

Research Article

Occurrence, diversity and morphology of poroid wood decay by *Ganoderma* spp. from tropical moist deciduous forest region of Bangladesh

M. I. Mafia, F. M. Aminuzzaman*, Mohammad Salahuddin Mahmood Chowdhury and Jannatul Ferdous Tanni

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

*Correspondence: aminsaup@yahoo.com

*ORCID: <https://orcid.org/0000-0003-4804-0100>

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ABSTRACT

There are many hot spots in tropical moist deciduous forest region where wood decay fungi grow naturally. An investigation was carried out to collect, identify and preserve wood decay *Ganoderma* spp. on the basis of morphological characteristics from Pabna, Dhaka and Rajshahi under tropical moist deciduous forest region in Bangladesh during June to September 2016 and July to October 2017. This study was conducted to record the morphological variability, distribution, habitat and diversity of the *Ganoderma* population. A total of 40 *Ganoderma* samples were collected and identified to nine species under Ganodermataceae family. The samples were collected from the sites by walking through the area following standard method. The field data and laboratory analytical data was recorded during sample collection and in the laboratory, respectively. The highest density of occurrence (23%) was recorded for *Ganoderma lucidum* and *Ganoderma oregonense* followed by *Ganoderma applanatum* (20%), *Ganoderma praelongum* (19%), *Ganoderma lesklokorka* (18.5%), *Ganoderma pfeifferi* (17%), *Ganoderma boninense* (15%), *Ganoderma lipsiense* (13%) and *Ganoderma tsugae* (11%). The highest frequency of occurrence (10%) was recorded for *Ganoderma applanatum* and *Ganoderma oregonense* followed by *Ganoderma lucidum* (9%), *Ganoderma pfeifferi* (8%), *Ganoderma boninense* (8%), *Ganoderma praelongum* (7%), *Ganoderma lesklokorka* (7%), *Ganoderma tsugae* (6%) and *Ganoderma lipsiense* (5%). During survey, Koroi (*Albizia procera*), Aurjun (*Terminalia arjuna*), Sisso plant (*Dalbergia sissoo*), Neem (*Azadirachta indica*), Golden shower (*Acacia auriculiformis*) and Rain tree (*Albizia lebbek*) were found as hosts of *Ganoderma* spp. The specimens were preserved in the SAU Herbarium of Macro Fungi (SHMF) and might be useful in mushroom breeding and development program for medicine and food industry sector in future.

Keywords: Basidiocarp, *Ganoderma*, tropical moist deciduous forest, wood decay fungi

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INTRODUCTION

The term “Mushroom” is used mainly for the fruiting body produced by the macro-fungi: Ascomycota or Basidiomycota, of which some are edible, many are poisonous and non-

edible. More than 10,000 species of mushrooms are present in and around the world and about 2000 of them are considered as edible (Rumainul *et al.*, 2015). These edible fungi are more important for a tropical/subtropical country like Bangladesh, which has a climate, most congenial for the natural growth of such fungi (Purakasthya & Chandra, 1985). Mushroom have high nutritional value along with high proteins, vitamins, minerals, fibers, trace elements content and even low or more or less no calories and cholesterol contents. The number of recognized mushroom species has been reported to be 14000, which is about 10% of the total estimated mushroom species on the earth (Cheung, 2008). 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. 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 values (Chan, 1981; Chang & Miles, 1988).

Ganoderma is regarded as the ‘King of all herbs’ all around the world. *Gano* means shine, *Derma* means skin – it has shining skin which is of red color. *Ganoderma* is the greatest herb on earth which can enhance immunity to optimum levels. *Ganoderma* is a genus of polypore mushrooms that grow on wood, and include about 80 species, many from tropical regions (Kirk *et al.*, 2010). Because of their extensive use in traditional Asian medicines, and their potential in bioremediation, they are a very important genus economically. *Ganoderma* can be differentiated from other polypores because they have a double-walled basidiospore. They are popularly referred to as shelf mushrooms or bracket fungi. *Ganoderma* are characterized by basidiocarps that are large, perennial, woody brackets also called "conks". They are lignicolous and leathery either with or without a stem. The fruit bodies typically grow in a fan-like or hoof-like form on the trunks of living or dead trees. They have double-walled, truncate spores with yellow to brown ornamented inner layers. *Ganoderma*, more than 5000 years old, has various names. In China, it is known as Lingzhi, Japan – Reishi, Arab – Al Kam’ah, Indonesia – Jamur. It has more than 200 natural active elements, divided into three categories 30% water soluble elements, 65% organic soluble elements, 5% volatile elements. Another study (Rumainul & Aminuzzaman, 2016) recorded several *Ganoderma* species as *Ganoderma lucidum*, *Ganoderma boninense* (Growing stage); *Ganoderma tsugae*; *Ganoderma zonatum* (Young stage); *Ganoderma applanatum* and *Ganoderma resinaceum* from Bangladesh. They have high nutritive and medicinal values and contribute to a healthy diet, because of their rich source of vitamins, minerals and proteins (Garcha *et al.*, 1993). There are 38,000 varieties of mushroom found on earth. 36,000 are poisonous, 2,000 are edible, 200 are having special medicinal properties. Out of these 200 – top 6 have greatest medicinal properties. Therefore, it is essential to give efforts in introducing new mushrooms as a source of food and medicinal interest. The *Ganoderma* red mushroom has exceptional anti-stress qualities that can help improve memory, reduce tension and sharpen your concentration. The knowledge on biodiversity at the community and species level is more important for monitoring the effectiveness and effects of natural and artificial disturbances (Packham *et al.*, 2002). Data on their diversity in different vegetation types is important for planning and managing ecosystem biodiversity (Engola *et al.*, 2007). The biodiversity of mushroom is recently reported from the tropical moist deciduous forest region of Bangladesh (Rumainul *et al.*, 2015; Rumainul & Aminuzzaman, 2016). Tropical moist deciduous forest region is under about 80% of Bangladesh's rainfalls area during the

monsoon season extending from June to September. Collection and preservation of *Ganoderma* spp. is utmost important to improve the study of genetic diversity of collected specimen for future utilization. The survey was conducted to collect and identify *Ganoderma* spp. from Dhaka, Pabna and Rajshahi under tropical moist deciduous forest region of Bangladesh and to study distribution, diversity and habitat of collected specimen.

MATERIALS AND METHODS

Collection site

The survey was conducted in Dhaka, Pabna, Rajshahi biosphere reserved areas, which are situated in tropical moist deciduous forest region of Bangladesh (Figure 1). Survey and collection of *Ganoderma* spp. was conducted during rainy season starting from June to October, 2016 and 2017 because maximum macro fungi bloom when there is plenty of rainfall occurs. The collection sites were forests, residential area, botanical garden, parks and nearby villages of those above mentioned areas of tropical moist deciduous forest region where woody plants are available.

Sampling of *Ganoderma* spp.

The collection was made following a standard method of Hailing (Hailing, 1996). Systematic and periodical survey of different locations and other habitats were done in the tropical moist deciduous forest region of the country. Necessary materials and equipment such as isolation kit, slants, isolation chamber, data recording sheet, digital camera for photography, digging equipment, were arranged.

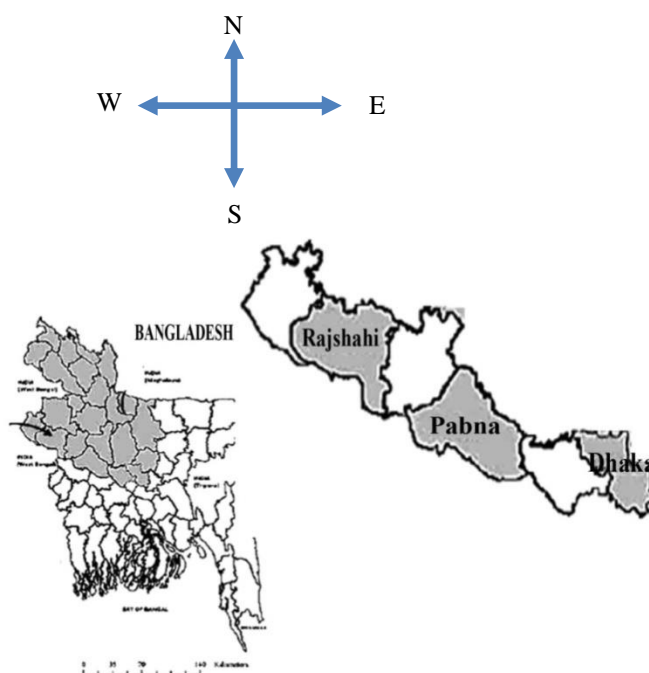


Figure 1. Survey area of tropical moist deciduous forest region of Bangladesh

Collection of samples was usually made during day time. Field characteristics of samples like locality, habitat, type of soil, forest type were recorded in the data sheet which was prepared

following the method of Molina (Molina *et al.*, 1995). Spotted samples were minutely inspected in their natural habitats and brought to laboratory for detailed study.

Morphological and analytical experiment

The collected specimens were brought to the laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh and the analytical experiments were done on the recording of data on morphological parameters used for identification such as size of the basidiocarp, umbo, scale, gills, color, gills edges, gill attachment, gill spacing, stipes, length, width, shape, type of veil, annulus (position), volva, carpophores shape, cap color, cap surface, cap margin, cap diameter, and spore diameter (Srivastova & Bano, 2010). The basidiocarps were rehydrated by soaking in water for few minutes before analyzing their morphology. Qualitative characters such as color, shape, and presence of hymenia were evaluated by eye observation while texture was determined by feeling the back and top surfaces using fingers (Svrcek, 2000). Most of the morphological data were recorded during collection period that is when the mushroom was in fresh form. For microscopic characters, permanent glass slides were made from rehydrated basidiocarps with the aid of a sharp surgical blade. Basidiocarps were immersed in cotton blue stain and glycerin and placed on glass slides and covered with cover slips. Motic compound microscope (40x) were used to observe the slides. Spore size was measured by Motic Images plus 2.0 software (Rumainul *et al.*, 2015). Final identification and classification were done by comparing recorded characteristics of mushrooms with the color dictionary of mushroom given by Dickinson & Lucas, (1982); the mushroom guide and followed by the reference of Jorden, (2000) and Pegler & Spooner, (1997).

Drying of samples

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

Preservation of samples

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

Habitat, distribution and diversity analysis

The specimens were found attached to various substrata. The surrounding environment temperature, moisture condition, vegetation and soil type was recorded for biodiversity of macro fungi.

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

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

Collected samples were wrapped in polybag and brought to the laboratory for their further study. The frequency and density of different species has been determined by using the above formulas (Zoberi, 1973).

RESULTS AND DISCUSSION

Biodiversity, distribution, morphological and ecological characterization of collected *Ganoderma* spp. are presented in Table 1 and Table 2. Photographs of the collected specimens were presented in Plate 1 and Plate 2. *Ganoderma* spp. are wood decay poroid macro fungi using for long time in industry and medicinal purposes. In the present study a total of 40 *Ganoderma* samples were collected and identified to nine species under Ganodermataceae family. The species were *Ganoderma applanatum*, *Ganoderma lipsiense*, *Ganoderma pfeifferi*, *Ganoderma tsugae*, *Ganoderma boninense*, *Ganoderma lucidum*, *Ganoderma oregonense*, *Ganoderma lesklokorka* and *Ganoderma praelongum*.

Ganoderma applanatum was recorded in association with *Terminalia arjuna* (Aurjun) where the recorded temperature was 28°C in the surveyed area. For the similarity in temperature, this species was also found in Chittagong and Rangamati Hill Tracts as well as in Sylhet and Moulvibazar under Tropical ever-green and semi-evergreen forest region. But the species was previously reported on *Acacia auriculiformis* (Rumainul *et al.*, 2015; Rubina *et al.*, 2017) and *Swietenia mahagoni* (Das & Aminuzzaman, 2017) and on *Dalbergia sissoo* (Aminuzzaman & Das, 2017) also. The density of its presence was 20%. *Ganoderma applanatum* was found in National Botanical Garden, Dhanmondi Lake and in National Zoo also in association with *Azadirachta indica* (Neem) with the frequency of 1.35-4.05% and density 1.5-3.76% (Tanni *et al.*, 2020). In a study Moncalvo & Ryvarden, (1997) published a world list of *Ganoderma* species. The study considered the species described in last 200 years listing 386 names for Ganodermataceae as whole. Taxonomy and 58 diversity of *Ganoderma lipsiense* and *Ganoderma applanatum* was also reported in India (Bhosle *et al.*, 2010).

Ganoderma lipsiense was recorded in association with Neem (*Azadirachta indica*) (Rubina *et al.*, 2017). The density of its presence was 13% and frequency was 5%. This species was recorded from national botanical garden, Dhaka with a density of 5% (Rubina *et al.*, 2017). *Ganoderma lipsiense* was found in National Botanical Garden and in Romna Park also with the frequency and density 2.70% and 1.5%, respectively (Tanni *et al.*, 2020). On the other hand, *Ganoderma lipsiense* was also reported from India in association with *Dalbergia sissoo* plant (Bhosle *et al.*, 2010; Dwivedi *et al.*, 2012) and in China (Wang *et al.*, 2012). In present experiment, this species was collected when the recorded temperature was 29°C. This species were also described from Modhupur under tropical moist deciduous forest and southern region of Bangladesh due to climatic similarity (Rashid *et al.*, 2017).

Table 1. Morphology of basidiocarp and characterization of basidiospore of collected *Ganoderma* spp. from tropical moist deciduous forest region of Bangladesh

Species name	Common name	Basidiocarp	Spore
<i>Ganoderma applanatum</i>	Lingzhi or Reishi mushroom	Pileus shape: Flat; dark brown color with the white at end of the edge; Length; 6.5 to 7.5cm and Width; 3.5 to 9 cm; Surface character: Dry in nature; Texture of the fruiting body: Woody, tough and brittle; Spore bearing surface under cap: Micro pores; Pores color: Whiten Pores; Pores spacing: Crowded, Stipe: Pseudo stipe present.	Spore size (Average): Length: 8.8µm and Width: 6.3µm; Spore shape: Ellipsoid, rough and moderately thick walled Spore Color: Dark brown
<i>Ganoderma lipsiense</i>	Lingzhi and Reishi mushroom	Pileus shape: Convex; dark brown to cocoa coloured, Length: 16cm and Width: 18cm; Surface character: Dry in nature; Margin: Incurved in shape and margin thick, coffee colour; Texture of the fruiting body: Corky and tough; Spore bearing surface under cap: Pores on hymenium; Pores color: Milky coffee; Pore spacing: Crowded.	Spore size: Length: 8 µm; Width: 6.3µm. Spore shape: Ellipsoid; smooth and thin walled Spore Color: Pale brown
<i>Ganoderma pfeifferi</i>	Lingzhi or Reishi mushroom	Pileus shape: Convex; Color: Black; Length: 3.8 to 7 cm and Width: 4.5 cm to 8.5 cm; Surface character: Dry in nature and blackish; Margin: Incurved in shape; Texture of the fruiting body: Woody and corky; Spore bearing surface under cap: Pores on hymenium; Pores color: Milky white in color	Spore size: Length: 7µm; Width: 5 µm. Spore shape: Ovoid; smooth and thick walled. Color: Brownish
<i>Ganoderma tsugae</i>	Reishi mushroom	Pileus shape: Flat; Color: Dark brown and white; Length: 8cm, Width: 6 cm; Surface character : Dry in nature; Texture of the fruiting body: Woody, tough and brittle; Spore bearing surface under cap: Micro pores; Pores: White; Pores spacing: Crowded Stipe: Present.	Spore size (Average): Length: 8.2µm; Width: 5.9µm; Spore shape: Ellipsoid, rough and moderately thick walled Color: Dark Brown
<i>Ganoderma tsugae</i>	Lingzhi or Reishi mushroom	Pileus shape: Finger to funnel shaped; Color: Brown; Length: 15 cm; Width: 10.5 cm; Surface character and zonation: Reddish yellowish and dry in nature; Margin: Incurved in shape; Texture of the fruiting body: Woody to corky; Spore bearing surface under cap: Pores on hymenium; Pores color: Yellowish to white in color; Pore spacing: Crowded; Stipe: Present; Size: 2.3 cm-3.3 cm., Shape: Equal; Color: Brick red	Spore size: Length: 6.9 µm; Width: 8.4 µm. Spore shape: Ellipsoid; smooth and thick walled Color: Brownish
<i>Ganoderma boninense</i>	Lingzhi or Reishi mushroom	Pileus shape: Concave; Color: White color cap, Length: 20 cm; Width: 6.5 cm, Surface character: Dry in nature, Margin: Incurved in shape; Texture of the fruiting body: Brittle and woody, Spore bearing surface under cap: Pores on hymenium, Stipe: Present; Size: 3.2 m. Shape; Equal; Position: Central; Color: Chocolatey; Firmness: Solid.	Spore size: Length: 7.7µm; Width: 4.0 µm. Spore shape: Elongated, smooth and thin walled Color: Brown

<i>Ganoderma lucidum</i>	Lingzhi or Reishi mushroom	Pileus shape: Flat; Color: Dark red with white border, Length: 6.5 to 8 cm; Width: 7.5 to 7 cm, Surface character: Brittle, reddish brown and dry in nature; Margin: Incurved in shape, thick and coffee color; Texture of the fruiting body: Corky to woody, Spore bearing surface under cap: Pores on hymenium; Pores color: Whitish; Pore spacing: Crowded; Stipe: Absent or short	Spore size: Length: 8.0 μm , Width: 6.6 μm . Spore shape: Ellipsoid; smooth and thick walled Color: Brown
<i>Ganoderma oregonense</i>	Lingzhi or Reishi mushroom	Whitish Pileus shape of cap was infundibuliform shaped; Size of fructification was 3.5 \times 4.5 cm; The color of pileus (cap) was grey. The cap edge was round and hardy. Beneath the cap hymenophores were absent. Regular shaped pores were present underside of the cap; The texture of the fruiting body was brittle and corky.	Spore size: Length: 8.0 μm , Width: 6.6 μm . Spore shape: Ellipsoid; smooth and thick walled Color: Brown
<i>Ganoderma lesklokorka</i>	Self forming white rot fungus	Pileus shape: Convex; Color: Dark brown to red colored; Length: 16 cm; Width: 18.5 cm; Surface character and zonation: Dry in nature, .Margin: Incurved in shape and margin thick, red color; Texture of the fruiting body: Corky and tough; Spore bearing surface under cap: Pores on hymenium; Pores color: white; Pore spacing: Crowded	Spore size: Length: 6.5 μm ; Width: 4.5 μm Spore shape: Ellipsoid; smooth and thin walled. Color: Pale brown
<i>Ganoderma praelongum</i>	Lingzhi or Reishi mushroom	Shape of cap was infundibuliform; Size of fructification was 3.5 \times 4.5 cm; The color of pileus (cap) was grey; The cap edge was round and hardy. Beneath the cap hymenophores were absent. Regular shaped pores were present underside of the cap; The color of pores was grey; Surface characters and zonation was dry.	Spore size (Average): 7.2 \times 4.6 μm . Spore shaped: Irregular shaped, smooth and single walled; Spore color: Hyaline
<i>Ganoderma</i> sp.	Lingzhi or Reishi mushroom	Pileus shape: Convex; Color: White; Length: 25.1 cm; Width: 15.2 cm; Surface character and zonation: Dry in nature, slightly zonate, solitary, crust and rigid; Margin: Incurved in shape and margin thick, white color; Texture of the fruiting body: Corky and tough; Spore bearing surface under cap: Pores; Pores color: white color; Pore spacing: Crowded.	Spore size: Length: 10.9 μm ; Width: 8.4 μm ; Spore shape: Ellipsoid, smooth and thin walled; Color: Pale brown









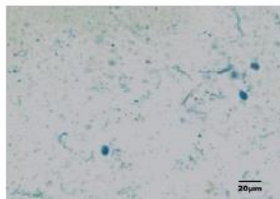


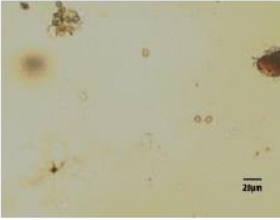


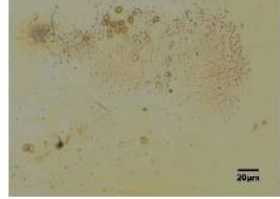


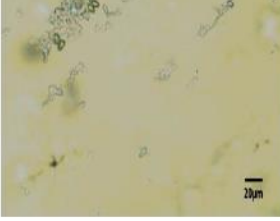
	Basidiocarp	Spore bearing surface under cap	Spores (100×)
<i>G. applanatum</i>			
<i>G. lipsiense</i>			
<i>G. pfeifferi</i>			
<i>G. tsugae</i>			
<i>G. tsugae</i>			
<i>G. boninense</i>			

Plate 1. Specimen collected from tropical moist deciduous forest region



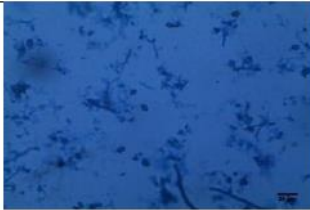


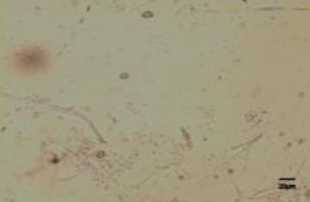


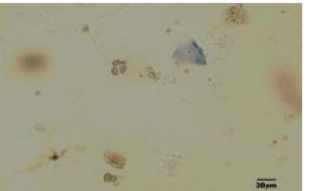


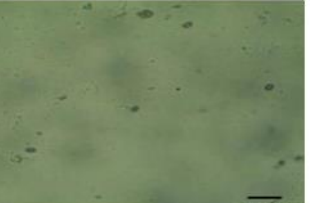


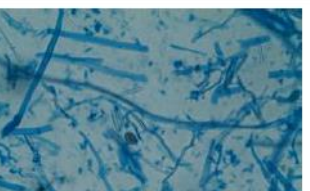
	Basidiocarp	Spore bearing surface under cap	Spores (100×)
<i>G. lucidum</i>			
<i>G. oregonense</i>			
<i>G. lesklokorka</i>			
<i>G. praelongum</i>			
<i>Ganoderma</i> sp.			

Plate 2. Specimen collected from tropical moist deciduous forest region

Ganoderma pfeifferi was recorded in association with the *Acacia auriculiformis* (Golden shower) (Rubina *et al.*, 2017). The density of its presence was 17%. This species was recorded from national botanical garden, Dhaka with a density of 35% (Rubina *et al.*, 2017). *Ganoderma pfeifferi* was found in National Botanical Garden and in Romna Park collected from the bark wood of *Dalbergia sissoo* (Sissoo) (Tanni *et al.*, 2020). On the other hand, *Ganoderma pfeifferi* was also reported in India (Bhosle *et al.*, 2010; Dwivedi *et al.*, 2012) and in China (Wang *et al.*, 2012).

Table 2. Ecological characterization of collected *Ganoderma* spp. from tropical moist deciduous forest region of Bangladesh

Species name	Host	Location	Habit	Frequency (%)	Density (%)	Temperature (°C)	Soil type	Weather conditions
<i>Ganoderma applanatum</i>	<i>Terminalia arjuna</i>	Dhaka	Scattered and unabundant	10	20	28	Sandy	Dry
<i>Ganoderma lipsiense</i>	<i>Azadirachta indica</i>	Pabna	Scattered and unabundant	5	13	29	Sandy	Moist
<i>Ganoderma pfeifferi</i>	<i>Acacia auriculiformis</i>	Dhaka	Scattered and unabundant	8	17	32	Loam	Moist
<i>Ganoderma tsugae</i>	<i>Terminalia bellirica</i>	Rajshahi	Scattered and unabundant	6	11	38	Sandy	Dry
<i>Ganoderma tsugae</i>	<i>Terminalia bellirica</i>	Dhaka	Scattered and unabundant	8	11	30	Loam	Moist
<i>Ganoderma boninense</i>	<i>Dalbergia sissoo</i>	Pabna	Scattered and unabundant	8	15	28	Loamy	Moist
<i>Ganoderma lucidum</i>	<i>Albizia procera</i>	Dhaka	Scattered and abundant	9	23	25	Loam	Moist
<i>Ganoderma oregonense</i>	<i>Terminalia arjuna</i>	Dhaka	Scattered and abundant	10	23	25	Loam	Moist
<i>Ganoderma lesklokorka</i>	<i>Samanea saman</i>	Pabna	Scattered and unabundant	7	18.5	33	Sandy	Moist
<i>Ganoderma praelongum</i>	<i>Terminalia arjuna</i>	Pabna	Scattered and unabundant	7	19	30	Loam	Moist
<i>Ganoderma</i> sp.	<i>Dalbergia sissoo</i>	Rajshahi	Scattered and unabundant	8	16	38	Loam	Moist

In current study, *Ganoderma pfeifferi* was found in association with *Acacia auriculiformis* with recorded temperature 32°C. This genus was also reported from Southern region and tropical ever-green and semi-evergreen forest region of Bangladesh due to common climatic conditions. The average temperature is 12.1-35.1°C, average annual rainfall is 195 cm in Southern region and in Tropical ever-green and semi-evergreen forest region (Rashid *et al.*, 2016; Tanjim *et al.*, 2019). The average temperature is 12.1-35.1°C, average annual rainfall is 195 cm and average relative humidity is 70-84% of the collection site in the present study.

Ganoderma tsugae was recorded in association with *Terminalia bellirica* (Bohera tree) (Aminuzzaman & Das, 2017; Rubina *et al.*, 2017). But this species was previously found in association with *Acacia auriculiformis* (Golden shower) (Rumainul *et al.*, 2015) under tropical moist deciduous forest region of Bangladesh. The frequency and density of it's presence was 6-8% and 11% respectively. Another survey found the density of this species

12.5% and frequency 50% under social forest region of Bogra (Aminuzzaman & Das, 2017). *Ganoderma tsugae* was found in National Botanical Garden, Romna Park, Dhanmondi Lake and in National Zoo associated with *Swietenia macrophylla* (Mahogany) tree (Tanni *et al.*, 2020). In other study (Rubina *et al.*, 2017) recorded its density 10% in national botanical garden, Dhaka. *Ganoderma tsugae* was also reported from India (Vyas *et al.*, 2014). This species was also found in southern forest region of Bangladesh for similarity in required climatic condition.

Ganoderma boninense was recorded in association with *Dalbergia sissoo* (Sisso) tree (Aminuzzaman & Das, 2017). But this species was also found in association with *Mangifera indica* from national botanical garden (Rubina *et al.*, 2017) and *Bambusa* sp. from tropical moist deciduous forest region of Bangladesh (Rumainul *et al.*, 2015). The frequency and density of its presence was 8% and 15%, respectively. Another survey found this species in social forest region of Bogra, Bangladesh with frequency of 75% and density of 43.5% (Aminuzzaman & Das, 2017). The pathogenicity of *Ganoderma boninense* was examined (Cooper *et al.*, 2011). This species was also seen in Chittagong and Rangamati Hill Tracts as well as in Sylhet and Moulvibazar forest region (Tanjim *et al.*, 2019). In tropical ever-green and semi-evergreen forest region, the average temperature is 12.1-35.1°C, average annual rainfall is 195 cm, average relative humidity is 70-84% recorded.

In the present study *Ganoderma lucidum* was recorded in association with *Albizia procera* (Koroi), *Terminalia arjuna* (Aurjun) and *Dalbergia sissoo* (Sisso plant) and which was supported by Aminuzzaman and Das (2017) and Rubina *et al.* (2017). Another study (Marzana *et al.*, 2018) found *Ganoderma lucidum* in association with *Tectona grandis* (Shegun) in Kaptai, Rangamati of Chittagong Hill tracts under tropical evergreen and semi-evergreen forest of Bangladesh. Other study (Rumainul *et al.*, 2015) found this species in association with *Leucaena leucocephala* (Ipil-Ipil) and *Acacia auriculiformis* (Golder shower) under tropical moist deciduous forest region of Bangladesh. The density of its presence was 19% and 23%. Another survey (Marzana *et al.*, 2018) found this species from Chittagong Hill tracts with a frequency and density of 11.11% and 2.78% respectively. There are three species were collected during the investigation, viz- *Ganoderma applanatum*, *Ganoderma tsugae* and *Ganoderma lucidum* on the bark of tree and on dead plant, *Ganoderma* sp. Among the species, the highest frequency of *Ganoderma tsugae* was 33.33% and the density was 95% (Rashid *et al.*, 2017). *Ganoderma lucidum* was found in every survey area associated with *Azadirachta indica* (Neem) (Tanni *et al.*, 2020). But another finding (Das & Aminuzzaman, 2017) described the species from Bogra district under social forest region of Bangladesh with a frequency and density of 75% and 25% respectively. This species was found from national botanical garden, Dhaka, Bangladesh with a density of 25%. The difference in frequency and density of the species might be due to the difference in geographic area of the collection sites (Rubina *et al.*, 2017). The morphology of 53 specimens of *Ganoderma lucidum* was studied from Norway and found large variation among the species (Ryvarden, 1995). This species was also recorded in mangrove forest region and Tropical ever-green and semi-evergreen forest region of Bangladesh due to resemblance in climatic requirements. In Mangrove forest region, the average temperature is 25.5°C, average annual rainfall is 164-200cm, average relative humidity is 80-90%. *Ganoderma oregonense* was recorded in association with *Terminalia arjuna* (Aurjun). The

calculated frequency was 10% and density 23%. One species of *Ganoderma* namely *Ganoderma lesklokorka* was recorded in association with *Albizia lebbeck* (Rain tree). The density of its presence was 18.5%. *Ganoderma lesklokorka* was reported as a new bluing species from Ohio and Bethany, West Virginia (Allen *et al.*, 2009). This was also reported in Germany (Passie *et al.*, 2002). *Ganoderma praelongum* was recorded in association with the *Terminalia arjuna* (Aurjun). But the species was previously reported on *Diospyros ebony* (Das & Aminuzzaman, 2017). *Ganoderma* spp. were recorded in association with the *Dalbergia sissoo* (Sisso plant) with the frequency and density of 9%, 8%, 18% and 16% respectively. Four species of *Ganoderma* were found during collection such as- *Ganoderma* spp., *Ganoderma tsugae*, *Ganoderma applanatum* and *Ganoderma boninense* from Sylhet division. The frequencies of collected of *Ganoderma* were 37.5, 12.5, 12.5% and the densities were 12, 24, 4%, respectively. The color of *Ganoderma tsugae* was dark brown and white, *Ganoderma applanatum* was dark brown and *Ganoderma boninense* was brick red. The spore size of *Ganoderma* spp. were $13.2 \times 8.9 \mu\text{m}$, $11.8 \times 8.7 \mu\text{m}$ and $9.2 \times 6.8 \mu\text{m}$, accordingly. These *Ganoderma* spp. were collected from soil, Mehogani (*Swietenia macrophylla*) and Shimul (*Bombax ceiba*) tree, respectively (Tanjim *et al.*, 2019). *Ganoderma* spp. were also found at Rajshahi, Pabna, and Dhaka, and Bogra districts of Bangladesh in tropical moist deciduous forest (Rumainul *et al.*, 2015). It was also reported in China (Wang *et al.*, 2012) and in India (Dwivedi *et al.*, 2012; Thiribhuvanamala *et al.*, 2011; Ram *et al.*, 2010).

CONCLUSION.

Forty *Ganoderma* samples were collected where nine species were identified under Ganodermataceae family. The highest density of occurrence (23%) was recorded for *Ganoderma lucidum* and *Ganoderma oregonense* collected from Dhaka region followed by *Ganoderma applanatum* (20%), *Ganoderma praelongum* (19%), *Ganoderma lesklokorka* (18.5%), *Ganoderma pfeifferi* (17%), *Ganoderma boninense* (15%), *Ganoderma lipsiense* (13%) and *Ganoderma tsugae* (11%). The highest frequency of occurrence (10%) was recorded for *Ganoderma applanatum* and *Ganoderma oregonense* obtained from Dhaka region followed by *Ganoderma lucidum* (9%), *Ganoderma pfeifferi* (8%), *Ganoderma boninense* (8%), *Ganoderma praelongum* (7%), *Ganoderma lesklokorka* (7%), *Ganoderma tsugae* (6%) and *Ganoderma lipsiense* (5%). This investigation emphasizes further analytical studies to know its survival techniques of macro fungi in the woody plants, their role in forest ecosystem and to search their edible, medicinal and toxic properties for industrial uses.

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Authors' contributions

This manuscript was prepared by M.I.Mafia. F.M. Aminuzzaman, M.S.M. Chowdhury and J.F. Tanni helped in preparation of this manuscript. F.M. Aminuzzaman finalized this manuscript and all authors approved the final version of this manuscript.

Conflict of author

The authors declare that there is no conflict of interest.

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