BIODIVERSITAS
Volume 19, Number 4, July 2018
Pages: 1579-1585

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d190451

Short Communication: Macrofungal diversity in Mt. Makiling Forest Reserve, Laguna, Philippines: with floristic update on roadside samples in Makiling Botanic Gardens (MBG)

ALMA E. NACUA[1,2], HAZEL JOY M. PACIS[2,3], JEFFREY R. MANALO[2], CARIZA JANE M. SORIANO[2], NIKKI ROSE N. TOSOC[2], ROBERT PADIROGAO[2], KEN JOSEPH E. CLEMENTE[4,♥], CUSTER C. DEOCARIS[5,6,7]

[1]Urban Biodiversity Laboratory, Universidad de Manila. 659 A. Cecilia Muñoz, Ermita 1000, Manila, Philippines
[2]Graduate School, University of the East. 2219 Recto Avenue, Sampaloc 1008, Manila, Philippines
[3]Bureau of Plant Industry. 692 San Andres St., Malate 1004, Manila, Philippines
[4]University of Santo Tomas. España Blvd., Sampaloc 1015, Manila, Philippines. ♥email: keclemente@ust.edu.ph
[5]De La Salle University. Taft Avenue, Malate, Manila, Philippines
[6]Technological Institute of the Philippines. 938 Aurora Blvd., Cubao, Quezon City, Philippines
[7]Polytechnic University of the Philippines. Anonas Street, Sta. Mesa, Manila 1008, Philippines

Manuscript received: 11 May 2018. Revision accepted: 29 July 2018.

Abstract. *Nacua AE, Pacis HJM, Manalo JR, Soriano CJM, Tosoc NRN, Padirogao R, Clemente KJE, Deocaris CC. 2018. Macrofungal diversity in Mt. Makiling Forest Reserve, Laguna, Philippines: with floristic update on roadside samples in Makiling Botanic Gardens (MBG). Biodiversitas 19: 1579-1585.* The Mt. Makiling Forest Reserve (MMFR) stands as a highly biodiverse habitat and the only intact natural forest near Metro Manila, the Philippines. It is one of the 18 key centers of plant biodiversity and 32 key ecotourism sites in the Philippines. In monitoring the implementation plans for protecting MMFR, the information pertaining to the mushroom biodiversity across decades is important. Therefore, we aim to study mushroom as an indicator for biodiversity since there has been studies in the past 30 years on the macrofungi of MMFR which we summarized here along with ours. Sampling was done in August 2017 based on the transect line of 1000 m along roadsides of Makiling Botanic Gardens (MBG). The distribution of the sampling units was carried-out using random and stratified sampling. Our study describes 21 macrofungal taxa collected from MMFR. Of these, 20 taxa belong to Basidiomycota and only one belongs to Ascomycota. Polyporaceae was found as the most dominant macrofungi family (24%). There were six (6) species that are medicinal, and no poisonous species noted. There are eleven (11) species in this study which are unique records compared with previous studies done in the macrofungi of MMFR. This is the first study done comparing mushroom across 30 years on a reserved area. Information on these macrofungal flora across time serves as a reference for the currently existing conservation efforts and implementation of biodiversity-related policies in MMFR.

Keywords: Ascomycota, Basidiomycota, flora, macrofungi, Makiling

INTRODUCTION

Fungi comprises an astounding breadth of taxa and ecologies, from the mushroom-forming fungi to yeasts, rusts, smuts, mold, and other symbionts. There is an estimate of 1.5 million fungal species on Earth, of which only about 70,000 have been described. Yet despite this, limited information is available for most species as it is estimated to take 1,000 years to characterize the over 1 million still unidentified species (Hawksworth 2004, Mueller and Schmit 2007).

Referred to as mushrooms, macrofungi are frequently visible to the naked eye (> 1 cm in size). These eukaryotes possess morphologically distinct spore-bearing fruiting bodies and commonly appear with stalks. Of the four fungal phyla recognized, macrofungi belong to the Ascomycota and Basidiomycota with an estimated 53,000 to 110,000 species (Hibbett, Binder et al. 2007, Mueller and Schmit 2007). While macrofungi grow best during the rainy season, they can be found in almost all types of substrates, e.g., soil, grassy ground, rotten wood, decaying organic matter, etc. (López-Quintero, Straatsma et al. 2012).

The nutritional and medicinal properties of many macrofungi are well known and documented. Fruit bodies of about 200 mushroom species are being consumed throughout the world, preferably as a delicacy. They are generally regarded as healthy foods, poor in calories and in fat, but rich in crude fiber, proteins, chitin, vitamins, minerals and bioactive mycochemicals (Manzi, Gambelli et al. 1999, Kalač 2013). Many edible mushrooms are also valued in complementary and alternative medicine, including *Lentinula edodes* (shiitake mushroom), *Grifola frondosa* (maitake), *Hericium erinaceus*, *Flammulina velutipes*, *Pleurotus ostreatus*, and *Tremella mesenterica* (Sullivan, Smith et al. 2006). Limited local studies on macrofungi revealed several biological activities such as anti-hypertensive (Eguchi, Dulay et al. 2014), anti-microbial (Reyes, del Rosario et al. 2017, Gaylan, Estebal et al. 2018), anti-thrombotic (San Pedro, Mangansat et al.

2016), anti-mutagenic (Canalita and Bajo 2017) and anti-angiogenic (Deocaris and de Castro et al. 2005).

As one-third of global fungal diversity is believed to exist in the tropical regions with macrofungi comprising 10% of that diversity (Mueller, Schmit et al. 2007), fungal biodiversity in the Philippines covers 3956 species and 818 genera based on old published enumeration from the classic studies done in the 1930s (Teodoro 1937) as well as the updated list in 1977 (Quimio and Capilit 1981). However, despite a strong historical foundation for mycology in the Philippines which dates back to as early as 1820 (Graff 1916), it has been noted that "there are only a few recent developments in terms of fungal survey to advance the field probably" which may be attributed to small number of mycologists in the country (Cumagun 2015)."

The collection and identification of the macrofungi in the wild could be an enormous input to promote and conserve mushroom biodiversity. In our paper, we present a recent survey of the macrofungi in Mt. Makiling Forest Reserve (MMFR), a 4,000-hactare forest that is the major headwaters of the Laguna Lake vegetation in Southern Philippines. Mt. Makiling stands as a highly biodiverse habitat and the only intact natural forest near Metro Manila, and which according to a recent hydrologic modeling study, has its forest reserve affected by the adverse impacts of climate variability (Combalicer and Im 2012).

Mt. Makiling is one of the 18 key centers of plant biodiversity and 32 key ecotourism sites in the Philippines (Ranada 2013) and is recognized by the Food and Agriculture Organization of the United Nations as a model of "Exemplary Forest Management in Asia" (Durst et al. 2005). Despite a Philippine law in protecting MMFR by the UPLB, the economic growth in the region through exploitation of the rich natural resources base has been moving forward with environmental and social consequences. In monitoring the implementation plans for protecting MMFR, the information pertaining to the mushroom biodiversity across decades is important. Therefore, we are studying mushroom as an indicator for biodiversity since there has been studies in the past 30 years on the macrofungi of MMFR which we are summarizing here along with ours. The study is done to understand biodiversity and provide a trend of biodiversity across time.

MATERIALS AND METHODS

Description of the sampling area

Mt. Makiling rises to a maximum elevation of 1,130 m above sea level (asl) with more than 3,000 hectares of its forest reserve above 400 m asl. Its forest reserve is located at coordinates 14°08'N 121°12'E and is 65 km from Metro Manila, the Philippines. Connecting the political boundary of the provinces of Laguna and Batangas, the forest covers sections of the municipalities of Bay, Los Banos, and Calamba in Laguna, and Sto. Tomas in Batangas. Since 1990, the University of the Philippines-Los Baños (UPLB) has been granted by the Philippine government exclusive control, jurisdiction and administration of the forest reserve by virtue of the Republic Act 6967. Wet months are usually from May to December and drier periods are from January to April. The average annual rainfall is about 2.4 m. Mean annual temperatures range from 25.5-27.5°C. The coldest month is January and the warmest are in April and May. There has been no recorded eruption of Mt. Makiling in recent history but volcanism is still evident through its geothermal features, like mud spring and hot springs. The soil in the Forest Reserve is clay-loam derived from volcanic tuff and ash. High in organic matter, the soil is very fertile. Acidity is typical of rainforest soil, the pH ranging from 4.3 to 6.5. The location of the study could be seen in Figure 1.

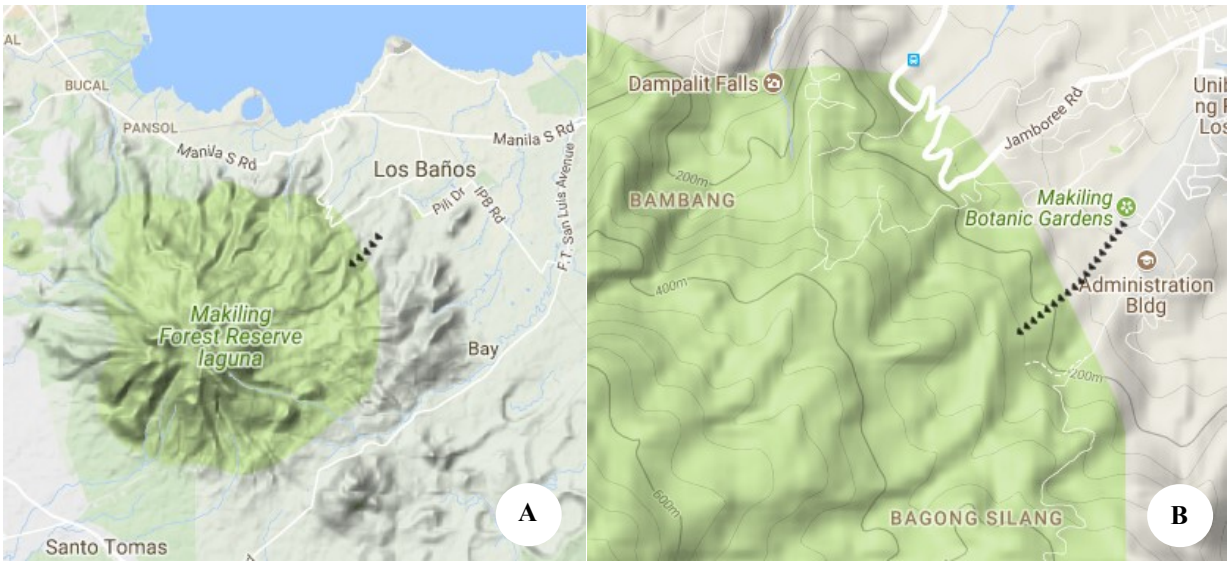

Figure 1. A. Geographical satellite view of the study site in Mt. Makiling Forest Reserve, Philippines. B. 1000-meter transect line indicated by black arrowheads traversing from the road of Makiling Botanic Gardens towards the mountain area. (Figures was made using ©Scribble Maps)

Sample collection

Sampling was done in August 2017 based on the transect line of 1000 m from Makiling road to Botanic Garden of Mt. Makiling Forest Reserve. The distribution of the sampling units was carried-out using random and stratified sampling (de Vries 1986). Collection of macroscopic fungi was performed in the morning when temperature is favorable and fruiting bodies of the macrofungi are expanded. Fruiting bodies were carefully detached and stored in water-proof containers with moisture absorbent. The collected macrofungi specimens were preserved either in 2% (for fleshy) and 4% formaldehyde (for woody or hard). All the macrofungi were photographed in their natural habitat, collected, identified and classified. All samples were kept by the Bureau of Plant Industry (BPI) of the Republic of the Philippines.

Characterization and identification

Macrofungal specimens were characterized and identified based on standard procedures in Quimio (2001) and Tadiosa et al. (2012). The following criteria were used to describe and identify the collected specimens: (i) cap or pileus- size (cm), shape, color and color changes (upper and lower surface), margin, and firmness of basidiocarp; (ii) gills or lamellae-attachment to the stipe, thickness, forking, color and color changes, and orientation of hyphae in the inner gills; (iii) stipe or stalk- size (cm), diameter (cm), attachment or position, shape, and firmness; (iv) presence or absence of cystidia, basidia, and basidioles; (v) presence or absence of sterigmata; (vi) mycelium-if visible, color when still attached to the basal stipe and the roots; (vii) hyphae, relative size, presence or absence of septation and clamp connection; (viii) habitat (substrate) and (ix) edibility (Stamets and Chilton 1983, Angeles, Arma et al. 2016). Ecology, habitat and edibility status were also noted. Confirmation of initial identities of the specimens was done by consulting with an expert from the National Museum of the Philippines, Manila.

RESULTS AND DISCUSSION

Surveys of macrofungi has been reported by different researchers as it is estimated that about 60% of the known Philippine fungi are data derived from field surveys in Mt. Makiling Forest Reserve (Quimio and Capilit 1981, Quimio 1986, De Castro and Dulay 2015). The extensive bibliography on fungi in Mt. Makiling has provided essential data for the aims of this paper.

Our study describes 21 macrofungal taxa collected from Mt. Makiling Forest Reserve in August 2017 (Table 1). Of these, 20 taxa belong to Basidiomycota and only one belongs to Ascomycota. Furthermore, the samples were classified under 10 families and 17 genera. There were 15 samples identified up to species level, and 6 samples were identified only at the genus level. *Polyporaceae* with 5 species had the highest distribution in terms of species occurrence (24%), followed by *Stereaceae* with 3 species (14%), *Agaricaceae*, *Fomitopsidaceae*, *Ganodermataceae*, and *Russulaceae* each with 2 species (10%), and Sarcoscyphaceae, Bondarzewiaceae, Cantharellaceae, and Dacrymycetaceae each with only one species (5%). *Panaeolus papilionaceus* has not been assigned officially under a family, hence the term *incertae sedis*. The collected macrofungi are listed in Table 1 together with their morphological and ecological descriptions.

Moreover, our checklist also includes six (6) species of medicinal value – *Ganoderma lucidum, Ganoderma sinense, Trametes pubescens, Trametes versicolor, Stereum hirsutum*, and *Stereum ostrea*. Notably, *Ganoderma lucidum* has been recorded to contain antitumor polysaccharides such as (1→3)-ß-glucan (Han et al. 1995) and proteoglycan (Baek et al. 2002) while *Trametes versicolor* shows cytotoxic activity in restricting the proliferation of cancer cells in case of leukaemia and breast cancer due to polysaccharide-protein compounds (Lau et al. 2004). Some edible species are also found with no poisonous species noted.

The species diversity and distribution of macrofungi in this study may have been affected by some factors. One is the prevailing meteorological parameters. The study area exhibits type I climate which is characterized to have two marked distinct seasons - dry and wet. Our team and that of de Castro's (De Castro and Dulay 2015) both surveyed in August (2013 and 2017) due to favorable growth conditions for the mushrooms. Mt. Makiling rains are usually frequent between June to September which is accompanied by the abundant collection of macroscopic fungi during field sampling. Heavy rains are known to cause mushrooms to grow and decompose its substrates quickly. Recent studies have provided evidence of climate-induced elevational shifts in fungal productivity and diversity (Parmesan and Yohe, 2003; Walther, 2010). Forest fungi have been known to colonize new areas faster than tree or shrub species (Bebber et al. 2013; Bebber et al. 2014) and hence can be used as proxies to monitor early climate change impacts on forest communities (Alday et al. 2017).

Another factor for the macrofungal diversity is the presence of diversity of vascular plants in the region (Schmit and Mueller 2007). Rare occurrence of other mushroom families may be caused by biological barriers such as restricted reproductive strategies that can be caused by substrate, nutrient, or atmospheric limitations. Mt. Makiling Forest Reserve is home to 225 families, 949 genera, and 2,038 species, 19 sub-species, 167 varieties, and many cultivars of flowering plants and ferns (Pancho 1983). Macrofungi are suitably occurring in varying habitats with the pronounced climate and presence of lignocellulosic agricultural wastes found in the forest. It must be noted that there was also a recent study by De Castro and Dulay (2015) documenting macrofungi in a multistorey agroforestry system of Mt. Makiling which is located opposite side of the mountain with reference to the sampling site of this study. Interestingly, records show distinct mushroom floral patterns in opposite areas of Mt. Makiling. For instance, *Russula virescens* has been

Table 1. Checklist of the 21 taxa (species or genus level) of macrofungi identified from the roadsides of Makiling Botanic Gardens of the Mt. Makiling Forest Reserve, the Philippines and their morphological and ecological descriptions

	Family	Species (or genus level)	Cap	Cap diameter (mm)	Gills	Spore color	Ecology	Habitat/Substrate	Edibility
Ascomycota	Sarcoscyphaceae	*Cookeina speciosa*	infundibuliform	11	smooth	unidentified	saprotrophic	decaying woods	edible
Basidiomycota	Agaricaceae	*Coprinus sp.*	conical	63	free	black	saprotrophic	decaying leaves	edible
		Lepiota cristata	umbonate	12	crowded	deep red to reddish brown	saprotrophic	decaying leaves	inedible
	Bondarzewiaceae	*Heterobasidion annosum*	offset	26	lacking	unidentified	parasitic	decaying woods	inedible
	Cantharellaceae	*Cantharellus sp.*	infundibuliform	74-82	decurrent	white cream	saprotrophic	deciduous or mixed forest	edible
	Dacrymycetaceae	*Dacryopinax spathularia*	coral like	8	lacking	white	saprotrophic	decaying woods	inedible
	Fomitopsidaceae	*Daedalea sp.*	offset	33	teeth like	white	saprotrophic	decaying woods	inedible
		Fomitopsis sp.	offset	42	lacking	white	saprotrophic	decaying woods	inedible
	Ganodermataceae	*Ganoderma lucidum*	offset	42 (primordia)	lacking	brown	saprotrophic	decaying woods	edible, medicinal
		Ganoderma sinense	offset	18	lacking	brown	saprotrophic	decaying woods	inedible, medicinal
	Polyporaceae	*Hexagonia sp.*	crustose	37	lacking	white	saprotrophic	decaying woods	inedible
		Polystictus sp.	flat	56	lacking	white	saprotrophic, parasitic	decaying woods	inedible
		Lentinus tigrinus	infundibuliform	17	decurrent	white	saprotrophic	decaying woods, dried leaves	edible
		Trametes pubescens	offset	32	lacking	white	saprotrophic	decaying woods	inedible, medicinal
		Trametes versicolor	offset	42	lacking	white	saprotrophic	decaying woods	edible, medicinal
	Russulaceae	*Lactifluus piperatus*	infundibuliform	23	crowded	white	saprotrophic, mycorrhizal	decaying leaves	semi-edible
		Russula virescens	flat to convex	23	adnate	white	mycorrhizal	deciduous or mixed forest	edible
	Stereaceae	*Stereum ostrea*	offset	19	lacking	white yellowish to brownish	saprotrophic	decaying woods	inedible, medicinal
		Stereum hirsutum	offset	16	lacking	white	saprotrophic	decaying woods	inedible, medicinal
		Stereum sp.	infundibuliform	24	decurrent	unidentified	saprotrophic	decaying woods	inedible
	incertae sedis	*Panaeolus papilionaceus*	campanulate	9	adnate	black	saprotrophic	decaying leaves	edible

Table 2. Macrofungi found in different areas or habitats in Mt. Makiling Forest Reserve, Philippines

Roadside samples in MBG **(This study 2018)**	Multistorey Agroforestry Systems **(De Castro & Dulay 2015)**	Associated with Decaying Dipterocarps **(Tadiosa et al. 2012; Tadiosa & Militante 2006)**	Mt. Makiling (representative samples with majority collected from the foot of the mountain) **(Quimio 2001)**	
Cantharellus sp.	*Agaricus perfuscus*	*Auricularia auricula-judae*	*Agaricus sylvaticus*	*Marasmius ramealis*
Cookeina speciosa	*Auricularia auricula*	*Auricularia polytricha*	*Agaricus rhoadsii*	*Marasmius rotula*
Coprinus sp.	*Auricularia polytricha*	*Auricularia sp.*	*Agaricus merilli*	*Marasmius scorodinius*
Dacryopinax spathularia	*Boletinellus sp.*	*Corticium sp.*	*Agaricus perfuscus*	*Mycena vulgaris*
Daedalea sp.	*Cantharellus infundibuliformis*	*Daedalea ambigua*	*Agaricus pocillator*	*Mycena fibula*
Hexagonia sp.	*Coprinus sp.*	*Fomes pachyphloeus*	*Agaricus augustus*	*Mycena alcalina*
Fomitopsis sp.	*Corticum sp.*	*Fomes senex*	*Agrocybe sp.*	*Mycena sp.*
Ganoderma lucidum	*Crepidotus herbarun*	*Fomes sp.*	*Armillaria sp.*	*Nematoloma fasciculare*
Ganoderma sinense	*Ganoderma applanatum*	*Ganoderma applanatum*	*Amanita hemiphaba*	*Ompholatus (?) sp.*
Heterobasidion annosum	*Ganoderma lucidum*	*Ganoderma lucidum*	*Amanita angustilamellata*	*Omphalina (?) sp.*
Lactifluus piperatus	*Geastrum triplex*	*Ganoderma sp.*	*Cantharellus aureus*	*Oudemansiella canarii*
Polystictus sp.	*Lentinus sajor-caju*	*Hexagonia tenuis*	*Cantharellus infundibuliformis*	*Panaeolus foenisecii*
Lentinus tigrinus	*Lentinus tigrinus*	*Hexagonia sp.*	*Chlorophyllum molybdites*	*Panus rudis*
Lepiota cristata	*Marasmius scorodinius*	*Hymenochaete tenuissima*	*Clitocybe dealbata*	*Pholiota sp.*
Panaeolus papilionaceus	*Oudemansiella canarii*	*Lenzites striata*	*Clitocybe gibba*	*Pleurotus ostreatus*
Russula virescens	*Polystictus sp.*	*Phellinus gilvus*	*Collybia dryophila*	*Pleurotus cystidiosus*
Stereum ostrea	*Schizophyllum commune*	*Polyporus sanguineus*	*Collybia reinakeana*	*Pleurotus pulmonarius*
Stereum hirsutum	*Stereum sp.*	*Polyporus semilaccatus*	*Conocybe tenera*	*Pleurotus opuntiae*
Stereum sp.	*Termitomyces clypeatus*	*Polyporus sp.*	*Coprinus niveus*	*Pleurotus flabellatus*
Trametes pubescens	*Tremella sp.*	*Polystictus affinis*	*Coprinus fibrillosus*	*Pleurotus sapidus*
Trametes versicolor		*Polystictus flabelliformis*	*Cortinarius callisteus*	*Pleurotus ulmarius*
		Polystictus xanthopus	*Cortinarius sp.*	*Pleurotus cornucopiae*
		Poria sp.	*Crepidotus herbarum*	*Pluteus cervinus*
		Poria straminea	*Entoloma lividum*	*Psathyrella diseeminatus*
		Schizophyllum commune	*Gymnopilus sp.*	*Psilocybe sp*
		Stereum sp.	*Hebeloma sp.*	*Russula emetica*
		Trametes corrugata	*Hygrocybe miniate*	*Schizophyllum commune*
			Hygrophorus pratensis	*Stropharia rugosoannulata*
			Laccaria ochropurpurea	*Suillus granulatus*
			Lactarius piperatus	*Termitomyces clypeatus*
			Lentinus sajor-caju	*Termitomyces albuminosa*
			Lentinus crinipillis	*Termitomyces eurhizus*
			Lepiota cristata	*Tricholoma sp.*
			Lepiota besseyi	*Tricholomopsis sp.*
			Leucocoprinus luteus	*Volvariella volvacea*
			Marasmius foetidis	
n=21	n=20	n=27	n=71	

distinctively identified in Makiling trail roads within UPLB upper campus. Members from the genus *Russula* is found to be an indicator of lead (Pb) on its fruiting body (Cayir et al. 2009). It can be associated with public utility vehicles accessing the upper campus of UPLB.

In total, eleven (11) species in this study is unique with reference to the records of De Castro and Dulay (2015), Tadiosa et al. (2012), Tadiosa and Militante (2006), and Quimio (2001). Table 2 presents the comparison of species recorded by different authors with Quimio (2001) having the most number of species recorded representing the first effort in documenting macrofungal diversity in MMFR. In summary, this is the first study done comparing mushroom across 30 years on a reserved area. As a consequence, information on these macrofungal flora across time serves as a reference for the currently existing conservation efforts and implementation of biodiversity-related policies in MMFR.

In conclusion, a total of 21 macrofungi taxa (both genus and species level) belonging to 10 families and 17 genera had been recorded in roadside samples within the Makiling Botanic Gardens (MBG) vicinity at Mt. Makiling Forest Reserve. The study declares that *Polyporaceae* was found as the most dominant macrofungi family (24%). There were six (6) species that are medicinal, and no poisonous species noted. There are eleven (11) species in this study which are unique records compared with previous studies done in the macrofungi of MMFR. The researchers emphasize the need for the integration of local macrofungi researches into a general macroecological framework and in national biodiversity assessments in order to establish useful information to aid in harnessing the potential of these valued macrofungal resources.

ACKNOWLEDGEMENTS

We acknowledge Roberto G. Visco, Director of the Mt. Makiling Center for Mountain Ecosystem, College of Forestry and Natural Resources, University of the Philippines-Los Banos for granting access to the collection site, Mary Anne B. Guerrero of the Mushroom Laboratory, Bureau of Plant Industry and Edwin R. Tadiosa of the National Museum of the Philippines for assistance in species identification. We would also like to acknowledge the Commission on Higher Education (CHED) for the DARE-TO funding extended to the Urban Biodiversity Laboratory of Universidad de Manila.

REFERENCES

Alday JG, De Aragón JM, de-Miguel S, Bonet JA. 2017. Mushroom biomass and diversity are driven by different spatio-temporal scales along Mediterranean elevation gradients. *Sci Rep* 7:45824. DOI: 10.1038/srep45824

Angeles LP, Arma EJM, Basaca CW, Biscocho HEH, Castro AE, Cruzate SM, Garcia RJG, Maghari LME, Pagadora RS, Tadiosa ER. 2016. Basidiomycetous Fungi in Mt. Palay-palay Protected Landscape, Luzon Island, Philippines. Asian J Biodiv 7 (1): 79-95. DOI: 10.7828/ajob.v7i1.867

Baek SJ, Kim YS, Yong HM, Chae JB, Lee SA, Bae WC, Park DW, Kim DH, Lee JW, Park SK. 2002. Antimetastatic effect of proteoglycan isolated from the mycelium of *Ganoderma lucidum* IY009 in vitro and in vivo. Yakhak Hoeji 46: 11-17

Baldrian P, Vetrovsky T, Cajthaml T, Dobiasova P, Petrankova M, Snajdr J, Eichlerova I. 2013. Estimation of fungal biomass in forest litter and soil. Fungal Ecol 6: 1-11

Bebber DP, Holmes T, Gurr SJ. 2014. The global spread of crop pests and pathogens. Glob Ecol Biogeogr. 23 (12): 1398–1407

Bebber DP, Ramotowski MA, Gurr SJ. 2013. Crop pests and pathogens move polewards in a warming world. Nat Clim Change 3 (11): 985–988

Boddy L, Jones TH. 2008. Interactions between Basidiomycota and invertebrates. In: Boddy L, Frankland JC, van West P (eds.). Ecology of Saprotrophic Basidiomycetes. Elsevier, Amsterdam, 153-177

Canalita DC, Bajo LM. 2017. Toxicity, antimicrobial, and antimutagencicity potentials of the ethyl acetate extract from the mushroom *Coriolus versicolor* (L.: Fries.) Quelet. Analysis 9: 10.

Cayir A, Coşkun M, Coşkun M. 2010. The heavy metal content of wild edible mushroom samples collected in Canakkale Province, Turkey. Biol Trace Elem Res 134: 212-219

Chakraboty S, Newton AC. 2011. Climate change, plant disease and food security: an overview. Plant Pathol 60: 2-14

Combalicer E, Im S. 2012. Change anomalies of hydrologic responses to climate variability and land-use changes in the Mt. Makiling forest reserve. J Environ Sci Manag Special Issue 1: 1-13

Cumagun CJR. 2015. Philippine Fungal Diversity: Benefits and Threats to Food Security BSP-UP Professorial Chair Lectures Banko Central ng Pilipinas - University of the Philippines Los Banos.

De Castro ME, Dulay RM. 2015. Macrofungi in multistorey agroforestry system in Mt Makiling Forest Reserve, Los Banos Laguna, Philippines. J Chem Biol Phys Sci 2: 1646-1655

de Vries PG. 1986. Line intersect sampling. Sampling Theory for Forest Inventory. Springer: 242-279.

Deocaris CC, de Castro MCP, Oabel AT, Co E and Mojica E-RE. 2005. Screening for Anti-angiogenic Activity in Shiitake Mushroom (*Lentinus edodes* Berk) Extracts. J Med Sci 5 (1): 43-46

Durst PB, Brown C, Tacio HD, Ishikawa M. 2005. In Search of Excellence: Exemplary Forest Management in Asia and the Pacific. RAP Publication 2005/02, Asia Pacific Forestry Commission, Bangkok.

Eguchi F, Dulay RM, Kalaw SP, Yoshimoto H, Miyazawa N, Seyama T, Reyes RG. 2014. Antihypertensive activities of a Philippine wild edible white rot fungus (*Lentinus sajor-caju*) in spontaneously hypertensive rats as models. Adv Environ Biol 8 (24): 74-81

Fisher MC, Henk DA, Briggs CJ, Brownstein JS, Madoff LC, McCraw SL, Gurr SJ. 2012. Emerging fungal threats to animal, plant and ecosystem health. Nature 484: 186-194.

Gaylan CM, Estebal JC, Tantengco OA, Ragragio EM, Tantengco EM. 2018. Anti-Staphylococcal and Antioxidant Properties of Crude Ethanolic Extracts of Macrofungi Collected from the Philippines. Phcog J 10 (1): 106-109

Graff PW. 1916. Bibliography and new species of Philippine fungi. Mycologia 8 (5): 253-288

Han MD, Jeong H, Lee JW, Back SJ, Kim SU, Yoon KH. 1995. The composition and bioactivities of ganoderan by mycelial fractionation of *Ganoderma lucidum* IY009. Korean J Mycol 23: 285–297

Hawksworth DL. 2004. Fungal diversity and its implications for genetic resource collections. Stud Mycol 50: 9-18

Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF, Eriksson OE, Huhndorf S, James T, Kirk PM, Lücking R. 2007. A higher-level phylogenetic classification of the Fungi. Mycol Res 111 (5): 509-547

Hilszczańska D. 2012. Medicinal properties of macrofungi. Leśne Prace Badawcze (Forest Research Papers) 73 (4): 347–353

Kalač P. 2013. A review of chemical composition and nutritional value of wild-growing and cultivated mushrooms. J Sci Food Agric 93 (2): 209-218

Lau CBS, Ho CY, Kim CF, Leung KN, Fung KP, Tse TF, Chan HHL, Chow MSS. 2004. Cytotoxic activities of *Coriolus versicolor* (Yunzhi) extract on human leukemia and lymphoma cells by induction of apoptosis. Life Sci 75: 797–808

López-Quintero CA, Straatsma G, Franco-Molano AE and Boekhout T. 2012. Macrofungal diversity in Colombian Amazon forests varies with regions and regimes of disturbance. Biodivers Conserv 21 (9): 2221-2243

Manzi P, Gambelli L, Marconi S, Vivanti V, Pizzoferrato L. 1999. Nutrients in edible mushrooms: an inter-species comparative study. Food Chem 65 (4): 477-482

Mueller GM, Schmit JP, Leacock PR, Buyck B, Cifuentes J, Desjardin DE, Halling RE, Hjortstam K, Iturriaga T, Larsson KH. 2007. Global diversity and distribution of macrofungi. Biodivers Conserv 16 (1): 37-48

Mueller GM, SchmitJP. 2007. Fungal biodiversity: what do we know? What can we predict? Biodivers Conserv 16 (1): 1-5

Pancho J. 1983. Vascular flora of Mount Makiling and vicinity (Luzon: Philippines). Kalikasan Philipp J Biol Part 1. Vol. Suppl. 1: 1-476

Parmesan C, Yohe G. 2003. A globally coherent finger-print of climate change impacts across natural systems. Nature 421: 37-42

Quimio TH. 1986. Records of Philippine fungi. Proc: Plant Sci 96 (5): 359-362

Quimio TH. 2001. Common mushroom in Mt Makiling, Museum of Natural History. UP Los Banos Laguna,

Quimio TH. and Capilit A. 1981. Enumeration and bibliography of Philippine fungi (1936-1977), National Institutes of Biotechnology and Applied Microbiology, Philippines.

Ranada P. 2013. Mt. Makiling named ASEAN Heritage Park. UPLB Horizon Special Issue

Reyes RG, del Rosario MAG, Padua JPG, Malonzo MAC, Barza AJJ, Sumi R, Mori N, Miyazawa N, Eguchi F. 2017. The first report on the mycelial growth performance and antibacterial activity of Collybia reinakeana RGR-FE–NSC strain, a Philippine endemic edible mushroom. Int J Pharm Res 6 (1): 113-119

San Pedro A, Mangansat JM, Peria NT. 2016. Philippine wild medicinal mushroom, *Ganoderma lucidum* (Curtis: Fr.) P. Karst., exhibits anticoagulative effect in intrinsic pathway. Adv Environ Biol (4): 92-96

Schmit JP, Mueller GM. 2007. An estimate of the lower limit of global fungal diversity. Biodivers Conserv 16 (1): 99-111

Stamets P, Chilton JS. 1983. The mushroom cultivator. Western Distribution by Homestead Book Co., Olympia, Washington

Sullivan R, Smith JE, Rowan NJ. 2006. Medicinal mushrooms and cancer therapy: translating a traditional practice into Western medicine. Perspect Biol Med 49 (2): 159-170

Tadiosa ER, Ag Bayani ES, Agustin NT. 2011. Preliminary study on the macrofungi of BazalBaubo Watershed, Aurora Province, Central Luzon, Philippines. Asian J Biodiv 2: 149-171

Teodoro NG. 1937. An enumeration of Philippine fungi. Technical Bulletin, Department of Agriculture and Commerce, Philippine Islands, Manila

Vries PG. 1986. Sampling theory for forest inventory. Springer-Verlag, Wageningen

Walther GR, 2010. Community and ecosystem responses to recent climate change. Philos Trans Royal Soc B 365: 2019-2024

Walther GR, Post E, Convey P, Menzel A, Parmesan C, Beebee TJ, Fromentin JM, Hoegh-Guldberg O, Bairlein F. 2002. Ecological responses to recent climate change. Nature 416: 389-395