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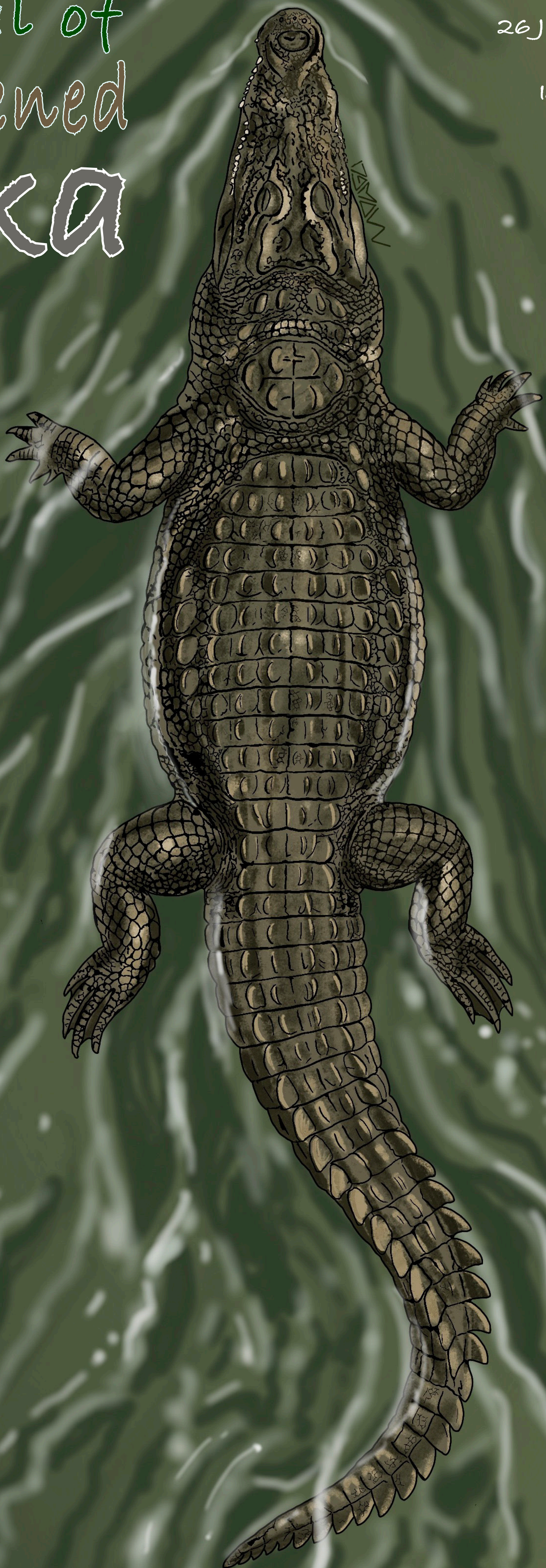

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Registered Office: 3A2 Varadarajulu Nagar, FCI Road, Ganapathy, Coimbatore, Tamil Nadu 641006, India
Ph: +91 9385339863 | www.threatenedtaxa.org
Email: sanjay@threatenedtaxa.org

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Cover: Nile Crocodile *Crocodylus niloticus* regulating body temperature on a warm day. Digital art on Procreate by © Aakanksha Komanduri.

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ARTICLE

Macrofungal species richness, composition, distribution, and ecological preference along the elevation gradient in Agasthyamala Biosphere Reserve, southern Western Ghats, India

Kurunnan Kandy Akshaya [1], Arumugam Karthikeyan [2], Arunachalam Rajasekaran [3], Binai Nagarajan [4] & Cheravengat Kunhikannan [5]

[1–5] ICFRE–Institute of Forest Genetics & Tree Breeding, R.S. Puram, Coimbatore, Tamil Nadu 641002, India.
[1] akshayakkatholi@gmail.com, [2] karthikarumugam13@gmail.com (corresponding author), [3] a.rajsekaran@gmail.com,
[4] teakguynew@gmail.com, [5] kunhikannan@gmail.com

Abstract: Fungi are a part of the forest ecosystem as saprotrophs, mycorrhizal symbionts, pathogens, and parasites/predators. The health status of an ecosystem is reflected in its macrofungal species richness and diversity. The present study emphasizes the effect of elevation and substrate availability on macrofungal composition, species richness, and distribution in Agasthyamala, a highly endemic, rich tropical wet evergreen forest type. The study was conducted at the forests of Agasthyamala situated in Thiruvananthapuram District, Kerala, part of the Western Ghats, for a period of four years (2021–2024). Macrofungal sampling and quadrats of (10 x 10m) were laid out in 15 different locations under various elevation classes. A record of 1,929 individuals and 112 macrofungal species from 13 orders, 41 families, and 73 genera was documented. Of these, 86% were saprotrophic, 11% were ectomycorrhizal, 2% were pathogenic, and 1% were parasitic. The low- and mid-elevations exhibit high species richness which gradually decrease with increasing elevation. This trend has been explained with the help of substrate availability and other factors. The mid-elevation was supported with more substrate availability and diversity, including dead wood, fallen twigs, litter, soil, and live trees. The presence of an adequate substrate and its diversity, along with other factors including temperature, precipitation, vegetation type, and soil properties influence the macrofungal species richness, diversity, and distribution. Hence, the knowledge of the factors influencing the macrofungal community are very important to study their future species composition and richness under a global climate change scenario.

Keywords: Basidiomyctes, climate change, diversity, ecosystem, ectomycorrhiza, fungi, mushroom, litter, saprotrophs, vegetation.

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Competing interests: The authors declare no competing interests.

Author details: Ms. K.K. Akshaya has completed post graduate in botany and worked as senior research fellow. She has undertaken a PhD in mycology aspects. Dr. A. Karthikeyan is the head of the Forest Pathology division & Senior scientist with specialization of mycology, plant pathology and done research aspects of mycorrhiza. Dr. A. Rajasekaran is the head of the Forest Ecology and Climate Change division & scientist-E with specialization in non-wood forest products andplant ecology. Dr. B. Nagarajan is the group co-ordinator research & scientist G with specialization in forest genetics and tree reproduction. Dr. C. Kunhikannan, retired director, ICFRE-Institute of Forest Genetics and Tree Breeding, Coimbatore and Scientist-G with specialization in forest ecology and plant biodiversity.

Author contribution: KKA has done the survey in Agasthyamala forests of Western Ghats of India and identified the macrofungi. She has written the full part of this manuscript with able guidance of AK & CK. AR & BN revised the manuscript. CK reviewed this manuscript prior to submission.

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INTRODUCTION

Macrofungi are necessary for the ecological functioning of forests. They are involved in different functions including increasing plant-soil connections, improving soil structure, promotion of soil microorganisms, improving organ function, resistance to antagonistic plant root disease pathogens, and the degradation of wood in the forest ecosystem (Huo 2010). Numerous studies on the key elements influencing plant and animal communities were carried out by ecologists. Unfortunately, because of their often concealed nature and frequently short-lived sporocarps, community assembly in macrofungi is rarely researched and understood (Senn-Irlet et al. 2007). Research works have shown that a variety of environmental factors and landscape variability can control the composition of fungal communities (Ferrari et al. 2016). To determine the proportional of environmental variables to fungal diversity and composition in an ecosystem, it is to assess the fungal communities in various ecosystems. Fungal biodiversity displays the variability of habitat and is strongly tied to total site biodiversity; it may be able to give insight into changes in ecosystems (Boddy et al. 2014). The diversity and composition of fungal communities can be influenced by a wide range of biotic and abiotic variables (Tedersoo et al. 2014). According to some research, plant diversity, temperature, and precipitation are the main factors influencing the macrofungal flora (Tedersoo et al. 2014). The development and reproduction of macrofungi are significantly influenced by a variety of factors, including elevation, temperature, light, humidity, soil, surrounding vegetation, and human activities (Tapwal et al. 2013). It is very important to understand the dynamics and composition of the fungal community over place and time may be a helpful tool for assessing the health of forests and setting conservation priorities in various areas. The majority of macromycete studies, however, focus on taxonomy and systematics. Research over an elevation gradient in the Costa area was conducted by Caiafa et al. (2017), who discovered that the functional diversity of macromycetes changes with elevation, that it is more closely associated with microclimatic factors than with vegetation structure, and that heterogeneity of trait abundance and niche complementarity. A few studies have been conducted to study the influence of elevation on macrofungal composition and distribution. Hence this study focuses on the macrofungal species richness, composition, distribution, and ecological preference along the elevation gradient in Agasthyamala Biosphere Reserve, southern Western Ghats, Kerala.

MATERIALS AND METHODS

Study area

Agasthyamala consists of a compact block of hilly range on the southernmost end of Western Ghats, Thiruvananthapuram District of Kerala State. It comprises Neyyar, Peppara, and Schendurney wildlife sanctuaries and the remaining areas of Achenkovil, Thenmala, Konni, Punalur, Thiruvananthapuram Forest Division, and Agasthyavanam Special Division. Agasthyamala was established as a Biosphere Reserve in 2001. The study area has a tropical, humid climate, which is found throughout the western slopes of the Western Ghats (Mohanan & Sivadasan 2002). The temperature of the area ranges from 27–35 ^{o}C with an annual rainfall between 2,400 and 3,500 mm. The soil type is mainly lateritic and red loamy. River Neyyar and Karamanayar drain through the Agasthyamala Biosphere Reserve. The area is well known for its species richness and endemism. The distinguished diversity in ecological conditions and variation in altitude have been accountable for the rich and diverse vegetation in the study area. The tropical wet evergreen forests was one of the major forest types in Agasthyamala distributed in 800–1,400 m elevation range. The second major forest type, southern tropical moist deciduous forests, was seen at lower altitudes from 300–800 m (Mohanan & Sivadasan 2002).

Survey of macrofungi

Macrofungal survey was carried out during monsoon and post-monsoon seasons of 2021–2024 in different forest areas of Agasthyamala Biosphere Reserve, where the sites were selected on the basis of elevation gradient. The macrofungal species from different elevations were documented and these elevations grouped into three elevation classes like low elevation class (300–599 m), mid elevation class (600–899 m), and high elevation class (900–1,199 m). Macrofungal species are arranged according to the elevation classes. During the field survey, macrofungal species were detected by the presence of sporocarps (basidiocarps and ascocarps) that are visible to naked eye (Kirk et al. 2008). In a single field visit, a few macrofungal species were visible hence repeated surveys were done in all the selected sites. Location details of each elevation class were tabulated (Table 1).

Macrofungal sampling

The macrofungal assessment was done using the quadrat method as suggested by Harsh (2021). Fifteen quadrat plots of size (10 x 10m) were laid out across the elevation gradient. These sample plots were categorized into three elevation classes based on the elevation gradient. Fresh samples of macrofungal species collected from each location. The number of sporocarps of each species in each plot was recorded with geographic coordinates and elevation details using a Garmin GPS (*e*trex 30 xs). All the collected macrofungi were photographed within their natural habitat and their ecological characteristics were recorded. Spore prints were made during the study and deposited in the Forest Protection Division Laboratory at ICFRE-IFGTB, Coimbatore (IFGTB/FP- 101 to 108). The collected specimens were kept in a thermocol box and brought into the laboratory for drying. The specimens were dried in a hot air oven at 50 °C for seven hours. These dried specimens were prepared as fungal herbaria for reference work in posterity.

Collection of macrofungi and field observations

Macrofungal fruiting bodies exist on different substrates are separated using various tools like knives, scissors, and forceps. Fresh specimens were collected from each plot with great care to the sporocarps. Soil present on the fruiting bodies was removed using a soft paint brush. The macrofungal fruiting bodies seen on the wood were collected along with the substratum. A small hand lens carried to observe the minor features of the sporocarps. The habitat and morphological features were recorded and the specimens were photographed within their natural habitat before collection using iPhone 6S (Apple iPhone 6s. Released on 25 September 2015, Model number A1688, 143 g, 7.1 mm thickness. iOS 9, up to iOS 15.8.4. 64GB storage, manufacturer: Apple inc. (Designed in Cupertino, California, USA)) to facilitate further identification of the species. The collected specimens were kept in a thermocol box in which dried leaves (dried using hot air oven) of *Casuarina equisetifolia* are arranged as a bed (Akshaya et al. 2023). During collection, the number of sporocarps (fruiting bodies) produced by each species in each plot were counted and recorded in the field book. The field book contains other details such as date of collection, collection number, collector name, locality, habit, habitat, geographic coordinates, elevation, nature of substratum and the forest type. Collected specimens were taken to the field station for further processing.

Table 1. Details of elevation classes, elevation band, locations under each elevation class.

Elevation classes	Elevation band (in m)	Locations
Low-elevation	300–599	Peppara Check Post Vazhukkanpara Kallar Bonacaud picket station Agasthyamala Trekking area
Mid-elevation	600–899	GB Division Top Division Kurushumala Elakkad 36 Mala
High-elevation	900–1,199	Cardamom Estate Kilavanthottam Pandimotta Pandipath Pandipath Top

Drying and preservation of macrofungi

Collected specimens were preserved on open flame at the field station. The tough specimens were kept drying for a longer time (Swapna et al. 2008). The dehydrated specimens were packed in long brown paper covers containing naphthalene balls which prevent the attack of mites and insects. The packed specimens were labelled with date of collection and collection number. After reaching the Forest Protection Division laboratory of ICFRE-Institute of Forest Genetics & Tree Breeding, Coimbatore, the samples were properly dried using a hot air oven at 50 °C for seven hours (Akshaya et al. 2023). Then the dried specimens were labelled with other field details and deposited (IFGTB/FECC- 001 to 112) in the Forest Ecology and Climate Change Division Laboratory, ICFRE- IFGTB for future references.

Examination of spore colour

Spore print is an important character for distinguishing bracket fungi, coral fungi, fleshy gilled fungi, and fleshy pore fungi. Examination of the spore colour of macrofungal species has been done just after the collection and before drying. It is taken by keeping the hymenium surface (spore producing surface) of a fruiting body (with removed stalk) on a glass overnight and covered using a bowl to prevent air currents. Later, this setup gives information on the arrangement of gills and spore colour (Image 1). After recording spore colour and other details, the spore prints were properly tagged and maintained for further microscopic studies (Swapna et al. 2008).

Species identification

The macrofungal species were identified with the help of monographs and the available literature (Christensen 1968; Ryvarden & Johansen 1980). The confirmation of macrofungi at species level was done with the help of Mycologist (Dr. Nirmal S.K. Harsh, former scientist-G & head, Forest Pathology Division & former group coordinator research, Forest Research Institute, Dehradun).

Classification of substrates

Substrates were classified into six categories. These include dead wood, fallen twig, live tree, soil, litter, and dung.

Ecological preference of macrofungi

The nature of substratum was recorded in field as well as from the available literature. The majority of macrofungi associate with forest trees are in obligatory symbiotic ectomycorrhizal (ECM) associations. Saprotrophic fungi are significant group of decomposers, as they grow on a variety of substrates including dead wood, fallen twig, litter, dung, bark and wood of standing trees. In live and dead trees, a number of macrofungi act as pathogens or parasites (Swapna et al. 2008).

Soil sampling and analysis

After removing the debris from the soil surface, composite soil samples were augured from 20 cm depth. The soil samples were collected in zip lock covers and taken to the Soil and Water Testing Laboratory, ICFRE-IFGTB, Coimbatore. Soil samples were air dried and sifted through 2 mm sieve. Standard procedures adopted for analyzing physico-chemical properties are given (Table 2).

Data analysis

Macrofungal species identified from each plot, number of individuals (sporocarps), nature of substratum, soil data, vegetation, GPS coordinates along with the elevation were documented in Microsoft Excel (2007). The data was analyzed using SPSS (version 17.0). One way analysis of variance was done, and the significant difference was determined according to Duncan's Multiple Range Test at significant level of $P < 0.05$.

RESULTS

Macrofungal species composition and distribution

A total of 1,929 individuals were recorded from Agasthyamala, belonging to 112 species, 73 genera, 41 families and 13 orders (Table 3). Most of the macrofungal species come under the division Basidiomycota (92%) and remaining ones were of Ascomycota (8%) (Figure 1a). The dominant order represented in this location is Agaricales (46.43%) and family Polyporaceae (20.54%) is the dominant family (Figure 1b,c). The list of species recorded in this study have been tabulated (Table 3). The low elevation class was recorded with 42 species. Among them 26 species were confined only to low elevation. These include *Auricularia mesenterica*, *Cellulariella acuta*, *Clavaria rosea* var. *subglobosa*, *Clavulinopsis imperata*, *Cotylidia* sp., *Crepidotus variabilis*, *Dacrymyces capitatus*, *Daldinia concentrica*, *Earliella scabrosa*, *Favolaschia calocera*, *Mycena manipularis*, *Fomitopsis quercina*, *Ganoderma lobatum*, *Gymnopus* sp., *Laccaria* sp., *Lycoperdon pyriforme*, *Marasmius guyanensis*, *Marasmius siccus*, *Marasmius* sp. 2, *Microporellus dealbatus, Panaeolus antillarum, Resupinatus tristis, Scleroderma bovista, Stereum* sp., *Tremella fuciformis,* and *Xerotus archeri.*

Areas in mid-elevation revealed the existence of

Table 2. Details of procedures followed for physio-chemical analysis of soil.

Parameters	Methods	Author (s)
Soil pH	pH meter -1:2.5 soil water ratio (Systronics - pH System 361)	Jackson (1973)
Electrical conductivity	Conductometry -1:2.5 soil water ratio (Systronics - Conductivity TDS Meter 308)	Jackson (1973)
Organic carbon	Chromic acid wet digestion	Walkley & Black (1934)
Available nitrogen	Alkaline permanganate method (Kelplus (CLASSIC-DX))	Subbiah & Asija (1956)
Available phosphorus	Neutral / Alkaline soils 0.5 M $NaHCO_3$ extract, Ascorbic acid method (Shimadzu UV 1780 Spectrophotometer)	Olsen et al. (1954)
	Acid soils	Bray & Kurtz (1945)
Available potassium	Flame photometer, Neutral normal Ammonium acetate extraction (Systronics- Flame photometer 128)	Stanford & English (1949)
Calcium & magnesium	Versanate Method	Jackson (1973)
Texture	Hydrometer method	Bouyoucos (1936)

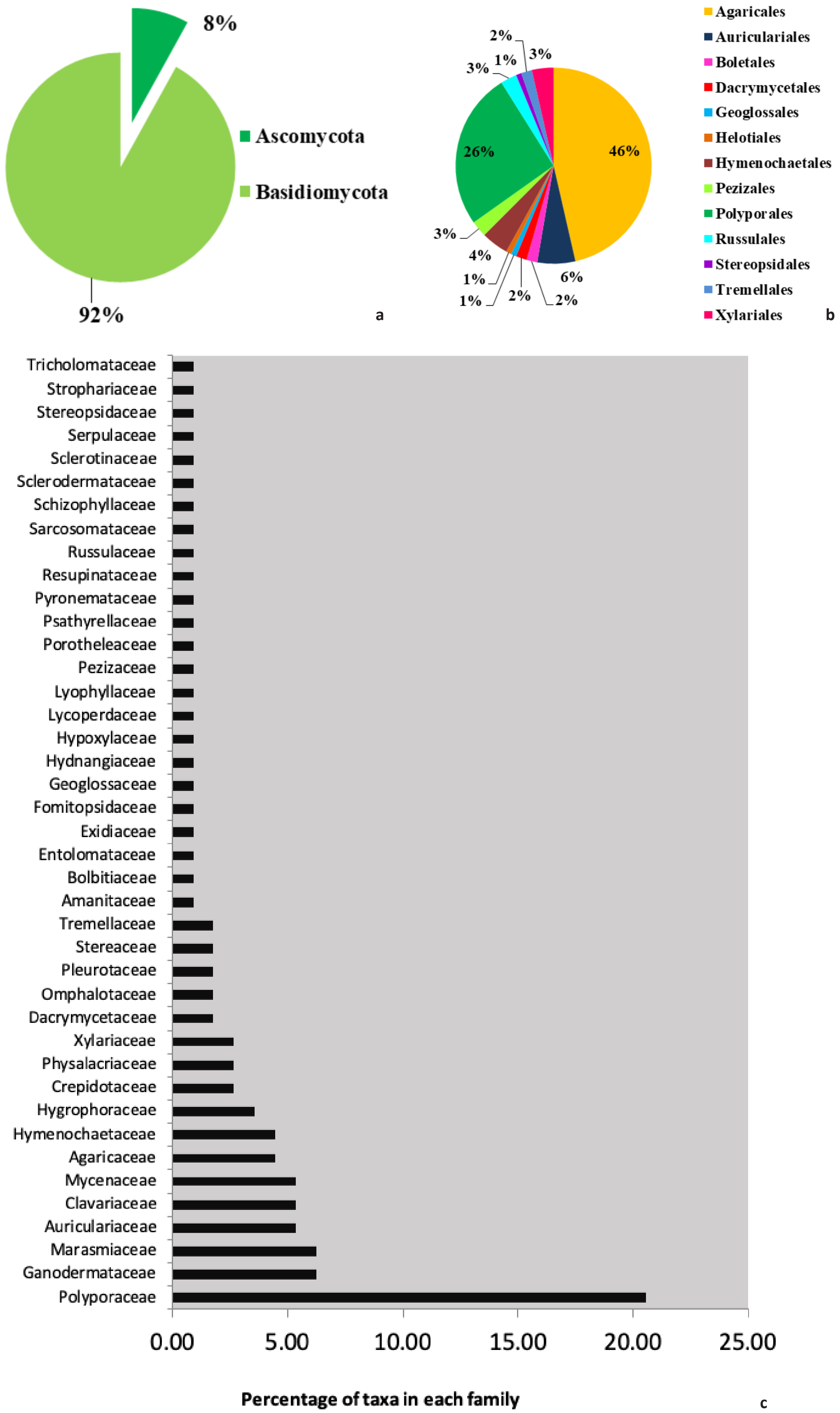

Figure 1. Percentage of distribution of macrofungi: a—different phyla | b—different orders | c—different families.

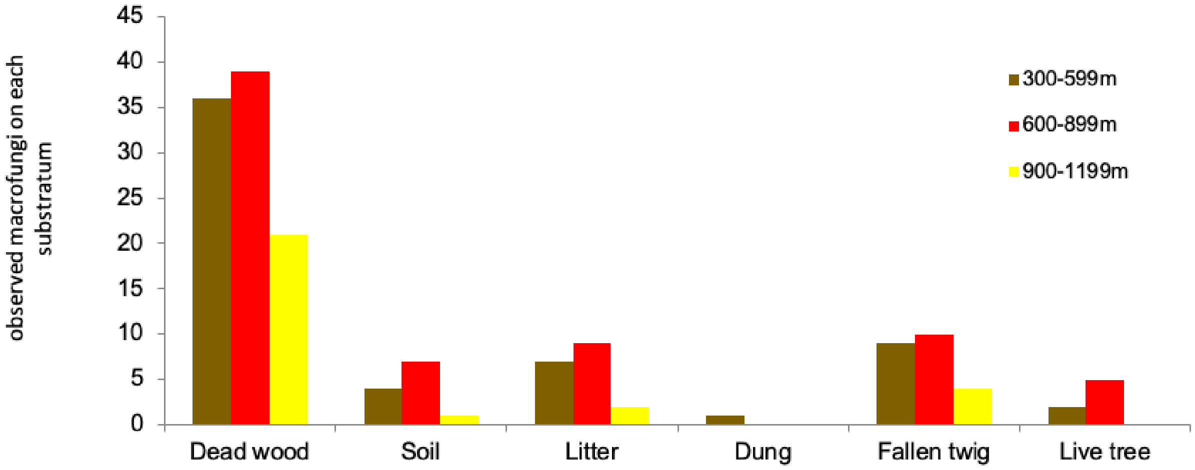

Figure 2. Substrate presence versus observed macrofungi on each substratum in different elevation classes.

71 macrofungal species. Among them, 59 species was restricted to mid elevation class (600–899 m). Species such as *Agaricus* sp., *Amanita vaginata*, *Auricularia fucosuccinea*, *Auricularia nigricans*, *Chlorophyllum molybdites*, *Clavaria miniata*, *Clavaria zollingeri*, *Collybia cookei*, *Crepidotus* sp. 1, *Crepidotus* sp. 2, *Cuphophyllus pratensis*, *Daedaleopsis confragosa*, *Entoloma* sp., *Exidia glandulosa*, *Exidia recisa*, *Favolus grammocephalus, Ganoderma* sp. 1, *Ganoderma tsugae*, *Geoglossum* sp., *Gerronema* sp., *Hygrocybe ceraceae*, *Hygrocybe conica*, *Hymenopellis radicata*, *Hymenopellis* sp., *Lentinus badius*, *Lentinus sajor–caju*, *Lentinus* sp., *Lentinus tigrinus*, *Leucocoprinus fragilissimus*, *Marasmiellus ramealis*, *Marasmius rotula*, *Melanotus* sp., *Mycena adscendens*, *Mycena rhenana*, *Neofavolus alveolaris*, *Panellus pusillus*, *Panus* sp., *Peziza occidentalis*, *Phellinus* sp. 1, *Phellinus* sp. 2, *Phellinus* sp. 3, *Plectania* sp., *Pleurotus* sp., *Pleurotus pulmonaris*, *Polyporus grammocephalus*, *Porodaedalea chrysoloma*, *Poronia nagarholensis*, *Royoporus spathulatus*, *Russula cyanoxantha*, *Schizophyllum commune*, *Scutellina setosa*, *Serpula similis*, *Stereopsis hiscens*, *Tetrapyrgos nigripes*, *Trametes betulina*, *Trame gibbosa, Trametes pubescens, Trametesversicolor, Xerotus nigritum, Xylaria hypoxylon* were restricted to mid elevation class.

There are 18 species of macrofungi identified from the high elevation class (900–1,199 m). Among them eight species such as *Cruentomycena* sp., *Ganoderma* sp. 2, *Ganoderma tropicum*, *Macrolepiota procera*, *Mucronella bresadole*, *Stereum ostrea*, *Termitomyces microcarpus*, and *Tremella mesenterica* were collected only in high elevation.

Two species such as *Dacrymyces spathularia* and *Hexagonia tenuis* were common to all the three elevation classes.

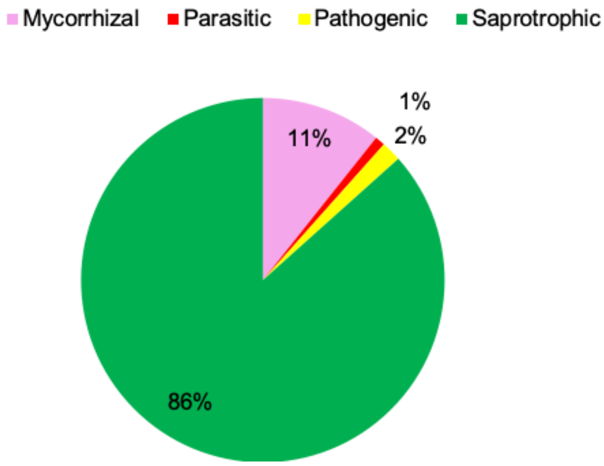

Figure 3. Ecological preference of macrofungi in Agasthyamala.

There are 10 species such as *Clavulinopsis laeticolor*, *Coprinellus disseminatus*, *Cyptotrama asprata*, *Dacrymyces spathularia*, *Dicephalospora rufocornea*, *Fuscoporia gilva*, *Hexagonia tenuis*, *Leucocoprinus rubrotinctus*, *Metacampanella caesia,* and *Xylaria polymorpha* were common to both low and mid elevations.

Three species, *Dacrymyces spathularia*, *Hexagonia tenuis,* and *Microporus vernicipes*, were found in both mid and high elevations.

Macrofungal species such as *Pycnoporus sanguineus*, *Microporus xanthopus*, *Microporus affinis*, *Marasmius haematocephalus*, *Hexagonia tenuis*, *Guepinia helvelloides*, *Ganoderma applanatum*, *Dacrymyces spathularia*, and *Auricularia delicata* were reported from both high and low elevations in the present study.

Table 3. Composition of macrofungi across elevation gradient in Agasthyamala forest.

Species	Identification characters	Division	Order	Low	Mid	High
Agaricus sp.	Fleshy in texture, gills free, annulus present, volva absent	Basidiomycota	Agaricales		1	
Amanita vaginata	Grey in colour, annulus absent, striated cap margin, gills free, volva present	Basidiomycota	Agaricales		2	
Auricularia delicata	Light brown in color, Ear shaped, gelatinous in texture, smooth hymenium	Basidiomycota	Auriculariales	4		1
Auricularia fuscosuccinea	Ear shaped, hymenium smooth, velvety texture on outside	Basidiomycota	Auriculariales		72	
Auricularia mesenterica	Grey in color, hairy surface with concentric grey, white zones, smooth hymenium	Basidiomycota	Auriculariales	26		
Auricularia nigricans	Dark brown in color, ear shaped, hairy outer surface, smooth hymenium and slightly wrinkled	Basidiomycota	Auriculariales		1	
Cellulariella acuta	Greyish in color, tough and leathery in texture, poroid hymenium	Basidiomycota	Polyporales	26		
Chlorophyllum molybdites	Umbrella shaped, white color with brown scales on cap, stipe with annulus	Basidiomycota	Agaricales		3	
Clavaria miniata	Erect, orange in color, soft and fleshy, cylindrical shaped, smooth surface throughout the entire body	Basidiomycota	Agaricales		74	
Clavaria rosea var. *subglobbosa*	Club shaped with rounded or subglobose apex, smooth surface	Basidiomycota	Agaricales	1		
Clavaria zollingeri	Lavender in color, coral like, highly branched with pointed tips, smooth surface, soft and brittle in texture	Basidiomycota	Agaricales		1	
Clavulinopsis imperata	Yellow in color, erect, unbranched with slightly pointed apex, solitary	Basidiomycota	Agaricales	2		
Clavulinopsis laeticolor	Orange in color, unbranched with rounded apex, smooth surface, slender, form small clusters	Basidiomycota	Agaricales	20	4	
Collybia cookei	Pale cream in color, small cap with thin stipe, convex cap, small sclerotium is present.	Basidiomycota	Agaricales		2	
Coprinellus disseminatus	Bell shaped, dense clusters, cap with radial striations, thin fragile stipe, gills turn in color from grey to black with age	Basidiomycota	Agaricales	60	83	
Cotylidia sp.	Fan shaped, leathery in texture, short stipe, smooth surface present on the inner side of the fruiting body	Basidiomycota	Hymenochaetales	42		
Crepidotus sp. 1	Shell shaped, lateral attachment to the substratum, cream in color, sessile, radiating gills	Basidiomycota	Agaricales		57	
Crepidotus sp. 2	Fan shaped, sessile, pale cream in color, smooth surface, slippery in texture	Basidiomycota	Agaricales		175	
Crepidotus variabilis	Shell shaped, white in color, sessile, radiating gills from the point of attachment with the substratum	Basidiomycota	Agaricales	4		
Cruentomycena sp.	Reddish in color, small, convex cap, presence of red exudate, moderately spaced gills	Basidiomycota	Agaricales			1
Cuphophyllus pratensis	Yellow in color, thick widely spaced and decurrent waxy gills, short and thick stipe	Basidiomycota	Agaricales		3	
Cyptotrama asprata	Golden yellow in color, cap is marked with pointed scales, gills yellowish to pale in color and adnate to slightly decurrent, yellow colored small stipe with rough texture	Basidiomycota	Agaricales	3		
Dacrymyces capitatus	Small, gelatinous in texture, globose structure, yellow orange in color, smooth and shiny surface	Basidiomycota	Dacrymycetales	13		
Dacrymyces spathularia	Spatula shaped, gelatinous, yellow orange in color, found in clusters, shrink and dry during dry conditions	Basidiomycota	Dacrymycetales	10	59	56
Daedaleopsis confragosa	Bracket shaped, sessile, presence of concentric zones, maze like pores present on hymenium,	Basidiomycota	Polyporales		1	
Daldinia concentrica	Hard, spherical, dark brown in color, distinct concentric rings visible inside, charcoal like texture	Ascomycota	Xylariales	2		
Dicephalospora rufocornea	Disc shaped, short stalked, yellow in color, very small in size, found in clusters	Ascomycota	Helotiales	14	1	

Species	Identification characters	Division	Order	Low	Mid	High
Earliella scabrosa	Thin bracket shaped, sessile, rough surface with concentric zones, leathery to rough in texture	Basidiomycota	Polyporales	10		
Entoloma sp.	Conical cap with central stipe, silky surface, annulus and volva are absent, crowded gills	Basidiomycota	Agaricales		1	
Exidia glandulosa	Gelatinous, rubbery and soft in texture, possess glandular dots, smooth surface	Basidiomycota	Auriculariales		1	
Exidia recisa	Gelatinous in nature, amber brown in color, smooth surface and shiny with irregular margin	Basidiomycota	Auriculariales		9	
Favolaschia calocera	Small, fan shaped, bright orange in color, distinct honey comb like pores with hexagonal shape, stipe short and lateral, leathery in texture	Basidiomycota	Agaricales	32		
Favolus grammocephalus	Semicircular in shape, yellowish-brown in color, hymenium is poroid with hexagonal shape, short and lateral stipe, leathery texture	Basidiomycota	Polyporales		1	
Fomitopsis quercina	Hard woody bracket, semicircular in shape, rough surface, brown in color, small and densely packed pores on hymenium	Basidiomycota	Polyporales	5		
Fuscoporia gilva	Semicircular in shape, finely hairy, margin with yellow in color, small, round pores on hymenium	Basidiomycota	Agaricales	39	9	
Ganoderma applanatum	Large in size, bracket shaped, hard surface with woody texture, presence of concentric growth zones, pore surface is white when fresh and turns brown when scratched	Basidiomycota	Polyporales	9		5
Ganoderma lobatum	Semicircular in shape with lobed margins, varnished look, dark brown in color, presence of concentric zones, pores small, round and numerous, woody in texture	Basidiomycota	Polyporales	11		
Ganoderma sp.1	Bracket shaped, shiny surface, pores in the underside, stipe absent with woody texture	Basidiomycota	Polyporales		1	
Ganoderma sp. 2	Bracket shaped, numerous small spores on the underside, sessile, woody texture	Basidiomycota	Polyporales			13
Ganoderma tropicum	Semicircular, dark brown in color, hard and woody, poroid hymenium	Basidiomycota	Polyporales			13
Ganoderma tsugae	Bracket shaped, short stipe, shiny and varnished surface, poroid underside, woody texture	Basidiomycota	Polyporales		6	
Geoglossum sp.	Tongue shaped, erect, black in color, upper part of the club is fertile and lower part is sterile stalk	*Ascomycota*	Geoglossales		4	
Gerronema sp.	Convex cap with depressed centre, thin and delicate, smooth surface, gills decurrent, spaced, slender stipe, no ring and volva	Basidiomycota	Agaricales		1	
Guepinia helvelloids	Gelatinous and soft, funnel shaped, orange in color, smooth and shiny	Basidiomycota	Auriculariales	19		68
Gymnopus sp.	Cap convex to flat, thin and dry in texture, smooth surface, gills adnexed to adnate attachment, stipe slender, long and tough	Basidiomycota	Agaricales	1		
Heaxagonia tenuis	Thin, leathery, bracket in shape, sessile, dark brown in color, thin and wavy margin, leathery texture	Basidiomycota	Polyporales	3	6	2
Hygrocybe ceraceae	Yellow in color, smooth surface, gills waxy in texture, adnate to slightly decurrent, slender stipe	Basidiomycota	Agaricales		1	
Hygrocybe conica	Conical to bell shaped, gills waxy and thick, yellow to orange-red in color Cap turns black when bruised	Basidiomycota	Agaricales		1	
Hymenopellis radicata	Convex shaped cap, gills free to adnexed, moderately spaced, slender stipe, greyish-brown in color	Basidiomycota	Agaricales		1	
Hymenopellis sp.	Convex shaped cap, gills free to adnexed, moderately spaced, slender stipe	Basidiomycota	Agaricales		1	
Laccaria sp.	Small, convex to depressed cap, smooth surface, thick widely spaced gills, slender stipe, orange brown in color	Basidiomycota	Agaricales	1		
Lentinus badius	Brown to dark brown in color, surface dry and scaly, decurrent gills, edges serrated, leathery and tough texture	Basidiomycota	Polyporales		1	

Species	Identification characters	Division	Order	Low	Mid	High
Lentinus sajor caju	Fan shaped, white in color, surface smooth, margin inrolled during young stage, gills decurrent, stipe short, leathery to fleshy in texture	Basidiomycota	Polyporales		22	
Lentinus sp.	White in color, dry surface, decurrent gills, stipe tough, leathery to tough in texture	Basidiomycota	Polyporales		5	
Lentinus tigrinus	Whitish to cream in color with brown scales arranged in a tiger like pattern, decurrent gills	Basidiomycota	Polyporales		4	
Leucocoprinus fragilissimus	Cap thin and fragile, pale yellow in color, strongly striated with small central disc, gills free from stipe	Basidiomycota	Agaricales		1	
Leucocoprinus rubrotinctus	Cap whitish to cream in color with pinkish scales, gills free from the stipe, stem slender, cylindrical and fragile with reddish tinge, thin and delicate ring present on the stipe	Basidiomycota	Agaricales	3	1	
Lycoperdon pyriforme	Pyriform shaped, surface covered with small granules on young stage, grows in clusters, yellowish in color	Basidiomycota	Agaricales	1		
Macrolepiota procera	Large cap, umbrella in shape, surface with dark brown scales, central dark umbo present, gills free from the stipe, large thick and movable ring present on the stipe	Basidiomycota	Agaricales			1
Marasmiellus ramealis	Small cap with convex to flat, surface smooth, gills adnate to slightly decurrent, widely spaced, stipe thin, slender and tough, central and smooth	Basidiomycota	Agaricales		51	
Marasmius guyanensis	Small cap. Smooth surface, distant gills, thin wiry and tough dark blackish stipe	Basidiomycota	Agaricales	3		
Marasmius haematocephalus	Cap bright in color, small convex, smooth surface, thin, distant and well-spaced gills, free to adnate, stipe thin, wiry and tough, dark brown to black in color	Basidiomycota	Agaricales	3		1
Marasmius rotula	Small cap, umbilicate, surface deeply pleated, gills widely spaced and free from the stipe	Basidiomycota	Agaricales		1	
Marasmius siccus	Bright orange in color, small convex cap with a depressed centre, surface strongly pleated, distant gills and free from the stipe, long and slender stipe	Basidiomycota	Agaricales	6		
Marasmius sp.	Cap small and convex to flat, pleated, widely spaced gills, free, thin, wiry and tough stipe	Basidiomycota	Agaricales	7		
Melanotus sp.	Small cap with semicircular in shape, surface smooth, gills adnate, moderately spaced	Basidiomycota	Agaricales		17	
Metacampanella caesia	Cap campanulate, surface smooth and thin, gills moderately spaced, slender, long and fragile stipe	Basidiomycota	Agaricales	10	1	
Microporellus dealbatus	Bracket shaped fruiting body, thin and leathery, attached laterally to the substratum, small , round spores on hymenium, white to cream coloured, thin, tough and leathery	Basidiomycota	Polyporales	1		
Microporous affinis	Thin, fan shaped, tough and leathery in texture, cap surface concentrically zoned, color reddish-brown to dark brown, small round pores on the underside with white to cream color	Basidiomycota	Polyporales	12		19
Microporus vernicipes	Bracket shaped, brown to reddish-brown in color, concentrically zoned, smooth surface, small round pores on the underside with white to cream in color, stipe lateral and short with varnished appearence	Basidiomycota	Polyporales	4		4
Microporus xanthopus	Fan shaped, thin tough and leathery, cap brown to dark brown in color with concentric zones, small pores on the hymenium with white to cream in color, distinct lateral stipe with bright yellow in color	Basidiomycota	Polyporales	15		4
Mucronella bresadole	Small coral like fruiting body with pointed teeth, white in color, soft and fragile, found in clusters	Basidiomycota	Agaricales			31
Mycena adscendens	Cap small, bell shaped, white to pale grey in color, surface smooth and translucent, gills adnate to slightly decurrent, moderately spaced, white in color, thin, delicate and translucent stipe with fine hairs at the base	Basidiomycota	Agaricales		1	

Species	Identification characters	Division	Order	Low	Mid	High
Mycena manipularis	Small bell shaped to conical cap, surface smooth, gills adnate to slightly decurrent, moderately spaced, long slender and fragile stipe	Basidiomycota	Agaricales		2	
Mycena rhenana	Cap small, bell shaped to convex, greyish in color, gills adnate to slightly decurrent, moderately spaced, stipe thin, slender and fragile	Basidiomycota	Agaricales		6	
Neofavolus alveolaris	Semicircular bracket shaped, thin, leathery, yellowish in cap color, honey comb like pores on underside, stipe absent	Basidiomycota	Polyporales		1	
Panaeolus antillarum	Cap greyish white in color, surface smooth during young stage, initially gills are in grey color and later black in color, stipe tall, thick and smooth, no ring is present	Basidiomycota	Agaricales	1		
Panellus pusillus	Very small fan shaped fruiting body, gills decurrent, close and narrow, stipe short and laterally attached to the substratum	Basidiomycota	Agaricales		26	
Panus sp	Fan shaped cap, surface hairy, greyish brown in color, decurrent gills, thick and widely spaced, short stem with tough texture	Basidiomycota	Polyporales		5	
Peziza occidentalis	Cup shaped ascocarp, brown color on the inner surface, hymenium smooth, stipe absent	Ascomycota	Pezizales		1	
Phellinus sp.1	Bracket shaped, hard and woody in texture, dark brown to blackish in color, small round pores on the underside	Basidiomycota	Hymenochaetales		1	
Phellinus sp.2	Bracket shaped, hard and woody in texture, dark brown to blackish in color, small round pores on the underside	Basidiomycota	Hymenochaetales		1	
Phellinus sp.3	Bracket shaped, hard and woody in texture, dark brown to blackish in color, small round pores on the underside	Basidiomycota	Hymenochaetales		4	
Plectania sp.	Cup shaped, black in color, smooth inner surface, shiny black in color, stipe short	*Ascomycota*	Pezizales		10	
Pleurotus pulmonaris	Fan shaped, pale cream in color, smooth surface, decurrent gills, stipe short, soft and fleshy in texture	Basidiomycota	Agaricales		7	
Pleurotus sp.	Fan shaped, white in color, smooth surface, decurrent gills, soft and fleshy in texture	Basidiomycota	Agaricales		4	
Porodaedalea chrysoloma	Hoof shaped, thick, woody, dark brown in color, rough surface, small pores on the underside, color yellowish brown to brown	Basidiomycota	Hymenochaetales		14	
Poronia nagaraholensis	Disc like stroma, black ostioles on surface, perithecia embedded in stroma	*Ascomycota*	Xylariales		2	
Pycnoporus sanguineus	Bright orange in color, bracket shaped, thin, tough and leathery, small round pores on the underside, thin and corky type of flesh	Basidiomycota	Polyporales	16		10
Resupinatus tristis	Small, shell shaped, short stipe lateral in position, cap grey in color, gills radiating from the point of attachment	Basidiomycota	Agaricales	8		
Royoporus spathulatus	Fan shaped, grows in clusters, white in color, color changes with age, small round pores on the underside which is white in color	Basidiomycota	Polyporales		55	
Russula cyanoxantha	Cap convex to flat, smooth surface, gills adnate and white to cream in color, stipe white, cylindrical and brittle, central in position and smooth	Basidiomycota	Russulales		1	
Sanguinoderma rugosum	Bracket shaped, thick, hard and woody, dark brown in color, surface rough, small round pores on the underside, pore surface white to cream in color during initial stage later becoming brown with age	Basidiomycota	Polyporales		1	
Schizophyllum commune	Fan shaped fruiting body, greyish in color, sessile, distinctively split gills, white in color	Basidiomycota	Agaricales		10	
Scleroderma bovista	Globose shaped, partly buried in soil, thick and tough, peridium yellowish to brown in color, mature fruiting body breaks irregularly to release spores	Basidiomycota	Boletales	1		

Species	Identification characters	Division	Order	Low	Mid	High
Scutellina setosa	Small cup shaped, inner surface bright orange in color, margin surrounded with dark brown bristles, inner surface smooth and outer surface slightly hairy	Ascomycota	Pezizales		2	
Serpula similis	Yellowish in color, leathery texture, sessile, hymenium turmeric yellow daedaloid pores	Basidiomycota	Boletales		11	
Stereopsis hiscens	Small, fan shaped, upper surface brown in color, hymenium smooth surface, thin and leathery texture	Basidiomycota	Stereopsidales		8	
Stereum ostrea	Thin, bracket shape, concentric bands are present, smooth hymenium	Basidiomycota	Russulales			27
Stereum sp.	Bracket shaped, smooth hymenium, concentric zones are present, tough and leathery in texture	Basidiomycota	Russulales	14		
Termitomyces microcarpus	Cap umbonate, gills free to slightly adnate, stipe cylindrical, whitish and bulbous at base, found in clusters	Basidiomycota	Agaricales			80
Tetrapyrgos nigripes	Small, convex, gills adnate to adnexed, widely spaced, white to cream in color, slender stipe, black in color	Basidiomycota	Agaricales		1	
Trametes betulina	Bracket shaped, upper surface with concentric zones, wavy margin, porous hymenium, leathery texture during fresh, later hard and woody on drying	Basidiomycota	Polyporales		1	
Trametes gibbosa	Bracket shaped, upper surface furrowed, greyish in color, margin wavy, porous hymenium, thick, tough and woody on drying	Basidiomycota	Polyporales		1	
Trametes pubescence	Thin, bracket shaped, upper surface pubescent, wavy margin, porous hymenium	Basidiomycota	Polyporales		25	
Trametes versicolor	Thin, fan shaped, upper surface with zones of concentric bands of varying colors – brown, cream, porous hymenium with white to cream in color, stipe absent	Basidiomycota	Polyporales		18	
Tremella fuciformis	Gelatinous, translucent and forms irregular lobes, white in color, soft, slippery in texture and fragile in nature	Basidiomycota	Tremellales	2		
Tremella mesenterica	Gelatinous, lobed, irregular in shape, bright yellow in color, soft, jelly and slippery in texture, smooth surface	Basidiomycota	Tremellales			48
Xylaria hypoxylon	Erect, black base with white tips on young stage, black portion rough and white portion powdery, hard and woody when mature and soft and brittle when young	*Ascomycota*	Xylariales		9	
Xylaria polymorpha	Erect, club shaped, black in color, hard and woody on mature and brittle when dry	*Ascomycota*	Xylariales	14	16	
Xerotus archeri	Rust orange in color, small fan shaped, widely spaced radiating gills with orange to brown in color, sessile	Basidiomycota	Polyporales	85		
Xerotus nigritum	Small, fan shaped, black in color, widely spaced radiating gills, balck in color, sessile	Basidiomycota	Polyporales		37	

Macrofungal species richness along the elevation gradient

Among the different elevation classes, low elevation and mid elevation classes were observed with more number of macrofungi compared to high elevation class (Table 4). The low elevation class recorded 42 macrofungal species with species richness (11.8 ± 2.8). Mid elevation class recorded 71 species with species richness (14 ± 2.9). High elevation class recorded 18 species with species richness (5.4 ± 2.30) In Wet evergreen forests of Agasthyamala, low elevation and mid elevation possess high species richness and found to be gradually decreased with increasing elevation.

Substrate availability along elevation gradient

The presence of substrates up on which macrofungi exist in different elevation classes were diverse in nature (Figure 2). Each elevation class had more number of macrofungi found on dead wood compared to other types (Low elevation (39% of dead wood); mid elevation (45% of dead wood) and high elevation (16% of dead wood). The mid elevation class (600–899 m) was recorded with more availability and diversity of substrates *viz*., dead wood (45%), fallen twig (69%), live tree (72%), soil (52%), and litter (45%) in contrast to low and high elevation classes (Image 2). Presence of dung (cow) is noted in a low elevation area (Figure 2; Image 2e).

Ecological preference of macrofungi

The current study shows that 86% of macrofungal species are saprotrophic, 11% of species were mycorrhizal, 2% were pathogenic, and remaining 1% is parasitic in nature. Higher percentage of saprotrophic fungi (86%) are observed in the study (Figure 3). Many of the polypores are saprotrophic which depend up on dead and decaying wood, fallen twig and litter. Species like *Microporus xanthopus*, *Cyptotrama asprata*, and *Auricularia delicata* were saprophytic in nature.

Certain species such as *Amanita vaginata*, *Cuphophyllus pratensis, Macrolepiota procera, Leucocoprinus rubrotinctus Russula cyanoxantha,* and *Termitomyces microcarpus* were reported as mycorrhizal. The study revealed the existence of parasitic and pathogenic fungi also. *Ganoderma applanatum* is a parasitic fungus reported from the study. Species such as *Fuscoporia gilva* and *Ganoderma lobatum* are pathogenic fungi. The low elevation class were recorded with saprotrophic fungi (91%), mycorrhizal fungi (2%), pathogenic fungi (5%) and parasitic fungi (2%). The mid elevation class shows that 93% of fungi were saprotrophic, followed by 6% of mycorrhizal fungi, and 1% of pathogenic fungi. The high elevation class were noted with 83% of saprotrophic fungi followed by 11% of mycorrhizal fungi and 6% of parasitic fungi.

Edaphic properties

The edaphic variables play an essential role on determining the fungal communities in an ecosystem. pH is an important factor that controls the macrofungal species richness. Electrical conductivity, Organic matter, base cations, Nitrogen, etc are important for determining the species composition of macrofungi. Selected edaphic properties are represented (Table 5). pH ranged from 3.86 to 4.58, which shows that soil pH increases slightly with elevation. Electrical conductivity shows very low in overall. Organic carbon shows highest at low elevation (1.97%) and decreases with elevation. The available Nitrogen peaks at low elevation (386.62kg/ha), drops sharply at higher elevations. The availability of Nitrogen reduces significantly at high elevation. There is no significant elevation-related trend were found among the edaphic parameters including available phosphorus and available potassium. calcium and magnesium were decreasing with increasing elevation.

Table 4. Macrofungal species richness across elevation gradient.

Elevation Classes	Elevation band (in m)	Species richness
High-elevation	900–1,199	5.4 ± 2.30a
Mid-elevation	600–899	14 ± 2.91b
Low-elevation	300–599	11.8 ± 2.86b

Values shown are means; standard deviations of the means. Values with different lowercase letters (a, b) are significantly different at $P < 0.05$.

The present study noted that there is a slight increase of bulk density with elevation. The texture of soil samples across all elevations shows loam sandy.

DISCUSSION

Fungi are the most species rich taxa in the terrestrial ecosystem (Wang et al. 2020) after flowering plants. Among the fungal group, macrofungi are highly economic important and play an inevitable role in the forest ecosystem including material cycling, energy flow and plant community succession. Many of the macrofungi are becoming extinct or are in danger due to loss of habitat and hosts, over exploitation, climate change, developmental activities, and pollution (Harsh 2021). Several researches have been conducted to explain the factors influencing the macrofungal species composition and distribution (Kujawska et al. 2021). The studies on the macrofungal diversity along the elevation gradient in Agasthyamala Biosphere Reserve, southern Western Ghats showed that elevation is a factor for macrofungal growth and distribution along with other biotic and abiotic variables.

Akshaya et al. (2023) conducted a study on the status of macrofungal diversity in wet evergreen forests of Agasthyamala biosphere reserve, Southern Western Ghats that form the foundational data of the area. The study revealed the existence of 62 macrofungal species in Agasthyamala Biopshere Reserve. This study revealed the existence of 112 macrofungal species and most of the species belonged to the division Basidiomycota (92%).The macrofungi belong to Basidiomycota are omnipresent in forest soils (Cairney 2005) and play an important role in nutrient cycling. Agaricales (46.43%) was the dominant order, similar to the study by Tapwal et al. (2013). More recently, Gogoi et al. (2024) also had the similar result of dominance of the order Agaricales. Polyporaceae is the dominant family having highest number of macrofungal species. The dominance of polyporaceae family has been reported in the earlier

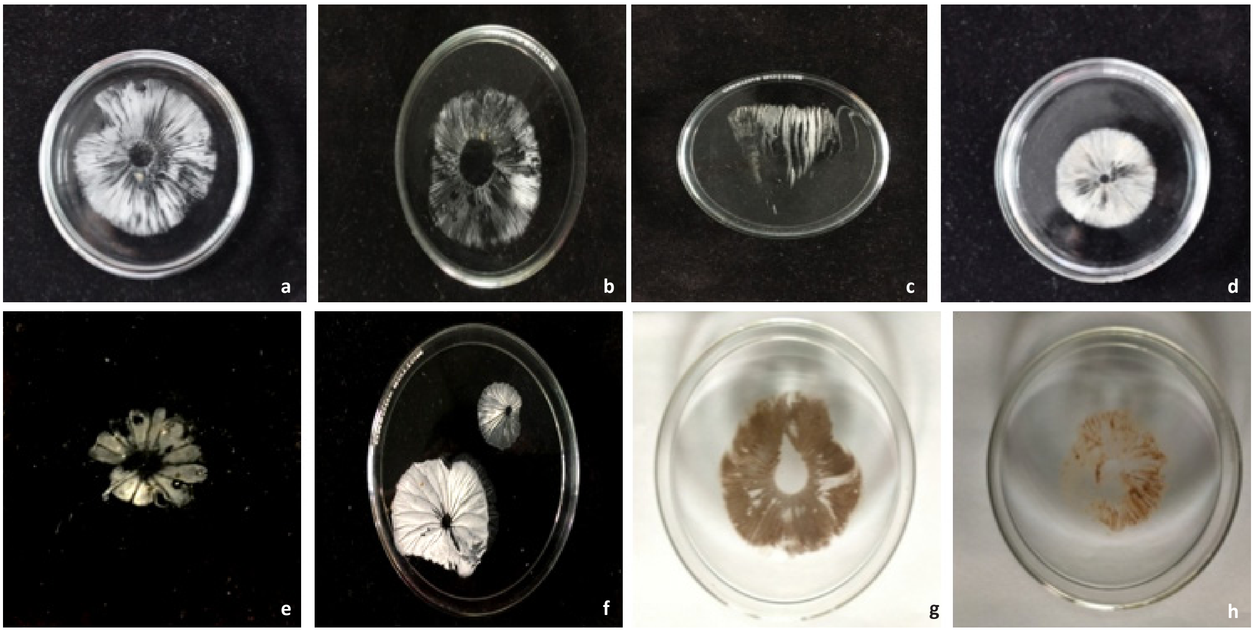

Image 1. Spore print images of macrofungal species collected from Agasthyamala forest: a—*Russula cyanoxantha* (Mycorrhizal) | b—*Amanita vaginata* (Mycorrhizal) | c—*Macrolepiota procera* (Mycorrhizal) | d—*Leucoagaricus rubrotinctus* (Mycorrhizal) | e—*Marasmius haematocephalus* (Saprotrophic) | f—*Cyptotrama asprata* (Saprotrophic) | g—*Chlorophyllum molybdites* (Saprotrophic) | h—*Cuphophyllous pratensis* (Mycorrhizal). © K. K. Akshaya.

Image 2. Different types of habitat of macrofungi identified from wet evergreen forests of Agasthyamala Biosphere Reserve, Kerala: a—soil (*Clavulinopsis laeticolor*) | b—dead wood (*Pleurotus ostreatus*) | c—fallen twig (*Favolus grammocephalus*) | d—live tree (*Ganoderma* sp.) | e—dung (*Paneolus anticillarum*) | f—litter (*Marasmius haematocephalus*). © K. K. Akshaya.

Table 5. The selected edaphic properties across the elevation gradient.

Soil parameters	Low-elevation (Mean ± SD)	Mid-elevation (Mean ± SD)	High-elevation (Mean ± SD)
pH	3.86 ± 0.05a	4.13 ± 0.02b	4.58 ± 0.26c
Electrical conductivity (dS/mm)	0.03 ± 0.01a	0.09 ± 0.04a	0.17 ± 0.18a
Organic carbon (%)	0.76 ± 0.38a	1.97 ± 1.25a	1.33 ± 1.14a
Available nitrogen (kg/ha)	315.84 ± 14.60a	386.26 ± 46.61a	380.94 ± 69.28a
Available phosphorus (kg/ha)	9.98 ± 6.90a	15.23 ± 3.33a	15.27 ± 8.92a
Available potassium (kg/ha)	121.44 ± 40.46a	165.58 ± 22.85ab	213.44 ± 73.36b
Calcium (meq/100 g)	3.2 ± 1.33a	3.72 ± 0.58a	3.5 ± 1.10a
Magnesium (meq/100 g)	1.41 ± 0.70a	1.5 ± 1.58a	0.80 ± 0.55a
Bulk density (gm/cc)	1.09 ± 0.04a	1.13 ± 0.07ab	1.23 ± 0.10b
Texture	Loam sandy	Loam sandy	Loam sandy

Values with different lowercase letters (a, b) are significantly different ($p < 0.05$).

studies conducted by Mohammad et al. (2019); Kumar & Gogoi (2024). The study stated that the abundance of this family in an area is due to the availability of substrates such as dead and decayed wood, fallen twigs, and others. Each elevation class reported a larger number of saprotrophic fungi belonging to the Polyporaceae family (low-elevation 91%, mid-elevation 93%, and high-elevation 83%).

The present study shows that low elevation (300–599 m) and mid elevation (600–899 m) classes were observed with more number of macrofungal species compared to high elevation class (900–1,199 m). According to Li et al. (2018b) more macrofungal species were recorded in regions with optimum conditions depending on the season, temperature and amount of rainfall. Some studies showed that temperature, precipitation and plant diversity are the main drivers of macrofungal flora (Tedersoo et al. 2014). Moore (2008) studied that the composition and diversity of macrofungi were different which may due to the difference in vegetation types along the elevation. Chen et al. (2018) stated that the growth of sporocarps of macrofungi is depending up on light. The macrofungal species show a positive correlation with low light habitat. The availability of strong light inhibits mycelia growth (Miles & Chang 2004). The suitable light will help macrofungal sporocarps to grow (Miles & Chang 2004; Chen et al. 2018). In high altitude area, the forest canopy was large and causes high light level, high temperature and low humidity that promote the low sporocarp production (Jayaseelan et al. 2014). Moreover, the variation in the sporocarp structures that increases the degree of dispersal of fungal spores which contributes to the abundance of macrofungal species in an area (Mohammad et al. 2019).

According to Cozzolino et al. (2016), edaphic variables play an essential role on determining the fungal communities. The present study shows that low pH values were associated with low and mid elevations. This lower pH supports more number of macrofungal species. The high pH decreases the macrofungal species by negatively influencing the expansion of fungi and the production of sporocarps. This is similar to those studies by Puangsombat et al. (2010). The effect of electrical conductivity on shaping the fungal community is ignorant. Here, the occurrence of more macrofungal species were directed towards the low electrical conductivity plots. High elevation areas were recorded with high electrical conductivity compared to low and mid elevation areas. This result is in accordance with the study by Alem et al. (2020). Base cations like Ca^{2+}, Mg^{2+}, K^{+} are essential in plant photosynthesis, that can affect the amount of carbon, which is needed for fungi in the soil (He et al. 2017).

Organic matter is inevitable for mycelia growth and network formation of fungi. This is because of the fact that organic matter has strong water holding capacity and nutrient availability. High level of organic carbon supports high level of macrofungi especially the saprophytic species. Some cases, ectomycorrhizal fungi may also attract organic matter rich sites (Lindahl & Tunlid 2015). Nitrogen is vital factor for the composition of fungi. Nitrogen helps in the mycelium and sporocarp formation (Trudell & Edmonds 2004).

Topography is an indirect environmental variable. This variable serves as an important driver of microhabitat in forest ecosystems. This is because different topographic conditions results in various microhabitats. Different microhabitats results in the composition and distribution of variety of macrofungi (Chen et al. 2018).

The diversity in macrofungal species are based on habitat. The fungi growing on various substrates may exhibit distinct growth and dispersion features (Senn-Irlet et al. 2007). The study revealed the presence of different types of substrate for macrofungi including soil, dead wood, fallen twig, live tree, animal dung and litter. Saprotrophic fungi are important for cycling of soil nutrients because they are one of the most active degraders of forest ecosystem. According to Li et al. (2018a) saprotrophic macrofungi are dominant and diverse fungal group in tropical forest. The dominance of this type of macrofungi is seen in this study. The dead wood dependent saprophytes were seen more in each elevation class. Saprotrophic macrofungi include *Sanguinoderma rugosum*, *Auricularia delicata*, *Dacrymyces spathularia*, and *Daldinia concentrica*. The present study noted with ectomycorrhizal fungi such as *Cuphophyllus pratensis*, *Leucocoprinus rubrotinctus*, and *Russula cyanoxantha*. The symbiotic mycorrhizal association enhances the overall well-being of the ecosystem by making an efficient nutrient uptake system in nature. Macrofungi that grow on woody substrate may be saprophytic or pathogenic as stated by Mueller et al. (2007). The human settlements in Agasthyamala have the practise of cattle farming and poultry farming. Most of the people in Agasthyamala are settled in the low elevation areas. Coprophilous macrofungi '*Panaeolus antillarum*' was reported from low elevation area only. This may be due to high grazing by cow in that area.

CONCLUSION

Elevation plays an important role in contributing macrofungal diversity, composition and distribution. The low and mid elevation areas showing high number of macrofungal species compared to high elevation area. There are a lot of factors playing important role in determining growth and distribution of macrofungi such as soil properties, temperature, precipitation, vegetation type, forest canopy, substrate availability. The variation in macrofungal composition and distribution is due to difference in vegetation type along with altitude that causes differences in the availability of substrate. The high elevation areas are dominated by mosses, liverworts, lichens. The vegetation composition affects the availability of substrate and hence contributed to variation in composition of macrofungi in high elevation area compared to low and mid elevation areas. In addition, the forest canopy gap was huge at high altitudes resulting high intensity of light, higher temperatures and low humidity causes low production of sporocarps. Edaphic variables like soil pH, organic carbon, base cations, Nitrogen have important role on shaping fungal communities in an ecosystem. The information on mycodiversity and substrate relationship is important for conservation and utilisation as well as for the sustainable forest ecosystem management. Understanding the factors tailoring the macrofungal communities in an ecosystem is very tectonic to predict future species composition and richness under global climate change scenario.

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ravi@threatenedtaxa.org & ravi@zooreach.org

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