BIODIVERSITY, DISTRIBUTION AND MORPHOLOGICAL CHARACTERIZATION OF MACROFUNGI IN SYLHET AND MOULVIBAZAR UNDER TROPICAL EVERGREEN AND SEMI-EVERGREEN FOREST REGIONS OF BANGLADESH

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DHAKA-1207

JUNE, 2016

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Registration No. 15-06961

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
In partial fulfillment of the requirements
For the degree of

MASTER OF SCIENCE
IN
PLANT PATHOLOGY
SEMESTER: JULY-DECEMBER, 2014

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CERTIFICATE

This is to certify that the thesis entitled,**"BIODIVERSITY, DISTRIBUTION AND MORPHOLOGICAL CHARACTERIZATION OF MACROFUNGI IN SYLHET AND MOULVIBAZAR UNDER TROPICAL EVERGREEN AND SEMI-EVERGREEN FOREST REGIONS OF BANGLADESH"** submitted to the Department of Plant Pathology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **PLANT PATHOLOGY,** embodies the result of a piece of bona fide research work carried out by **TANZIM AHMED** bearing **Registration No. 15-06961** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: 18.05.2017
Place: Dhaka, Bangladesh

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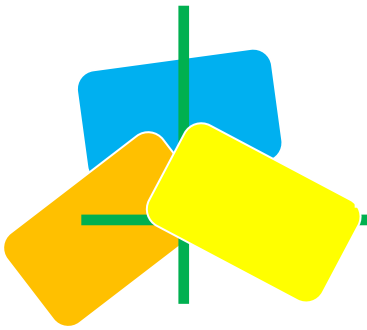

DEDICATED

TO MY FATHER

ACKNOWLEDGEMENT

At first the author expresses his gratefulness to Almighty Allah who has helped him in pursuit of his education in Agriculture and for giving the strength of successful completion of this research work.

The author is highly grateful and greatly obliged to his supervisor, ***Dr. F. M. Aminuzzaman****, Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his continuous encouragement, innovative suggestions and affectionate inspiration throughout the study period.*

With deepest emotion the author wish to express his heartfelt gratitude, indebtedness, regards sincere appreciation to his benevolent research Co-supervisor ***Dr. Md. Belal Hossain****, Associate Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for his intellectual guidance, intense supervision, affectionate feelings and continuous encouragement during the entire period of research work and for offering valuable suggestions for the improvement of the thesis writing and editing.*

Cordial thanks are extended to all respected teachers of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh and the entire staff member of the Department of Plant Pathology (SAU).

The author would like to thank all staffs and workers of Plant Pathology department and all farm labor of Sher-e-Bangla Agricultural University, Dhaka for their valuable and sincere help in carrying out the research work.

The author also expresses his especial thanks to his well-wishers and friends for their help and support during his work.

Finally the author expresses his heartfelt indebtedness to his beloved father and mother, brother and sisters for their sacrifice, encouragement and blessing to carry out higher study which can never be forgotten.

June, 2016 *The Author*

ABSTRACT

Tropical evergreen and semi-evergreen forest regions under Sylhet and Moulovibazar districts which is located at 24.8917°N and 91.8833°E, in the north eastern region of Bangladesh. A total of 53 macro fungal samples were collected and identified to 15 genera and 25 species. The predominant species were *Ganoderma tsugae, Ganoderma applanatum, Ganoderma bonninese, Agaricus bernardii, Coprinus disseminates, Daeleopsis confragosa, Schizophyllum commune, Pleurotus ostreatus, Pleurotus populinus, Mycena epiptergia, Steccherinum ochraceum* and *Steccherinum ciliolatum.*The maximum frequency (37.5%) was recorded for *Ganoderma tsugae* and *Pleurotus ostreatus.* The maximum density was 26.8% recorded for *Coprinus* sp.. The predominant families were Ganodermataceae, Agaricaceae, Polyporaceae, Schizophyllaceae, Pleurotaceae, Mycenaceae and Steccherinaceae. The specimens were deposited to the Sher-E-Bangla Agricultural University Herbarium of Macro Fungi (SHMF). This is the first details investigation macrofungi recorded from Sylhet and Moulovibazar regions of Bangladesh.

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CHAPTER I

INTRODUCTION

Macrofungi is a fleshy spore bearing fruiting body of a fungus. Macrofungi have been the objects of much curiosity and speculation since time immemorial. They are one of the most important components of the forest ecosystem. Metzler and Metzler (1992) reported that most macrofungi producing fungi are members of the phylum Basidiomycota, also known as basidiomycetes that have a stem (stipe) and cap (pileus), and gills (lamellae, singular–lamella) or pores on the underside of the cap. Their edibility, poisonous nature, psychotropic properties, mycorrhizal and parasitic associations with the forest trees make them economically important and interesting to study. The northeast region of India abounds in forest wealth, including many species of trees and other woody plants. The biodiversity of woody flora is correlated with an equally diverse mycoflora. The high humidity during monsoon period provides ideal atmospheric conditions for the growth of many saprophytes, including the macrofungi. They have diverse shapes, sizes and colors and also have varied appearance, ranging from patches on wood to brackets, coral-like tufts simple clubs rosettes cauliflower like structure or centrally or laterally stalked fruit bodies. Macrofungi can be categorized as edible or non-edible. Right from the beginning man has learnt to differentiate the edible and non-edible mushroom through numerous observation, trial sand errors. Through these experiences man has learned to use macrofungi as a part of their diet. Seasonal mushroom hunting and collection are the part of seasonal activity ofthe people. Barros *et al.* (2008) reported the wild macrofungi are richer sources of protein and have a lower amount of fat than commercial macrofungi. The proteins of wild edible mushroom contains considerable

amounts of non-essential amino acids like alanine, arginine, glycine, glutamic acid, aspartic acid, proline and serine (Manzi and Pizzoferrato, 2000).The add-value arising from macrofungi are bioactive materials which lead to an increase in its consumption and therefore, stimulating the commercialization of edible species. Macrofungi also have been used extensively in traditional medicine for curing variety of diseases including viral infection, bacterial infection, cancer, tumor, inflammation, cardio vascular diseases (Benedict and Brady, 1972; Iwalokum *et al.*, 2007). Many researchers have been working on wild mushroom and reported more than 2000 species of edible mushroom all over the world (Adhikari, 2000; Purakasthya & Chandra, 1985) have reported 283 edible species from India, out of which some are cultivated. Production of mushroom all over the world exceeds three million tones. Most of the exporting countries are Netherlands, Poland, Ireland, Belgium, India and China. Among these countries China is the largest exporter of preserved macrofungi. In India most commonly cultivated mushroom species are Button (*Agaricus bisporus*), Oyster (*Pleurotus* spp.) and Paddy straw mushroom (*Volvariella volvacea*) as documented by (Harsh and Joshi, 2008).In India, mushroom is a unique non-traditional cash crop and as popular as food among the tribal people of north east India. Many rural communities of Nagaland are using macrofungi in the traditional dishes because of their delicious flavor. The favorable climatic condition of north-eastern states of India leads to rich mushroom diversity and form a valuable non-timber forest resource for local folk.

Macrofungi are sold in traditional markets or commercially exploited as food or medicines. Some of the edible species like *Termitomyces eurrhizus, Lentinus conatus, Schizophyllum commune, Tricholoma giganteum* and *Pleurotus* are sold in the markets of Kohima district of Nagaland by the local people (Tanti *et al.,* 2011). In-spite of rich diversity of macrofungi in Nagaland state very few studies have been reported on diversity and market survey from North-Eastern Hills of India (Verma *et al.*,1993; Singh *et al.*,2007 and Sarma *et al.*,2010). Detailed study on biodiversity, distribution and morphological characterization of macrofungi in tropical moist deciduous forest, mangrove forest and social forest have been carried out (Rumainul *et al.*, 2015; Rumainul and Aminuzzaman, 2016; Das and Aminuzzaman, 2016; Das *et al.*, 2017; Aminuzzaman and Das, 2017). But no such kind of work had been carried out in tropical evergreen and semi-evergreen forest of Bangladesh.

The present study was conducted to generate a database on morphology and ecology of important wild edible macrofungi species of Sylhet tropical evergreen and semi-evergreen forest of Bangladesh with the following objectives.

1. To study the biodiversity, distribution and morphology of macrofungi in Sylhet and Moulovibazar tropical evergreen and semi-evergreen forest of Bangladesh.

2. To identify the macrofungi up to the genus and species level from Sylhet and Moulovibazar tropical evergreen and semi-evergreen forest of Bangladesh.

CHAPTER II
REVIEW OF LITERATURE

The forest of Bangladesh can be grouped in to four broad categories depending on their location, nature and type of management. They are mangrove forest, tropical moist deciduous forests, tropical evergreen and semi evergreen forests and village forests. Among them the mushroom biodiversity of tropical moist deciduous forest and mangrove forest have been described. The main purpose of this chapter is to review the previous studies, which are related to the present study. Therefore, an attempt has been made here to compile the research work carried out on the subject elsewhere.

Das and Aminuzzaman (2017) first time investigated the largest tidal halophytic forest in the world which lies a little south to the Tropic of Cancer between the latitudes 21°30'N and 22°30'N, and longitudes 89°00'E and 89°55'E. This forest is the greatest source of diverse xylotrophic fungi and the predominant families were recorded-Polyporaceae, Ganodermataceae, Hymenochaetaceae, Fomitopsidaceae, Xylariaceae, Steccherinaceae and Gloeophyllaceae. The maximum frequency (75%) was recorded for *Daedaleopsis confragosa* and 50% for *Trametes elegans*, *Trametes conchifer*, *Polyporus sanguineus*, *Ganoderma curtisis* and *Irpex lacteus.* The maximum density was 31.82% for *Polyporus sanguineus* which was found on the Sundari (*Heritiera fomes*) tree.

Rubina *et al.;*(2017) conducted a survey in National Botanical Garden, Dhaka located at 24°00 N (Latitude), 90°00′ E (Longitude) to document the morphology, diversity and distribution of macro fungi during the rainy seasons of July to October, 2015. A total of 23 macro fungi samples were collected and identified to 20 species under 10 genera and 10 families. The predominant genera were *Ganoderma* sp., *Lepiota* sp., *Daedeleopsis* sp., *Russula* sp., *Psythyrella* sp., *Lycoperdon* sp., *Crepidotus* sp., *Psilocybe* sp, *Flammulina* sp. and *Cantharellus* sp. The survey revealed that five species are edible, six species have medicinal value, three species are inedible and three are unknown. The maximum density of occurrence was exhibited by *Psilocybe cubensis* (45%) followed by *Lepiota* sp. (40%), *Ganoderma pfeifferi* (35%) and *Ganoderma lucidum* (25%).

Aminuzzaman and Das (2016) carried out a research in Bogra district under the Social forest region of Bangladesh to study the biodiversity, distribution and morphology of wild macro fungi during June to October, 2015. A total of 32 fungal samples were collected and identified to 16 species belong to two genera under 7 families. The polypore genera were *Ganoderma* sp. (87.5% of collected samples) and *Polyporus* sp. (12.5%). The maximum frequency of occurrence (75%) was exhibited by *Ganoderma lucidum, Ganoderma multipileum, Ganoderma boninense, Ganoderma* sp. and the maximum density was exhibited by *Ganoderma resinaceum* (66.67%).

Das *et al.*(2016) investigated the largest single block of tidal halophytic forest Mangrove (Sundarban) and collected 72 macro fungal samples identified to 21genera and 32 species. The dominant species were *Agaricus*

campestris, *Agaricus xanthodermus*, *Agaricus silvicola*,*Agaricus augustus*, *Agaricus arvensis*, *Agaricus bitorquis*, *Coprinus silvaticus*, *Coprinus plicatilis*, *Marasamius* sp.,*Marasamius siccus*, *Marasmius nigrodiscus*, *Marasmiellus albuscorticis*, *Volvariella hypopithys*, *Volvariella specios*, *Crepidotus alabamenis* and *Crepidotus applanatus*. The maximum frequency (75%) was recorded for *Agaricus silvicola*, *Lepiota* sp., *Marasmiellus albuscorticus* and *Volveriella speciosa.* The maximum density was 287.5% recorded for *Coprinus silvicatus.* The predominant families were Agaricaceae, Marasmiaceae, Pluteaceae, Crepidotaceae and Mycenaceae.

Sharareh *et.al.* (2016) reported that the wild macrofungi provide a significant source of nutritional and medicinal bioactive compounds. They have been collected and consumed by people from many countries for thousands of years. However, there is a shortage of information in the literature regarding Iranian wild macrofungi. Thus, this mini-review tries to outline recent efforts made in order to collect, identify, and maintain wild macrofungi of Iran. This review may also encourage more research on collection, assessment, and biochemical analysis of Iranian wild macrofungi in order to establish a germplasm bank of wild macrofungi for the future identification and further research.

Beuy and Viroj (2016) stated that Linzhi (*Ganoderma lucidum)* is a well-known medicinal mushroom. This mushroom originated from China becomes the widely used supplementation worldwide. The usefulness to kidney is mentioned in the literature. Linzhi (*Ganoderma lucidum*) is a well-known medicinal mushroom. This mushroom originated from China

becomes the widely used supplementation worldwide. The active ingredient in the mushroom is mentioned for anti-oxidative, glucose controlling and anti-cancerous proliferative activities. In nephrology, the advantage of Linzhi on kidney is also mentioned. However, the evidence in human beings is limited. In this short manuscript, the authors discuss on evidence of Linzhi's clinical usefulness in renal diseases.

Deepak *et al.* (2016) reported that macrofungi are well known for their nutritional as well as therapeutic values worldwide. They have been reported to be the most valuable ones for humans. Investigations on the therapeutic and nutritional properties of macrofungi are underway throughout the world. Researchers are providing crucial data on the array of bioactive compounds found within these fascinating fungi. People are now accepting macrofungi more as food and food supplements. Various academic and research institutes are all involved actively in research on bioactive metabolites of macrofungi.

Rahaman *et al.* (2016) conducted a survey from June to October, 2014 in 5 districts namely Kushtia, Chuadanga, Jessore, Satkhira and Khulna. A total of 16 mushroom species belong to 10 genera, under 8 families were recorded during the survey. *Lepiota cristata* was found abundantly in the survey areas among the other collected species and it exhibited the maximum frequency of occurrence (25%), whereas the maximum density (13.51%) was recorded for *Hypholoma fasciculeare* and *Coprinellus micaceus*, followed by *Lepiota cristata*, *Coprinus comatus* and *Mycena californiensis* (10.81%). Furthermore, the density of *Gymnopilus purpuratus*, *Coprinus sterquilinus*, *Marasmius oreades*, *Hypholoma capnoides* and *Coprinellus plagioporus*

were recorded as 8.10%. Moreover, *Lepiota cristata* was distributed in Daulatpur of Kushtia and Koira of Khulna districts in the south western region of Bangladesh.

Vieira *et al.* (2016) studied that the wild mushroom *Leucopaxillus candidus* (Bres.) to obtain information about its chemical composition, nutritional value and bioactivity. Free sugars, fatty acids, tocopherols, organic and phenolic acids were analysed by chromatographic techniques coupled to different detectors. *L. candidus* methanolic extract was tested regarding antioxidant potential (reducing power, radical scavenging activity and lipid peroxidation inhibition). *L. candidus* was shown to be an interesting species in terms of nutritional value, with high content in proteins and carbohydrates, but low fat levels, with the prevalence of polyunsaturated fatty acids. Mannitol was the most abundant free sugar and tocopherol was the main tocopherol isoform. Other compounds detected were oxalic and fumaric acids, phydroxybenzoic and cinnamic acids. The methanolic extract revealed antioxidant activity and did not show hepatoxicity in porcine liver primary cells.

Rumainul *et al.* (2015) reported that mushroom flora is an important component of the ecosystem and their biodiversity study has been largely neglected and not documented for the tropical moist deciduous forest regions of Bangladesh. They investigated macrofungi flora in seven different areas of tropical moist deciduous forest region of Bangladesh namely Dhaka, Gazipur, Bogra, Rajshahi, Pabna, Jaipurhat and Dinajpur. Mushroom flora associated with these forest regions were collected, photographed and preserved. The predominant genera were *Ganoderma* sp., *Lepiota* sp., *Marasmius* sp. and *Collybia* sp.

Krishna *et al*. (2015) collected the fruiting bodies of macrofungi from some forests, fences, waste fields, timber depots of Telangana state during rainy season. This is an attempt to give a broad picture of diversity of macrofungi belonging to the class Basidiomycetes in some forest areas of Telangana region. There were 50 fruiting bodies were collected and cultured and among them only ten were identified based on their macroscopic features and molecular identification since they showed good lignolytic activity.

Kinge and Mih (2015) studied the diversity and distribution of species of *Ganoderma* in south western Cameroon. Four species, *Ganoderma weberianum, Ganoderma cupreum, Ganoderma steyaertanum, Ganoderma zonatum* are new records for Cameroon. The remaining 11 species belong to *Ganoderma ryvardense, Ganoderma lobenense* and *Ganoderma* species 1-9 with different affinities might be new to science. Six plant species were identified as hosts to different species of *Ganoderma.* They are *Elaeis guineensis, Cassia* sp., *Acacia* sp., *Pinus sylvestris, Avocado* sp.and unidentified hardwood, with *E. guineensis*.

Manna *et al*. (2014) reported that among 18 macrofungi species related to tribal use, the most usable species were *Astraeus hygrometricus*, *Amanitavaginata* var.*alba*, *Amanita banningiana*, *Russula nigricans*, *Termitomyces eurrhizus* and *Termitomyces microcarpus.* Monsoon and post-monsoon periods which fall during the second half of August are found tobe the optimum time for the production of 11 wild edible macrofungi. Out of the total calculated production, 47.2%of the same was noted during this time. These regions with tribal populations, especially the Santals in the forest fringes, have traditional knowledge related to macrofungi.

Vyas *et al*. (2014) conducted an experiment on Patharia forest which is mixed and dry deciduous type, dominated by *Acacia* sp., *Butea monosperma, Tectona grandis* and ground flora consisting of *Biophytum sensitivum, Cynodon dactylon, Lanata camara* etc. During the period of July 2011-July 2013, wild macrofungi were collected from Patharia forest and 18 mushroom species belonging to 12 families were identified viz. *Vascellum pretense, Lycoperdon pyriform, Coniphora puteana, Clitocybe geotrapa, Ganoderma tsugae, Microglossum virde, Panaeolus sphinctrinus, Pleurotus cornucopiae, Fomes fomentarius,Tyromyces lacteus, Lenzites betulina, Hypholoma elongatum, Pholita highlandensis, Serpula lacrymans, Tremella mesenterica, Lepisa nuda, Collybia butyracea* and *Omphalina ericetorum*.

Chelela *et al.* (2014) conducted a survey to assess mycological knowledge and socio-economic benefits along the wild edible macrofungi value chain among Benna ethnic groups in the southern highlands of Tanzania. They collected wild edible macrofungi in the Miombo woodland surrounding six villages during rainy season in January 2014. From the survey, mushroom collection and selling was gender oriented dominated by women at 70 and 93.5%, respectively. Moreover, it was found that 30% of men were involved in collecting and only 6.5% in selling. About 45 species of wild edible macrofungi were collected mainly from *Lactarius, Russula, Cantharellus* and *Amanita* species.

Andrew *et al.* (2013) reported the diversity and distribution of macrofungi 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 of 2010 and 2011. A total of 177 macrofungal species belonging to 83 genera and 38 families were recorded. Species richness was

higher in the rainy seasons (134 species) than in the early dry seasons (89 species) and tended to decrease with altitude, with 116 and 112 species for low and high altitudes, respectively. Eighty-eight species were recorded only in the rainy seasons, 43 species in the early dry seasons only, and 46 species were common to both seasons. Sixty-five species were found only in the low altitude, 61 species only in the high altitude, and 51 species were common to both altitudes. *Auricularia auricular* was the most abundant species during the rainy seasons, while *Coltricia cinnamomea* was rare during the rainy seasons, and the most abundant during the dry seasons.

Pandey *et al.* (2013) conducted a study in Joypore Reserve Forest located in Assam, India to investigate the diversity of macro fungi associated with different tree species. Thirty macro fungal species representing 26 genera belonging to 17 families were collected from six different sites in the study area. Out of these maximum six genera assignable to family Polyporaceae, five genera to Russulaceae, three genera to Agaricaceae, two genera to Ganodermataceae and Cantharellaceae each and rest of the families were represented by single genus only. The study revealed that maximum frequency of occurrence was exhibited by *Trametes versicolor* and *Schizophyllum commune* (83.33%), followed by *Microporus xanthopus Pycnoporus sanguineus* (66.67%) and *Coprinus disseminates* (50%). The rest of the species exhibited the frequency distribution ranging between 16.67-33.33%. The maximum density was recorded for *Schizophyllum commune* (126.67%) followed by *Trametes versicolor* (120%) and *Xylaria polymorpha* (93.33%).

Farooq *et al.* (2013) performed an experiment on Soon Valley Sakasar located in District Khushab of the province Punjab, Pakistan coordinates 72°00'and 72°30' E longitudes 32°25' and 32°45' N latitudes with diversified ecosystem. The ethno- mycological study of soon valley has been strongly neglected in the past. So, the survey was conducted during 2010-11 in four villages i.e. Nowshedra, Dhaka, Sakhiabad and Knaty garden of the Soon Valley. A total of 25 mushroom species belonging to 9 families and 14 genera were identified from the study area. Among the collected mushroom species *Agaricus* was found as most dominant genus (36%) followed by *Innocybe* (12%).

Chandulal *et al.* (2013) collected and identified 17 species belonging to two different classes namely, Gastromycetes – *Daldinia concentrica* [(Xylariaceae) (cramp ball)], *Lycoperedon pyriforme* [(Lycoperdaceae, edible) (wood or stump puff ball)], *Scleroderma citrinum* (sclerodermataceae, edible); Hymenomycetes – *Cantharrellus umbonatus, Coriolusversicolor* (polyporaceae, inedible), *Schizophyllum commune* (Schizophyllaceae, inedible),*Ganoderma luncidum* (Ganodermataceae), *Ganoderma applanatun* (ganodermataceae), *Laetiporus sulphureus* (Polyporaceae, edible), *Lepiota organensis, Collybia butyracea,Lentineullus cochleatus* (Aurisclpinaceae, edible), *Galerina unicolor* (Hymenogatraceae), *Citocybe flaccid* (Trichomataceae, edible), *Oudemansiella redicata* (Physalacriaceae, edible), *Hygrophorus eburnes* (Hygrophoraceae, edible) and *Agaricus campestris* (Agaricaceae, edible). The investigation proves the existence of a distinct biodiversity of macrofungi.

Das *et al*. (2013) reported three species namely *Russula sharmae*, *R. dubdiana* and *R. sikkimensis* as new taxa in west district of Sikkion (India), located in the Eastern Himalaya. Macro- and micro morphological illustrated descriptions of these species are given along with their taxonomic positions and relations to allied species.

Farid *et al.* (2013) found forty four species of macrofungi belonging to twenty nine genera were collected from different localities in Erbil Governorate of Kurdistan region. The identified species were *Agaricus* sp., *Clitocybe* sp., *Collybia* sp., *Coprinus* sp., *Cortinarius* sp., *Craterellus* sp., *Crepidotus* sp., *Exidia* sp., *Fomes* sp., *Galerina* sp., *Hebeloma* sp., *Helvella* sp., *Auricularia auricula-judae, Hygrocybe pratensis, Inocybe* sp., *Lactarius* sp., *Laccaria sp., Mycena* sp., *Peziza* sp., *Pluteus* sp., *Psathyrella* sp., *Panellus* sp., *Paxillus atrotomentosus, Russula fellea, Scutellinia scutellata, Trichloma* sp., *Tyromyces* sp., *Lepiota* sp. and *Cystoderma* sp.

Hosen *et al.* (2013) described a new monotypic genus in the boletaceae, *Borofutus*, typified by *B. dhakanus*, using morphological and molecular evidence. This is a putatively ectomycorrhizal fungus associated with *Shorea reobusta*. *Borofutus* is sister to Spongi forma in molecular phylogenetic analysis using DNA nucleotide sequences of single or multiple loci. They presented a description, line drawings, phylogenetic placement and comparison with allied taxa of macrofungi.

Kumar *et al.* (2013) reported that, the macrofungal diversity and nutrient content of some edible macrofungi of Nagaland, India. They collected young and matured carpophores of 15 wild edible mushroom species from 12 locations in different districts of Nagaland. Out of the four species belongs

to family Agaricaceae, two belongs to Tricholomataceae and rest belongs to Boletaceae, Cantherallaceae, Russulaceae, Sarcoscyphaceae, Auriculariaceae, Polyporaceae, Schizophyllaceae, Pleurotaceae and Lyophyllaceae during the survey.

Shannon Berch (2013) investigated and identified the Truffles (true and false) are fruiting bodies of ectomycorrhizal fungi and some of them produce appealing aromas, are recreationally and commercially harvested, and even cultivated. Until recently, commercial truffles have all been Mediterranean in distribution but some of these species are now cultivated around the world and other native species are being collected and marketed. While cultivation of black truffles can be complicated by horticultural challenges, production of other species appears to be less problematic. The potential for the discovery and commercialization of novel native truffles is good, but only if trained dogs are used for exploration and harvesting can this potential be sustainably and ethically realized in worldwide.

Pushpa and Purushothama (2012) conducted a survey on the biodiversity of macrofungi belonging to the class Basidiomycetes in Bangalore. The survey were conducted from June 2007 to November 2010 in eight different places which included scrub jungles and urban places in a around Bangalore. A total number of 90 species in 48 genera belonging to 19 families in 05 orders were recorded, 28 species were found to be recorded for the first time in India. Among the collected species *Coprinus disseminates* followed by *Coprinus fibrillosis* and *Schizophyllum communae* was found to be abundant in their occurrence in selected locations.

Pithak and Pukahute (2012) conducted a survey on the diversity of macrofungi in dry dipterocarp forest at Phuphan National Park to study the variety of macrofungi grown in the Dry Dip- terocarp forest during the year 2008-2009 by releve method and to study the relationship between *Shoreasia mensis* Miq. And ectomycorrhizal of the Amanitaceae and the Belotaceae families. The findings of the study revealed the presence of a total 34 types of macrofungi in Dry Dipterocarp forest at the Phuphan where there were 26 types found in both years.

Dwivedi *et al.* (2012) studied on the taxonomy and diversity of macro fungi in semi evergreen and moist deciduous forest of Amarkantak where more than 50 samples were collected which is situated in Madhya Pradesh in India. Extensive surveys were conducted from July 2010 to September 2010, where collection, characterization, preservation and photo of macro fungal carried the genera like is *Agaricus, Amanita, Nyctalis, Russula, Boletus, Macrolapiota, Ganoderma and Termitomyces.* Out of 50 samples only 16 samples were identified up to species level. This preliminary study shows that the forest is very rich in diversity of macrofungi.

Bankole and Adekunle (2012) conducted an experiment on biodiversity of macrofungi in Lagos State, Nigeria as they collected in Lagos State for 12 months. The predominant macrofungi collected included *Agaricus campestris, Coprinus comatus, Daldinia concetrica*, *Ganoderma adspersum*, *Ganoderma applanatum, Ganoderma lucidum, Mycena haematopus, Mycena* sp., *Pleurotus ostreatus, Pleurotus tuber-regium, Polyporus* sp., *Polyporus squamosus, Polyporus sulphureus, Trametes versicolor, Xylaria polymorpha* and *Xylaria* sp. during investigation.

Smith and Thiers (2011) reported that fruit bodies of the genus *Tylopilus* are encountered as large stout bolete macrofungi, which generally arise from the ground or occasionally from the wood. They have stout stipes, which do not have a ring. A key field character which distinguishes them from members of genus *Boletus* is the presence of their pink-tinged pores. It is a polyphyletic morphology that does not unite the *Tylopilus* species using traditional morphological characteristics of macrofungi.

Onyango and Ower (2011) investigated morphological characters and spawn production procedures of three Kenyan native strains of wood ear mushroom [*Auricularia auricula* (L. ex Hook.) Underw]. Nine basidiocarps were selected from collections made in three forest reserves within Kakamega Forest in Western Kenya and morphologically characterized of macrofungi fruiting bodies.

Karwa and Rai (2010) reported on the tapping into the edible fungi biodiversity of Melghat forest in Central India for occurrence of wild edible fungi and their prevalent favorable ecological factors in consecutive years in the months of June to February (2006-2008). A total of 153 species of macrofungi were recorded, collected, photographed and preserved. The enormous biomass in the forest favors variety of edible and medicinal macrofungi. Dominating species belong to genera *Agaricus, Pleurotus, Termitomyces, Cantharellus, Ganoderma, Auricularia, Schizophyllum, Morchella*, etc in Melghat forest in Central India.

Hanlon and Harrington (2010) conducted study on diversity and distribution of Agaricomycete species in the Republic of Ireland (ROI) and the records are compared with similar records from Northern Ireland, England, Scotland

and Wales. The number of Agaricomycete species recorded from Ireland is much lower than in the other countries examined. The ROI has 100, 700, 1300 and 2200 fewer species than Northern Ireland, Wales, Scotland and England respectively. When species records according to major taxonomic clades are examined, it is evident that under-recording the species from the ROI is common throughout all of the clades of Agaricomycetes.

CHAPTER III
MATERIALS AND METHODS

3.1 Experimental site

Experiment was conducted at the Laboratory, Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka. The samples were collected from different location of Sylhet and Moulovibazar districts of Bangladesh.

3.2 Source of data and sampling procedure

A systematic sampling procedure was used baseline survey. Eight locations under tropical evergreen and semi-evergreen forest of Sylhet and Moulovibazar districts were selected for conducting survey analysis on mushroom biodiversity, distribution, habitat and morphology. A pre-designed collection procedure and data analysis procedure were used to collect information on level of knowledge on biodiversity, habitat and morphology of macrofungi.

3.3 Collection of macrofungi samples

Detailed survey was carried out in 8 locations such as- Sylhet (Jaintiapur, Gowainghat, Jaflong, Tilagor Eco Park) and Moulavibazar (Sreemangal, Madhabkundu, Lawachara, Barlekha)of Bangladesh from July to October, 2016, to record the morphological variability in the macrofungi population. The collection was made by method given by Hailing (1996). Spotted macrofungi were inspected in their natural habitats and brought to laboratory for detailed study. Photographs were taken by means of a Sony Camera with power of 16 megapixels. The collected macro fungi were studied for their

macroscopic detail partnering the habit, habitat, morphology and other phenotypic parameter noted in fresh form. Standard methods of collection, preservation, macroscopic and microscopic preservations were recorded. Collected specimens were preserved as dried specimens in the Plant Pathology Laboratory of Sher-e-Bangla Agricultural University.

3.4 Collection site

Collection site was two districts of Sylhet and Moulovibazar (Jaintiapur, Gowainghat, Jaflong, Tilagor Eco Park, Sreemangal, Madhabkundu, Lawachara, Barlekha) located is located at 24.8917°N and 91.8833°E, in the north eastern region of Bangladesh (Figure 1 and Table 1). Minimum and maximum temperature was 12.9°C and 31.6°C. The average annual relative humidity was 68-85%. The dominant tree species of this area were Kala koroi (*Albizia lebbeck*), Koroi (*Albizzia procera*), Shil koroi (*Albizia lucidior*), Mehagani (*Swietenia mahagoni*), Sissoo (*Dalbergia sissoo*), Chatim (*Alstonia scholaris*), Boilam (*Anisoptera scaphula*), Kadam (*Anthocephalus chinensis*), Chapalish (*Artocarpus chama*), Telsur (*Hopea odorata*), Neem (*Azadirachta indica*), Shimul (*Bombax ceiba*). During rainy season, there is abundant growth of several kinds of macrofungi.

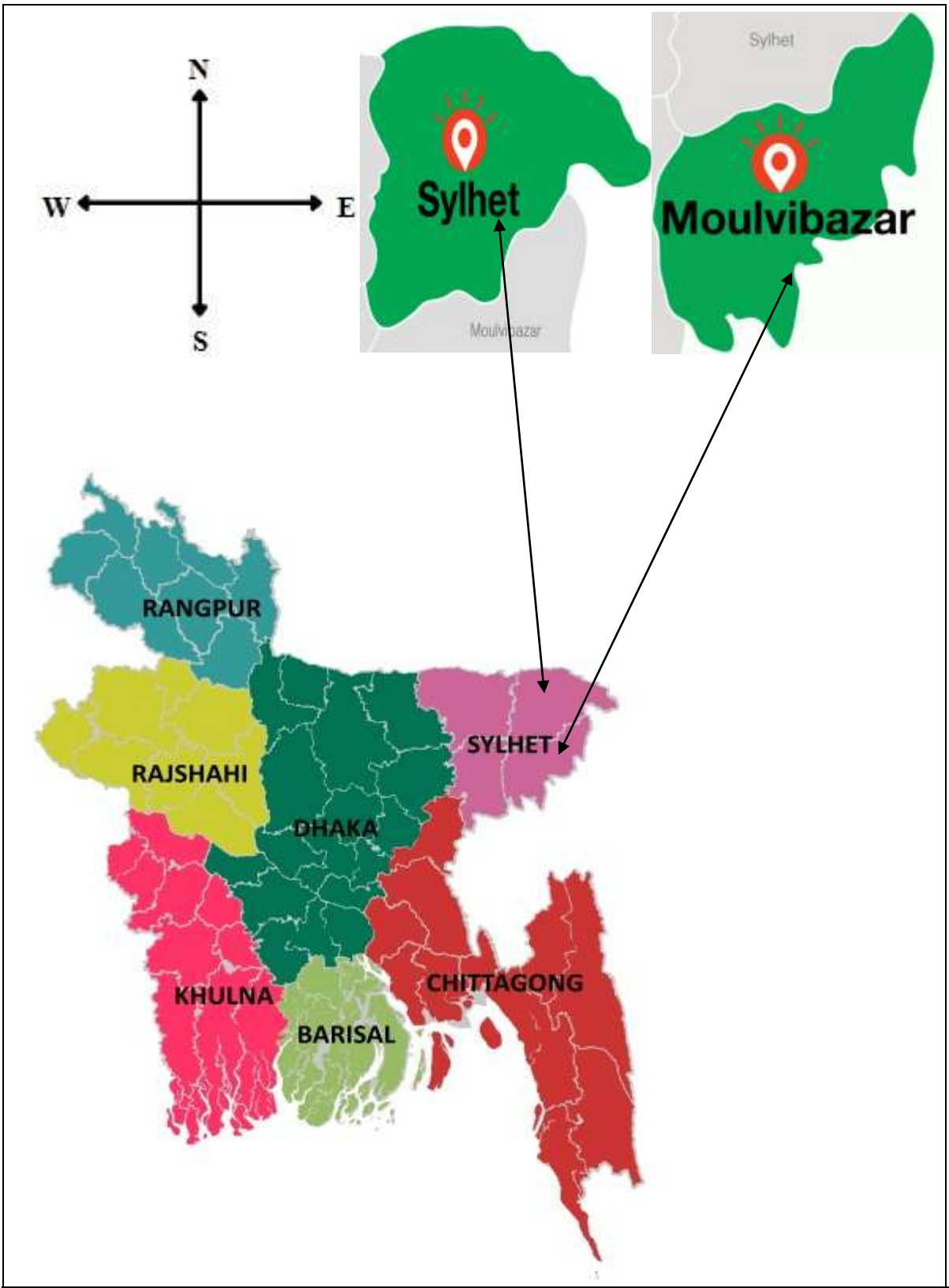


Figure 1: Survey areas of Sylhet division of Bangladesh

Table -1: Survey areas of Sylhet division of Bangladesh

District(s)	Surveyed Location(s)			
Sylhet	Jaintiapur	Gowainghat	Jaflong	Tilagor Eco Park
Moulavibazar	Sreemangal	Madhabkundu	Lawachara	Barlekha
Districts = 2	Locations = 8			

3.5 Processing of macrofungi

Freshly harvested macrofungi was washed by water for removing debris. It has been realized that merely fleshy collected mushroom is of no use unless these are properly preserved. During the analysis period some precautions were followed before processing of macrofungi were followed on the basis of study purpose and structure of the mushroom (Kim, 2004).

3.6 Drying

Collected specimens were dried by using electrical air flow drier. The power supply capacity of this drier was 1000 voltage, which easily remove moisture from collected mushroom within three to seven hours with regular interval basis power supply (15 minutes switch off and 30 minutes switching) depending on the structure and texture of the species (Kim, 2004).

3.7 Storage

Dried macrofungi were stored in Zip lock poly bag during research period. Silica gel was used at the rate of 10% of dry basis during the storage period. Collecting specimens dried with the help of electric dryer dried specimens are preserved with 10% silica gel (Kim, 2004).

3.8 Morphological observation

Data on the following parameters were recorded for identification of macrofungi such as locality, habitat, type of soil, forest type, size of the fructification, carpophores shape, umbo, scale, the gills, color, gills edges, stipes, length, width, color, shape, type of veil, annuls (position), volva, (Srivastava and Bano (2010). Cap color, cap surface, cap margin, cap diameter, stipe length, gill attachment, gill spacing and spore print. Individual spore characteristics like shape, size and color were recorded. For this purpose, compound microscope (Motic BA210) was used and measuring shape, size and color with help of Motic Images Plus 2.0 software. Final identification and classification were done by comparing recorded characteristics of macrofungi with the color dictionary of mushroom given by Dickinson and Lucus (1982), the mushroom guide and followed by the reference of Jorden (2004) and Pegler and Spooner (1997).

3.10 Morphological characterization procedures

The basidiocarps were rehydrated by soaking in water for few minutes before analyzing their morphology. Qualitative characters such as color, shape, and presence of hymenia were evaluated by eye observation while texture was determined by feeling the back and top surfaces using fingers. Most of the morphological data were recorded during collection period that is when the mushroom was in fresh form. For microscopic characters, permanent glass slides were made from rehydrated basidiocarps with the aid of a sharp surgical blade. Basidiocarps were immersed in cotton blue stain and glycerin and placed on glass slides and covered with cover slips. Motic compound microscope (40x) were used to observe the slides. Spore size was measured by Motic Images plus 2.0 software.

3.11 Habitat, distribution and diversity analysis

The specimens were found attached to various substrata. The surrounding environment temperature, soilpH, moisture condition, vegetation recorded for biodiversity of macrofungi. Soil pH, soil moisture were measured by pH meter and air temperature by thermometer during collection period. Collected samples were wrapped in polybag and brought to the laboratory for their further study. The frequency and density of different species has been determined by the following formulas (Zoberi, 1973).

$$\text{Frequency of fungal species (\%)} = \frac{\text{Number of site in which the species is present}}{\text{Total number of sites}} \times 100$$

$$\text{Density (\%)} = \frac{\text{Total number of individual of a particular species}}{\text{Total number of species}} \times 100$$

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Morphology and ecology of *Agaricus* sp.

4.1.1 Scientific Name: ***Agaricus bernardii***

Common name: Salt-loving mushroom

Family: Agaricaceae.

Morphological features

Pileus shape: Convex; Color: Dark brown and creamy

Length: 2.6cm, Width: 2.1cm

Surface character and zonation: Moderately in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Distant

Stipe: Present

Spore size (Average): Length: 8.6µm; Width: 8.4µm

Spore shape: Moderately thick walled, smooth and oval, Color: Black and Brown

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was less moist weather. The frequency of its presence was 12.5% and the density was 8%.

Host : Soil surface.

PLATE 1. ***Agaricus bernardii***; Mature fruiting body (A), Gills (B), Spores (C).

4.1.2 Scientific Name: ***Agaricus* sp.**

Family: Agaricaceae.

Morphological features

Pileus shape: Convex and Flat; Color: Dark brown and white

Length: 3.1cm, Width: 1.8cm

Surface character and zonation: Moderately in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Distant

Stipe: Present

Spore size (Average): Length: 17.2µm; Width: 9.3µm

Spore shape: Thick walled, smooth and ellipsoid, Color: Dark brown and Yellow

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was less moist weather. The frequency of its presence was 25% and the density was 16%.

Host: Soil surface.

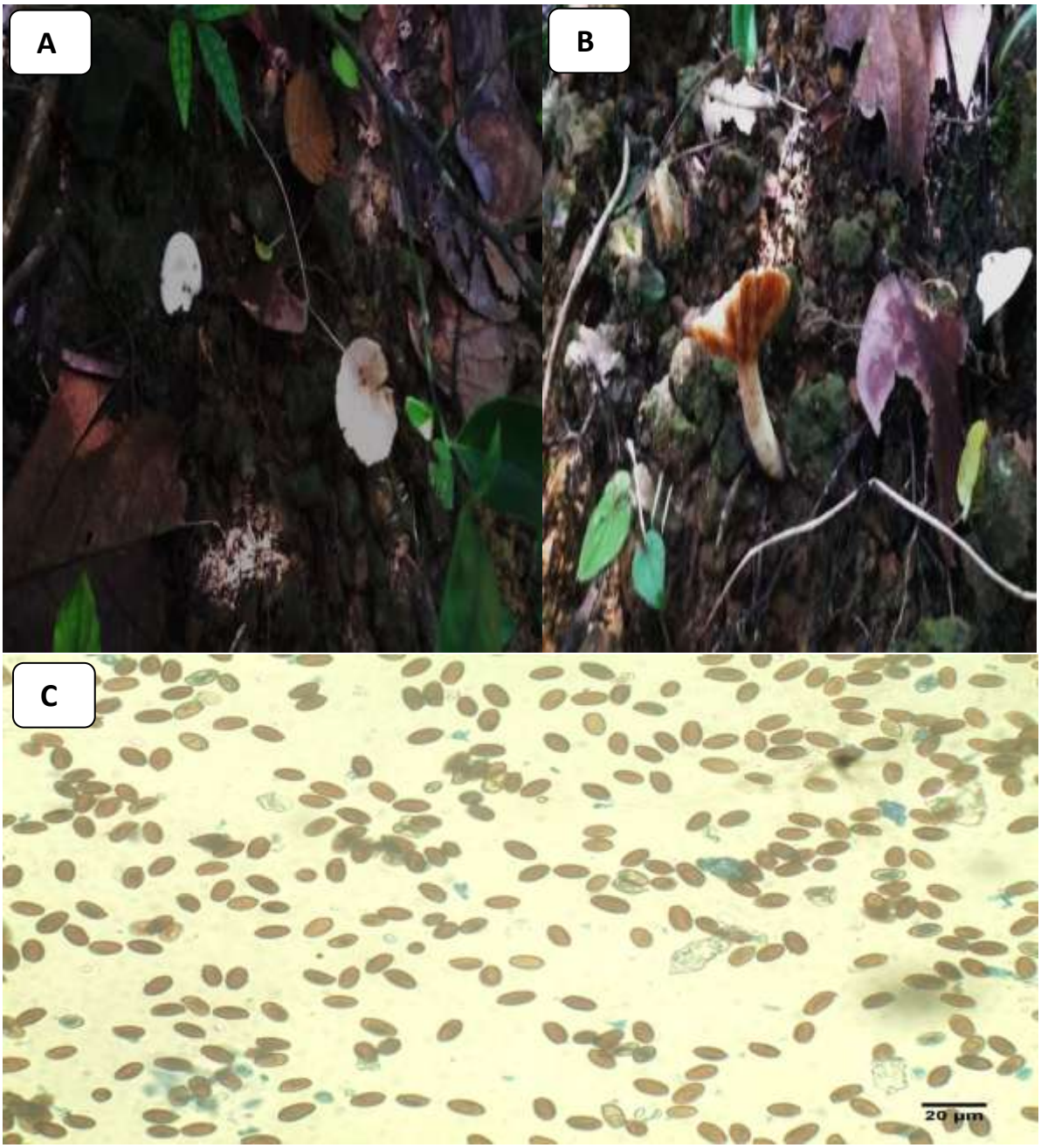


PLATE 2. *Agaricus* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.2 Morphology and ecology of *Coprinus* sp.

4.2.1 Scientific Name: ***Coprinus disseminatus***

Common name: Inkcaps

Family: Agaricaceae.

Morphological features

Pileus shape: Conical; Color: White

Length: 1.8cm, Width: 0.6cm

Surface character and zonation: Moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: white

Gills spacing: Distant

Stipe: Present

Spore size (Average): Length: 12.3µm; Width: 7.2µm

Spore shape: Moderately thick walled, smooth and ellipsoid, Color: Dark yellow and Brown

Ecological features

Habit: Clustered and constancy of occurrence in specific habitat was abundant. Type of soil was sandy to clay loam; factor affecting their distribution was moderately moist weather. The frequency of its presence was 25% and the density was 108%.

Host : Neem (*Azadirachta indica*) tree.

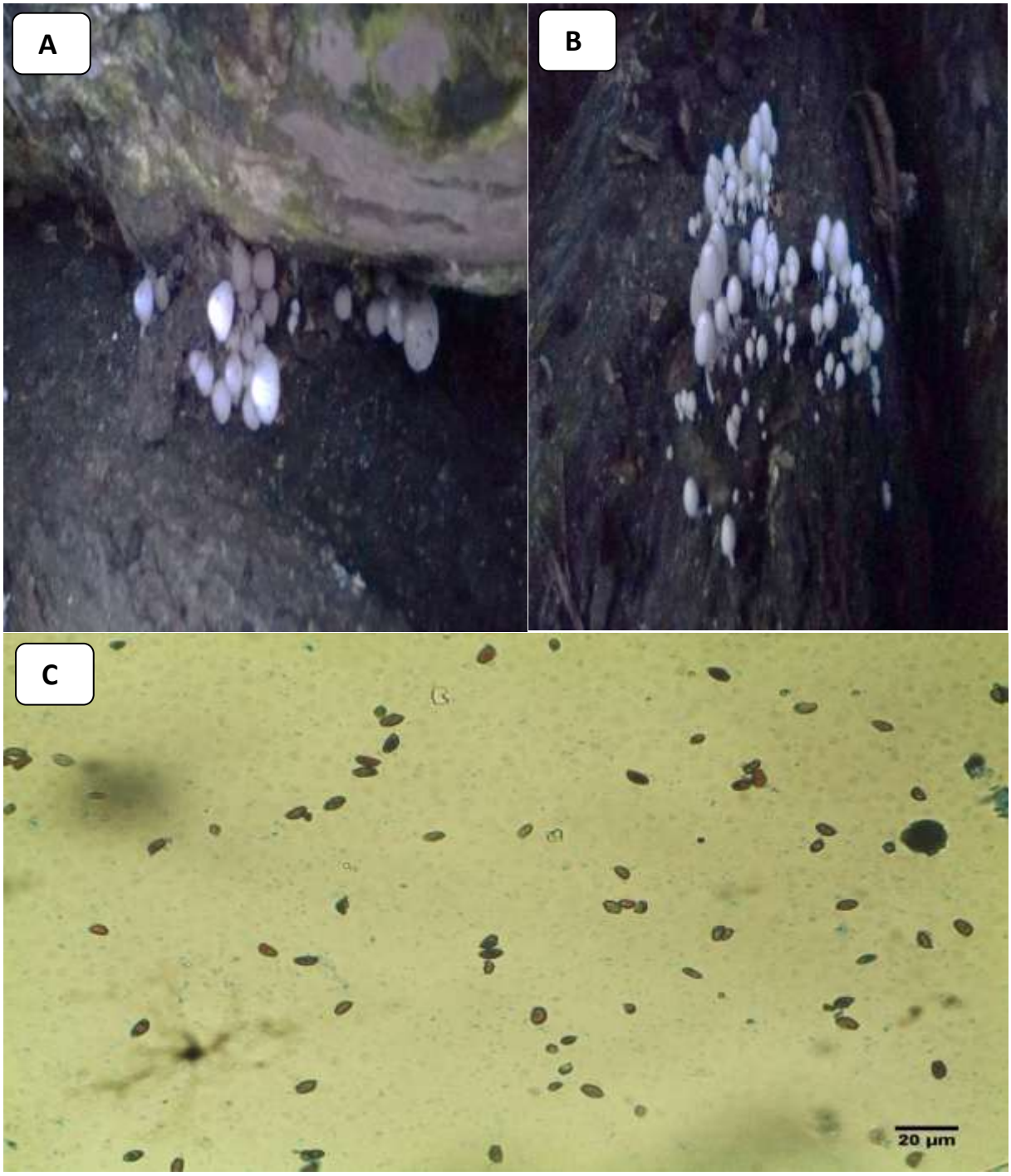


PLATE 3. ***Coprinus disseminatus***; Mature fruiting body (A), Gills (B), Spores (C).

4.2.2 Scientific Name: ***Coprinus* sp.**

Family: Agaricaceae.

Morphological features

Pileus shape: Umbonate; Color: Dark brown and yellow

Length: 2.1cm, Width: 0.8cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: White

Gills spacing: Distant

Stipe: Present

Spore size (Average): Length: 11.2µm; Width: 8.6µm

Spore shape: Moderately thick walled, rough and ellipsoid, Color: Black

Ecological features

Habit: Clustered and constancy of occurrence in specific habitat was abundant. Type of soil was sandy to sandy loam; factor affecting their distribution was less moist weather. The frequency of its presence was 12.5% and the density was 268%.

Host: Soil surface.

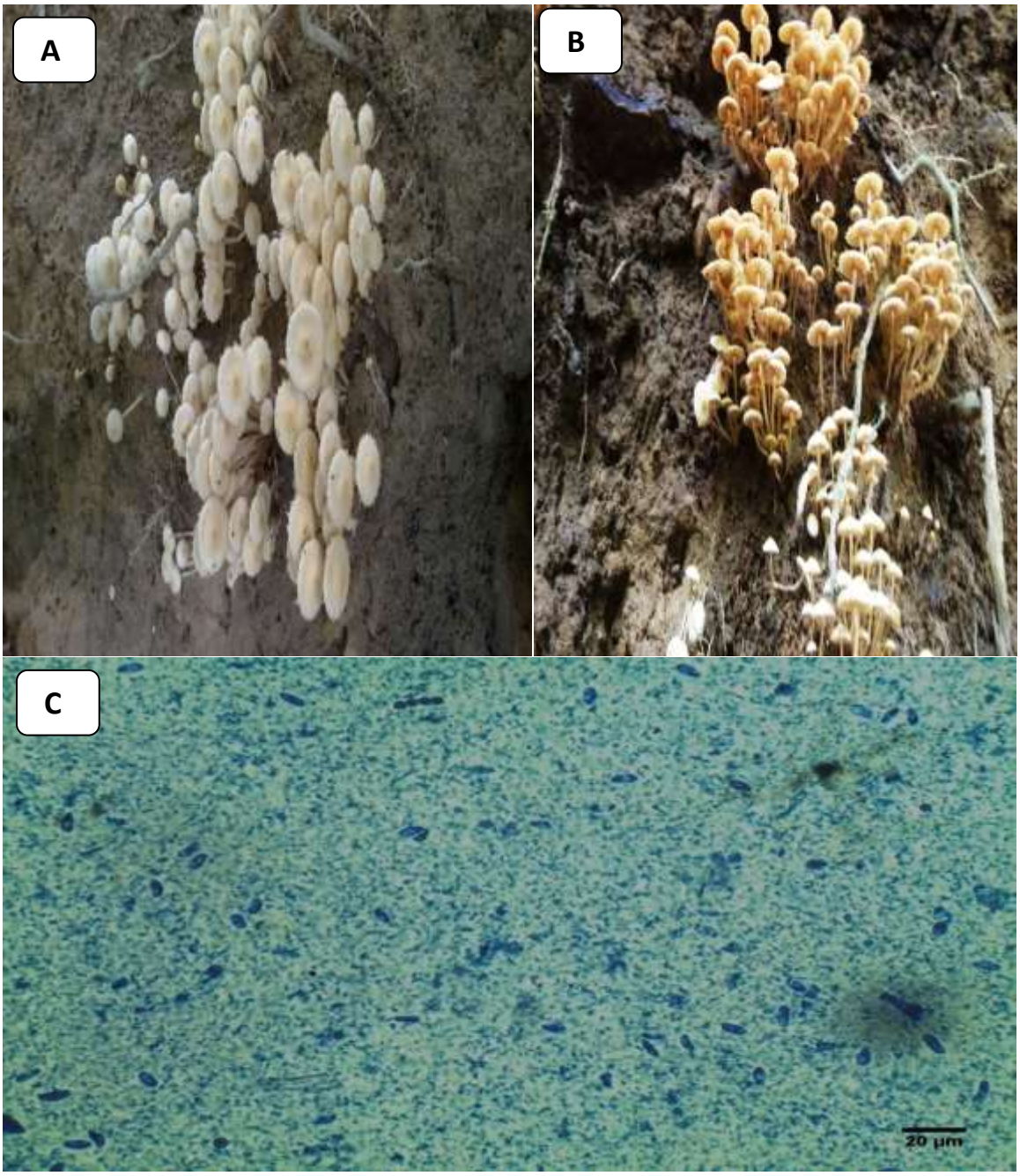


PLATE 4. *Coprinus* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.3 Morphology and ecology of *Ganoderma* sp.

4.3.1 Scientific Name: ***Ganoderma tsugae***

Common name: Hemlock varnish shelf.

Family: Ganodermataceae

Morphological features

Pileus shape: Finger like; Color: Dark brown and white

Length: 2.6cm, Width: 0.7cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Woody, tough and brittle

Spore bearing surface under cap: Micro pores

Pores: White

Pores spacing: Crowded

Stipe: Present

Spore size (Average): Length: 13.2µm; Width: 8.9µm

Spore shape: Moderately thick walled, rough and ellipsoid, Color: Dark Brown

Ecological features

Habit: Scattered and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was dry weather. The frequency of its presence was 37.5% and the density was 12%.

Host: Soil surface.

PLATE 5. ***Ganoderma tsugae***; Mature fruiting body (A), Pores (B), Spores (C).

4.3.2 Scientific Name: ***Ganoderma applanatum***

Common name: The artist's bracket,artist's Conk or bear bread

Family: Ganodermataceae

Morphological features

Pileus shape: Flat; Color: Dark brown with the white at end of the edge.

Length: 2.4cm, Width: 3.1cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Woody, tough and brittle

Spore bearing surface under cap: Micro pores

Pores color: White

Pores spacing: Crowded

Stipe: Pseudo stipe present

Spore size (Average): Length: 11.8µm; Width: 8.70µm

Spore shape: Moderately thick walled, rough and ellipsoid, Color: Dark brown and yellow

Ecological features

Habit: Scattered and constancy of occurrence in specific habitat was abundant. Type of soil was sandy to sandy loam around the tree; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 24%.

Host : Soil surface.

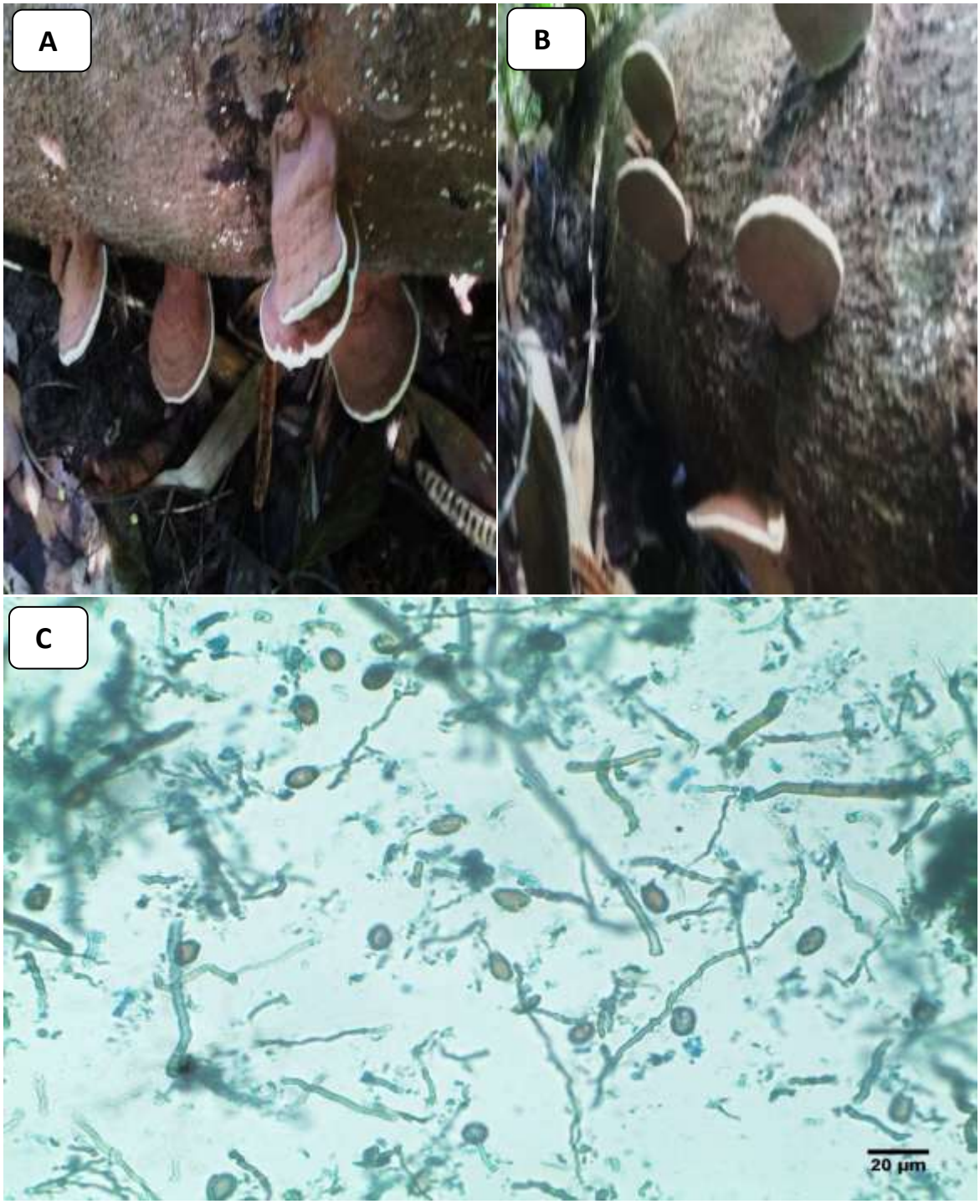


PLATE 6. ***Ganoderma applanatum***; Mature fruiting body (A), Pores (B), Spores (C).

4.3.3 Scientific Name: ***Ganoderma boninense***

Common name: Lingzhi or Reishi mushroom.

Family: Ganodermataceae

Morphological features

Pileus shape: Flat; Color: Dark brick red

Length: 2.6cm, Width: 3.5cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Woody, tough and brittle

Spore bearing surface under cap: Micro pores

Pores color: White

Gills spacing: Crowded

Stipe: Pseudo stipe present

Spore size (Average): Length: 9.2µm; Width: 6.8µm

Spore shape: Moderately thick walled, rough and ellipsoid, Color: Dark Brown

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam around the tree; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 4%.

Host :Shimul (*Bombax ceiba)* tree.

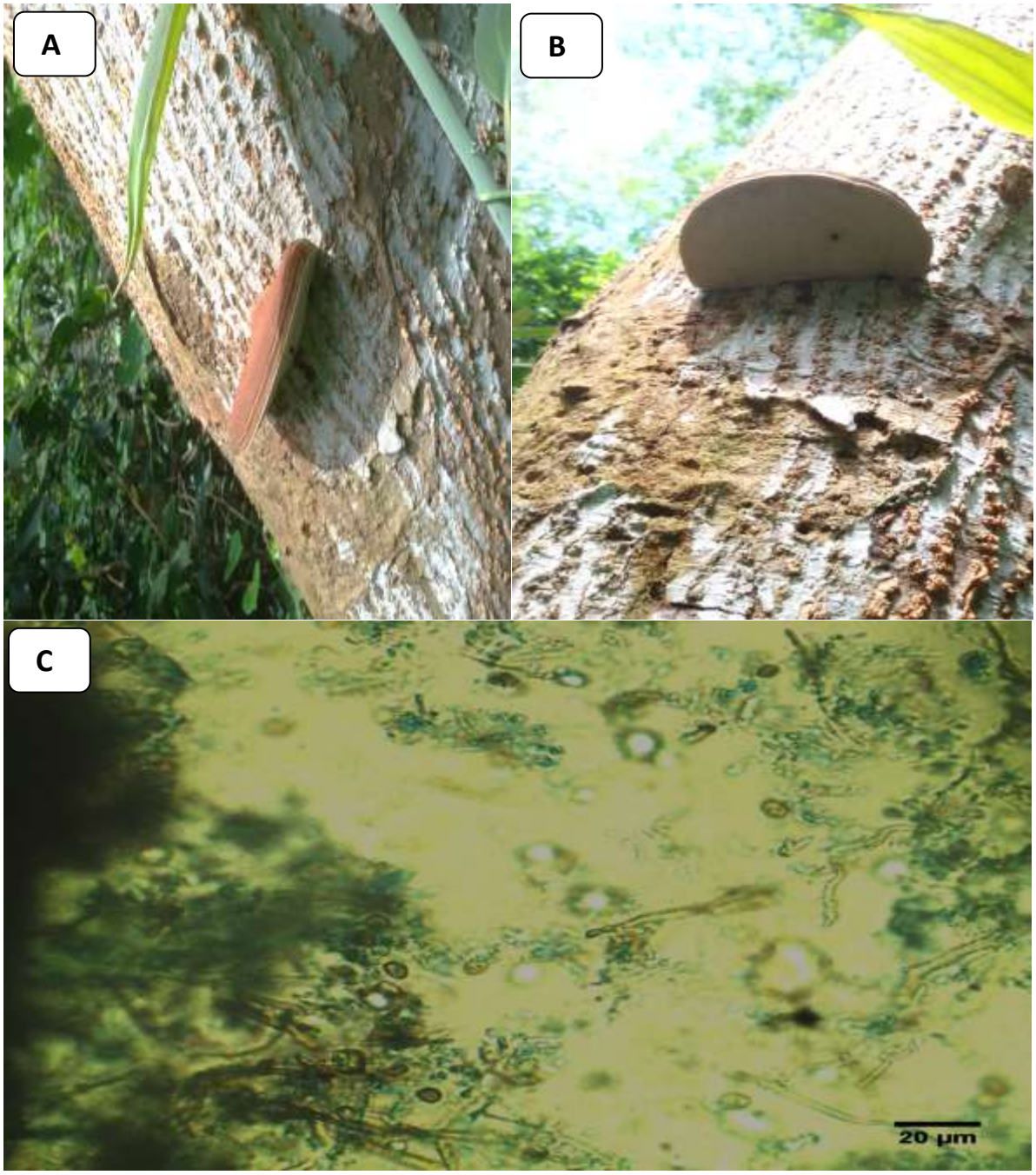


PLATE 7. ***Ganoderma boninense***; Mature fruiting body (A), Pores (B), Spores (C).

4.3.4 Scientific Name: ***Ganoderma* sp.**

Family: Ganodermataceae

Morphological features

Pileus shape: Flat; Color: Dark yellow with the white color at the end of edge

Length: 1.6cm, Width: 2.1cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Woody, tough and brittle

Spore bearing surface under cap: Micro Pores

Pores color: White

Pores spacing: Crowded

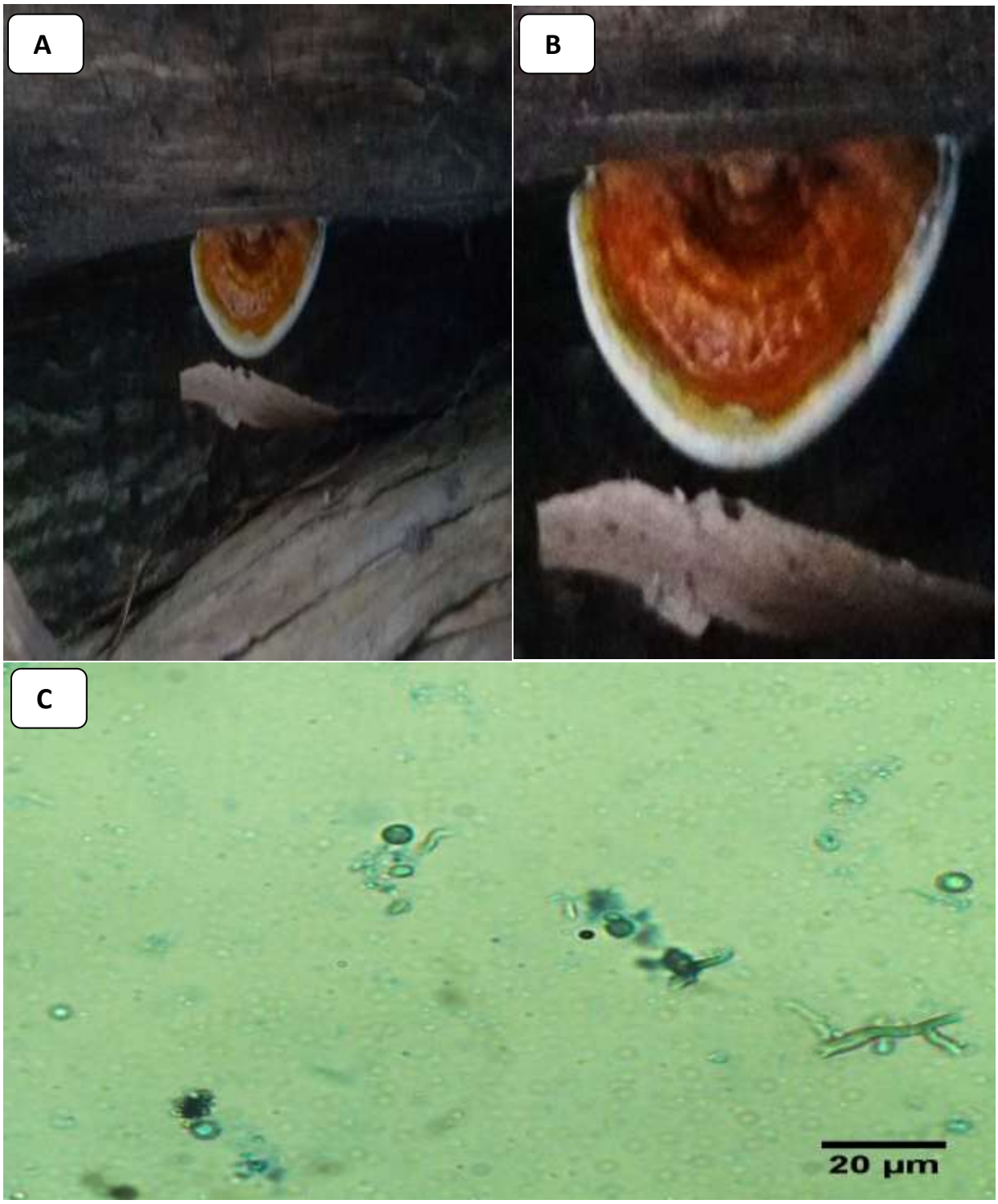
Spore size (Average): Length: 8.6µm; Width: 7.2µm

Spore shape: Thick walled, smooth and eoval, Color: Dark Brown

Ecological features

Habitat: On the tree. Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 4%.

Host : Sisso (*Dalbergia sissoo*) tree.



8. *Ganoderma* sp.; Mature fruiting body (A,B), Spores (C).

4.5 Morphology and ecology of *Daedaleopsis* sp.

4.5.1 Scientific Name: ***Daedaleopsis confragosa***

Common name: Thin walled maze polypore or the blushing
Family: Polyporaceae

Morphological features

Pileus shape: Flat; Color: Dark brown and whitish at the end of edge

Length: 4.2cm, Width: 5.4cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Macro pores

Pores color: White

Pores spacing: Distant

Stipe: Pseudo stipe present

Spore size (Average): Length: 8.6µm; Width: 5.8µm

Spore shape: Moderately thick walled, smooth and oval, Color: Dark and light Brown

Ecological features

Habit: Scattered and constancy of occurrence in specific habitat was unabundant. Type of soil was loam to clay loam; factor affecting their distribution was less dry weather. The frequency of its presence was 25% and the density was 28%.

Host : Soil surface.

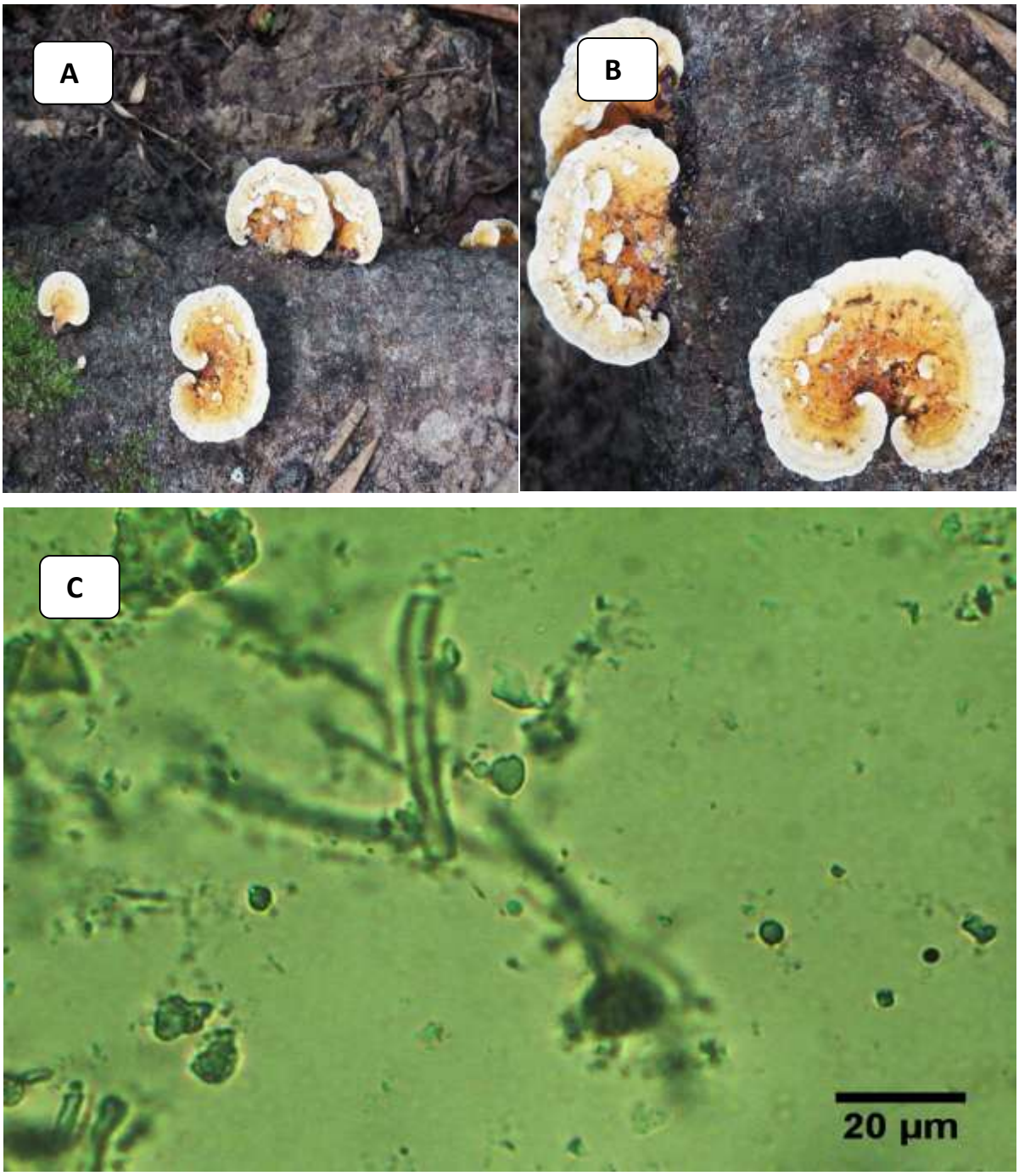


PLATE 9. ***Daedaleopsis confragosa***; Mature fruiting body (A, B), Spores (C).

4.5.2 Scientific Name: ***Daedaleopsis* sp.**

Family: Polyporaceae

Morphological features

Pileus shape: Flat and wavy; Color: White

Length: 4.4cm, Width: 5.2cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Macro Pores

Pores color: White

Pores spacing: Distant

Stipe: Pseudo stipe present

Spore size (Average): Length: 6.2µm; Width: 5.8µm

Spore shape: Moderately thick walled, smooth and oval, Color: Dark and light Brown

Ecological features

Habitat: On the tree. Habit: Scattered and constancy of occurrence in specific habitat was abundant. Type of soil was sandy to sandy loam; factor affecting their distribution was less dry weather. The frequency of its presence was 12.5% and the density was 12%.

Host :Koroi (*Albizia lebbeck*) tree.

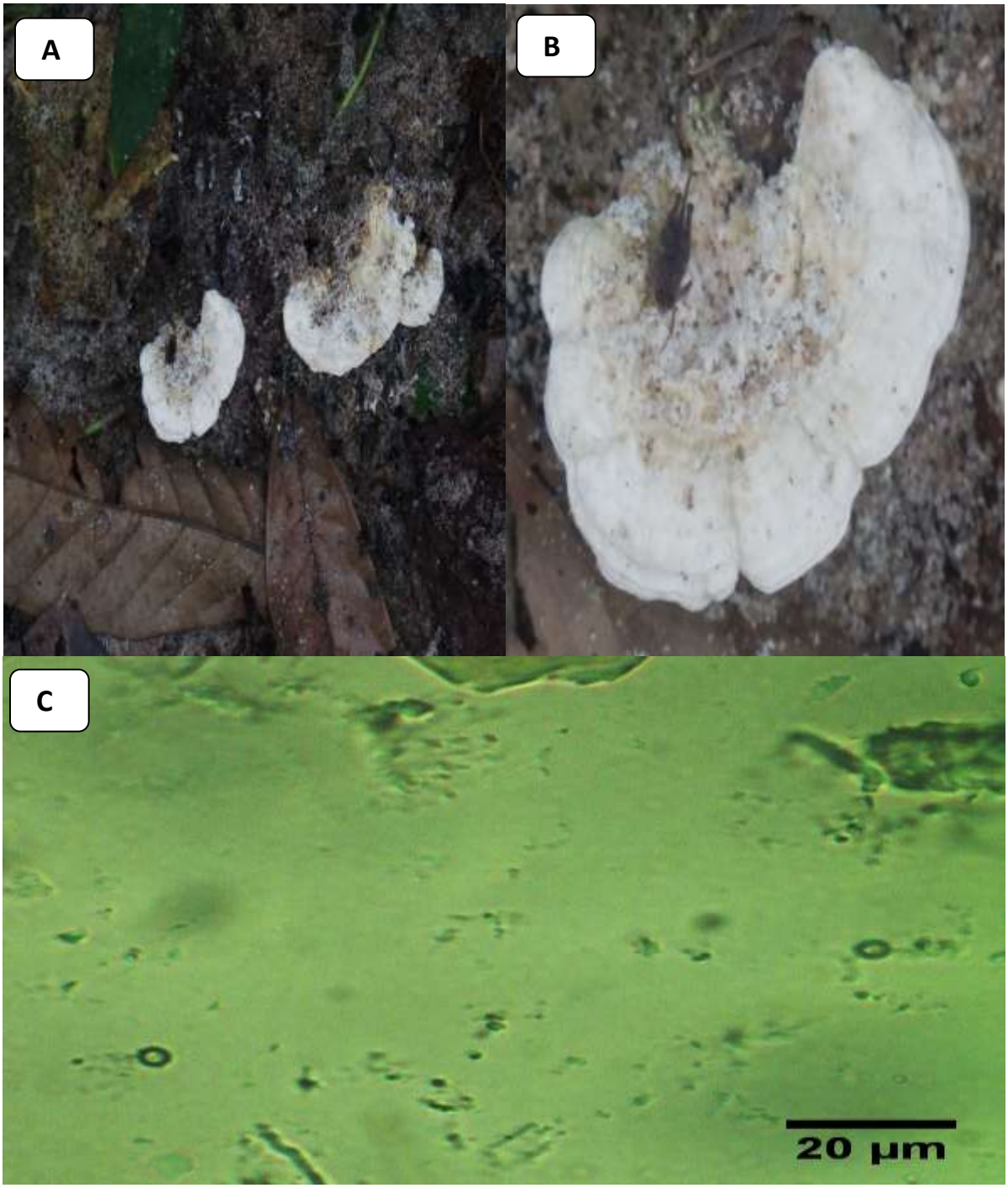


PLATE 10. *Daedaleopsis* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.6 Morphology and ecology of *Trametes* sp.

4.6.1 Scientific Name: ***Trametes* sp.**

Family: Polyporaceae

Morphological features

Pileus shape: Flat; Color: Dark brown and whitish at the end of edge

Length: 2.2cm, Width: 4.1cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Mciro Pores

Pores color: White

Pores spacing: Crowded

Stipe: Pseudo stipe present

Spore size (Average): Length: 8.2µm; Width: 6.4µm

Spore shape: Single walled, smooth and oval, Color: Light Brown

Ecological features

Habit: Clustered and constancy of occurrence in specific habitat was abundant. Type of soil was sandy to sandy loam around the tree; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 36%.

Host : Sissoo (*Dalbergia sissoo*) tree.

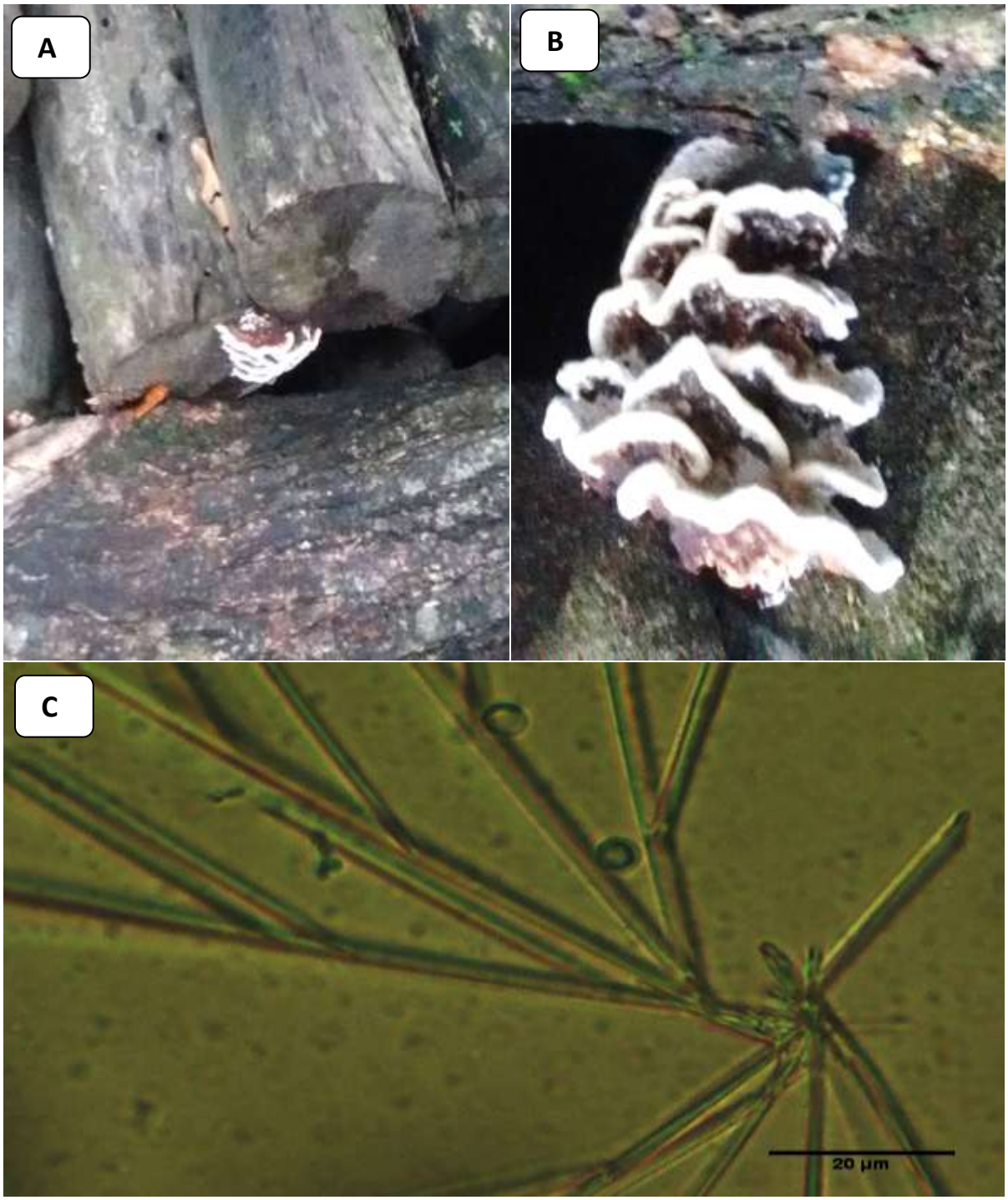


PLATE 11. *Trametes* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.7 Morphology and ecology of *Volvariella* sp.

4.7.1 Scientific Name: ***Volvariella* sp.**

Family: Pluteaceae

Morphological features

Pileus shape: Flat and Depressed, Ovate; Color: Brown and creamy

Length: 4.2cm, Width: 1.8cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Distant

Stipe: Present

Spore size (Average): Length: 14.1µm; Width: 8.4µm

Spore shape: Moderatelythick walled, smooth and ellipsoid, Color: Dark yellow

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was moderately moist weater. The frequency of its presence was 25% and the density was 12%.

Host : Soil surface.

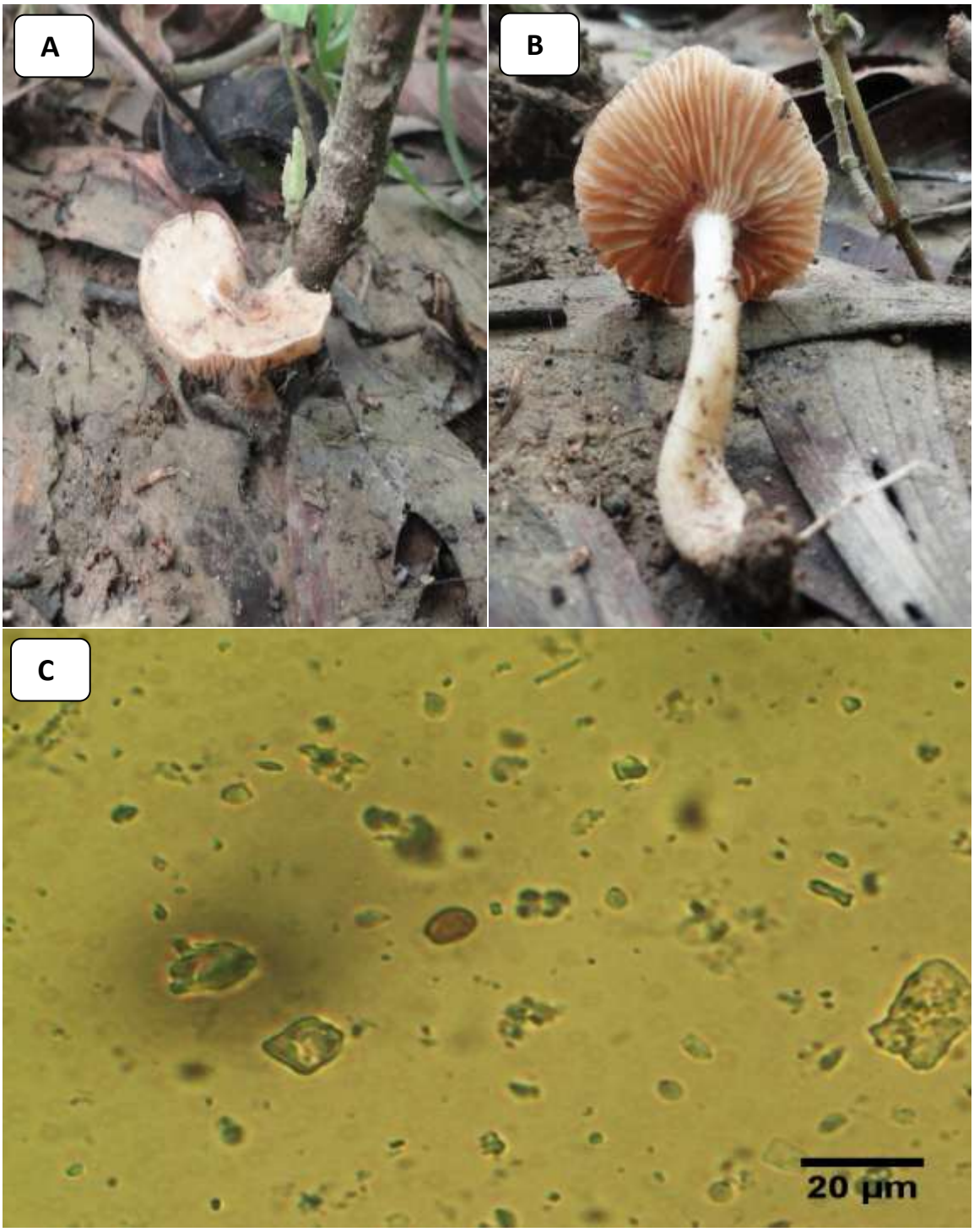


PLATE 12. *Volvariella* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.8 Morphology and ecology of *Tylopilus* sp.

4.8.1 Scientific Name: ***Tylopilus rubrobrunneus***

Common name: Bitter bolete or the bitter tylopilus

Family: Boletaceae

Morphological features

Pileus shape: Convex; Color: Dark brown and black spot top of the cap

Length: 3.1cm, Width: 4.8cm

Surface character and zonation: Less dry in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Micro pores

Pores color: Light yellow

Pores spacing: Crowded

Stipe: Present

Spore size (Average): Length: 12.1µm; Width: 8.7µm

Spore shape: Thick walled, smooth and oval, Color: Dark brown and black

Ecological features

Habitat: On the tree/surface. Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam; factor affecting their distribution was less moist weather. The frequency of its presence was 25% and the density was 4%.

Host :Shimul (*Bombax ceiba*) tree.

PLATE 13. ***Tylopilus rubrobrunneus***; Mature fruiting body (A), Gills (B), Spores (C).

4.9 Morphology and ecology of *Schizophyllum sp.*

4.9.1 Scientific Name: ***Schizophyllum commune***

Common name: Split-gill

Family: Schizophyllaceae

Morphological features

Pileus shape: Flat with crenate; Color: Dark brown

Length: 0.8cm, Width: 0.4cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Distant

Stipe: Pseudo stipe present

Spore size (Average): Length: 11.6µm; Width: 9.6µm

Spore shape: Moderately thick walled, smooth and oval, Color: Brown an light yellow

Ecological features

Habitat: On the tree. Habit: Scattered and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam around the tree; factor affecting their distribution was dry weather. The frequency of its presence was 25% and the density was 104%.

Host :Koroi (*Albizia lebbeck*) tree.

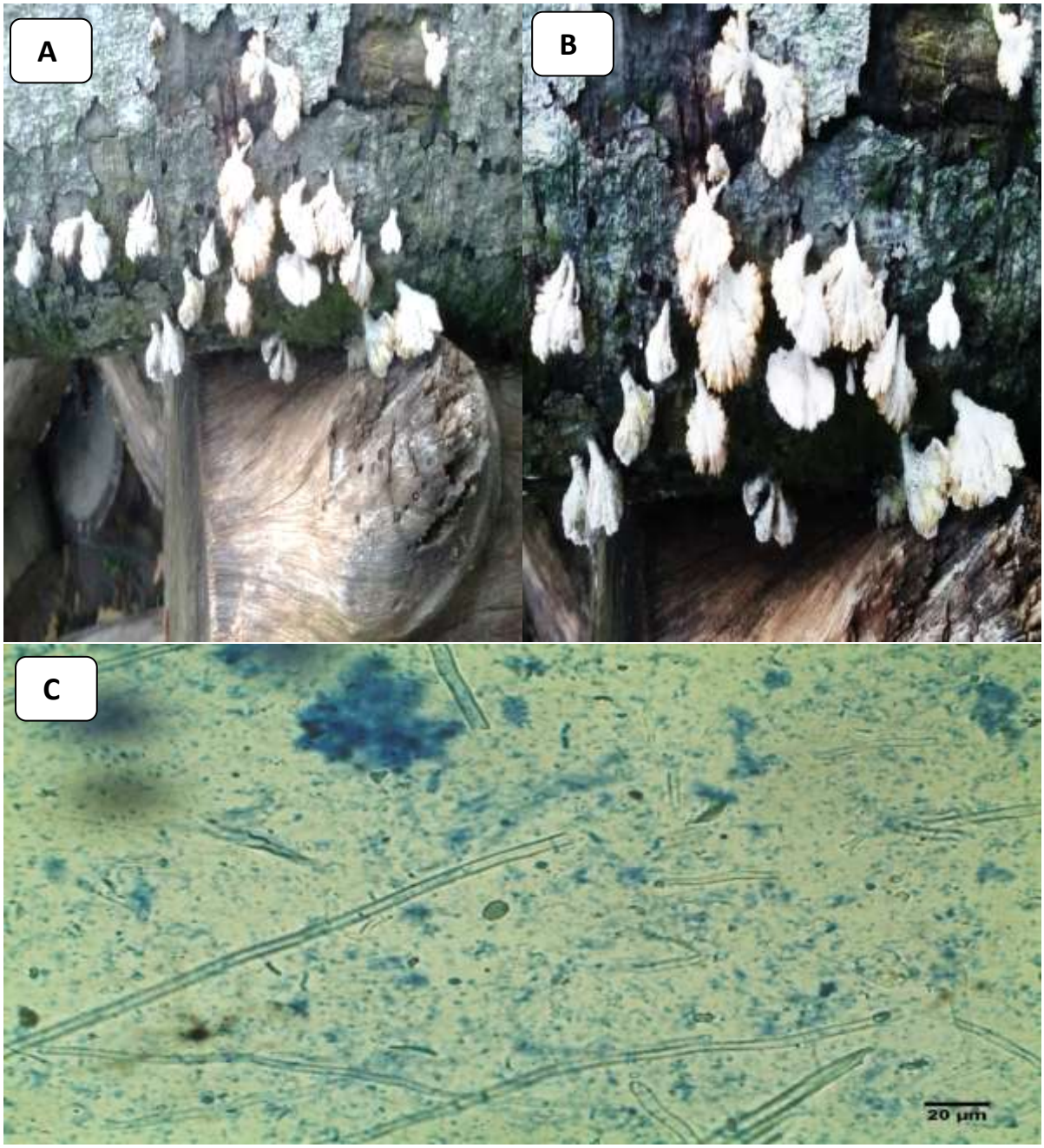


PLATE 14. ***Schizophyllum commune***; Mature fruiting body (A), Gills (B), Spores (C)

4.9.2 Scientific Name: ***Schizophyllum* sp.**

Family: Schizophyllaceae

Morphological features

Pileus shape: Flatan crenate; Color: white

Length: 0.9cm, Width: 0.6cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Distant

Stipe: Pseudo stipe present

Spore size (Average): Length: 7.6µm; Width: 7.4µm

Spore shape: Single walled, smooth and oval, Color: Brown

Ecological features

Habitat: On the tree. Habit: Scattered and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam around the tree; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 28%.

Host :Kadam (*Neolamarckia cadamba*) tree.

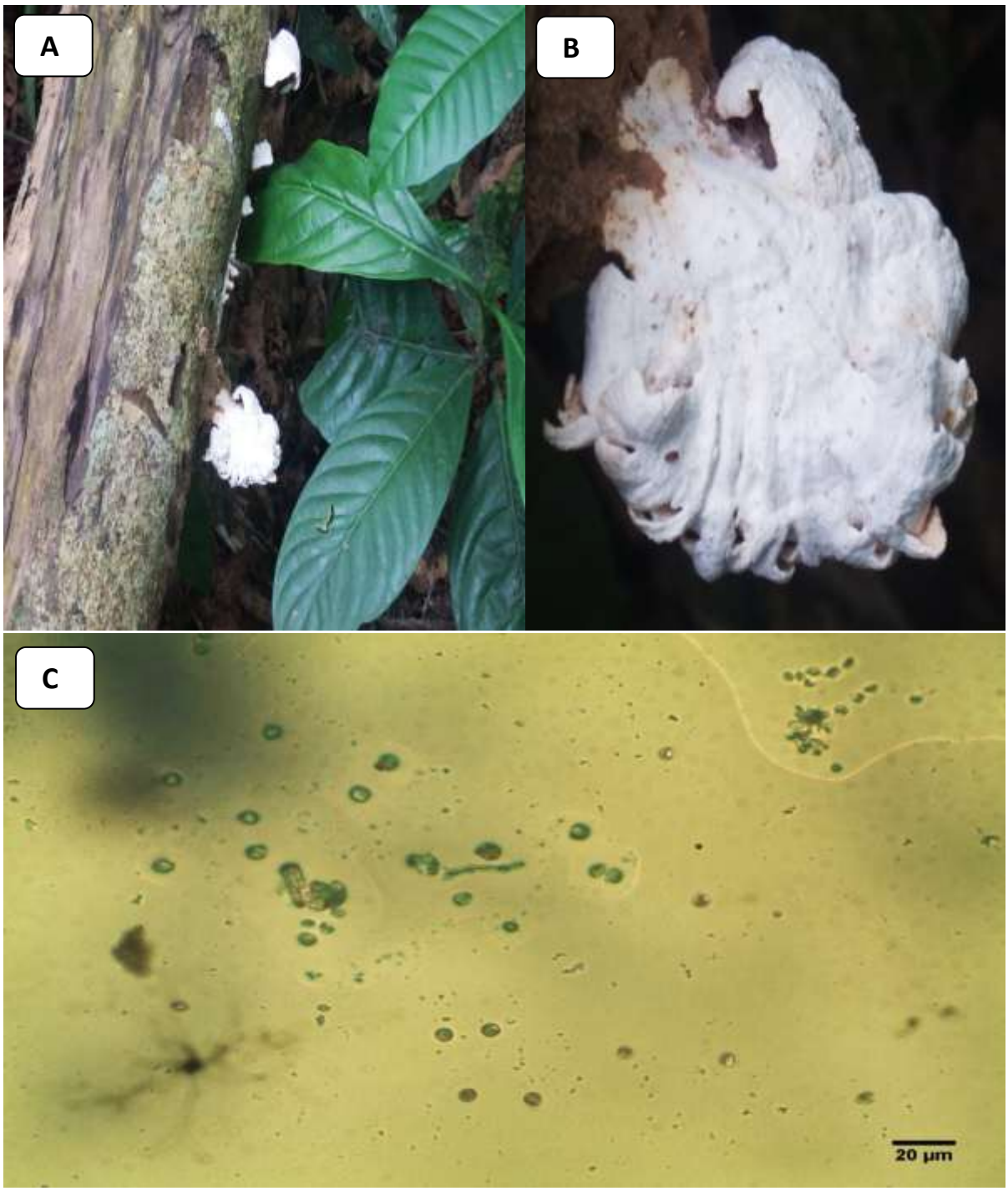


PLATE 15. *Schizophyllum* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.10 Morphology and ecology of *Pleurotus sp.*

4.10.1 Scientific Name: ***Pleurotus ostreatus***

Common name: Oyster mushroom

Family: Pleurotaceae

Morphological features

Pileus shape: Flat and wavy at the end of edge; Color: White

Length: 3.1cm, Width: 1.7cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: White

Gills spacing: Distant

Stipe: Pseudo stipe present

Spore size (Average): Length: 6.7µm; Width: 5.6µm

Spore shape: Single walled, smooth and round, Color: Light Brown

Ecological features

Habit: Clustered and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was less moist. The frequency of its presence was 37.5% and the density was 36%.

Host : Soil surface.

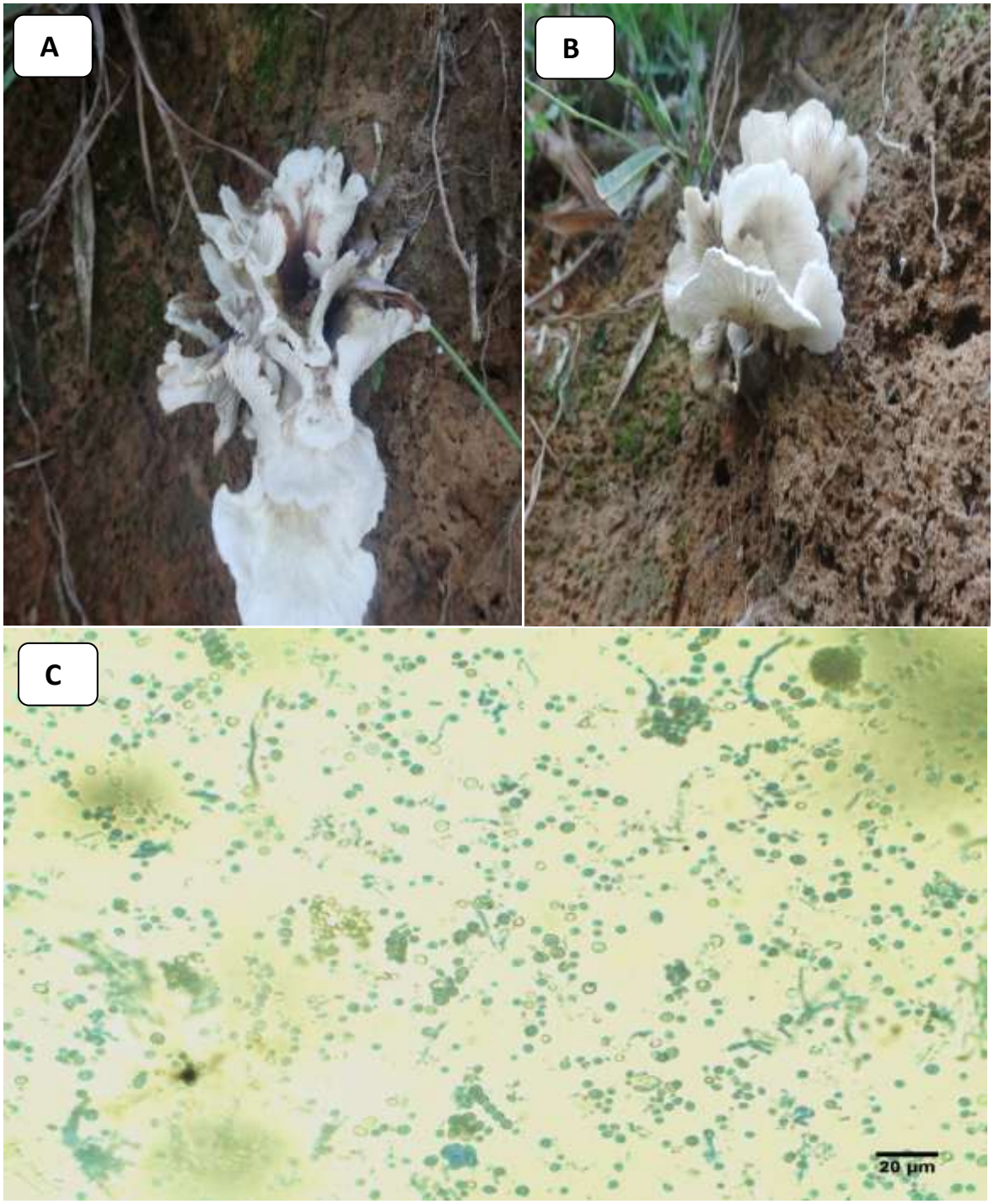


PLATE 16. ***Pleurotus ostreatus***; Mature fruiting body (A), Gills (B), Spores (C).

4.10.2 Scientific Name: ***Pleurotus populinus***

Common name: Aspen oyster mushroom

Family: Pleurotaceae

Morphological features

Pileus shape: Flat and wavy at the end of edge; Color: Milky white

Length: 3.2cm, Width: 2.6cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: White

Gills spacing: Distant

Stipe: Pseudo stipe present

Spore size (Average): Length: 9.3µm; Width: 7.8µm

Spore shape: Single walled, smooth and oval, Color: Dark and light Brown

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 12%.

Host : Soil surface.

PLATE 17. ***Pleurotus populinus***; Mature fruiting body (A), Gills (B), Spores (C

4.11 Morphology and ecology of *Mycena* sp.

4.11.1 Scientific Name: ***Mycena epipterygia***

Family: Mycenaceae

Morphological features

Pileus shape: Convex and Ovate; Color: Dark brown and creamy

Length: 2.1cm, Width: 0.4cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Crowded

Stipe: Present

Spore size (Average): Length: 9.6µm; Width: 6.8µm

Spore shape: Moderately thick walled, rough and ellipsoid, Color: Dark yellow

Ecological features

Habitat: On the tree. Habit: Scattered and constancy of occurrence inspecific habitat was unabundant. Type of soil was sandy to clay loam; factor affecting their distribution was less moist weather. The frequency of its presence was 25% and the density was 28%.

Host :Chatim (*Alstonia scholaris*) treee

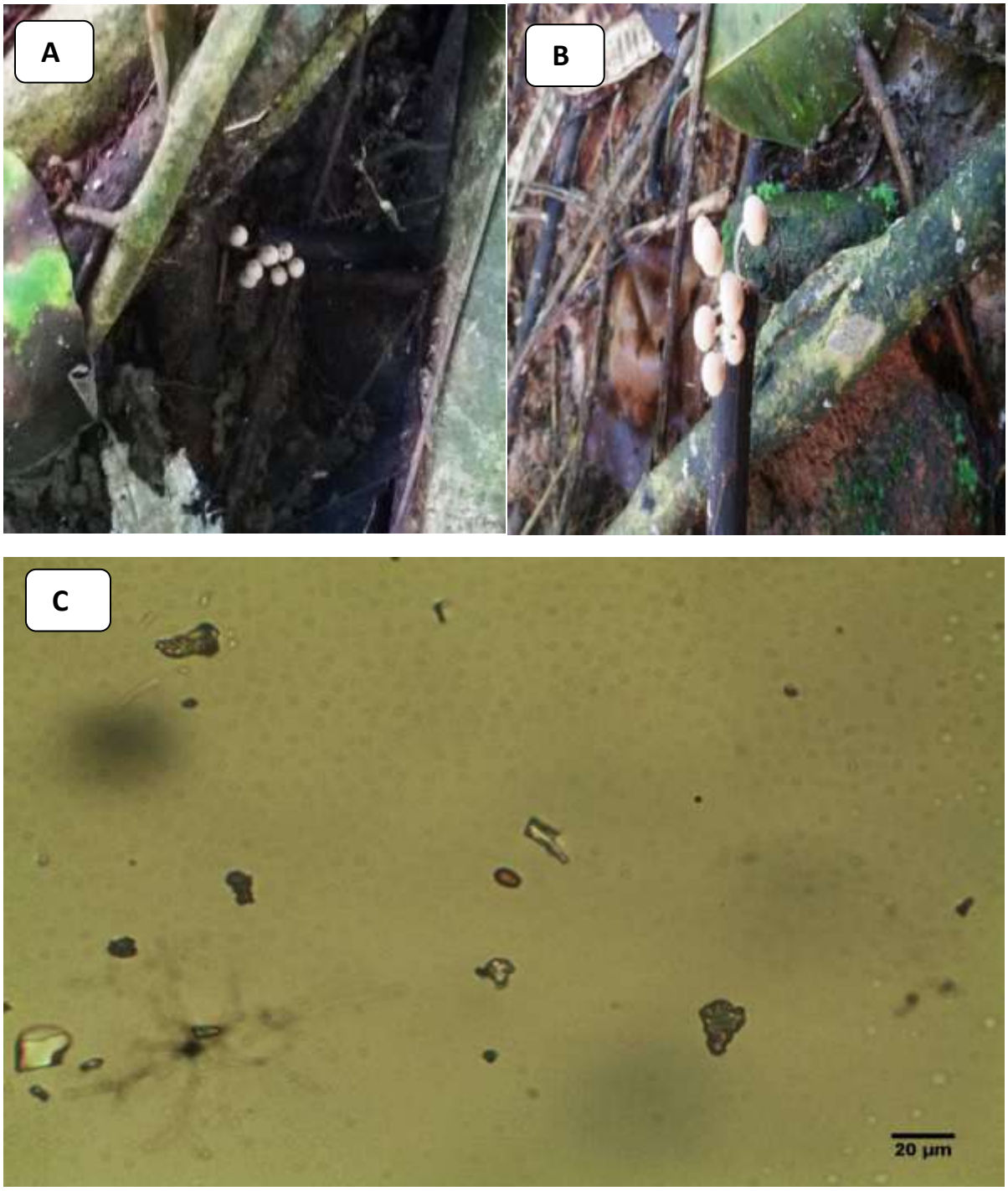


PLATE 18. ***Mycena epipterygia***; Mature fruiting body (A), Gills (B), Spores (C).

4.11.2 Scientific Name: ***Mycena* sp.**

Family: Mycenaceae

Morphological features

Pileus shape: Convex and Ovate; Color: Brown and creamy

Length: 4.8cm, Width: 0.8cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Distant

Stipe: Present

Spore size (Average): Length: 10.2µm; Width: 8.3µm

Spore shape: Moderately thick walled, rough and ellipsoid, Color: Black

Ecological features

Habit: Scattered and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam under the humus; factor affecting their distribution was dry weather. The frequency of its presence was 25% and the density was 12%.

Host : Humus

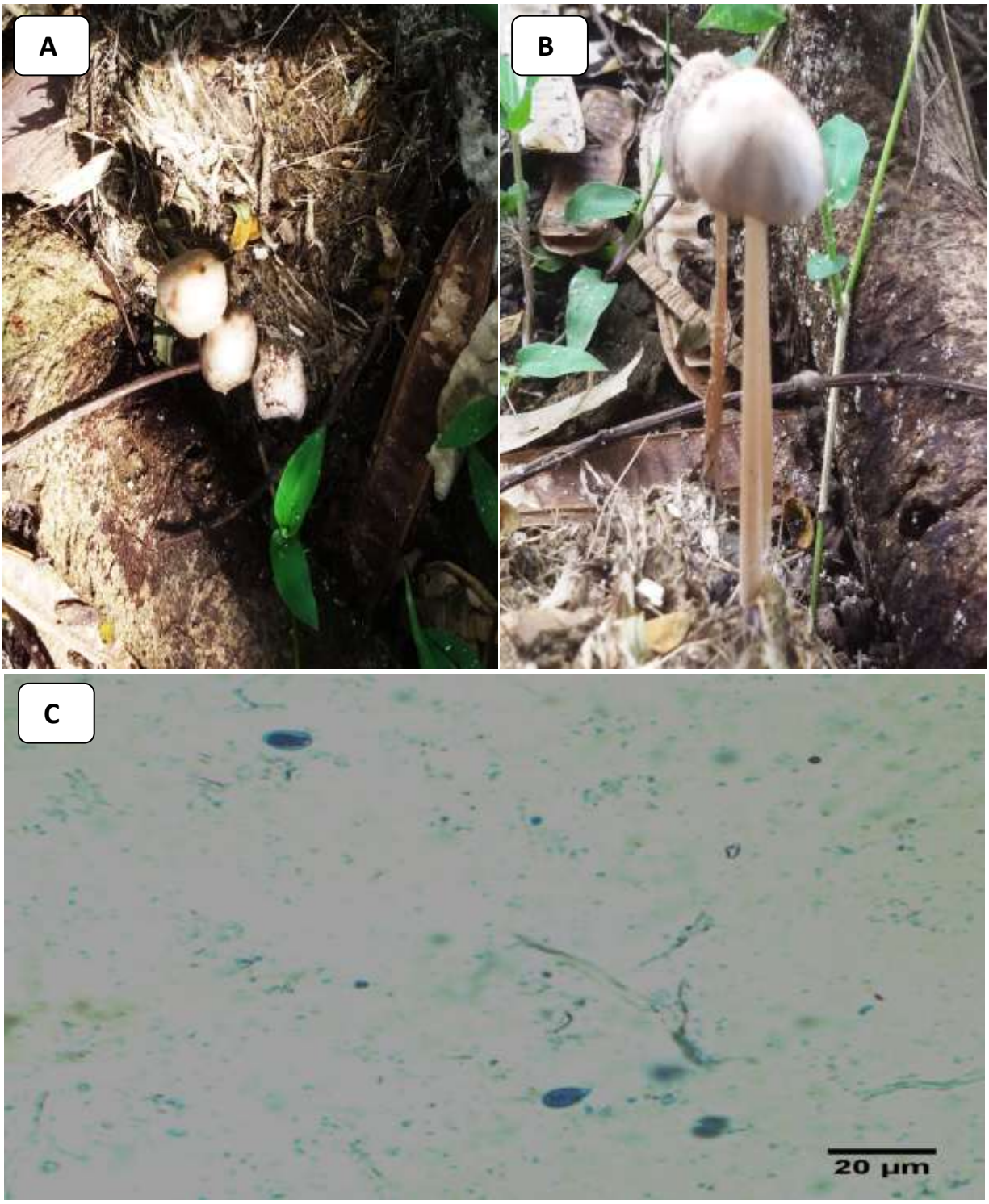


PLATE 19. *Mycena* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.12 Morphology and ecology of *Steccherinum* sp.

4.12.1 Scientific Name: ***Steccherinum ochraceum***

Common name: Ochre spreading tooth

Family: Steccherinaceae

Morphological features

Pileus shape: Flat and wavy at the end of edge; Color: White with the creamy at centre

Length: 3.1cm, Width: 3.4cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Teeth

Teeth color: White and brown

Teeth spacing: Crowded

Spore size (Average): Length: 14.1µm; Width: 10.2µm

Spore shape: Moderately thick walled, smooth and oval, Color: Dark yellow

Ecological features

Habitat: On the tree. Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam; factor affecting their distribution was dry weather. The frequency of its presence was 25% and the density was 4%.

Host : Sissoo (*Dalbergia sisso*) treee

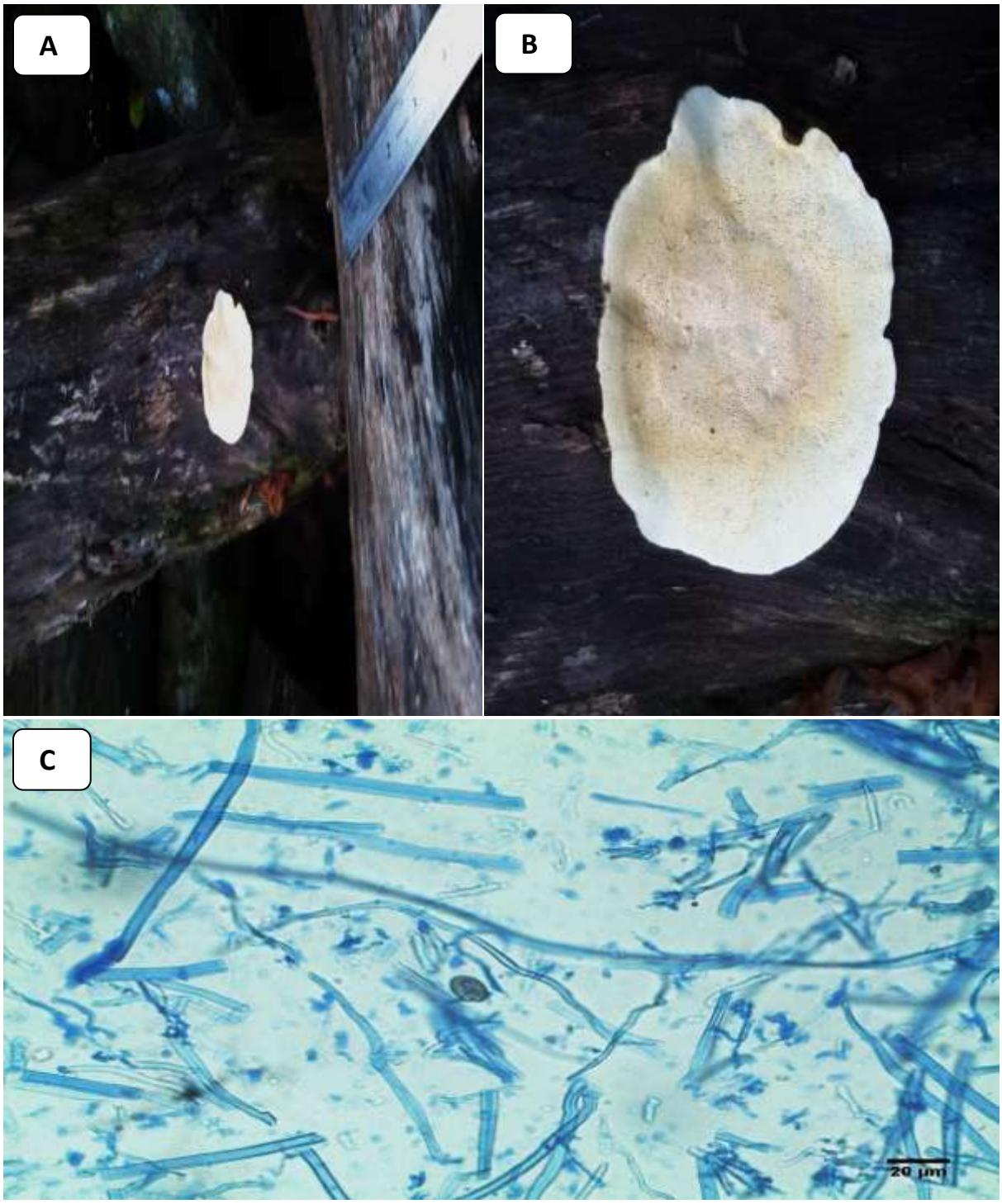


PLATE 20. ***Steccherinum ochraceum***; Mature fruiting body (A), Teeth (B), Spores (C).

4.12.2 Scientific Name: ***Steccherinum ciliolatum***

Family: Steccherinaceae

Morphological features

Pileus shape: Flat and crenate wavy; Color: White and slight blue

Length: 2.8cm, Width: 4.2cm

Surface character and zonation: Dry in nature

Texture of the fruiting body: Tough and brittle

Spore bearing surface under cap: Teeth

Teeth color: Slight blue

Teeth spacing: Crowded

Spore size (Average): Length: 16.8µm; Width: 14.2µm

Spore shape: Moderately thick walled, rough and oval, Color: Dark and light Brown

Ecological features

Habitat: On the tree. Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 4%.

Host : Sissoo (*Dalbergia sisso*) treee

PLATE 21. ***Steccherinum ciliolatum***; Mature fruiting body and teeth (A), Spores (B).

4.13 Morphology and ecology of *Cortinarius* sp.

4.13.1 Scientific Name: ***Cortinarius colymbadinus***

Family: Cortinariaceae

Morphological features

Pileus shape: Convex and Depressed; Color: Dark brick red

Length: 1.8cm, Width: 2.1cm

Surface character and zonation: Less dry in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brick red

Gills spacing: Crowded

Stipe: Present

Spore size (Average): Length: 8.4µm; Width: 6.2µm

Spore shape: Moderately thick walled, smooth and oval, Color: Brown

Ecological features

Habit: Scattered and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was dry weather. The frequency of its presence was 12.5% and the density was 12%.

Host : Soil surface.

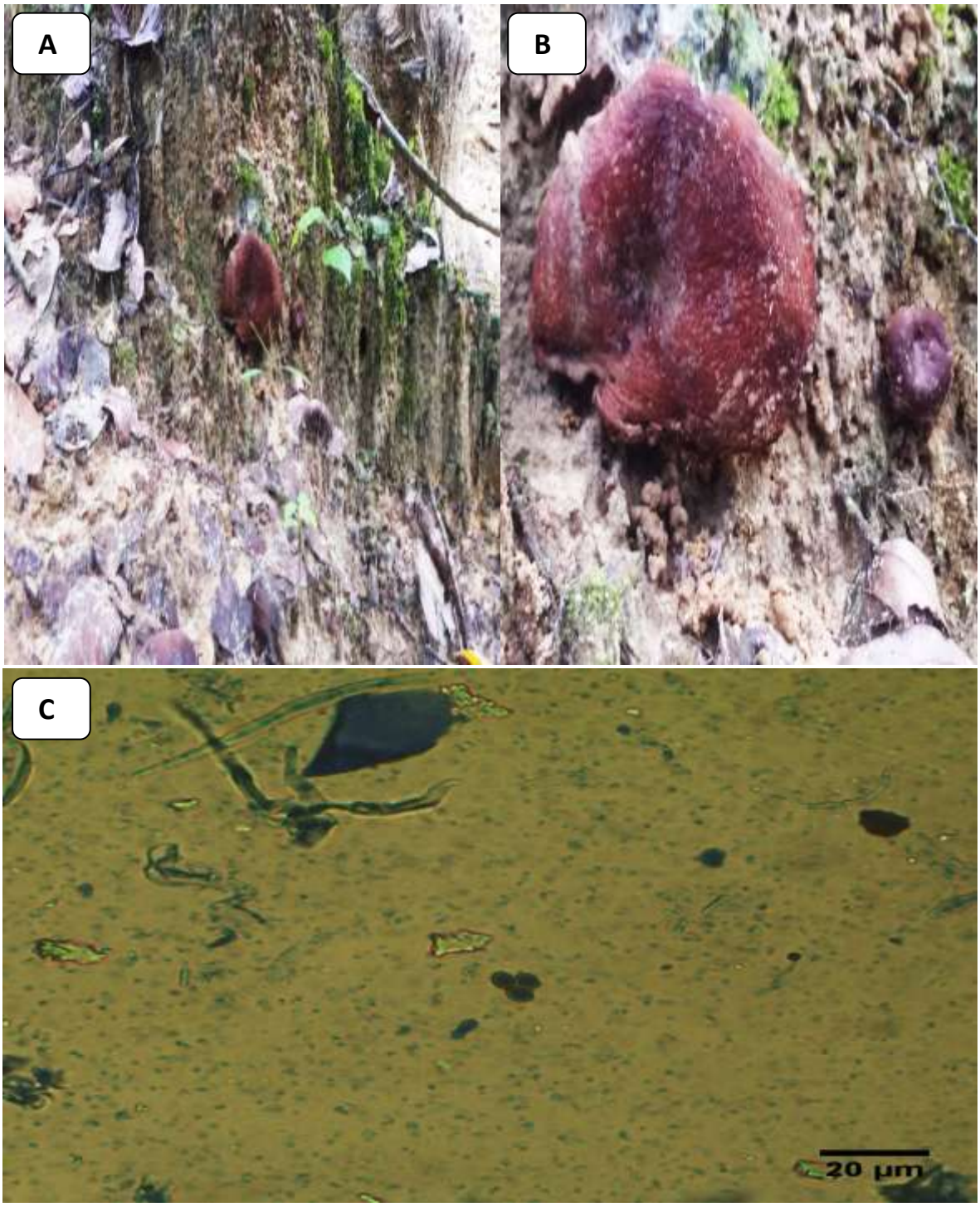


PLATE 22. ***Cortinarius colymbadinus;*** Mature fruiting body (A, B), Spores (C).

4.14 Morphology and ecology of *Amanita* sp.

4.14.1 Scientific Name: ***Amanita regalis***

Common name: The royal fly agaric or the king of Sweden Amanita

Family: Amanitaceae

Morphological features

Pileus shape: Ovate; Color: Dark brown with light brown scale

Length: 2.2cm, Width: 1.1cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Brown

Gills spacing: Crowded

Stipe: Present

Spore size (Average): Length: 7.8μm; Width: 5.3 μm

Spore shape: Single walled, smooth and ellipsoid, Color: Dark and light Brown

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather. The frequency of its presence was 12.5% and the density was 4%.

Host : Soil surface.

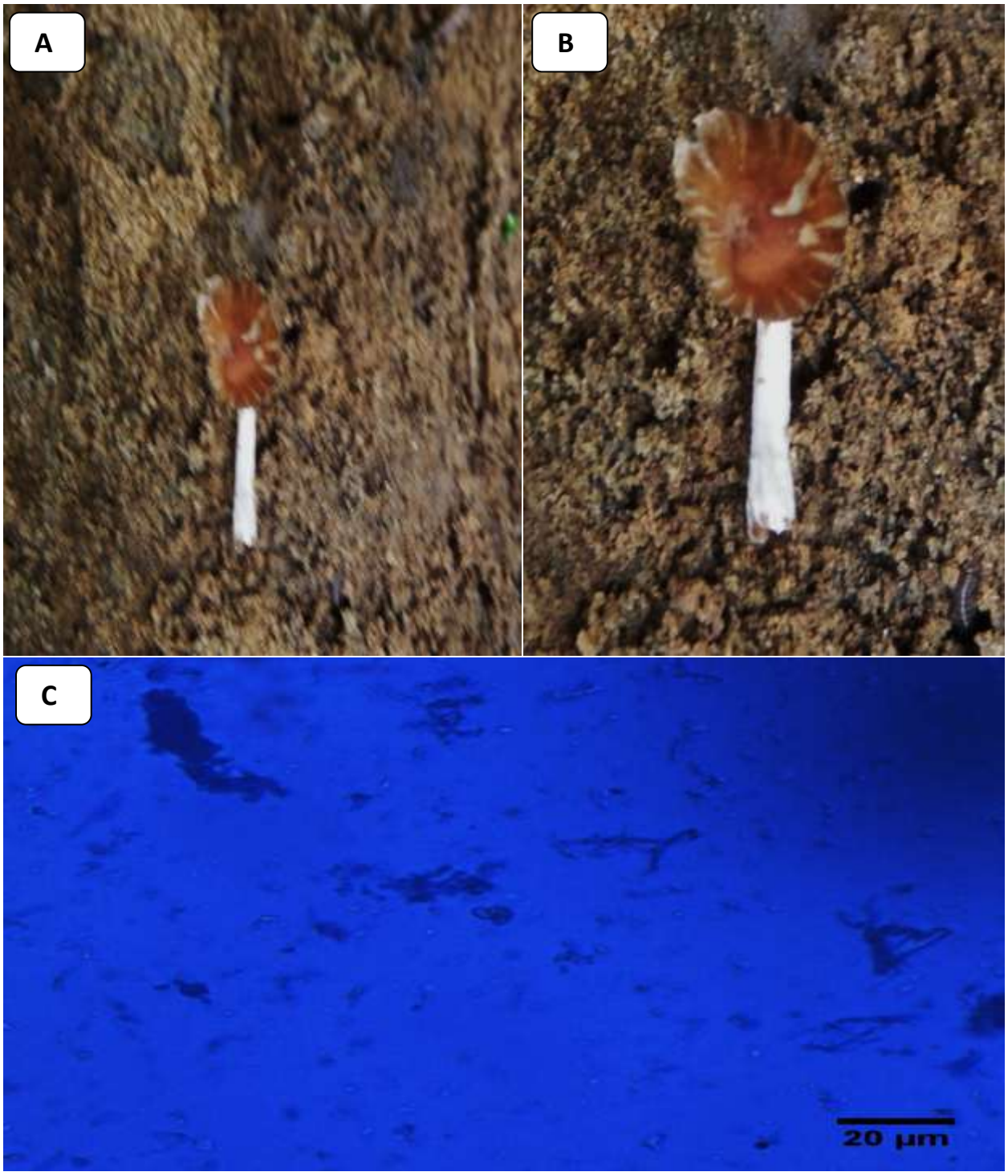


PLATE 23. ***Amanita regalis***; Mature fruiting body (A), Gills (B), Spores (C).

4.15 Morphology and ecology of *Cantharellus* sp.

4.15.1 Scientific Name: ***Cantharellus subalbidus***

Common name: White chanterelle

Family: Cantharellaceae

Morphological features

Pileus shape: Flat and Depresse; Color: Brown and creamy

Length: 2.1cm, Width: 2.3cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: Slight yellow

Gills spacing: Distant

Stipe: Present

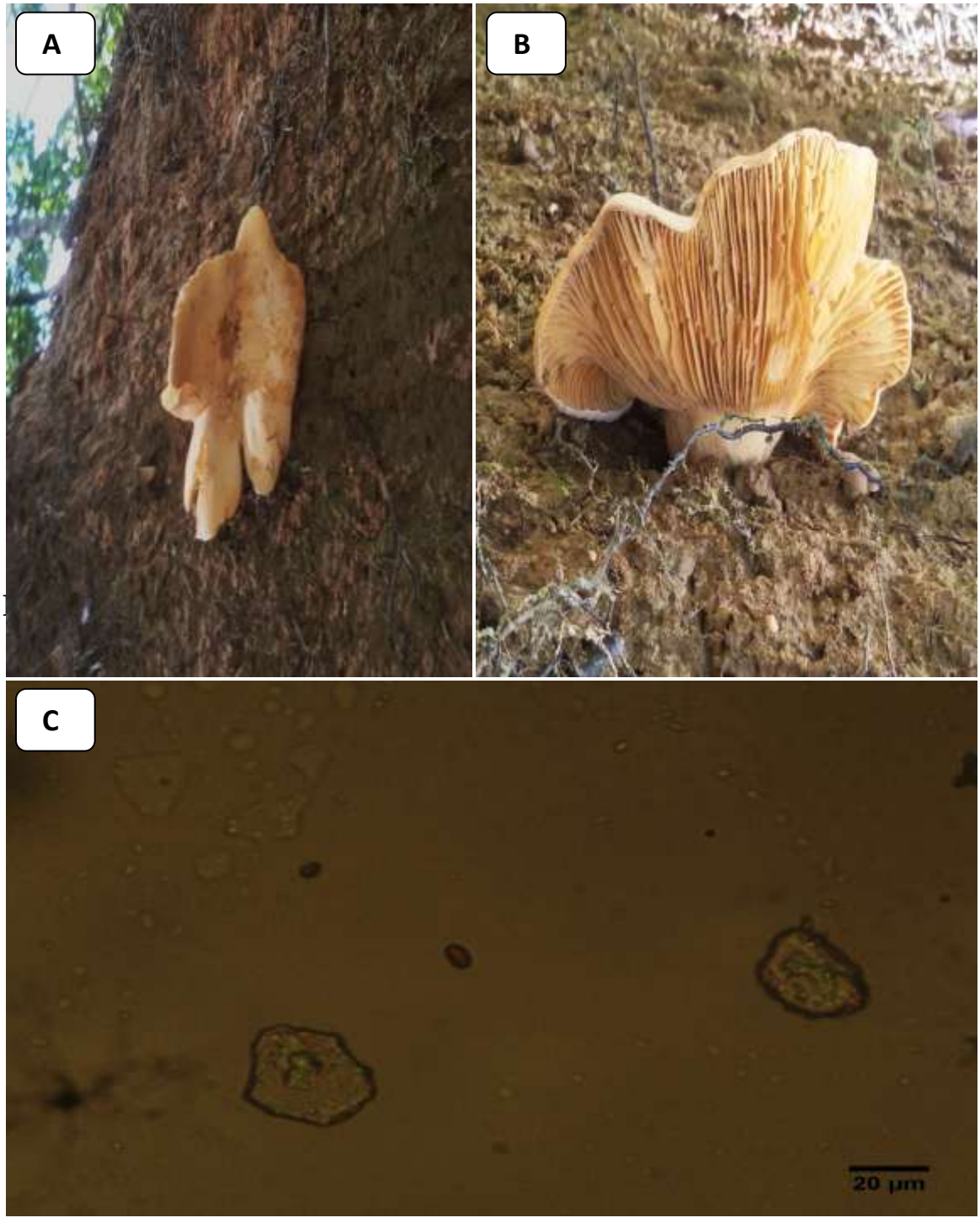
Spore size (Average): Length: 9.2µm; Width: 6.8µm

Spore shape: Moderately thick walled, smooth and ellipsoid, Color: Dark yellow

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to sandy loam; factor affecting their distribution was dry weather. The frequency of its presence was 25% and the density was 4%.

Host : Soil surface



LATE 24. ***Cantharellus subalbidus***; Mature fruiting body (A), Gills (B), Spores (C).

4.16 Morphology and ecology of *Russula* sp.

4.16.1 Scientific Name: ***Russula monspeliensis***

Family: Russulaceae

Morphological features

Pileus shape: Flat and depressed; Color: White

Length: 2.1cm, Width: 1.3 cm

Surface character and zonation: Moderately moist in nature

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gills color: White

Gills spacing: Crowded

Stipe: Present

Spore size (Average): Length: 6.4µm; Width: 5.6µm

Spore shape: Single walled, smooth and round, Color: Light Brown

Ecological features

Habit: Solitary and constancy of occurrence in specific habitat was unabundant. Type of soil was sandy to clay loam; factor affecting their distribution was less moist weather. The frequency of its presence was 12.5% and the density was 4%.

Host : Soil surface.

PLATE 25. ***Russula monspeliensis***; Mature fruiting body (A), Gills (B), Spores (C).

Detailed survey was carried out in eight locations of tropical evergreen and semi-evergreen of Sylhet divisioin (Jaintiapur, Gowainghat, Jaflong, Tilagor Eco Park) and Moulavibazar (Sreemangal, Madhabkundu, Lawachara, Barlekha) of Bangladesh from July to October, 2016 to record the morphological and ecological characteristics of the macrofungi.

During survey, 25 macrofungi species were identified under 15 genera and 13 families. Two species of macrofungi were recorded under Agaricaceae family in Sreemangal and Madhabkundu such as- *Agaricus bernardii* and *Agaricus* sp. from the soil organic matter near tree where the spore color were dark brown and creamy with spore size of 8.6×8.4μm and 17.2×9.3μm, respectively. The findings of the present study was supported by Das *et al*., (2016). They found the spore color of *Agaricus bernardii* as brown and size of spore was 6.4×3.8 μm. This species on the soil surafce from the mangrove forest regions of Bangladesh. The frequencies of *Agaricus bernardii* and *Agaricus* sp.were 12.5, 25% and densities were 8 and 16%, respectively. The species were also reported from tropical moist deciduous forest of Bangladesh which was recorded in association with *Dalbergia sissoo* tree (Rumainul *et al.*,2015).

Two species of *Coprinus* were indentified under Agaricaceae family viz. *Coprinus disseminates* and one unidentified *Coprinus* with the frequency of 25, 12.5% and density of 16, 26.8%, respectively. The spore color were dark brown and creamy with spore size was 8.6×8.4 μm and 17.2×9.3μm, respectively which was collected from Neem (*Azadirachta indica*) tree and also from the soil surface. The findings of the present study was supported

by Das *et al.* (2016). The collected *Coprinus disseminates* with white colored spore and size of spore was 12.3×7.2 µm from the mangrove forest. *Another unidentified Coprinus* sp. *with the frequency of 12.5% and density of 26.8% and the spore color were dark brown and creamy with spore size was 8.6×8.4 µm and 17.2×9.3µm that was unique charateristics which was not supported previous study..*

Four species of *Ganoderma* were found during collection such as- *Ganoderma tsugae, Ganoderma applanatum* and *Ganoderma boninense* from Sylhet division. The frequencies of collected of *Ganoderma* were 37.5, 12.5, 12.5% and the densities were 12, 24, 4%, respectively. The color of *Ganoderma tsugae* was dark brown and white, *Ganoderma applanatum* was dark brown and *Ganoderma boninense* was brick red. The spore size of *Ganoderma* spp. were 13.2×8.9µm, 11.8×8.7µm and 9.2×6.8µm, accordingly. These *Ganoderma* spp. were collected from soil, Mehogani (*Swietenia macrophylla*) and Shimul (*Bombax ceiba)* tree, respectively. The findings of the present study was supported by Das and Aminuzzaman (2017) and Rubina *et al.* (2017). Das *et al*. (2017) reported that the spore of *Ganoderma applanatum* was brown colored. In another study Rubina *et al.* (2017) recorded brown colored spore of *Ganoderma boninense. Ganoderma boninense* was collected from the Bogra social forest (Aminuzzaman and Das, 2016). *Ganoderma* sp. were also found at Rajshahi, Pabna, Jaipurhat, and Dhaka districts of Bangladesh in tropical moist deciduous forest (Rumainul *et al.,* 2015). It was also reported in China (Wang *et al.,* 2012) and in India (Dwivedi *et al.,* 2012; Thiribhuvanamala *et. al.,* 2011; Ram *et al.,* 2010; Cooper *et al.*, 2011; Kinge *et al.*, 2011&2015; Bhosle *et al.,* 2010).

Two species of *Daedaleopsis* found on the Telsur (*Hopea odorata*) and Koroi (*Albizzia procera*) tree such as-*Daedaleopsis confragosa and Daedaleopsis* sp. from Tilagor Eco Park, Lawachara and Jaflong, respectively. The color and spores size were dark brown and white and thespores size were 8.6×5.8µm and 6.2×5.8µm, respectively. The frequencies of *Daedaleopsis* spp. were 25, 12.5% and the densities were 28 and 12%, respectively from soil and the Koroi (*Albizia lebbeck*) tree. The findings of the present study was supported by Rumainul *et al.* (2015) and (Das *et al.*, 2017). *Daedaleopsis confragosa* was previously identified from the mangrove forest (Das *et al.*, 2017) with brown colored spore and spore size were 5.63×4.13µm. This species was also recorded from tropical moist deciduous forest (Rumainul *et al.,* 2015).

One species of *Trametes* sp. was identified from Sissoo (*Dalbergia sissoo*) tree with the frequency 12.5% and density of 36% respectively. The color of spores was dark brown and the spores size were 8.2×6.4µm. The findings of the present study was supported by Das and Aminuzzaman (2017). Das and Aminuzzaman (2017) were reported *Trametes* sp. from the Mangrove forest region of Bangladesh with the average spore size 7.7×4.8µm.

One species of *Volvariella* sp. found in Tilagor Eco Park and Barlekha which spores was dark yellow and Spore size were 14.1×8.4µm. The findings of the present study was supported by Rumainul *et al.* (2015).The spore size of *Volvariella* sp. Was 10.5×10.1 µm. This species was founded in deciduous forest.

Tylopilus rubrobrunneus was collected on the root zone of Neem (*Azadirachta indica*) from Sreemangal and Jaflong with the frequency and density of 25 and 4%, respectively. The spores color was dark brown and black with the size of 12.1×8.7µm. The results of that study was supports with our findings of Tom Murray (2013) where the color of spore was dark brown.

Two species of *Schizophyllum* found such as- *Schizophyllum commune* and unidentified *Schizophyllum* sp. were collected from Sreemangal, Madhabkundu and Jaintiapur. The spores color was brown with the size of 11.6× 9.6µm and 7.6× 7.4µm, respectively. These species were collected from Kala koroi (*Albizia lebbeck*) and Kadam (*Anthocephalus chinensis*) tree, respectively. The findings of the present study was supported by Murray (2013) and Chandulal *et al.* (2013). The *Schizophyllum commune* and unidentified *Schizophyllum* sp. species were also recorded on the Sissoo (*Dalbergia sissoo*) tree by Das *et al.* (2016) from Mangrove forest and deciduous forest (Rumainul *et al.*, 2015) of Bangladesh.

Two species of *Pleurotus* were recorded from Jaintiapur, Tilagor Eco Park and Barlekha such as- *Pleurotus ostreatus* and *Pleurotus populinus* with the frequency of 37.5, 12.5% and density of 36, 12%, respectively. The spores color was dark and light brown with the size of 6.7× 5.6µm and 9.3× 7.8µm, respectively. The result of the present study was supported by Das *et al.* (2017). Previously *Pleurotus* was identified with the brown color of spores by Change *et al.*, (1988). The *Pleurotus ostreatus* was also reported from the Mangrove forest regions of Bangladesh with the frequency and density of

25% and 2.85%, respectively (Das *et al.*, 2016). They found the spore color was brown and hyaline with the average spore size of 5.6 ×4.25µm.

Two species of *Mycena* were collected from Gowainghat, Jaflong and Tilagor Eco Park viz. *Mycena epipterygia* and one unidentified *Mycena* sp. were collected with same frequency (25%). *Mycena epipterygia* was identified form Chatim (*Alstonia scholaris*) tree. The spores color was dark yellow and black with the size of 9.6× 6.8µm and 10.2×8.3µm, respectively. The findings of the present study was supported by Das *et al.* (2016). The *Mycena epipterygia* was previously reported from mangrove forest of Bangladesh with hyaline and brown colored spores where average spore size was 9.01×5.47µm (Das *et al.*,2016). The frequency of its presence was 50% and the density was 56.25% in mangrove forest.

Two xylotrophic macro fungi namely- *Steccherinum ochraceum* and *Steccherinum ciliolatum* were identified on the bark of Mehagani (*Swietenia mahagoni*) and Sissoo (*Dalbergia sissoo*) tree, respectively. The spore color was dark yellow and brown with the size of 14.1×10.2µm and 16.8×14.2µm, respectively. This species was also reported from the mangrove forest of Bangladesh in association with Mehagani (*Swietenia mahagoni*) tree (Das and Aminuzzaman (2017). They found spore color of the species as hyaline with an average spore size of 13.2µm×7.06µm.

Furthermore, one species of *Cortinarius colymbadinus* was found in Tilagor Eco Park and Barlekha on the root zone of Boilam (*Anisoptera scaphula*) with the frequency of 12.5% and the density 12%. The spores color was brown with the size of 8.4×6.2µm. The findings of the present study was supported by Das *et al.* (2016). They reported *Cortinarius semisanguineus*

from mangrove forest of Bangladesh. *Cortinarius corrugates* was also reported at Pathorghata and Dumki in association with *Musa* sp. tree with the brown spore color and size of spore was 6.5-7×5-7µm.

Amanita regalis was found in Sreemangal with the frequency and density of 12.50 and 4%, respectively. The spores color was dark and light brown with the size of 7.8×5.3µm. The result of the present study was supported by Rashid *et al.* (2016). They recorded *Amanita brunnescens* on Sissoo (*Dalbergia sissoo)* tree and both of *A. griseoverrucosa* and *A. vaginata* on coconut (*Cocos nucifera*) tree from southern region of Bangladesh. Another species *Amanita muscaria* was also reported from Bangladesh in tropical moist deciduous forest in association with humus (Rumainul *et al.,* 2015). *Amanita* sp. was also recorded from the mangrove forest (Das *et al.*, 2016) with the frequency and density of 25% and 46.88%, respectively.

Cantharellus subalbidus was collected from Sreemangal and Madhabkundu with the frequency and density of 25 and 4%, respectively. The spores color was dark yellow with the size of 9.2×6.8µm. The findings of the present study was supported by Murray (2013).

In the present study *Russula monspeliensis* was identified from Madhabkundu. The spores color was light brown with the size of 6.4×5.6µm. The frequency of its presence was 12.5% and the density was 4%. The findings of the present study was supported by Rubina *et al.* (2017). They recorded *Russula nobilis* from national botanical garden, Dhaka, Bangladesh in association with kalmegh (*Andrographis paniculata*) where spore size was 4.0 µm x 3.4 µm.

The genus *Russula* sp. was also reported in India (Mohanan, 2011). Pala *et al*. (2012) reported the 7 species of *Russula* in Southern Kashmir Himalayas. Two ectomycorrhizal species of genus *Russula* have been characterized and identified from Kashmir Himalaya using morphanatomical and molecular methods targeting its rDNA (Itoo *et al*., 2013).

CHAPTER V

SUMMARY AND CONCLUSION

There is increasing interest in the mapping of macrofungal flora of many areas to obtain the distribution records similar to those already existing. Experiment was conducted at the Laboratory, Department of Plant Pathology (DPP), Sher-e-Bangla Agricultural University (SAU), Dhaka. A detailed survey was carried out in Sylhet (Jaintiapur, Gowainghat, Jaflong, Tilagor Eco Park) and Moulvibazar (Sreemangal, Madhabkundu, Lawachara, Barlekha) districts of tropical evergreen and semi-evergreen forest regions in Bangladesh to collect and identify macrofungi. Samples were collected during July to October, 2016.

There are 25 species with 15 genera under 13 families. Highest 4 species were found under Ganodermataceae and Agaricaceae family. Three (3) species under Polyporaceae family. There are 2 species under- Schizophyllaceae, Pleurotaceae, Mycenaceae, Steccherinaceae family. Highest frequency was 37.5% for *Ganoderma tsugae*, and *Pleurotus ostreatus*. Highest density was 26.8% for *Coprinus* sp. The predominant families were Ganodermataceae, Agaricaceae, Polyporaceae, Schizophyllaceae, Pleurotaceae, Mycenaceae and Steccherinaceae. Through this survey it can be concluded that tropical evergreen and semi-evergreen forest regions of Bangladesh shows distinct biodiversity and distribution of macrofungal population.

However, the list of macrofungi in this study provides the baseline information needed for the assessment of changes in biological diversity in Sylhet division. It is an important first step towards producing a checklist of macrofungi in Sylhet division of Bangladesh. Through this study we are

reporting the existing biodiversity of macrofungi in this region for the first time.

Further study may be needed to ensure the biodiversity and distribution, edibility or toxicity of macrofungi in Tropical Evergreen and Semi-Evergreen Forest regions of Bangladesh. It is also needed to collect macrofungi in different seasons as well as in different forest regions to identify the new exotic species of macrofungi, which will represent a complete overview about the available macrofungi in Sylhet division of Bangladesh.

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