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Data Collection of Macrofungi Diversity at Arboretum Forest in IPB University Dramaga Campus

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Abstract: Characteristics of forests can affect the species richness of macrofungi. Macrofungi data was collected based on three forest areas in the IPB University Campus Forest: conservation parks, inspiration lakes, and bamboo arboretums. Data was collected by opportunistic methods and by recording macroscopic morphological characters. The results showed that 16 species were identified (one species of the order Xylariales, 11 species of the order Agaricales, and four species of the order Polyporales). The species with the highest diversity distribution were at station 1 (dominating 80%). This is because station 1 has a higher shade density and more diverse vegetation types. Macrofungi found growing on various substrates ranging from litter (types include *Marasmius* sp3.), soil (*Leucocoprinus* sp., *Agaricus* sp., *Collybiopsis* sp., *Termitomyces* sp., and *Cystoagaricus* sp.), soil mixed with litter (*Enrtoloma* sp.), african seeds (*Xylaria* sp.), twigs (*Marasmius* sp2.), weathered wood (*Lentinus* sp., *Lepiota* sp., *Marasmius* sp1., *Coprinellus* sp., *Ganoderma* sp., *Amauroderma* sp. and *Deconia* sp.). It is noteworthy that the discovery of *Entoloma* sp. in this urban forest is a rare occurrence.

Keywords: Ascomycota, Basidiomycota, Ecology, Inventorisation, IPB Forest

INTRODUCTION

The existence of fungal species worldwide is estimated at 1.5 million, and 28,700 are macroscopic fungi (macrofungi). Macrofungi are fungi whose sporocarp are relatively large and can be seen without using microscope aids (Sima *et al.* 2022). Macrofungi have a typical sporocarp structure consisting of lamella, hoods, stalks, rings, and volvas, but some macrofungi lack any of these parts, such as the absence of rings (Alexopolus *et al.* 1996). Adaptation of macrofungi is also essential because some can live in specific substrates or in various substrates ranging from weathered wood, live wood, soil, and tree roots. The environmental conditions of a place largely determine the level of diversity and life cycle of macrofungi. Some influential climate components are temperature and rainfall (Adeniyi *et al.* 1998).

Macrofungi constitute a significant component in terrestrial ecosystems because they can produce lignocellulose degrading enzymes such as cellulase, ligninase, and hemicellulase so that the material cycle in nature can continue, including the process of food webs, survival or germination of tree saplings, tree growth, and the entire health of the forest (Solle *et al.* 2017). Macrofungi are also very closely related to

humans; many macrofungi are used as a source type of macrofungi that are often consumed, such as oyster mushrooms, ear mushrooms, champignon mushrooms, and other edible mushrooms. At the same time, for medicine, one of them is *Ganoderma lucidum*.

However, the inventory of macrofungal diversity in tropical Asia (including Indonesia) is still meager. Until 2017, the type of macrofungi in Indonesia which has been well identified and recorded there were only 2273 types, or only about 0.15% of the number of types in the world (Retnowati *et al.* 2019). This is related to the limited interest in research on macrofungal diversity. Various forest management practices are also believed to affect the presence and productivity of macrofungi, both positively and negatively (Tomao *et al.* 2020), and one of them depends on the characteristics of the forest. The IPB University campus is one of the urban forests in Bogor Regency and provides several types of forests as education and research forests. This urban forest concept is intended to support the survival of flora and fauna in urban zones, including macrofungi. In this area, there is a type of forest, namely the Bamboo Arboretum, which is devoted to supporting the survival of flora and fauna, including the Bamboo Arboretum, Taman Konservasi Forest, and Telaga Inspirasi Forest. The IPB campus is located in the city of Bogor, which is an area with high rainfall, this condition is an ideal place for mushrooms to grow (Kaiserman *et al.* 2015). In addition, the environmental conditions of the IPB campus, which still has large open spaces with a variety of tree vegetation, also support the growth of macrofungi (Putri *et al.*, 2023). Therefore, macrofungal diversity data in the IPB forest arboretum needs to be recorded to improve macrofungi diversity data based on various characteristics of the forest.

METHODOLOGY

Study area

This research was conducted in the IPB Arboretum Forest, which was divided into three observation stations, including the Taman Konservasi (Station 1), Telaga Inspirasi (Station 2), and Bamboo Arboretum (Station 3) (Figure 1). The condition of the study area is presented in detail in Table 1.

Sample collection

The observation will be conducted in November 2023, starting at 08.00 -13.00 WIB. The data collection process is carried out by random sampling using opportunistic methods, meaning that it directly records

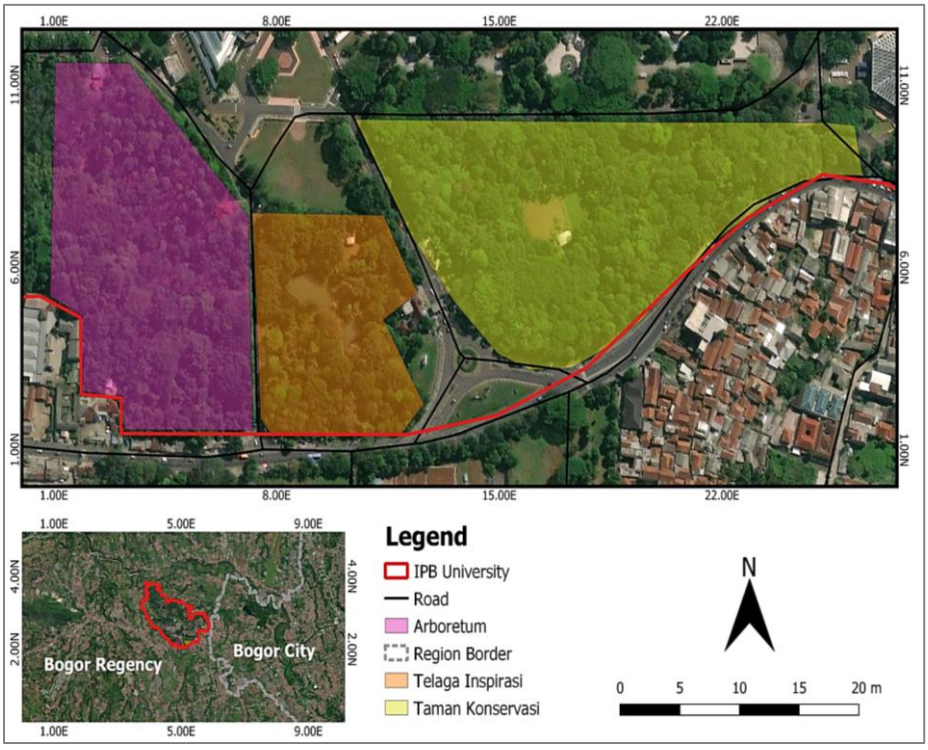

Figure 1. Location area research

Table 1. Characteristics of the study site

Location	Station 1	Station 2	Station 3
Name forest	Taman Konservasi Forest	Telaga Inspirasi Forest	Bamboo Arboretum
Type	Forest secondary	Forest secondary	Bamboo forest
Forest tree composition	Meranti *(Shorea* sp.) , gaharu (*Aquilaria malaccensis*), randu (*Bombax* sp.) , kayu afrika (*Dalbergia melanoxylon*), kruing (*Dipterocarpus*), pinus (*Pinus merkusii*) , dan cemara (*Casuarina* sp.)	Maja (*Agle marmelos*), Burahol (*Stelechocarpus burahol*), mundu (*Garcinia dulcis*), Gandaria (*Bouea marcophylla*), and Kecapi/sentul (*Sndoricum koetjape*)	Bamboo: Betung (*Dendrocalamus asper*), Apus (*Gigantochloa apus*), black (*G. atroviolacea*), Andong (*G. pseudoarundinaceae*) and Yellow (*Bambusa vulgaris*), but on this area is also planted with plants other than bamboo including Beringin (*Ficus benjamina*), Meranti (*Shorea* sp.), and Pulai (*Alstonia scholaris*).
Canopy cover	Moderate	Low	Low
Forest structure	Forest tree	Forest and plantation tree	Bamboo
Understory cover	Understory clearing	Understory clearing	-
Build up intervention	Low	Dominant	-

macrofungi found in the field (Schmit and Lodge 2005). Any macrofungi found documented are then coded and recorded on the tally sheet provided. Macroscopic morphological data observed include hood shape, surface texture, hood color, hood diameter and height, hymenophore type, individual properties (colonies or solitary), and substrate type (Putra 2020). The macrofungal species that have been discovered are described in their morphological forms and taxonomic forms. Then, an ecological analysis of the diversity of macrofungal species was carried out.

RESULTS AND DISCUSSION

Condition area

The Taman Konservasi Forest is a green open space (RTH), one of the conservation areas of local flora and fauna on the IPB campus, located right next to the IPB coin or in front of the rectorate building. The park is planted with a variety of solid wood tree vegetation (hardwood), which is suitable for the habitat of several reptiles, such as the mane chameleon (*Bronchocela jubata*). The park is also facilitated by a jogging track and wildlife conservation areas such as deer sheds. Therefore, this area is used for education and research, forest healing, and eco-education. Across this park is Telaga Inspirasi Forest, which also includes the RTH area and is a refuge location for local flora and fauna for several species, such as heliconia, birds, and tree snakes. As the name implies ('*telaga*' means a lake), a lake is found in this area, a spring water source for water treatment plants (WTP). This area is used not only for education, research, forest healing, and eco-education but also as a path for migratory birds and as an area to preserve water for WTP.

a) Taman Konservasi Forest

b) Telaga Inspirasi Forest

c) Bamboo Arboretum

Figure 2. Station area for data collection

The Arboretum Bamboo location is quite far from the previous two areas (Taman Konservasi Forest and Telaga Inspirasi Forest), located in the southern part of the IPB campus. This area is dedicated to the collection and preservation of various types of bamboo from different regions in Indonesia and serves as a natural laboratory for researching the characteristics of various bamboo. This area has a flat and undulating topography, and there is a small river originating from Telaga Inspirasi to the west, namely the Cihideung River. There are about six types of bamboo parked in this forest. The condition of the study area is presented in detail in Table 1.

Richness of Macrofungi

Ecology and Species Diversity

The discovery of macrofungi around the IPB forest arboretum consists of the Ascomycota and Basidiomycota divisions, with nine families and 16 species (Table 2). The distribution of macrofungi from

Table 2. Macrofungi found in the arboteum forest IPB

Division	Ordo	Family	Species	Substrate	Station
Ascomycota	Xylariales	Xylariaceae	*Xylaria* sp.	African shed	1
Basidiomycota	Agaricales	Agaricaceae	*Leucocoprinus* sp.	Soil	1
			Lentinus sp.	Weathered wood	1
			Lepiota sp.	Weathered wood	1
			Agaricus sp.	Soil	1
		Pshysalacriaceae	*Marasmius* sp1.	Weathered wood	1
		Omphalotaceae	*Collybiopsis* sp.	Soil	1
		Marasmiaceae	*Marasmius* sp2.	Twigs	1
		Psathyrellaceae	*Marasmius* sp3.	Leaf litter	1
			Coprinellus sp.	Weathered wood	1
			Termitomyces sp.	Soil	1
			Cystoagaricus sp.	Soil	2
		Entolomataceae	*Entoloma* sp.	Soil mixed with leaf litter	2
	Polyporales	Polyporaceae	*Ganoderma* sp.	Weathered wood	1
			Amauroderma sp.	Weathered wood	1
		Ganodermataceae	*Deconia* sp.	Weathered bamboo	3

the three observation locations shows a very significant difference, with station 1 at 81%, station 2 at 13%, and station 3 at 6% (Figure 3). The Basidiomycota group found includes two orders, namely Agaricales (six families, 13 species) and Polyporales (two families, two species)(Table 2). The Ascomycota group found includes one order, namely Xylariales (one family, one species)(Table 2). All recorded macrofungi have different substrates, including seeds, soil, leaf litter, soil mixed with leaf litter, decayed bamboo, and decayed wood (Table 2).

The abundant distribution of macrofungi at station 1 compared to other stations is thought to be due to the characteristics of the Taman Konservasi Forest (Table 1), making it have higher humidity and more diverse shade than Telaga Inspirasi and Bamboo Arboretum (Table 1). Generally, mushrooms grow in moist/high relative humidity (RH) and rich substrates. Roberts and Evans (2011) also argue that humid and sheltered environmental conditions strongly influence macrofungal habitats. A humid environment can accelerate spore growth and minimize water evaporation in the body of macrofungi. The sheltered environment will produce more litter so that the organic carbon content (C-organic) available to support the survival of organisms around vegetation is more optimal.

The high density of the forest canopy also has implications for the percentage of light entering and reaching the forest floor. The tighter the canopy of a forest, will accelerate the growth of sporocarp and primordia in macrofungi because the growth of sporocarp and the development of primordia of most macrofungi are triggered by the presence of light (Miles 2004). It is also harmoniously stated by Iwabuchi *et al.* (1994); Sysouphanthong *et al.* (2010), and Chen *et al.*

(2017) that vegetation composition can determine understory light availability, moisture, and litter composition. Other environmental factors are temperature, soil properties, including substrate acidity level (pH), and chemical compounds around the environment. In addition, differences in observation time can also be a factor in differences in macrofungal species diversity (Usman & Fitriyaningsih 2011; Schappe *et al.* 2017).

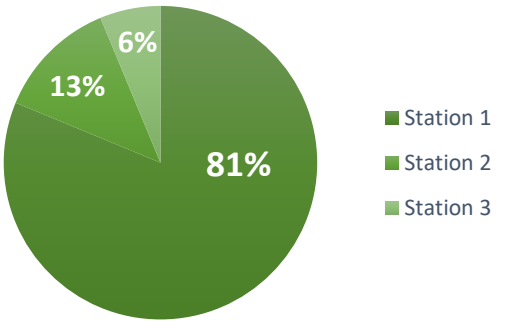

Figure 3. Distribution of macrofungi by location (station 1, station 2, and station 3)

Prevalence and Characteristics of Basidiomycota and Ascomycota

As a result of field surveys, Basidiomycota taxa (8 families, 15 species) have a higher richness than Ascomycota taxa (one family, one species). The abundance of Basidiomycota taxa in an ecosystem is unsurprising because these macrofungi are the most essential components of the litter group and saprotrophic trees. In addition, the larger size of Basidiomycota specimens compared to Ascomycota makes these taxa easier to inventory, whereas Ascomycota taxa generally form microscopic sporocarps, so they are often not recorded in surveys (Watling 1995). Other researchers have also documented the dominance of Basidiomycota in different forest ecosystems (e.g. Gómez-Hérnandez *et al.* 2019; Holec & Kucera 2020). Species taxa classified under the order Basidiomycota consist of 8 families (Agaricaceae, Pshysalacriaceae, Omphalotaceae, Psathyrellaceae, Entolomataceae, Marasmiaceae, Polyporaceae, Ganodermataceae) while the rest belong to the order Polyporales which consists of two families (Polyporaceae and Ganodermataceae) (Table 2).

The abundance of Agaricales compared to the order Polyporales shows that the IPB campus forest arboretum has more optimal environmental conditions to support growth for the Agaricales group. Common characteristics of Agaricales are umbrella-shaped sporocarp, lamella-type hymenophores, fleshiness, and short life cycles (Susan & Retnowati 2017). The life cycle of the order Agaricales is short because the fruit body contains much water, so it is intolerant to areas exposed to direct sunlight (Ambarawati *et al.* 2023). Therefore, habitat conditions dominated by litter and weathered wood twigs with low light intensity strongly support the growth of these macrofungi. The presence of Agaricales macrofungi in lowland forests has a significant function as decomposers and some are known to form ectomycorrhiza with some plants from the tribes Myrtaceae, Dipterocarpaceae, and Fagaceae (Clasen *et al.* 2018).

The group of macrofungi of the order Polyporales is characterized by pore-type hymenophores, fan-like fruit bodies, and dry texture. Sippola *et al.* (2004) also add that most species of Polyporales can live yearly and withstand dry conditions. Polyporales species also include cosmopolitan species (can live on various substrates) and dependent genera (obligate) on substrates. The order Polyporales found in the IPB forest arboretum grows more on deadwood substrates, especially on dicotyledonous plants of the Gymnosperm group. This condition is the same as the research of Ambarawati *et al.* (2023), in which the order Polyporales in the University of Mataram is also found in deadwood substrates, especially Gymnosperms. Therefore, the saprof nature of wood makes macrofungi from the Polyporales group act as the main decomposer in the forest ecosystem.

Unlike the Ascomycota taxa, Xylariales taxa are the only order we found in the IPB arboretum forest. Xylaria is characterized by a dense shape of the sporocarp and is shaped like a finger or mace. These macrofungi can be found in weathered wood, leaves, fruits, seeds, animal waste, soil, and termite nests (Wangsawat *et al.* 2021).

Macrofungi Profile in the Arboretum IPB Forest

In the exact location, around the IPB arboretum forest, the findings of macrofungi species in this study are almost the same as those recorded by

several previous researchers such as Putra (2020); Putra *et al.* (2020); Putra *et al.* (2019), one of them are *Marasmius* sp., *Ganoderma* sp., *Amauroderma* sp., and *Coprinellus* sp.. However, we uniquely found the macrofungal species *Entoloma* sp., where the species is rarely found around the IPB arboretum forest. Here is a picture of the macrofungi morphology that we collected.

Xylaria sp.

Xylaria sp. has such a unique shape that it resembles the finger of a dead person that this species is often called a "*zombie fungus*" (Figure 4a). These macrofungi grow colonizing on the substrate of African woodshed. The height of the sporocarp is 3.4 cm and has a white color at the tip while, the stalk body is black. The white part was originally powdered but eventually became hardened.

Figure 4. Macrofungal morphology. a) *Xylaria* sp.; b) *Leucocoprinus* sp.; c) *Lentinus* sp.; d) *Agaricus* sp. ; e) *Termitomyces* sp.; f) *Ganoderma* sp. ; g) *Collybiopsis* sp.; h) *Coprinellus* sp.; i) *Marasmius* sp1.; j) *Entoloma* sp.; k) *Marasmius* sp2.; l) *Amauroderma* sp.; m) *Lepiota* sp.; n) *Cystoagaricus* sp.; o) *Marasmius* sp3.; p) *Deconia* sp.

***Leucocoprinus* sp.**

Leucocoprinus sp. has a white umbrella-like hood shape (Figure 4b) with a finely fluted hood texture. The diameter of the hood is 2 cm with a height of 8 cm sporocarp. The type of hymenophores is lamellae with medium distance inter-lamellae. This microfungus has a characteristic where the fruit body is easily fragile and the stem is equipped with a thin ring. When found, these macrofungi grow solitary on the soil substrate.

***Lentinus* sp.**

Lentinus sp. has a funnel-shaped cap with a brownish color (Figure 4c). *Lentinus* sp. has characteristics where fine hairs cover its edges. *Lentinus* sp. was found to have a cap with a diameter of 2 cm and a stalk and roots. The type of hymenophore is a modification of pores and grows on decayed wood substrates in colonies.

***Agaricus* sp.**

Agaricus sp. has a brown cap shaped like an umbrella and an abstract pattern in the middle (Figure 4d). The cap diameter is 7 cm and the sporocarp height is 5 cm. The hymenophore type is lamella with closely spaced lamellae. The surface of the cap is scaly. A distinctive feature of Agaricus is its fleshy pileus and brown spores. This macro fungus grows solitarily in soil substrate.

***Termitomyces* sp.**

Termitomyces sp. has a brownish-gray hood resembling an umbrella (Figure 4e). This macrofungus is also known as "*white roped fungus*" because at the base of the stipe often appears a white rope (rhizomorph). The texture of the hood is smooth, and the type of hymenophores is lamellae with medium distance inter-lamellae. The diameter of the hood is 5 cm and the height of the sporocarp is 5.3 cm. These macrofungi are found on soil substrates in colonies.

***Ganoderma* sp.**

Ganoderma sp. has a fan-shaped cap that is golden brown in color with a white margin (Figure 4f). *Ganoderma* sp. has a smooth cap texture with a pored type of hymenophores and a cap diameter of 11.5 cm. A distinctive feature of this macrofungus is that it does not have a true stem, allowing it to grow attached to the substrate. When found, this species grows on decaying wood in colonies.

***Collybiopsis* sp.**

The *Collybiopsis* sp. has a cream-brown fan-shaped cap (darker brown in the center) (Figure 2g) and has a smooth texture. The type of hymenophores is lamellae with medium spacing between the lamellae and slightly sticky on the cap's surface. The diameter of the cap is 2 cm with a sporocarp height of 5 cm. This macrofungi grows in soil substrates in colonies.

***Coprinellus* sp.**

Coprinellus sp. includes small mushrooms known as "*fairy hats*" when young or "*crushed troop hats*" when adults (Figure 4h). The hood is white with a diameter of 1 cm and a sporocarp of 3.5 cm. The type of hymenophores is lamellae with medium distance inter-lamellae. When found, these macrofungi grow on weathered wood substrates in colonies. Macroscopically, these macrofungi are very similar to those discovered by Putra and Thamrin (2020), namely *Coprinellus sect. Disseminated*, but further observation is needed to confirm this.

***Marasmius* sp1.**

Marasmius sp1. grows colonizing in twigs. The shape of the hood is slightly curved *semi-globose* and fiery orange-red, but may fade to brownish-orange with age (Figure 4i). The surface of the hood is smooth with a hood diameter of 0.8 cm and the height of the sporocarp is 2 cm. The type of hymenophores in this macrofungi is lamellae with medium distance inter-lamellae.

***Entoloma* sp.**

Entoloma sp. grows on solitary soil mixed with leaf litter substrates. The hood is *depressed* in light purple and dark purple in the middle (Figure 2j). The texture of the hood is slightly rough with *an entire* margin. The diameter of the hood is 0.5 and the height of the sporocarp is 1.5 cm. The type of hymenophores is lamellae with medium distance inter-lamella. The characteristic of this macrofungi is that it has a diverse and striking hood color, ranging from white, orange, brown, blue, and black to purple.

***Marasmius* sp2.**

Marasmius sp2. has a flat cap with an orange-brownish umbo/knob and a smooth texture (Figure 4k). The diameter of the hood is 1.2 cm and the height of the sporocarp is 4.5 cm. The type of hymenophores is lamellae with medium inter-lamellae. This macrofungi grows on weathered wood substrates in colonies.

***Amauroderma* sp.**

Amauroderma sp. grows solitary on the roots of weathered wood. This macrofungus has a fan-like fruit body shape with a hard texture and a black-gray-dark

brown-dark beige-dark brown color pattern (Figure 4l). The hood is smooth and 8 cm in diameter. The type hymenophores is porous and undergoes discoloration (hygrophorus) becoming darker after being taken from the substrate. These macrofungi have a stipe that is directly embedded in the substrate (basal tomentum).

***Cystoagaricus* sp.**

Cystoagaricus sp. or synonymously *Cyptotrama* sp. has a hood shape resembling an umbrella with a fiery orange color (Figure 4m). A distinctive feature of these macrofungi is that they are on the surface of the hood, and their stipe is scaly. The diameter of the hood is 0.8 cm with a sporocarp height of 2.5 cm. When it blooms, the type hymenophores of this macrofungi will look lamella with medium distance inter-lamellae. These macrofungi grow on soil substrate in colonies.

***Lepiota* sp.**

Lepiota sp. has a hood shape resembling an umbrella, white and black in the middle (Figure 4n). The surface of the hood is slightly scaly, with a hood diameter of 1.8 cm, and the height of the sporocarp is 4.2 cm. The type of hymenophores is lamella with medium distance inter-lamellae. When found, this species grows on weathered wood in solitary.

***Marasmius* sp3.**

Marasmius sp3. one of the basidiomycota that has a size so small, has an umbrella-shaped hood with a diameter of 0.2 cm, and the height of the sporocarp is 1.6 cm. The color hood is orange, and there is a distinctive brown papilla in the middle (Figure 4o). The type of hymenophores is lamellae with medium distance inter-lamellae. These macrofungi do not have rings but have stipe black with and grow in colonies on leaf litter substrate.

***Deconica* sp.**

Deconia sp. has a shape resembling an umbrella and is cream-colored (Figure 4p). The surface of the hood has pustules (like flour grains) with a hood diameter, a hood diameter of 1.5 cm, and a sporocarp height of 1.5 cm. The type of hymenophores is lamella with medium distance inter-lamellae. One distinctive feature of this species is its stipe exposure at the edges. These macrofungi are currently found growing on weathered bamboo substrates.

CONCLUSIONS

Data on macrofungal diversity obtained in this study as many as 16 species, consisting of 2 divisions (Ascomycota, Basidiomycota), 3 orders (Xylariales, Agaricales, and Polyporales), 10 families (*Xylariaceae*, *Agaricaceae*, *Omphalotaceae*, *Psathyrellaceae*, *Marasmiaceae*, *Entolomataceae*, *Strophariaceae*, *Polyporaceae*, and *Ganodermataceae*). Different forest characteristics significantly affect the distribution of macrofungal diversity. The characteristics of the forest include forest type, forest vegetation composition, canopy cover, and forest structure. Station 1 recorded 11 species (*Xylaria sp., Lentinus sp., Agaricus* sp., *Lentinus* sp., *Lepiota* sp., *Marasmius* sp1., *Marasmius* sp2., *Marasmius* sp3., *Coprinellus* sp., *Collybiopsis* sp., *Termitomyces* sp., *Ganoderma* sp., and *Amauroderma* sp.), station 2 recorded two species (*Cystoagaricus* sp., and *Entoloma* sp.), and station 3 recorded one species (*Deconia* sp.).

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