p-ISSN 2012-3612 | e-ISSN 2782-8824
www.edjournal.cfnr-uplb.org

Ecosystems and Development Journal
Volume 11 | Numbers 1 & 2 | pp. 82–92 | 2021

Macrofungal taxa and diversity for monitoring of productivity and sustainability of Bombongan-Lewin Subwatershed in Laguna, Philippines

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ABSTRACT. Macroscopic fungi (Basidiomycetes and Ascomycetes) are equally important organisms with other lifeforms. They sustain the watershed ecosystem's productivity through nutrient cycling and decomposition, carbon storage, and plant symbiosis. However, there is a paucity of information and limited appreciation of fungal resources as an integral component of watersheds. This paper examined species composition and macrofungal diversity for monitoring the productivity and sustainability of the Bombongan-Lewin Subwatershed (BLW). With the help of stakeholders, a 2–ha permanent biodiversity monitoring plot was established and subdivided into 50 subplots measuring 20 x 20 m each. The fungal habitat was categorized across vegetation types and land use, while soil at the rhizosphere layer was collected for physicochemical analysis. Macroscopic fungi were sampled during wet months for morpho-anatomical characterization using a classical approach for identification. Population dynamics were determined, including substrates, density, biomass, importance values, diversity index, and structured community survey. The fungal habitats were generally classified as natural forest and agroforestry plantations where soil pH is strong to moderately acidic (pH 3.4 – 4.7). The total macrofungal taxa recorded were 163 species from 56 genera and 35 families. Fruiting bodies mainly inhabit secondary growth forests where litter was abundant with relatively higher soil phosphorus (7%) and potassium (40–50%). Functional values were represented by taxa of wood decomposers, mycorrhizas, and food sources. Fungal habitats showed very high to moderate Shannon diversity (H'= 4.11–2.48) with a significant difference at 5% level ($F_{6,234} = 0.27$, $F_c = 9.94$) using Scheffe's pairwise comparison. Fungal biomass ($r = 0.83–0.86$, $p < 0.05$) and habitat area ($r = 0.88–0.91$, $p < 0.05$) have strong positive correlations with species richness, abundance, and diversity, indicating their ecological importance. Knowledge sharing and appreciation of fungal values for continued regular biodiversity monitoring and conservation are important to sustain watershed functions.

Keywords: biodiversity conservation, ecological restoration, ethnomycological survey, fungal habitat, mycorrhizas

INTRODUCTION

Fungi are an integral component of watersheds, given their unifying role in maintaining soil productivity and growth of diverse plant life. Watersheds are self-sustaining ecosystems highly dependent on forest health and water quality. Fungi have a primary role in wood decomposition and nutrient cycling in forest ecosystems, sustaining forest regeneration worldwide (Lonsdale *et al*. 2008). Studies show that fungi contribute up to 50% of primary productivity and about 80% recycling of soil macronutrients, namely nitrogen, phosphorous, and potassium (Brearly *et al*. 2016; Fogel & Hunt 1983). Specific groups of fungi facilitate the decomposition of leaf litter and wood. Lignin, a component of the leaves, is the target of lignin-degrading fungi on the forest floor. Basidiomycetes causing brown rot and white rot degrade cellulose, hemicellulose, and lignin in wood. More humus is being produced when ligninolytic fungi are abundant, indicating soil fertility (Osono 2007). Mycorrhizas, the fungi associated with plant roots, facilitate the exchange of water and nutrients, which occurs at the site of infection. Mutualism benefits plants by increasing

resistance to pests and diseases and improving nutrient uptake on problem soils (Tahat *et al*. 2010; Hoff *et al*. 2004). These processes highlight the significant role of the macrofungi, which could contribute to assessing the productivity of watersheds despite degradation issues that limits watershed carrying capacity (Cruz 1998).

Since fungi are known heterotrophs reliant on moisture and organic substrates to grow, they are natural indicators of watershed stability. Their high sensitivity to environmental variables is evident in species composition, abundance, and diversity in some of the country's important watersheds, protected landscapes, and mountain ecosystems (Tadiosa *et al*. 2011; Arenas *et al*. 2015; Nacua *et al*. 2018; Parlucha *et al*. 2021). Current literature, however, has not yet fully described the macrofungal communities present in the BLW, which could provide additional important taxa to supplement previous mycological works in the area (Pampolina *et al*. 2014; Niem & Baldovino 2015). To proceed with biodiversity conservation planning, identifying fungal taxa is crucial to developing population estimates and abundance trends through baselining and monitoring activities (Dahlberg & Mueller 2011). Hence, this paper aims to investigate the macrofungal species composition, diversity, and assess community perception of fungal resources to sustain the ecological functions of the BLW in Cavinti, Laguna. It is hypothesized that forest land use affects fungal species composition and diversity. Information generated would provide insights towards formulating relevant policies for biodiversity monitoring, conservation, and sustainable management of the subwatershed.

METHODOLOGY

Site description

The Bombongan–Lewin Subwatershed (BLW) lies at the southeastern portion of Laguna Bay (14° 37' to 14° 21' N 121° 24' to 121° 37' E). The watershed (**Figure 1**) covers eight municipalities including Cavinti, Kalayaan, Luisiana, Lumban, Magdalena, Majayjay, and Pagsanjan in the Province of Laguna, and Lucban in Quezon. The total land area of the subwatershed is 13,352 ha, of which only 3,176 ha of the total area is left as an open canopy forest based on the land use map (Cruz 2014). The climatic condition reflects Type 4 of the Corona classification system, in which the rainfall is distributed all year round. April and July were the driest months, while abundant rainfalls in May. The current land use is mainly for agricultural cultivation, domestic, and industrial uses.

Establishment of plots and collection of macrofungi

Prior to field sampling, the researchers coordinated with the local government units and secured gratuitous permits from the concerned DENR offices. A two-hectare biodiversity monitoring plot was established in Cavinti, Laguna, wherein fifty 20 x 20 m permanent field plots were delineated and marked. Within the plots, 10 x 10 m subplots were designated for the opportunistic sampling of macrofungi on soil, litter, and woody substrates. This sampling method accounts for conspicuous fungi or identifiable fruiting bodies. Sampling was conducted during the wet months (June to August). The fungi were recorded in a field notebook with the following information: plot where it was collected, identification code, substrate, and distinct features, along with photographs in its natural habitat. Photos of fungi on the substrate were taken to provide valuable information like pigmentation, odor, texture, presence or absence of sap, the distance of lamella in gilled sporocarps, the structure of stalk, and other features. Samples of sporocarps were collected and transferred in paper bags using a trowel. Fleshy mushrooms were pickled in enclosed containers with 30% ethyl alcohol to prevent desiccation.

Processing of fungal samples and identification

Samples of collected fungal sporocarps were processed after fieldwork to prevent deterioration. Dimensions (mm) and dry weights (g) of sporocarps were determined to identify and

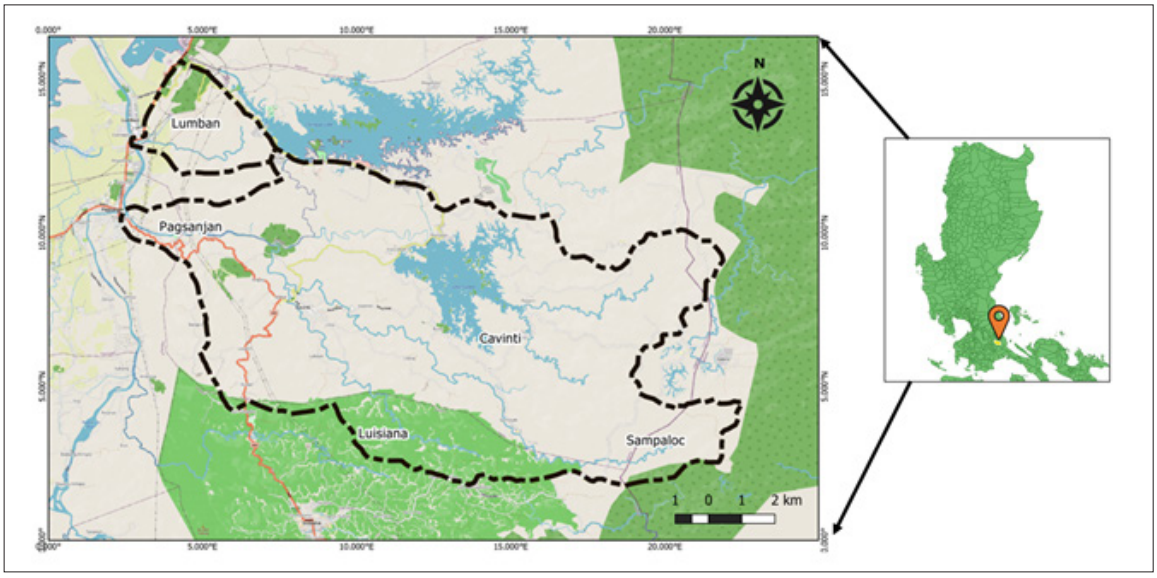

Figure 1. Map of the Bombongan-Lewin Subwatershed in Laguna, Philippines

calculate dominance values, respectively. Tissue samples were prepared on slides to examine the hymenial layer, spores, and other microscopic structures for photomicrography and characterization. Identification was made by comparing morphological and anatomical characters in published literature, online databases, and use of identification keys by Arora (1986), Quimio (2001), and Brundrett *et al*. (1996). The identity of fungal specimens was verified at the Museum of Natural History (MNH) collection, University of the Philippines Los Baños (UPLB). All samples of macrofungi were placed in paper envelopes with labels and preserved as voucher specimens at the mycological collections of the College of Forestry and Natural Resources (CFNR) in UPLB.

Soil collection and analysis

Within the 2–ha plot, composite soil samples were collected according to the type of vegetation, namely mixed forest, secondary growth forest, bamboo grove, rangeland, coconut farm, and *Lanzones* plantation. A 15 cm deep, 5 cm wide, and 2 cm thick soil was collected using a trowel. For each type, 5–10 soil samples were collected to represent the type of vegetation. Soil samples were stored in plastic bags, sealed with a rubber band, and properly labeled. After collection, unnecessary debris such as litter, roots, and pebbles was eliminated before the soil samples were air-dried for at least 24 hrs. Routine analysis of soil pH, percentage organic matter, and nitrogen, phosphorus, and potassium concentrations was determined at the Analytical Soils Laboratory in UPLB.

Fungal diversity parameters and data analysis

Density, frequency, dominance, and relative values per fungal taxa were calculated (Magurran 1988). Fungal diversity was determined using the importance values of each taxon. The Shannon Weiner (H') and Evenness (E) indexes were calculated to compare the richness and abundance of the macrofungi in each habitat. A modified five-point scale was used to describe species diversity from very low to very high. The formulas used were as follows:

(Equation 1)

$$H' = -\sum \frac{Ni}{N} \times \ln \frac{Ni}{N}$$

(Equation 2)

$$E = \frac{H' \text{ value of species}}{\ln (\text{total number of all species in fungal habitat})}$$

The data were tested for normality using the Shapiro–Wilk test. Diversity using a one-way analysis of variance (ANOVA) at 95% confidence interval ($\alpha = 0.05$). Using Scheffe's test, means were compared for significance among variables. Relationships between soil and fungal diversity parameters among fungal habitats were compared using Rstudio version 1.4.1717 (R Studio Team 2021).

Ethnomycological survey

Household interviews were conducted to identify valuable and edible macroscopic fungi not documented in the field. The survey questionnaire contains information on edible fungi, ecology, and important uses in the community. Respondents were chosen through stratified random sampling of barangays and households of the BLW, particularly from Lumban and Cavinti. Results were analyzed using descriptive statistics.

RESULTS AND DISCUSSION

Fungal habitat categories

Seven fungal habitats were identified within the 2–ha biodiversity monitoring plots, which comprise natural forest and cultivated land (**Figure 2**). The designation was based on the dominant vegetation and land use type, namely: bamboo grove (BG), coconut farm (CF), scrubland (SL), *Lanzones* plantation (LP), mixed-land use type forest (MF), rangeland (RL), and secondary growth forest (SGF). Generally, the MF and SGF have more floral species in canopy and undergrowth vegetation consisting of ferns and herbs. Managed plots, such as in CF and RL, have an open canopy with grass cover. Field data showed that SGF plots have the highest area covered and highest species richness (n = 74), followed by MF (n = 55), and least in RL (n = 2).

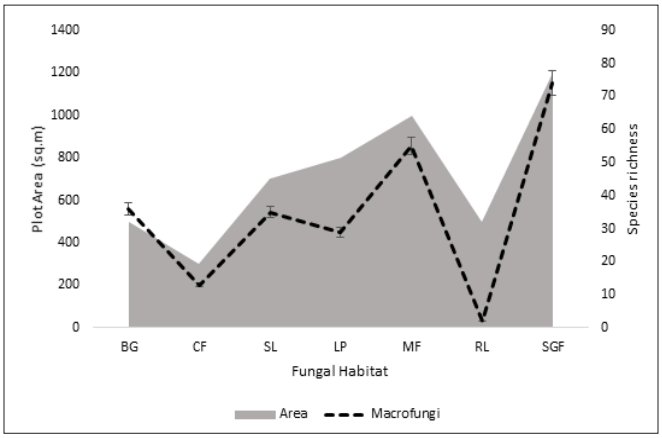

Figure 2. Fungal habitats in the 2–ha biodiversity monitoring plot and macrofungal taxa counts. *(Legend: BG = bamboo grove; CF = coconut farm; LP = Lanzones plantation; MF = mixed forest, SL = scrubland; RL= rangeland; SGF = secondary growth forest.)*

Soil characteristics

Results of the soil analysis of the fungal habitats are summarized in **Table 1**. Soil pH in all fungal habitat show moderate to strong acidity. Bamboo grove was the most acidic habitat with pH 3.4. Whereas coconut farm, *Lanzones* plantation, mixed forest, and secondary growth forest equally have a pH of 4.7. The organic matter (%OM), nitrogen (N), and phosphorus (P) did not significantly vary among the habitats. The secondary growth forest has the highest potassium (0.92 K me^{-1} 100 g $soil^{-1}$), while soil carbon is highest in mixed forest (6.36 C).

Table 1. Soil characteristics of the 2-hectare biodiversity monitoring plot of Bombongan–Lewin Subwatershed.

Fungal habitat	pH	%OM	%N	P (ppm)	K (me^{-1}100 g $soil^{-1}$	Total C
LP	4.7	3.6	0.19	1.1	0.72	6.19
MF	4.7	3.7	0.2	1	0.77	6.36
SGF	4.7	3.1	0.18	1.4	0.92	5.33
CF	4.7	3.2	0.14	1	0.52	5.50
RL	4.6	3.2	0.17	1.3	0.42	5.50
BG	3.4	3.4	0.19	1.4	1.65	5.85

Legend: BG = bamboo grove; CF = coconut farm; LP = Lanzones plantation; MF = mixed forest; RL= rangeland, SGF = secondary growth forest.

Macrofungal taxa composition of Bombongan-Lewin Subwatershed

A total of 163 taxa of macroscopic fungi from 56 genera belonging to 35 families and 16 orders were identified based on morpho-anatomical characters. The dominant group was the Basidiomycetes (94%) compared to Ascomycetes (6%). The 16 identified orders and their distribution in all habitats are shown in **Appendix 1**. Most of the fungi identified were under the order Agaricales (14 families), in which the family Marasmiaceae has the highest species richness (n = 26). It was followed by order Polyporales (5 families) with identified 28 taxa of Polyporaceae.

The current study shows a higher number of basidiomycetes than ascomycetes as a common trend in literature conducted in watershed ecosystems (Lapitan *et al*. 2010; Tadiosa *et al*. 2011; Nacua *et al*. 2018). In Cavinti, Laguna, fungal surveys from a Karst forest type reported 41 species from 34 genera from over 500 samples with *Daldinia concentrica* (Bolton) Ces. & De Not. As the most abundant (Niem & Baldovino 2015). The variation in the species richness is attributed to different fungal habitats representing the BLW. The study was similar to Schmit *et al*.'s (2005) findings, wherein they found that the abundance of trees in an ecosystem was a reliable basis for estimating macrofungal richness. The sporocarps tend to appear more in habitats with denser canopy and vegetation, including those with a high tree, shrubs, and understorey biomass. Habitats converted into agroforestry production areas have lesser floral species diversity than in natural, unmanaged forests (Martinez *et al*. 2009). Further, some macrofungi considered rare species in the present study are possibly new records in the BLW area, namely, *Geastrum saccatum* Fr., *Crepidotus* sp., *Irpex* sp., and *Cymatoderma elegans* Jungh. (**Figure 3**).

Functional values of macrofungi

Ten fungal substrates were determined from all habitats (**Figure 4**). Overall, woody substrates (*e.g*. felled log, wood slab, tree branch) were the most abundant. Macrofungal species that thrive on wood were from the order Podoscyphales, Polyporales, Theleporales, Tremellales, and Xylariales. This is followed by the fungal species thriving in soil and leaf litter. The small fruiting bodies of Marasmiaceae were observed on the leaf litter and occasionally on twigs. Some species of Agaricales like the Pluteaceae and Hygrophoraceae are mycorrhizal.

Moreover, the Agaricales fungi did not thrive on one specific substrate type like those in Marasmiaceae, Mycenaceae, and Strophariaceae. Parasitic fungi from Polyporales were species of *Fomitopsis*, *Phellinus*, and *Favolus alveolarius*

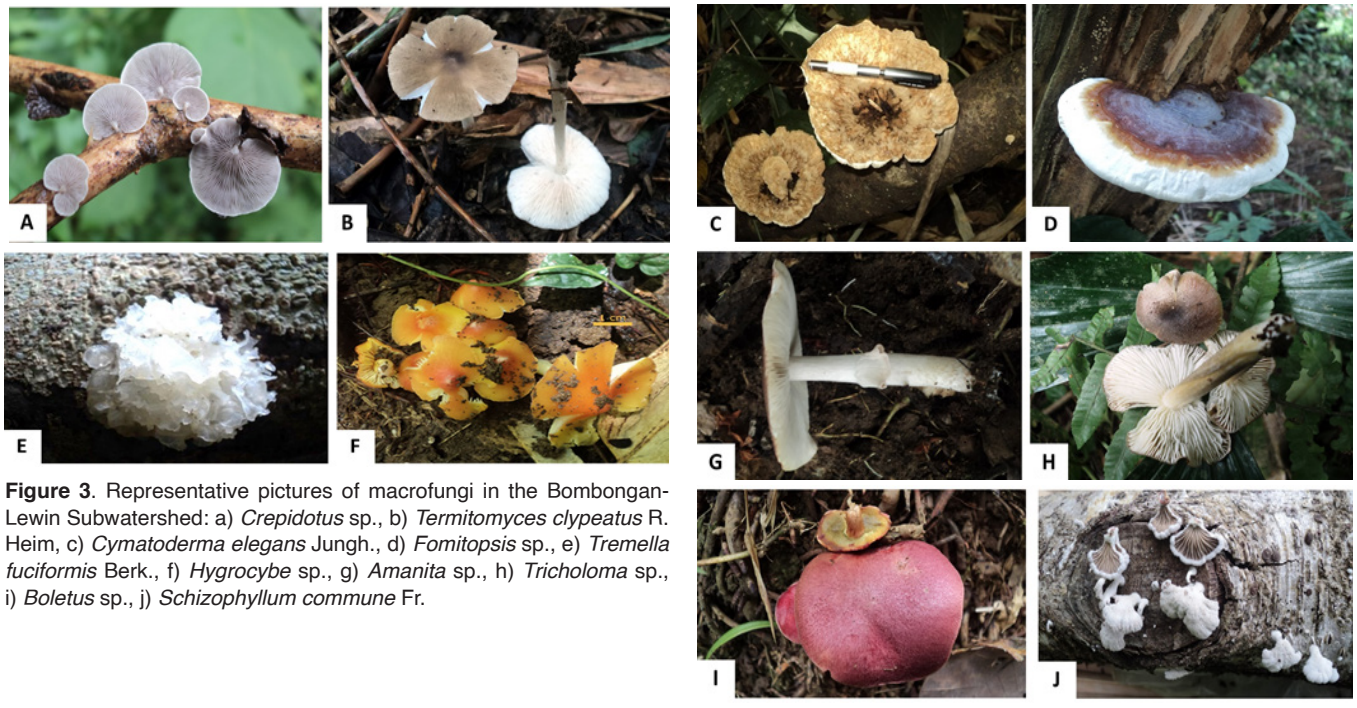

Figure 3. Representative pictures of macrofungi in the Bombongan-Lewin Subwatershed: a) *Crepidotus* sp., b) *Termitomyces clypeatus* R. Heim, c) *Cymatoderma elegans* Jungh., d) *Fomitopsis* sp., e) *Tremella fuciformis* Berk., f) *Hygrocybe* sp., g) *Amanita* sp., h) *Tricholoma* sp., i) *Boletus* sp., j) *Schizophyllum commune* Fr.

Bosc (Fr.). These bracket fungi attack living trees, although *Oudemansiella* sp., an agaric, thrives in living trees and dead trees. Species of *Favolaschia*, *Collybia*, and *Marasmius* decompose decaying fronds and husks of coconut. Animal manure was the least abundant substrate, which allowed the growth of species of *Coprinus* and *Aleuria*.

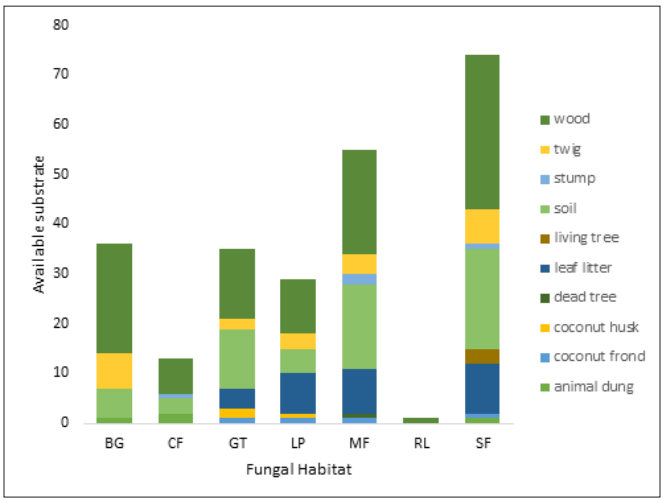

Figure 4. Distribution of organic substrates in different fungal habitats of the 2–ha Biodiversity monitoring plot of Bombongan–Lewin Subwatershed. (*Legend: BG = bamboo grove; CF = coconut farm; LP = Lanzones plantation; MF = mixed forest, SL = scrubland; RL= rangeland, SF = secondary growth forest).*

The proportion of saprophytic fungi is higher (89%) than mycorrhizal species (11%). Thus, all the fungi species with the highest importance values (IV) were saprophytes or decomposers of organic debris, while some species also parasitized living trees. These fungi are either known as facultative saprophytes or facultative parasites. When the fungi find a susceptible tree, the saprobic fungus uses the opportunity to obtain nourishment leading to wood decay. This was observed in *Polyporus* and *Fomitopsis* that can only be found in habitats with trees and abundant woody substrate. The species with the highest IV in the bamboo grove was *Hysterium* sp. (35%), a fungus causing decay on bamboo culms. *Lepiota* sp. 3 was the highest (42%) in the coconut farm, acting as a decomposer of animal manure. The three habitats, namely the scrubland (51%), mixed forest (16%), and *Lanzones* plantation (58%), had *Polyporus* sp. 4 as the most important saprophyte. The bracket fungus decomposes wood and parasitizes some of the living trees in the field. As for the secondary growth forest, *Fomitopsis* sp. 1 had the highest IV defined by its biomass. The abundance of saprophytes in BLW suggests their contribution to natural pruning and thinning in the natural forests to maintain carbon pools and stabilize the nutrient cycling process. In addition, the ectomycorrhizal genera identified were *Amanita*, *Boletus*, *Cantharellus*, *Clavulinopsis*, *Hydnum*, *Hygrocybe*, *Hygrophorus*, *Laccaria*, and *Tricholoma*. These fungi were mostly found on bare soil with partial shade from the host plant and understory species. Interestingly, the recorded mycorrhizas have associations with locally important plant species. A sole specimen of *Amanita* is possibly associated with *Bamban* (*Donax canniformis* [(G. Forst.) K.Schum.], colonies of *Hygrocybe* and *Tricholoma* were abundant on *Pandanus simplex* Merr. understorey, *Cantharellus* were confined within bamboo groves, and *Boletus* sp. was found only on the roots of coconut trees (*Cocos nucifera* L.). The presence of the ectomycorrhizas within the habitat possibly indicates their nutritional roles in host plant productivity.

Table 2. Most important macrofungi per habitat in Bombongan–Lewin Subwatershed.

Taxa	Fungal habitat	(%) Importance value*	Ecological function
Hysterium sp.	Bamboo grove (BG)	35.40	Saprophyte; decomposer of twigs, bark, and bamboo culms (Jayasiri *et al.* 2018)
Lepiota sp. 3	Coconut farm (CF)	42.35	Saprophyte; indicator of low soil C and N (Reverchon et al. 2010)
Polyporus sp.12	Scrubland (SL)	51.12	Parasitic; cause of white-rot decay; food source of beetle larvae (Lee *et al.* 2016; Schigel 2011)
Polyporus sp.4	*Lanzones* Plantation (LP)	57.77	
Polyporus sp.4	Mixed forest (MF)	16.19	
Schizophyllum commune Fr.	Rangeland (RL)	100.00	Parasitic sap-rot fungus; early colonizer of wood (Takemoto *et al.* 2010)
Fomitopsis sp.1	Secondary growth forest (SGF)	15.33	Saprophyte; cause of brown-rot decay of trees (Liu *et al.* 2021)

**Formula for importance value IV = relative dominance + relative frequency + relative density*

Macrofungal diversity across habitat types

The computed Shannon index range from moderate to extremely high, and all six habitats show an even distribution (**Table 3**). SGF was the most diverse (H' = 4.11) with the most significant number of fungi observed, although its evenness index indicates the repetitive occurrence of taxa (E = 0.96). MF came next designated with very high diversity (H' = 3.87). The diversity of fungal species was high in BG, SL, and LP, indicating no significant differences. Further, CF has moderate diversity (H' = 2.48) and the highest evenness (E = 0.97). The computed values support the data in **Appendix 1** on common

and frequently occurring species that lead to high diversity. Shannon index of habitats in the watershed is comparable with fungal diversity values in other mountain ecosystems in Southern Luzon (Parlucha *et al*. 2021).

Table 3. Fungal diversity indices of the two-ha biodiversity monitoring plot of the Bombongan-Lewin Subwatershed.

Fungal habitat	Shannon index* (H')	Evenness index** (E)	Diversity category
Secondary growth forest (SGF)	4.112a	0.955	extremely high
Mixed forest (MF)	3.873a	0.966	very high
Bamboo grove (BG)	3.366a	0.939	high
Scrubland (SL)	3.284b	0.924	high
Lanzones plantation (LP)	3.078b	0.914	high
Coconut farm (CF)	2.481c	0.967	moderate

Means with the same letters are not the same.

**H^'= –∑Ni/N × ln Ni/N ** E = H' / ln (S)*

The ANOVA test revealed that the mean density and biomass values in all habitat types have no significant difference at a 95% confidence interval. However, the mean Shannon index values of the habitats indicate that at least two means were significantly different (F6,234 = 0.27, Fc = 9.94). Scheffe's test for comparison indicates that the Shannon index means of secondary growth forest-bamboo grove, coconut farm-rangeland is significant at 5% level. Positive correlations were evident among fungal biomass, diversity parameters, and soil properties (**Figure 5**). Biomass has a strong positive relationship (r = 0.83–0.86, p < 0.05) with fungal habitat area, Shannon diversity, richness, and abundance. Likewise, habitat area was positively correlated with Shannon diversity, fungal taxa richness, and abundance (r = 0.88–0.91, p < 0.05). Moderate correlations (r = 0.71) were shown by soil nitrogen with Shannon index. Evenness showed negative correlations with soil properties, while soil carbon has no linear relationship among variables.

Results of the correlation between fungal diversity and nitrogen in BLW confirm the study of Trudell & Edmonds (2004). Higher N supply in soil indicates abundant decomposers than mycorrhizas which were consistently observed in all fungal habitats. Fungi are sensitive to soil N, suggesting their usefulness as bioindicators in disturbed ecosystems. Although soil carbon has weak correlations with most variables, Bastida *et al*. (2021) reported that soil C was found to be positively correlated with fungal biomass (r = 0.65, p < 0.05) on a biome scale.

Uses of fungal resources in Bombongan-Lewin Subwatershed
The summary of the ethnomycological survey from 41 respondents is presented in **Figure 6**. In terms of habitat, most fruiting bodies were commonly found in farmland (61%) and

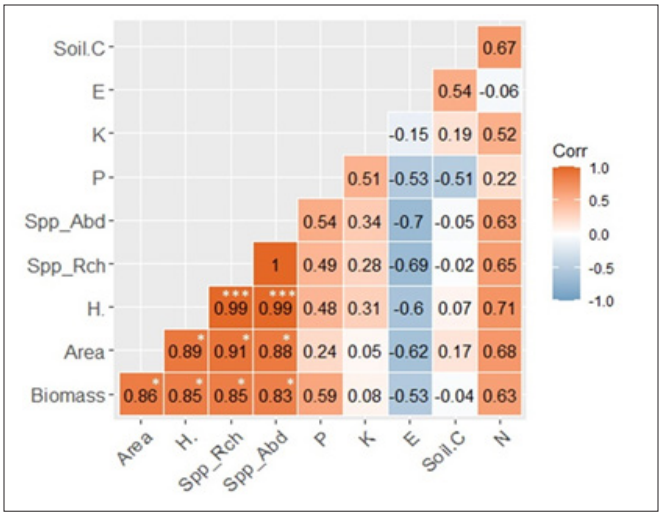

Figure 5. Correlation coefficients showing relationships between fungal biomass, diversity parameters (species richness, abundance, Shannon (H') index, evenness), and soil properties (soil C, N, P, K). Asterisk mark (*) means significance at a 5% level.

forests (20%). About 34% said they saw fungi on tree stumps, followed by soil (22%). The collection of fungi was mostly for food. Three of the respondents stated that they harvest edible fungi to sell in the market for subsidiary income. One harvested *Mamarang* (*Termitomyces albuminosa* (Beck.) Heim) and sold the fungi at PhP 200 for every five plastic bags. Other respondents said that annual profits ranged from PhP 20–37 kg^{-1} of *Mamarang*. This implies that fungi were occasionally an alternative food and income source. Harvesting of fungi is not site-specific, and the local community does not necessarily collect in the same locations. Respondents stated that fungi appear whenever lightning occurs and during wet seasons. Although the people were certain that fruiting bodies appear after thunder strikes, they were uninformed about why fungi exist and how they function in the environment.

About 75% of the respondents eat mushrooms. Some distinct characteristics that they consider as edible were the color (46%), substrate (17%), odor (6%), and presence of either ring or volva (4%). Based on their description, the edible fungi they consumed were identified as species of *Auricularia* (*Tengang daga*), *Termitomyces* (*Mamarang*/*Kabuting punso*), *Tricholom*a (*Kabuting lapad*/*dagat*'), and *Coprinus* (*Kabuting dayami*). Sporocarps were usually cooked with vegetables. None of the respondents stated any negative effects, such as allergies or stomach upsets after consumption. Indigenous knowledge based on personal accounts proved useful in recording fungi with the seasonal occurrence and potential for food, medicinal, and industrial applications (Musngi *et al*. 2005; De Leon *et al*. 2013). Edible fungi such as *Coprinus* and *Termitomyces* contain protein, tocopherols, crude fiber, and healthy fats (Stojkovic *et al*. 2013; Kansci *et al*. 2003). *Auricularia* was also a good source of minerals (Ca, Mg, K,, P, and Na), reaching over 1000 mg kg^{-1} dry mass^{-1} (Bandara *et al*. 2019). Yet, the ethnomycological survey results suggest the respondents' limited knowledge on the existence of fungi and their ecological functions in the environment.

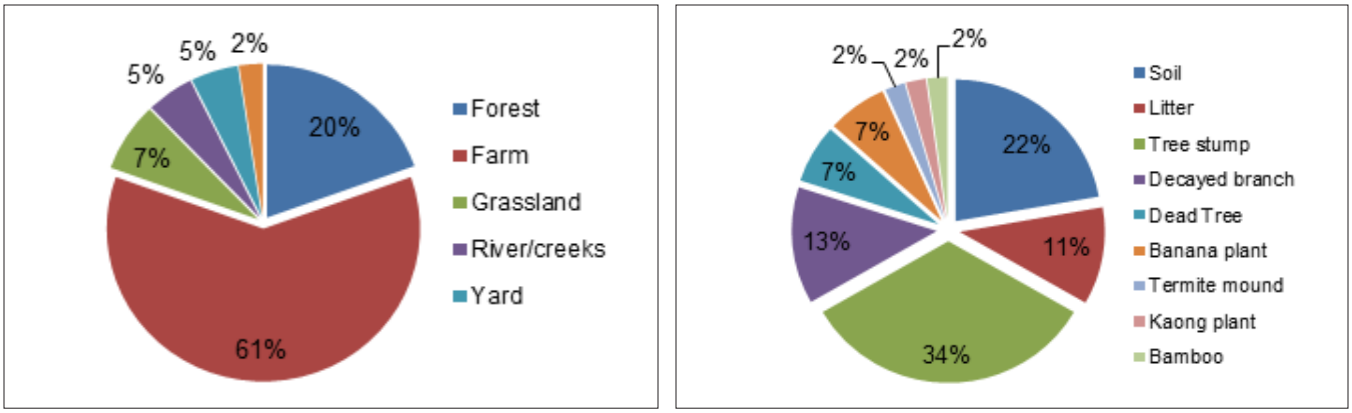

Figure 6. Fungal habitats (left) and substrates (right) identified by the respondents from Bombongan–Lewin Subwatershed.

Fungal resources conservation for watershed sustainability

The classical methods for fungal diversity remain reliable in comparing multiple data across different ecosystem types. Identifying macrofungi even to genus level and understanding fungal habitats were sufficient bases to determine priority areas for biodiversity conservation and sustainable watershed management in developing countries (Balmford *et al*. 2000; Schmidt & Lodge 2004; Ortega & Lorite 2007). However, few works of literature describe the population dynamics of specific fungi due to irregular fruiting coupled with a low level of awareness. A notable example from the current study was the variations in the occurrence of *Microporus* species from May to August. Microporus have five morphospecies in BLW during sampling. In dry periods, only two species occurred [*Microporus affinis* (Blume & T. Nees) Kuntze and *M. xanthopus* (Fr.) Kuntze]. Towards the rainy months, three more *Microporus* species appeared. Although the genus is not the most abundant in terms of biomass, they have 60–70% frequency in all habitats indicating moisture abundance and favorability of watershed for mycelial growth.

Results from completed surveys, research, and herbarium data should be organized to provide seasonal information. These can be utilized for documenting fungal populations for further verification using molecular techniques as additional information for the mycological community (Wollan *et al*. 2008). Moreover, effective dissemination of information on fungi diversity and its significant contribution to forest productivity should be popularized to reflect the management strategies for local governance needed for implementation in the watershed (Branco 2011; Taylor *et al*. 2013). The social paradigm remains an essential element in biodiversity conservation efforts where domestic values are specifically inherent in local communities across tropical countries (Brechin *et al*. 2002). In this study, several mycorrhizal fungi are mutually associated with plants having economic values. Information on hosts and niches of the fungi presents conservation priorities in the BLW. Raw materials for hat and basket weaving were sourced from natural forests, as observed in some damaged stands. Thus, stakeholders should be properly informed about the resources they depend on and the impacts of their activities in the fungal habitat and the BLW in general. Regular dialogue on watershed resources conservation at the community level involving multi-sectoral participation should also be addressed. The management strategies and policies would be the possible outputs for effective conservation efforts in the watershed.

CONCLUSIONS AND RECOMMENDATIONS

The macrofungal survey in the BLW revealed a diverse species composition and abundance of saprophytic and mycorrhizal fungi across habitats. High Shannon diversity index in the secondary growth forest within watershed suggests that macrofungi can influence the health of habitats by supplying organic substrates and soil nutrients. The macrofungi can function in maintaining the productivity of the watershed through nutrient cycling, decomposition, carbon storage, and mutual associations, notwithstanding their importance as a source of food, medicine, and livelihood. As one of the bioindicators of watershed conditions, regular monitoring of macrofungi should be conducted with equal importance among other life forms. The management of BLW should implement a policy of adopting science-based monitoring and biodiversity conservation schemes using a participatory approach.

ACKNOWLEDGEMENTS

This paper is part of the PCAARRD–DOST funded project "National Research and Development Project for Watershed Management." Special thanks to the local government units and community of Cavinti, Laguna. The authors are also grateful for the assistance of the study leaders, project staff, and students who helped make this study possible.

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Appendix 1. Taxa of macrofungi and habitats in Bombongan-Lewin Subwatershed (BLW) in Laguna.

Division/ Family	Fungal Taxa[1]	Fungal Habitat[2]
	ASCOMYCOTA	
Cudoniaceae	*Spathularia* sp.	LP SGF
Geastraceae	*Geastrum saccatum* Fr.	SGF
Hysteriaceae	*Hysterium* sp.	BG SL
Pezizaceae	*Aleuria* sp.	CF
Sarcoscyphaceae	*Cookeina* sp. 2	MF
	Cookeina sulcipes (Berk.) Kuntze.	MF SGF SL
	Cookeina tricholoma (Mont.) Kuntze.	MF SGF
Xylariaceae	*Daldinia concentrica* (Bolton) Ces. & De Not.	BG
	Xylaria hypoxylon (L.) Grev.	SL
	Xylaria spp. [1-3]	BG CF LP MF SGF SL
	BASIDIOMYCOTA	
Agaricaceae	*Agaricus* sp.	LP
	Coprinus comatus (O.F.Müll.) Pers.	SGF
	Coprinus spp. [1-6]	CF MF SGF BG
	Lepiota spp. [1-3]	CF SGF SL
	Leucocoprinus spp. [1-2]	MF SGF
Amanitaceae	*Amanita* spp. [1-2]	SGF
Clavariaceae	Clavariaceae [1]	SL
	Clavulinopsis spp. [1-2]	BG MF SGF SL
	Scytinopogon sp.	MF SL
Crepidotaceae	*Crepidotus* spp. [1-2]	LP MF
Hydnangiaceae	*Hydnum* sp.	MF
	Laccaria sp.	LP
Hygrophoraceae	*Hygrocybe* spp. [1-5]	BG LP MF SGF
	Hygrophorus spp. [1-2]	MF SGF
	Lyophyllum sp.	SGF
	Termitomyces spp. [1-2]	BG MF SL
Marasmiaceae	*Marasmius* spp. [1-26]	BG MF LP SGF SL
	Marasmiaceae [1]	MF
Mycenaceae	*Mycena* spp. [1-4]	BG CF MF SGF
Physalacriaceae	*Oudemansiella* spp. [1-2]	MF SGF
Pleurotaceae	*Pleurotus* spp. [1-2]	SGF SL
Psathyrellaceae	*Psathyrella* spp. [1-2]	MF SGF SL
Schizophyllaceae	*Schizophyllum commune* Fr.	BG MF SGF RL
Strophariaceae	*Pholiota* spp. [1-2]	LP SGF
	Psilocybe spp. [1-2]	MF SGF SL
	Stropharia spp. [1-2]	MF SGF
Tricholomataceae	*Calyptella* sp.	MF
	Clitocybe spp. [1-2]	BG LP SGF
	Collybia spp. [1-2]	SGF SL
	Tricholoma sp.	SL
	Agaricales [1-2]	BG CF MF SGF SL
Auriculariaceae	*Auricularia* spp. [1-3]	BG LP MF SL

Appendix 1. Taxa of macrofungi and habitats in Bombongan-Lewin Subwatershed (BLW) in Laguna *(Cont.)*

Division/ Family	Fungal Taxa[1]	Fungal Habitat[2]
Boletaceae	*Boletus* sp.	MF
	Boletales [1-2]	SGF SL
Cantharellaceae	*Cantharellus* spp.[1-2]	BG SGF
Corticiaceae	*Corticium* spp. [1-2]	BG CF LP MF SGF SL
Podoscyphaceae	*Cymatoderma elegans* Jungh.	MF
Fomitopsidaceae	*Fomitopsis* spp. [1-2]	MF SGF
Ganodermataceae	*Ganoderma applanatum* (Pers.) Pat.	SGF SL
	Ganoderma sp.2	MF
Meruliaceae	*Irpex* sp.	SGF
Phaeolaceae	*Phaeolus* sp.	BG
Polyporaceae	*Earliella scabrosa* (Pers.) Gilb. & Ryvarden	BG
	Favolaschia spp. [1-2]	BG LP MF SGF SL
	Favolus alveolarius (Bosc) Fr.	MF SGF
	Favolus sp.	SL
	Hexagonia spp. [1-2]	BG
	Lentinus sp.	LP
	Microporus affinis (Blume & T. Nees) Kuntze	BG SGF
	Microporus spp. [3-5]	BG LP MF SGF SL
	Microporus xanthopus (Fr.) Kuntze	BG SGF SL
	Phellinus sp.	SGF
	Polyporus arcularius (Batsch) Fr.	SGF
	Polyporus spp. [1-11]	BG LP MMF SL SGF
	Trametes sp.	CF SGF
	Polyporales [1-2]	SGF SL
Stereaceae	*Stereum* spp.[1-9]	BG CF LP MF SGF SL
	Xylobolus sp.	BG
	Rusullales	SGF
Thelephoraceae	*Thelophora* spp. [1-2]	BG MF
Tremellaceae	*Tremella fuciformis* Berk.	BG MF

[1]Numbers in the superscript indicate count of morphotaxa recorded in BLW;

[2]Legend: BG = bamboo grove; CF = coconut farm; LP = Lanzones plantation; MF = mixed forest, SL = scrubland; RL= rangeland, SF = secondary growth forest.