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Biodiversity of edible mushrooms in Vindhya forest of northern India

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ABSTRACT

Various fleshy fungi are traditional food use which were collected from Vindhya forest region and other location for their morphological characterization. Present study deals with the diversity of fleshy fungi in Vindhya forest of northern India. Vindhya forest region is very common for diversity of fleshy fungal population. Extensive surveys were conducted from July 2012 to September 2012 and July 2013 to September 2013. The fleshy fungi were collected date wise as per as possible correct scientific name with citation of authors name and taxonomic position. Some other information also recorded such as collecting date and place, habit, single/ branching and growing substrates. The fleshy fungi were collected during this study included eight species of *Pleurotus,* two species of *Volvariella*, *Lentinus, Lycoperdon* and *Agaricus* and one species of *Cococybe, Calocybe, Flammulina, Tricholoma, Auricularia, Hypomyces, Armillaria, Russula* and *Ganoderma.*

Key-words: *Agaricus,* Diversity, Fleshy fungi, Taxonomy, Vindhya forest

Edible mushroom are the special product of the forest. The diversity of mushroom and their natural beauty inhabit major threat in the biological world and India has been a frame for these fungi. Describing the number of fungi on earth was a position of conversation and several studies have focused on enumerating the world's fungal diversity (Crous *et al.* 2006). Only a part of total fungal wealth has been subjected to scientific study and mycologists continue to disentangle the unknown and hidden wealth one third of fungal diversity of the globe exists in India and of this only 50% are characterized until now (Manoharachary *et al.* 2005). Mushrooms have been extensively studied in the western countries, while tropical countries like India especially in Vindhya forest of northern India these were less explored the range and diversity of basidiomycetes fungi were found more in Vindhya region. However, no determined efforts were made for a detailed study of them. Till today no research have been done on natural mushroom flora. Further attempt on isolation, characterization and maintenance of cell mycelial culture both *in vitro* and *ex vitro* yet to carry out. Mean while in Vindhya region several mushrooms were reported and described on morphological basis by the various workers (Rahi 2001). The main objectives was to typical diversity of fleshy fungi, characterize, collect preserve and evaluate edibility of these different species in dry deciduous forest of Vindhya region of northern India.

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MATERIALS AND METHODS

The field survey was conducted for collection of various fleshy fungi from different localities of the Vindhya forest which is situated in northern India. Vindhya forest is situated between 23°52'N and 31°28'N latitudes and 77°3' and 84°39'E longitudes. It has an average elevation between 313 and 483 m (Sagar and Singh 2004). The mushroom surveys depend on timing and location of observations. The collected mushrooms were studies for their macroscopic and microscopic details habitat, habit, morphology and other phenotypic parameter noted in fresh form (Nage *et al*. 1991, Maerz and Paul 1930). The survey methods were adopted according to techniques adopted by Natrajan *et al.* (1981), Susan Metzler and Van Metzaler (1992). Standard methods of collection, preservation, macroscopic and microscopic observations were recorded. Colour terms and notations from Maerz and Paul (1930) parts of each collection was preserved as wet form in FAA solution in glass jars and dried specimens in the department. Crystal of 14-dichlorobenzene was used to protect dried specimens against insect infestation. Some collected edible fleshy fungi were also cultured and maintained for further studied. The map of collection locality was sketched with GPS coordinate. The collection information like, Collection place and season, habit, single/ group (bunch) and growing substrate were noticed during collection of edible mushrooms.

The survey of Vindhya forest habitats of systematic and periodical were undertaken during July 2012 to September 2012 and July 2013 to September 2013. Required materials and equipments such as isolation kit, slants, petri-dishes containing different medium, isolation chamber, typed data

Table 1 Collection of edible mushrooms from Vindhya forest region and other locations

Collection month and year	Collection place	Habit	Single/Bunch	Growing substrate	Order	Family	Common name	Genus and species
July 2012	Chakia, Chandauli	Collybeoid	Single	Lawns, fields, grassy areas	Agaricales	Bolbitiaceae	Tecnus	*Cococybe cyanopus* (Atk.) Kuhner
July 2012	Chunar, Mirzapur	Boletoid	Single	Peat moss and leaf fall of forest	Agaricales	Agaricaceae	Common puffball/ Rugra	*Lycoperdon giganteum* (Pers.)
Aug 2012	Adalpura, Mirzapur	Inocybeoid	Single	Bargad tree	Agaricales	Lyophyllaceae	Dudhiya Khukhuri	*Calocybe indica* (Puk.)
Aug 2012	Windom fall park, Mirzapur	Volverielloid	Single	Peat moss	Agaricales	Pluteaceae	Paddy straw	*Volvariella volvacea* (Singer.)
Aug 2012	Windom fall park, Mirzapur	Pleurotoid	Bunch	Mango tree	Agaricales	Pleurotaceae	Tree mushroom	*Pleurotus flabellatus* (P.Kumm.)
Sept 2012	Jakhini, Mirzapur	Pleurotoid	Bunch	Sal tree	Agaricales	Pleurotaceae	Pearl oyster mushroom	*Pleurotus ostreatus*(Fr.)
Sept 2012	Belahara, Mirzapur	Pleurotoid	Cluster	Ficus tree	Agaricales	Pleurotaceae	Tree ear mushroom	*Pleurotus florida* (Fr.)
Sept 2012	Barkachchha Khurd, Mirzapur	Pleurotoid	Bunch	Mango tree	Agaricales	Pleurotaceae	King oyster mushroom	*Pleurotus eryngii* (DC.) Quel.
Sept 2012	Barkachchha Kala, Mirzapur	Agaricoid	Bunch	Standing dead wood	Agaricales	Physalacriaceae	Enokitake	*Flammulina velutipes* (R. Singer)
Sept 2012	RGSC, BHU, Burkachchha, Mirzapur	Agaricoid	Single litter materials	Dry woods,	Agaricales	Marasmiaceae	Shiitake/Sawtooth oak mushroom/Dingli	*Lentinus edodes* (Berk.)
Sept 2012	RGSC, BHU, Burkachchha, Mirzapur	Pleurotoid	Single	Tamrindus tree	Agaricales	Pleurotaceae	Kher mushroom	*Pleurotus sajor-caju* (Fr.) Singer
Sept 2012	RGSC, BHU, Burkachchha, Mirzapur	Volverielloid	Single	Sagon tree	Agaricales	Pluteaceae	Paddy straw	*Volvariella esculenta* (Mass) Singer
Oct 2012	Gortutwa, Mirzapur	Boletoid	Cluster	Dead wood tree	Agaricales	Agaricaceae	Wolf -fart puffball/ Rugra	*Lycoperdon pyriforme* (Pers.)
Oct 2012	Vindhyachal, Mirzapur	Agaricoid	Bunch	Compost materials, leaf fall, and peat moss litter	Agaricales	Agaricaceae	Khumbhi	*Agaricus bisporus* (Lange) Imbach.
Oct 2012	Vindhyachal, Mirzapur	Agaricoid	Bunch	Peat moss on ground	Agaricales	Agaricaceae	Bhumophor	*Agaricus placomyces* (Lange) Imbach.
July 2013	Rasulpur, Mirzapur	Pleurotoid	Bunch	Tamrindustree	Agaricales	Pleurotaceae	Indian oyster mushroom	*Pleurotus pulmonarius* (Fr.) Singer

(*Continued*)

Table 1 (*Concluded*)

Collection month and year	Collection place	Habit	Single/Bunch	Growing substrate	Order	Family	Common name	Genus and species
Aug 2013	Ranibari, Mirzapur	Pleurotoid	Solitary to Clustered	Dead conifer logs and stumps	Agaricales	Pleurotaceae	Angel's wings mushroom	*Pleurotus porrigens* (Pers.) P. Kumm.
Aug 2013	Windom fall park, Mirzapur	Pleurotoid	Bunch	living/ dead deciduous trees	Agaricales	Pleurotaceae	Oyster mushroom	*Pleurotus onesti* (Jacq.)
Sept 2013	Bhiskuri, Mirzapur	Tricholomatoid	Single	Peepal tree	Agaricales	Tricholomataceae	Yellow knight	*Tricholoma equestre* (L.) P.Kumm.
Sept 2013	Chunar, Mirzapur	Pleuteoid	Cluster	Rotting branches and twigs and decaying stumps and logs	Auriculariales	Auriculariaceae	black ears mushroom/ jelly fungus	*Auricularia polytricha*(Mont.) Sacc.
Sept 2013	Chandraprabha wild fire sanctuary, Chandauli	Pleuteoid	Single	Plant debris and peat moss	Hypocreales	Hypocreaceae	Lobster mushroom	*Hypomyces lactifluorum* (Singer)
Sept 2013	Chandraprabha wild fire sanctuary, Chandauli	Armillariod	Single	Composted material on deep soil	Agaricales	Physalacriaceae	Roger mushroom	*Armillaria ponderosa* (Singer)
Sept 2013	Robertsganj, Sonbhdra	Agaricoid	Single	Dry woods, litter materials, peat moss	Agaricales	Marasmiaceae	Black forest mushroom /Dingli	*Lentinus russaticeps*(Berk.)
Sept 2013	Robertsganj, Sonbhadra	Agaricoid	Single	Sal, teak, bamboo	Russulales	Russulaceae	Patra	*Russula violacea* (Quél.)
Oct 2013	Vindhyachal, Mirzapur	Strophariod	Cluster	Root on Dalbergia sissoo living and dead	Polyporales	Polyporaceae	Conks/ Bracket fungi/ Reishi/ King of Herbs	*Ganoderma lucidum* (Curtis) P.Karst.

sheet, digital camera for photography, digging equipment, were approved and collection of samples were usually made during day time and field characteristics of mushrooms were recorded in the data sheet which prepared by method of Devi (1995).

All the collected edible mushrooms were observed on the basis of morphological and other phenotypic parameters recorded in fresh samples. The size of fruit body of collected mushrooms was measured in centimeters. The different part of fruit bodies like, cap, stalk, gills, volva, annulus, shape, weight and colour recorded as present and absent. The morphological observations such as cap, gills, stalk, veil, spores, growth and germination were studied by method of Singer (1986), Kaur and Atri (2004) and Upadhyay and Kaur (2004).

The collected edible mushrooms were listed as date wise as for as possible correct scientific name with citation of author's name and taxonomy position (Nage *et al.* 1991). Identification of edible fleshy fungi was done with the help of literature and expertise available in the department. Whenever need the consultation about confirming the identification of mushrooms was done with Directorate of Mushroom Research, Solan, Himachal Pradesh and RAU, Pusa, Samastipur (Bihar). Identification procedures adopted by the local tribes were documented. Various uses of edible fungi by the local peoples were also recorded. A detail questioner was developed for recording the data.

RESULTS AND DISCUSSION

Collection of edible mushroom from different locations

Result showed that, collection of various edible mushrooms from different localities of Vindhya forest for their nutritional value and yield potential. The fleshy fungi were collected date wise as per as possible correct scientific name with citation of authors name and taxonomic position. Some other information also recorded such as collecting date and place, habit, single/branching, and growing substrates. The fleshy fungi were collected during this study included eight species of *Pleurotus,* two species of *Volvariella*, *Lentinus, Lycoperdon* and *Agaricus* and one species of *Cococybe, Calocybe, Flammulina, Tricholoma, Auricularia, Hypomyces, Armillaria, Russula* and *Ganoderma* given in Table and Fig 1. The map with Global Positioning System (GPS) coordinate was also prepared for collection of the edible mushroom among different forest or localities.

This finding was confirmative with the result of Dwivedi

Table 2 Morphological studies of collected edible mushrooms

Name of specimen	Cap	Stalk	Gills	Volva	Annulus	Shape	Colour
Cococybe cyanopus (Atk.) Kuhner	+	+	+	-	-	Convex	Cinnamon brown
Lycoperdon giganteum (Pers.)	-	-	-	-	-	Pear shaped	Dirty white
Calocybe indica (Puk.)	+	+	+	-	+	Umbrella	Milky creamy
Volvariella volvacea (Singer)	+	+	+	+	+	Umbonate	Brown
Pleurotus flabellatus (P.Kumm.)	+	+	+	-	-	Sea Seep shaped	Whitish to cream
Pleurotus ostreatus (Fr.)	+	+/-	+	-	-	Oyster shell-shaped to fan-shaped/semicircular	Grayish to brown
Pleurotus florida (Fr.)	+	+	+	-	-	Sea seep shaped	Grayish to brown
Pleurotus eryngii (DC.) Quel.	+	+	+	-	-	Sea seep shaped	Whitish to cream
Flammulina velutipes (R. Singer)	+	+	+	-	-	Velutipes	Orange-brown
Lentinus edodes (Berk.)	+	+	+	-	+	Convex	Golden oak
Pleurotus sajor-caju (Fr.) Singer	+	+	+	-	-	Sea seep shaped	Brownish to cream
Volvariella esculenta (Mass) Singer	+	+		-		Umbrella	Brown
Lycoperdon pyriforme (Pers.)	-	-	-	-	-	Pear shaped	Dirty white
Agaricus bisporus (Lange) Imbach.	+	+	+	-	+	Button	White
Agaricus placomyces (Lange) Imbach.	+	+	+	-	+	Button	Creamy to brownish
Pleurotus pulmonarius (Fr.) Singer	+	+	+	-	-	Sea seep	Whitish to cream
Pleurotus porrigens (Pers.) P. Kumm.	+	-	+	-	-	Angel's wings	White
Pleurotus onesti (Jacq.)	+	+	+	-	-	Sea seep	Grayish to brown
Tricholoma equestre (L.) P.Kumm	+	+	+	-	+	Saddle/ Convex	Yellow to yellow-green
Auricularia polytricha (Mont.) Sacc.	+	-	-	-	-	Flattened ear-shaped mushroom	Cloudy
Hypomyces lactifluorum (Singer)	+	-	-	-	-	Concave	Reddish orange color
Armillaria ponderosa (Singer)	+	+	+	-	+	Convex to shield shaped	White to cream
Lentinus russaticeps (Berk.)	+	+	+	-	+	Convex	Black oak mushroom
Russula violacea (Quél.)	+	+	+	-	-	Convex	White ton brownish
Ganoderma lucidum (Curtis) P.Karst.	+	-	-	-	-	Bracket/ circular shaped	Brown, reddish, green and creamy white

Whereas, + for present and – for absent.

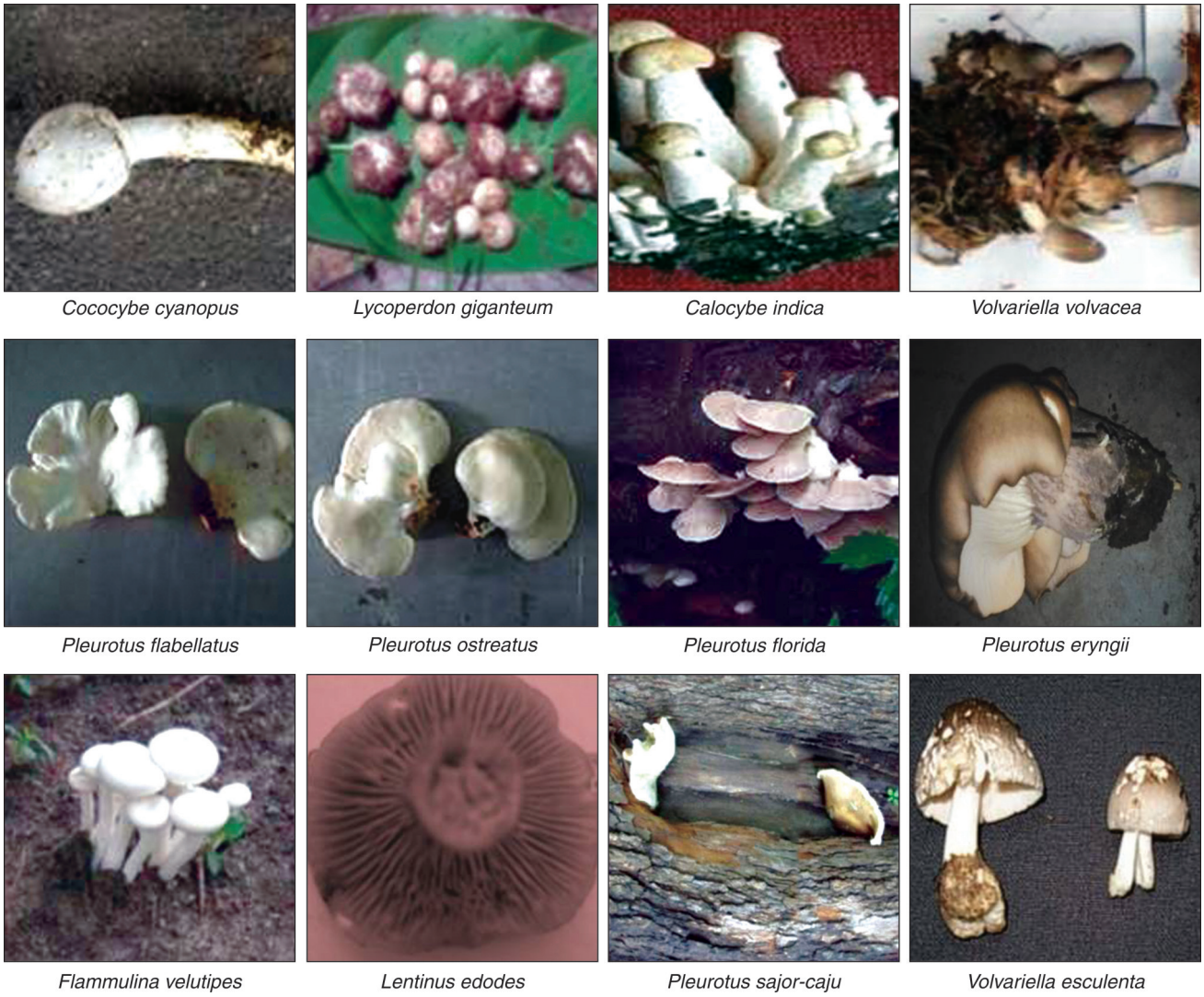

Fig 1 Photographs of collected edible mushrooms from Vindhya forest region

et al. (2012) that deals with the diversity of macro fungi in semi evergreen and moist deciduous forest of Amarkantak where more than 50 samples were collected which is situated in Madhya Pradesh in India. The collection, characterization, preservation and photo of macro fungi carried the genera like are *Agaricus*, *Amanita*, *Nyctalis*, *Russula*, *Boletus*, *Macrolapiota*, *Ganoderma*, *Termitomyces* were identified. Out of 50 samples only 16 samples were identified up to species level. This preliminary study shows that the forest is very rich in mushroom diversity.

Morphological parameters of collected edible mushrooms

All the 25 collected edible mushrooms were observed morphologically and other phenotypic parameter noted in fresh form (Table 2). The fruiting structures like cap, stalk, gills, volva and annulus were observed as present / absent during collection. The shape and colour of fruit bodies was also recorded. The volva was only present in *Volvariella* species. The fruiting structure like cap, stalk, gills, volva and annulus were not present in *Lycoperdon* species. The annulus was present in *Calocybe, Volvariella, Lentinus, Agaricus, Tricholoma and Armillaria* species. *Auricularia* and *Hypomyces* species were having only cap. *Ganoderma* species was having only cap and stalk. Various shapes like convex, pear shaped, umbrella, umbonate, sea seep shaped, oyster shell-shaped to fan-shaped/semicircular, velutipes, button were recorded as per species of edible mushrooms.

The collected fruit bodies were finds different colour like cinnamon brown in *Cococybe cyanopus;* dirty white in *Lycoperdon giganteum*; milky creamy in *Calocybe indica*; brown in *Volvariella volvacea* and *V. esculenta*; whitish to cream in *Armillaria ponderosa, Pleurotus pulmonarius, Pleurotus flabellatus* and *Pleurotus eryngii*; grayish to brown in *Pleurotus ostreatus, Pleurotus onesti* and *Pleurotus florida*; orange-brown in *Flammulina velutipes*; golden oak in *Lentinus edodes*; brownish to cream in *Pleurotus sajor-caju*; creamy to brownish in *Agaricus placomyces*; white in *Agaricus bisporus* and *Pleurotus porrigens*; yellow to yellow-green in *Tricholoma equestre*; cloudy in *Auricularia polytricha*; reddish orange color in *Hypomyces lactifluorum*;

black oak mushroom in *Lentinus russaticeps*; white to brownish in *Russula violacea* and brown, reddish, green and creamy white in *Ganoderma lucidum* respectively.

The accordance result of Ali *et al.* (2012) who described the detail of morphological characteristics of six taxa belonging to the family Tricholomataceae was carried out. The taxa were described and identified using conventional keys, as *Hygrophoropsis aurantiaca, Pleurotus* sp. *Ompholatus olivascens, Cantharellus infundibuliformis, Cantharocybe gruberi* and *Clitocybe alexandri*.

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