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Diversity of macrofungi in three land-cover types in Mandiangin Timur Village, Banjar Regency, South Kalimantan, Indonesia

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Abstract. *Azzahra I, Soendjoto MA, Fithria A, Rezekiah AA, Riefani MK. 2026. Diversity of macrofungi in three land-cover types in Mandiangin Timur Village, Banjar Regency, South Kalimantan, Indonesia. Biodiversitas 27 (3): d270311. https://doi.org/10.13057/biodiv/d270311.* Information on macrofungi across different land-cover types in rural areas, particularly in South Kalimantan Province, remains limited, although these organisms have potential applications in village development and community empowerment. This study aimed to record macrofungal species and their substrates in three land-cover types, namely *dukuh* (DU), agricultural land (AL), and shrubland (SL) in Mandiangin Timur Village, Banjar Regency, South Kalimantan, Indonesia; to compare fungal communities among these land-cover types; and to evaluate their utilization by the local community. Fungi and their substrates were surveyed along a 200 m × 3 m transect in each land-cover type as a baseline inventory. Supporting data included microenvironmental parameters such as soil pH, air temperature, air humidity, and light intensity, as well as information on mushroom utilization obtained through community interviews. A total of 52 macrofungal species representing 25 families were recorded. Of these, 47 species (25 families) were found in DU, 15 species (8 families) in AL, and 9 species (4 families) in SL. The Sørensen similarity index was highest between AL and SL (0.50), followed by DU and AL (0.35), and lowest between DU and SL (0.29). Each species was observed growing on a single substrate. Most species (63.46%) occurred on dead wood, while the remainder were found on soil, litter, and living wood. *Bolbitius reticulatus* was the only species recorded on the living stem of durian (*Durio zibethinus*). Of the total species documented, 20 were reported by the community as being utilized, and 18 of these were both reported and recorded during the village survey. Most of these species are used as food. Regular education and training programs are therefore recommended to enhance community knowledge, promote safe utilization, and support the conservation of macrofungi.

Keywords: Agroforestry ecosystem, edible fungi, ethnomycology, species richness, substrate

INTRODUCTION

Fungi are essential components of natural ecosystems (Tang et al. 2015; Cipriani-Avila et al. 2025). They function as decomposers of organic matter, including the decay of wood litter (Floudas et al. 2020; Lustenhouwer et al. 2020), participate in nutritional symbioses that maintain soil fertility and enhance nutrient availability (Powell and Rillig 2018; Al-Nasser et al. 2024), and act as mediators between organisms and their environment (Bahram and Netherway 2022). Fungi represent one of the most diverse groups of organisms on Earth (Inone 2023; Costa et al. 2025). Global fungal diversity is estimated to range from 1.5 to 13.2 million species (Costa et al. 2025), while Hawksworth and Lücking (2017) proposed a narrower estimate of 2.2 to 3.8 million species. Of these, approximately 120,000 species have been formally accepted (Hawksworth and Lücking 2017), and 151,381 species have been named and classified (Fang et al. 2023).

Based on size, fungi are classified into macrofungi and microfungi (Castañeda-Ramírez et al. 2022). Macrofungi produce fruiting bodies that are visible to the unaided eye (Putra et al. 2019), whereas microfungi are microscopic and require magnification for observation (Sucharzewska et al. 2023). Fungi exhibit a distinct life cycle that differs fundamentally from that of plants. They reproduce through spores, grow hyphae, and form specialized reproductive structures (Inone 2023). As heterotrophic organisms, fungi do not perform photosynthesis; instead, they obtain nutrients by secreting extracellular enzymes to decompose organic matter in their surroundings and subsequently absorbing the released compounds (Barzee et al. 2021; Amara and El-Baky 2023).

A preliminary survey in Banjar Regency indicated that macrofungi grow abundantly in a land-cover type locally known as *dukuh*, or fruit islands, as referred to by the Banjar community of South Kalimantan. Macrofungal species appeared highly diverse in *dukuh*, likely due to the favorable microclimatic conditions. *Dukuh* is a traditional agroforestry system established on land surrounding settlements or former agricultural fields, where various fruit-producing tree species are planted in irregular patterns with non-uniform age strata (Itta et al. 2021; Hafizianor et al. 2023). *Dukuh* areas are distributed across 13 villages in Karang Intan District and 9 villages in Pengaron District, both located within Banjar Regency (Hafizianor et al. 2023). Owing to their heterocultural structure, *dukuh* differ from gardens, which are typically monocultural systems cultivated with a single crop species, such as rubber, oil palm, or coffee, and developed by local communities or government initiatives.

Macrofungi are also present in other village land-cover types, including agricultural land and shrubland. However, their diversity appeared lower in these areas compared with *dukuh*. This difference is likely related to variation in vegetation type and structure, which constitute key characteristics of land-cover. The diversity, abundance, and composition of macrofungal communities are strongly influenced by vegetation type (Huang et al. 2025), and the conversion of forest to agricultural land has been shown to reduce fungal diversity (Kusuma et al. 2025).

Despite these observations, no comprehensive published data are available on fungal species in *dukuh* or in the other two land-cover types within the village. Moreover, information on community utilization of mushrooms remains undocumented, although fungi have recognized ecological and economic value (Lu et al. 2020; Niego et al. 2021), including contributions to household income, food security, and health. Numerous mushroom species have been used as food or processed food products (Barzee et al. 2021; Pardosi et al. 2024; Pouris et al. 2024), as well as raw materials for medicinal applications (Ślusarczyk et al. 2021; Hobbs 2023; Łysakowska et al. 2023).

The specific objectives of this study were to record macrofungal species across three land-cover types, compare the fungal communities occurring in these habitats, and evaluate their utilization by local communities. The findings provide a foundation for increasing public awareness of biological resource conservation, particularly mushrooms, and for promoting their sustainable use.

MATERIALS AND METHODS

Study area

Macrofungi were collected in Mandiangin Timur Village, one of 26 villages administratively located in Karang Intan District, Banjar Regency, South Kalimantan Province, Indonesia (Banjar Regency Central Statistics Agency 2024). Sampling was conducted from January to April 2025 (Figure 1). The village covers 3,168.79 ha and is geographically situated between 3°28'42.833" S to 3°34'41.028" S and 114°55'39.982" E to 114°59'39.633" E (The Government of Mandiangin Timur Village 2025).

The village comprises five land-cover types: *dukuh*, agricultural land, shrubland, settlements, and mining areas. The first three land-cover types were selected for macrofungal data collection because nearly 100% of their area is covered by understory and or woody vegetation, creating relatively shaded microhabitats. Settlements and mining areas were excluded. Settlements consist primarily of residential and functional buildings with sparse vegetation, while mining areas are largely devoid of vegetation and characterized by exposed, barren soil.

The *dukuh* (DU) sampling site, with a starting coordinate of 3°28'25.7" S 114°57'16.9" E, is dominated by various species of edible fruit-producing tree species. These include durian (*Durio zibethinus*), enau (*Arenga pinnata*), cempedak (*Artocarpus integer*). Non-fruit-producing species such as *ipo* (*Homalanthus populneus*), *markuung* (*Ficus callosa*), and *sungkai* (*Peronema canescens*) are also present, along with understory species including *laos* (*Alpinia galanga*), *mantangan* (*Merremia peltata*), and *sirih* (*Piper betle*).

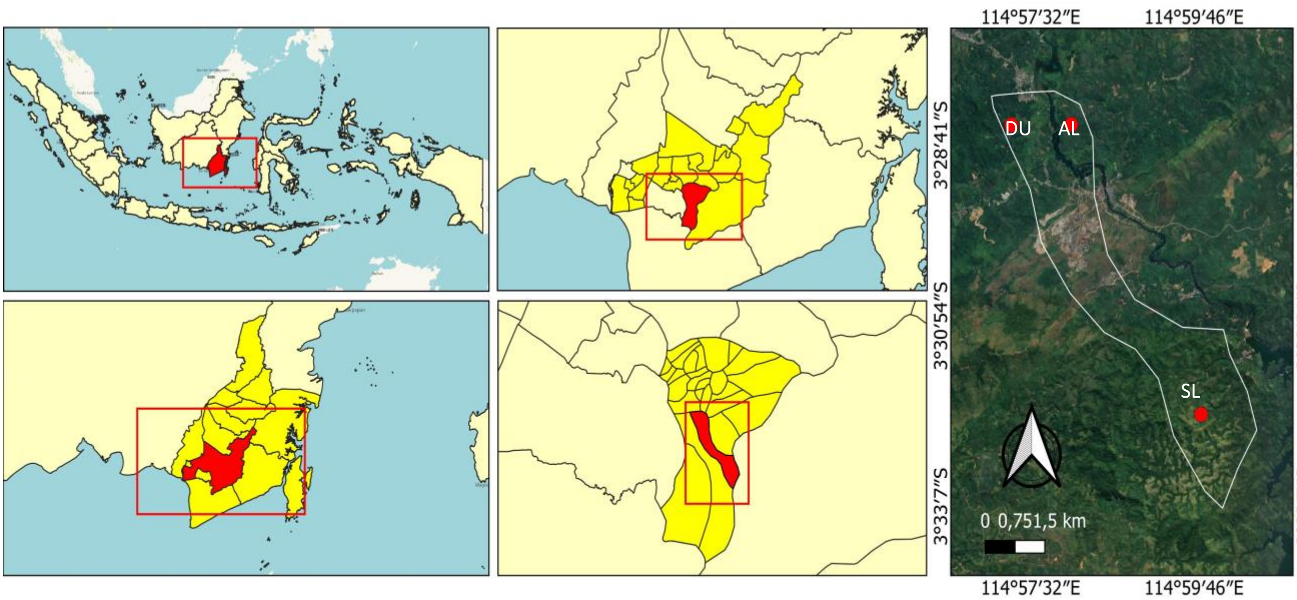

Figure 1. Map of research locations and sampling points in Mandiangin Timur Village, Karang Intan District, Banjar Regency, South Kalimantan Province, Indonesia

Agricultural land (AL), with a starting coordinate of 3°28'25.3" S 114°58'05.6" E, is cultivated with upland rice, maize, or chili. Prior to its current use, the area was a rubber plantation that was cleared due to declining productivity or land-use conversion decisions by the owner. Shrubland (SL), with a starting coordinate of 3°31'59.2" S 114°59'51.5" E, is dominated by understory vegetation and woody plants in seedling or sapling stages. This land-cover type typically develops during fallow periods or after temporary abandonment of agricultural land. Understory species include *apa-apa* (*Flemingia macrophylla*), *goletrak* (*Borreria alata*), *kirinyuh* (*Chromolaena odorata*), *menuntil* (*Dianella ensifolia*), *ilalang* (*Imperata cylindrica*), *paku pedang* (*Nephrolepis biserrata*), and *paku payung* (*Dipteris conjugata*). Woody species include *alaban* (*Vitex pinnata*), *jejambuan* (*Syzygium* spp.), *kimalaka* (*Phyllanthus emblica*), and several *mahang* species (*Macaranga* spp.).

Procedure

In each land-cover type, an observation transect approximately 200 m in length and 3 m in width was established following the contour. This approach was adopted to minimize disturbance to fungal populations, particularly because this represents the first study of its kind in the area. Although contour variation within the sampling sites was limited, it was considered representative of habitat gradients. A 3 m width facilitated effective observation. Surveys were conducted three times at four-day intervals.

Each macrofungal species was documented photographically from at least three angles, namely top, side, and underside views. These photographs served as photo vouchers. Identification was conducted by comparing field photographs with reference illustrations from field guides and scientific publications, including Lodge et al. (2004); Hasan et al. (2022); Putra et al. (2022); Ekyastuti et al. (2023); Sayuti et al. (2023); Lefi et al. (2024); Noordin et al. (2024); Adhikari et al. (2025); and Nurzahra et al. (2025).

Morphological characteristics recorded included the shape, color, size, and texture of fruiting bodies, pileus, warts, hymenium, ring, veil remnants, cortina, stipe, and volva. Species were identified using taxonomic keys and classified at appropriate taxonomic ranks from kingdom to species. Scientific names followed binomial nomenclature rules and were validated by a mycologist. Species identities were further cross-checked using online databases such as Mushroom Observer, MycoPortal, iDigBio, and iNaturalist.

Specimen vouchers were not collected because the study focused on macrofungal diversity and spatial distribution rather than molecular taxonomy. In addition, identification at institutions outside the province would require substantial resources, and no specialized fungal institutions are currently available in South Kalimantan Province.

Field data included land-cover type, substrate type, and environmental variables. Substrates were categorized as dead wood, live wood, litter, and soil. Environmental variables included light intensity, air temperature, air humidity, and soil pH. Measurements were conducted in situ with two replicates at points as close as possible to the recorded macrofungal species. These measurements were considered representative of environmental conditions within an approximate 3 m radius.

To assess mushroom utilization, structured interviews were conducted with 31 randomly selected adult residents who consented to participate. These interviews represent the initial phase of subsequent ethnomycological research. Questions addressed whether residents use mushrooms, the local names of the species used, their purposes such as food or medicinal use, and criteria for distinguishing edible, inedible, and poisonous mushrooms. When local names were mentioned, respondents were shown photographs of species documented during the survey to confirm identification.

Data analysis

Quantitative analyses were conducted to determine macrofungal species richness across and within land-cover types (S), substrate utilization ratio (SUR), and the Sørensen Similarity Index (SSI) among land-cover types. Species richness was prioritized over diversity indices because many species were scattered, partially hidden within substrates, or not fully developed. To reduce bias, individuals were not counted.

The substrate utilization ratio was calculated as $SUR = Ns/Na$, where Ns represents the number of macrofungal species occurring on a specific substrate and Na represents the total number of species recorded on all substrates. The Sørensen Similarity Index was calculated as $SSI = 2C/(A + B)$, where A and B represent the number of species recorded in land-cover types A and B, respectively, and C represents the number of species shared between them.

Environmental data were summarized as minimum and maximum ranges and mean values. The mean was calculated as $(\sum Xi)/n$, where Xi represents each measurement and n represents the total number of observations. Qualitative analysis was conducted by comparing the utilization status reported by informants, including edibility and medicinal properties, with information available in scientific references.

RESULTS AND DISCUSSION

Diversity of macrofungi

A total of 52 macrofungal species representing 25 families were recorded across the three land-cover types in types (*dukuh*, agricultural land, and shrubland) in Mandiangin Timur Village (Table 1). The majority were distributed in *dukuh* (DU), where 47 species belonging to 25 families were documented. In contrast, 15 species (8 families) were recorded in agricultural land (AL) and 9 species (4 families) in shrubland (SL). The total number of macrofungal species recorded in the three land-cover types of Mandiangin Timur Village (52 species, 25 families) exceeds that reported from the karst forest of Kalipoh Village, Kebumen

District, Central Java, Indonesia (34 species, 18 families) (Armadhan et al. 2023). However, it is substantially lower than the 148 species (33 families) recorded across five land-use types in Toro Village, Sigi Regency, Central Sulawesi, Indonesia (Yusran et al. 2022).

Table 1. Macrofungal species and their distribution on land-cover types and substrate types in Mandiangin Timur Village, Banjar Regency, South Kalimantan, Indonesia

Family and species of macrofungi		**DU**				**AL**				**SL**			
		DW	**LW**	**L**	**S**	**DW**	**LW**	**L**	**S**	**DW**	**LW**	**L**	**S**
Agaricaceae	*Lepiota castanea* Quél.	-	-	-	1	-	-	-	-	-	-	-	-
	Leucocoprinus cepistipes (Sowerby) Pat.	1	-	-	-	-	-	-	-	-	-	-	-
Auriculariaceae	*Auricularia auricula-judae* (Bull.) Quél.	1	-	-	-	-	-	-	-	-	-	-	-
Bolbitiaceae	*Bolbitius reticulatus* (Pers.) Ricken	-	1	-	-	-	-	-	-	-	-	-	-
Clavariaceae	*Clavaria pampeana* Speg.	-	-	-	1	-	-	-	-	-	-	-	-
	Clavulinopsis amoena (Zoll. & Moritzi) Corner	-	-	-	1	-	-	-	-	-	-	-	-
	Clavulinopsis sulcata Overeem	-	-	-	1	-	-	-	-	-	-	-	-
Dacrymycetaceae	*Dacryopinax spathularia* (Schwein.) G.W. Martin	1	-	-	-	1	-	-	-	1	-	-	-
Ganodermataceae	*Ganoderma applanatum* (Pers.) Pat.	1	-	-	-	-	-	-	-	-	-	-	-
Geastraceae	*Geastrum saccatum* Fr.	-	-	1	-	-	-	-	-	-	-	-	-
Gomphaceae	*Ramaria stricta* (Pers.) Quél.	-	-	-	1	-	-	-	-	-	-	-	-
Hygrophoraceae	*Hygrocybe cantharellus* (Schwein.) Murrill	-	-	1	-	-	-	-	-	-	-	-	-
	Hygrocybe miniata (Fr.) P.Kumm.	-	-	-	1	-	-	-	-	-	-	-	-
Hypoxylaceae	*Daldinia concentrica* (Bolton) Ces. & De Not.	1	-	-	-	1	-	-	-	-	-	-	-
Lycoperdaceae	*Lycoperdon perlatum* Pers.	-	-	-	1	-	-	-	-	-	-	-	-
Marasmiaceae	*Marasmius crinis-equi* F. Muell. ex Kalchbr.	-	-	1	-	-	-	-	-	-	-	-	-
	Marasmius siccus (Schwein.) Fr.	-	-	1	-	-	-	1	-	-	-	-	-
	Marasmius tenuissimus (Sacc.) Singer	-	-	1	-	-	-	1	-	-	-	1	-
	Tetrapyrgos nigripes (Fr.) E.Horak	-	-	-	-	-	-	-	-	1	-	-	-
Mycenaceae	*Mycena haematopus* (Pers.) P.Kumm.	1	-	-	-	-	-	-	-	-	-	-	-
Nidulariaceae	*Cyathus poeppigii* Tul. & C. Tul.	1	-	-	-	-	-	-	-	-	-	-	-
Omphalotaceae	*Collybiopsis menehune* (Desjardin, Halling & Hemmes) R.H. Petersen	-	-	-	1	-	-	-	-	-	-	-	-
Panaceae	*Panus fasciatus* (Berk.) Pegler	-	-	-	-	1	-	-	-	-	-	-	-
	Panus neostrigosus Drechsler-Santos & Wartchow	1	-	-	-	-	-	-	-	-	-	-	-
Pluteaceae	*Pluteus* cf. *cervinus*	1	-	-	-	-	-	-	-	-	-	-	-
Polyporaceae	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	1	-	-	-	1	-	-	-	-	-	-	-
	Favolus tenuiculus P. Beauv.	1	-	-	-	-	-	-	-	-	-	-	-
	Hexagonia tenuis (Fr.) Fr.	1	-	-	-	1	-	-	-	1	-	-	-
	Lentinus crinitus (L.) Fr.	1	-	-	-	-	-	-	-	-	-	-	-
	Lentinus sajor-caju (Fr.) Fr.	1	-	-	-	-	-	-	-	1	-	-	-
	Lentinus squarrosulus Mont.	1	-	-	-	-	-	-	-	-	-	-	-
	Microporus affinis (Blume & T. Nees) Kuntze	1	-	-	-	-	-	-	-	-	-	-	-
	Microporus xanthopus (Fr.) Kuntze	1	-	-	-	-	-	-	-	-	-	-	-
	Pycnoporus sanguineus (L.) Murrill	1	-	-	-	1	-	-	-	1	-	-	-
	Royoporus spatulatus (Jungh.) A.B.De	1	-	-	-	-	-	-	-	-	-	-	-
	Trametes elegans (Spreng.) Fr.	1	-	-	-	1	-	-	-	-	-	-	-
	Trametes hirsuta (Wulfen) Lloyd	1	-	-	-	-	-	-	-	1	-	-	-
	Trametes polyzona (Pers.) Justo	1	-	-	-	-	-	-	-	-	-	-	-
	Trametes pubescens (Schumach.) Pilát	1	-	-	-	1	-	-	-	1	-	-	-
Psathyrellaceae	*Coprinopsis atramentaria* (Bull.) Redhead, Vilgalys & Moncalvo	1	-	-	-	-	-	-	-	-	-	-	-
	Coprinellus disseminatus (Pers.) J.E. Lange	-	-	-	-	-	-	1	-	-	-	-	-
	Candolleomyces candolleanus (Fr.) D. Wächt. & A. Melzer	-	-	-	-	-	-	1	-	-	-	-	-
	Coprinellus micaceus (Bull.) Vilgalys, Hopple & Jacq. Johnson	-	-	-	1	-	-	-	1	-	-	-	-
Pyronemataceae	*Aleuria aurantia* (Pers.) Fuckel	1	-	-	-	-	-	-	-	-	-	-	-
Sarcoscyphaceae	*Cookeina sulcipes* (Berk.) Kuntze	1	-	-	-	-	-	-	-	-	-	-	-
	Cookeina tricholoma (Mont.) Kuntze	1	-	-	-	-	-	-	-	-	-	-	-
Schizophyllaceae	*Schizophyllum commune* Fr.	1	-	-	-	1	-	-	-	1	-	-	-
Stereaceae	*Stereum ostrea* (Blume & T. Nees) Fr.	1	-	-	-	-	-	-	-	-	-	-	-
Thelephoraceae	*Thelephora anthocephala* (Bull.) Fr.	-	-	-	1	-	-	-	-	-	-	-	-
	Thelephora terrestris Ehrh. ex Pers.	-	-	-	1	-	-	-	-	-	-	-	-
Xylariaceae	*Xylaria curta* Fr.	-	-	-	-	1	-	-	-	-	-	-	-
	Xylaria papyrifera (Link) Fr.	1	-	-	-	-	-	-	-	-	-	-	-
∑ macrofungal species based on substrate and land-cover type		30	1	5	11	10	0	4	1	8	0	1	0

Note: Presence of macrofungal species: 1: present; -: absent. Land-cover type: DU: *dukuh*, fruit islands; AL: agricultural land; SL: shrubland. Substrate: DW: dead wood, decayed wood; LW: live wood; L: litter; S: soil

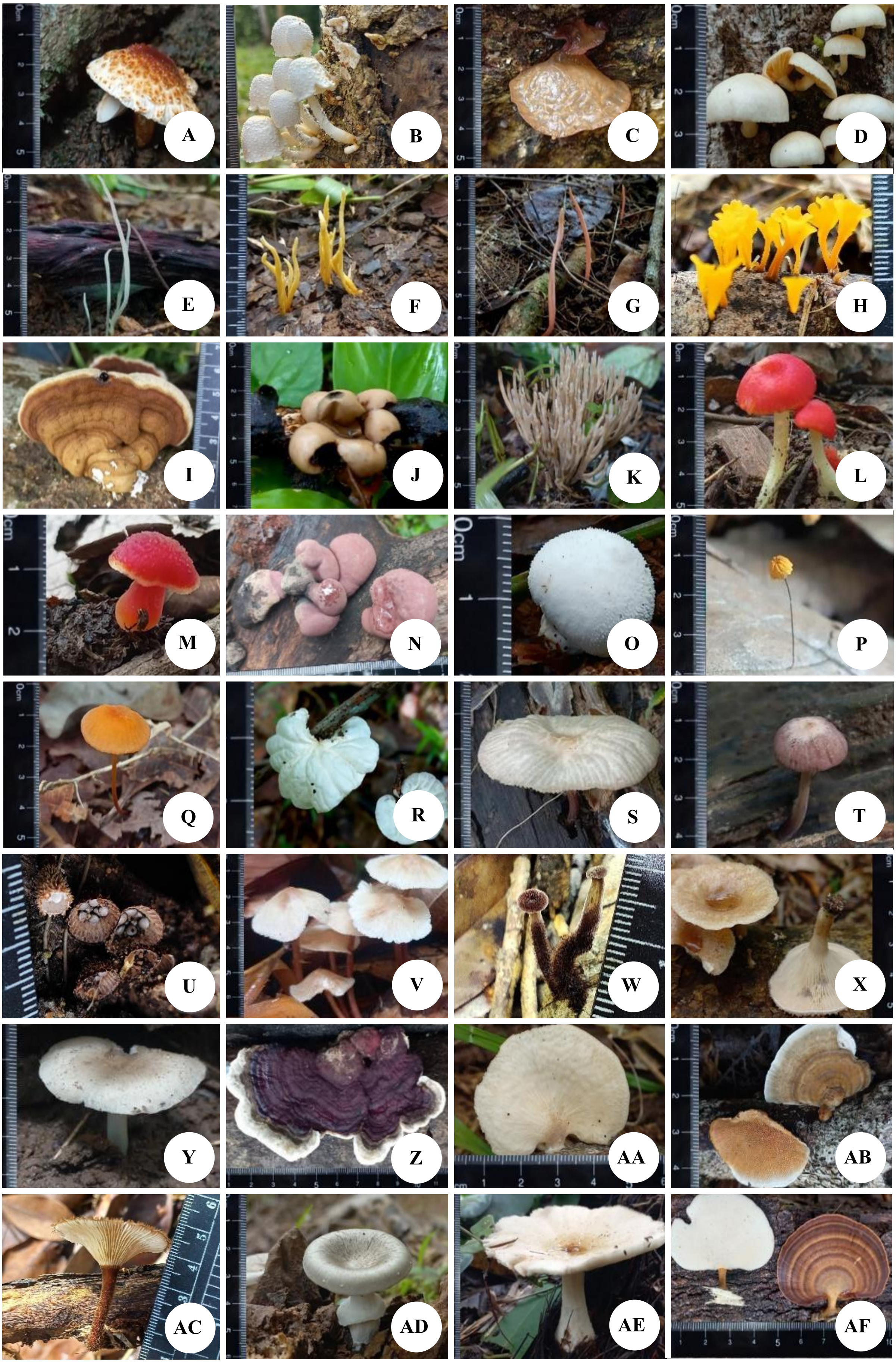
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Figure 2. Various shapes and colors of macrofungi in Mandiangin Timur Village: A. *Lepiota castanea*, B. *Leucocoprinus cepistipes*, C. *Auricularia auricula-judae*, D. *Bolbitius reticulatus*, E. *Clavaria pampeana*, F. *Clavulinopsis amoena*, G. *Clavulinopsis sulcata*, H. *Dacryopinax spathularia*, I. *Ganoderma applanatum*, J. *Geastrum saccatum*, K. *Ramaria stricta*, L. *Hygrocybe cantharellus*, M. *Hygrocybe miniata*, N. *Daldinia concentrica*, O. *Lycoperdon perlatum*, P. *Marasmius crinis-equi*, Q. *Marasmius siccus*, R. *Marasmius tenuissimus*, S. *Tetrapyrgos nigripes*, T. *Mycena haematopus*, U. *Cyathus poeppigii*, V. *Collybiopsis menehune*, W. *Panus fasciatus*, X. *Panus neostrigosus*, Y. *Pluteus* cf. *cervinus*, Z. *Earliella scabrosa*, AA. *Favolus tenuiculus*, AB. *Hexagonia tenuis*, AC. *Lentinus crinitus*, AD. *Lentinus sajor-caju*, AE. *Lentinus squarrosulus*, AF. *Microporus affinis*, AG. *Microporus xanthopus*, AH. *Pycnoporus sanguineus*, AI. *Royoporus spatulatus*, AJ. *Trametes elegans*, AK. *Trametes hirsuta*, AL. *Trametes polyzona*, AM. *Trametes pubescens*, AN. *Coprinopsis atramentaria*, AO. *Coprinellus disseminatus*, AP. *Candolleomyces candolleanus*, AQ. *Coprinellus micaceus*, AR. *Aleuria aurantia*, AS. *Cookeina sulcipes*, AT. *Cookeina tricholoma*, AU. *Schizophyllum commune*, AV. *Stereum ostrea*, AW. *Thelephora anthocephala*, AX. *Thelephora terrestris*, AY. *Xylaria curta,* AZ. *Xylaria papyrifera*

Assuming comparable sampling methods, these differences may reflect variations in ecosystem characteristics (vegetation diversity and abundance), environmental factors (intra- versus extra-Kalimantan conditions), land status (unprotected versus protected areas), and community engagement in biodiversity management (mixed versus indigenous communities).

Based on presence and absence data derived from a single transect in each land-cover type, the Sørensen Similarity Index was highest between AL and SL (0.50), followed by DU and AL (0.35), and lowest between DU and SL (0.29). These values reflect differences in habitat structure and field conditions among land-cover types. In DU, tree canopies form multilayered vertical strata according to tree height, which reduce direct sunlight reaching the forest floor. In contrast, SL is characterized by a single, low canopy layer positioned close to the ground surface. This relatively open structure permits greater light penetration, resulting in distinct microclimatic conditions that likely influence macrofungal community composition.

Three key methodological considerations should be addressed in future studies. Increased sampling replication is necessary, as establishing multiple transects within each land-cover type would enhance sampling robustness, better represent spatial heterogeneity, and reduce potential bias resulting from limited coverage. Seasonal timing must also be carefully aligned with macrofungal fruiting periods. Observations should ideally begin in early November, approximately one month after the onset of the rainy season, and continue until early February, when rainfall typically declines. Seasonal rainfall is a primary driver of macrofungal fruiting, and species richness is generally higher during the rainy season than during the dry season (Njuguini et al. 2018).

In addition, the complementary use of photo vouchers and specimen vouchers should be considered. Methodologically, photo vouchers proved to be a practical and non-destructive approach for documenting macrofungal diversity in areas with limited taxonomic infrastructure. However, future research would benefit from increased sampling replication, alignment with peak fruiting seasons, and the inclusion of specimen vouchers and molecular analyses to improve taxonomic accuracy. When systematically collected with comparative scales and detailed field notes, they can generate valuable long-term ecological datasets (Paton et al. 2020; Lofgren and Stajich 2021; Mesaglio et al. 2023). They are particularly suitable for monitoring phenological trends, supporting biodiversity documentation, and promoting citizen science (Heilmann-Clausen et al. 2015; Greene et al. 2023). Moreover, non-destructive documentation contributes to maintaining ecosystem balance and preserving genetic diversity (Lodge et al. 2004; Heberling and Isaac 2018). Nevertheless, specimen vouchers remain indispensable for taxonomic revision and for microscopic or molecular (DNA-based) identification. Proper collection, preservation, and curation are essential to prevent specimen degradation, loss of diagnostic characteristics, and potential taxonomic bias (Prance and Fechner 2017; Læssøe and Petersen 2019; Meineke and Daru 2021).

Environmental factors

Species richness was highest in *dukuh*, followed by agricultural land and shrubland, reflecting differences in vegetation structure, shading intensity, air temperature, and humidity. Macrofungal richness showed a positive association with higher air humidity and lower light intensity and temperature, whereas soil pH did not appear to influence species richness within the studied sites. Dead wood was the dominant substrate, emphasizing the ecological importance of maintaining woody debris for sustaining fungal diversity.

Macrofungal species richness across land-cover types was influenced by environmental conditions, although the strength and direction of these relationships were not always consistent (Table 2). Species richness decreased sequentially from DU to AL to SL, coinciding with a decline in air humidity. This pattern was accompanied by increasing air temperature and light intensity, whereas soil pH remained relatively similar across sites.

DU exhibited the highest average air humidity (91.11%) and the lowest mean light intensity (2,578 lux), conditions that are generally favorable for macrofungal growth. In contrast, SL showed lower average humidity (83.38%), higher temperature (30.83°C), and greater light intensity (5,771 lux), conditions that may limit fungal development. These findings are consistent with the ecological requirement of many macrofungi for moist and shaded environments.

Each land-cover type possesses distinct vegetation structures that influence shading levels and microclimatic conditions. Shade level can be categorized qualitatively as high (multiple vegetation layers blocking sunlight), moderate (partial blockage), or low (minimal obstruction). Quantitatively, higher light intensity is positively correlated with higher air temperature, whereas higher air temperature is negatively correlated with air humidity.

In Mandiangin Timur Village, increased light intensity and air temperature were associated with reduced fungal species richness, while higher air humidity corresponded with increased richness. These findings align with previous research indicating that fungal occurrence is positively correlated with air humidity (Hu et al. 2022).

Soil pH was the only measured environmental factor not correlated with species richness in the present study. However, this pattern may be site-specific. In other ecosystems, soil pH has been shown to influence fungal distribution. For example, in forests, soil pH ranging from 6.0-7.5, soil moisture of 67-80%, and air temperature of 28-32°C strongly support macrofungal growth (Nurzahra et al. 2025). In estuarine and coastal systems, pH interacts with salinity, temperature, dissolved oxygen, and nutrient availability to shape fungal communities (Lin et al. 2023; Wu et al. 2023).

Table 2. Range and average of environmental factor conditions in the sampled land-cover types

Land-cover type	Macrofungal species richness	Environmental factors			
		Soil pH	Air humidity (%)	Air temperature (°C)	Light intensity (lux)
Dukuh (DU)	47	4.8-6.3 (5.89; n=94)	85-96 (91.11; n=94)	26-30 (28.40; n=94)	606-3,954 (2,578; n=94)
Agricultural land (AL)	15	5.2-6.2 (5.95; n=30)	80-89 (85.96; n=30)	28-32 (30.00; n=30)	2,911-7,212 (4,349; n=30)
Shrubland (SL)	9	5.2-6.2 (5.78; n=18)	76-91 (83.38; n=18)	29-34 (30.83; n=18)	4,508-7,622 (5,771; n=18)

Note: The top value in each cell is RV: range value, the minimum and maximum value of the measurement results, while the bottom one is AV: average value and n: number of measurement samples

Substrate

In addition to environmental factors, substrate availability and type strongly influence fungal diversity (Suryani et al. 2024). A substrate is an organic material that provides nutrients and physical support for fungal growth and development (Zeb et al. 2023). In the present study, each recorded species was observed on only one substrate type per occurrence, and no species was found simultaneously occupying multiple substrates. Although previous studies have reported that many fungi are restricted to a single substrate (Ye et al. 2019; Suryani et al. 2024), this does not preclude the possibility that some species may colonize multiple substrates under different environmental conditions.

Dead wood constituted the primary substrate, supporting 63.46% of recorded species. The remaining species occurred on soil (21.15%), litter (13.46%), and living wood (1.92%). The predominance of dead wood as a substrate is consistent with numerous studies reporting that macrofungi are frequently associated with decaying woody material (Shainidze et al. 2019; Siahaan et al. 2019; Soriano et al. 2021; Armadhan et al. 2023; Zeb et al. 2023; Lefi et al. 2024; Nordin et al. 2024; Nurzahra et al. 2025).

Multiple species were occasionally observed on dead wood of the same plant species, whereas certain macrofungal species are known to colonize a wide range of host plants. For example, *Schizophyllum commune*, an edible species, has been reported to grow on 92 woody plant species (Yusran et al. 2023).

The only species recorded on living wood (bark scaling) was *Bolbitius reticulatus*, which was observed growing on the main tree of durian (*D. zibethinus*) at approximately 150 cm above ground level. The host tree was estimated to be 40 m tall with a diameter at breast height of 125 cm. Durian represents a major fruit commodity in *dukuh* systems and is an important source of income for local farmers; therefore, the presence of fungi on living stems warrants attention.

Information on *B. reticulatus* remains limited. The species has been reported to have a broad but often inconspicuous distribution (Kaygusuz 2022) and belongs to a small, fragile, saprotrophic genus that may also occur on manure (Amandeep et al. 2013; Kaygusuz 2022; Usman et al. 2022). In the present study, this species did not appear to adversely affect durian growth. Nevertheless, continued monitoring is advisable to ensure that its presence does not pose potential risks to economically important trees.

The observation of *B. reticulatus* on living durian stems warrants attention. The occurrence of fungi on living durian wood and species known only by local names also requires additional investigation to clarify ecological roles and potential economic implications. Several fungi are known to be pathogenic to *D. zibethinus*, including *Fusarium solani* and *Lasiodiplodia pseudotheobromae*, which cause stem rot, and *Phytophthora palmivora*, which causes stem canker and fruit rot in durian and other perennial crops such as cacao and rubber. Although *B. reticulatus* did not appear to harm the durian tree in this study, continued monitoring is recommended, especially given the economic importance of durian cultivation in *dukuh* systems.

Utilization of macrofungi by the community

Most informants (64.52%) stated that 20 fungal species (38.46% of all recorded species) were recognized by local names and used (Table 3). However, one species (*jamur hati minjangan*) is only known by its local name and has not yet been scientifically identified; therefore, it is excluded from further discussion pending additional investigation.

Eighteen species (34.62%) were found growing in Mandiangin Timur Village and reported by informants as edible, although their actual consumption is relatively rare. Literature sources confirm that 15 species (28.85%) are edible, whereas 2 species (3.85%) are categorized as inedible.

Several species showed inconsistencies between local use and published edibility records, indicating the need for further ethnomycological, nutritional, and toxicological studies. Some species reported by informants as edible have conflicting records in the literature. For example, *Trametes elegans* and *Trametes hirsuta* are generally described as inedible but medicinal in multiple references, yet local residents consume them. This discrepancy raises important questions: Are these mushrooms processed in a particular way to make them safe for consumption? Or is their edibility context-dependent (e.g., age of fruit body, preparation method)? A similar conflict is observed for *Coprinellus disseminatus*, which is reported as edible in some sources but inedible or even poisonous in others. Such inconsistencies highlight the need for further ethnomycological and toxicological investigations.

Another species widely known as edible but not found growing in the village during the study period is *Volvariella volvacea*. This mushroom is obtained from traveling vegetable vendors or village markets. It is highly valued for its taste and nutritional content and is commonly cultivated in many Asian countries, including Indonesia.

Regarding inedible or potentially poisonous mushrooms, informants reported identifying them based primarily on morphology and color, especially if a particular species had previously caused illness or death. Mushrooms with umbrella-shaped caps and ring-like structures at the base or center of the stipe were considered unsafe for consumption. Additionally, mushrooms exhibiting a greenish or bluish glow, particularly visible at night, were regarded as potentially toxic and even fatal. While such local knowledge reflects practical experience, reliance solely on morphological cues may be unreliable.

Several wild macrofungi species are known for their economic value, their nutritional value contributing to food security, and their use as traditional medicines by some local communities (Noordin et al. 2024). People should exercise caution when using mushrooms, especially as a food source, even if they recognize the signs of inedible or potentially poisonous mushrooms. Ukwuru et al. (2018) stated that identifying poisonous mushrooms based on their morphological characteristics is not easy because mushroom features can be distorted by handling and cooking.

Table 3. Macrofungi used by residents of Mandiangin Timur Village

Local name	Scientific name	References that confirm the benefits of macrofungi
Kulibir ping	*Aleuria aurantia*	Edible (Boa 2004; Venkatachalapathi and Paulsamy 2016; Wu et al. 2019; Yusran et al. 2021; Hu et al. 2022; Bolesławska et al. 2024); medicinal (Venkatachalapathi and Paulsamy 2016; Wu et al. 2019; Hu et al. 2022; Kim et al. 2022); poisonous (Wu et al. 2019)
Kulat kulibir, kulat bitak, jamur kuping	*Auricularia auricula-judae*	Edible (Boa 2004; Lee et al. 2009; Qonitah et al. 2023; Rawiningtyas et al. 2022; Sękara 2015; Yusran et al. 2021, 2024); Adhikari et al. 2025; Giri et al. 2025; medicinal (Boa 2004; Rawiningtyas et al. 2022; Sękara 2015)
Kulat apam	*Candolleomyces candolleanus*	Edible and medicinal (Han et al. 2024)
Kulat mangkok	*Cookeina sulcipes*	Edible (Boa 2004; Lee et al. 2009; Ahmadni et al. 2024); medicinal (Yusran et al. 2024)
Kulat mangkok bulu	*Cookeina tricholoma*	Edible (Boa 2004; Praxedes et al. 2023; Ahmadni et al. 2024; Drewinski et al. 2024); medicinal (Yusran et al. 2024)
Kulat/jamur petiti	*Coprinellus disseminatus*	Inedible (Hu et al. 2022); edible (Boa 2004; Drewinski et al. 2024); poisonous (Wu et al. 2019)
Kulat/jamur tiram hutan	*Coprinellus micaceus*	Edible (Boa 2004; Zahid et al. 2006; Tersoo-Abiem et al. 2019); medicinal (Zahid et al. 2006; Wu et al. 2019; Hu et al. 2022)
Kulat susu	*Coprinopsis atramentaria*	Edible (Wu et al. 2019; Aghayeva et al. 2022; Hu et al. 2022; Yusran et al. 2024); medicinal (Wu et al. 2019; Hu et al. 2022)
Kulat lamak baung	*Favolus tenuiculus*	Edible (Boa 2004; Teke et al. 2021; Dejene et al. 2023)
Jamur tumpu	*Lentinus sajor-caju*	Edible (Lee et al. 2009; Wu et al. 2019; Yusran et al. 2021, 2024; Bastos et al. 2023; Qonitah et al. 2023); medicinal (Wu et al. 2019)
Kulat bantilung	*Hygrocybe cantharellus*	Edible (Boa 2004; Lee et al. 2009; Wu et al. 2019; Hu et al. 2022; Adhikari et al. 2025); medicinal (Wu et al. 2019)
Kulat bantilung	*Hygrocybe miniata*	Edible (Lee et al. 2009; Wu et al. 2019; Hu et al. 2022)
Kulat bakul	*Panus neostrigosus*	Edible (Boa 2004; Drewinski et al. 2024)
Kulat tugal	*Pluteus* cf. *cervinus*	Edible (Boa 2004)
Kulat lamak baung	*Royoporus spatulatus*	Edible (Bastos et al. 2023; Yusran et al. 2024)
Kulat kurikit, kulat karitip, jamur gerigit	*Schizophyllum commune*	Edible (Boa 2004; Lee et al. 2009; Dasayanaka and Wijeyaratne 2017; Wu et al. 2019; Yusran et al. 2021, 2024; Hu et al. 2022; Drewinski et al. 2024); medicinal (Balan et al. 2022; Dasgupta et al. 2025; Hu et al. 2022; Wu et al. 2019)
Kulat kipas	*Trametes elegans*	Inedible (Krishna et al. 2015; Hu et al. 2022; Adhikari et al. 2025), medicinal (Boa 2004; Wu et al. 2019; De Leon et al. 2021; Kanakasundar et al. 2023; Lodi et al. 2025)
Kulat kipas	*Trametes hirsuta*	Inedible (Boa 2004; Krishna et al. 2015; Hu et al. 2022); medicinal (Begum et al. 2023; Wu et al. 2019; Lodi et al. 2025)
Jamur gadang, jamur merang	*Volvariella volvacea*	Edible (Boa 2004; Wu et al. 2019; Balan et al. 2022; Bastos et al. 2023; Ali et al. 2024; Yusran et al. 2024); medicinal (Wu et al. 2019; Ali et al. 2024)
Jamur hati minjangan	-	Unknown

Note: Macrofungi numbered 1-18 were found in Mandiangin Timur Village

In conclusion, macrofungi in Mandiangin Timur Village showed substantial variation among land-cover types, with 52 species from 25 families recorded overall, and *dukuh* supporting the highest richness (47 species), followed by agricultural land (15 species) and shrubland (9 species). This pattern indicates that more complex vegetation structure, higher humidity, lower temperature, and lower light intensity in *dukuh* provide more favorable conditions for macrofungal occurrence than the more open agricultural and shrubland habitats. Most species were associated with dead wood, highlighting the ecological importance of woody debris as the main substrate for macrofungal growth. The study also showed that local residents recognize and utilize a considerable proportion of these fungi, mainly as food, although some inconsistencies between local knowledge and literature-based edibility records indicate the need for caution. Overall, these findings provide baseline information on macrofungal diversity, habitat association, substrate preference, and community use, and emphasize the importance of conservation, continued monitoring, and community education to support the sustainable utilization of macrofungi in the village.

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