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Research Article

Macrofungi in Some Forests of Telangana State, India

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The fruiting bodies of macrofungi were collected from some forests, fences, waste fields, timber depots of Telangana state during rainy season. This is an attempt to give a broad picture of diversity of macrofungi belonging to the class Basidiomycetes in some forest areas of Telangana region. A total number of 50 fruiting bodies were collected and cultured and among them only ten were identified based on their macroscopic features and molecular identification since they showed good lignolytic activity.

1. Introduction

The total forest cover in India according to the latest Forest Report 2013 is 69.8 million hectares and this constitutes 20.64% of the geographic area. The state of Telangana is one of the progressive states in the southern part of India with an area of 114,840 sq.km, while the recorded forest area is 29242.08 sq.km. The annual rainfall is between 900 to 1500 mm in northern Telangana and 700 to 900 mm in southern Telangana, from the southwest monsoons and it is a semiarid area and has a predominantly hot and dry climate. The Basidiomycota is the second largest phylum of kingdom Fungi, with approximately 23,000 species [1] including many of the common macroscopic forest fungi (e.g., mushrooms, shelf fungi). Mushroom is a general term utilised mostly for the fruiting body of the macrofungi, belongs to Ascomycota and Basidiomycota, and represents only a short reproductive stage in their life cycle. Investigations on the taxonomy and diversity of macrofungi are gaining importance, as many macrofungi are facing a threat of extinction due to environment destruction. Wild mushrooms have deep biological and economical impact. Information on mushroom diversity is important because of its major functions in natural and organised eco-schemes as ectomycorrhizal fungi. The fungal group becomes a significant component for reforestation programs. Furthermore, they are significant as nourishment source for human beings and animals [2]. The macrofungi were also used as a bioindicator of environmental quality [3]. Most of the fleshy and gilled macrofungi were prevalent in the rainy times of the year as this time is favourable for their output, since there is ample moisture, favourable warmth, relative humidity, and sunshine, which furthermore aids the macrofungi in the decomposition of dead organic tissue. The early dry time of the year collection was predominated by the polypores since there is decline in rainfall and relative humidity, boost in warmth, and sunshine and most of the fleshy macrofungi will not withstand these conditions. During rainy season, there is abundant growth of several kinds of Basidiomycetes. Many fungal species groups do not produce visible fruit bodies or other species-specific characteristics, or these characteristics are extremely rare and cannot be detected in traditional surveys; hence these can be studied using molecular methods [4–6]. Further, Basidiomycetes are considered to be a very interesting group of fungi with their exceptional adjustment abilities and as natural lignocellulose degraders with different ecological groups such as white rot, brown rot, and leaf litter fungi [7]. Many kinds of macrofungi are not edible but possess variety of pharmaceutical and medicinal qualities. A fraction of complete fungal wealth has been subjected to scientific scrutiny and mycologists continue to unravel the unexplored and hidden wealth; one-third of fungal diversity of the globe exists in India and of this only 50% is characterized until now [8]. About 10,000 species within the overall fungal estimates of 1.5 million belong to

this group. Mushrooms alone are represented by about 41,000 species, of which approximately 850 species are recorded from India [9]. Some of the wild edible mushrooms have been reported from South West India [10]. The first listed Indian Fungi was published [11] and that was revised by Vasudev [12] and extra additional lists appeared in between culminating with the fungi of India (Bilgrami et al. [13]).

The present communication is the collection, culture, identification, and preservation of the macrofungi in some forests of Telangana region. This study adds extra information to the present knowledge on the data of diversity of fungi in Telangana region and also to understand their bioprospects.

2. Materials and Methods

2.1. Study Area. The fruiting bodies of white rot fungi were collected in rainy season from the forest of Etunagaram, Bhadrachalam, Kothagudem, Narsampet, Ilandhu, Khammam, Bodhan, and Nirmal of Telangana region.

2.2. Culturing and Preservation. The collected fruit bodies were cultured for their mycelial growth as per the method suggested [14]. A small piece of fruiting body was dipped in 0.01% mercuric chloride to remove surface contamination and washed several times with distilled water to remove the traces of mercuric chloride and transferred aseptically on to 3% malt extract agar [15] slants and was incubated for 5–7 days. The mycelium collected from the growing edge of those slants was transferred on to new malt extract agar slants and incubated further 5–7 days to obtain pure culture. Pure cultures were subcultured on malt extract agar slants and plates every fortnight.

2.3. Characterization of Macrofungi. Based on macroscopic features, namely, size, shape, sporocarp nature, color, spore print, margin of pileus, characters of lamella, spacing of gills, characters of the stipe, and the presence or absence of veils on stipes, the fungi were identified, http://en.wikipedia.org/wiki/Template:Mycomorphbox.

2.4. Identification of Macrofungi

2.4.1. Macroscopic Identification. Seven mycological characters useful in tentative identification of mushrooms are hymenium type, cap shape, gills, stipe character, color of the spore print, ecological type, and edibility.

2.4.2. Molecular Identification. Based on their lignolytic activity (data not shown here) ten species of wild macrofungi were selected for confirmation of their identities using molecular methods (see Figure 1). Collected fruiting bodies are initially cultured on malt agar (MEA), and the genomic DNA of the macrofungi was extracted using modified CTAB method [16]. The genomic DNA of the macrofungi was then subjected to PCR to amplify the ITS regions of the nuclear ribosomal DNA using two primers: ITS 1 (5′TCCGTAGGTGAA CCTTGCGG3′) and ITS 4 (5′TCCTCCGCTTATTGATATGC3′) [17]. The PCR products were then purified using QIAGEN purification kit following the manufacturer's instructions and the purified PCR products were sent to SciGenom, Cochin, for outdoor DNA sequencing. Related gene sequences for each of the macrofungal specimens were obtained from NCBI GenBank and then automatically aligned using ClustalW program incorporated in BioEdit v. 7.1.9 [18]. Manual sequence alignments were then performed using Bioedit to allow maximum sequence similarity. Finally, phylogenetic tree was constructed based on maximum parsimony using PAUP v. 4.0 b10 [19].

3. Results

The fruiting bodies of white rot fungi were collected in rainy season from few forest areas of Telangana state (Table 1). The collected fruit bodies were cultured until the pure cultures were obtained. The lists of identified wild mushrooms were depicted in Tables 2 and 3. The fungi that belong to Polyporales are more in number than other orders. *Schizophyllum radiatum* belong to the order Agaricales. All the collected fungi were saprotrophic and were not edible. Based on seven mycological characters they were characterized. The climatic conditions in Telangana are congenial for prevalence of macrofungi and hence recorded maximum genera. During the systematic surveys at different forests of Telangana, total 50 mushroom samples were collected and these samples belong to different genera out of which only 10 mushroom samples were identified based on their lignolytic activity (data not shown here) and were identified basing on the molecular identification and macroscopic characters. All collected mushrooms have been deposited in the department herbarium with accession numbers. The ten identified mushrooms by molecular level are *Trametes versicolor* (GenBank Accession number HF953984), *Pycnoporus cinnabarinus* strain SYBC–L14, *Daedaleopsis flavida* strain 5A, *Trametes elegans voucher, Trametes hirsuta, Fomitopsis feei* (GenBank Accession number AY 515327.1), *Trametes gibbosa* (GenBank Accession number AY351924.1), *Trametes elegans* GenBank (Accession number AY351925.1), *Ganoderma lucidum,* and *Schizophyllum radiatum* (GenBank Accession number HE863742.1).

4. Discussion

In Basidiomycotina more than 2000 species of edible mushrooms are reported in the publications from different components of the world. People all over Asian countries in the twentieth century know that mushrooms are important biosource of novel secondary metabolites. In India, the alternative systems of medicine utilize the curative properties of mushrooms. Secondary metabolites of these mushrooms are chemically diverse and possess a broad spectrum of biological activities, which are explored in traditional medicines [20]. In India, several mushrooms have been reported as medicinal mushrooms which have antioxidant, antimicrobial, and anti-inflammatory activity with antitumor

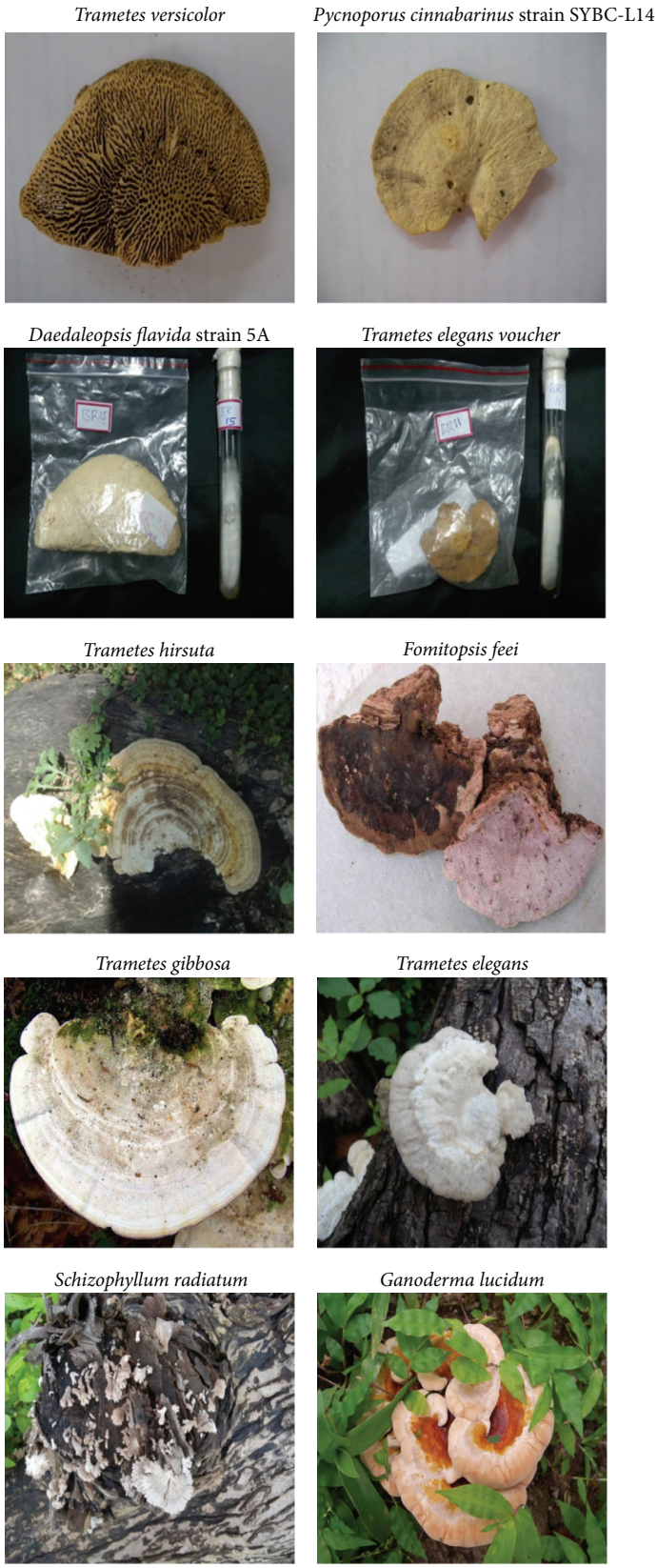

Figure 1: Photographs of identified macrofungi.

Table 1: List of macrofungi collected in some forests of Telangana state.

Site Number	Site name	*Strain name*	Source	Altitude
1	Eturnagaram forest	*Abortiporus biennis*	Ground-dwelling	18° 20′ 20″ N, 80° 25′ 45″ E
		Agaricus xanthodermus	Hardwood	
		Cantharellus subalbidus	Hardwood	
		Tyromyces sp.	Tree	
		Gleophyllum sp.	Tree	
		Gomophus sp.	Tree	
		Trametes pubescens	Dead wood	
		Trametes elegans voucher	Wood log	
		Pycnoporus cinnabarinus	Wood log	
	Eturnagaram Timber Depot	*Trametes hirsuta*	Wood log	
		Oligoporus sp.	Wood log	
		Schizophyllum radiatum	Wood log	
		Trichaptum	Wood log	
		Trametes versicolor	Wood log	
		Trametes gibbosa	Wood log	
		Fomitopsis feei	Tree	
2	Bhadrachalam forest	*Auricularia auricula*	Wood log	17° 40′ 12″ N, 80° 52′ 48″ E
		Clitocybe philophylla	Tree	
		Tremella foliacea	Fallen branches	
		Trametes hirsuta	Dead wood	
		Daedaleopsis flavida	Fallen branches	
		Ganoderma lucidum	Wood log	
		Stereum hirsutum	Dead wood	
		Trametes betulina	Wood log	
		Ganoderma sp.	Wood log	
		Inonotus hispidus	Tree	
3	Bodhan	*Phellinus igniarius*	Tree	18° 40′ 12″ N, 77° 54′ 0″ E
		Tremella aurantia	Wood log	
		Stereum ostrea	Tree barks	
		Dichomitus sp.	Wood log	
		Trametes sp.	Wood log	
4	Nirmal	*Ganoderma applanatum*	Tree	19° 6′ 0″ N, 78° 21′ 0″ E
		Amauroderma	Wood log	
		Trametes ochracea	Wood log	
		Trametes elegans	Wood log	
		Pycnoporus coccineus	Wood log	
5	Illandu Timber Depot	*Pleurotus* sp.	Wood log	17° 36′ 0″ N, 80° 19′ 48″ E
		Trametes sp.	Wood log	
		Daedaleopsis confragosa	Wood log	
		Pycnoporus sanguineus	Dead wood	
		Phyllotopsis	Wood log	

Table 1: Continued.

Site Number	Site name	*Strain name*	Source	Altitude
6	Kothagudem	*Piptoporus betulinus*	Tree	17° 33′ 0″ N, 80° 37′ 48″ E
		Trametes sp.	Wood log	
		Ganoderma sp.	Wood log	
7	Narsampet	*Ganoderma* sp.	Wood log	17° 55′ 35.02″ N, 79° 53′ 48.99″ E
		Daedaleopsis sp.	Wood log	
		Trametes sp.	Wood log	
		Pycnoporus sp.		
8	Khammam	*Schizophyllum commune*	Wood log	17° 15′ 0″ N, 80° 9′ 0″ E
		Trametes sp.	Wood log	

Table 2: Classification of identified wild mushrooms.

Division	Class	Order	Family	Genus	Species	Place
Basidiomycota	Agaricomycetes	Polyporales	Polyporaceae	*Trametes*	*versicolor*	Etunagaram
				Trametes	*hirsuta*	Etunagaram
				Trametes	*elegans voucher*	Etunagaram
				Ganoderma	*lucidum*	Depott
				Daedaleopsis	*flavida*	Bhadrachalam
				Trametes	*gibbosa*	Etunagaram
				Trametes	*elegans*	Etunagaram
						Depot
Basidiomycota	Basidiomycetes	Polyporales	Polyporaceae	*Pycnoporus*	*cinnabarinus*	Etunagaram
				Fomitopsis	*feei*	Etunagaram
Basidiomycota	Basidiomycetes	Agaricales	Schizophyllaceae	*Schizophyllum*	*radiatum*	Khammam

and other properties [21]. Study on mushrooms in South India such as Tamil Nadu, Kerala, Karnataka, and Andhra Pradesh was neglected as regards to studies on agarics until 1975 [22]. All these collected white rot fungi were rich in medical importance. *Ganoderma lucidum* is well known to promote health and longevity, lowers the risk of cancer and heart disease, and boosts the immune system [23]. Polysaccharides from mushrooms as anticancer agents, other constituents exhibiting antioxidants and antihypertensive, cholesterol-lowering, liver protection, antifibrotic, anti-inflammatory, antidiabetic, antiviral, and antimicrobial-like activities, have overtly primed its potential as dietary supplements [24]. Some of the Indian mushrooms which are having the medicinal properties are *Agaricus bisporus* [25], *Astraeus hygrometricus* [26], *Volvariella bombycina* [27], *Ramaria formosa* [28], *Pleurotus sajor-caju* [29], *Pleurotus pulmonarius* [30], *Pleurotus ostreatus* [31], *Phellinus rimosus* [32, 33], *Lycoperdon perlatum* [34], *Lentinus tuber-regium* [35], and *Lentinus squarrosulus* [36]. One of the authors [37] worked on *Schizophyllum radiatum* and reported the potentials of extracellular biosynthesis of silver nanoparticles, their characterization, and antimicrobial activity on gram-positive and gram-negative bacteria. The *S. radiatum* was also studied for its antimicrobial and antioxidative properties under submerged fermentation. The supernatant of the seed media obtained after separating the mycelia has been used for the synthesis of silver nanoparticles, whereas the species of *Fomitopsis feei* were recorded in decolorization of triphenyl methane dyes, namely, bromophenol blue, basic fuchsin, methyl violet, methyl green, ethyl violet, and malachite green [38]. This report clearly explains that the bioremediation by utilising fungal organisms was advised to be the cost-effective and ecofriendly method of decolorization of effluents released from the dye industries. The genus *Trametes* and its species have many immunomodulatory and anticancer effects [39]. The genus of *Daedaleopsis* has antibiotic, antihypersensitive, and antitumour properties [40].

A constant monitoring and collection, identification, and preservation of the wild mushrooms are the need of the hour to explore and make use of the bioprospects of the diversified macrofungal species. This is a preliminary and basic work carried out to locate and identify the bioprospects of the existing macrofungi which will pave the way for understanding an elaborate study on this aspect.

5. Conclusion

Amongst the vast number of living forms very little amount of attention has been paid to conservation of fungal biodiversity. Due to loss of natural habitats, soil and air pollution expansion of monocropping and loss of genetic diversity many fungal species are on threat. For the smooth working of this terrestrial environment, the preservation of mushroom differences is discriminating. Keeping in view this gigantic mushroom treasure it is the high time to completely save this biodiversity. A few mushrooms are known to be the

Table 3: Mycological characters of identified wild mushrooms.

Name	Hymenium type	Cap shape	Which gills	Stipe character	Spore print colour	Ecological type	Edibility
T. versicolor	Pores	Offset or distinct	Decurrent	—	White to yellow	Saprotrophic	Edible but unpalatable
T. hirsuta	Pores	Distinct	Decurrent	Bare	Cream	Saprotrophic	Inedible
T. elegans voucher	Pores and gills	No distinct cap	Decurrent	—	White	Saprotrophic	Inedible
Ganoderma lucidum	Pores	Offset or indistinct	Irregular	Bare	Brown	Saprotrophic	Edible
Daedaleopsis flavida	Pores	No distinct cap	Decurrent	—	White	Saprotrophic	Inedible
T. gibbosa	Pores	Offset	Decurrent	Bare	White to cream	Saprotrophic	Inedible
T. elegans	Pores	Distinct	Decurrent	Bare	Cream	Saprotrophic	Inedible
Pycnoporus cinnabarinus	Pores	Distinct	Decurrent	Bare	Cream	Saprotrophic	Inedible
Fomitopsis feei	Pores	No distinct cap	Decurrent	—	Brown	Saprotrophic	Inedible
Schizophyllum communae	Pores	Offset or indistinct	Decurrent	—	White	Saprotrophic	Inedible

wellsprings of different bioactive substances like antibacterial, antifungal, antiviral, antiparasitic, antioxidant, anti-inflammatory, antiproliferative, anticancer, antitumour, cytotoxic, anti-HIV, hypocholesterolemic, antidiabetic, anticoagulant, and hepatoprotective substances, among others. These mushrooms have been utilized as ethnomedicines by tribals for treatment of different sicknesses. Numerous mushrooms still stay unreported and their healthful and in addition medical advantages are obscure to us. Henceforth, an opportune examination in regard to isolation, identification, and characterization of the current mushroom vegetation is vital. Biotechnological devices can be utilized with a specific end goal to accomplish the *in situ* and *ex situ* preservation of huge numbers of the mushroom species. The outcome of the present study elaborates the information on the facts and figures of diversity of fungi of the study area.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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