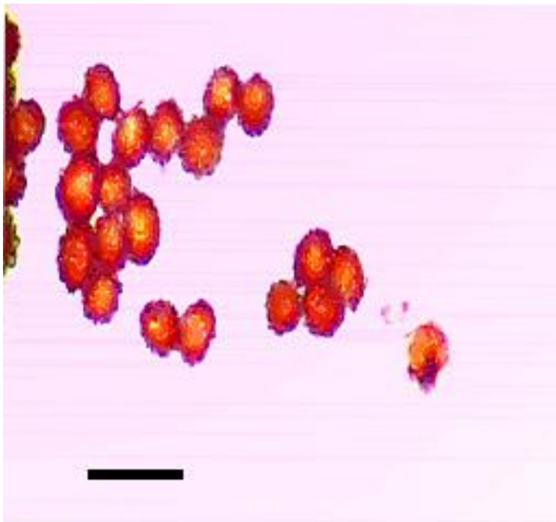


Plate 54.C

Plate 54.A. Field photo of *Russula queletii*
Plate 54.B. Laboratory photo of *Russula queletii* (scale bar = 2 cm)
Plate 54.C. Spores of *Russula queletii* (scale bar = 20 µm)

Plate 55.A

Plate 55.B

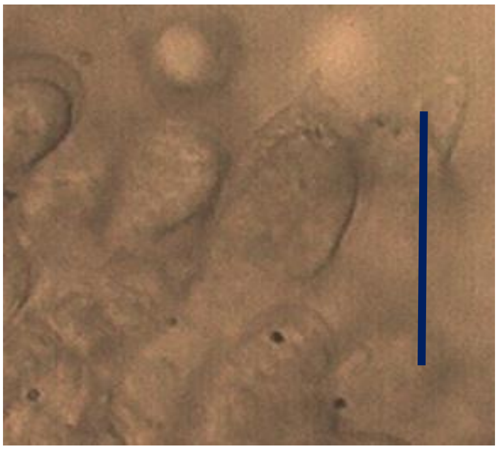


Plate 55.C

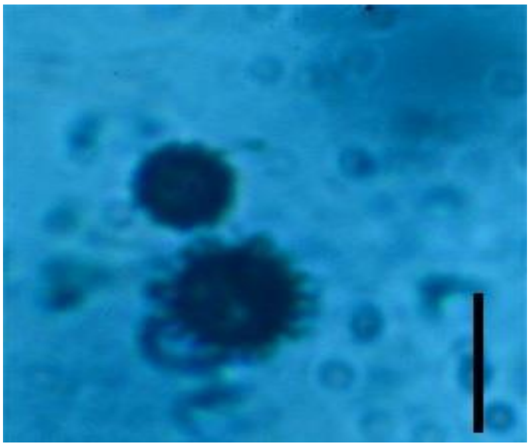


Plate 55.D

Plate 55.A. Field photo of *Scleroderma citrinum*
Plate 55.B. Laboratory photo of *Scleroderma citrinum* (scale bar = 2 cm)
Plate 55.C. Basidia of *Scleroderma citrinum* (scale bar = 20 µm)
Plate 55.D. Spores of *Scleroderma citrinum* (scale bar = 10 µm)

Plate 56.A

Plate 56.B

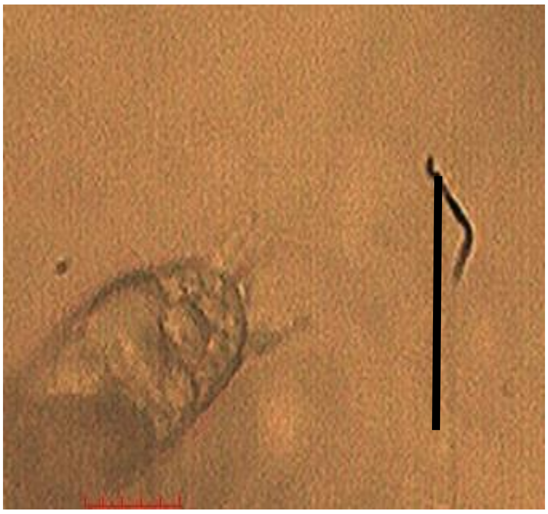


Plate 56.C

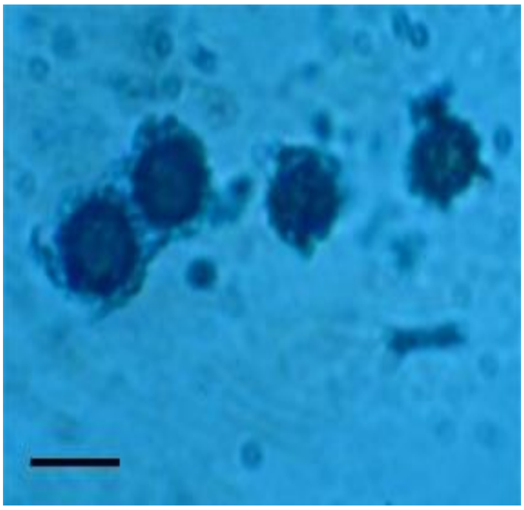


Plate 56.D

Plate 56.A. Field photo of *Scleroderma verrucosum*
Plate 56.B. Laboratory photo of *Scleroderma verrucosum* (scale bar = 2 cm)
Plate 56.C. Basidia of *Scleroderma verrucosum* (scale bar = 20 µm)
Plate 56.D. Spores of *Scleroderma verrucosum* (scale bar = 10 µm)

Plate 57.A

Plate 57.B

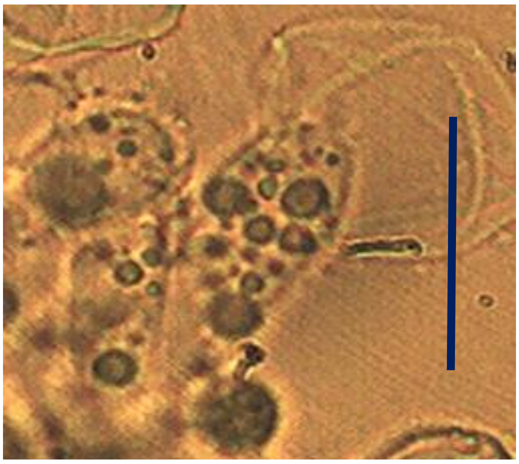


Plate 57.C

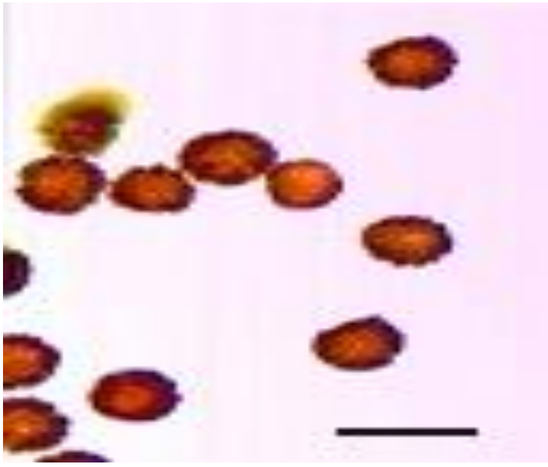


Plate 57.D

Plate 57.A. Field photo of *Strobilomyces verruculosus*
Plate 57.B. Laboratory photo *Strobilomyces verruculosus* (scale bar = 2 cm)
Plate 57.C. Basidia of *Strobilomyces verruculosus* (scale bar = 30 µm)
Plate 57.D. Spores of *Strobilomyces verruculosus* (scale bar = 20 µm)

Plate 58.A

Plate 58.B

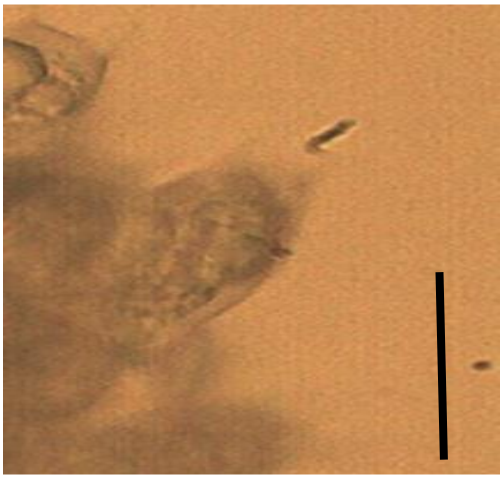


Plate 58.C

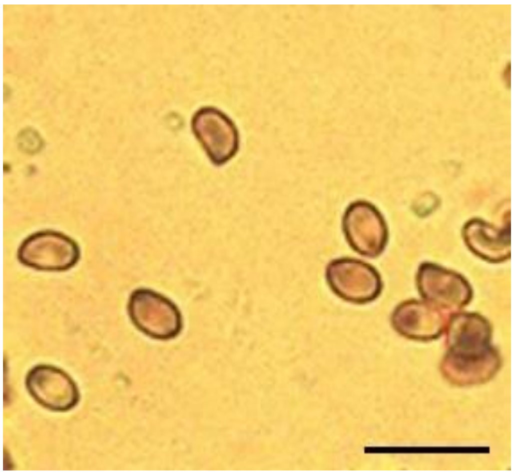


Plate 58.D

Plate 58.A. Field photo of *Termitomyces clypeatus*
Plate 58.B. Laboratory photo of *Termitomyces clypeatus* (scale bar = 1 cm)
Plate 58.C. Basidia of *Termitomyces clypeatus* (scale bar = 30 µm)
Plate 58.D. Spores of *Termitomyces clypeatus* (scale bar = 20 µm)


Plate 59.A


Plate 59.B


Plate 59.C

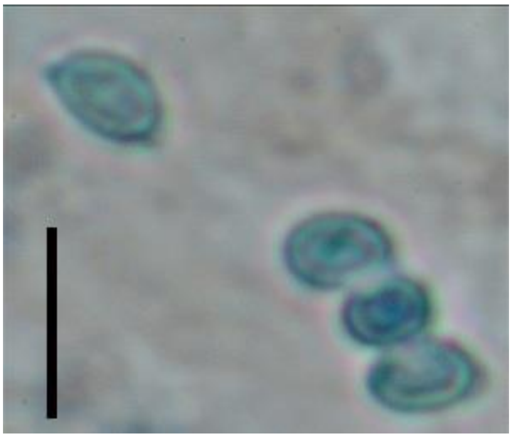


Plate 59.D

Plate 59.A. Field photo of *Termitomyces robustus*
Plate 59.B. Laboratory photo of *Termitomyces robustus* (scale bar = 4 cm)
Plate 59.C. Basidia of *Termitomyces robustus* (scale bar = 10 µm)
Plate 59.D. Spores of *Termitomyces robustus* (scale bar = 15 µm)

Plate 61.A

Plate 61.B

Plate 61.C

Plate 60.A. Field photo of *Thelephora ganbajun*
Plate 60.B. Laboratory photo of *Thelephora ganbajun* (scale bar = 2 cm)
Plate 60.C. Spores of *Thelephora ganbajun* (scale bar = 20 µm)

Plate 61.A

Plate 61.B

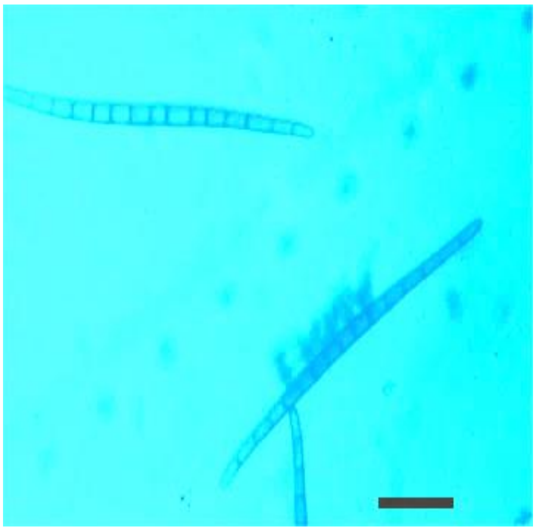


Plate 61.C

Plate 61.A. Field photo of *Trichoglossum hirsutum*
Plate 61.B. Laboratory photo *Trichoglossum hirsutum* (scale bar = 1 cm)
Plate 61.C. Asci of *Trichoglossum hirsutum* (scale bar = 5 µm)

Plate 62.A

Plate 62.B

Plate 62.A. Laboratory photo *Volvariella taylorii* (scale bar = 1 cm)
Plate 62.B. Spores of *Volvariella taylorii* (scale bar = 30 µm)

Plate 63

Plate 64

Plate 63. Spore print of specimen
Plate 64. Field work photo

Appendix I. Monthly Diversity indices of mushrooms during the study period 2014-2016

Site	**Indices**	**2014**							**2015**							**2016**							
		May	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Avg**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Avg**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Avg**	**Avg. value 2014-2016**
1	H_S	2.51 (±0.17)	2.68 (±0.18)	3.18 (±0.18)	3.09 (±0.1)	2.88 (±0.14)	1.28 (±0.22)	**2.6 (±0.17)**	2.78 (±0.17)	3.16 (±0.6)	3.38 (±0.27)	3.27 (±0.09)	2.27 (±0.12)	1.93 (±0.14)	**2.8 (±0.14)**	2.47 (±0.03)	3.3 (±0.13)	3.44 (±0.02)	3.13 (±0.27)	3.28 (±0.21)	3.1 (±0.06)	**3.12 (±0.2)**	2.84
	D_S	0.92 (±0.17)	0.94 (±0.18)	0.96 (±0.18)	0.96 (±0.1)	0.54 (±0.14)	0.95 (±0.22)	**0.88 (±0.17)**	0.94 (±0.17)	0.96 (±0.06)	0.97 (±0.27)	0.96 (±0.09)	0.97 (±0.12)	0.95 (±0.14)	**0.96 (±0.14)**	0.94 (±0.03)	0.96 (±0.13)	0.97 (±0.02)	0.96 (±0.27)	0.97 (±0.21)	0.95 (±0.06)	**0.96 (±0.2)**	0.96
	J'	0.53 (±0.17)	0.52 (±0.18)	0.6 (±0.18)	0.58 (±0.1)	0.57 (±0.14)	0.28 (±0.22)	**0.51 (±0.17)**	0.57 (±0.17)	0.6 (±0.6	0.61 (±0.27)	0.6 (±0.09)	0.44 (±0.12)	0.41 (±0.14)	**0.54 (±0.14)**	0.5 (±0.03)	0.63 (±0.13)	0.61 (±0.02)	0.57 (±0.27)	0.63 (±0.21)	0.62 (±0.06)	**0.59 (±0.2)**	0.55
	D_{Mg}	2.55 (±0.17)	3.3 (±0.18)	4.73 (±0.18)	4.13 (±0.1)	4.36 (±0.14)	3.89 (±0.22)	**3.83 (±0.17)**	3.3 (±0.17)	4.77 (±0.6)	5.61 (±0.27)	4.95 (±0.09)	5.22 (±0.12)	4.03 (±0.14)	**4.65 (±0.14)**	3.47 (±0.03)	5.5 (±0.13)	5.16 (±0.02)	5.07 (±0.27)	2.86 (±0.21)	4.64 (±0.06)	**4.45 (±0.2)**	4.32
2	H_S	3.01 (±0.15)	3.2 (±0.13)	3.39 (±0.22)	3.28 (±0.17)	3.04 (±0.07)	2.84 (±0.17)	**3.13 (±0.15)**	3.1 (±0.12)	3.45 (±0.18)	3.47 (±0.21)	3.48 (±0.2)	3.22 (±0.1)	2.94 (±0.08)	**3.27 (±0.15)**	3.32 (±0.23)	3.62 (±0.25)	3.59 (±0.22)	3.37 (±0.23)	3.29 (±0.26)	2.93 (±0.1)	**3.35 (±0.22)**	3.22
	D_S	0.95 (±0.15)	0.96 (±0.13)	0.97 (±0.22)	0.96 (±0.17)	0.96 (±0.07)	0.95 (±0.17)	**0.96 (±0.15)**	0.95 (±0.12)	0.97 (±0.18)	0.97(±0.21)	0.97 (±0.2)	0.96 (±0.1)	0.95 (±0.08)	**0.96 (±0.15)**	0.96 (±0.23)	0.97 (±0.25)	0.97(±0.22)	0.97 (±0.23)	0.96 (±0.26)	0.95 (±0.1)	**0.96 (±0.22)**	0.93
	J'	0.55 (±0.15)	0.57 (±0.13)	0.6 (±0.22)	0.61 (±0.17)	0.6 (±0.07)	0.55 (±0.17)	**0.58 (±0.15)**	0.57 (±0.12)	0.61 (±0.18)	0.63 (±0.21)	0.64 (±0.2)	0.6 (±0.1)	0.55 (±0.08)	**0.6 (±0.15)**	0.58 (±0.23)	0.62 (±0.25)	0.64 (±0.22)	0.62 (±0.23)	0.61 (±0.26)	0.54 (±0.1)	**0.6 (±0.22)**	0.59
	D_{Mg}	3.99 (±0.15)	4.97 (±0.13)	5.85 (±0.22)	5.06 (±0.17)	4.11 (±0.07)	3.3 (±0.17)	**4.55 (±0.15)**	5.22 (±0.12)	7.21 (±0.18)	6.91 (±0.21)	5.71 (±0.2)	5.38 (±0.1)	3.52 (±0.08)	**5.66 (±0.15)**	2.55 (±0.23)	3.3 (±0.25)	4.73 (±0.22)	4.13 (±0.23)	4.36 (±0.26)	3.89 (±0.1)	**3.83 (±0.22)**	4.68

Appendix III: Paper published in peer reviewed journal

1. Lalrinawmi, H., Josiah M.C. Vabeikhokhei, John Zothanzama, Zohmangaiha (2017). Edible mushrooms of Mizoram. *Sci Vis* 17 (3), 172—181.

2. Lalrinawmi, H., John Zothanzama, Benjamin Held, Josiah M.C. Vabeikhokhei, Zohmangaiha & Robert A. Blanchete (2018). The gilled mushroom *Amanita spissacea* (Amanitaceae): a new report for India. *Journal of Threatened Taxa* 10(10): 12413–12417.

Appendix IV: List of paper published in conference/ symposium

1. Lalrinawmi, H. and Zothanzama, J. (2016). A report on soil macro fungi in some selected sites of Mizoram. In: *Current Trends of Biodiversity Research in Mizoram.* H. Lalramnghinglova, Vanramliana and H. Lalthanzara (Editions). (2016). Scientific Book Centre, Guwahati, pp. 132–141.

2. Lalrinawmi, H. and Zothanzama, J. (2016). Wild Mushrooms of Hmuifang Forest, Mizoram. Science and Technology for shaping the future of Mizoram: *Proceedings of the Mizoram Science Congress*, 2016. Allied Publishers Private Limited, New Delhi, pp. 331–337.

Appendix V: List of presentation in conference/symposium/seminar

1. "*Wild edible mushrooms from Jhumlands in the vicinity of Aizawl*". in 'International Symposium on Integrated Land Use Management in Eastern Himalaya held on 17th -22nd March 2014 at Mizoram University, Aizawl, Mizoram.

2. "*Inventorying the Soil Mushrooms of Mizoram*". in 'National Seminar on Issues of Wildlife Conservation in India with special reference to Mizoram' held on 24th -25th April 2014 at Mizoram University, Aizawl, Mizoram.

3. "*A report on soil macro fungi in some selected sites of Mizoram*" in Two Day Workshop on Current Trends of Biodiversity Research in Mizoram held on 20th to 21st March 2015 at Pachhunga University College, Aizawl, Mizoram.

4. "*Survey of wild soil mushrooms in Hmuifang forest, Mizoram"* in Mizoram Science Congress held on 13th -14th October 2016 at Mizoram University, Aizawl, Mizoram.

Apppendix VI: List of seminar/symposium/conference/workshops attended

1. International Symposium on Integrated Land Use Management in Eastern Himalaya held on 17th -22nd March 2014 at Mizoram University, Aizawl, Mizoram.

2. *National Seminar on Issues of Wildlife Conservation in India with special reference to Mizoram* held on 24th -25th April 2014 at Mizoram University, Aizawl, Mizoram.

3. *Two Days Workshop on Current Trends of Biodiversity Research in Mizoram* organized by Department of Environmental Science, Mizoram University and Department of Zoology, Pachhunga University College, sponsored by CSIR, New Delhi held on 20th -21st March 2015 at Pachhunga University College, Aizawl, Mizoram.

4. *Northeast India Biodiversity Portal* organized by Ashoka Trust for Research in Ecology and the Environment (ATREE) in collaboration with Mizo Academy of Sciences on 7th May 2016 at Pachhunga University College, Aizawl, Mizoram. 5. *Mizoram Science Congress 2016* organized by MISTIC, MSS, MAS, STAM, MMS, GSM & BIOCONE, sponsored by NEC, DST (SERB) and MISTIC held on 13th-14th October 2016 at Mizoram University, Aizawl, Mizoram.

6. *One Day Workshop on Environmental Impact Assessment* organized by State Environmental Impact Assessment Authority and State Environmental Expert Appraisal Committee, Aizawl, Mizoram, held on 11th November, 2016 at Aijal Club, Aizawl, Mizoram.

Appendix II: Monthly physico-chemical properties of soil from the two sites during the period of study 2014-2016

Site	Parameters	2014												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg**
1	**SMC (%)**	21.50 (±0.96)	21.95 (±0.67)	28.3 (±0.85)	25.2 (±0.70)	39.86 (±0.50)	52.67 (±0.94)	35.07 (±0.62)	23.38 (±0.59)	39.37 (±0.75)	29.5 (±0.43)	33.9 (±0.60)	27.5 (±0.43)	**31.48 (±0.67)**
	WHC (%)	85.01 (±0.72)	76.7 (±0.79)	62.04 (±0.70)	74.91 (±0.45)	77.03 (±0.60)	75.12 (±0.45)	71.11 (±0.44)	68.30 (±0.43)	82.78 (±0.75)	88.56 (±0.54)	80.60 (±0.61)	90.50 (±0.57)	**77.72 (±0.59)**
	pH	5.06 (±0.15)	5.15 (±0.13)	6.12 (±0.18)	5.52 (±0.19)	4.88 (±0.12)	5.54 (±0.18)	4.86 (±0.13)	5.07 (±0.14)	5.52 (±0.1)	5.38 (±0.2)	5.52 (±0.17)	5.21 (±0.14)	**5.32 (±0.15)**
	OC (%)	1.45 (±0.14)	1.22 (±0.10)	1.8 (±0.15)	2.45 (±0.13)	3.74 (±0.14)	3.26 (±0.13)	3.46 (±0.17)	3.40 (±0.18)	2.55 (±0.09)	2.70 (±0.17)	1.70 (±0.07)	1.20 (±0.12)	**2.41 (±0.13)**
	N (%)	0.20 (±0.17)	0.19 (±0.15)	0.3 (±0.13)	0.56 (±0.18)	0.79 (±0.21)	0.79 (±0.21)	0.74 (±0.20)	0.78 (±0.22)	0.55 (±0.17)	0.35 (±0.12)	0.20 (±0.11)	0.21 (±0.12)	**0.47 (±0.17)**
2	**SMC (%)**	24.90 (±0.99)	20.75 (±0.74)	16.90 (±0.77)	22.50 (±0.60)	36.24 (±0.86)	35.59 (±0.98)	25.72 (±0.33)	23.67 (±0.69)	30.45 (±0.48)	28.68 (±0.70)	30.40 (±0.47)	24.90 (±0.50)	**26.72 (±0.66)**
	WHC (%)	72.67 (±0.44)	69.10 (±0.82)	73.70 (±0.50)	69.70 (±0.72)	65.07 (±0.35)	72.10 (±0.57)	66.41 (±0.67)	57.50 (±0.50)	65.80 (±0.79)	59.87 (±0.81)	91.40 (±0.64)	80.60 (±0.76)	**70.33 (±0.63)**
	pH	5.21 (±0.14)	5.03 (±0.15)	5.01 (±0.28)	5.09 (±0.09)	4.95 (±0.14)	5.22 (±0.25)	4.81 (±0.20)	4.85 (±0.24)	5.19 (±0.08)	4.79 (±0.12)	5.60 (±0.16)	5.64 (±0.09)	**5.11 (±0.16)**
	OC (%)	1.35 (±0.18)	2.98 (±0.14)	3.12 (±0.06)	3.14 (±0.16)	3.65 (±0.13)	3.26 (±0.15)	2.18 (±0.14)	1.81 (±0.09)	1.52 (±0.12)	1.74 (±0.07)	1.70 (±0.11)	1.30 (±0.13)	**2.31 (±0.12)**
	N (%)	0.25 (±0.17)	0.2 (±0.15)	0.25 (±0.17)	0.3 (±0.15)	0.42 (±0.19)	0.72 (±0.22)	0.75 (±0.23)	0.65 (±0.20)	0.5 (±0.19)	0.45 (±0.16)	0.29 (±0.14)	0.26 (±0.18)	**0.42 (±0.18)**

Appendix II (Cont.): Monthly physico-chemical properties of soil from the two sites during the period of study 2014-2016

Site	Parameters	2015												
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg**
1	**SMC (%)**	25.27 (±0.81)	22.68 (±0.67)	27.45 (±0.72)	30.05 (±0.43)	35.1 (±0.19)	44.5 (±0.70)	35.43 (±0.68)	33.3 (±0.86)	32.5 (±0.75)	54 (±0.69)	21.85 (±0.70)	27.9 (±0.70)	**5.34 (±0.14)**
	WHC (%)	79.34 (±0.37)	78.54 (±0.45)	82.12 (±0.50)	75.67 (±0.55)	73.21 (±0.35)	75.20 (±0.45)	73.69 (±0.45)	74.20 (±0.40)	83.50 (±0.71)	79.30 (±0.35)	77.79 (±0.63)	80.78 (±0.58)	**32.5 (±0.66)**
	pH	5.16 (±0.16)	5.32 (±0.18)	5.27 (±0.13)	5.74 (±0.18)	4.88 (±0.12)	5.54 (±0.18)	5.87 (±0.13)	5.32 (±0.11)	4.67 (±0.14)	6.2 (±0.13)	5.06 (±0.09)	5.1 (±0.18)	**77.78 (±0.48)**
	OC (%)	1.24 (±0.09)	1.18 (±0.09)	2.01 (±0.17)	2.54 (±0.16)	2.58 (±0.16)	2.64 (±0.15)	2.86 (±0.13)	2.90 (±0.10)	2.80 (±0.16)	2.70 (±0.14)	1.88 (±0.12)	1.45 (±0.18)	**2.23 (±0.14)**
	N (%)	0.20 (±0.12)	0.22 (±0.15)	0.23 (±0.14)	0.37 (±0.25)	0.52 (±0.35)	0.78 (±0.45)	0.75 (±0.43)	0.82 (±0.49)	0.42 (±0.35)	0.31 (±0.27)	0.21 (±0.21)	0.30 (±0.26)	**0.43 (±0.28)**
2	**SMC (%)**	23.32 (±0.53)	23.12 (±0.49)	25.08 (±0.94)	26.22 (±0.46)	26.20 (±0.64)	26.25 (±0.49)	29.21 (±0.86)	27.10 (±0.83)	34.80 (±0.95)	32.42 (±0.69)	26.11 (±0.51)	23.78 (±0.57)	**5.19 (±0.14)**
	WHC (%)	80.22 (±0.75)	83.45 (±0.40)	77.1 (±0.43)	69.44 (±0.62)	65.34 (±0.58)	72.14 (±0.23)	72.35 (±0.61)	65.10 (±0.44)	65.30 (±0.42)	88.40 (±0.23)	82.78 (±0.35)	81.40 (±0.66)	**26.97 (±0.66)**
	pH	5.53 (±0.14)	5.67 (±0.16)	5.44 (±0.13)	4.21 (±0.07)	4.95 (±0.11)	5.22 (±0.17)	4.93 (±0.13)	4.77 (±0.18)	5.34 (±0.13)	5.60 (±0.16)	5.18 (±0.09)	5.45 (±0.16)	**75.25 (±0.48)**
	OC (%)	1.62 (±0.15)	1.57 (±0.12)	2.66 (±0.10)	2.76 (±0.22)	2.95 (±0.12)	3.45 (±0.21)	3.06 (±0.15)	2.65 (±0.11)	1.38 (±0.15)	1.80 (±0.16)	1.66 (±0.15)	1.60 (±0.21)	**2.26 (±0.15)**
	N (%)	0.16 (±0.12)	0.19 (±0.14)	0.42 (±0.19)	0.37 (±0.18)	0.51 (±0.22)	0.67 (±0.24)	0.79 (±0.26)	0.64 (±0.23)	0.52 (±0.25)	0.22 (±0.19)	0.3 (±0.20)	0.21 (±0.18)	**0.42 (±0.20)**

Appendix II (Cont.): Monthly physico-chemical properties of soil from the two sites during the period of study 2014-2016

Site	Parameters	2016													
		Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Avg**	Avg 2014-2016
1	**SMC (%)**	5.01 (±0.13)	5.22 (±0.16)	5.67 (±0.17)	5.55 (±0.14)	4.95 (±0.12)	5.86 (±0.12)	5.98 (±0.09)	5.42 (±0.06)	4.88 (±0.06)	5.96 (±0.08)	5.5 (±0.11)	5.52 (±0.16)	**5.46 (±0.12)**	5.37 (±0.14)
	WHC (%)	25.55 (±0.29)	27.01 (±0.78)	22.45 (±0.93)	26.22 (±0.66)	35.06 (±0.72)	50.12 (±0.80)	33.5 (±0.81)	30.4 (±0.71)	37.44 (±0.70)	42.34 (±0.77)	32.01 (±0.87)	29.77 (±0.76)	**32.66 (±0.73)**	32.22 (±0.69)
	pH	88.01 (±0.68)	83.12 (±0.97)	79.32 (±0.38)	79.03 (±0.26)	75.56 (±0.53)	76.12 (±0.45)	73.12 (±0.35)	72.54 (±0.41)	75.30 (±0.45)	84.11 (±0.88)	84.55 (±0.52)	89.11 (±0.25)	**79.99 (±0.51)**	78.50 (±0.53)
	OC (%)	1.66 (±0.29)	1.66 (±0.33)	1.98 (±0.23)	2.55 (±0.48)	3.26 (±0.26)	2.82 (±0.47)	2.96 (±0.33)	3.02 (±0.24)	2.62 (±0.34)	2.73 (±0.36)	1.98 (±0.34)	1.67 (±0.48)	**2.41 (±0.35)**	2.35 (±0.21)
	N (%)	0.21 (±0.17)	0.19 (±0.15)	0.27 (±0.19)	0.55 (±0.28)	0.71 (±0.38)	0.70 (±0.37)	0.75 (±0.39)	0.79 (±0.40)	0.3 (±0.29)	0.23 (±0.21)	0.25 (±0.25)	0.18 (±0.16)	**0.43 (±0.27)**	0.45 (±0.24)
2	**SMC (%)**	5.43 (±0.12)	5.32 (±0.17)	5.25 (±0.24)	4.89 (±0.09)	4.82 (±0.16)	5.32 (±0.07)	4.95 (±0.11)	4.85 (±0.06)	5.52 (±0.06)	5.62 (±0.14)	5.40 (±0.10)	5.41 (±0.13)	**5.23 (±0.12)**	5.18 (±0.14)
	WHC (%)	25.78 (±0.37)	26.01 (±0.82)	25.67 (±0.85)	34.02 (±0.71)	34.59 (±0.86)	32.72 (±0.57)	23.65 (±0.49)	25.56 (±0.35)	33.24 (±0.65)	30.04 (±0.38)	31.22 (±0.54)	24.03 (±0.82)	**28.88 (±0.62)**	27.52 (±0.65)
	pH	84.12 (±0.52)	77.83 (±0.67)	75.32 (±0.47)	69.65 (±0.26)	65.45 (±0.53)	73.46 (±0.45)	71.86 (±0.35)	67.25 (±0.41)	66.36 (±0.45)	86.14 (±0.88)	86.44 (±0.52)	87.04 (±0.25)	**75.91 (±0.45)**	73.83 (±0.53)
	OC (%)	1.50 (±0.13)	1.31 (±0.11)	1.35 (±0.17)	1.66 (±0.21)	2.84 (±0.14)	3.97 (±0.13)	3.75 (±0.21)	3.25 (±0.19)	2.52 (±0.09)	1.94 (±0.15)	1.75 (±0.08)	1.72 (±0.15)	**2.30 (±0.15)**	2.30 (±0.14)
	N (%)	0.31 (±0.20)	0.27 (±0.18)	0.31 (±0.20)	0.44 (±0.28)	0.46 (±0.29)	0.69 (±0.31)	0.77 (±0.36)	0.69 (±0.31)	0.43 (±0.27)	0.33 (±0.22)	0.41 (±0.26)	0.3 (±0.22)	**0.45 (±0.26)**	0.43 (±0.21)

ABSTRACT

The present study was carried out from two different forests in Aizawl District i.e., Hmuifang (Site-1) and Mizoram University Campus (Site-2). Hmuifang is situated in the southern part of Aizawl with an elevation of 1619 meters above sea level. The area lies between the coordinates 92°45'19"E - 92°45'24"E longitudes and 23°27'22"N - 23°27'31"N latitudes. Mizoram University is in the Western part of Aizawl with an elevation range from 330m to 880m above mean sea level (msl). The area lies between the coordinates 23^{o}45’25” N - 23^{o}43’37” N latitudes and 92^{o}38’39” E - 92^{o}40’23’E longitudes.

Mushrooms as a whole are considered as the indicators of the forest life support system. To date, there is no systematic reports of soil mushrooms in Mizoram. Therefore, considering the lack of systematic studies on soil mushrooms, the present study was undertaken with the aim to generate a baseline data on taxonomy and diversity of the soil mushrooms in Mizoram. The present study entitled “Study on soil mushroom in Aizawl District of Mizoram, India” with the following objectives.

1. Taxonomical study of the specimens.
2. To study diversity of soil mushroom from two forests sites.
3. To determine the physico-chemical characteristics of the soil.

Collection of soil mushrooms was carried out during January 2014 to December 2016. The best collecting season is rainy season. A survey of fungal fruiting bodies was carried out in the selected sites and the fruiting body of mushrooms were photographed in their natural habitat before collection is done. All-important morphological characters were noted down in a notebook. Color and size were taken from the fresh specimens and the morphology of the fructification was studied with a hand lens.

For taxonomical study, mushrooms were photographed in their natural habitat before collection is done. All-important morphological characters were noted down

in a notebook. Color and size were taken from the fresh specimens and the morphology of the fructification was studied with a hand lens. Collected specimens were identified according to standard macroscopic and microscopic characteristics through consultation with appropriate literatures (Bas, 1969; Singer, 1986; Arora, 1986; Surcek, 1988; Ainsworth and Bisby, 2000; Mohanan, 2013). Spore print of the collected specimens were taken then, the color of the spore print was noted (Surcek, 1988). For microscopic study, thin sections of dried specimens were taken with the help of a sharp razor blade and were mounted in 3% KOH solution and stained in 2% aqueous phloxine. Sections are also mounted in Lactophenol or 60% lactic acid + cotton blue. Nomenclature, taxonomic position and author names follow the databases: Index Fungorum- IFS (http://www.indexfungorum.org), the International Plant Names Index – IPNI (http://www.ipni.org) and MycoBank (http://www.mycobank.com). Specimens collected were air dried in sunlight or with a blower and packed in polythene bags for herbarium specimens. They are also preserved in FAA solution and kept in specimen bottles or containers. They were then labeled with appropriate voucher numbers. During the period altogether 62 specimens could be identified according to standard macroscopic and microscopic characteristics from the collection sites.

For the diversity study, mushrooms were sampled monthly from May to October from the two sites during 2014-2016. Sampling of the mushrooms were not showing any results during the dry season (November to April) and hence were not represented throughout the study. Sampling were taken from five plots of 20m X 20m square plots. In case of small macro fungi occurring in groups/clusters, a frame of 20cm X 20cm was put on top of the fruit body clusters and those fruit bodies inside the frame was treated as a single individual of the species (Mani and Kumaresan, 2009).

The following indices were then calculated:

Cumulative species richness

Cumulative species number was calculated following the method of Zothanzama (2011). The species accumulated at each sampling was noted and the cumulative species richness of mushrooms in both the sites were calculated from the collecting seasons May to October for three year of the study periods 2014-2016. The species accumulation graph was then plotted as number of species accumulated within each sampling time.

Index of species diversity of the mushrooms were calculated using the Shannon's diversity Index (H_s), Simpson Index of Dominance (D_S), Margalef's Diversity Index (D_{Mg}) and Pielou's Evenness Index (J') as suggested by Pielou,1975, Simpson (1949), Clifford and Stephenson (1975) and Pielou, 1966 respectively.

Shannon's diversity Index (H_s): $H_s = -\sum piLnpi$

Where p_i = the proportion of individuals found in the i^{th} species or $pi = \frac{ni}{N}$

Where, n_i =the abundance of the individual in the i^{th} species; N = the abundance of all the species.

Simpson Index of Dominance (D_S): $Ds = \sum[\frac{[\{ni(ni-1)\}]}{[\{N(N-1)\}]}]$

Where, ni = No. of individuals of the i^{th} species; N= total no. of individual

As the Simpson's index values increases, diversity decreases. Simpson index is therefore usually expressed as "1- D" or "1/D".

Margalef's Diversity Index (D_{Mg}): $\mathbf{DMg} = \frac{(S-1)}{LnN}$

Where, S = number of species recorded; N = total number of individuals; Ln = Natural Logarithm

Pielou's Evenness Index (J'): $J' = \frac{H}{LnS}$

Where, H = Shannon–Wiener's diversity index; S = total number of species in the sample; Ln = Natural Logarithm

A total of 62 mushroom species belonging to 18 families with 34 genera were identified from both the sites during the collecting period of May to October 2014 to 2016. 35 species were recorded from Site-1 (Hmuifang) and 48 species were recorded from the Site-2 (Mizoram University Campus). From the collected specimens, *Amanita spissacea* was recorded for the first time in India. It was observed that the species continue to increase with each year as shown in the species accumulation curve.

Species diversity-

The diversity indices were calculated from the collections made during the mushroom growing season i.e., May to October for each of the years 2014-2016. Species diversity of soil mushrooms was found to be higher in Mizoram University Campus than in Hmuifang forest.

The annual average Shannon diversity index (H_s) in Site-1 were 2.6, 2.8 and 3.12 for the year 2014, 2015 and 2016 respectively and 3.13, 3.27 and 3.25 for the year 2014, 2015 and 2016 respectively in Site-2. The Shannon diversity index (H_s) in Site-2 shows higher value than Site-1.

The annual average Simpson index of Dominance (D_s) in Site-1 was 0.96 for the year 2014, 2015 and 2016 respectively, and 0.88, 0.96 and 0.96 for the year 2014, 2015 and 2016 respectively in Site-2. The Simpson index of Dominance (D_s) in Site-1 shows higher value than Site-2.

The annual average Pielou's Evenness index (J') in Site-1 were 0.51, 0.54 and 0.59 for the year 2014, 2015 and 2016 respectively, and 0.58, 0.6 and 0.6 for the year 2014, 2015 and 2016 respectively in Site-2. The Pielou's Evenness index (J') in Site-2 shows higher value than Site-1.

The annual average Margalef's Diversity Index of Species Richness (D_{Mg}) were 3.83, 4.65, 4.45 for the year 2014, 2015 and 2016 respectively in Site-1 and 4.55, 5.66 and 3.83 for the year 2014, 2015 and 2016 respectively in Site-2. The Margalef's Diversity Index of Species Richness (D_{Mg}) in Site-2 shows higher value than Site-1

The average Shannon diversity index (Hs), Simpson index of Dominance (D_s), Evenness index (J'), Margalef's Diversity Index of Species Richness (D_{Mg}) during the study period 2014-2016 were 2.84, 0.96, 0.55 and 4.32 respectively in Site-1. The average H_s, D_s, J' and D_{Mg} during the study period 2014-2016 were 3.22, 0.93, 0.59, 4.68 respectively from Site-2. The average mushroom diversity from Site-1 were lower than that of Site-2 for all the indices except for Simpson's index of dominance $D_{S.}$

All the diversity indices i.e., Shannon-Weiner's Diversity Index, Simpson Index of Dominance, Evenness Index and Margalef's Species Richness were found to be higher in Site-2 than Site-1. The greater species number in Site-2 may be due to higher plant diversity.

For soil physico-chemical characteristic study, pH of soil samples was measured by 1:2.5 (soil: water suspension) (Anderson and Ingram, 1993), Soil moisture was measured by Oven drying method (Anderson and Ingram, 1993), Soil organic carbon is estimated by Rapid dichromate oxidation method (Walkley and Black, 1934), total nitrogen estimation was done by Kjeldahl method following (Anderson and Ingram, 1993), using Kel plus nitrogen Auto-analyser (KES 04l, DISTYL-EM). The statistica analysis of soil physico-chemical characteristics were calculated using Microsoft Office Excel. The data were analysed statistically for correlation coefficient or significance level of soil characteristics and diversity of the soil mushrooms using the Statistical Package SPSS 16.0.

The annual average Soil Moisture Content in Site-1 were 29.85 %, 32.50 % and 32.66 % for the year 2014, 2015 and 2016 respectively and 26.72 %, 26.97 % and 28.88 % for the year 2014, 2015 and 2016 respectively in Site-2. The average

Soil Moisture Content of Site-1 shows higher value than Site-2 during study period of 2014-2016.

The annual average Water holding Capacity in Site-1 were 78.05 %, 77.78 % and 79.99 % for the year 2014, 2015 and 2016 respectively and 70.33 %, 75.25 % and 75.91 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Water holding Capacity in Site-1 shows higher value than Site-2 during study period of 2014-2016.

The annual average pH of soil in Site-1 were 5.32, 5.34 and 5.46 for the year 2014, 2015 and 2016 respectively and 5.11, 5.19 and 5.23 for the year 2014, 2015 and 2016 respectively in Site-2. The average pH of soil in Site-1 shows highest value shows higher value than Site-2 during study period of 2014-2016.

The annual average Organic Carbon in Site-1 were 2.41 %, 2.23 % and 2.41 % for the year 2014, 2015 and 2016 respectively and 2.31 %, 2.26 % and 2.3 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Organic Carbon in Site-1 shows higher value than Site-2 during study period of 2014-2016.

The annual average Total Nitrogen in Site-1 were 0.47 %, 0.43 % and 0.43 % for the year 2014, 2015 and 2016 respectively and 0.42 %, 0.42 % and 0.45 % for the year 2014, 2015 and 2016 respectively in Site-2. The average Total Nitrogen in Site-1 shows higher value than Site-2 during study period of 2014-2016.

Pearson correlation (r) indicated that there was positive correlation between total nitrogen of Site-2 with Shannon Wiener's Diversity Index of Site-2 and Margalef's Species Richness of Site-2 in 2014.

Pearson correlation co-efficient (r) analysis indicated that there was positive correlation between total nitrogen of Site-2 with Shannon Wiener's Diversity Index of Site-2 and Margalef's Species Richness of Site-2 in 2014.

Pearson correlation co-efficient (r) showed positive correlation between Organic Carbon of Site-2 with Margalef's Species Richness of Site-2 and Total Nitrogen of Site-2 with Margalef's Species Richness of Site-2 in 2015.

Pearson correlation co-efficient (r) also positive correlation between Total Nitrogen of Site-2 with Margalef's Species Richness of Site-2 in 2016.

This work highlighted the species composition, diversity and soil characteristics and its relation to soil mushrooms. It provides the first baseline data on soil mushroom composition, density and diversity and their correlation with soil physico-chemical parameters of the State, which is expected to be important for future references. However, a more detailed and specific study is required to explore and identify soil mushrooms as they are one of the indicators of forest health.

From the current findings and other works mentioned, it is observed that the diversity of the mushrooms is dramatically influenced by numerous environmental factors both biotic and abiotic, as well as complex interactions among them.

Keywords: mushroom, soil, diversity, taxonomy, forest.