



Macro Fungi Biodiversity at the Central and Northern Biosphere Reserved Areas of Tropical Moist Deciduous Forest Region of Bangladesh

M. I. Romainul¹ and F. M. Aminuzzaman^{1*}

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 between both authors. Author MIR wrote the protocol, carried out the research and wrote the first draft of the manuscript. Author FMA designed and supervised the study also edited the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Mushrooms are considered as macro fungi as well as seasonal fungi, which occupy diverse niches in natural forest ecosystem. It appears predominantly during rainy season, if temperature and moisture become favorable in that ecosystem. Investigation of diversity of macro fungi is gaining importance because of the disappearance due to the threat of habitat destruction. This investigation deals with the biodiversity of macro fungi at Dhaka, Gazipur, Bogra, Rajshahi, Pabna, Jaipurhat and Dinajpur district of central and northern region of Bangladesh, where 50 samples were collected, morphologically characterized, photographed and preserved. They were identified to 8 genera and 9 species. The predominant genera were *Trametes*, *Daedaleopsis*, *Collybia* and *Armillaria*. This preliminary investigation suggested that, the central and northern region of Bangladesh under tropical moist deciduous forest region is enriched with diversity of wild mushrooms.

*Corresponding author: Email: aminsaupp@yahoo.com;

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1. INTRODUCTION

Mushroom is typically above ground producing fleshy spore bearing fruiting body of a fungus. Some of them are edible along with high nutritive value. Wild types of edible mushroom have been consumed by human being from thousands of years. Though its nutritive value is still untapped, edible species of mushroom are associated with people living 13,000 years ago in Chile, according to the geological records [1]. Nowadays, some mushrooms are also considered as a source of diet in human health and fetch income in Bangladesh, due to the increasing demand of consumption of mushroom as food and medicine.

Bangladesh is a South Asian country with very low proportion of forests. The total 10.2% of the land area in Bangladesh are covered by forest, which amounts approximately 1.3 million hectares [2]. The government forests area are situated within 12 districts in eastern and south-eastern part of the country, which covers more than 90% [3]. Only 4.65% of forested area are situated in the central and north-western part of the country, which covering 0.12 million ha [4]. These forests area are classified as tropical moist deciduous forest region of Bangladesh [5]. The texture of this forest's soil is generally sandy loam as well as silty loam. The surface soil of this forest area are consisting of organic matters, which ranges from low (<1.5% under grassland) to moderate (2-5% under forest cover) and acidic in nature (pH5.2 -5.5), as well [6]. In the northern part, the mean annual rainfall increases more than 2,300 mm, whereas the mean annual temperature is 26.3°C. The average maximum and minimum temperatures are approximately 27.5°C and 18.5°C, accordingly [7].

Mushrooms are typically found in waste lands, where generally absence of artificial activities of any human-being such as, forest lands, field lands or, on the moist branches of trees. Throughout this investigation, we tried to represent the existing biodiversity of mushroom in this forest region. Bangladesh has basic four types of forest, among them this investigation was conducted in Dhaka, Gazipur, Bogra, Rajshahi, Pabna, Jaipurhat, and Dinajpur, which are situated in the tropical moist deciduous forest region of Bangladesh. Due to the wide variation

in climates, soils and plant communities, the tropical moist deciduous forest region of Bangladesh has within its boundaries is one of the greatest diversity of mushrooms. Several types of mushroom are grown abundantly in this forest region during and after the rainy season. Therefore, the aim of this initial investigation is to promote knowledge about the available common type of wild mushroom of the central and northern forest area of Bangladesh belongs to tropical moist deciduous forest region. This article represents as part of continuing investigations describing some newly reported mushrooms from the central and northern biosphere reserved areas of tropical moist deciduous forest region of Bangladesh.

2. MATERIALS AND METHODS

2.1 Survey Area

The survey area was Dhaka, Gazipur, Bogra, Rajshahi, Pabna, Jaipurhat and Dinajpur of central and northern biosphere reserved areas of tropical moist deciduous forest region of Bangladesh (Fig. 1). Survey was conducted during the end of rainy season starting from July to October, 2013 and 2014 respectively. According to the Bangladesh Meteorological Department, Dhaka is located at 23°42'37" N (Latitude), 90°24'26" E (Longitude) and it has an average elevation of 4 meters (13.12 ft.). Gazipur is located at 24.00°N (Latitude), 90.43°E (Longitude) and it has an average elevation of 10 meters (32.8 ft.). Bogra is located at 24°51'00" N (Latitude), 89°22'00" E (Longitude) and it has an average elevation of 24 meters (78 ft.). Rajshahi is located at 24°22'00" N (Latitude), 88°36'00" E (Longitude) and it has an average elevation of 31 meters (101 ft.). Pabna is located at 24°00'00" N (Latitude), 89°15'00" E (Longitude) and it has an average elevation of 8 meters (26 ft.). Jaipurhat is located at 25.1° N (Latitude), 89.02° E (Longitude) and it has an average elevation of 29 meters (94.25 ft.). Dinajpur is located at 25°37'37" N (Latitude), 88°38'19" E (Longitude) and it has an average elevation of 34 meters (111 ft.). University campus, residential area, botanical garden, parks, forest and nearby villages of those above mentioned areas of tropical moist deciduous forest region were selected as collection area.

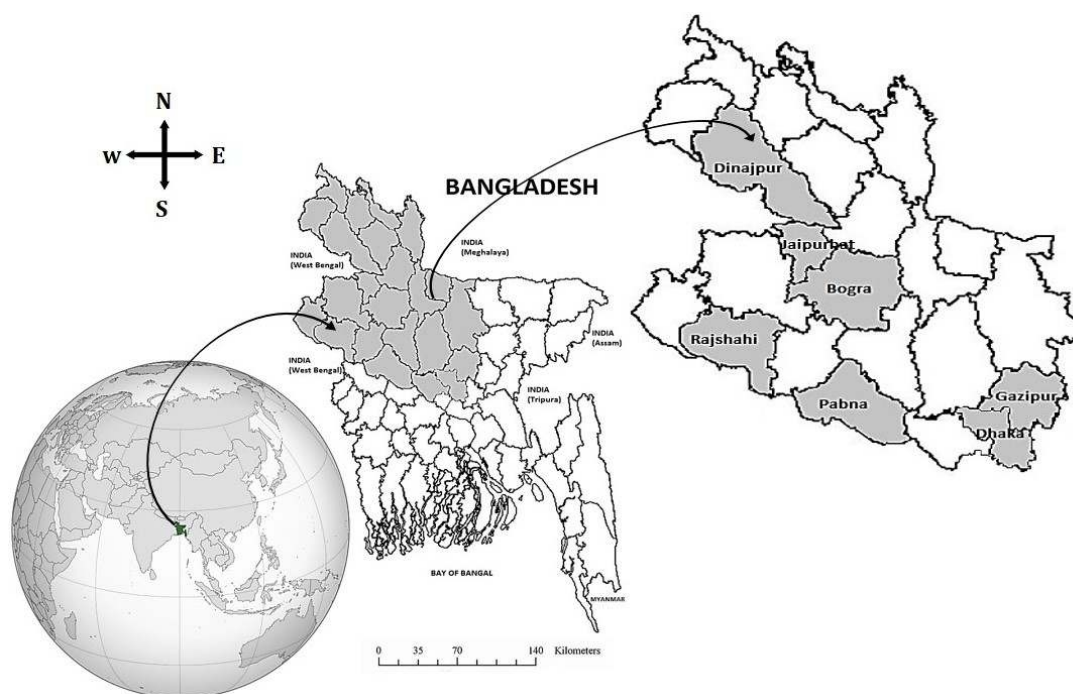


Fig. 1. Central and northern biosphere reserved areas of tropical moist deciduous forest region of Bangladesh

2.2 Collection of Mushrooms

Collection was conducted following the method of Hailing [8]. Survey of different locations was done systematically at different area in the central and northern part of tropical moist deciduous forest region of Bangladesh during July to October, 2013 and 2014, respectively. Required equipment was carried out while collection, such as isolation kit, slants, isolation chamber, data recording sheet, digital camera for photograph, digging tools, heat convector card board. During day time, collection of specimens were usually done, while a field characteristics of mushrooms were recorded in the data sheet, which was also prepared by following Molina et al. [9]. After that, the specimens were dried in hot air oven at 40°C to 50°C and stored in air tight containers with desiccators like, silica gel for future microscopic studies. A detailed study was conducted into the laboratory. Photographs were taken through using Sony Cyber-Shot Camera with the magnification of 14.2 megapixels.

2.3 Identification of Collected Mushrooms

The collected mushroom samples were identified on their morphological, macroscopic,

physiological and ecological features according to the previously published documents by Arora, Singer [10-12]. The morphological parameters used for identification of mushrooms specimens were cap color, cap surface, cap margin, cap diameter, stipe length, gill attachment, gill spacing and spore diameter [1]. The spore diameter and the photograph of spores were calculated using the Motic microscope (Motic Images Plus 2.0) with the magnification of 40x. One mature and one immature (growing) mushroom were sampled for each collection to record accurate information. Through comparing recorded characteristics the mushrooms were identified following Dickinson and John, Jorden, Pegler and Spooner [13-15].

3. RESULTS

Through the investigation, 8 genera and 9 species of mushroom were identified [Figs. 2 & 3]. The identified genera were *Trametes*, *Daedaleopsis*, *Pycnoporus*, *Boletus*, *Tuber*, *Collybia*, *Panaeolus* and *Armillaria*. The details about the identified mushrooms through this investigation on that particular time in the tropical moist deciduous forest region (central and northern biosphere reserved areas) of Bangladesh were described below:

3.1 Genus: *Trametes*

3.1.1 *Trametes versicolor*

Family: Polyporaceae

Common name: Polypore or Bracket mushroom

Color: Young: Dark violate along with white border; Mature: Dark violate along with white border

Length: Mature: 8.2 cm; Young: 4.8 cm

Width: Mature: 5.4 cm; Young: 3.8 cm

Spore bearing surface under cap: Pores on hymenium

Spore diameter (Average): Length: 8.62 μm ; Width: 5.6 μm

Pileus: Color: Creamy; Surface character: Dry in nature; Margin: Regular in shape; Cuticle: Not peeling

Texture of the fruiting body: Brittle and woody

Flesh odor: Fragrant and disagreeable

Pores color: White

Ecological features: Locality found: Dinajpur; Nature: Saprotrophic; Habitat: On the bark wood of the tree, in closely associated with Royal siris (*Albizia procera*) tree; Habit: Solitary and somewhat are caespitose cluster; Type of association: Stem associated; Forest type: Leveled; Constancy of occurrence in specific habitat: Abundant; Type of soil: Loamy soil in nature; Factors affecting their distribution: Moist weather around the habitat.

3.2 Genus: *Daedaleopsis*

3.2.1 *Daedaleopsis confragosa*

Family: Polyporaceae

Common name: Blushing bracket

Color: Young: Whitish to creamy in circle; Mature: Whitish to creamy in circle and somewhat pinkish circle around the border

Length: Mature: 4.1 cm to 5.4 cm; Young: 1.4 cm to 1.5 cm;

Width: Mature: 6.4 cm to 8 cm; Young: 3 cm to 3.8 cm

Spore bearing surface under cap: Teeth in very young stage

Spore diameter (Average): Length: 6.88 μm ; Width: 6.44 μm

Pileus: Color: Pinkish; Surface character: Leathery and dry in nature; Margin: Regular in shape; Cuticle: Not peeling

Texture of the fruiting body: Brittle, tough, leathery and woody

Flesh odor: Fragrant

Firmness: Very hard

Ecological features: Locality found: Botanical garden, Mirpur, Dhaka; Habitat: On bark wood of the tree, in an association near the Ipil-Ipil (*Leucaena leucocephala*) tree; Habit: Solitary and somewhat are caespitose cluster; Type of association: Trunk associated; Forest type: Leveled; Constancy of occurrence in specific habitat: Abundant; Type of soil: Loamy soil in nature; Factors affecting their distribution: Literally more moist weather around the habitat.

3.2.2 *Daedaleopsis confragosa* var. *tricolor*

Family: Polyporaceae

Common name: Blushing Bracket

Color: Young: Dark red; Mature: Dark red

Length (Mature): 8.5 cm

Width (Mature): 12.3 cm

Spore bearing surface under cap: Teeth (beginning stage)

Spore diameter (Average): Length: 4.84 μm ; Width: 4.06 μm

Cap of the carpophore: Size: 8.5 cm x 12.3 cm; Shape: Umbilicate

Pileus: Color: Pinkish; Surface character: Leathery and moist in nature; Margin: Regular in shape; Cuticle: Not peeling

Texture of the fruiting body: Brittle, tough, leathery and woody

Flesh odor: Fragrant

Firmness: Solid and very hard

Ecological features: Locality found: Botanical garden, Mirpur, Dhaka; Nature: Saprotrophic; Habitat: On bark wood of the tree, in an association near the Ipil-Ipil (*Leucaena leucocephala*) and Golden shower (*Acacia auriculiformis*); Habit: Caespitose cluster; Type of association: Root associated; Forest type: Mixed; Constancy of occurrence in specific habitat: Abundant; Type of soil: Loamy soil in nature; Factors affecting their distribution: More moist weather around the habitat.

3.3 Genus: *Pycnoporus*

3.3.1 *Pycnoporus cinnabarinus*

Family: Polyporaceae

Common name: Cinnabar Red Polypore

Color: Young: Orange-Red; Mature: Orange-Red

Length: Mature: 4.2 cm; Young: 3.1 cm

Breadth: Mature: 2.5 cm; Young: 1.8 cm

Width: Mature: 0.8 cm to 9 cm

Spore bearing surface under cap: Pores

Spore diameter (Average): Length: 3.75 μm ; Width: 2.48 μm

Cap of the carpophore: Shape: Flat
Pileus: Color: Orange-red; Surface character: Smooth, Silky, somewhat dry in nature; Margin: Incurved in shape; Cuticle: Not peeling
Texture of the fruiting body: Woody
Flesh odor: Fragrant
Firmness: Solid
Ecological features: Locality found: Bogra; Nature: Parasitic; Habitat: On humus, in an association with the stem of Bamboo (*Bambuseae*) tree; Habit: Scattered; Type of association: Closely associated; Forest type: Leveled; Constancy of occurrence in specific habitat: Un-abundant; Factors affecting their distribution: Less moist or moderately dry weather around the habitat

3.4 Genus: *Boletus*

3.4.1 *Boletus amygdalinus*

Family: Boletaceae
Common name: Summer bolete
Color: Young: Yellowish with brown shades; Mature: Yellow
Length (Mature): 9.8 cm
Width (Mature): 7.1 cm
Spore bearing surface under cap: Pores
Spore diameter (Average): Length: 12.1 μm ; Width: 5.6 μm
Cap of the carpophore: Size: 7.1 cm \times 2.5 cm; Shape: Convex
Pileus: Color: Greyish and brownish; Surface character: Smooth, silky, leathery and dry in nature; Margin: Regular; Cuticle: Half peeling
Texture of the fruiting body: Spongy and some extent woody
Flesh odor: Fragrant
Lamellae: Present; Pores attachment: Adnate; Pores color: Pale yellow; Gill shape and width: Broad; Pores spacing: Crowded; Lamellulae: Present; Forking pattern: Unbranched
Stipe: Present; Size: 7.3 cm; Shape: Bare; Position: Central; Surface characteristics: Dry and polished; Color: Yellowish and some are greyish to light brown (change color upon bruising); Firmness: Solid
Ecological features: Locality found: Botanical garden, Mirpur, Dhaka; Habitat: On soil; near the mango (*Magifera indica*) and Ipil-Ipil (*Leucaenaleucocephala*) trees; Habit: Scattered; Type of association: Scattered; Forest type: Leveled; Constancy of occurrence in specific habitat: Un-abundant; Type of soil: Loom; pH of soil: 6.1; Moisture: 6.8%, Temperature: 35°C; Factors affecting their distribution: Less moist weather

3.5 Genus: *Tuber*

3.5.1 *Tuber aestivum*

Family: Tuberaceae
Common name: Truffle
Color: Young: White; Mature: White
Length (Mature): 1.1 cm to 1.5 cm
Width (Mature): 1.1 cm to 1.3 cm
Spore bearing surface under cap: Glebal
Spore diameter (Average): Length: 12.9 μm ; Width: 7.94 μm
Cap of the carpophore: Size: 1.1 cm to 1.3 cm; Shape: Flat
Pileus: Color: White; Surface character: Glabrous and dry in nature; Margin: Irregular; Cuticle: Not peeling
Texture of the fruiting body: Spongy
Flesh odor: Fragrant
Ecological features: Locality found: Botanical garden, Mirpur, Dhaka; Habitat: On bark wood of the plant; in an association with the Dahlia plant (*Dahlia* sp.); Habit: Scattered and some are caespitose cluster; Type of association: Close; Forest type: Leveled; Constancy of occurrence in specific habitat: Un-abundant; Type of soil: Loom; Factors affecting their distribution: Less moist weather.

3.6 Genus: *Collybia*

3.6.1 *Megacollybia platyphylla*

Family: Marasmiaceae
Common name: Broad gilled collybia
Color: Young: White; Mature: White
Length: 1.3 cm
Width: 1.4 cm
Spore bearing surface under cap: Ridges or ribs
Spore diameter (Average): Length: 4.63 μm ; Width: 4.13 μm
Cap of the carpophore: Size: 1.4 cm
Pileus: Color: Whitish; Surface character: Smooth and dry in nature; Margin: Incurved
Texture of the fruiting body: Soft and spongy
Flesh odor: Fragrant
Lamellae: Present; Gill attachment: Subdecurrent; Gill color: White; Gill shape and width: Narrow; Gill spacing: Crowded; Lamellulae: Present; Forking pattern: Branched
Stipe: Present; Size: 0.5 cm; Shape: Radicating; Position: Excentric; Surface characteristics: Dry and glabrous; Color: White to creamy; Firmness: Solid
Ecological features: Locality found: Ramna park, Ramna, Dhaka; Habitat: On the bark wood

of the tree; in an association with the Mahogany (*Swietenia mahogany*) tree; Habit: Solitary; Type of association: Closed; Forest type: Leveled; Constancy of occurrence in specific habitat: Un-abundant; Type of soil: Loom; Factors affecting their distribution: More moist weather

3.7 Genus: *Panaeolus*

3.7.1 *Panaeolus foeniseccii*

Family: Bolbitiaceae

Common name: Brown hay cap

Color: Young: Pink and purple; Mature: Pink and purple

Length: 4.9 cm

Width: 1.0 cm

Spore bearing surface under cap: Gills

Spore diameter (Average): Length: 11.2 μm ; Width: 7.4 μm

Cap of the carpophore: Size: 1.0 cm; Shape: Convex

Pileus: Color: Brownish; Surface character: Smooth; Margin: Regular; Cuticle: Fully peeling

Texture of the fruiting body: Soft and spongy

Flesh odor: Fragrant

Lamellae: Present; Gill attachment: Adnaxed; Gill color: Pale reddish; Gill shape and width: Narrow; Gill spacing: Close; Lamellulae: Present; Forking pattern: Branched

Stipe: Present; Size: 4.5 cm to 4.9 cm; Shape: Bare; Position: Central; Surface characteristics: Dry and glabrous; Color: White to light brown; Firmness: Solid

Ecological features: Locality found: Ramna park, Ramna, Dhaka; Habitat: On humus; Habit: Scattered; Forest type: Leveled; Constancy of occurrence in specific habitat: Un-abundant; Type of soil: Loom; Factors affecting their distribution: Moist weather

3.8 Genus: *Armillaria*

3.8.1 *Armillaria mellea*

Family: Physalacriaceae

Common name: Honey fungus

Color: Young: Brown; Mature: Brown with dark brown spots on cap

Length: 4.8 cm

Width: 1.4 cm

Spore bearing surface under cap: Gills

Spore diameter (Average): Length: 7.15 μm ; Width: 3.88 μm

Spore shape: Single walled, smooth and ellipsoidal

Cap of the carpophore: Size: 1.2 cm to 1.4 cm; Shape: Convex or flat

Pileus: Color: Brownish; Surface character and Zonation: Smooth and silky; Margin: Regular

Texture of the fruiting body: Soft and spongy

Flesh odor: Pleasant

Lamellae: Present; Gill attachment: Adnate; Gill color: Pale brownish; Gill shape: Narrow; Gill spacing: Crowded; Lamellulae: Present; Forking pattern: Branched

Stipe: Present; Size: 4.8 cm; Shape: Equal; Position: Central; Surface characteristics: Dry and polished; Color and color changes: Grey to light brown; Firmness: Tubular

Annulus (position): Present and single

Scale: Present and brown

Ecological features: Locality found: Botanical garden, Mirpur, Dhaka; Habitat: On soil, in an association with the Mahogany (*Swieteniamahogany*) and Ipil-Ipil (*Leucaenaleucocephala*) tree; Habit: Solitary; Type of association: Close; Forest type: Leveled; Constancy of occurrence in specific habitat: Abundant; Type of soil: Sandy; Factors affecting their distribution: Moist weather

4. DISCUSSION

Mushroom becomes the object of curiosity and speculation of modern research as it is an important component of the ecosystem, since the beginning of nature. It also becomes more interesting, while the scientist discover its various kinds of properties as well. Nowadays, mushrooms become economically more important, due to its edibility, psychotropic properties, mycorrhizal symbiosis as well as parasitic association with the host trees. The association with such type of similar substrate like wood, litter and soil are also express a role for them in these micro habitats [16]. These kind of fleshy macro fungi generally grown in an alternation of specific season but the most productive seasons are rainy seasons, just starting after summer. Therefore, an investigation was conducted just after the rainy season at the central and northern part of Bangladesh under tropical moist deciduous forest region to identify the preliminary species, those are being available each year into that moist environment on some specific area. As a result among 50 samples, 8 genera and 9 species were able to identify through this present investigation, including 2 species of *Daedaleopsis* and 1 species each of the genera *Trametes*, *Pycnoporus*, *Boletus*, *Tuber*, *Collybia*, *Panaeolus* and *Armillaria*. On the other hand, a similar type

of investigation was also conducted by Rumainul et al. into these same biosphere reserved areas of tropical moist deciduous forest region of Bangladesh, where 14 genera and 24 species were reported [17].

The genus *Trametes* was found in Dinajpur district of tropical moist deciduous forest region at the northern part of Bangladesh. It was first described by Elias Magnus Fries as a saprobion on the deadwood of hardwoods [18]. The genus has



Fig. 2. Fruiting body of collected mushrooms: a. *Trametes versicolor*; b. *Daedaleopsis confragosa*; c. *Daedaleopsis confragosa* var. *tricolor*; d. *Pycnoporus cinnabarinus*; e. *Boletus amygdalinus*; f. *Tuber aestivum*; g. *Megacollybia platyphylla* (growing phase); h. *Panaeolus foenisecii*; i. *Armillaria mellea*

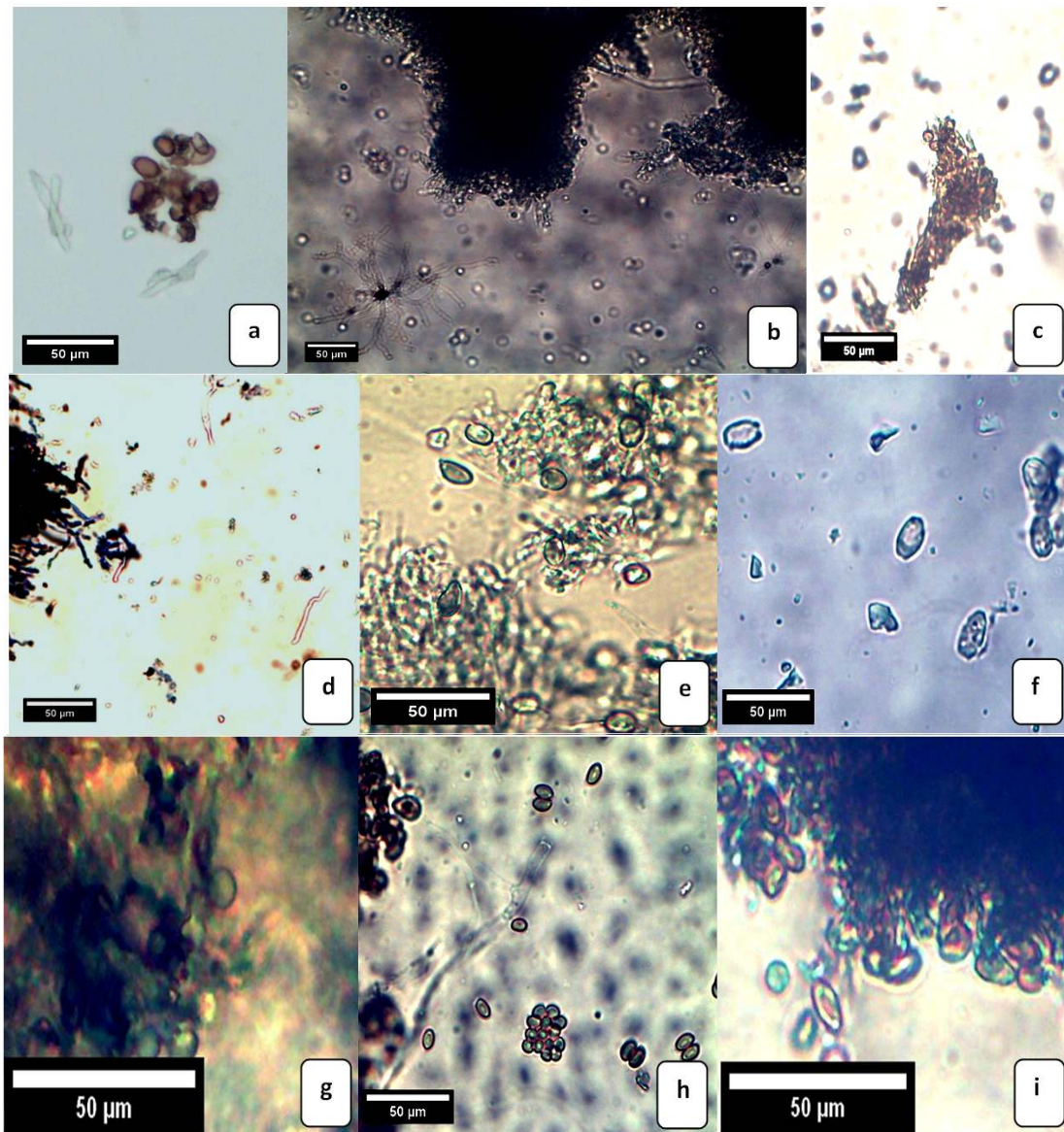


Fig. 3. Spores of the collected mushrooms: a. *Trametes versicolor*; b. *Daedaleopsis confragosa*; c. *Daedaleopsis confragosa* var. *tricolor*; d. *Pycnoporus cinnabarinus*; e. *Boletus amygdalinus*; f. *Tuber aestivum*; g. *Megacollybia platyphylla*; h. *Panaeolus foenicicii*; i. *Armillaria mellea*

a widespread distribution and contains about 50 species [19]. The genus was also found in the Western Ghats region of India [20], whereas the species *Trametes versicolor* was also reported in and around Bangalore (Karnataka) of India and found medicinal importance [21]. The exact species of *Trametes versicolor* was also reported in Lagos State of Nigeria [22] as well as in Chungcheong Province of Korea [23]. Furthermore, the genus *Daedaleopsis* is widely

distributed genus contains 6 species [19]. In this investigation, 2 species of *Daedaleopsis* were found in Dhaka district of Bangladesh. This genus was also first reported in Europe at 1791, having the antioxidant properties [24] and the same species of *Daedaleopsis confragosa* was also reported as saprophyte in Central Luzon of Philippines [25]. On the other hand, *Pycnoporus* sp. was found at Bogra district in Bangladesh. This genus contains 5 distinct species, which

was saprobic on the dead wood of hardwoods [26]. It was found in some other places of Europe and North America. *Pycnoporus cinnabarinus* was also found in Northeast Ohio [27] and studied by Rasheeda et al. [28]. Furthermore, *Boletus* sp. was also found in Dhaka of Bangladesh and was first reported by Elias Magnus Fries in 1821 [18]. Almost 100 species were identified of this same genus and this genus was also found earlier in Lithuania, Poland [29]. *Boletus amygdalinus* was also described as saprophyte in nature [30,31]. The phylogenetic, morphological and taxonomic characteristics of *Borofutus*, a new genus of *Boletaceae* from tropical Asia were also studied in China [32]. *Tuber* sp. was collected from Dhaka district of Bangladesh. It was found in almost all European countries [33]. Furthermore, *Collybia* sp. was also found at Dhaka district of the tropical moist deciduous forest region in Bangladesh throughout the investigation. *Collybia* sp. has nearly 3 species [34]. The genus *Collybia* sp. have a widespread but rarely distributed in north temperate areas as saprophyte [35], whereas the species named *Megacollybia platyphylla* was also reported by Hughes et al. [36] as saprophyte.

Finally, *Armillaria* sp. was found in Dhaka district of the tropical moist deciduous forest region of Bangladesh throughout the investigation. It has commonly 45 species [36]. The species *Armillaria* was also reported by Ram et al. [37] and Giri et al. [38] in India, having medicinal importance. However, *Armillaria mellea* was also studied as saprophyte by Coetzee et al. in 2001 [39].

5. CONCLUSION

In the investigation, 8 genera including 9 species were identified from the 50 collected samples. The identified genera were *Trametes*, *Daedaleopsis*, *Pycnoporus*, *Boletus*, *Tuber*, *Collybia*, *Panaeolus* and *Armillaria*. In the future investigation would also needed in different seasons as well as in different forest regions to identify the new existing exotic varieties of mushroom flora, which will be also beneficial to represent the complete overview of available macro fungi of Bangladesh.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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