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Species Listing of Macrofungi Found in the Ifugao Indigenous Community in Ifugao Province, Philippines

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The Philippines is known as one of the megadiverse countries in the world. One of its important biological resources are macrofungi which play an active role in wood decomposition, thereby contributing to nutrient recycling in the forest ecosystem. However, in spite of the important ecological role of macrofungi, little is known about their biodiversity in the Philippines. Investigations on the taxonomy and diversity of macrofungi are also gaining importance, as many macrofungi species are on the brink of extinction due to environmental destruction. Therefore, this study was conducted to document the different species of macrofungi in Ifugao Province, Philippines to come up with a species list of macrofungi in areas inhabited by the Ifugao indigenous community. Purposive sampling method was done to scan the nine barangay study sites: Bangaan, Poitan and Viewpoint in the municipality of Banaue, Bokiawan, Hapao and Poblacion in the municipality of Hungduan, and Chaya, Chumang and Mapawoy in the municipality of Mayoyao. Collected macrofungal samples were identified using both morphological and molecular methods. A total of 144 macrofungal samples were collected; out of these, 109 species were identified: 74 morphologically and 35 molecularly. Of these samples, 71 macrofungi were identified up to the species level while 34 could only be identified up to the genus level. The identified macrofungi belonged to 30 families, 47 genera and 47 species. Sixteen identified species of macrofungi were utilized as food as declared by the community and these are *Agaricus* sp., *Auricularia auricula*, *Coprinellus disseminatus, Coprinus comatus, Lentinus sajor-caju, Lenzites elegans, Mycena sp., Oudemansiella canarii, Phellinus* sp., *Pleurotus djamor, Pleurotus ostreatus, Pleurotus* sp., *Schizophyllum commune, Trametes elegans, Termitomyces* sp. and *Vascellum pratense.* This study is the first report on macrofungal diversity in the area inhabited by the Ifugao community in Ifugao Province.

Key Words: edible macrofungi, Ifugao community, mushrooms, morphological identification, molecular identification

INTRODUCTION

The Philippines is a nation blessed with a number of different ethnic groups. One of the 110 indigenous tribes scattered throughout the country (Waddington 2002) are members of the Ifugao community who live in the upland areas of Ifugao Province located in Northern Philippines. The members of the Ifugao community are mountain agricultural people who obtain their livelihood through multiple land use such as rice terrace farming, swidden cultivation and the diverse use and management of resources from privately owned secondary forest (called *"Muyong"*). The Ifugao community utilizes forest resources such as fruits, medicinal plants, and wood-inhabiting macrofungi.

Macrofungi (sometimes also referred to as macromycetes) include all of the fungi that produce spore -containing structures called sporocarps that are large enough to be seen without the need of specialized optical instruments (Lukes 2011). Chang and Miles (1991) broadly defined the term "mushrooms" as those macrofungi with a distinctive fruiting body. The latter can be hypogeous (below ground) or epigeous (above ground) and are usually collected manually (Rai et al. 2005). These include fungi in the phylum Basidiomycota (commonly referred to as basidiomycetes) which produce the familiar umbrella-shaped sporocarps, including the gilled mushrooms and boletes, as well as polypores, earthstars, tooth fungi, puffballs, false truffles, jelly fungi and crust fungi, whose sporocarps may have various other shapes. Other macromycetes include the morels, truffles, and cup fungi, which are members of the phylum Ascomycota (commonly referred to as ascomycetes) (Lukes 2011). Macrofungi exhibit patterns of diversity related largely to substrate and host availability and their fruiting patterns are largely climate driven. The productive seasons for macrofungi and the frequency and duration of fruiting are dictated largely by the local climate. Temperature also has a major impact on the fruiting of macrofungi, an effect that may not be limited to the fruiting season (Lodge et al. 2004). Altogether, the Kingdom Fungi encompasses an enormous diversity of taxa with varied ecologies, life cycle strategies, and morphologies ranging from unicellular aquatic chytrids to large mushrooms in which the fruiting body can be several centimeters or more across. However, little is known of the true biodiversity of the Kingdom Fungi, which has been estimated at 1.5 million to 5 million species, with only about 5% of these having been formally classified (Coste et al. 2012).

A number of studies have been conducted worldwide to attest to the macrofungal diversity of different localities, including such examples as the forests of the Western Ghats of India (Brown et al. 2006). The number of macrofungi in Asia, including the Philippines, is certainly very high, and Mueller et al. (2007) estimated the total species of macrofungi as between 10,000 and 25,000. Musngi et al. (2005) reported that most taxonomic work on macrofungi in the Philippines has focused on general descriptions of members of the Basidiomycota, and described four species of *Auricularia (Auricularia auricula, Auricularia fuscosuccinea, Auricularia polytricha* and *Auricularia tenuis)* from studies centered at the Central Luzon State University, Science City of Muñoz, Nueva Ecija. In Mt. Makiling, Laguna, Quimio (1996) collected a total of 117 specimens belonging to the Agaricales. Reyes et al. (1997) isolated the mycelia of *Collybia reineckeana* from Puncan, Carrangalan, Nueva Ecija, whereas Daep and Cajuday (2003) documented nine species in the Tricholomataceae, three species in the Coprinaceae, two species in the Pluteaceae, and one species in the Auriculariaceae in Mt. Malinao in Albay. In Mt. Apo in Mindanao, Biadnes and Tangonan (2003) studied Basidiomycetes and recorded 87 species representing 25 genera. In Aurora province, Tadiosa et al. (2011) conducted a preliminary study of the macroscopic fungi of the watershed of Bazal-Baubo, and a total of 684 fungi were collected, including 107 species, 68 genera and 38 families. Of this total, 91 species were basidiomycetes, 14 were ascomycetes and two were myxomycetes. In the Taal Volcano Protected Landscape in Southern Luzon, Tadiosa and Briones (2013) identified 75 species of macrofungi, whereas Sibounnavong et al. (2008) reported seven species of macrofungi during the dry season in Puncan, Carranglan, Nueva Ecija. In six Aeta communities in Central Luzon, Philippines, 76 species of macrofungi were reported by De Leon et al. (2013).

People are known to use macrofungi in many different ways, but these can be divided into four basic categories: (1) edible, (2) medicinal, (3) poisonous, and (4) those used for other purposes, which includes a large number of macrofungi whose properties remain undefined. Furthermore, Niem and Baldovino (2015) stated that macrofungi have important roles in forest ecosystems. In addition, some macrofungi with medicinal properties are important to pharmacology, while others have industrial applications because of their biodegradation and biodeterioration potential. However, information and documentation of macrofungi is limited in the Philippines, especially in the mountainous zone occupied by indigenous communities. Therefore, the objective of the study described herein was to collect, characterize, document, and identify (using morphological and molecular methods) the different species of macrofungi that are found in the Ifugao communities in the Ifugao Province. It is hoped that as a result of this study, some species of edible macrofungi can be documented for future possible utilization by the indigenous communities and the entire database generated can serve as the baseline information for future research.

MATERIALS AND METHODS

Study Site

The specimens of macrofungi documented in the present study were collected from nine barangays: Bangaan, Poitan and Viewpoint in the municipality of Banaue; Poblacion, Hapao and Bokiawan in the municipality of

Fig. 1. Map and location of the general study area in Ifugao Province, Philippines.

Hunduan; and Chaya, Mapawoy and Chumang, in the municipality of Mayoyao. All of these municipalities are located in the Province of Ifugao in the Philippines (Fig. 1). Ifugao Province is in the Cordillera Administrative Region, which belongs to the Luzon islands. It was chosen as a study site because it has numerous rice terraces and the associated woodlots or *muyongs* which consist of a variety of softwoods and hardwoods that may serve as host to several species of macrofungi (De Leon 2018). Accessibility was also considered in the selection of the study sites.

Species Collection

Collecting activities were carried out during the rainy season (July to September 2015 and 2016) in the nine selected barangays of the three municipalities of Ifugao. The study sites were thoroughly searched to locate specimens of macrofungi, and this was done with the assistance of the tribal head who is the individual most familiar with the area and with the macrofungi present. All specimens were collected at their fruiting stage and initially photographed in their natural habitat. All important information relating to them such as the substrate pH, relative humidity, air temperature, and vegetation in the sampling area was recorded. In addition, the global coordinates of the sampling sites were recorded with the use of Global Positioning System (GPS) (Garmin eTrek H).

After the photographs were taken, fleshy macrofungi were handpicked carefully or cut using a knife for those specimens that are difficult to collect. Fruiting bodies were dug carefully so as not to damage their bases, whereas the fruiting bodies of bracket macrofungi were extracted from the tree bark, and wrapped in brown paper and placed in paper bags. All collected specimens were properly labeled and brought back to the Department of Biological Sciences–Interactive Laboratory, Biology Department, Central Luzon State University (CLSU), Science City of Muñoz, Nueva Ecija, Philippines for morphological identification. Later, molecular identification was carried out in the Fungal Biology Laboratory of the Department of Biological Sciences at the University of Arkansas (Fayetteville, Arkansas, United States of America).

Morphological Characterization

All the specimens of macrofungi were identified based on their macroscopic and microscopic features. The morphology of the different components of the fruiting body has diagnostic value that facilitates species determination. Different macroscopic features of the fruiting body, such as the size and attachment of the pileus and stipe as well as the gills margins, were observed and noted. Important microscopic features of the mushroom, such as the spore size, color and shape, were also included.

Microscopic morphology of the spores was observed using a compound microscope; the hymenium was cut into pieces and these were placed in distilled water, yielding a spore suspension. A few drops of the spore suspension were placed on a microscopic slide and covered with a glass cover slip, and the mounted spore suspension was examined under the compound microscope. The diameter of spores was determined using an ocular micrometer.

Morphological features of collected specimens were compared with the descriptions provided in the published literature, including Quimio (2001), Lodge et al. (2004), and Tadiosa (2011). Taxonomic classification was based on the works of Kuo (2011) and Quimio (2001).

Molecular Extraction

Genomic DNA from collected samples was extracted using Promega Wizard® Purification kit with minor modifications to suit macrofungal fruiting body sample extraction. Initially, the fruiting bodies were sliced aseptically using a sterile scalpel to expose the inner tissue. Collected sample tissues were placed in 2 mL autoclaved microtubes. To each tube, 600 µL of Nuclei Lysis Solution was added and incubated overnight, then the incubated macrofungal tissue samples were ground using a sterilize microcentrifuge tube pestle. Samples were then incubated at 65°C for 30 min in an analog heatblock (VWR), vortexing (Fisher Vortex Genie 2) at 10 min intervals. Incubated samples were then centrifuged (Eppendorf Centrifuge 5415 C) at 10,000 rpm for 3 min; subsequently, 500 µL of the supernatant was pipetted out and transferred to new 2 mL microtubes. To this, 200 µL of protein precipitation solution was added and vortexed for 20 s, and then centrifuged for 3–6 min at 10,000 rpm. The supernatant was transferred to new 2 mL microtubes, making sure that no protein was present in the sample. To the supernatant, 600 µL of room temperature 100% Isopropanol was added to precipitate DNA. The microtubes were then inverted several times, and then centrifuged at 10,000 rpm for 1 min. Then, the supernatant was carefully decanted without losing the pellet. To the pellet, 600 µL of 70% room temperature EtOH was added, then inverted several times to mix the samples. The microtubes were centrifuged again for another minute at 10,000 rpm and then EtOH was pipetted out without disturbing the pellet. Microtubes were then inverted in a clean Kimwipe for DNA drying overnight. Finally, the dried DNA was resuspended in a 30 µL rehydration solution (a component of the Wizard® genomic DNA purification kit) and stored in −20°C freezer until further use.

The DNA samples were then subjected to PCR (Bio Rad T100 Thermal Cycler) to amplify approximately 700 bp of the Internal Transcribed Spacer (ITS) regions of the nuclear ribosomal DNA using two primers: ITS1F (5'-CTTGGTCATTTAGAGGAAGTAA-3') and ITS4 (5'-TCCTCCGCTTATTGATATGC-3') (Bruns et al. 1998). The polymerase chain reaction (PCR) reaction included 12.5 µL of 2X Green GoTaq® (Reaction Buffer [pH 8.5], 400 µM dATP, 400 µM dGTP, 400 µM dCTP, 400 µM dTTP and 3 mM MgCl2), 1.25 µL of ITS1F, 1.25 µL of ITS4, 9 µL of ddH2O and 1 µL extracted genomic DNA to make a volume of 25 µL. The PCR conditions were as follows: 95°C for 5 min, followed by 95°C for 20 s, 52°C for 30 s and 72°C for 1.30 min, followed by 95°C for 20 s at 37 cycles with a final extension step of 72°C for 7 min and infinity at 12°C.

The PCR products and 1 kb DNA ladder stained with 0.5 µL SYBR safe (EDVOTEK) were run for 24 min at 100 V on 1% agarose gel (prepared in 1X TAE buffer) and were analyzed under a gel documentation system (BIO RAD Molecular Imager + Image Lab software version 5). After confirmation of the expected size of amplified fragments, the PCR products were sent to a third party (GENEWIZ, Boston, USA) for DNA sequencing. Forward and reverse sequence reads for each of the macrofungal specimens were aligned using Geneious 9.1.7 software, and a consensus sequence for each specimen was generated. The consensus sequences were then used for BLAST analysis, and only published, related ITS sequences were obtained from National Center for Biotechnology Information (NCBI) GenBank for use in the identification of fungal specimens. All gene generated sequences were also deposited at NCBI GenBank with the accession number reported herein.

Species Listing

A listing was compiled for the genera and species of the macrofungi collected in the general study area, and the numbers of different genera and species were noted in order to provide a preliminary assessment of the assemblage present (Lodge et al. 2004). The natural habitat of each type of macrofungi was also recorded, particularly the locality where it was collected and the substrate involved, such as leaf litter, decaying wood, or soil. Analysis of the species occurrence was based on the listing of the different macrofungi found in the area and their frequency of occurrence in the nine barangays of Banaue, Hungduan and Mayoyao, Ifugao Province were computed.

Preservation of Collected Samples

The specimens collected were preserved by air drying for the bracket macrofungi and soaking in 95% ethanol for the fleshy macrofungi. Voucher specimens were deposited in the Center for Tropical Mushroom Research and Development (CTMRD) at the Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines.

RESULTS

Collection Sites

The mushrooms were collected in Barangays Bangaan, Poitan and View Point in Banaue, Brgys. Bokiawan, Hapao and Poblacion in Hungduan and Brgys, Chaya, Chumang and Mapawoy in Mayoyao, Ifugao Province, Cordillera Administrative Region (CAR), Philippines. The areas support diverse environments inhabited by numerous species of macrofungi. The geographic location, elevation,

Table 1. Nine study sites in Ifugao, Philippines with their geographic location, elevation, air temperature and relative humidity.

Municipality	Study Site	Geographic Location	Elevation (m)	Air temperature (ºC)	Relative Humidity (%)
Banaue	Brgy. Bangaan	N15º44'15.6", E120º56'07.1"	108	28.0	60
	Brgy. Poitan	N16º54'37.4", E121º07'47.8"	963	23.4	90
	Brgy Viewpoint	N16º54'44.7", E121º04'31.4"	1340	24.2	78
Hungduan	Brgy. Poblacion	N16º50'08.4", E121º00'15.0"	1919	29.0	80
	Brgy. Hapao	N16º52'37.9", E121º00'19.1"	983	25.5	92
	Brgy. Bokiawan	N16º50'19.9", E121º00'38.1"	903	20.9	92
Mayoyao	Brgy. Chaya	N16º58'41.5", E121º13'26.6"	1054	29.1	99
	Brgy. Mapawoy	N16º58'32.3", E121º13'57.1"	1141	29.7	98
	Brgy. Chumang	N16º58'01.0", E121º12"59.8"	1119	27.0	99

air temperature and relative humidity of the six study sites were recorded (Table 1).

Species Listing of Macrofungi in the Nine Study Sites

There were 144 specimens of macrofungi collected in the study sites. Of these, 34 were identified up to the genus level, while 71 were identified to the species level using both morphological and molecular methods of identification. The identified macrofungi belonged to 30 families, 47 genera and 47 species (Tables 2 and 3). A total of 35 specimens of macrofungi were identified by means of molecular methods. An approximately 600 base pair fragment of the nrDNA–ITS region was amplified using ITS1F and ITS4 primers. BLAST analysis showed that all the macrofungal specimens possess 94% and above pairwise identity with examples deposited in GenBank, NCBI, as shown in Table 3.

A species list of the morphologically (Table 2) and molecularly (Table 3) identified macrofungi was compiled. The latter was arranged alphabetically by family, taxonomic name, the locations or where they were found, and their substrate pH and growth habit. Relevant notes on some species are also reported.

All the macrofungi collected in the nine barangays were assigned to taxonomic family, and the location was noted as well as their frequency of occurrence (Table 4).

DISCUSSION

The species list provided herein represents the first report of macrofungal diversity based on species richness in the Ifugao, Province. Representative species are presented in Figure 2. It also provides information on the occurrence of some important taxa, such as the collected species of *Oudemansiella canarii*, *Tremella fuciformis* and *Tremella mesenterica*, which were new record for the province. In addition, important utilized species were also collected and documented. These were *Agaricus* sp., *Auricularia auricula, O. canarii, Lentinus sajor-caju, Coprinus disseminatus, Schizophyllum commune, Mycena* sp., *Vasellum pratense, Termitomyces* sp., *Pleurotus ostreatus, Pleurotus djamor, Pleurotus* sp., *Coprinus comatus, Trametes elegans* and *Phellinus* sp. We earlier reported the utilization of these species as food by the Ifugao community in De Leon et al. (2018). Some of these species were also utilized as food by the Aeta and Kalanguya communities, as reported by De Leon et al. (2012, 2016), as well as the Gaddang community (Lazo et al. 2015). Moreover, De Castro and Dulay (2015) also claimed that *A. auricula* and *O. canarii* are edible. In fact, Ruegger et al.

Table 2. Morphologically identified macrofungi.

Family/ Scientific Name	Location	Host/ Substratum	pH of Substratum	Growth Habit
Agaricaceae				
Agaricus sp.	Poitan	Decaying wood	6.18	Solitary
Leucocoprinus sp.	Chumang	Soil	6.50	Gregarious
Auriculariaceae				
Auricularia auricula	Poitan, Viewpoint, Hapao, Poblacion	Standing trees, decaying wood	5.75-6.40	Gregarious (3-6 in a group)
Auricularia cornea	Poitan	Wood	5.75	Gregarious (2-3 in a group)
Auricularia mesenterica	Viewpoint	Trunk of living tree	6.78	Resupinate
Auricularia polytricha	Viewpoint, Bokiawan	Decaying wood	6.20-6.53	Gregarious scattered
Auricularia sp.	Chaya	Decaying wood	4.10	Solitary to gregarious
Exidia saccharina	Viewpoint	Decaying wood	5.42	Resupinate
Coprinaceae				
Coprinus sp.	Bangaan	Muddy soil	6.37	Gregarious (in clusters)
Crepidotaceae				
Crepidotus variabilis	Viewpoint, Hapao	Decaying wood	5.00-6.65	Gregarious scattered
Crepidotus sp. 1	Poitan	Decaying wood	6.03	Gregarious (3-5 in a group)
Crepidotus sp. 2	Viewpoint	Decaying wood	6.35	Solitary to gregarious
Dacrymycetaceae				
Dacryopinax spathularia	Bangaan, Viewpoint, Bokiawan	Decaying wood, bamboo trunk	4.50-6.24	Gregarious
Entolomataceae				
Entoloma conferendum	Mapawoy	Soil	4.90	Solitary
Fomitopsidaceae				
Daedalea sp.	Bangaan	Trunk of living tree	5.20	Solitary to gregarious
Ganodermataceae				
Ganoderma applanatum	Poitan, Chaya, Mapawoy	Trunk of living tree, decaying wood	5.30-6.50	Solitary
Ganoderma sp. 1	Bangaan	Decaying wood	5.30	Solitary
Ganoderma sp. 2	Poblacion	Decaying wood	5.50	Solitary
Ganoderma sp. 3	Chaya	Trunk of living tree	4.70	Solitary
Ganoderma sp. 4	Chaya	Decaying wood	4.20	Solitary
Gomphaceae				
Ramaria sp.	Chaya	Soil	6.50	Gregarious (in clustrers)
Hygrophoraceae				
Hygrocybe sp.	Viewpoint, Mapawoy	Decaying wood, soil	4.28-6.70	Solitary
Hymenochaetaceae				
Phellinus sp. 1	Poitan	Decaying wood	7.20	Solitary
Phellinus sp. 2	Viewpoint	Decaying wood	6.90	Solitary
Inocybaceae				
Inocybe sp.	Viewpoint	Soil	5.44	Solitary to gregarious (2-3 in a group)

Table 2. Continuation ...

Family/ Scientific Name	Location	Host/ Substratum	pH of Substratum	Growth Habit
Lycoperdaceae				
Vascellum pratense	Poblacion	Soil	6.10	Gregarious (3-6 in a group)
Lyophyllaceae				
Termitomyces sp.	Chaya	Termite mound	7.10	Solitary
	Viewpoint	Soil	6.37	Gregarious
Marasmiaceae				
Marasmius rotula	Poitan	Leaf litter	6.24	Solitary to gregarious
Megacollybia platyphylla	Chaya	Decaying wood	6.30	Solitary
Meruliaceae				
Chondrostereum purpureum	Poblacion	Decaying wood	4.90	Solitary to gregarious (2-3 in a group)
Flavodon flavus	Viewpoint	Decaying wood	6.40	Gregarious
	Viewpoint, Chumang	Decaying wood	6.60-7.20	Gregarious
Nidulariaceae				
Cyathus striatus	Bangaan	Decaying wood	5.59	Gregarious
Pezizaceae				
Peziza sp.	Chaya	Banana trunk	6.70	Resupinate
Physalacriaceae				
Oudemansiella canarii	Bangaan	Trunk of living tree	6.32	Solitary
Oudemansiella sp.	Bangaan	Decaying wood	6.53	Solitary
Pleurotaceae				
Pleurotus djamor	Chaya	Soil	7.20	Solitary to gregarious
	Chumang	Decaying wood	6.70	Gregarious
Pleurotus sp.	Chaya	Decaying wood	6.70	Gregarious
Polyporaceae				
Favolus acervatus	Oitan	Decaying wood	6.70	Solitary
Hexagonia tenuis	Viewpoint, Chumang	Decaying wood	5.50-6.40	Solitary
Lentinus sajor-caju	Bangaan	Decaying wood, Soil	6.10	Solitary to gregarious (2-3 in a group)
Lentinus sp.	Mapawoy	Soil	7.40	Solitary to gregarious (2-3 in a group)
Microporus affinis	Poblacion	Decaying wood	4.60	Solitary to gregarious
Polyporus arcularius	Bangaan	Decaying wood	6.37	Solitary
Polyporus brumalis	Viewpoint	Decaying wood	6.37	Solitary
Polyporus hirsutus	Poitan	Decaying wood	6.70	Solitary
Polyporus varius	Poitan	Soil	6.17	Solitary to gregarious (2-3 in a group)
Polyporus sp.	Chaya	Decaying wood	4.70	Solitary
Polyporus sp. 1	Viewpoint	Decaying wood	6.40	Solitary
Polyporus sp. 5	Bokiawan	Decaying wood	4.60	Solitary
Polyporus sp. 7	Chumang	Decaying wood	6.30	Solitary to gregarious
Polyporus sp. 9	Viewpoint, Mapawoy	Decaying wood	4.30	Solitary

Table 2. Continuation ...

Family/ Scientific Name	Location	Host/ Substratum	pH of Substratum	Growth Habit
Pycnoporus sanguineus	Poitan, Hapao, Chumang	Decaying wood	4.90-6.90	Solitary to gregarious
Trametes elegans	Poblacion	Decaying wood	4.20	Solitary to gregarious
Trametes hirsuta	Bangaan, Poitan, Viewpoint, Poblacion, Chaya, Chumang, Mapawoy	Decaying wood	6.60	Gregarious (superimposed)
Trametes suaveolens	Poblacion, Bokiawan	Decaying wood	4.60	Solitary to gregarious
Trametes versicolor	Hapao, Chaya, Chumang	Decaying wood	6.60	Gregarious (superimposed)
Psathyrellaceae				
Coprinellus comatus	Bokiawan	Rice hay	5.40	Solitary to gregarious
Coprinus disseminatus	Poblacion	Soil	6.00	Gregarious
Coprinopsis atramentaria	Poblacion	Soil	6.00	Gregarious (in clusters)
Coprinellus sp.	Poblacion	Soil	6.40	Gregarious
Parasola plicatilis	Bokiawan	Decaying wood	5.10	Solitary to gregarious
Psathyrella sp.	Viewpoint	Decaying wood	6.38	Solitary to gregarious (2-3 in a group)
Russulaceae				
Lactarius sp.	Chaya	Soil	7.20	Solitary
Schizophyllaceae				
Schizophyllum commune	Bangaan, Poitan, Viewpoint, Poblacion, Mapawoy	Bamboo trunk, trunk of living tree, decaying wood	4.86-5.82	Gregarious (3-6 in a group)
Strophariaceae				
Pholiota highlandensis	Poblacion	Decaying wood	5.20	Solitary
Thelephoraceae				
Thelephora anthocephala	Chaya	Decaying wood	4.30-5.70	Gregarious (in clusters)
Thelephora sp	Bangaan	Decaying wood	6.60	Gregarious (in clusters)
Trichlomataceae				
Mycena sp. 1	Viewpoint	Soil	6.28	Solitary
Mycena sp. 2	Bangaan	Decaying wood	4.68	Solitary
Mycena sp. 3	Poitan	Decaying wood	6.03	Solitary to gregarious (2-3 in a group)
Mycena sp. 4	Poitan	Decaying wood	6.34	Solitary to gregarious
Tremellaceae				
Tremella fuciformis	Bangaan	Decaying wood	5.95	Resupinate
Tremella mesenterica	Viewpoint	Decaying wood	5.88	Resupinate
Xylariaceae				
Daldinia concentrica	Poitan, Viewpoint, Chaya, Mapawoy	Tree trunk, Decaying wood	7.10	Solitary to gregarious (4-7 in a group)

(2001) mentioned that *O. canarii* is edible and common in the Brazilian territory. *Termitomyces* sp., on the other hand, was utilized as food in the rural areas of Tanzania (Tibuhwa 2013). Furthermore, *S. commune*, which was documented to be utilized as food only by the Ifugao community, was reported to have medicinal properties by Niem and Baldovino (2015).

Another noteworthy finding is that some of the species of macrofungi collected are not utilized by the Ifugao community; however, reports from the literature indicate their edibility and economic importance. For example, *Auricularia cornea* is reported to be utilized as food in Tanzania (Tibuhwa 2013). Leonard (2012) also noted that this fungus is edible and used in Chinese cookery and was exported to China in the 19th century. Another example is *A. polytricha*, which is utilized as food in Tanzania (Tibuhwa 2013) and by six Aeta

Table 3. Macrofungi identified from sequence analysis of ITS genes.

Scientific Name	Location	Maximum Score	Query Cover %	E value	% Identity	Source Accession #	GenBank Accession #
Amanitaceae							
Amanita alboflavescens	Chaya	955	97	0.0	94	FJ441037	MF377419
Entolomataceae							
Entoloma jubatum	Chaya	297	23	4e-73	96	LN850582	MF377420
Marasmiaceae							
Marasmiellus palmivorus	Mapawoy	1254	94	0.0	100	KR056290	MF377432
Polyporaceae							
Pycnoporus coccineus	Poblacion	1233	81	0.0	99	JF792518	MF377427
Pycnoporus sanguineus	Poblacion	1153	93	0.0	99	FJ372672	MF377426
Trametes elegans	Bangaan	1098	97	0.0	100	JN164921	MF377403
Trametes elegans	Bangaan	1158	96	0.0	99	JN164936	MF377404
Trametes elegans	Bokiawan	1170	96	0.0	99	JN164936	MF377436
Trametes elegans	Bokiawan	1170	97	0.0	100	JN164921	MF377435
Trametes elegans	Chaya	1146	99	0.0	99	JN164921	MF377424
Trametes elegans	Chumang	1090	96	0.0	100	JN164921	MF377423
Trametes elegans	Poitan	1170	97	0.0	100	JN164921	MF377417
Trametes elegans	Viewpoint	1170	97	0.0	100	JN164921	MF377409
Trametes elegans	Viewpoint	1157	97	0.0	99	JN164936	MF377412
Trametes elegans	Viewpoint	1170	95	0.0	100	JN164921	MF377414
Trametes elegans	Viewpoint	1088	97	0.0	99	JN164936	MF377407
Trametes elegans	Viewpoint	1079	96	0.0	100	JN164921	MF377411
Trametes elegans	Viewpoint	1092	99	0.0	99	JN164921	MF377406
Trametes elegans	Viewpoint	1170	95	0.0	100	JN164921	MF377405
Trametes elegans	Viewpoint	1149	92	0.0	99	JN164936	MF377410
Trametes ellipsospora	Hapao	1002	85	0.0	100	KC848249	MF377428
Trametes hirsuta	Bangaan	1142	67	0.0	99	LC317800	MF377438
Trametes hirsuta	Bokiawan	1155	100	0.0	99	JF439511	MF377434
Trametes hirsuta	Poblacion	1140	100	0.0	99	LC317800	MF377425
Trametes hirsuta	Poitan	1157	73	0.0	99	JF439511	MF377415
Trametes hirsuta	Poitan	1157	81	0.0	99	JF439511	MF377416
Trametes hirsuta	Hapao	1164	99	0.0	100	KF573024	MF377430
Trametes hirsuta	Viewpoint	1170	99	0.0	100	JN164921	MF377408
Uncultured fungus	Bokiawan	1177	100	0.0	99	KX514704	MF377433
Uncultured fungus	Chumang	1044	100	0.0	99	FN391307	MF377422
Uncultured fungus	Viewpoint	1061	100	0.0	100	FN391307	MF377413
Psathyrellaceae							
Coprinellus disseminatus	Viewpoint	1031	99	0.0	96	Y461838	MF377437
Schizophyllaceae							
Schizophyllum commune	Bokiawan	1158	95	0.0	99	JF439509	MF377431
Schizophyllum commune	Chumang,	1175	100	0.0	99	MH307932	MF377418
Uncultured fungus	Chaya	1192	97	0.0	99	KX515614	MF377421

communities living in Pampanga and Zambales (De Leon et al. 2012). *Dacryopinax spathularia* was reported by Niem and Baldovino (2015) as edible. Both *Tremella fuciformis* and *Tremella mesenterica* are not utilized in Ifugao but have been reported to be edible and to possess medicinal properties (Tibuhwa 2013). These macrofungi could then be harnessed for their medicinal and economic potential and later could be introduced to the

Table 4. Number of macrofungi reported per family and frequency of occurrence in the nine barangays of Ifugao, Province, Philippines. The codes for each location are Brgy. Bangaan (BBA), Brgy. Poitan (BP), Brgy. Viewpoint (BVP), Brgy. Bokiawan (BBO), Brgy. Hapao (BHA), Brgy. Poblacion (BPO), Brgy. Chaya (BC), Brgy. Chumang (BCH) and Brgy. Mapawoy (BM).

Family	BBA	BP	BVP	BBO	BHA	BPO	BC	BCH	BM	Total	%
Agaricaceae		1						1		2	22
Amanitaceae							1			1	11
Auriculariaceae		2	4	1	1	1	1			10	66
Coprinaceae	1									1	11
Crepidotaceae		1	2		1					4	33
Dacrymycetaceae	1		1	1						3	33
Entolomotaceae							1		1	2	22
Fomitopsidaceae	1									1	11
Ganodermataceae	1	1				1	3		1	7	55
Gomphaceae							1			1	11
Hygrophoraceae			1						1	2	22
Hymenochaetaceae		1	1							2	22
Inocybaceae			1							1	11
Lycoperdaceae						1				1	11
Lyophyllaceae							1			1	11
Marasmiaceae									1	1	11
Meruliaceae			2			1		1		4	33
Nidulariaceae	1									1	11
Pezizaceae							1			1	11
Physalacriaceae	2									2	11
Pleurotaceae						1	2	1		4	33
Polyporaceae	6	8	15	6	5	6	4	7	3	60	100
Psathyrellaceae			2	2		3				7	33
Russulaceae							1			1	11
Schizophyllaceae	1	1	1	1		1	1	1	1	8	88
Strophariaceae						1				1	11
Thelephoraceae	1						1			2	22
Tricholomataceae	1	3	2				1			7	44
Tremellaceae	1		1							2	22
Xylariaceae		1	1				1		1	4	44
TOTAL	17	19	34	11	7	16	20	11	9	144	

community for future possible utilization, allowing members of the community to benefit more from the macrofungi found in their area.

Furthermore, molecular identification confirmed the identity of some of the specimens of macrofungi collected in the present study. Most of the molecularly identified macrofungi belong to the family Polyporaceae. Determining nucleotide sequences of specimens of macrofungi provides additional information on their biodiversity and also enriches the GenBank database resource by adding molecular taxonomy and phylogenetic analysis research, which ultimately may facilitate macrofungal domestication and characterization for human benefits (Das et al. 2013). For instance, Awala and Oyetayo (2015) reported that the rDNA of *Trametes* sp. collected from Akure, Nigeria was amplified using the primers ITS4 and ITS5. However, data obtained from the Basic Local Alignment Search Tool (BLAST) revealed differences in the sequence from their *Trametes* sp. and the *Trametes* sequences on GenBank. The results revealed that the *Trametes* from Akure was 99% related to *Trametes lactinea* (Berk.) Sacc. Therefore, molecular techniques represent a tool that could be used to adequately characterize and identify intraspecific and interspecific variation of specimens (Zakaria et al. 2009).

Fig. 2. Representative species of macrofungi collected from nine study sites: (A) *Auricularia auricular*, (B) *Dacryopinax spathularia*, (C) *Entoloma conferendum*, (D) *Hexagonia tenuis*, (E) *Coprinopsis atramentaria*, (F) *Daldinia concentrica*, (G) *Auricularia polytricha*, (H) *Earliella scabrosa*, (I) *Tremella mesenterica*, (J) *Crepidotus variabilis*, (K) *Microporus vernicipes*, (L) *Polyporus varius*, (M) *Tremella fuciformis*, (N) *Pycnoporus sanguineus*, and (O) *Trametes hirsuta*.

The Philippines supports a very rich and diverse assemblage of macrofungi that are naturally growing on different substrates such as leaf litter, decaying plant residues and decomposing logs of trees during the rainy season.

Among the specimens collected, the family Polyporaceae (60) had the highest number of specimens recorded (Table 4), and these were collected in all the nine barangays. Similar results were reported by Tadiosa et al. (2011) and De Leon et al. (2012), who indicated that members of the family Polyporaceae were predominant in the province of Aurora and in selected provinces of Central Luzon. Lazo et al. (2015) also reported that *S. commune* was present in all of the study sites in the Gaddang community in Nueva Vizcaya. This finding is not surprising, since most of the collected macrofungi in the area were growing on decaying woody debris and logs, which are common in mountainous areas where trees are abundant. It indicates that macrofungi found in the area were saprophytic. These are macrofungi for which the carbon source is decaying wood and soil organic material

(Hou et al. 2012). Macrofungi growing in the wild play important roles in maintaining the nutritional value of forests (Niem and Baldovino 2015). As decomposers, they maintain forest health by returning organic material to the soil, making carbon available to plants and other organisms (Senn-Irlet et al. 2007).

There were more species collected at the Brgy. View Point study site compared with the other barangays (Table 4). This result could be because of the geographical location of the study site. As Bernicchia (2001) reported, a combination of various climatic factors such as rainfall, temperature, relative humidity, wind velocity, and direction is responsible for the existing mycological composition of the area, since macrofungi depend greatly on moisture for their growth. The study area in question is generally exposed to the southwest monsoon and gets a fair share of the rainfall brought about by the tropical cyclones which occur, especially during the maximum rainy period. The rainy season, on the other hand, is a prolific fruiting time for macrofungi due to the rather constant and often high moisture content of the substratum and humidity of the air (Tadiosa et al. 2011).

In Brgy. Hapao, the lowest number of macrofungi were collected and recorded; this could be because among the nine barangays, more cliffs were found in this area, so it was more difficult for the researcher to collect specimens. The abiotic parameters may also be a factor that has a major impact on macrofungi fruiting. Lodge et al. (2004) stated that macrofungi exhibit patterns of diversity that are related largely to substratum and host availability, and their fruiting is climate driven.

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