

BIODIVERSITY OF WOOD DECAY FUNGI ON *DALBERGIA SISSOO*

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BIODIVERSITY OF WOOD DECAY FUNGI ON

DALBERGIA SISSOO

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CERTIFICATE

This is to certify that the thesis entitled “**BIODIVERSITY OF WOOD DECAY FUNGI ON *DALBERGIA SISSOO***” submitted to the Department of Plant Pathology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfillment of the requirements for the degree of Master of Science (M.S.) in Plant Pathology, embodies the result of a piece of bona fide research work carried out by **Mst. Asmaul husna, Registration No. 11-04321** under my supervision and guidance. No part of the thesis has been submitted anywhere for any other degree or diploma.

I further certify that any help or sources of information, as have been availed of during the course of this investigation have been duly acknowledged by the Author.

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DEDICATED
TO
MY BELOVED
PARENTS

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BIODIVERSITY OF WOOD DECAY FUNGI ON *DALBERGIA SISSOO*

ABSTRACT

A survey was conducted on biodiversity and distribution of wood decay macro fungi in northern social forest regions in five upazillas (Dupchanchia, Adomdighi, Sonatola, Sherpur and Dhunot) of Bogra district in Bangladesh on sisso tree (*Dalbergia sisso*). A total of fifty (50) plants were randomly selected for collection of wood decay fungi in each location. The northern region of Bangladesh (Bogra) is located at 24°32' and 25°07' north latitudes and between 88°58' and 89°45' east longitudes. "*Dalbergia sissoo*" commonly known as Indian Rosewood is a large deciduous tree that produced very heavy strong and stout wood with of good quality. Now a days the plant is in threat (dying) due to fungal infection and other unknown reasons. A total of 43 samples of wood decay fungi belonging 9 families were collected and identified to 15 genera and 21 species. The predominant genus was *Ganoderma*. Among the *Genoderma* spp., the highest density (23.2%) and frequency (55%) was found in *Ganoderma tsugae*. Among the fleshy macro fungi, the highest density (55%) and frequency (33%) was found in *Psathyrella candolleana*. The macro fungi were preserved in Sher-e-Bangla Agricultural University Herbarium of Macro Fungi (SHMF).

CHAPTER	CONTENTS	PAGE NO.
	TITLE	
	ACKNOWLEDGEMENTS	i
	ABSTRACT	ii
	CONTENTS	iii-v
	LIST OF TABLE	vi
	LIST OF PLATES	vii
	LIST OF FIGURE	viii
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-13
III	MATERIALS AND METHODS	14-19
	3.1. Collection site	14
	3.2. Experimental site	16
	3.3. Sampling procedure	16
	3.4. Collection of macro fungi samples	16
	3.5. Morphological observation during collection	17
	3.6. Processing of macro fungi	17
	3.6.1. Drying	17
	3.6.2. Storage	18
	3.7. Morphology and microscopic characterization	18
	3.8. Habitat, distribution and diversity analysis	18-19

CONTENTS		
CHAPTER	TITLE	PAGE NO.
IV	RESULTS AND DISCUSSION	82-89
	4.1.1. <i>Ganoderma boninense</i>	20-21
	4.1.2. <i>Ganoderma tsugae</i>	22-23
	4.1.3. <i>Ganoderma lipsiense</i>	24-25
	4.1.4. <i>Ganoderma lucidum</i>	26-27
	4.1.5. <i>Ganoderma sessile</i>	28-29
	4.1.6. <i>Ganoderma applanatum</i>	30-31
	4.1.7. <i>Trametes versicolor</i>	32-33
	4.1.8. <i>Auricularia cornea</i>	34-35
	4.1.9. <i>Poronidulus conchifer</i>	36-37
	4.1.10. <i>Irpex lacteus</i>	38-39
	4.1.11. <i>Ganoderma</i> sp.	40-41
	4.1.12. <i>Ganoderma</i> sp.	42-43
	4.1.13. <i>Marasmius oreades</i>	44-45
	4.1.14. <i>Coprinellus plagioporus</i>	46-47
	4.1.15. <i>Marasmius siccus</i>	48-49
	4.1.16. <i>Amanita muscaria</i>	50-51
	4.1.17. <i>Pleurotus ostreatus</i>	52-53
	4.1.18. <i>Laetiporus sulphureus</i>	54-55
	4.1.19. <i>Podoscypha petalodes</i>	56-57
	4.1.20. <i>Calvulina coralloides</i>	58-59
	4.1.21. <i>Cornus florida</i>	60-61
	4.1.22. <i>Marasmius haematocephalus</i>	62-63
	4.1.23. <i>Psathyrella candolleana</i>	64-65
	4.1.24. <i>Crepidotus</i> sp.	66-67

CHAPTER	TITLE	PAGE NO.
	4.1.25. Unidentified	68-69
V	SUMMARY AND CONCLUSION	90-91
	REFERENCES	92-101

LIST OF TABLES

Serial no.	Title of the tables	Page no.
01	Survey upazilla(s) of Bogra district in Bangladesh	16
02	Morphology of basidiocarp and characterization of basidiospore of collected Macrofungi from different locations of Bogra district	70-79
03	Ecological characterization of collected macrofungi from different Locations of Bogra district	80-82

LIST OF PLATES

Sl. no.	Title of the plates	Page no.
01	<i>Ganoderma boninense</i>	21
02	<i>Ganoderma tsugae</i>	23
03	<i>Ganoderma lipsiense</i>	25
04	<i>Ganoderma lucidum</i>	27
05	<i>Genoderma sessile</i>	29
06	<i>Ganoderma applanatum</i>	31
07	<i>Trametes versicolor</i>	33
08	<i>Auricularia cornea</i>	35
09	<i>Poronidulus conchifer</i>	37
10	<i>Irpex lacteus</i>	39
11	<i>Ganoderma sp.</i>	41
12	<i>Ganoderma sp.</i>	43
13	<i>Marasmius oreades</i>	45
14	<i>Coprinellus plagioporus</i>	47
15	<i>Marasmius siccus</i>	49
16	<i>Amanita muscaria</i>	51
17	<i>Pleurotus ostreatus</i>	53
18	<i>Laetiporus sulphureus</i>	55
19	<i>Podoscypha petalodes</i>	57
20	<i>Calvulina coralloides</i>	59
21	<i>Cornus florida</i>	61
22	<i>Marasmius haematocephalus</i>	63
23	<i>Psathyrella candolleana</i>	65
24	<i>Crepidotus sp.</i>	67
25	Unidentified	69

LIST OF FIGURE

Sl.no.	List of figure	Page no.
01	Different upazilla(s) under Bogra district in Bangladesh (SOUECE: Internet browse)	15

CHAPTER I

INTRODUCTION

“Dalbergia sissoo” commonly known as Indian Rosewood is a large deciduous tree growing up to 8ft in girth and 100ft in height. It produced very heavy strong and stout wood with of good quality. It is one of the most important timber trees used in carving, furniture, door and window frames etc. (Limaye, 1957; Streets, 1962; Kayastha, 1985). Sisso grows in subtropical to tropical climate where maximum shade temperature varies from about 39° to 49°C and the absolute minimum shade temperature about 4° to 6°C. The average annual rainfall varies from 900 to 1500 mm. Most of the time, Sisso is grown naturally in road side, riverbed and ails for shade purpose and also cultivated in community or private area. It is widely distributed in sandy and alluvial soil in sub-Himalayan tract up to 1300m (Manandhar, 1989). For the last 30 years the species has been the most widely planted tree. Now, it has been started dying since last few years. Trees of varying ages are affected by fungal diseases (Parajuli *et al.* , 1999). Sisso mortality is one of the major national problems in the country especially in the northern region. The mycelia of these wood decaying fungi grow into the xylem and phloem system and block the flow of water and sap. Fungi are the main agents of wood decomposition; play a vital role in the ecology (Rayner, 1992; White, 2004). The composition of the fungal community in dead trees reflects the process of wood decay and is further influenced by microclimatic variation (Heilmann-Clausen, 2001).

Wood decay is the biological process by which cellulose and lignin, the two most abundant organic compounds are converted to carbon dioxide and water with a release of energy to maintain forest processes. Wood decay cycles essential nutrients needed for the regeneration of small trees to replace dead, decaying trees. The causal agents of wood decay are macro fungi often seen fruiting bodies on living or dead trees. The wood decay fungi holding two major groups that is Basidiomycota and Ascomycota. The Basidiomycota are the largest, most important common group of fungi that cause wood decay.

Most scientists know them as the macro fungi that grow on living or dead trees. Mushroom is a general term used mainly for the fruiting body of the macro fungi (Ascomycota and Basidiomycota) and represents only a short reproductive stage in their life cycle (Das, 2010). A few significant wood rotters are the Ascomycota. Among the forest mycological communities these fungi are either saprobes on decaying wood and other organic material like cow dung or are symbiotic with the living cells of plant roots, forming mycorrhizal associations with trees or parasitic on living plants (Bruns *et al.*, 1991; O'Brien *et al.*, 2005).

The purpose of the study is to collect, morphologically characterize and preserve macro fungal species present in road side grown sisso plant under social forest of Bogra district of Bangladesh. The identification of macro fungi relies on the collection of fruiting bodies, which in turn is largely dependent up on the availability of moisture. The macro fungi enlisted in this study will provide the baseline information needed for the assessment of changes in biological diversity. Biodiversity, a contraction of "biological diversity" generally refers to the variety and variability of life on Earth. Nilsson and Presson (1978) reported that, the color, shape and size of the fruiting body of mushroom can vary tremendously. Determination of biodiversity of mushroom mainly has done by using morphological characterization, habitat and phenotypical appearances of mushrooms in fresh form. Mushrooms are seasonal fungi, which occupy additional lists appeared in between culminating with the diverse niches in nature in the forest ecosystem. Their habitat and climate are major factors that indicate their biodiversity. Characterization done for 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 . The color, structure or ornamentation of spore varying from species

to species of Mushrooms (Svrcek, 2000). It is important to properly identify the mushroom that is collected. It gives an outline to the researchers about the occurrence of macro fungi and their biodiversity on sisso plant (Rumainul *et al.*, 2016). The knowledge on biodiversity at the community and species level is more important for monitoring the effectiveness and affects of natural and artificial disturbances (Packham *et al.*, 2002). With the view of the above facts in mind, the present research work was undertaken with the following objectives:

- i. To collect, study the morphological characteristics and identify the wood decay fungi from sisso plant grown in Bogra district under social forest region of Bangladesh and
- ii. To study the biodiversity of wood decay fungi of sisso plant.

CHAPTER II

REVIEW OF LITERATURE

The main purpose of this part is to review the previous studies, which are related to the present study. Therefore, an attempt has been made here to compile the research work carried out on the subject elsewhere.

Nilsson and Presson (1978) found that color, shape and size of the fruiting body of fleshy fungi can vary tremendously and to avoid a poisonous species it is most important to properly identify the mushrooms. They reported mushroom species as the indicators of the forest life system. Data of different vegetation types is important for planning to determine biodiversity and habitat at the community and species level they reported. Their habitat and climate are major factors that indicate their biodiversity.

Gilbertson (1980) studied that Brown rot fungi are involved in the biodegradation of wood with a preference for conifers (softwood) although there have also been some reports of these organisms degrading hardwood.

Eriksson *et al.* (1990) reported that Basidiomycete's fungi are known for the efficiency in wood decay and to cause the most destructive form of wood decay by rapid depolymerization of polysaccharidic components.

Cromack and Caldwell (1992) reported that Wood-decay fungi have key-roles in the ecology of nemoral and boreal forests since they are the major agents of wood decomposition and nutrient cycling.

KlemanLeyer *et al.* (1992) reported Brown rot fungi are characterized by a rapid strength loss caused by the marked depolymerization of cellulosic fractions at incipient decay.

Tyler (1992) stated that ectomycorrhizal fungi associated with early decay stages of hardwoods on sisso plant. The dynamics of wood decay are linked closely to the presence and ecological functions of fungi. Decay of down wood proceeds through a series of stages marked by degree of wood breakdown,

changes in the diversity of associated biota, progressions of nutrient transformations and other processes.

Zabel and Morrell (1992) reported that Wood decay by Basidiomycetes can be divided into two basic groups; white rot, in which lignin and holocellulose is degraded, and brown rot, in which cellulose and hemicellulose are degraded preferentially and lignin partly modified.

Zabel and Morrell (1992) reported the fungi play an important role in the functioning of forest ecosystems by the remediation of structurally bound nutrients and carbon turnover, however they are also the major cause of decay in-service wood. They are divided into brown and white rot fungi depending on visual appearance of the wood after decay.

Zabel and Morrell (1992) studied white and brown rot fungi were originally so classified based upon the visible color of the wood following decay but the two groups have been found to have significantly different approaches to degradation.

Green *et al.* (1995) reported Degradation by brown rot fungi starts by hyphal invasion of the wood through the wood cell lumen and colonization of ray cells and axial parenchyma, where stored carbohydrates are accessible as a ready energy source. The fungus establishes here and penetrates through the pit membrane.

Collins (1999) studied that the lignocellulose substance of wood cells is more resistant to degradation by microorganisms.

Hickman (1997) reported that the fungi are parasitic and colonize living trees and attack the woody cell walls and degrade the woody tissue.

Hibbett and Donoghue (2001) studied that fungal species within this group show similar macroscopic decay patterns, but the methods employed to facilitate wood decay can vary significantly from species to species; a phenomenon explained to some extent.

Deshmukh (2004) reported that Degradation of wood elements by higher fungi plays a significant role in the huge economic losses of timber and forest products. Microbial degradation of lignin in wood is accomplished primarily by white-rot causing fungi belonging to Basidiomycotina. A number of these organisms are able to degrade all cell wall components simultaneously but some of them cause selective attack on one or more components of the wall of sisso plant.

Dreistadt *et al.* (2004) reported a species of fungus that digests moist wood, and causing it to rot. Some species of wood-decay fungi attack dead wood causes brown rot like *Armillaria* (honey fungus), *Ganoderma applanatum* (artist's conk), *Ganoderma lucidum* (varnish fungus rot), *Laetiporus sulphureus* (sulfur fungus), *Pleurotus ostreatus* (oyster mushroom), *Schizophyllum commune* (common split gill), *Stereum species* (parchment fungus) and *Trametes versicolor* (turkey tail).

Muller *et al.* (2002) reported that a number of invertebrates are associated with wood 43 decay fungi, serve as vectors for fungal pathogens, or are fungivorous (consume fungi) and 44 influence rates of wood decay and nutrient mineralization.

Agrahar and Subbuakshmi (2005) conducted an experiment on Meghalaya mushrooms. Meghalaya (25°47'N and 26°10'N latitude and 89°45'E and 92°47'E longitude) is a hilly state projecting like a monument between the two plains of Assam in the north and Bangladesh in south. It has a wide variation in altitude, topography and agro climate. 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 plat parts, in mycorrhizal association with higher plants, etc. They conducted a survey to identify the edible fungi of this region with respect to their morphology distribution, habitat and edibility.

Antonín and Buyck (2006) reported that In the Dhaka district of the tropical moist deciduous forest region in Bangladesh, all the three species of *Marasmius* sp. were found. It was also reported in Madagascar and Mascarenes.

Niazi *et al.* (2006) reported that the biodiversity of wood decay fungi and ectomycorrhizas from Himalayan moist temperate forests of Pakistan where *Russula brevipes* was found associated with *Pinus wallichiana*. *Russula brevipes* and its morphotypes / ectomycorrhiza have been described and illustrated.

Kirk *et al.* (2008) reported that Four species of *Marasmius* such as *Marasmius siccus*, *Marasmiellus albuscorticis*, *Marasmius nigrodiscus* and one unidentified species of *Marasmius* were detected in the Khulna district of magrove forest region in Bangladesh having the second highest density of *Marasmiellus albuscorticis* (106.25%) and associated with the dead leaflet of Coconut (*Cocos nucifera*) tree. About 500 species of *Marasmius* have been already identified around the world.

Hanlon and Harrington (2010) conducted study on diversity and distribution of Agaricomycete species in the Republic of Ireland (ROI) and the records are compared with similar records from Northern Ireland, England, Scotland and Wales. The number of Agaricomycete species recorded from Ireland is much lower than in the other countries examined. The ROI has 100, 700, 1300 and 2200 fewer species than Northern Ireland, Wales, Scotland and England respectively. When species records according to major taxonomic clades are examined, it is evident that under-recording of Agaricomycete species from the ROI is common throughout all of the clades.

Ram *et al.* (2010) conducted a field experiment for collection of various decaying fungi from different localities of Eastern Uttar Pradesh forest during the rainy season on dead and decaying plant or animal remains.

Buchalo *et al.* (2011) proposed the criteria for the correct identification of the taxonomic position of mushrooms such as presence and morphology of

teleomorph stage; colour, morphology and growth rate of mycelia colony; type of anamorph; presence, dislocation and morphology of clamp connections; special hyphal structures and other characteristics.

Onyango *et al.* (2011) reported that the morphological characters and spawn production procedures of three Kenyan native strains of wood ear mushroom. Nine Basidiocarps were selected from a collection of three forests reserves within Kaka mega forest in western Kenya. Mycelia were raised on 2% malt extract agar and bottle culture technology was used for spawn production. Variation occurred in external Basidiocarps features such as colour, 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.

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

Srivastava *et al.* (2011) found four species of *Termitomyces* in the Gorakhpur forest division, India naming *Termitomyces heimii*, *Termitomyces clypeatus*, *Termitomyces mammiformis* and *Termitomyces microcarpus* characterized by different morphological traits.

Rajala *et al.* (2011) reported that the process of wood decay is reflected in the composition and richness of associated fungal communities which is also interconnected with the cause of tree death.

Pithak and Pukahute (2012) conducted a survey on the diversity of mushrooms in dry dipterocarp forest at Phuphan National Park to study the variety of mushrooms grown in the Dry Dipterocarp forest during the year

2008-2009 by releve method and to study the relationship between *Shorea merrillii* Miq. and Ectomycorrhizal of the Amanitaceae and the Boletaceae families. The findings of the study reveals the presence of a total 34 types of mushrooms in Dry Dipterocarp forest at the Phuphan where there were 26 types found in both years.

Pushpa and Purushothama (2012) conducted a survey on the biodiversity of mushrooms belonging to the class Basidiomycetes in Bangalore. The survey were conducted from June 2007 to November 2010 in 8 different places which included scrub jungles and urban places in Bangalore. A total number of 90 species in 48 genera belonging to 19 families in 05 orders were recorded, 28 species were found to be recorded for the first time in India. Among the collected species *Coprinus disseminates* followed by *Coprinus fibrillosis* and *Schizophyllum commune* was found to be abundant in their occurrence. The Simpson and Sannon diversity biodiversity index was found to be 0.8 and 1.24, respectively.

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

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

16 samples were identified up to species level. This preliminary study shows that the forest is very rich in mushroom diversity.

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

Pandey *et al.* (2013) conducted a study in Jeypore Reserve Forest located in Assam, India to investigate the diversity of macro fungi associated with different tree species that causes wood degradation. Thirty macro fungal species representing 26 genera belonging to 17 families were collected from six different sites in the study area. Out of these maximum six genera assignable to family Polyporaceae, five genera to Russulaceae, three genera to Agaricaceae, two genera to Ganodermataceae and Cantharellaceae each and rest of the families were represented by single genus only. The study revealed that maximum frequency of occurrence was exhibited by *Trametes versicolor* and *Schizophyllum commune* (83.33%), followed by *Microporus xanthopus*, *Pycnoporus sanguineus* (66.67%) and *Coprinus disseminates* (50%). The rest of the species exhibited the frequency distribution ranging between 16.67-33.33%. The maximum density was recorded for *Schizophyllum commune* (126.67%) followed by *Trametes versicolor* (120%) and *Xylaria polymorpha* (93.33%). The density of rest of the species were ranged between 3.33- 6.67%.

Andrew *et al.* (2013) reported the diversity and distribution of macro fungi in the Mount Cameroon Region. These were assessed at low and high altitudinal ranges in the four flanks of the mountain during the rainy and early dry seasons of 2010 and 2011. A total of 177 macro fungal species belonging to 83 genera and 38 families were recorded. Species richness was higher in the rainy seasons (134 species) than in the early dry seasons (89 species) and tended to decrease with altitude, with 116 and 112 species for low and high altitudes, respectively. Eighty-eight species were recorded only in the rainy seasons, 43 species in the early dry seasons only, and 46 species were common to both seasons. Sixty-five species were found only in the low altitude, 61 species only in the high altitude, and 51 species were common to both altitudes.

Sverdrup-Thygeson *et al.* (2014) reported that to monitoring fungi related to wood decay is to identify the appropriate spatial and temporal scales. In a review of studies on Saproxylic species and associated dead wood distribution in Europe.

Rumainul *et al.* (2015) reported that biodiversi mushroom flora study of mushroom flora has been largely neglected and not documented for the tropical moist deciduous forest regions of Bangladesh. They recorded mushrooms flora from seven different areas of tropical moist deciduous forest region of Bangladesh namely Dhaka, Gazipur, Bogra, Rajshahi, Pabna, Jaipurhat and Dinajpur. Mushroom flora associated with these forest regions were collected, photographed and preserved. A total of fifty samples were collected and identified to fourteen genera and twenty four species. The predominant genera were *Ganoderma* sp., *Lepiota* sp., *Marasmius* sp. and *Collybia* spp. The entire mushroom flora and its morphological characteristics have been described and illustrated.

Hosen *et al.* (2015) reported that three species of *Amanita* were recorded, viz. was found in Pathorghata of *Amanita brunnescens*, *Amanita griseoverrucosa* and *Amanita vaginata*. *Amanita brunnescens*. Borguna districts in the southern

region with a frequency and density of 6.25% and 9.30%, respectively in an association with *Dalbergia sissoo* tree. Mycorrhizal with various hardwoods and conifers; growing alone, scattered, or gregariously; summer and fall; widely distributed and common east of the Rocky Mountains.

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

Kinge and Mih (2015) studied the diversity and distribution of wood decay species of *Ganoderma* in south western Cameroon. They collected 57 samples of *Ganoderma* from oil palm and other hosts for identification using comparative morphology and molecular techniques. Morphological and molecular characterization of the 57 species showed that they belonged to 17 species of *Ganoderma* of which two species, *Ganoderma tornatum* and *Ganoderma chalceum* are new records for Cameroon. Four species, *Ganoderma weberianum*, *Ganoderma cupreum*, *Ganoderma steyaertanum*, *Ganoderma zonatum* are new records for Cameroon. The remaining 11 species belong to *Ganoderma ryvardense*, *Ganoderma lobenense* and *Ganoderma* species 1-9 with different affinities might be new to science. Six plant species were identified as hosts to different species of *Ganoderma*. They are *Elaeis guineensis*, *Cassia* sp., *Acacia* sp., *Pinus sylvestris*, *Avocado* sp. and unidentified hardwood, with *E. guineensis*, hosting the highest number of species. Belong to *Ganoderma ryvardense*, *Ganoderma lobenense* and *Ganoderma* species 1-9 with different affinities might be new to science.

Arnstadt *et al.* (2016) reported that Fungi associated with wood decay are the filamentous species of Basidiomycota and Ascomycota. Wood decay fungi

contribute to the accumulation of dead and decaying wood. They also found that ascomycete fungi likely play a prominent role in wood decay.

Rumainul *et al.* (2016) reported that One species of *Ganoderma* under the family ganodermataceae namely *Ganoderma lucidum* was found during investigation with the frequency of 11.11% and density of 2.78%. The species was found on the predominant Teak/Segun (*Tectona grandis*) tree. During the collection of *Ganoderma* species the weather was moist in nature and the temperature range was 34°C to 36°C. The genus *Ganoderma* was also reported in China, India and also in Bangladesh.

Aminuzzaman *et al.* (2016) reported that One species of each of *Calvulina coralloides* and *Gomphus clavaticus* were detected on soil surface and Rain tree (*Albizia lebbek*), respectively. *Cantharella* sp. was collected from dead trunk of Mahogany (*Macrophylla mahogoni*) tree in dry weather with the range of 29°C to 31°C. This species was not previously reported from any forest regions of Bangladesh.

Das *et al.* (2016) reported that the species was previously reported from mangrove forest region of Bangladesh in association with *Albizia saman* tree. *Laccaria* sp. under the family hydangiaceae was identified on *Dalbergia sissoo* tree with the frequency and density of 11.11% and 2.78%, respectively. During the collection time the temperature ranged from 32°C to 33°C.

Rashid *et al.* (2016) reported that A total ten number *Amanita bisporigera* was found in Modhupur and Pathorghata in natural forest zones of Bangladesh on the root zone of *Dalbergia sissoo* The frequency of its presence was 11.11% and the density was 20%.

Rashid *et al.* (2016) reported that three species of *Amanita* were also reported in Pathorghata of Borguna districts in the southern region with a frequency and density of 6.25% and 9.30%, respectively in an association with *Dalbergia sissoo* tree.

CHAPTER I I I

MATERIALS AND METHODS

Periodic surveys were made to the study area for the collection of wood decay fungi on sisho plant during rainy season June to September of 2016 and 2017. Different road sites of five (5) Upazillas under Bogra district in Bangladesh were surveyed in rainy season for the collection of wood decay fungi.

3.1 Collection site

The northern region of Bangladesh (Bogra) is located at 24°32' and 25°07' north latitudes and between 88°58' and 89°45' east longitudes (Bangladesh Bureau of Statistics. Retrieved July 14, 2014). It has an average elevation of 24 meters (78 ft.) belongs to Dupchanchia, Adomdighi, Sonatola, Sherpur and Dhunot Thana. Fifty (50) plants were randomly selected in each location. The collection sites were social forests roadside and nearby villages of the above mentioned location of Bogra district.

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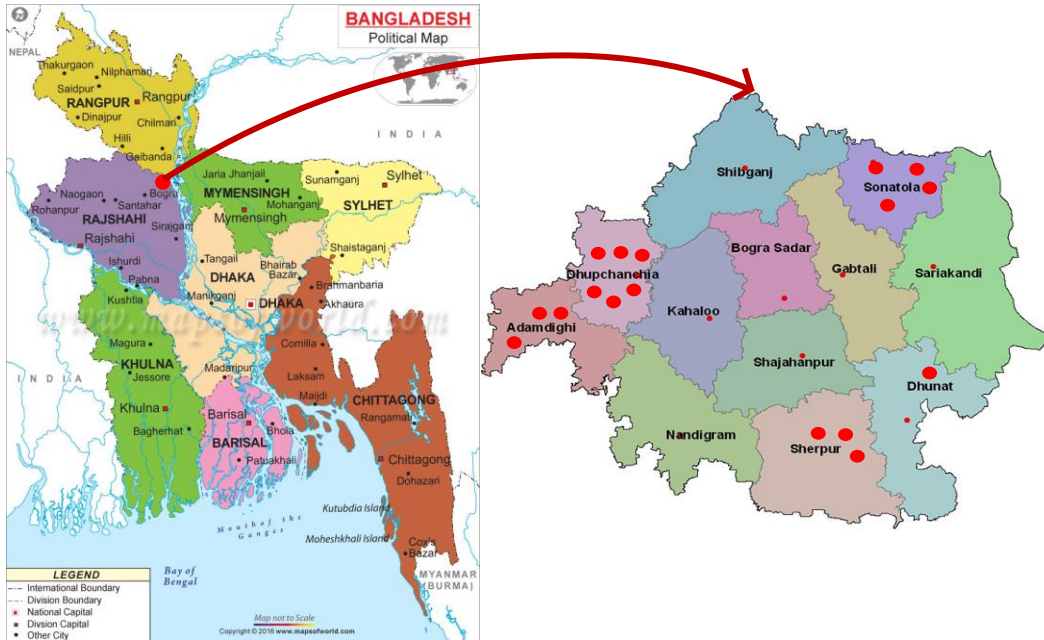


Fig.1. Survey area (●) under Bogra district in Bangladesh.

Table 1. Survey upazilla(s) of Bogra district in Bangladesh

District	Name of surveyed upazilla(s)	Number of location
Bogra	Dupchanchia	6
	Adamdighi	3
	Sonatala	4
	Dhunat	1
	Sherpur	3
Total	5	17

3.2 Experimental site

The analytical experiments was conducted in the Laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh.

3.3 Sampling procedure

A pre-designed collection and data analysis procedure was applied to collect information on biodiversity, distribution, habitat and morphology of mushroom from the above mentioned regions of Bangladesh.

3.4 Collection of macro fungi samples

The collection was made following the method of Hailing *et al.*1996. Systematic and periodical survey of different locations and other habitats was done in Bogra district under social forest region of Bangladesh. Necessary materials and equipment such as isolation kit, slants, isolation chamber, data recording sheet, digital camera for photography, digging equipment, heat convector card board were arranged and collection of samples were usually made during daytime a field characteristics of mushrooms was recorded in the data sheet which was prepared following Molina *et al.* 1995. Spotted mushrooms were minutely inspected in their natural habitats and brought to laboratory for detailed study.

3.5 Morphological observation during collection

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

3.6 Processing of macro fungi

For removing debris freshly harvested mushroom was washed by water. During the analysis period some precautions were followed before processing of mushroom. Mainly two types of preservation process-one was short term preservation and another was long term preservation were followed on the basis of study purpose and structure of the mushroom (Kim, 2004).

3.6.1 Drying: Collected samples were cleaned and dried by using electrical air flow drier the 1000 voltage, which can easily remove the moisture content from the collected mushrooms within 3-7 controlling hours with a regular interval basis power supply (15 minutes switch off and 30 minutes switching) depending on the structure and texture of the species (Kim, 2004)

3.6.2 Storage: Dried mushrooms were stored into a zip-lock type polybag during the survey period for further studies. Silica gels were used at the rate of 10% of dry basis during the storage period (Kim, 2004).

3.7 Morphology and microscopic characterization

The basidiocarps were rehydrated by soaking in water for few minutes before analyzing their morphology. Qualitative characters such as color, shape and presence of hymenia were evaluated by eye observation while texture was determined by feeling the back and top surfaces using fingers. Most of the morphological data was recorded during collection period that was when the mushroom was in fresh form. Permanent glass slides were made from rehydrated basidiocarps with the aid of a sharp surgical blade for the microscopic characterization basidiocarps were immersed in cotton blue stain and glycerin and placed on glass slides and covered with cover slips. Furthermore, the spore size was measured using Motic microscope with the magnification of 40x (Svrcek, 2000). The final identification and classification was done by comparing the previously recorded characteristics of mushroom following the color dictionary of mushroom written by Dickinson and John, 1982. The mushroom guide and identifier by Jorden, 2000 and the mushroom identifier by Pegler and Spooner, 1997.

3.8 Habitat, distribution and diversity analysis

The specimens were collected from sisso plant. The surrounding environment temperature, soil pH, moisture condition, vegetation recorded for biodiversity of mushroom. Soil pH, soil moisture were measured by pH meter and air temperature by thermometer during collection period. Soil moisture was usually expressed in units termed pH, collected samples were wrapped in polybag and brought to the laboratory for their further study. The frequency and density of different species has been determined by the following formulas (Zoberi, 1973).

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

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

CHAPTER IV

RESULTS

This investigation was carried out at 17 different locations of Bogra district to record the morphology, diversity and distribution of wood decay fungi on sissoo plant. A total of 43 wood decay fungi were collected from 17 locations of Bogra district and identified to 15 genera and 21 species.

Morphological (Table 2) and ecological characterization (Table 3) of collected macro fungi are given below:

4.1.1. *Ganoderma boninense*

Common name: Lingzhi or Reishi mushroom

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Adamdighi, Dupchanchia, Dhunut Thana in Bogra district.

Macroscopic character

Pileus shape: Concave; **Color:** White color cap

Length: 4.1 cm; Width: 2.9 cm

Surface character and zonation: Dry in nature

Margin: Incurved in shape

Texture of the fruiting body: Brittle and woody

Spore bearing surface under cap: Pores on hymenium

Stipe: Present, Size: 3.2 cm, Shape: Equal; Position: Central

Color: Chocolaty, **Firmness:** Solid

Spore morphology

Spore size (µm): 5.1 × 5.3 µm

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scatter and un-abundant. Type of soil was loamy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 5 % and frequency was 12%



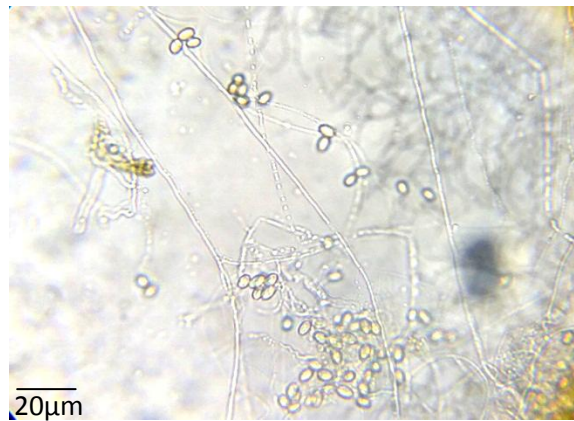
A



B



C



D

Plate no.1. *Ganoderma boninense*; Fruiting body (A), Pores (B), In an association with the host (C), Spores (D) (40x).

4.1.2. *Ganoderma tsugae*

Common name: Hemlock varnish self, Lingzhi or Reishi mushroom

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dhunat, Sherpur, Sonaola Thana in Bogra district.

Macroscopic character

Pileus shape: Conical, **Color:** Young: Brick red, Mature: Brick red in center with white cap

Length: 3.8 cm; Width: 2.1cm

Stipe: Present; **Size:** 8.1 cm. **Shape:** Position: Lateral; **Color:** Chocolatey, **Firmness:** Solid

Surface character and zonation: Dry in nature

Margin: Irregular in shape

Texture of the fruiting body: Brittle and woody

Spore bearing surface under cap: Pores on hymenium

Spore morphology

Spore size (µm): 4.1 × 4.3 µm

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (sisso) tree.

Habit: Scatter and un abundant. Type of soil was loamy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 23.2 % and frequency was 55%



A



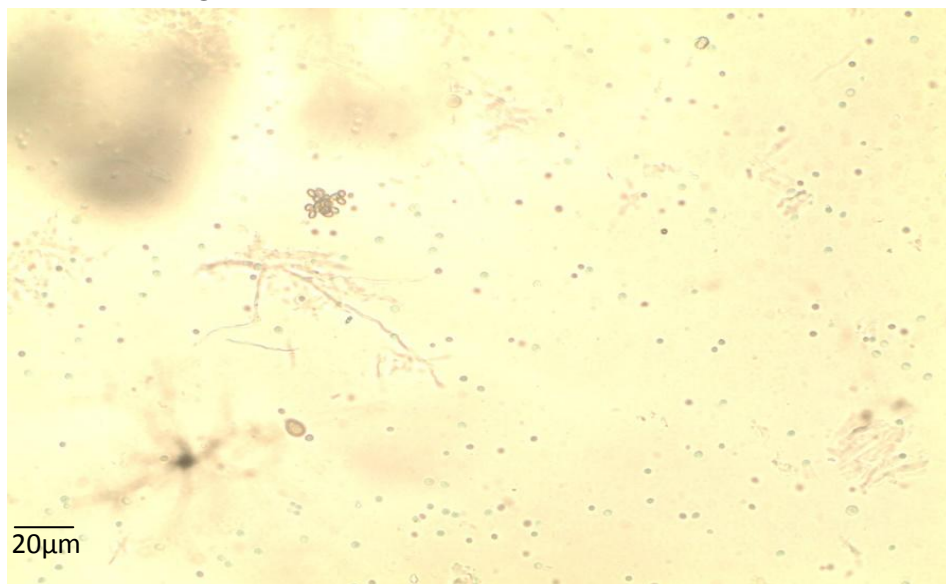
B



C



D



E

Plate no.2. *Ganoderma tsugae*; Fruiting body (A, B), In an association with the host (C), Pores (D), Spores (E) (40x).

4.1.3. *Ganoderma lipsiense*

Common name: Lingzhi and Reishi mushroom

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dupchanchia, Adomdighi Thana of Bogra district.

Macroscopic character

Pileus shape: Convex; **Color:** Dark brown to cocoa colored

Length: 8cm; Width: 6.5cm

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Incurved in shape. Margin thick, coffee color

Texture of the fruiting body: Corky and tough

Spore bearing surface under cap: Pores on hymenium

Pores color: Milky coffee; **Pore spacing:** Crowded

Spore morphology

Spore size (µm): 5.5 × 5.3 µm

Spore shape: Ellipsoid, Smooth and Thick walled; **Color:** Pale brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 5 % and frequency was 10%



A



B



C



D

Plate no. 3. *Ganoderma lipsiense*; Fruiting body (A), Pores (B), In an association with the host (C), Spores (D) (40x).

4.1.4. *Ganoderma lucidum*

Common name: Lingzhi or Reishi mushroom

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dhunat, Sherpur Thana in Bogra district.

Macroscopic character

Pileus shape: Kidney to funnel shaped; Color: Brick red

Length: 15.3-22.1 cm; Width: 10.5 -17.6 cm

Surface character and zonation: Reddish yellowish and dry in nature

Margin: Incurved in shape; Texture of the fruiting body: Woody to corky

Spore bearing surface under cap: Pores on hymenium

Pores color: Yellowish to white in color, **Pore spacing:** Crowded

Stipe: Present; Size: 3.5 cm-4.5 cm. Shape: Equal; **Color:** Brick red

Spore morphology

Spore size (μm): $3.1 \times 3.5 \mu\text{m}$

Spore shape: Ellipsoid, Smooth and Thick walled; Color: Brownish

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and constancy of occurrence in specific habitat was abundant. Forest type mixed. Type of soil was loamy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 4.5 % and frequency 25%



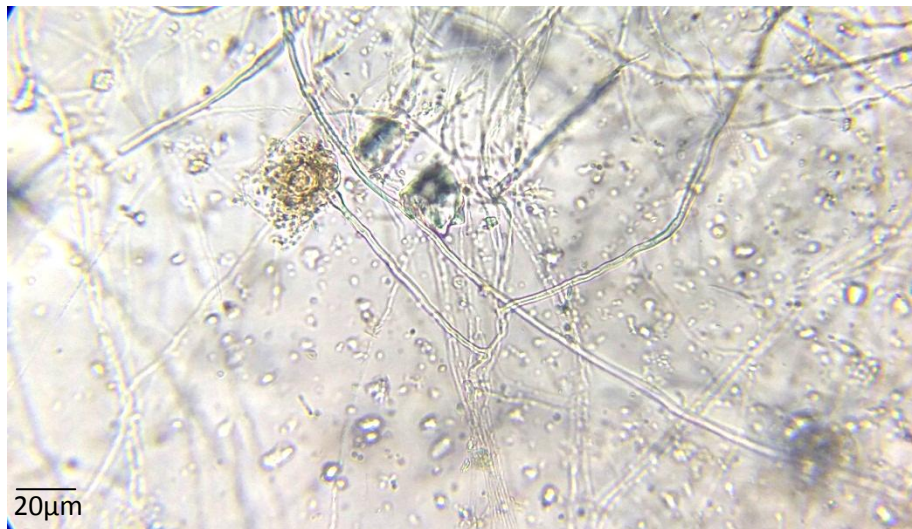
A



B



C



D

Plate no. 4. *Ganoderma lucidum*; Fruiting body with the association of the host (A, B); Pores (C); Spore (D) (40x).

4.1.5. *Ganoderma sessile*

Common name: Reishi, lingzhi, varnish shelf, artists conk.

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Adamdighi, Dhunut Thana in Bogra district.

Macroscopic character

Pileus: Kidney to funnel shaped; **Color:** The color of pileus (cap) was brick red and creamy.

Length: 15.3-22.1 cm; Width: 10.5 -17.6 cm

Surface character and zonation: Reddish yellowish and dry in nature.

Margin: Incurved in shape;

Texture of the fruiting body: Woody to corky

Spore bearing surface under cap: Pores on hymenium

Pores color: Yellowish to white in color, **Pore spacing:** Crowded

Stipe: The length and width of stipe was 8.2 and 6.8 cm, Respectively.

Spore morphology

Spore size (μm): $5.4 \times 4.3 \mu\text{m}$

Spore shape: Spore shaped were single walled, rough, irregular and oval shaped; **Color:** Brownish

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and abundant. Forest type mixed. Type of soil was loamy; factor affecting their distribution was moderately moist weather.

Biodiversity: The frequency of its presence was 25% and the density was 12.86%.



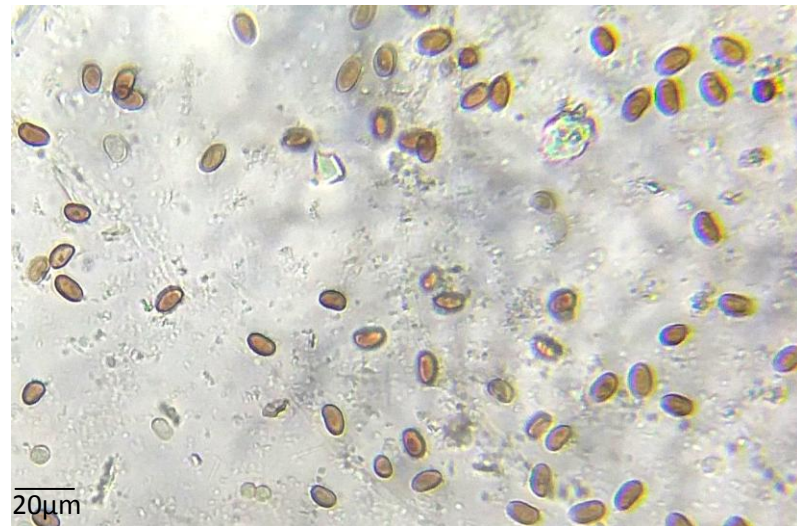
A



B



C



D

Plate no. 5. *Ganoderma sessile*; Fruiting body with the association of the host (A, B); Pores (C); Spore (D) (40x).

4.1.6. *Ganoderma applanatum*

Common name: Bracket fungi

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dhunat, Sonatola Thana in Bogra district.

Macroscopic character

Pileus shape: Convex; **Color:** Dark brown to creamy to white

Length: 7.7 cm; Width: 4.9 cm

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Incurved in shape. Margin thick, creamy white color

Texture of the fruiting body: Corky and tough

Spore bearing surface under cap: Pores

Pores color: dark brick color; **Pore spacing:** Crowded

Spore morphology

Spore size (µm): 5.58 × 5.3 µm

Spore shape: Ellipsoid, Smooth and Thick walled; **Color:** Pale brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (sisso) tree.

Habit: Scattered and unabundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 6.5% and frequency was 13%



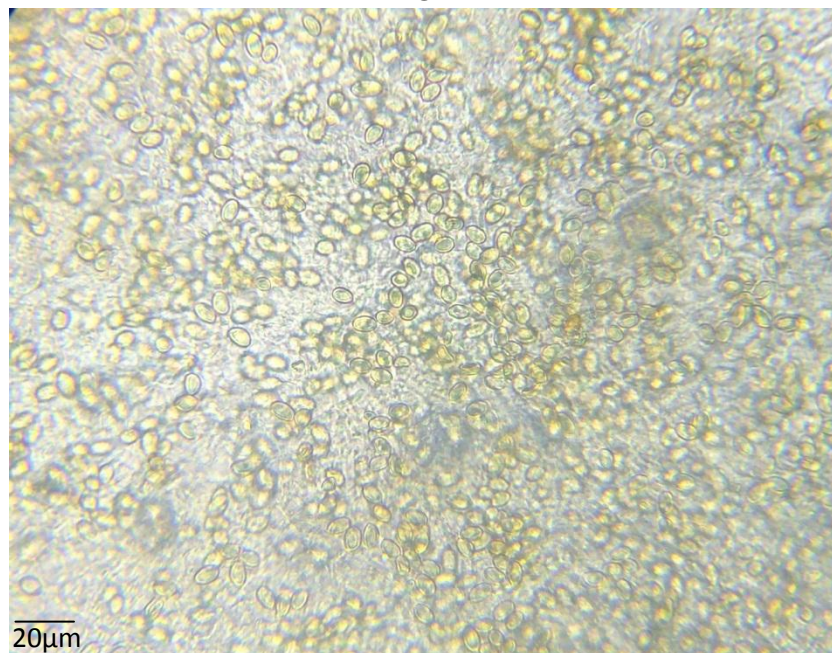
A



B



C



D

Plate no. 6. *Ganoderma applanatum*; Fruiting body (A); In an association of the host (B); Pores(C); Spores (D) (40x)

4.1.7. *Trametes versicolor*

Common name: Turkey tail

Family: Polyporaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Sonatola, Dupchanchia Thana in Bogra district.

Macroscopic characters

Pileus shape: Convex; **Color:** Color (young) was yellow, color (matured) was yellow. Spore bearing surface under cap was pores. Length 1.2 cm; width 9.8 cm.

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Incurved in shape. Margin thick, milky white color

Texture of the fruiting body: Corky and tough

Spore bearing surface under cap: Pores

Pores color: Milky white; **Pore spacing:** Crowded

Spore morphology

Spore size (μm): $6.2 \times 5.3 \mu\text{m}$

Spore shape: Ellipsoid, Smooth and Thick walled; **Color:** Pale brown

Ecological features:

Habitat: On Bark wood of the *Dalbergia sissoo* (sisso) tree.

Habit: Scattered and un abundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather.

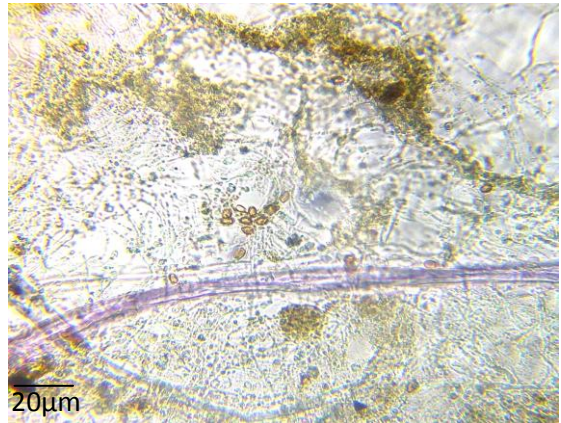
Biodiversity: The density of its presence was 12.3 % and frequency was 35%



A



B



C

Plate no. 7. *Trametes versicolor*; Fruiting body with the association of the host (A); Sores (B); Spore (C) (40x)

4.1.8. *Auricularia cornea*

Common name: wood ear jelly

Family: Ganodermataceae

Temperature of the Location: 34°C

Division/Region: Social forest region of Adamdighi, Dhunut Thana in Bogra district.

Macroscopic characters

Pileus shape: Convex; **Color:** Color (young) was milky white, color (matured) was brown. Spore bearing surface under cap was ridges. Length 2.5; Width 2.3 cm.

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Round in shape. Margin thick, white color

Texture of the fruiting body: Smooth, Stipe absent, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore bearing surface under cap: Pores

Pores color: Milky coffee; **Pore spacing:** Crowded

Spore morphology

Spore size (µm): 6 × 3.92 µm

Spore shape: Ellipsoid, Smooth and Thick walled; **Color:** Pale brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and un abundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 4.5 % and frequency was 15%



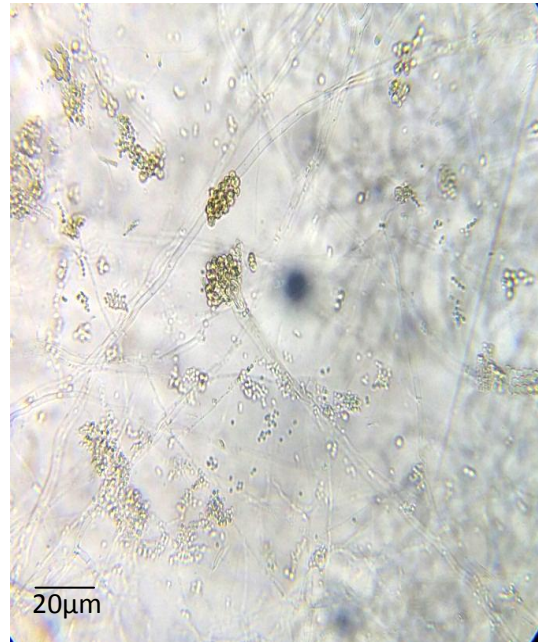
A



B



C



D

Plate no. 8. *Auricularia cornea*; Fruiting body with the association of the host (A, B); Pores (C); Spore (D) (40x).

4.1.9. *Poronidulus conchifer*

Common name: Ganoderma

Family: Polyporaceae

Temperature of the Location: 34°C

Division/Region: Social forest region of Sherpur, Dupchanchia Thana in Bogra district.

Macroscopic characters

Pileus shape: Convex; **Color:** Color (young) was white, color (matured) was brown. Length 5.4 cm width 4.2 cm. Spore bearing surface under cap was pores.

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Round in shape. Margin thick, white color

Texture of the fruiting body: Smooth, Stipe absent, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore bearing surface under cap: Pores

Pores color: Milky white; **Pore spacing:** Crowded

Spore morphology

Spore size (µm): 5.5 × 5.3 µm

Spore shape: Ellipsoid, Smooth and Thick walled; **Color:** Pale brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and un abundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather

Biodiversity: The density of its presence was 4.5 % and frequency was 15%



A



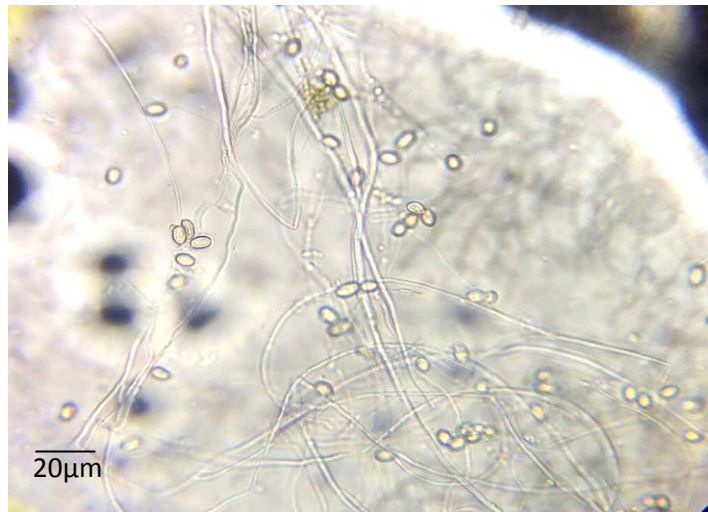
B



C



D



E

Plate no. 9. *Poronidulus conchifer*; Fruiting body with the association of the host (A, B); Pores (C, D); Spore (E) (40x)

4.1.10. *Irpex lacteus*

Common name: Milk-white toothed polypore.

Family: Steccherinaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dupchanchia, Adomdighi Thana in Bogra district.

Morphology features

Pileus: White. The shape of cap was flat shaped. The cap edge was irregular.

Color: whitish to grayish.

Length: 17.5 cm; Width: 24.6 cm

Surface character and zonation: whitish and dry in nature.

Margin: Incurved in shape;

Texture of the fruiting body: Woody to corky

Spore bearing surface under cap: Pores on hymenium

Pores color: White or grey in color, **Pore spacing:** Crowded

Stipe: Stripe is not present.

Spore morphology

Spore size (μm): 7.1×4.3 μm

Spore shape: Spore shaped were single walled, rough, irregular and oval shaped; **Color:** Brownish

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and abundant. Forest type mixed. Type of soil was loamy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 5% and the frequency was 2.86%.



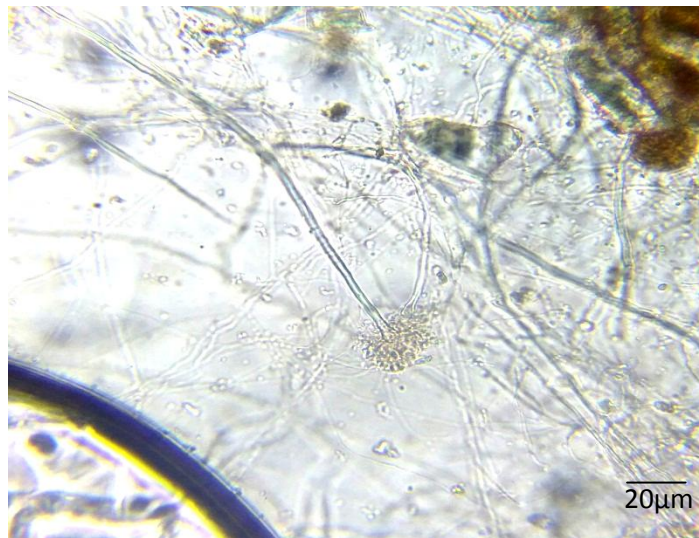
A



B



C



D

Plate no. 10. *Irpex lacteus*; Fruiting body (A), In an association with the host (B), Pores(C), Spores (D) (40x).

4.1.11. *Ganoderma* sp.

Common name: Self forming white rot fungus

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Sherpur, Dhunut, Sonatola Thana in Bogra district.

Macroscopic character

Pileus shape: Convex; **Color:** Dark brown to cocoa colored

Length: 18.6 cm; Width: 21.5 cm

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Incurved in shape. Margin thick, coffee color

Texture of the fruiting body: Corky and tough

Spore bearing surface under cap: Pores on hymenium

Pores color: dark coffee; **Pore spacing:** Crowded

Spore morphology

Spore size (µm): 7.03 × 4.86 µm

Spore shape: Ellipsoid, Smooth and Thick walled; **Color:** Pale brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 5.5 % and frequency was 10%.



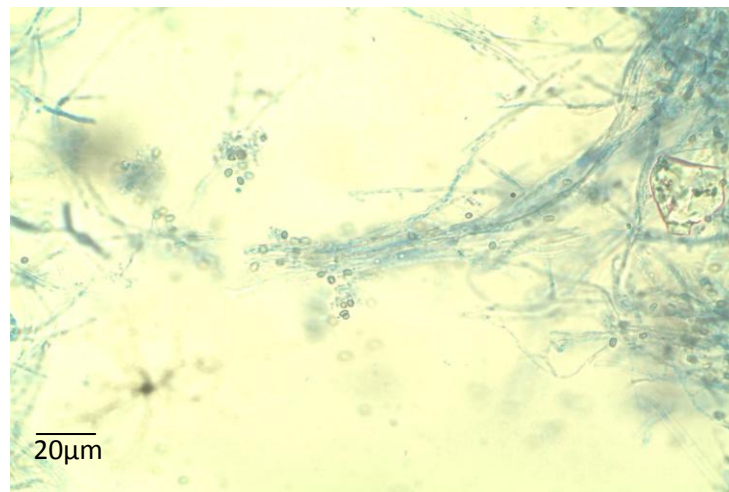
A



B



C



D

Plate no. 11. *Ganoderma* sp.; Fruiting body (A), In an association with the host (B), Pores (C), Spores (D) (40x).

4.1.12. *Ganoderma* sp.

Common name: Ganoderma

Family: Ganodermataceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Sonatola, Sherpur Thana in Bogra district.

Macroscopic character

Pileus shape: Convex; **Color:** Dark brown to cocoa colored

Length: 7.1 cm; Width: 4.2 cm

Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid.

Margin: Incurved in shape. Margin thick, red brick color

Texture of the fruiting body: Corky and tough

Spore bearing surface under cap: Pores

Pores color: dark brick color; **Pore spacing:** Crowded

Spore morphology

Spore size (µm): 7.1 × 4.1 µm

Spore shape: Thin walled, smooth and ellipsoid; **Color:** Pale brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was sandy; factor affecting their distribution was moderately moist weather.

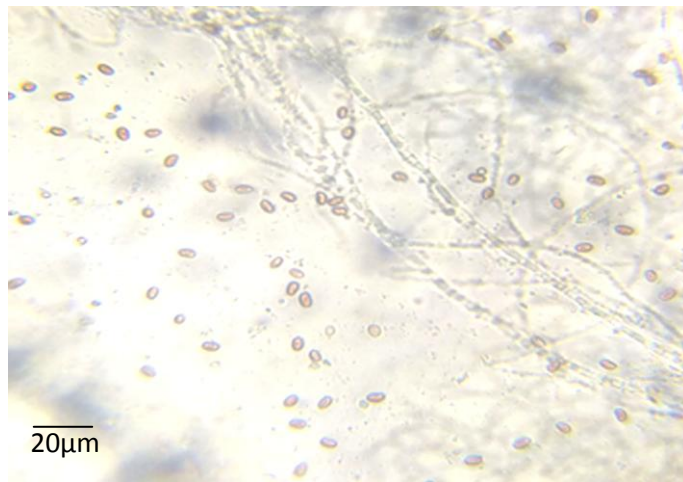
Biodiversity: The density of its presence was 6.5% and frequency was 13%



A



B



C

Plate no. 12. *Ganoderma* sp.; Fruiting body with the association of the host (A); Pores (B); Spores (C) (40x)

4.1.13. *Marasmius oreades*

Common name: California fungi

Family: Marasmiaceae

Temperature of the Location: 34°C

Division/Region: Social forest region of Dhunat, Dupchanchia Thana in Bogra district.

Morphological characters

Pileus shape: Convex, round and wavy; **Color:** Fleshy yellow; **Length:** 3.2 cm; **Width:** 2.1 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gill

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: Brown; **Gill shape and width:** Moderately broad

Stipe: Color of stipe was yellowish and blackish. The average length and width of stipe was 1.1 and 0.3 cm, respectively. The texture of the fruiting body was soft and spongy.

Shape: Equal; Position: Central;

Surface characteristics: Dry and glabrous; **Color:** White, **Firmness:** Narrow

Spore morphology

Spore size (μm): $5.58 \times 5.3\mu\text{m}$

Spore color: Color was brown, spore shaped were single walled, oval and irregular shaped.

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

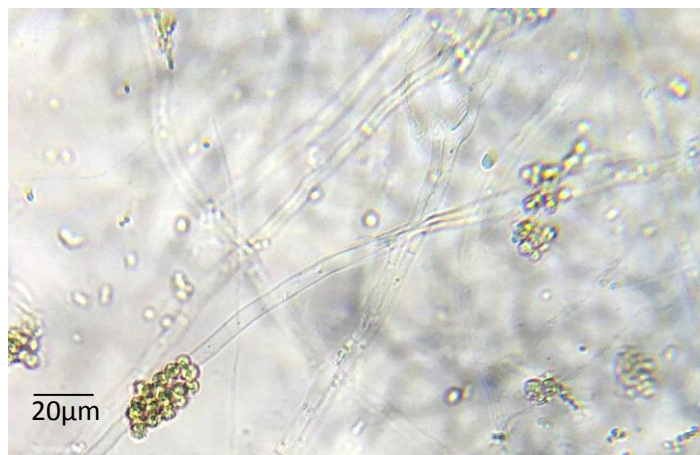
Biodiversity: The density of its presence was 14.3 % and frequency was 25%



A



B



C

Plate no.13. *Marasmius oreades*; Fruiting body with an association of the host (A); Pores (B); Spores(C) (40x)

4.1.14. *Coprinellus plagioporus*

Common name: Inky cap

Family: Psathyrellaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dupchanchia, Adamdighi Thana in Bogra district

Macroscopic characters

Pileus shape: Infundibuliform, light yellow; **Color:** creamy white to light brown; Length: 10.5 cm; Width: 6 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: light Brown; **Gill shape and width:** Moderately broad

Stipe: Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was absent.

Spore morphology

Spore size (µm): 7.1 × 5.3 µm

Spore shape: Elongated, Smooth and Thick walled; Color: Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and un abundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

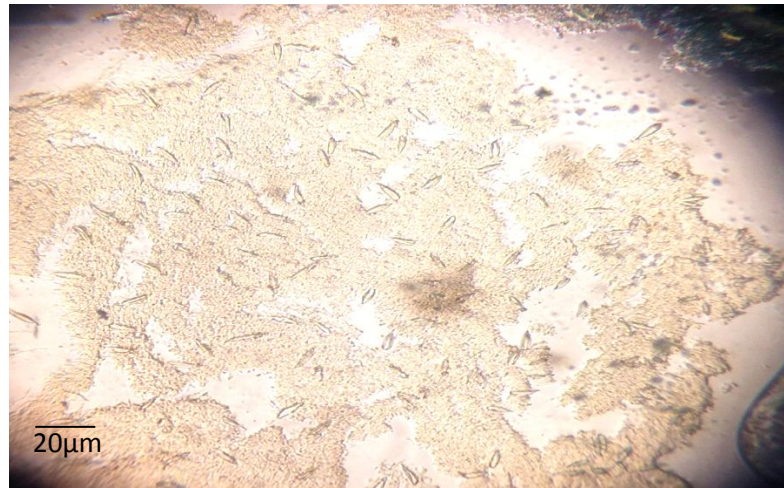
Biodiversity: The density of its presence was 5.6 % and frequency was 9.7%



A



B



C

Plate no. 14. *Coprinellus plagioporus*; Fruiting body with an association of the host (A); Pores (B); Spores (C) (40x)

4.1.15. *Marasmius siccus*

Common name: Orange Pinwheel Marasmius

Family: Marasmiaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Sherpur, Dhunut Thana in Bogra district.

Morphological characters

Pileus shape: Convex, round; **Color:** brick red

Length: 3.8 cm. ; Width: 1.2 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: white; **Gill shape and width:** Moderately broad

Stipe: Color of stipe was dark brownish. The average length of stipe was 2.6 cm and 0.1 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe.

Shape: Equal; Position: Central;

Surface characteristics: Dry and glabrous; **Color:** White, **Firmness:** Narrow

Spore morphology

Spore size (μm): $5.2 \times 5.3 \mu\text{m}$

Spore color: Black, spore shaped were single walled, rough and irregular shaped.

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

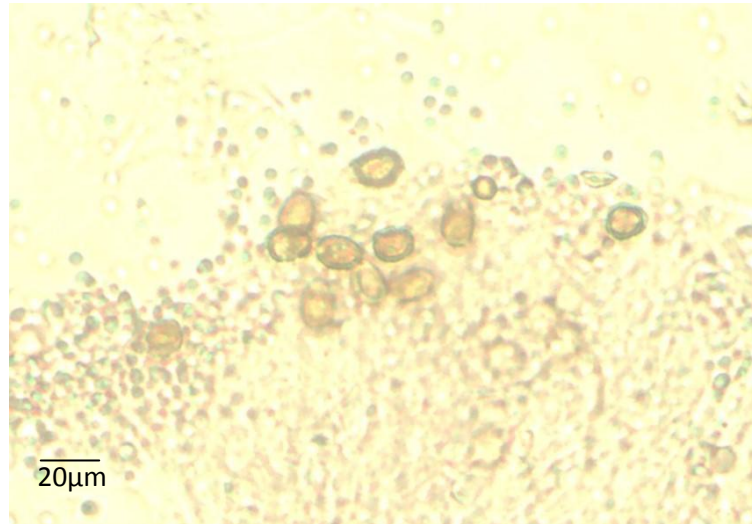
Biodiversity: The density of its presence was 18.3 % and frequency was 40%



A



B



C

Plate no. 15. *Marasmius siccus*; Fruiting body with an association of the host (A, B); Spores (C) (40x)

4.1.16. *Amanita muscaria*

Common name: American fly agaric

Family: Amanitaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dupchanchia, Sonatola Thana in Bogra district

Macroscopic character

Pileus shape: Convex; **Color:** Red brick; **Length:** 2.9 cm; **Width:** 2.1 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: Brown; **Gill shape and width:** Moderately broad

Stipe: Present; **Size:** 2.4 cm. **Shape:** Equal; **Position:** Central; **Surface characteristics:** Dry and glabrous; **Color:** White, **Firmness:** Narrow

Spore morphology

Spore size (µm): 7.2 × 4.6 µm

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 12.3 % and frequency 25%



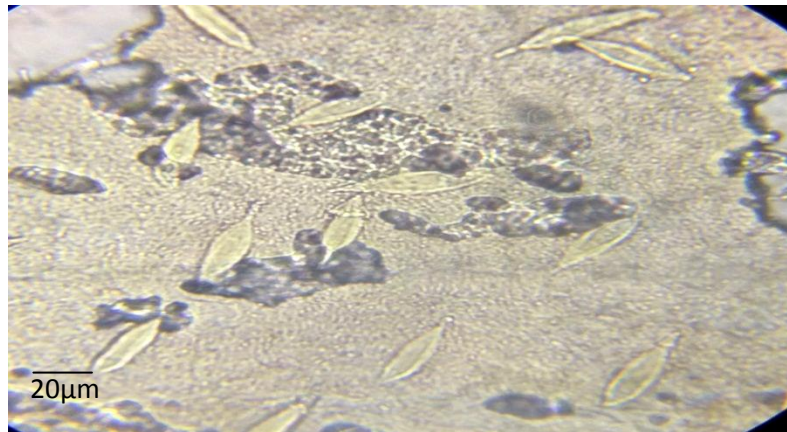
A



B



C



D

Plate no. 16. *Amanita muscaria*; Fruiting body with an association of the host (A, B); Pores(C); Spores (D) (40x)

4.1.17. *Pleurotus ostreatus*

Common name: Oyster mushroom

Family: Pleurotaceae

Temperature of the Location: 34°C

Division/Region: Social forest region of Sherpur, Dupchanchia Thana in Bogra district.

Morphological characters:

Pileus shape: convex, milky white; **Color:** creamy white,

Length 5.1 cm; Width: 4.3 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: light Brown; **Gill shape and width:** Moderately broad

Stipe: Stipe present (2.1cm), shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was absent.

Spore morphology

Spore size (μm): $5.6 \times 4.2 \mu\text{m}$

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and un abundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 10.4 % and frequency was 21%



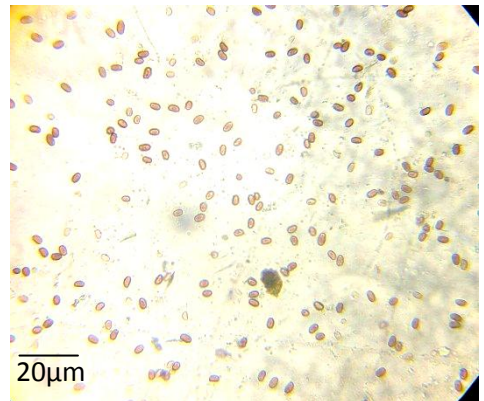
A



B



C



D

Plate no. 17. *Pleurotus ostreatus*; Fruiting body with an association of the host (A, B); Pores (C); Spores (D) (40x)

4.1.18. *Laetiporus sulphureus*

Common name: Chicken Mushroom

Family: Polyporaceae.

Temperature of the Location: 35°C

Division/Region: Social forest region of Dhunat, Sherpur Thana in Bogra district

Morphological characters:

Pileus shape: convex, milky white; **Color:** creamy white to light brown in color

Length 23.2 cm; Width: 25 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Teeth

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: white to light Brown; **Gill shape and width:** Moderately broad.

Stipe: Stipe absent, surface characteristic was moist, color and color changes was white, firmness was absent.

Spore morphology

Spore size (µm): 6.58 × 4.3µm

Spore shape: Thin walled, smooth, elongated; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and un abundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 23.7 % and frequency was 33%



A



B



C



D

Plate no.18. *Laetiporus sulphureus*; Fruiting body (A); In an association with the host (B); Pores(C); Spores (D) (40x)

4.1.19. *Podoscypha petalodes*

Common name: Frilly fungus

Family: Polyporaceae.

Temperature of the Location: 35°C

Division/Region: Social forest region of Sonatola, Sherpur Thana in Bogra district

Morphological characters:

Pileus shape: concex; **Color:** creamy white margin to brown center in color

Length 9.2 cm; Width: 5.5 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape, crenate.

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: white to light Brown; **Gill shape and width:** Moderately broad.

Stipe: Stipe present, surface characteristic was moist, color and color changes was white, firmness was absent.

Spore morphology

Spore size (μm): $3.5 \times 4.3 \mu\text{m}$

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 20.6 % and frequency was 40%



A



B



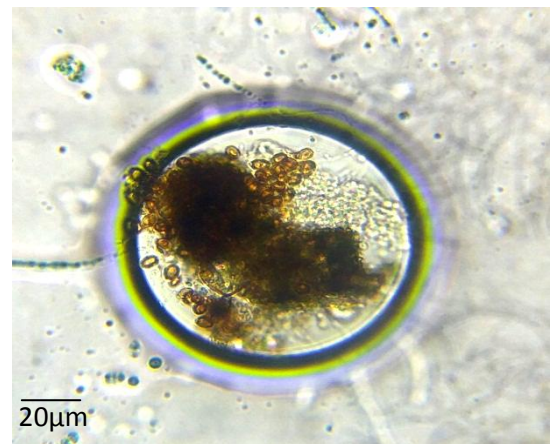
C



D



E



F

Plate no.19. *Podoscypha petalodes*; Fruiting body (A, B); In an association with the host (C, D); Pores (E); Spores (F) (40x)

4.1.20. *Calvulina coralloides*

Common name: Fall fungus or slime mold

Family: Polyporaceae.

Temperature of the Location: 35°C

Division/Region: Social forest region of Sherpur, Dupchanchia Thana in Bogra district

Morphological characters:

Pileus shape: Appendiculate; **Color:** creamy white margin to brown in color

Length 12.3 cm; Width: 10.2 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: unknown

Gill attachment: Adnex ; **Gill spacing:** Crowded

Gill color: white to light Brown; **Gill shape and width:** Moderately broad.

Stipe: Stipe present, surface characteristic was moist, color and color changes was white, firmness was absent.

Spore morphology

Spore size (µm): 5.5 × 5.3 µm

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

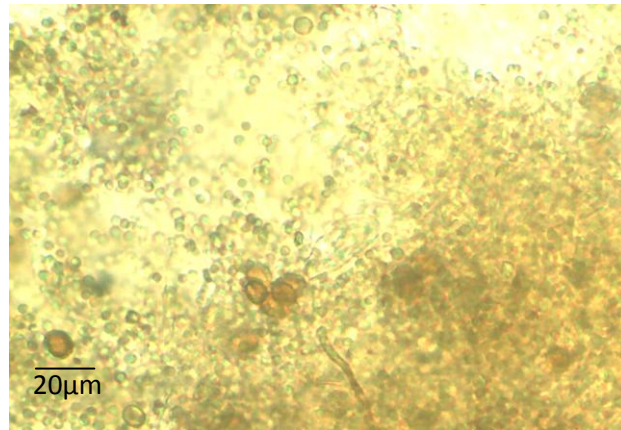
Biodiversity: The density of its presence was 23.6 % and frequency was 37%



A



B



C

Plate no. 20. *Calvulina coralloides*; Fruiting body (A); In an association with the host (B); Spores(C) (40x)

4.1.21. *Cornus florida*

Common name: Dogwood fungus

Family: Polyporaceae.

Temperature of the Location: 35°C

Division/Region: Social forest region of Dhunat, Adomdighi Thana in Bogra district

Morphological characters:

Pileus shape: convex; **Color:** white in color

Length 2.3 cm; Width: 1.2 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** smooth

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: White; **Gill shape and width:** Moderately broad.

Stipe: Stipe present (2.4), surface characteristic was moist, color and color changes was white, firmness was absent.

Spore morphology

Spore size (µm): 6.5 × 5.3 µm

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 5.6 % and frequency was 12%



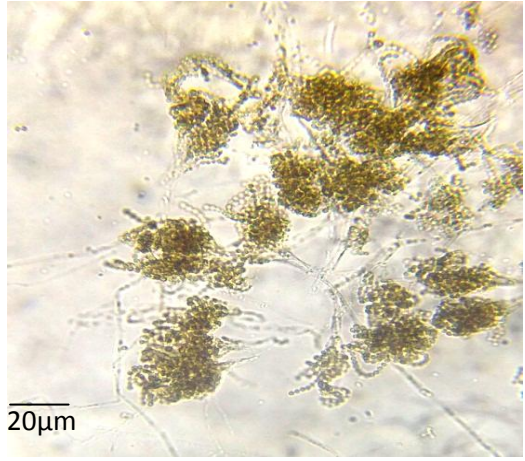
A



B



C



D

Plate no. 21. *Cornus florida*; In an association with the host (A, B); Pores (C); Spores (D) (40x)

4.1.22. *Marasmius haematocephalus*

Common name: purple pinwheel mushrooms

Family: Polyporaceae.

Temperature of the Location: 35°C

Division/Region: Social forest region of Adomdighi, Sonatola Thana of Bogra district

Morphological characters:

Pileus shape: convex; **Color:** brick red

Length 2.2 cm; Width: 1.2 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** smooth

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: Brick red; **Gill shape and width:** Moderately broad.

Stipe: Stipe present (4.6), surface characteristic was moist, color and color changes was dark brown, firmness was absent.

Spore morphology

Spore size (μm): $5 \times 4.1 \mu\text{m}$

Spore shape: Thin walled, smooth, elongated; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

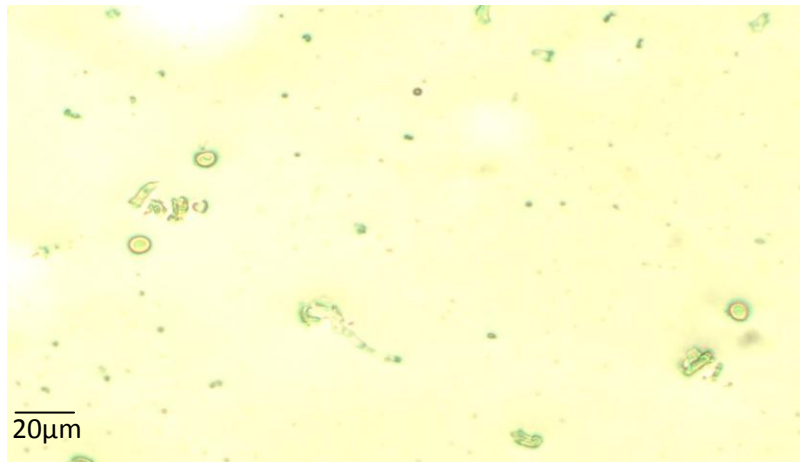
Biodiversity: The density of its presence was 4.6 % and frequency was 10%



A



B



C

Plate no.22. *Marasmius haematocephalus*; Fruiting body (A); Pores (B); Spores (C) (40x)

4.1.23. *Psathyrella candolleana*

Common name: Pale Brittle stem

Family: Psathyrellaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Adomdighi, Dhunut Thana in Bogra district

Macroscopic character

Pileus shape: Convex; **Color:** Brownish; **Length:** 3 cm; **Width:** 2.1 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gill

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: Brown; **Gill shape and width:** Moderately broad

Stipe: Present; **Size:** 4.1 cm. **Shape:** Equal; **Position:** Central; **Surface characteristics:** Dry and glabrous; **Color:** White, **Firmness:** Narrow

Spore morphology

Spore size (µm): 3.2 × 3.3 µm

Spore shape: Elongated, Smooth and Thick walled; **Color:** Brown

Ecological features

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 21.5 % and frequency was 30%



A



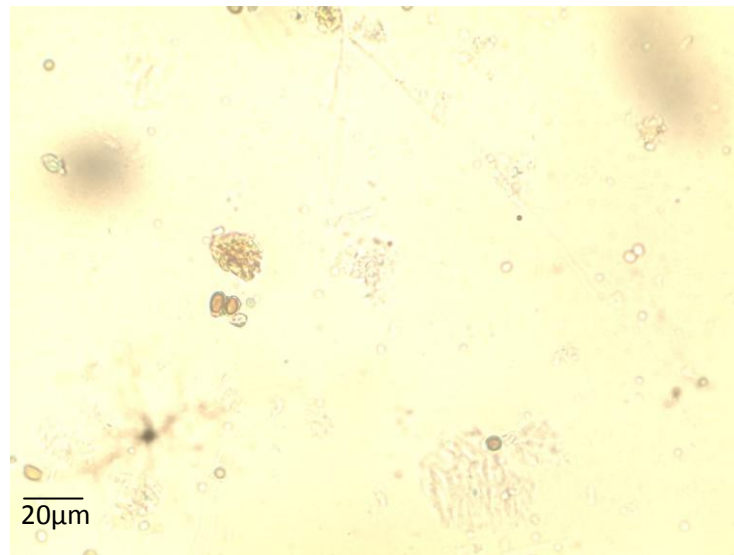
B



C



D



E

Plate no.23. *Psathyrella candolleana*; Fruiting body (A) ; In an association of the host (B); Pores(C,D); Spores (E) (40x)

4.1.24. *Crepidotus* sp.

Common name: Oysterling Mushroom

Family: Crepidotaceae

Temperature of the Location: 33°C

Division/Region: Social forest region of Dupchanchia, Sherpur Thana in Bogra district

Morphological characters

Pileus shape: Convex; **Color:** white;

Length: 3.2 cm; Width: 2.1 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** Irregular in shape

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: White; **Gill shape and width:** Moderately broad

Stipe: stipe and volva was absent on the lower part of the stipe

Surface characteristics: Dry and glabrous; **Color:** White, **Firmness:** Narrow

Spore morphology

Spore size (μm): $6.95 \times 6.65 \mu\text{m}$

Spore color: Spore color was brown, spore shaped were thick walled, slightly rough and oval shaped

Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

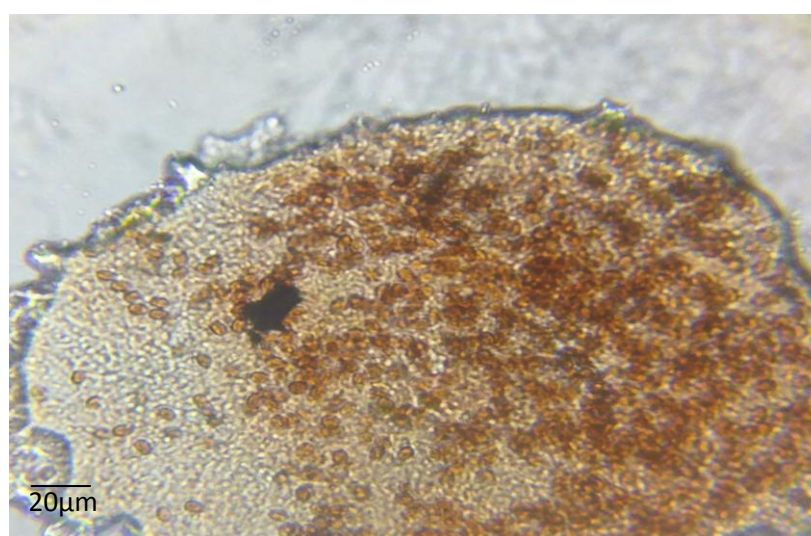
Biodiversity: The density of its presence was 11.14 % and frequency was 27%



A



B



C

Plate no.24. *Crepidotus sp.*; Fruiting body with an association of the host (A); Pores (B); Spores(C) (40x)

4.1.25. UNIDENTIFIED

Temperature of the Location: 34°C

Division/Region: Social forest region of Dupchanchia, Adomdighi Thana of Bogra district

Morphological characters:

Pileus shape: convex; **Color:** brown

Length 8.7 cm; Width: 6.5 cm

Surface character and zonation: Dry and smooth in nature; **Margin:** smooth

Texture of the fruiting body: Soft and spongy

Spore bearing surface under cap: Gills

Gill attachment: Adnex; **Gill spacing:** Crowded

Gill color: Brown; **Gill shape and width:** Moderately broad.

Stipe: Stipe absent, surface characteristic was moist, color and color changes was dark brown, firmness was absent.

Spore morphology

Spore size (µm): 5.5× 5.1 µm

Spore shape: Thin walled, smooth, elongated; **Color:** Brown

Ecological features

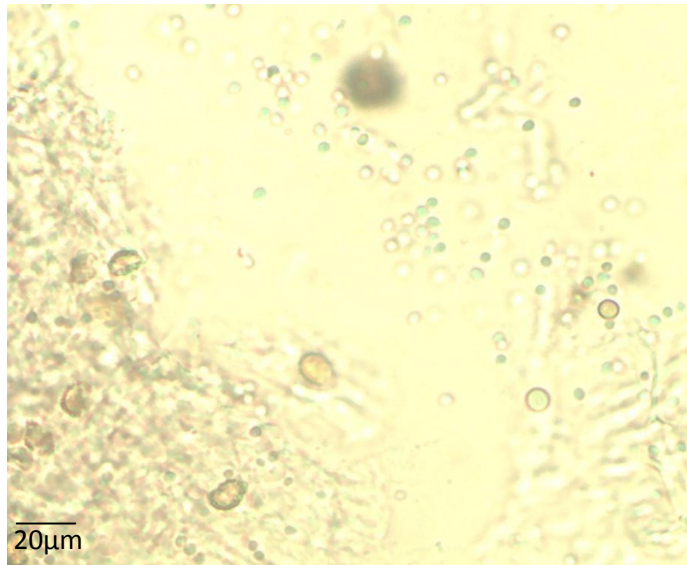
Habitat: On Bark wood of the *Dalbergia sissoo* (Sisso) tree.

Habit: Scattered and unabundant. Type of soil was loam; factor affecting their distribution was moderately moist weather.

Biodiversity: The density of its presence was 10.6 % and frequency 20%



A



B

Plate no.25. Unknown; Fruiting body with an association of the host (A); Spores (B) (40x)

Table 2. Morphology of basidiocarp and characterization of basidiospore of collected macro fungi from different locations of Bogra district

Characterization			
Species name	Common name	Basidiocarp	Spore
<i>Ganoderma boninense</i>	Lingzhi or Reishi mushroom	Pileus shape concave; Color white, cap 4.1 × 2.9 cm, Surface character and zonation was dry in nature, margin incurved in shape, Texture of the fruiting body was brittle and woody, spore bearing surface under cap was porous on hymenium, stipe present, size 3.2 cm., shape equal; position central; Color chocolaty, firmness solid .	Spore size was 5.1 × 5.3 μm Elongated, Smooth and Thick walled; Brown color
<i>Ganoderma tsugae</i>	Hemlock varnish self, Lingzhi or Reishi mushroom	Pileus shape conical, Color Brick red, Brick red in center with white cap 3.8 × 2.1 cm in shape. Stipe Present; Size 8.1 cm Shape, Position Latera; Color Chocolaty, Firmness Solid Surface character and zonation was Dry in nature, Margin Irregular in shape Texture of the fruiting body was Brittle and woody Spore bearing surface under cap Pores on hymenium.	Spore size was 4.1 × 4.3 μm Elongated, Smooth and Thick walled; Brown color

Continue Table 2

Species name	Common name	Basidiocarp	Spore
<i>Ganoderma lipsiense</i>	Lingzhi and Reishi mushroom	Pileus shape convex; Color dark brown to cocoa that was 8.5×6.5 cm. Surface character and zonation was dry in nature, slightly zonate, solitary, crust and rigid. Margin Incurved in shape. Margin thick, coffee color. Texture of the fruiting body was corky and tough Spore bearing surface under cap was Pores on hymenium.Pores color milky coffee; Pore spacing crowded.	Spore size was 5.5 × 5.3 μm Ellipsoid, Smooth and Thick walled; Brown color
<i>Ganoderma lucidum</i>	Lingzhi or Reishi mushroom	Pileus shape Kidney to funnel shaped; Color: Brick red 15.3-22.1 ×10.5 -17.6 cm, Surface character and zonation was Reddish yellowish and dry in nature, Margin Incurved in shape; Texture of the fruiting body Woody to corky, Spore bearing surface under cap Pores on hymenium Pores color Yellowish to white Pore spacing Crowded Stipe Present; Size 3.5×4.5 cm. Shape equal, Color brick red	Spore size was 3.1 × 3.5 μm Ellipsoid, Smooth and Thick walled; Brown color
<i>Ganoderma sessile</i>	Reishi, lingzhi, varnish shelf, artists conk.	Pileus Kidney to funnel shaped; The color of pileus (cap) was brick red and creamy. 15.3-22.1 ×10.5-17.6 cm in shape, Surface character and zonation reddish yellowish and dry in nature, Margin incurved in shape; Texture of the fruiting body was woody to corky Spore bearing surface under cap Pores on hymenium, Pores color yellowish to white, Pore spacing was crowded.	Spore size was 3.1 × 3.5 μm Spore shaped were single walled, rough, irregular and oval shaped, Brown color.

Continue Table 2

<i>Ganoderma applanatum</i>	Bracket fungi	Pileus convex, Color dark brown to creamy to white, 7.7 ×4.9 cm in shape, Surface dry in nature, slightly zonate, solitary, crust and rigid, Margin incurved in shape, Margin thick, creamy white color. Texture of the fruiting body corky and tough. Spore bearing surface under cap Pores. Pores color dark brick color; Pore spacing was crowded.	Spore size was 5.58 × 5.3 μm Ellipsoid, Smooth and Thick walled; Brown color.
<i>Trametes versicolor</i>	Turkey tail	Pileus shape convex; color was yellow. Spore bearing surface under cap was pores. 1.2 ×9.8 cm in shape. Surface character and zonation was dry in nature, slightly zonate, solitary, crust and rigid. Margin incurved in shape, Margin thick, milky white color. Texture of the fruiting body was Corky and tough Spore bearing surface under cap was Pores, Pores color milky white; Pore spacing was crowded.	Spore size was 6.2 × 5.3 μm Ellipsoid, Smooth and Thick walled; Brown color
<i>Auricularia cornea</i>	Wood ear jelly	Pileus shape convex; Color was milky white. Spore bearing surface under cap was ridges that was 2.5× 2.3 cm. Surface character and zonation was dry in nature, slightly zonate, solitary, crust and rigid. Margi round in shape. Margin thick, white color Texture of the fruiting body was Smooth, Stipe absent, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped. Spore bearing surface under cap. Pores color was milky coffee; Pore spacing was crowded.	Spore size was 6 × 3.92 μm Ellipsoid, Smooth and Thick walled; Brown color

Continue Table 2

<i>Poronidulus conchifer</i>	Ganoderma	Pileus shape Convex; Color (young) was white, color (matured) was brown, 5.4 × 4.2 cm in shape, Spore bearing surface under cap was pores. Surface character and zonation was dry in nature, slightly zonate, solitary, crust and rigid. Margin Round in shape, Margin thick, white color. Texture of the fruiting body Smooth, Stipe absent, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped. Spore bearing surface under cap was Pores, Pores color milky white	Spore size was 5.5 × 5.3 μm Ellipsoid, Smooth and Thick walled; Brown color
<i>Irpex lacteus</i>	Milk-white toothed polypore.	Pileus white, The shape of cap was flat shaped. The cap edge was irregular. Color whitish to grayish. 17.5 × 24.6 cm. Surface character and zonation whitish and dry in nature. Margin incurved in shape; Texture of the fruiting body was woody to corky, Spore bearing surface under cap pores on hymenium, Pores color white or grey. Pore spacing crowded, Stripe is not present.	Spore size was 7.1 × 4.3 μm Ellipsoid, Smooth and Thick walled; Brown color
<i>Ganoderma sp.</i>	Self-forming white rot fungus	Pileus shape convex; Color dark brown to cocoa colored, 18.6 × 21.5 cm in shape. Surface dry in nature, slightly zonate, solitary, crust and rigid. Margin incurved in shape. Margin thick, coffee color. Texture of the fruiting body corky and tough. Spore bearing surface under cap pores on hymenium, pores color dark coffee; Pore spacing crowded.	Spore size was 7.03 × 4.86 μm Ellipsoid, Smooth and Thick walled; Brown color
<i>Ganoderma sp.</i>	Ganoderma	Pileus shape Convex; Color Dark brown to cocoa colored 7.1 × 4.2 cm in shape, Surface Dry in nature, slightly zonate, solitary, crust and rigid, Margin Incurved in shape. Margin thick, red brick color Texture of the fruiting body corky and tough, Spore bearing surface under cap Pores, Pores color dark brick color, Pore spacing crowded.	Spore size was 7.1 × 4.1 μm Ellipsoid, Smooth and Thick walled; Brown color

Continue Table 2

Species name	Common name	Basidiocarp	Spore
<i>Marasmius oreades</i>	California fungi	Pileus shape convex, round and wavy; Color Fleshy yellow; 3.2 ×2.1 cm in shape, Surface character and zonation was Dry and smooth in nature; Margin Irregular in shape, Texture of the fruiting body Soft and spongy, spore bearing surface under cap was gill,Gill attachment Adnex; Gill spacing Crowded,Gill color Brown; Gill shape and width moderately broad,Color of stipe was yellowish and blackish. The average length and width of stipe was 1.1 and 0.3 cm, respectively. The texture of the fruiting body was soft and spongy. Shape equal; Position central; Surface characteristics dry and glabrous; Color white, firmness narrow.	Spore size was 5.58 × 5.3µm Spore shaped were single walled, oval,irregular.Color brown.
<i>Coprinellus plagioporus</i>	Inky cap	Pileus shape infundibuliform, light yellow; Color creamy white to light brown; 10.5 ×6 cm in shape,Surface character and zonation was dry and smooth in nature; Margin irregular in shape,Texture of the fruiting body was soft and spongy, Spore bearing surface under cap was gills,Gill attachment adnex; Gill spacing crowded. Gill color light brown; Gill shape and width moderately broad,Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was absent.	Spore size was 7.1 × 5.3 µm Elongated Smooth and Thick walled; Brown color .

Continue Table 2

Species name	Common name	Basidiocarp	Spore
<i>Marasmius siccus</i>	Orange Pinwheel Marasmius	Pileus shape convex, round; Color brick red, 3.8 × 1.2 cm in shape, Surface character and zonation was dry and smooth in nature; Margin irregular in shape, Texture of the fruiting body soft and spongy, Spore bearing surface under cap was gills, Gill attachment Adnex; Gill spacing Crowded, Gill color white; Gill shape and width Moderately broad, Color of stipe was dark brownish. The average length of stipe was 2.6 cm and 0.1 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Shape equal; Position central; Surface characteristics dry and glabrous; Color white, firmness narrow.	Spore size was 5.2 × 5.3 μm Spore color was black, spore shaped were single walled, rough and irregular shaped.
<i>Amanita muscaria</i>	American fly agaric	Pileus shape convex; Color red brick; 2.9 × 2.1 cm in shape, Surface character and zonation dry and smooth in nature; Margin irregular in shape, Texture of the fruiting body soft and spongy, Spore bearing surface under cap was gills, Gill attachment adnex; Gill spacing crowded, Gill color brown; Gill shape and width Moderately broad, Present; Size 2.4 cm. Shape Equal; Position Central; Surface characteristics Dry and glabrous; Color white	Spore size was 7.2 × 4.6 μm Ellipsoid, Smooth and Thick walled; Brown color.

Continue Table 2

Species name	Common name	Basidiocarp	Spore
<i>Pleurotus ostreatus</i>	Oyster mushroom	Pileus convex, milky white; Color creamy white, 5.1cm ×4.3 cm in shape. Dry and smooth in nature; Margin irregular. Texture of the fruiting body was soft and spongy. Spore bearing surface under cap was gills. Gill attachment was adnex and crowded spacing. Gill color was light brown; Gill shape and width was moderately broad. Stipe present (2.1cm), shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was absent.	Spore size was 5.6 × 4.2 μm Elongated, Smooth and Thick walled; Brown color.
<i>Laetiporus sulphureus</i>	Chicken Mushroom	Pileus shape convex, milky white; Color creamy white to light brown 23.2 × 25 cm in shape, Surface character and zonation dry and smooth in nature; Margin irregular in shape, Texture of the fruiting body soft and spongy, Spore bearing surface under cap teeth, Gill attachment was adnex ; Gill spacing was crowded, Gill color white to light brown; Gill shape and width moderately broad, Stipe absent, surface characteristic was moist, color and color changes was white, firmness was absent.	Spore size was 6.58 × 4.3 μm Elongated, Smooth and Thick walled; Brown color.

Continue Table 2

Species name	Common name	Basidiocarp	Spore
<i>Podoscypha petalodes</i>	Frilly fungus	Pileus shape concex; Color creamy white margin to brown center in color, 9.2 ×5.5 cm in shape, Surface character and zonation dry and smooth in nature; Margin irregular in shape, crenate. Texture of the fruiting body was soft and spongy.Spore bearing surface under cap was gills, Gill attachment adnex ; Gill spacing crowed, Gill color white to light Brown; Gill shape and width Moderately broad, Stipe present, surface characteristic was moist, color and color changes was white, firmness was absent.	Spore size was 3.5×4.3µm. Elongated, Smooth and Thick walled; Brown color.
<i>Calvulina coralloides</i>	Fall fungus or slime mold	Pileus shape appendiculate; Color creamy white margin to brown in color, 12.3× 10.2 cm in shape, Surface character and zonation dry and smooth in nature; Margin irregular in shape, Texture of the fruiting body was soft and spongy, Spore bearing surface under cap unknown,Gill attachment adnex ; Gill spacing was crowed,Gill color white to light brown; Gill shape and width Moderately broad,Stipe present, surface characteristic was moist, color and color changes was white, firmness was absent.	Spore size was 5.5 × 5.3 µm. Elongated, Smooth and Thick walled; Brown color.

Continue Table 2

Species name	Common name	Basidiocarp	Spore
<i>Cornus florida</i>	Dogwood fungus	Pileus shape convex; Color white in color, 2.3× 1.2 cm in shape, Surface character and zonation dry and smooth in nature; Margin smooth, Texture of the fruiting body soft and spongy, Spore bearing surface under cap was gills, Gill attachment adnex ; Gill spacing crowed, Gill color white ; Gill shape and width moderately broad, Stipe present (2.4), surface characteristic was moist, color and color changes was white, firmness was absent.	Spore size was 6.5 × 5.3µm. Elongated, Smooth and Thick walled; Brown color.
<i>Marasmius hematocephalus</i>	Purple pinwheel mushrooms	Pileus shape convex; Color white in color, 2.2× 1.2 cm in shape, Surface character and zonation dry and smooth in nature; Margin smooth, Texture of the fruiting body soft and spongy, Spore bearing surface under cap was gills, Gill attachment adnex ; Gill spacing crowed, Gill color white ; Gill shape and width moderately broad, Stipe present (2.4), surface characteristic was moist, color and color changes was white, firmness was absent	Spore size was 5 × 4.1 µm. Elongated, Smooth and Thick walled; Brown color.

Species name	Common name	Basidiocarp	Spore
<i>Psathyrella candolleana</i>	Pale Brittle stem	Pileus shape convex; Color brownish; 3 ×2.1 cm in shape, Surface character and zonation was dry and smooth in nature; Margin: irregular in shape, Texture of the fruiting body was soft and spongy, Spore bearing surface under cap was gill, Gill attachment was adnex; Gill spacing crowed, Gill color brown; Gill shape and width moderately broad, Stipe Present; Size 4.1 cm. Shape Equal; Position Central; Surface characteristics dry and glabrous; Color white, firmness narrow.	Spore size was 3.2 × 3.3 μm. Elongated, Smooth and Thick walled; Brown color.
<i>Crepidotus sp.</i>	Oysterling Mushroom	Pileus shape convex; Color white; 3.2× 2.1 cm in shape, Surface character and zonation was dry and smooth in nature, Margin irregular in shape,Texture of the fruiting body Soft and spongy, Spore bearing surface under cap was gills,Gill attachment adnex; Gill spacing crowed, Gill color white; Gill shape and width moderately broad,stipec and volva was absent on the lower part of the stipe, Surface characteristics Dry and glabrous; Color white, firmness narrow.	Spore size was 6.95× 6.65μm. Spore color was brown, spore shaped were thick walled, slightly rough and oval shaped,
UNIDENTIFIED	Unknown	Pileus shape convex; Color brown 8.7 ×6.5 cm, Surface character and zonation was Dry and smooth in nature; Margin smooth, Texture of the fruiting body was Soft and spongy, Spore bearing surface under cap Gills, Gill attachment: Adnex ; Gill spacing Crowed, Gill color brown ; Gill shape and width Moderately broad. Stipe absent, surface characteristic was moist, color and color changes was dark brown, firmness was absent.	Spore size was 5.5× 5.1 μm. Spore shape was thin walled, smooth, elongated; Color Brown,

Table 3: Ecological characterization of collected macro fungi on sisso plant from different locations of Bogra district under social forest region

Species name	Family name	Location	Habit	Frequency (%)	Density (%)	Temp. (°C)	Soil type	Weather conditions
<i>Ganoderma boninense</i>	Ganodermataceae	Dupchanchia	Scattered and unabundant	10	5	33	Sandy	Moist
<i>Ganoderma tsugae</i>	Ganodermataceae	Dhunat	Scattered and unabundant	55	23.2	33	Sandy	Moist
<i>Ganoderma lipsiense</i>	Ganodermataceae	Adamdighi	Scattered and unabundant	15	4.5	34	Sandy	Moist
<i>Ganoderma lucidum</i>	Ganodermataceae	Dhunat	Scattered and unabundant	15	4.5	34	Sandy	Moist
<i>Ganoderma sessile</i>	Ganodermataceae	Adamdighi	Scattered and unabundant	25	4.5	33	Sandy	Moist
<i>Ganoderma applanatum</i>	Ganodermataceae	Dhunat	Scattered and unabundant	13	6.5	33	Sandy	Moist
<i>Trametes versicolor</i>	Polyporaceae	Sonatala	Scattered and unabundant	15	4.5	34	Sandy	Moist
<i>Auricularia cornea</i>	Ganodermataceae	Adamdighi	Scattered and unabundant	12	5	33	Sandy	Moist
<i>Poronidulus conchifer</i>	Polyporaceae	Sherpur	Scattered and unabundant	35	12.3	33	Sandy	Moist
<i>Irpex lacteus</i>	Steccherinaceae	Dupchanchia	Scattered and unabundant	25	12.86	33	Sandy	Moist

Continue Table 3

Species name	Family name	Location	Habit	Frequency (%)	Density (%)	Temp. (°C)	Soil type	Weather conditions
<i>Ganoderma</i> sp.	Ganodermataceae	Sherpur	Scattered and unabundant	5	2.86	33	Sandy	Moist
<i>Ganoderma</i> sp.	Ganodermataceae	Sonatala	Scattered and unabundant	10	5.5	33	Sandy	Moist
<i>Marasmius oreades</i>	Marasmiaceae	Dhunat	Scattered and unabundant	25	14.3	34	Sandy	Moist
<i>Coprinellus plagioporus</i>	Psathyrellaceae	Dupchanchia	Scattered and unabundant	9.7	5.6	33	Sandy	Moist
<i>Marasmius siccus</i>	Marasmiaceae	Sherpur	Scattered and unabundant	40	18.3	33	Sandy	Moist
<i>Amanita muscaria</i>	Amanitaceae	Dupchanchia	Scattered and unabundant	25	12.3	33	Sandy	Moist
<i>Pleurotus ostreatus</i>	Pleurotaceae	Sherpur	Scattered and unabundant	21	10.4	34	Sandy	Moist
<i>Laetiporus sulphureus</i>	Polyporaceae	Dhunat	Scattered and unabundant	33	23.7	35	Sandy	Moist
<i>Podoscypha petalodes</i>	Polyporaceae	Sonatala	Scattered and unabundant	40	20.6	35	Sandy	Moist
<i>Calvulina coralloides</i>	Polyporaceae	Sherpur	Scattered and unabundant	37	23.6	35	Sandy	Moist

Continue Table 3

Species name	Family name	Location	Habit	Frequency (%)	Density (%)	Temp. (°C)	Soil type	Weather conditions
<i>Cornus florida</i>	Polyporaceae	Dhunat	Scattered and unabundant	12	5.6	35	Sandy	Moist
<i>Marasmius haematocephalus</i>	Polyporaceae	Adomdighi	Scattered and unabundant	10	4.6	35	Sandy	Moist
<i>Psathyrella candolleana</i>	Psathyrellaceae	Adamdighi	Scattered and unabundant	30	21.5	33	Sandy	Moist
<i>Crepidotus</i> sp.	Crepidotaceae	Dupchanchia	Scattered and unabundant	27	11.14	33	Sandy	Moist
UNIDENTIFIED	unknown	Dupchanchia	Scattered and unabundant	20	10.6	34	Sandy	Moist

CHAPTER V

DISCUSSION

Now-a-days mushrooms are becoming more popular and object of curiosity of modern research as the important component of ecosystems. It also becomes more interesting, while the scientists discover its various important properties as well. Mushrooms alone are represented about 41,000 species reported by Deshmukh *et al.*, (2014).

A detailed survey was carried out in five (5) Upazillas namely Dupchanchia, Adomdighi, Sherpur, Sonatola and Dhunot of Bogra district under social forest region of Bangladesh from June to September, 2016 and 2017 to record the morphological variability, distribution, habitat and biodiversity of the macro fungi population. A total of 43 mushroom samples were collected and identified to 24 samples belong to 9 families. Among this 15 genera and 21 species were recorded.

Six species of *Ganoderma* were recorded viz. *Ganoderma bonensis*, *Ganoderma tsugae*, *Ganoderma lipsiense*, *Ganoderma lucidum*, *Ganoderma sessile*, *Ganoderma appalanatum*, Two species of *Ganoderma*, Three species of *Marasmius* viz. *Marasmius oreades*, *siccus*, *haematocephalus* were recorded in association with *Dalbergia sissoo* (sisso) plant.

On the other hand *Trametes versicolor*, *Irpex lacteus*, *Poroniduius conchifer*, *psathyrella candolleana*, *Crepidotus* sp., *Amanita muscaria*, *Coprinellus plagioporus*, *Pleurotus ostreatus*, *Laetiporus sulphurens*, *Podoscyphha petalodes*, *Leocarpus fragills*, *Cornus florida* were recorded in association with *Dalbergia sissoo* (sisso) plant.

Ganoderma boninense was recorded in association with *Dalbergia sissoo* (Sisso) tree which frequency of its presence was 12% and density was 5%, was supported by Aminuzzaman and Das (2017). But this species was also found in association with *Mangifera indica* (Mango) from national botanical garden (Rubina *et al.*, 2017) and *Bambusa* sp. (Bamboo) from tropical moist deciduous

forest region of Bangladesh (Rumainul *et al.*, 2015). The frequency and density of its presence was 8% and 15%, respectively. Aminuzzaman and Das (2017) found this species in social forest region of Bogra, Bangladesh with a frequency of 75% and a density of 43.5%. The pathogenicity of *Ganoderma boninense* was examined (Cooper *et al.*, 2011).

Ganoderma tsuage was recorded in association with *Dalbergia sissoo* (Sisso), *Terminalia bellirica* (Bohera) tree which was supported by Aminuzzaman and Das (2017) and Rubina *et al.* (2017). But this species was also found in association with *Acacia auriculiformis* (Golden shower) as reported by Rumainul, *et al.* (2015) under tropical moist deciduous forest region of Bangladesh. The frequency and density of its presence was 6-8% and 11% respectively. Aminuzzaman and Das (2017) found the density of this species as 12.5% and frequency 50% under social forest region of Bogra. In another study Rubina *et al.* (2017) recorded its density 10% in national botanical garden, Dhaka. *Ganoderma tsuage* was also reported from India (Vyas, 2014). The recorded frequency of its presence was 55% and density was 23.2%, respectively in *Dalbergia sissoo* (Sisso) tree.

Ganoderma lipsiense was recorded in association with *Azadirachta indica* (Neem) which was supported by Rubina *et al.* (2017). The density of its presence was 13% and frequency was 5%. This species was recorded from national botanical garden, Dhaka with a density of 5% (Rubina *et al.*, 2017). On the other hand, *Ganoderma lipsiense* was also reported from India in association with *Dalbergia sissoo* plant (Bhosle *et al.*, 2010; Dwivedi *et al.*, 2012) and in China (Wang *et al.*, 2012). The recorded frequency of its presence was 10% and density was 5% in *Dalbergia sissoo* (Sisso) tree.

In the present study *Ganoderma lucidum* was recorded in association with *Albizia procera* (Koroi), *Terminalia arjuna* (Aurjun) and *Dalbergia sissoo* (Sisso) plant which frequency of its presence was 25% and density was 4.5%, was supported by Aminuzzaman and Das (2017) and Rubina *et al.* (2017). In another study Marzana *et al.*, (2018) found *Ganoderma lucidum* in association

with *Tectona grandis* (Shegun) in Kaptai, Rangamati of Chittagong Hill tracts under tropical evergreen and semi-evergreen forest of Bangladesh. In other study Rumainul *et al.* (2015) found this species in association with *Leucaena leucocephala* (Ipil-Ipil) and *Acacia auriculiformis* (Golden shower) under tropical moist deciduous forest region of Bangladesh. Marzana *et al.* (2018) found this species from Chittagong Hill tracts with a frequency and density of 11.11% and 2.78% respectively. But Das and Aminuzzaman (2017) described the species from Bogra district under social forest region of Bangladesh with a frequency and density of 75% and 25% respectively. Rubina *et al.* (2017) found this species from national botanical garden, Dhaka, Bangladesh with a density of 25%. The difference in frequency and density of the species might be due to the difference in geographic area of the collection sites. Ryvardeen, (1995) studied the morphology of 53 specimens of *Ganoderma lucidum* from Norway and he found large variation among the species.

Ganoderma sessile were recorded in association with *Dalbergia sissoo* (sisso) which frequency of its presence was 25% and density was 12.86%, respectively was supported by Aminuzzaman and Das (2017). The density of this species 18.75% and frequency 25% under social forest region of Bogra, Bangladesh.

Ganoderma applanatum were recorded in association with Golden shower *Acacia auriculiformis* (Golden shower), *Azadirachta indica* (Neem) and *Dalbergia sissoo* (sisso) plant (Rashid *et al.*, 2017). The density of 1st type its presence was 10%. The density of 2nd type its presence was 20%. Moncalvo and Ryvardeen (1997) published a world list of *Ganoderma* species. The study considered the species described in last 200 years listing 386 names for Ganodermataceae as whole. Taxonomy and diversity of *Ganoderma lipsiense* and *Ganoderma applanatum* was also reported in India (Bhosle *et al.*, 2010). The recorded frequency of its presence was 13% and density was 6.5%, respectively in *Dalbergia sissoo* (Sisso) plant.

Auricularia cornea were recorded by Marzana *et al.* (2018) in association with *Dalbergia sissoo* (sisso), *Bambusa vulgaris* (Bamboo), *Albizia saman* (Rain tree)

tree with a frequency and density of 22.22% and 38.89%, respectively. This species was reported from mangrove forest region of Bangladesh. The recorded frequency of its presence was 15% and density was 4.5%, respectively in *Dalbergia sissoo* (Sisso) plant.

Trametes versicolor was found in association with *Dalbergia sissoo* (sisso) tree which frequency of its presence was 35% and density was 12.3%, respectively. Das and Aminuzzaman (2017) found this species on dead logs of *Cocos nucifera* (Coconut) tree with 25% frequency and 4.55% density in mangrove forest regions of Bangladesh. Marzana *et al.* (2018) found this species associated with *Albizia lebbeck tree* with 22.22% frequency and 13.89% density. Romainul and Aminuzzaman (2016) found this species in association with *Albizia procera* (Royal siris) tree. *Trametes versicolor* was also reported in and around Bangalore (Karnataka) of India and found medicinal importance (Pushpa *et al.*, 2012). It was first described by Elias magnus fries in 1835. This genus has a widespread distribution and contains fifty species (Kirk *et al.*, 2008). This genus was also found in India (Thiribhuvanamala *et al.*, 2011).

Ganoderma sp. was found in association with sisso (*Dalbergia sissoo*) tree. The recorded frequency and density of this species were 10% and 5.5%, respectively. Aminuzzaman and Das (2016) found this species with the bark of *Dalbergia sissoo* (Sisso) under social forest region of Bangladesh. In another study, Rubina *et al.* (2017) found this species on root of *Terminalia bellirica* (Bohera).

Taxonomy and diversity of *Ganoderma lipsiense* and *Ganoderma applanatum* was also reported in India (Bhosle *et al.*, 2010). It was also reported in China (Wang *et al.*, 2012) and in India (Dwivedi *et al.*, 2012; Thiribhuvanamala *et al.*, 2011; Ram *et al.*, 2010). The recorded frequency and density of its presence were 1.35-2.7% and 0.76-2.25% respectively. The recorded frequency of its presence was 13% and density was 6.5%, respectively.

Marasmius oreades was found in association with sisso (*Dalbergia sissoo*) which was supported by Marzana *et al.* (2018). Das *et al.* (2016) found *Marasmius siccus* on dead branch of *Albizia procera* (Koroi) and computed its frequency

50% and density 18.75% in mangrove forest region of Bangladesh. Marzana *et al.* (2018) found the frequency of *Marasmius rotula* as 11.11% and density as 8.33%. Rumainul *et al.* (2015) mentioned that in the Dhaka district of the tropical moist deciduous forest region in Bangladesh, all the three species of *Marasmius* sp. were found. They furthermore added that, in their study, they collected this species from bark wood of tree from Romna park. It contains about 500 species (Kirk *et al.*, 2008) and it was also reported in Madagascar as well as the Mascarenes (Antonín and Buyck, 2006). Rahaman *et al.* (2016) found *Marasmius oreades* in Koira of Khulna district, having a frequency and density of 12.5% and 8.10%, respectively in an association with *Bambusa vulgaris* (Bamboo). The species was scattered in distribution with un-abundant in occurrence and found in the moist weather with the range of 29 to 30 degree celcius temperature. Das *et al.* (2016) mentioned that three species of *Marasmius* such as-*Marasmius oreades*, *Marasmius siccus* and *Marasmius haematocephalus*. The recorded frequency of its presence was 25% and density was 14.3%, respectively.

Amanita muscaria was found in association with *Dalbergia sissoo* (sisso) tree. *Amanita* sp. were previously described from Pabna, Dinajpur and Dhaka districts of Bangladesh (Rumainul *et al.*, 2015). This species was also reported from India (Dwivedi *et al.*, 2012). *Amanita cinereovelata* was first identified from sal forest of Bangladesh (Hosen *et al.*, 2015). A total ten number *Amanita bisporigera* was found in Modhupur and Pathorghata in natural forest zones of Bangladesh on the root zone of (*Dalbergia sissoo*) on leaved forest zones. The frequency of its presence was 11.11% and the density was 20% (Rashid *et al.*, 2017). Three species of *Amanita* were also reported in Pathorghata of Borguna districts in the southern region with a frequency and density of 6.25% and 9.30%, respectively in an association with *Dalbergia sissoo* (Sisso) tree (Rashid *et al.*, 2016). Also found in forest of northern Thailand (Lee *et al.*, 2007). The recorded frequency of its presence was 25% and density was 12.3%, respectively.

Poronidulus conchifer was recorded in association with *Ixora superba* (white rangun) in social forest region of Bangladesh. The density of its presence was

4.5% and frequency was 15%. Descriptions, figures of microscopic characters, data on ecology and distribution of the species was reported in Czech Republic and Slovakia (Vašutová *et al.*, 2008). The recorded frequency of its presence was 15% and density was 4.5%, respectively.

Coprinellus plagioporus was recorded in Dupchanchia Upazilla of Bogra district in social forest with the frequency and density of 9.7 and 12.9%, respectively. This species was also found in Daulatpur of Kushtia district associated with *Artocarpus heterophyllus* (Jackfruit) tree with a frequency and density of 12.5% and 8.10%, respectively. Rahaman *et al.*, (2016) also reported the species in *Artocarpus heterophyllus* (Jackfruit) tree in south western region of Bangladesh which frequency of its presence was 12.5% and density was 8.10%, respectively.

Pleurotus ostreatus was reported by Das and Aminuzzaman (2017) in association with *Albizia saman* (Rain) tree in mangrove forest region in Bangladesh which frequency was 25% and the density was 3.13%, respectively.

Psathyrella candolleana recorded in Dupchanchia upazilla of Bogra district with the frequency and density of 33 and 55.5%, respectively. Rubina *et al.* (2017) found this species in association with White rangun (*Ixora superba*) from national botanical garden, Dhaka, Bangladesh with a density of 5%. This genus was also reported from India by (Mohan, 2011; Thiribhuvanamala *et al.*, 2011; Hansen, 1992).

Irpex lacteus was reported by Das and Aminuzzaman (2017) in *Swietenia macrophylla* (Mahogany) tree from Mangrove Forest Regions of Bangladesh. The highest frequency was found 50% and the highest density of 22.73%, respectively. The recorded density and frequency was 5% and 2.86%, respectively *Dalbergia sissoo* (sisso) tree.

Cornus florida was found by Romainul *et al.* (2015) in the dead root zone of *Dalbergia sissoo* (Sisso) tree from Tropical Moist Deciduous Forest Region of Bangladesh which frequency and density was 23% and 12.3%, respectively. The recorded density and frequency was 5.6% and 12%, respectively.

Laetiporus sulphurens, *Podoscypha petalodes* were recorded in Sonatola Upazilla of Bogra district with the frequency and the density of 19.7, 20% and 23.6, 35.6%, respectively. This species of mushroom was found on the dead logs of *Dalbergia sissoo* (Sisso) . This types of macro fungi were also reported by Kirk *et al.*, (2008).

CHAPTER VI

SUMMARY AND CONCLUSION

Macro fungi are an important component of the ecosystem. Their edibility, poisonous nature, psychotropic properties, mycorrhizal and parasitic association with the trees make them economically important and interesting. The mushrooms grown in the wild play an important role to maintain the forest properties. For the study of bio-diversity, habitat and morphology of mushroom a survey was conducted in five (5) thanas of Bogra district. After morphological study in both survey area and laboratory and spore observation under microscope the following 21 different species were found from 43 collected samples and these were *Ganoderma lucidum*, *Ganoderma bonensis*, *Ganoderma tsugae*, *Ganoderma lipsiense*, *Trametes versicolor*, *Ganoderma appalanatum*, *Ganoderma sessile*, *Irpex lacteus*, *Poroniduius conchifer*, *Ganoderma* sp., *psathyrella candolleana*, *Marasmius oreades*, *Marasmius siccus*, *Crepidotus* sp., *Amanita muscaria*, *Coprinellus plagioporus*, *Pleurotus ostreatus*, *Laetiporus sulphurens*, *Podoscypha petalodes*, *Leocarpus fragills*, *Cornus florida*, *Marasmius haematocephalus* that were recorded with an association of sisso plant.

Among the total 21 identified species, highest species eight (8) were found under the Ganodermataceae family. Then species were found under the Polyporaceae, Marasmiaceae, Crepidotaceae, Amanitaceae, Hymenochataceae, Auriculariaceae, Mycenaceae, Pleurotaceae, Steccherinaceae, Pleurotaceae and Agaricaceae family. The investigation proves that northern regions of Bangladesh has distinct biodiversity of mushroom population. Among the *Genoderma* sp. the highest density and frequency was found in *Ganoderma tsugae*, the density and frequency of its presence was 40% and 23.2% that's the highest percentage of their existence. On the other hand the highest density and frequency was found in *Podoscypha petalodes* species. The density and frequency of its presence was 20% and 40% that's the highest percentage of their existence. *Dalbergia sissoo* is a useful multipurpose tree, producing fuel wood, timber and fodder. It is widely

used as medicinal and sleeper of rail line. It is most useful for compacting the soil especially in roadside. But now a days the plant is died due to fungal infection. They parasitic and colonize living trees and attack the woody cell walls and degrade the woody tissue. By studying the biodiversity we can easily detect the fungal species that cause decay of sisso plant and their management practices. This survey helps further continuation in the near consecutive years to refine the more findings with relevant information along with the present findings.

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