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Taxonomic classification, population density and distribution of macro-basidiomycetes at CSU-Lallo

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Key words: Ecological niche parameters, Macro-basidiomycetes, Population density, Population distribution, Taxonomic classification.

Abstract

The present study was conducted to assess as well as monitor the status of macro-basidiomycetes in terms of species richness, abundance and distribution at Cagayan State University Lal-lo. It sought to profile the macro-basidiomycetes and looked into the ecological factors affecting their density and distribution. The study employed the Descriptive Classification Survey (Colmerin) design and quadrant method in field sampling. Opportunistic method for macro-basidiomycetes sampling was also used during the survey on the months of July to October 2017. Field sampling of macro-basidiomycetes resulted to the identification of five orders, 17 genera and 20 species with a total of 34 individuals. Majority of the basidiomycetes belonged to *Order Polyporales*. One species, a wood decay macrofungus, remained unidentified. Results showed that *Schizophyllum commune* (Fr.) (a) has the highest population density, while *Ganoderma pfeifferi* (Bres) has the lowest. In terms of population distribution, only six species were most distributed, and five species, including the unknown species, were least distributed. Correlation analysis showed that amount of rainfall, soil moisture and air moisture had positive effects on the density and distribution of some macro-basidiomycetes, while elevated soil and air temperature reduced the density and distribution of these species. In contrast, an increase in air and soil temperatures made the population of *Volvariella volvacea* to be more abundant and more dispersed. Results of this research shall be an important contribution in the creation of conservation actions and policies for strengthening the biodiversity conservation, especially of the country's mycoflora.

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Introduction

Macro basidiomycetes are a large group of many familiar macrofungi which includes toadstools, bracket fungi, fairy clubs, puffballs, stinkhorn, earthstars, bird's nest fungi and jelly fungi, to name a few. They were long considered a strange group of organisms, poorly understood and difficult to study due to their largely hidden nature and frequently sporadic and short-lived sporocarps, that is the fruiting body or visible portion of a macrofungi. Hence, they have largely been neglected and overlooked in national and international nature conservation actions (Egbe, *et al.*, 2013).

In spite of their economic importance and ecological role, few studies on macrofungal diversity have been conducted in the Philippines. Literature review reveals that earlier study of Quimio and Capilit (1981) noted that the Philippines has 3,755 fungal species. The study of Tadiosa *et al.*. (2011) in the Bazal-Baubo Watershed in Aurora Province also denoted high macrofungal species diversity in this area. The Taal Volcano Protected Landscape in Talisay, Batangas was also reported to have vast macrofungal communities. Macrofungi were also described in Mt. Palay-Palay National Parking Cavite (Tadiosa *et al.*, 2005). De Leon *et al.*. (2013) likewise identified several macrofungi in six Aeta communities in Central Luzon. These studies indicate high species richness for mycoflora, but still many areas remained unexplored (Dela Cruz, 2014) and many species of macro-basidiomycetes remain undiscovered.

The province of Cagayan Valley is one of the least explored portions of Northern Luzon. There is little progress of fungal biodiversity research in the province, and it is therefore of urgent need to promote studies on fungal diversity. In response to this, the researcher deemed it necessary to conduct a preliminary survey at Cagayan State University at Lal-lo as beginning of the endeavour of uncovering the rich mycoflora of the province. The Cagayan State University Lal-lo campus is one of the eight satellites of Cagayan State University. It is located in the barangay of Sta. Maria at the Municipality of Lal-lo. It is a mountainous campus with a land area of 1,500 hectares. It has a rich biodiversity and diverse ecosystems mainly due to its large portion of forested area. With its elevated location and dense vegetation, it becomes an ideal habitat for diverse fauna and flora, including mycoflora, which is yet to be fully documented. Hence, the present work aimed to survey, collect, and identify macro-basidiomycetes that are naturally growing in the premises of Cagayan State University-Lal-lo Campus. Herein, the study provides a taxonomic listing of macro-basidiomycetes. It likewise looked into the species' population density and distribution. Furthermore, the study sought to describe the ecological niche parameters of the species of macro-basidiomycetes and determine any significant relationship of species' population and distribution with that of the ecological niche parameters.

Materials and methods

Locale and Research Design

The study was conducted at Cagayan State University at Lal-lo, Cagayan, Northern Luzon. It is located at latitude 18° 11' 54" North and longitude 121° 39' 54" East, and 2.7km away from the national highway. The annual rainfall over the area is 2,018 mm and an average annual temperature of 26.4°C. The climate of the study site is predominantly tropical, which is characterized by significant rainfall most of the months, with a short dry season. Rainfall and temperature diminish up the slopes and further inland.

Descriptive Classification Survey (Colmerin) was used as the design of the study. The five (5) sites at Cagayan State University Lal-lo were used as areas of the study and these are the Turbine, Coco-Mandarin Plantation, Coco-Cacao Plantation, DBP Forest and the Ecological Park.

Samples and Sampling Procedure

Simple Purposive sampling was used in determining the study sites, which was already listed on the above paragraph. The sites have been chosen for the reason that the area were inhabited by macro-basidiomycetes as per surveyed, and that they were not used for farming that requires tilling and constant under brushing for fungi may be disturbed. Quadrant method was used in field sampling, where each quadrant measures 10×10 meters. A total of twenty five (25) sampling plots were established; 5 quadrants per station. Opportunistic Sampling was employed in identifying the macro-basidiomycetes in all the sites. All macro-basidiomycetes found inside each quadrant during the collection date were taken as samples of the study.

The researcher, together with research assistants, counted the number of fruiting bodies per species and these data were used to determine the population density and distribution of macro-basidiomycetes.

Collection of Data

The collection of data was done once a week during Saturdays from July to October 2017. Inventory and collection of all macro-basidiomycetes representatives were done every collection. Ecological niche parameters such as amount of rainfall, soil and air moisture and soil and air temperature were all duly recorded during the four months of data gathering.

Collection and Documentation of Fungal Specimens

Macro-basidiomycetes were photo-documented in their natural habitat. The top and bottom portion of each specimen were captured for clearer and more precise identification. Morphometric data such as the different features of the stipe (stalk), pileus (cap), and gills of the fruiting bodies were gathered while color was through ocular observation.

Fruiting bodies were carefully collected using shovel obtaining part of the substrate to ensure that they were not damaged. Collected specimens were properly labelled and individually placed in a box and were brought to the laboratory for identification. Some were air dried in the laboratory for thorough classification and description.

Fungal Identification

Pre taxonomic classification was done by the researcher with the use of Dichotomous Key of Classification of fungi and fungal classification guides. Sample specimens of macro-basidiomycetes were brought to the Museum of Natural History at University of the Philippines Los Baños to authenticate their identification.

Analysis of Data

The population densities of macro-basidiomycetes were computed using the formula:

Population Density = N/A

Pearson r Correlation was used to determine the relationship of the population density and distribution of macro-basidiomycetes to that of the ecological niche parameters such as amount of rainfall, soil and air moisture, and soil and air temperature.

To determine the Population Distribution of the different species of basidiomycetes in the 25 stations, the following scale was used:

Number of Stations Found	Adjectival Description
21 – 25	Most Distributed
16 – 20	Widely Distributed
11 – 15	Fairly Distributed
6 – 10	Less Distributed
1 – 5	Least Distributed

Results and discussion

Taxonomic Classification of Macro-basidiomycetes at CSU Lal-lo

A total of 34 species of macro-basidiomycetes were collected during the months of July to the end of October 2017. Of these, 24 species belonged to *Order Polyporales* which comprised of 10 genera; five species are identified under *Order Agaricales* which consists of four genera, two species of *Order Aphyllophorales* under one genera, and one species each under *Order Auriculares* and *Order Sclerodermatales.*

There is one unknown species, subject to further classification and identification. Overall, there were five (5) orders and 17 genera of macro-basidiomycetes, of which the majority were wood rotting fungi (Table 1).

Table 1. List of Macro-Basidiomycetes found at CSU Lal-lo Campus with their Taxonomic Classification and Total Sporocarp Count.

Scientific Name	Order	Remarks	Total Sporocarp count
Polyporus leptocephalus (Jacq)Fr.	Polyporales		130
Polyporus sp. (a)	Polyporales		212
Polyporus sp. (b)	Polyporales		159
Polyporus sp. (c)	Polyporales		185
Polyporus sp. (d)	Polyporales		650
Microporus xanthopus(Fr.) Kunze	Polyporales		270
Microporus sp. (a)	Polyporales		730
Microporus sp. (b)	Polyporales		850
Hexagonia tenuis (Hook)Fr.	Polyporales		345
Hexagonia sp. (a)	Polyporales		358
Hexagonia sp. (b)	Polyporales		248
Hexagonia sp. (c)	Polyporales		332
Pycnoporus cinnabarinus (Jacq.Fr.)P.Karsten	Polyporales		335
Pycnoporus sanguineus (L.) Murrill	Polyporales		168
Trametes versicolor(L.)Pil.	Polyporales		333
Trametes hirsuta (Wulfen)Lloyd	Polyporales		605
Trametes sp.	Polyporales		427
Ganoderma pfeifferi (Bres)	Polyporales		58
Ganoderma lucidum (Ley.ex.Fr.)Kar.	Polyporales	Medicinal	173
Ganoderma applanatum (Pers.)Pat.	Polyporales	Edible but unpalatable	927
Coltricia perennis (L.) Murrill	Polyporales		200
Stereum hirsutum(Willd.)Gray	Polyporales		1,021
Daedalea sp.	Polyporales		372
Lenzites sp.	Polyporales		111
Lentinus velutinus(Fr.)Sacc.	Agaricales		338
Lentinus squarrosulus (Mont.)	Agaricales	Edible	6,827
Volvariella volvacea (Bull.ex.Fr.)Sing.	Agaricales	Edible	203
Omphalina grossula(Pers.)Singer	Agaricales		4,347
Crepidotus sp.	Agaricales		550
Schizophyllum commune(Fr.) (a)	Aphyllophorales	Edible	8,156
Schizophyllum commune(Fr.) (b)	Aphyllophorales	Edible	6,671
Auricularia auricula (Hook.)Under.	Auriculariales	Edible	4,843
Geastrum saccatum (Fr.)	Sclerodermatales		1,236
Unknown species		Unidentified	777

Schizophyllum commune (Fr.) (a) holds the highest record with 8,156 fruiting bodies found over the collection period of four months, followed by *Lentinus squarrosulus* (Mont.) with 6,827 sporocarps. *Schizophyllum commune* (Fr.) (b) ranks third with 6,671 total sporocarps. *Auricularia auricula* (Hook.) Under. and *Omphalina grossula* (Pers.) Singer found to have more than 4,000 fruiting bodies, with the former being higher by half a thousand. These species are found in cluster and really grow robustly.

Population Density of Macro-Basidiomycetes

Out of 34 species of macro – basidiomycetes, five (5) species were found to have pronounced density in one or more stations, and these are *Schizophyllum commune* (Fr.) (b), *Schizophyllum commune* (Fr.) (a), *Lentinus squarrosulus* (Mont.), *Auricularia auricula* (Hook.) Under and *Omphalina grossula* (Pers.) Singer. The *Schizophyllum commune* (Fr.) (b) has the highest recorded density. These fungal species are similar with each other in that they grow abundantly in cluster.

Population Distribution of Macro-Basidiomycetes

As gleaned from Fig. 1, the species that occupy all the 25 substations/ plots are the following: *Lentinus squarrosulus* (Mont.), *Schizophyllum commune* (Fr.) (a), and *Auricularia auricula* (Hook.)Under. Other species also with most distributed population are *Polyporus sp.* (a), *Polyporus sp.* (b), *Omphalina grossula* (Pers.)Singer and *Schizophyllum commune* (Fr.) (b). It implies that these species are well-adapted to wide range of environment as they are found across all stations.

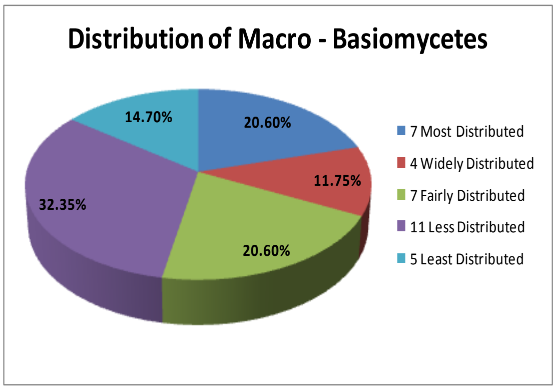


Fig. 1. Population Distribution of Macro-Basidiomycetes.

It was observed that the species with fair and low distribution comprised most of bracket fungi, which are saprobes of wood. This trend is attributed to the fact that not all stations have enough wood as substrates for these fungi. This idea is supported by the findings of Yamashita, *et al.*, (2007) which states that occurrence of fungal species increased significantly with increasing number of pieces of coarse woody debris. Overall, there are seven (7) mostly distributed species, four (4) widely distributed, seven (7) fairly distributed, 11 less distributed and five (5) least distributed. Not all species are well-distributed, some were found only in few plots, which suggest that the habitat of these fungi must be sustained so that the mycoflora and other inhabitants are conserved and become less susceptible to extinction.

Population Density and Distribution of Macro-Basidiomycetes per Week

Fig. 2 illustrates the trend of population density of the macro – basidiomycetes per week of collection. Most species had remarkable decline during the 7th week where temperature was highest and precipitation and moisture were lowest. However, after the heavy down pour in the 8th week, the density of the species had increased. This was because moisture increased and temperature decreased significantly as an effect of high degree of rainfall. With these observations, it was assumed that amount of rainfall and moisture content positively affects the population density of basidiomycetes, while temperature (Jang and Hur, 2014) has the opposite or reverse effect on density of fungal species.

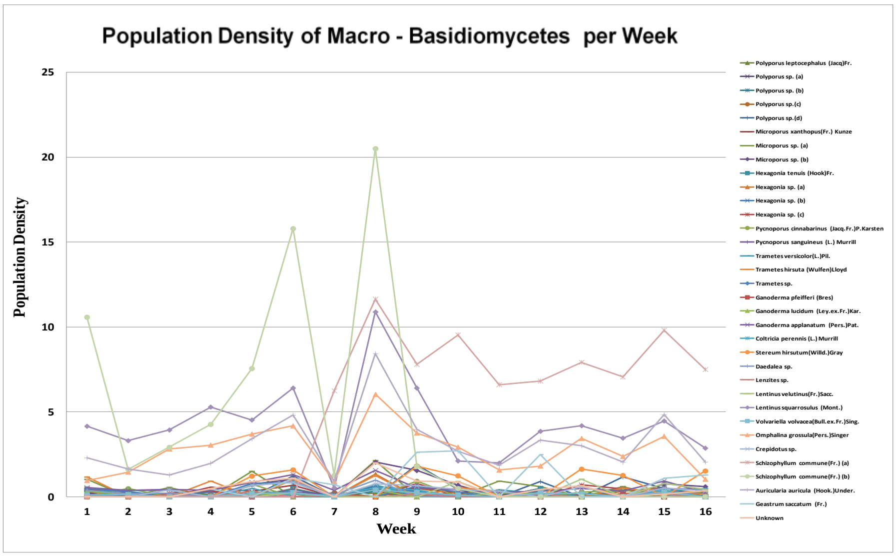


Fig. 2. Population Density of Macro – Basidiomycetes per Week.

As shown in Fig. 3, the population distribution of soft and fleshy macro-basidiomycetes are greater than the distribution of hard and woody ones. Besides, the distribution of soft textured fungi also follows the trend of rainfall, moisture and temperature. Notice that before and at week 7, there is lesser distribution of fleshy fungi as compared to their distribution during the 8th week and the weeks after. On the other hand, the early month collection was predominated by tough, woody polypores, since there was a decrease in rainfall and an increase in temperature, conditions where the fleshy macro fungi cannot withstand.

Overall Population Density and Distribution of Macro-basidiomycetes per Station

Fig. 4 presents the data for the overall density of macro-basidiomycetes per station. The highest population density of macro fungi is at Station 5 (DBP Forest), indicating that approximately seven sporocarps can be counted per square meter. In terms of ecological parameters, station 5 is lowest in air and soil temperature, and average in other parameters. The high density of fungi in this station could be attributed to the fact that the environment has adequate moisture and generally cooler than other stations. Aside from the presence of creek that provides extra moisture, the station is also abundant with fallen trunks and branches, which add as an additional substrate for wood decay fungi.

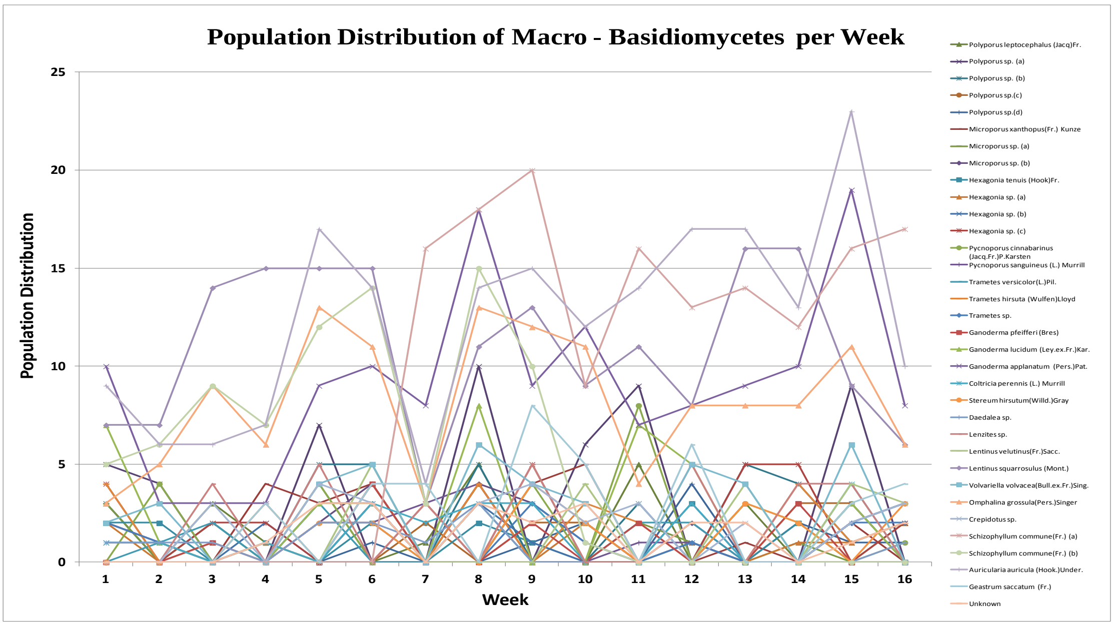


Fig. 3. Population Distribution of Macro-Basidiomycetes per Week.

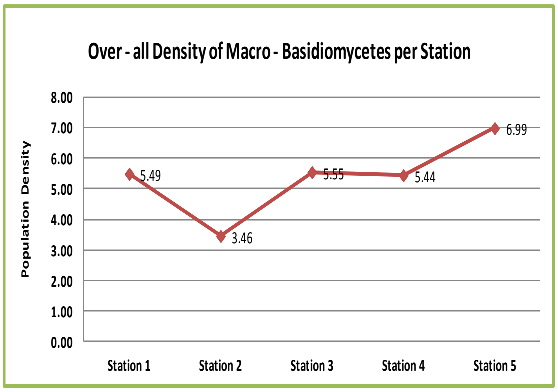


Fig. 4. Over – all Density of Macro – Basidiomycetes per Station.

Overall distribution of macro-basiomycetes is shown in Fig. 5. Station 5 (DBP Forest) is home for the most number of fungal species (25 species) as well as the most populated by basidiomycetes. It was followed by Station 2 with 22 species, next is Station 4 with 21 species and Station 1 with 20 species.

The present data suggest that a number of species of fungi were found in heavily vegetated areas where large trees, shrubs, and lianas abound. There were plenty of fallen branches, stumps and rotten trunks of wood that favoured the luxuriant growth of the fungi. The station with the least abundance of basidiomycetes is Station 3 with 17 species recorded. This may be due to the fact that this station is lowest in terms of rainfall and moisture. As demonstrated by previous studies (Sharon Talley, *et al.*, 2002), moisture and precipitation are important in explaining the fungal abundance and richness of habitats.

Relationship Between Population Density of the Different Species of Macro-Basidiomycetes and Ecological Niche Parameters

Species with positive correlation with amount of rainfall include *Polyporus sp. (a)*, *Polyporus sp.* (b), *Trametes versicolor* (L.) Pil, *Stereum hirsutum* (Willd.) Gray and *Lentinus squarrosulus* (Mont). This indicates that as the amount of rainfall becomes higher, so is the population density of these species of basidiomycetes, and a decrease of amount of precipitation means a decline in their population density. This finding is consistent to that of Talley, *et al*., (2002) that fungal abundance and richness displayed a positive relationship with precipitation.

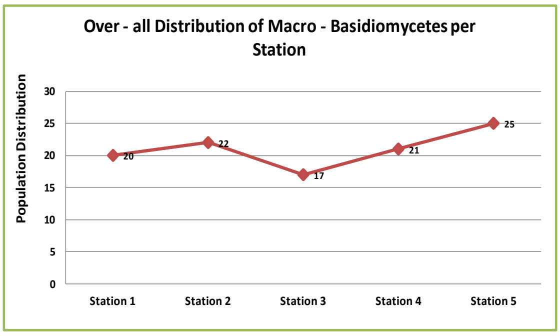


Fig. 5. Over – all Distribution of Macro – Basidiomycetes per Station.

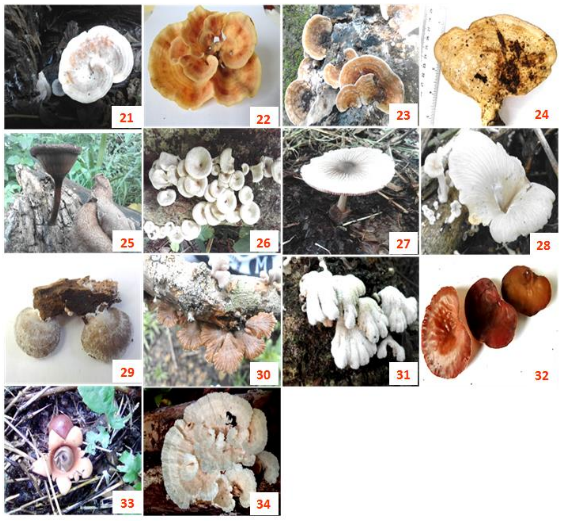
For soil moisture, species that are found to be positively correlated are *Polyporus sp.* (b) (r = .628, p = .001)*, T. versicolor* (r = .484, p = .014)*, Trametes hirsuta* (Wulfen) Lloyd (r = .461, p = .02), *Ganoderma applanatum* (Pers.) Pat. (r = .448, p = .025)*,* and *S. hirsutum* (r = .479, p = .015). It implies that the higher the moisture content of soil, the more abundant these species will be.

With regard to air moisture, two species were found to have a significant relationship. One is *Polyporus sp.* (d) with r value of -0.522 and a corresponding probability of 0.007, which means that an increase in air moisture decreases the population density of the species. *Polyporus* sp. (d) is a tough and leathery bracket fungus that reproduces every two to three weeks, especially a week or two after a heavy downpour.

Because of its woody sporocarp, it is not suitable for very wet and humid environment as these might soften up and eventually damage the sporocarp. In contrast, *Schizophyllum commune* (Fr.) (a) (r = .398, p = .049) grows abundantly with more moisture in the air. *S. commune* tend to grow plentifully whenever moisture is available.

Photos of Macro-Basidiomycetes collected at Cagayan State University at Lal-lo

1. *Polyporus leptocephalus* (Jacq)Fr.
2. *Polyporus sp.(a)*
3. *Polyporus sp.(b)*
4. *Polyporus sp.(c)*
5. *Polyporus sp.(d)*
6. *Microporus xanthopus* (Fr.) Kunze
7. *Microporus sp.(a)*
8. *Microporus sp.(b)*
9. *Hexagonia tenuis* (Hook)Fr.
10. *Hexagonia sp.(a)*
11. *Hexagonia sp.(b)*
12. *Hexagonia sp.(c)*
13. *Pycnoporus cinnabarinus (Jacq.Fr.)P.Karster*
14. *Pycnoporus sanguineus (L.) Murrill*
15. *Trametes versicolor* (L.)Pil.
16. *Trametes hirsuta* (Wulfen)Lloyd
17. *Trametes sp.*
18. *Ganoderma pfeifferi* (Bres)
19. *Ganoderma lucidum* (Ley.ex.Fr.)Kar
20. *Ganoderma applanatum* (Pers.)Pat.



21. *Coltricia perennis* (L.) Murrill
22. *Stereum hirsutum* (Willd.)Gray
23. *Daedalea sp.*
24. *Lenzites sp.*
25. *Lentinus velutinus*(Fr.)Sacc.
26. *Lentinus squarrosulus* (Mont.)
27. *Volvariella volvacea*(Bull.ex.Fr.)Sing.
28. *Omphalina grossula* (Pers.)Singer
29. *Crepidotus sp.*
30. *Schizophyllum commune* (Fr.) (a)
31. *Schizophyllum commune* (Fr.) (b)
32. *Auricularia auricula* (Hook.)Under.
33. *Geastrum saccatum* (Fr.)
34. Unknown species

As for soil temperature, species such as *Microporus sp.* (a)*, Hexagonia* sp. (b)*, Daedalea sp., Crepidotus sp.*, and *Geastrum saccatum* (Fr.) all have negative correlation coefficients, indicating that as temperature of soil increases, the population density of these species is reduced. This result is also similar with another study, indicating that wood – rotting fungi and ground fungi showed decreased numbers at higher temperatures (Jang and Hur, 2014). Air temperature is negatively correlated with *Hexagonia* sp. (b), *Daedalea sp, Crepidotus* sp., *G. saccatum,* which denotes that abundance of these species tends to decline whenever there is a rise in air temperature. These basidiomycetes require enough moisture to thrive, and with high temperature, the environment becomes warmer than necessary which results to drying up of sporocarps due to moisture loss.

Volvariella volvacea (Bull.ex.Fr.) Sing. is an exception to this as it has a positive relationship with temperature. *V. volvacea* is commonly found in decaying stump of banana trees. This may be the reason why it multiplies when the weather is warm. Decay of banana tree parts is hastened by warm temperature, so if it is warm there will be more decomposing banana tubers, and hence, more *V. volvacea* will grow.

The trend for fungi to be less abundant as temperatures increase, and moisture and precipitation decrease are consistent with result of studies done by Jang and Hur (2014) and Sharon M Talley, *et al.*, (2002) on the effects of weather on fungal abundance. According to the studies, low relative humidity and extreme temperatures inhibit growth and spore germination of fungi. Furthermore, fungal abundance and richness displayed a positive relationship with precipitation.

Relationship Between Population Distribution of the Different Species of Macro-Basidiomycetes and Ecological Niche Parameters

The amount of rainfall is positively correlated with the following species: *Polyporus sp.* (b), *Trametes versicolor* (L.) Pil., *Stereum hirsutum* (Willd.) Gray, and *Lentinus squarrosulus* (Mont.). This suggests that these species become more distributed when amount of rainfall increases. Similar findings (Talley *et al.*, 2002; Bernicchia, 2001) suggest that macro fungi tend to proliferate during period of frequent and high precipitation as it leads to high moisture content in fungal substrata and also high relative humidity. There are five (5) species whose distribution is related to soil moisture, namely *Polyporus* sp. (b)*, T. versicolor, Trametes hirsuta* (Wulfen) Lloyd*, Ganoderma applanatum* (Pers.) Pat.*,* and *S. hirsutum*. They all have positive relationship with soil moisture, which implies that their population distribution increases as the moisture content of the soil increases.

Meanwhile, *Schizophyllum commune* (Fr.) (a) has a positive relationship with air moisture, which indicates that its population is more dispersed as atmospheric moisture rise up. On the other hand, the distribution of *Polyporus* sp. (d) has inverse relationship with air moisture. It only means that a high content of moisture in the air reduce the distribution of this species.

Moisture content, both in soil and in air, is an essential factor to the distribution of fungal species. Adequate moisture induces mycelial formation, which give rise to new fruiting bodies. In addition, moisture initiates germination of dormant spores embedded in the soil that soon colonize the area. These are few reasons why moisture generally increases the distribution of most fungi. Egbe *et al.*, (2013) support this finding, that relative humidity is positively related to fungal prevalence.

Apparently, not all fungal species become more distributed with the presence of high moisture. Instead, their distribution was reduced like that of the *Polyporus* sp. (d), which could not tolerate very high moisture. It could be that too much moisture destroys the spores and sporocarps of this species. With regard to soil temperature, species, which significantly correlated, have negative relationship with this parameter. *Microporus* sp. (a), *Hexagonia* sp (b), *Daedalea* sp., *Crepidotus* sp., and *Geastrum saccatum* (Fr.) tend to significantly decrease in distribution as soil temperature gets too high.

The same pattern is also seen with *Hexagonia* sp (b), *Daedalea sp., Crepidotus sp.,* and *G. saccatum* with respect to air temperature. These species have decreased dispersal when air temperature reached higher degree. On the contrary, *Volvariella volvacea* (Bull.ex.Fr.) Sing. displayed a positive relationship with air temperature, suggesting that the warmer it gets the better is the population distribution of *V. volvacea*. Elevated temperature negatively affects fungal distribution due to moisture loss as indicated in the findings of Boddy *et al.*, 2013.

Conclusions

Despite limited time for collection, the result of the survey indicates that the five sites of Cagayan State University have abundant and diverse mycological resources, of which some are yet to be identified. Further and more intensive sampling efforts in the campus will undoubtedly uncover more species of macro-basidiomycetes including some possible new species. It was also found out that species vary in terms of their population density, as well as population distribution, among species and across stations, and that their populations are significantly related to ecological niche parameters such as amount of rainfall, soil and air moisture, and soil and air temperature.

Recommendations

In the light of the foregoing conclusions, the following recommendations are offered:

1. Further study must be conducted on the morphological analysis and on the identification of macro – basidiomycetes until the species level.
2. A follow – up study should be conducted that delves on the physico – chemical analysis of ecological niche parameters, and to include other ecological variables.
3. A parallel study should be conducted for a longer duration, e.g. for at least two (2) wet seasons, that will look into the relative abundance and ecological distribution of macro – basidiomycetes.
4. An inter – agency body composed of qualified staff of CSU Lal-lo, Local Government of Lal-lo, Department of Environment and Natural Resources and from the private sector shall be organized to ensure the proper management, protection and maintenance of the ecological balance of the sites and become a biodiversity area or eco-tourism site.

References

Barroetaveña C, La Manna L, Alonso MV. 2008. Variables affecting *Suillus luteus* fructification in ponderosa pine plantations in Patagonia, Argentina. Forest Ecology Management **256,** 1868-1874.

Bernicchia AP. 2001. *Aphyllophoraceous* wood inhabiting fungi of Lanaitu Valley, Sardinia. Mycotaxon **77,** 15-23.

Boddy L, Ulf B, Simon E, Gange ZC. 2013. Climate Variation Effects on Fungal Fruiting, 1–14. Retrieved from http:// dx.doi.org/10.1016/j.funeco.2013.10.006

Colavolpe MB, Alberto´ E. 2014. Cultivation requirements and substrate degradation of the edible mushroom *Gymnopilus pampeanus* – a novel species for mushroom cultivation. Science Horticulture **180,** 161-166.

Da Silva EJ. 2005. Mushroom in medicine and culture. Int. J. Med. 328 J. Ecol. Nat. Environ. Mushrooms **7,** 75-78.

Daep NA, Cajuday LA. 2003. Mushroom Diversity at Mt. Malinao, Albay. PSSN Nature News **2,** 57.

Dalisay TU. 2001. Saprophytic fungi. Workbook on tropical fungi: Collection, Isolation and Identification. The Mycological Society of the Philippines, Inc 180-206.

De Castro ME, Dulay RM. 2015. Macrofungi in Multistorey Agroforestry Systems in Mt. Makiling Forest Reserve, Los Baños, Laguna, Philippines. Journal of Chemical, Biological and Physical Sciences. Retrieved from: ijbpas.com/pdf/2017/December/ 1512192595MS%20IJBPAS%202017%204322.pdf

De Leon AM, Reyes RG, Dela Cruz T. 2012. An Ethnomycological Survey of Macrofungi Utilized by Aeta Communities in Central Luzon, Philippines. Mycosphere, **3(2),** 251-259.

Dela Cruz TE. 2014. Biodiversity, taxonomy, ecological patterns and conservation of myxomycetes and macrofungi in Puerto Galera Biosphere Reserve and Sablayan Watershed Forest Reserve, Mindoro, Philippines. UNESCO Man and the Biosphere Programme.

Dela Cruz. 2013**.** Review of Mycology in the Philippines. Philippines.

Egbe EA, Tonjock RA, Ebai MT. 2013. Diversity and Distribution of Macrofungi (mushrooms) in the Mount Cameroon Region. Journal of Ecology and the Natural Environment, Vol **5,** 318-334. Retrieved from http://www.academicjournals.org/ JENE. DOI: 10.5897/JENE2013.0379

Foziya K, Chandra R. 2017. Effect of Physiochemical Factors on Fruiting Body Formation in Mushroom 33-35.

Gómez- Hernández M, Williams-Linera G, Guevara R, Lodge DJ. 2012. Patterns of Macromycete Community Assemblage Along an Elevation Gradient: options for fungal gradient and metacommunity analyses. Biodiversity and Conservation **21,** 2247-2268.

Graff PW. 1913. Additions to the Basidiomycetes flora of the Philippines. Philip. Journ. Sci. **8,** Bot 229-307.

Jang SK, and Hur TC. 2014. Relationship between Climatic Factors and the Distribution of Higher Fungi in Byeonsanbando National Park, Korea.Mycobiology 27-32. http://dx.doi.org/10.5941/ MYCO.2 014.42.1.27.

Jang SK, Kim SW. 2012. Relationship between higher fungi distribution and climatic factors in Naejangsan National Park. Kor J Mycol **40,** 19-38.

Kurtzman RH, Martinez-Carrera D. 2013. Light, what it is and what it does for mycology. Micología Aplicada International, vol. **25,** 23-33.

Lindblad I. 1998. Wood- Inhabiting Fungi on Fallen Logs of Norway Spruce: Relations To Forest Management and Substrate Quality. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1756-1051.1998.tb01877.x

Lodge DJ, Ammirati JF, O'Dell TE, Mueller MG. 2004. Collecting and Describing Macrofungi, 128-158. In Tibuhwa, D. D., (2011). Substrate specificity and phenology of macrofungi community at the University of Dares Salaam main campus, Tanzania. J. Appl. Biosci. **46,** 3173-3184.

Moore D, Gange AC, Gange EG, Boddy L. 2008. Fruit bodies: their production and development in relation to environment. In: Boddy, L., Frankland, J.C., van West, P. (Eds.*),* Ecology of Saprotrophic Basidiomycetes. Elsevier, Amsterdam 79-102.

Mueller GM, Bills GF. 2004. Introduction. In: Mueller GM, Bills GF. Foster MS (eds). Biodiversity of Fungi Inventory and Monitoring Method. Elsevier Academic Press, San Diego.

Ong PS, Afuang LE, Rosell–Ambal RG. 2002. Philippines Biodiversity Conservation Priorities. DENR–PAWB, CIP BCP – UPCIDS and FPE. Quezon City, Philippines.

Quimio TH. 2002. Checklist and database of Philippine Fungi (1806-2001). Laguna: ASEAN Regional Center for Biodiversity Conservation.

Redhead S. 1997. Standardized inventory methodologies for components of British Columbia's biodiversity: Macrofungi. Resource inventory committee, Vancouver. In: Scott T.B. (2006). A preliminary checklist of Arizona macrofungi. CANOTIA **2,** 47-78.

Santos JV. 1986. Guide to Philippine flora and fauna*:* Natural Resources Management Center, Ministry of Natural Resources and the University of the Philippines **4,** 46-135.

Seen-Irlet B, Heilmann-Clausen J, Genney D, Dahlberg A. 2007. Guidance for the conservation of mushrooms in Europe. Convention on the conservation of European wildlife and natural habitats. 27th meeting, Strasbourg 26-29 November 34.

Tadiosa ER, Agbayani ES, Agustin NT. 2011. Preliminary Study on the Macrofungi of BazalBaubo Watersheds, Aurora Province, Central Luzon, Philippines. Asian Journal of Biodiversity **2,** 149-171. http://dx.doi.org/10.7828/ajob.v2i 1.96

Tadiosa ER, Arsenio JJ, Marasigan MC. 2007. Macroscopic Fungal Diversity of Mt. Makulot, Cuenca, Batangas, Philippines. Journal of Nature Studies **6,** 1-2.

Tadiosa ER, Briones RU. 2013. Fungi of Taal Volcano Protected Landscape, Southern Luzon, Philippines. Asian Journal of Biodiversity **4,** 46-65.

Talley, Sharon M. 2002. The Effects of Weather on Fungal Abundance and Richness Among 25 Communities In The Intermountain West.

Tapwal A, Kumar R, Pandey S. 2013. Diversity and frequency of macrofungi associated with wet ever green tropical forest in Assam, India 73-78. DOI: 10.13057/biodiv/d140204.

Yamashita S. 2017. Effects of Forest Use on Aphyllophoraceous Fungal Community Structure in Sarawak, Malaysia.