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Studies on the diversity of macrofungus in Kodaikanal region of Western Ghats, Tamil Nadu, India

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Abstract. *Boobalan T, Mohan Rasu K, Arumugam N, Saravanan S, Jothi Basu M, Jeyakanthan J, Arun A. 2018. Studies on the diversity of macrofungus in Kodaikanal region of Western Ghats, Tamil Nadu, India. Biodiversitas 19: 2283-2293.* We have demonstrated the distribution of macro fungal communities in the selected forest territory of Kodaikanal (Poondi) region, which houses about 100 mushrooms species diverse forms of mushrooms including both the soil-inhabiting (n = 45) and wood-inhabiting (n = 55) species. Kodaikanal is situated on a plateau between the Parappar and Gundar valleys; this area experiences peculiar lower temperature between 8.2°C and 19.7°C, higher humidity between 92% and 95%, which in turn enhances the growth of different types of mushrooms throughout the year. However, the peak production and macro fungal flushes were observed during the winter season followed by the northeast monsoon (Oct-Dec 2015). A total of 100 species belonging to 51 families were documented from this study sites. Moreover, some species (e.g., *Ganoderma* sp and *Phellinus* sp) persists all around the year in this region. However, some incidents of logging and burning of host trees have resulted in the decline of the macro fungal populations in this region. Hence the present study highlights the diversity of macro fungal population and also suggests their importance as part of biodiversity conservation.

Keywords: Basidiomycetes fungi, mushrooms diversity, soil-inhabiting mushrooms, tree-inhabiting mushrooms

INTRODUCTION

Mushroom is a seasonal growing macro fungus that plays a vital role in terrestrial ecosystem and functions as decomposers (Hawksworth 2001; Mueller et al. 2007; Prakash 2016; Adeniyi et al. 2018). Fungi are large biodiversity group of microorganism in the ecosystem and consist of about 1.5 million species across the globe, where India ranks third largest fungal diversified country with about 2,70,000 species, next to the largest insect biodiversity (Manoharachary et al. 2005). There are many varieties of mushrooms such as fairy clubs, toadstools, puffballs, stinkhorns, earthstars, bird's nest fungi, jelly fungi and these are generally of saprophytic in nature capable of using wood as a nutrient source by utilizing a ligninolytic enzyme (Karwa and Rai 2010). Mushrooms also play an important role in global carbon cycle, in addition, they are essential to the survival of other organisms in numerous ways, act as source of novel bioactive compounds, biocontrol agents, plant pathogens and are also involved in the degradation process (Arun et al. 2008; Arun and Eyini 2011). Wild mushrooms are also becoming more important for their nutritional, sensory and especially pharmacological characteristics including the significant content of vitamins (Günç Ergönül et al. 2013; Heleno et al. 2010).

In this context, mushrooms have a long history of use in oriental medicine to prevent and fight numerous diseases through a balanced diet (Valverde et al. 2015). It is very important to document and understand the biodiversity at regional, national and global level. Because India is one of the 17 mega diverse countries of the world and biodiversity conservation is the responsibility of every country. According to Ministry of Environment and Forest in India With only 2.4% of the world's land area, about 16.7% of the world's human population and 18% livestock together contribute about 8% of the known global biodiversity. Recently, Gadgil et al. (2011) have raised voice against the illegal practices that are spoiling the ecosystem and have suggested the need for effective conservation of ecologically sensitive areas in the Western Ghats India. Kodaikanal is covered with a dense forest of *Acacia mearnsii* (Australian black wattle), eucalyptus and pine, which was introduced in the period of 1960s between 1,800 and 2,400 m of Kodaikanal surrounding regions for households and industry purposes (Rangan et al. 2010). The macrofungal forest diversity has been classified based on three main factors such as terricolous saprotrophic, wood-inhabiting and ectomycorrhizal (EcM) (Kutszegi et al. 2015). Many environmental factors are important drivers for the diversity of macrofungal species richness. Wood-inhabiting fungal communities are host specificity or the amount and diameter (Lonsdale et al. 2008), age (Heilmann-Clausen 2001), decay stage (Heilmann-Clausen et al. 2014), species identity (Küffer et al. 2008), complexity (Heilmann-Clausen

and Christensen 2005), and spatio-temporal availability of dead wood (Halme et al. 2013). The microclimatic condition and inside pH of wood also play on important role in macrofungal growth (Salerni et al. 2002).

In this scenario, the aim of the present study is to study the distribution and presence of macro fungal species in the forest patches of the Kodaikanal (Poondi) region. Also that, isolating the sporocarps from mushrooms that were cultivated in the laboratory conditions for numerous studies. From the collection and diversity documentation, we have studied the morphological characters of the mushrooms, host specificity, forest-type preference, seasonal growth pattern and adaptation over lower temperature extremes.

MATERIALS AND METHODS

Study area

The present study area is situated about 45 km eastwards from Kodaikanal (Poondi: 10°11'11.63"N and 77°20'33.89"E; 1981.2 m) (Jan-Dec 2015) (Figure 1). This area is surrounded by Kodaikanal Wildlife Sanctuary, which is about 60,895.482 hectares (608.95 sq.km) and consisted of different macro fungal species. Hand held thermo-hygrometer (Mextech™, Mumbai, India) was used to record the temperature and relative humidity is prevailing in the sampling sites. The average temperature of Kodaikanal was about 15.93°C with an average of 17.29°C in summer (Mar, May, Jun, Jul and Aug) and mean winter temperature was about 14.1°C (Dec, Jan and Feb) with average annual rainfall of 1,650 and 1,800 mm (Rangan et al. 2010). The main reason for selecting this region as the study area is due to their peculiar climatic features, which enhance the growth of a variety of plants like acacia, eucalyptus and pinus (Jan-Dec 2015), which in turn influences the growth of mushrooms in the study area.

Sampling of macrofungi

A group of 6 people, three at each side of the central line walked along transects the length of 20m each end and all macro fungi within the transect belt were recorded. We have used meter sticks to describe an area of 2m on both sides and walked forward the length of transects observed the type and number of individual of the species (Ortega-Martinez and Martinez-Pena 2008). To avoid the double counting, after complete the first transect the following transects were laid 5m intervals. Each macro fungi species within each transect was collected in separate specimen bags in order to avoid spore contamination among the different specimens, and these were photographed in colored and tagged. Morphological features such as size, color, shape, and texture of the sporocarps were recorded as these features might change with drying. Identification of specimen was based on macroscopic and microscopic features.

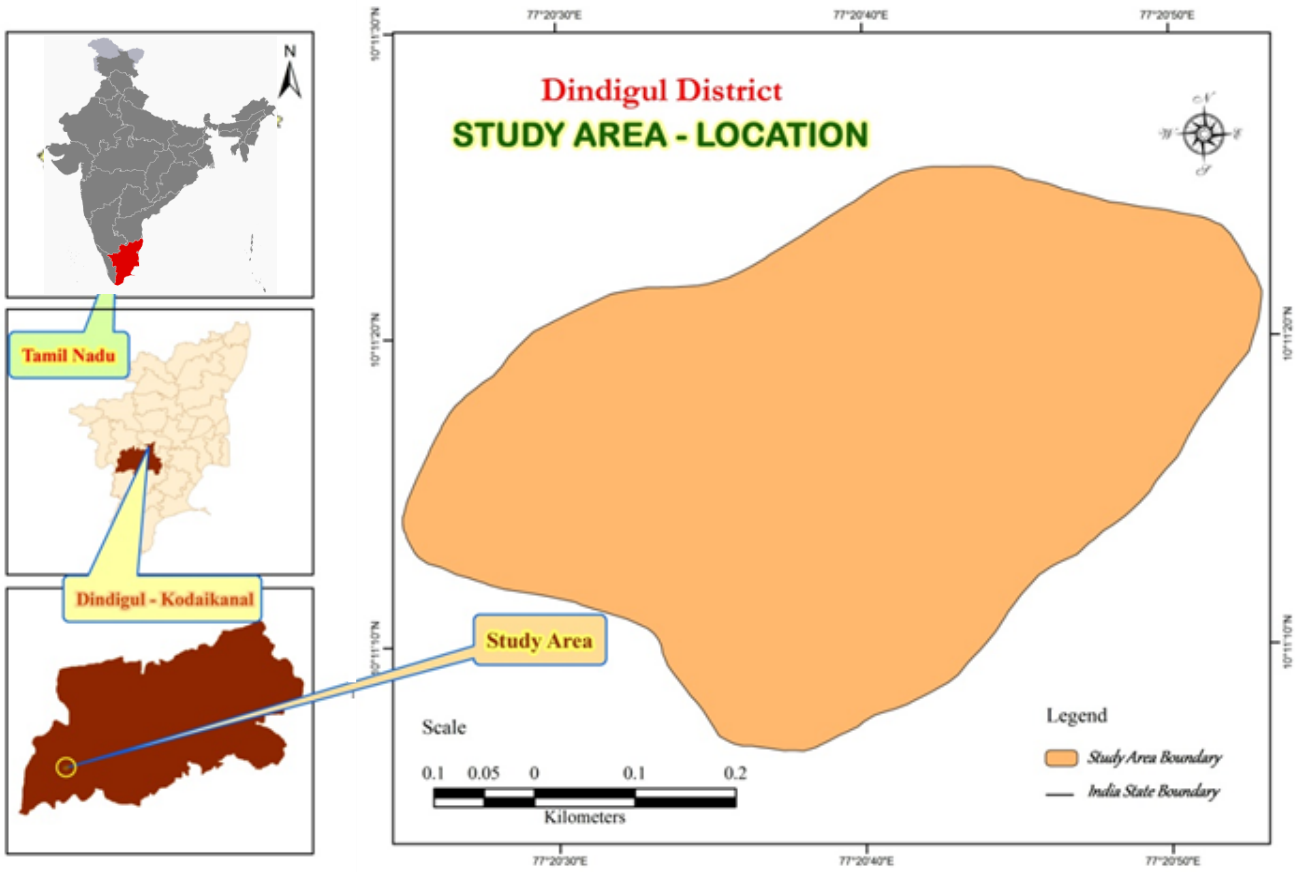

Figure 1. Map showing distribution of mushrooms species in Kodaikanal region of Poondi, India

Table 1. Overall diversity indexes

Soil habituating		Wood habituating	
Shannon-Weiner	**Simpson**	**Shannon-Weiner**	**Simpson**
2.079	1.877	2.025	5.025

The macroscopic features used were: the cap size, shape, color, surface texture and surface moisture, gill color, attachment, spacing, lamellules, the stem size, shape, surface texture and surface moisture, the presence or absence of partial and universal veils, flesh color and texture. Using standard protocols, diversity indices such as Simpson and Shannon-Weiner diversity indices were used (Table 1).

Identification of mushrooms

The mushrooms were photographed at the collection spot and were identified based on its primary mode of nutrients (fungi parasitic on living plant material), very fresh dead material, wood-decay fungi, ectomycorrhizal fungi and litter-decay fungi found on forest floor according to Ferris et al. (2000) and Takahashi and Kagaya (2005). Identification was also made based on various specific characters such as the diameter of fruiting bodies, cap, odor, flesh, gills, stem and veil (Watling 1971). Furthermore, monographs, identification keys and field guide of mushroom were referred for further species identification (Ostry and O'Brien 2010; Kaul 2001). Apart from that mushrooms were identified and confirmed by their morphological characters using the software identification of mushrooms (Discover mushroom, 1997 – Version: 5.1.2600.5512.); (Det pro, 2000 – Identification of Fungi, Kees Uljé, van Dijkstraat 21, 2405 XE Alphen aan den Rijn, The Netherlands); (Match maker, 2003, Version 1.10).

Phenology of mushrooms

Phenology studies, i.e., the time-scale between fruit body appearance and disappearance, was monitored bi-monthly (throughout the year) and found 80% of the total species fruit bodies appeared between July to October and disappeared in between March and April. The phenological pattern of appearance and disappearance of fruit bodies were observed to different across species, in soil and wood habiting mushroom. The wood and soil macro fungi with the highest fruiting season (of over 12 months) include *Ganoderma applanatum*, *Ganoderma austral*, *Ganoderma oregonense*, *Phellinus igniarius*, *Phlebia radiate* and *Pleurotus ostreatus*. In soil, *Amanita muscaria*, *Cheilymenia theleboloides*, *Rhizopogon roseolus*, *Russula parazurea*, *Scleroderma areolatum*, *Scleroderma citrinum*, *Scleroderma cepa*. Similarly, Macro fungi in both wood and soil possess shorter (compressed) or latent fruiting seasons ranging between 1-28 days were mostly members of the family Agaricaceae. The rainy months of August to October marked the peak of fruit body appearance or phenological activity and almost 65% of all fruit bodies were observed during this period.

RESULTS AND DISCUSSION

Among the collected 100 mushroom species 79 were identified at the species level, and 21 were identified as for genus level belonging to 51 families from the Kodaikanal (Poondi) region of the Western Ghats during the study period (2015) (Figures 2-3). Among the species 45 were isolated from the soil host surfaces, whereas the remaining 55 were isolated from the tree host surfaces of tree species such as black wattle (n = 42), eucalyptus (n = 3), pinus (n = 6) and Erythrina indica (n = 4). All these host trees were of invasive tree types and were observed to accommodate many number mushrooms than that of the other native tree species. Also, each tree inhabiting mushroom species was observed to dependent only on specific host species.

Diversity and distribution

A total of 100 species were collected in both wood and soil. Overall diversity index was indicated to wood habituating mushrooms have more index regarding diversity compared with soil habituating mushrooms (Table 1). In Soil the identified species belong to 21 families of 9 orders. Majority of the fungi belonged to the Agaricales (31 species), followed by the boletes (8 species) while the Cantharanthales, Pezizales, Physarales, Polyparels, Russulales, and Xylariales were each represented by just a single species. The species abundance of the families was also assessed. The most abundant family was the Agaricaceae with ten species, followed by Psathyrellaceae 7 species, Boletaceae 4 species, Marasmiaceae 3 species, Sclerodermataceae 3 species, Amanitaceae 2 species, Suillaceae 2 species, and others are single species. Whereas in wood identified species belong to 38 families of 14 orders. Among Polyporales 18 species and Agaricales 16 species are contributing in the diversity, followed by others species are single.

Also, the species abundance of the families has also assessed in the soil habitutating fungi. The most abundant family was the Polyporaceae with eight species, followed by Ganodermataceae 4 species, Xylariaceae 3 species, Inocybaceae 2 species, Dacrymycetaceae 2 species, Tricholomataceae 2 species, Pleurotaceae 2 species, and others are present 1 species respectively. From the present study site, macro fungal diversity of about 100 mushrooms belonging to both the soil inhabiting and wood-inhabiting species were documented. The earlier reports suggest that total macro fungal diversity of India is about 850 species (Kakati and Chutia 2009). Similarly, Arun and Eyini 2011 reported the macro fungal diversity of about 132 species from the Thandigudi region of Kodaikanal, Western Ghats. However, those species diversity was quite different from the present study. In this study, we found 75 wood habituating mushrooms species, among 63 mushroom species were sharing rainy and winter season survival, 7 species were surviving all season (All year round) and only 2 were surviving in the dry season. Figure 4 where as in soil, 70 mushroom species were identified, among 62 mushrooms were surviving in both rainy and winter sessions. Only 8 mushroom species were surviving all session (All year round) (Figure 5).


Antrodia malicola
Armillaria sp
Artomyces pyxidatus
Auricularia auricula
Basidioradulum radula
Camarops polysperma
Ceratiomyxa fruticulosa
Clitocybe gibba
Coprinopsis lagopus
Crepidotus applanatus
Crepidotus autochthonus
Crepidotus mollis
Dacrymyces palmatus
Dacryopinax sp
Daedaleopsis confragosa
Daldinia concentrica
Ganoderma applanatum
Ganoderma australe
Ganoderma oregonense
Ganoderma pfeifferi
Gymnopilus decipiens
Hypholoma fasciculare
Laetiporus sulphureus
Lenzites betulina
Leucogyrophana romellii
Lycogala terrestre
Lycoperdon pyrifome
Meruliopsis sp
Micromphale perforans
Oligoporus fragilis
Oligoporus sp
Panellus stipticus
Peniophora incarnata
Peniophora rufomarginata
Phellinus sp
Phlebia sp
Phyllotopsis nidulans
Pisolithus arhizus
Pluteus cervinus
Pleurotus ostreatus
Pleurotus sp
Plicatura crispa
Schizophyllum commune
Sparassis crispa
Steccherinum sp

Figure 2. Wood-inhabiting mushrooms

Tree inhabiting mushrooms

Tree host mushrooms were isolated from various wooden surfaces mostly during the rainy seasons. They include 55 species belong to 38 families (Table 2; Figure 2). Moreover, the development of sporocarps was basically observed to dependent on upon natural condition like temperature, precipitation, and dampness. However, some other tree host mushrooms were observed throughout the year (Jan-Dec 2015) (e.g., *Ganoderma australe*, *Ganoderma applanatum* and *Phellinus* sp.) and these species were also observed to be completely appended to the host trees. Hence these mushroom types are also considered as wood spoiling mushrooms.

Soil-inhabiting mushrooms

Most of the macro fungal species were isolated from the dirt accumulated soil surfaces and were collected during the wet and dry seasons. The maximum types of mushrooms were isolated during the wet season only (Sep-Dec). They include 45 species belong to 21 families (Jan-Dec 2015) (Table 3; Figure 3). Moreover, these macro fungal flushes were observed to concurrently produce numerous fruit bodies during the downpour as a result of the decrease in the ambient temperature. Conversely, some other macro fungal species such as *Amanita muscaria*, *Russula parazurea,* and *Scleroderma citrinum* were observed throughout the year irrespective of seasons.

Temperature-dependent macrofungal flushes

Macro fungal flushes were observed to be a temperature dependent phenomenon, where the abundant growth was observed at winter season (Oct-Dec). Temperature prevailing in this region during the winter season was observed between 8.8°C (min) and 16.9°C (max) (Figure 6), with higher humidity range between 92% and 95%. Furthermore, the winter season is exactly followed by the northwest monsoon in the months between October and December. Hence it is likely that rain could trigger the germination of the spores and enhance the growth of macro fungal populations. Because the flush of the spores was observed followed by the continuous drizzle or light rain lasting for about 10-15 days. Most of the tree-inhabiting mushrooms were found in the dead matter of woods, and the spores were observed to be germinated from the basal part of the wood where the fall of the direct sunlight is avoided.

Moreover, it was observed that the canopy cover of the trees was acting as a shield and maintaining the optimal microclimate in the places was these kinds of flushes were observed. These observations suggest that lower temperature and continuous rain influences the macro fungal distribution and its abundance. Also, there were few observations on the logging and burning of the host tree resources that has eventually resulted in the depletion of macro fungal populations (Figure 6).

Effects of climatic factors on fungal species richness

Values of fungal species richness, humidity, and temperature varied significantly during the year. Temperature and humidity showed rather opposing patterns, whereas changes in fungal species richness matched well with changes temperature (Figure 6). Fungal species richness negatively and positively correlated with temperature in soil fungi (Estimate =-0.01, SE = 0.007, adj. R^2 = 0.11, T =-1.9, P = 0.06, whereas a significant positive correlation was recorded between fungal species richness in wood habitat fungi. Changes in temperature are due to seasonal variation caused by humidity and precipitation.

Figure 3. Soil inhabiting mushrooms

Table 2. Diversity of wood macrofungi and their phenology, substrate tendency and sociability (WD: Wood Debris, W: Wood)

Order	Family	Scientific name	Red data list	Edible/ non-edible	No. of ind.	Phenology	Substrate
Polyporales	Fomitopsidaceae	*Antrodia malicola*	NA	Non-edible	7	Oct-Dec	WD
Agaricales	Physalacriaceae	*Armillaria mellea*	NA	Edible	13	Oct-Nov	WD
Russulales	Auriscalpiaceae	*Artomyces pyxidatus*	NA	Edible	29	Oct-Nov	WD
Auriculariales	Auriculariaceae	*Auricularia auricula*	NA	Edible	31	Sep-Oct	W
Hymenochaetales	Schizoporaceae	*Basidioradulum radula*	NA	Non-edible	20	Aug-Dec	WD
Boliniales	Boliniaceae	*Camarops polysperma*	NA	Non-edible	5	Sep-Oct	WD
Protosteliida	Ceratiomyxidae	*Ceratiomyxa fruticulosa*	NA	Non-edible	19	Sep-Oct	WD
Agaricales	Tricholomataceae	*Clitocybe gibba*	NA	Edible	22	Aug-Nov	WD
Agaricales	Psathyrellaceae	*Coprinopsis lagopus*	NA	Non-edible	27	Sep-Oct	WD
Agaricales	Inocybaceae	*Crepidotus applanatus*	NA	Edible	9	Sep-Oct	WD
Agaricales	Crepidotaceae	*Crepidotus autochthonous*	NA	Edible	51	Sep-Oct	W
Agaricales	Inocybaceae	*Crepidotus mollis*	NA	Edible	14	Sep-Oct	W
Dacrymycetales	Dacrymycetaceae	*Dacrymyces palmatus*	NA	Non-edible	25	Oct-Nov	WD
Dacrymycetales	Dacrymycetaceae	*Dacrymyces capitatus*	NA	Non-edible	16	Oct-Dec	WD
Polyporales	Polyporaceae	*Daedaleopsis confragosa*	NA	Non-edible	10	Sep-Oct	WD
Xylariales	Xylariaceae	*Daldinia concentrica*	NA	Non-edible	3	Oct-Nov	W
Polyporales	Ganodermataceae	*Ganoderma applanatum*	NA	Non-edible	47	TYR	W, WD
Polyporales	Ganodermataceae	*Ganoderma australe*	NA	Non-edible	61	TYR	W, WD
Polyporales	Ganodermataceae	*Ganoderma oregonense*	NA	Non-edible	29	TYR	W, WD
Polyporales	Ganodermataceae	*Ganoderma pfeifferi*	NA	Non-edible	35	Sep-Nov	W, WD
Agaricales	Cortinariaceae	*Gymnopilus decipiens*	NA	Non-edible	60	Oct-Nov	W
Agaricales	Strophariaceae	*Hypholoma fasciculare*	NA	Non-edible	5	Oct-Nov	WD
Polyporales	Polyporaceae	*Laetiporus sulphureus*	NA	Non-edible	23	TYR	W, WD
Polyporales	Polyporaceae	*Lenzites betulina*	NA	Non-edible	40	Sep-Dec	WD
Boletales	Hygrophoropsidaceae	*Leucogyrophana romellii*	NA	Non-edible	26	Oct – Nov	WD
Liceida	Tubiferaceae	*Lycogala terrestre*	NA	Non-edible	5	Oct-Nov	W, WD
Agaricales	Agaricaceae	*Lycoperdon pyriforme*	NA	Non-edible	11	Oct-Nov	W
Polyporales	Irpicaceae	*Meruliopsis taxicola*	NA	Non-edible	14	Oct-Nov	W, WD
Agaricales	Marasmiaceae	*Micromphale perforans*	NA	Non-edible	6	Sep-Nov	WD
Polyporales	Polyporaceae	*Oligoporus fragilis*	NA	Non-edible	27	Oct-Nov	W, WD
Polyporales	Polyporaceae	*Oligoporus caesius*	NA	Non-edible	19	Sep-Nov	W, WD
Agaricales	Mycenaceae	*Panellus stipticus*	NA	Non-edible	12	Sep	WD
Russulales	Peniophoraceae	*Peniophora incarnata*	NA	Non-edible	5	Oct-Nov	W
Russulales	Peniophoraceae	*Peniophora rufomarginata*	NA	Non-edible	5	Aug-Dec	W, WD
Hymenochaetales	Hymenochaetaceae	*Phellinus igniarius*	NA	Non-edible	3	TYR	W, WD
Polyporales	Meruliaceae	*Phlebia radiata*	NA	Non-edible	10	TYR	W, WD
Agaricales	Tricholomataceae	*Phyllotopsis nidulans*	NA	Edible	16	Oct-Nov	W, WD
Boletales	Sclerodermataceae	*Pisolithus arhizus*	NA	Non-edible	3	June-Nov	W, WD
Agaricales	Pluteaceae	*Pluteus cervinus*	NA	Edible	18	Oct-Nov	W, WD
Agaricales	Pleurotaceae	*Pleurotus ostreatus*	NA	Edible	71	Oct-Nov	W, WD
Agaricales	Incertae sedis	*Plicatura crispa*	NA	Non-edible	7	Oct-Nov	W, WD
Agaricales	Schizophyllaceae	*Schizophyllum commune*	NA	Non-edible	33	Oct-Nov	W, WD
Polyporales	Sparassidaceae	*Sparassis crispa*	NA	Non-edible	21	Oct-Nov	WD
Polyporales	Steccherinaceae	*Steccherinum ochraceum*	NA	Non-edible	5	Sep-Dec	WD
Russulales	Stereaceae	*Stereum complicatum*	NA	Non-edible	4	Aug-Nov	W, WD
Thelephorales	Thelephoraceae	*Thelephora terrestris*	NA	Non-edible	5	Oct-Nov	WD
Polyporales	Polyporaceae	*Trametes cervina*	NA	Non-edible	29	Oct-Nov	W, WD
Polyporales	Polyporaceae	*Trametes gibbosa*	NA	Non-edible	40	Aug-Dec	W, WD
Polyporales	Coriolaceae	*Trametes ochracea*	NA	Non-edible	22	Sep-Oct	W, WD
Polyporales	Polyporaceae	*Trametes versicolor*	NA	Non-edible	55	Oct-Nov	W, WD
Trechisporales	Trechisporaceae	*Trechispora mollusca*	NA	Non-edible	20	Sep-Dec	W, WD
Tremellales	Tremellaceae	*Tremella foliacea*	NA	Edible	12	Oct-Nov	W, WD
Xylariales	Xylariaceae	*Xylaria hypoxylon*	NA	Non-edible	4	Sep-Oct	WD
Xylariales	Xylariaceae	*Xylaria polymorpha*	NA	Non-edible	7	Oct-Nov	WD

Table 3. Diversity of soil-inhabiting mushrooms from Western Ghats region in Dindigul District, India (DLL: Decomposing Leaf Litter, S: Soil)

Order	Family	Scientific name	Red data list	Edible/ non-edible	No. of ind.	Phenology	Substrate
Agaricales	Agaricaceae	*Agaricus augustus*	NA	Edible	7	Sep-Nov	DLL
Agaricales	Agaricales	*Agaricus arrensis*	NA	Edible	19	Sep-Nov	S
Agaricales	Agaricales	*Agaricus crocodilinus*	NA	Edible	5	Sep-Oct	DLL
Agaricales	Agaricales	*Coprinus comatus*	NA	Edible	4	Sep-Oct	DLL, S
Agaricales	Amanitaceae	*Amanita muscaria*	NA	Non-Edible	23	TYR	DLL
Agaricales	Strophariaceae	*Agrocybe praecox*	NA	Edible	11	Nov-Dec	DLL, S
Agaricales	Agaricaceae	*Bovista plumbea*	NA	Edible	9	Oct-Nov	Grass
Pezizales	Pyronemataceae	*Cheilymenia theleboloides*	NA	Non-Edible	18	TYR	Cow dung, S
Agaricales	Agaricaceae	*Chlorophyllum molybdites*	NA	Edible	15	Oct-Nov	S
Boletales	Gomphidiaceae	*Chroogomphus rutilus*	NA	Edible	21	Oct-Dec	S
Cantharellales	Clavulinaceae	*Clavulina rugosa*	NA	Edible	6	Oct-Nov	S
Agaricales	Psathyrellaceae	*Coprinus disseminatus*	NA	Edible	20	Oct-Nov	DLL, WD
Agaricales	Psathyrellaceae	*Coprinus domesticus*	NA	Edible	5	Oct-Nov	DLL, WD
Agaricales	Psathyrellaceae	*Coprinus plicatilis*	NA	Edible	10	Sep-Nov	DLL, S
Physarales	Physaraceae	*Fuligo septic*	NA	Non-Edible	4	Oct-Nov	Grass
Agaricales	Hygrophoraceae	*Hygrocybe perplexa*	NA	Edible	37	Oct-Nov	DLL
Agaricales	Inocybaceae	*Inocybe sororia*	NA	Non-Edible	18	Oct-Nov	S
Agaricales	Hydnangiaceae	*Laccaria proxima*	NA	Non-Edible	32	Sep-Nov	S, DLL
Agaricales	Agaricaceae	*Lepiota brebissonii*	NA	Non-Edible	17	Sep-Oct	S
Agaricales	Agaricaceae	*Lycoperdon echinatum*	NA	Edible	18	Sep-Nov	S
Agaricales	Agaricaceae	*Lycoperdon perlatum*	NA	Edible	13	Sep-Dec	S
Agaricales	Marasmiaceae	*Marasmius alliaceus*	NA	Edible	22	Sep-Nov	DLL, S
Agaricales	Marasmiaceae	*Marasmius oreades*	NA	Edible	3	Sep-Oct	DLL, S
Agaricales	Marasmiaceae	*Mycena vitilis*	NA	Non-Edible	11	Sep-Oct	DLL, S
Agaricales	Bolbitiaceae	*Panaeolina foenisecii*	NA	Non-Edible	23	Oct-Nov	S
Agaricales	Bolbitiaceae	*Panaeolus sphinctrinus*	NA	Non-Edible	15	Oct-Nov	S
Polyporales	Polyporaceae	*Polyporus arcularius*	NA	Non-Edible	13	Sep-Nov	S, DW
Xylariales	Xylariaceae	*Poronia punctata*	NA	Non-Edible	10	Sep-Oct	Cow dung
Agaricales	Psathyrellaceae	*Psathyrella candolleana*	NA	Non-Edible	27	Sep-Oct	S
Agaricales	Psathyrellaceae	*Psathyrella obtusata*	NA	Non-Edible	19	Sep-Oct	S
Agaricales	Psathyrellaceae	*Psathyrella senex*	NA	Non-Edible	14	Sep-Oct	S
Agaricales	Psathyrellaceae	*Psathyrella hirta*	NA	Non-Edible	15	Aug-Nov	S
Agaricales	Hymenogastraceae	*Psilocybe cubensis*	NA	Non-Edible	26	Sep-Nov	S
Boletales	Rhizopogonaceae	*Rhizopogon roseolus*	NA	Edible	9	TYR	S
Russulales	Russulaceae	*Russula parazurea*	NA	Edible	117	TYR	S
Boletales	Sclerodermataceae	*Scleroderma areolatum*	NA	Non-Edible	53	TYR	S
Boletales	Sclerodermataceae	*Scleroderma citrinum*	NA	Non-Edible	39	TYR	S
Boletales	Sclerodermataceae	*Scleroderma cepa*	NA	Non-Edible	25	TYR	S
Boletales	Suillaceae	*Suillus granulatus*	NA	Edible	30	July-Dec	S
Boletales	Suillaceae	*Suillus bovines*	NA	Edible	126	Sep-Nov	S
Agaricales	Physalacriaceae	*Xerula radicata*	NA	Edible	41	July-Sep	S

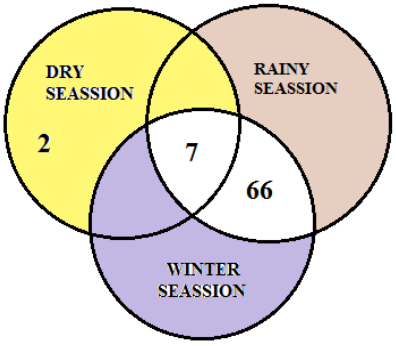

Figure 4. Distribution of wood habitat fungal diversity in the study area

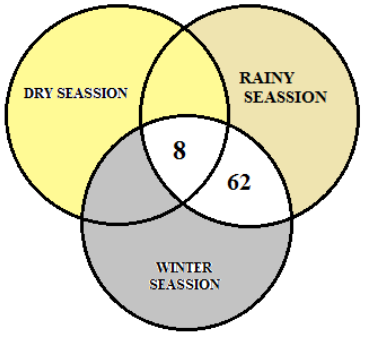

Figure 5. Distribution of soil habitat fungal diversity in the study area

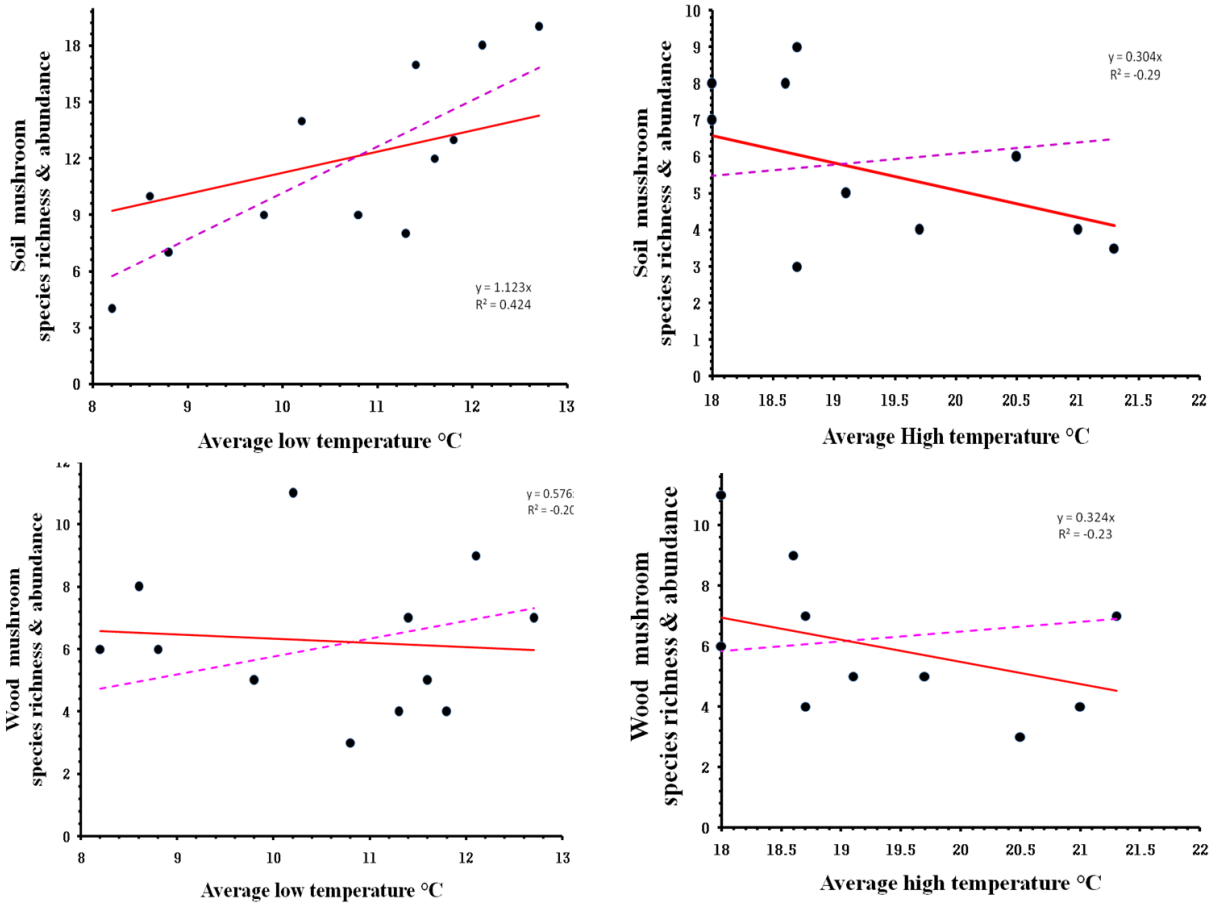

Figure 6. Generalized linear models showing the relationships between climatic variables and fungal species richness during sampling events in the study area

Soil-inhabiting mushrooms were observed to be more during the wet seasons of the year in the dirt accumulated soil surfaces. It was suggested that the fruiting process of macro fungi requires surplus energy and nutrients at the time of their vegetative growth, which is abundant in the dirty soil surfaces (Busch and Braus 2007). Similarly, the tree-inhabiting macro fungi are also observed to be abundant during the wet seasons of the year. Environmental factors such as temperature, humidity and rainfall are reported to influence the formation of sporocarps (Dighton et al. 1981). Soil mushrooms were observed to be abundant in the soil enriched with dead and decaying leaves. There are studies highlighting the importance of dirt richness on the survival and growth of saprobic mushrooms (Packham et al. 2002; Gates et al. 2011). Dirt porosity, type of soil, supplement accessibility and pH are the important primary components of the dirt development that eventually act as a substrate to the mushrooms (Karwa and Rai 2010). Most importantly, macro fungal flushes seem to be a temperature dependent phenomenon. Because the changes in temperature, precipitation are likely to influence the climate changes (Kauserud et al. 2008) and the factors affecting fruiting are directly and indirectly controlled by the microclimatic features (Yang et al. 2012). In the present study, microclimatic stability was observed to be influenced and maintained by the canopy cover. Greater canopy covers are reported to maintain the humidity at high ranges (Hardwick et al. 2015), and thereby enhances the fungal growth. Moreover, shade tree diversity and forest canopy cover are therefore important in maintaining high fungal diversity and its production (Ostry N. A.; O'Brien, J.G. 2010). Another important factor influencing the macro fungal flushes is drizzle or continuous rain lasting for about 10-15 days. According to Manoharachary et al. (2005) continuous rain could favor rapid growth of macro fungi when organic matter or its decomposition products are easily available. Among the 95 macro fungi species that was observed in the study area, there are a few biodynamic mixes having tremendous medical functions, e.g., *Ganoderma* sp: anticancer, cell reinforcement, antiviral and antifungal properties (Paterson 2006). Based on the study we observed that some of the mushroom species (*Coprinus* sp., *Amanita muscaria*, *Agaricus* sp., *scleroderma* sp.) were abundantly present soil and wood surfaces throughout the year, whereas the organisms such as (*Ganoderma pfeifferi*,

Thelephora terrestris, *Lycoperdon* sp., *Ganoderma oregonense*) were observed in very rarely in few areas. We also observed that the forest fire has substantially reduced the biodiversity of mushrooms. Thus it should be avoided to restore the biodiversity of mushrooms. Hattori (2001) also insists the deforestation and firing could spoil the biodiversity of mushrooms to an unpredictable extent. Macro fungal biodiversity protection is crucial to other environmental biodiversity. In this scenario, it is very important to pay attention to the ecologically sensitive areas, which confronts the dangers due to mismanagement (Gadgil et al. 2011). Macro fungal species are not only beautiful but also play crucial roles in decomposition, nutrient cycling, contribute to soil structure, health, fruiting bodies provide food and medicinally valuable compounds (Maser et al. 2008). They are vital to the forest ecosystem and are to be essentially conserved.

In conclusions, mushrooms are vital to break down the organic matter and recycling nutrients of ecosystems. In conservation biology macrofungi are the interface of organisms between life and death-without them, all ecosystems would fail. In the diversity analysis, 11 macrofungus from wood and 22 soil habitats are edible and frequently used by the scheduled tribes of the study area. The nonedible mushrooms of wood habitat like Polyporales and Hymenochaetales are have been used for the treatment of cancer because of the presence of their bioactive compounds. These wood habitat mushrooms were recorded to be high in their numbers compared to soil habitat. Among the wood habitat, the dominant family was identified as Agaricaceae. Even though these wood habitats are high, their economic value is yet to study well. In soil habitat is dominated by the family of Polyporales and Agaricaceae equally. Compared to wood habitat, edibility of soil mushroom is high because of easy accessibility and availability. This soil habitat also holding considerable no of nonedible mushrooms, they also used for the treatment of cancer, wound healing. ie., medicinal value. An extensive study in Poondi, Kodaikanal region of Western Ghats helps to explore the useful metabolites from these mushrooms for the benefit of mankind.

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