



Biodiversity and Distribution of wild Mushrooms in the Southern Region of Bangladesh

S. N. Rashid¹, F. M. Aminuzzaman^{1*}, M. R. Islam¹, M. Rahaman¹
and M. I. Romainul¹

¹Department of Plant Pathology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Authors SNR and FMA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MRI and MR managed the analyses of the study. Author MIR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A survey was conducted to study the biodiversity as well as the distribution of wild mushrooms, which naturally grow, in different localities, at different seasons, in the southern region of Bangladesh. A total 24 species of mushrooms belonging to 17 genera and 14 families were identified. Those mushrooms were collected between July and October, 2013 and 2014, accordingly from 16 sub-districts of Barisal, Patuakhali, Borguna, Pirojpur, Jhalokhathi districts, which situated in the southern region of Bangladesh. The identified genera were viz., *Amanita* sp., *Agaricus* sp., *Ganoderma* sp., *Armillaria* sp., *Coprinus* sp., *Cortinarius* sp., *Hebeloma* sp., *Mycena* sp., *Lepiota* sp., *Lycoperdon* sp., *Macrolepiotia* sp., *Daldinia* sp., *Tuber* sp., *Volvariella* sp., *Steccherinum* sp., *Hypholoma* sp. and *Coprinellus* sp. Moreover, the maximum frequency of occurrence in this survey was exhibited by *Ganoderma applanatum*, *Amanita vaginata* and *Agaricus silvicola* (18.75%), whereas, the maximum density was recorded for *Coprinus silvaticus* (48.83%). The collected specimens were deposited to SAU herbarium of mushroom flora (SHMF).

*Corresponding author: E-mail: aminsaupp@yahoo.com;

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1. INTRODUCTION

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 [1]. A mushroom is the fleshy spore bearing fruiting body of a fungus, typically produced above ground soil, or on its food source. Some species of mushrooms are edible and poisonous. Mushrooms have been existing on earth even long time before man appeared on earth, as it is evident from the fossil records of the lower cretaceous period [2]. Although, biologically speaking, possibly man might have used mushroom as food gatherer and hunter on the chronology of cultural evolution, but their nutritive value is untapped till now. Wild edible fungi were being collected and consumed by people for thousands of years. The geological records reveal that edible species associated with people living 13,000 years ago in Chile. Many mushrooms have been used as food and medicines. So they contribute towards diet, income and human health. Some mushrooms have been important source of revenue for rural communities in India and other developing countries [3]. Wild, edible mushrooms are the special forest products. The use of wild mushrooms for food in all probability began with the prehistoric man. During the long period human as a hunter gathered the fungi of the forest that has served as important sources of nourishment. Mushrooms have been found in fossilized wood, that are estimated to be 300 million years old and almost certainly, prehistoric man has used mushroom collected in the wild as food [4]. There are many edible i.e. *Volvarias*, polypore and tubers fungi that used ethno botanical food by the tribal of forest regions of India and Nepal [5]. These fungi are obviously nontoxic as these have been in intimate human consumption by native and tribal, since antiquity [6]. These are invariably high protein rich and have been considered as potential source of proteins, amino acids, vitamins and minerals. Besides, they are valued for food and medicinal properties by people. However, the food value and acceptance of these edible fungi by the scientific and civilized world have not been recognized. These edible fungi are more important for a tropical or, subtropical country like Bangladesh, which has a climate, most congenial for the natural growth of such fungi [7]. The scope is limitless and this is high time we surveyed,

collected, conserved, recorded and identified the biodiversity in general and fungal diversity in particular as no one knows when and how some these valuable forms might be lost for forever. A systematic study of the edible fleshy fungi will explore the possibility for the scientific cultivation of the fungi in the tribal area for their nutritional security. This may be also helpful in the upliftment of the forest dwellers and tribes depending on forest produces. To date, about 1,200 species of fungi belonging to the order Agaricales, Russulales and Boletales are described in comparison to about 14,000 species of mushrooms reported worldwide that contributes 10 percent of the global mushroom flora. So far, about 1,105 to 1,208 species of mushrooms belonging to 128-130 genera have been documented and among these, 300-315 species belonging to 75-80 genera are considered edible [8]. It has an estimated wealth of mushroom biodiversity that needs to be tapped properly, as there are still several undescribed species yet to be identified. Efforts need to be made to identify and exploit this mushroom flora for utility as their biodiversity and conservation strengthen the food security of a country. Due to increased awareness of the pharmacological values and nutritional values of mushrooms, there is more demand and consumer preference for different varieties of mushrooms among the people and farmers that are urged to exploit the wild mushrooms for utilization. The mushroom genome stands out as a virtually untapped resource for novel antimicrobials. Recently many antibacterial, antifungal and insecticidal properties have been identified from mushrooms. Scientists worldwide are now focusing on the exploitation of bio-molecular from mushrooms for pest and disease management, which is a challenging field of study. Edible mushrooms are considered as healthy food, because their mineral content is higher than that of meat or fish and most vegetables, apart from their nutritional value mushrooms have potential medicinal benefits [9, 10]. Recent studies confirm that they are an important source of food and income in both developing and developed countries. Indigenous peoples are utilizing mushroom for the treatment of different type of diseases and also as an aphrodisiac and tonic [11]. Different types of edible mushrooms are cultivated on large scale for commercial use and many more species of mushrooms grow wild in nature which has much nutritional and medicinal value [12].

The southern region of Bangladesh is located between 22° 80" N, 90° 37" E and the investigated districts were Barisal (Sub-districts: Sadar, Babugonj, Ujirpur and Bakergonj), Patuakhali (Sub-districts: Sadar, Dumki and Golachipa), Borguna (Sub-districts: Sadar, Betagi, Bamna and Pathorghata), Pirojpur (Sub-districts: Sadar and Bhandaria) and Jhalokhathi (Sub-districts: Sadar, Nolchity and Rajapur), which were placed about 3-4m above from the sea level. The minimum and maximum temperatures are between 12.1°C and 35.1°C, respectively. The average annual rainfall is about 1955mm. The available growing tree species of these areas are Sisso (*Dalbergia sissoo*), Rain tree (*Samanea saman*), Mehogoni (*Swietenia macrophylla*), Babla (*Acacia nilotica*), Koroi (*Albizia richardiana*), Coconut (*Cocos nucifera*), Betal nut (*Areca catechu*) and Akashmoni (*Acacia auriculiformis*). During the rainy season, there is abundant growth of several kinds of mushroom. The aim of this survey was to collect and study on the biodiversity, distribution, habitat and morphology of wild mushrooms associated with forest trees of southern region of Bangladesh.

2. MATERIALS AND METHODS

2.1 Collection Site

The collection of samples was conducted in 16 Sub-districts of 5 districts named, Barisal (Sub-districts: Sadar, Babugonj, Ujirpur and Bakergonj), Patuakhali (Sub-districts: Sadar, Dumki and Golachipa), Borguna (Sub-districts: Sadar, Betagi, Bamna and Pathorghata), Pirojpur (Sub-districts: Sadar and Bhandaria) and Jhalokhathi (Sub-districts: Sadar, Nolchity and Rajapur), which is situated in the southern region of Bangladesh (Fig. 1). This region is located between 22° 80" N, 90° 37" E and about 1-1.5 m above from the sea level [13]. The investigation was designed to collect the mushroom samples in the areas of forest, university campus, college campus, farms, surrounding residence, nearby roadside as well as villages of Barisal, Patuakhali, Borguna, Pirojpur, Jhalokhathi districts. The minimum and maximum temperatures of these areas are 12.1°C and 35.1°C, accordingly, whereas the average annual rainfall is about 1955 mm (Wikipedia). The prominently grown tree species of these areas are Sisso (*Dalbergia sissoo*), Rain tree (*Samanea saman*), Mehogoni (*Swietenia macrophylla*), Babla (*Acacia nilotica*), Koroi (*Albizia richardiana*), Coconut (*Cocos nucifera*),

Betal nut (*Areca catechu*) and Akashmoni (*Acacia auriculiformis*). Several kinds of mushrooms are abundantly grown during the rainy season in these areas. Therefore, a survey was conducted to explore these areas for mushroom emanating in different seasons under varying environment (Table 1).

2.2 Experimental Site

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

2.3 Source of Data and Sampling Procedure

A systematic sampling procedure was conducted during the survey. For conducting the survey analysis on mushroom's biodiversity, distribution, habitat and morphology 16 sub-districts belong to 5 districts of southern region of Bangladesh were selected. A pre-designed collection procedure and data analysis procedure were used to collect information on level of knowledge on biodiversity, habitat and morphology of mushroom in selected regions of Bangladesh.

2.4 Collection of Mushroom Samples

A detailed survey was carried out from July to October, 2013 and 2014, accordingly to record the morphological variability in the mushrooms population. The collection was made followed by the method of Hailing [14]. Spotted mushrooms were inspected in their natural habitats and brought to laboratory for detailed study. Photographs were taken by using Samsung camera with the power of 12 megapixels. The collected fleshy fungi were studied for their macroscopic detail, patterning the habit, habitat, morphology and other phenotypic parameter noted in fresh form. Standard methods of collection, preservation, macroscopic and microscopic preservations were recorded. Collections were preserved as dried specimens in the key laboratory of department of plant pathology at Sher-e-Bangla Agricultural University (SAU) in Dhaka, Bangladesh.

2.5 Processing of Mushrooms

Fleshy mushrooms are highly perishable, as it is susceptible to deterioration by the enzyme and microorganism. It has been realized that merely fleshy collected mushrooms cannot be utilized for

further analysis, unless they are properly preserved. Therefore, some precautions were followed before processing of mushrooms during the analysis period. Firstly, these mushrooms were washed out through water for removing debris. Then, two types of preservation processes were followed. One is short term preservation and another is long term preservation on the basis of study purpose as well as structure of the mushrooms [15].

2.6 Drying

Collected samples were dried by using electrical air-flow drier. The power supply capacity of this

drier was 1000 w, which can easily remove the moisture content from those collected mushrooms, within 3 to 7 hours, maintaining the regular interval basis power supply (15 minutes' switch-off after 30 minutes' switch-on) depending on the structure and texture of those species [15].

2.7 Storage

Dried mushrooms were stored into the Zip-lock type polybags during survey. Silica gel was used at the rate of 10% of dry basis during the storage period [15].

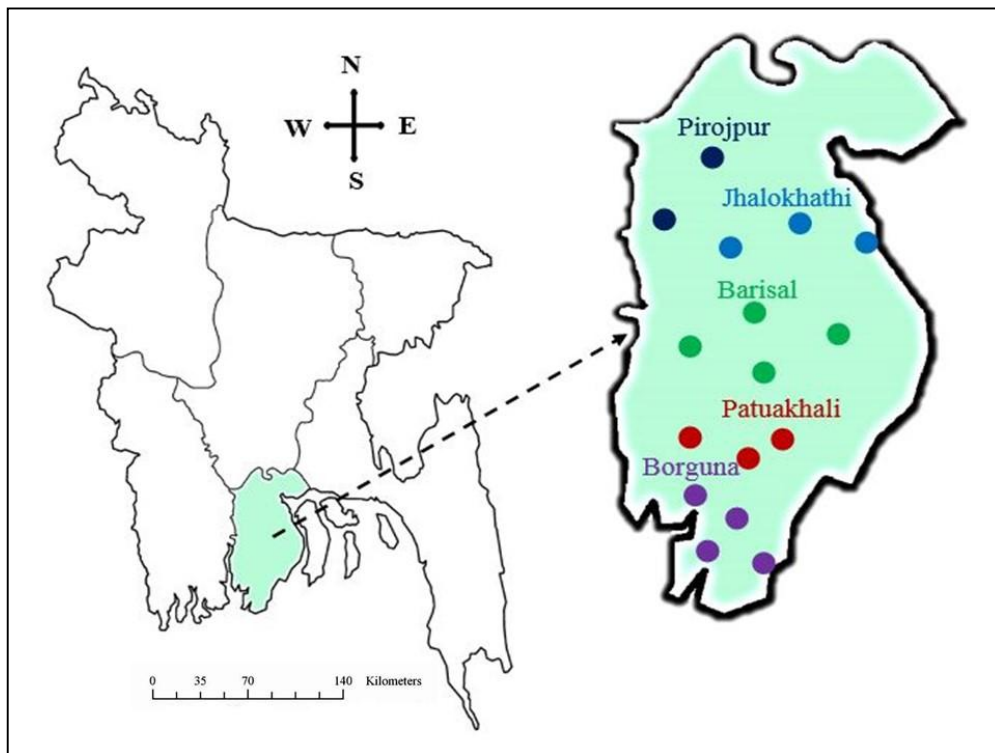


Fig. 1. Survey areas of southern region of Bangladesh

Table 1. Survey areas of southern region of Bangladesh

Serial no.	District(s)	Surveyed sub-district(s)				
		Name of surveyed sub-district(s)				Number of sub-district
1	Barisal	Sadar	Babugonj	Ujirpur	Bakergonj	4
2	Borguna	Sadar	Betagi	Bamna	Pathorghata	4
3	Patuakhali	Sadar	Dumki	Golachipa	-	3
4	Pirojpur	Sadar	Bhandaria	-	-	2
5	Jhalokhathi	Sadar	Nolchity	Rajapur	-	3
Total district = 5		Total sub-district = 16				16

2.8 Morphological Observation

Data on the following parameters were recorded for identification of mushrooms 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, cap color, cap surface, cap margin, cap diameter, stipe length, gill attachment, gill spacing and spore print [16] Individual spore characteristics like shape, size and color were also recorded. For these purposes, motic compound microscope was used to measure shape, size and color with the help of Motic Images Plus 2.0 software. The final identification and classification were done by comparing recorded characteristics of mushrooms with the help of color dictionary of mushroom [17,18,19].

2.9 Morphological Characterization Procedures

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

2.10 Habitat, Distribution and Diversity Analysis

The sample of mushrooms were found attached to various substrata, such as decaying wood, rotting plant parts, termite's nests, cow dungs, leaf litters etc. The surrounding environment, temperature, soil pH, moisture content and vegetation were recorded for biodiversity of mushroom. The soil pH and moisture content were measured by pH meter, whereas the air temperature was measured by thermometer during collection periods. Collected samples were wrapped in polybag and brought to the

laboratory for further study. The frequency and density of different species had been determined by the following formulas [20].

Frequency of fungal species (%) = [(Number of site in which the species is present/Total number of sites) x 100]

Density (%) = [(Total number of individual of a particular species/Total number of species) x 100]

3. RESULTS

3.1 Morphology, Habitat and Biodiversity of *Amanita* sp.

3.1.1 *Amanita brunnescens*

Common name: Cleft-footed amanita

Family: Amanitaceae

3.1.1.1 Morphology of *Amanita brunnescens*

Size of fructification was 9-10×3.2-3.5 cm. The color of pileus (cap) was ash. The shape of cap was umbonate or, convex. The cap edge was split and grooved. Brownish scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Amanita brunnescens*. The color of gills was deep brown and the color of stipe was white to whitish. The length and width of stipe was 2-3 cm and 1-1.5 cm, respectively. Ring or anal was present on the stipe and volva was present on the lower part of the stipe in some *Amanita brunnescens*. Spore color was deep brown, spore shaped was single welled, smooth, ellipsoidal and spore size was 11.5-12×6-8 μm.

3.1.1.2 Habitat of *Amanita brunnescens*

The mushroom *Amanita brunnescens* were found on the root zone of Sisso (*Dalbergia sissoo*). Relative humidity was 79%. The recorded soil pH for *Amanita brunnescens* was 7.0-8.

3.1.1.3 Biodiversity of *Amanita brunnescens*

Amanita brunnescens was found in Pathorghata. A total of four *Amanita brunnescens* were found during collection. The frequency of its presence was 6.25% and the density was 9.30%.



Fig. 2. Fruiting body of collected mushrooms; *Amanita brunnescens* (a & b); *Amanita griseoverrucosa* (c & d); *Amanita vaginata* (e & f); *Agaricus silvicola* (g & h); *Agaricus campestris* (i)

3.1.2 *Amanita griseoverrucosa*

Common name: Pale gray wart Lepidella

Family: Amanitaceae

3.1.2.1 Morphology of *Amanita griseoverrucosa*

Size of fructification was 12-13×5-6 cm. The color of pileus (cap) was brown. The shape of

cap was convex. The cap edge was round smooth. Fleshy brown color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were present. The color of gills was white. Color of stipe was brown. The length and width of stipe was 5-7 cm and 2-3 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color

was light brown, spore was single walled, round to oval shaped and spore size was 8-9×7-8 µm.

3.1.2.2 Habitat of *Amanita griseoverrucosa*

Amanita griseoverrucosa were associated with Coconut (*Cocos nucifera*). This mushroom was found on road side of forest. Humidity was 84%. The recorded soil pH was 6. Soil type was clay loam for *Amanita griseoverrucosa*. The average recorded temperature was 29°C.

3.1.2.3 Biodiversity of *Amanita griseoverrucosa*

Amanita griseoverrucosa was found in Pirojpur, Barisal. A total of three *Amanita griseoverrucosa* were found during collection. The frequency of its presence was 12.5% and the density was 6.97%.

3.1.3 *Amanita vaginata*

Common name: Grisette

Family: Amanitaceae

3.1.3.1 Morphology of *Amanita vaginata*

Size of fructification was 9-10×3-5 cm. The color of pileus (cap) was brown. The shape of cap was convex. The cap edge was round smooth. Fleshy brown color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were present. The color of gills was white. Color of stipe was brown. The length and width of stipe was 5-7 cm and 2-3 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was light brown, spore was single walled, round to oval shaped and spore size was 7-8×5-6 µm.

3.1.3.2 Habitat of *Amanita vaginata*

Amanita vaginata were associate with Coconut (*Cocos nucifera*) and mushroom was found on road side of forest. Relative humidity was 75%. The recorded soil pH was 6.5-6.8. Soil type was clay loam for *Amanita vaginata*. The average recorded temperature was 29.5°C.

3.1.3.3 Biodiversity of *Amanita vaginata*

Amanita vaginata was found in Pirojpur, Barisal and Jhalokhathi. A total of two *Amanita vaginata* were found during collection. The frequency of its presence was 18.75% and the density was 4.65%.

3.2 Morphology, Habitat and Biodiversity of *Agaricus* sp.

3.2.1 *Agaricus silvicola*

Common name: Wood Mushroom

Family: Agaricaceae

3.2.1.1 Morphology of *Agaricus silvicola*

Fructification size was 9-10×3-4 cm. The color of pileus (cap) was as like as soil color. The shape of cap was convex. The cap edge was lobed. Brown color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Agaricus silvicola*. The color of gills was white to brown gills. Color of stipe was brown to white mixed. The length and width of stipe was 5-7 cm and 2-3 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe in *Agaricus silvicola*. Spore color is deep brown and single walled, smooth, oval shaped and spore size were 10-11×7-8 µm.

3.2.1.2 Habitat of *Agaricus silvicola*

This mushroom was associate with Mehogoni (*Swietenia macrophylla*) tree root zone of forest. Forest type was mixed. Relative humidity was 72% and soil pH was 6 to 6.5 and soil type was clay loam. Average recorded temperature was 30°C.

3.2.1.3 Biodiversity of *Agaricus silvicola*

Agaricus silvicola was found in Patuakhali, Barisal, Jhalokhathi. A total of five *Agaricus silvicola* were found during collection. The frequency of its presence was 18.75% and the density was 11.62%.

3.2.2 *Agaricus campestris*

Common name: Field mushroom or meadow mushroom.

Family: Agaricaceae

3.2.2.1 Morphology of *Agaricus campestris*

Size of fructification was 10-11×3.5-4 cm. The color of pileus (cap) was ash to white mixed. The shape of cap was convex and umbonate shape. The cap edge was grooved and split. Brown

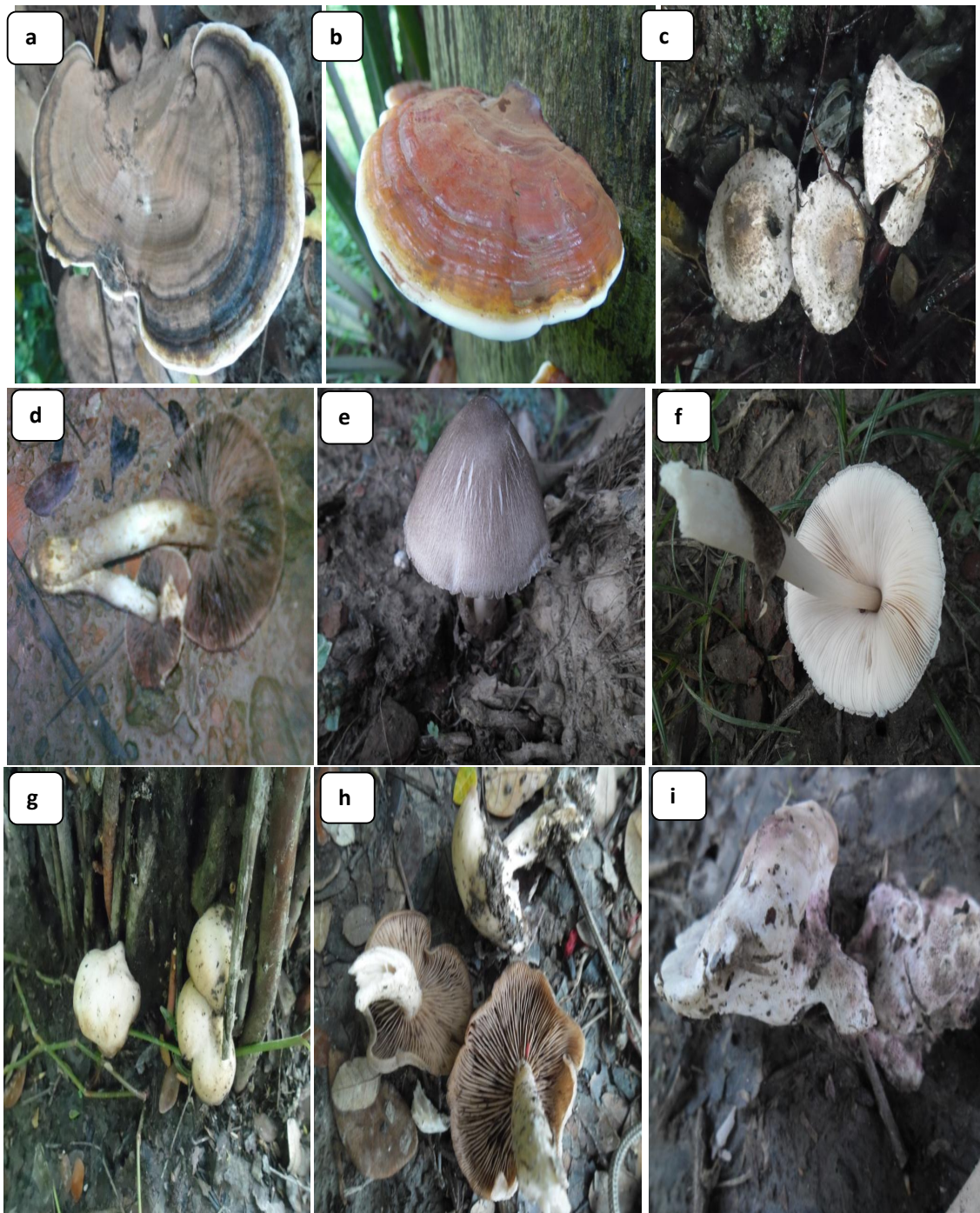


Fig. 3. Fruiting body of collected mushrooms; *Ganoderma applanatum* (a & b); *Armillaria mellea* (c & d); *Cortinarius corrugates* (e & f); *Hebeloma crustuliniforme* (g & h); *Tuber aestivum* (i)

color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Agaricus campestris*. The color of gills

was pink. Color of stipe was white to light brown. The length and width of stipe was 3 cm and 1.4 cm, respectively. Ring or anal was present on the stipe and volva was absent on the lower part of

the stipe in *Agaricus campestris*. The color of spore was reddish and structure was single walled, smooth, ellipsoidal and spore size was 6-7 x 4.5-5 μm .

3.2.2.2 Habitat of *Agaricus campestris*

The mushroom was found on the root zone of Sisso (*Dalbergia sissoo*). Forest type was mixed and leaved. Relative humidity was 77%, soil pH was 6 to 6.5 and soil type was clay loam. Average recorded temperature was 31°C.

3.2.2.3 Biodiversity of *Agaricus campestris*

Agaricus campestris was found in Patuakhali and Pathorghata. A total of three *Agaricus campestris* were found during collection. The frequency of its presence was 12.5% and the density was 6.97%.

3.3 Morphology, Habitat and Biodiversity of *Ganoderma* sp.

3.3.1 *Ganoderma applanatum*

Common name: Lingzhi or Reishi mushroom

Family: Ganodermataceae

3.3.1.1 Morphology of *Ganoderma applanatum*

Fructification size was 4-5x2-3 cm. The color of pileus (cap) was brown with white margin. The shape of cap was hard and flat. The cap edge was undulating. Scale was not found on the cap. Beneath the cap hymenophores were not present. Regular shaped gills (lamellae) were not present underside of the cap of *Ganoderma applanatum*. Pseudostem present under the cap. Ring and volva was absent. The color of spore was reddish and structure was single walled, smooth, oval shaped and spore size was 6.5-7x4-5 μm .

3.3.1.2 Habitat of *Ganoderma applanatum*

The mushrooms were found on the bark of Mehogoni (*Swietenia macrophylla*). Forest type was mixed for all species of *Ganoderma*. Average relative humidity was 72%, average soil pH was 6.3 to 6.5. Soil type was clay loam. Average recorded temperature was 28 °C for *Ganoderma applanatum*.

3.3.1.3 Biodiversity of *Ganoderma applanatum*

Ganoderma applanatum was found in Patuakhali, Barguna and Barisal. A total of 15 *Ganoderma applanatum* were found during

collection. The frequency of its presence was 18.75% and the density was 34.88%.

3.4 Morphology, Habitat and Biodiversity of *Armillaria* sp.

3.4.1 *Armillaria mellea*

Common name: Honey fungus

Family: Physalacriaceae

3.4.1.1 Morphology of *Armillaria mellea*

Size of fructification was 15-17x8-9 cm. The color of pileus (cap) was white and tip portion brown. The shape of cap was umbonate or convex. The cap edge was split and grooved. Brownish scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap of *Armillaria mellea*. The color of gills was deep brown and the color of stipe was brown to whitish. The length and width of stipe was 11-12 cm and 3-4 cm, respectively. Ring or anal was absent on the stipe and volva was present on the lower part of the stipe. Spore color was brown, spore shaped were single walled, smooth and ellipsoidal and spore size was 7.5-8 x 3.75-4 μm .

3.4.1.2 Habitat of *Armillaria mellea*

The mushroom *Armillaria mellea* were found on the root zone of Coconut (*Cocos nucifera*). The recorded soil pH was 7.0-8. Soil type was clay loam. Average relative humidity was 71% and temperature 27°C for *Armillaria mellea*.

3.4.1.3 Biodiversity of *Armillaria mellea*

Armillaria mellea was found in Barisal and Jhalokhathi. A total of 13 *Armillaria mellea* were found during collection. The frequency of its presence was 12.5% and the density was 30.23%.

3.5 Morphology, Habitat and Biodiversity of *Cortinarius* sp.

3.5.1 *Cortinarius corrugates*

Common name: Wrinkled Cortinarius

Family: Cortinariaceae

3.5.1.1 Morphology of *Cortinarius corrugates*

Size of fructification was 22-23x8-9 cm. The color of pileus (cap) was ash color. The shape of

cap was ovate. The cap edge was grooved. Ash color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was milky white. The length and width of stipe was 8 cm and 3 cm,

respectively. Gills were present and color of gills are milky white. Black ring or annulus was present on the upper part of stipe and volva was absent on the lower part of stipe. The color of spore was brown, structure was single walled, smooth, oval shaped and size of spore was 6.5-7×5-6 µm.

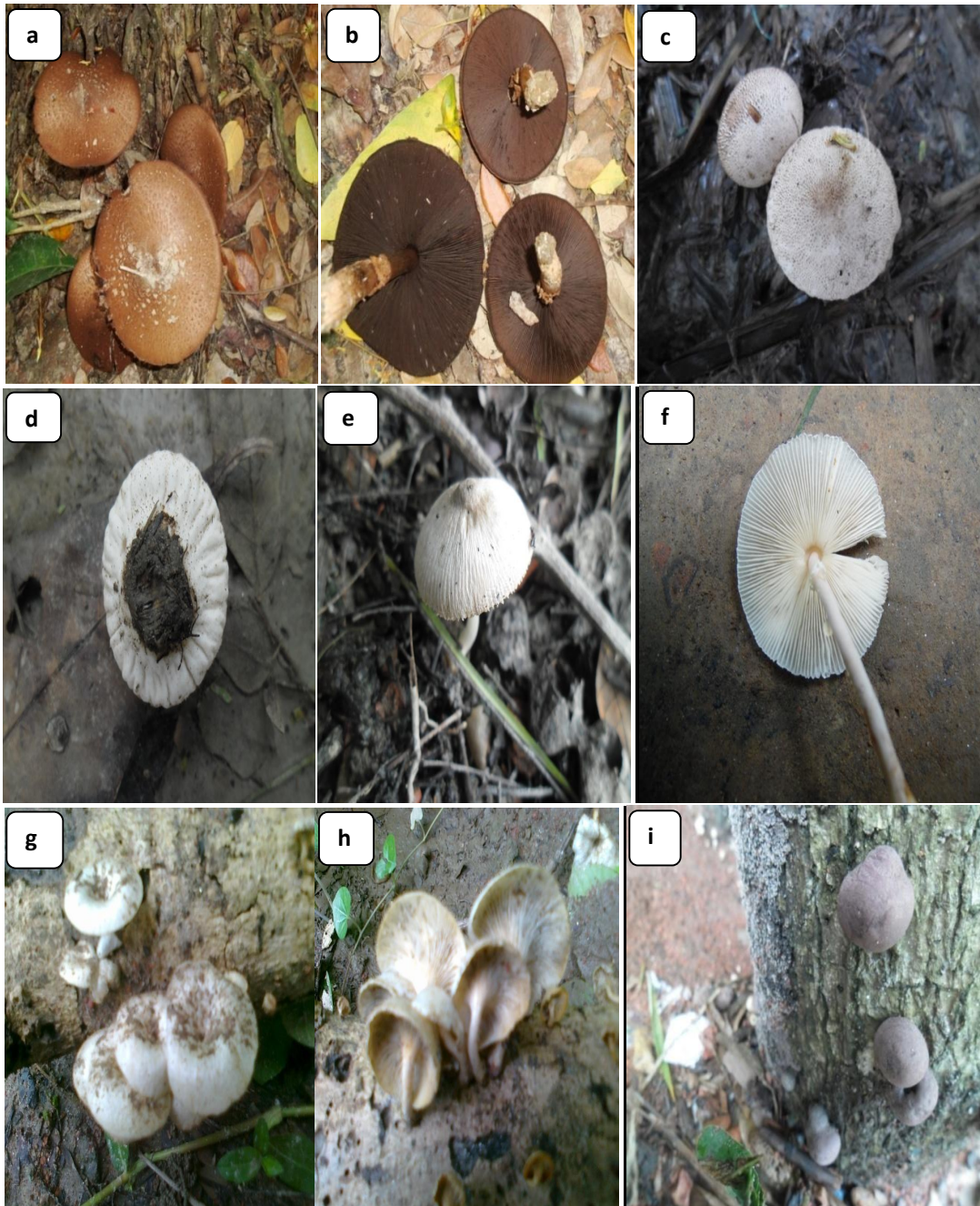


Fig. 4. Fruiting body of collected mushrooms; *Lepiota americana*(a & b); *Lycoperdon erlatum* (c & d); *Mycena epipterygia* (e & f); *Mycena cinerella* (g & h); *Daldinia concentrica* (i)



Fig. 5. Fruiting body of collected mushrooms; *Coprinellus micaceus* (a & b); *Macrolepiota procera* (c & d); *Volvariella gloiocephala* (e & f); *Volvariella volvacea* (g & h); *Volvariella hypopithys* (i)

3.5.1.2 Habitat of *Cortinarius corrugates*

The mushroom was found on the on the root zone of banana (*Musa* sp.) tree. Forest type was

mixed. Average relative humidity was 87%, soil pH was 6.2 and soil type was clay. Average recorded temperature was 29°C.



Fig. 6. Fruiting body of collected mushrooms; *Volvariella hypopithys* (a); *Volvariella speciosa* (b & c); *Steccherinum ochraceum* (d & e); *Coprinus silvaticus* (f & g); *Hypholoma fasciculare* (h & i)

3.5.1.3 Biodiversity of *Cortinarius corrugates*

Cortinarius corrugates was found in Pathorghata and Dumki. A total of 7 *Cortinarius corrugates* were found during collection. The frequency of its presence was 12.5% and the density was 16.7%.

3.6 Morphology, Habitat and Biodiversity of *Hebeloma* sp.

3.6.1 *Hebeloma crustuliniforme*

Common name: Poison pie or fairy cakes

Family: Hymenogastraceae

3.6.1.1 Morphology of *Hebeloma crustuliniforme*

Size of fructification was 5-7x2-3 cm. The color of pileus (cap) was white. The shape of cap was convex and umbonate shape. The cap edge was grooved. White color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were present underside of the cap. The color of gills was creamy white. Color of stipe was white to light brown. The length and width of stipe was 3-4 cm and 1.5-2 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. The color of spore was brown, structure was single walled, rough, oval shaped and size of spore was 5-6x4-5 µm.

3.6.1.2 Habitat of *Hebeloma crustuliniforme*

The mushroom was found on the on the root zone of Betal nut (*Areca catechu*). Average relative humidity was 77%, soil pH was 6.2 and soil type was clay. Average recorded temperature was 29°C.

3.6.1.3 Biodiversity of *Hebeloma crustuliniforme*

Hebeloma crustuliniforme was found in Pathorghata, Bamna. A total of nine *Hebeloma crustuliniforme* were found during collection. The frequency of its presence was 12.5% and the density was 20.93%.

3.7 Morphology, Habitat and Biodiversity of *Tuber* sp.

3.7.1 *Tuber aestivum*

Common name: Truffle

Family: Tuberaceae

3.7.1.1 Morphology of *Tuber aestivum*

Fructification size was 2-3x4-7 cm. The color of pileus (cap) was white color. The shape of cap was irregular. The cap edge was thick, spongy heart. White mixed violet scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were not present underside of the cap. Stipe was absent. Gills were not present. Ring or anal was absent. Spore color was deep brown, spore shaped were single walled, smooth and elongated shaped and size were 5.5-6 × 4-5 µm.

3.7.1.2 Habitat of *Tuber aestivum*

The mushroom was found on associate with Mehogoni (*Swietenia macrophylla*) tree of the forest. Average relative humidity was 83%, soil pH was 6.7 and soil type was clay loam. Average temperature was recored 28.4 °C during collection.

3.7.1.3 Biodiversity of *Tuber aestivum*

Tuber aestivum was found in Barisal. A total of two *Tuber aestivum* were found during collection. The frequency of its presence was 6.25% and the density was 4.6%.

3.8 Morphology, Habitat and Biodiversity of *Lepiota* sp.

3.8.1 *Lepiota Americana*

Common name: Rogers mushroom

Family: Agaricaceae

3.8.1.1 Morphology of *Lepiota americana*

Size of fructification was 17-19x7-8cm. The color of pileus (cap) was brown. The shape of cap was convex and umbonate shape. The cap edge was grooved and split. brown color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of gills was dark brown. Color of stipe was brown. The length and width of stipe was 8-9cm and 2.8-3cm, respectively. Ring or anal was present on the stipe and volva was absent on the lower part of the stipe. The color of spore was brown, structure was single walled, rough, elongated shaped and size of spore was 5.5-6x4.5-5µm.

3.8.1.2 Habitat of *Lepiota americana*

The mushroom was found on the on the root zone of Betal nut (*Areca catechu*) tree. Average relative humidity was 78%, soil pH was 6.4 and soil type was clay loam. Average recorded temperature was 26°C.

3.8.1.3 Biodiversity of *Lepiota americana*

Lepiota americana was found in Barisal and Jhalokhathi. A total of 13 *Lepiota americana* were found during collection. The frequency of its presence was 12.5% and the density was 30.23%.

3.9 Morphology, Habitat and Biodiversity of *Lycoperdon* sp.

3.9.1 *Lycoperdon perlatum*

Common name: common puffball, warted puffball, gem-studded puffball, or the devil's snuff-box,

Family: Agaricaceae

3.9.1.1 Morphology of *Lycoperdon perlatum*

Size of fructification was 10-12x4-5 cm. The color of pileus (cap) was white. The shape of cap was button shaped. The cap edge was round smooth. Fleshy white color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were absent underside of the cap but tiny gills were present underside of the cap. The color of gills was white. Color of stipe was whitish. The length and width of stipe was 0.5-1 cm and 1.5-2 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was brown, spore structure was single walled, round and crescent shaped and spore size was 8.5-9x6-7 µm.

3.9.1.2 Habitat of *Lycoperdon perlatum*

The mushroom was found on the on the root zone of Babla (*Acacia nilotica*) tree. Average relative humidity was 82%, soil pH was 5-6 and soil type was clay loam. Average recorded temperature was 29°C.

3.9.1.3 Biodiversity of *Lycoperdon perlatum*

Lycoperdon perlatum was found in Pathorghata. A total of five *Lycoperdon perlatum* were found during collection. The frequency of its presence was 6.25% and the density was 11.62%.

3.10 Morphology, Habitat and Biodiversity of *Mycena* sp.

3.10.1 *Mycena epipterygia*

Family: Mycenaceae

3.10.1.1 Morphology of *Mycena epipterygia*

Size of fructification was 12-13x3.8-4 cm. The color of pileus (cap) was white. The shape of cap was convex and umbonate shape. The cap edge was grooved and split. White color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped

gills (lamellae) were present underside of the cap. The color of gills was creamy white. Color of stipe was white to light brown. The length and width of stipe was 3.7-3.9 cm and 1.5-2 cm' respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was brown, spore shaped were single walled, smooth and ellipsoidal and spore size was 7-8 × 3-4 µm.

3.10.1.2 Habitat of *Mycena epipterygia*

The mushroom was found on the root zone of Babla (*Acacia nilotica*) tree. Forest type was mixed and leaved. Average relative humidity was 77%, soil pH was 6.5 and soil type was clay loam. Average recorded temperature was 31°C.

3.10.1.3 Biodiversity of *Mycena epipterygia*

Mycena epipterygia was found in Pathorghata and Dumki. A total of nine *Mycena epipterygia* were found during collection. The frequency of its presence was 12.5% and the density was 16.27%.

3.10.2 *Mycena cinerella*

Common name: Tropical white mushroom

Family: Mycenaceae

3.10.2.1 Morphology of *Mycena cinerella*

Size of fructification was 9-10x4.5-5 cm. The color of pileus (cap) was white. The shape of cap was oyster shaped. The cap edge was grooved white color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of gills was white to light yellow. Color of stipe was white. The length and width of stipe was 4-5 cm and 2.8-3 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was deep brown, spore shaped were single walled, smooth and oval shaped and spore size was 8-9 × 3-4 µm.

3.10.2.2 Habitat of *Mycena cinerella*

The mushroom was found on associate with Mehogoni (*Swietenia macrophylla*) tree of the forest. Average relative humidity was 84%, soil pH was 7.0 and soil type was clay loam. Average temperature was recorded 29.5 °C during collection.

3.10.2.3 Biodiversity of *Mycena cinerella*

Mycena cinerella was found in Babugonj and Pathorghata. A total of nine *Mycena cinerella* were found during collection. The frequency of its presence was 12.5% and the density was 27.90%.

3.11 Morphology, Habitat and Biodiversity of *Daldinia* sp.

3.11.1 *Daldinia concentrica*

Common name: Cramp balls

Family: Xylariaceae

3.11.1.1 Morphology of *Daldinia concentrica*

Fructification size was 4-5x1.5-2 cm. The color of pileus (cap) was pink and black color. The shape of cap was ovate. The cap edge was hard and round. Scale was not found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were not present underside of the cap. Stipe was absent. Gills were not present. Ring or anal was absent and volva was absent. Spore color was deep brown, spore shaped were single walled, smooth and round shaped and size were 5-6x3-4 µm.

3.11.1.2 Habitat of *Daldinia concentrica*

The mushroom was found on associate with Mehogoni (*Swietenia macrophylla*) tree of the forest. Average relative humidity was 77%, soil pH was 5.8 and soil type was clay loam. Average temperature was recorded 28.3 °C during collection.

3.11.1.3 Biodiversity of *Daldinia concentrica*

Daldinia concentrica was found in Barisal. A total of eight *Daldinia concentrica* were found during collection. The frequency of its presence was 6.25% and the density was 18.60%.

3.12 Morphology, Habitat and Biodiversity of *Coprinellus* sp.

3.12.1 *Coprinellus micaceus*

Common name: Mica cap, Shiny cap and Glistening inky cap.

Family: Psathyrellaceae

3.12.1.1 Morphology of *Coprinellus micaceus*

Fructification size was 6-8x3.7-4 cm. The color of pileus (cap) was fleshy and creamy. The shape of cap was umbonate. The cap edge was grooved. Fleshy and creamy scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was white. The length and width of stipe was 6-7 cm and 0.5-0.8 cm, respectively. Gills were present and color of gills are brown to white. Ring or anal was absent on the upper part of the stipe and volva was absent on the lower part of the stipe. Spore color was deep brown, spore shaped were single walled, and smooth and oval shaped spore size was 11-12 × 8-9 µm.

3.12.1.2 Habitat of *Coprinellus micaceus*

The mushroom was found on associate with Mehogoni (*Swietenia macrophylla*) tree of the forest. Average relative humidity was 73%, soil pH was 7.0 and soil type was clay loam. Average temperature was recorded 29°C during collection.

3.12.1.3 Biodiversity of *Coprinellus micaceus*

Coprinellus micaceus was found in Barisal and Pathorghata. A total of four *Coprinellus micaceus* were found during collection. The frequency of its presence was 12.5% and the density was 39.53%.

3.13 Morphology, Habitat and Biodiversity of *Macrolepiota* sp.

3.13.1 *Macrolepiota procera*

Common name: Parasol mushroom

Family: Lepiotaceae

3.13.1.1 Morphology of *Macrolepiota procera*

Size of fructification was 13-15x4-5 cm. The color of pileus (cap) was white and tip portion is pink. The shape of cap was convex and umbonate shaped. The cap edge was round smooth. Fleshy white color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were present underside of the cap. The color of gills was white. Color of stipe was whitish. The length and width of stipe was 6-7 cm and 1-2 cm, respectively. Ring or anal was present on the stipe and volva was absent on the lower part of the stipe. Spore color was brown, structure was single walled,

smooth, oval shaped and size of spore was 7.5-8×5-6 µm.

3.13.1.2 Habitat of *Macrolepiota procera*

The mushroom was found on the on the root zone of Mehogoni (*Swietenia macrophylla*). Forest type was mixed. Average relative humidity was 79%, soil pH was 5.5-6 and soil type was clay loam. Average recorded temperature was 27°C.

3.13.1.3 Biodiversity of *Macrolepiota procera*

Macrolepiota procera was found in Barisal, Jhalokhathi. A total of nine *Macrolepiota procera* were found during collection. The frequency of its presence was 12.5% and the density was 20.93%.

3.14 Morphology, Habitat and Biodiversity of *Volvariella* sp.

3.14.1 *Volvariella gloiocephala*

Common name: Big sheath mushroom

Family: Pluteaceae

3.14.1.1 Morphology of *Volvariella gloiocephala*

Size of fructification was 12-13x5-6 cm. The color of pileus (cap) was ash color. The shape of cap was convex and flat. The cap edge was grooved. Ash color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was ash color. The length and width of stipe was 9-10 cm and 2.5-3 cm, respectively. Gills were present and color of gills are creamy color. ring or anal was absent on the upper part of stipe and volva was absent on the lower part of stipe. Spore color was brown, spore shaped were single walled, smooth and ellipsoidal and spore size was 7-8 × 3-4 µm.

3.14.1.2 Habitat of *Volvariella gloiocephala*

The mushroom was found on the on the root zone of Coconut (*Cocos nucifera*) tree. Average relative humidity was 80%, soil pH was 6.2 and soil type was clay. Average recorded temperature was 28°C.

3.14.1.3 Biodiversity of *Volvariella gloiocephala*

Volvariella gloiocephala was found in Pathorghata and Patuakhali. A total of seven

Volvariella gloiocephala were found during collection. The frequency of its presence was 12.5% and the density was 16.27%.

3.14.2 *Volvariella volvacea*

Common name: Paddy straw mushroom

Family: Pluteaceae

3.14.2.1 Morphology of *Volvariella volvacea*

Size of fructification was 12-13x5-6 cm. The color of pileus (cap) was ash color. The shape of cap was convex and flat. The cap edge was grooved. Ash color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was white color. The length and width of stipe was 9-10 cm and 2.5-3 cm, respectively. Gills were present and color of gills are creamy color. ring or anal was absent on the upper part of stipe and volva was present on the lower part of stipe. Spore color was brown, spore shaped were single walled, smooth and ellipsoidal and spore size was 7.5-8 × 3.5-4 µm.

3.14.2.2 Habitat of *Volvariella volvacea*

The mushroom was found on the on humus. Average relative humidity was 78%, soil pH was 6.2-6.5 and soil type was clay. Average recorded temperature was 27°C.

3.14.2.3 Biodiversity of *Volvariella volvacea*

Volvariella volvacea was found in Pirojpur and Patuakhali. A total of 13 *Volvariella volvacea* were found during collection. The frequency of its presence was 12.5% and the density was 30.23%.

3.14.3 *Volvariella hypopithys*

Family: Pluteaceae

3.14.3.1 Morphology of *Volvariella hypopithys*

Size of fructification was 12-14x4-5 cm. The color of pileus (cap) was white color. The shape of cap was convex and flat. The cap edge was grooved. White color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was white color. The length and width of stipe was 6-7 cm and 2.5-3 cm, respectively. Gills were present and color of

gills are creamy color. ring or anal was absent on the upper part of stipe and volva was present on the lower part of stipe. Spore color was brown, spore shaped were single walled, smooth and rounded and spore size was $8-9 \times 5-6 \mu\text{m}$.

3.14.3.2 Habitat of *Volvariella hypopithys*

The mushroom was found on the on the root zone of Mehogoni (*Swietenia macrophylla*). Average relative humidity was 85%, soil pH was 6.2 and soil type was clay. Average recorded temperature was 28°C.

3.14.3.3 Biodiversity of *Volvariella hypopithys*

Volvariella hypopithys was found in Pirojpur. A total of 5 *Volvariella hypopithys* were found during collection. The frequency of its presence was 6.25% and the density was 11.62%.

3.14.4 *Volvariella speciosa*

Common name: Big sheath mushroom, rose-gilled grisette, or stubble rosegill.

Family: Pluteaceae

3.14.4.1 Morphology of *Volvariella speciosa*

Size of fructification was 12-14x4-5 cm. The color of pileus (cap) was white color. The shape of cap was convex and flat. The cap edge was grooved. White color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was white color. The length and width of stipe was 6-7 cm and 2.5-3 cm, respectively. Gills were present and color of gills are creamy color. Ring or anal was absent on the upper part of stipe and volva was present on the lower part of stipe. Spore color was brown, spore shaped were single walled, smooth and ellipsoidal and spore size was $8.5-9 \times 3.5-4 \mu\text{m}$.

3.14.4.2 Habitat of *Volvariella speciosa*

The mushroom was found on the on the root zone of Mehogoni (*Swietenia macrophylla*) tree. Average relative humidity was 81%, soil pH was 6.2-6.5 and soil type was clay. Average recorded temperature was 26.8°C.

3.14.4.3 Biodiversity of *Volvariella speciosa*

Volvariella speciosa was found in Pirojpur. A total of 3 *Volvariella speciosa* were found during

collection. The frequency of its presence was 6.25% and the density was 9.30%.

3.15 Morphology, Habitat and Biodiversity of *Steccherinum* sp.

3.15.1 *Steccherinum ochraceum*

Common name: Ochre spreading tooth

Family: Phanerochaetaceae

3.15.1.1 Morphology of *Steccherinum ochraceum*

Size of fructification was 12-14x4-5 cm. The color of pileus (cap) was yellow color. The shape of cap was flat. The cap edge was grooved. Yellow color scale was found on the cap. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was white color. The length and width of stipe was 2-3 cm and 0.5-1cm, respectively. Gills were present and color of gills are creamy color. Ring or anal was absent on the upper part of stipe and volva was absent on the lower part of stipe. Spore color was brown, spore shaped were single walled, smooth and oval and spore size was $6-7 \times 3-4 \mu\text{m}$.

3.15.1.2 Habitat of *Steccherinum ochraceum*

The mushroom was found on the on the root zone of Koroi (*Albizia richardiana*). Average relative humidity was 70%, soil pH was 6-7 and soil type was clay. Average recorded temperature was 26.4°C.

3.15.1.3 Biodiversity of *Steccherinum ochraceum*

Steccherinum ochraceum was found in Barisal. A total of 6 *Steccherinum ochraceum* were found during collection. The frequency of its presence was 6.25% and the density was 13.95%.

3.16 Morphology, Habitat and Biodiversity of *Coprinus* sp.

3.16.1 *Coprinus silvaticus*

Common name: Erdeitintagomba

Family: Agaricaceae

3.16.1.1 Morphology of *Coprinus silvaticus*

Size of fructification was 4-5x2.5 cm. The color of pileus (cap) was ash color. The shape of cap

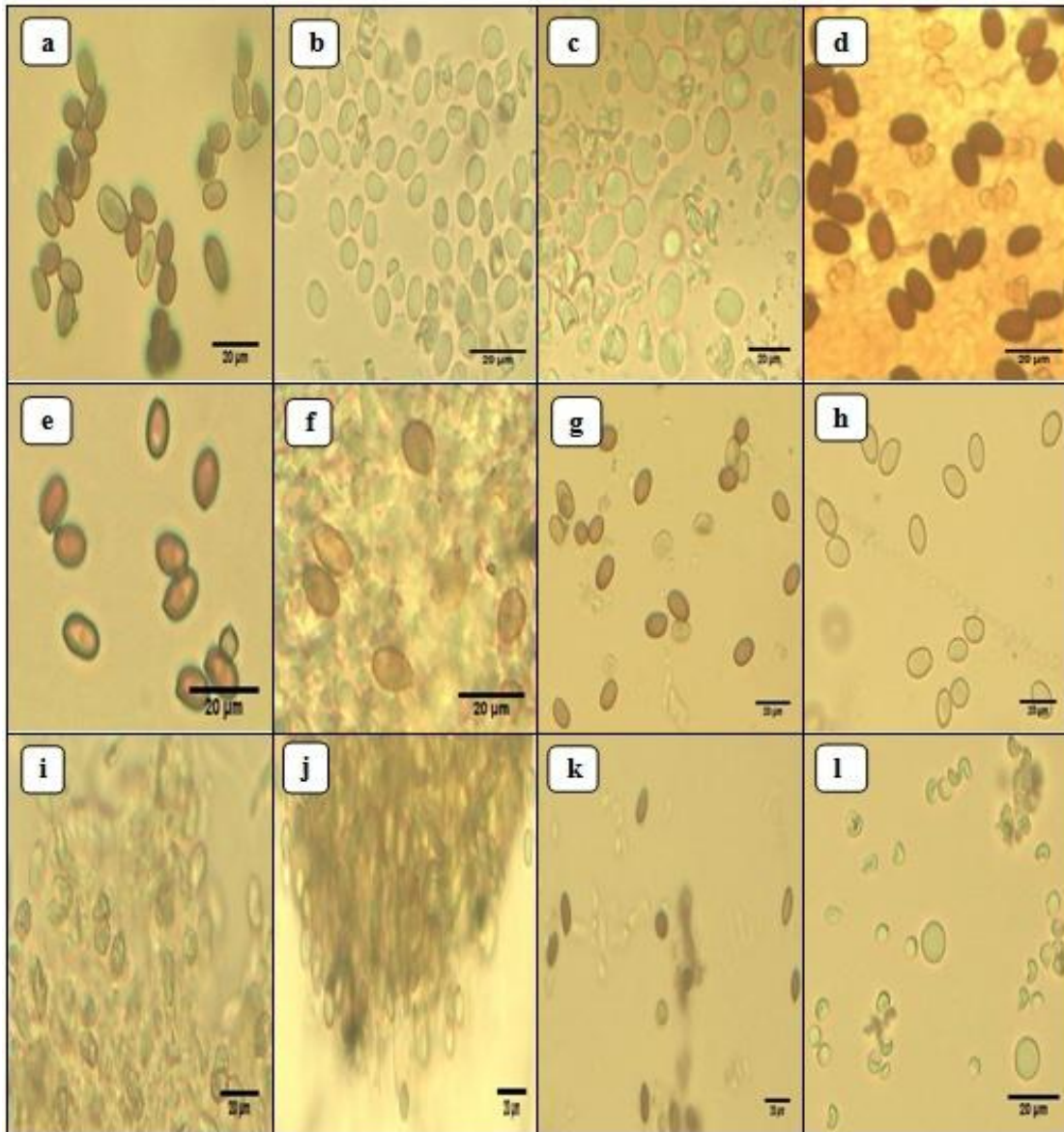


Fig. 7. Spores of the collected mushrooms; a. *Amanita brunnescens*; b. *Amanita griseoverrucosa*; c. *Amanita vaginata*; d. *Agaricus silvicola*; e. *Agaricus campestris*; f. *Ganoderma applanatum*; g. *Armillaria mellea*; h. *Cortinarius corrugates*; i. *Hebeloma crustuliniforme*; j. *Tuber aestivum*; k. *Lepiota americana*; l. *Lycoperdon perlatum*

was convex and flat. The cap edge was grooved. White color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped gills (lamellae) were present underside of the cap. The color of stipe was white color. The length and width of stipe was 3-4 cm and 0.5-1 cm, respectively. Gills were present and color of gills are brown color. ring or anal was absent on the upper part of stipe and volva was present on the lower part of stipe. Spore color was deep

brown, spore shaped were single walled, smooth and ellipsoidal and spore size was $7-8 \times 3-4 \mu\text{m}$.

3.16.1.2 Habitat of *Coprinus silvaticus*

The mushroom was found on the on the root zone of Mehogoni (*Swietenia macrophylla*). Average relative humidity was 74%, soil pH was 6.2 and soil type was clay. Average recorded temperature was 29°C.

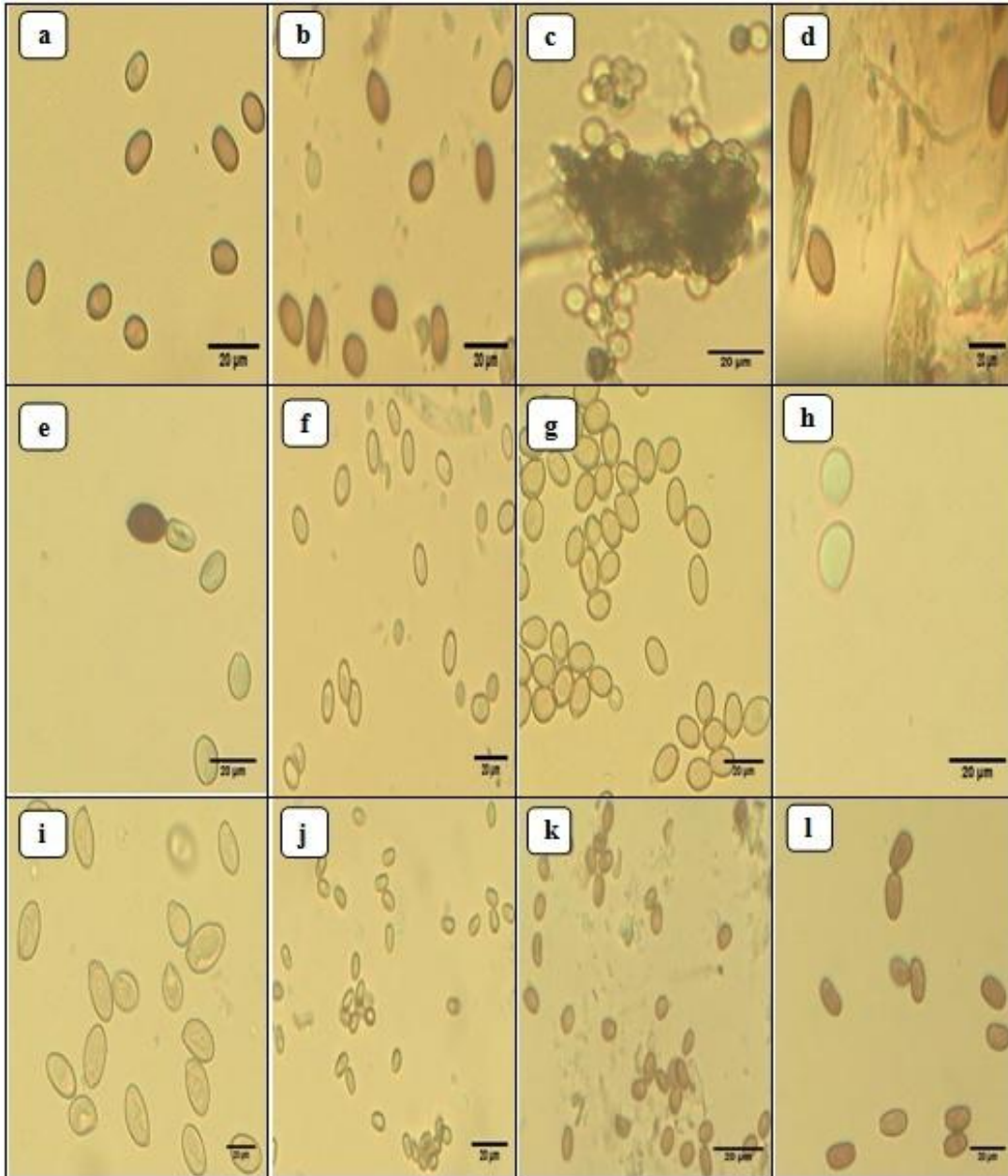


Fig. 8. Spores of the collected mushrooms; a. *Mycena epipterygia*; b. *Mycena cinerella*; c. *Daldinia concentrica*; d. *Coprinellus micaceus*; e. *Macrolepiota procera*; f. *Volvariella gloiocephala*; g. *Volvariella volvacea*; h. *Volvariella hypopithys*; i. *Volvariella speciosa*; j. *Steccherinum ochraceum*; k. *Coprinus silvaticus*; l. *Hypholoma fasciculare*

3.16.1.3 Biodiversity of *Coprinus silvaticus*

Coprinus silvaticus was found in Barisal. A total of 21 *Coprinus silvaticus* were found during collection. The frequency of its presence was 6.25% and the density was 48.83%.

3.17 Morphology, Habitat and Biodiversity of *Hypholoma* sp.

3.17.1 *Hypholoma fasciculare*

Common name: The sulphur tuft, sulfur tuft or clustered woodlover

Family: Strophariaceae

3.17.1.1 Morphology of *Hypholoma fasciculare*

Size of fructification was 9-11x4-6 cm. The color of pileus (cap) was brown. The shape of cap was convex and umbonate shape. The cap edge was grooved and split. Brown color scale was found on the cap. Beneath the cap hymenophores were absent. Regular shaped gills (lamellae) were present underside of the cap. The color of gills was brown. Color of stipe was white. The length and width of stipe was 4-5 cm and 0.5-1 cm, respectively. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe. Spore color was brown, spore shaped were single walled, smooth and elongated and spore size was 6-7 × 3-4 μm.

3.17.1.2 Habitat of *Hypholoma fasciculare*

The mushroom was found on the Mehogoni (*Swietenia macrophylla*) tree. Average relative humidity was 78%, soil pH was 6 to 6.5 and soil type was clay loam. Average recorded temperature was 31°C.

3.17.1.3 Biodiversity of *Hypholoma fasciculare*

Hypholoma fasciculare was found in Pirojpur. A total of 12 *Hypholoma fasciculare* were found during collection. The frequency of its presence was 6.25% and the density was 27.90%.

4. DISCUSSION

A detailed survey was carried out in 16 Sub-districts of 5 districts named, Barisal, Patuakhali, Borguna, Pirojpur and Jhalokhathi of southern region in Bangladesh from July to October, 2013 and 2014, accordingly to record the morphological variability, distribution, habitat, and biodiversity of the mushrooms population.

Three species of *Amanita* were recorded, viz. *Amanita brunnescens*, *Amanita griseoverrucosa* and *Amanita vaginata*. *Amanita brunnescens* was found 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. Mycorrhizal with various hardwoods and conifers; growing alone, scattered, or gregariously; summer and fall; widely distributed and common east of the Rocky Mountains [21]. Furthermore, *Amanita griseoverrucosa* was found in Pirojpur and Barisal districts with a frequency and density of

12.5% and 6.97%, respectively, which associated with Coconut (*Cocos nucifera*) tree. Also found in forest of northern Thailand [22]. *Amanita vaginata* was also found in Pirojpur, Barisal and Jhalokhathi with an association of Coconut (*Cocos nucifera*) tree. The frequency was 18.75%, whereas the density was 4.65%. All the species of *Amanita* described in this study was new record of southern region of Bangladesh where *Amanita cinereovelata* was first identified from sal forest of Bangladesh [23]. The same species was also reported in Switzerland [24], California [25,26] and North America [27]. This genus was also reported from Bangladesh [28] and India [29].

Two species of *Agaricus* were also identified, viz *Agaricus silvicola* and *Agaricus campestris*. *Agaricus silvicola* was found in Sadar, Babugonj and Nolchity sub-districts of Patuakhali, Barisal and Jhalokhathi districts in the southern region with a frequency and density of 18.75% and 11.62%, accordingly in an association with *Swietenia macrophylla* tree. Furthermore, *Agaricus campestris* was found in Golachipa and Bamna sub-districts of Patuakhali and Barguna districts with a frequency and density of 12.5% and 6.97%, respectively in an association with *Dalbergia sissoo* tree. The genus *Agaricus* sp. was also reported from India [30,8,4] and south western region of Bangladesh [31].

On the other hand, *Ganoderma applanatum* was also found in Babugonj, which is situated in Barisal district in southern region of Bangladesh, with the frequency and density of 18.75% and 34.88%, accordingly. Same species was also found in Pathorghata and Dumki sub-districts of Borguna and Patuakhali districts in southern region of Bangladesh. This species was reported by Rumainul *et al.* at the tropical moist deciduous forest of Bangladesh [28]. It was also reported in China [32] and in India [29,8,4].

Armillaria mellea was found in Ujirpur and Rajapur of Barisal and Jhalokhathi districts with a frequency and density of 12.5% and 30.23%, respectively in an association with *Cocos nucifera* tree. This species was also reported from Bangladesh in tropical moist deciduous forest and it was recorded in an association with *Swietenia macrophylla* and *Leucaena leucocephala* tree [28,33]. *Armillaria mellea* was also found in India [4].

Cortinarius corrugates was found in Sadar and Pathorghata sub-districts of Patuakhali and

Barguna districts in southern region of Bangladesh with a frequency and density of 12.5% and 16.7%, accordingly. *Cortinarius* sp. was also found in North America and Europe [34].

Hebeloma crustuliniforme was found in Pathorghata and Nolchity sub-districts of Barguna and Jhalokhathi districts with a frequency and density of 12.5% and 20.93%, respectively. In this survey, the species was associated with *Areca catechu*, whereas, these species was also reported in an association with Bambuseae tree in the tropical moist deciduous forest of Bangladesh [28]. *Hebeloma* sp. was also reported in the western United States [35].

Tuber aestivum was found in Babugonj of Barisal district in southern region of Bangladesh, with a frequency and density of 6.25% and 4.6%, accordingly. This species was also reported from Bangladesh at tropical moist deciduous forest in Dhaka, which was associated with *Dahlia* sp. [28, 33]. In the present survey, this species was associated with *Swietenia macrophylla*. *Tuber* sp. was also found in almost all over the European countries [36].

Lepiota americana was found in Bakergonj and Rajapur sub-districts of Barisal and Jhalokhathi districts with a frequency and density of 12.5% and 30.23%, respectively. This species was also reported from Bangladesh in tropical moist deciduous forest, associated with *Mangifera indica* tree [28]. In this present study, *Lepiota americana* was associated with *Areca catechu*. Around 400 species were already identified all over the world and most of them are poisonous. The species was first reported by South African mycologist named, Christian Hendrik Persoon in 1797 [37]. It was also reported in India [29,8]. The genus *Lepiota* sp. was also reported from south western region of Bangladesh [31].

Lycoperdon perlatum was found in Pathorghata of Borguna district in southern region of Bangladesh, with a frequency and density of 6.25% and 11.62%, accordingly. It was associated with *Acacia nilotica* tree. The same species was also reported from Bangladesh in tropical moist deciduous forest in an association with the stem of *Bambuseae* tree [28]. It was also found in almost all over the world [38]. It has been also reported from Africa [39], China [40], Himalayas [41], Japan [42], southern India [43], Australia [44], Europe [45], New Zealand [46], and Brazil [47], as well. Furthermore, it has been

collected from subarctic areas of Greenland and subalpine regions of Iceland [48]. In North America, where it is considered as the most common puffball species and it ranges from Alaska [49] to Mexico [50]. Although, it is less common in Central America [51]. This species is popular on postage stamps and has been depicted on stamps from Guinea, Paraguay, Romania and Sweden [52].

Mycena epipterygia was found in Sadar and Bamna sub-districts of Patuakhali and Borguna districts with a frequency and density of 12.5% and 16.27%, respectively, in an association with *Acacia nilotica*. It grows gregariously from the well decayed deadwood of conifers [21]. On the other hand, *Mycena cinerella* was found in Sadar and Rajapur sub-districts of Pirojpur and Jhalokhathi districts in southern region of Bangladesh with a frequency and density of 12.5% and 27.90%, accordingly, in an association with *Mehogoni (Swietenia macrophylla)*. The same species was also reported by Emmett [53]. This genus was also reported from Bangladesh [28,31].

Daldinia concentrica was found in Babugonj sub-district of Barisal district in southern region of Bangladesh with a frequency and density of 6.25% and 18.60%, accordingly, in an association with *Swietenia macrophylla* tree. This species was also found in Navsari, south Gujarat, India [2].

Coprinellus micaceus was found in Babugonj, Pathorghata sub-districts of Barisal and Borguna districts in southern region of Bangladesh with a frequency and density of 12.5% and 39.53%, respectively, in an association with *Swietenia macrophylla* tree. In one instance it was discovered about 120 m (400 ft) underground in an abandoned coal mine, growing on wooden gangways and props used to support the roof [54]. This species was also reported from south western region of Bangladesh [31].

Macrolepiota procera was found in Ujirpur and Sadar sub-districts of Barisal and Jhalokhathi districts in the southern region of Bangladesh with a frequency and density of 12.5% and 20.93%, respectively and found associated with *Swietenia macrophylla* tree. The same species was also reported by Romainul et al. from Bangladesh [28].

Furthermore, the 4 species of *Volvariella* sp. were recorded, viz. *Volvariella gloiocephala*,

Volvariella volvacea, *Volvariella hypopithys* and *Volvariella speciosa*. *Volvariella gloiocephala* was found in Pathorghata and Dumki sub-districts of Borguna and Patuakhali districts with a frequency and density of 12.5% and 16.27%, accordingly, in an association with *Cocos nucifera* tree, whereas, *Volvariella volvacea* was found in Bhandaria and Dumki sub-districts of Pirojpur and Patuakhali districts with a frequency and density of 12.5% and 30.23%, respectively. This species was reported from Bangladesh [28]. On the other hand, *Volvariella hypopithys* was found in Bhandaria of Pirojpur district in the southern region of Bangladesh with a frequency and density of 6.25% and 11.62%, accordingly, in an association with *Swietenia macrophylla*. The same species was also reported from Bangladesh [28], whereas, *Volvariella speciosa* was found in Bhandaria of Pirojpur district in the southern region of Bangladesh with a frequency and density of 6.25% and 9.30%, respectively. This species was found in an association with *Swietenia macrophylla* tree. This genus was also reported from Bangladesh at tropical moist deciduous forest in Dhaka [28] as well as in the south western region of Bangladesh [31] and in India [8].

Steccherinum ochraceum was found in Babugonj of Barisal district in the southern region of Bangladesh with a frequency and density of 6.25% and 13.95%, accordingly, in an association with *Albizia richardiana*. It's widely distributed in North America, but more common east of the Rocky Mountains [21].

Coprinus silvaticus was found in Sadar of Barisal district in the southern region of Bangladesh with a frequency and density of 6.25% and 48.83%, respectively, in an association with *Swietenia macrophylla* tree. It has also been noted for growing indoors on rotting wood in humid environments [21]. The genus *Coprinus* sp. was also reported from south western region of Bangladesh [31].

Hypholoma fasciculeare was found in Sadar of Pirojpur district in the southern region of Bangladesh with a frequency and density of 6.25% and 27.90%, accordingly, in an association with *Swietenia macrophylla* tree. *Hypholoma fasciculare* grows prolifically on the dead wood of both deciduous and coniferous trees. It is more commonly found on decaying deciduous wood due to the lower lignin content of this wood relative to coniferous wood. *Hypholoma fasciculare* is widespread and

abundant in northern Europe and North America. It has been recorded from Iran [55] and also eastern Anatolia in Turkey [56]. It can appear anytime from spring to autumn [57]. This species was also reported from south western region of Bangladesh [31].

5. CONCLUSION

The survey was conducted in 16 Sub-districts of Barisal, Patuakhali, Borguna, Pirojpur and Jhalokhathi districts in the southern region of Bangladesh. In the survey, 24 species of mushrooms belonging to 17 genera and 14 families were collected and identified. The identified 4 species of *Volvariella* were *Volvariella gloiocephala*, *Volvariella volvacea*, *Volvariella hypopithys* and *Volvariella speciosa*, whereas, the 3 species of *Amanita* were *Amanita brunnescens*, *Amanita griseoverrucosa* and *Amanita vaginata*. Furthermore, 2 species of *Agaricus*, viz *Agaricus silvicola* and *Agaricus campestris*, as well as 2 species of *Mycena*, viz *Mycena epipterygia* and *Mycena cinerella* were identified. On the other hand, 1 species of each of *Ganoderma applanatum*, *Armillaria mellea*, *Cortinarius corrugates*, *Hebeloma crustuliniforme*, *Tuber aestivum*, *Lepiota americana*, *Lycoperdon perlatum*, *Daldinia concentrica*, *Coprinellus micaceus*, *Macrolepiota procera*, *Steccherinum ochraceum*, *Coprinus silvaticus* and *Hypholoma fasciculare* were collected and identified. The highest frequency of occurrence (18.75%) was found for *Ganoderma applanatum*, *Amanita vaginata* and *Agaricus silvicola*, followed by 12.5% for *Armillaria mellea* and *Hebeloma crustuliniforme*, whereas, the lowest frequency was 6.25% for rest of the species. The highest density was 48.83% recorded for *Coprinus silvaticus* followed by 39.53% for *Coprinellus micaceus* and the lowest density was 4.6% for *Tuber aestivum*. Among the total 24 species, highest 4 species were recorded under Pluteaceae family, 3 species under Agaricaceae family, 3 species under Amanitaceae and another 2 species were found under Mycenaceae family. The survey proves that, the southern region of Bangladesh has distinct biodiversity of mushroom population.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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