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Distribution of polypores along the altitudinal gradients in Silent Valley National Park, Southern Western Ghats, Kerala, India

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Abstract

The distribution pattern of polypores in Silent Valley National Park along different altitudinal gradient were analyzed. A total of 34 species under five families were documented by the plot-based survey conducted from the National Park. Most of the species showed a drastic reduction in density as the altitude increases. In lower altitude wet evergreen forest at Sairandhri (1000-1050 m) possessed more number of species (29 species) and found to be gradually decreasing as the altitude increases. The species richness decreased to 27 species (7 % reduction) at Poochippara (1150-1200 m) and in Walakkad (1300-1350 m) it was reduced to 25 (14 % reduction). Interestingly it was reduced to 11 species in Sispara (1950-2000 m) with 63 % reduction as comparing to that of the lower altitude. At Cheriyamkandam (2100-2150 m) and Valliyamkandam (2200-2250 m) the species richness was found to be 8 and 5 with 72 per cent and 83 per cent reduction respectively as comparing to that of Sairandhri. This monotonic decrease in species richness is also reflected in the polypore density. The density was found to be decreased from 2613 at Sairandhri (1000-1050 m) to 435 in high altitude shola forest at Valliyamkandam (2200-2250 m).

Key words – Clinal Variation – Diversity – Evergreen – Mycology – Polyporales – Shola Forest

Introduction

Polypores or bracket fungi are macrofungi forming woody fruiting bodies with pores or tubes on the underside. The polypores are Basidiomycetes producing holobasidia and ballistosporic basidiospores typically on the inside of the tubes lining the underside of the fructification (Leelavathy & Ganesh 2000). Most of the polypores are wood inhabiting, and rest are terrestrial. The polypores are polyphyletic and inhabit Coarse Wood Debris consuming the wood for their growth and reproduction (Ranadive et al. 2012a, 2012b), but some soil-inhabiting species form mycorrhiza with trees. Polypores plays a primary and central role in decomposition and nutrient cycling in forest ecosystems.

The importance of polypores and the diversity of polypores in tropical forest were not known or not properly assessed, but relatively well-studied in temperate areas. The tropics are very rich source of potentially useful polypores, many of which probably have not even been recognized, described or named (Yamashita et al. 2015). Polypores shows highest diversity in old natural

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forests with abundant Coarse Wood Debris than in younger forests or plantations. Consequently, a number of species have declined drastically and are under threat of extinction due to logging and deforestation.

The polypores capable of selective delignification may have diverse industrial applications like waste water treatment, wood treatment to improve digestibility of lignocellulose materials for cattle feed and for bio pulping wood in paper industry, thus reducing the energy cost (Wu et al. 2005). Polypores possess varying degrees of edibility and many of them are used as food by indigenous people worldwide and some are cultivated commercially (Essien & Akpan 2014). Polypores have a long history in disease treatment in various folk medicines such as in Asia, Russia, USA, Canada, Mexico and Venezuela and are extensively applied in Traditional Chinese Medicine up to the present day.

A wide range of environmental factors influence the timing and development of fruit bodies, including nutritional factors, gaseous regime, pH, light, microclimate, disturbance and inter and intra-specific mycelial interaction (Moore et al. 2008). Understanding the responses of the lowest trophic level is critical if we are to adapt to and mitigate the ecological consequences of climate change (Walther et al. 2002, Walther 2010). The plant host has been identified as an influential factor in the production of fruit bodies, because of the need for some nutritional elements to build sporophores in the forest (Selosse et al. 2001). Influences of climatic variables on fungal physiology in vitro are well-documented (Dickie et al. 2010).

Earlier reports showed that the productivity fruit bodies is mostly related to average monthly rainfall and average monthly temperature (Lagana et al. 2002, Salerni et al. 2002, Aragon et al. 2007, Krebs et al. 2008, Pinna et al. 2010). Regarding rainfall and temperature, a few attempts to explain the duration of fungal fruiting in relation to climate change have recently been discussed (Straatsma et al. 2001, Mihail et al. 2007, Gange et al. 2007, Kauserud et al. 2008, 2011). Furthermore, the productivity of fungi is also determined by habitat characteristics. Generally, forest stands display greater epigeous mushroom productivity than mature stands (Pinna et al. 2010). As polypore growth and distribution are affected by a multitude of environmental factors, differences in elevation also affect its occurrence. Here the study was conducted to understand the influence of elevational gradient on the distribution of polypores in evergreen and shola forest of Silent Valley National Park.

Materials & Methods

Study area

Silent Valley National Park (SVNP) lies within the geographical extremes of latitudes 11º, 2’ N and 11º, 13’ N and longitudes 76º, 24’ E and 76º, 32’ E (Fig. 1) in the southwest corner of Nilgiri hills of Southern Western Ghats. Silent Valley National Park constitutes part of the core area of India's first biosphere reserve, the Nilgiri Biosphere Reserve. Silent Valley Division, comprised of Silent Valley National Park as its core area (89.52 sq. km) was formed on 16th May 1986. In 2007 an area of 148 sq. km. was added to this division as buffer zone. The present study was carried out in the core area of the National Park. The terrain of the SVNP is generally undulating with steep escarpments and many hillocks. The elevation ranges from 900 M to 2,300 M above MSL with the highest peak at 2,383 M (Anginda peak). Both the south west monsoon and the north eastern monsoon cause rains in this area. The major share, however, comes from the south west monsoon, which sets in during the first week of June. The heaviest rainfall is during the months of June, July, and August. The variation in the intensity of rainfall is observed across the area. The elevated hills on the western side of Silent Valley receive an average of 5045 mm and near Walakkad, the rainfall even reaches up to 6500 mm.

The forests exhibit considerable variation in floristic composition, physiognomy and life forms due to climatic, edaphic and altitudinal variations. About 75-80 per cent of the land in the Protected Area is covered with thick woody vegetation and about 20% of the area is having grassland and little area is under rocky patches with little vegetation cover. The Silent Valley in general embodies vast stretches of wet evergreen forest in the undulating hills and valleys between elevation of 900 m and 1500 m. The Evergreen forest of Silent Valley is the home par excellence of the broad leaved evergreen trees in multi-storeyed canopies often reaching up to 40 m or more. The dominant tree species in this type of forest are usually about 45 m in the height, and consists generally of *Cullenia exarillata, Machilus macrantha, Elaeocarpus munronii, Palaquim ellipticum, Mesua ferrea, Calophyllum inophyllum, Cinnamomum malabatrum Canarium strictum, Syzygium cumini, Syzygium laetum, Dysoxylum malabaricum, Poeciloneuron indicum, Mangifera indica, Artocarpus integrifolia, Holigarna grahamii, Hopea glabra, Garcinia gummi-gutta.*

The shola forests is seen in cliffs and sheltered folds above 1800 m where water is available in surplus. The Sispara area enriched with typical shola forests. Because of wind and high altitude these forests are stunted, the trees seldom attaining a height above 10m. Lauraceae and Myrtaceae members constitute the bulk of the flora. The dominant species found are *Rhododendron arboreum, Schefflera rostrata, Ternstroemia gymnanthera, Michelia nilgirica, Gordonia obtusa, Ilex wightiana, Meliosma pinnata, Cinnamomum sulphuratum, Cinnamomum wightii, Litsea floribunda, Litsea stocksii, Euonymaus crenulatus, Glochidion ellipticum, Symplocos racemosa*.

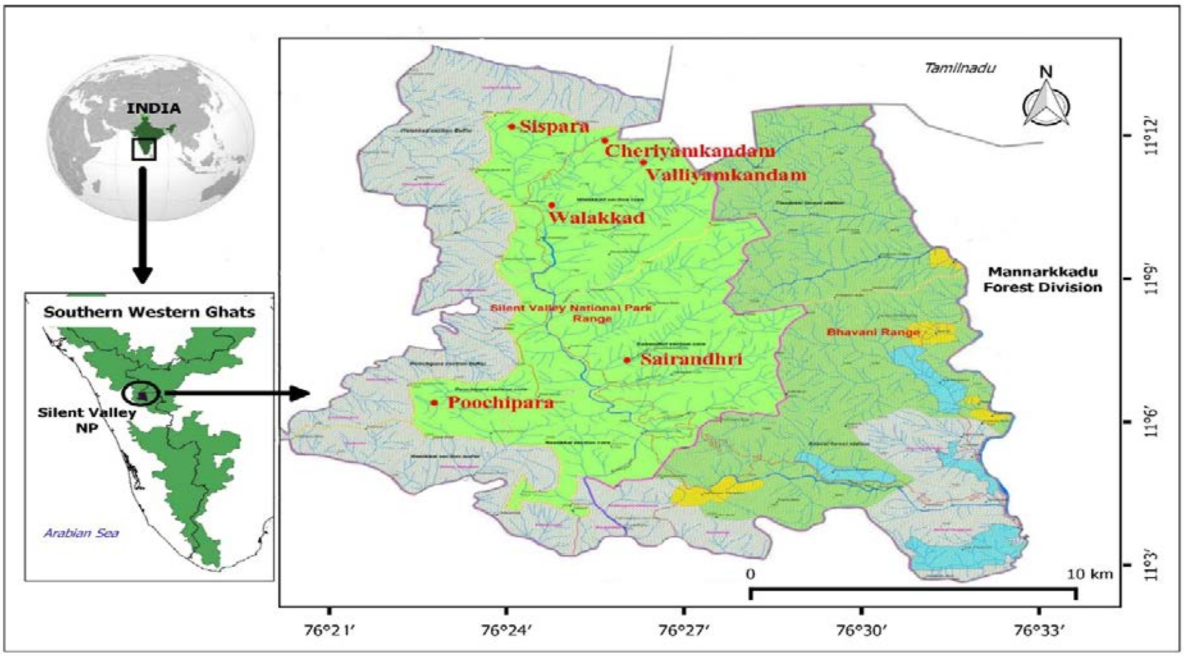

Fig. 1 – Silent Valley National Park, Southern Western Ghats, India.

Survey methodology

The polypores were surveyed in Silent Valley National Park (SVNP) During March 2014 to February 2015. Six permanent sample plots of size 100 m × 100 m were established in evergreen and shola forests (3 in each ecosystem) as per the methodology followed earlier studies (Yamashita et al. 2010, Mohanan 2011). In evergreen forests, the sample plots were taken in three different locations with altitudinal gradient viz. Sairandhri (1000-1050 m), Poochipara (1150-1200 m) and Walakkad (1300-1350 m) sections (Figs 2-4). Three sample plots of shola forest were taken in different locations viz., Sispara (1950-2000 m), Cheriyamkandam (2100-2150 m) and Valliyamkandam (2200-2250 m) (Figs 5-7). The sample plots were visited during pre-monsoon, monsoon and post monsoon periods for the documentation of polypores including collection of sporocarps, labelling, identification of rot character, taking photographs, recording macromorphological description and details of substratum in the illustrated data sheet. The rot characters were documented by examining the substrate characters and basal attached portion of polypore. A total area of 60,000 m^2 was surveyed in each of the three climatic seasons.

Fig. 2 – Wet evergreen forest at Sairandhri

Fig. 3 – Wet evergreen forest at Poochippara

Fig. 4 – Wet evergreen forest at Walakkad

Fig. 5 – Shola forests at Sispara (1950-2000m)

Fig. 6 – Shola forests Cheriyamkandam (2100-2150m)

Fig. 7 – Shola forests at Valliyamkandam (2200-2250 m)

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 at 70º C and stored in polythene zip-cover under less humid conditions. The specimens were identified based on their macro and micro morphological features. The color names and color codes of the specimens were given as per Kornerup & Wanscher (1967). The identification key provided by Bakshi (1971), Leelavathy & Ganesh (2000), (Ranadive et al. 2011, 2017, 2018) were used for the confirmation of polypore species. Some of the specimens were compared with those in the Herbaria at Kerala Forest Research Institute, Peechi. The taxonomy and nomenclature are as per Indexfungorum (http://www.indexfungorum.org/names/names.asp), and the authors of scientific names are according to the 'Authors of Fungal Names' (http://www.indexfungorum.org/ authorsoffungalnames.htm). All the specimens collected during the study period were catalogued and kept under less humid conditions in the Department of Forest Management and Utilization, College of Forestry at Kerala Agricultural University.

Results

The distribution pattern of polypores in Silent Valley National Park along different altitudinal gradient were analyzed. Most of the species showed a drastic reduction in density as the altitude increases (Table 1). In lower altitude wet evergreen forest at Sairandhri (1000-1050 m) possessed high species richness (29 species) and found to be gradually decreasing as the altitude increases. The species richness decreased to 27 species (7 % reduction) at Poochippara (1150-1200 m) and in Walakkad (1300-1350 m) it was reduced to 25 (14 % reduction). Interestingly it was reduced to 11 species in Sispara (1950-2000 m) with 63 % reduction as comparing to that of the lower altitude. At Cheriyamkandam (2100-2150 m) and Valliyamkandam (2200-2250 m) the species richness was found to be 8 and 5 with 72 per cent and 83 per cent reduction respectively as comparing to that of Sairandhri. This monotonic decrease in species richness is also reflected in the polypore density. The density was found to be decreased from 2613 at Sairandhri (1000-1050 m) to 435 in high altitude shola forest at Valliyamkandam (2200-2250 m).

Discussion

The studies on the polypore diversity along the elevation gradient in Changbaishan Nature Reserve, Northeastern China also showed a monotonic decrease pattern in species richness (Dai et al. 2014). The polypore richness had decreased from 153 to 8 species with increasing elevation from 800 m to 1800 m, showing typical monotonic decrease pattern. They have discussed that the prevailing forest type shift and the abiotic factors were responsible for the decreasing pattern of species richness along the elevation gradient. In the present study also the forest type shift from the wet evergreen forest to the high altitude shola forest is more influential. Similarly the diversity of macrofungi in the Mount Cameroon Region was also found to decrease with the altitude (Andrew et al. 2013).

At different positions along the altitude gradient, a positive correlations existed with respect to the relationship between species richness and diversity (Table 2). Sairandhri was at the lowest altitude (1000-1150 m) and showed the highest Shannon-wiener index (2.9) and Margalef richness index (3.6). Diversity and richness decreased to 1.2 and 0.66 respectively in Valliyamkandam (2200-2250 m). A gradual reduction was observed in both the diversity and richness with increasing altitude (Fig. 8). Similarly the studies on diversity and ecological distribution of macrofungi in the Laojun Mountain region, China also found that the diversity and richness were in positive relation and both were decreased with the elevation (Zhang et al. 2010).

The present study demonstrates that elevation is a factor in distribution of polypore species. Schmit et al. (2005) also found that there was a trend of decreasing macrofungal richness at higher latitudes. The macrofungal growth and distribution are affected by a multitude of factors. A number of environmental factors are associated with differences in elevation and the more important of these are temperature and precipitation, duration and intensity of illumination, physical and chemical characteristics of the soil, topographic position, tree density (Zhang et al. 2010). These factors could potentially explain some of the variation in macrofungal species richness (Straatsma et al. 2001, Mulder & Zwart 2003, Rolstad et al. 2004, Gilbert et al. 2008). In the present study, remarkable changes in both the environment and ecological situation is prominent in both wet evergreen and shola forests. The tree composition also showed a significant difference in both the habitats.

The study of variation that exists for dominance and evenness showed that the degree of dominance increased and the degree of evenness decreased along the altitude gradient (Fig. 9). Similar pattern of increasing dominance of some macrofungi species which are able to tolerate the prevailing environmental severity were recorded in Laojun Mountain region in China (Zhang et al. 2010). The species like *Phylloporia pectinata*, *Fulvifomes cesatii*, *Leucophellinus hobsonii*, *Trametes ochracea* and *Trametes pubescens* were recorded only from high altitude shola forest, indicating its environmental tolerance and habitat preference. *Trametes ochracea* showed high density in shola forest while *Trametes menziesii* and *Microporus xanthopus*, the dominant species in wet evergreen forest were recorded with low density.

The phenomenon that many sporocarps of certain polypore species become smaller with increasing elevation was noted during the field work (Plate 19). The studies on macrofungi of East Himalaya and their adaptive characteristics by Mao (1985) also reached a similar conclusion that fruiting bodies become smaller with increasing elevation. The smaller sporocarps also seem better adapted for the more extreme environmental conditions that exist at higher elevations (Zhang et al. 2010). The lower temperatures, more abundant precipitation, greater humidity, stronger radiation in shola forest could be the reason for the smaller sporocarps production.

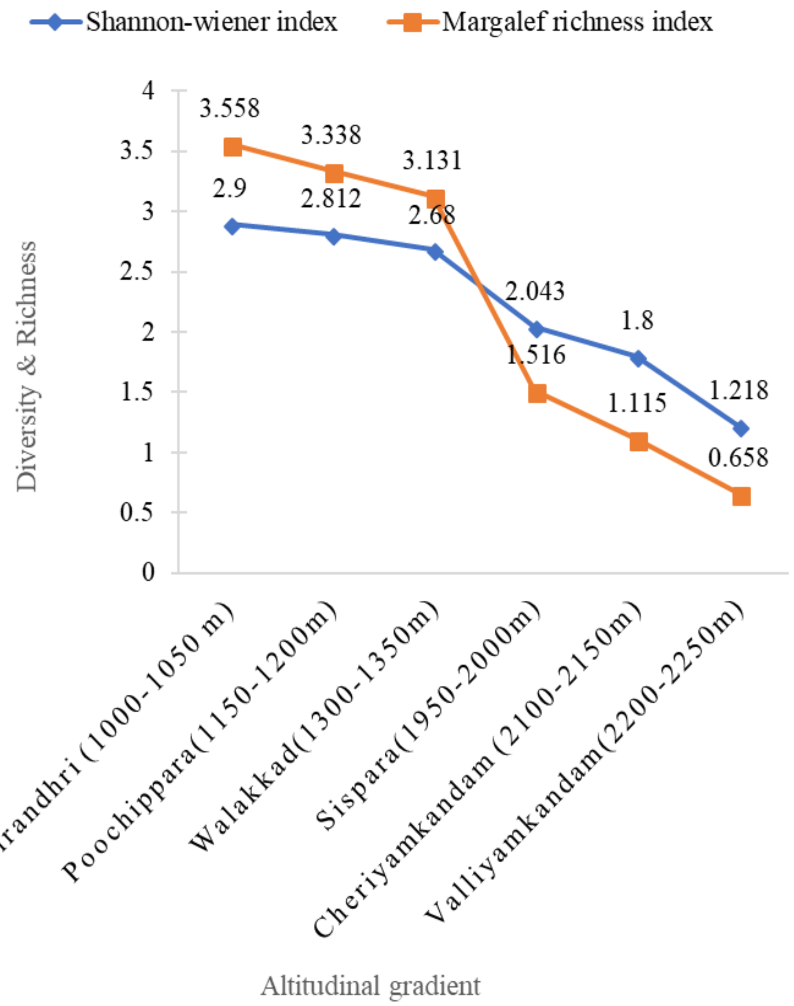

Fig. 8 – Diversity and richness along the altitudinal gradient

Table 1 Density of polypores in Silent Valley at different altitudes.

Sl. No.	*Fungal species*	Distribution of polypores in different locations (No. of individuals)					
		Wet evergreen forest			Shola forest		
		Sairandhri (1000-1050 m)	Poochippara (1150-1200 m)	Walakkad (1300-1350 m)	Sispara (1950-2000 m)	Cheriyamkandam (2100-2150 m)	Valliyamkandam (2200-2250 m)
(I)	**FAMILY: FOMITOPSIDACEAE**						
1	*Daedalea dochmia* (Berk. & Broome) T. Hatt. 2005 ** (Fig. 10)	294	287	271	-	-	-
2	*Fomitopsis feei* (Fr.) Kreisel 1971 * (Fig. 11)	87	76	53	-	-	-
(II)	**FAMILY: GANODERMATACEAE**						
3	*Ganoderma australe* (Fr.) Pat. 1889 ** (Fig. 12)	108	94	95	-	66	-
4	*Ganoderma lucidum* (Curtis) P. Karst. 1881 * (Fig. 13)	48	38	31	21	-	-
(III)	**FAMILY: GANODERMATACEAE**						
5	*Fulvifomes cesatii* (Bres.) Y.C. Dai 2010 * (Fig. 14)	-		-	108	-	-
6	*Fuscoporia contigua* (Pers.) G. Cunn. 1948 ** (Fig. 15)	36	18	15	-	-	-
7	*Fuscoporia ferrea* (Pers.) G. Cunn. 1948 * (Fig. 16)	12	11	7	-	-	-
8	*Fuscoporia senex* (Nees & Mont.) Ghob.-Nejh. 2007 ** (Fig. 17)	21	14	7	-	-	-
9	*Fuscoporia wahlbergii* (Fr.) T. Wagner & M. Fisch. 2001 ** (Fig. 18)	43	20		26	1	-
10	*Inonotus pachyphloeus* (Pat.) T. Wagner & M. Fisch. 2002 ** (Fig. 19)	23	16	-	-	-	-
11	*Phellinus dependens* (Murrill) Ryvarden 1972 ** (Fig. 20)	16	17	18	-	-	-
12	*Phellinus fastuosus* (Lév.) S. Ahmad 1972 ** (Fig. 21)	11	4	6	-	-	-
13	*Phellinus* gilvus (Schwein.) Pat. 1900 * (Fig. 22)	211	224	324	-	-	-

Table 1 Continued.

Sl. No.	*Fungal species*	Distribution of polypores in different locations (No. of individuals)					
		Wet evergreen forest			Shola forest		
		Sairandhri (1000-1050 m)	Poochippara (1150-1200 m)	Walakkad (1300-1350 m)	Sispara (1950-2000 m)	Cheriyamkandam (2100-2150 m)	Valliyamkandam (2200-2250 m)
14	*Phellinus nilgheriensis* (Mont.) G. Cunn. 1965 ** (Fig. 23)	106	96	68	36	-	-
15	*Phylloporia pectinata* (Klotzsch) Ryvarden 1991 ** (Fig. 24)	-	-	-	-	63	66
(IV)	**FAMILY: POLYPORACEAE**						
16	*Cellulariella acuta* (Berk.) Zmitr. & Malysheva 2014 * (Fig. 25)	88	69	56	-	-	-
17	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden 1985 * (Fig. 26)	24	32	28	39	-	-
18	*Funalia caperata* (Berk.) Zmitr. & Malysheva 2013 * (Fig. 27)	76	45	38	-	-	-
19	*Favolus tenuiculus* P. Beauv. 1806 *(Fig. 28)	57	48	21	-	-	-
20	*Hexagonia tenuis* (Fr.) Fr. 1838 * (Fig. 29)	158	129	109	-	-	-
21	*Microporellus obovatus* (Jungh.) Ryvarden 1972 * (Fig. 30)	34	16	28	33	-	-
22	*Microporus affinis* (Blume & T. Nees) Kuntze 1898 * (Fig. 31)	49	122	48	-	-	-
23	*Microporus xanthopus* (Fr.) Kuntze 1898 * (Fig. 32)	226	229	214	50	55	-
24	*Neofomitella rhodophaea* (Lév.) Y.C. Dai, Hai J. Li & Vlasák 2015 ** (Fig. 33)	265	257	246	-	-	-
25	*Polyporus grammocephalus* Berk. 1842 * (Fig. 34)	21	17	13	-	-	-
26	*Polyporus leprieurii* Mont. 1840 * (Fig. 35)	37	20	21	-	-	-
27	*Polyporus* sp. * (Fig. 36)	3	-	-	-	-	-
28	*Spongipellis* unicolor (Fr.) Murrill 1907 * (Fig. 37)	9	-	-	-	-	-

Table 1 Continued.

Sl. No.	*Fungal species*	Distribution of polypores in different locations (No. of individuals)					
		Wet evergreen forest			Shola forest		
		Sairandhri (1000-1050 m)	Poochippara (1150-1200 m)	Walakkad (1300-1350 m)	Sispara (1950-2000 m)	Cheriyamkandam (2100-2150 m)	Valliyamkandam (2200-2250 m)
29	*Trametes marianna* (Pers.) Ryvarden 1973 * (Fig. 38)	263	249	136	-	-	-
30	*Trametes menziesii* (Berk.) Ryvarden 1972 * (Fig. 39)	267	241	253	77	69	67
31	*Trametes pubescens* (Schumach.) Pilát 1939 * (Fig. 40)	-	-	-	32	57	70
32	*Trametes ochracea* (Pers.) Gilb. & Ryvarden 1987 * (Fig. 41)	-	-	-	265	248	231
(V)	**FAMILY: SCHIZOPORACEAE**						
33	*Leucophellinus hobsonii* (Berk. ex Cooke) Ryvarden 1988 * (Fig. 42)	-	-	-	45	-	-
34	*Schizopora paradoxa* (Schrad.) Donk 1967 * (Fig. 43)	21	25	23	-	38	1
	Total individuals	**2613**	**2415**	**2129**	**732**	**597**	**435**
	Total species	**29**	**27**	**25**	**11**	**8**	**5**

[*Annual, ** Perennial]

Table 2 The diversity indices of different sites with altitudinal gradient at Silent Valley National Park.

Sl.No	Study locations	Margalef richness Index	Shannon-wiener Index	Pielou's Evenness Index	Berger-Parker Dominance index
1	Sairandhri (1000-1150 m)	3.558	2.900	0.861	0.112
2	Poochippara (1150-1200 m)	3.338	2.812	0.853	0.119
3	Walakkad (1300-1350 m)	3.131	2.680	0.833	0.152
4	Sispara (1950-2000 m)	1.516	2.043	0.852	0.362
5	Cheriyamkandam (2100-2150 m)	1.115	1.800	0.749	0.466
6	Valliyamkandam (2200-2250 m)	0.658	1.218	0.756	0.531

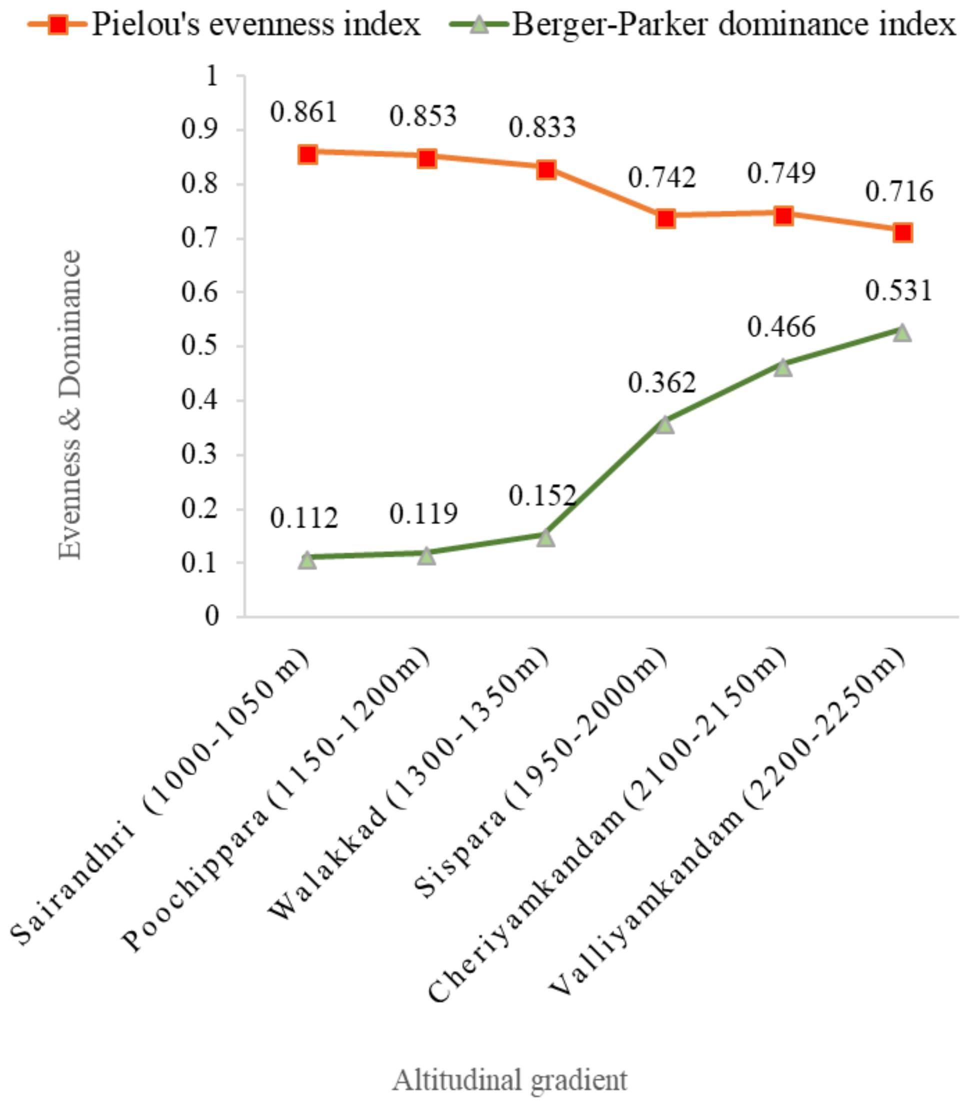

Fig. 9 – Dominance and evenness along the altitudinal gradient

Fig. 10 – *Daedalea dochmia*

Fig. 11 – *Fomitopsis feei*

Fig. 12 – *Ganoderma austral*

Fig. 13 – *Ganoderma lucidum*

Fig. 14 – *Fulvifomes cesatii*

Fig. 15 – *Fuscoporia contigua*

Fig. 16 – *Fuscoporia ferrea*

Fig. 17 – *Fuscoporia senex*

Fig. 18 – *Fuscoporia wahlbergii*

Fig. 19 – *Inonotus pachyphloeus*

Fig. 20 – *Phellinus dependens*

Fig. 21 – *Phellinus fastuosus*

Fig. 22 – *Phellinus gilvus*

Fig. 23 – *Phellinus nilgheriensis*

Fig. 24 – *Phylloporia pectinate*

Fig. 25 – *Cellulariella acuta*

Fig. 26 – *Earliella scabrosa*

Fig. 27 – *Funalia caperata*

Fig. 28 – *Favolus tenuiculus*

Fig. 29 – *Hexagonia tenuis*

Fig. 30 – *Microporellus obovatus*

Fig. 31 – *Microporus affinis*

Fig. 32 – *Microporus xanthopus*

Fig. 33 – *Neofomitella rhodophaea*

Fig. 34 – *Polyporus grammocephalus*

Fig. 35 – *Polyporus leprieurii*

Fig. 36 – *Polyporus* sp.

Fig. 37 – *Spongipellis unicolor*

Fig. 38 – *Trametes marianna*

Fig. 39 – *Trametes menziesii*

Fig. 40 – *Trametes pubescens*

Fig. 41 – *Trametes ochracea*

Fig. 42 – *Leucophellinus hobsonii*

Fig. 43 – *Schizopora paradoxa*

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References

Andrew EE, Kinge TR, Tabi1 EM, Thiobal N, Mih AM. 2013 – Diversity and distribution of macrofungi (mushrooms) in the Mount Cameroon Region. Journal of Ecology and the Natural Environment 5(10): 318–334.

Aragon DJM, Bonet JA, Fischer CR, Colinas C. 2007 – Productivity of ectomycorrhizal and selected edible saprotrophic fungi in pine forests of the pre-Pyrenees mountains, Spain: Predictive equations for forest management of mycological resources. Forest Ecology and Management 252: 239–256.

Bakshi BK. 1971 – *Indian Polyporaceae (on trees and timber).* ICAR, New Delhi, 246p.

Dickie IA, Kalucka I, Stasi'nka M, Oleksyn J. 2010 – Plant host drives fungal phenology. Fungal Ecology 3(4): 311–315.

Essien EE, Akpan SM. 2014 – Phytochemical and anti-nutrients evaluation of some wild fruiting polypore macrofungi. Journal of Chemical and Pharmaceutical Research 6(12): 792–796.

Gange AC, Gange EG, Sparks TH, Boddy L. 2007 – Rapid and recent changes in fungal fruiting patterns. Science 316: 71.

Gilbert GS, Gorospe J, Ryvarden L. 2008 – Host and habitat preferences of polypore fungi in Micronesian tropical flooded forests. Mycological Research 112:674–680.

Kauserud H, Stige LC, Vik JO, Okland RH et al. 2008 – Mushroom fruiting and climate change. Proceedings of the National Academy of Sciences of the United States of America 105: 3811–3814.

Kauserud H, Heegaard E, Halvorsen R, Boddy L, Hoiland K, Stenseth NC. 2011-Mushroom's spore size and time of fruiting are strongly related: Is moisture important?. Biology Letters 7(2): 273-276.

Kornerup A, Wanscher JH. 1967-*Methuen Handbook of Colour*. Methuen and Co. Ltd., London, 243p.

Krebs CJ, Carrier P, Boutin S, Boonstra R, Hofer E. 2008 – Mushroom crops in relation to weather in the southwestern Yukon. Canadian Journal of Botany 86: 1497–1502.

Lagana A, Angiolini C, Salerni E, Perini C et al. 2002 – Periodicity fluctuations and successions of macrofungi in forests (Albies alba Miller) in Tuscany, Italy. Forest Ecology and Management 169: 187–202.

Leelavathy KM, Ganesh PN. 2000 – *Polypores of Kerala*. Daya Publishing House, Delhi, 165p.

Mao XL. 1985. Alpine macrofungi of East Himalaya and their adaptive characteristics. Journal of Mountain Research. 3: 299–307.

Mihail D, Bruhn JN, Bonella P. 2007 – Spatial and temporal patterns of morel fruiting. Mycological Research 3: 339–346.

Mohanan C. 2011 – *Macrofungi of Kerala*. KFRI Handbook No. 27. Kerala Forest Research Institute, Peechi, Kerala, India, 597p.

Moore D, Gange AC, Gange EG, Boddy L. 2008 – Fruit bodies: Their production and development in relation to environment. British Mycological Society Symposium Series 28: 79–103.

Mulder C, Zwart D. 2003 – Assessing fungal species sensitivity to environmental gradients by the Ellenberg indicator values of above-ground vegetation. Basic and Applied Ecology 4: 557–568.

Pinna S, Gevry MF, Cote M, Sirois L. 2010 – Factors influencing fructification phenology of edible mushrooms in a boreal mixed forest of eastern Canada. Forest Ecology and Management 260 (3): 294–301.
Ranadive KR. 2013 – An overview of Aphyllophorales (wood rotting fungi) from India. International Journal of Current Microbiology and Applied Sciences 2(12): 112–139.
Ranadive K, Jagtap N, Khare H. 2017 – fungifromindia: the first online initiative to document fungi from India. IMA Fungus (Mycolens) 8(2):67–69. (http://www.ingentaconnect.com/contentone/ima/imafung/2017/00000008/00000002/art00008).
Ranadive KR, Jagtap N, Khare H, Ranade V et al. 2018 – IAD: The first online initiative to the documentation of Aphyllophorales Fungi from India. International Journal of Life Sciences, Special Issue, A9: 15–24. (Fungifromindia http://www.fungifromindia.com/fungiFrom India/databases/IAD/)
Ranadive KR, Jagtap N, Vaidya J. 2012a – Host diversity of genus *Phellinus* from world. Elixir Appl. Botany 52, 11402–11408.
Ranadive KR, Joshi T, Khare H, Jagtap N et al. 2012b – Host distribution of *Phellinus* from India. Indian Journal of Forestry 35 (01), 67–72.
Ranadive KR, Vaidya JG, Jite PK, Ranade VD et al. 2011 – Checklist of Aphyllophorales from the Western Ghats of Maharashtra State, India. Mycosphere 2 (2), 91–114.
Rolstad J, Satersdal M, Gjerde I, Storaunet KO. 2004 – Wood-decaying fungi in boreal forest: Are species richness and abundances influenced by small-scale spatiotemporal distribution of dead wood. Biological Conservation 117: 539–555.
Salerni E, Lagana A, Perini C, Loppi S, De Dominicis V. 2002 – Effects of temperature and rainfall on fruiting of macrofungi in oak forests of the Mediterranean area. Israel Journal of Plant Sciences 50: 189–198.
Schmit JP, Mueller GM, Leacock PR, Mata JL et al. 2005 – Assessment of tree species richness as a surrogate for macrofungal species richness. Biological Conservation 121: 99–110.
Selosse MA, Martin F, Tacon FT. 2001 – Intraspecific variation in fruiting phenology in an ectomycorrhizal Laccaria population under Douglas fir. Mycological Research 105: 524–531.
Straatsma G, Ayer F, Egli S. 2001 – Species richness, abundance, and phenology of fungal fruit bodies over 21 years in a Swiss forest plot. Mycological Research 105: 515–523.
Walther GR. 2010 – Community and ecosystem responses to recent climate change. Philosophical Transactions of the Royal Society B 365: 2019–2024.
Walther GR, Post E, Convey P, Menzel A et al. 2002 – Ecological responses to recent climate change. Nature 416: 389–395.
Wu J, Xiao YZ, Yu HQ. 2005 – Degradation of lignin in pulp mill wastewaters by white- rot fungi on biofilm. Bioresource Technology 96: 1357–1363.
Yamashita S, Hattori T, Lee SS, Okabe K. 2015 – Estimating the diversity of wood-decaying polypores in tropical lowland rain forests in Malaysia: the effectof sampling strategy. Biodiversity and Conservation 24: 393–406.
Zhang Y, Hyde KD, Zhou DQ, Zhao Q, Zhou TX. 2010 – Diversity and ecological distribution of macrofungi in the Laojun Mountain region, southwestern China. Biodiversity and Conservation 19: 3545–3563.