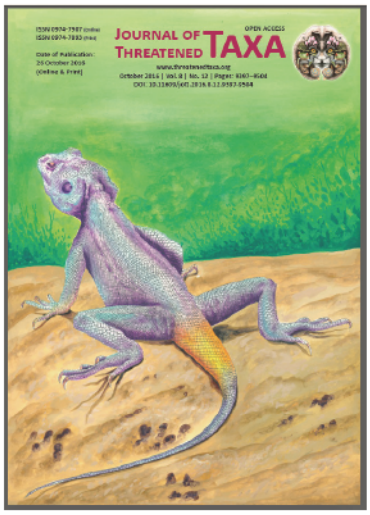

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COMMUNICATION

DIVERSITY AND SEASONALITY OF POLYPORE FUNGI IN THE MOIST DECIDUOUS FORESTS OF PEECHI-VAZHANI WILDLIFE SANCTUARY, KERALA, INDIA

A. Muhammed Iqbal, Kattany Vidyasagaran & P. Narayan Ganesh

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Diversity and seasonality of polypore fungi in the moist deciduous forests of Peechi-Vazhani Wildlife Sanctuary, Kerala, India

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Abstract: The objective of present study was to understand the diversity, distribution and seasonality of polypore fungi in the moist deciduous forests of Peechi-Vazhani Wildlife Sanctuary in three different seasons. Results obtained showed that density and frequency of occurrence have been varied significantly during different seasons and the community structure and species composition during monsoon and post monsoon seasons were distinct from pre-monsoon season. *Fomitopsis feei* with higher abundance values dominated the moist deciduous forests during monsoon season (17.72) and post-monsoon season (13.79). During pre-monsoon season, *Daedalea flavida* was the dominant species with abundance value of 10.93. The above fungi were predominant during all the seasons due to their high ecological amplitude. Fungal diversity analysis showed that species richness was higher during monsoon season and revealed the influence of seasonal variation on fungal diversity. The high species similarity was observed between monsoon and post monsoon season compared to pre-monsoon and monsoon.

Keywords: Diversity, Kerala, moist deciduous forests, monsoon, polypore fungi, species composition.

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Author Details & Author Contribution: A. Muhammed Iqbal, research student at College of forestry, Kerala Agricultural University conducted the study as part of the MSc forestry degree. All field studies, specimen collection and preparation of article in the prescribed format was done by him. K. Vidyasagaran, Dean, College of Forestry, Kerala Agricultural University and he is the Principal investigator of the study. P.N. Ganesh, Associate Professor, Department of Botany, Sree Krishna College. Eminent researcher in India who studied the polypores of Kerala and published a monograph on that. The specimens were identified with his help.

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INTRODUCTION

In contrast with the autotrophic plant communities, the distribution of the heterotrophic fungal community will be regulated by their demand for food resources, which will naturally tend to be diverse in supply and of limited duration. This leads to the noticeable distribution of species over space and time. Most of the polypore fungi are widely distributed in both tropical and temperate regions, although, some species are confined to specific ecological zones. In tropical forests, polypores occur in different habitat types and are found with higher frequency and diversity (Nogueira-Melo et al. 2014). On account of this the presence and abundance of fruit bodies and its diversity can be used to determine the species composition and community structure of polypores. Furthermore, the fruiting and development of sporocarps of polypores happen only when the environmental and ecological conditions are advantageous, but their mycelia exist on the substrate unobtrusively for long period (Lodge et al. 2004). Moreover, fungal fruiting is a seasonal event controlled by climatic factors. Environmental factors like rainfall, temperature and relative humidity play a role in growth of polypores (Ingold 1965). The geographical features of Kerala with peculiar physiographic, edaphic and climatic gradient have contributed significantly to the development of diverse types of forest ecosystem and moist deciduous forests have maximum extent in the state with 44% of total forest area (Mohanan 2011). Research is needed to unravel the influence of various environmental factors on the species richness of polypore fungi in the moist deciduous forests of Kerala. With the available data on the taxonomic studies undertaken on polypore diversity in the natural stands of Kerala, it is difficult to conclude the effect of climatic influence on diversity and abundance. No comprehensive studies on the diversity and distribution of polypore fungi in Kerala have been undertaken. A detailed analysis of the polypore fungi will give a better picture of their distribution pattern. Peechi-Vazhani Wildlife Sanctuary is located in the Thrissur District of Kerala with moist deciduous forest as major vegetation type. The sanctuary experiences typical south-east monsoon every year, hence, by comparing the observations and findings on polypores across different climatic seasons in the study area, it will be possible to unearth crucial data on the distribution and occurrence of polypore fungi in the moist deciduous forest.

Materials and Methods

Study Area

Peechi-Vazhani Wildlife Sanctuary (PVWS) lies within the geographical extremes of latitudes $10^0$26'N & $10^0$40'N and longitudes $76^0$15'E & $76^0$28'E, covering an area of 125km^2 in Thrissur District, Kerala State (Fig. 1). Annual average precipitation in the sanctuary is 3,000mm and is situated at an altitude of 45–900 m. As per Champion & Seth (1986), the forest type of the sanctuary, nearly 80% is moist deciduous forest, 15% is evergreen and semi-evergreen and the remaining five per cent is under teak and soft wood plantations.

Survey, collection and identification of fungi

The survey was conducted during January 2012 to October 2014 in PVWS, Kerala for collection of polypores. Three permanent fixed size sample plots of 100×100 m were established in three different locations, viz., Vellani, Mannamangalam and Olakkara sections of the sanctuary as per the methodology of earlier fungal studies (Yamashita et al. 2010; Mohanan 2011). Also subplots of 10x10 m were fixed in each permanent plot for detailed analysis. The sample plots were visited during pre-monsoon (January–May), monsoon (June–September) and post monsoon (October–December) periods for the documentation of polypores including collection of sporocarps, labelling, rot character identification, taking photographs and recording macro-morphological description and details of substratum in the illustrated data sheet. A total area of 30,000m² was surveyed in each of the three climatic seasons. Additional collection of polypores was also made from "off plots" in the study area. Thus, a combination of opportunistic and plot-based survey was carried out to maximize the documentation of polypore diversity and distribution. The polypore specimens collected from the study area were kept in paper bags and brought to the lab. The specimens were properly air dried or oven dried and stored in polythene zip-cover under less humid conditions. The specimens were identified based on their macro and micro morphological features. The identification key provided by Bakshi (1971) and Leelavathy & Ganesh (2000) were used for the confirmation of polypore species. The micro-morphological characteristics of the polypores were drawn with the help of camera lucida. Some of the specimens were compared with those in the Herbaria at Kerala Forest Research Institute, Peechi. All the specimens collected during the study period were catalogued and kept under less humid conditions in

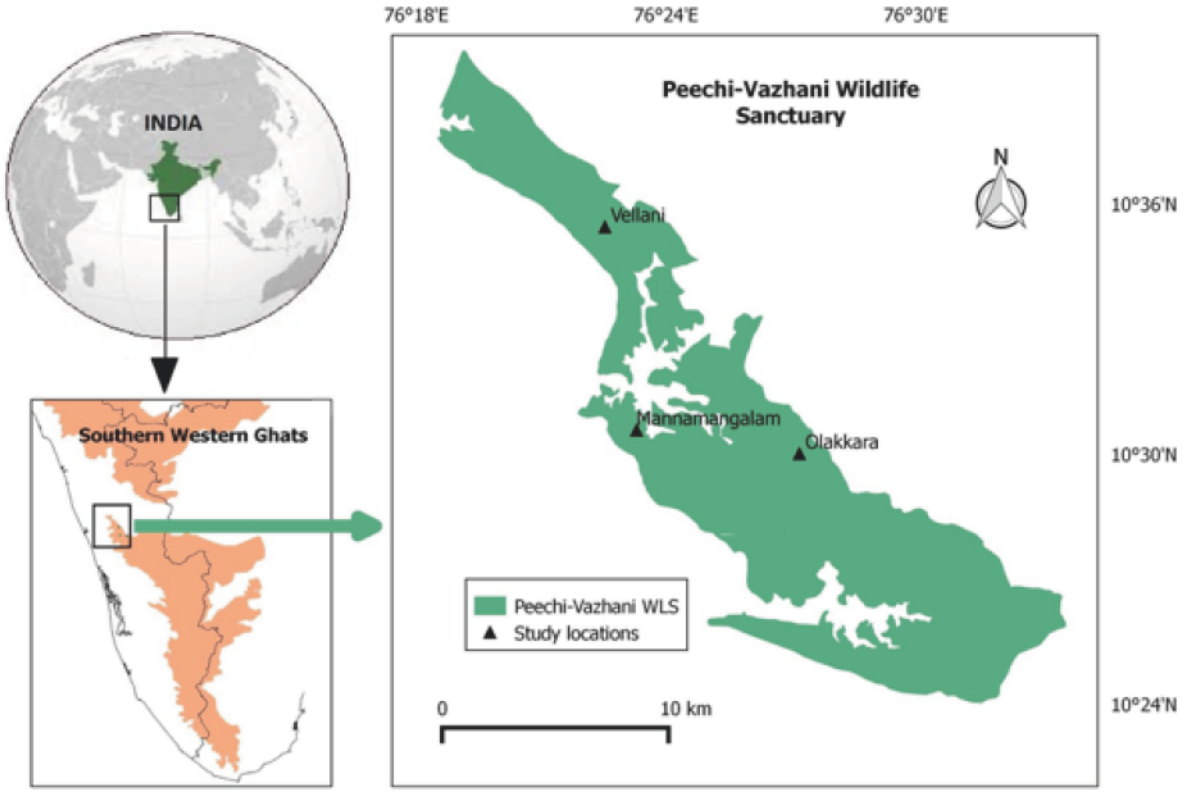

Figure 1. Study areas in Peechi-Vazhani Wildlife Sanctuary

the Department of Forest Management and Utilization, College of Forestry at Kerala Agricultural University. After proper identification, the current names of the identified polypores and their taxonomic details were accessed from the website: www.mycobank.org (accessed on 15 January 2015).

Data analysis

The polypore community has been quantitatively analyzed for their abundance, frequency, density and their relative values as similar to vegetation studies (Curtis & McIntosh 1950). In order to determine the quantitative relationship between the polypore species, the following parameters were used (each basidiocarp is considered as an individual).

In addition to the quantitative analysis, the diversity of polypores was calculated using PAST 3.04 to compare the diversity of polypores of the PVWS, Shannon-Weiner diversity Index *H*_ (Shannon & Weaver 1963) and Simpson's Diversity Index (*D*) (Simpson 1949) were used.

1. a. Simpson Index, $D = 1- \Sigma (ni / N)^2$

Where, ni – Number of individuals of the species, N - Total number of individuals in the plot, D - Diversity

b. Concentration of dominance, $Cd = \Sigma (ni / N)^2$

2. a. Shannon-Weiner's index, $H' = 3.3219 (Log N-1/N \Sigma ni log ni)$

Where, ni – Number of individuals of the species, N - Total number of individuals, S- Total number of species

b. $H_{max} = 3.3219 \log 10 S$

Where, H_{max} is the maximum dispersion taking into account the number of species present in the plot.

c. Equitability (E) = H'/ Hmax

Similarity of each polypore community was calculated using Sorenson similarity index (QS)= 2c/ a+b, Where a and b represent the species numbers occurring in two different plots, and c, the species occurring in both plots (Sorenson 1948). Principal component analysis (PCA -Bi plot) was done using the statistical software PAST 3.04.

RESULTS AND DISCUSSION

Community structure of polypores

During the pre-monsoon period, a total of 227 individuals of polypores per hectare belonging to 13 different species were recorded (Table 1) and the structural analysis of polypore community indicated that *Daedalea flavida* had maximum relative density

Table 1. Abundance, density, relative density, percentage frequency and relative frequency of polypores during pre-monsoon period in the Peechi-Vazhani Wildlife Sanctuary

	Fungal species	A	D	R.D	P.F	R.F
1	*Daedalea flavida* Lev.	10.93	55	24.08	5	18.75
2	*Fomitopsis feei* (Fr.) Kreisel	9.5	6	2.79	0.67	2.5
3	*Fulvifomes nilgheriensis* (Mont.) Bondartseva & S. Herrera	8.2	14	6.02	1.67	6.25
4	*Fuscoporia gilva* (Schwein) T. Wagner & M. Fisch.	10.44	31	13.8	3	11.25
5	*Fuscoporia senex* (Nees & Mont.) Ghobad-Nejhad	6.5	4	1.91	0.67	2.5
6	*Hexagonia tenuis* (Hook.) Fr.	8.75	12	5.14	1.33	5
7	*Melanoporia nigra* (Berk.) Murrill	9	6	2.64	0.67	2.5
8	*Microporus affinis* (Blume & T. Nees) Kuntze.	7.78	23	10.28	3	11.25
9	*Microporus xanthopus* (Fr.) Kuntze.	8	21	9.4	2.67	10
10	*Nigroporus vinosus* (Berk.) Murrill	6	6	2.64	1	3.75
11	*Phellinus dependens* (Murrill) Imazeki	7.63	20	8.96	2.67	10
12	*Trametes cotonea* (Pat. & Har.) Ryvarden	5.33	11	4.7	2	7.5
13	*Trametes hirsuta* (Wulfen) Lloyd	7.57	18	7.78	2.33	8.75
	Total	**105.64**	**227**	**100**	**26.66**	**100**

A - Abundance; D - Density; R.D - Relative density; P.F - Percentage frequency; R.F - Relative frequency

(24.08%) and lowest value was recorded for *Fuscoporia senex* (1.91%). High abundance was recorded for *Daedalea flavida* (10.93) and lowest abundance was represnted by *Trametes cotonea* (5.33). Maximum relative frequency for *Daedalea flavida* (18.75%) and lowest relative frequency value of 2.5% was recorded for three species, namely, *Fomitopsis feei*, *Melanoporia nigra* and *Fuscoporia senex.* In terms of percentage frequencies *Daedalea flavida* topped the figures with 5% and lowest value was represented for three species namely *Fomitopsis feei*, *Melanoporia nigra* and *Fuscoporia senex* with 0.67%.

A total of 648 individuals of polypores per hectare representing 20 species were recorded during monsoon season (Table 2) and structural analysis indicated that *Fomitopsis feei* recorded the highest relative density (22.79 %) and lowest value was recorded for *Polyporus virgatus* (0.15%). Out of 21 species *Fomitopsis feei* recorded the highest abundance (17.72) and lowest value was recorded for *Polyporus virgatus* (3.00). However, high percentage frequency and relative frequency values were noticed for *Fomitopsis feei* (8.33% and 14.29) and the lowest relative frequency was observed with *Polyporus arcularius* and *Polyporus dictyopus* (0.57% and 0.33%).

During post monsoon period, a total of 815 individuals of polypores per hectare belonging to 22 species were recorded (Table 3) and the structural analysis showed that *Fomitopsis feei*, an annual polypore with highest relative density (26.50%) and lowest value was recorded for *Polyporus virgatus* (0.12%). Highest abundance was recorded for *Fomitopsis feei* (13.78) and lowest abundance value was recorded for *Polyporus virgatus* (3.00). The relative frequency and percentage frequency worked out indicated the maximum value for *Fomitopsis feei* (19.58% and 15.67%) and lowest relative frequency value of 0.42% was recorded for *Polyporus virgatus* and lowest percentage frequency was observed with *Polyporus arcularius* (0.33%).

Different fungal species exhibits different fruiting phenologies, which vary from year to year and maximum richness of fruiting species occurs only during brief periods and differs among years (Lodge et al. 2004). Density and frequency percentage of occurrence of polypores over three different seasons demonstrated a remarkable variation in the community structure. During the pre-monsoon period, polypore density was 227 individuals per hectare but during the monsoon period the number of individuals has been increased tremendously to 648 individuals per hectare and the same pattern has also been followed during post monsoon period with a density of 815 individuals per hectare. In case of percentage frequency, during pre-monsoon period 26.66% and observed a wide spread during monsoon and post monsoon with 58.33% and 80% respectively. The rapid increase in the number of individuals and percentage frequency over the season signifies that certain conditions especially the spore release, dispersal and germination has been influenced by the climatic variations. Falling water drops and

Table 2. Abundance, density, relative density, percentage frequency and relative frequency of polypores during monsoon period in the Peechi-Vazhani Wildlife Sanctuary

	Fungal species	A	D	R.D	P.F	R.F
1	*Daedalea flavida* Lev.	14.24	81	12.45	5.67	9.71
2	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	11.45	42	6.48	3.67	6.29
3	*Fomitopsis feei* (Fr.) Kreisel	17.72	148	22.79	8.33	14.29
4	*Fulvifomes nilgheriensis* (Mont.) Bondartseva & S. Herrera	9	15	2.31	1.67	2.86
5	*Fuscoporia gilva* (Schwein) T. Wagner & M. Fisch.	12.1	40	6.22	0.67	1.14
6	*Fuscoporia senex* (Nees & Mont.) Ghobad-Nejhad	6.5	4	0.67	3.33	5.71
7	*Ganoderma lucidum* (Curtis) P. Karst.	13	9	1.34	0.67	1.14
8	*Hexagonia tenuis* (Hook.) Fr.	6.5	13	2.01	2	3.43
9	*Melanoporia nigra* (Berk.) Murrill	6.5	4	0.67	0.67	1.14
10	*Microporellus obovatus* (Jungh.) Ryvarden	7.89	50	7.72	6.33	10.86
11	*Microporus affinis* (Blume & T. Nees) Kuntze.	7	33	5.04	4.67	8
12	*Microporus xanthopus* (Fr.) Kuntze.	11	33	5.09	3	5.14
13	*Nigroporus vinosus* (Berk.) Murrill	2.67	3	0.41	1	1.71
14	*Phellinus dependens* (Murrill) Imazeki	7.56	23	3.5	3	5.14
15	*Polyporus arcularius* (Batsch) Fr.	13	4	0.67	0.33	0.57
16	*Polyporus grammocephalus* Berk.	9	27	4.17	3	5.14
17	*Polyporus virgatus* Berk. & M. A Curtis	3	1	0.15	0.33	0.57
18	*Trametes cingulata* Berk.	10.33	31	4.78	3	5.14
19	*Trametes cotonea* (Pat. & Har.) Ryvarden	13.14	61	9.47	4.67	8
20	*Trametes hirsuta* (Wulfen) Lloyd	11.43	27	4.12	2.33	4
	Total	**193.03**	**648**	**100**	**58.33**	**100**

relative humidity of the atmosphere plays an important part in basidiospore liberation and dispersal (Ingold 1965). Sporocarps of some higher fungi including many woody and leathery bracket fungi are formed only on a damp substratum but can survive considerable periods of desiccation and will commence to shed spores again with a return of moist conditions (Hawker 1965). The frequency percentage of occurrence and density of each polypores species during different seasons showed an interesting fruiting pattern.

Seasonal influence on polypore association

A principal component analysis (PCA) was done to find the association among polypores during pre-monsoon, monsoon and post monsoon season based on their composition and density (Fig. 2). It was observed that all the three seasons are far from the centre, among this, the species composition during monsoon and post monsoon was close to each other and noticed significant positive correlation. In this, the horizontal axis is linked with monsoon and post monsoon, and the vertical axis with pre-monsoon season. The results showed that the distribution of *Daedalea flavida* was less influenced by monsoon and post monsoon seasons and more linked to the pre-monsoon period. Also species like *Microporus xanthopus*, *Microporus affinis*, *Phellinus dependens*, *Fuscoporia gilva* were linked more to the pre-monsoon season. The distribution pattern of *Fomitopsis feei* was highly contributed by the monsoon and post monsoon seasons. It was also observed that species like *Ganoderma lucidum*, *Microporellus obovatus*, *Polyporus grammocephalus*, *Earliella scabrosa* and *Trametes cingulata* were linked to the monsoon and post monsoon. The density of *Fomitopsis feei*, a brown rot fungus during pre-monsoon period was six and it has distributed extensively with a density of 148 and 216 during monsoon and post monsoon respectively.

The present study analyzed that the distribution of *Fomitopsis feei* was highly controlled by the climatic variations and those of *Ganoderma lucidum*, *Microporellus obovatus, Earliella scabrosa, Polyporus grammocephalus* and *Trametes cingulata* were also associated with the climatic fluctuations (Image 1). In case of perennial species like*, Phellinus dependens, Fuscoporia gilva, Fuscoporia senex* and *Fulvifomes nilgheriensis*, their density and percentage frequency

Table 3. Abundance, density, relative density, percentage frequency and relative frequency of polypores during post-monsoon period in the Peechi-Vazhani Wildlife Sanctuary

	Fungal species	A	D	R.D	P.F	R.F
1	*Coriolopsis sanguinaria* (Klotzsch) Teng.	11	7	0.9	0.67	0.83
2	*Coriolopsis telfarii* (Klotzsch) Ryvarden	12.5	8	1.02	0.67	0.83
3	*Daedalea flavida* Lev.	12.7	97	11.94	7.67	9.58
4	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	11	48	5.85	4.33	5.42
16	*Fomitopsis feei* (Fr.) Kreisel	13.79	216	26.5	15.67	19.58
5	*Fulvifomes nilgheriensis* (Mont.) Bondartseva & S. Herrera	6.86	16	1.96	2.33	2.92
6	*Fuscoporia gilva* (Schwein) T. Wagner & M. Fisch.	10.25	41	5.03	4	5
7	*Fuscoporia senex* (Nees & Mont.) Ghobad-Nejhad	4.33	4	0.53	1	1.25
8	*Ganoderma lucidum* (Curtis.) P. Karst.	10	10	1.23	1	1.25
9	*Hexagonia tenuis* (Hook.) Fr.	4.57	11	1.31	2.33	2.92
10	*Melanoporia nigra* (Berk.) Murrill	4.5	6	0.74	1.33	1.67
11	*Microporellus obovatus* (Jungh.) Ryvarden	12.25	65	8.02	5.33	6.67
12	*Microporus affinis* (Blume & T. Nees) Kuntze.	6.64	31	3.8	4.67	5.83
13	*Microporus xanthopus* (Fr.) Kuntze.	7.06	38	4.62	5.33	6.67
14	*Nigroporus vinosus* (Berk.) Murrill	5.4	9	1.1	1.67	2.08
15	*Phellinus dependens* (Murrill) Imazeki	6.82	25	3.07	3.67	4.58
17	*Polyporus arcularius* (Batsch) Fr.	9	6	0.74	0.67	0.83
18	*Polyporus grammocephalus* Berk.	7.85	34	4.17	4.33	5.42
19	*Polyporus virgatus* Berk. & M. A Curtis	3	1	0.12	0.33	0.42
20	*Trametes cingulata* Berk.	9.82	36	4.42	3.67	4.58
21	*Trametes cotonea* (Pat. & Har.) Ryvarden	12	68	8.34	5.67	7.08
22	*Trametes hirsuta* (Wulfen) Lloyd	10.27	38	4.62	3.67	4.58
	Total	**191.61**	**815**	**100**	**80**	**100**

pattern has not been influenced by the climatic factors. The density and frequency of occurrence of *Daedalea flavida* during pre-monsoon, monsoon and post monsoon was 55, 81, 97 and 5.00, 5.67, 7.67 respectively. Therefore, it was not so much evident that climatic fluctuations have an influence on the distribution. Hence, all these species which were observed in all the three seasons and are more linked to the pre-monsoon period (Fig. 2). Environmental conditions, particularly seasonal fluctuations act distinctly on different fungi to operate in the selection of species available for community development and but also to act differently upon different phases in the life history of a single species. Thus germination, growth, reproduction, spore release, dispersal and survival may not all be influenced in the same direction by a given factor at a given level (Park 1968).

The number of species reported during pre-monsoon, monsoon and post-monsoon showed a wide variation. During pre-monsoon period, 13 species were recorded while during monsoon and post monsoon period the number of species were 20 and 22 respectively. A total of 13 species were common in all the three seasons. A significant positive correlation has been noticed in the species composition during monsoon and post monsoon season and this was attributed due to the presence of annual species. In the pre-monsoon, long lived species with woody fruitbodies like *Phellinus dependens, Fulvifomes nilgheriensis, Fuscoporia senex, Fuscoporia gilva* and *Daedalea falvida* were the major species. During monsoon season, seven more species have been recorded from the pre monsoon period. It is due to the fact that annual species like *Earliella sacbrosa*, *Ganoderma lucidum*, *Microporellus obovatus*, *Polyporus arcularius*, *P. grammocephalus*, *P. virgatus* and *Trametes cingulata* had been germinated during the monsoon season. It was also noticed that during post-monsoon season two more species have been recorded in addition to the species encountered during monsoon season. The annual, with fleshy fruit body species like *Coriolopsis telfarii* and *C. sanguinaria* were observed during post-monsoon period. This could be

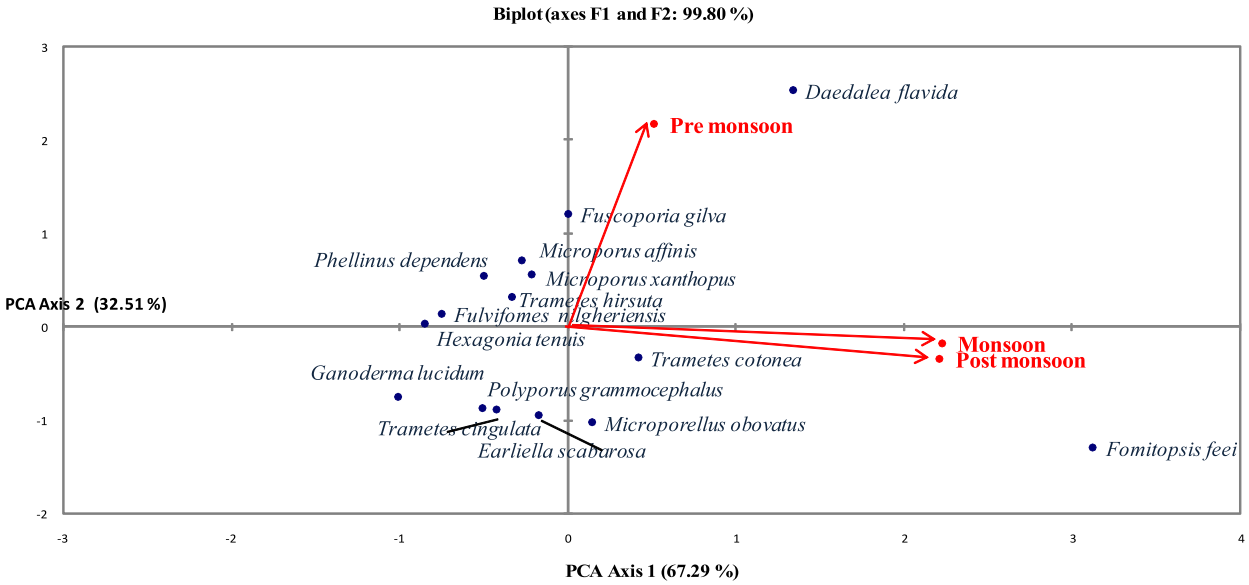

Figure 2. PCA bi-plot of polypores in Peechi-Vazhani Wildlife Sanctuary during different seasons

due to differences in the time lag between the onset of advantageous fruiting conditions and fruit body production between the different species of polypores (Cooke & Rayner 1984). The diversity and distribution of macrofungi in the Mount Cameroon region has shown the similar pattern of species distribution over different seasons. It was explained that most of the fleshy macrofungi were recorded in the rainy seasons as this period is favourable for their production, since there is adequate moisture, favourable temperature, relative humidity and sunshine, which also aids the macrofungi in the decomposition of dead organic matter. While the early dry season there is decrease in rainfall and relative humidity, increase in temperature and sun shine, most of the fleshy macrofungi cannot withstand these conditions. The long lived, woody and corky fruit bodied species found during dry seasons have unique adaptations of surviving for several years producing a new layer of spore producing surfaces thus elevate above the ground ensuring a continuous supply of food material. It might also be probable that these species are not readily eaten by insects and other animals, thus the increase in their abundance (Andrew et al. 2013).

The present study corresponds to Karim et al. (2013) in deciduous forest of Iran and it was explained that seasonal changes in rainfall, temperature and moisture are essential factor in distribution of macrofungi. The maximum numbers of macrofungal species were found in wet season. During the present study, it was discussed that an increase of 32% in the number of species from pre-monsoon to monsoon period and 41% from pre-monsoon to post-monsoon. Temperature and precipitation during growing season explained 24–90 % variation in the occurrence of wood rotting fungi in various forests of India (Sharma 2006).

Diversity of polypores

The diversity parameters like Simpson's index of diversity, concentration of dominance (Cd) and Shannon-Weiner index derived for the polypores species during different seasons revealed the species diversity interaction among them in the moist deciduous forests. The Simpson's index of diversity for three seasons, viz., pre-monsoon, monsoon and post-monsoon were 0.88, 0.90 and 0.88 respectively (Table 4). It showed that for every hundred individuals of polypores taken at random in different seasons, 88, 90, 88 individuals belong to different species. In case of concentration of dominance (Cd), it was recorded as 0.12, 0.10 and 0.12 respectively while the Shannon-Weiner index, the parameter which explains both the species richness as well as species evenness was recorded as 2.32, 2.56 and 2.56 respectively. The Shannon-Weiner index for monsoon and post-monsoon season has no significant difference as it has increased from the pre-monsoon season. Hence, it was revealed from the present study that the species appeared during the pre-monsoon season has been co-existed with species that emerged during the monsoon and post-monsoon season. A fluctuating environment may facilitate co existence

Table 4. Diversity indices of polypores during different seasons in PVWS

	Pre-monsoon	Monsoon	Post-monsoon
Simpson's Index	0.88	0.90	0.88
Concentration of dominance (Cd)	0.12	0.10	0.12
Shannon-Weiner Index	2.32	2.56	2.56
H_{max}	3.70	4.39	4.52
Equitability (E)	0.63	0.58	0.57

Table 5. Sorenson's similarity index of polypore community in PVWLS

	Location	Similarity index pre-monsoon & monsoon	Similarity index monsoon & post-monsoon	Similarity index pre-monsoon & post-monsoon
1	Vellani	0.80	0.97	0.77
2	Mannamangalam	0.88	0.93	0.81
3	Olakkara	0.76	0.96	0.73

of basidiomycetes fungi, the primary decomposer of wood with the functional groups white and brown rot fungi which differ with respect to decay strategy and high species richness may be important for maintaining ecosystem processes under changing environmental conditions (Toljander et al. 2006). Notably, Pradhan et al. (2013) found almost similar pattern of species richness for macrofungi in the deciduous forests of West Bengal that Simpson's index of diversity was 0.923 (with evenness of 92.28) and Shannon Weiner index was 3.73.

This may be due to the fact that during monsoon and post monsoon seasons, the short lived annual polypores were produced extensively and get disintegrated during the pre-monsoon period due to change in temperature. Seasonal change in temperature has an important immediate influence in fungi with limits outside the range are automatically excluded and give a cyclical pattern to the community (Park 1968).

Species similarity among seasons

Similarities in species composition of polypores between different seasons were analysed using Sorensen's similarity index. Sorensen's similarity index ranges from 0.73 to 0.97. The result of Sorensen's similarity index worked out in PVWS (Table 5) showed that the similarity between pre-monsoon and monsoon ranges from 0.76 to 0.88, similarity between monsoon and post monsoon ranges from 0.93 to 0.97 and the similarity between pre-monsoon and post-monsoon ranges from 0.73 to 0.81. Mehus (1986) discussed the fruit body production of macrofungi in forests of North Norway during the late summer and autumn and it was hypothesised that in good seasons, there is a higher similarity in species than in poor seasons. Compared to other season pairs, the similarity between pre-monsoon and post monsoon was low, while the similarity between monsoon and post monsoon was very strong and near to almost 100%. This may be due to the fact that during monsoon and post monsoon seasons, the short lived

Image 1. Emergence of *Trametes cotonea* (A), and *Polyporus grammocephalus* (B)

annual polypores were produced extensively and get disintegrated during the pre-monsoon period due to change in temperature. Seasonal change in temperature has an important immediate influence in fungi with limits outside the range are automatically excluded and give a cyclical pattern to the community (Park 1968).

CONCLUSION

Community structure and species diversity of polypores in the moist deciduous forests is highly related to the climatic factors. The favourable climatic conditions play a crucial role in germination and wide spread annual polypore species. The stress tolerance and behavioural attributes of polypores species during different seasons points out their ecological strategies in a diverse moist deciduous forests.

REFERENCES

Andrew, E.E., T.R. Kinge, E.M. Tabil, N. Thiobal & A.M. Mih (2013). Diversity and distribution of macrofungi (mushrooms) in the Mount Cameroon Region. Journal of Ecology and The Natural Environment 5(10): 318–334; http://dx.doi.org/ 10.5897/JENE2013.0379

Bakshi, B.K. (1971). *Indian Polyporaceae (On Trees and Timber).* ICAR, New Delhi, 246p.

Champion, S.H.G. & S.K. Seth (1986). *A Review of The Forest Types of India*, Government of India, New Delhi, xxvii+404pp.

Cooke, C.R. & A. D.M. Rayner (1984). *Ecology of Saprotrophic Fungi*. Longman, London, 414p.

Curtis, J.T. & R.P. McIntosh (1950). The interrelations of certain analytical and synthetic phytosociological characters. *Ecology* 31: 434–455.

Hawker L. E. (1965). Environmental influence on reproduction, pp. 436-465. In: Ainsworth, G.C. & A.S. Sussman (eds.). *The Fungi - An Advanced Treatise - Vol. II.* Academic press. London.

Ingold C. T. (1965). Spore release, pp. 679–707. In: Ainsworth, G.C. & A.S. Sussman (eds.). *The Fungi- an advanced treatise. Vol. II.* Academic press. London.

Karim, M., M.R. Kavosi & G. Hajizadeh (2013). Macrofungal Communities in Hyrcanian Forests, North of Iran: Relationships with Season and Forest Types. *Ecologia Balkanica* 5(1): 87–96.

Leelavathy, K.M. & P.N. Ganesh (2000). *Polypores of Kerala*. Daya Publishing House, Delhi, 165pp.

Lodge, D.J., J.F. Ammiranti, T.E. O'dell & G.M. Mueller (2004). Collecting and Describing Macrofungi, pp. 128–158. In: Mueller, G.M., G.F. Bills & M.S. Foster (eds.). *Biodiversity of Fungi: Inventory and Monitoring Methods*. Elsevier Academic Press, USA,

Mehus, H. (1986). Fruit body production of macrofungi in some North Norwegian forest types. *Nordic Journal of Botany* 6(5): 679–702.

Mohanan, C. (2011). *Macrofungi of Kerala.* KFRI Handbook No. 27. Kerala Forest Research Institute, Peechi, Kerala, India, 597pp.

Nogueira-Melo, P.J.S. & T.B. Gibertoni (2014). The community structure of macroscopic basidiomycetes (Fungi) in Brazilian mangroves influenced by temporal and spatial variations. *Revista de Biologia Tropical* 62(4): 1587–1595.

Park, D. (1968). The ecology of terrestrial fungi, pp. 5–39. In: Ainsworth, G.C. & A.S. Sussman (eds.). *The Fungi - An Advanced Treatise. Vol. III.* Academic press. London.

Pradhan, P., A.K. Duttaa, A. Roy, S.K. Basu & K. Acharyaa (2013). Macrofungal diversity and habitat specificity: a case study. *Biodiversity* 14(3): 147–161; http://dx.doi.org/ 10.1080/14888386.2013.805660

Shannon, C.E. & W. Weiner (1963). *The Mathematical theory of Communication*. University of Illinois Press, Urbana, U.S.A. 117pp.

Simpson, E.H. (1949). Measurement of diversity. *Nature* 163: 688.

Sharma, J.R. (2006). Wood rotting fungi of Temperate Himalaya, pp. 101–120. In: Mukerji, K.G. & C. Manoharachary (eds.). *Current Concepts in Botany*. IK International Publishing House Pvt. Ltd., New Delhi.

Sorenson, T. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. *Biologiske Skrifter* 5: 1-34.

Toljander, Y.K., B.D. Lindahl, L. Holmer & N.O.S. Högberg (2006). Environmental fluctuations facilitate species co-existence and increase decomposition in communities of wood decay fungi. *Oecologia* 148: 625–631; http://dx.doi.org/ 0.1007/s00442-006-0406-3

Yamashita, S., T. Hattori & H. Abe (2010). Host preference and species richness of wood inhabiting aphyllophoraceous fungi in a cool temperate area of Japan. *Mycologia* 102: 11–19; http://dx.doi.org/10.3852/09-008.

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