

Review

Considering Sampling Methods for Macrofungi Exploration in Turgo Tropical Forest Ecosystem

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ABSTRACT

Diversity of macrofungi is widely studied because of its role as decomposer, and highly reported of its potentially using for foods, agricultures, medicinal purposes, and bioremediation. This study was carried out to consider sampling methods for macrofungi exploration especially in Turgo tropical forest ecosystem. There were two sampling method models which adequately bring our macrofungi collection to have valid data. The first is adaptive sampling which includes fixed-size plots where prior we decided how many tracks, plots, or what size to examine at each site to help keeping our focus on track. By having a fixed plot, we allowed ourselves to find our macrofungi and work on the identification process thoroughly without racing against the time as much. Then we can obtain frequency, distribution, density and others ecological quantitative data by sampling plots. Another way, we can choose opportunistic sampling, we mean carefully walking on through chosen site as study area and collecting conspicuous sporocarp of macrofungi. This method needs no plots and does not produce any quantitative data but looking for many more diversity on macrofungi. The way of sampling, depends on the duration of observation and the purposes of the research. According to the consideration result, we concluded to choose the adaptive sampling method to explore the macrofungi in Turgo tropical forest ecosystem.

INTRODUCTION

From mycological science, the diversity of Indonesian macrofungi or mushrooms is widely unknown and poorly understood. As well as we know the tropical country has high biodiversity, such as animals and plants, thus those organisms will provide microbes living as decomposer like macrofungi. Ministry of Environment and Forestry of Indonesia has reported Indonesia give a great biodiversity on big five world positions, especially in the plant number of species, 55% are endemic plants. It is included the saprophytic plants, we call decomposer such as fungi, 80,000 species were documented (Yuwono et al., 2014). It has been estimated, 1,5 million fungi species are distributed in the world, and an estimated 14,000-15,000 species of fungi are categorized as macrofungi (Hawksworth,

2015). In the research of Leveile, Henning, Overeem, and Boedijin noted there was recorded 500 species macrofungi Agaricales in the year between 1845-1951, and recorded 1600 collections of macrofungi specimens are in Herbarium Bogoriense (Retnowati, 2004) while other groups macrofungus like polypores, pyrenomycetes, coral-club shaped, jelly, discomycetes, truffles, boletes, crust fungi, tooth fungi, gasteroid fungi, chanterelles and parchment fungi still underestimated, eventhough lichens are better known, with 595 species documented.

Macrofungi is a group fungi that has a sporocarp structure which can be seen with the naked eye, called the fruit body. Macrofungi diversity can be recognized and divided into various forms (morphogroups) namely, boletes, chanterelles, coral

fungi, spine fungi, fungi brackets, puffballs, earthballs, earthstars, stinkhorns, truffles, morels, and disc- and cup-fungi, most of which belong to the Ascomycota and Basidiomycota phyla (Lindsay et al., 2013). The diversity form, macrofungi become identified by key determination. Macrofungi has an important role in the ecosystem as decomposers, ectomycorrhiza for plant roots, and food for certain organisms. Due to the specifications of its role in the ecosystem and the variety of morphology, making macrofungi influenced by the environmental composition in nature and the time process of the formation of fruit body or known as fruiting. According to Lodge et al. (2004). that there are three factors that affect wealth the variety of macrofungi species in a place or ecosystem: geography, vegetation, and succession.

To know the diversity, ecology, and relation environmental factors to the macrofungi we need adequate methods to have interpretive data; sampling is the best choice for macrofungi exploration by some consideration results below. We emphasized in Turgo tropical forest ecosystem.

OVERVIEW

Deciding Priority to Sampling Macrofungi in Tropical Forest and Conservation Area

According to Law no. 5 of 1990, the conservation of biological natural resources along with their ecosystem regulation, species and ecosystem services, especially for protected areas. The Turgo tropical forest ecosystem that was the target of our research on macrofungi exploration, is one of the conservation areas incorporated in the Mount Merapi National Park (TNGM) based on the Ministry of Forestry's decree 2004; and belongs to the Pakem-Turi resort, Sleman, Yogyakarta, Indonesia. Turgo becomes a unique ecosystem because it consists of several different plant community ecosystems at some point. Some of the plants that dominate the Turgo forest are high canopy species such as *puspa* (*Schima wallichii*), pine (*Pinus merkusii*), *rasamala* (*Altingia excelsa*), *kina* (*Cinchona ledgeriana*) and there is one forest ecosystem point where various type of bamboos are able to grow well. All the forests in the Turgo conservation area are wet tropical forest climate type C, with rainfall 1,869.8 - 2,495 mm / year. Turgo tropical forest is also a vital area for preservation of orchids on the island of Java, with estimates there are dozens of species that are endemic one of which is famous is *Vanda tricolor* var. *suavis*. Turgo Forest has been used for long time by local people to meet their daily needs; usually a place to look for firewood and grass, to find a source of food such as mushrooms, which

have been known to the citizens are *keprok* mushrooms, ear mushrooms and oyster mushrooms. Why do we choose macrofungi sampling in a conservation area like Turgo Natural Forest? According to Molina, et al. (2001) mention that conservation of fungi and fungal ecosystem aims to know the ecological function of fungi in the forest; four critical functions of fungi in the forest into conservation considerations:

1. Nutrient cycling, retention and soil structure
2. Food sources for many wildlife
3. Fungal plant pathogens
4. Mycorrhizal communities

Macrofungi researches in the forest usually have their own trends, some are divided into groups, such as macrofungi diversity inventory and ecology. In the history of research in the Indonesian forest has done a lot of researches on macrofungi inventory, including in the area of Mount Bawakaraeng (Hiola, 2011); Mount Merapi National Park (TNGM) special area Tlogo Muncar and Tlogo Nirmolo (Prasetyaningsih and Rahardjo, 2015); several genera have been recorded in Gunung Halimun National Park (Retnowati, 2004); Alas Purwo National Park (Firdaus et al., 2016). Central Kalimantan's Cimtrop Forest (Putir et al., 2008). Basidiomycetes diversity in the protected areas of KPHP Sorong Selatan (Khayati and Warsito, 2016) and one of the largest studies donated in the study of the taxonomic genus of *Marasmiellus* on the island of Java and Bali (Retnowati, 2012). The aforementioned studies were focused on the diversity of mushroom communities in both the genera and species in a region or place; some chose to identify whether the fungus species were found to be edible or inedible with a variety of libraries. This is based on the consideration that Indonesia has a wide range of high macrofungi diversity, but its species and distribution are not widely known, even in protected areas such as tropical forests in nature reserves or national parks. According to Retnowati's research recommendation (2012), field inventories such as the genus *Marasmiellus* in Java, Bali and other islands in Indonesia, will produce more diversity than 35 species of *Marasmiellus* and their kinship. Also the study of macrofungi taxonomy in various islands such as Java is very important as a consideration of national conservation areas due to the diversity of island and biodiversity that disappears in line with the loss of native habitat. From the inventory method that focuses on diversity, Retnowati (2012) found *Marasmiellus* typical Java island that is *Marasmiellus javanicus*.

In the history of macrofungi ecological research, investigators are more interested in characterizing population structure and macrofungi

communities. They emphasized the study of frequency, biomass, density, presence of one or various species of macrofungi. Although the actual concept of an individual fungi is not the same as that of an animal or a plant, the quantitative calculations of the fruit bodies and biomass, and the presence of macrofungi on a substrate have long been used (Zak and Willig, 2004). Andrew et. al. (2013) used a conspicuous macrofungi fruit bodies calculation to express the diversity index differences from the four sampling sites of Mount Cameroon (Ideau, Bafia, Ekona, Buea Town) and the distribution of each species. Another trend is to monitor the number of macrofungi fruit body varieties to determine the abundance and fruiting pattern of macrofungi associated with chestnut (*Castanea sativa*) from 4 years in Trás-os-Montes, Portugal (Baptista et al., 2010). The analysis of the mycorrhizal macrofungi community relationship with the plants also became familiar with the calculation of the density, and the frequency of the macrofungi fruit body, among the macrofungi communities in Hyrcanian Forests relation to forest type and season (Karim et al., 2013); macrofungi and vegetation relationships in Burren, Ireland (Harrington, 2003). The study of vegetation and macrofungi relationships was aimed to find out the variety of host and type of macrofungi periodically, when and where macrofungi grow well, along with its physical and biological condition.

Not only ecology and inventory of priority sampling macrofungi, ethnology approach also serve as a reference method of macrofungi research. Khaund and Joshi (2013) managed to record the type of edible macrofungi along with the local name of macrofungi which is utilized by the Khasi ethnic society in Meghalaya India to be a traditional special food (Khaund and Joshi, 2013). Knowledge of edible macrofungi society, becoming the knowledge for researchers to maintain resource sustainability.

From the research trends mentioned above, what are the reasons made us to choose Turgo as a macrofungi sampling site? It is mentioned in The Fifth National Report of Indonesia to The Convention on Biological Diversity that the cover in Indonesia 52.2% forests area and 47.8 % is non-forests area. Go Green Indonesia data said, about 863,074.8 ha. undergoes functional changes from forests to various purposes such as plantations, rice fields, settlement, and bare land in monitoring for the period 2012-2013. It is this change of forest function that can alter the diversity of other biodiversity such as macrofungi, because conserving fungi is not like conserving animals or plants that can be conserved by ex-situ; habitat shedding from macrofungi is the main step of conservation of the

existence of macrofungi (Molina et al., 2001). Forest management is indispensable, changes in biotic communities in forest plants will have a direct effect on the structure and number of macrofungi fruit bodies; fires and illegal logging became a major disruption; the reduction in the number of fruit body quantities, and the number of mycorrhizas are the main effects of the two causes. Therefore, by knowing the biodiversity, habitat, ecological data, important values of macrofungi in Turgo tropical forest ecosystem as a conservation area, we may remain a conservation place of Javaland orchid with balanced ecosystem, and maintain edible and inedible macrofungi sustainability in the conserved forest ecosystem.

Sampling Methods for Macrofungi - Short and Long Term

Studying macrofungi certainly requires the suited method in accordance with the purpose of study. Proper sampling and analysis will raise the recommendations of further studies, so the management of macrofungi as natural resources can still be implemented.

Why sampling is so necessary in macrofungi research? Almost same as other research purposes, the inability for researchers to detect and calculate all the existing macrofungi in the nature. The difference is that macrofungi don't follow the scheduled times to bring up the fruit body, environmental conditions greatly affect the fruiting process. Almost of the macrofungi are saprophytic, which role is to decompose the remains of organisms so that the substrate as a macrofungi habitat becomes an important factor in macrofungi growth. The population or community dynamics are still very poorly studied. In addition, the term fruit body is not representative of one fruit with one individual, so it is difficult for researchers to explain that one body of fruit that can represent all parts of the mycelia rhizomorph buried in the soil, with different fruiting mechanisms. Some species for example *Coprinus*, can fruit whenever environmental factors still appropriate for its fruiting, but most species fruit in particular season. In Turgo tropical forest ecosystem, we couldn't found *Russula* on March-June, till we found them on July and August. We couldn't see any Coprinoid mushrooms genus *Psathyrella* in long drought season, but it started to be widely distributed in early rainy season. We can conclude that the main factors of fruiting are temperature and climate, it is proved that the fungus species did not exist in summer and abundant in spring and autumn in Hyrcanian forest, North of Iran (Karim et al., 2013). However it is most effective for analysing macrofungi by counting and

interpreting the fruit body. Due to time and space constraints, sampling-site becomes a solution to represent an ecosystem in macrofungi inventory and monitoring.

Sampling-site requires sampling methods based on purposes, from various literatures were collected that a suitable macrofungi sampling for tropical forest ecosystems, especially Turgo, is as follows:

1. Opportunistic Sampling

Mentioned that the technique is used by many mycologist and mushroom hunters to collect as much of the macrofungi as possible. This method puts more emphasis on inventory; diversity becomes the main purpose. This method also does not require transect plot or boundary, which is determined only the location of sampling or sampling-site. Mushroom foraging and opportunistic sampling mechanism are almost the same, mushroom foraging is usually done by a group of people or families to collect as much as possible with the purpose of recreation; edible macrofungi becomes an option to hunt based on season and predetermined location. So mushroom foraging as activity to introduce macrofungi to others or to be cooked, without scientific purpose. While opportunistic sampling, is aimed scientifically by selecting area boundaries from various considerations, the inventory is usually limited by labor; to characterize until species begin from macroscopic and microscopic morphology, to molecular analysis, the researchers can define the number of macrofungi that can be characterized after collection. Taxonomy and evolution studies are well suited to use this method. The method also called as “walk-through”, if the purposes is to locate a specific rare macrofungi (Pilz et al., 1996).

2. Substrate-based Sampling

Substrate-based sampling methods are used for macrofungi that occur only on specific substrate or particular host. This sampling only focuses on a population of a habitat or confined to a specific substrate. Wiensczyk and Berch (2001) conducted a macrofungi sampling of pine forests in British Columbia. Its application was to undertake any macrofungi inventory existing on the ground and associated with the pine vegetation population. *Tricholoma magnivelare* is a commercial one in the forests of British Columbia, targeted by investigators, so that the distribution and population dynamics of this type of fungus can be studied in terms of management to keep the British Columbia pine forests well and remain a habitat for *Tricholoma magnivelare* (Peck Red) (Wiensczyk and Berch, 2001). Other researchers monitored the variety of

ectomycorrhizas in the special vegetation of *Castanea sativa*, where and when the fruiting of various ectomycorrhiza is closely related to the conservation of the agro-ecosystem of *Castanea sativa* as a provider of wood with economic value and edible macrofungi around the ecosystem (Baptista et al., 2010). Both studies are substrate-based with a focus on vegetation management for the sustainability of natural and macrofungal resources. This method can also be used to calculate ecological data, as in Angelini et al. (2015) that compared the indices of diversity, similarity, macrofungi abundance of different vegetation populations of different species: *Carpinus betulus*, *Pinus* spp. *Quercus cerris*, *Quercus frainetto*, *Quercus petraea*, *Quercus ilex* and the Collestrada forest in Umbria, central Italy. The purpose of the study was to determine which vegetation possessed the highest and lowest biodiversity values, in relation to the selected vegetation. This method produces qualitative and quantitative analysis, to study the macrofungi ecological function in a homogeneous vegetation population is very suitable to use this method.

3. Plot-based Sampling

This method has differences with other sampling methods. If the previous two methods only specify representative sampling-sites, adaptive-plot-based sampling uses plot and transect design used for sampling. Replicative and consistent plots assists investigators to focus sampling on their plots and ignore sampling of organisms outside the plot. In many studies the plots are designed with different sizes and shapes. Kinge et al. (2017) used transects based on elevation differences (low-mid-high) in the Awing forest, Cameroon with the size of one large plot of each transect 50 x 20 m; Lindner and Stanosz (2006) used a total plot of 60 x 100 m area, then divided into two large subplots with transect size 10 x 100 meters, sampling was done on the squares plot sized 5x5 m on the left and on the right to collect all macrofungi in all twigs and debris, for the tree is done along the transect with the size of the tree diameter ≥ 15 cm. In terms of determining the number and amount of plots and transects is certainly based on the priorities and objectives of the study. Eldridge, Skinner and Entwisle (2003) revealed basically plot sampling for non-vascular plants including macrofungi divided into two, namely survey-targeted sampling and standardized plot sampling. Both are differentiated by time and needs, Rossman, Tullos, O'Dell and Thorn (1998) conserved macrofungi using a standardized, permanent plots for pilot-program for two years. How are these permanent plots considered and designed? This is based on a good mapping of

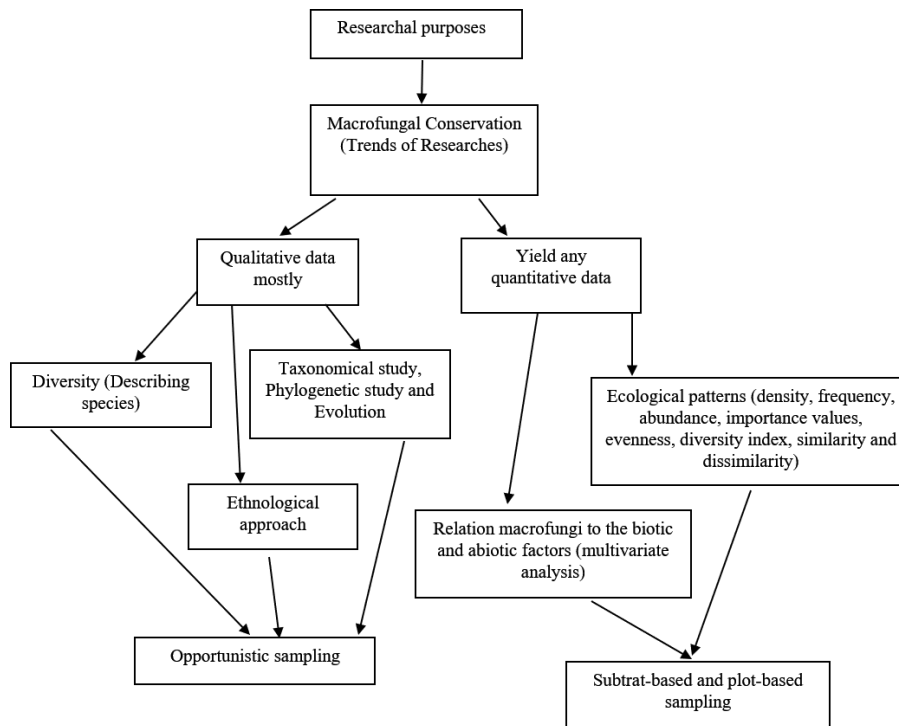


Figure 1. The Main Map of Decision Macrofungi Sampling

researchers, conservationists and taxonomists about the types of forest vegetation they have in Costa Rica, macrofungi associations and substrates, and types of macrofungi that have been inventoried and studied. The area and the representative of the sampling area become the benchmark for making a permanent plot; 2 year pilot program for sampling macrofungi using the distance between plots, same size and replicative circular plot, transect design and distance between, the number of plots, as well as appropriate scheduling for macrofungi sampling over the period of two years without changing the design at all (Anonymous, 1997). Standardized plots is an option for monitoring of macrofungi diversity with long-lasting validity data, in contrast to the adaptive-plot (survey-targeted) based sampling used to define rapid macrofungi-ecological patterns without reducing the prevalence of data; and information will be highly fluctuating from time to time, so the conclusions are valid for a short period of time. However there are some unique considerations that used by some mycologist in Douglas-Fir forests, Oregon to sampling hypogeous ectomychorizzal fungus like truffles. Truffles were recorded by sampling from twenty-five-square 4 square meter circular plots of 100 square meters. It is common to the others, but recording of cover by exposed mineral soil, coarse woody debris by decaying class and *Piloderma bicolor* mycelium related as factors to the truffles fruiting underground is unique. This is needed excavation to measure, so if we want to estimate hypogeous macrofungi, we need the

“markers” of their appearances of their fruiting underground (Pilz et al., 1996).

Researchal Purposes Impact to Decision of Sampling

It has been elaborated that researchal purposes and certain limitations such as time and place will influence the methods of macrofungi sampling to be used. However, all sampling methods have their respective weaknesses, none of which are really effective for mapping the distribution and ecology patterns of macrofungi, even macrofungi inventory, due to macrofungi fruiting on the substrate and special environmental conditions, so that habitat conservation and management becomes more important than protecting species - rare species of macrofungi itself. In a macrofungi species monitoring study, plots are not made on a minimum extent as representative sites. Monitoring uses exploratory selected substrates of macrofungi living is then made as markpoint, this method is similar to substrate-based sampling, but to see population dynamics of one species, investigators should study with substrate preferences where macrofungi reproduce and reappear when - at a certain season. This is related to the type of spreading of the macrofungi spores and their resistance in producing fruit bodies; it has been investigated that the *Auricularia delicata* mushroom only grows in the Bingungan forest with an altitude of 1200 m more when the rainy season begins until the end of the rainy season, and does not appear in other forests in Turgo. Pyrenomycetes mushrooms group like

Xylaria spp. fruit many in the rainy season and survive in the dry season in the forests of Turgo, Tritis and Bingungan. The importance of modeling habitats to find out detailed macrofungi habitat preferences and to analyse the relationship of abiotic and biotic factors to the rate of population growth when macrofungi fruiting, so hypotheses and strategic recommendations, management for conservation can be established (Molina et al., 2001). The process from defining ecological patterns, standardization, to determine habitat-modelling for monitoring is a conservation step in sequence based on many considerations. Figure 1 shows the framework of how we choose macrofungi sampling, related trends and purpose to be achieved in macrofungi researches.

Considering Between Opportunistic and Adaptive Plot-based Sampling

Furthermore, the discussion on how our research considerations refers to two methods that can be used in macrofungi exploration research in the Turgo conservation area. Table 1 shows the comparison between the two recommended methods, namely opportunistic sampling and adaptive plot-based sampling.

Other considerations are also taken into estimation if we use opportunistic sampling then we will focus on macrofungal diversity in Turgo. Many of this sampling is to be used in taxonomical study and building phylogenetic trees of a group or polymorphism of macrofungi species. Molecular analysis certainly use a long time to spend with various experiments on the variety of DNA primers used. As sequence analysis uses ITS rDNA to study the evolution of macrofungi Coprinoid group, genus *Parasola* which requires no sampling but only using a collection of herbarium of Szeged Microbial Collection, Hungary (Nagy et al., 2009); or using a random sampling site to analyze the ITS rDNA sequence analysis as well as Retnowati's (2012) comparison study old and new *Marasmius* findings

on Java and Bali, Indonesia. Taxonomical studies require the preservation of good collections of specimens in order for the specimens to be fully characterized and correctly identified. This method is almost selected when our research purposes are focused on diversity, and species descriptions but this will eliminate a lot of ecological data, so this qualitative method is ruled out and using other alternative methods, adaptive plot-based sampling. Adaptive plot-based sampling means investigators decide priority to sampling how many plots or tracks and what size to examine at each site by sampling conspicuous macrofungi sporocarp. Some of the reasons behind the use of this method are:

1. The term fruit body is not representative with one individual, so it is difficult for researchers to explain that one fruit body that can represent all parts of the mycelia rhizomorph buried in the soil. Fruiting process is affected by many factors. Conspicuous sporocarp is targeted by this method.
2. Short term research, but needs ecological patterns macrofungi and its distribution in Turgo tropical forest ecosystem.
3. Trying to detect important or rare species and mapping diversity of edible, inedible macrofungi found.
4. Geological condition.

The explanation from the first point that is very difficult to calculate all fruit bodies scattered in the Turgo forest, sampling with sized-plot and track design such as illustrations of Figures 2, 3 and 4 above helped us focus on the tracks and the presence of fruit bodies of macrofungi. However there remains a method for inventorying based on vegetative mycelium as well as detecting microfungi. Investigation is done by isolating, cultivating, and observing mycelia and spores under a microscope. Certain tests and trials are carried out by treatment of media differences, temperature, and inhibitors, and more modern uses of antibodies and PCR or DNA sequencing analysis (Egger et al., 1992). Then

Table 1. Comparison of between two sampling methods for macrofungi exploration.

Types of Sampling	Opportunistic Sampling	Adaptive Plot-based Sampling
Surveying intensity	Species mandatory	Species, genus, morphogroups
Type of data collected	Morphological characteristic; collecting, describing species	Ecological data
Type of measurement	Qualitative data mostly	Quantitative data
Statistical rigour	Low	Moderate to high (standardised)
Re-survey interval	Never	Sometimes, periodical sampling
Analysis methods	Monovariate	Bivariate, multivariate, statistics
Requirement	Sampling chosen-site	Transect and plot design

an easier and cheaper alternative sampling target is to collect macrofungi sporocarp. The advantages are also able to get information when macrofungi thrives a lot of fruit bodies, whether a certain time, or every year will continue to exist, and how long fruit body of macrofungi can survive.

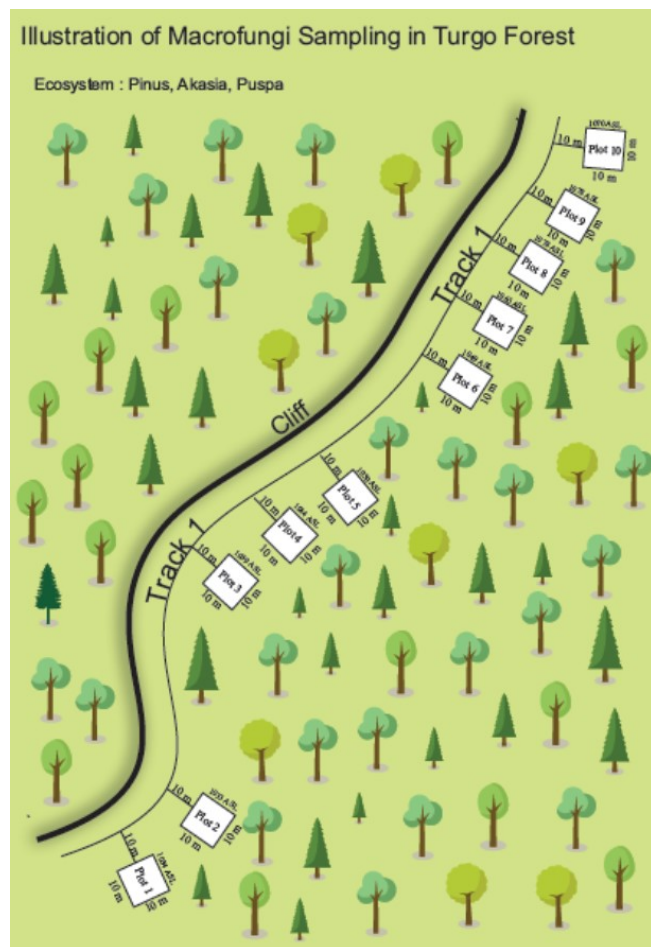


Figure 2. Plot and Track Design in Turgo Forest.

The second point is based on the fact this study was limited by a short time investigation. This project was in accordance with the contract of the research, so the results should be reported at the specified time, with research that took a period of three months, including preparation, macrofungi identification, and data analysis. With a wide range of research purposes, ultimately the sampling design was made simple; meaning not eating too much time, and reporting the results just in time. The use of fixed size plot-based sampling helps us to stay focused on the paths, and sampling; if there were no macrofungi fruit body in the plot we made, then we moved on a new plot with the same size between the same plot, and remained representative of the forest vegetation type. So the macrofungi sporocarp was the main target, and ignores the form of the macrofungi vegetative mycelia. Ecological data are well obtained (diversity index, similarity index, frequency, presence, density, and importance), and

some macrofungi can be categorized as edible or inedible macrofungi. This method also has been considered by Kuszegi et. al (2015), by a reason large total area about 31.500 m² for sampling units and wide research purposes, they needed simple methods using sporocarp surveys to conduct characterizing the macrofungal composition with quadrat fixed plot 5x5 m in two years sampling (3 time sampled each sampling unit per year). They explained too that those data was biased by all disadvantages of using sporocarp incidences to estimate macrofungal abundance; it only provided an underestimate fungal species richness just in the sampling unit.

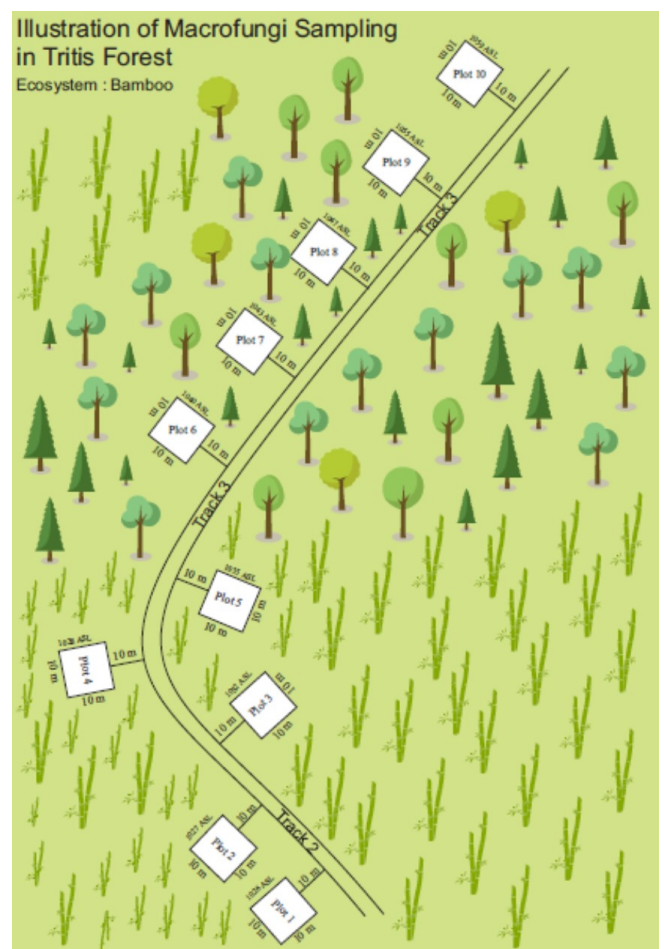


Figure 3. Plot and track design in Tritis Forest.

The third explanation is to try to detect unique or rare species that can be found between the three forests as sampling places. In research report of Prasetya et. al (2017, unpublished), investigators have obtained an ecologically appropriate pattern, with a rapid sampling method via adaptive plot-based sampling. From the research, the three sampling forests have a moderate-to-high variety of macrofungi, which is dominated by agarics, which has the highest ecological importance value, *Auricularia delicata* (Mushroom) is a mushroom that is identified as a unique local mushroom, which is consumed by people around Turgo as food. That

fungus only grows in the Bingungan forest and does not grow in other forests, in the area of Turgo. Survey approaches can be done by determining the priority of the species based on the important values, geography differences, ranking from the highest to the lowest. Historical data on where and the continuity of a unique species in an area, became the foundation for macrofungi conservation (Molina et al., 2001). Detection is the most fundamental purpose to monitoring one or some unique species in an ecosystem. Its purpose to document the current production of macrofungi, edibility, and fruiting variability with space and time. The monitoring will be made to determine what information is collected and what comparisons are made (Molina et al., 1993).

sampling the vegetation of the canopy thrives on the non-cliff side (Figure 2). In the forest Tritis sampling was done on the bamboo vegetation area; so that the parallel plots displacement becomes a series following where the bamboos vegetation were found and grown (Figure 3). In the Bingungan forest, sampling was done in series then switch random sampling because the area was overgrown with herbs and shrubs, there were not found macrofungi fruit bodies. To analyse the data, then the number might be equated. The decision to cross the basin into which the water channel from the hill to the bottom. Recording of microclimatic conditions such as light intensity, humidity, air pressure, and temperature are important for comparative studies of macrofungi diversity based on the influence of abiotic factors and elevation.

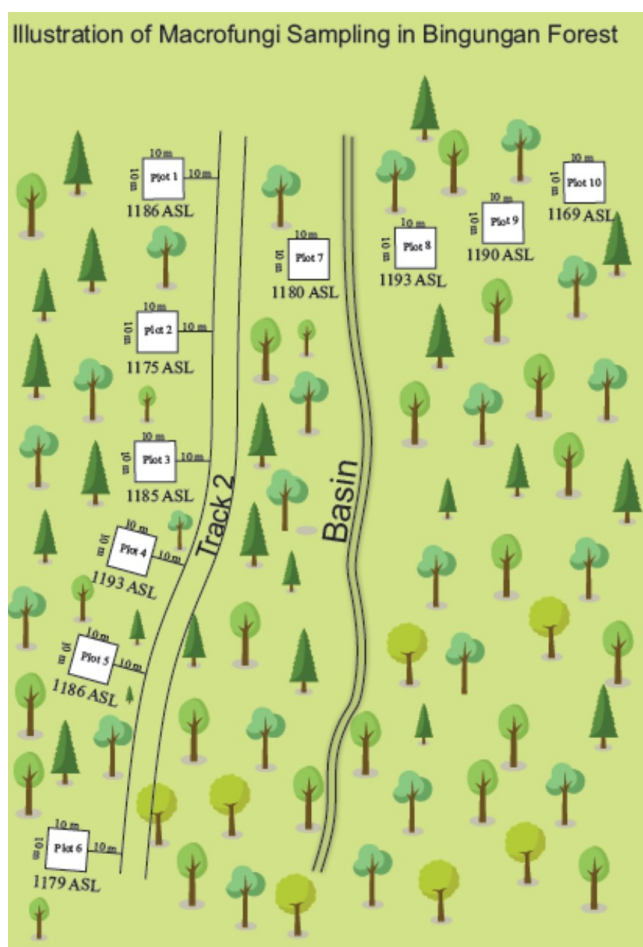


Figure 5. Plots and track design in Bingungan forest.

Finally, that every research has a variable that can not be controlled, such as weather conditions and geology. In this case the geological condition of the sampling -site; Turgo's macrofungi exploration has to deal with the Turgo forest, where on one side there is heterogeneous vegetation, and one other side of the ravine along a path that does not allow investigators to make plots on the cliff side, given the difficulties in sampling, risk of accident. So the parallel consideration is not suitable; we were

CONCLUSION

Macrofungi exploration in turgo tropical forest ecosystem needs macrofungal patterns, detecting important, unique or rare species, and also their distribution, thus can be continued researches on monitoring and describing species deeply. We assumed the difference between each months are extreme, a longer study, increasing sampling frequency and area, also improving replication of habitats will provide better comparison among habitats, vegetation, and richness of macrofungi. Management of macrofungal biodiversity will be standardised in the future. We concluded by considerations above to choose adaptive plot-based sampling to know the ecological patterns and macrofungi diversity rapidly.

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