MORPHOLOGY AND ECOLOGY OF MUSHROOM IN THE TROPICAL EVERGREEN AND SEMI-EVERGREEN FOREST REGIONS OF COX'S BAZAR IN BANGLADESH

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CERTIFICATE

This is to certify that the thesis entitled, **"MORPHOLOGY AND ECOLOGY OF MUSHROOM IN THE TROPICAL EVERGREEN AND SEMI-EVERGREEN FOREST REGIONS OF COX'S BAZAR IN 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 **MD. ATTAUL GUNI** bearing **Registration No. 10-03929** 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.

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MORPHOLOGY AND ECOLOGY OF MUSHROOM IN THE TROPICAL EVERGREEN AND SEMI-EVERGREEN FOREST REGIONS OF COX'S BAZAR IN BANGLADESH

ABSTRACT

BY

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Tropical evergreen and semi-evergreen forest of Cox's Bazar is located in between 21°35′0″N and 92°01′0″E which consists of wide range of wildlife sanctuaries. This forest is the greatest source of diverse macrofungi (Mushroom) species. In a survey program 16 species of mushrooms belongs to 13 genera were identified under 13 families. The dominant families were Auriculariaceae, Agaricaceae, Polyporaceae, Ganodermataceae and Marasmiaceae. The predominant genera were *Auricularia*, *Agaricus*, *Ganoderma*, *Marasmius* and *Trametes*. The maximum frequency (60%) was recorded for *Auricularia auricula* with the density of 25%. The maximum density was 158.33% for *Trametes versicolor*.This is the first detailed investigation on macrofungi in Cox's Bazar forest region of Bangladesh.

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CHAPTER I

INTRODUCTION

Mushroom is a general term used mainly for the fruiting body of the macrofungi (Ascomycota and Basidiomycota) and represents only a short reproductive stage in their life cycle (Das, 2013). They are one of the most diverse groups of organisms on earth, and constitute a significant part of terrestrial ecosystems. They form a large share of the species richness and are key-players in ecosystem processes (Keizer, 1998; Seen-Irlet *et al.*, 2007). Mushrooms are economically important since they serve as food, medicine, bio control agents, chemical producers of bioactive compounds used in the pharmaceutical and many other industries (Duarte *et al.*, 2006). It has been known that several macrofungal species, such as *Trametes versiocolor*, serve as decomposers of organic persistent pollutants (Tran *et al.*, 2010; Tran *et al.*, 2013). Macrofungi are useful in the bioremediation of industrial waste and the accumulation of heavy metals from the environment (Demirbas 2000; Kalac *et al.*, 2004). Lignicolous macrofungi also have secondary metabolites which expressed significant effects such as antibacterial activity (Hur *et al.*, 2004; Kalyoncu *et al.*, 2010). They can also be grown and used as a cash crop (Mandeel and Al-Laith 2007). In spite of their beneficial properties some also have harmful effects on plants.

The term mushrooms or Macromycetes has been variously defined by several authors. All the definitions lay emphasis on the production of fruiting bodies that are visible to the unaided eye (Da Silva,2005; Lodge *et al.*,2004; Redhead,1997; Seen-Irlet *et al.*,2007). According to Da Silva (2005), mushrooms are fleshy conspicuous fungi that have provided food for

millennia and are in many cases associated with potentates and royalty because of their pleasant taste and flavour.

Macrofungi include well-known groups that have been described by popular terms such as ‘gilled fungi’, ‘cup fungi’, ‘bracket fungi’, ‘puffballs’, and ‘truffles’.These terms reflect the morphological diversity that is encountered within the macrofungi. Ecologically, macrofungi can be classified into three groups: the saprophytes, the parasites and the symbiotic (mycorrhizal) species. Most terrestrial macrofungi are saprobes or mycorrhizal symbionts,but some are pathogens of plants or fungi. Macrofungi fruiting on woody substrata are usually either saprobes or plant pathogens (Mueller *et al.,* 2007).

Macrofungi were long considered a strange group of organisms, poorly understood and difficult to study due to their largely hidden nature and frequently sporadic and short-lived sporocarps. Hence they have largely been neglected and overlooked in national and international nature conservation actions. However, through the research our knowledge of macrofungi has significantly increased. It is now largely feasible to evaluate the present status and future for macrofungi species and how human activities such as land management procedures will affect macrofungi diversity (Seen-Irlet *et al.,* 2007).

Mushrooms are widespread in nature and they remain the earliest form of fungi known to mankind (Okhuoya *et al.,* 2010). The issue of fungal diversity, its extent and conservation, has attracted more attention in the last 10 to 15 years than in any period of history (Hawksworth, 2004). Mushrooms appear to be collected and consumed during almost the entire year, but most fungi are collected during the rainy seasons, suggesting the importance of rainfall patterns in fungal phenology (Dijk *et al.,* 2003).

Such is the case in tropical Africa, where many species are found in the rainy seasons, but there are a few species that are present throughout the year (Adekunle and Ajao, 2005; Gbolagade *et al.*, 2006).

However, the slow development of mushroom cultivation practices is changing due to research that have illuminated the potentials of mushroom-forming fungi, mushroom products and their uses in different spheres of human welfare (Wasser, 2007). Given that the forest is the major habitat for macrofungi and other living organisms, there is need for appropriate design of management schemes to safeguard remnants of the tropical rain forest, as a result of rampant deforestation in the tropics due to increasing demand for land for cultivation and illegal logging practices. Effective strategies and solutions to sustainable forest management require taking into account economic and social interests of the forest dwellers as well as understanding of process regulating the functioning of tropical rain forests.

The ecology of organisms is crucial for utilization of resources. With continuous deforestation and environmental degradation, which are contributing to loss in global biodiversity and which in many cases are irrever-sible, there is a risk of loss of macrofungi diversity and subsequent loss of knowledge of their existence and uses. Only about 6.7% of 1.5 million species of fungi estimated in the world have been described and most of these are in temperate regions. The tropical region which is undoubtedly hosting the highest mycodiversity has been inadequately sampled and the mycoflora scarcely documented (Hawksworth, 2001). This makes the situation of macrofungi in the tropical forests unclear (Hawksworth, 2004). However new species are still being identified in the tropics (Douanla-Meli *et al.*, 2007).

Mushroom is one of the promising concepts for crops diversification in Bangladesh as well as the whole world.Keeping this view in mind the present research work was conducted by a systematic survey in Cox's Bazar forest regions of Bangladesh with the following objectives –

1) To study the morphology and ecology of mushrooms in from tropical evergreen and semi-evergreen forest in Cox'x Bazar regions of Bangladesh.

2) To identify the mushrooms up to the genus and species level from tropical evergreen and semi-evergreen forest in Cox'x Bazar regions of Bangladesh.

CHAPTER I I
REVIEW OF LITERATURE

There are four broad categories of forest depending on their location, nature and type of management in Bangladesh such as -tropical moist deciduous forests, mangrove forest, tropical evergreen and semi-evergreen forests and village forests. Among them the mushroom biodiversity of Cox'x Bazar regions are 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 to compile the research work carried out on the subject elsewhere.

Das and Aminuzzaman (2017) studied the largest tidal halophytic forest in the world 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 Polyporaceae, Ganodermataceae, Hymenochaetaceae, Fomitopsidaceae, Xylariaceae, Steccherinaceae and Gloeophyllaceae accordingly. 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) collected macrofungi 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 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 were collected and identified to 21 genera and 32 species. They found 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.

Markson *et al.* (2017) conducted a research and found a total of 80 species of mushroom belonging to 40 families and 55 genera were identified species and varieties spread over in the following genera viz., *Agaricus, Agrocybe, Aleuria, Amanita, Arachnopeziza, Armillaria, Armillariella, Ascocoryne, Atroumbonata, Auricularia, Betula, Bisporella, Boletus, Bonderzewia, Cantharellus, Cerrena, Clitocybe, Coenocybe, Collybia,Coltricia, Coprinellus, Coprinus, Cortinarius, Craterellus, Crepidotus, Cystoderma, Daedaleopsis, Entoloma, Exidia, Fomes, Fomitopsis, Galerina, Ganoderma, Gloeophyllum, Gymnopus, Gyromitra, Hebeloma, Helvella, Hydrochaete, Hygrocybe, Inocybe, Laccaria, Lentinus, Lepiota, Marasmus, Mycena, Omphalotus, Peziza, Pleurotus, Psathyrella, Schizophyllum, Scutellinia, Tapinella*, *Tramates* and *Tyromyces.*

Sharareh *et al.* (2016) reported that the wild mushrooms 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. There was a shortage of information in the literature regarding Iranian wild mushrooms. Thus, this mini-review tries to outline recent efforts made in order to collect, identify, and maintain wild mushrooms of Iran. This review may also encourage more research on collection, assessment, and biochemical analysis of Iranian wild mushrooms in order to establish a germplasm bank of wild mushrooms.

Beuy and Viroj (2016) described Linzhi (*Ganoderma lucidum)* is a well-known medicinal mushroom. 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.

Deepak *et al.* (2016) reported that Mushrooms are well known for their nutritional as well as therapeutic values in worldwide. They have been reported to be the most valuable ones for the human health. Investigations on the therapeutic and nutritional properties of the mushrooms were underway throughout the world. Researchers were providing crucial data on the array of bioactive compounds found within these fascinating fungi. People are now accepting mushrooms more as food and food supplements.

Rahaman *et al.* (2016) surveyed and collected 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%.

Vieira e*t al.* (2016) studied that the 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) investigated mushrooms 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. A total of fifty samples were collected and identified to fourteen genera and twenty four species. The predominant genera were *Ganoderma* sp., *Lepiota* sp., *Marasmius* sp. and *Collybia* sp.

Krishna *et al*. (2015) 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 macrofungi 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*, hosting the highest number of species.

Manna *et al*. (2014) collected 18 mushroom species related to tribal use, the most usable species were *Astraeus hygrometricus, Amanita vaginata* 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 to be the optimum time for the production of 11 wild edible mushrooms. Out of the total calculated production, 47.2% of the same was noted during this time.

Vyas *et al*. (2014) conducted and 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 mushrooms value chain among Benna and Hehe ethnic groups in the Southern Highlands of Tanzania. They collected wild edible mushrooms 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.

Andrew *et al.* (2013) recorded 177 macrofungal species belonging to 83 genera and 38 families were recorded. 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. Six of the 12 morpho-groups identified occurred across the sites, with the gilled fungi being the most frequent. *Cyathus striatus* was found only in Buea Town during the rainy seasons.

Pandey *et al.* (2013) conducted and identified 26 genera belonging to 17 families were collected from six different sites. Out of these maximum six genera assignable to family *Polyporaceae*, five genera to *Russulaceae*, three genera to *Agaricaceae*, two genera to *Ganodermataceae* and *Cantharellaceae*. 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%) during the survey.

Farooq *et al.* (2013) carried out an experiment and found 25 mushroom species belonging to 9 families and 14 genera were identified. Among the collected mushroom species *Agaricus* was found as most dominant genus

(36%) followed by *Innocybe* (12%) in distribution. All the mushroom species exhibited remarkable variation in terms of habitat, season and locations. Ethnological survey revealed that 12 species are edible, 9 inedible and 4 act as poisonous ones.

Chandulal *et al.* (2013) collected 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*, *Coriolus versicolor* (polyporaceae, inedible), *Schizophyllum commune* (Schizophyllaceae, inedible) (the split gill), *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).

Das *et al*. (2013) described 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 micromorphological illustrated descriptions of these species are given along with their taxonomic positions and relations to allied species.

Farid *et al.* (2013) 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) reported a new monotypic genus in the boletaceae, *Borofutus,* typified by *B. dhakanus*, using morphological and molecular evidence. This was 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 and described as description, line drawings, phylogenetic placement and comparison with allied taxa of macrofungi.

Kumar *et al.* (2013) collected young and matured carpophores of 15 wild edible mushroom species from 12 locations in different districts of Nagaland. Out of them, four species belongs to family Agaricaceae, two belongs to Tricholomataceae and rest belongs to Boletaceae, Cantherallaceae, Russulaceae, Sarcoscyphaceae, Auriculariaceae, Polyporaceae, Schizophyllaceae, Pleurotaceae and Lyophyllaceae families.

Shannon (2013) described that 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 in the survey area.

Pushpa and Purushothama (2012) conducted a survey on the biodiversity of mushrooms and collected 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. The Simpson and Sannon diversity biodiversity index was found to be 0.8 and 1.24 respectively during investigation.

Pithak and Pukahute (2012) conducted a survey on the diversity of mushrooms to study the variety of mushrooms grown in the Dry Dipterocarp 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 reveals the presence of a total 34 types of mushrooms 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 macrofungi and reported 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.

Bankole and Adekunle (2012) conducted an experiment on biodiversity of mushrooms and collected *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. of macrofungi in selected locations.

Smith and Thiers (2011) described that fruiting bodies of the genus *Tylopilus* are encountered as large stout bolete mushrooms, 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.

Karwa and Rai (2010) identified a total of 153 species of mushrooms were recorded, collected, photographed and preserved. The enormous biomass in the forest favors variety of edible and medicinal mushrooms. Dominating species belong to genera *Agaricus, Pleurotus, Termitomyces, Cantharellus, Ganoderma, Auricularia, Schizophyllum, Morchella* species of mushrooms.

Hanlon and Harrington (2010) conducted and identified the Agaricomycete species in the Republic of Ireland (ROI) and the records are compared with similar records. 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 recorded according to major taxonomic clades are examined, it is evident that under-recording of Agaricomycete species from the ROI is common throughout all of the clades from the Northern Ireland, England, and Scotland.

CHAPTER I I I

MATERIALS AND METHODS

The samples were collected from Cox's Bazar forest regions at low and high altitudinal ranges during the raining season of Bangladesh. Then the experiment was conducted for the identification at the Laboratory, Department of Plant Pathology (DPP), Sher-e-Bangla Agricultural University (SAU), Dhaka.

Collection sites were Chakaria, Cox's Bazar Sadar, Maheshkhali, Ramu and Teknaf of Cox's Bazar Division of Bangladesh (Figure 1and Table-1) located between 21°35′0″N and 92°01′0″E which consists of three wildlife sanctuaries. Collection site was Cox's Bazar forests region residential area, roadsides and nearby villages of Chakaria, Cox's Bazar Sadar, Maheshkhali, Ramu and Teknaf of Cox's Bazar.Detailed survey was carried out in five Locations such as- Chakaria, Cox's Bazar Sadar, Maheshkhali, Ramu and Teknaf districts of Chittagong in Bangladesh from July to October, 2016, to record the morphological variability in the mushrooms population. The collection was made by method given by Hailing (1996). Each macrofungi species within each transect was collected in separate specimen bags in order to avoid spore contamination among the different specimens and these were photographed in coloured and tagged.

Morphological features such as size, colour, shape and texture of the sporocarp were recorded as these features might change with drying (Srivastava and Bano, 2010). At instances when more than one day was spent in the field, a local portable dryer (oven) was used to dry the specimens while for the closer sampling site, specimens of unidentified macrofungi were transported immediately to the laboratory using baskets and coolers.

They were oven dried at 45°C for 12 to 24 h, depending on the thickness of the specimen and preserved in the refrigerator at 4°C for later identification (Kim, 2004). Identification of specimen was based on macroscopic and microscopic features. The macroscopic features used were: the cap size, shape, colour, surface texture and surface moisture, gill colour, attachment, spacing, lamellules, the stem size, shape, surface texture and surface moisture, the presence or absence of partial and universal veils, flesh colour and texture. Microscopic features were carried out using standard microscopic methods (Roy and De, 1996).

The information of the various characters stated was used to identify each specimen by comparison with illustrations in colour field guides and also by the use of descriptions and keys (Ian *et al.*, 2003; Jordan, 1993; Osemwegie and Okhuoya, 2009; Osemwegie *et al.*, 2010; Roda 2010; Scott, 2006). Final identification and classification were done by following the recorded characteristics of mushrooms 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).

Standard protocols of collection, preservation, macroscopic and microscopic preservations were recorded.Collected mushroom was preserved as dried specimens in the Plant Pathology Laboratory of Sher-e-Bangla Agricultural University.

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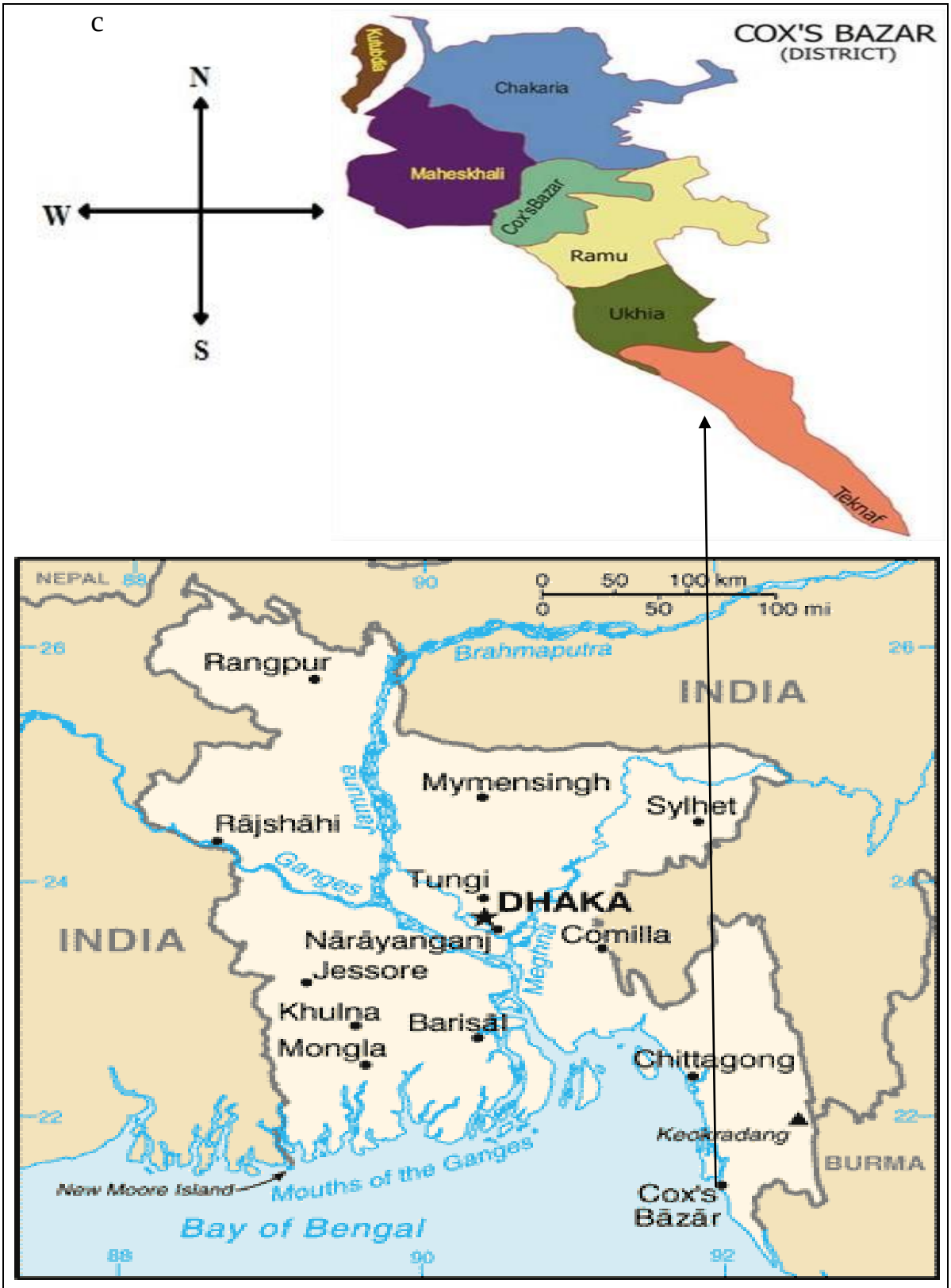


Figure 1 : Survey areas of Cox's Bazar of Bangladesh

Table -1 : Survey areas of Cox's Bazar of Bangladesh

District	Name of surveyed Locations
Cox's Bazar	Chakaria, Cox's Bazar Sadar, Maheshkhali, Ramu and Teknaf
	Locations = 5

The different forests are mixed type of forests are impregnated with decaying wood and rotting plant parts, termites nests, cow dungs, leaf litters, soil surface etc. The specimens were found tightly attached to various substrata even in humus. The surrounding environment temperature, soil pH, moisture condition, vegetation recorded for biodiversity of mushroom. Soil pH, soil moisture were measured by pH meter and air temperature by thermometer during collection period. Soil moisture is usually expressed in units termed pH. The 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

RESULT AND DISCUSSION

4.1 Morphology and Ecology of *Agaricus* sp.

4.1.1 Scientific Name : ***Agaricus augustus***

Common Name : The prince

Family : Agaricaceae

Location : Maheskhali and Chakaria

Morphology

The average size of the basidiocarp was 3.3×2.6cm. The color of pileus (cap) was ash and brown. The shape of cap was convex and flat with the cap edge was round. Beneath the cap hymenophores were absent. Regular shaped black gills (lamellae) were present underside of the cap. Color of stipe was whitish and brownish. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was dark brown and hyaline. The spore shaped were thick walled, smooth, regular and ellipsoidal and average spore size was 8.3 × 4.8µm (Plate-1). The findings of the present study was supported by Das *et al.* (2016). They reported that the spore color of *Agaricus aungustus* was brown and the average spore size was 10.3 × 7.22 µm.

Ecology

Agaricus aungustus was found on the root zone of coconut tree (*Cocos nucifera*).The habit was solitary and constancy of occurrence was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution was and the average temperature was 29.5^0c. The frequency of its presence was 40% and density was 4.17%. But in another study Das *et al*., (2016) found *Agaricus aungustus* on soil surface.

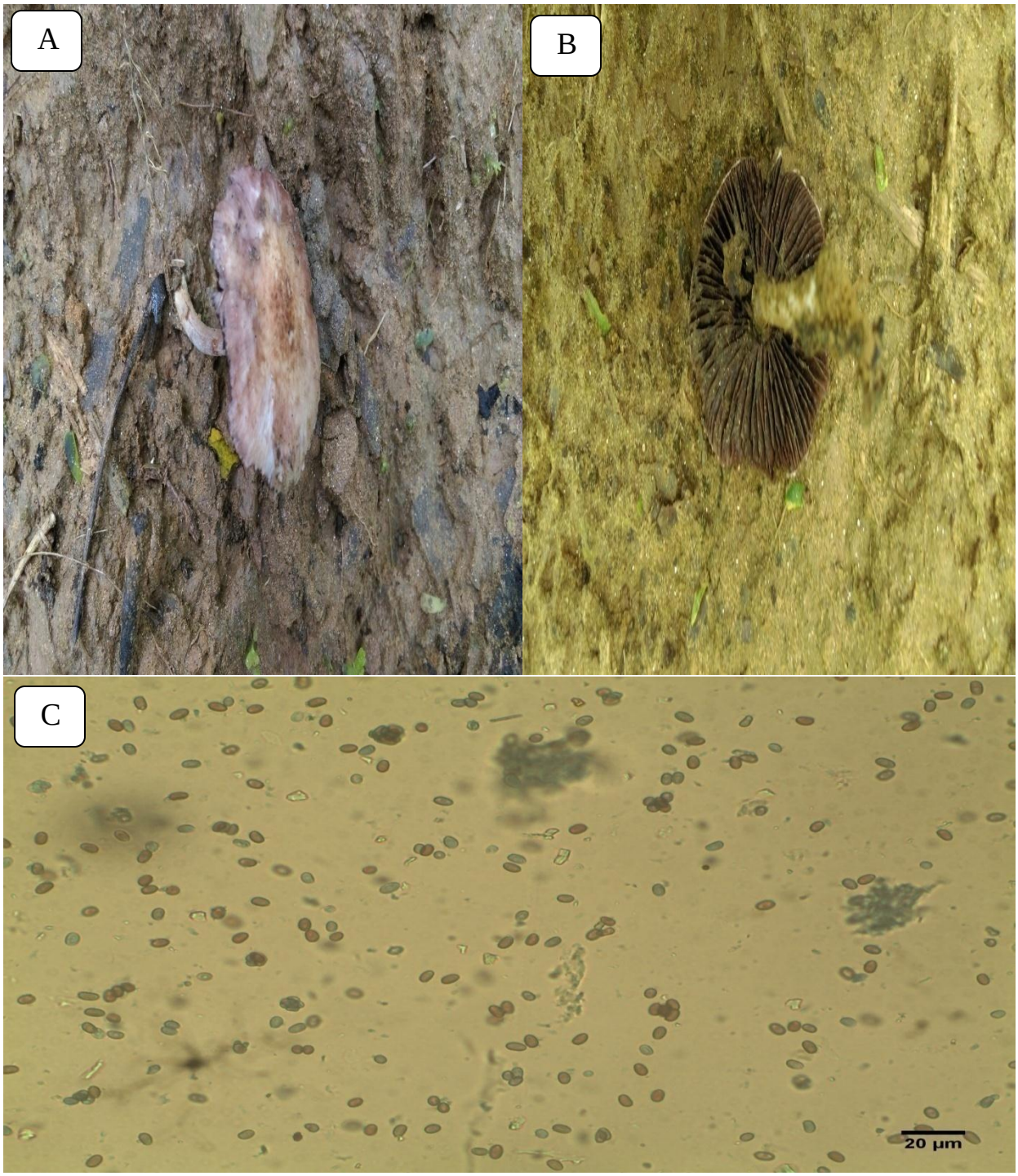


PLATE-1 : ***Agaricus aungustus***; Mature fruiting body (A), Gills (B), Spores (C).

4.1.2 Scientific Name : ***Agaricus tri sulphuratus***

Family : Agaricaceae

Location : Teknaf

Morphology

The average size of the basidiocarp was 3.2×2.4cm. The color of pileus (cap) was deep yellow. The shape of cap was flat and depressed shaped and cap edge was round. Fleshy yellow scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped yellow colored gills (lamellae) were present underside of the cap. Color of stipe was yellowish and brownish. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was dark brown,black. The spores shaped were thick walled, smooth, regular and ellipsoidal shaped and average spore size was 10.3.5 × 7.8µm (Plate-2). The findings of the present study was supported by Murray (2013). He reported that the spore color of *Agaricus tri sulphuratus* was deep brown.

Ecology

The mushroom was on soil and habit was solitary with the constancy of occurrence was un-abundant. Type of soil was sandy loam. The factors affecting their distribution was moderately moist weather and the average temperature was 30.2^0c. The frequency of its presence was 20% and density was 4.17%. The results of the present study corroborates with the findings of Murray (2013). He found *Agaricus augustus* on the soil surface.

PLATE-2 : ***Agaricus tri sulphuratus*** ;Mature fruiting body (A,B), Spores (C).

4.1.3 Scientific Name : ***Agaricus silvicola***

Family : Agaricaceae

Location : Cox's Bazar Sadar

Morphology

The average size of the basidiocarp was 2.8×1.4cm. The color of pileus (cap) was white. The shape of cap was ovate and convex with the cap edge was round smooth. Beneath the cap hymenophores were absent. Regular shaped creamy gills (lamellae) were present underside of the cap. Color of stipe was whitish and and ring or anal was present on the stipe. Spore color was light brown,hyaline and the spore shaped were single walled, smooth, regular and round. The average spore size was 5.3 × 4.6µm (Plate-3). The findings of the present study was supported by Rashid *et al.* (2016). They reported that the spore color of *Agaricus silvicola* was brown and the average spore size was 10-11x7-8 µm. But they found spore color of *Agaricus campestris* was reddish and spore size was 6-7x4.5-5 µm.

Ecology

The mushroom was found on soil besides mehogoni tree (*Swietenia macrophylla*) .The habit was solitary with the constancy of occurrence was un-abundant. Type of soil was sandy loam and the factors affecting their distribution was less moist weather. The frequency of its presence was 20% and density was 4.17%. These species was reported for Bangladesh in tropical moist deciduous forest which was recorded in association with *Dalbergia sissoo* tree (Rumainul *et al.,* 2015) and India (Thiribhuvanamala *et. al.,* 2011; Hansen, 1992).

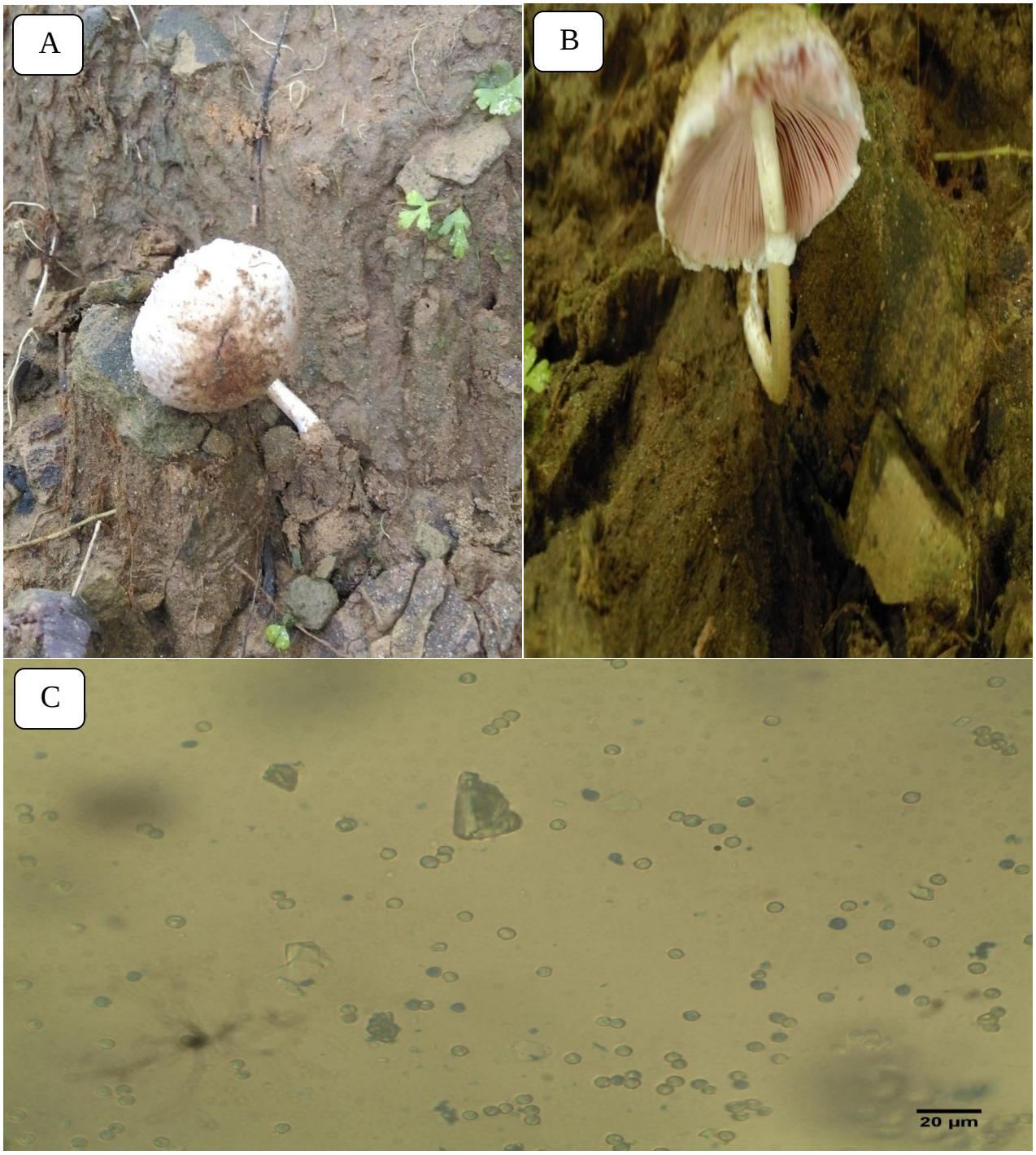


PLATE-3: ***Agaricus silvicola.***; Mature fruiting body (A), Gills (B), Spores (C).

4.2 Morphology and Ecology of *Auricularia* sp.

4.2.1 Scientific Name : ***Auricularia auricula***

Common Name : Jew's ear, wood ear, jelly ear

Family : Auriculariaceae

Location : Chakaria, Cox's Bazar Sadar and Ramu

Morphology

The average size of the basidiocarp was 1.6×1.8cm. The color of pileus (cap) was light brown (young) and brown (mature). The shape of cap was flat and the cap edge was round smooth. Beneath the cap tiny hymenophores were present. The pseudostipe was present under the lower part of the cap. Spore color was dark brown, yellowish and the spore shaped were thick walled, smooth and ellipsoidal. The average spore size was 8.4×3.4µm (Plate-4). The findings of the present study was supported by Das *et al.* (2016). He reported that the spore color of *Auricularia auricula* was brown.

Ecology

The mushroom was found on the bark of rain (*Albizia saman*) tree. Habit was caespitose clustered. The constancy of occurrence was abundant. Type of soil was loamy clay loam around the rain tree. The factors affecting their distribution were moist weather. The frequency of its presence was 60% and density was 25%. The results of the present study corroborates with the findings of Das *et al.* (2016) where they recorded this species in association with rain tree (*Albizia saman*).

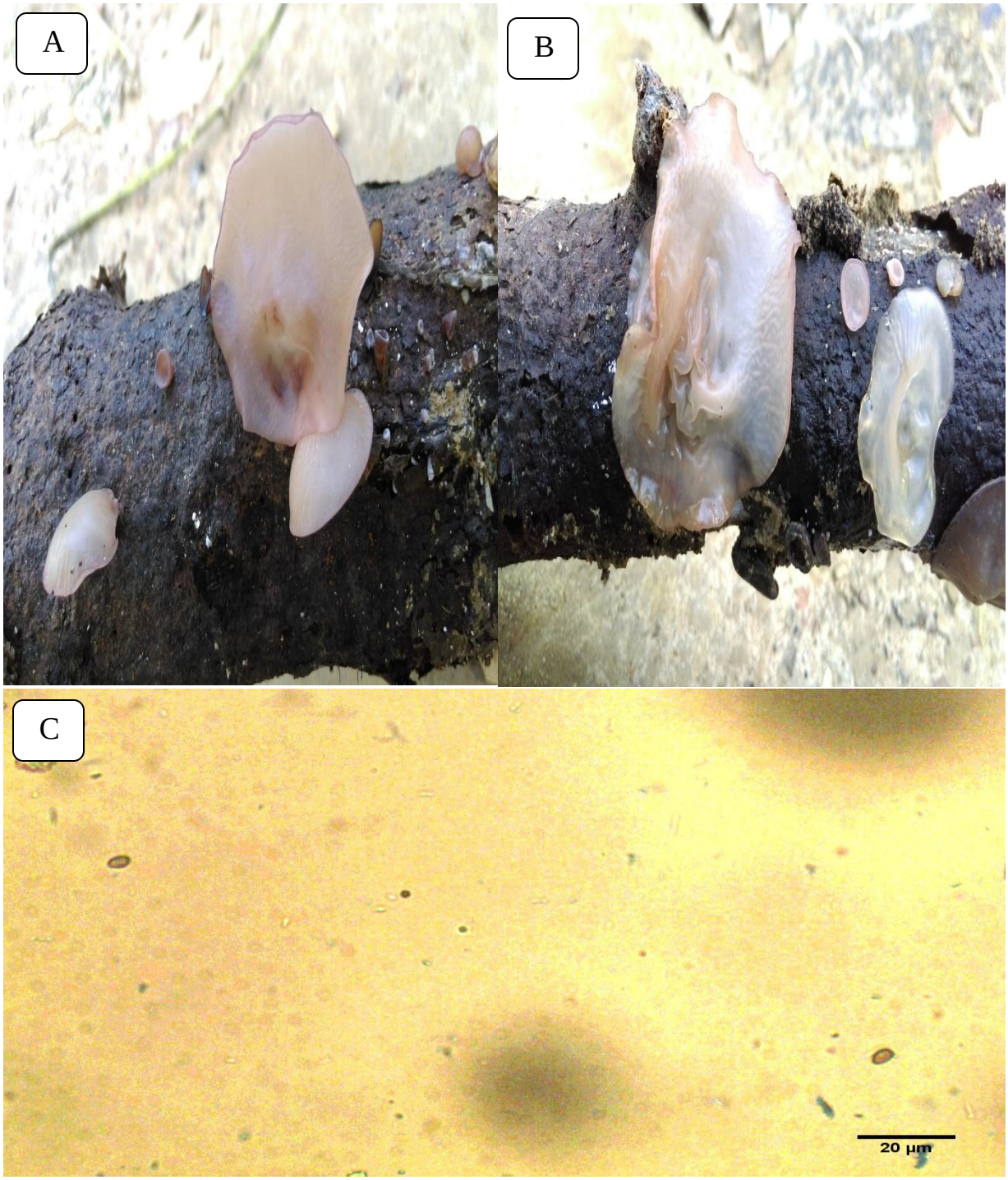


PLATE-4: ***Auricularia auricula***; Mature fruiting body (A,B), Spores (C).

4.2.2 Scientific Name : ***Auricularia cornea***

Common Name : Wood ear or Jews ear

Family : Auriculariaceae

Location : Maheskhali and Ramu

Morphology

The average size of the basidiocarp was 1.0×0.9cm. The color of pileus (cap) was brown (young) to dark brown (mature). The shape of cap was ovate and depressed shaped and cap edge was round smooth. Fleshy white Color scale was found on the cap.The color of gills was dark brown. Color of stipe was whitish and brownish. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was dark brown,black,hyaline,light yellowish, spore shaped were single walled, smooth, regular and ellipsoidal shaped and average spore size was 7.5 × 3.5µm (Plate-5). The findings of the present study was supported by Das *et al.* (2016). They reported that the spore color of *Auricularia cornea* was brown and the average spore size was 6 × 3.92 µm.

Ecology

The mushroom was found on the dead log of Sissoo (*Dalbergia sissoo*). The constancy of occurrence was abundant. Type of soil was loamy clay loam around the root surface of the mushroom. The factors affecting their distribution were moist weather and the average temperature was 18.5^0c. The frequency of its presence was 40% and density was 50%. The results of the present study corroborates with the findings of Das *et al.* (2016) where they recorded this species in association with rain tree (*Albizia saman*).

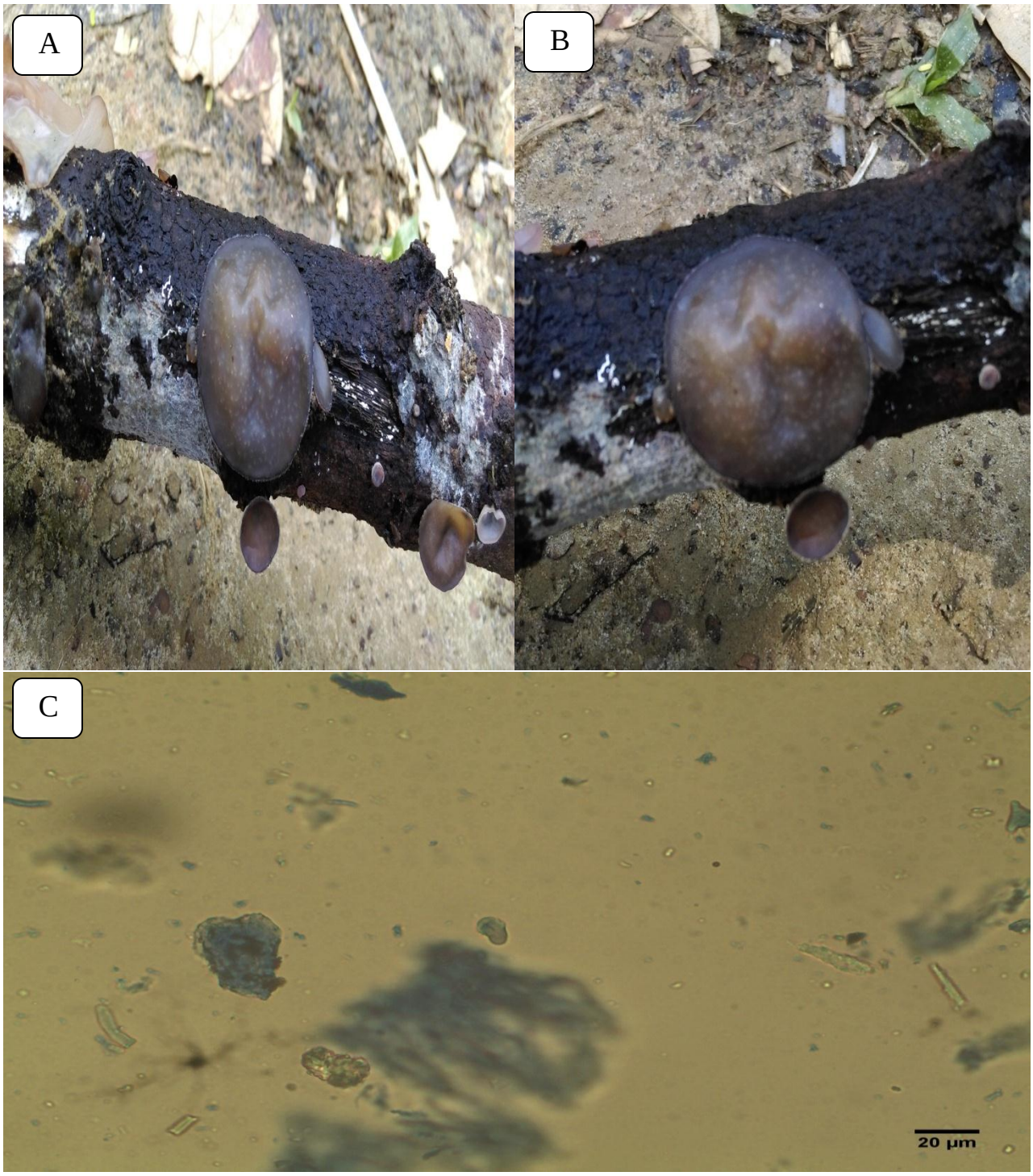


PLATE-5 : ***Auricularia cornea***; Mature fruiting body (A,B), Spores (C).

4.2.4 Scientific Name : ***Auricularia delicata***

Family : Auriculariaceae

Location : Teknaf

Morphology

The average size of the basidiocarp was 1.7×2.6cm. The color of pileus (cap) was deep black. The shape of cap was ovate and depressed shaped and cap edge was round smooth. Beneath the cap tiny hymenophores were present. The pseudostipe was present under the cap. Spore color was dark and the spore shaped were thick walled, smooth and oval. The average spore size was 13.6 × 8.4µm (Plate-6).The results of the present study corroborates with the findings of Das *et al.* (2016).

Ecology

The mushroom was found on the dead log of Mango (*Mangifera indica*) tree. The habit was clustered with the constancy of occurrence of mushroom was abundant. Type of soil was loamy to sandy loam under the root zone of Mango tree. The factors affecting their distribution were less moist weather. The frequency of its presence was 20% and density was 12.50%. The results of the present study corroborates with the findings of Das *et al.* (2016).

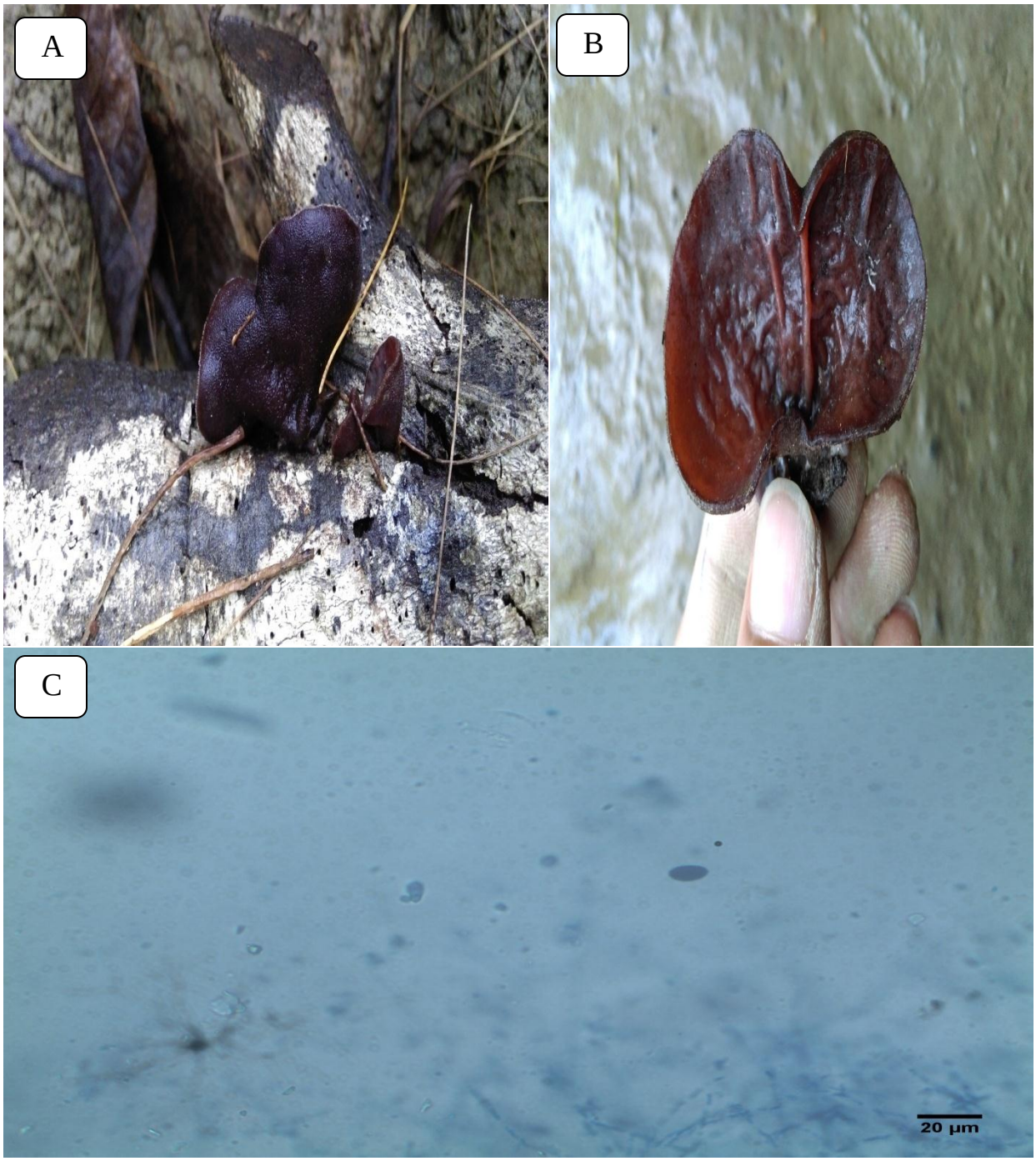


PLATE-6: ***Auricularia delicata***; Mature fruiting body (A,B), Spores (C).

4.2.5 Scientific Name : ***Auricularia* sp.**

Family : Auriculariaceae

Location : Teknaf and Ramu

Morphology

The average size of the basidiocarp was 1.8×2.2cm. The color of pileus (cap) was brown and pink. The shape of cap was flat and the cap edge was wavy. Beneath the cap tiny hymenophores were present. The pseudostipe was present under the cap. Spore color was brown,light yellowish and the spore shaped were thick walled, rough and ellipsoidal. The average spore size was 12.2×6.2µm (Plate-7). The findings of the present study was supported by Murray (2013). where spore color was yellow and brown. He reported that the spore color of *Auricularia* sp. was hyaline and the average spore size was 12-19×4-8 µm.

Ecology

The mushroom species was found on dead branch of Koroi (*Albizia procera*) tree and the habit was scattered. The constancy of occurrence habitat was abundant. Type of soil was loam to clay loam around the collected area. The factors affecting their distribution was less moist weather. The frequency of its presence was 40% and density was 12.50%. The results of the present study corroborates with the findings of Murray (2013). But he found *Auricularia* sp on Sissoo (*Dalbergia sissoo*) tree.

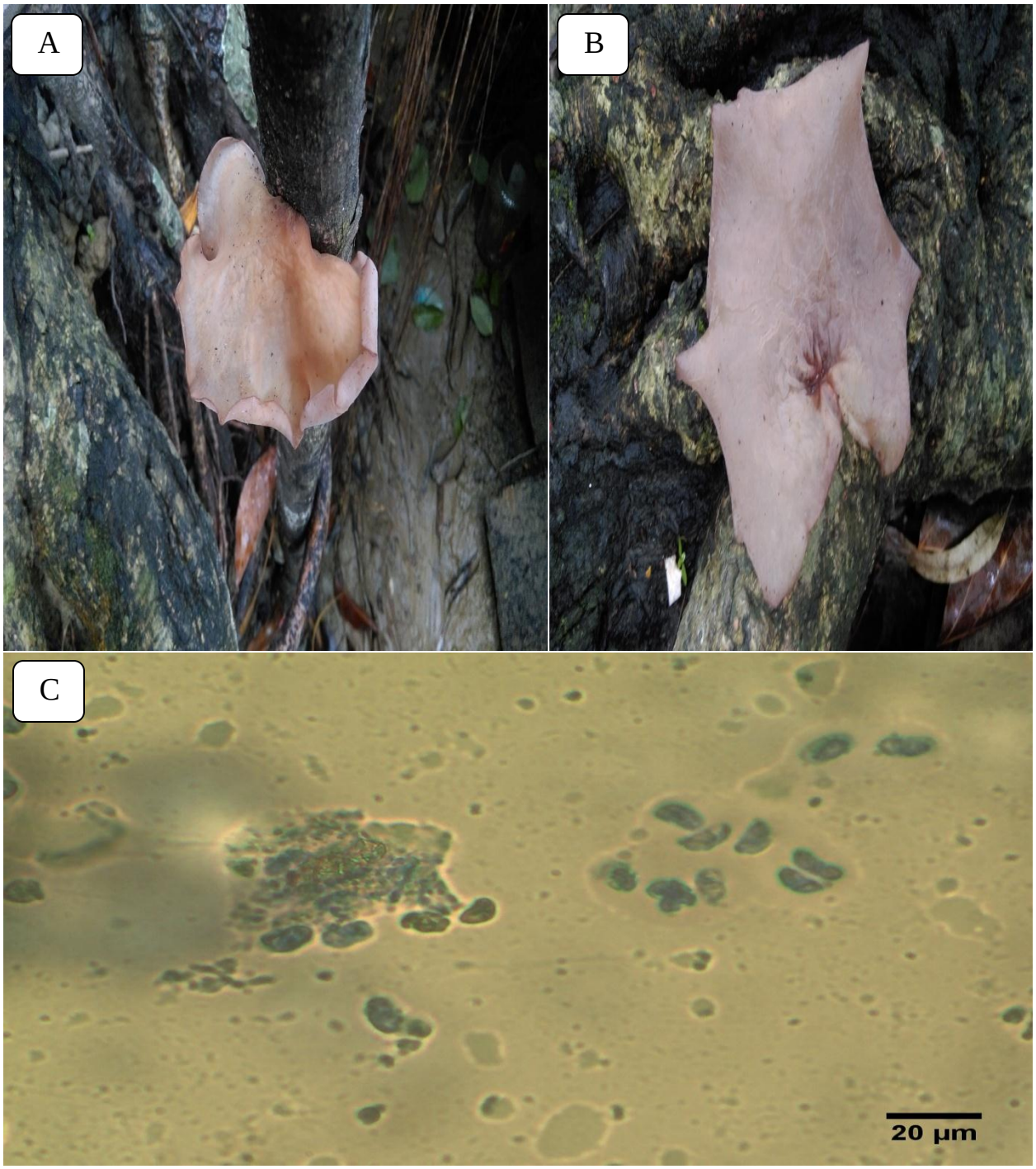


PLATE-7: *Auricularia* sp.; Mature fruiting body (A,B), Spores (C).

4.3. Morphology and Ecology of *Marasmius* sp.

4.3.1 Scientific Name : ***Marasmius nigrodiscus***

Family : Marasmiaceae

Location : Chakaria and Ramu

Morphology

The average size of the basidiocarp was 2.7×1.6cm. The color of pileus (cap) was brown and creamy. The shape of cap was ovate and convex with the cap edge was round but rough. Beneath the cap hymenophores were absent. Regular shaped brown gills (lamellae) and stipe were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was brown, hyaline and spore shaped were single walled, rough, irregular. The average spore size was 6.7 × 5.8µm (Plate-8). The results of the present study corroborates with the findings of Das *et al.,(*2016) and they found the spore color was light brown and spore size was 8.6x5.2 µm.

Ecology

The mushroom was on soil with the mixed of waste materials. The habit was scattered and constancy of occurrence was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution was less moist weather and the average temperature was 30.2^0c. The frequency of its presence was 40% and density was 4.17%. The results of the present study corroborates with the findings of Das *et al.* (2016) . They found *Marasmius nigrodiscus* on Sissoo (*Dalbergia sissoo*) tree.

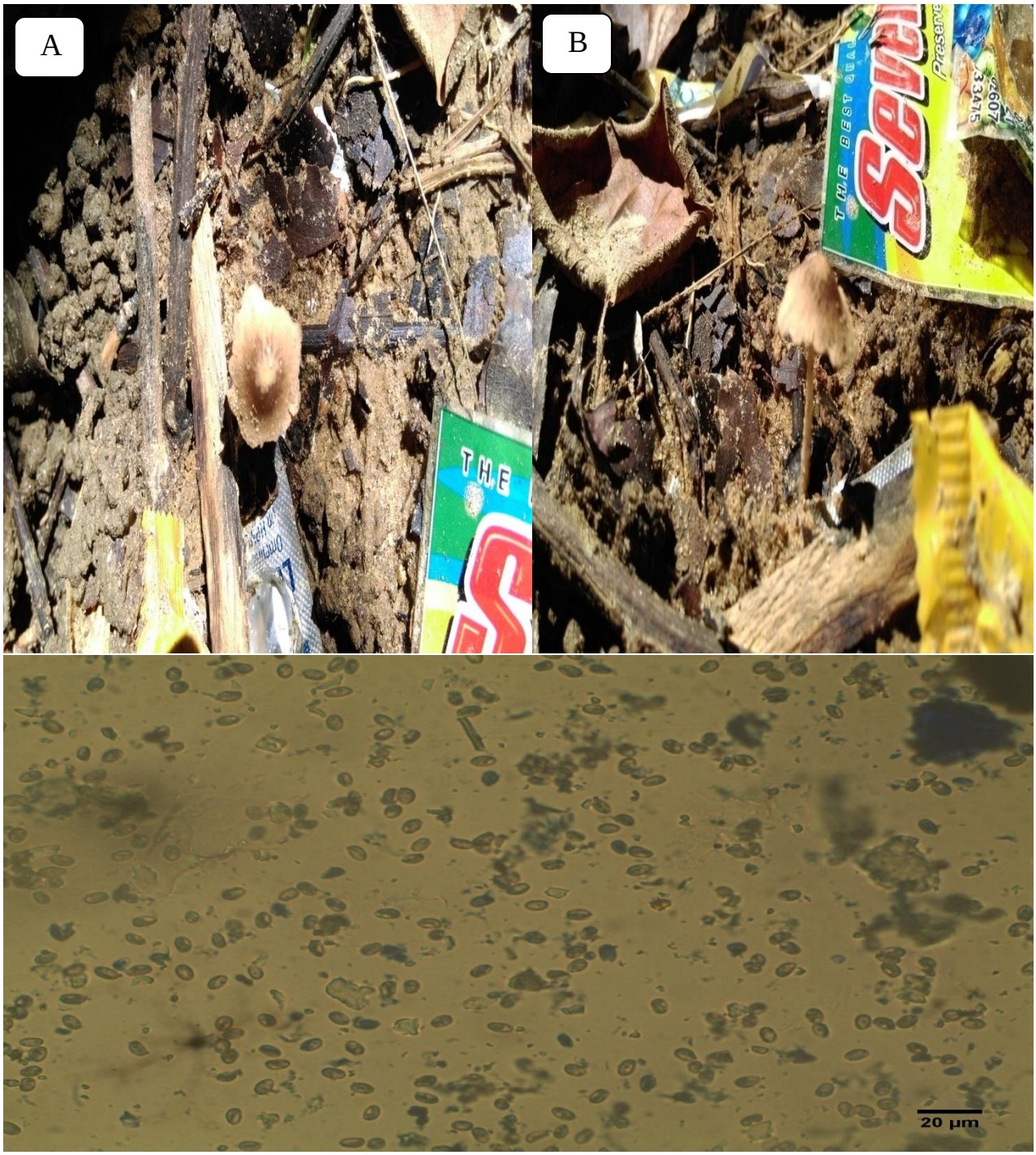


PLATE-8: ***Maramius nigrodiscus***; Mature fruiting body (A),Gills (B),Spores (C).

4.3.2 Scientific Name : ***Marasmius* sp.**

Family : Marasmiaceae

Location : Ramu

Morphology

The average size of the basidiocarp was 1.2×2.1cm. The color of pileus (cap) was brown with the cramy in the centre. The shape of cap was flat and depressed with the cap edge was round wavy. Fleshy brown color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped white gills (lamellae) and short stipe were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was hyaline, light yellowish and the spore shaped were single walled, rough, regular and round. The average spore size was 10.2 × 9.6µm (Plate-9). The findings of the present study was supported by Das *et al.* (2016). They found the spore color of *Marasmius* sp. was brown and the average spore size was 5.25 ×5.18 µm.

Ecology

The mushroom was found on the soil from the unknown tree. The habit was solitary and constancy of occurrence was un-abundant. Type of soil was clay to clay loam. The factors affecting their distribution was moist weather and the average temperature was 28.5^0c. The frequency of its presence was 20% and density was 4.17%. The results of the present study corroborates with the findings of Das *et al.* (2016) and they found *Marasmius* sp. on Sissoo (*Dalbergia sissoo*) tree.

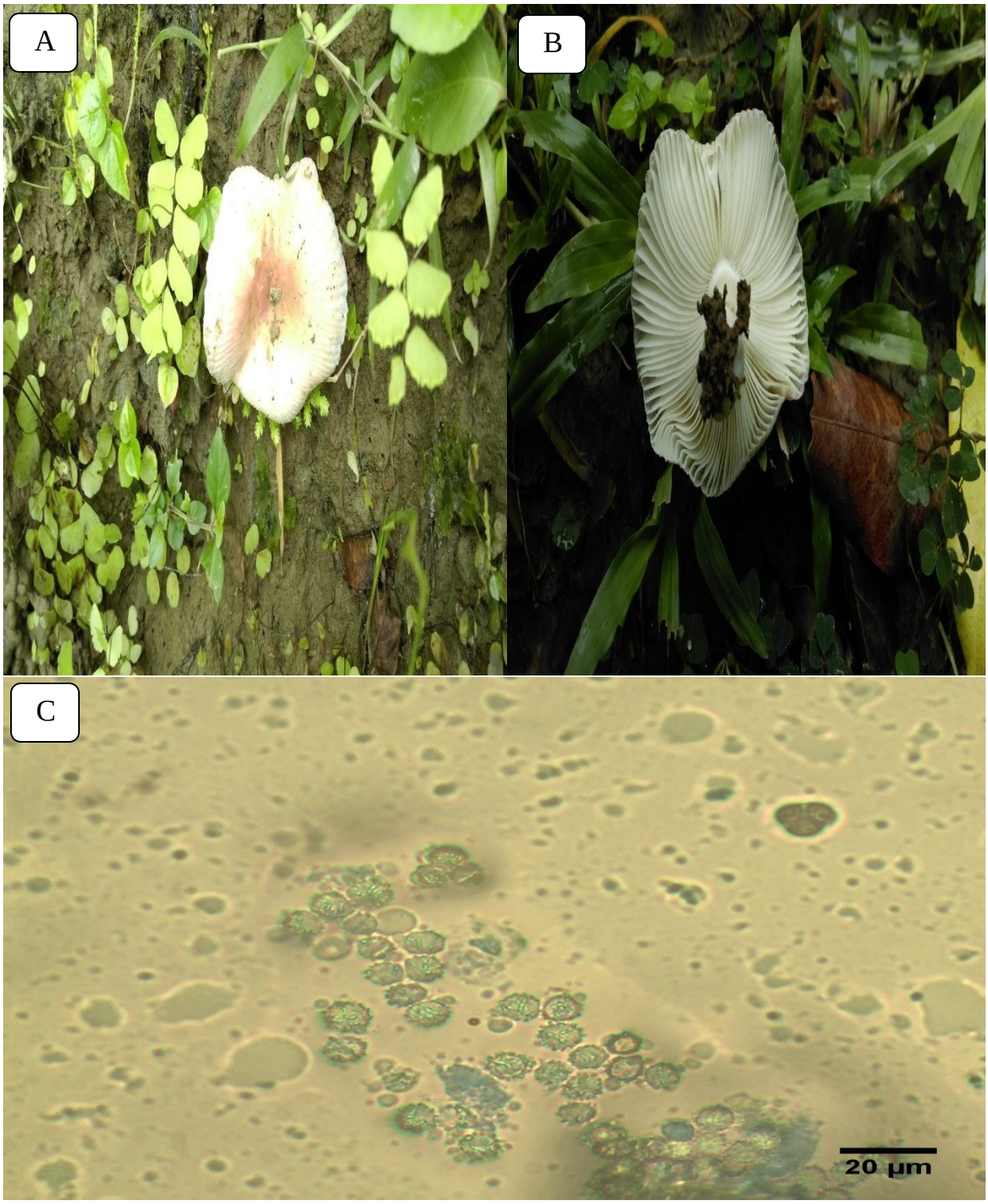


PLATE-9: *Maramius* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.3.3 Scientific Name : ***Maramius* sp.**

Family : Marasmiaceae

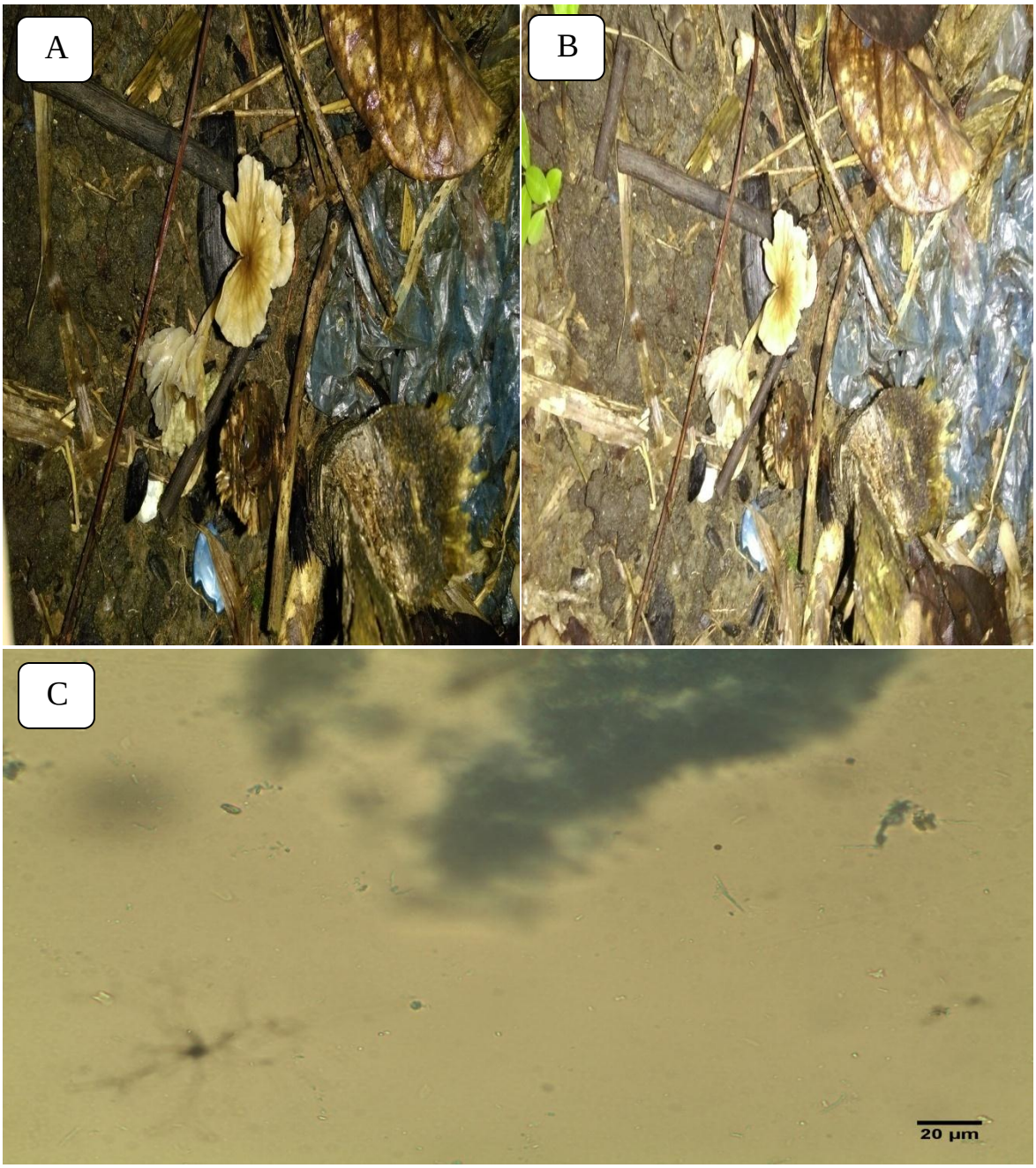
Location : Chakaria

Morphology

The average size of the basidiocarp was 2.1×1.1cm. The color of pileus (cap) was brown. The shape of cap was infundibulliform and depressed and the cap edge was round wavy. Beneath the cap hymenophores were absent. Regular shaped split-gills (lamellae) and pseudostipe were present under the cap. Spore color was ligh brown, hyaline and the spore shaped were single walled, smooth and ellipsoidal. The average spore size was 8.6 × 4.1µm (Plate-10). The findings of the present study was supported by Das *et al.* (2016). They found the spore color of *Maramius* sp. was brown and the average spore size was 5.25×5.18 µm.

Ecology

The mushroom was on the soil with the mixed waste materials. The habit was scattered and the constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was sandy to clay loam around the collected area. The factors affecting their distribution was moist weather and the average temperature was 29.5^0c. The frequency of its presence was 40% and density was 20.83%. The results of the present study corroborates with the findings of Das *et al.* (2016). They recorded this species on Sissoo (*Dalbergia sissoo*) tree.



SPLATE-10: ***Maramius*** **sp.;** Mature fruiting body (A), Gills (B), Spores (C).

4.4 Morphology and Ecology of *Ganoderma* sp.

4.4.1 Scientific Name : ***Ganoderma cupreolaccatum***

Family : Ganodermataceae

Location : Cox's Bazar Sadar

Morphology

The average size of the basidiocarp was 3.1×4.4cm. The color of pileus (cap) was dark black. The shape of cap was flat with the cap edge was round and rough surface. Beneath the cap hymenophores were present. The brown color of pores were under the cap. Spore color was light brown, hyaline and spore shaped were single walled, smooth, regular and round. The average spore size was 7.6 × 3.8µm (Plate-11). The findings of the present study was supported by Wani *et al.* (2012). They found the spore color of *Ganoderma cupreolaccatum* was hyaline.

Ecology

The mushroom was found on the bark on Sissoo (*Delbarzia sissoo*) from tropical forest. The habit was solitary with the constancy of occurrence was un-abundant. Type of soil sandy sandy loam under the root zone of Sissoo tree. The factors affecting their distribution was dry weather and the average temperature was 33.2^0c. The frequency of its presence was 20% and density was 4.17%. The results of the present study corroborates with the findings of Dwivedi *et al.* (2012)ey. They found *Ganoderma cupreolaccatum* with dead logs of unknown tree.

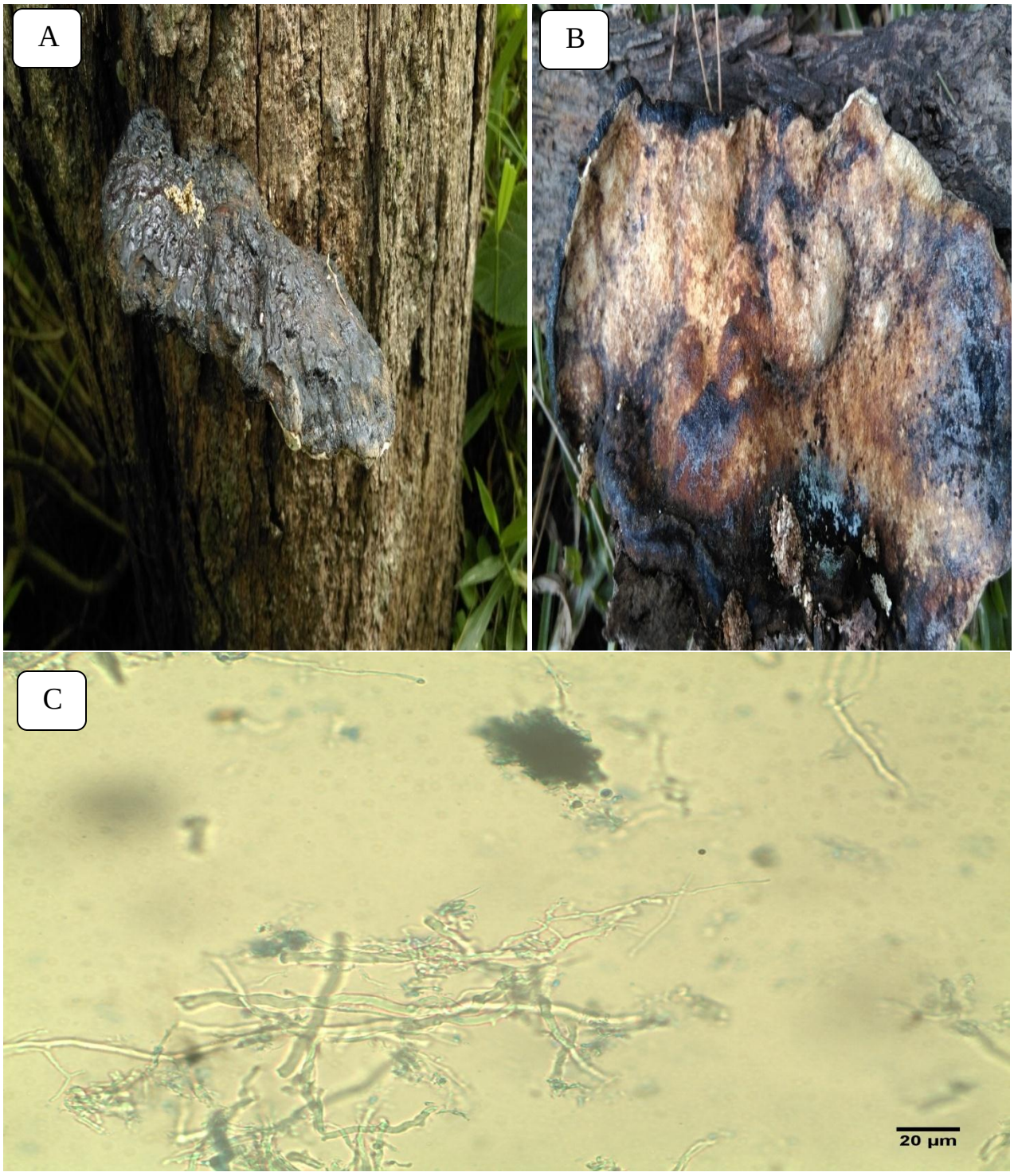


PLATE-12: ***Ganoderma cupreolaccatum***; Mature fruiting body (A), Pores (B), Spores (C).

4.4.2 Scientific Name : ***Ganoderma lucidum***

Common Name : Reishi or Lingzhi

Family : Ganodermataceae

Location : Maheskhali and Teknaf

Morphology

The average size of the basidiocarp was 2.8×4.6cm. The color of pileus (cap) was brick red. The shape of cap was flat with the cap edge was round wavy. Beneath the cap hymenophores were present. The micro pores and long stipe were present underside of the cap. Spore color was dark brown,black,hyaline,light yellowish, spore shaped were single walled, smooth, regular and ellipsoidal shaped and average spore size was 9.3× 3.8µm (Plate-12). The findings of the present study was supported by Aminuzzaman and Das (2016). They found the spore color of *Ganoderma cupreolaccatum* was brown and the average spore size was 9.0 ×5.53 µm.

Ecology

The mushroom was found on the soil surface of the root of Silkoroi (*Albizzia procera*) tree . The habit was solitary with the constancy of occurrence was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution was less moist weather and the average temperature was 30.4^0c. The frequency of its presence was 40% and density was 4.17%. The results of the present study corroborates with the findings of Aminuzzaman, and Das (2016). They found *Ganoderma lucidum* with Sissoo (*Dalbergia sissoo*) tree.

PLATE-12: ***Ganoderma lucidum***; Mature fruiting body (A), Pores (B),Spores (C).

4.4.3 Scientific Name : ***Ganoderma* sp.**

Family : Ganodermataceae

Location : Chakaria

Morphology

The average size of the basidiocarp was 2.2×3.6cm. The color of pileus (cap) was dark brown wiith white round margin at the end of cap. Beneath the cap hymenophores were present. The whitish pores and pseudostipe were present underside of the cap. Spore color was dark brown ,light yellowish and spore shaped were thick walled, smooth and ellipsoidal and the average spore size was 11.2 × 8.4µm (Plate-13). The findings of the present study was supported by Das and Aminuzzaman (2017). They found the spore color of *Ganoderma* sp. was hyaline and brown with the average spore size was 6.2 ×3.9 µm.

Ecology

The mushroom was on the root of Silkoroi (*Albizzia procera*) tree. The habit was solitary with the constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution was less moist weather and the average temperature was 30^0c. The frequency of its presence was 20% and density was 4.17%. The results of the present study corroborates with the findings of Das and Aminuzzaman (2017).

PLATE-13: *Ganoderma* sp.; Mature fruiting body (A), Pores (B), Spores (C).

4.5 Morphology and Ecology of *Trametes* sp.

4.5.1 Scientific Name : ***Trametes versicolor***

Common Name : Turkey tail

Family : Polyporaceae

Location : Chakaria and Cox's Bazar Sadar

Morphology

The average size of the basidiocarp was 1.6×2.8cm. The color of pileus (cap) was light brown to white. The shape of cap was flat with the cap edge was round wavy. Beneath the cap hymenophores were present. The tiny micro pores and pseudostipe were present underside of the cap. Spore color was dark brown ,light yellowish and the spore shaped were thick walled, smooth, regular, oval and ellipsoidal. The average spore size was 10.3× 8.4µm (Plate-14). The findings of the present study was supported by Das and Aminuzzaman (2017) .They found the spore color of *Trametes versicolor* was brown with the average spore size was 6.1µm×4.38µm.

Ecology

The mushroom was found on the Bamboo (*Bambusa vulgaris*) tree from the mixed type forest. The habit was clustered with the constancy of occurrence in specific habitat was abundant. Type of soil was sandy to clay loam. The factors affecting their distribution were moderately moist weather and the average temperature was 29.5^0c. The frequency of its presence was 40% and density was 158.33%. The results of the present study corroborates with the findings of Das and Aminuzzaman (2017). But they found *Trametes versicolor* on the Coconut (*Cocos nucifera*) tree.

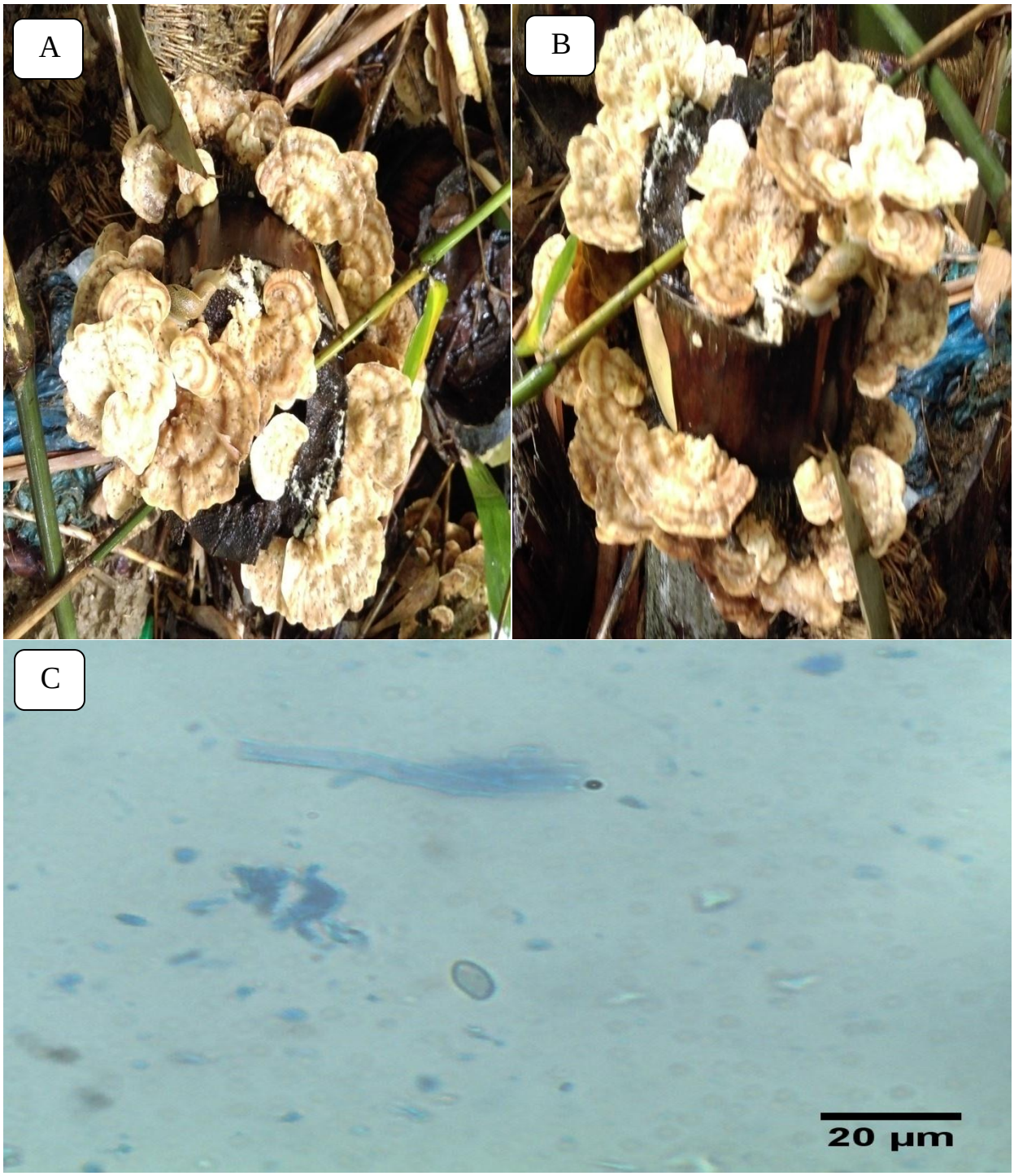


PLATE-14: ***Trametes versicolor***; Mature fruiting body (A,B), Spores (C).

4.5.2 Scientific Name : ***Trametes* sp.**

Family : Polyporaceae

Location : Maheskhali

Morphology

The average size of the basidiocarp was 2.8×3.2cm. The color of pileus (cap) was white to brown. The shape of cap was flat with the cap edge was round wavy. Beneath the cap hymenophores were present. The miro pores and psudostipe were present underside of the cap. Spore color was ligh brown, hyaline and spore shaped were single walled, rough, irrregular and round. The average spore size was 6.8 × 3.6µm (Plate-15). The findings of the present study was supported by Das and Aminuzzaman (2017). They found brown color spore of *Trametes* sp. with the average spore size of 7.7µm×4.8µm.

Ecology

The mushroom was found on the root zone of Sissoo (*Delbarzia sissoo*)tree. The habit was clustered with the constancy of occurrence of a particular mushroom in specific habitat was abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution were less moist weather and the average temperature was 30.2^0c. The frequency of its presence was 50% and density was 8.33%. In a previous study Das and Aminuzzaman (2017) found this fungus on soil surface.

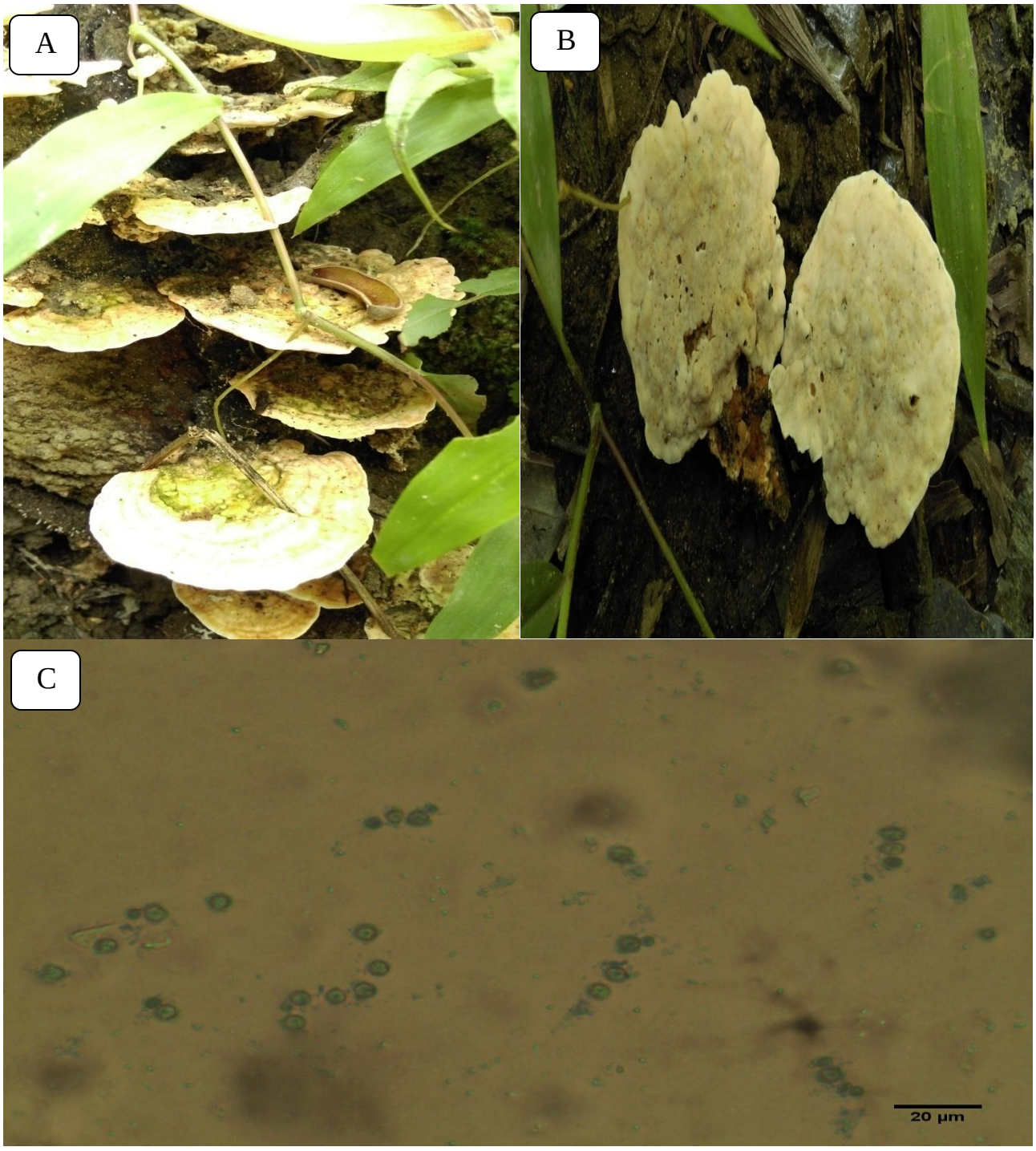


PLATE-15: *Trametes* sp.; Mature fruiting body (A), Pores (B), Spores (C).

4.6 Morphology and Ecology of *Pleurotus* sp.

4.6.1 Scientific Name : ***Pleurotus ostreatus***

Common Name : Oyster mushroom

Family : Pleurotaceae

Location : Chakaria and Teknaf

Morphology

The average size of the basidiocarp was 3.2×1.6cm. The color of pileus (cap) was milky white. Fleshy white color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped white gills (lamellae) and pseudostipe were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was light brown, hyaline and the spore shaped were single walled and ellipsoidal and the average spore size was 12.3× 4.6µm (Plate-16). The findings of the present study was supported by Change *et al.* (1988). They found the spore color of *Pleurotus ostreatus* as brown and red with average spore size of 8.3 × 4.2 µm.

Ecology

The mushroom was found on root zone of Banana (*Musa sapientum) tree.* The habit was clustered with the constancy of occurrence in specific habitat was abundant. Type of soil was clay to clay loam. The factors affecting their distribution was moist weather and the average temperature was 29.6^0c. The frequency of its presence was 40% and density was 8.33%. The results of the present study corroborates with the findings of Change *et al.* (1988). They found *Pleurotus ostreatus* with dead wood of rain (*Albizia saman*) tree.

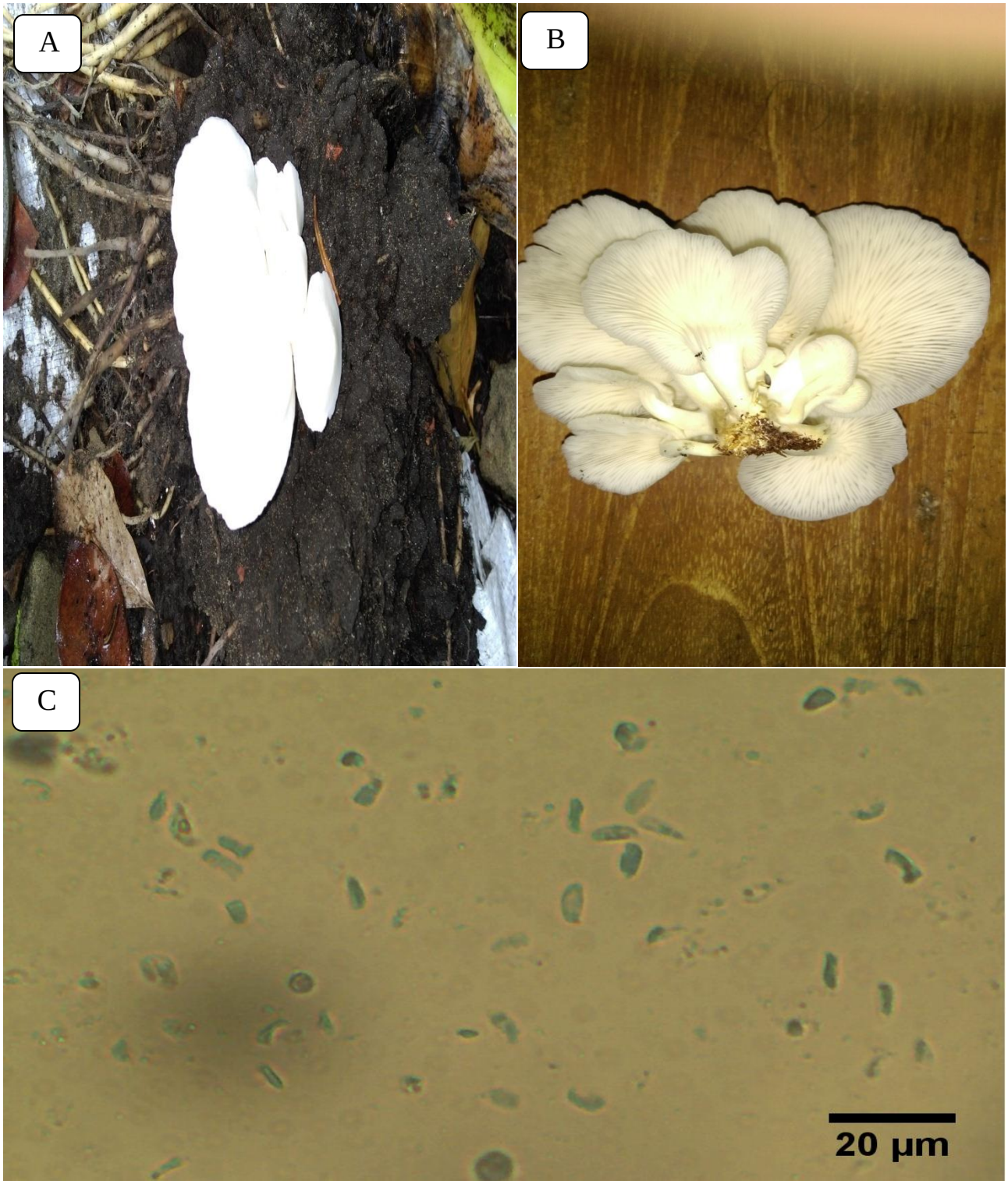


PLATE-16: ***Pleurotus ostreatus***; Mature fruiting body (A), Gills (B), Spores (C).

4.7 Morphology and Ecology of *Russula* sp.

4.7.1 Scientific Name : ***Russula emetica***

Common Name : The sickener

Family : Russulaceae

Location : Maheskhali

Morphology

The average size of the basidiocarp was 1.3×2.4cm. The color of pileus (cap) was red. The shape of cap was depressed with the cap edge was round smooth. Beneath the cap hymenophores were absent. Fleshy brown and milky white color distant gills and stipe were presentunder the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was slight blue and the spore shaped were thick walled, rough, regular and round. The average spore size was 9.2×8.4µm (Plate-17). The findings of the present study was supported by Pala *et al.* (2012). They found brown and blue colored spore of *Russula emetica*.

Ecology

The mushroom was collected on soil surface of the rain (*Albizia saman*) tree. The habit was solitary with the constancy of occurrence habitat was un-abundant. Type of soil was loam to sandy loam. The factors affecting their distribution was moderately moist weather and the average temperature was 28.5^0c. The frequency of its presence was 20% and density was 4.17%. In the previous study Pala *et al.* (2012) collected this species from soil surface.

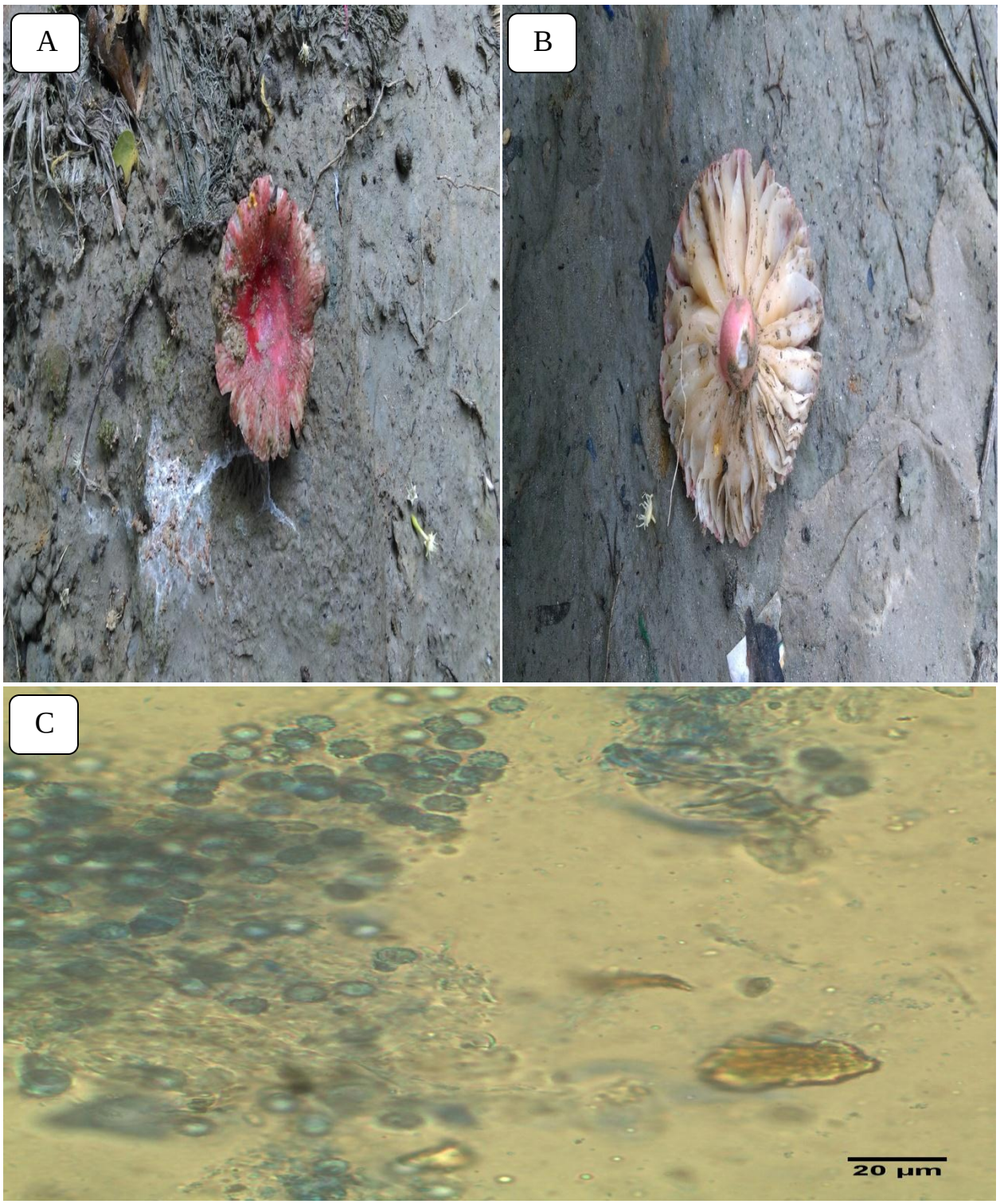


PLATE-17: ***Russula emetica***; Mature fruiting body (A), Gills (B), Spores (C).

4.8 Morphology and Ecology of *Cortinarius* sp.

4.8.1 Scientific Name : ***Cortinarius vibratilis***

Family : Cortinariaceae

Location : Ramu

Morphology

The average size of the basidiocarp was 1.6×1.2cm. The color of pileus (cap) was yellow. The shape of cap was convex with the cap edge was round smooth. Fleshy regular shaped gills (lamellae) and stipe were present underside of the cap.The color of gills was dark brown. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was dark brown, light yellowish and the spore shaped were thick walled, smooth, regular and ellipsoidal shaped and average spore size was 10.2×3.8µm (Plate-18). The findings of the present study was supported by Das *et al.*, 2016 and Rashid, 2013. They found the spore color of *Cortinarius vibratilis* was light yellow with the average spore size was 8.2 × 4.8 µm.

Ecology

The mushroom was collected on the root zone of Mehagani (*Swietenia mahagoni*) from the forest. The habit was solitary with the constancy of occurrence of habitat was un-abundant. Type of soil was sandy to clay loam. The factors affecting their distribution was moist weather and the average temperature was 28.5^0c. The frequency of its presence was 20% and density was 8.33%. The results of the present study corroborates with the findings of Das *et al.* (2016) where they recorded this fungus in association with root zone of Date palm (*Phoenix sylvestris*) tree.

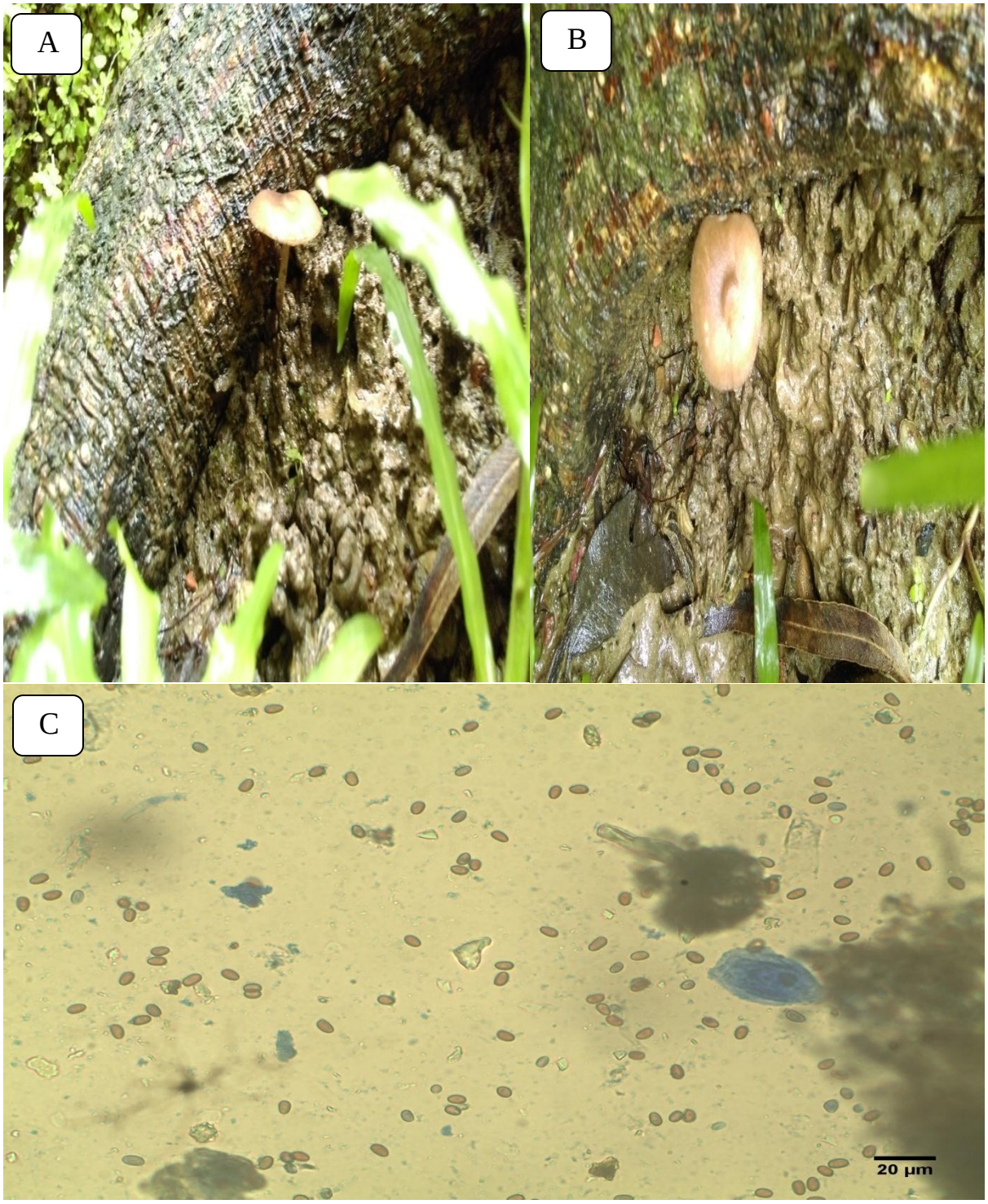


PLATE-18: ***Cortinarius vibratilis***; Mature fruiting body (A, B), Spores (C).

4.9 Morphology and Ecology of *Steccherinum* sp.

4.9.1 Scientific Name : ***Steccherinum ochraceum***

Common Name : Ochre spreading tooth.

Family : Steccherinaceae

Location : Cox's Bazar Sadar and Ramu

Morphology

The average size of the basidiocarp was 2.8×4.6cm. The color of pileus (cap) was white to brown. The shape of cap was flat cap edge was round wavy. Beneath the cap hymenophores were absent. Regular shaped light brown teeth (lamellae) were present underside of the cap. Spore color was dark brown, hyaline and spore shaped were single walled, irregular and round and the average spore size was 5.6 × 3.8µm (Plate-19). The findings of the present study was supported by Das and Aminuzzaman (2017). They found the spore color of *Steccherinum ochraceum* hyaline with the average spore size of 13.2µm×7.06µm.

Ecology

The mushroom was collected on the root zone of Mehagani (*Swietenia mahagoni*) from the mixed type of forest. The habit was solitary with the constancy of occurrence habitat was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution were moist weather and the average temperature was 30.2^0c. The frequency of its presence was 40% and density was 4.17%. The results of the present study corroborates with the findings of Das and Aminuzzaman (2017) where they recorded this fungus in association with Mehagoni (*Swietenia mahagoni*) tree.

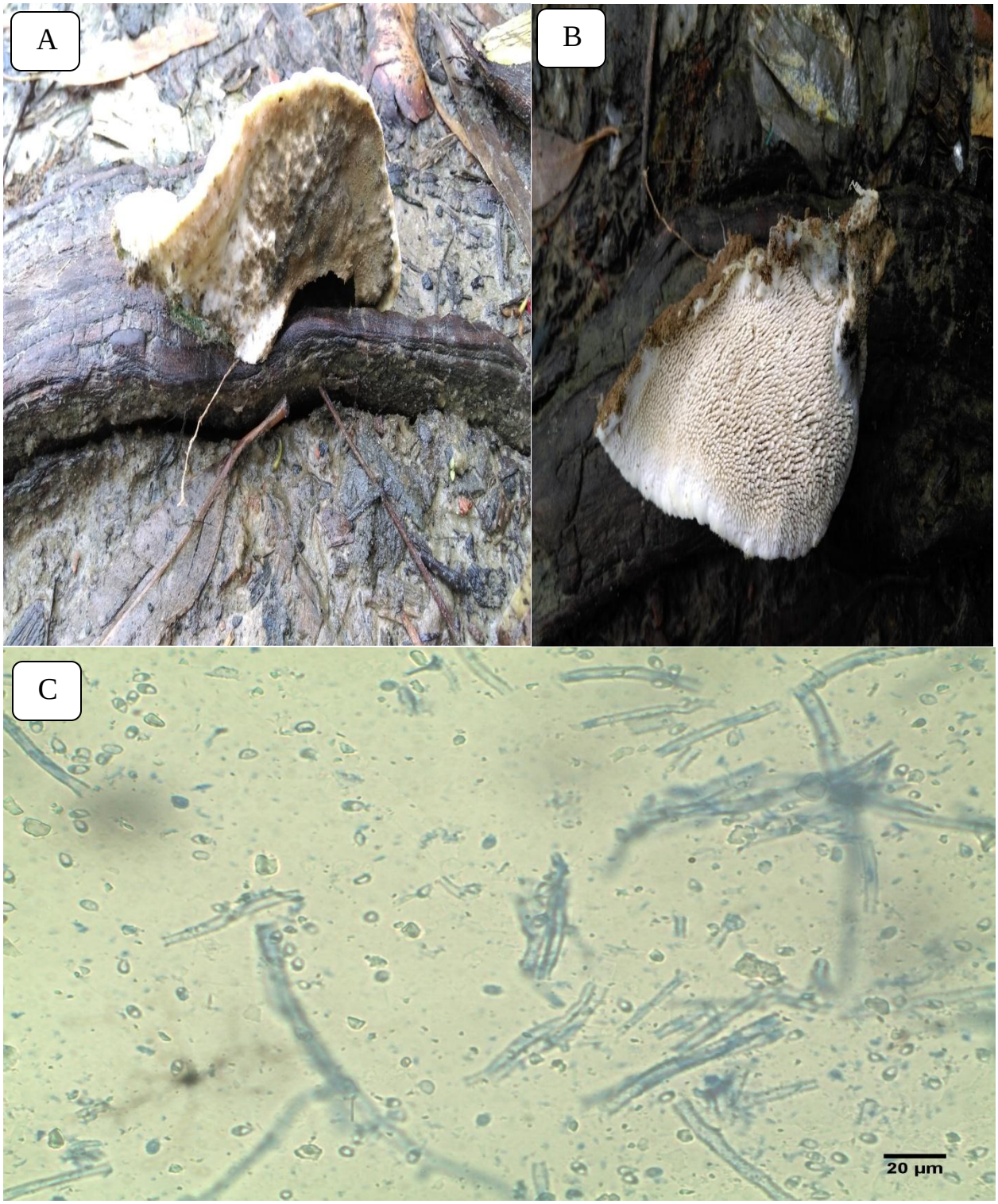


PLATE-19: ***Steccherinum ochraceum***; Mature fruiting body (A), Teeth (B), Spores (C).

4.10 Morphology and Ecology of *Armillaria* sp.

4.10.1 Scientific Name : ***Armillaria* sp.**

Family : Physalacriaceae

Location : Teknaf

Morphology

The average size of the basidiocarp was 4.4×2.5cm. The color of pileus (cap) was light brown to white. The shape of cap was depressed with the cap edge was round smooth. Beneath the cap hymenophores were absent. Regular shaped brow distant gills (lamellae) and long stipe were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was dark brown, light yellowish and spore shaped were thick walled, smooth, regular and ellipsoidal. The average spore size was 16.2×10.6.5µm (Plate-20).

Ecology

The mushroom was found on the soil surface with the mixture of humus from the mixed type of forest. The habit was solitary with the constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution was less moist weather and the average temperature was $30,5^0$c. The frequency of its presence was 20% and density was 4.17%.

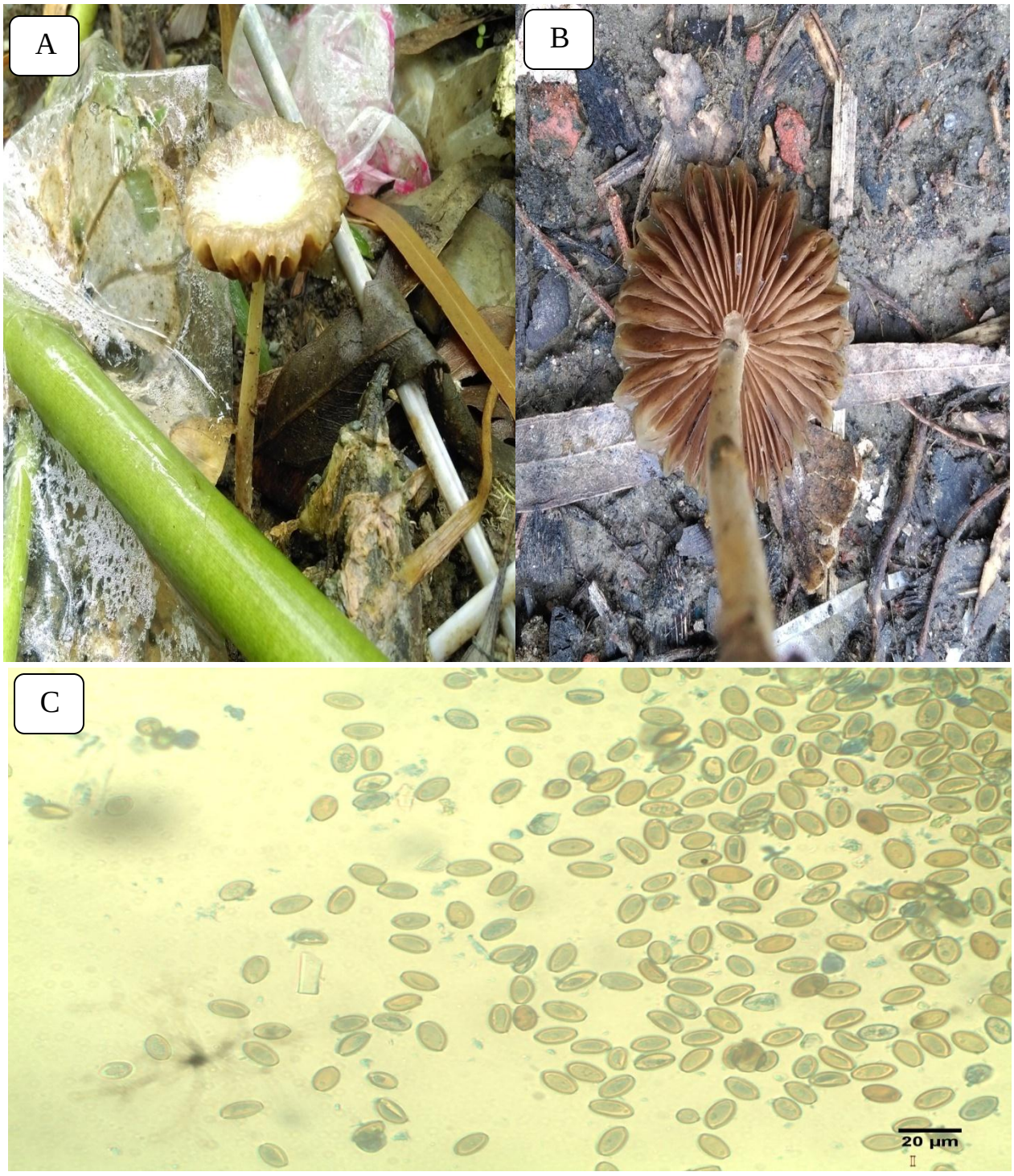


PLATE-20: *Armillaria* sp.; Mature fruiting body (A), Gills (B), Spores (C).

4.11 Morphology and Ecology of *Crepidotus* sp.

4.11.1 Scientific Name : ***Crepidotus applanatus***

Common Name : Oysterling Mushroom

Family : Crepidotaceae

Location : Chakaria

Morphology

The average size of the basidiocarp was 1.8×1.6cm. The color of pileus (cap) was white. The shape of cap was ovate with the cap edge was round smooth. Fleshy white Color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped white gills (lamellae) and short stipe were present underside of the cap. Spore color was brown, hyaline and the spore shaped were single walled, smooth, irregular and the average spore size was 8.7 × 3.6µm (Plate-21). The findings of the present study was supported by Das *et al.* (2016). They found the spore color of *Crepidotus applanatus* hyaline with the average spore size was 6.95× 6.65 µm.

Ecology

The mushroom was found on the soil surface from the mixed type of forest. The habit was scattered with the constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was sandy to clay loam. The factors affecting their distribution was less moist weather and the average temperature was 31.5^0c. The frequency of its presence was 20% and density was 20.8%. The results of the present study corroborates with the findings of Das *et al.* (2016). They recorded the fungus in association with the bark of rain (*Albizia saman*) tree.

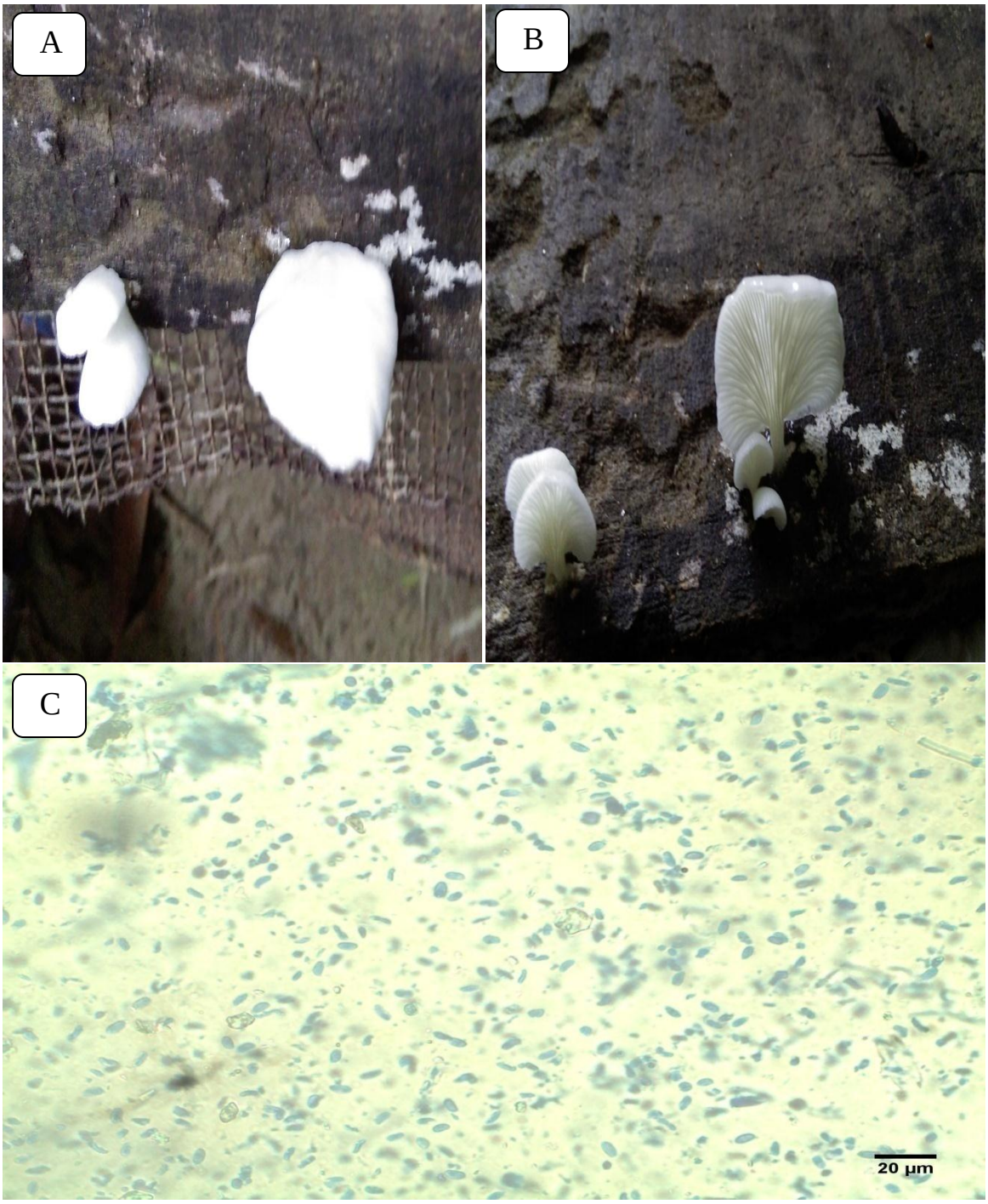


PLATE-21: ***Crepidotus applanatus***; Mature fruiting body (A), Gills (B), Spores (C).

4.12 Morphology and Ecology of *Inonotus* sp.

4.12.1 Scientific Name : ***Inonotus hispidus***

Common Name : Shaggy Bracket

Family : Hymenochaetaceae

Location : Ramu

Morphology

The average size of the basidiocarp was 1.6×1.9cm. The color of pileus (cap) was brown to pink. The shape of cap was flat with the cap edge was round smooth. Beneath the cap hymenophores were present. The micro pores were present underside of the cap. Spore color was Brownish to yellow and the spore shaped were thick walled, rough, irregular and ellipsoidal shaped and average spore size was 13.2 × 6.4µm (Plate-22). The findings of the present study was supported by Das and Aminuzzaman (2017). They found the spore color of *Inonotus hispidus* light yellow with the average spore size was 7.45× 4.45µm.

Ecology

The mushroom was found on the dead log of Gamer (*Gmelina arborea*) tree. The habit was solitary with the constancy of occurrence of habitat was un-abundant. Type of soil was sandy to sandy loam. The factors affecting their distribution was dry weather and the average temperature was 33.2^0c. The frequency of its presence was 20% and density was 4.17%. The results of the present study corroborates with the findings Das and Aminuzzaman (2017). They recorded this fungus in association with the Goran (*Ceriops decandra*) tree.

PLATE-21: *Inonotus hispidus*; Mature fruiting body (A,B), Spores (C).

4.12.2 Scientific Name : ***Inonotus cuticularis***

Common Name : Samtporling

Family : Hymenochaetaceae

Location : Cox's Bazar Sadar and Teknaf

Morphology

The average size of the basidiocarp was 3.4×4.8cm. The color of pileus (cap) was milky white ot brown. The shape of cap was flat with the cap edge was round wavy. Beneath the cap hymenophores were present. The tiny teeth were present underside of the cap. Spore color was dark brown, light yellowish and the spore shaped were thick walled, rough, irregular and ellipsoidal. The average spore size was 9.2 × 6.1µm (Plate-23). The findings of the present study was supported by Das and Aminuzzaman (2017). They found the spore color of *Inonotus* sp. was hyaline with the average spore size was 8.0µm×5.17µm.

Ecology

The mushroom was found on the root of Bamboo (*Bambusa vulgaris*)tree. The habit was clustered and constancy of occurrence of soil was sandy to clay loam. The factors affecting their distribution was moist weather and the average temperature was 29.5^0c. The frequency of its presence was 40% and density was 12.5%. The results of the present study corroborates with the findings of Das and Aminuzzaman (2017) where they recorded this fungus associated with the Bamboo (*Bambusa vulgaris*) tree.

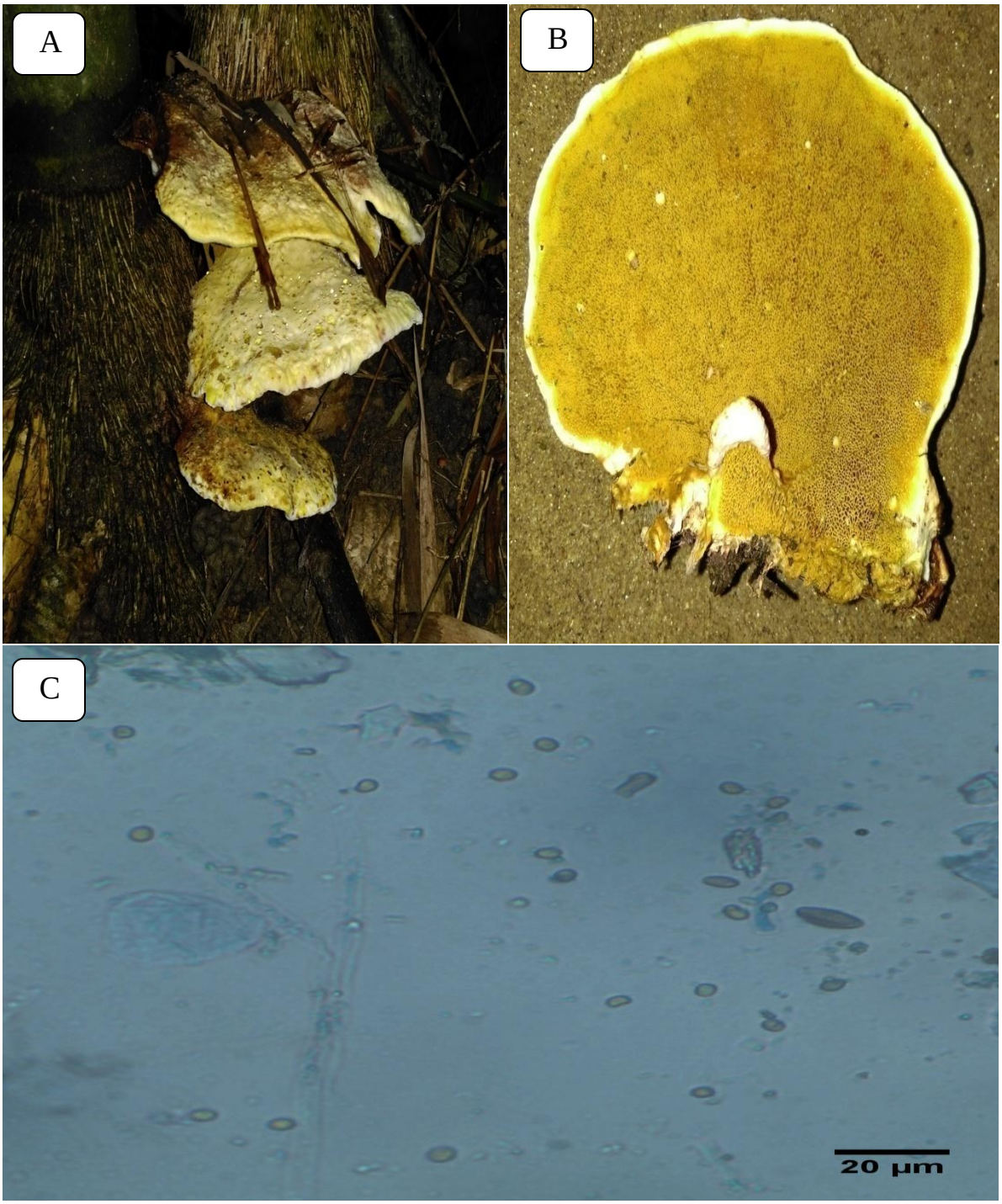


PLATE-23: ***Inonotus cuticularis***;Mature fruiting body (A), Teeth (B), Spores (C).

4.13 Morphology and Ecology of *Amanita* sp.

4.13.1 Scientific Name : ***Amanita sp.***

Family : Amanitaceae

Location : Maheskhali

Morphology

The average size of the basidiocarp was 2.4×0.8cm. The color of pileus (cap) was dark brick red. The shape of cap was ovate with the cap edge was round smooth. Powdery substance was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) anad stipe were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was dark brown,blackand the spore shaped were thick walled, smooth, regular and oval. The average spore size was 10.1×7.8µm (Plate-24). The findings of the present study was supported by Das *at al.* (2016). They found the spore color of *Amanita* sp. brown with the average spore size was 7.2×4.6 µm.

Ecology

The mushroom was found on the soil surface of Bamboo (*Bambusa vulgaris*) tree. The habit was solitary with the constancy of was un-abundant. Type of soil was sandy and the factors affecting their distribution was moderately moist weather. The frequency of its presence was 20% and density was 4.17%. The results of the present study corroborates with the findings of Das *at al.* (2016) where they collected *Amanita* sp.from the soil surface.

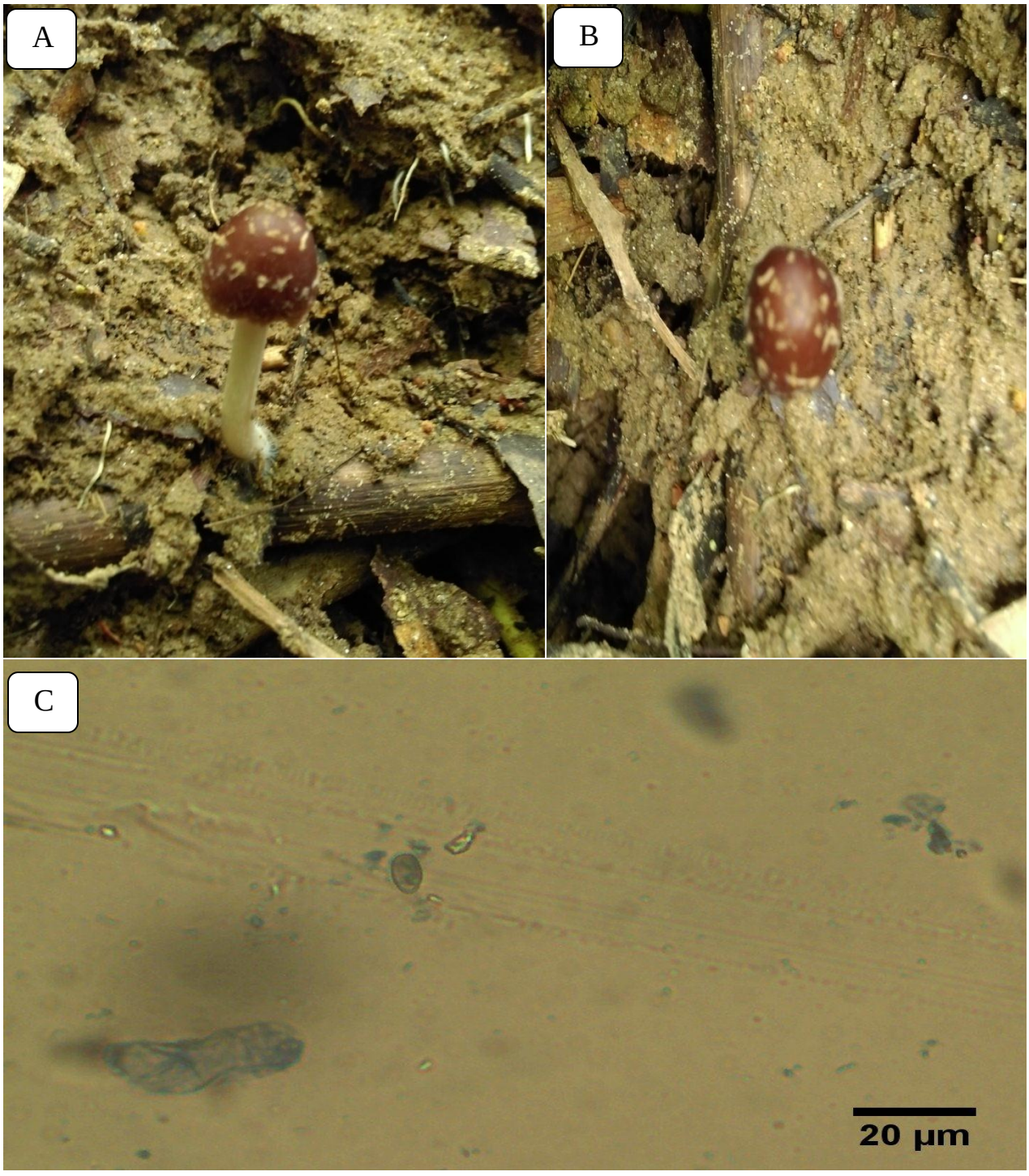


PLATE-24: *Amanita* sp.; Mature fruiting body (A,B), Spores (C).

Detailed survey was carried out in five locations of Cox's Bazar (Chakaria, Cox's Bazar Sadar, Maheshkhali, Ramu and Teknaf) of Bangladesh from July to October, 2016 to record the morphological variability, ecology and biodiversity of the mushrooms population.

During investigation, 24 mushrooms species were found under 13 families. Three species of mushrooms were recorded under Agaricaceae family in Chakaria, Maheshkhali, Ramu and Teknaf) of Cox's Bazar in Bangladesh . Two species of Agaricus viz- *Agaricus tri sulphuratus, Agaricus aungustus and Agaricus* sp. were identified with the frequency of 20, 40, 20% and density of 4.17, 4.17 and 4.17%, respectively. *Agaricus aungustus* was recently identified from the mangrove forest region of Bangladesh (Das *et al.*, 2016). And these species were also reported for Bangladesh in tropical moist deciduous forest which was recorded in associated with *Dalbergia sissoo* tree (Rumainul *et al.,* 2015) and India (Mohanan, 2011; Thiribhuvanamala *et. al.,* 2011; Hansen, 1992).

The highest number of mushrooms was found under the Auriculariaceae family. Four species of *Auricularia* were collected from the Cox's Bazar such as- *Auricularia auricula, Auricularia cornea, Auricularia delicata* and *Auricularia* sp..The highest frequency was found for *Auricularia auricula* of 60% and then 40% for *Auricularia cornea with the 25 and 50%, respectively. Auricularia delicata* and *Auricularia* sp. were indentified with the frequency of 20, 40% and density of 45.83, 12.5%, respectively. *Auricularia cornea* was found in mangrove forest recently (Das *et al*., 2016).

Three species were collected under the family of Marasmiaceae viz- *Maramius nigrodiscus, Maramius* sp. and calculated the frequency and density of40, 20% and density of 4.17% for all species. Recently, a research was conducted by Das *et al.* (2016) and they identified both the species of under Marasmiaceae family. But this

species was also reported for Bangladesh in tropical moist deciduous forest at Dhaka (Rumainul *et al.*, 2015) and (Islam, 2013, Kirk *et al.*, 2008). Even it was also reported in madagascar as well as the Mascarenes (Antonin and Buyck, 2006).

Three species of *Ganoderma* were found during collection such as- *Ganoderma cupreolaccatum, Ganoderma lucidum and Ganoderma* sp. from the Cox's bazaar, Teknaf and Maheskhali. The frequency and density were calculated and found that the highest frequency among the *Ganoderma* was 40% for *Ganoderma lucidum* and 20% for rest of the species. *Ganoderma lucidum* and *Ganoderma* sp. were identified from the Mangrove forest (Das and Aminuzzaman, 2017) and Bogra social forest (Aminuzzaman and Das, 2016). *Ganoderma* sp. was also found at Rajshahi, Pabna, Jaipurhat, and Dhaka districts of Bangladesh in tropical moist deciduous forest (Rumainul *et al.,* 2015). It was also reported from 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). On the other hand, *Ganoderma* sp. was also reported in India (Bhosle *et al.*, 2010).

Two species of *Trametes* such as- *Trametes ochracea and Trametes* sp. were collected from Chakaria, Cox's Bazar Sadar and Maheskhali with the frequency 40, 8.33% and density of 158.33, 50% respectively. The highest frequency was found for *Trametes ochracea* of 158.33%. Das and Aminuzzaman (2017) reported *Trametes* sp. from the Mangrove forest region of Bangladesh.

One species of *Pleurotus ostreatus* was identified from the Chakaria and Teknaf with the frequency and density of 40% and 8.33%, respectively. Previously, *Pleurotus* was identified by Change *et al.*, 1988. Recently this species was identified by Das *et al.* (2016) form the Mangrove forest regions of Bangladesh.

One species of *Russula* was detected from the Maheshkhali region of Cox's Bazar with the frequency and density of 20 and 4.17% respectively. 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. Even two ectomycorrhizal species of genus *Russula* have been characterized and identified from Kashmir Himalaya using morphanatomical and molecular methods targeting its r DNA (Itoo *et al.*, 2013).

Two species of mushrooms under the family of Hymenochaetaceae viz- *Innonotus dryadeus* and *Steccherium ochraceum* were collected from the dominant Koroi (*Albizzia procera*), *Chapalish tree* (*Artocarpus chaplasha*) tree with the same frequency of 11.11and density of 2.78%, respectively.

Furthermore, one species of *Cortinarius* was found from the forest region of Ramu such as- *Cortinarius vibratilis* on the root zone of Mehagani (*Swietenia mahagoni*). *Cortinarius* also identified by Kallol *et al.* (2016) form the Mangrove forest. This species was also reported at Pathorghata in association with *Musa* sp. tree (Rashid, 2013).

The xylotrophic macro fungi namely- *Steccherinum ochraceum* was identified from the forest region of Ramu and Cox's Bazar Sadar on the dead root log of Mehagani (*Swietenia mahagoni*) from the mixed type of forest. This species was also reported by Das and Aminuzzaman (2017) from the mangrove forest.

One species of *Armillaria* was collected from the Teknaf of Cox's Bazar with the frequency and density of 20 and 4.17% respectively. No *Armillaria* was reported before in Bangladesh. And one species of *Crepidotus* was found namely *Crepidotus applanatus* in Chakaria on the soil surface of mixed forest. This species

was idebtified on the bark of Rain (*Albizia lebbeck*) tree from Mangrove forest (Das et a., 2016) and also was reported in India (Thiribhuvanamala *et. al.*, 2011).

Two species of *Inonotus* were collected from the Ramu, Teknaf and Cox's Bazar Sadar such as- *Inonotus hispidus* and *Inonotus cuticularis* on the dead log of Gamer (*Gmelina arborea*) and Bamboo (*Bambusa vulgaris*), respectively. *Inonotus hispidus* was idenfied by Das *et al.* (2016) from the mangrove forest.

Amanita sp. was found in Maheshkhali of from the mixed forest with the frequency And density of 20 and 4.17%, respectively. This species was also reported associated with Sissoo (*Dalbergia sissoo)* tree from Bangladesh in tropical moist deciduous forest (Rumainul *et al.,* 2015) and also from the mangrove forest (Das *et al.*, 2016). *Amanita* sp. was also identified by Hosen *et al.* (2015).

CHAPTER V

SUMMARY AND CONCLUSION

The forest regions are the main source of wild mushrooms and the possible reason for the growth and survival of various kinds of naturally occurring mushrooms can be the prevailing climatic condition with different vegetation which provided the favorable environment. There are 17% forest regions of Bangladesh and most of the forests are full of natural resources. Cox's Bazar forest region is one of the natural sanctuaries which is full of diversified natural resources. And the present investigation showed that there are numerous diversified wild mushrooms in the Cox's Bazar forest regions of our country.

During Survey, 24 mushrooms species were found under 13 families. Three species of mushrooms were recorded under Agaricaceae family in Chakaria, Maheshkhali, Ramu and Teknaf) of Cox's Bazar in Bangladesh . The highest number of mushrooms was found under the Auriculariaceae family. Four species of *Auricularia* were collected from the Cox's Bazar such as- *Auricularia auricula, Auricularia cornea, Auricularia delicata* and *Auricularia* sp..The highest frequency was found for *Auricularia auricula* of 60% and then 40% for *Auricularia cornea* with the 25 and 50%, respectively. Three species of *Ganoderma* were found during collection such as- *Ganoderma cupreolaccatum, Ganoderma lucidum and Ganoderma* sp. from the Cox's bazaar, Teknaf and Maheskhali.

Two species of *Trametes* such as- *Trametes ochracea and Trametes* sp. were collected from Chakaria, Cox's Bazar Sadar and Maheskhali with the frequency 40, 8.33% and density of 158.33, 50% respectively. One species of *Pleurotus ostreatus* was identified from the Chakaria and Teknaf with the frequency and density of 40% and 8.33%, respectively. One species of *Russula* was detected from the Maheshkhali region of Cox's Bazar with the frequency and density of 20 and 4.17% respectively.

The xylotrophic macro fungi namely-*Steccherinum ochraceum* was identified from the forest region of Ramu and Cox's Bazar Sadar on the dead root log of Mehagani (*Swietenia mahagoni*) from the mixed type of forest. One species of *Armillaria* was collected from the Teknaf of Cox's Bazar with the frequency and density of 20 and 4.17% respectively. *Amanita* sp. was found in Maheshkhali of from the mixed forest with the frequency and density of 20 and 4.17%, respectively.

Future investigation is also needed in different seasons as well as in different forest regions to identify the new domestic and also exotic species of macrofungi, which will represent a complete overview on available macrofungi under tropical evergreen and semi-evergreen forest under Cox's Bazar of Bangladesh.

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