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Documentation of wild edible mushrooms from Meghalaya, Northeast India

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Abstract

The present study aimed to generate information on the mushroom diversity from Shyrwat and Upper Shillong Reserve Forests of Meghalaya, Northeast India. A total of 22 mushrooms were collected during the rainy season (July to September) 2014, and identified on the basis of macroscopic and microscopic characteristics. The mushrooms representing 16 genera, 14 families and 6 orders were identified. Based on the traditional knowledge obtained from local people, a total of 11 species, viz. *Armillaria mellea, Boletus edulis, Gomphus floccosus, Lactarius deliciosus, Lactarius indigo, Laccaria laccata,, Lactarius rubidus, Lentinus edodes, Ramaria formosa, Russula parvovirescens* and *Suillus bovinus* were found to be edible. Out of these 11 edible species, 7 species were first time recorded from the investigated areas. Therefore, detail morphological and microscopic characteristics of these 7 species are documented in this study.

Key words – *Boletus edulis – Lactarius deliciosus – Lentinus edodes – Russula parvovirescens*

Introduction

The state of Meghalaya is located in the Northeastern region of India. It lies between 25°5'-26°10' N latitudes, 89°47'- 92°47' E longitudes. The state occupies 22,429 km^2 and 15,657 km^2 of total geographical area and total forest area, respectively. Mushroom diversity was investigated in Shyrwat Reserve Forest and Upper Shillong Reserve Forest, consisting of a total area of 0.44 km^2 and 7.66 km^2. Both the Reserve Forests are situated in East Khasi Hills district and adjacent to each other,which lies at 25°44' 50.6" N, 91°53'20.1" E and 25°32' 52" N, 91°52'69" E respectively. Mushrooms are macrofungi with outstanding fruiting body that can be hypogeous or epigeous, large enough to be seen with the naked eye & can be picked by hand. (Chang ST & Miles 1992).These macrofungi producing prominent sporocarps are categorised as gilled fungi, bracket fungi, coral fungi, jelly fungi, birds nest fungi and puffballs (Bates 2006). These are considered as forest indicators as they indicate about the ecosystem damage or maturity (Stamets 2000). In the biological world; diversity, economic value and environmental importance of mushrooms occupy a prominent place (Sarma 2010). These non-wood forest resources, used by mycophilic societies, has been documented around the world (Harkonen et al. 1993, Jones & Whalley 1994, Chang & Lee 2004, Roberto et al. 2005).Wild edible mushrooms are a natural resource with a high nutritional value (Khaund & Joshi 2013) and one of the main resources for the development of drugs and nutraceuticals (Lakhanpal & Rana 2005). In addition to their pharmacological features, mushrooms are considered as essential food diet owing to their nutritional value consisting of high protein and low fat contents (Agahar & Subbulakshmi 2005). These

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macrofungi serves as an important dietary food in many countries (Gbolagade 2006). Mushrooms occupy a place above vegetables and below the high proteins in meat, fish and therefore can solve world's food scarcity problem (Boa 2004). In developing countries like India, mushrooms are the source of progress in the fields of food, medicine and unemployment (Khatun et al. 2011). In hilly regions of North East India, wild edible mushrooms are sold in the local markets, and thus provide provisions to the local villagers as well forest dwellers during the rainy season, when other non-timber forest products are unavailable in the forest (Harsh 2008). Studies on macrofungi have been an area of importance among scientists and in general people; for their specific role in human welfare, food industry, drugs and biodegradation (Ozturk et al. 2003). Many cultures have built up a convenient knowledge to find out which mushrooms are suitable to consume and which one are poisonous (Hobbs 1995). The use of wild mushrooms as food and medicine is well documented (Kaul & Kachroo 1974, Purkayastha & Chandra 1985, Bhatt & Lakhanpal 1988, 1989,Sarkar et al. 1988, Harsh et al. 1993, 1996, 1999, Kaul 1993, Rai et al. 1993, Boruah et al. 1996, Sharma & Doshi 1996, Sharda et al. 1997, Barua et al. 1998, Adhikary et al. 1999, Singh & Rawat 2000, Boruah & Singh 2001, Sagar et al. 2005, Sharma et al. 2009, Karwa 2010, Giri et al. 2012 & Semwal et al. 2014). Out of 14,000 species of mushrooms reported worldwide, about 1,200 species belonging to the order Agaricales, Boletales and Russulales are described from India, which contributes 10 percent of the global mushroom diversity (Thiribhuvanamala et al. 2011). Still the meticulous study of macrofungi with reference to their edibility and medicinal properties are yet to be properly explored (Jonathan & Fasidi 2003). A recent report indicates that about 1,105 to 1,208 species of mushrooms belonging to 128-130 genera have been documented and among these species, 300-315 species belonging to 75-80 genera are considered edible (Thiribhuvanamala et al. 2011). Knowledge about wild edible mushrooms and their nutritional value has been documented from Assam, Arunachal Pradesh, Nagaland, and Manipur in Northeast India (Sarma 2010, Tanti et al. 2011, Tapwal et al. 2013, Kumar et al. 2013, 2014, 2015), but limited reports are available from the state of Meghalaya (Barua 1998, Agrahar & Subbulakshmi 2005, Khaund 2013, Kabita et al. 2014). In Meghalaya, a huge diversity of macrofungi found growing on the forest-floor, twigs and branches, rotting plants and in mycorrhizal association with higher plants, etc. was earlier reported (Barua et al. 1998). The edible species reported from Meghalaya includes *Agaricus biosporus , Albatrellus sp., Boletus edulis,Cantharellus cibarius, Cantharllus floccosus, Craterallus odoratus, Clavaria aurea, Clavaria flava, Clavaria Cinerea, Gomphus floccosus, Laccaria lateritia ,Lactarius volemus, Lentinus edodes, , Ramaria boyrytis, Ramaria Formosa, Tricholoma Saponaceum ,Tricholoma viridiolivaceum* (Barua 1998, Khaund 2013, Kabita et al. 2014). Though the state is rich in mushroom diversity, owing to the lack of adequate knowledge on edible and poisonous nature, extensive consumption is hampered. Therefore, edible fungi of the region still need to be scientifically explored. Besides these; global warming, habitat destruction or overexploitation may pose negative effects on wild edible mushrooms. The present study is therefore designed to explore the diversity of wild edible mushrooms from the biodiversity rich state of Meghalaya.

Materials & Methods

Regular surveys were conducted during rainy season from July to September, 2014 in Shyrwat Reserve Forest and Upper Shillong Reserve Forest. Survey and sample collection was done following the method of Metzler 1992, Lodge et al. 2004 & Natrajan et al. 2005. After collection, samples were first stored in sterile labelled containers and brought to the laboratory for identification and preservation. Proper care was taken of the fleshy fungi to avoid distortion. The specimens were dried and stored in air tight plastic containers, properly labelled and naphthalene balls were added to avoid the damage caused by microfungi and bacteria. Soft textured wet specimens were preserved in 2% formaldehyde and the leathery wet textured samples were preserved in 4% formaldehyde, and kept in the laboratory of Rain Forest Research Institute, Jorhat, Assam. The identification of edible mushrooms were based on the morphological characters of the fruiting bodies following the guidelines mentioned in the websites, viz. www.mushromexpert.com, www.rogersmushrooms.com, http://lifehacker.com, http://www.wisegeek.com, http://www.soppognyttevekster.no, http://www.mnn.com, Manual of Common Edible Mushrooms(Christensen 1972) and scholarly article (Hall et al 2003). In addition to

this, the traditional knowledge provided by local people was also kept in mind. The frequency was calculated by the formula given below:

$$\text{Frequency of fungal species (\%)} = \frac{\text{Number of sites in which the species is present}}{\text{Total numbers of sites}} \text{ X100}$$

Results & Discussion

A total of 22 mushroom species were collected and identified. The identified species belongs to 14families, viz. Physalacriaceae, Suillaceae, Russulaceae, Hydnangiaceae, Gomphaceae, Amanitaceae, Marasmiaceae, Hymenochaetaceae, Inocybaceae, Boletaceae, Thelephoraceae, Hygrophoropsidaceae, Sclerodermataceae and Cortinariaceae. Out of 22 species, only 11 species, viz. *Armillaria mellea, Suillus bovinus, Lactarius deliciosus, Laccaria laccata, Lactarius indigo, Russula parvovirescens,Gomphus floccosus, Boletus edulis, Ramaria formosa, Lentinus edodes* and *Lactarius rubidus* that belongs to 7 families were confirmed as edible. Among these 11 edible species, 7 species were found to be unrecorded from this area. Detailed morphological and microscopic characteristics of these 7 species were carried out. Classification and frequency of all the species are presented in Table 1 and Table 2, respectively.

Table 1 Classification of identified mushroom species.

Scientific name	Family	Order	Identified species
Armillaria mellea	Physalacriaceae	Agaricales	*Armillaria mellea*
Suillus bovinus	Suillaceae	Boletales	*Suillus bovinus*
Lactarius deliciosus	Russulaceae	Russulales	*Lactarius deliciosus*
Laccaria laccata	Hydnangiaceae	Agaricales	*Laccaria laccata*
Lactarius indigo	Russulaceae	Russulales	*Lactarius indigo*
Russula parvovirescens	Russulaceae	Russulales	*Russula parvovirescens*
Lactarius rubidus	Russulaceae	Russulales	*Lactarius rubidus*
Ramaria Formosa	Gomphaceae	Gomphales	*Ramaria formosa*
Gomphus floccosus	Gomphaceae	Gomphales	*Gomphus floccosus*
Gomphus floccosus	Marasmiaceae	Agaricales	*Lentinus edodes*
Boletus edulis	Boletaceae	Boletales	*Boletus edulis*
Amanita pantherina	Amanitaceae	Agaricales	*Amanita pantherina*
Coltricia cinnamomea	Hymenochaetaceae	Hymenochaetales	*Coltricia cinnamomea*
Inocybe perlata	Inocybaceae	Agaricales	*Inocybe perlata*
Suillus sibricus	Suillaceae	Agaricales	*Suillus sibricus*
Thelephora penicillata	Thelephoraceae	Thelephorales	*Thelephora penicillata*
Lactarius scrobiculatus	Russulaceae	Russulales	*Lactarius scrobiculatus*
Russula emetica	Russulaceae	Russulales	*Russula emetica*
Inocybe sororia	Inocybaceae	Agaricales	*Inocybe sororia*
Hygrophoropsis rufa	Hygrophoropsidaceae	Boletales	*Hygrophoropsis rufa*
Scleroderma citrinum	Sclerodermataceae	Boletales	*Scleroderma citrinum*
Cortinarius sanguineus	Cortinariaceae	Agaricales	*Cortinarius sanguineus*

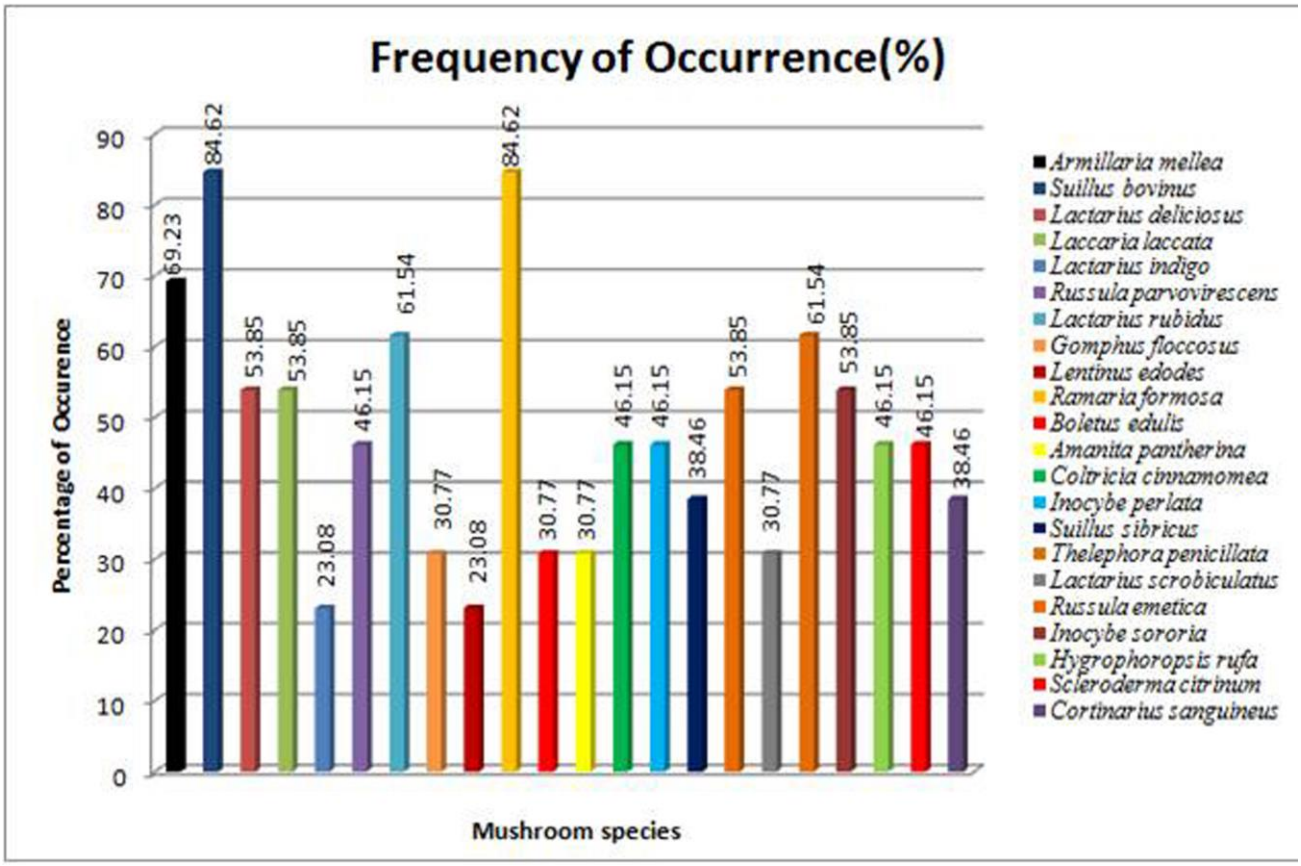

Fig. 1– Frequency of occurrence of mushroom species in Shyrwat Reserve Forest and Upper Shillong Reserve Forest, Meghalaya

The macroscopic and microscopic characters of seven identified wild edible mushrooms are discussed below.

***Lactarius indigo* Schwein. Fr., Epicrisis Systematis Mycologici: 341 (1838)** Fig. 2A

Pileus 4-15cm across, convex then depressed initially with an inward margin and sticky. Colour indigo blue when fresh, later fading to grey colour, turn deep green when cracked. **Stipe** 2-9 cm long, 1.5-3.0 cm thick becoming hollow, often tapered toward the base. **Gills** attached with the stipe and downward, close, colour of gills same as with the pileus or paler to yellowish at maturity, secrete latex when injured. Odour is mild. **Spores** broadly ellipsoid to subglobose, 6-8 x 4.5-7µm and reticulate, spores colour whitish.

Collection examined – India, Meghalaya, Upper Shillong Reserve Forest (25°32'52"N 91°52'69"E), scattered or in groups on soil in Pine forest, 12 August 2014, K. Kalita. (ML/RFRI/001).

***Laccaria laccata*(Scop.) Cooke, Grevillea 12 (63): 70 (1884)** Fig. 2B

Pileus 1.5–5.5cm across, convex then flattened, sometimes uplifted and finally wavy at margin, often with a central depression and margin smooth. Color reddish or orange brown and often change as it dries out. **Stipe** 2.5-9 cm long, up to 1.5 cm thick, equal or tapering to base, smooth or sometimes with fine hairs, colour same as the cap and hollow, often compressed or twisted. **Gills** pinkish, dusted white with spores when mature, attached to the stipe and close. **Spores** globose, spiny, 7–10µm in diameter, spines are 1-2 µm long and about 1 µm wide , spore colour white, cream or yellowish.

Collection examined – India, Meghalaya, Upper Shillong Reserve Forest (25°32'52"N 91°52'69"E), in cluster, on soil in Pine forest, 13 August 2014, R. Kumar. (ML/RFRI/019).

***Russula olivacea* (Schaeff.) Fr., Epicrisis Systematis Mycologici: 356 (1838)** Fig. 2C

Pileus 5–14cm across, globose, centrally depressed and olive green to brown in color. **Stipe** 3-6 cm long, 1.5 -2.5 cm thick, white coloured and smooth, brownish around the base. **Gills** attached with the stem and downward, close, cream to pale yellow, often bifurcate near the stem. **Spores** 7–10 X 6–8 µm, elliptical with spines, up to 1.5 µm high, sometimes reticulate.

Collection examined – India, Meghalaya, Shyrwat Reserve Forest (25°44'50.6"N 91°53'20.1"E), in dense clusters, around trunks, in Pine forest, 07 July 2014, S. Pandey. (ML/RFRI/081).

***Lactarius rubidus* var. rubidus Hesler & A.H. Sm., North American species of Lactarius:505(1979)** Fig. 2D

Pileus 2-7 cm across, convex with a slightly inward margin at early stage, turns flat when matured, occasionally with a small umbo and somewhat wrinkled, normally with a depressed disc, the margin wavy and sometimes uplifted, surface smooth, fragile, colour reddish brown to orange, secrete watery latex when cut. **Stipe** 2.5**–**5 cm tall, 0.5**–**1.5 cm thick, tapered to slightly narrowed base, fragile, hollow at maturity, same as cap colour or somewhat paler, often with orange colored hair at the base. **Gills** attached to the stem and running slightly downward, close, pale pinkish-brown coloured, secret watery latex when cracked. **Spores** 6**–**7.5 µm, globose to subglobose, reticulate ornamentation, spore colour slightly yellowish.

Collection examined – India, Meghalaya, Upper Shillong Reserve Forest (25°32'52"N 91°52'69"E), scattered in humus, rotting wood, in Pine forest, 22 September 2014, R.N.Bezbaroa. (ML/RFRI/95).

***Suillus bovinus* (L.) Roussel, Flore du Calvados et terrains adjacents, composée suivant la méthode de Jussieu: 34 (1806)** Fig. 2E

Pileus 3–10cm, convex, yellow colored with a distinct white margin, slimy or sticky. **Stipe** typically 6 to 10 mm in diameter and 5 to 8cm tall, brown colored and rusty. **Pores** are yellow, becoming grey-green and turning darker when injured, tubes reddish grey. Shape of pores large, angular, compound, pores are gradually more elongated towards the stem. **Spores** ellipsoid subfusiform, 8–10 x 3–4 µm. Spore color light to dark brown.

Collection examined – India, Meghalaya, Shyrwat Reserve Forest (25°44'50.6"N 91°53'20.1"E), in cluster or scattered, in Pine forest, 07 July 2014, R. Kumar. (ML/RFRI/004).

***Lactarius deliciosus* (L.) Gray, A natural arrangement of British plants 1:624 (1821)** Fig. 2F

Pileus 3–10cm across, convex then slightly funnel-shaped, concentric bands on surface, becoming slight greenish, colour pale yellowish to dull greyish green. **Stipe** 5 to 7cm long and 1.5 to 2cm diameter, slightly sticky and hollow, orange coloured, depressions with green patches occurs. **Gills** slightly decurrent, closely spaced, pale pinkish becoming dull, secrets colored latex when cut. **Spores** elliptical, reticulate with thin to thick ridges forming a network, 7–9 x 6–7 µm, colour white, creamy or yellowish.

Collection examined – India, Meghalaya, Upper Shillong Reserve Forest (25°32'52"N 91°52'69"E), solitary or in groups, on soil, in Pine forest, 12 August 2014, K. Kalita. (ML/RFRI/048).

***Russula parvovirescens* (Schaeff.) Fr., Anteckningar öfver de i Sverige växande ätliga svampar: 50 (1836)** Fig. 2G

Pileus 5–15cm across, round, later convex with a depression, velvety, finally pulling down, often wavy but sometimes uplifted, creamy white in color with grey patches on surface. **Stipe** 3.5 to 8 cm long and 1.5 to 3 cm thick, whitish to pale cream, browning slightly, but later fades. **Gills** almost free, cream coloured, somewhat fragile, initially attached to the stem and get free from the base at maturity. **Spores** ellipsoid to subglobose with warts, 5–8 × 4.5–6 µm and reticulated or partially reticulated, spore colour creamy white.

Fig. 2 − A, *Lactarius indigo.* B, *Laccaria laccata* . C, *Russula olivacea.* D, *Lactarius rubidus*. E, *Suillus bovinus* . F, *Lactarius deliciosus.* G, *Russula parvovirescens*

Collection examined – India, Meghalaya, Shyrwat Reserve Forest (25°44'50.6"N 91°53'20.1"E), solitary, on ground, in Pine forest, 6 July 2014, S. Pandey. (ML/RFRI/034).

Table 2 Edibility and frequency of occurence of identified wild mushrooms.

Scientific name	Edibility	Frequency of occurrence
Armillaria mellea	Edible	69.23
Suillus bovinus	Edible	84.62
Lactarius deliciosus	Edible	53.85
Laccaria laccat	Edible	53.85
Lactarius indigo	Edible	23.08
Russula parvovirescens	Edible	46.15
Lactarius rubidus	Edible	61.54
Gomphus floccosus	Edible	30.77
Lentinus edodes	Edible	23.08
Ramaria Formosa	Edible	84.62
Boletus edulis	Edible	30.77
Amanita pantherina	Inedible	30.77
Coltricia cinnamomea	Inedible	46.15
Inocybe perlata	Inedible	46.15
Suillus sibricus	Inedible	38.46
Thelephora penicillata	Inedible	53.85
Lactarius scrobiculatus	Inedible	30.77
Russula emetica	Inedible	61.54
Inocybe sororia	Inedible	53.85
Hygrophoropsis rufa	Inedible	46.15
Scleroderma citrinum	Inedible	46.15
Cortinarius sanguineus	Inedible	38.46

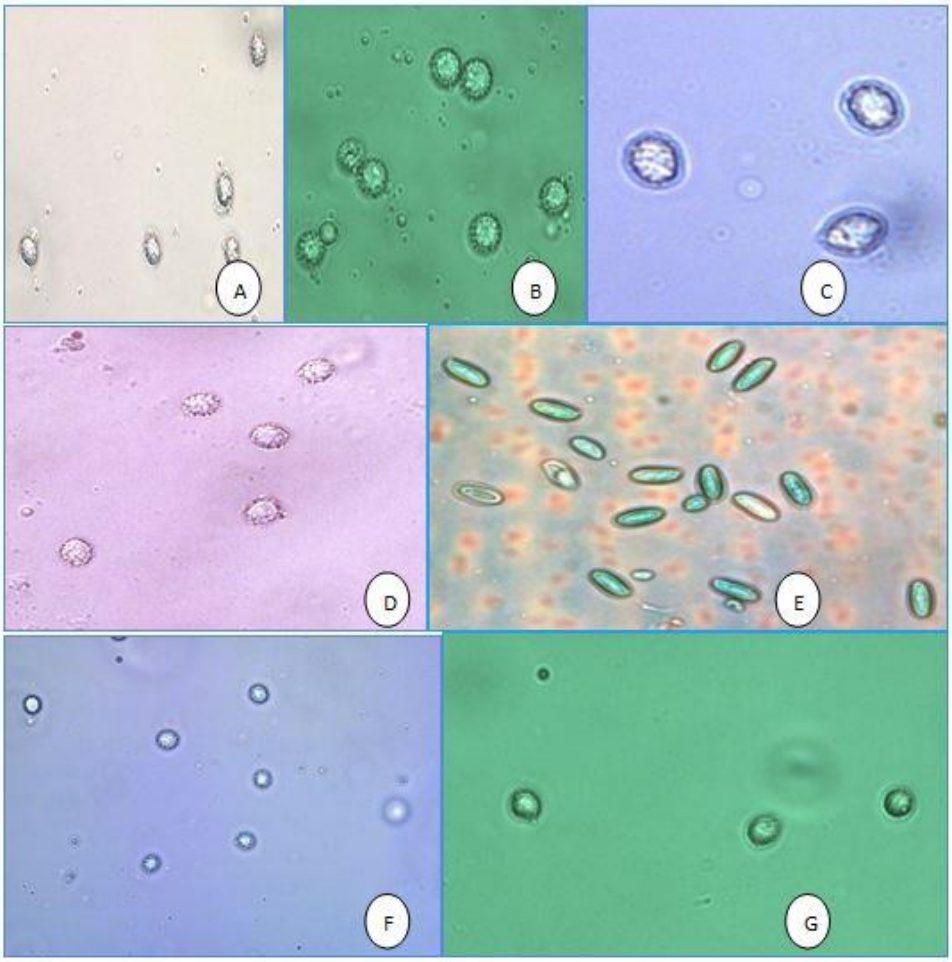

Fig. 3 – Spores − A, *Lactarius indigo.* B, *Laccaria laccata.*C, *Russula olivacea.* D, *Lactarius rubidus.* E, *Suillus bovines.* F, *Lactarius deliciosus.* G, *Russula parvovirescens.*

Conclusion

The rational utilization and sustainable development of key resources have the potential influence on the survival and economic prosperity of various ethnic people in the states like Meghalaya of Northeast India; therefore conservation and sustainable utilization of biological resources is the major concern in this region. Wild edible mushroom are such kind of biological resources that needs to be explored and conserved for providing livelihood opportunities. Unfortunately, shifting cultivation, urbanisation, population growth and deforestation, has led to biodiversity loss in most of the Northeastern states of India. Therefore, these wild edible macrofungi are under serious threat as their natural habitat has been disturbed. Hence, it has become necessary to scientifically document and characterize the wild edible macrofungi that are slowly vanishing. Though a few edible mushrooms have been reported from Meghalaya; the region as such still remains to be entirely unexplored. Further investigations are required to unveil the macrofungal diversity that may provide better understanding on the species diversity of these wild edibles.

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