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First Report on Unreported Macrofungal diversity of Vindhyan Region of Central India with special reference to Agaricales

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Abstract

Vindhyan region is very rich in biodiversity because of its variety of geology, land shapes like plateau, plane, valley and hill areas. There are varieties of climate and altitudinal variations compiled with varied ecological habitats. This region is still unexplored due to unawareness and less attention towards this subject. The study was first time conducted in this region to explore macrofungi which have socio-economic and medicinal importance. The study was conducted in 5 different sites from June 2012 to September 2013 which includes urban,rural as well as agricultural areas of Rewa region, Chuhiya region, Tyonthar region, Sohagi region forest and Semariya region. A total no of 37 mushroom species in 19 genera belonging to 13 families in 10 orders were first time recorded in this region. Shannon diversity index, Simpson diversity index and species richness was highest in Rewa region which were 1.3311, .9445 and 1.69 respectively. Several workers have studied the floristic composition previously but they have neglected fungi in their biodiversity studies. The floristic composition of this region has been studied earlier by several workers, but the fungi which forms an important component of the ecosystem has been largely neglected in biodiversity studies. The key objective of this survey was to study the diversity and distribution of different macrofungi of Vindhyan region.

Keywords: Biodiversity index, macrofungi, species richness, species diversity.

Introduction

Mushroom is broadly defined as "a macro fungus with a distinctive fruiting body which can be either epigenous or hypogenous and large enough to be seen with the naked eye and to be picked by hand"[1]. Mushrooms belong to the kingdom fungi, which constitutes the most diverse group of organisms after insects on this biosphere. Defining the exact number of fungi on the earth has always been a point of discussion and several studies have been focused on enumerating the world's fungal diversity[2]. In 1990 the magnitude of fungal diversity was estimated conservatively to be at least 1.5 million species in the world.[3] Of the 1.5 million estimated fungi, 140,000 species produce fruiting bodies of sufficient size and suitable structure to be considered macro fungi, which can be called "mushrooms". Of these, about 7000 species are considered to posses varying degrees of edibility, and more than 3000 species are regarded as prime edible mushrooms. To date, only 200 of them are experimentally grown, 100 economically cultivated, approximately 60 commercially cultivated, about 10 have reached an industrial scale of production in many countries[4]. Mushrooms appeal to different people in different ways. They are objects of beauty for artists, and for medical people they are the possible source of new drugs. There are many traditional methods for testing edibility of these fungi but they are unreliable[5]. Agaricales are characterized by hymenium covered initially by volva or annulus and exposed at maturity. The order has 33 extant families, 413 genera and over 13,000 described species[6].

Only a fraction of total fungal biodiversity has been subjected to scientific scrutiny and mycologists continue to unravel the unexplored, hidden and fascinating fungal biodiversity as many macro-fungi are becoming extinct or facing threat of extinction because of habitat destruction and global climate change[7]. In Indian context, all edible mushrooms other than the common button mushrooms, *Agaricus* are grouped under the specialty mushrooms[8]. India primarily has mushroom species belonging to the order Agaricales. These are also called gilled mushrooms (for their distinctive gills). The order has 33 existing families, 413 genus and over 13,000 reported species[9]. Mushroom species provide good indicator of the forest life support system[10]. State of fungal species is an indicator to estimate the damage and maturity of an ecosystem. The information about the diversity of mushrooms in different vegetation types helps in managing ecosystem biodiversity [11]. The objectives of present study were to identify the mushrooms up to genus and species level and to compare the diversity of mushrooms of Vindhyan Region, India with the other regions of India.

Material and Methods

Study Area: The main sampling sites in this study were Chuhiya region which includes forest area as well as grassland

area (Govindgarh), Semariya region, Sohagi Ghati, Teonthar region and local areas of Rewa city like University forest, Agriculture College, university campus, some villages situated near by city. All these sampling sites are located in central India figure-1 and table-1.

Table-1
Sampling Sites of Vindhyan Plateue of central India

Sampling site	Longitude andLatitude
Chuhiya Forest (CF)	24^0 20' 58.8372 N, 81^0 20'57.3144 E
Rewa Local Area (RLF)	24^0 34' 19.9956 N, 81^0 19' 59.2608 E
Sohagi Forest (SoF)	24^0 58' 42.3078 N, 81^0 41' 21.1626 E
Teonthar Forest (TF)	24^0 58' 50.2314 N, 81^0 38' 46.6434 E
Semariya Forest (SeF)	24^0 28' 12.3078 N, 81^0 25' 31.1626 E

Collection of mushrooms: The location, vegetation around and period of the year were noted down for convenience of repeated visits. Since different species of fungi and their fruiting bodies are associated with certain plants soil porosity, soil types and pH as well as nutrient availability also help determine the species of edible fungus growing in a location. So all the minute details were recorded. Different Sampling sites were visited at least thrice (Pre-monsoon, monsoon and post-monsoon) from month June to September for year 2012-13. Sampling was done using quadrant method each measuring 10 × 10 m. Total of 50 sampling plots in the above 5 sampling sites were studied. Visits were made mostly during the rainy season when the fruit bodies are being produced. Some ectomycorrhizal fungi fruit abundantly, some fruit very infrequently some early in the season and some late, some persist for several weeks, some only for a few days. Visits were made in the morning allowing time to return to the laboratory in the afternoon for detailed examination and to begin proper drying of specimens on the day of collection. If this is not possible, then equipment and materials needed for temporary drying and storage of fruit bodies will need to be taken on collecting trips. Notebook, data sheets and ruler, for examining and recording features of the fruit bodies while they are still fresh. Drying racks, fan heaters for drying fruit bodies if laboratory facilities are not available. Petridishes containing potato dextrose medium for isolation of mushroom mycelium, isolation chamber for culturing mushrooms under aseptic condition, chemical reagents for biochemical analysis were arranged and collection of samples were usually made during day time and field characteristics of mushrooms were recorded in the data sheet which was prepared as per Nair, M.C. and Devi 1995 [11]. Simultaneously a spore print was prepared by placing the pileus downwards where a black and white paper (half white and half black) was covered with bell jar[12,13]. Further biochemical spot test (macro chemical and micro chemical test) and other necessary processing were carried out[14].

Equipments: Use of large cool box or basket, so that specimens do not get squashed. Greaseproof paper sheets or bags and marker pens, to separate, identify and keep collections fresh polythene bags provide warm, humid Trowel, penknife and small brush, for excavating beneath fruit body for rhizomorphs and roots, sectioning fruit bodies to observe color changes and removing soil from the base of the fruit body. Lens or magnifying glass, camera for close-up photographs,

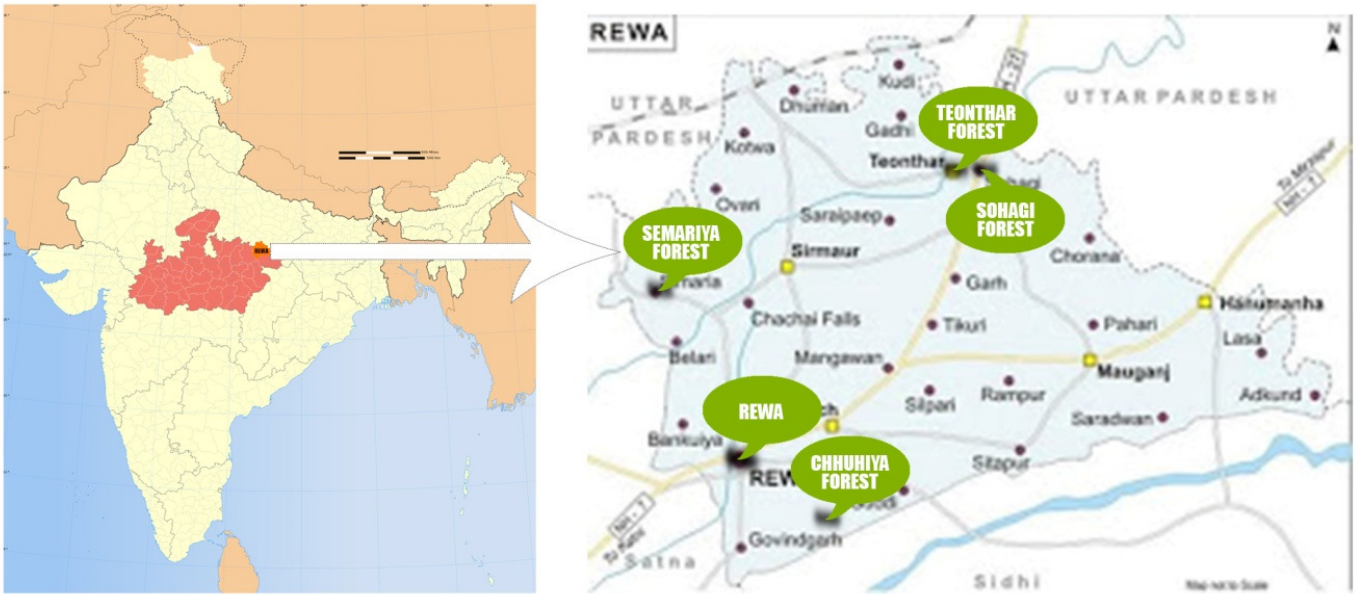

Figure-1(a)
Showing study sites of macro fungi collection

Identification: Specimens were identified to their respective families, genera and species by consulting the available help of expert were also taken whenever required literature[15-20]. Some of the mushroom samples were sent to Agharkar Research Institute Pune for the identification.

Data Analysis: The frequency of occurrence for each the species was calculated by following formula as suggested by Aung O.M., Soytong K. and Hyde K.D.2008[21]. Shannon diversity index for mushroom calculated as suggested by Margalef R., Pushpa H. and Purushothama K.B.[22,23].

$H = - \sum(n/N) \log_e (n/N)$

Where: H is the diversity index, N is the total number of the individual of all the species and n is the total numbers of the individual species.

Simpson Index of Diversity was calculated as suggested by Simpson E.H.,1949 [24].
Simpson Index of Diversity =1-D

$D = \sum n (n-1) / N (N-1)$
Where: n = The total number of organism of a particular species, N = The total number of organism of all species

With the help of the values of diversity index, the evenness of the mushroom was also calculated suggested by Pielou E.C., 1996[25].
$e = H/ \log S$

Where: e is evenness, H is Shannon diversity index and S is the number of species.

With the help of the values of diversity index, the species richness of the mushroom was also calculated by following formula:
$S = N/\sqrt{n}$

Where: S is Species Richness, N is Total no of Species, n is Total no of individuals.

Results and Discussion

The study of biodiversity of mushrooms revealed that mushrooms listed in table-2 are first time reported in this area. Total 37 species in 19 genera belonging to 13 families in 9 orders of basidiomycetes and gastromycetes were considered for the diversity study. Out of 37, only 14 were identified up to species level and 27 were identified up to genus level. A list of macro fungi with their respective families has been provided in table-2 and figure-2. Family Agaricaceae dominated by 22% (2 genera, 8 species). The mushroom specimen collected were assigned to 5 different groups recognized basically as outlined by Garret S.D.[26].

Saprophytic macro fungi (on litter, terrestrial, humus), Wood Rot macro fungi (cellulytic and Lignolytic), Symbiotic macro fungi (ectomycorrhizal associated with trees, with termites), Parasitic macro fungi, Coprophilous macro fungi.

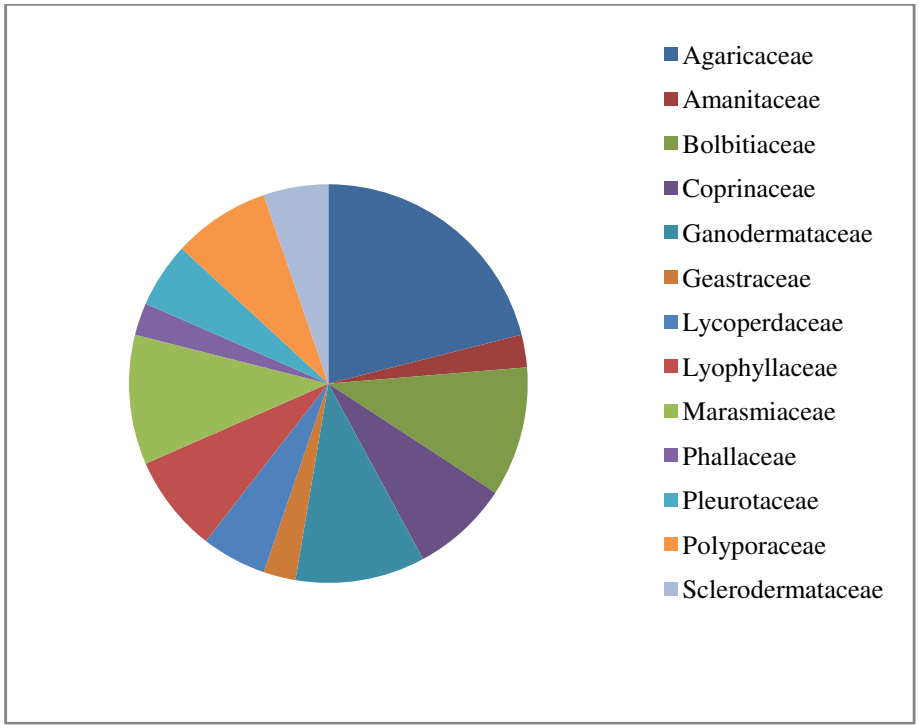

Figure-2
Family wise distribution of mushrooms

Table-2
Classification of different mushroom species according to their family and genus

Class	Order	Family	Genus	Species
Homobasidiomycetes	Agaricales	Agaricaceae	*Agaricus*	*Agaricus campestris*
				Agaricus augustus
				Agaricus bisporus
				Leucoagaricus sp.
			Macrolapiota	*Macrolapiota procera*
				Lepiota sps.
				Lepiota sps.
				Lepiota sps.
		Amanitaceae	*Amanita*	*Amanita sps*
		Coprinaceae	*Coprinus*	*Coprinus comatus*
				Coprinus sp.
				Coprinus sp.
		Lyophyllaceae	*Termitomyces*	*Termitomyces hemi*
				Termitomyces microcarpus
	Tricholomatales	Pleurotaceae	*Pleurotus*	*Pleurotus sp., Pleurotus sp.*
		Marasmiaceae	*Marasmius*	*Marasmius sp.*
			Marasmius	*Marasmius sp.*
			Clitocybe	*Clitocybe sp.*
	Polyporales		*Megacolibia*	*Megacolibia platyphylla*
		Polyporaceae	*Lentinus*	*Lentinus sp.*
				Meripilus giganteus
			Piptoporus	*Piptoporus betulinus*
	Ganodermatales	Ganodermataceae	*Ganoderma*	*Ganoderma lucidum*
				Ganoderma applanatum
				Ganoderma sp.
				Ganoderma sp.
	Geastrales	Geastraceae	*Geastrum*	*Geastrum sps.*
	Cortinariales	Bolbitiaceae	*Panaeolus*	*Panaeolus foeniseii*
				Panaeolus semioratus
				Panaeolus sp.,
				Panaeolus sp.
	Lycoperdales	Lycoperdaceae	*Lycoperdon*	*Lycoperdon sp.*
				Lycoperdon sp.
	Boletales	Sclerodermataceae	*Pisolithus*	*Pisolithus tinctorius*
			Scleroderma	*Scleroderma sp.*
Gastromycetes	Phallales	Phallaceae	*Phallus*	*Phallus impudicus*

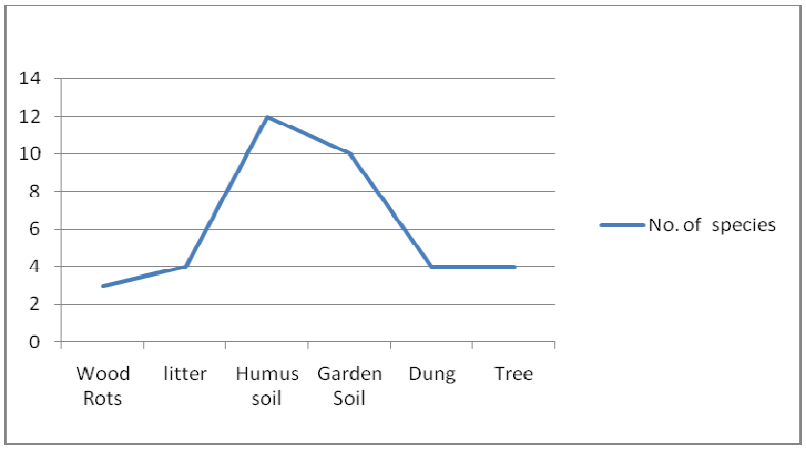

Figure-3
Distribution of Mushroom species in different habitat

There were 37 species in total of which 70%were saprophytic, 8% were wood rots, parasites and coprophillus macro fungi were represented same by (11%) each table-2. The number of species collected from all five study sites showed that a maximum number of 27 species collected in local Rewa region, 18 species in Sohagi Forest, 13 species in Chuhiya Ghati, 12 in Semariya Forest and 10 species in Tyonthar Region. Among all the sampling sites Rewa region was found with highest no. of species (27) and highest no. of individual (253). *Agaricus augustus*, *Marasmius sp*., *Clitocybe sp.* and *Shyzophyllum sp*. were collected only in this site table-3 Shannon's diversity and Simpson diversity indices were found to be 1.3311 and 0.9445 respectively (table-4) Species evenness and species richness were found to be 0.2561 and 1.69 respectively. Species richness of this was found to be maximum when compared to other collection sites (table-4).

Among 18 species collected in Sohagi Ghati forest, Shannon's diversity and Simpson diversity index came out to be 1.1823 and 0.9296 respectively. Species richness and species evenness came out to be 1.607 and 0.2786 respectively which is lesser than local Rewa city (table-4). This may be due to the heavy vehicle transportation (NH 75) and deforestation in this area. The most common species found in this region were *Agaricus sp., Aman sp., Megacolibia platyphylla, Ganoderma sp., Panaeolus sp, Pisolithus tinctorius, Scleroderma sp.*

Among 13 species collected in Chuhiya Ghati forest *Agaricus campestris, Agaricus bisporus*, *Termitomyces hemi, Termitomyces microcarpus,, Megacolibia platyphylla, Lentinus sps., Piptoporus betulinus, Ganoderma lucidum, Ganoderma applanatum, Ganoderma sp.(2), Geastrum (local name 'putu') Panaeolus sp,* were collected from this site (table-3) and figure-5. This may be due to the presence of sandy soil which favors the growth of this macrofungi. Shannon's diversity and Simpson diversity index of this sampling site was observed to be 0.95894 and 0.84908 respectively. Species richness and species evenness was found to be 1.04 and 0.2660 respectively which is lesser than Sohagi forest. This is may be due to heavy traffic load of heavy and light vehicles emitting the gaseous and particulate air pollutants and human interference in the forest ecosystem.

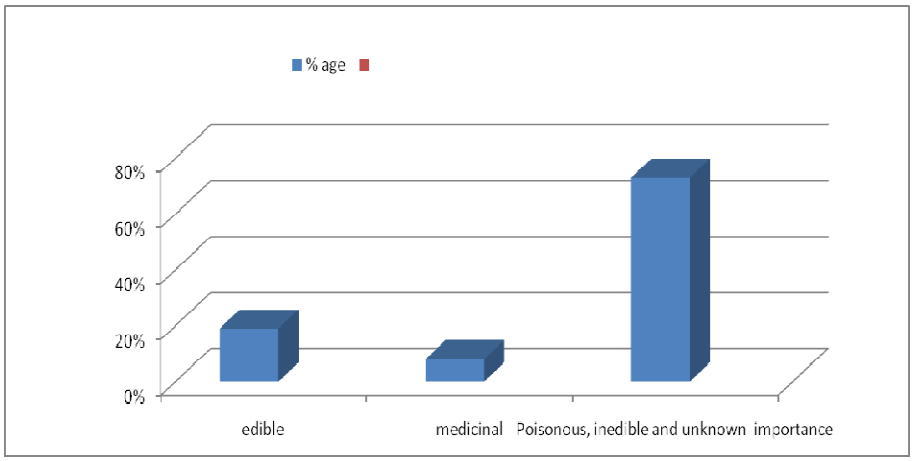

Figure-4
Economic importance of collected mushrooms

Table-3
Distribution of macro fungi in different sampling sites

Species name	CF	LRC	SoF	TF	SeF
Agaricus campestris	+	+	+	+	+
Agaricus augustus	-	+	-	-	-
Agaricus bisporus	+	+	+	-	+
Macrolapiota procera	-	+	-	-	+
Lepiota sps	-	+	-	-	-
Lepiota sps	-	+	+	+	-
Lepiota sps	-	+	+	-	-
Lepiota sps	-	+	+	-	-
Amanita sps.	-	-	+	+	+
Amanita sps.	-	-	+	+	+
Coprinus comatus	-	+	-	-	+
Termitomyces hemi	+	+	-	-	+
Termitomyces microcarpus	+	+	-	-	+
Pleurotus sps.	-	+	-	-	+
Pleurotus sps.	-	+	-	-	-
Marasmius sp.	-	+	-	-	-
Marasmius sp.	-	+	-	-	-
Clitocybe	-	+	-	-	-
Megacolibia platyphylla	+	-	+	+	_
Lentinus sps.	+	+	-		+
Piptoporus betulinus	+	-	-	-	-
Ganoderma lucidum	+	+	-	-	+
Ganoderma applanatum	+	+	-	-	-
Ganoderma sp.	_	-	+	+	-
Ganoderma sp.	+	-	+	-	-
Geastrum sps	+	-	-	-	-
Panaeolus foeniseii	-	+	+	+	-
Panaeolus sp.	+	+	+	-	-
Panaeolus sp.	-	+	+	-	-
Panaeolus sp.	-	+	+	-	-
Lycoperdon sp	-	+	+	+	-
Lycoperdon sp.	-	+	+	+	-
Pisolithus tinctorius	-	-	+	+	+
Scleroderma sps	-	+	+	+	-
Leucoagaricus	-	+	-	-	-
Phallus impudicus	-	-	-	+	-
Shyzophyllum	-	+	-	-	

12 species collected from Semariya forest. Shannon's diversity and Simpson diversity index was found to be 0.9901 and 0.8903 respectively. Species richness and species evenness of this region was found to be 1.06 and 0.9175 respectively (table-4) which is lesser than Rewa, Sohagi Ghati and Chuhiya Ghati forest, because this forest is highly interfered and degraded by tribals and poor peoples who are continuously exploiting the forest. Among 10 species collected in Tyonthar region *Phallus impudicus* with unpleasant smell was found only in this region. It was completely absent in other sampling sites (table-3) Shannon's diversity and Simpson diversity index was found to be 0.9240 and 0.8754 respectively. Species richness and species evenness of was found to be 0.84 and 0.9239 respectively (table-4).

Table-4
Statistics of Species diversity, Richness and Evenness of mushrooms in and around Rewa districts sampling sites

Attributes	Sampling Sites				
	CF	**LRC**	**SoF**	**TF**	**SeF**
No.of species(s)	13	27	18	10	12
No.of Individual	154	253	127	143	128
Shannon Diversity	0.9589	1.3311	1.1823	0.9240	0.9901
Simpson Diversity	0.8491	0.9445	0.9296	0.8754	0.8903
Species Richness	1.04	1.69	1.607	0.84	1.06
Species evenness	0.2660	0.2561	0.2766	0.9239	0.9175

The mushrooms collection in and around Rewa district was also studied for their economic importance through local people. It was found that 19% mushrooms are edible, 3% mushrooms are of medicinal importance and 73% mushrooms were inedible or of unknown importance (figure-4). Further biochemical analysis will help us in exploiting their metabolites.

Discussion: Started a series entitled "South Indian Agaricales" and presented a list of 230 *Agaric* and Bolete *species* distributed among 67 genera from southern Indian states excluding Kerela Garret, S.D.[27]. Manjula B[28] Studied and reviewed the state of Indian Agaricales providing a very exhaustive list of Agaricoid and Boletoid fungi from India and Nepal. This is so far the best comprehensive list, which enumerates 538 valid genera and 20 families in the order Agaricales from India. From a survey of mushrooms in the North West Himalayas recorded agarics belonging to 300 species, 59 genera and 15 families of Agaricales Manjula B[28]. Diversity of agarics (gilled mushrooms) of Maharashtra, India was studied by Senthilarasu G[30]. Edible fungi biodiversity of Central india also studied by

Karwa Alka, and Rai Mahendra K.[31]. A total of 110 mushrooms belonging to 20 genera were recorded during the systematic survey conducted at different parts of Madhya Pradesh and Chattisgarh by Upadhyay M.K.[32]. Taxonomic study of some of the wild mushrooms (Ectomycorhiza) of Jabalpur was first time conducted by Sharma Rohit[33]. Biodiversity of Pathariya forest of Sagar M.P. has been done by Vyas Deepak, Chaube Anjali and Dehariya Poonam[34] and reported *Agaricus bisporus, Agaricus bitorquis, Calvattia cyathiformis, Cantharellus sp., Clitocybe infundibuliformits, Lactarius controversus, Lactarius stramineous, Lycoperdon oblongisporum, Lactarius controversus, Lycoperdon oblongisporum, Pleurotus florida, Russula sp, Amanita sp., Boletus sp., Ganoderma lucidum, Ganoderma applanatum ,Scleroderma sp.* from Central India. Studies on the edible tribal mushrooms of M. P. and development of technology for large scale production was done by Rahi D.K.[35] Comparison of macrofungal communities of Vindhyan Region with other parts of India revealed that species diversity of macrofungi is related to their particular habitat. The factors like geographic location elevation, temperature, humidity, light and surrounding flora greatly influence the growth and development of macrofungi[36]. Observed that presence of several factors favour the growth of mushrooms.These factors are Temperature, climatic conditions, vegetation (deciduous and semi deciduous forests), availability of degradable materials in this region. Saprophytes dominated in our investigated areas. Similar observations were made by Karwa Alka, and Rai Mahendra K. and Nidhi Anand and Chowdhry[31,38]. Factors like litter accumulation and decomposition and extracellular enzymes promote sporocarps formation[36,39]. Present research indicates that there are very less mychorhizal fungi are present in this region. Mycorrhizal formation and production of sporocarp is negatively affected by excess mineral fertilizers. Degradable organic plant waste is available freely which helps fungi to colonize and these have a major role in the decomposition of organic matters in the sampled[40], absence of sporocarps with the associating trees, an important source of identification and reduce degeneration potential of the fungal[41].

Conclusion

Vindhyan region is still unexplored due to unawareness and less attention towards this subject. The study is first time conducted in this region to explore macro fungi which have socio-economic and medicinal importance. On the basis of above findings it can be concluded that Vindhyan region of central India being rich in vegetation; forest can be a good source of potential edible and medicinal mushroom.

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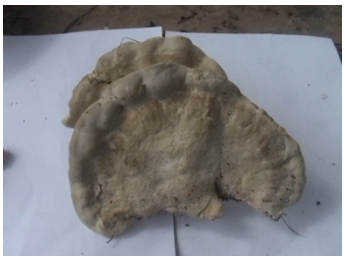
Puff Balls

Lentinus Sp



Birch Polypore

Unidentified

Panaeolus sp.

Mycena sp.

Panaeolus sp.

Agaricus sp.

Lepiota sp.

Agaricus

Panaeolus sp.

Agaricus sp

Macrolepiota procera

Tricholoma sp

lucoagaricus sp.

Unidentified

Amanita sp.

Not Identified

Not Identified

Pleurotus sp.


Ganodearma sp.


Pisolithus sp.


Coprinus sp.


Macro lepiota


Unknown species


Cystoderma


Not identified


Coprinus sp.

Figure-5
Specimen of some collected Mushrooms from study sites

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