

DIVERSITY, DISTRIBUTION AND MORPHOLOGY OF WILD MUSHROOMS

COLLECTED FROM GAJNI FOREST OF BANGLADESH

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Abstract

A survey was carried out in Gajni forest from June to August of 2017 and 2018 to document the diversity, distribution and morphological characterization of wild mushrooms. A total of 32 mushroom samples were collected and identified to 28 species belonging to 11 genera, under 8 families. *Ganoderma* sp. was found abundantly in the survey area among the other collected species and it exhibited the maximum frequency of occurrence (75%), whereas the maximum density (20.50%) was recorded for *Agaricus bitorquis* and the dominant host was Shal tree (*Shorea robusta*). The dominant genera were *Ganoderma*, *Agaricus*, *Trametes*, *Volvariella* and *Amanita*. The dominant family of collected wild mushrooms was Ganodermataceae followed by Polyporaceae, Agaricaceae, Amanitaceae, Rusullaceae, Pluteaceae, Marasmiaceae and Strophariaceae. Among collected species, 5 species were found edible, 12 species had medicinal value and 11 species were inedible, poisonous or of unknown importance. The specimens were deposited to the Sher-e-Bangla Agricultural University Herbarium of Macro Fungi (SHMF). This is a report of wild mushrooms diversity and their distribution in the Gajni forest region of Bangladesh. This study was asserted that a wide range of mushroom plays an important role in the ecosystem of Gajni forest and might be useful in food and industry sector in future.

Keywords: Diversity; Macrofungi; Ecosystem; Gajni forest; Medicinal

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1. Introduction

Fungi are considered the largest biotic community after insects (Steyart *et al.*, 1980). The actual range of properly estimated fungi is updated from 2.2 to 3.8 million (Hawksworth and Lücking, 2017). Mushrooms are the heterotrophic organisms and quite specific in their nutritional and ecological requirements. It belongs to Ascomycota and Basidiomycota. The structure which is recognized as mushroom is a highly organized system of hyphae, collectively called mycelium. Under the favorable conditions of temperature and moisture, the mycelium gives rise to one or more fruiting bodies, or mushrooms (Choudhary *et al.*, 2015).

Wild edible mushrooms have been collected and consumed by people for thousands of years. In China where the eating of wild fungi was first reliably noted several hundred years before birth of the Christ (FAO, 2004). Globally, there are 2327 recorded useful species; 2166 are edible of which 1069 species are used as food, with at least other 100 known food species lacking published evidence (Boa, 2004). According to Mizuno (1993), Wasser (1995) and Ferreira *et al.* (2010), approximately 700 species of Basidiomycetes have been found to possess significant pharmacological activities. Wild edible mushrooms are collected, consumed and sold in over 80 countries worldwide with a value of US \$2 billion (Boa, 2004).

The macrofungal species composition and diversity vary with nutrient (particularly nitrogen), moisture, forest type and disturbance (O'Hanlon and Harrington 2012; Pradhan *et al.* 2013). Mushrooms are seasonal fungi, which occupy diverse niches in nature in the forest ecosystem (Stamets, 2000). Major functions of mushrooms in natural and organized eco-systems as ectomycorrhizal fungi made this macro fungal group a significant component for reforestation programs. The macrofungi were also used as a bioindicator of environmental quality (Andrew *et al.*, 2013).

Investigations on the taxonomy and diversity of macro fungi are gaining importance as wild mushrooms have a deep biological and economical impact. Many workers have been working on wild mushrooms. Rashid *et al.* (2016) mentioned that mushroom diversity in Bangladesh is quite promising and the country has a huge possibility to utilize the resources. The total forest area of Bangladesh is 2.6 million hectares, which is nearly 17.4% of the total land area of the country. Gajni forest is covered near about 9660 acres of land of Bangladesh. It is very urgent to explore this area in different environmental condition to observe and study the diversity of mushrooms that prevail in this area.

The knowledge of diversity at the community and species level is important for monitoring the effectiveness and effects of natural and artificial disturbances (Pakham, 2002). Data on their diversity in different vegetation types is important for planning and managing ecosystem diversity (Engola *et al.*, 2007). The purpose of the present survey was to study the diversity and distribution of wild mushrooms and generate a database on morphology, habitat, ecology and cultural characteristics of species from the Gajni forest region of Bangladesh.

2. Materials and methods

2.1. Survey area

Jhinaigati natural forest area locally called Gajni forest in Sherpur district was selected for conducting survey. The forest is located in adjacent with India, positioning at 25°16'N latitude and 90°08'E longitudes having a wide range of ecosystem.

2.2. Experimental site

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

2.3. Sampling on wild mushroom

Several surveys were made to the selected area for collection of wild mushrooms during the rainy season from June to August in 2017 and in 2018. Sampling of wood-inhabiting macrofungi on different tree species was done following Unterseher *et al.*, (2008). The samples were collected from the sites by walking through the area. For determination of the morphological variability of wild mushroom's population in the selected area the spotted and fleshy mushrooms were minutely inspected, collected and brought to the laboratory for detailed inspection.

2.4. Photography

Some photographs were taken during collection and some were taken after drying. Each sample was wrapped with necessary information tagging viz. date of collection, sample number, location name and host name.

2.5. Drying and storage of collected mushrooms

Mushrooms were dried and processed following the established method (Kim, 2004). Collected samples were cleaned and sun dried for 3-4 days. The samples were then dried by using hot airflow electrical drier (Model: PTC-10M, Miyako, Japan) for 4 to 8 hrs to remove the whole moisture content. Dried mushrooms were stored in a zip-lock polybag for further studies. Silica gels were used at the rate of 10% of dry basis during the storage period.

2.6. Morphological characterization

Morphological characters were recorded for identification of mushroom specimens such as size of the fruiting body, scale, gills color, gills edges, stipes, length, width, shape, type of vail, volva including locality, habitat and type of soil of collection site (Srivastava and Bano, 2010). Final identification and classification were done by comparing recorded characteristics of mushrooms with the color dictionary of mushroom (Dickinson and Lucas, 1982), the mushroom guide followed by the reference of Jorden (2004) and Pegler and Spooner (1992).

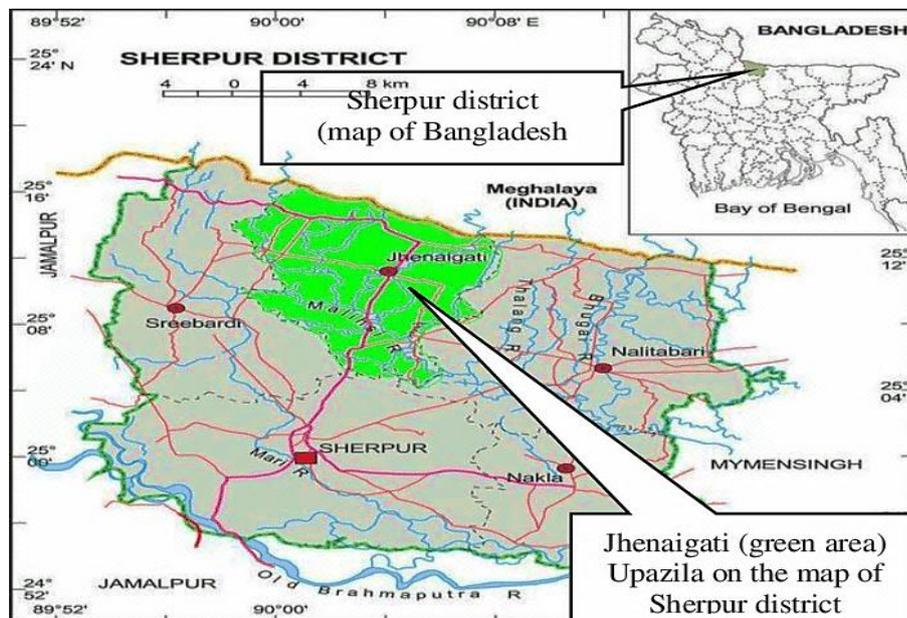


Figure 1: Survey area of wild mushrooms at Gajni forest in Sherpur district of Bangladesh.

2.7. Microscopic characterization

Semi-permanent glass slides were made from rehydrated basidiocarps for the microscopic characterization. Basidiocarps were immersed in cotton blue stain and glycerin and placed on glass slides and covered with coverslips. Furthermore, the spore was observed using a light microscope with the magnification of $\times 100$ and $\times 400$.

2.8. Mushroom cultures

Growth rate of collected wild mushrooms were investigated on potato dextrose agar media (20 g dextrose, 20 g agar powder, 200 g infused potato extracts in 1000 mL water). The media was sterilized at 121°C at 15 PSI for 15 min. Then the media was poured on petri plate and fragments of fruiting body from the lower part were placed on the middle of a plate. Inoculated culture plates were incubated at 25°C for the growth of mycelium. After 5 to 7 days, photographs of mycelial growth on culture were taken and the plates were preserved in a cool place for study on different parameters such as color of mycelia and growth pattern.

2.9. Habitat, distribution and diversity analysis

The mushrooms were found in an association with various substrata. The surrounding environment, temperature, moisture condition and vegetation were recorded for the study of biodiversity of wild mushroom. The air temperature was measured by thermometer during the collection. The distribution of mushrooms in the locality was also recorded. The frequency and density of different species have been determined by using the following formulas (Zoberi, 1973):

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

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

3. Results

In total of 32 mushroom specimens were collected from Gajni forest and identified to 28 species which belonging to 8 families including 15 species of Ganodermataceae, 4 species of Polyporaceae, 2 species of Agaricaceae, 2 species of Amanitaceae, 2 species of Russulaceae, 2 species of Pluteaceae and 1 species of each of the family Marasmiaceae and Strophariaceae. The evenness and species richness was found in Ganodermataceae family. The second dominated species was found under Polyporaceae family. *Ganoderma* sp. was found abundantly in the survey area among the other collected species and it exhibited the maximum variation in color and size. The dominant host was Shal tree (*Shorea robusta*). The morphology of basidiocarp and basidiospore are presented in Figure 1 to 6 and tabulated in Table 1.

Among all the species, the highest frequency was 75% recorded for *Volvariella gloiocephala*, *Ganoderma applanatum* and the highest density 20.25% was found for *Agaricus bitorquis*. The lowest frequency was 10% recorded for *Trametes versicolor*, *Polyporus* sp. and the lowest density of 2.25% was found for *Amanita excels* and *Trametes versicolor* (Table 2). Among identified species, 5 species were edible, they are- *Agaricus bitorquis*, *Agaricus arvensis*, *Volvariella gloiocephala*, *Volvopluteus gloiocephalus*, *Ganoderma lucidum*, Twelve (12) species had medicinal value and 11 species were inedible, poisonous or unknown importance (Table 3).

Table 1: Morphological characterization of basidiocarp and basidiospores of collected wild mushrooms from Gajni forest.

S. No.	Species name	Characterization of basidiocarp	Characterization of Spore
1	<i>Agaricus bitorquis</i> (Quel.) Sacc.	Size of fruiting body was 3.1×4.5cm. Pileus (cap) was white colour and ovate, edge was round but slightly wavy. Hymenophores were absent. Regular white color gills were present underside of the cap. Ring or anal was absent on the stipe and volva was absent.	Spore colour was brown. Spores were thin walled, round shaped, scattered.
2	<i>Agaricus arvensis</i> Schaeff.	Size of fruiting body was 1.5×2.1 cm. Pileus (cap) was white and round smooth. Hymenophores were absent. White color gills were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe.	Spore colour was brown. Spores were thick walled, conicle shaped, scattered.
3	<i>Amanita muscaria</i> (L.) Lam.	Size of fruiting body was 4.5×3.5 cm. Pileus was blackish white, round, smooth and ellipsoid. Hymenophores were absent. Regular white color gills (lamellae) were present underside of the cap. Ring or anal was absent on the stipe and volva was absent.	Spore colour was light brown. Spores were thin walled, round shaped.
4	<i>Amanita excels</i> var. <i>spissa</i> (Fr.)	Size of fruiting body was 4.5 ×3.5 cm. Pileus was blackish, corcky and ellipsoid. Hymenophores were absent. Regular blackish color gills (lamellae) were present underside of the cap. Ring or anal was absent on the stipe and volva was absent.	Spore colour was slightly brown. Spores were thick walled.

5	<i>Lactarius deliciosus</i> (L. ex Fr.) S.F.Gray	Size of fruiting body was 3×3.5cm. Pileus was pinkish, ovate and edge was round but slightly wavy. Hymenophores were absent. Regular pinkish color gills (lamellae) were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe.	Spore colour was light brown. Spores were thin walled, round shaped, scattered.
6	<i>Russula nobilis</i> Velen.	Size of fruiting body was 2.5×1.5 cm. Pileus shape was funnel shape. Color was pink to red. Texture of the fruiting body was soft and spongy. Stipe was present. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe.	Spore colour was blackish. Spores were thick walled.
7	<i>Gymnopilus purpuratus</i> (Cooke & Masee) Singer	Size of pileus was 8.1 × 7.5cm. Pileus shape was concave. Color was white. Surface character and zonation was soft, smooth in nature. Margin was slightly dentate, incurved in shape. Texture of the fruiting body was soft. Spore bearing surface was pores under the gills.	Spore colour was blackish. Spores were thin walled, round shaped, clustered.
8	<i>Volvariella gloiocephala</i> (Fr.) Gillet	Size of fruiting body was 10.5×6.8 cm. Pileus color was white (Young and mature), soft and fleshy. Gill attachment was free. Shape was ovate or flat. Pileus color was creamy, brownish. Volva was present on the lower part of the stipe.	Spore colour was light brown. Spores were thin walled, elliptical shaped, scattered.
9	<i>Volvopluteus gloiocephalus</i> (DC.) Vizzini, Contu & Justo	Size of fructification was 4.2×2.4 cm. Pileus was brown and creamy colour, flat and edge was smooth and striate. Cream color scale was found on the cap. Beneath the cap hymenophores were present. Regular shaped light brown gills (lamellae) were present underside of the cap. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe.	Spore colour was blackish. Spores were thin walled, round shaped, clustered.
10	<i>Gymnopus iocephalus</i> (Berk. & M.A. Curtis) Halling	Size of fruiting body was 4.1× 2.5 cm. Pileus shape was funnel shape. Color was violet with white strip. Texture of the fruiting body was Soft and spongy. Spore bearing surface under cap was Gills. Stipe was present. Ring or anal was absent on the stipe and volva was absent on the lower part of the stipe.	Spore colour was brown. Spores were thick walled, irregular round shaped, clustered.
11	<i>Trametes elegans</i> (Spreng.) Pat.	Size of basidiocarp was 2.3 ×3.7 cm. Pileus (cap) was brown and creamy. Shape of cap was flat and cap edge was undulating. Light yellow color scale was present on the cap. The white and brown color macro pores were present under the cap. The surface characters were dry in nature. The texture of the fruiting body was hard, brittle and woody.	Spore colour was light brown. Spores were thick walled, irregular round shaped.
12	<i>Trametes versicolor</i> (L.) Lloyd	Size of pileus was 4× 3.5 cm. Pileus shape was convex. Color was brown to white coloured. Margin was incurved in shape. Margin thick, cream colour. Texture of the fruiting body was corky and tough. Spore bearing surface under cap was pores on hymenium. Pores color was milky. Pore spacing was crowded.	Spore colour was blackish. Spores were thick walled, elongated shape.
13	<i>Ganoderma tropicum</i> (Jungh.) Bres.	Size of pileus 7.5×6.5 cm. Pileus shape flat. Color was dark red with white border. Surface character and zonation was brittle, rugose, reddish brown and dry in nature. Margin was incurved in shape, thick and coffee color. Texture of the fruiting body is corky to woody. Pores on hymenium.	Spore colour was brown. Spores were thick walled, round shaped.
14	<i>Ganoderma applanatum</i> (Pers.) Pat.	Size of pileus was 12.5×9.8 cm. Pileus shape was convex. Color was cocoa to brownish. Surface character and zonation was dry in nature. Margin was incurved in shape. Texture of the fruiting body was corky. Pores on Hymenium.	Spore colour was brown. Spores were thick walled, oblong shaped, smooth.

15	<i>Ganoderma lobatum</i> (Schwein.) G.F. Atk.	Size of pileus 8.3×9.8 cm. Pileus shape was convex to irregular in shape. Pileus color was mature cocoa brown. Surface character and zonation was dry in nature laccate, highly sulcate, brown of chestnut. Margin was incurved in shape, hard, acute. Texture of the fruiting body was woody and corky. Spore bearing surface under cap was pores on hymenium.	Spore colour was brown. Spores were thick walled, ovate shaped, smooth.
16	<i>Ganoderma orbiforme</i> (Fr.) Ryvarden	Size of pileus 6.3×3.8 cm. Pileus shape was convex to irregular in shape. Pileus color was coccoa brown. Surface character and zonation was dry in nature. Margin was incurved in shape, hard, acute. Texture of the fruiting body was woody and corky. Spore bearing surface under cap was Pores on hymenium.	Spore colour was blackish. Spores were thick walled, ovate shaped, smooth.
17	<i>Ganoderma sinense</i> (J.D. Zhao, L.W. Hsu& X.Q. Zhang)	Size of pileus 7.5×6.5 cm. Pileus shape was slightly wavy, grissy red color. Surface and zonation was brittle and dry in nature. Margin was incurved in shape, thick and coffee color. Texture of the fruiting body is corky to woody. Pores on hymenium.	Spore colour was brown. Spores were thick walled, oval shaped, clustered.
18	<i>Ganoderma fornicatum</i> (Fr.) Pat.	Size of pileus 6.5×4.5 cm. Pileus shape was slightly wavy and convex, blackish brown color. Surface and zonation was Brittle, brown and dry in nature. Margin was incurved in shape, thick and coffee color. Texture of the fruiting body is corky.	Spore colour was blackish. Spores were thin walled, oblong shaped.
19	<i>Ganoderma tsugae</i>	Size of pileus was 3.8×3.1 cm. Color was brick red with white cap. Pileus shape was conical. Surface character and zonation was dry in nature. Margin was irregular in shape. Texture of the fruiting body was brittle and woody. Pores on hymenium.	Spore colour was brown. Spores were thin walled, ovate shaped, scattered.
20	<i>Ganoderma australe</i> (Fr.) Pat.	Size of pileus was 8.1 ×7.5cm. Pileus shape was concave. Color was cocoa. Surface character and zonation was dry in nature. Margin was incurved in shape. Texture of the fruiting body was brittle and woody. Spore bearing surface was pores on hymenium.	Spore colour was slightly black. Spores were thin walled.
21	<i>Ganoderma</i> sp. P.Karst	Size of pileus was 3.8 ×2.4 cm. Pileus shape was finger like. Color was upper portion coccoa and lower portion brick red. Surface character and zonation was dry in nature. Margin was incurved in shape. Spore bearing surface under cap was pores on hymenium.	Spore colour was blackish. Spores were thick walled, round shaped.
22	<i>Ganoderma</i> sp. P.Karst	Size of pileus was 3.5 ×2.4cm. Pileus shape was oval. Color was coccoa and blackish. Surface character and zonation was dry in nature. Spore bearing surface under cap was pores on hymenium.	Spore colour was blackish. Spores were thin walled, round shaped.
23	<i>Ganoderma boninense</i> (Pat.)	Size of pileus was 4.1×2.9 cm. Pileus shape was concave. Color was white color, cap. Surface character and zonation was dry in nature. Margin was incurved in shape. Texture of the fruiting body was brittle and woody.	Spore colour was light brown. Spores were thin walled, round shaped.
24	<i>Ganoderma lucidum</i> (Curtis) P. Karst.	Size of pileus was 7.1×6.9 cm. Pileus shape was concave. Color was black with white stripe. Surface character and zonation was dry in nature. Margin was incurved in shape. Texture of the fruiting body was brittle and woody. Spore bearing surface under cap was pores on hymenium.	Spore colour was brown. Spores were thick walled, oval shaped, scattered.
25	<i>Ganoderma calidophilum</i> (J.D. Zhao, L.W. Hsu & X.Q. Zhang)	Size of pileus was 7.1 ×6.9 cm. Pileus shape was concave. Color was red. Surface character and zonation was dry in nature. Margin was incurved in shape. Texture of the fruiting body was brittle and woody. Spore bearing surface under cap was pores on hymenium.	Spore colour was brown. Spores were thick walled, oblong shaped, scattered.

26	<i>Ganoderma pfeifferi</i> (Bres.)	Size of pileus was 8.1 × 7.5cm. Fruiting body is brittle and woody in texture. Pileus shape was incurved. Color was cocoa. Surface character and zonation was dry in nature. Margin was incurved in shape. Spore bearing surface was pores on hymenium.	Spore colour was light brown. Spores were thin walled, ovate shaped.
27	<i>Polyporus</i> sp. P.Micheil ex Adans	Size of fruting body was 4.5×2.8 cm. Color was yellow, soft and fleshy. Pileus was cup shaped. Gill attachment was Free. Volva was abscent.	Spore colour was slightly brown. Spores were thin walled, round.
28	<i>Polyporus lipsiensis</i> (Batsch) E.H.L. Krause	Size of pileus was 6×4.5 cm. Pileus shape was Convex. Color was Dark brown to cocoa coloured. Surface character and zonation was Dry in nature, slightly zonate, solitary, crust and rigid. Margin was incurved in shape. Margin thick, coffee colour. Texture of the fruiting body was Corky and tough. Spore bearing surface under cap was Pores on hymenium.	Spore colour was light brown. Spores were thin walled, oblong shaped.

Table 2: Ecological and cultural characterization of collected wild mushrooms from Gajni forest.

Species name	Family	Frequency (%)	Density (%)	Occurrence	Utilization	Growth on PDA
<i>Agaricus bitorquis</i>	Agaricaceae	70	20.25	Abundant	Edible	Whitish, fluffy, irregular
<i>Agaricus arvensis</i>	Agaricaceae	70	18.60	Infrequent	Edible	Whitish, fluffy, round
<i>Amanita muscaria</i>	Amanitaceae	25	7.45	Abundant	Inedible	Whitish, fluffy, round
<i>Amanita excelsa</i>	Amanitaceae	25	2.25	Infrequent	Inedible	Whitish, fluffy, round
<i>Lactarius deliciosus</i>	Russulaceae	50	10.75	Abundant	Inedible	Whitish, flat, irregular
<i>Russula nobilis</i>	Russulaceae	10	3.25	Infrequent	Inedible	Whitish, flat, irregular
<i>Gymnopilus purpuratous</i>	Strophariaceae	35	5.15	Abundant	Unknown	Whitish, flat, irregular
<i>Volvariella gloiocephala</i>	Pluteaceae	75	15.75	Infrequent	Edible	Whitish, flat, irregular
<i>Volvopluteus gloiocephalus</i>	Pluteaceae	60	8.25	Abundant	Edible	Whitish, flat, irregular
<i>Gymnopus iocephalus</i>	Marasmiaceae	70	15.25	Abundant	Inedible, Poisonous	Blackish, flat, irregular
<i>Trametes elegans</i>	Polyporaceae	55	5.25	Abundant	Inedible	Whitish, fluffy, round
<i>Trametes versicolor</i>	Polyporaceae	10	2.25	Infrequent	Inedible, Poisonous	Grayish white, fluffy, round
<i>Ganoderma tropicum</i>	Ganodermataceae	50	8.50	Abundant	Inedible, medicinal	Whitish, flat, irregular
<i>Ganoderma applanatum</i>	Ganodermataceae	75	12.75	Abundant	Inedible, medicinal	Whitish, flat, irregular

<i>Ganoderma lobatum</i>	Ganodermataceae	50	10.75	Abundant	Inedible, medicinal	Whitish, flat, irregular
<i>Ganoderma orbiforme</i>	Ganodermataceae	50	12.50	Abundant	Inedible	Whitish, fluffy, irregular
<i>Ganoderma sinense</i>	Ganodermataceae	30	5.25	Abundant	Inedible, medicinal	Brownish, flat, irregular
<i>Ganoderma fornicatum</i>	Ganodermataceae	50	7.75	Abundant	Inedible, medicinal	Grayish, flat, irregular
<i>Ganoderma tsugae</i>	Ganodermataceae	60	10.20	Abundant	Inedible, medicinal	Whitish, flat, irregular
<i>Ganoderma australe</i>	Ganodermataceae	50	5.5	Abundant	Inedible, medicinal	Whitish, flat, irregular
<i>Ganoderma</i> sp.	Ganodermataceae	20	3.25	Abundant	Inedible, medicinal	Whitish, flat, irregular
<i>Ganoderma</i> sp.	Ganodermataceae	50	12.50	Abundant	Inedible	Whitish, fluffy, irregular
<i>Ganoderma boninense</i>	Ganodermataceae	50	6.50	Abundant	Inedible, medicinal	Whitish, cottony, irregular
<i>Ganoderma lucidum</i>	Ganodermataceae	25	5.25	Infrequent	Edible, medicinal	Grayish white, fluffy, irregular
<i>Ganoderma calidophilum</i>	Ganodermataceae	60	10.50	Abundant	Inedible, medicinal	Whitish, flat, irregular
<i>Ganoderma pfeifferi</i>	Ganodermataceae	50	3.5	Abundant	Inedible, medicinal	Grayish, flat, irregular
<i>Polyporus</i> sp.	Polyporaceae	10	2.25	Infrequent	Inedible, Poisonous	Grey whitish, flat, irregular
<i>Polyporus lipsiensis</i>	Polyporaceae	50	7.75	Abundant	Inedible	Whitish, flat, irregular

Table 3: Economic importance and uses of collected wild macro fungi from Gajni forest.

Economic importance/Uses	Total number of collected species
Edible	5
Medicinal	12
Inedible, poisonous and unknown importance	11

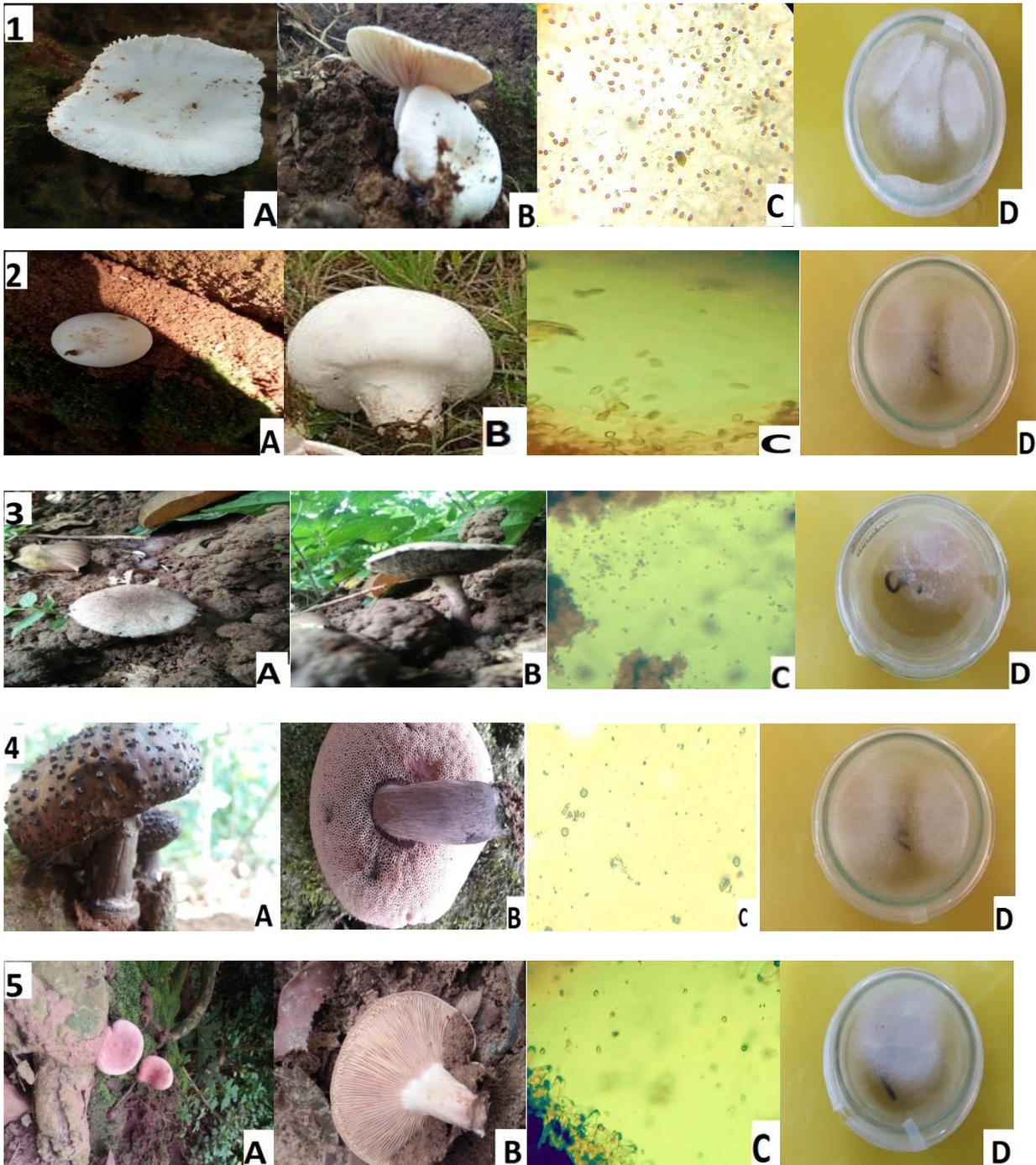


Figure 1: Basidiocarp and spore morphology of collected wild mushrooms from Gajni forest : 1. *Agaricus bitorquis*, 2. *Agaricus arvensis*, 3. *Amanita muscari*, 4. *Amanita excelsa*, 5. *Lactarius deliciosus* (A. Fruiting Body, B. Gill, C. Spore, D. Culture growth in PDA).

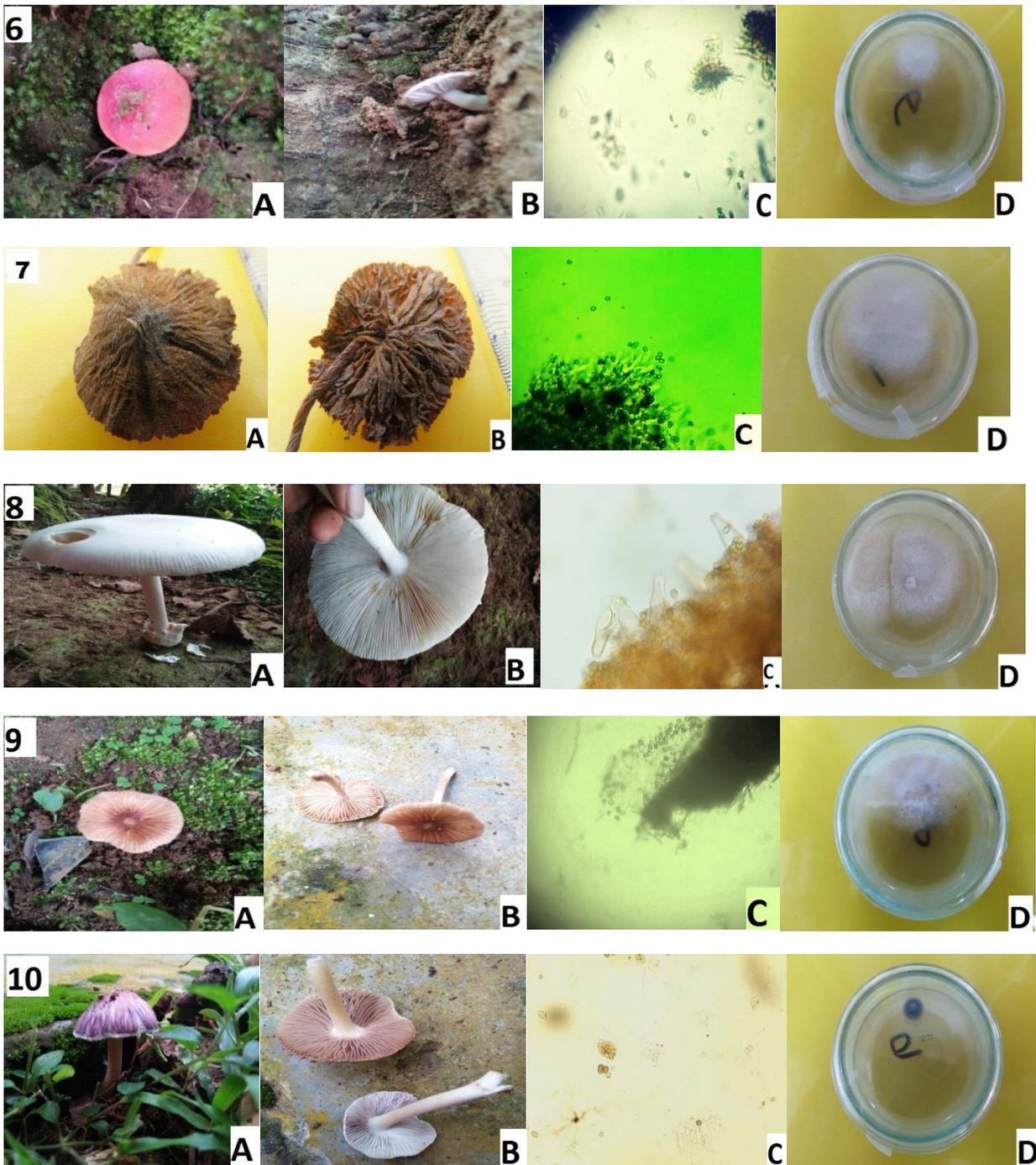


Figure 2: Basidiocarp and spore morphology of collected wild mushrooms from Gajni forest : 6. *Russulanobillis*, 7. *Gymnopilus purpuratous* 8. *Volvariella gloiocephala*, 9. *Volvopluteus gloiocephalus*, 10. *Gymnopus iocephalus*; (A. Fruiting Body, B. Gill, C. Spore, D. Culture growth in PDA).

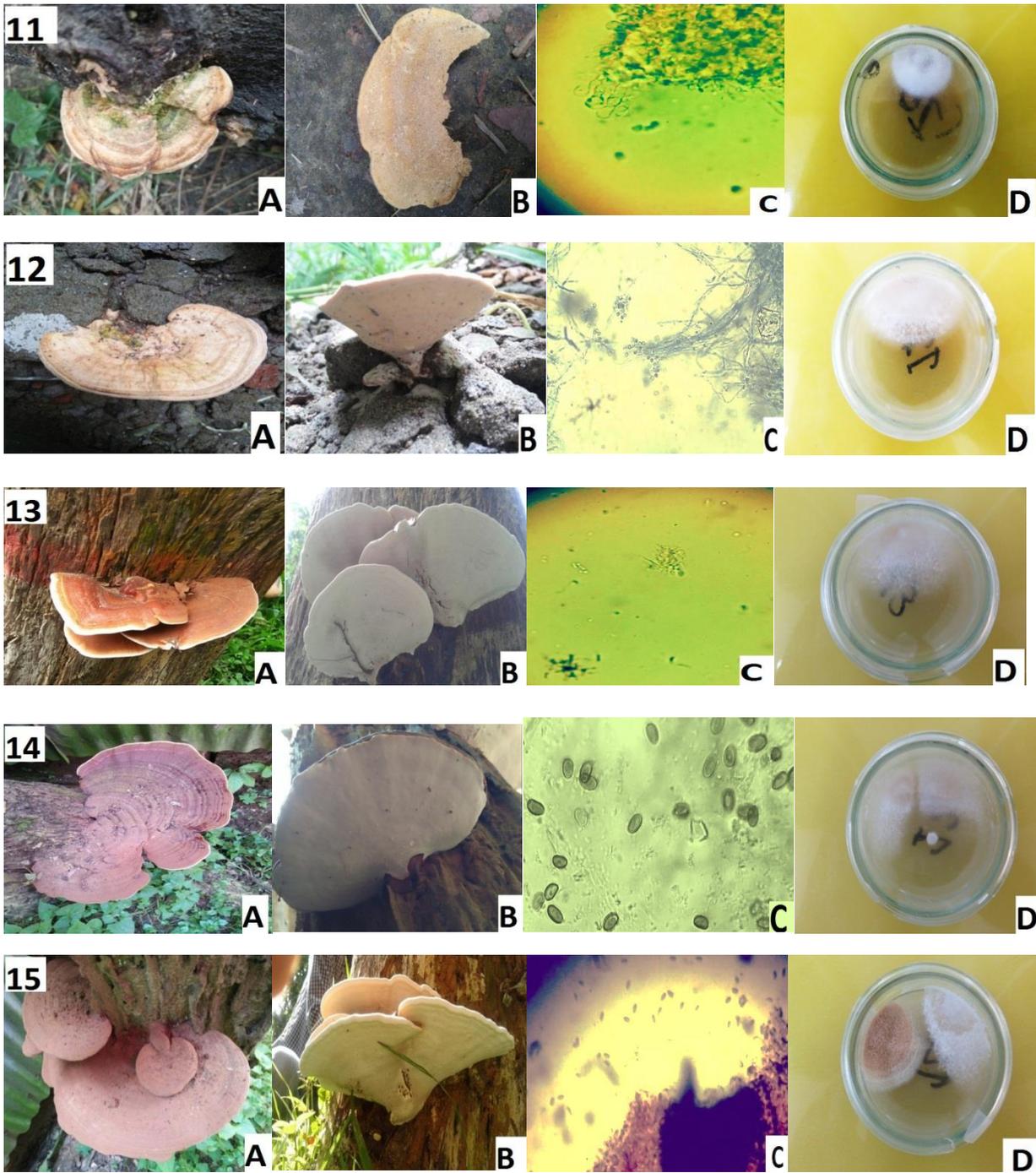


Figure 3: Basidiocarp and spore morphology of collected wild mushrooms from Gajni forest : 11. *Trametes elegans*, 12. *Trametes versicolor*, 13. *Ganoderma tropicum*, 14. *Ganoderma appalantum*, 15. *Ganoderma lobatum*; (A. Fruiting Body, B. Gill, C. Spore, D. Culture growth in PDA).

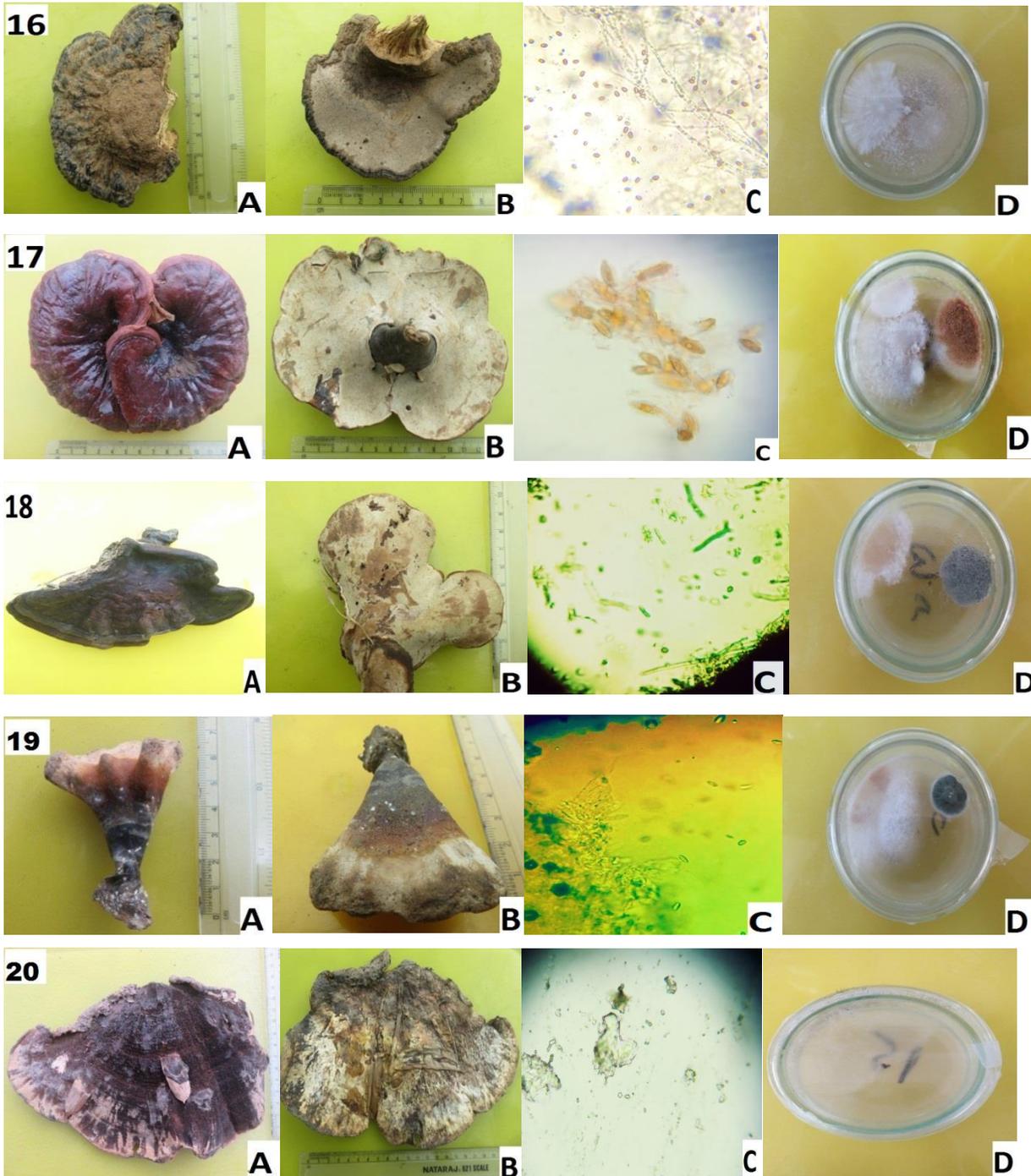


Figure 4: Basidiocarp and spore morphology of collected wild mushrooms from Gajni forest : 16.*Ganoderma orbiforme*, 17.*Ganoderma sinense*, 18.*Ganoderma fornicatum*, 19.*Ganoderma tsugae*, 20. *Ganoderma australe*; (A. Fruiting Body, B. Gill, C. Spore, D. Culture growth in PDA).

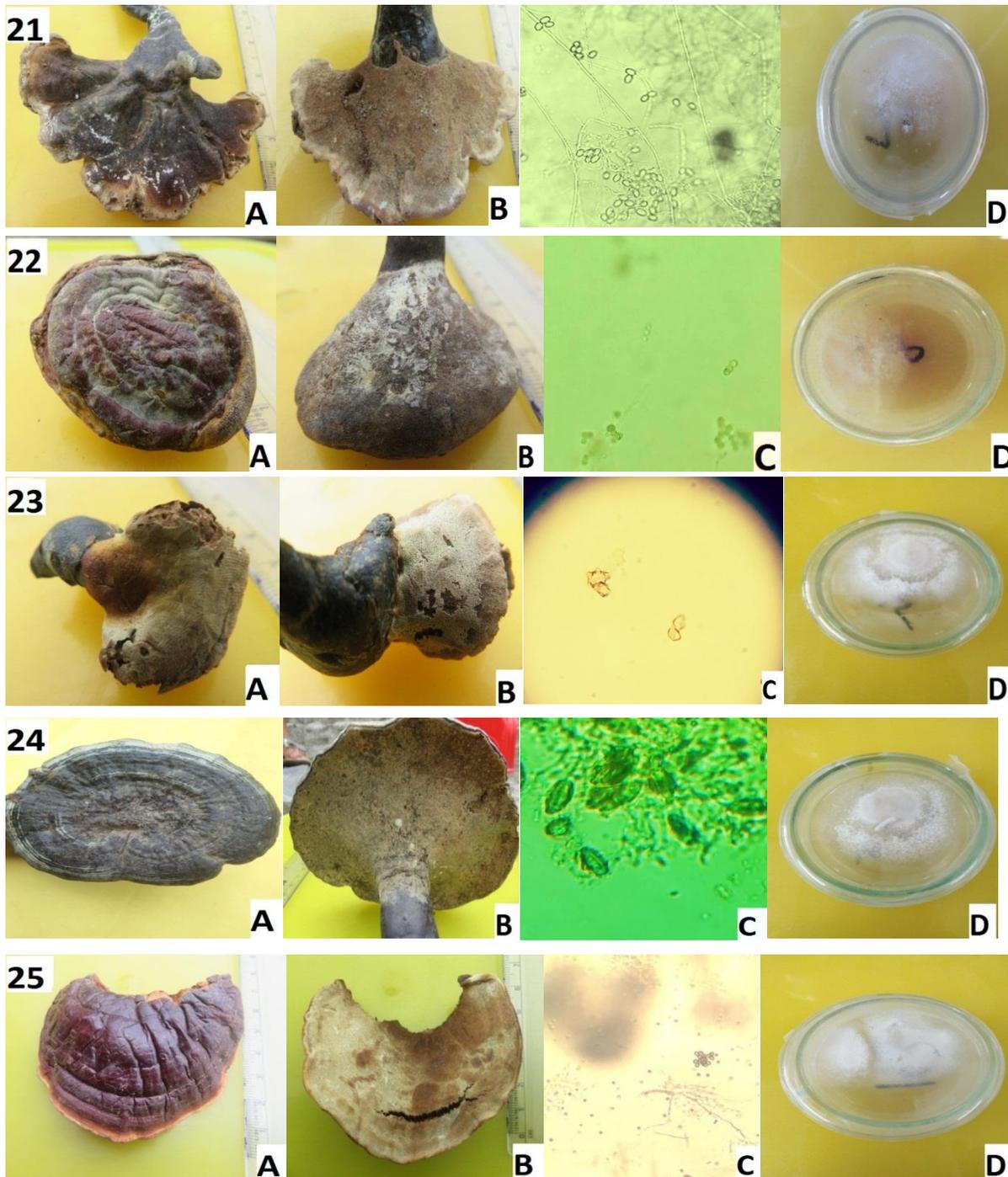


Figure 5: Basidiocarp and spore morphology of collected wild mushrooms from Gajni forest : 21. *Ganoderma* sp, 22. *Ganoderma* sp, 23. *Ganoderma boninense*, 24. *Ganoderma lucidum*, 25. *Ganoderma calidophilum*; (A. Fruiting Body, B. Gill, C. Spore, D. Culture growth in PD).

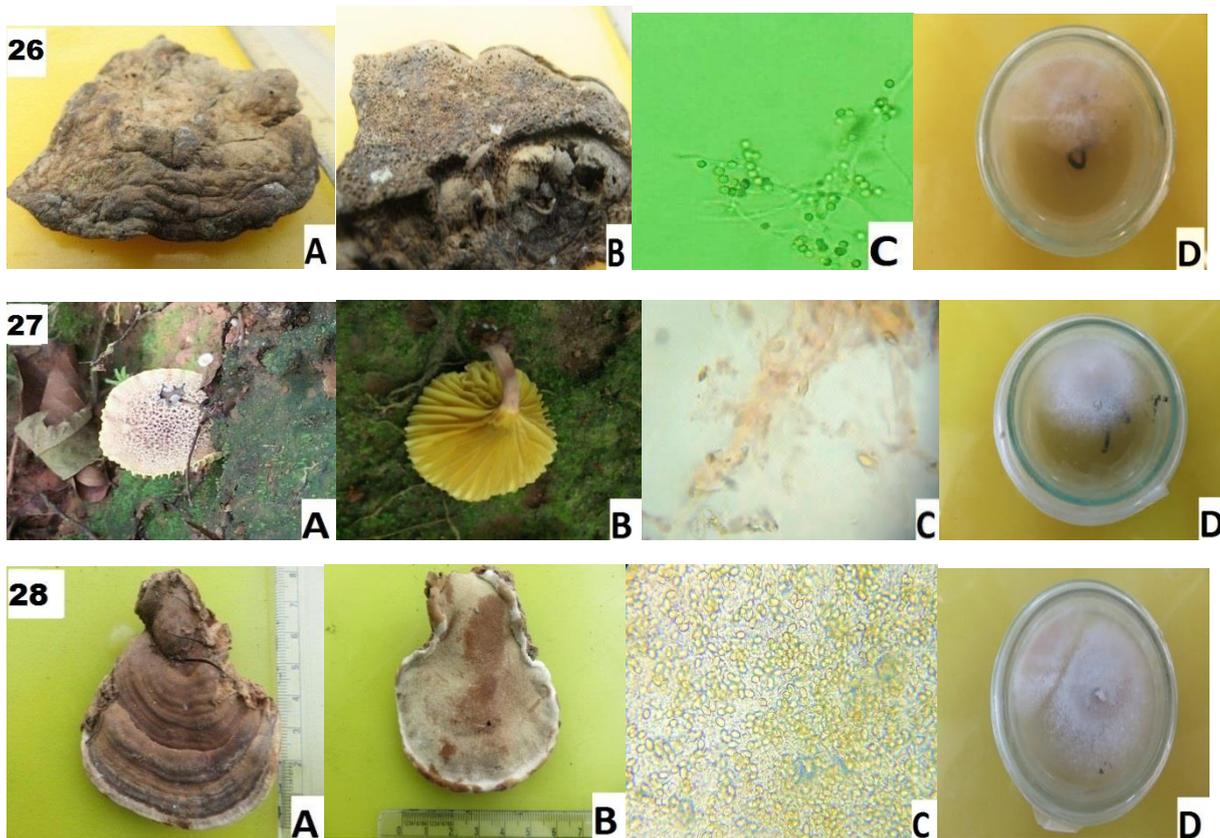


Figure 6: Basidiocarp and spore morphology of collected wild mushrooms from Gajni forest : 26.*Ganoderma pfeifferi*, 27. *Polyporus* sp, 28.*Polyporus lipsiensis*; (A. Fruiting Body, B. Gill, C. Spore, D. Culture growth in PDA).

4. Discussion

A wide range of mushrooms biodiversity was reported by Aminuzzaman and Das (2017) in mangrove forest region of Bangladesh and Marjana *et al.* (2018) in Chittagong Hill Tracts under Tropical Evergreen forest. Various species of mushrooms among the different forest region in Bangladesh was previously reported (Rumainul *et al.*, 2015; Rahaman *et al.*, 2016; Rashid *et al.*, 2016 and Rubina *et al.*, 2017).

In the present study 15 species of *Ganoderma* were recorded. *G. applanatum* was recorded in association with Shal tree with the frequency of 75% and density of 12.75%. It was first found in 1902 by American mycologist named William Murrill. Furthermore, *G. lucidum* and *G. lobatum* both were reported with the frequency of 25%, 50% and density of 5.25%, 10.75% respectively in Gajni forest under the tropical deciduous forest of Bangladesh. Geographical distribution of *Ganoderma* is also reported in Pan tropical species originally described from Venezuela, French Guyana (Steyaert, 1980), China, New Guinea and Egypt (Bilgrami *et al.*, 1991). Ryvardeen (1995) studied the morphology of 53 specimens of *G. lucidum* from Norway and he found large variation among the species. *G. boninense* and *G. tsugae* was reported in Gajni forest with the frequency of 50%, 60% and the density was 6.5%, 10.20% respectively. *G. fornicatum*, *G.*

tropicum, *G. feifferi* and *G. austral* species were found with the same frequency of 50% and the density were 7.75%, 8.50%, 3.5%, 5.5% respectively. *G. calidophilum* was found with the frequency of 60% and density of 10.5%. Moncalvo and Ryvarden published a world list of *Ganoderma* species in 1997. Taxonomy and diversity of *Ganoderma* species was also reported in Maharashtra India by Bhosle *et al.* (2010). Taxonomy and diversity of *Ganoderma* was also reported in India (Ram *et al.*, 2010; Thiribhuvanamala *et al.*, 2011; Dwivedi *et al.*, 2012) and in China (Wang *et al.*, 2012). The *Ganoderma* species were previously reported from tropical moist deciduous forest region of Bangladesh by Romainul *et al.* (2015). He found found *G. Lobatum* species in this area. In other study Marzana *et al.* (2018) found *G. lucidum* in Kaptai, Rangamati of Chittagong Hill tracts under tropical evergreen and semi-evergreen forest of Bangladesh. Tanjim *et al.*, (2019) reported *Ganoderma* species in tropical evergreen and semi-evergreen forest region of Bangladesh and Tanni *et al.*, (2020) also reported the species from forest tree of different parks and gardens of Dhaka city, Bangladesh.

Two species of Agaricaceae such as- *A. bitorquis* and *A. arvensis* was identified in association with the root zone of Shal tree (*Shorea robusta*) and soil surface having the frequency of 70%, 50% and density of 20.25% and 18.60%, respectively in the Gajni forest area. The top most density of *A. bitorquis* was 20.25% was observed in this survey. Agaricaceae was reported first by Sathe and Rahalkar (1975), providing a very exhaustive list of fungi from India and Nepal. Gray (1997) reported that *A. campestris* as common wild mushrooms in Europe and America. The genus *Agaricus* species was also reported by Tibuhwa (2011) in Tanzania. Furthermore, the genus *Agaricus* was also reported in south western region of Bangladesh as described by Rahaman *et al.* (2016).

Two species of Pluteaceae, namely *Volvariella golocephala* and *Volvopluteus gloiocephalus* was detected in Gajni forest with an association with humus having the frequency of 75%, 60% and density of 8.25% and 15.75% respectively. The top most frequency of *V. golocephala* was 75% was observed at the time of the survey. The genus *Volvariella* was reported by Natrajan and Kumar (1986) in N.W. Himalaya. The species *V. gloiocephala* and *V. gloiocephalus* was previously reported from the other part of tropical moist deciduous forest region of Bangladesh on the humus of moist soil as stated by Romainul *et al.* (2015).

Four species under the Polyporaceae family were identified as- *Trametes elegans*, *Trametes versicolor*, *Polyporus* sp and *Polyporus lipsiensis*. The frequency of *T. elegans* was 55% and the density was 5.25%. *T. elegans* was found on dead wood of Shal tree (*Shorea robusta*) in Gajni forest. *T. versicolor* and *Polyporus* sp. was found with the frequency of 10% and density of 2.25% for both species. *P. lipsiensis* was found with the frequency of 20% and density of 3.25%. This genus has a widespread distribution and contains fifty species (Kirk *et al.*, 2008). This genus was found in India (Thiribhuvanamala *et al.*, 2011). *T. versicolor* was reported in and around Bangalore (Karnataka) of India and found medicinal importance (Pushpa *et al.*, 2012).

Two species of *Russulaceae* was recorded as *Russula nobilis* and *Lactarius deliciosus* with the frequency of 10%, 50% and density of 3.25% and 10.75% respectively. The genus *Russula* sp. was also reported from India. Seven species of *Russula* was recorded in Southern Kashmir Himalayas. Two ectomycorrhizal species of genus *Russula* have been characterized and identified from Kashmir Himalaya using morpho-anatomical and molecular methods targeting its r DNA. A monograph on Russulaceae has been reported (Bhatt, 1986 and Lakhanpal, 2005). This species was already reported from Bangladesh in association with the Golden shower tree (*Acacia auriculiformis*) Rumainul *et al.* (2015) and Kalmegh (*Andrographis paniculata*) Rubina *et al.*, (2017).

Two species of Amanitaceae was recorded as *A. muscaria* and *A. excelsa* with the same frequency of 25% and density of 7.45% and 2.25%, respectively. In a previous collection from different parts of Himachal Pradesh six more species in Amanitaceae were collected bringing the total number to 18 in the N.W. Himalayas in India (Natrajan and Kumar, 1986). Chin (1988) recorded that twenty species of edible and poisonous mushrooms collected from forests in Sarawak, one of the poisonous mushrooms was *A. excelsa*. It was also reported from the other part of tropical moist deciduous forest regions-Dhaka, Gazipur, Bogra, Rajshahi, Pabna, Jaipurhat and Dinajpur of Bangladesh on the humus of moist soil as reported previously (Rumainul *et al.*, 2015).

One species of *Marasmiaceae* was recorded as *Gymnopus ioccephalus* with the frequency of 70% and density of 15.25%. The species was scattered in distribution with un-abundant in occurrence. It was reported in Madagascar as well as the Mascarenes (Antonín and Buyck, 2006). In Tasmania Horton (2006) found this species. It contains about 500 species (Kirk *et al.*, 2008). It was also reported by Farook *et al.* (2011) in India. Three species belongs to the genus *Marasmius* were reported from tropical moist deciduous forest region in Bangladesh (Rumainul *et al.*, 2015). Das *et al.* (2016) mentioned three species of *Marasmius* and Rahaman *et al.* (2016) found *Marasmius oreades* in Koira of Khulna district.

One species of *Gymnopilus purpuratous* under the Strophariaceae family was found in Gajni forest that is associated with Shal tree and the frequency was 35% and density was 5.15%. Karwa and Rai (2010) tapping this fungi biodiversity in Central India. Rashid *et al.* (2016) found this species with Mehogani tree in Barisal, Patuakhali, Borguna, Pirojpur, Jhalokhathi districts, which situated in the southern region of Bangladesh.

All the collected species were cultured on PDA and grows as whitish, fluffy or flat type, irregular mycelia which was reported previously (Tesfaw *et al.*, 2015).

5. Conclusions

In this survey, 30 mushrooms samples were collected and identified to 28 species belonging to 8 families where 5 species were found edible, 12 species had medicinal value and 11 species were inedible, poisonous

or unknown importance. Major distributed genera were *Ganoderma*, *Agaricus*, *Trametes*, *Volvariella* and *Amanita*. Dominant host was Shal tree (*Shorea robusta*). Gajni forest has diverse geographical and climatic conditions that make the region a natural habitat of mushrooms. Hence a timely research on the existing mushroom flora and their documentation and preservation is essential. This study thus recommends further research to explore the diversity and richness of the studied taxa in unstudied parts and in every part of the forest in different season or time. This survey helps further continuation to bring out the more findings with relevant information along with the present findings in future.

Competing interests

Authors have declared that no competing interests exist.

Author contributions

A. A. Joty conducted the research and wrote the article; **A. A. Joty, F. M. Aminuzzaman, A. Tanjina, D. R. B. Sonchita and M. N. Islam** collected mushroom samples from Gajni forest and analyze the data; **F. M. Aminuzzaman** designed and supervised the study and edited the manuscript; **N. Sultana** read the manuscript and contributed to the methodology of the study.

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