SPECIES LISTING AND SEASONALITY OF MACROFUNGI IN THE CAMPUS OF ISABELA STATE UNIVERSITY, PHILIPPINES

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Abstract: Macrofungi are important decomposers abundant in forested areas around the world. However, its diversity and seasonality are poorly known in the Philippines. Isabela province is located at the northern part of the Philippines. It is mainly part of the Cagayan Valley region which has wide varieties of living organisms due to its climatical and geographical conditions. Among universities and local colleges in the province, Isabela State University, particularly the Echague Campus (ISU-E), caters the vast agricultural and forest land. This research aimed to enlist the macrofungal species and their seasonality in the campus of ISU-E. Lists of macrofungal species were compared between dry seasons (March-August 2020) and wet season (September 2020 – February 2021). Macrofungal samples were characterized and identified based on their morphology. A total of 31 species belonged to 15 families and 20 genera during the dry season, while 43 species were collected and identified to 19 families and 32 genera during the wet season. The family Polyporaceae had the highest number of species during both seasons. The present study is the first to record the list of macroscopic fungi present in Isabela State University as affected by the change of seasons.

Keywords: *dry season, fungi, mushrooms, mycology, wet season*

1. INTRODUCTION

The Philippines has a total of 4,698 reported fungal species belonging to 1,031 genera (Quimio, 2002). Fungi play a key role in terrestrial ecological system. They can form symbiotic associations with plant root as mycorrhizal fungi which contribute to the essential nutrient cycling, decomposing organic matter, and some are pathogenic fungi (Gadd et al., 2003). Macrofungi or mushrooms exhibit a large fruiting body, which is ubiquitous in nature. However, most taxonomic work on Philippine macrofungi focused on general descriptions of Basidiomycota (Musngi et al., 2005) and some Ascomycota. Strengthening the human resources on systematic mycology has not been as attractive as before, resulting to stalled progress of fungal inventories and research on macrofungal diversity and conservation. Fungal systematics is hardly getting a good share of research money, especially in developing countries like the Philippines (Quimio, 1978; Quimio, 2001).

Isabela in the Cagayan Valley region is the biggest province on the island of Luzon and the second largest in the Philippines (PSA, 2021). Furthermore, it is one of the agricultural provinces that produce rice and corn due to the favorable terrain. It is also the 10th wealthiest province in the Philippines. Isabela State University (ISU-E), located in

Echague, Isabela, is the Main Campus among its 12 other satellite schools. ISU-E is an agricultural university which hosts a rich diversity of plants and animals (PSA, 2016), including microscopic and macroscopic fungi. The present study used traditional morphological techniques to collect, characterize, and identify macrofungi species. Since most macrofungal research focus mainly on their diversity during the wet season because of their abundance, this study aimed to document and compare macrofungal species during the dry and wet season in ISU-E. This study represents the first effort of seasonal macrofungal species listing to better understand their occurrence under different environmental conditions.

2. METHODOLOGY

The collection of mushrooms inside the campus of ISU-E was done in two parts: dry season, from March to August 2020, and wet season, September 2020 to February 2021. Rainy season or wet season is the ideal time to collect mushrooms where most places are humid with diffused sunlight. During this period, fungi mostly grow on the dead, decomposed leaves, and logs (Quimio, 1978; Pungpa et al., 2020).

2.1 Study site and sample collection

Mushroom samples were collected in five (5) different locations at the Isabela State University (ISU-E) in Echague, Isabela which lies within a 386 ha reservation. Mushroom collections were made in the closed canopy of trees with lesser anthropogenic activities and disturbances. The following sites included the forested areas around the Cagayan Valley Agriculture and Resource Research and Development (CVARRD), College of Nursing, College of Arts and Sciences, Institute of Fisheries, and College of Agriculture.

These locations are forested areas with diffused sunlight and have lots of leaf litter on the ground surface, as the mushrooms like to grow on dead and decomposing leaves and twigs (Quimio, 2001). All visible mushrooms on substrates such as soil, leaf litters, cow dung, and decayed logs were collected. The dry season collection started from March to August 2020 and the wet season from September 2020 to February 2021. Fungal specimens in their natural habitat were photographed and described. Collected fruiting bodies were initially stored in a sterile polypropylene bag and were immediately taken to the laboratory for identification. Collected fruiting bodies were then dissected and identified based on their mycological features. ISU-PAGASA AGROMET station provided the climate data during sample collections.

2.2 Morphological characterization

The collected macrofungal species were identified based on their macroscopic and microscopic features. Morphological data for each specimen include mushrooms' cap, gills, and stipe. The spore print was also prepared from fleshy mushrooms, while sectioning was done for non-fleshy mushrooms to observe microscopic features such as spore color, shape, and size. Taxonomic identification was made by comparing these morphologies with published literature of Quimio (2001), Lodge et al. (2004), Mueller et al. (2012), and Tadiosa et al. (2011). Taxonomic classification was based on the works of Quimio (2001) and Kuo (2019).

2.3 Preservation of specimens

Collected specimens were air-dried at 40°C in a drying oven for 48 hours. Samples were then kept in a sterile polypropylene bag to prevent moisture and mold formation. Samples were labeled with a specimen code, date, and collection place. Prepared herbarium specimens were deposited at the fungal collection of Laboratory of Microbiology and Bio-industry of ISU-E.

2.4 Species identification

Morphological characteristics of mushrooms, including the cap, stem, gills or pores, partial veil, universal veil, and the flesh of the fruiting bodies, were determined for each of the specimens. Substrate types were also recorded. Morphological identification was made by photo comparison with published textbooks and taxonomic literature. Morphological characters were noted and compared to the field guides and taxonomic keys provided in (Bishop & McGrath, 1978; Quimio, 1978; Svrcek, 2000; Quimio, 2001; Dugan, 2006; Kuo, 2019).

3. RESULTS AND DISCUSSION

3.1 Effect of temperature and relative humidity

Weather conditions during the wet season indicated 78-83% relative humidity with an average temperature of 21-30°C, cloudy with scattered rain showers. During the dry season, relative humidity ranges from 55% to 61%, with 28-35°C. Isabela State University-Philippine Atmospheric, Geophysical and Astronomical Services Administration (ISU-PAGASA) AGROMET Station, Echague, Isabela provided the climate data. An 83% relative humidity recorded during the mushrooms sample collection conformed to the findings of Abd Wahab et al. (2019) in Malaysia, where they found the ideal temperature for mushrooms is at least 25-30°C with a relative humidity of 70-90%.

Temperature and relative humidity during the wet season primarily affect the number of mushrooms that are growing within the study sites compared with dry seasons where there is no enough rain. During the dry season, fungi have lower diversity, considering that moisture on substratum is not sufficient for the growth of their fruiting bodies. The weather and temperature were set as limiting factors for the increased mushroom collection in the collection sites (Quimio, 1978; Bernicchia, 2001; Pungpa et al., 2020).

3.2 List of mushroom species present in ISU during the wet season

Forty-three species belonging to 19 families were collected during the wet season. Thirty-eight (38) mushrooms were identified up to species level and 5 to generic level as recorded in Table 1. Among these identified mushrooms, 41 belonged to Basidiomycota, including Agaricales (Gilled Mushroom), Auriculariales (Jelly Fungi), Hymenochaetales, Pezizales (Cup Fungi), Phallales (Stinkhorn Mushroom), and Polyporales (Polypore Fungi), which recorded the highest number of macrofungi collected. Two (2) species were identified and classified under class Ascomycota, namely, *Cookenia* sp. and *Daldinia concentrica,* collected on decaying logs. Furthermore, genus *Trametes* was the most diverse with six (6) species, including *T. elegans, T. gibbosa, T. pubescens, T. suaveolens, T. versicolor,* and *T. villosa*.

Table 1. List of mushroom species in ISU during the wet season.

Code	Species	Family	Substrate type
MW1	*Cortinarius pholideus*	Cortinariaceae	Soil
MW2	*Cypototrama asprata*	Physalacriaceae	Soil
MW3	*Mutinus ravenelii*	Phallaceae	bamboo roots
MW4	*Auricularia polytricha*	Auriculariaceae	decaying log
MW5	*Lentinus tigrinus*	Polyporaceae	decaying log
MW6	*Polyporus sanguineus*	Polyporaceae	decaying log
MW7	*Ganoderma applanatum*	Ganodermataceae	decaying log
MW8	*Trametes elegans*	Polyporaceae	decaying log
MW9	*Marasmius siccus*	Marasmiaceae	Soil
MW10	*Phallus indusiatus*	Phallaceae	Soil
MW11	*Xerula radicata*	Physalacriaceae	Soil
MW12	*Cotylidia* sp.	Repetobasidiaceae	decaying log
MW13	*Podoscypha* sp.	Meruliaceae	leaf litter
MW14	*Microporus vernicipes*	Polyporaceae	decaying log
MW15	*Polyporus varius*	Polyporaceae	decaying log
MW16	*Polyporus alveolaris*	Polyporaceae	decaying log
MW17	*Trametes versicolor*	Polyporaceae	decaying log
MW18	*Trametes villosa*	Polyporaceae	decaying log
MW19	*Trametes gibbosa*	Polyporaceae	decaying log
MW20	*Auricularia auricularia judae*	Auriculariaceae	decaying log
MW21	*Daldinia concentrica*	Hypoxylaceae	decaying log
MW22	*Trametes suaveolens*	Polyporaceae	decaying log
MW23	*Parasola plicatilis*	Psathyrellaceae	leaf litter
MW24	*Schizophyllum commune*	Schizophyllaceae	decaying log
MW25	*Marasmius* sp.	Marasmiaceae	decaying log
MW26	*Coprinus congregatus*.	Agaricaceae	cow dung
MW27	*Cookeina* sp.	Sarcoscyphaceae	decaying log
MW28	*Trametes pubescens*	Polyporaceae	decaying log
MW29	*Panaeolus cyaniscens*	Bolbitiaceae	leaf litter
MW30	*Lenzites betulina*	Fomitopsidaceae	decaying log
MW31	*Sparassis crispa*	Sparassidaceae	decaying log
MW32	*Spongipellis pachyodon*	Meruliaceae	decaying log
MW33	*Rhizomarasmius pyrrhocephalus*	Rhizomaceae	cow dung
MW34	*Phallus ravenelii*	Phallaceae	bamboo roots
MW35	*Macrolepiota phaelepiota*	Agaricaceae	soil
MW36	*Baeospora myosura*	Marasmiaceae	soil
MW37	*Ganoderma lucidum*	Ganodermataceae	soil
MW38	*Macrolepiota procera*	Agaricaceae	soil
MW39	*Chlorophyllum molybdites*	Agaricaceae	soil
MW40	*Leucoagaricus rubrotinctus*	Agaricaceae	decaying log
MW41	*Daedalea confragosa*	Polyporaceae	decaying log
MW42	*Tyromyces* sp.	Polyporaceae	decaying log
MW43	*Bondarzewia berkeleyi*	Russulales	bamboo roots

Note: MW=macrofungi during wet season

As shown in Table 1, the survey has listed mushroom species first recorded in this province. These mushrooms include *Leucogaricus rubrinticus, Macrolepiota procera, Chlorophyllum molybdites*, *Coprinus congregatus, Macrolepiota phaelepiota*, *Panaeolus cyanescens*, *Cortinarius pholideus*, *Lenzites betulina*, *Daldinia concentrica*, *Marasmius siccus*, *Podoscypha* sp., *Spongipellis pachyodon*, *Mutinus ravenelii, Phallus ravenelii, Phallus indusiatus*, *Xerula radicata, Cypototrama asprata*, *Daedalea confragosa*, *Microporus vernicipes*, *Polyporus alveolaris*, *Polyporus varius*, *Trametes gibbosa*, *Trametes villosa, Trametes suaveolens, Tyromyces* sp., *Parasol plicatilis*, *Cotylidia* sp, *Rhizomarasmius pyrrhocephalus, Bondarzewia berkeleyi*, and *Sparassis crispa*.

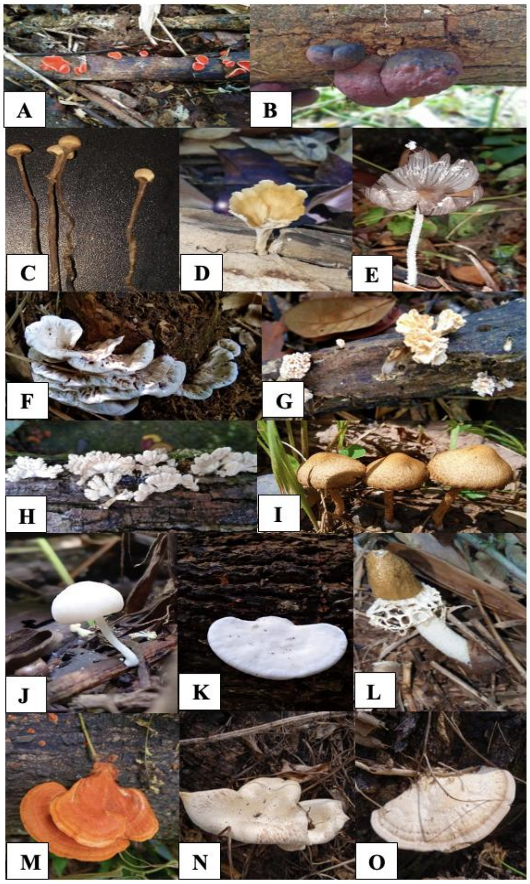

Figure 1. Representative photographs of mushrooms collected in ISU-E during the wet season. (A. *Cookenia* sp., B. *Daldinia concentrica*, C. *Rhizomarasmius pyrrhocephalus* D. *Cotylidia* sp. E. *Parasola plicatilis*, F. *Bondarzewia berkeleyi*, G. *Sparassis crispa*, H. *Schizophyllum commune*, I. *Cortinarius pholideus* J. *Panaeolus cyaniscens*, K. *Lenzites betulina*, L. *Phallus indusiatus*, M. *Polyporus sanguineus*, N. *Lentinus tigrinus*, O. *Trametes elegans*).

Figure 1 shows some of the interesting macrofungi species in Isabela State University during the wet season. Most of the macrofungi collected during the wet season adhered to decaying logs as their substrate (Table 1). Wood-rot fungi or Polypores favor wood as their main substrate. These species dominated the collection sites since these areas were largely covered with dead logs and woods.

3.3 List of mushroom species present in ISU during the dry season

Thirty-one (31) mushroom species belonging to 20 genera and 15 families were collected and identified based on their morphological characteristics during the dry season as shown in Table 2. Most species were classified and identified under Basidiomycota. On the other hand, Ascomycota had only one species represented by *Cookenia* sp. Families classified under Ganodermataceae and Polyporaceae were the most abundant among the different mushrooms collected throughout this season.

Table 2. List of mushroom species in ISU during the dry season.

Code	Species	Family	Substrate Type
MD1	*Auricularia polytricha*	Auriculariaceae	decaying log
MD2	*Termitomyces striatus*	Tricholomataceae	soil
MD3	*Calvatia cythiformis*	Agaricaceae	termite mount
MD4	*Ganoderma lucidum*	Ganodermataceae	bark of tree
MD5	*Ganoderma applanatum*	Ganodermataceae	decaying log
MD6	*Daedalea dickinsii*	Fomitopsidaceae	decaying log
MD7	*Phellinus linteus*	Hymenochaetaceae	bark of tree
MD8	*Pleurocybella porrigens*	Marasmiaceae	bark of tree
MD9	*Polyporus sanguineus*	Polyporaceae	decaying log
MD10	*Ganoderma adspersum*	Ganodermataceae	bark of tree
MD11	*Pleurotus porrigens*	Pleurotaceae	bark of tree
MD12	*Agaricus arvensis*	Agaricaceae	termite mount
MD13	*Podoscypha* sp.	Meruliaceae	dried leaves
MD14	*Trametes pubescens*	Polyporaceae	decaying log
MD15	*Geastrum triplex*	Geastraceae	dried leaves
MD16	*Trametes elegans*	Polyporaceae	decaying log
MD17	*Lentinus sajor – caju*	Polyporaceae	decaying log
MD18	*Ganoderma japonicum*	Ganodermataceae	bark of tree
MD19	*Psathyrella candolleana*	Psathyrellaceae	soil
MD20	*Auricularia auricula – judae*	Auriculariaceae	decaying log
MD21	*Clavulina cristata*	Clavulinaceae	bark of tree
MD22	*Phellinus ignarius*	Hymenochaetaceae	decaying log
MD23	*Schizophyllum commune*	Schizophyllaceae	decaying log
MD24	*Trametes hirsuta*	Polyporaceae	decaying log
MD25	*Trametes versicolor*	Polyporaceae	decaying log
MD26	*Phellinus gilvus*	Hymenochaetaceae	decaying log
MD27	*Lentinus tigrinus*	Polyporaceae	decaying log
MD28	*Marasmius* sp.	Marasmiaceae	decaying log
MD29	*Coprinus* sp.	Agaricaceae	cow dung
MD30	*Cookenia* sp.	Sarcoscyphaceae	soil
MD31	*Geastrum fimbriatum*	Geastraceae	dried leaves

Note: MD=macrofungi during dry season

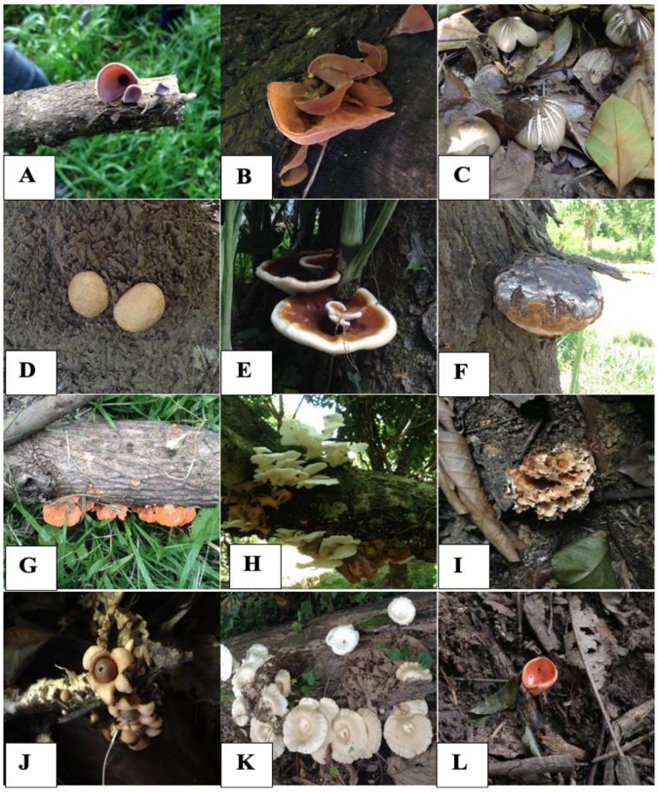

Figure 2. Representative photographs of mushrooms collected in ISU during the dry season. (A. *A. polytricha* B. *A. auricula-judae*, C. *T. striatus*, D. *C. cythiformis*, E. *G. lucidum* F. *P. linteus*, G. *P. sanguineus*, H. *P. porrigens*, I. *C. cristata*, J. *G. triplex*, K. *L. sajor-caju*, L. *Cookenia* sp.).

Figure 2 shows documented photographs of macrofungi collected during the dry season. It can be observed that most of these mushrooms are luxuriantly growing on decaying logs and leaves (Figure 3). Tantengco and Ragragio (2018) also reported the occurrence of *A. polytricha*, *A. auricula-judae*, *S. commune*, *and G. lucidum* in their study of mushrooms species being utilized by Aetas in Bataan, Philippines. Family Polyporaceae remained to be the most abundant among the different mushrooms collected during the dry season as shown in Figure 3. There were seven (7) species collected during the dry season including *Polyporus sanguineus*, *Trametes pubescens*, *Trametes elegans*, *Trametes hirsuta*, *Trametes versicolor*, *Lentinus sajor-caju*, and *Lentinus tigrinus*. Families Phallaceae, Marasmiaceae, Hymenochaetaceae and Agaricaceae, on the other hand, were observed to occur during the dry season only. The presence of Family Phallaceae in the study sites indicates that this type of mushroom is common in tropical regions, including Isabela Province. The reason could be due to their tolerance to warmer temperatures, low to very low humidity, and low to no rainfall (Chang et al., 2004; Pungpa et al., 2020). Furthermore, Sibounnavong et al. (2008) disclosed that Polypores could remain on the substrate for months, even years, because of their rigid structures. Similarly, Tadiosa et al. (2011) and De Leon et al. (2013) disclosed that Polypores dominated the survey in the province of Aurora and parts of Central Luzon, Philippines.

The succession of vegetation during the wet season also affects the high number of mushrooms collected, specifically low temperature, high relative humidity, and soil moisture. Apart from the significant species collected such as Polyporaceae, Ganodermataceae, Hymenochaetaceae, Agaricaceae, Auriculariaceae, and Marasmiaceae, other species of mushrooms are considered as rare which can be attributed to the anthropogenic activities within the area, environmental stress, or degradation, which do not support fungal growth and proliferation (Gates et al., 2011). The gilled and fleshy macrofungi were mostly found during the rainy seasons since this period sets an optimum condition for their reproduction due to sufficient moisture, appropriate temperature, humidity, and a little sunlight, which also supported the macrofungi in the degradation of organic matter (Kava, 2012; Andrew et al., 2013). The high number of macrofungi during the wet season is strong evidence that climatic conditions set optimum environments for the fruiting bodies among species of mushrooms. It could be suggested that the difference in climates such as rainfall, humidity, and temperature could affect the number and diversity of mushrooms. However, at the onset of the wet season, some genera such as *Marasmius* and *Coprinus* were observed to fruit out but quickly disappear as larger fruiting bodies of other mushroom species appeared. According to Gates et al. (2011), this pattern of succession is due to mushrooms with small and delicate fruiting bodies where moisture from the environment affects them more quickly than larger species, which requires mycelial proliferation before fruiting body production. Based on the lists the number of macrofungi species increases during the wet season faster than the dry season. These observations were also recorded by Paul et al. (2019) in their study where family Polyporaceae dominated at their site in Batu Timbang of the Imbak Canyon. Moreover, they also concluded that the occurrence of these macrofungi might be attributed to climatic and seasonal factors such as humidity and the high environmental moisture for the abundant polypores to grow on the cellulose-rich substrate (Svrcek, 2000; Sutjaritvorakul et al., 2017)

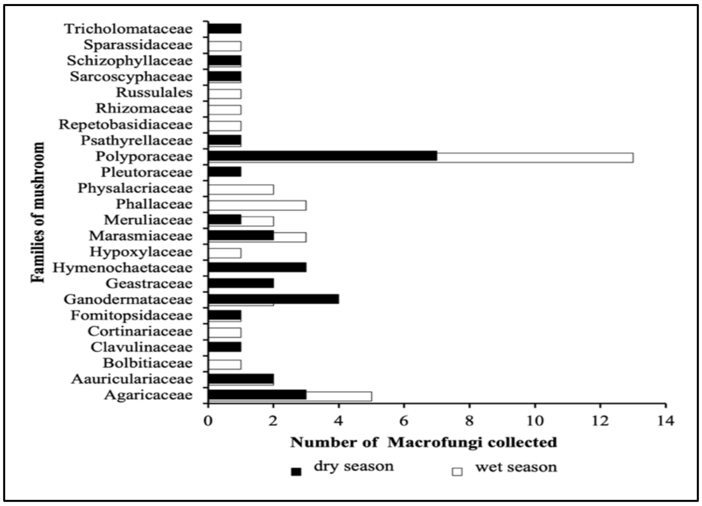

Figure 3. Families of macrofungi species collected during the wet and dry season.

The dry season was predominated mostly by bracket fungi and polypores as shown in Figure 3 which could be attributed to the decreased rainfall and humidity, increased temperature, and sunlight exposure. For instance, *P. sanguineus*, *T. hirsuta*, and *L. sajor-caju* are classified as Polypores while *G. lucidum* and *G. applanatum* are classified under Ganodermataceae contain rigid structures that could withstand pressure and extreme temperature (Andrew et. al., 2013). These results were parallel to those of Sutjaritvorakul et al. (2017) where they found that polypores and bracket fungi dominated during the dry season since fleshy macrofungi cannot tolerate these extreme conditions.

The study site has a wide range of habitats for mushrooms, including termite mount, soil, dried leaves, decaying log, cow dung, the bark of a living tree, and bamboo roots as shown in Figure 4. Most mushrooms were collected in decayed logs, which recorded 25 species during the wet season, while only 15 species occurred in the dry season. Other substrates include soil with ten (10) species collected during the wet season, and tree bark, which recorded seven (7) species in the dry season. The mushrooms in decaying logs indicate that most mushrooms collected from the study sites were wood-rotting mushrooms and could consume lignin. Optimally, growing mushrooms on rotten logs and woods indicate the ability of these fungi to degrade woody substrates. This result corroborated with Tibuhwa's (2011) study that mushrooms are substrate-specific, thus affecting their phenology. Succession in community composition is sometimes related to the quality of the substrates. In 2001, Heilmann-Clausen reported in their study that decaying logs can be a host to a wide variety of mushrooms.

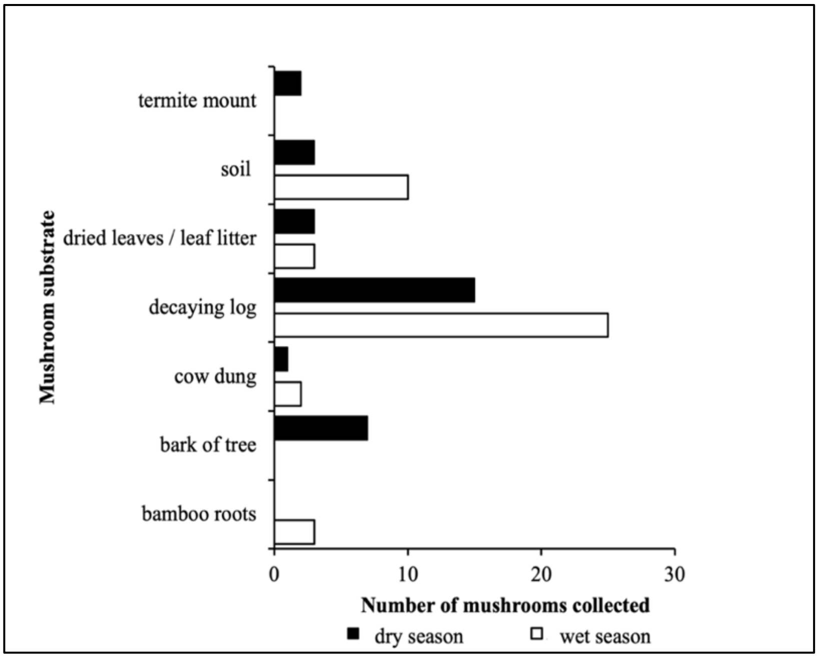

Figure 4. Number of mushrooms collected in ISU based on substrate.

4. CONCLUSIONS

This current study provided a list of mushroom species that were present within the premises of the ISU-E. In summary, 74 mushroom species were collected and identified during the wet and dry seasons belonging to 24 different families and 46 genera. Family Polyporaceae recorded the most significant number of species in the dry and wet seasons, which was followed by Ganodermataceae and Agaricaceae. It is worthy to note that during the dry season, 14 species recurred from the wet season. On the other hand, 17 species from the wet season did not recur during the dry season, thus, implying that mushrooms require an optimum environmental condition and substrates for their fruiting bodies to proliferate.

The current study is the first to enlist the present mushroom species during the wet and dry seasons in ISU-E to raise opportunities for mushroom research and development. However, challenges such as lack of interest in Mycology and mushroom research prevent conclusive evaluation of fungal diversity. In addition to the traditional morphological and taxonomical identification, research must be backed-up with molecular systematics and biotechnology in identifying and classifying these organisms that will further enhance the Philippines' mushroom research.

5. ACKNOWLEDGMENT

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