

Biodiversity of Macrofungi: A Literature Review

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ABSTRACT

Macrofungi are known to be heterotrophic eukaryotes that dwell in rotten wood, decaying matter, grassy ground, and other substrates. Most of them are saprotrophs or decomposers. They provide a big contribution to nutrient cycling as primary producers. The diversity of macrofungi are studied across the globe yet 10% of the species are only identified. This review aimed to provide a systematic information of the diverse species of macrofungi that were collected in the selected sample sites of the Philippines specifically in Catanduanes, Laguna, Nueva Vizcaya, Northern Samar, and Camarines Sur. A total of 250 macrofungal taxaspecies were collected from the five different sample sites. 25 species were found to be present in Nueva Vizcaya, 71 species in Laguna, 81 species in Catanduanes, 39 species in Northern Samar, and 35 species in Camarines Sur. The top 5 families with the most number of species are *Psathyrellaceae*, *Marasmiaceae*, *Tricholomataceae*, *Agariceae*, and *Polyporaceae*. The family with the highest number of species collected was known to be *Polyporaceae* with a total of 62 species and are present in each sample site. Thus, the dominance of this species is evident as it corresponds to the climate and substrate in the country. To maintain the species richness in the area, regular monitoring of macrofungi should be implemented. It is also recommended that more studies of macrofungal biodiversity should be conducted in the Philippines.

Key words: macrofungi, *Polyporaceae*, Ascomycota, Basidiomycota, taxonomy, saprophytic, biodiversity

INTRODUCTION

The third kingdom of organisms, fungi, is made up of a wide variety of heterotrophic eukaryotes with chitinous cell walls that range from unicellular to syncytial filamentous forms and are split into six phyla: Ascomycota, Basidiomycota, Chytridiomycota, Glomeromycota, Microsporidia, and Zygomycota (Kirk et al., 2008, cited in Azeem et al., 2020). Most of the described fungi belonged to the subkingdom Dikarya which consists of *Ascomycota*, *Taphrinomycotina* (yeast-like and some filamentous fungi), *Saccharomycotina* (the true yeasts) and *Pezizomycotina* (with majority of the filamentous and mushroom-forming ascomycetes), and *Basidiomycota*, *Pucciniomycotina* (rust fungi-plant pathogens), *Ustilaginomycotina* (true smuts, some yeasts, and some filamentous fungi), and *Agaricomycotina*, the most of the mushroom-producing fungi (Cannon et al., 2018, cited in Azeem et al., 2020).

Macrofungi are organisms with reproductive structures that can be seen with a naked eye. They are called ascocarps and basidiocarps. Respectively, they are significant in representing Ascomycota and Basidiomycota. Many of them are saprotrophs or decomposers which provide a big contribution to nutrient cycling as primary producers, as well as play a significant role in food web (Lodge et al., 2004, cited in Cavalacante et al., 2021). They are best grown in rainy seasons and can flourish in all kinds of substrates such as rotten wood, decaying organic matter, grassy ground, etc. (Lopez-Quintero et al., 2012, cited in De Leon, 2021). Macrofungi are a big part of the forest ecosystem. They provide a variety range of ecosystem services such as medicinal, ecological, and biotechnical applicatons (Hyde et al., 2029; Kinge et al., 2020).

They are known to participate in nutrient cycling and also act as decomposers and mutualistic symbionts, which are essential in humans' needs (Yadav et al., 2021).

Studies about macrofungi are widely conducted throughout the globe. In Akwa Ibom State, Nigeria, 60 species of wild macrofungi were found to be present in forest areas (Okon et al. 2022), whereas in the urban city of Jena, Germany, 1172 species of basidiomycetes are found in a 4500-hectare area (Purahong et al., 2022). In addition, 46,124 out of 69,000 discovered fungi are Basidiomycetes and Ascomycetes (Karim et al., 2013 cited in Purahong et al., 2022). In a 14,000 identified species globally, more than 2,000 characterized species are found edible or medicinal (Meenu & Xu, 2019).

May local studies were also conducted about macrofungi: Dulay et al. (2022) reported to have found 116 macrofungi in Tarlac Province; and Jacob et al., (2022) stated that 367 validated species in the country from 1906 up to the present, which are recorded and are classified to 66 families and 130 genera. These records may not be a surprise as Philippines is one of the mega-biodiverse countries in the world as it ranks 5th in the number of plant species, and 5% of the world's flora of which are Philippine species (Convention on Biological Diversity).

Analyzing the weather conditions from the Philippines, its climate is tropical and maritime with a relatively high humidity, temperature, and precipitation. Except for Baguio City, the country's average temperature is 26°C. The months of June to November consists of rainy seasons. The relative humidity ranges from 71%-85% in the months of March to September. The rainfall distribution depends from one region to another, as it has different winds and mountain systems. With this discovery from PAGASA (2022), the diversity of macrofungi is widely present in the country as the fruiting body formation of the macrofungi is favorable in the soil's humidity, and air temperature (Ruijten, 2021). Although macrofungi may be the one who had the longest history of diversity studies of any group of fungi, yet some species remain undiscovered. Of the 1.5 million species of fungi, 140,000 species of which are macrofungi, and only 14,000 are identified (Meenu & Xu, 2019). It means that only 10% are officially named.

This review aimed to collate the results obtained from the studies conducted in the Philippines about identifying and classifying the macrofungal species through their morphological characteristics. Its aim was to provide a systematic information with its diverse species present in the selected provinces of the country. Furthermore, the environmental factors of Macrofungal occurrence was also discussed.

MATERIALS AND METHODS

Their studies were conducted in the selected sites of the province of Camarines Sur, Laguna, Bugkalot tribal community in Alfonso Castañeda, Nueva Vizcaya, Northeastern Samar, and Northern Catanduanes.

The desired quadrats were laid out, all macroscopic fungi found inside the quadrat were photographed, collected, identified and classified (Tadosa et al., 2021). Following the study of Lodge et al. (2004), the size, colour, shape and texture of the sporocarp were recorded during field observation due to the changes that might occur if the macrofungi's features are involved in drying. The macrofungi was then identified based on macroscopic features. The cap size, shape, colour, surface texture and moisture, gill colour, attachment, spacing, lamellules, the stem size, and shape are involved in macromorphological characterization. For further analysis and preservation, the macrofungi were kept each in different labelled envelope to avoid contamination of its spores (Rahayu et al., 2021).

The macro and microscopic characterization of macrofungi were identified in the following literatures: A Field Guide to the Larger Fungi of FRIM (Lee, 2017 cited in Rahayu et al., 2021), a guidebook to the macrofungi of Tasik Bera (Zainuddin, 2010 cited in Rahayu et al. 2021), and a guide book to the macrofungi of Fraser's Hill (Thi, 2011 cited in Rahayu et al., 2021). The works of Tadosa and Arsenio (2014), and

Quimio and Capilit (1983), cited in Paguiguiran et al. (2020) and the works of Kuo (2020) were also included.

RESULTS AND DISCUSSION

Table 1: List of species collected in five different sample sites.

FAMILY	NUEVA VISCAYA	LAGUNA	CATANDUANES	NORTHERN SAMAR	CAMARINES SUR	Total no. of Species:
<i>Bolbitiaceae</i>	1					1
<i>Crepidotaceae</i>	1	1				2
<i>Marasmiaceae</i>	2	2	3	4	2	13
<i>Mycenaceae</i>	1	1	3		1	6
<i>Pleurotaceae</i>	1	1	2			4
<i>Psathyrellaceae</i>	3	1	3	6	1	13
<i>Schizophyllaceae</i>	1	1	1	1	1	5
<i>Tricholomataceae</i>	1	5	2	1	1	10
<i>Auriculariaceae</i>	1	1	2	2	3	9
<i>Boletaceae</i>	1	2				3
<i>Hymenochaetaceae</i>	1		1		1	3
<i>Ganodermataceae</i>	1	2	5	2	1	11
<i>Meripilaceae</i>	1					1
<i>Polyporaceae</i>	7	14	22	10	9	62
<i>Russulaceae</i>	2		1	1		4
<i>Cudoniaceae</i>		1				1
<i>Geastraceae</i>		1				1
<i>Hysteriaceae</i>		1				1
<i>Pezizaceae</i>		1			2	3
<i>Sarcoscyphaceae</i>		3	3	1		7
<i>Xylariaceae</i>		3				3
<i>Agariceae</i>		5	1	2	2	10
<i>Amanitaceae</i>		1				1
<i>Clavariaceae</i>		3	1			4
<i>Hynangiceae</i>		2	1			3
<i>Hygrophoraceae</i>		4	1	1		6
<i>Physalacrisceae</i>		1	2			3
<i>Strophariaceae</i>		3				3
<i>Cantharellaceae</i>		1				1
<i>Corticaceae</i>		1				1
<i>Podoscyphaceae</i>		1				1
<i>Fomitopsidaceae</i>		1	1	3	1	6
<i>Meruliaceae</i>		1	1	1	1	4
<i>Phaeoloceae</i>		1				1

Table 1 continued: List of species collected in five different sample sites.

FAMILY	NUEVA VISCAYA	LAGUNA	CATANDUANES	NORTHERN SAMAR	CAMARINES SUR	Total no. of Species:
<i>Stereaceae</i>		3			3	6
<i>Thelophoraceae</i>		1	1			2
<i>Trameliaceae</i>		1	1		1	3
<i>Coriolaceae</i>			5			5
<i>Dacrymycetaceae</i>			1	1		2
<i>Gomphaceae</i>			1			1
<i>Pezizaceae</i>			1			1
<i>Phallaceae</i>			1			1
<i>Pterulaceae</i>			1			1
<i>Serpulaceae</i>			2			2
<i>Stereaceae</i>			2	1		3
<i>Xylariaceae</i>			4	2		6
<i>Cortinatiaceae</i>			1			1
<i>Omphalotaceae</i>			1			1
<i>Paxillaceae</i>			1			1
<i>Pluteaceae</i>			1			1
<i>Strophariaceae</i>			1			1
<i>Xylariales</i>					4	4
<i>Hypoxylaceae</i>					1	1
TOTAL	25	71	81	39	35	250

The results show that a total of 250 macrofungal species were collected from the five different sampling sites. 25 species were found to be present in Nueva Vizcaya, 71 species in Laguna, 81 species in Catanduanes, 39 species in Northern Samar, and 35 species in Camarines Sur. The family with the highest number of species is *Polyporaceae*. 15 families which had the lowest species are *Bolbitiaceae*, *Hypoxylaceae*, *Gomphaceae*, *Pezizaceae*, *Phallaceae*, *Pterulaceae*, *Phaeoaloceae*, *Cantharellaceae*, *Corticaceae*, *Podoscyphaceae*, *Amanitaceae*, *Cudoniaceae*, *Geastraceae*, *Hysteriaceae*, *Bolbitiaceae*.

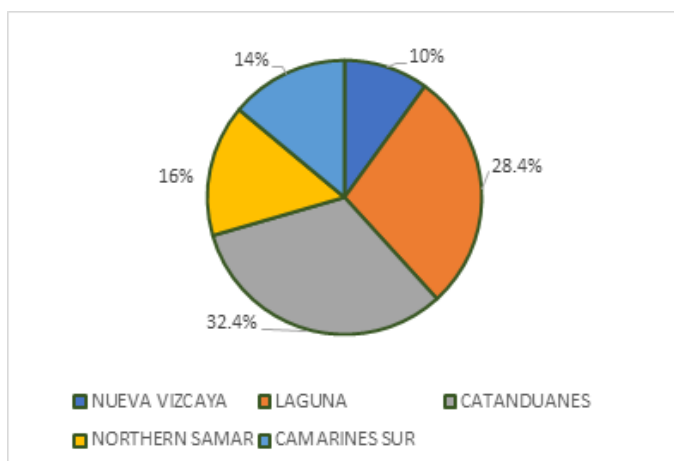


Figure 1: Percentage of number of species collected in each sample site

Among the five sample sites, Catanduanes had the most number of species collected with a percentage of 32.4%. The least number of species was found in Nueva Vizcaya with a percentage of 10%. Catanduanes is an island of mountainous terrain with narrow coastal plains and interior valleys. Moreover, the amount of substrate in this area had a significant effect on the growth of macrofungi. The observed macrofungal diversity was supported by the presence of tree trunks, branches, roots, and leaves (Tadosa et al., 2021).

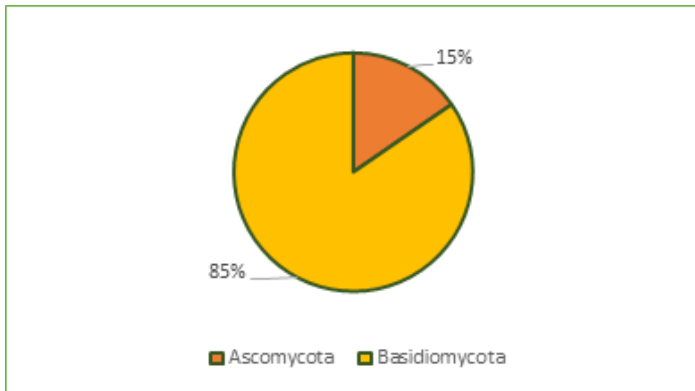


Figure 2: Percentage of Ascomycota and Basidiomycota collected in five different sample sites

Out of 52 families, 44 are Basidiomycetes consisting of 85% and 8 are Ascomycetes, of which are 15%. Most taxonomic characterization that occurred in some studies were viewed on the Basidiomycetes (Musngi et al., 2005 cited in Paguiguiran et al., 2020) where it was found similar in this study. The species that were mostly collected were identified to be wood-rotters, which grow on decaying media such as bamboos, twigs, logs, and tree trunks. These Basidiomycetes contribute a significant role in the ecosystem since they degrade the residues of lignocellulose plants and trees (Chang & Chou, 1995 cited in Torres, 2020).

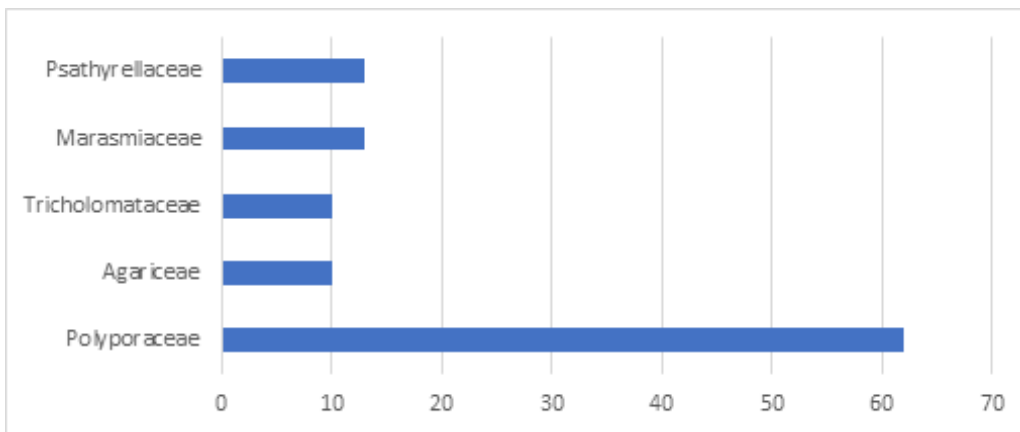


Figure 3: Top 5 Families with the most number of species

The top 5 families with the most number of species are *Psathyrellaceae*, *Marasmiaceae*, *Tricholomataceae*, *Agariceae*, and *Polyporaceae*. The family with the highest number of species identified was known to be *Polyporaceae* with a total of 62 species and are present in each sample site. The next two highest species were found in the families of *Marasmiaceae* and *Psathyrellaceae*, both had 13 species. The third highest number of species are *Tricholomataceae* and *Agariceae*, both had 10 species.

The polypores, or bracket fungi are the major species that occur on the stumps and tree trunks. They are either parasites that live on trees or saprophytes inhabiting on dead woods. Their textures are woody as they maintain their attachment to the host year after year (Yuan et al., 2023). These macrofungi are present in all types of ecosystems but survive mostly in mountainous areas and grasslands where they obtain nutrients

from the branches, roots, trunk, bamboo, and rotten wood (Tadiosa et al., 2021).

Factors that affect Macrofungal Growth

Macrofungi produces composite enzymes that are able to degrade environmental pollutants Uddin *et al.* (2020). Furthermore, they produce organic compounds that bind soil particles to enhance the soil formation, structure, and absorption (Oregon State University Extension Service, 2021).

The species richness is one of the factors that contributes to the survival of macroscopic fungal growth. There is a strong influence of environmental factors, specifically the availability of water, air temperature, vegetation density, and humidity (Wati et al., 2019). The greater the diversity of macrofungi will be if there is a higher vegetation density (Ekyastuti et al., 2023).

The diversity of species and its richness depend to its different habitats. This study was conducted in the mountainous regions of Laguna, Camarines Sur, Nueva Vizcaya, Northeastern Samar, and Northern Catanduanes where humidity is high, thus it was similar in the findings of Schmit et al. 2005, cited in Soriano et al., 2021). In the places with denser canopy and vegetation, scorocarps are more visible. Habitats with areas that are involved in agroforestry have lesser floral species diversity compared to unmanaged forests (Martinez et al., 2009 cited in Soriano et al., 2021). Climate is recognized to be a factor for fruiting body formation and seasonal changes have been linked to changes in the phenology, abundance and distribution of fungal species (Sutjaritvorakul et al., 2017 cited in Yuan, et al., 2023).

CONCLUSIONS AND RECOMMENDATIONS

A total macrofungal taxa 250 species were collected from the five different sample sites. 25 species were found in Nueva Vizcaya, 71 species in Laguna, 81 species in Catanduanes, 39 species in Northern Samar, and 35 species in Camarines Sur. The family with the highest number of species is Polyporaceae with a total of 62 species and are present in each sample site. Polyporaceae is known to be present on dead woods and maintain its attachment to the host year after year. Thus, the dominance of this species which corresponds to the climate and substrate present in the sample sites of the Philippines is not surprising. In addition, Catanduanes had the most number of species consisting 32.4% of the total collection. It was found out that Catanduanes consists of mountainous terrain and a good substrate where the macrofungal biodiversity was observed. To maintain the species richness in the area, regular monitoring of macrofungi should be implemented. It is also recommended that more studies of macrofungal biodiversity should be conducted in the Philippines.

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