State of Nature Conservation in Malaysia 2025, 1–12
doi: 10.62613/sonc2025.v1flc01

CHAPTER 1

Fungal diversity of Peninsular Malaysia

THI BEE KIN[1]* and NUR AQILAH MUSTAFA BAKRAY[2]

Abstract: Fungi can be found growing in a vast diversity of environments and substrates. Malaysia is one of the countries to have great diversity of micro- and macrofungi living in diverse habitats. In Peninsular Malaysia, the efforts to document micro- and macrofungal diversity of various ecosystems have been continuously carried out. A short review of the history of mycology in Malaysia, documentation activities and conservation efforts on micro- and macrofungi were presented here. New species and records of fungi found in Peninsular Malaysia were presented, especially interesting and noteworthy species. Some of these fungi, which are endemic, rare and threatened, were also highlighted. The importance and roles of fungi in balancing the ecological services in the forest ecosystem were discussed.

INTRODUCTION

Malaysia is one of the mega-diversity countries with rich diversity of flora, fauna, and fungi. Approximately 4,000 fungi, including both microfungi and macrofungi, were documented in Malaysia (Lee *et al*. 2012). However, the actual number of fungi species is expected to be much higher than what is documented. Earlier estimates suggested that approximately 70% of Malaysian macrofungi remained undescribed (Lee *et al.* 2008). Moreover, many new species or new records of fungi have been discovered and reported over the past 14 years.

In Malaysia, studies on microfungi are limited, but have received increasing attention with recent efforts focusing on soil fungi, marine fungi, and insect-associated fungi due to their crucial roles in ecosystems and advancement of molecular tools, particularly in DNA sequencing.

For macrofungi, intensive surveys and documentation have been ongoing since 2006 under the Ninth Malaysia Plan. Collections were conducted across various forest types in Peninsular Malaysia, including freshwater swamp forests, peat swamp forests, limestone forests, lowland and hill forests, highland forests and island forests. A total of 165 expeditions were documented, covering 145 localities in Peninsular Malaysia (Figure 1).

Sampling covered several island forests, such as Pulau Redang in Terengganu, Pulau Aur in Johor (Zainuddin *et al.* 2010), Pulau Pangkor in Perak (Thi and Lee 2012), Pulau Bidong in Terengganu (Tsia and Aqilah 2019), and Langkawi in Kedah (Noorlidah *et al*. 2005). Highland forests included Cameron Highlands (Thi and Lee 2011) and Fraser's Hill (Thi and Lee 2010; Thi *et al.* 2011), while inland locations included Terengganu National Park (Thi and Lee 2008), Royal Belum State Park (Thi and Lee 2010), Temengor Forest Reserve (Thi 2013), Gunung Ledang (Thi and Lee 2017) and Gunung Korbu (Nur Aqilah *et al.* 2020). Limestone ecosystems included Gunung Senyum (Thi and Lau 2012) and Perlis State Park (Ag. Ahmadni *et al*. 2024), alongside swamp forests such as Tasik Bera

[1] Forest Research Institute Malaysia (FRIM), 52109 Kepong, Selangor, Malaysia.
[2] Department of Biological Sciences and Biotechnology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.
***Corresponding author: thibeekin@frim.gov.my**

(Zainuddin *et al.* 2010). Additionally, fungal inventories were conducted in urban forests, including Kota Damansara Community Forest (Thi *et al.* 2012) and Pulai Trail in Bangsar (Nur Aqilah *et al.* 2026). Further inventories have been conducted by university lecturers and independent researchers across various sites in Peninsular Malaysia, including Sungkai Wildlife Reserve (Jaya Seelan 2014) and at the UiTM campus (Nur Amirah Sakinah *et al.* 2023). Although a diverse array of species was documented across these regions, the map indicates that several forest areas remain unexplored, whereas others are well-investigated. Based on the past and recent mycological studies, historical review of fungal research, micro- and macrofungal fungal diversity and ecological roles, fungal research and conservation in Peninsular Malaysia is presented in this chapter.

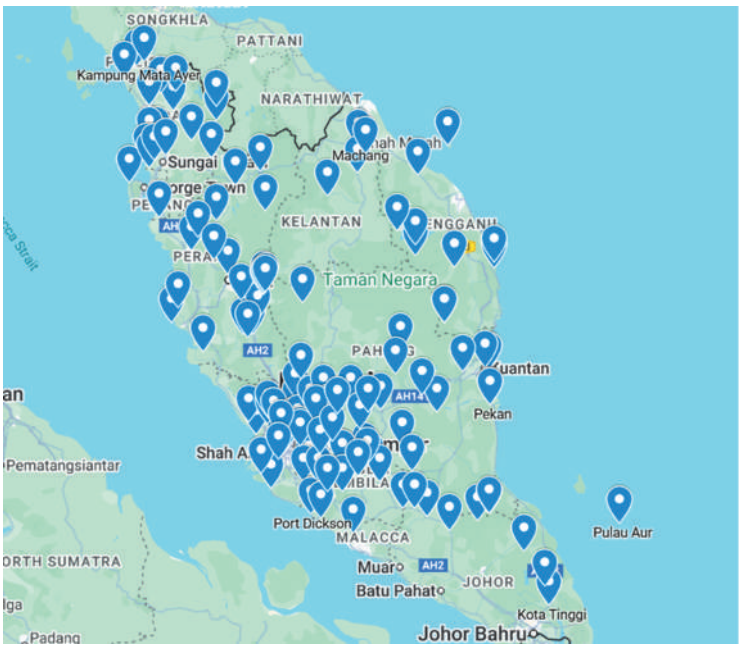

Figure 1. Distribution map of sampling sites across Peninsular Malaysia. Blue pins indicate the 145 localities visited during 165 fieldwork expeditions for macrofungi collection from 2006 to present.

Historical review of mycology in Malaysia

The history of mycology and fungal collecting in Malaysia dates back roughly 150 years, evolving from early colonial botanical surveys to modern systematic inventories. In Malaysia, the early fungal studies and collections were mainly on macrofungi, carried out by visiting scientists in the 19th centuries, including O. Beccari (1865 – 1879), W.B. M.C. Cooke (1878 – 1885), as well as H.N. Ridley and I.H. Burkill (1888 – 1912). E.J.H. Corner is one of the active mycologists in the 20th century and had collected a large number of macrofungi in Malaysia, followed by S.S. Lee and R. Watling on ectomycorrhizal fungi (1990 – 2000), and T. Hattori on polypores (1995 – 2025).

During the 19th century, V. Cesati examined Beccari's collections and described 20 new fungal species from Sarawak, Borneo (Cesati 1879), while M.C. Cooke described numerous new species from Peninsular Malaysia (Cooke, 1885). Subsequently, H.N. Ridley and I.H. Burkill (1888 – 1912) made extensive fungal collections in Singapore and Malaya. In the 20th century, E.J.H. Corner collected extensively across Peninsular Malaysia, Singapore, and Sarawak. His systematic publication of these collections across a series of comprehensive monographs (Corner 1932, 1950, 1962, 1967, 1968, 1970, 1974, 1980a, 1980b, 1981, 1984a, 1984b, 1992, 1993, 1994) laid the groundwork for tropical Basidiomycota taxonomy and established the foundational framework for Southeast Asian macrofungi.

Later in the 1990s, S.S. Lee carried out taxonomic research on macrofungi and ectomycorrhizal associations in the tropical rainforests of Peninsular Malaysia (Lee 1995, 2005; Lee *et al.* 1997, 2002, 2003). At the same time, T. Hattori extensively studied and identified polypore fungi in Malaysia (Hattori and Lee 1999, 2003, 2012; Hattori *et al.* 2025), while also conducting detailed type studies on Asian and West Pacific polypores originally described by the prominent British mycologist E.J.H. Corner (Hattori 2000, 2001a, 2001b, 2002, 2003a, 2003b, 2005). Since 2006, studies and documentation on macrofungi have been carried out by the Forest Research Insitute Malaysia (FRIM) researchers. Several guidebooks to macrofungi have been published, including *A Guidebook to the Macrofungi of Tasik Bera* (Zainuddin *et al.* 2010), *A Guidebook to the Macrofungi of Fraser's Hill* (Thi *et al.* 2011) and *A Field Guide to the Larger Fungi of FRIM* (Lee 2017). There are two formal checklists of fungi in Malaysia. In the documentation, Chip (1921) listed 861 fungi, while Lee *et al.* (2012) listed 3,804 fungi.

Historically, microfungi research in Malaysia began in the early 1900s, focused primarily on agricultural crop health and plant pathogens that infect and cause disease in crops. In the late 1910s and early 1920s, C.F. Baker collected specimens of microfungi and myxomycetes (slime molds) across Penang and Singapore. P.A. Saccardo subsequently described Baker's collection, documenting these Malaysian microfungi in his multi-volume work, *Sylloge Fungorum* (Saccardo 1882–1931). Concurrently, A.R. Sanderson working together with Baker on Malaysian myxomycetes and primitive lower fungi. Later, in 1921, T.F. Chipp gathered and organised this baseline data into a comprehensive checklist (Chipp 1921). Their collective work established the baseline species checklists that modern mycologists in Malaysia rely on today to study tropical microfungi, such as *Aspergillus*, *Penicillium*, and *Fusarium*.

In 1969, J. Kohlmeyer's pioneering work extended Malaysian microfungi research beyond farm crops and into marine and mangrove habitats. Jones and Tan (1987) listed 32 manglicolous species from Gelang Patah, Johor. This was expanded by Jones and Kuthubutheen (1989) to 82 species across Morib, Kuala Selangor, Port Dickson, and Sementa mangroves. Alias *et al.* (1995) documented 100 marine fungal species (82 ascomycetes, 15 asexual forms, and three basidiomycetes) from Kuala Selangor, Morib, and Port Dickson. Later studies by Alias and Jones (2000a, 2000b) detailed 53 species specifically associated with *Rhizophora apiculata* at Morib.

FUNGAL DIVERSITY AND RESEARCH IN PENINSULAR MALAYSIA

Occurrence, distribution, and roles of macrofungi

Macrofungi, commonly known as mushrooms, are visible fungi that have fruiting bodies (Lee *et al.* 2012). This group of fungi belongs predominantly to the phyla Basidiomycota and Ascomycota. Malaysia's tropical forests host a rich diversity of macrofungi. There are many different types of macrofungi, such as agarics, boletes, polypores, coral fungi, cup fungi, jelly fungi, stinkhorns, earthballs, and puffballs (Thi *et al.* 2011). Over 1,800 species of macrofungi have been documented in Malaysia (Lee *et al.* 2012), and this number continues to grow as novel species are discovered that have yet to be recorded in the national fungal checklist.

Many macrofungi species were documented from various types of forests. Specific examples of these are the following: 61 species from freshwater swamp forest at Tasik Bera (Zainuddin *et al.* 2010); 72 species from highland forest at Fraser's Hill (Thi *et al.* 2011); 123 species from regenerated lowland dipterocarp forest at FRIM (Lee 2017), and more than 300 species from old growth lowland dipterocarp forest at Endau Rompin National Park (Thi 2025).

Hattori *et al.* (2007) and Yamashita *et al.* (2015) demonstrated that polypore diversity is exceptionally high in Malaysian lowland rainforests. A survey in Pasoh Forest Reserve recorded 140 species and estimated around 188 polypore species in a single 2-hectare plot (Yamashita *et al.* 2015), with many recorded species likely endemic to tropical Asia (Hattori and Lee 2003). Globally, Zhao *et al*. (2026) ranked Malaysia 4th worldwide and 2nd in Asia (behind China) with a total of 179 type specimens. Type specimens are the most critical vouchers in a herbarium as they defined a species, serving as the permanent reference for the first specimen bearing a newly published scientific name. Some of the polypores are rare or endemic to a particular region, for example *Buglossoporus malesianus* found at Cameron Highlands and Mt. Kinabalu, is restricted to the highland areas in tropical forest (Hattori 2017). Similarly, *Climacodon sanguineus* is recorded from Cameron Highlands (Thi *et al.* 2008), while *Corneroporus subcitrinus* is a rare fungus known from lowland areas of the Malay Peninsula and Borneo (Corner 1989a; Hattori 2001b; Yamashita *et al.* 2009). Furthermore, *Podopostia stellifera* (previously *Postia stellifera*) is a rare, terrestrial stalked polypore described from lowland Peninsular Malaysia (Hattori *et al.* 2010).

In 2013, two additional new polypores discovered and described from the tropical rainforests of Peninsular Malaysia belong to the genus *Lignosus* (family Polyporaceae). Commonly known as Tiger Milk mushrooms, these fungi are highly valued medicinal species native to Malaysia (Tan *et al*. 2013). *Lignosus tigris* and *L. cameronensis* are sclerotium-bearing polypore discovered from tropical rain forests of Lata Iskandar, Pahang, Malaysia using taxonomic and phylogenetic studies.

Another new species discovered in Peninsular Malaysia is *Amanita malayensis* (Tang *et al.* 2017), an ectomycorrhizal fungus that grows gregariously on the ground under secondary or disturbed lowland forests and parks, often associated with ectomycorrhizal host trees. *Hebeloma radicans* (Eberhardt *et al*. 2021) belongs to the Hymenogastraceae, another ectomycorrhizal family of agarics. This fungus was collected from a lowland tropical dipterocarp-oak forest (*Dipterocarpus* and *Quercus*) in Endau-Rompin National Park, Johor. The discovery of *H. radicans* represented the first formal documentation that the genus *Hebeloma* and ectomycorrhizal members of Hymenogastraceae are naturally present in tropical forests of the Malay Peninsula (Eberhardt *et al*. 2021).

In addition, new records for Malaysia were also reported, including *Macrolepiota dolichaula* (Thi *et al.* 2018), *Climacodon sanguineus* (Thi *et al.* 2020), and *Spongispora temasekensis* (Mohd Salleh *et al.* 2020), which were found in Peninsular Malaysia. Furthermore, *Pleurocordyceps nipponica*, an entomopathogenic fungus, was reported as a new record for Malaysia after being isolated from a cicada nymph in Johor and an ant in Kedah (Shahbaz *et al.* 2026b). At present, a collection of macrofungi in FRIM's *Fungarium* is still being identified and some species are new to the region. The number of species of macrofungi is increasing with the recent new discoveries of macrofungi in Peninsular Malaysia, Sabah, and Sarawak. Many undiscovered species are expected to be found in our forests in the future.

Macrofungi play very important roles in the forest ecosystem, acting as saprophyte, mutualists and pathogens. Most of the polypores are saprobic, decomposing wood debris or leaf litter on forest floor for nutrient cycling (Hattori *et al.* 2012; Adarsh *et al.* 2015). Besides, macrofungi such as genus *Amanita*, *Russula*, *Lactarius*, boletes and include other ectomycorrhizal fungi that act as mutualists, forming symbiotic associations with the roots of trees in families, particularly with Dipterocarpaceae, Fagaceae and some Fabaceae, enhancing nutrient uptake. Some of the macrofungi are pathogens, for example *Rigidoporus microporus* and *Pyrrhoderma noxium*, maintaining forest ecosystems by regulating populations of the plants (Thi *et al*. 2011; Lee 2017). In addition to their ecological importance, macrofungi also has medicinal properties (Chang and Lee 2004).

Occurrence, distribution, and roles of microfungi

Microfungi are generally characterised by its microscopic fungi that lack visible fruiting bodies. reproductive structures that are not visible to the naked eye (e.g., yeast, mildew, mould, smuts, rusts, etc.), while macrofungi produce large conspicuous fruiting bodies (e.g., mushroom, bracket fungi, puffballs, morels, jelly fungi, etc.) (Lee *et al.* 2012). Compared to macrofungi, the microfungi taxa are larger, more diverse and widely distributed. It is important to note that the distinction between microfungi and macrofungi is not absolute as they are not mutually exclusive taxonomic divisions.

Most of the microfungi are grouped into the Phylum Ascomycota, with some from Basidiomycota, Glomeromycota, Mucoromycota and other taxa. These fungi include yeasts and mildews from Ascomycota, moulds mainly from Ascomycota and Mucoromycota, smuts and rusts from Basidiomycota, endomycorrhizae from Glomeromycota and marine fungi from Ascomycota, Basidomycota and minority group. Although microfungi is the largest group and found all over the world, Malaysia only recorded over 1,100 species (Lee *et al*. 2012), which is slightly lower than the macrofungi in Malaysia because these groups of fungi were understudied.

Based on our fieldwork observations and current sampling gaps, we estimate that numerous species of microfungi remain to be discovered in Malaysia. *The Checklists of Fungi in Malaysia* documented significant fungal diversity in Malaysia. However, the recorded diversity of microfungi in Malaysia is likely an underestimate of the actual diversity, as gaps remain in the study of particular fungi group (microfungi) and their microhabitats (Lee *et al.* 2012). A study by Foster *et al.* (2022) in Sabah also revealed previously undocumented fungal lineages, which could suggest the potential for further discoveries.

Based on the *Checklists of Fungi of Malaysia* (Lee *et al.* 2012), 1,141 species of ascomycete fungi have been recorded, including a small number of macrofungi such as cup fungi, and dead man's fingers (Lee *et al.* 2012). Records of 728 mould species (Lee *et al.* 2012), and 139 species of marine fungi (Jones *et al* . 2013) were documented. The number of smut fungi and rust fungi recorded from Malaysia were 15 species and 75 species, respectively (Lee *et al.* 2012, Ono *et al.* 2023). A total of 229 species of marine microfungi have been recorded in Peninsular Malaysia (Zainuddin *et al.* 2007). Alias *et al.* (2010) reported 33% of the world's total marine manglicolous fungi have been recorded in Malaysia, with a total of 390 marine mangrove fungi.

Over the past several years, numerous new species and new records of microfungi have been documented for Malaysia that have yet to be incorporated into the national checklist. Notably, this represents the first time microfungi from Peninsular Malaysia are being formally reported. These additional records include four yeast species from Perak (Ooi *et al.* 2016), 25 species of marine fungi (Jones et al., 2013), and 18 species of rust fungi, including one species recorded in Peninsular Malaysia for the first time (Ono *et al.* 2023); two species of enthomopathogenic fungi (Kin *et al.* 2017), and six new soil fungus from peat soil records for Malaysia (Noman *et al.* 2023). Approximately 20 species of endomycorrhizae (Glomeromycota) associated with *Eucalyptus* hybrids were reported (Thi *et al.* 2025). However, there are still a lot of undiscovered species of microfungi in Malaysia.

Microfungi act as saprobes, pathogens, endophytes, and epiphytes in the ecosystem. As saprobes, microfungi have the ability to break down organic matter, decomposing the components of soil, which are important for nutrient cycling and maintaining ecological balance (Rillig 2026). Some microfungi are plant pathogens that cause diseases to plants (Mohd Zainudin *et al.* 2025) while some are entomopathogenic fungi, parasitising and killing insects. These have the potential to be used as biocontrol agents (Yazid *et al.* 2020; Shahbaz *et al.* 2026a). Microfungi that act as endophytes live within a plant tissue and

epiphytes, colonising the surface without penetrating the plant's tissue. These are beneficial fungi, and essential for promoting plant health, enhancing stress tolerance, and producing bioactive compounds with potential for pharmaceutical application (Radu and Cheah 2002; da Silva *et al.* 2022).

Microfungi are also being used in both industrial and commercial purposes such as food, medicine, and chemical sectors. For instance, various cheeses are produced from *Penicillium* (Frisvad 2014), while *Aspergillus* species are utilised in the production of ingredients for producing soft drinks in the food industry as citric acid producer (Show *et al.* 2015). Microfungi are also being used in the medicinal industry, such as *Penicillium* species that naturally produce penicillin antibiotics (Charles 2018).

Ethnomycology studies in Peninsular Malaysia

Ethnomycology studies in Peninsular Malaysia focus primarily on documenting the traditional use of wild macrofungi for food and medicine. Ethnomycological knowledge in Malaysia is predominantly held by rural and indigenous communities, such as the Semai, Temuan, Bateq, Che Wong, and Jakun. Traditional ethnomycological knowledge transmission is largely oral, preserved and transmitted primarily by women and community elders, mainly for self-consumption. Several studies have been carried out by Chang and Lee (2004), Lee *et al.* (2009), Ayu *et al.* (2019), as well as Shyen and Aqilah (2020) in Peninsular Malaysia.

Chang and Lee (2004) documented nine species of macrofungi utilised by the Temuans of Johor, five of which were used for medicine (*Amauroderma* sp., *Lignosus* spp., *Microporus xanthopus*, *Pycnoporus sanguineus*, *Xylaria polymorpha*) and four for food (*Auricularia* spp., *Cookeina* spp., *Lentinus* spp., *Termitomyces* spp.). In the study by Lee *et al.* (2009), 31 species of macrofungi were collected for food, but only 14 species were used for medicinal purposes across the Semai, Temuan, Bateq, Che Wong, and Jakun sub-tribes. Ayu *et al.* (2019) documented the ethnomedical knowledge of the Jakun community at Kampung Peta in Endau Rompin Johor National Park, identifying 20 macrofungi species with medicinal properties. In Terengganu, the edible wild boletoid mushroom, *Tylopilus griseipurpureus* or locally known as the "*gelam* mushroom", is consumed by local communities in Setiu and Besut, Terengganu. Additionally, Mohammad and Hamzah (2015) documented ten macrofungal species utilised for food and traditional medicine by the Bateq indigenous community in Kampung Kuala Koh, Kelantan. Abdullah and Rusea (2009) listed 13 of the most common wild edible fungi species consumed primarily by the Malays and village communities across Peninsular Malaysia and Borneo. There is an urgent need for continued ethnomycological documentation to safeguard indigenous knowledge against loss and to accelerate scientific discovery.

THREATS AND CONSERVATION STATUS OF FUNGI

In Malaysia, fungi are facing various threats, which include deforestation, land development and conversion to agricultural lands, human activities, and climate change. All these are reducing fungal biodiversity and ecosystem functions (Qu *et al*. 2026).

Due to deforestation and conversion of land use, fungi are at risk of being wiped out due to habitat loss, even before we get to know much about them. Human activities such as over-collection for traditional medicine, like *Lignosus rhinocerus*, *Ganoderma* species or for food, like *Auricularia auricula-judae* from forests may also decrease the fungi populations. Trampling and compaction of forest floor when harvesting can reduce the sporophores produced (Simon *et al.* 2006). Climate change, specifically extreme changes of the surrounding temperatures and rainfall can disrupt fungal fruiting and life cycles (Mridu *et al.* 2024).

The conservation status of micro- and macrofungi in Malaysia are still poorly understood. Most of the fungi in Malaysia has yet to be evaluated using the International Union for Conservation of Nature (IUCN) Red List criteria. From approximately 80 macrofungi species that were proposed for IUCN assessment, only 25 species of macrofungi found in Malaysia currently have conservation status according to published data from the IUCN Red List. Five species are categorised as vulnerable (VU), three species are endangered (EN), four species with near threated (NT), six species with least concern (LC), and seven species with data deficient (DD) status. The fungi species with the status VU and EN are facing a high risk of becoming extinct in the wild. Therefore, more research is needed to assist in the conservation and protection of fungi.

Table 1. List of Malaysian macrofungal species and their conservation status.

No.	Species	Location	Conservation Status
1	*Amanita aporema*	Peninsular Malaysia	VU
2	*Buglossoporus magnus*	Peninsular Malaysia	VU
3	*Calostoma insigne*	Peninsular Malaysia and Sarawak	EN
4	*Cantharellus carneoflavus*	Sabah	EN
5	*Cantharellus cerinoalbus*	Peninsular Malaysia	LC
6	*Cantharellus cuticulatus*	Peninsular Malaysia and Sabah	NT
7	*Cantharellus diminutivus*	Peninsular Malaysia	DD
8	*Cantharellus fuligineus*	Sabah	NT
9	*Cantharellus inconspicuus*	Peninsular Malaysia	DD
10	*Cantharellus incrassatus*	Peninsular Malaysia	DD
11	*Cantharellus omphalinoides*	Peninsular Malaysia and Sabah	LC
12	*Cantharellus pudorinus*	Peninsular Malaysia	DD
13	*Cantharellus sordidus*	Malaysia (in general)	DD
14	*Cantharellus subcibarius*	Sabah	VU
15	*Cantharellus subamethysteus*	Peninsular Malaysia	DD
16	*Chlorogaster dipterocarpi*	Sabah	VU
17	*Craterellus hypolyssoides*	Sarawak	DD
18	*Craterellus aureus*	Peninsular Malaysia	LC
19	*Craterellus cornucopioides*	Peninsular Malaysia	LC
20	*Craterellus verrucosus*	Peninsular Malaysia and Sabah	NT
21	*Durianella echinulate*	Peninsular Malaysia, Sabah and Sarawak	VU
22	*Hydnum repandum*	Peninsular and Sabah	LC
23	*Lycoperdon perlatum*	Peninsular Malaysia, Sabah and Sarawak	LC
24	*Spongiforma squarepantsii*	Sarawak	EN
25	*Spongispora temasekensis*	Peninsular Malaysia	NT

There are challenges in the conservation efforts of fungi. Examples are the limited and lack of research funding, shortage of local mycologists, and the lack of public awareness, including limited understanding of the fungi's ecological roles, making conservation efforts difficult.

Overall, public awareness regarding diversity and the importance of fungi in our ecosystem, ongoing monitoring, and extensive sampling are required for effective macrofungal documentation and conservation programs in Malaysia. It is therefore crucial to document and highlight the richness of the diversity of both macrofungi and microfungi before they become extinct.

CONCLUSION

Malaysia has various forest ecosystems and harbours a vast diversity of fungi. Although fungi are essential for forest ecosystems and have economic importance, they are facing threats resulting from habitat destruction, climate change, and different types of pollution. Therefore, sustainable forest management and conservation are essential to maintaining fungi diversity and keeping the forest ecosystems that they thrive in healthy.

REFERENCES

Abdullah, F. and Go, Rusea. 2009. Documentation of inherited knowledge on wild edible fungi from Malaysia. *Blumea - Biodiversity, Evolution and Biogeography of Plants* 54: 35–38. https://doi.org/10.3767/000651909X475996

Ag. Ahmadni, A.S., Shamsul Kamar, N.A., Amir Hadi, M. and Terhem, R. 2023. Assessment of macrofungi diversity in Perlis State Park, Perlis, Malaysia. *Journal of Wildlife and Biodiversity* 8(1): 298–307. https://doi.org/10.5281/zenodo.10206965

Alias, S.A. and Jones, E.B.G. 2000a. Colonization of mangrove wood by marine fungi at Kuala Selangor mangrove stand, Malaysia. In *Aquatic Mycology Across the Millennium*, K.D. Hyde, W.H. Brief and S.B. Pointing (Eds.), pp. 9–21. Hong Kong: Fungal Diversity Press.

Alias, S.A. and Jones, E.B.G. 2000b. Vertical distribution of marine fungi on *Rhizophora apiculata* at Morib mangrove, Selangor, Malaysia. *Mycoscience* 41: 431–436.

Alias, S.A., Kuthubutheen, A.J. and Jones, E.B.G. 1995. Frequency of occurrence of fungi on wood in Malaysian mangroves. *Hydrobiologia* 295(1): 97–106.

Alias, S.A., Zainuddin, N. and Jones, E.B.G. 2010. Biodiversity of marine fungi in Malaysian mangroves. *Botanica Marina* 53: 545-554.

Chang, Y.S. and Lee, S.S. 2004. Utilisation of macrofungi species in Malaysia. *Fungal Diversity* 15: 15–22.

Charles, T. 2018. Mycology presents *Penicillin*. *Mycologia* 37: 460–475. https://doi.org/10.1080/00275514.1945.12024006

Chipp, T.F. 1921. A list of the fungi of the Malay Peninsula. *The Garden' Bulletin Straits Settlements* 2: 311–418.

Cooke, M.C. 1885. Fungi of Malayan Peninsula. *Grevillea* 14(70): 43–44.

Corner, E.J.H. 1932. The fruit-body of *Polystictus xanthopus* Fr. *Annals of Botany* 46: 71–111.

Corner, E.J.H.1950. Monograph of Clavaria and allied genera. London: Dawsons.

Corner, E.J.H. 1967. Notes on *Clavaria*. *Transactions of the British Mycological Society* 50: 33–44.

Corner, E.J.H. 1968. A monograph of *Thelephora* (Basidiomycetes). *Nova Hedwigia* 27: 1–110.

Corner, E.J.H.1971. Merulioid fungi in Malaysia. *Gardens' Bulletin, Singapore* 25: 355–381.

Corner, E.J.H. 1970. *Phylloporus* Quél and *Paxillus* Fr. in Malaya and Borneo. *Nova Hedwigia* 20: 793–822.

Corner, E.J.H.1974. *Boletus* and *Phylloporus* in Malaysia: further notes and descriptions. *Gardens' Bulletin, Singapore* 27: 1–16.

Corner, E.J.H. 1980. *Boletus longipes* Mass., a critical Malaysian species. *Gardens' Bulletin, Singapore* 33: 290–296.

Corner, E.J.H. 1980. *Entoloma* (Fr.) Kummer in the Malay peninsula. *Gardens' Bulletin, Singapore* 33: 297–300.

Corner, E.J.H. 1983. Ad Polyporaceas I. *Amauroderma* and *Ganoderma*. *Beih*. *Nova Hedwigia* 75: 1–182.

Corner, E.J.H. 1984. Ad Polyporaceas II. *Polyporus*, *Mycobonia* and *Echinochaete*. *Beih*. *Nova Hedwigia* 78: 1–129.

Corner, E.J.H. 1984. Ad Polyporaceas III. *Piptoporus*, *Buglossoporus*, *Laetiporus*, *Meripilus*, and *Bondarzewia*. *Beih. Nova Hedwigia* 78: 133–222.

Corner, E.J.H. 1981. The agaric genera *Lentinus*, *Panus*, and *Pleurotus* with particular reference to Malaysian species. *Beih. Nova Hedwigia* 69: 1–169.

Corner, E.J.H. 1992. Notes on the development of the fruit-bodies of four Malayan species of *Amanita* (Basidiomycetes). *Gardens' Bulletin Singapore* 44(1): 43–45.

Corner, E.J.H. 1993. *Psathyrella* (Agaricales) with ornamented spores in the Malay Peninsula. *Gardens' Bulletin Singapore* 45(2): 337–357.
Corner, E.J.H. 1994. Agarics in Malesia: I Tricholomatoid, II Myceniod. *Beih. Nova Hedwigia* 109: 1–271.
Corner, E.J.H. and Bas, C.1962. The genus *Amanita* in Singapore and Malaya. *Persoonia* 2(3): 241–304.
da Silva, S.G.M., de Melo, B.A., dos Santos, M.T., Rios, R.R.S., de Santa'Anaa Santos, C.M., Júnior, K.A.L.R., de Albuquerque Maranhão, F.C. *et al.* 2022. Endophytic fungi: Benefits for plants and biotechnological potential. *Research, Society and Development* 11(4): e9211427008. https://doi.org/10.33448/rsd-v11i4.27008
Eberhardt, U., Schütz, N., Beker, H.J., Lee, S.S. and Horak, E. 2021. *Hebeloma* in the Malay Peninsula: Masquerading within *Psathyrella*. *MycoKeys* 28(77): 117–141. https://doi.org/10.3897/mycokeys.77.57394
Frisvad, J.C. 2014. Penicillium: *Penicillium*/Penicillia in Food Production. In *Encyclopedia of Food Microbiology (2nd Ed.)*, C.A. Batt and M.L. Tortorello (Eds.), pp. 14–18. https://doi.org/10.1016/B978-0-12-384730-0.00249-4
Foster, R., Hartikainen, H., Hall, A. and Bass, D. 2022. Diversity and phylogeny of novel cord-forming fungi from Borneo. *Microorganisms* 10(2): 239. https://doi.org/10.3390/microorganisms10020239
Hattori, T. 2017. Biogeography of polypores in Malesia, Southeast Asia. *Mycoscience* 58(1): 58–69.
Hattori, T. 2000. Type studies of the polypores described by E.J.H. Corner from Asia and the West Pacific I. Species described in *Polyporus*, *Buglossoporus*, *Meripilus*, *Daedalea*, and *Flabellophora*. *Mycoscience* 41: 339e349. https://doi.org/10.1007/BF02463947
Hattori, T. 2001a. Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas II. Species described in *Gloeophyllum*, *Heteroporus*, *Microporellus*, *Oxyporus*, *Paratrichaptum*, and *Rigidoporus*. *Mycoscience* 42: 19e28. https://doi.org/ 10.1007/BF02463971
Hattori, T. 2001b. Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas III. Species described in *Trichaptum*, *Albatrellus*, *Boletopsis*, *Diacanthodes*, *Elmerina*, *Fomitopsis* and *Gloeoporus*. *Mycoscience* 42: 423–431. https://doi.org/10.1007/BF02464338
Hattori, T. 2002. Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas IV. Species described in *Tyromyces* (1). *Mycoscience* 43: 307e315. https://doi.org/10.1007/s102670200045
Hattori, T. 2003a. Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas V. Species described in *Tyromyces* (2). *Mycoscience* 44: 265e276. https://doi.org/10.1007/s10267-003-0114-3
Hattori, T. 2003b. Type studies of the polypores described by E.J.H. Corner from Asia and West Pacific Areas VI. Species described in *Tyromyces* (3), *Cristelloporia*, *Grifola*, *Hapalopilus*, *Heterobasidion*, *Ischnoderma*, *Loweporus*, and *Steccherícium*. *Mycoscience* 44: 453e463. https://doi.org/10.1007/s10267-003-0139-7
Hattori, T. 2005a. Type studies of the polypores described by E.J.H.Corner from Asia and West Pacific Areas VII. Species described in *Trametes* (1). *Mycoscience* 46: 303e312. https://doi.org/10.1007/s10267-005-0250-z
Hattori, T. 2005b. Diversity of wood-inhabiting polypores in temperate forests with different vegetation types in Japan. *Fungal Diversity* 18: 73e88.
Hattori, T. and Lee, S.S. 2003. Community structure of wood-decaying Basidiomycetes in Pasoh. In *Pasoh: Ecology of a Lowland Rain Forest in Southern Asia*, T. Okuda, N. Manokaran, Y. Matsumoto, K. Niiyama and S.C. Thomas (Eds.), pp. 163–170. Tokyo: Springer. https://doi.org/10.1007/978-4-431-67008-7_12
Hattori, T., Kozue, S., Ota, Y., Thi B.K., Lee, S.S. and Baharuddin, S. 2011. *Postia stellifera* sp. nov., a stipitate and terrestrial polypore from Malaysia. *Mycotaxon* 114(1): 151–161.
Hattori, T., Noraswati, M.N.R. and Salmiah, U. 2007. Basidiomycota: Diversity of Malaysian polypores. *Malaysian Fungal Diversity*: 55–68.
Hattori, T., Yamashita, S. and Lee, S.S. 2012. Diversity and conservation of wood-inhabiting polypores and other aphyllophoraceous fungi in Malaysia. *Biodiversity and Conservation* 21(11): 2721–2738.

Hattori, T., Akiba, M., Ota, Y., Mohd-Farid, A., Thi, BK. and Lee, S.S. 2025. Taxonomic reevaluation on *Pyrrhoderma* (Basidiomycota, Hymenochaetales) and reclassification of *Pyrrhoderma* species based on phylogenetic and type studies. *Mycoscience* 66(1): 88–108.

Jaya Seelan, S.S., Ahmad, A.H., Sepiah, M. and Tan, P.E. 2014. Biodiversity inventory of macrofungi at Sungkai Wildlife Reserve, Perak, Malaysia. *Journal of Wildlife and Parks* 27: 17–24.

Jones, E.B.G., Alias, S.A. and Pang, K.L. 2013. Distribution of marine fungi and fungus-like organisms in the South China Sea and their potential use in industry and pharmaceutical application. *Malaysian Journal of Science* 32 (SCS Special Issue): 95–106.

Jones, E.B.G. and Kuthubutheen, A.J. 1989. Malaysian mangrove fungi. *Sydowia* 41: 160–169.

Jones, E.B.G. and Tan, T.K. 1987. Observations on manglicolous fungi from Malaysia. *Transactions of the British Mycological Society* 89: 390–392.

Kin, P.K, Azmi, W.A., Kamarudin, N., Ali, S. and Moslim, R. 2017. The occurrence of entomopathogenic fungi on mineral and peat soils in Peninsular Malaysia. *American Journal of Agricultural and Biological Sciences* 12: 1–12.

Kohlmeyer, J. 1969. Ecological notes on fungi in mangrove forests. *Transactions of the British Mycological Society* 53: 237-250.

Lee, S.S. 1995. Fungi – Mushrooms. In *A Guidebook to Pasoh*, S.S. Lee (Ed.), pp.66–72. *FRIM Technical Information Handbook No.3*. Kepong: Forest Research Institute Malaysia.

Lee, S.S. 2005. Macrofungal diversity in Peninsular Malaysia focusing on the ectomycorrhizal fungi. *Clusiana* 44(1-2): 57–66.

Lee, S.S. 2017. *A Field Guide to the Larger Fungi of FRIM*. *Research Ramphlet No. 135*. Kepong: Forest Research Institute Malaysia. 174pp.

Lee, S.S., Alexander, I.J. and Watling, R. 1997. Ectomycorrhizas and putative ectomycorrhizal fungi of *Shorea leprosula* Miq. (Dipterocarpaceae). *Mycorrhiza* 7(2): 63-81.

Lee, S.S., Chang, Y.S. and Noraswati M.N.R. 2009. Utilization of macrofungi by some indigenous communities for food and medicine in Peninsular Malaysia. *Forest Ecology and Management* 257(10): 2062–2065. https://doi.org/10.1016/j.foreco.2008.09.044

Lee, S.S., Watling, R. and Yahya, N.S. 2002. Ectomycorrhizal basidiomata fruiting in lowland rain forests of Peninsular Malaysia. *Bois et Forêts des Tropiques* 274(4): 33–43.

Lee, S.S., Watling, R. and Turnbull, E. 2003. Diversity of putative ectomycorrhizal fungi in Pasoh Forest Reserve. In *Pasoh: Ecology and Natural History of a Southeast Asian Lowland Tropical Rainforest*, T. Okuda, N. Manokaran, Y. Matsumoto, K. Niiyama, S.C. Thomas and P.S. Ashton (Eds.), pp. 149–159. Tokyo: Springer-Verlag.

Lee, S.S., Alias, S.A., Jones, E.G.B., Zainuddin, N. and Chan, H.T. 2012. *Checklist of fungi in Malaysia. FRIM Research Pamphlet No. 132*. Kepong: Forest Research Institute Malaysia.

Mohd Salleh, S., Thi, B.K. and Patahayah, M. 2020. *Spongispora temasekensis* G. Wu, S.M.L. Lee, E. Horak & Zhu L. Yang. Malaysia Biodiversity Information System (MyBIS). https://www.mybis.gov.my/art/288

Mohd Zainudin, N.A.I., Rosli, M.N.H., Wan Ahmad Kamal, W.H.A-S., Azahar, N., Nordin, N.A., Salleh, S., Yusof, M.T. and Ikhsan, Z. 2025. Microfungi associated with leaf spot of cocoa in Pahang, Malaysia. *Jurnal Riset Perkebunan* 6(1): 36–44.

Mridu, Atri, N.S. and Kumar, J. 2024. Impact of climatic variations on fungi, mycorrhiza and lichens –an appraisal. *Current Research in Environmental & Applied Mycology (Journal of Fungal Biology)* 14(1): 89–107. https://doi.org/10.5943/cream/14/1/5

Noman, E.A., Al-Gheethi, A.A., Talip, B.A., Mohamed, R.M.S.R., Almoheer, R., Al-Wrafy, F.A., Al-Shorgani, N. and El Enshasy, H.A. 2023. New fungal strains from peat soil in Malaysia: Morphological and Molecular Characteristics. *Sustainability* 15: 5902. https://doi.org/10.3390/su15075902

Noorlidah, A., Vikineswary, S., Yusoff, M. and Desjardin, D. E. 2005. Higher fungi of northeast Langkawi. *Malaysian Journal of Science* 24: 95–102.

Nur Amirah Sakinah, M.S.F., Nur Amalina, M.I., Farah Ayuni, F., Nurul Farizah, A., Hafizi, R. and Nor Azliza, I. 2023. Diversity and ecological roles of macrofungi within UiTM Jengka, Pahang, Malaysia. *Bioresources and Environment* 1(3): 1–13.

Nur Aqilah, M.B., NurJannah, S., Salleh, S., Thi, B.K., Ahmad Fitri, Z., Mohd Khairul Faizi, M., Haja Maideen, K.M. and Nizam, M.S. 2020. Elevation influence the macrofungi diversity and composition of Gunung Korbu, Perak, Malaysia. *Biodiversitas* 21: 1707–1713.

Ono, Y., Baharuddin, S. and Izumi, O. 2023. Additional records of rust fungi (Pucciniales) in Peninsular Malaysia and Penang Island. *Bulletin of the College of Education, Ibaraki University (Natural Science)* 72: 77–94.

Qu, X., Li, X., Bardgett, R.D., Kuzyakov, Y., Revillini, D., Sonne, C., Xia, C. *et al.* 2024. Deforestation impacts soil biodiversity and ecosystem services worldwide. *Proceedings of the National Academy of Sciences of the United States of America* 121(13): e2318475121. https://doi.org/10.1073/pnas.2318475121

Radu, S. and Cheah, Y.K. 2002. Preliminary screening of endophytic fungi from medicinal plants in Malaysia for antimicrobial and antitumor activity. *Malaysian Journal of Medical Science* 9(2): 23–33.

Rillig, M.C. 2026. Fungal diversity, ecology and functions in soil ecosystems. *Nature Reviews Microbiology* 2026: 01321. https://doi.org/10.1038/s41579-026-01321-y

Saccardo, P.A. 1882–1931. *Sylloge fungorum omnium hucusque cognitorum*. 25 vols. Patavii (Padua): Sumptibus auctoris.

Shahbaz, M., Chong, K.P., Abdullah, S. and Jaya Seelan, S.S. 2026a. Entomopathogenic fungi as potential biological control agents against basal stem rot in oil palm plantations of Sabah, Malaysia. *Scientific Reports* 16: 20070.

Shahbaz, M., Mohadden, F.Z., Jeremiah Sia, Y.R., Yap, J.W. & Jaya Seelan, S.S. 2026b. Taxonomy and phylogeny of *Pleurocordyceps* (Polycephalomycetaceae, Hypocreales) associated with ants and cicadas from Malaysia, including a new species and new records. *Phytotaxa* 750(4): 219–237. https://doi.org/10.11646/phytotaxa.750.4.1

Show, P.L., Oladele, K.O., Siew, Q.Y., Aziz Zakry, F.A., Lan, J.C.W. and Ling, T.C. 2015. Overview of citric acid production from *Aspergillus niger*. *Frontiers in Life Science* 8(3): 271–283. https://doi.org/10.1080/21553769.2015.1033653

Simon, E., Martina, P., Christoph, B., Werner, S. and François, A. 2006. Mushroom picking does not impair future harvests - Results of a long-term study in Switzerland. *Biological Conservation* 129: 271–276. https://doi.org/10.1016/j.biocon.2005.10.042

Tan, C.S., Ng, S.T. and Tan, J. 2013. Two new species of *Lignosus* (Polyporaceae) from Malaysia — *L. tigris* and *L. cameronensis*. *Mycotaxon* 123: 193–204.

Tang, L.P., Lee, S.S., Zeng, N.K., Cai, Q., Zhang, P. and Yang, Z.L. 2017. Notes on *Amanita* section *Caesareae* from Malaysia. *Mycologia* 109(4): 557–567. https://doi.org/10.1080/00275514.2017.1394789

Thi, B.K. 2013. Inventory of macrofungal diversity of Sungai Enam Basin at Temengor Forest Reserve, Perak. *Proceedings of the 2nd Temengor Scientific Expedition 2012*, pp. 171–178. Perak: Pulau Banding Foundation.

Thi, B.K. 2025. Macrofungal Diversity at Endau Rompin National Park. Paper presented at Johor National Park, 31 October 2025.

Thi, B.K. and Jing, Y. 2025. Preliminary findings on the study of mycorrhizal fungi community structure in *Eucalyptus* hybrid plantation forest (*E. grandis* x *E. urophylla*). Paper presented at Sino-ASEAN Network of Forestry Research Institutes (SANFRI): The fourth Early Career Academics Forum. Impiana KLCC Hotel. 3-5 December 2025.

Thi, B.K. and Lee, S.S. 2008. Survey of macrofungi at Gua Bewah and Sungai Cicir, Terengganu National Park. In Biodiversity Resources and Conservation Status in Peninsular Malaysia, E. Sivananthan, Y. Siti Hawa, A.B. Abu Kadir, Hasdi Hassan, B.L. Lim, H. Rosli, A. Noorlidah, M.N. Shukor and I. Rahman (Eds.), pp. 155–162. Kuala Lumpur: Department of Wildlife and National Park.

Thi, B.K. and Lee S.S. 2010. Macrofungi of Fraser's Hill: Part 1. *Conservation Malaysia: A Bulletin Supporting Plant and Animal Conservation in Malaysia* 11: 6–8.

Thi B.K. and Lee S.S. 2010. A survey of macrofungi at Sungai Kejar, Taman Diraja Belum, Gerik, Perak. In *Proceeding of National Biodiversity Seminar 2008*, Y. Mohd Nawayai, M.N. Shukor, I. Rahmah, S.M.K. Syarifah Khadiejah, M. Mohd Rufino Baipura and T.S. Frankie (Eds.), pp. 155–162. Cheras: Department of Wildlife and National Park.

Thi, B.K. and Lee, S.S. 2017. Diversity of macrofungi at Gunung Ledang Johor National Park. In *Gunung Ledang: Geology, Biodiversity and Socio-economic Environment*, B. Ahmad Naqiyuddin, A. Abdul Rauf, M.Y. Farida Zuraina, H.R. Singh and L. Tokiman (Eds.), pp.71–75. Shah Alam: Penerbit Press Universiti Teknologi Mara.

Thi, B.K., Ho, W.M. and Thooyavan, S. 2018. White parasol: a new fungus record for Malaysia. *Conservation Malaysia: A Bulletin Supporting Plant and Animal Conservation in Malaysia* 28: 4–5.

Thi, B.K., Lee, S.S., Zainuddin, N. and Chan, H.T. 2011. *A Guidebook to the Macrofungi of Fraser's Hill (Siri Alam dan Rimba No.14)*. Kepong: Forest Research Institute Malaysia.
Thi, B.K., Mohd Salleh, S. and Noorsiha, A. 2020. *Climacodon sanguineus* (Beeli) Maas Geest. Malaysia Biodiversity Information System (MyBIS). https://www.mybis.gov.my/art/287
Tsia, M.K. and Aqilah, M. 2019. Macrofungi of Pulau Bidong. *Universiti Malaysia Terengganu Journal of Undergraduate Research* 1(2): 26–35.
Yamashita, S., Hattori, T., Okabe, K. and Lee, S.S. 2015. Estimating the diversity of wood-decaying polypores in tropical lowland rain forests in Malaysia: the effect of sampling strategy. *Biodiversity Conservation* 24: 393–406. https://doi.org/10.1007/s10531-014-0815-2
Yazid, S.N.E., Jinap, S., Ismail, S.I., Magan, N. and Samsudin, N.I.P. 2020. Phytopathogenic organisms and mycotoxigenic fungi: Why do we control one and neglect the other? A biological control perspective in Malaysia. *Comprehensive Reviews in Food Science and Food Safety* 2020: 1–27.
Zainudin, N., Alias, S.A. and Jones, E.B.G. 2007. Frequency of occurrence of marine fungi from Malaysian mangroves. In *Innovations and Technologies in Oceanography for Sustainable Development*, S.M. Phang, V.C. Chong, A. Hussin, S.A. Alias and S.C. Ho (Eds.), pp. 269–280.
Zainuddin, N., Lee, S.S., Chan, H.T. and Thi, B.K. 2010. *A Guidebook to the Macrofungi of Tasik Bera (Siri Alam dan Rimba No.13)*. Kepong: Forest Research Institute Malaysia.
Zhao, H., Yuan, H.S., Cui, Y.J., Wang, K., Wu, F., Dai, Y.C. and Yuan, Y. 2026. Global polypore diversity and distribution patterns. *Fungal Diversity* 136: 136002. https://doi.org/10.65390/fdiv.2026.136002