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RESEARCH ARTICLE

BIODIVERSITY, DISTRIBUTION AND MORPHOLOGICAL CHARACTERIZATION OF MUSHROOMS IN THE SOUTH WESTERN REGION OF BANGLADESH

M. Rahaman, F. M. Aminuzzaman* , M. B. Hossain, S. N. Rashid and M. I. Rumainul

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

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Corresponding Author

F. M. Aminuzzaman
E-mail:
aminsaupp@yahoo.com

Abstract

The south western region of Bangladesh is known as mangrove forest region, positioning at 22°55'N latitude and 89°15'E longitudes having a wide range of ecosystem. The present survey was conducted to record the biodiversity, distribution and morphological characterization of mushrooms of south western region of Bangladesh. The survey was conducted from June to October, 2014 in 5 districts namely Kushtia, Chuadanga, Jessore, Satkhira and Khulna. A total of 16 mushroom species belong to 10 genera, under 8 families were recorded during the survey. *Lepiota cristata* was found abundantly in the survey areas among the other collected species and it exhibited the maximum frequency of occurrence (25%), whereas the maximum density (13.51%) was recorded for *Hypholoma fasciculeare* and *Coprinellus micaceus*, followed by *Lepiota cristata*, *Coprinus comatus* and *Mycena californiensis* (10.81%). Furthermore, the density of *Gymnopilus purpuratus*, *Coprinus sterquilinus*, *Marasmius oreades*, *Hypholoma capnoides* and *Coprinellus plagioporus* were recorded as 8.10%. Moreover, *Lepiota cristata* was distributed in Daulatpur of Kushtia and Koira of Khulna districts in the south western region of Bangladesh. This is the first report of macro fungi biodiversity and their distribution in the south western region of Bangladesh.

Introduction:-

Mushrooms are seasonal fungi, which occupy diverse niches in nature and forest ecosystem. They predominantly occur during the rainy and spring seasons. Mushrooms are in fact the 'fruit' of the underground fungal mycelium. They are macromycetes forming macroscopic fruiting bodies such as agarics, boletes, jelly fungi, coral fungi, stinkhorns, bracket fungi, puffballs and bird's nest fungi. They are fleshy, sub fleshy or sometimes leathery, woody and bear fertile surface either on lamellae or lining the tubes, opening out by means of pores. The lamellate members are called agarics and the tube bearing poroid members, as boletes and polypores. Among fungi, Basidiomycotina in particular have attracted considerable attention as a source of new and novel metabolites with antibiotic, antiviral, phytotoxic and cytostatic activities. Mushrooms alone are represented by about 41,000 species, where approximately 850 species are already recorded from India (Deshmukh, 2004) mostly belonging to Agaricales, also known as gilled mushrooms (for their distinctive gills), or euagarics. The Agaricales has 33 extant families, 413 genera and over 13000 described species (Kirk *et al*., 2008). Basidiomycetes mushroom have been valued as both food and medicine for thousands of years. 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). Mushrooms not only treated as food, but also their wastage can be recycled into fertilizers and additives that utilized for tree plantations and improving soil conditions. They are low calorie food with very little fat and are highly suitable for obese persons (Hyseyin *et al.,* 2009). Many genera of mushrooms are edible and rich in essential nutrients, such as carbohydrates, proteins, vitamins, mineral, fat, fibers and various amino acids (Okwulehie and Odunze, 2004). A major chunk of the

population consume mushrooms, because of its easy availability, flavor, meaty taste and medicinal values (Moore and Chiu, 2001).The wild mushrooms are richer sources of protein and have a lower amount of fat than commercial mushrooms (Lillian *et al*., 2008). Wild mushroom protein also contains considerable amounts of non-essential amino acids, such as alanine, arginine, glycine, glutamic acid, aspartic acid, proline and serine. It can be used for the food to solve the malnutrition problem (Manandhar, 2003). Mushrooms generally possess most of the attributes of nutritious food as they contain many essential nutrients in good quantity (Fukushima, 2000).A number of reviews have been published on the nutritional value of mushrooms, so we shall not dwell on the subject here (Kurtzman, 1993; Kurtzman, 1995; Kurtzman, 1997).Therefore, it is essential to give an efforts to introduce new mushrooms as a source of food and medicinal interest (Suseem and Mary, 2013).

Mushroom species are the indicators of the forest life support system (Stamets, 2000). The presence or absence of fungal species is a useful indicator to assess the damage or the maturity of an ecosystem. Data on their diversity in different vegetation types is important for planning and managing ecosystem biodiversity (Engola *et al*., 2007). Forests of Bangladesh can be grouped into four broad categories depending on their location, nature and type of management like i) mangrove forest, ii) tropical evergreen and semi evergreen forest, iii) tropical moist deciduous forests and iv) village forest. The biodiversity of mushroom is recently reported from the tropical moist deciduous forest region of Bangladesh (Rumainul *et al*., 2015; Rumainul and Aminuzzaman, 2016). Survey on biodiversity and distribution of mushrooms in rest of the forest region is not available. 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). The present research investigation was conducted by a systematic survey in the south western region of Bangladesh that covers one part of mangrove forest region with the objective of identifying the mushrooms up to the genus and species level. Moreover, determining the diversity, distribution and habitat as well as morphology characterization of mushrooms from the south western region of Bangladesh.

Materials and methods:-

Collection Site:-

The south western region of Bangladesh is located between 22°55'N latitude and 89°15'E longitudes belongs to Kushtia, Chuadanga, Jessore, Satkhira and Khulna districts and about 9m to 10m above from the sea level. The collection sites were natural forests, university campus, colleges, farms, residential areas, roadside and nearby villages of the above mentioned districts.

Experimental Site:-

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

Sampling Procedure:-

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

Collection of Mushrooms:-

A detailed survey was carried out in Kushtia, Chuadanga, Jessore, Satkhira and Khulna districts under the south western region of Bangladesh (Fig. 1.) from June to October, 2014 to determine the morphological variability of mushroom's population following the methodology of Hailing, 1996. Furthermore, the spotted and fleshy mushrooms were minutely inspected, collected and brought to the laboratory for detailed inspection.

Morphological Observation during Collection:-

The data for the identification of mushrooms were recorded after collection on the following parameters, such as locality, habitat, type of soil, forest type, size of the fructification, carpophores shape, umbo, cap color, cap surface, cap margin, cap diameter, scale, gill color, gill edges, gill attachment, gill spacing, stipe length, width, color, shape, type of veil, annuls (position) and volva (Srivastava and Bano, 2010).

Mushroom Processing:-

The photographs were taken in different angles and some morphological data, viz. size of fructification, pileus diameter, stipe length and their color were recorded after the collection of mushrooms. Mushrooms were dried and processed following the predefined method (Kim, 2004).

Drying:-

Collected samples were cleaned and dried by using electrical air flow drier controlling the1000 voltage, which can easily remove the moisture content from the collected mushrooms within 3-7 hours with a regular interval basis power supply (15 minutes switch off and 30 minutes switching) depending on the structure and texture of the species (Kim, 2004).

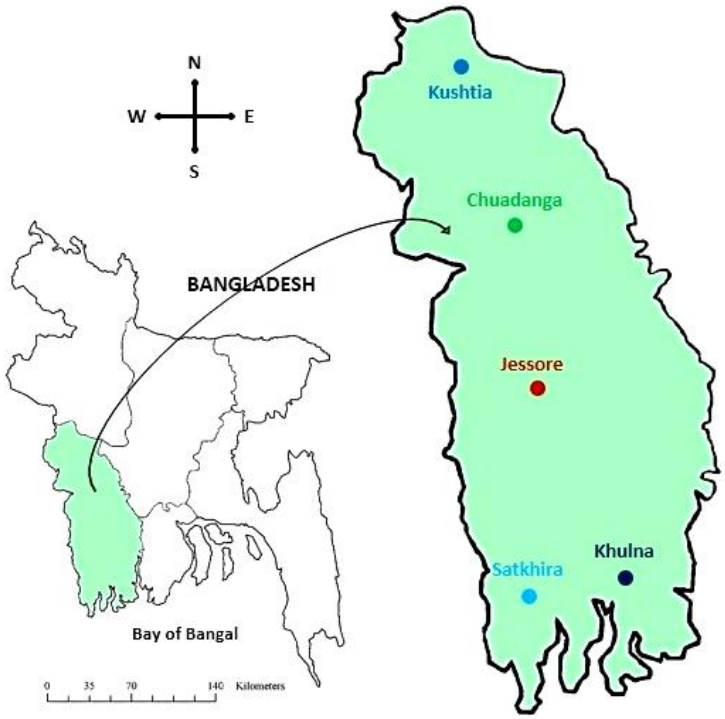


Fig. 1. Mushroom survey area in the south western region of Bangladesh.

Storage:-

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

Morphology and Microscopic Characterization:-

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

Habitat, Distribution and Diversity Analysis:-

The mushrooms were found in an association with various substrata. The surrounding environment, temperature, soil pH, moisture condition and vegetation were recorded for the biodiversity of mushroom. The soil pH and moisture were measured by pH meter. On the other hand, the air temperature was measured by thermometer during the collection. Collected samples were wrapped with polybag and brought into the laboratory for further study. The distribution of mushrooms on the locality was also recorded. The frequency and density of different species has been determined by the following formulas (Zoberi, 1973):

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

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

Results:-

The minimum and maximum temperature was 31°C and 36°C accordingly, during the survey. Furthermore, the average annual rainfall was about 1809.4mm.Throughout the survey, 16 mushroom species belong to 10 genera, under 8 families were identified (Fig. 2 to Fig. 5).The dominant tree species in the survey areas are Sisso (*Dalbergia sissoo)*, Rain tree (*Samanea saman*), Mehogoni (*Swietenia macrophylla)*, Babla *(Acacia nilotica)*, Koroi (*Albizia richardiana)*, Coconut (*Cocos nucifera),* Betal nut (*Areca catechu),* Akashmoni (*Acacia auriculiformis)*, Banyan *(Ficus benghalensis)* and Jackfruit *(Artocarpus heterophyllus*). Biodiversity, distribution and morphological characterization of collected mushrooms were described below:

1.1.*Gymnopilus purpuratus*

Family:- Cortinariaceae
Locality:- Laksmikhola, Kushtia (Daulatpur)
Temperature of the Location:- 34^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was pink and purple, Color (matured) was pink and purple, Length 3cm and width 1.6cm, Spore bearing surface under cap was gills (Plate 1).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was pinkish, surface characters and zonation was cracking. Pileus margin was regular, pileus cuticle was half peeling, texture of the fruiting body was spongy, and flesh odor was disagreeable. Lamellae present, gill attachment was adnexed, gill color was light brown, shape and width was moderately broad, gill spacing was close, lamellulae was present, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was pink, firmness was narrow, veil absent. Annulus (position) absent, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, ellipsoidal shaped and size of spore was 4.7-5.4×3.0-3.3µm.

Ecology:-
Habitat was on bark soil, forest type mixed, trees on which these mushrooms grow was *Cocos nucifera*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was more moist weather. Size of the fructification was 1.5× 1.6cm. The frequency of its presence was 12.5% and density was 8.10%.

1.2. *Agaricus silvicola*

Common name:- Wood mushroom
Family:- Agaricaceae
Locality:- Laksmikhola, Kushtia (Daulatpur)
Temperature of the Location:- 34^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was grayish, color (matured) was grayish, length 5cm and width 2cm, spore bearing surface under cap was gills (Plate 2).

Pileus:-
Cap of the carpophore size was convex, pileus color was grayish, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae present, gill attachment was sinuate, gill color was white, shape and width was moderately broad, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was solid, veil absent. Annulus (position) present, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, round to oval shaped and size of spore was 6.0-7.1× 4.0-4.2µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Cocos nucifera*, types of association was solitary and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 2.0×2.2cm. The frequency of its presence was 12.5% and density was 2.70%.

1.3.*Volvariella gloiocephala*

Common name:- Stubble Rosegill
Family:- Pluteaceae
Locality:- Faridpur, Jessore (Sadar)
Temperature of the Location:- 36^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was pink and purple, color (matured) was pink and purple. Length 5.5cm and width 3.9cm. Spore bearing surface under cap was gills (Plate 3).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was grayish, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was emarginate, gill color was pinkish, shape and width was broad, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was solid, veil absent. Annulus (position) absent, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was light brown, structure was single walled, smooth, oval shaped and size of spore was 4.9-5.6× 3.9-3.9µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow was *Swietenia mahagoni*, types of association was solitary and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 3.9× 3.7cm. The frequency of its presence was 12.5% and density was 2.70%.

1.4.*Volvariella volvacea*

Common name:- Straw mushroom
Family:- Pluteaceae
Locality:- Shankarchandra, Chuadanga, (Sadar)
Temperature of the Location:- 35^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was brown,color (matured) was brown. Length 10.6cm and width 9.4cm. Spore bearing surface under cap was gills (Plate 4).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was brownish, surface characters and zonation was leathery. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was free, gill color was pinkish, shape and width was broad, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness is tubular, veil present. Annulus (position) present, volva present, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was light brown, structure was single walled, smooth, oval shaped and size of spore was 7.0-8.2× 4.9-5.2µm.

Ecology:-
Habitat was base of the tree, forest type mixed, trees on which these mushrooms grow was *Musa acuminata*, types of association was solitary and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 9.4×9.1cm. The frequency of its presence was 12.5% and density was 5.40%.

1.5.*Volvariella hypopithys*

Family:- Pluteaceae
Locality:- Koira, Khulna
Temperature of the Location:- 33^0C
Division/Region:- Mangrove Forest

Macroscopic Characteristics:-
Color (young) was brown,color (matured) was brown. Length 5.4cm and width 3.2cm. Spore bearing surface under cap was gills (Plate 5).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was brownish, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was

disagreeable. Lamellae presence, gill attachment was emarginate, gill color was light brown, shape and width was moderately broad, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was light brown, structure was single walled, smooth, ellipsoidal shaped and size of spore was 12.1-13.0×7.6-8.4µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Bambusa vulgaris*, types of association was solitary, habit was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was clay loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 3.2×3.3cm. The frequency of its presence was 12.5% and density was 2.70%.

1.6.*Volvariella nigrovolvacea*
Family:- Pluteaceae
Locality:- Paisshabari, Shyamnagar, Satkhira
Temperature of the Location:- 31^0C
Division/Region:- Mangrove Forest

Macroscopic Characteristics:-
Color (young) was brown,color (matured) was brown. Length 10.8cm and width 7.9cm. Spore bearing surface under cap was gills (Plate 6).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was brownish, surface characters and zonation was leathery. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was emarginate, gill color was light brown, shape and width was broad, gill spacing was crowded, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was light brown, structure was single walled, smooth, round shaped and size of spore was 6.3-7.9× 5.9-6.7µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Ziziphus jujuba*, types of association was solitary and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was clay loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 7.9× 8.1cm. The frequency of its presence was 12.5% and density was 2.70%.

1.7. *Lepiota cristata*
Common name:- Stinking dapperling
Family:- Agaricaceae
Locality:- Refaitpur, Kushtia (Daulatpur) and Koira, Khulna
Temperature of the Location:- 33^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was white, color (matured) was white, length 3.5cm and width 1.7cm, spore bearing surface under cap was gills (Plate 7).

Pileus:-
Cap of the carpophore size was umbonate, pileus color was white, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was half peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae present, gill attachment was sinuate, gill color was white, shape and width was narrow, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was narrow, veil absent. Annulus (position) absent, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was light brown, structure was single walled, smooth, oval shaped and size of spore was 6.5-7.0× 4.6-4.8µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow was *Bambusa vulgaris*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 1.7× 1.5cm. The frequency of its presence was 25% and density was 10.81%.

1.8. *Coprinus comatus*

Common name:- Shaggy mane
Family:- Agaricaceae
Locality:- Faridpur, Jessore (Sadar)
Temperature of the Location:- 36^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was brown,color (matured) was brown. Length 10.6cm and width 6.5cm. Spore bearing surface under cap was gills (Plate 8).

Pileus:-
Cap of the carpophore size was conical, pileus color was brownish, surface characters and zonation was scaly. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was adnexed, gill color was deep brown, shape and width was moderately, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was fistulose, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, oval shaped and size of spore was 6.6-8.0×4.8-5.4µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Swietenia mahagoni*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 6.5× 6.2cm. The frequency of its presence was 12.5% and density was 10.81%.

1.9. *Coprinus sterquilinus*

Family:- Agaricaceae
Locality:- Faridpur, Jessore, (Sadar)
Temperature of the Location:- 36^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was white,color (matured) was white. Length 8.0cm width 3.5cm. Spore bearing surface under cap was gills (Plate 9).

Pileus:-
Cap of the carpophore size was ovate, pileus color was white, surface characters and zonation was smooth. Pileus margin was regular, pileus cuticle was half peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae present, gill attachment was adnexed, gill color was light black, shape and width was moderately broad, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was dark brown, structure was single walled, smooth, globose shaped and size of spore was 13.1-14.3× 9.9-10.4µm.

Ecology:-
Habitat was on humus, forest type mixed, trees on which these mushrooms grow were *Swietenia mahagoni*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam; factors affecting their distribution were moderately moist weather. Size of the fructification was 3.5× 3.3cm. The frequency of its presence was 12.5% and density was 8.10%.

1.10. *Marasmius oreades*

Common name:- Fairy ring mushroom
Family:- Marasmiaceae
Locality:- Koira, Khulna
Temperature of the Location:- 33^0C
Division/Region:- Mangrove Forest

Macroscopic Characteristics:-
Color (young) was light yellow, color (matured) was light yellow. Length 1.2cm and width 1.0cm. Spore bearing surface under cap was gills (Plate 10).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was light yellow, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was emarginate, gill color was light brown, shape and width was narrow, gill spacing was crowded, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was grey to light brown, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was light brown, structure was single walled, smooth, sub-globose shaped and size of spore was 5.0-5.4× 4.0-3.8µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Bambusa vulgaris*, habit was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was clay loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 1.0×0.9cm. The frequency of its presence was 12.5% and density was 8.10%.

1.11. *Hypholoma fasciculare*

Common name:- Clustered woodlover
Family:- Strophariaceae
Locality:- Munshigonj, Shyamnagar, Satkhira
Temperature of the Location:- 32^0C
Division/Region:- MangroveForest

Macroscopic Characteristics:-
Color (young) was brown,color (matured) was brown. Length 1.1cm and width 0.7cm. Spore bearing surface under cap was gills (Plate 11).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was brownish, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was adnexed, gill color was deep brown, shape and width was narrow, gill spacing was crowded, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, ellipsoidal shaped and size of spore was 7.6-8.7× 5.1-5.2µm.

Ecology:-
Habitat was on bark wood of the tree, forest type mixed, trees on which these mushrooms grow was *Cocos nucifera*, types of association was solitary, habit was scattered and constancy of occurrence of a particular mushroom in specific habitat was abundant. Type of soil was clay loam; factors affecting their distribution were moderately moist weather. Size of the fructification was 0.7× 0.8cm. The frequency of its presence was 12.5% and density was 13.51%.

1.12. *Hypholoma capnoides*

Family:- Strophariaceae
Locality:- Paisshabari, Shyamnagar, Satkhira
Temperature of the Location:- 32^0C
Division/Region:- Mangrove Forest

Macroscopic Characteristics:-
Color (young) was brown, color (matured) was brown. Length 2.3cm and width 1.2cm. Spore bearing surface under cap was gills (Plate 12).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was brownish, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was half peeling, texture of the fruiting body was soft and flesh odor was

disagreeable. Lamellae presence, gill attachment was adnexed, gill color was deep brown, shape and width was narrow, gill spacing was crowded, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, ellipsoidal shaped and size of spore was 7.4-8.6×5.3-5.3µm.

Ecology:-
Habitat was on bark wood of the tree, forest type mixed, trees on which these mushrooms grow were *Phoenix dactylifera*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was clay loam; factors affecting their distribution were moderately moist weather. Size of the fructification was 1.2× 1.3cm. The frequency of its presence was 12.5% and density was 8.10%.

1.13. *Coprinellus micaceus*

Common name:- Shiny Cap
Family:- Psathyrellaceae
Locality:- Laksmikhola, Kushtia (Daulatpur)
Temperature of the Location:- 34^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was pink and purple, color (matured) was pink and purple, length 6.0cm and width 2.2cm, spore bearing surface under cap was gills (Plate 13).

Pileus:-
Cap of the carpophore size was convex, pileus color was pinkish, surface characters and zonation was smooth. Pileus margin was regular, pileus cuticle was half peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae present, gill attachment was seceding, gill color was light brown, shape and width was moderately broad, gill spacing was close, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was absent, veil absent. Annulus (position) absent, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, ellipsoidal shaped and size of spore was 8.7-9.6×5.8-6.4µm.

Ecology:-
Habitat was on bark wood of the tree, forest type mixed, trees on which these mushrooms grow were *Artocarpus heterophyllus*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat is un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 2.2×2.5cm. The frequency of its presence was 12.5% and density was 13.51%.

1.14. *Coprinellus plagioporus*

Family:- Psathyrellaceae
Locality:- Moslempur, Kushtia (Daulatpur)
Temperature of the Location:- 33^0C
Division/Region:- Khulna

Macroscopic Characteristics:-
Color (young) was brown, color (matured) was brown, length 10.5cm and width 4.0cm, spore bearing surface under cap was ridges (Plate 14).

Pileus:-
Cap of the carpophore size was infundibuliform, pileus color was grayish, surface characters and zonation was cracking. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae absent.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was absent, veil absent. Annulus (position) absent, volva absent, scale absent, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was dark brown, structure was single walled, smooth, ellipsoidal shaped and size of spore was 10.1-11.7×5.9-6.6µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Artocarpus heterophyllus*, types of association was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 5.0 ×5.2cm. The frequency of its presence was 12.5% and density was 8.10%.

1.15. *Mycena californiensis*

Family:- Mycenaceae
Locality:- Koira, Khulna
Temperature of the Location:- 33^0C
Division/Region:- Mangrove Forest

Macroscopic Characteristics;-
Color (young) was red,color (matured) was red. Length 1.9cm and width 0.7cm. Spore bearing surface under cap was gills (Plate 15).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was red, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle is not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was emarginate, gill color was reddish brown, shape and width was narrow, gill spacing was crowded, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was red, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, sub-globose shaped and size of spore was 4.8-5.1× 3.7-3.1µm.

Ecology:-
Habitat was on soil, forest type mixed, trees on which these mushrooms grow were *Cocos nucifera*, habit was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was clay loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 0.7× 0.6cm. The frequency of its presence was 12.5% and density was 10.81%.

1.16. *Termitomyces heimii*

Family:- Lyophyllaceae
Locality:- Koira, Khulna
Temperature of the Location:- 33^0C
Division/Region:- Mangrove Forest

Macroscopic Characteristics:-
Color (young) was brown, color (matured) was brown. Length 8.4cm and width 2.4cm. Spore bearing surface under cap was gills (Plate 16).

Pileus:-
Cap of the carpophore size was unbonate, pileus color was brownish, surface characters and zonation was glabrous. Pileus margin was regular, pileus cuticle was not peeling, texture of the fruiting body was soft and flesh odor was disagreeable. Lamellae presence, gill attachment was seceding, gill color was reddish brown, shape and width was moderately broad, gill spacing was crowded, lamellulae was presence, forking pattern was unbranched.

Stipe:-
Stipe present, shape was equal, position was central, surface characteristic was moist, color and color changes was white, firmness was tubular, veil absent. Annulus (position) absent, volva absent, scale present, umbo present and convex well shaped.

Spore Morphology:-
The color of spore was brown, structure was single walled, smooth, oval shaped and size of spore was 10.9-11.8× 7.7-8.2µm.

Ecology:-
Habitat was on bark wood of the tree, forest type mixed, trees on which these mushrooms grow was *Bambusa vulgaris*, types of association was solitary, habit was scattered and constancy of occurrence of a particular mushroom in specific habitat was un-abundant. Type of soil was clay loam, factors affecting their distribution was moderately moist weather. Size of the fructification was 2.4×2.6cm. The frequency of its presence was 12.5% and density was 2.70%.

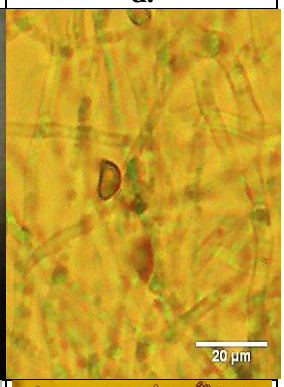
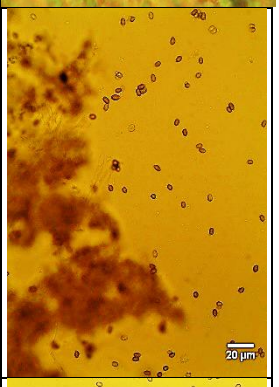
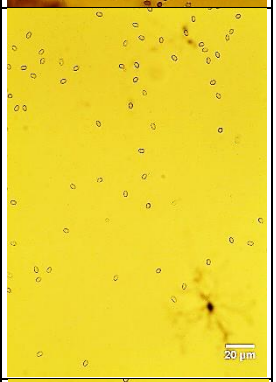
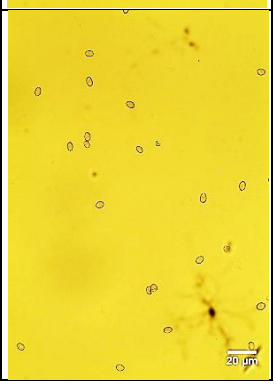
Plate no.	Name of the Mushroom (s)	Mature fruiting bodies of mushroom (s) from different angles			Spore (s) in 40x microscopic magnification
		a.	b.	c.	d.
1.	*Gymnopilus purpuratus*				
2.	*Agaricus silvicola*				
3.	*Volvariella gloiocephala*				
4.	*Volvariella volvacea*				

Figure 2. Pictures of fruiting bodies and spores of collected mushrooms.

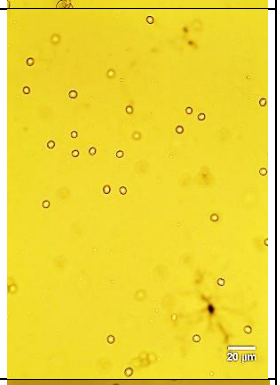
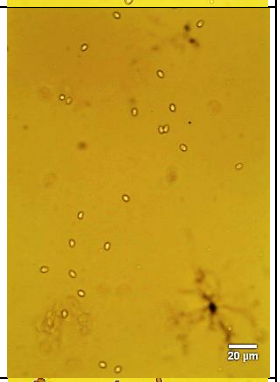
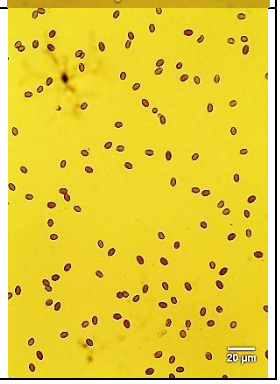
Plate no.	Name of the Mushroom (s)	Mature fruiting bodies of mushroom (s) from different angles			Spore (s) in 40x microscopic magnification
		a.	b.	c.	d.
5.	*Volvariella hypopithys*				
6.	*Volvariella nigrovolvacea*				
7.	*Lepiota cristata*				
8.	*Coprinus comatus*				

Figure 3. Pictures of fruiting bodies and spores of collected mushrooms.

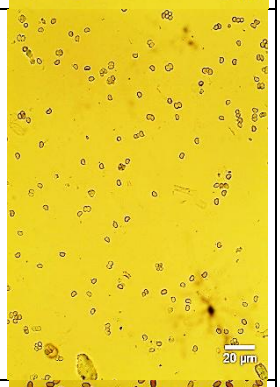
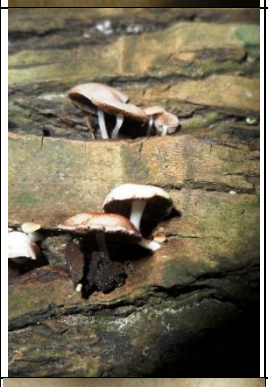
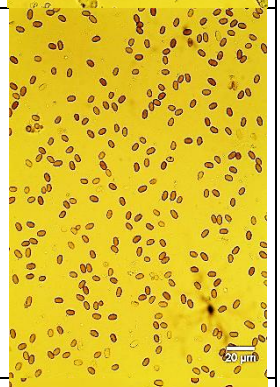
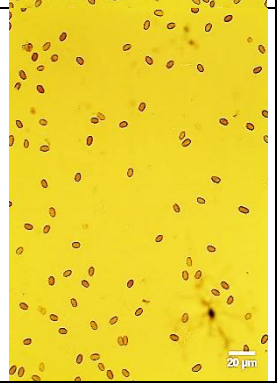
Plate no.	Name of the Mushroom (s)	Mature fruiting bodies of mushroom (s) from different angles			Spore (s) in 40x microscopic magnification
		a.	b.	c.	d.
9.	*Coprinus sterquilinus*				
10.	*Marasmius oreades*				
11.	*Hypholoma fasciculare*				
12.	*Hypholoma capnoides*				

Figure 4. Pictures of fruiting bodies and spores of collected mushrooms.

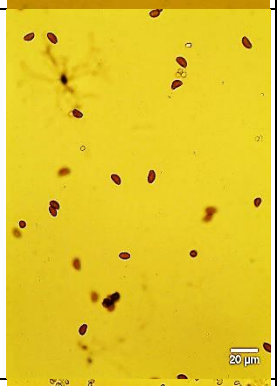
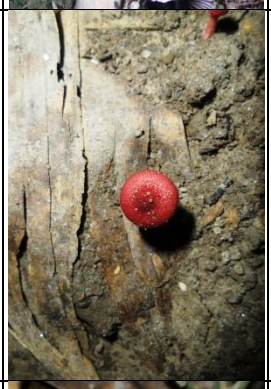
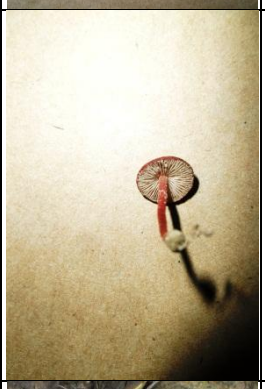
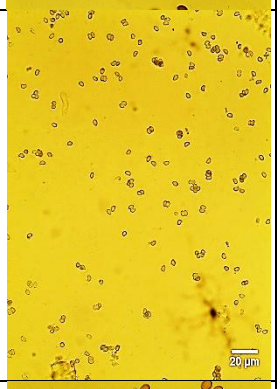
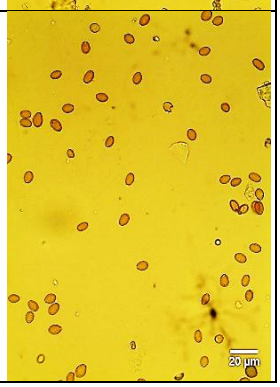
Plate no.	Name of the Mushroom (s)	Mature fruiting bodies of mushroom (s) from different angles			Spore (s) in 40x microscopic magnification
		a.	b.	c.	d.
13.	*Coprinellus micaceus*				
14.	*Coprinellus plagioporus*				
15.	*Mycena californiensis*				
16.	*Termitomyces heimii*				

Figure 5. Pictures of fruiting bodies and spores of collected mushrooms.

Discussion:-

A survey was conducted in five districts viz. Kushtia, Chuadanga, Jessore, Satkhira and Khulna of the south western region of Bangladesh from June to October, 2014 to record the morphological variability, habitat, distribution and biodiversity of mushrooms population. Throughout this survey one species of *Agaricus*, viz. *Agaricus silvicola* was identified, which was found in Daulatpur of Kushtia district in the south western region of Bangladesh having a frequency and density of 12.5% and 2.70%,respectively. This species was found in an association with *Cocos nucifera* tree. The genus *Agaricus* was also reported in India and Lagos State of Nigeria (Chandulal *et al*., 2013; Mohanan, 2011; Thiribhuvanamala *et al.*, 2011; Bankole and Adekunle, 2012).

Lepiota cristata was also found in Daulatpurof Kushtia and Koira of Khulna districts, having a frequency and density of 25% and 10.81%, respectivelyin an association with *Bambusa vulgaris* tree. The exact species was first reported by South African mycologist Christian Hendrik Persoon in 1797 (Chater and Brummitt, 1966). It was also reported from Bangladesh and India (Rumainul *et al*. 2015; Dwivedi et al. 2012; Thiribhuvanamala et al., 2011).

Furthermore, *Mycena californiensis* was found in Koira of Khulna district in an association with *Cocos nucifera* tree, having a frequency and density of 12.5% and 10.81%,accordingly. The genus *Mycena* was also reported in an association with *Swietenia mahagoni* tree from the previous investigation of tropical deciduous forest region of Bangladesh and also from the Lagos State of Nigeria (Rumainul *et al*., 2015; Bankole and Adekunle, 2012).

Marasmius oreades was found in Koira of Khulna district, having a frequency and density of 12.5% and 8.10%, respectively in an association with *Bambusa vulgaris*. About 500 species of *Marasmius* have been already identified around the world (Kirk et al., 2008).Three species of *Marasmius* including *M. oreades* were already reported from Dhaka district under the investigation of tropical deciduous forest region of Bangladesh (Rumainul *et al.*, 2015)andalso reported in Madagascar as well as in Mascarenes (Antonin and Buyck, 2006).

Coprinellus micaceus was found in Daulatpur of Kushtia district associated with *Artocarpus heterophyllus* tree with a frequency and density of 12.5% and 13.51%, accordingly. On the other hand, *Coprinellus plagioporus* was also found in Daulatpur of Kushtia district associated with *Artocarpus heterophyllus* tree with a frequency and density of 12.5% and 8.10%, respectively.

Three species of *Volvariella*, namely*Volvariella gloiocephala*, *Volvariella volvacea* and *Volvariella hypopithys* were found in Sadar sub-district of Jessore, Sadar sub-district of Chuadanga and Koira of Khulna districts in an association with *Swietenia mahagoni*, *Musa acuminata* and *Bambusa vulgaris* trees having a frequency of 12.5% of each and density of 2.70%, 5.40% and 2.70% respectively. Furthermore, one rare species named *Volvariella nigrovolvacea* was also found in an association with *Ziziphus jujube* tree. The species *Volvariella volvacea* and *Volvariella hypopithys* were also previously reported from the tropical moist decidious forest region of Bangladesh on the humus of moist soil (Rumainul *et al*., 2015) and Volvariella nigrovolvacea was reported in spain (Vila *et al.*, 1999).

Coprinus comatus and *Coprinus sterquilinus* were found in the Sadar sub-district of Jessore district associated with Swietenia mahagoni tree in the south western region of Bangladesh having a frequency of 12.5% each and density of 10.81% and 8.10%, respectively. The exact species of *Coprinus comatus* was reported from the Lagos State of Nigeria (Bankole and Adekunle, 2012) and Coprinus sterquilinus was also reported by Desjardin (Desjardinet al., 2015). Furthermore, the genus Coprinus was also reported in Bangalore, India(Pushpa and Purushothama, 2012).

Gymnopilus purpuratus was found in Daulatpur of Kushtia district in an association with *Cocos nucifera* tree at the south western region of Bangladesh, having a frequency and density of 12.5% and 8.10%, accordingly.

Hypholoma fasciculare and *Hypholoma capnoides* were found in Shyamnagar of Satkhira district in an association with *Cocos nucifera* and *Phoenix dactylifera* trees at the south western region of Bangladesh, having a frequency of 12.5% each and density of 13.51% and 8.10%, respectively. Different species under the genus *Hypholoma* was also reported (Smith, 1951).

Moreover, *Termitomyces heimii* was found in Koira of Khulna district in an association with *Bambusa vulgaris* trees at the south western region of Bangladesh, having a frequencyand density of 12.5% and 2.70%,accordingly. The

same species was recently reported from the tropical moist decidious forest region of Bangladesh on the humus of moist soil (Rumainul *et al*., 2015)

Conclusion:-

Throughout the present survey, 16 species of mushrooms belong to 10 genera under 8 families were identified. The predominant genera were *Volvariella*, *Coprinus*, *Hypholoma* and *Coprinellus*. The identified four species of *Volvariella* were *Volvariella gloiocephala*, *Volvariella volvacea*, *Volvariella hypopithys* and *Volvariella nigrovolvacea*, two species of *Coprinus* were *Coprinus comatus* and *Coprinus sterquilinus*, two species of *Hypholoma* were *Hypholoma fasciculare* and *Hypholoma capnoides* and two species of *Coprinellus* were *Coprinellus micaceus* and *Coprinellus plagioporus*. Furthermore, one species of each of *Gymnopilus purpuratus*, *Agaricus silvicola*, *Lepiota cristata*, *Marasmius oreades*, *Mycena californiensis* and *Termitomyces heimii* were recorded. The highest four species were found under Agaricaceae family and four species were found under Pluteaceae family. The final findings of this present survey emphasized on the importance and diversity of macro fungi at the south western region in Bangladesh. This survey needs further continuation in the near consecutive years to refine the more findings with relevant information along with the present findings. This study reported the existing of macro fungi biodiversity for the first time in the south western region of Bangladesh.

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