INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
ISSN Print: 1560–8530; ISSN Online: 1814–9596
25–163/2025/34:340306
http://www.fspublishers.org

Full Length Article

Distribution and Species Listing of Wild Macrofungi in Bazal, Maria Aurora, Philippines

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Received 20 February 2025; Accepted 22 April 2025; Published online 25 May 2025

Editor: Arshad Javaid

Abstract

This study was carried out to report the natural habitat, physical distribution, and taxonomic listing of wild macrofungi in Bazal, Maria Aurora, Philippines. Sampling was conducted in August, September and December 2024 across three habitat types *viz*., secondary forest, agroforest and developed land at elevations ranging from 180 to 330 m above sea level (masl.). Most of the collected macrofungi were growing solitary or gregarious on decaying woody substrates, which is common in the secondary forest that accounted for the highest proportion of the total collection (68%), followed by the agroforest, which is dominated by coconut trees (26%). In comparison, developed land contributed the least (6%). Majority of the macrofungi (57%) were collected at 180–230 masl., followed by 35% at 231–280 masl., while the highest elevation range (281–330 masl.) had the lowest collection share (8%). A total of 165 macrofungal collections were classified into two phyla, six classes, 14 orders, 35 families, 52 genera and 121 species. Among these, 60 species were morphologically identified at the genus level and required further confirmation through DNA barcoding. Most documented macrofungal species belonged to the phylum Basidiomycota and within this phylum, the family Polyporaceae contained the highest number of species, followed by Mycenaceae, Auriculariaceae, Ganodermataceae, and Marasmiaceae families. Majority of the species belonged to genera namely *Trametes, Auricularia, Filoboletus, Ganoderma* and *Microporus*. It concludes that Bazal, Maria Aurora is a natural habitat that supports a diverse array of macrofungal species, which have promising potential for economic, medicinal and environmental applications.

Keywords: Conservation; Diversity; Distribution; Elevation; Wild macrofungi

Introduction

Macrofungi are ubiquitous saprophytic higher fungi with macroscopic fruiting bodies with members mainly belonging to the phylum Basidiomycota and few in Ascomycota (Zhao 2023). They play essential roles in the environment through their involvement in nutrient cycling, decomposition and as symbionts of plants *via* mycorrhizae (Kubicek and Druzhinina 2007). As saprophytic heterotrophic organisms, these fungi can grow on lignocellulosic substrates by producing various lignocellulosic enzymes to degrade them. In this regard, forest ecosystems, with their diverse range of potential substrates, can support the growth of these macrofungi (Suwannarach *et al.* 2022). However, excessive and uncontrolled resource exploitation, together with an uninformed public, has made forest ecosystems one of the most challenged niches that require holistic management.

To cite this paper: Dulay RM, AC Catacutan, S Kalaw, RM Pineda, K Rivera, K Kimura, F Eguchi, RN Napoles, R Reyes (2025). Distribution and species listing of wild macrofungi in Bazal, Maria Aurora, Philippines. *Intl J Agric Biol* 34:340306. https://doi.org/10.17957/IJAB/15.2366

Regarding conservation, one potential approach is to apply the Japanese concept of Yama-Sato-Umi, which is directly translated into Mountain-Village-Reef. This is because the community's ecosystem and economic well-being are intertwined, emphasizing the ecological effect of anthropogenic activities. In many developing countries, communities depend significantly on ecological services, so their needs and interests must be considered. Within the forest ecosystems, the significant reliance of communities on non-timber forest products (NTFP) is highlighted, which contribute significantly to their livelihoods (Mukul *et al.* 2016). The developing utilization of NTFP can help mitigate environmental impacts by reconciling complex relationships between ecology, economy, and culture (He *et al*. 2014). Among these NTFP, macrofungi specifically mushrooms remain an underutilized resource despite their recognized value as a sustainable and nutritious food that can generate livelihood and environmental protection in the countryside (Dulay *et al.* 2023). Given these benefits, there is a significant potential for exploring wild macrofungi as a means to manage ecosystem and also as sustainable economic resource. Therefore, new species of these macrofungi must be explored to maximize the potential of mushrooms in social alleviation and environmental conservation. Such efforts enriched the limited scholarly works on Philippine mushroom diversity and offered valuable insights into unknown resources.

The Philippines is the second-largest archipelago in the world and is recognized as a megadiverse country with rich biodiversity and high endemism, encompassing 75% of the world's biodiversity (Ani and Castillo 2020). While much attention is given to its flora and fauna, it is notable that the country's tropical climate also supports the growth of numerous wild and edible fungi (Kalaw *et al.* 2021). However, despite these natural advantages, research on ethnomycology and biodiversity in the Philippines remains limited. To date, most of the distribution and diversity studies are concentrated in select areas of Luzon, leaving larger areas uninvestigated. One particularly promising region known for its high biodiversity is the province of Aurora. Located in east-central Luzon, Aurora spans 3,147.32 km² and is bordered by the Northern Sierra Madre Natural Park to the north, the central range of the Sierra Madre to the west, and the Philippine Sea to the east. Its unique topography and Type IV climate featuring year-round rain make an environment conducive to fungal growth. Salerni *et al*. (2002) emphasized that rainfall plays a critical role in stimulating the fruiting of mycelium. These conditions make Aurora an ideal site for further exploration of macrofungal diversity, which could provide critical data to enhance the understanding of Philippine macrofungi and support broader conservation and economic goals. This study was undertaken to investigate the natural habitats and physical distribution, and to prepare a taxonomic checklist of wild macrofungi in Bazal, Maria Aurora, Philippines, to serve as a reference and initial study of local conservation efforts through the introduction of mushroom technology.

Materials and Methods

Permit acquisition

The ethical clearance of the project from the Central Luzon State University (CLSU) Ethics Review Committee was issued and received by the team on October 27, 2023.

Study sites

The secondary forest (SF), agroforest (AF), and developed land (DL) near the Aurora State College of Technology Bazal Campus were the sites of this study. These sites are located at approximately 15°48'20"N 121°24'58"E in the Barangay of Bazal, Municipality of Maria Aurora, Province of Aurora, Island of Luzon, Philippines. The place is characterized by mountainous terrain and features a stretch of the Bazal River (Fig. 1). During the ocular inspection, topographical information about the collection sites was documented, including the identification of trails and vegetation. The topography is moderately steep in the lower portions and generally steep in the upper areas. At lower elevations, coconut trees are the predominant vegetation specifically in the agroforest, while various plants can be found with increased elevation and in the secondary forest. This makes the area ecologically and agriculturally significant. Importantly, the collection sites are restricted to the most accessible parts of the mountainous terrain in Bazal, allowing residents to easily gather macrofungi as non-timber forest products.

Field sampling of macrofungi

The study employed purposive and opportunistic sampling methods. Macrofungi were collected during August, September and December in 2024. Natural disasters and internal conflicts prevented collection in the months of October and November. During the collection of the species, temperature and relative humidity (atmospheric moisture) were recorded between 9:00 AM and 12:00 PM in the habitats where the macrofungi were acquired. The natural habitats of the macrofungi were also documented. The relative humidity and temperature were measured. The location and elevation of each macrofungal specimen were recorded using a global positioning system (GPS). Specimens were carefully collected for morphological identification and tissue cultured on potato dextrose agar medium in the laboratory to rescue the secondary mycelia for future studies. Substrate samples were also collected to analyze their pH.

Morphological identification

The morphological identification of the collected macrofungi was conducted by analyzing morphometric data. Macroscopic characteristics were examined for morphological identification, focusing on the attributes of

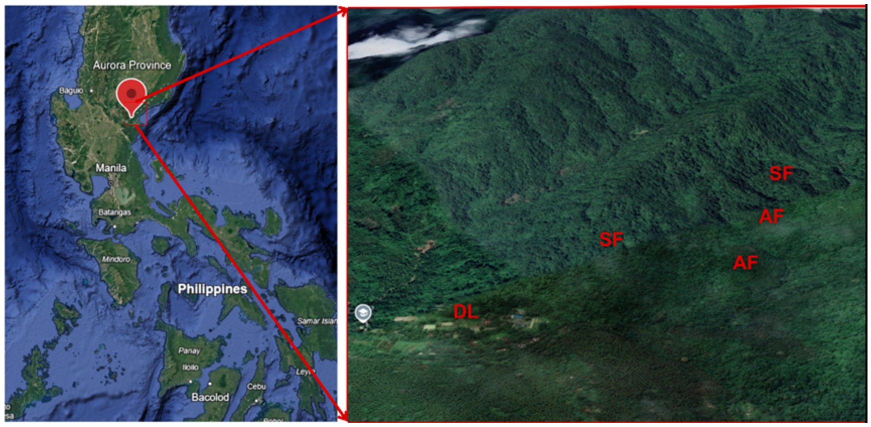

Fig. 1: Map of the study sites in Bazal, Maria Aurora, Aurora, Philippines showing the different habitat types within the collection site: Secondary Forest (SF), Agroforest (AF), and Developed land (DL)

Fig. 2: Macrofungi species collected in Bazal, Maria Aurora. (**a**) *Ganoderma applanatum*, (**b**) *Auricularia auricula-judae*, (**c**) *Volvariella volvacea*, (**d**) *Microcoporus affinis*, (**e**) *Clavulinopsis laeticolor*, (**f**) *Schizophyllum commune*, (**g**) *Tremella fuciformis,* (**h**) *Lentinus tigrinus*

the cap, gills and stalk and compared in the taxonomic works of Bustillos *et al*. (2024), Pictorial Guide on Philippine Indigenous Mushrooms (2023), Tadiosa *et al*. (2011), Leon *et al.* (2013), Arenas *et al*. (2018), Dulay *et al*. (2020) and Peterson's Field Guide on Mushrooms of McKnight and McKnight (1987) and further authenticated by mycologists.

Results

Macrofungi of bazal

Majority of the collected specimens were wood rotters, thriving on fallen branches, trees, and rotten logs, which are abundant in the secondary forest. In the agro-forested areas, macrofungi were found in coconut crown shafts and shells. Other specimens were obtained from soil, leaf litter, and termite mounds. The pH of the soil substrates ranged from 4.8 to 7.2. The average temperature during the collection months ranged from 16.6°C to 26.6°C, with relative humidity reaching 95%. During the study, observed precipitation varied from 21.6 mm to 149.0 mm over the sampling months, the latter is influenced by typhoons that tend to make landfall in this region during the end of the year.

A total of 165 macrofungi were collected during the three months of collection. These were identified and taxonomically classified into 121 species. Table 1 presents the 121 species of macrofungi with their edibility, substrate, and growth habit. These characteristics provide insight into the ecological roles and potential uses of the identified fungi. The majority exhibited a growth habit that was solitary or gregarious, with a few being cespitose.

Table 1: Edibility, growth habits, substrate, and habitat of 121 macrofungal species in Bazal, Maria Aurora

Species Name	Edibility	Substrate	Growth habit
Anthracobia melaloma	NE	Rotten trunk	Gregarious
Athelia sp.	NE	Rotten trunk	Scattered
Auricularia auricula-judae	E	Dead stem	Gregarious
Auricularia mesenterica	E	Rotten log	Gregarious
Auricularia nigricans	E	Rotten twig	Gregarious
Auricularia polytricha	E	Dead tree	Gregarious
Auricularia sp. 1	E	Dead stem	Solitary
Auricularia sp. 2	E	Rotten log	Gregarious
Bisporella citrina	NE	Dead stem	Gregarious
Bolbitius titubans	NE	Soil	Gregarious
Bolbitius sp.	NE	Rotten coconut husk	Solitary
Campanella sp.	NE	Fallen twig	Gregarious
Cantharellus lateritius	E	Soil	Solitary
Cheimonophyllum sp. 1	NE	Coconut stem	Scattered
Cheimonophyllum sp. 2	NE	Rotten stem	Scattered
Chrysomphalina grossula	NE	Rotten twig	Gregarious
Chrysomphalina sp.	NE	Rotten twig	Solitary
Clavulinopsis laeticolor	NE	Soil	Gregarious
Clavulinopsis sulcata	NE	Soil	Gregarious
Cookenia speciosa	E	Rotten stem	Solitary
Cookeina sulcipes	E	Rotten twig	Gregarious
Cookeina tricholoma	E	Rotten twig	Gregarious
Coprinellus aureogranulatus	NE	Rotten branches	Gregarious
Coprinellus disseminatus	NE	Rotten twigs	Gregarious
Coriolopsis aspera	NE	Rotten log	Solitary
Cymatoderma caperatum	NE	Rotten log	Solitary
Cymatoderma elegans	NE	Rotten log	Solitary
Cymatoderma sp. 1	NE	Dead wood	Gregarious
Cymatoderma sp. 2	NE	Dead wood	Gregarious
Dacrymyces tortus	NE	Dead tree	Gregarious
Entoloma turci	NE	Leaf litter	Solitary
Favolaschia pustulosa	NE	Tree	Gregarious
Favolus pseudoemerici	NE	Tree	Gregarious
Favolus sp. 1	NE	Fallen twig	Gregarious
Favolus sp. 2	NE	Rotten stem	Gregarious
Filoboletus manipularis	E	Stem	Gregarious
Filoboletus sp. 1	E	Rotten coconut shaft	Gregarious
Filoboletus sp. 2	E	Rotten coconut shaft	Gregarious
Filoboletus sp. 3	E	Stem	Gregarious
Filoboletus sp. 4	E	Rotten coconut shaft	Gregarious
Filoboletus sp. 5	E	Rotten coconut shaft	Gregarious
Fomitopsis pinicola	NE	Tree	Solitary
Ganoderma applanatum	E	Tree	Solitary
Ganoderma curtisii	E	Tree	Scattered
Ganoderma lucidum	E	Rotten stem	Gregarious
Ganoderma sp. 1	E	Fallen tree	Gregarious
Ganoderma sp. 2	E	Rotten log	Solitary
Ganoderma sp. 3	E	Tree	Solitary
Gymnopus foetidus	NE	Fallen twig	Gregarious
Heimiomyces tenuipes	E	Dead tree	Gregarious
Helvella sp.	E	Twig	Solitary
Hygrocybe quieta	NE	Soil	Solitary
Infundibulicybe sp.	NE	Leaf litter	Solitary
Lentinus sajor-caju	Ee	Rotten wood	Gregarious
Lentinus swartzii	E	Rotten wood	Gregarious
Lentinus tigrinus	E	Rotten wood	Gregarious
Lenzites sp. 1	NE	Rotten stem	Gregarious
Lenzites sp. 2	NE	Rotten stem	Gregarious
Lenzites sp. 3	NE	Rotten wood	Solitary
Marasimius maximus	E	Leaf litters	Cepitose
Marasmiellus sp. 1	NE	Leaf litter	Solitary
Marasmiellus sp. 2	NE	Leaf litter	Solitary
Marasmius capillaris	NE	Gregarious	Gregarious
Marasmius quercophilus	NE	Gregarious	Gregarious
Marasmius rotula	NE	Rotten twig	Gregarious
Marasmius sp. 1	NE	Leaf litter	Gregarious
Marasmius sp. 2	NE	Leaf litter	Solitary
Marasmius sp. 3	NE	Leaf litter	Solitary
Mensularia radiata	NE	Rotten log	Gregarious
Microporus affinis	NE	Rotten twig	Solitary
Microporus sp. 1	NE	Rotten trunk	Gregarious
Microporus sp. 2	NE	Tree	Solitary
Microporus sp. 3	NE	Tree	Gregarious
Microporus sp. 4	NE	Twig	Solitary
Microporus sp. 5	NE	Rotten twig	Gregarious
Microporus xanthopus	NE	Dead tree	Gregarious
Mycena flavescens	NE	Dead tree	Gregarious
Mycena leaiana	NE	Rotten log	Gregarious
Mycena rosella	NE	Rotten trunk	Gregarious
Mycena sp. 1	NE	Rotten coconut shell	Gregarious
Mycena sp. 2	NE	Rotten trunk	Gregarious
Neofavolus suavissimus	NE	Rotten trunk	Gregarious
Panellus mitis	NE	Rotten log	Gregarious
Panaeolus antillarum	NE	Horse dung	Gregarious
Phillipsia hartmannii	NE	Fallen logs	Solitary
Phylloporus sp.	E	Soil with plant roots	Solitary
Pleurotus sp. 1	E	Rotten trunk	Cepitose
Pleurotus sp. 2	E	Rotten trunk	Cepitose
Pluteus sp. 1	NE	Leaf litter	Gregarious
Pluteus sp. 2	NE	Soil with leaf litter	Gregarious
Pluteus sp. 3	NE	Soil with leaf litter	Gregarious
Polyporus tuberaster	NE	Rotten log	Solitary
Polyporus sp.	E	Rotten stem	Gregarious
Pseudaleuria sp.	NE	Soil with leaf litter	Solitary
Resupinatus sp. 1	NE	Rotten twig	Gregarious
Resupinatus sp. 2	NE	Rotten twig	Gregarious
Schizophyllum commune	E	Rotten log	Gregarious
Schizophyllum sp.	E	Dead wood	Gregarious
Stereum complicatum	NE	Rotten log	Gregarious
Stereum ostrea	NE	Dead tree	Gregarious
Stereum sp.	NE	Tree	Gregarious
Termitomyces eurhizus	E	Termite mound	Solitary
Trametes ochrachea	E	Rotten trunk	Gregarious
Trametes sp. 1	E	Rotten trunk	Gregarious
Trametes sp. 2	E	Rotten trunk	Gregarious
Trametes sp. 3	E	Rotten trunk	Gregarious
Trametes sp. 4	E	Rotten trunk	Gregarious
Trametes sp. 5	E	Rotten trunk	Gregarious
Trametes sp. 6	E	Rotten trunk	Gregarious
Trametes sp. 7	E	Rotten trunk	Gregarious
Trametes sp. 8	E	Rotten trunk	Gregarious
Trametes sp. 9	E	Rotten trunk	Gregarious
Trametes sp. 10	E	Rotten trunk	Gregarious
Trametes versicolor	E	Decaying log	Gregarious
Tremella fuciformis	E	Rotten log	Gregarious
Tremella globispora	E	Rotten log	Gregarious
Tremella sp.	E	Rotten log	Gregarious
Trichaleurina javanica	E	Rotten stem	Gregarious
Tyromcyes chioneus	NE	Rotten stem	Gregarious
Volvariella volvacea	E	Coconut shaft	Solitary
Xylaria polymorpha	NE	Soil	Cespitose

Table 1: Continued

Table 1: Continued

E: edible and **NE:** not edible

In terms of edibility, most of the collected mushrooms were classified as non-edible, while the remaining included edible species, some of which were considered non-palatable. Most collections were made in the secondary forest, where a relatively high diversity of substrates existed, and favorable humidity and moisture levels were maintained.

Table 2: Distribution of 165 collected macrofungi belonging to 121 macrofungal species in three collection site types and three elevation ranges

Species Name	Habitat Types			Elevation (masl.)		
	Developed Land	Agroforest	Secondary Forest	180- 230	230 - 280	280 – 330
Anthracobia melaloma			•	•		
Athelia sp.			•	•		
Auricularia auricula-judae		•	•	•	•	•
Auricularia mesenterica			•		•	
Auricularia nigricans			•		•	
Auricularia polytricha			•		•	
Auricularia sp. 1			•		•	
Auricularia sp. 2			•	•		
Bisporella citrina			•		•	
Bolbitius titubans			•		•	
Bolbitius sp.			•		•	
Campanella sp.		•			•	
Cantharellus lateritius			•	•		
Cheimonophyllum sp. 1			•	•		
Cheimonophyllum sp. 2			•	•		
Chrysomphalina grossula			•		•	
Chrysomphalina sp.			•		•	
Clavulinopsis laeticolor		•		•		
Clavulinopsis sulcata		•		•		
Cookeina speciosa	•		•		•	
Cookeina sulcipes		•	•	•	•	•
Cookeina tricholoma		•	•	•	•	
Coprinellus aureogranulatus		•		•		
Coprinellus disseminatus			•	•		
Coriolopsis aspera		•				•
Cymatoderma caperatum			•	•		
Cymatoderma elegans			•		•	
Cymatoderma sp. 1			•		•	
Cymatoderma sp. 2			•		•	
Dacrymyces tortus			•	•		
Entoloma turci		•		•		
Favolaschia pustulosa			•		•	
Favolus pseudoemerici			•	•		
Favolus sp. 1			•		•	
Favolus sp. 2			•	•		
Filoboletus manipularis			•	•		
Filoboletus sp. 1			•	•		
Filoboletus sp. 2			•	•		
Filoboletus sp. 3			•		•	
Filoboletus sp. 4		•		•		
Filoboletus sp. 5		•		•		
Fomitopsis pinicola			•		•	
Ganoderma applanatum		•	•		•	•
Ganoderma curtisii		•		•		
Ganoderma lucidum		•		•		
Ganoderma sp. 1			•			•
Ganoderma sp. 2		•				•
Ganoderma sp. 3			•		•	
Gymnopus foetidus			•		•	
Heimiomyces tenuipes			•		•	
Helvella sp.			•	•		
Hygrocybe quieta		•		•		
Infundibulicybe sp.			•	•		
Lentinus sajor-caju			•		•	
Lentinus swartzii			•		•	
Lentinus tigrinus			•		•	
Lenzites sp. 1			•	•		
Lenzites sp. 2			•	•		
Lenzites sp. 3						

Table 2: Continued

Table 2: Continued

Marasimius maximus		•		•		
Marasmiellus sp. 1		•		•		
Marasmiellus sp. 2		•		•		
Marasmius capillaris			•	•		
Marasmius quercophilus			•	•		
Marasmius rotula			•	•		
Marasmius sp. 1			•	•		
Marasmius sp. 2			•		•	
Marasmius sp. 3			•		•	
Mensularia radiata		•		•		
Microporus affinis	•				•	
Microporus sp. 1			•		•	
Microporus sp. 2			•		•	
Microporus sp. 3			•		•	
Microporus sp. 4			•		•	
Microporus sp. 5			•	•		
Microporus xanthopus			•	•		
Mycena flavescens			•	•		
Mycena leaiana			•		•	
Mycena rosella		•		•		
Mycena sp. 1			•	•		
Mycena sp. 2			•	•		
Neofavolus suavissimus			•	•		
Panellus mitis		•		•		
Panaeolus antillarum	•			•		
Phillipsia hartmannii			•		•	
Phylloporus sp.			•		•	
Pleurotus sp. 1			•		•	
Pleurotus sp. 2			•		•	
Pluteus sp. 1			•		•	
Pluteus sp. 2	•			•		
Pluteus sp. 3	•			•		
Polyporus tuberaster			•		•	
Polyporus sp.			•	•		
Pseudaleuria sp.			•		•	
Resupinatus sp. 1			•	•		
Resupinatus sp. 2			•	•		
Schizophyllum commune			•	•		
Schizophyllum sp.			•		•	
Stereum complicatum			•	•		
Stereum ostrea		•				•
Stereum sp.			•	•		
Termitomyces eurhizus			•		•	
Trametes ochrachea			•		•	
Trametes sp. 1			•		•	
Trametes sp. 2			•		•	
Trametes sp. 3			•	•		
Trametes sp. 4			•	•		
Trametes sp. 5			•	•		
Trametes sp. 6	•			•		
Trametes sp. 7			•	•		
Trametes sp. 8			•	•		
Trametes sp. 9			•	•		
Trametes sp. 10			•	•		
Trametes versicolor			•		•	•
Tremella fuciformis		•	•	•		
Tremella globispora			•	•		
Tremella sp.		•		•		
Trichaleurina javanica			•	•		
Tyromyces chioneus			•		•	
Volvariella volvacea		•	•	•	•	
Xylaria polymorpha			•	•		

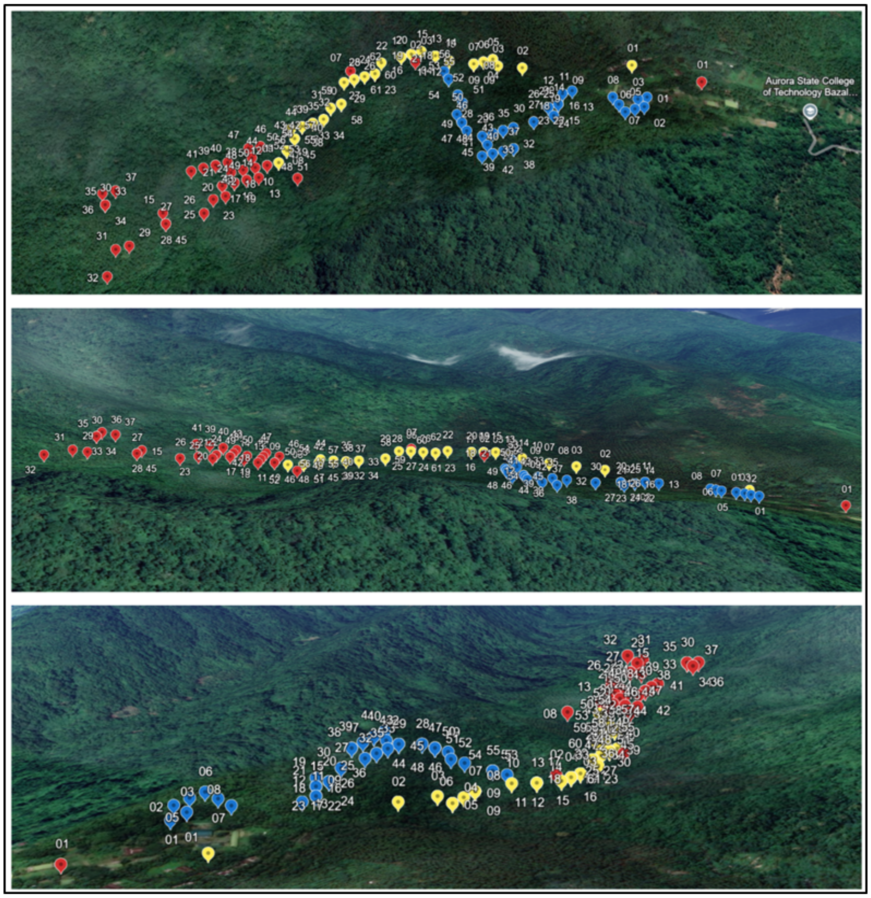

Fig. 3: Distribution of 165 collected macrofungi in three collection months, August (red), September (blue), and December (yellow) across the three collection site types

Depending on the substrate and natural habitat, the specimens demonstrated symbiotic, parasitic, and saprophytic behavior. Some of the collected macrofungi in their natural habitat (Fig. 2).

Physical distribution

The physical distribution of various macrofungi across three distinct habitats and elevation ranges was examined. Table 2 presents the distribution of 165 collected macrofungi, identified as 121 individual species. However, the distribution frequency was calculated based on the number of collections rather than on species count, as some species were found to have multiple occurrences across different site types and elevation ranges.

Among the collection sites, the secondary forest had the highest percentage (68%) of collected macrofungi. The agroforested area, dominated by coconut trees, has accounted for 26%, while the developed land contributed only 6%. Additionally, the relationship between macrofungal species distribution and elevation was analyzed across three elevation ranges: 180–230, 231–280 and 281–330 m above sea level (masl.) (Table 3). Most specimens (57%) were collected at 180–230 masl., followed by 35% at 231–280 masl. The highest elevation range, 281–330 masl., had the lowest collection share with only 8%. The distribution of the collected macrofungi in three collection months across the different collection site types is depicted in Fig. 3.

Taxonomic listing of macrofungi

After the documentation of the physical characteristics of the study sites and the distribution of macrofungi, morphological identification of the collected specimens was conducted to create a taxonomic checklist of macrofungi in Bazal. The 165 macrofungal collections were classified into two phyla, six classes, 14 order, 35 families, 52 genera, and 121 species. Of these collections, 61 species were identified at the species level and 60 were only identified at the genus level. Majority of the collected macrofungi species belonged to the *phylum Basidiomycota*, while only 10 were classified under the *phylum Ascomycota*. Within the Basidiomycota, the family Polyporaceae had the highest number of species, followed by *Mycenaceae*, *Auriculariaceae*, *Ganodermataceae*, and *Marasmiaceae*. The genera with the highest number of species were *Trametes, Auricularia*, *Filoboletus*, *Ganoderma*, and *Microporus.*

Table 3: Taxonomic positions of the collected macrofungi

Phylum	Class	Order	Family	Species
Ascomycota	Leotiomycetes	Helotiales	Helotiaceae	*Bisporella citrina*
	Pezizomycetes	Pezizales	Helvellaceae	*Helvella* sp.
			Pyronemataceae	*Anthracobia melaloma*
				Pseudaleuria sp.
			Sarcoscyphaceae	*Cookeina speciosa*
				Cookeina sulcipes
				Cookeina tricholoma
				Phillipsia hartmannii
	Sordariomycetes	Xylariales	Xylariaceae	*Xylaria polymorpha*
Basidiomycota	Agaricomycetes	Agaricales	Bolbitiaceae	*Bolbitius titubans*
				Bolbitius sp.
			Clavariaceae	*Clavulinopsi laeticolor*
				Clavulinopsi sulcata
			Cyphellaceae	*Cheimonophyllum* sp. 1
				Cheimonophyllum sp. 2
			Entolomataceae	*Entoloma turci*
			Galeropsidaceae	*Panaeolus antillarum*
			Hygrophoraceae	*Hygrocybe quieta*
				Chrysomphalina grossula
				Chrysomphalina sp.
			Lyophyllaceae	*Termitomyces eurhizus*
			Marasmiaceae	*Campanella* sp.
				Marasmius capillaris
				Marasmius quercophilus
				Marasmius rotula
				Marasmius sp. 1
				Marasmius sp. 2
				Marasmius sp. 3
				Marasmius maximus
			Mycenaceae	*Favolaschia pustulosa*
				Filoboletus manipularis
				Filoboletus sp. 1
				Filoboletus sp. 2
				Filoboletus sp. 3
				Filoboletus sp. 4
				Filoboletus sp. 5
				Mycena flavescens
				Mycena leiana
				Mycena rosella
				Mycena sp. 1
				Mycena sp. 2
				Panellus mitis
			Omphalotaceae	*Gymnopus foetidus*
				Marasmiellus sp. 1
				Marasmiellus sp. 2
			Pleurotaceae	*Pleurotus* sp. 1
				Pleurotus sp. 2
			Pluteaceae	*Pluteus* sp. 1
				Pluteus sp. 2
				Pluteus sp. 3
				Volvariella volvacea
			Psathyrellaceae	*Coprinellus aureogranulatus*
				Coprinellus disseminatus
			Schizophyllaceae	*Schizophyllum commune*
				Schizophyllum sp.
			Tricholomataceae	*Infundibulicybe* sp.
				Resupinatus sp. 1
				Resupinatus sp. 2
			Xeromphalinaceae	*Heimiomyces tenuipes*
		Atheliales	Atheliaceae	*Athelia* sp.
		Auriculariales	Auriculariaceae	*Auricularia auricula-judae*
				Auricularia mesenterica
				Auricularia nigricans
				Auricularia polytricha
				Auricularia sp. 1
				Auricularia sp. 2

Table 3: Continued

Table 3: Continued

	Boletales	Boletaceae	*Phylloporus* sp.
	Cantharellales	Hydnaceae	*Cantharellus lateritius*
	Hymenochaetales	Hymenochaetaceae	*Mensularia radiata*
	Pezizales	Chorioactidaceae	*Trichaleurina javanica*
	Polyporales	Fomitopsidaceae	*Fomitopsis pinicola*
		Ganodermataceae	*Ganoderma applanatum*
			Ganoderma curtsii
			Ganoderma lucidum
			Ganoderma sp. 1
			Ganoderma sp. 2
			Ganoderma sp. 3
		Incrustoporiaceae	*Tyromcyes chioneus*
		Panaceae	*Cymatoderma caperatum*
			Cymatoderma elegans
			Cymatoderma sp. 1
			Cymatoderma sp. 2
		Polyporaceae	*Coriolopsis aspera*
			Favolus pseudoemerici
			Favolus sp. 1
			Favolus sp. 2
			Lentinus sajor-caju
			Lentinus swartzii
			Lentinus tigrinus
			Lenzites sp. 1
			Lenzites sp. 2
			Lenzites sp. 3
			Microporus affinis
			Microporus xanthopus
			Microporus sp. 1
			Microporus sp. 2
			Microporus sp. 3
			Microporus sp. 4
			Microporus sp. 5
			Neofavolus suavissimus
			Polyporus tuberaster
			Polyporus sp.
			Trametes ochracea
			Trametes versicolor
			Trametes sp. 1
			Trametes sp. 2
			Trametes sp. 3
			Trametes sp. 4
			Trametes sp. 5
			Trametes sp. 6
			Trametes sp. 7
			Trametes sp. 8
			Trametes sp. 9
			Trametes sp. 10
	Russulales	Stereaceae	*Stereum complicatum*
			Stereum ostrea
			Stereum sp.
Dacrymycetes	Dacrymycetales	Dacrymycetaceae	*Dacrymyces tortus*
Tremellomycetes	Tremellales	Tremellaceae	*Tremella fuciformis*
			Tremella globispora
			Tremella sp.

Among the collected macrofungal specimens, *Ganoderma applanatum* had the highest number of samples (8), followed by *Auricularia auricula-judae* (7), *Cookenia speciosa* (6), *Microporus xanthopus* (4) and *Cookeina sulcipes* (4).

Discussion

This study provides valuable insights into the wild macrofungi in Bazal, Maria Aurora, emphasizing the diversified characteristics of 165 collected specimens about their natural habitat, physical distribution, and practical importance. Mushrooms have a significant role in ecosystems, contributing to nutrient cycling, decomposition, bioremediation, carbon sequestration, and biodiversity. However, their ecological functions vary by species, highlighting the need to explore macrofungal diversity further to uncover broader practical applications (Ogwu *et al.* 2025). Most specimens in this study were collected from decaying wood, including rotten trunks, dead trees, and fallen twigs, indicating that they are saprophytes. The abundance of wood-rotting fungi suggests the availability and richness of tree species that serve as substrates in the study site. This capacity of macrofungi helps facilitate nutrient cycling, support plant growth, and maintain ecological balance (Fukasawa 2021). In addition to the wood rotters, leaf litter mushrooms are the second most abundant documented macrofungi based on the substrate type. These organisms also play an important role by breaking down complex plant materials. Accumulated forest leaf litter is essential for shaping the forest environment (Tennakoon *et al*. 2021), and the action of fungi enhances physical, biological, and chemical processes affecting forest health.

Mushrooms also form symbiotic relationships aside from being a saprophyte, and in this study, two types of symbiosis were observed: mutualism and parasitism. In this study, macrofungal species that are symbiote of plants were collected including species of *Helvella*, *Phylloporus* and *Cantharellus*. They all show strong relation and interdependence with their plant host (Wei *et al*. 2024). Meanwhile, species of *Termitomyces,* a macrofungi collected from the termite mounds, is known to have obligate mutualistic relationships with termites. These fungi rely on organic matter collected by termites while assisting in the breaking down plant-derived materials, which are the food source of the termites (Ghorai *et al*. 2009). Conversely, some collected species exhibited parasitism. *Fomitopsis*, *Ganoderma* and *Microporus* were all found on living trees, suggesting that these fungi act as parasites. While parasitism typically harms the host, wood rot in living trees plays an essential ecological role. It promotes the formation of tree cavities that support forest fauna, facilitates tree uprooting and trunk breakage, and creates diverse microhabitats within forest ecosystems (Runnel *et al.* 2021). The ecological roles of these fungi, whether mutualistic or parasitic, are closely linked to the environmental conditions that influence their distribution across different habitats.

In the present study, macrofungal composition was highest at 180–230 masl. and lowest at 281–330 masl. This result aligns with the findings of Bustillos *et al*. (2024), where 57% of the collected macrofungi in Mt. Arayat, Pampanga were found at elevation between 100–250 masl., possibly due to differences in vegetation types at different elevations. Only species of *Auricularia auricula-judae* and *Cookeina sulcipes* were found across all the elevation ranges. At the same time, *Ganoderma* was the only genus consistently present at all elevations. Notably, the macrofungal diversity decreases as the elevation increases which is similar to the findings of Zhang *et al*. (2010) and Han *et al.* (2023) that both recorded the highest number of taxa at the lowest elevation. Local studies conducted by Dulay *et al*. (2020) and Bustillos *et al*. (2024) in the same geographical region of the collection sites reported the similar observations. Zhang *et al*. (2024) reported that increasing altitude leads to declining tree diversity and, thus, affects the abundance of organisms that depend on it, such as mushrooms. This observed pattern is primarily influenced by microclimatic factors, vegetation types, and substrate characteristics, creating varying conditions for fungal growth (Gómez-Hernández *et al.* 2012).

This paper also presents the observations in three distinct site types, including developed land, agroforest, and secondary forest. The developed land was characterized as a disturbed area with continuous human activities, the agroforest as an area dominated by coconut trees, and the secondary forest with different vegetation. Among the collection sites, the secondary forest yielded the highest macrofungal diversity, followed by the agro-forested area, while the developed area was found to be the least. These findings align with the study of Saado (2018) in Kereita Forest, Kikuyu Escarpment, Kenya, that reported the highest macrofungal diversity in the natural forests and the agricultural lands the lowest due to habitat alteration and reduction of diverse available substrates for fungal growth. The difference between the macrofungal diversity of secondary forests and agroforests can be attributed to the type and quantity of growing plants. Since the composition of the substrate influences the development of the mushroom's fruiting bodies, the diversity of the substrate plays a crucial role in shaping macrofungal communities (Siwulski *et al*. 2019). The more significant variation in substrates promotes a richer diversity of macrofungal species. Likewise, the low macrofungal diversity in the developed land is due to the unavailability of quality and sufficient substrates to support growth (Rudolf *et al*. 2012). Removing potential fungal hosts like trees and decomposing plant materials decreases macrofungal diversity.

After identifying the distribution patterns of the collected macrofungi, it is also important to describe their economic value, particularly their potential as commodities such as food and medicine. Consumption is the most immediate way to utilize these species. Therefore, information on the edibility of the collections is important. Moreover, different species of mushrooms encompass aspects of food functionality, including nutrition, taste, and physiological benefits (Valverde *et al*. 2015). Among the collected specimens, several are known to be edible, including *Auricularia* spp., *Cantharellus* spp., *Cookeina* spp., *Filoboletus* spp., *Ganoderma* spp., *Helvella* spp., *Lentinus* spp., *Marasmius* spp., *Phylloporus* spp., *Pleurotus* spp., *Polyporus* spp., *Schizophyllum* spp., *Termitomyces* spp., *Trametes* spp., *Tremella* spp., *Trichaleurina* spp. and *Volvariella* spp.

Pleurotus spp. and *Volvariella volvacea*, among the most widely cultivated mushrooms, are highly favored for their adaptability, high biological efficiency, and nutraceutical properties, being rich in protein, fiber, vitamins, and essential minerals while maintaining low caloric content (Raman *et al*. 2021). *Schizophyllum commune*, which is consumed in Asia, is notable for its bioactive compounds with antioxidant, antidiabetic, antimicrobial and anticancer properties (Prabsangob and

Sittiketgorn 2023). The *Auricularia* spp., which is the fourth most cultivated mushroom group, includes *A. auricula-judae*, *A. mesenterica*, *A. nigricans*, and *A. polytricha*. They are reported to have anti-cancer, anti-bacterial, anti-viral, immunomodulatory, antioxidant, hypoglycemic, and anti-hypercholesterolemic properties (Bandara *et al.* 2019). Despite their widespread cultivation, regional collections remain crucial due to strain variations (Dulay and Rivera 2017; Mendoza *et al*. 2020). Additional edible macrofungi collected include *Cookeina* spp., which is distinguished by vibrant cup-shaped fruiting bodies and consumed in multiple regions for their soft yet crispy texture (Fitra *et al*. 2020) and *Helvella* spp., which is highly regarded in Turkey and China for their bioactive properties (Wang *et al*. 2023). The bioluminescent *Filoboletus manipularis*, harvested seasonally in Indonesia and *Trichaleurina* sp., characterized to be underexplored edible species, were also collected (Qonitah *et al*. 2023). *Lentinus* spp., including *L. sajor-caju*, *L. swartzii* and *L. tigrinus*, contains different medicinal and pharmaceutically important compounds that are reported to have several bioactive properties (Fabros *et al*. 2022). *Polyporus* and *Phylloporus* spp., both commercially available, share similar medicinal properties with *Lentinus* but also exhibit memory-enhancing effects (Bandara *et al*. 2015; Tang *et al*. 2016). *Tremella* spp., one that is valued in Asia for centuries, contain polysaccharides that function as natural emulsifiers, thickeners, and food fortifiers, enhancing food quality while reducing artificial additives (Zhang *et al*. 2022).

Ganoderma and *Trametes* are not classified as inedible fungi, as they are widely used in food processing. However, their tough texture and bitter taste make them unpalatable for direct consumption. However, processing it into powder or extracts enables its use in various food products, such as bread and beverages, making its bioactive compounds more accessible (Tian *et al*. 2023). Lastly, the classification of certain mushrooms as non-edible does not necessarily imply toxicity; instead, many are impractical for consumption due to their physical characteristics. Examples from the collections include *Bisporella citrina, Coprinellus disseminatus, Mycena flavescens, Mycena rosella, Fomitopsis pinicola, Xylaria polymorpha, Cyathus stercoreus, Coriolopsis aspera, Microporus xanthopus, Lenzites* sp., *Stereum ostrea, Tyromyces chioneus,* and *Marasmius capillaris.* Despite being non-edible, many fungi hold significant value beyond food applications. Their functional properties can contribute to advancements in pharmaceuticals, agriculture and material sciences.

Conclusion

The secondary forests and agroforests of Bazal, Maria Aurora, Philippines, are natural habitats of 121 macrofungal species from two phyla, six classes, 14 orders, 35 families and 52 genera. The distribution is primarily influenced by the habitat types and elevation, wherein the abundance of varying substrates and lower elevations promote greater macrofungal diversity. Notably, out of 165 documented collections, 30 specimens were successfully tissue cultured for further studies. The molecular identification of 60 macrofungal species, which are morphologically identified down to the genus level is currently being studied in our laboratory. The findings of this study implicate the strong interaction between macrofungi, the environment, and the impact of anthropogenic activities. This suggests that future conservatory efforts must consider the dynamics and complexity of the ecology of Bazal, Maria Aurora, and the economic conditions of the community that depends on its rich flora and fauna.

Acknowledgements

The authors sincerely acknowledge the Department of Science and Technology-Science Education Institute (DOST-SEI), Philippines, for providing support by having a CIP Graduate fellow, Mr. Kenneth Rivera, in this project. The authors also extend their appreciation to their field guides from the Aurora State College of Science and Technology (ASCOT) and to Mr. Eduard Manzano, Mr. Rabbi Daniel Elas, Mr. Bismark Francisco, Ms. Vivian Baylon, and Ms. Luelyn Reyes for their invaluable assistance in collection and technical support.

Author Contributions

Conceptualization: RD, SK, KK, TK, RR, FE and AC; Methodology: RD, RR and AC; Investigation: RD, AC, RR, RN, RP and KR; Resources: RD and RR; Original draft preparation: RD, AC and RR; Review and editing: RD, AC, RP and RR; Supervision: RD and RR. All authors read and approved the final manuscript.

Conflict of Interest

All authors declare no conflict of interest

Data Availability

Data presented in this study will be available at fair request to the corresponding author.

Ethics Approval

The Ethical clearance of the project from the CLSU Ethics Review Committee was issued and received by the authors on October 27, 2023.

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