BIODIVERSITY, HABITAT AND MORPHOLOGY OF MUSHROOM OF DIFFERENT FOREST REGIONS OF BANGLADESH

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December, 2013

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BY

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

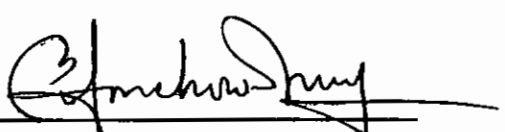
MASTER OF SCIENCE

IN

PLANT PATHOLOGY

SEMESTER: JULY-DECEMBER, 2013

Approved by:



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This is to certify that the thesis entitled, **"BIODIVERSITY, HABITAT AND MORPHOLOGY OF MUSHROOM OF DIFFERENT FOREST REGIONS OF BANGLADESH"** 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**, embodies the result of a piece of bona fide research work carried out by MD. HARUN-UR-RASHID, Registration No. 13-05769, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information has been availed of during the course of this investigation has duly been acknowledged.

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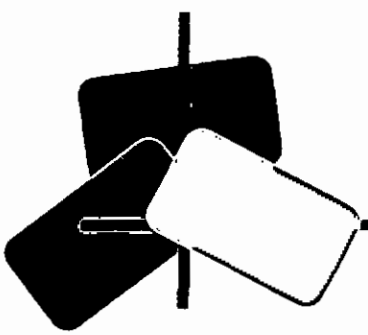

DEDICATED

TO MY PARENTS

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.

With deepest emotion the author wish to express his heartfelt gratitude, indebtedness, regards sincere appreciation to his benevolent research supervisor, Professor Dr. M. Salahuddin M. Chowdhury, 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.

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

The author wishes to express his deepest sense of gratitude to Associate Professor Khadija Akhter, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh for her inspiration and whole hearted co-operation.

Cordial thanks are extended to all respected teachers of the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Banngladesh and the entire staff member of the Department of Plant Pathology and especially to Mr. Md. Safiqul Islam, Senior computer operator, Department of Plant Pathology, SAU, for their co-operation throughout the study.

Finally the author expresses his heartfelt indebtedness to his beloved father Md. Lal Miah; mother Saleha Begum, brother Sahidul Islam for their sacrifice, encouragement and blessing to carry out higher study which can never be forgotten.

December, 2013 *The author*

BIODIVERSITY, HABITAT AND MORPHOLOGY OF MUSHROOM OF DIFFERENT FOREST REGIONS OF BANGLADESH

ABSTRACT

Studies on the biodiversity, habitat and morphology of mushrooms are gaining importance as many macro fungi are becoming extinct and facing threat of extinction because of habitat destruction. Present study deals with the biodiversity, habitat and morphology of mushroom grown in leaved, deciduous and mixed forest of Bangladesh. More than 117 samples were collected from nine selected districts of Bangladesh viz. Barisal, Borguna, Patuakhali, Perojpur, Jhalokathi, Bandorban, Dhaka, Gazipur and Tangail. More than 85% annual rainfall, mean daily temperature ranges between 29 to 31°C and relative humidity more than 80% is received during the monsoon period (June to September). Soil P^H ranges in between 6 to 6.5. Sandy clay, clay and clay loam soils are suitable for growing of mushrooms. Maximum Mushrooms grown on natural humus of the forest and maximum hard caped mushrooms such as *Ganoderma* grown on bark of tree or dead plant as parasite or saprophytes. The size of fructification ranges from 3-4×2-3 to 20-25×8-10 cm. The spore size was measured ranging between 5×3.5 to 24×9 μm. In total 20 different species were founded under 14 families viz. Amanitaceae (*Amanita hemibapha*, *Amanita bisporigera*, *Amanita rubescens*), Pyronemataceae (*Aleuria aurantia)*, Boletaceae (*Boletus subvelutipes, Tylopilus badiceps*, *Retiboletus ornatipes*), Agaricaceae (*Agaricus* sp.), Tricholomataceae (*Callistosporium* sp.), Marasmiaceae (*Gymnopus* sp.), Sarcosomataceae (*Bulgaria inquinans*), Russulaceae (*Russula crustosa*), Roselliniaceae (*Rosellinia* sp.), Cortinariaceae (*Cortinarius corrugatus*), Mycenaceae (*Mycena epipterygia*), Entolomataceae (*Nolanea strictia*), Ganodermataceae (*Ganoderma lucidum*, *Ganoderma apphannatum*, *Ganoderma tsuage*) and Polyporaceae (*Polyporus* sp.). The maximum frequency of occurrence was exhibited by *Ganoderma tsuage* (33.33%) and the maximum density was recorded for *Ganoderma tsuage* (95%). This informative study shows that the forest of Bangladesh is rich in mushroom diversity.

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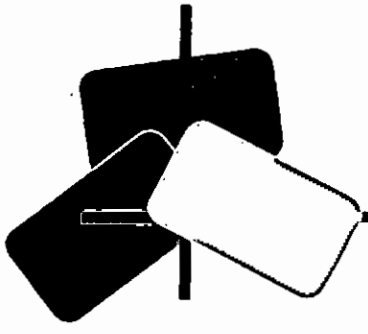


CHAPTER 1

INTRODUCTION

CHAPTER I

INTRODUCTION

A mushroom (or toadstool) is the fleshy, spore-bearing fruiting body of a fungus, typically produced above ground on soil or on its food source. The standard for the name "mushroom" is the cultivated white button mushroom, *Agaricus biosporus*; hence the word "mushroom" is most often applied to those fungi (Basidiomycota, Agaricomycetes) that have a stem (stipe), a cap (pileus), and gills (lamellae, singular lamella) or spores on the underside of the cap. "Mushroom" describes a variety of gilled fungi, with or without stem, and the term is used even more generally, to describe both the fleshy fruiting bodies of some Ascomycota and the woody or leathery fruiting bodies of some Basidiomycota, depending upon the context of the word (Bono, 1962 and Bakshi, 1971). Forms deviating from the standard morphology usually have more specific names, such as "puffball", "stinkhorn", and "morel", and gilled mushrooms themselves are often called "agarics" in reference to their similarity to *Agaricus* or their place Agaricales. Their fruiting bodies occur as small umbrella-like structures in the surrounding environment generally during rainy season. They vary much in shape, size and color; some of them are edible and some proven to be poisonous (referred to as toadstools). Mushrooms are higher fungi belonging to class Basidiomycetes in phylum Basidiomycota of the kingdom Fungi that produces fruit bodies (Alexopolous and Mims, 1996). Wild, edible mushrooms are the special forest products. The use of wild mushrooms for food in all probability began with the prehistoric man. During the long period human as a hunter gathered the fungi of the forest that has served as important sources of nourishment. Mushrooms have been found in fossilized wood that are estimated to be 300 million years old and almost certainly, prehistoric man has used mushroom collected in the wild as food. There are many edible i.e. volvarias, polypore and tubers fungi that used ethno botanical food by the tribal of forest regions of India, Bangladesh and Nepal.

There are about 3000 different species of edible mushroom in the world. From these species about 80 have been grown experimentally, 20 cultivated commercially and 4-5 produced on industrial scale throughout the world (Chang and Miles, 1988).

Mycorrhizal fungi are of great interest for environmental and forestry application due to the advantages that mycorrhizal provide for the host plant. Furthermore, some ectomycorrhizal fungi are also of economic importance in that they are edible, such as truffles, boletus and chanterelles (Walting, 1997 and Zambonelli, 2000). Some morphological characters of colonies and hyphae have been used to confirm the identity of ectomycorrhizal fungi in pure culture (Brundrett *et al.*, 1996) but these characters are not very distinctive with respect to those of sporulating fungi (Arx, 1980 and Gravesen, 1994). Humans have consumed fungi for sustenance, medicine, and culinary delight since ancient times. Some fungi are purposely cultivated, but most edible fungi are gathered from the wild. The Romans and Greeks treated mushrooms as a special kind of food (Miles and Chang, 2004), and there is historical evidence of mushroom consumption in ancient India (Chopra, 1933). There are also reports of the use of fungi by the indigenous cultures of South America (Henkel, 2004), Africa (Van Dijk, 2003), Australia (Trappe, 2009), and Asia (Yun, 1997).

Mushrooms are seasonal fungi, which occupy additional lists appeared in between culminating with the diverse niches in nature in the forest ecosystem. They predominantly occur during the rainy season and reviewed first by (Sathe and Rahalkar, 1825). The mushrooms also grow during spring when the snow melts.

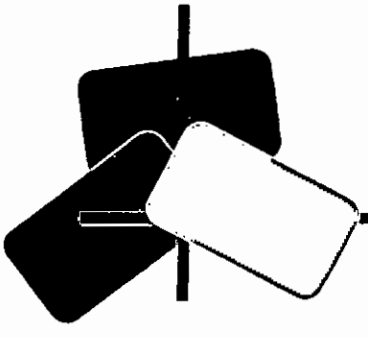
The color, shape and size of the fruiting body can vary tremendously. It is important to properly identify the mushroom that is collected, so as to avoid a poisonous species. Mushroom species are the indicators of the forest life system. Data of different vegetation types is important for planning and biodiversity at the community and species level is more important for monitoring the effectiveness and effects of natural habitat. Several mushrooms degrade organic materials or act as parasites on living organisms or saprophytes. Their habitat and climate are major factors that indicate their biodiversity (Nilsson and Presson, 1978). Present survey is to identify the mushrooms up to genus and species level, to record and compare with some diversity of mushrooms to other areas and to bring studies. Determinations of biodiversity of mushrooms usually have done by using morphological characterizations, habitat and phenotypical appearances of mushrooms in fresh form.

Characterized by different morphological traits i.e. shape of cap, cap edge, size of fructification, stipe length (cm), pileus length, margin of fruit body, color of fruit body, gills, scale, annulus, volva and spore print etc. Results indicate that all the species of mushrooms shows great diversity in their morphological characters (Srivastava *et al.*, 2010). Spore of fungi are vital for the dispersal of the species. The size of spore is on average 5 to 15 μm (thousandth of a milimeter). The color, structure or ornamentation of spore varying from species to species of Mushrooms (Svrcek, 2000).

Mushroom is one of the promising concepts for crop diversification in Bangladesh as well as the whole world. Due to increased awareness of the pharmacological values and nutritional values of mushrooms (Bisen, *et al*), there is more demand and consumer preference for different varieties of mushrooms among the people (Anderson *et al.*, 1979). The species diversity of fungi and their natural beauty occupy prime place in the biological world. The scope is limitless and this is high time to survey, collect, conserve, record and identifing the biodiversity, habitat and morphology in general and fungal diversity in particular as no one knows when and how some these valuable forms might be lost for forever. With the view in mind, the research work was undertaken with the following objectives.

1. Study the biodiversity and habitat of mushroom grown in different forest regions of Bangladesh,

2. Study the morphological characteristics of different mushrooms identified in selected districts of Bangladesh.



CHAPTER 2

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The main purpose of this chapter is to review the previous studies, which are related to the present study. Little work has been done on the prevalence and potential of macro fungi (mushroom) biodiversity, their habitat and morphology in Bangladesh. Therefore, an attempt has been made here to compile the research work carried out on the subject elsewhere.

Tapwal *et al.* (2013) conducted an experiment on diversity and frequency of macrofungi associated with wet ever green tropical forest in Assam, India. A study was conducted in Jeypore Reserve Forest located in Assam, India to investigate the diversity of macro fungi associated with different tree species. The diversity of broad leaves trees and high humidity during monsoon period favors ideal growth of diverse group of macrofungal fruiting bodies. Thirty macrofungal 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 ecological preference of the species reveled that maximum (17) species were saprophyte, living on dead substrates or decaying wood debris, ten species were found associated with roots of higher trees, while three species were found parasitic. Overall 20 species were found edible including some species having medicinal utilization. The present 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 *Trametesversi color* (120%) and *Xylariapol ymorpha* (93.33%). The density of rest of the species were ranged between 3.33- 6.67%.

Farooq (2013) reported that, mushrooms are fleshy, sometime tough umbrella like sporophores that bear holobasidia on the surface of gills or lamellae that hang down from the cap. Wild mushrooms have an intense biological as well as economic impact and constitutes a long relationship with mankind. Wild edible mushrooms have a worldwide distribution and their annual consumption may exceed due to nutritional value i.e. large amount of protein, low fat and pharmacological characteristics. They act as important therapeutic agents in tumor, cardiovascular, hypertension and cancer. There are about 2166 worldwide recognized edible species and about 470 species are possessing medicinal properties. Harvesting pressure has increased in many parts of the world and mushroom diversity is claimed to have decreased over the past decades. Presence or absence of mushroom species is a useful indicator to evaluate the damage or the maturity of an ecosystem. The work regarding to mushroom species has been documented by several researchers all over the Pakistan. Shibata recorded fifty one species of higher Basidiomycetes from province of Punjab and Khyber Pakhtoon Khawa. Forty nine species belongs to Agaricales, seven to Aphyllophorales and one to Auriculariales. Hattori and Murakami recorded 11 species of Aphyllophorales fungi from Pakistan; three species i.e. *Inonotus triqueter*, *Microporellus violaceocinerascens* and *Phylloporia weberiana* were new to Pakistan. Murakami reported seventy six species of *Agaricus*and allied fungi from northern parts of Pakistan. 323 species of Aphyllophorales belonging to 103 genera and 12 families. 12 species of Aphyllophorales, belonging to 9 genera and 3 families, collected from different areas of Azad Jammu and Kashmir. Thirty six species of mushrooms from Margalla Hills National Park and adjacent areas including three species of *Gasteromycetes*, one *Bolete* and twenty five species of *Agaricus*. 20 species of mushrooms and toadstools from Multan district. But, mushrooms of the Soon Valley are still unrevealed; so the current study was planned to prepare an inventory of mushrooms found in study area and conduct their ethnological studies.

Matthew *et al.* (2012) reported that, the rapid emergence of mushrooms and other fungal fruiting structures has long been shrouded in mysticism, as suggested by common names for fungi such as "toadstool," "Elvin saddle," "witches' butter," and "fairy ring." There are deeply held superstitions and misunderstandings regarding mushrooms and truffles.

For example, the Romans believed that truffles were the result of lightning strikes or thunderclaps; truffles were collected both because of their strong flavors but also because of their status as "mysterious products of the earth". Nonetheless, through keen observation of fungi in their natural habitats, humans have observed that some fungi depend directly on the dung, wood, insects, or grains where they are found.

Pushpa and Purushothama (2012) conducted an experiment on biodiversity of mushrooms belonging to the class Basidiomycetes in Bangalore. The survey was conducted from June 2007 to November 2010 in 8 different places which included scrub jungles and urban places in around Bangalore. A total number of 90 species in 48 genera belonging to 19 families in 5 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.

Dwivedi *et al.* (2012) studies on the taxonomy and diversity of macro fungi are gaining importance as many macro fungi are becoming extinct and facing threat of extinction because of habitat destruction. Present study deals with the 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. More than 85% of annual average rain fall is received during the monsoon month extending from June to September. The mean annual rain fall for Amarkantak is about 1619.9 mm distributed over ninety two average annual rainy days. The mean daily temperature ranges from 10.90^{0}C (January) to 39.10^0 C (May) with relative humidity of 80%. Amarkantak region is known for diverse macro fungal population. Extensive surveys were conducted from July 2010 to September 2010. Where collection, characterization, preservation and photo of macro fungal carried the genera like as *Agaricus, Amanita, Nyctalis,Russula, Boletus, Macrolapiota, Ganoderma, Termitomyces* were identified. Out of 50 samples only 16 samples were identified up to species level. This preliminary study shows that the forest is very rich in mushroom diversity.

Onyango *et al.* (2011) conducted an experiment on the morphological characters and spawn production procedures of three Kenyan native strains of wood ear mushroom. Nine basidiocarps were selected from collections made in three forest reserves within Kaka mega Forest in Western Kenya and morphologically characterized. Mycelia were raised on 2% malt extract agar and bottle culture technology was used for spawn production. The spawning experiment was arranged in completely randomized design with three replicates. Variations occurred in external basidiocarps features such as color, texture, and shape and presence of veined surfaces. Microscopic analysis of internal basidiocarps structures did not reveal significant differences. However, external features of mycelia colonies varied when cultured in malt extract agar. Results from spawn production showed that supplemented millet and sorghum grains can be successfully colonized by mycelia to produce high quality spawn.

Ahlawat *et al.* (2011) reported that, mushroom revolution is going to happen as a result of the improved productivity as well as vast increase in the number of environment controlled and seasonal growing units. The share of the button mushroom is bound to decline with more and more specialty mushrooms becoming available for seasonal cultivation. With the increased production, there is every livelihood that an organized mushroom marketing channel is established. A significant quantity of mushrooms is likely to be utilized for production and consumption of the value added products, as compared to present trend of fresh mushroom utilization. The venture will also be designed and directed towards complete recycling of the agro-wastes for production of food (mushroom), feed (cattle feed), fuel (biogas) and fertilizer (organic manure). With the proposed thrusts directed towards research on the development of the genetically improved strains and the production technologies, we do visualize lesser dependence on the imported strains and technologies. A sustained growth in mushroom productivity will depend on regular genetic improvement and management of biotic and abiotic stresses. India has diverse agro-climatic regions and is rich in mushroom diversity. Bio-prospecting will lay the foundation for effective allele mining. The vast gene pool available needs to be explored and utilized for genetic enhancement of cultivated mushrooms.

Hi-tech mushroom cultivation and processing will require higher degree of mechanization in wake of increased labor and raw material costs. Round the year cultivation of different mushrooms in rotation under the seasonal conditions is going yielding real gainful employment throughout the year to the poorest of the poor.

Michael Kuo (2011) reported that, the genus Russula includes some very beautyful and interesting species, and a lot of hard to disttinguish species. Because Russulas are typically fairly large, and because they are often brightly colored, amateur mushrroms are frequently interested in identifying them. About 20 or 30 species can be identified fairly and easily but there are perhaps 750 species worldwide. Cortinarius is the largest genus of mushrooms in the world containing an outstanding number of species often estimated well over a thousand. Although the mushrooms in Cortinarius are very diverse but it is usually pretty easy to figure out when we are looking at one, once we get the hang of it. First they have cortinas covering their gills when young (hence the name of the fungus). Sometimes the tiny fibers of the cortina are ephemeral and disappear but they frequently collapse against the stem to create a ring zone. Secondly the spore print is rusty brown and the mature gills of Cortinarius mushrooms are usually also also rusty brown. Finally they are terrestrial and mycorrhizal, so habitat of this mushrooms only in association with trees.

Smith and Thiers (2011) reported that, fruit bodies of the genus Tylopilus are encountered as large stout bolete mushrooms, which generally arise from the ground or occassionally from wood. They have stout stipes, which do not have a ring. A key field character which distinguishes them from members of the 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 characters.

Sawhasan (2011) reported that, Kanchanaburi forests are well known for high diversity of *Termitomyces*, an un-culturable and economic mushroom in Thailand, but their systematics are limited and unorganized.

They therefore, identified 28 *Termitomyces* isolates collected from 8 districts in Kanchanaburi province based on morphological characteristics. Nine species were identified as *T. albiceps*, *T. bulborhizus*, *T. cylindricus*, *T. heimii*, *T. microcarpus*, *T. radicatus*, *T.entolomoides*, *T. fuliginosus*, and *T. clypeatus*. Analysis of these *Termitomyces* species revealed that, morphological characteristics of *T. clypeatus* represented the most extremely variations that had not been described in any identification references. 13 selected *Termitomyces* isolates were monophyletic and diverged into 2 clades with no common characteristic that can be shared in each clade. In addition, the phylogenetic study demonstrated the monophyletic tree from pure Kanchanaburi *Termitomyces* isolates and mixture of Asia and African *Termitomyces* samples implied that both Asia and African *Termitomyces* species have evolved from the same ancestor.

Srivastava *et al.* (2010) reported that, Termitomyces is a wild mushroom growing in the symbiotic association of termite under or aboveground the termatorium, which is extensively used as human food and medicine from the time immortal. It has many more species throughout the country, but the study reveals in the Gorakhpur forest division confined that there are four species of Termitomyces are found. In order to determine the genetic diversity among these four species were studied by using morphological characterization, phenotypical appearance. Four species naming Termitomyces heimii, Termitomyces clypeatus, Termitomyces mammiformis and Termitomyces microcarpus characterized by different morphological traits i.e., shape of perforatorium, stipe length(cm), pileus length, margin of fruit body, colour of fruit body, gills, flesh, annulus, pseudorrhiza and spore print were recorded. Results indicated that all the four species of Termitomyces shows great diversity in their morphological characters.

RAM *et al.* (2010) reported that, several edible fleshy fungi grow wild in Eastern Uttar Pradesh forest during the rainy season on dead and decaying plant or animal remains. Local tribes collect a number of mushrooms and eat during rainy season. The traditional identification knowledge among the tribes is followed from generation to generation. The bio-diversity in the mushrooms is least documented in India.

The germ plasm collections of such mushrooms are very poor. These fleshy fungi are obviously nontoxic as these have been intimate human consumption since antiquity. However there are only few species of fleshy fungi which have been accepted as safe food by the civilized world, while many fleshy fungi have not yet recognized. Field survey was conducted for collection of various edible fleshy fungi from different localities of the Eastern Uttar Pradesh forest. The collected edible fleshy fungi were studied for their macroscopic detail parenting the habit, habitat, morphology and other phenotypic parameter noted in fresh form.

Crous (2006) reported that, fungi have been occupying a prominent position in the biological world because of their variety, economic and environmental importance. The study of fungal biodiversity has been carried out world over and 1.5 million species has been reported so far. About 50% of them have been characterized. The total numbers of fungal species in India is 27,000. The fungal biotechnology is an emerging area and they are intimately related with our life. Macro fungi are unique from fungal diversity point of view. Macro fungi grow prolifically and are found in many parts of the world. It is usual for a particular fungus to produce a visible fruiting body only under a precise combination of conditions, including geographic location, elevation, temperature, humidity, light and surrounding flora. Studies on macro fungi and their various aspects have been carried out in different parts of the globe. Studies on macro fungi have been an area of importance for the scientists in particular and the people in general, because of their role in human welfare, in food industry, in medicines, and biodegradation. However, the study of macro fungi, having edibility and medicinal properties are yet to be properly dealt with. Traditional mycological knowledge of most Indian ethnic groups has proven to be extensive and profound, consuming nearly 283 species of wild mushrooms out of 2000 species recorded world over. Despite having all the favorable conditions, mushroom farming is not spreading fast in India. Presently, about 70,000 ton of fresh mushroom is being produced in India as against over 5 million ton world production of mushroom annually. Wild mushrooms are a valuable non-timber forest resource used by mycophilic societies and their use has been documented in many countries around the world. They are sold in traditional markets or commercially exploited as food.

Agrahar and Subbuakshmi (2005) conducted an experiment on Meghalaya mushrooms. The region in general is blessed with a rich forest growth, with about 0-50% of the geographical area covered with lush green forests. These forests abound in macro fungi which are found growing on the forest-floor, wigs and branches, rotting plant parts, in mycorrhizal association with higher plants, etc. The edible fungal flora or the region as such still remains to be scientifically explored. The present investigation was, therefore, initiated to survey and identify the edible fungi of is region with respect to their morphology, distribution, habitat and edibility etc.

Zambonelli *et al.* (2005) conducted an experiment on morphological and molecular characterization of mycelia of ectomycorrhizal fungi in pure culture. Ectomycorrhizal fungi are also of economic importance in that they are edible, such as truffles, boletus and chanterelles. Several species are used in the commercial production of infected plants and the starting point is generally seedling inoculation either with spores or mycelia cultures. The first step in the production of infected plants using pure cultures of mycorrhizal fungi is to obtain axenic-mass cultures under controlled conditions. Even when the fruit bodies used to obtain these pure cultures are unambiguously identified based on their morphological characters; the identity of the isolated mycelia should also be confirmed by other methods. Misidentification of pure cultures can occur, in particular for those fungal isolates that grow very slowly on synthetic media, such as ectomycorrhizal fungi. Some morphological characters of colonies and hyphae have been used to confirm the identity of ectomycorrhizal fungi in pure culture but these characters are not very distinctive with respect to those of sporulation fungi.

Henkel *et al.* (2004) reported that, the Romans and Greeks treated mushrooms as a special kind of food and there is historical evidence of mushroom consumption in ancient Romans and Greeks. There are also reports of the use of fungi by the indigenous cultures of South America, Africa, Australia and Asia.

In Bern Convention, Bartolucci *et al.* (2002) and Alan (2008) reported that, *Fritillaria montana* Hoppe – is an endangered species listed in the third edition of the Red Book of Ukraine and Convention on the Conservation of European Wildlife and Natural Habitats. It is south-European-Albanian species found in disjunctive areas and its general natural range covers Central and Southern Europe (Italy, France, and Bulgaria), South Hungary, Austria and Albanian peninsula. Also it can be found in Moldova and Romania. In Ukraine *F. montana* occurs in the northeastern limit of its natural range, and is reported in Khmel'nytska, Chernovtsy and Odessa regions. At the present time, in Chernovtsy Region there are 9 habitats (sites) of *F. montana*. Previous investigations on Fritillaries mainly were attached to the morphology and phonetic studies and only particularly to the anatomy of vegetative organs. There no profound investigations on the floral anatomy or gynoecium morphology of Fritillaries because the most important taxonomical features in the flower organization in this genus are perigonium color, flower and tepal shape, shape of the nectarines.

Moncalov *et al.* (2002) reported that, Nolanea is a genus of small gray to brown pink-spored mushrooms which are mostly saprotrophic and grow on the ground. The cap can be conical, convex or umbonate in shape, often with a silky top. The gills have adnexed to adnate attachment (they can also be a little decurrent) and the stalk is fragile and often hallow. The spores are angular and are flesh colored to pink. It has been considered a subgenus of the large genus Entoloma rather than a genus in its own right. The species of Nolanea, Leptonia and Inocephalus interspersed with various pink gills species in a broadly monophyletic entolomatoid group.

Svrcek (2000) reported that, a cap or pileups is borne on a stalk. It can be various shapes viz. hemispherical or convex, depressed, offset, ovate, infundibuliform, umbonate and umbllicate etc.

Among them convex shape is most familiar and most of the cap of mushrooms becoming flat shape with the maturity. Cap edge can be undulating, lobed, grooved or plicate, and split shape. Among them grooved or plicate is more familiar. Hymenophores can be smooth surfaces, lamellae or gills, folds, tubes or teeth, on the underside of the cap.

Spore of fungi are vital for the dispersal of the species. The size of spore is on average 5 to 15 μm. The color, structure or ornamentation varying from species to species of mushrooms. Spore ornamentation can be globose, subglobose, cylindrical, fusiform, angular, echinulate, verrucose, obtusely fusiform, ovoid etc.

Watling, (1997) and Zambonelli (2000) reported that, mycorrhizal fungi are of great interest for environmental and forestry application due to the advantages that mycorrhizal provides nutrition for the host plant. Furthermore, some Ectomycorrhizal fungi are also of economic importance in that they are edible, such as truffles, boletus and chanterelles Some morphological characters of colonies and hyphae have been used to confirm the identity of ectomycorrhizal fungi in pure culture but these characters are not very distinctive with respect to those of sporulating fungi.

Alexopolous and Mims (1996) reported that, mushrooms are higher fungi belonging to class Basidiomycetes in phylum Basidimycota of the kingdom Fungi that produces fruit bodies wild, edible mushrooms are the special forest products. The use of wild mushrooms for food in all probability began with the prehistoric man. During the long period human as a hunter gathered the fungi of the forest that has served as important sources of nourishment. Mushrooms have been found in fossilized wood that are estimated to be 300 million years old and almost certainly, prehistoric man has used mushroom collected in the wild as food. There are many edible i.e. volvarias, polypore and tubers fungi that used ethno botanical food by the tribal of forest regions of India, Bangladesh and Nepal.

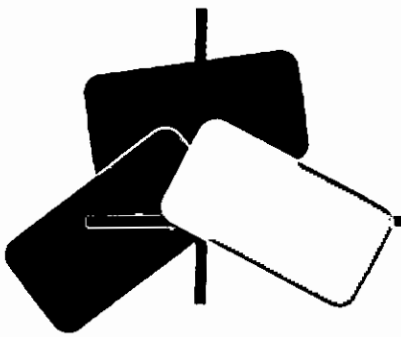
Chamberlin (1996) and Chandra (2010) conducted an experiment on Ethnomycology. Ethnomycological aspects were also deals with by few workers in different parts of India and world over. Some of the wild edible mushrooms have also been reported from Manipur and Arunachal Pradesh of North East India and South West China.

Susan and Van (1992) carried out extensive research on biology of Basidiomycetes mushrooms and they reported that, white-rot species of genus *Ganoderma* possess different medicinal effects and have been used as traditional medicines in many countries.

More than 250 *Ganoderma* species are described, however variable morphological characteristics makes species identification difficult. *Ganoderma* collections of 22 strains were isolated in Armenia, France, Iran, Italy and China. Cultural such as morphological, ecological and physiological characteristics were thoroughly described in submerged and static culture and using different nutrient media. Two collections of *G. lucidum* from Armenia genetically were identified as *G. lucidum,* two from three French collections as *G. lucidum,* one as *Trametes gibbosa*, four Italian and one Chinese collection also belongs to *G. lucidum* species. Armenian, Italian and French collections of *G. lucidum* are placed in the European *G. lucidum* clade. Seven collections of *G. applanatum* from Armenia and one from Iran are identified as *G. adspersum* species which is originally reported for Armenian mycobiota. One collection of *G. applanatum* from Armenia was confirmed by molecular analysis. One *Ganoderma* sp. strain from France and two strains from Iran were identified as belonging to *G. resinaceum.*

Chang and Miles (1988) reported that, there are about 3000 different species of edible mushroom in the world. From these species about 80 have been grown experimentally, 20 cultivated commercially and 4-5 produced on industrial scale throughout the world. Humans have consumed fungi for sustenance, medicine, and culinary delight since ancient times. Some fungi are purposely cultivated, but most edible fungi are gathered from the wild.

Nilsson and Presson (1978) reported that, the color, shape and size of the fruiting body can vary tremendously. It is important to properly identify the mushroom that is collected, so as to avoid a poisonous species. Mushroom species are the indicators of the forest life system. Data of different vegetation types is important for planning and biodiversity at the community and species level is more important for monitoring the effectiveness and effects of natural habitat. Several mushrooms degrade organic materials or act as parasites on living organisms or saprophytes. Their habitat and climate are major factors that indicate their biodiversity.



CHAPTER 3

MATERIALS AND METHODS

CHAPTRER III

MATERIALS AND METHODS

3.1 Experimental site

Experiment was conducted at the Seed Health Laboratory (SHL), Department of Plant Pathology (DPP), Sher-e-Bangla Agricultural University (SAU), Dhaka. Samples Data were collected from different natural forest zones of Bangladesh.

3.2 Collection time

The samples were collected during the period from June to September, 2013 and June to September, 2014.

3.3 Source of data and sampling procedure

During samples collection a systematic sampling procedure was followed. A pre-designed collection and data analysis procedures were used to collect the information on level of knowledge on biodiversity, habitat and morphology of Mushrooms.

3.4 Survey on mushroom biodiversity, habitat and morphology in selected locations of Bangladesh

The survey was conducted in nine (9) selected districts of Bangladesh comprising eighteen (18) Upazilla. The survey locations are shown in table 1 and figure 1.

Table 1. Survey area

Sl. No.	District(s)	Sample Upazilla (s)				
		Name of Sample Upazilla(s)				Number (s) of Upazilla
1	Barisal	Sadar	Goronodi	-	-	2
2	Borguna	Sadar	Betagi	Bamna	Pathorghata	4
3	Patuakhali	Sadar	Bauphal	Dashmina	Golachipa	4
4	Perojpur	Sadar	Bhandaria	-	-	2
5	Jhalokathi	Sadar	Nolchity	-	-	2
6	Bandorban	Hafejghona	-	-	-	1
7	Dhaka	Mirpur	-	-	-	1
8	Gazipur	Sadar	-	-	-	1
9	Tangail	Modhupur	-	-	-	1
Total	9					18

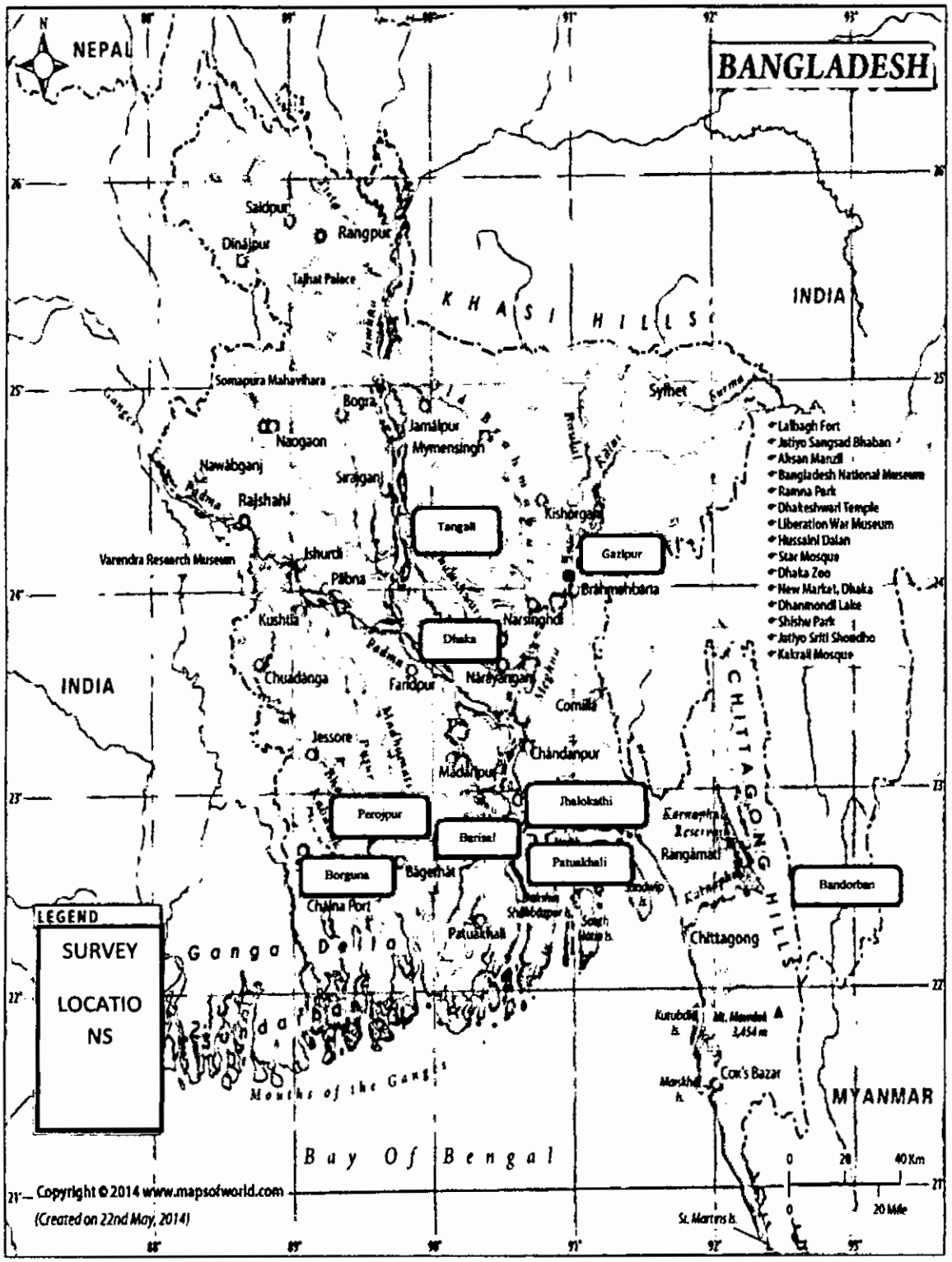


Figure 1. Survey locations

3.4.1Collection procedures

Periodic surveys were made to the survey area for the collection of macro fungi during rainy season (June to September) in 2013 and (June to September) in 2014. Different forest sites of eighteen (18) Upazila under nine (9) districts of Bangladesh have been surveyed in rainy season for the collection of macro fungi.

3.5 Mushroom processing

Freshly harvested mushroom was washed by water for removing debris. Fleshy mushroom is highly perishable as it is susceptible to deterioration by the enzyme and microorganism (Arora, 1991 and Deshmukh, 2004). It has been realized that merely fleshy collected mushroom is of no use unless these are properly preserved. During the analysis period we followed some precautions before processing of mushroom (Pathak *et al.*, 1998). Mainly we followed two types of preservation process-one is short term preservation and another is long term preservation on the basis of study purpose and structure of the mushroom.

3.5.1 Drying

Collected mushrooms were dried by using sun heat (Sun dry) when collected mushroom from remote area where electricity was not available. But most of the collected samples 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.

3.5.2 Storage

Samples were storaged in Ziploc poly bag during research period. Silica gel was used at the rate of 10% of dry basis during the study period for storing the mushroom long time and for further study.

3.6 Habitat, diversity and morphology analysis

3.6.1 Habitat and diversity analysis

The types of forests were leaved, deciduous and mixed (Table 2). The surrounding environmental temperature, relative humidity, soil P^H, moisture condition, vegetation were recorded for biodiversity of mushrooms (Aung *et al.*, 2008). Soil P^H and soil moisture were measured by P^H meter and air temperature by thermometer during collection period (Haksworth, 2004). 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 *et al.*, 1973).

$$\text{Freq. of fungal sp. (\%)} = \frac{\text{No. of site in which the sp. is present}}{\text{Total no. of sites}} \times 100$$

$$\text{Density (\%)} = \frac{\text{Total no. of individual of a particular species}}{\text{Total no. of species}} \times 100$$

Table 2. Survey forest and their characters

Particular	Forest		
	Leaved	Deciduous	Mixed
Character of the forest	The forest consists of those tree which contents leaves	The forest consists of those tree which contents leaves seasonally	The forest consists of both leaved and Deciduous tree
Dominating mushroom genus	*Amanita, Russula, Mycena*	*Amanita, Aleuria, Bulgaria, Tylopilus, Retiboletus, Laccaria* and *Rosellinia*	*Boletus, Boletellus, Russula, Cortinarius, Nolanea, Ganoderma* and *Polyporus*

3.6.2 Morphological characterization procedures

The fruiting body of mushroom usually composed of a stalk (stipe), a hymenium, a cap (pileus), spores, ring or annals (some species) and volva (some species). It is also multiform in its shape and coloring. The cap (pileus) is borne on a stalk (Badalyan *et al.*, 2004). It can be various shapes. The most familiar being hemispherical or convex, depressed, offset, umbonate, umblicate, infundibiliform with many of this becoming flat as it matures (Svrcek, 2000).

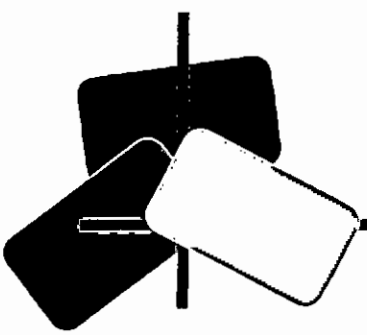
Cap edge may be grooved, plicate, and split shape. Spores of mushrooms are vital for the dispersal of the species. The form, color, and structure are varying from species to species (Svrcek, 2000). Regular survey and morphological characterization such as the fructification, carpophores shape, umbo, scale, the gills, color, gills edges, stipe length, width, color, shape, type of vail, annuls (Position), volva etc. were measured in fresh form during collection period (Srivastava *et al.*, 2010). Qualitative characters such as color, shape, and presence of hymenia were evaluated by eye estimation while texture was determined by feeling the back and top surfaces using fingers.

Most of the morphological data were recorded during collection period that was when the mushroom in fresh form.

For microscopic characters, free hand transverse sections of approximately 0.1mm thick were made from rehydrated basidiocarps with the aid of a sharp surgical blade. The sections were immersed in a diluted solution of methyl blue stain and left for 10 minutes. The thinnest sections were selected and placed on glass slides and covered with cover slips. Low power (×10) objectives of a standard light microscope were used to observe the sections. There are different types of color and spore ornamentation such as globose or subglobose, cylindrical, fusiform, filiform, angular, echinulate, verrucose, tuberculate, obtusely fusiform, ovoid and ellipsoid etc. (Svrcek, 2000). Spore size was measured by program software called Mycocam 2 produced by mycologist Richard Shotbolt.

3.6.3 Taxonomy

The taxonomy has been suggested on the basis of macro and microscopic characteristic following available literatures (Zoberi, 1973 and Alexopolous *et al.*, 1996) and identification at the species level based on identification key of Ahmad (1995) and Grimes (1994).



CHAPTER 4

RESULTS

CHAPTER IV

RESULTS

A survey was conducted on biodiversity, habitat and morphology of mushrooms grown in eighteen natural forest zones under nine districts viz. Barisal, Borguna, Patuakhali, Perojpur, Jhalokathi, Bandorban, Dhaka, Gazipur and Tangail. A total one hundred seventeen mushrooms under twenty species were collected and studied. Their biodiversity, habitat and morphology are described in this chapter.

4.1 Biodiversity, habitat and morphology of *Agaricus* sp.

A survey was conducted in Modhupur, Dhaka, Dashmina and Pathorghata. Only one species of *Agaricus* was recorded and that was unidentified. A total nine number of *Agaricus* mushrooms were found during collection. The biodiversity, habitat and morphology of its are described below.

4.1.1 Biodiversity

Agaricus sp. was found in Modhupur, Dhaka, Dashmina and Pathorghata. The frequency of its presence was 22.22% and the density was 40%.

4.1.2 Habitat

The mushroom was found on the root zone of *Leucaena leucocephala*. Forest type was leaved. Soil moisture was 6.5, soil P^H was 7.0 and soil type was sandy loam. Average temperature was recored 30 ^{0}C during collection.

4.1.3 Morphology

Fructification size was 12×4 cm.The color of pileus (cap) was brownish. The shape of cap was convex and umbonate. The cap edge was grooved and split. Brownish color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Agaricus* sp. The color of gills was deep brown. Color of stipe was whitish. The length and width of stipe was 5 cm and 0.7 cm.

Ring or anal was present on the stipe and volva was present on the lower part of the stipe in some *Agaricus* sp. Spore color was whitish, spore ornamentation was ovoid with a coarsely round cerculate surface and spore size was 12x8 µm (Plate 1).

(a) (b)

(c)

Plate 1. Photographs of *Agaricus* sp: umbonate shape cap (a), grooved cap edge (a), split cap edge (b), ring (b), volva (b), regular brown gills (b) and ovoid spore (c)

4.1.4 Taxonomy of *Agaricus* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Agaricales
Family: Agaricaceae
Genus: *Agaricus*
Species: Agaricus sp.

4.2 Biodiversity, habitat and morphology of *Amanita* sp.

Three species of Amanita were recorded viz. *Amanita hemibapha*, *Amanita bisporigera* and *Amanita rubescens* in four natural forest zones viz. Modhupur, Patuakhali, Pathorghata and Botanical garden (Dhaka) of Bangladesh. A total ten number of mushrooms of Amanita were found during collection.

4.2.1 Biodiversity

Amanita hemibapha was found in Dhaka and Patuakhali. The frequency of its presence was 11.11% and the density was 20%. *Amanita bisporigera* was found in Modhupur and Pathorghata. The frequency of its presence was 11.11% and the density was 20%. *Amanita rubescens* was found in Pathorghata. The frequency of its presence was 5.56% and the density was 15%.

4.2.2 Habitat

The mushroom *Amanita hemibapha* and *Amanita bisporigera* were found on the root zone of *Dalbergia sissoo* while *Amanita rubescens* were found on the natural humus of the forest. *Amanita bisporigera* was found on leaved forest zones while *Amanita hemibapha* and *Amanita rubescens* were found in deciduous forest zones. Soil moisture was 7 for three species viz. *Amanita hemibapha, Amanita bisporigera* and *Amanita rubescens*. The recorded soil P^H for *Amanita hemibapha* was 6.6, for *Amanita bisporigera* was 6.5, and for *Amanita rubescens* was 6.4. Soil type was clay for *Amanita hemibapha* and *Amanita bisporigera* and clay loam for *Amanita rubescens.* The average recorded temperature was 29.5 ^{0}C for three species of Amanita viz. *Amanita hemibapha, Amanita bisporigera* and *Amanita rubescens.*

4.2.3 Morphology of *Amanita* sp.

a. *Amanita hemibapha*

Fructification size was 8×2.5 cm.The color of pileus (cap) was yellowish. The shape of cap was ovate or convex. The cap edge was plicate or grooved. Yellowish scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Amanita hemibapha.* The color of gills was yellowish. Color of stipe was yellow. The length and width of stipe was 5 cm and 0.4-0.5 cm. Ring or anal was absent on the stipe but presnt on one specimen and volva was present on the lower part of the stipe in some *Amanita hemibapha.* Spore was unidentified (Plate 2).

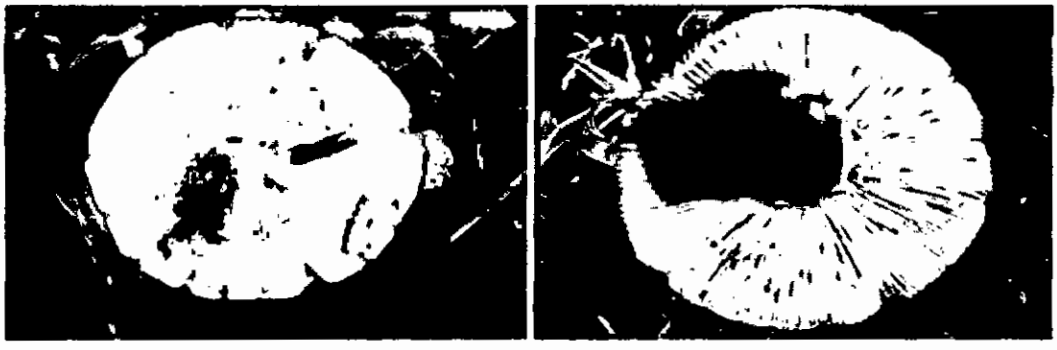
(a) (b)

(c)

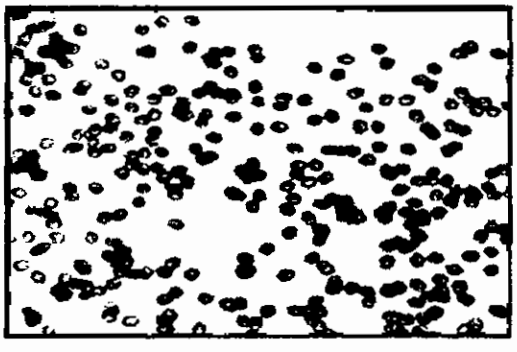
Plate 2. Photographs of *Amanita hemibapha*: Ovate shape (a and b) cap, convex shape cap (c), grooved cap edge (a, b, c), regular smooth yellow gills (c), ring (a)

b. *Amanita bisporigera*

Fructification size was 9×3 cm. The color of pileus (cap) was white. The shape of cap was convex. The cap edge was flat or grooved. Whitish scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Amanita bisporigera*. The color of gills was creamy white. Color of stipe was whitish. The length and width of stipe was 7-8 cm and 2.5 cm. Ring or anal was present on the stipe and volva was absent on the lower part of the stipe in some *Amanita bisporigera*. Spore color was white, spore ornamentation was hyaline and spore size was 6x5 µm (Plate 3).



(a) (b)



(c)

Plate 3. Photogrphs of *Amanita bisporigera*: Convex cap (a), flat cap (b), split cap edge (a), ring (b), creamy white gills(b) and hyaline spore (c)

c. *Amanita rubescens*

Fructification size was 7.9×3 cm. The color of pileus (cap) was coffee. The shape of cap was convex. The cap edge was round smooth. Fleshy coffee color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were absent underside of the cap of *Amanita rubescens* but tiny gills was present underside of the cap. The color of gills was yellow and white. Color of stipe was whitish. The length and width of stipe was 1.5 cm and 1cm. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in some *Amanita rubescens*. Spore was unidentified (Plate 4).

(a) (b)

Plate 4. Photographs of *Amanita rubescens*: Ovate cap and round cap edge (a and b) and white tiny gills (a, b)

4.2.4 Taxonomy of *Amanita* sp.

Domain: Eukaryota
Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Agaricales
Family: Amanitaceae
Genus: *Amanita*
Species: *Amanita hemibapha,*
Amanita bisporigera,
Amanita rubescesns

4.3. Biodiversity, habitat and morphology of *Aleuria* sp.

A survey was conducted in Perojpur and Borguna. One species of *Aleuria* was recorded and that was *Aleuria aurantia.* A total eight number of *Aleuria aurantia* mushrooms were found during collection. The biodiversity, habitat and morphology of its are described below.

4.3.1 Biodiversity

Aleuria aurantia was found in Perojpur and Borguna. The frequency of its presence was 11.11% and the density was 40%.

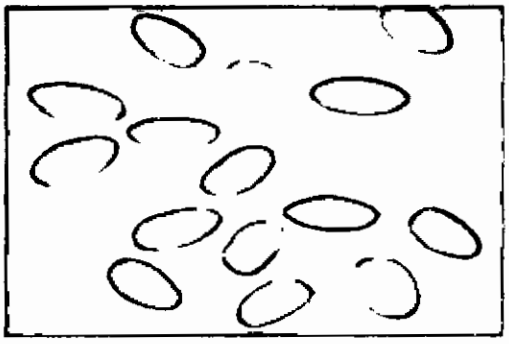
4.3.2 Habitat

The mushroom was found on the natural humus of the forest. Forest type was Deciduous. Soil moisture was 7, soil P^H was 7.0 and soil type was clay loam. Average temperature was recored 29.5 ^{0}C during collection.

4.3.3 Morphology

Fructification size was 7.9×3 cm. The color of pileus (cap) was orange peel. The shape of cap was convex and flat. The cap edge was grooved. Yellow color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Aleuria aurantia.* The color of gills was white to light yellow. Color of stipe was greenish white. The length and width of stipe was 3.5 cm and 0.8 cm. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in *Aleuria aurantia.* Spore print was white, spore ornamentation was ellipsoidal with a coarsely cerculate surface and spore size was 24x9 µm (Plate 5).

(a) (b)



(c)

Plate 5. Photographs of *Aleuria aurantia*: Convex cap (a), cap edge grooved (a and b) white to light yellow gills (b) and ellipsoidal spore (c)

4.3.4 Taxonomy of *Aleuria* sp.

Kingdom: Fungi
Phylum: Ascomycota
Class: Pezizomycetes
Order: Pezizales
Family: Pyronemataceae
Genus: *Aleuria*
Species: *Aleuria aurantia*

4.4 Biodiversity, habitat and morphology of *Boletus* sp.

A survey was conducted in Modhupur and Patuakhali. One species of *Boletus* was recorded and that was *Boletus subvelutipes*. Only one number of *Boletus subvelutipes* was found. The biodiversity, habitat and morphology of its are described below.

4.4.1 Biodiversity

Boletus subvelutipes was found in Modhupur and Patuakhali. The frequency of its presence was 11.11% and the density was 5%.

4.4.2 Habitat

This mushroom was found on the root zone of *Acacia auriculiformis*. Forest type was mixed. Soil moisture was 7, soil P^H was 6.7 and soil type was clay loam. Average recorded temperature was 30 ^{0}C.

4.4.3 Morphology

Fructification size was 8-13x4-7 cm. The color of pileus (cap) was ash. The shape of cap was convex. The cap edge was grooved or plicate. Ash color scale was found on the cap. Regular shaped gills (lamellae) were present underside of the cap of *Boletus subvelutipes*. The color of gills was white. Color of stipe was ash to white. The length and width of stipe was 6 cm and 1 cm. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in *Boletus subvelutipes*. Spore color was white, spore ornamentation was obtusely fusiform with transverse septa and spore size was 14×7.5 µm (Plate 6).

(a) (b)

(c)

Plate 6. Photographs of *Boletus subvelutipes*: Convex cap (a), grooved cap edge (a and b) and white gills (b) and obtusely fusiform spore (c)

4.4.4 Taxonomy of *Boletus* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Boletales
Family: Boletaceae
Genus: *Boletus*
Species: *Boletus subvelatipes*

4.5 Biodiversity, habitat and morphology of *Callistosporium* sp.

A survey was conducted in Modhupur, Patuakhali and Perojpur. One species of *Callistosporium* was recorded and the species was unidentified. Only one number of *Callistosporium* was found. The biodiversity, habitat and morphology of its are described below.

4.5.1 Biodiversity

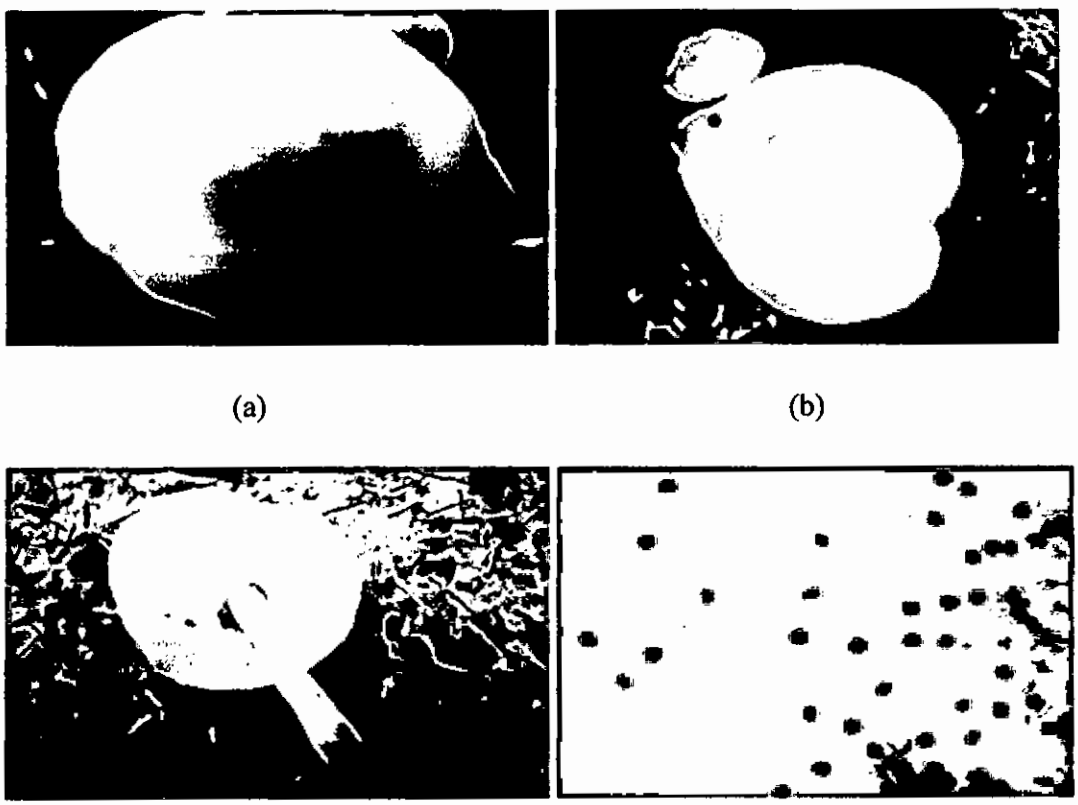
This mushroom was found in Modhupur, Patuakhali and Perojpur. The frequency of its presence was 16.67% and the density was 5%.

4.5.2 Habitat

This mushroom was found on the root zones of *Bambusa vulgaris*. Forest type was mixed. Soil moisture was 6, soil P^H was 6 to 6.5 and soil type was clay loam. Average recorded temperature was 30 ^{0}C.

4.5.3 Morphology

Fructification size was 8×2.5 cm. The color of pileus (cap) was yellowish. The shape of cap was ovate or convex. The cap edge was plicate or grooved. Yellowish scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Callistosporium* sp. The color of gills was yellowish. Color of stipe was yellow. The length and width of stipe was 5 cm and 0.4-0.5 cm. Ring or anal was absent on the stipe volva was absent on the lower part of the stipe in some *Callistosporium* sp. Spore color was brown, spore ornamentation was globose and spore size was 7×5 µm (Plate 7).



(a) (b)

(c) (d)

Plate 7. Photographs of *Callistosporium* sp: Ovate shape (a and b) cap, grooved cap edge (a, b, c), regular smooth yellow gills (c) and globose spore (d)

4.5.4 Taxonomy of *Callistosporium* sp.

Kingdom: Fungi

Phylum: Basidiomycota

Class: Agaricomycetes

Order: Agaricales

Family: Tricholomataceae

Genus: *Callistosporium*

Species: *Callistosporium* sp.

4.6 Biodiversity, habitat and morphology of *Bulgaria* sp.

A survey was conducted in Perojpur. One species of *Bulgaria* was recorded and the species was *Bulgaria inquinans.* The biodiversity, habitat and morphology of its are described below.

4.6.1 Biodiversity

This mushroom was found in Perojpur. The frequency of its presence was 5.56% and the density was 5%.

4.6.2 Habitat

This mushroom was found on the natural humus of forest. Forest type was deciduous. Soil moisture was 7, soil P^H was 6 and soil type was clay loam. Average recorded temperature was 29.5 ^{0}C.

4.6.3 Morphology

Fructification size was 4×1.3 cm. The color of pileus (cap) was brown. The shape of cap was round and an apex appendage was present. The cap edge was round. Scale was absent on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were absents underside of the cap of *Bulgaria sp.* Due to absnce of stipe ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in *Bulgaria sp.* and spore print was unidentified (Plate 8).

(a) (b)

(c)

Plate 8. Photographs of *Bulgaria inquinans*: Irregular shape mushrooms (a, b, c)

4.6.4 Taxonomy of *Bulgaria* sp.

Kingdom: Fungi
Phylum: Ascomycota
Class: Pezizomycetes
Order: Pezizales
Family: Sarcosomataceae
Genus: *Bulgaria*
Species: *Bulgaria inquinans*

4.7 Biodiversity, habitat and morphology of *Tylopilus* sp.

A survey was conducted in Borguna and Patuakhali. One species of Tylopilus was recorded and that was *Tylopilus badiceps*. Eight individual number of *Tylopilus badiceps* were found. The biodiversity, habitat and morphology are described below.

4.7.1 Biodiversity

Tylopilus badiceps species was found in Borguna and Patuakhali. The frequency of its presence was 11.11% and the density was 40%.

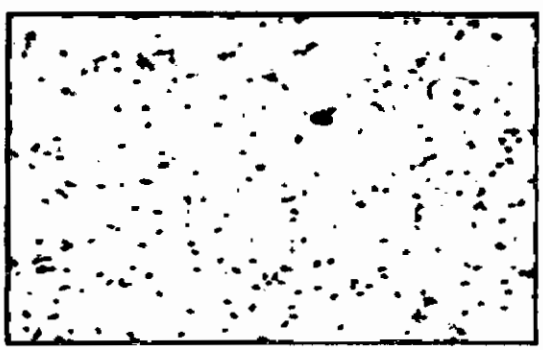
4.7.2 Habitat

The mushroom was found on the on the root zone of *Albizia saman*. Forest type was deciduous. Soil moisture was 7, soil P^H was 6.4 and soil type was clay loam. Average recorded temperature was 31 ^{0}C.

4.7.3 Morphology

Fructification size was 6.5x2 cm. The color of pileus (cap) was light brown to white. The shape of cap was convex and ovate. The cap edge was grooved. Whitish color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were absent underside of the cap of *Tylopilus badiceps*. The color of gills was white. Color of stipe was white. The length and width of stipe was 3-5 cm and 0.9-3 cm. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in *Tylopilus badiceps*. Spore was Ash, spore ornamentation and spore size was unidentified (Plate 9).

(a) (b)



(c)

Plate 9. Photographs of *Tylopilus badiceps*: Ovate cap (a), convex cap (b), grooved cap edge (b) and ash color spore (c)

4.7.4 Taxonomy of *Tylopilus* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Boletales
Family: Boletaceae
Genus: *Tylopilus*
Species: *Tylopilus badiceps*

4.8 Biodiversity, habitat and morphology of *Russula* sp.

A survey was conducted in Modhupur, Patuakhali and Pathorghata. One species of *Russula* was recorded and that was *Russula crustosa*. Five number of *Russula* were found during collection. The biodiversity, habitat and morphology are described below.

4.8.1 Biodiversity

Russula crustosa was found in Modhupur, Patuakhali and Pathorghata. The frequency of its presence was 16.67% and the density was 25%.

4.8.2 Habitat

The mushroom was found on the root zone of *Dalbergia sissoo*. Forest type was mixed and leaved. Soil moisture was 7, soil P^H was 6 to 6.5 and soil type was clay loam. Average recorded temperature was 31 ^{0}C.

4.8.3 Morphology

Fructification size was 11x3 cm. The color of pileus (cap) was pink to white mixed. The shape of cap was convex and umbonate shape. The cap edge was grooved and split. Pink color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Russula crustosa*. The color of gills was creamy white. Color of stipe was white to light brown. The length and width of stipe was 3 cm and 1.4 cm. Ring or anal was present on the stipe and volva was absent on the lower part of the stipe in *Russula crustosa*. The color of spore was greenish, ornamentation was globose and spore size was 6×4.5 µm (Plate 10).

(a) (b)

(c)

Plate 10. Photographs of *Russula crustosa*: Umbonate cap (a and b), grooved cap edge (a and b), ring on stipe (b), light brown gills (b) and globose spore (c)

4.8.4 Taxonomy of *Russula* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Russulales
Family: Russulaceae
Genus: *Russsula*
Species: *Russula crustosa*

4.9 Biodiversity, habitat and morphology of *Retiboletus* sp.

A survey was conducted in Barisal. One species of *Retiboletus* was recorded and that was *Retiboletus ornatipes*. Four number of *Retiboletus* were found during collection. The biodiversity, habitat and morphology are described below.

4.9.1 Biodiversity

Retiboletus ornatipes was found in Barisal. The frequency of its presence was 5.56% and the density was 20%.

4.9.2 Habitat

The mushroom was found on the on the root zone of *Albizia saman*. Forest type was deciduous. Soil moisture was 7, soil P^H was 6.1 and soil type was clay loam. Average recorded temperature was 29 ^{0}C.

4.9.3 Morphology

Fructification size was 7x3 cm. The color of pileus (cap) was brownish. The shape of cap was depressed and flat shape. The cap edge was split. Brownish color scale was found on the cap. Beneath the cap hymenophores were abesent. Regular shaped gills (lamellae) were absent underside of the cap of *Retiboletus ornatipes.* Color of stipe was white with black spot. The length and width of stipe was 4-5 cm and 0.8-1.5 cm. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in *Retiboletus ornatipes.* The color of spore was brown, ornamentation was ovoid with an aciculum and spore size was 5×3.5 µm (Plate 11).

(a) (b)

Plate 11. Photographs of *Retiboletus ornatipes*: Depressed shape cap (a), grooved cap edge (a), ovoid spore (b)

4.9.4 Taxonomy of *Retiboletus* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Boletales
Family: Boletaceae
Genus: *Retiboletus*
Species: *Retiboletus ornatipes*

4.10 Biodiversity, habitat and morphology of *Rosellinia* sp.

A survey was conducted in Borguna and Perojpur. One species of *Rosellinia* was recorded and that was unidentified. Four number of *Rosellinia* were found during collection. The biodiversity, habitat and morphology are described below.

4.10.1 Biodiversity

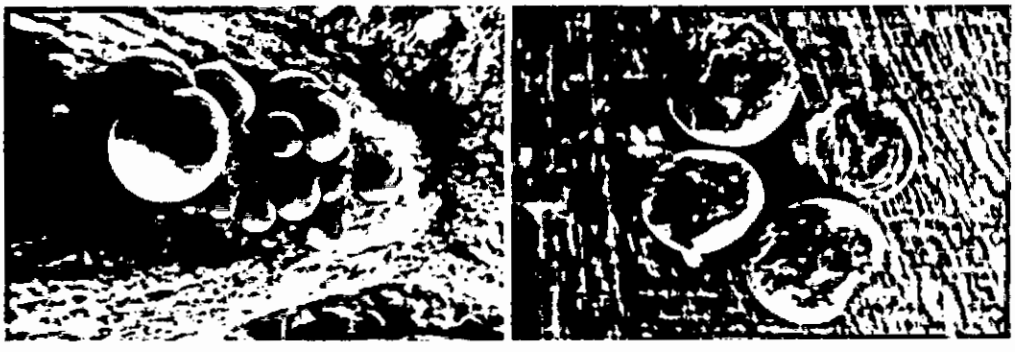
Rosellinia sp. was found in Borguna and Perojpur. The frequency of its presence was 11.11% and the density was 20%.

4.10.2 Habitat

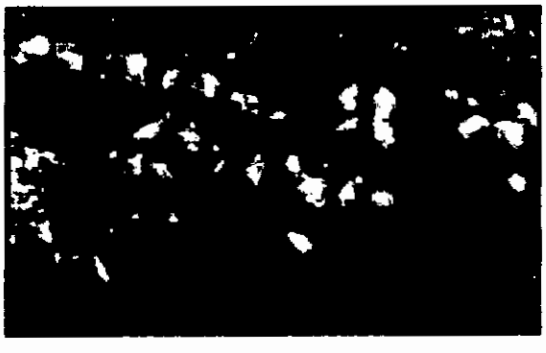
The mushroom was found on the on the natural humus of forest. Forest type was deciduous. Soil moisture was 7, soil P^H was 6.5 and soil type was clay loam. Average recorded temperature was 29.5 ^{0}C.

4.10.3 Morphology

Fructification size was 5x2 cm. The color of pileus (cap) was creamy and black color. The shape of cap was ovate. The cap edge was hard and round. Scale was not found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were not present underside of the cap of *Rosellinia* sp. Stipe was absent. Gills were not present. Ring or anal was absent and volva was absent in *Rosellinia* sp. The spore color, ornamentation and size were unidentified (Plate 12).



(a) (b)



(c)

Plate 12. Photographs of *Rosellinia* sp: Nut shape mushrooms (a,b,c)

4.10.4 Taxonomy of *Rosellinia* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Roselliniales
Family: Roselliniaceae
Genus: *Rosellinia*
Species: *Rosellinia* sp.

4.11 Biodiversity, habitat and morphology of *Cortinarius* sp.

A survey was conducted in Pathorghata and Golachipa. One species of *Cortinarius* was recorded and that was *Cortinarius corrugatus*. Only one number of *Cortinarius* was found during collection. The biodiversity, habitat and morphology are described below.

4.11.1 Biodiversity

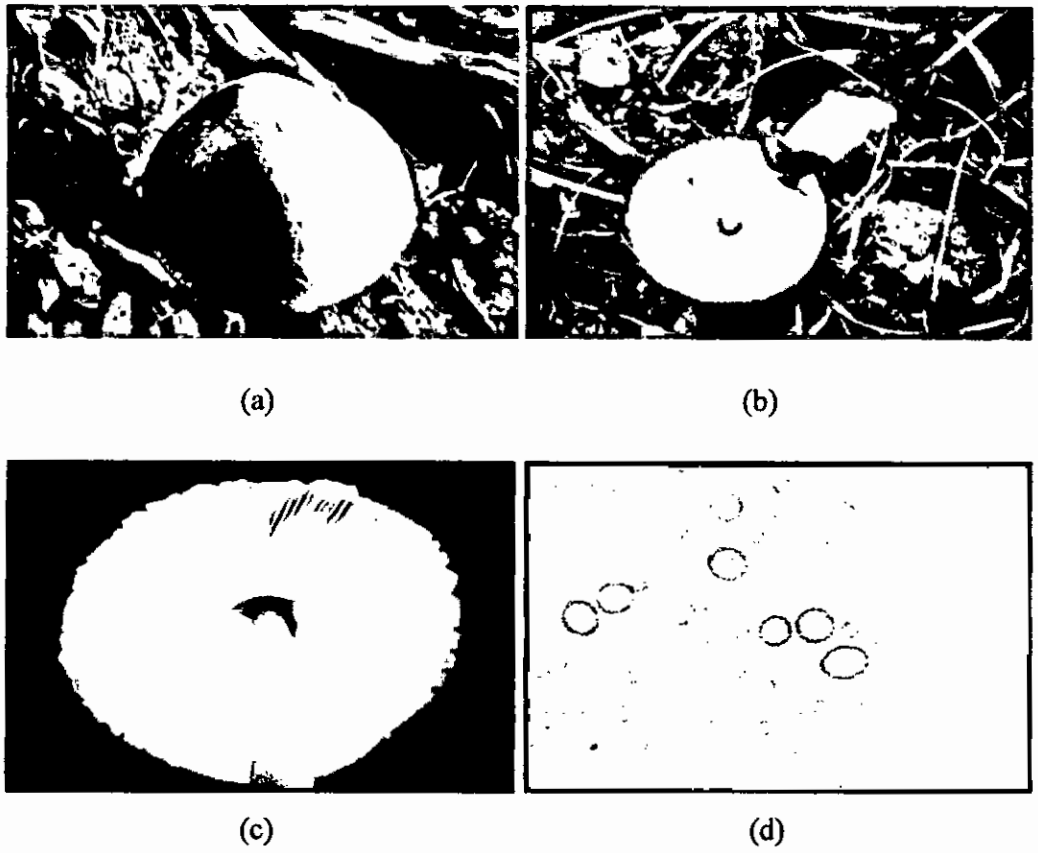
Cortinarius corrugatus was found in Pathorghata and Golachipa. The frequency of its presence was 11.11% and the density was 5%.

4.11.2 Habitat

The mushroom was found on the on the root zone of *Musa paradisiaca*. Forest type was mixed. Soil moisture was 6.5, soil P^H was 6.2 and soil type was clay. Average recorded temperature was 29 ^{0}C.

4.11.3 Morphology

Fructification size was 12x3 cm. The color of pileus (cap) was ash color. The shape of cap was ovate. The cap edge was grooved. Ash color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Cortinarius corrugatus.* The color of stipe was milky white. The length and width of stipe was 8 cm and 3 cm. Gills were present and color of gills are milky white. Black ring or anal was present on the upper part of stipe and volva was absent on the lower part of stipe of *Cortinarius corrugatus.* The color of spore was white, ornamentation was round circle and size of spore was 6×6 µm (Plate 13).



(a) (b)

(c) (d)

Plate 13. Photographs of *Cortinarius corrugatus*: Ovate shape cap and grooved cap edge (a), black ring (b) and white gills (c), round circle spore (d)

4.11.4 Taxonomy of *Cortinarius* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Agaricales
Family: Cortinariaceae
Genus: *Cortinarius*
Species: *Cortinarius corrugatus*

4.12 Biodiversity, habitat and morphology of *Gymnopus* sp.

A survey was conducted in Perojpur and Patuakhali. One species of *Gymnopus* was recorded and that was *Gymnopus* sp. Two number of *Gymnopus* were found during collection. The biodiversity, habitat and morphology are described below.

4.12.1 Biodiversity

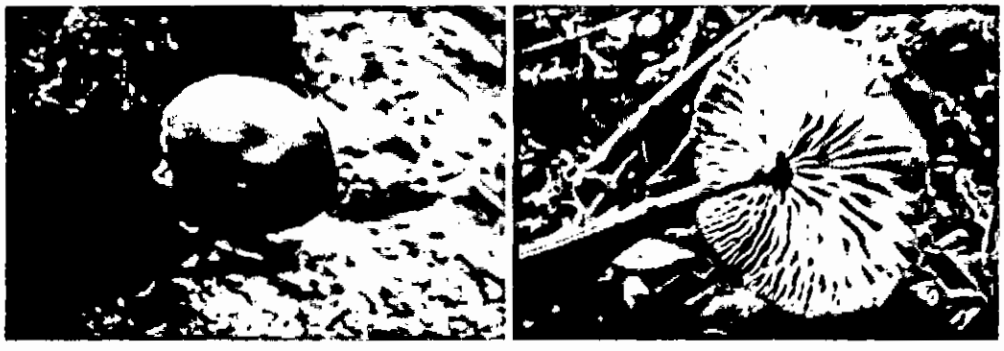
Gymnopus sp. was found in Perojpur and Patuakhali. The frequency of its presence was 11.11% and the density was 10%.

4.12.2 Habitat

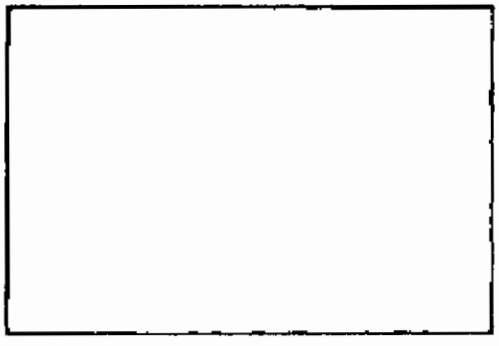
The mushroom was found on the root zone of *Swietenia macrophylla* and on natural humus of forest. Forest type was deciduous. Soil moisture was 7, soil P^H was 6.2 and soil type was sandy loom and clay loom. Average recorded temperature was 30 ^{0}C.

4.12.3 Morphology

Fructification size was 4-5x2-3 cm. The color of pileus (cap) was brick red. The shape of cap was convex. The cap edge was grooved. Scale was not found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Gymnopus* sp. The color of stipe was light purple. The length and width of stipe was 0.8-2 cm and 0.3-0.6 cm. Gills were present and color of gills are brown to white. Ring or anal was abesent on the upper part of stipe and volva was absent on the lower part of stipe of *Gymnopus* sp. The color of spore print was greenish, ornamentation was echinulate and size of spore was 11.5×8 μm (Plate 14).



(a) (b)



(c)

Plate 14. Photographs of *Gymnopus* sp: Convex cap (a), hard gills (b) and echinulate spore (c)

4.12.4 Taxonomy of *Gymnopus* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Agaricales
Family: Marasmiaceae
Genus: *Gymnopus*
Species: *Gymnopus* sp.

4.13 Biodiversity, habitat and morphology of *Mycena* sp.

A survey was conducted in Patuakhali. One species of *Mycena* was recorded and that was *Mycena epipterygia*. Six number of *Mycena* were found during collection. The biodiversity, habitat and morphology are described below.

4.13.1 Biodiversity

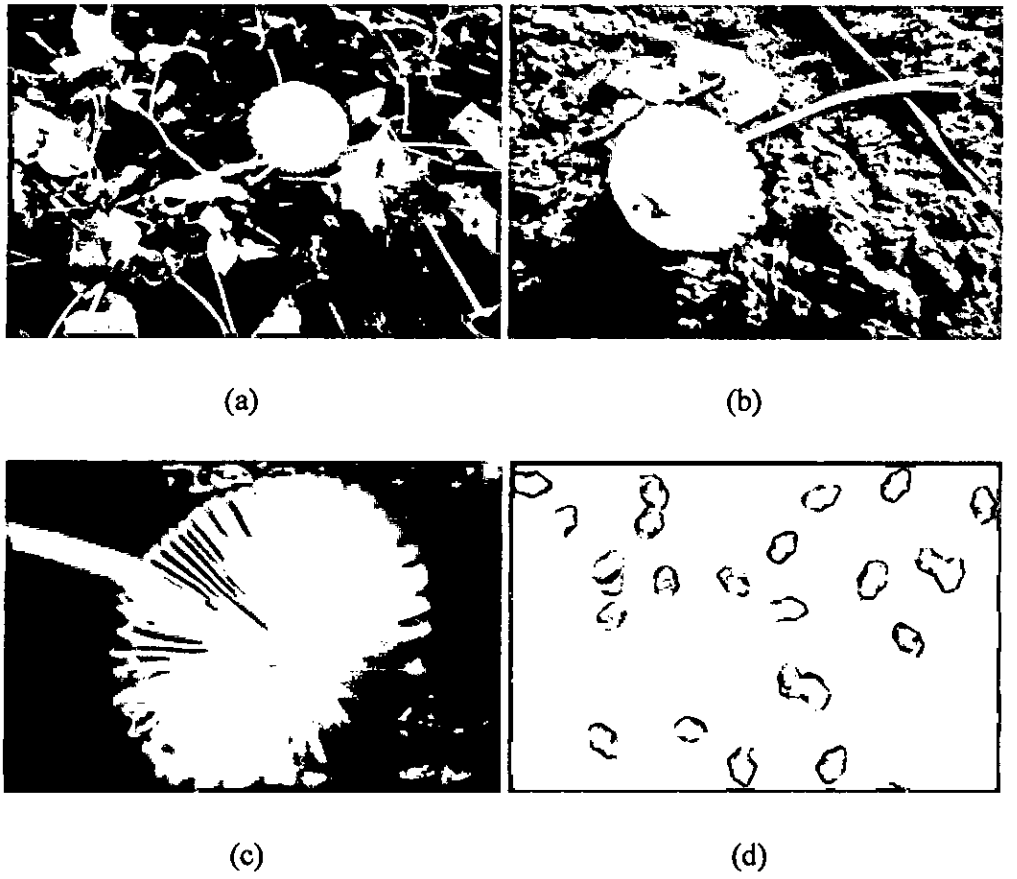
Mycena epipterygia was found in Patuakhali. The frequency of its presence was 5.56% and the density was 30%.

4.13.2 Habitat

The mushroom was found on the moist soil of the forest. Forest type was leaved. Soil moisture was 8, soil P^H was 6 and soil type was clay. Average recorded temperature was 30 ^{0}C.

4.13.3 Morphology

Fructification size was 6x2 cm. The color of pileus (cap) was fleshy and whitish. The shape of cap was umbonate. The cap edge was split. Fleshy and white scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Mycena epipterygia.* The color of stipe was white. The length and width of stipe was 9-10 cm and 0.5 cm. Gills were present and color of gills are white to light yellow. Ring or anal was abesent on the upper part of the stipe and volva was absent on the lower part of the stipe of *Mycena epipterygia.* The color of spore was ash, ornamentation was tuberculate and size of spore was 13×10 µm (Plate 15).



(a) (b)

(c) (d)

Plate 15. Photographs of *Mycena epipterygia*: Umbonate cap (a and b) and soft white gills (c) and tuberculate spore (d)

4.13.4 Taxonomy of *Mycena* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Agaricales
Family: Mycenaceae
Genus: *Mycena*
Species: *Mycena epipterygia*

4.14 Biodiversity, habitat and morphology of *Nolanea* sp.

A survey was conducted in Pathorghata. One species of *Nolanea* was recorded and that was *Nolanea strictia*. Seventeen number of *Nolanea* were recorded during collection.The biodiversity, habitat and morphology are described below.

4.14.1 Biodiversity

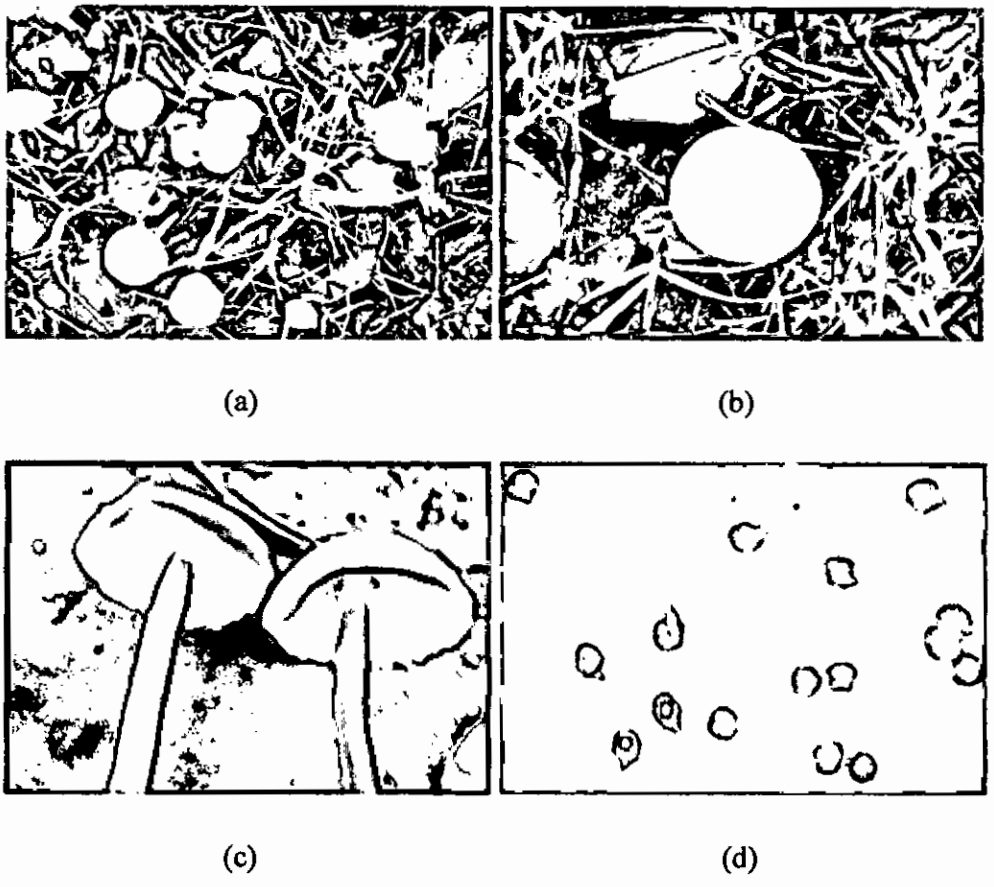
Nolanea strictia was found in Pathorghata. The frequency of its presence was 5.56% and the density was 85%.

4.14.2 Habitat

The mushroom was found on the natural humus of the forest. Forest type was mixed. Soil moisture was 7, soil P^H was 6.5 and soil type was sandy. Average recorded temperature was 30 ^{0}C.

4.14.3 Morphology

Fructification size was 11x3.8 cm. The color of pileus (cap) was fleshy and creamy. The shape of cap was umbonate. The cap edge was grooved. Fleshy and creamy scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Nolanea strictia.* The color of stipe was white. The length and width of stipe was 3.5-6 cm and 0.6-1.5 cm. Gills were present and color of gills are brown to white. Ring or anal was abesent on the upper part of the stipe and volva was absent on the lower part of the stipe of *Nolanea strictia.* Spore color was light violet, ornamentation was globose and subglobose. Spore size was 12×9 µm (Plate 16).



(a) (b)

(c) (d)

Plate 16. Photographs of *Nolanea strictia*: Umbonate cap (a and b), brown gills (c), violet color, globose and subglobose spore (d)

4.14.4 Taxonomy of *Nolanea* sp.

Kingdom: Fungi

Phylum: Basidiomycota

Class: Agaricomycetes

Subclass: Hymenomycetes

Order: Agaricales

Family: Entolomataceae

Genus: *Nolanea*

Species: *Nolanea strictia*

4.15 Biodiversity, habitat and morphology of *Ganoderma* sp.

A survey was conducted in Modhupur, Patuakhali, Perojpur, Bandorban, Borguna, Pathorghata, Jhalokathi and Dhaka. Three species of *Ganoderma* were recorded viz. *Ganoderma lucidum, Ganoderma apphannatum* and *Ganoderma tsuage*. A total thirty eight number of Ganoderma were found during collection. Their biodiversity, habitat and morphology are described below.

4.15.1 Biodiversity

Ganoderma lucidum was found in Modhupur, Patuakhali, Perojpur, Bandorban and Borguna. The frequency of its presence was 27.78% and the density was 50%.*Ganoderma apphannatum* was found in Modhupur, Dhaka, Perojpur, and Bandorban. The frequency of its presence was 22.22% and the density was 45%.*Ganoderma tsuage* was found in Modhupur, Patuakhali, Dhaka, Jhalokathi, Borguna and Pathorghata. The frequency of its presence was 33.33% and the density was 95%.

4.15.2 Habitat

The mushrooms were found on the bark of tree and on dead plat. Forest type was mixed for all three specise of Ganoderma. Average soil moisture was 4-6 for all three specise of Ganoderma. Average soil P^H was 6 to 6.5 for all three specise of *Ganoderma*. Soil type was clay loam. Average recorded temperature was 30 ^{0}C for three species viz. *Ganoderma lucidum, Ganoderma apphannatum* and *Ganoderma tsuage*.

4.15.3 Morphology of *Ganoderma* sp.

a. *Ganoderma lucidum*

Fructification size was 20-25×8-10 cm. The color of pileus (cap) was red. The shape of cap was hard and flat. The cap edge was undulating. Scale was not found on the cap. Beneath the cap hymenophores were not present. Regular shaped gills (lamellae) were not present underside of the cap of *Ganoderma lucidum*. Pseudostem present under the cap. Ring and volva was absent (Plate17).

b. *Ganoderma apphannatum*

Fructification size was 18×8 cm. The color of pileus (cap) was white with ash margin. The shape of cap was hard and flat. The cap edge was undulating. Scale was not found on the cap. Beneath the cap hymenophores were not present. Regular shaped gills (lamellae) were not present underside of the cap of *Ganoderma apphannatum*. Pseudostem present under the cap. Ring and volva was absent (Plate17).

c. *Ganoderma tsuage*

Fructification size was 19×10 cm. The color of pileus (cap) was red with white margin. The shape of cap was hard and flat. The cap edge was undulating. Scale was not found on the cap. Beneath the cap hymenophores were not present. Regular shaped gills (lamellae) were not present underside of the cap of *Ganoderma tsuage*. Pseudostem present under the cap. Ring and volva was absent (Plate17).

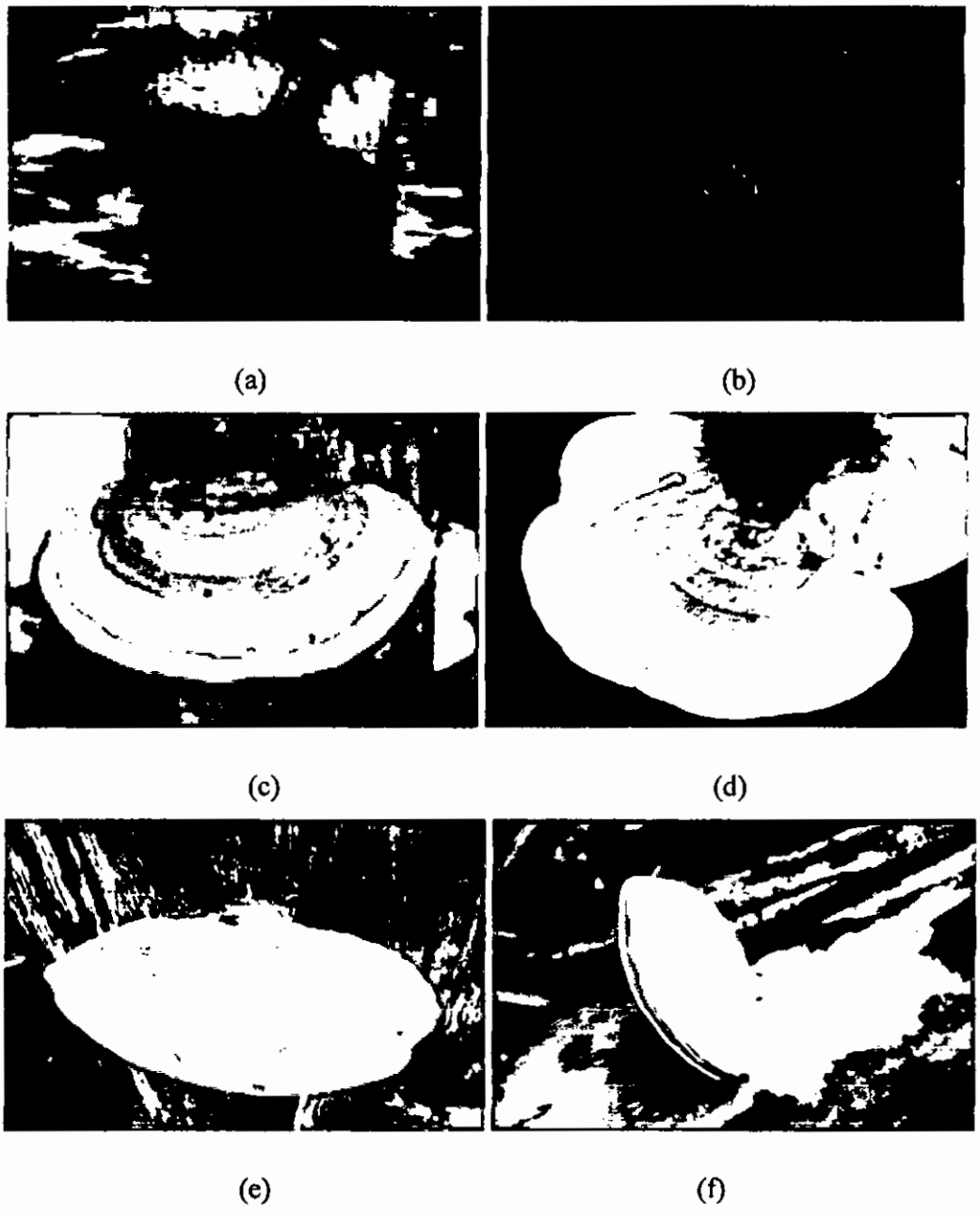


Plate 17. Photographs of *Ganoderma* sp: *Ganoderma lucidum* (a and b), *Ganoderma apphannatum* (c and d) and *Ganodrma tsuage* (e and f)

4.15.4 Taxonomy of *Ganoderma* sp.

Kingdom: Fungi
Phylum: Basidiomycota
Class: Agaricomycetes
Order: Polyporales
Family: Ganodermataceae
Genus:*Ganoderma*
Species: *Ganoderma lucidum,*
Ganoderma apphannatum,
Ganoderma tsuage

4.16 Biodiversity, habitat and morphology of *Polyporus* sp.

A survey was conducted in Borguna and Bandorban. One species of *Polyporus* was recorded and that was unidentified. Two number of *Polyporus* were found during collection. The biodiversity, habitat and morphology are described below.

4.16.1 Biodiversity

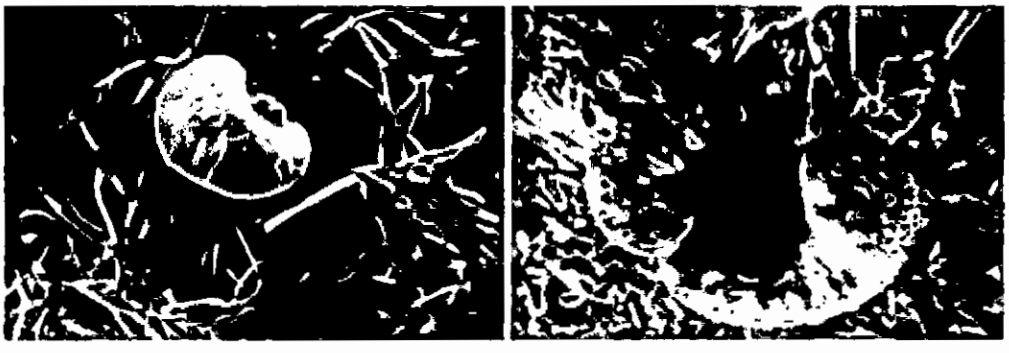
Polyporus sp was found in Borguna and Bandorban. The frequency of its presence was 11.11% and the density was 10%.

4.16.2 Habitat

The mushroom was found on the bark of tree and on the dead plant. Forest type was mixed. Soil moisture was 5, soil P^H was 6 and soil type was sandy loam. Average recorded temperature was 29 ^{0}C.

4.16.3 Morphology

Fructification size was 13×5 cm. The color of pileus (cap) was white with brick red in middle. The shape of cap was offset and infundibuli form. The cap edge was lobed. White scale was found on the cap. Beneath the cap hymenophores were present. Irregular shaped and minute gills (lamellae) were present underside of the cap of *Polyporus* sp. The color of stipe was brick red. The length and width of stipe was 2 cm and 1.5 cm. Color of gills were white. Ring or anal was abesent on the upper part of the stipe and volva was absent on the lower part of the stipe of *Polyporus* sp. (Plate 18).



(a) (b)

(c)

Plate 18. Photographs of *Polyporus* sp: Offset cap (a), lobed cap edge (b) and white minute gills (c)

4.16.4 Taxonomy of *Polyporus* sp.

Kingdom: Fungi

Phylum: Basidiomycota

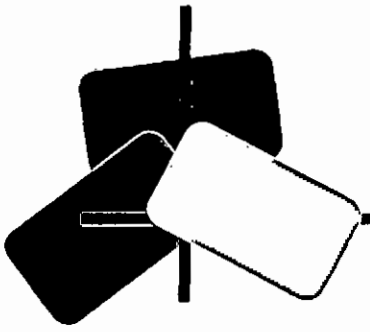
Class: Agaricomycetes

Order: Polyporales

Family: Polyporaceae

Genus: *Polyporus*

Species: *Polyporus* sp.



CHAPTER 5

DISCUSSION

CHAPTER V

DISCUSION

For the study of biodiversity, habitat and morphology of mushrooms a survey was conducted in 18 upazilla under 9 districts of Bangladesh viz. Barisal, Patuakhali, Perojpur, Jhalokathi, Borguna, Tangail, Dhaka, Gazipur and Bandorban. Survey was conducted during the period from June to September, 2013 and June to September, 2014. The key objective of the present study was to generate a database on macro fungal diversity of selected eighteen natural forest zones of Bangladesh with their ecological preferences.

In the present study 20 different mushroom species were founded under 14 families viz. Agaricaceae (*Agaricus* sp.), Amanitaceae (*Amanita hemibapha*, *Amanita bisporigera*, *Amanita rubescens*), Pyronemataceae (*Aleuria aurantia)*, Boletaceae (*Boletus subvelutipes*, *Tylopilus badiceps*, *Retiboletus ornatipes*), Tricholomataceae (*Callistosporium* sp.), Sarcosomataceae (*Bulgaria inquinans*), Russulaceae (*Russula crustosa*), Roselliniaceae (*Rosellinia* sp.), Cortinariaceae (*Cortinarius corrugatus*), Marasmiaceae (*Gymnopus* sp.), Mycenaceae (*Mycena epipterygia*), Entolomataceae (*Nolanea strictia*), Ganodermataceae (*Ganoderma lucidum*, *Ganoderma apphannatum*, *Ganoderma tsuage*) and Polyporaceae (*Polyporus* sp.). Among the total 20 species, maximum 3 species (*Amanita hemibapha*, *Amanita bisporigera*, *Amanita rubescens*) were found under Amanitaceae family, followed by Ganodermataceae family 3 species (*Ganoderma lucidum*, *Ganoderma apphannatum*, *Ganoderma tsuage*) and Boletaceae family 3 species (*Boletus subvelutipes*, *Tylopilus badiceps*, *Retiboletus ornatipes*). The rest of ten species were found fewer than ten individual families.

The maximum frequency of occurrence was exhibited by *Ganoderma tsuage* (33.33%), followed by *Ganoderma lucidum* (27.78%), *Ganoderma apphannatum* (22.22%) and *Amanita brunnescens* (22.22%). The rest of the species exhibited the frequency distribution ranging between 5.56-11.11%. The maximum density was recorded for *Ganoderma tsuage* (95%), followed by *Nolanea strictia* (85%) and *Ganoderma lucidum* (50%).

The densities of rest of the species were ranged between 5-45%. From my work, it was observed that, maximum fleshy fungi such as *Amanita* mushrooms grown on natural humus of the forest and maximum hard caped mushrooms such as *Ganoderma* grown on bark of tree or dead plant as parasite or saprophytes. Forest type was leaved, deciduous and mixed. Soil moisture ranged from 4 to 7 in P^H scale but 6-7 is most suitable for fleshy mushrooms. Soil P^H ranges in between 6-6.5. Sandy clay, clay, clay loam is best for growing of mushrooms. Temperature ranges from 29 to 31 is most suitable in case of Mushrooms habitat.

The present study was supported by Tapwal *et al.* (2013). They recorded the diversity and frequency of macro fungi associated with wet ever green tropical reserve forest in Assam, India. The diversity of broad leaves trees and high humidity during monsoon period favors ideal growth of diverse group of macro fungal fruiting bodies. 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 ecological preference of the species reveled that maximum (17) species were saprophyte, living on dead substrates or decaying wood debris, ten species were found associated with roots of higher trees, while three species were found parasitic. Overall 20 species were found edible including some species having medicinal utilization. The 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%). The density of rest of the species were ranged between 3.33- 6.67%.

Dwivedi *et al.* (2012) studied the taxonomy and diversity of macro fungi that are gaining importance as many macro fungi are becoming extinct and facing threat of extinction because of habitat destruction. They studied the 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. Amarkantak is located at 22°40_N 81°45_E/ 22.67°N 81.75°E. It has an average elevation of 1048 meters (3438 ft). More than 85% of annual average rain fall is received during the monsoon month extending from June to September. The mean annual rain fall for Amarkantak is about 1619.9 mm distributed over ninety two average annual rainy days.

In the present survey *Russula* sp. were indentified where this genus includes some very beautyful and interesting species, and a lot of hard to distinguish species. Because Russulas are typically fairly large, and because they are often brightly colored, amateur mushrroms are frequently interested in identifying them. About 20 or 30 species can be identified fairly and easily but there are perhaps 750 species worldwide (Michael Kau, 2011). Ram *et al.* (2010) also reported that, several edible fleshy fungi grow wild in Eastern Uttar Pradesh forest during the rainy season on dead and decaying plant or animal remains. Local tribes collect a number of mushrooms and eat during rainy season. The traditional identification knowledge among the tribes is followed from generation to generation. These fleshy fungi are obviously nontoxic as these have been intimate human consumption since antiquity. However there are only few species of fleshy fungi which have been accepted as safe food by the civilized world, while many fleshy fungi have not yet recognized. Field survey was conducted for collection of various edible fleshy fungi from different localities of the Eastern Uttar Pradesh forest. The collected edible fleshy fungi were studied for their macroscopic detail parenting the habit, habitat, morphology and other phenotypic parameter noted in fresh form.

Fungi have been occupying a prominent position in the biological world because of their variety, economic and environmental importance. The study of fungal biodiversity has been carried out world over and 1.5 million species has been reported so far. About 50% of them have been characterized.

The total numbers of fungal species in India is 27,000 where a limited number have been recorded and documented in Bangladesh. The fungal biotechnology is an emerging area and they are intimately related with our life. Macro fungi are unique from fungal diversity point of view. Macro fungi grow prolifically and are found in many parts of the world. It is usual for a particular fungus to produce a visible fruiting body only under a precise combination of conditions, including geographic location, elevation, temperature, humidity, light and surrounding flora. Studies on macro fungi and their various aspects have been carried out in different parts of the globe. Studies on Macro fungi have been an area of importance for the scientists in particular and the people in general, because of their role in human welfare, in food industry, in medicines, and biodegradation. However, the study of macro fungi, having edibility and medicinal properties are yet to be properly dealt with. Traditional mycological knowledge of most Indian ethnic groups has proven to be extensive and profound, consuming nearly 283 species of wild mushrooms out of 2000 species recorded world over.

In the present study the morphology of 20 species is different from each other. The size of fructification ranges from 3-4×2-3 to 20-25×8-10 cm. Different cap color of mushrooms were recorded viz. white, whitish, red, pink, yellow, yellowish, ash, brown, orange, creamy white, milky white and black (*Rosellinia*). Different shapes of cape were recorded viz. convex, ovate, umbonate, depressed and flat. Cap edge shapes were grooved or plicate, split and undulating. Brownish, white, yellow, pink and coffee color scales were found. Hymenophores were present beneath the cap of the fleshiest mushrooms but absent in *Ganoderma*. Different color of gills were recorded viz. white, whitish, red, pink, yellow, yellowish, ash, brown, orange, creamy white. Stipe length ranges from 0.8 to 10cm and width from 0.3 to 0.6cm. Colors of stipes were recorded white, whitish, greenish, yellow, yellowish, brown and creamy white. Ring (annals) and volva were present in some individual species.

The result of the present study is supported by Onyango *et al.* (2011). They mentioned that utilization of mushrooms collected from the wild requires adequate description of useful phonetic features and domestication protocols.

This study investigated morphological characters and spawn production procedures of three Kenyan native strains of wood ear mushroom. Nine basidiocarps were selected from collections made in three forest reserves within Kakamega Forest in Western Kenya and morphologically characterized. Mycelia were raised on 2% malt extract agar and bottle culture technology was used for spawning. The spawning experiment was arranged in completely randomized design with three replicates. Variations occurred in external basidiocarps features such as color, texture, and shape and presence of veined surfaces. Microscopic analysis of internal basidiocarps structures did not reveal significant differences.

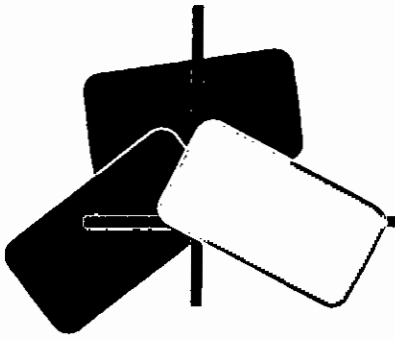
In the present study a genus *Tylopilus* was encountered which was reported as stout bolete mushrooms that generally arise from the ground or occassionally from wood. They have stout stipes, which do not have a ring. A key field character which distinguishes them from members of the genus Boletus is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

The present investigations are in accordance with the description given some researchers like Atri and Kaur (2005) who has collected from different localities of north eastern Punjab three mushrooms belonging to family Pluteaceae. They have illustrated and described for first time from India. Pradeep and Vrinda (2005) have also collected and studies using taxonomic descriptors of four species of Pluteus from western Ghat of Kerela, India. Upadhyay and kaur (2003) have recorded and described several species of mushroom viz. *Pluteus umbrosus, Volvariella cubensis, V.surrecta, Agrocybe putaminum, Entoloma coneri, Phaeocollybia latispora, Melanoleuca tristis* and *Collybia* that was supports the findings of the present study.

Under the present study three species of *Ganoderma* viz. *Ganoderma lucidum, Ganoderma apphannatum* and *Ganodrma tsuage* were recorded. Hard flat shape cap was observed and spore was absent on the cap.

The habitat and morphology of *Ganoderma* are quite different from fleshy mushrooms. *Ganoderma* was commonly known as reishi mushroom and special gift of Allah to human being as medicine. Bazzalo (1982), Susan and Van (1992) carried out extensive research on biology of Basidiomycetes mushrooms has markedly increased due to their potential use for the production of new biotech-products (pharmaceuticals, Nutraceuticals, etc.). In spite of their commercial importance there are many gaps to be filled in the current knowledge on their taxonomy and biology. They reported that white-rot species of genus *Ganoderma* possess different medicinal effects and have been using as traditional medicines in many countries. More than 250 *Ganoderma* species are described, however variable morphological characteristics makes species identification difficult. *Ganoderma* collections of 22 strains were isolated in Armenia, France, Iran, Italy and China. Cultural (morphological, ecological, physiological) characteristics and growth parameters of mycelia colonies and pellets, presence of chlamydospores were thoroughly described in submerged and static culture and using different nutrient media. Two collections of *G. lucidum* from Armenia genetically were identified as *G. lucidum,* two from three French collections as *G. lucidum,* one as *Trametes gibbosa,* four Italian and one Chinese collection also belongs to *G. lucidum* species. Armenian, Italian and French collections of *G. lucidum* are placed in the European *G. lucidum* clade. Seven collections of *G. applanatum* from Armenia and one from Iran are identified as *G. adspersum* species which is originally reported for Armenian mycobiota. One collection of *G. applanatum* from Armenia was confirmed by molecular analysis. One *Ganoderma* sp. strain from France and two strains from Iran were identified as belonging to *G. resinaceum.* The French *G. resinaceum* is closely related with *G. lucidum* sequences from USA. The sequence analyses revealed that *G. lucidum* from Armenia were monophyletic with respect to the Italian *G. lucidum* genotype. The genetic and morpho-physiological data presented here could assist further molecular taxonomic studies of *Ganoderma* species.

From my study it was observed that, there are different color of spore of different mushrooms viz. white, brown, ash, greenish, whitish, brownish and ash. The spore ornamentation variations were recorded as globose, subglobose, tuberculate, hyaline hyphae, ellipsoidal, obtusely fusiform, echinulate and ovoid shape. Among the different structure of spore globose and subglobose is more familiar. The spore size was measured ranging between 5×3.5 to 24×9 μm . The maximum size of spore was recorded for *Aleuria aurantia* (24×9μm) followed by *Boletus subvelutipes* (14×7.5μm) and minimum size was recorded for *Retiboletus ornatipes* (5×3.5μm) followed by *Russula crastosa* (6×4.5μm). The result of the present study is supported by Svrcek (2000) and he reported that, a cap or pileups is borne on a stalk. It can be various shapes viz. hemispherical or convex, depressed, offset, ovate, umbonate and umbllicate etc. Among them convex shape is most familiar and most of the cap of Mushrooms becoming flat shape with the maturity. Cap edge can be undulating, lobed, grooved or plicate, and split shape. Among them grooved or plicate is more familiar. Hymenophores can be smooth surfaces, lamellae or gills, folds, tubes or teeth, on the underside of the cap. Spore of fungi are vital for the dispersal of the species. The size of spore is on average 5 to 15 µmm (thousandth of a millimeter). The color, structure or ornamentation varying from species to species of Mushrooms. Spore ornamentation can be globose, subglobose, cylindrical, fusiform, angular, echinulate, verrucose, obtusely fusiform, ovoid etc.



CHAPTER 6

SUMMARY AND CONCLUSION

CHAPTER VI

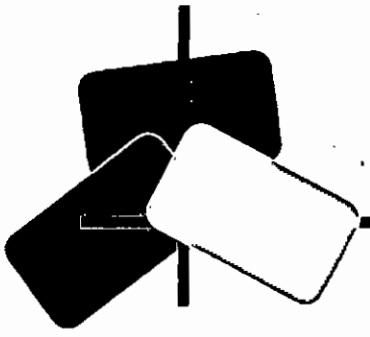
SUMMARY AND CONCLUSION

The demand of mushroom is increasing day by day in the world. To meet the growing demand of mushroom as a food the biodiversity, habitat and morphology is most important issue. For the study of biodiversity, habitat and morphology of mushroom a survey was conducted in 18 upazila of selected 9 districts named Barisal, Patuakhali, Perojpur, Jhalokathi, Borguna, Tangail, Dhaka, Gazipur and Bandorban for gathering knowledge about mushroom biodiversity, habitat and morphology in fresh form. After collecting some data in fresh form the sample were preservsd for authentic study in laboratory. After morphological study in both field and laboratory and spore ornamentation under microscope the follwing 20 different species were founded and these were *Agaricus* sp., *Amanita hemibapha, Amanita bisporigera, Amanita rubescens, Aleuria aurantia, Boletus subvelutipes, Bulgaria inquinans, Callistosporium* sp., *Tylopilus badiceps, Russula crustosa, Retiboletus ornatipes, Rosellinia* sp., *Cortinarius corrugatus, Gymnopus* sp., *Mycena epipterygia, Nolanea strictia, Ganoderma lucidum, Ganoderma apphannatum, Ganoderma tsuage, Polyporus* sp. etc. The habitat of fleshy mushroom mostly on natural humus of the forest and hard shape mushroom such as *Ganoderma* grow on the bark of living tree as parasites or on the dead plant body as saprophytes. Mixed type forest is best for mushroom growth and development. Morphologically most of the fruiting body of mushrooms is white and there are also some yellow, orange, brown, and ash color mushroom. Cap shape mostly convex and cap edge grooved in most of the species. Stipe is present in most of the fleshy mushroom and most of *Ganoderma* and *Polyporus* species attached with bark of tree by means of pseudostem. White gills present underside of the cap or pileus that is hymenophores present all of the fleshy fungi which grow on soil or humus and hymenophores absent in most of the mushroom which attached with tree.

Morphology and biodiversity of mushroom is quite new idea in Bangladesh. So there are less diversification of mushrooms than India, Pakistan, USA, Europe and other country due lack of proper study about mushrooms. The tribal people of Chittagong hill tracts first start to cultivate mushroom in hilly area.

The identification and use of wild edible mushrooms play a vital role in enrichment of the socio- economic life of the tribal people. However, identifying mushrooms can be a real challenge. The color, shape and size of the fruiting body can vary tremendously. It is important to properly identify the mushroom that is collected, so as to avoid a poisonous species. Besides their consumption, the use of mushrooms in folk medicines also paves the way for the bringing up new industries. The mushrooms grown in the wild plays an important role to maintain the forest health besides their medicinal importance and nutritional value. Therefore, it becomes quite necessary to explore, document and conserve this natural wealth. The present study provides a database on macro fungal diversity of Bangladeshi Forest, along with their ecological preferences and utilization, which was least documented earlier. As soil and climate situation of this region is very suitable for mushroom cultivation; Bangladesh has a huge prospect of mushroom cultivation. Through mushroom cultivation, it is possible to generate considerable employment opportunity, alleviate poverty, and reduce malnutrition to meet the required protein of Bangladeshi people. Even it is possible to earn a huge amount of foreign currency by exporting mushroom after meeting the domestic demand.

There is a large scope for commercial production of mushrooms which can supply essential nutrients and serve as a medicinal element. Growing of different varieties of edible mushrooms especially which have nutritional and medicinal value; we can supply required nutrients and medicine for our increasing population and can be used as a supplementation of other foods. So this is the high time to give emphasis on commercial production of mushrooms in Bangladesh.



CHAPTER 7

LITERATURE CITED

CHAPTER VII
LITERATURE CITED

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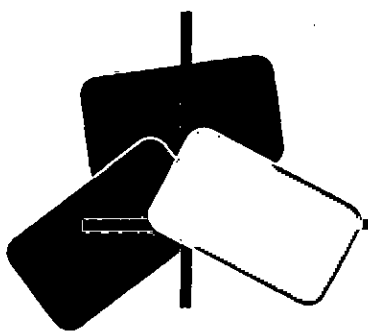


APPENDIX

Appendix I. Distribution of daily average temperature (°C), relative humidity (RH %) and rainfall (mm) of the experimental site in the month of June, 2013

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	31	67	0.00
2	31	69	0.00
3	30	65	0.00
4	30	67	0.00
5	30	66	0.00
6	31	68	0.00
7	29	70	0.00
8	30.5	69	0.00
9	30.5	70	0.00
10	29	72	0.00
11	32	73	0.20
12	32	76	0.30
13	32	77	0.50
14	31	78	20
15	30	79	30
16	29.5	79	30
17	30.3	80	40
18	29.8	84	50
19	32	82	10
20	31	85	20
21	31	86	40
22	29.5	87	20
23	29.5	83	0.00
24	31	84	0.00
25	31	81	0.00
26	31	81	0.00
27	30	83	50
28	29	84	80
29	32	84	80
30	32.5	85	100

Appendix II. Distribution of daily average temperature (°C), relative humidity (RH %) and rainfall (mm) of the experimental site in the month of July, 2013

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	31	68	34
2	31	74	33
3	30	78	98
4	31.5	78	25
5	30	66	78
6	31	91	0.00
7	29	88	26
8	30.5	85	80
9	30.5	83	89
10	27	72	37
11	28	73	28
12	32	76	100
13	28	77	120
14	31	78	120
15	30	86	90
16	29.5	79	80
17	30.3	89	39
18	29.8	84	0.00
19	32	82	0.00
20	27	84	130
21	27	86	120
22	28	88	119
23	29.5	83	75
24	31	88.5	79
25	29	90	80
26	31	93	69
27	27	94	109
28	29	90	102
29	28	84	103
30	30	85	30
31	31	84	30

Appendix III. Distribution of daily average temperature (°C), relative humidity (RH %) and rainfall (mm) of the experimental site in the month of August, 2013

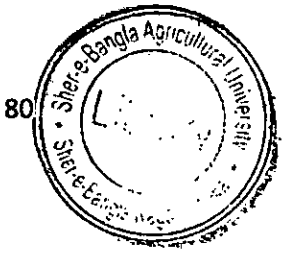
Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	25	80	40
2	27	89	30
3	28	65	30
4	30	67	48
5	29	66	78
6	31	68	13
7	29	73	27
8	31	70	0.00
9	30.5	70	0.00
10	31	79	0.00
11	30	73	28
12	32	88	120
13	29	90	120
14	29	81	130
15	30	79	140
16	29.5	79	90
17	30.3	80	39
18	27	89	150
19	28	82	140
20	29	78	125
21	31	86	139
22	31	79	120
23	30	88	75
24	31	89	79
25	29	81	80
26	30	85	69
27	30	83	25
28	29	92	100
29	32	90	26
30	30	85	30
31	31	67	30

Appendix IV. Distribution of daily average temperature (°C), relative humidity (RH %) and rainfall (mm) of the experimental site in the month of September, 2013

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	30	70	80
2	32	78	70
3	30	85	126
4	30	88	139
5	28	89	120
6	28	95	130
7	28.6	95	50
8	30.5	91	0.00
9	27.8	91	0.00
10	29	89	48
11	32	87	10
12	31	76	105
13	30	79	104
14	30	83	104
15	30	80	59
16	29.5	79	39
17	30.5	80	60
18	29.8	84	50
19	32	70	0.00
20	31	68	0.00
21	30	81	50
22	29.5	83	49
23	29.5	92	39
24	32	84	35
25	29	81	0.00
26	28	79	0.00
27	30	76	0.00
28	29	75	0.00
29	29	77	0.00
30	29	74	0.00

Appendix V. Distribution of daily average temperature (^{0}C), relative humidity (RH %) and rainfall (mm) of the experimental site in the month of June, 2014

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	28.5	81	04.0
2	28.5	84	00.0
3	29.4	83	00.0
4	31.0	80	00.0
5	31.1	80	00.0
6	31.4	79	00.0
7	31.2	78	00.0
8	31.1	75	00.0
9	31.5	85	04.6
10	29.8	86	13.8
11	27.6	87	07.4
12	29.5	85	06.0
13	28.5	85	22.9
14	30.9	78	00.0
15	31.9	77	00.0
16	31.1	81	00.0
17	31.5	88	08.0
18	29.9	85	07.0
19	29.5	90	92.0
20	27.3	95	31.6
21	28.1	96	42.2
22	26.5	96	65.4
23	24.5	96	18.6
24	26.5	89	00.0
25	29.4	81	00.0
26	29.3	90	01.0
27	29.0	85	00.6
28	29.0	87	04.6
29	30.1	88	17.0
30	29.5	87	06.6



Appendix VI. Distribution of daily average temperature (°C) , relative humidity (RH %) and rainfall (mm) of the experimental site in the month of July, 2014

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	29.8	85	56.0
2	29.8	81	40.0
3	28.8	90	83.0
4	28.9	87	50.0
5	27.5	91	122
6	29.3	89	18.0
7	30.1	82	02.0
8	29.0	93	74.0
9	29.0	93	75.0
10	29.9	86	26.0
11	30.9	86	26.0
12	31.2	80	20.0
13	31.4	81	40.0
14	30.0	83	40.0
15	30.1	84	27.0
16	29.2	84	50.0
17	28.5	89	22.6
18	29.6	84	00.0
19	30.3	82	00.0
20	31.0	72	02.0
21	28.9	84	09.0
22	28.8	84	15.0
23	29.6	85	20.0
24	30.8	80	01.0
25	31.5	84	40.0
26	27.4	84	94.0
27	24.5	90	922
28	24.4	88	176
29	25.0	81	20.0
30	27.4	79	10.0
31	27.9	82	42.0

Appendix VII. Distribution of daily average temperature (°C) , relative humidity (RH %) and rainfall (mm) of the experimental site in the month of August, 2014

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	30.7	84	04.8
2	30.8	84	03.2
3	29.9	81	09.2
4	30.0	84	04.8
5	29.5	82	08.2
6	29.7	83	00.1
7	30.3	88	20.8
8	28.8	80	00.2
9	30.2	80	00.0
10	29.4	84	10.0
11	29.0	91	13.2
12	29.3	88	120
13	29.3	93	02.0
14	28.0	94	10.0
15	28.0	91	17.6
16	27.8	93	43.5
17	28.0	90	00.9
18	29.2	90	03.2
19	27.0	96	114.2
20	28.3	90	04.2
21	38.5	93	01.0
22	28.9	91	14.8
23	29.3	92	45.8
24	28.3	94	68.0
25	28.3	95	84.3
26	27.5	92	00.2
27	29.3	83	00.0
28	27.7	91	12.6
29	30.5	84	02.0
30	30.4	85	06.2
31	30.0	80	08.8

Appendix VIII. Distribution of daily average temperature (°C) , relative humidity (RH %) and rainfall (mm) of the experimental site in the month of September, 2014

Date	Temperature (°C)	RH (%)	Rainfall (mm)
1	29.5	78	00.0
2	29.8	79	00.0
3	30.6	79	00.0
4	30.0	85	08.0
5	29.0	85	00.0
6	30.0	84	06.8
7	29.0	84	00.0
8	27.8	87	00.0
9	30.0	85	00.0
10	29.6	82	00.0
11	30.2	85	00.0
12	30.9	80	00.0
13	29.3	90	00.0
14	29.3	89	00.0
15	29.1	88	00.0
16	30.4	80	00.0
17	30.5	82	00.0
18	29.8	89	64.3
19	27.7	95	134.2
20	26.7	93	09.0
21	27.3	95	46.2
22	27.5	92	24.9
23	27.3	92	32.6
24	28.4	90	59.0
25	27.9	74	00.0
26	28.4	79	13.0
27	28.3	92	00.0
28	28.3	80	03.4
29	28.3	87	00.0
30	29.5	80	00.0