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Identification of Macrofungal Diversity in Limestone Mining Areas

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Abstract

This study aimed to identify the diversity of macrofungi in the Paciran limestone mining area. This type of research is quantitative descriptive, identifying and describing the macrofungi diversity level in the Paciran limestone mining area. The method used is observation with data collection using a 1x1 meter plot technique and then continued to count the macrofungal species in the plot and analyze it using the Shannon & Wienner (1963) diversity index equation. In addition, the morphological characteristics of each macrofungi were noted and entered into the observation table. The research results showed that 10 species of macrofungi belonging to two divisions, namely Ascomycota and Basidmycota, were identified, totaling 377 individuals. The Ascomycota division has a low level of diversity with a value of 0.6, while the Basidiomycota division has a medium level of diversity with a value of 1.40. The diversity of macrofungi in the Paciran limestone mining area can be used as a contextual learning resource for lower plant botany to provide insight and increase contextual knowledge related to macrofungi diversity for biology education students.

Keywords: Diversity Index, Macrofungi, Morphology, Limestone Mining.

INTRODUCTION

Fungal diversity is very high in Indonesia, with an estimated 200,000 out of 1.5 million species worldwide (Daud et al., 2021). Fungi are a group of species that develop by forming and distributing spores (Maizarmis, 2022; Pungpa et al., 2020; Wangdi et al., 2021). Fungi are known as cosmopolitan organisms (Putra et al., 2020). Fungi can be categorized into microfungi and macrofungi based on size (Kusuma et al., 2021; Nurlita et al., 2021). Macrofungi are a group of fungi that the eye can see, and the majority belong to the phyla Basidiomycota and Ascomycota (Lagrange & Vernoux, 2020; Li et al., 2020; Putra, 2020; Soliman & El-Sayed, 2021). Macrofungi have general structures: cap, blade, ring, stalk, and volva (Fuziyanti et al., 2022). Macrofungi play an important role in ecology; apart from that, they also play a role in the nutrient cycle of tropical forests (Rahayu et al., 2021; Sibero et al., 2021). The diversity of macrofungi is greatly influenced by several factors, including the level of pollutants in the soil due to mining.

Mining is the activity of extracting materials from the ground (Widiyani, 2017; Yulianti et al., 2020). Due to high extraction activities, mining areas tend to have high air and soil pollutant levels (Ramadhani et al., 2022). This is what can disrupt the growth of fungal diversity in the area. Apart from affecting fungal diversity, high levels of pollutants can also affect the vegetation type in an area, making it arid. Torres et al. (2020) explained that the vegetation type greatly influences fungal diversity as a substrate for fungal growth. The substrate for this fungus

includes forest floor soil, wood, litter, dunes, grasslands, and animal waste (Wibowo & Mardina, 2021). One example of mining in the Tuban area is Paciran limestone mining, which extracts sedimentary rock (Tolan & Hasan, 2023).

Several studies have been carried out to measure the level of macrofungi diversity, including in Indonesia (Khaled et al., 2022), including by Yusran et al. (2022) in the Lindu National Park area, Central Sulawesi, Nurhayat et al. (2021) in the Toba area of North Sumatra, Nadila et al. (2020) in Langsa Lama District, Aceh and Hujjatusnaini et al. (2021) identified the diversity of Basidiomycota fungi in the forests of Central Kalimantan. Most of the research that has been mentioned only explores the diversity of macrofungi and does not relate it to learning. This is per Taridala et al. (2022), who state that fungal diversity has yet to be utilized optimally. Therefore, we carried out a novelty from previous research by identifying the level of macrofungi diversity in the Paciran limestone mining area.

Based on the description regarding the level of macrofungi diversity in mining areas, the problem formulation in this research is how to identify macrofungi diversity in mining areas. This research aims to identify the diversity of macrofungi in mining areas.

METHOD

This type of quantitative descriptive research identifies and describes the diversity of macrofungi in the Paciran limestone mining area. The method used in this research is observation by directly observing the Paciran Limestone Mining area. The population in this study was all types of fungi in the Paciran limestone mining area. In contrast, the samples used in this study were macrofungi colonies found in the Paciran limestone mining area. The instruments used in this research were writing instruments, rulers, raffia rope, scissors, wooden stakes, tape measure, a hammer, and a cellphone camera. The data collection technique involves making 1x1 meter plots in several mining areas. Macrofungi found in the plot were identified morphologically (hyphae, cap, stalk, lamella, and body), and then the results of the observations were in the observation table. After recording the morphological characteristics, the number of individuals of each macrofungi species found was counted to analyze the level of diversity.

The variable in this research is a single variable, namely the diversity of macrofungi in the Paciran limestone mining area. The data analysis technique in this research is quantitative descriptive, which calculates the diversity index value using the Shannon & Wiennner diversity index equation (1963) in Khalmuratova et al. (2021).

$$\mathrm{H}' = -\sum_{i=1}^{s} \mathrm{pi}.\, ln\, \mathrm{pi}$$

Note:

H´ = Shannon-Wienner diversity index

pi = number of individuals found in genus *i* in a population

$$\text{pi} = \frac{ni}{N}$$

Note:

ni = number of individuals in one species;

N = total number of individuals of the species found

ln = natural logarithm

The results of the known diversity index (H') are grouped with the definition criteria of the Shannon-Wienner diversity value (1963) in Baderan et al. (2021), as in Table 1.

Table 1: Criteria for diversity index values

H' **value**	**Diversity Category**
H' <1	Low level
1 ≤ H′ ≤3	Medium Level
H' >3	High level

RESULTS AND DISCUSSION

The research results related to the diversity of macrofungi in the Paciran limestone mining area obtained ten types of macrofungi, which are presented in Figure 1. Each species found has a different type of family, morphological characteristics, and level of diversity.

Figure 1: The diversity of macrofungi found in the Paciran limestone mining area includes (a) *Schizophyllum commune*, (b) *Nectria cinnabarina*, (c) *Phallus indusianus*, (d) *Ganoderma lucidium*, (e) *Lentinus tigrinus*; (f) *Auricularia auricula*; (g) *Psilocybe cubensis*; (h) *Pycnoporus cinnabarinus*; (i) *Coprinellus disseminatus*; (j) *Agaricus placomy*.

The results of the morphological identification of macrofungi found in the Paciran limestone mining area are presented in Table 2.

Table 2: Identification of macrofungi morphology in the Paciran limestone mining area

Species	Morphological Characteristics					Community	Substrate
	Hyphae ***(Mycelium)***	**Hood** ***(Pileus)***	**Stalk** ***(Stipe)***	**Lamella** ***(Gills)***	**Body** ***(Basidiocarp)***		
Schizophyllum commune	Yes, it is partitioned	There, spread the fan	Yes, small	Striped folds	White and brown	Colony	Rock
Lentinus tigrinus	There is	There is	Yes, short	There is not any	Porous red	Colony	Wood
Phallus indusianus	There is	Flat serrated edges	Small size	Striped	Brownish white	Colony	Weathered tree
Ganoderma lucidium	There is not any	Oval and grooved	There is not any	porous	Oval-shaped, brownish	Colony	Weathered wood
Nectria cinnabarina	There is	There is not any	There is not any	Yes, in the form of coral	Round brownish white	Individual	Tree
Auricularia auricula	Yes, it is partitioned	There is not any	There is not any	There is	ear-shaped brown	Individual	Weathered wood
Psilocybe cubensis	Yes, it is partitioned	Resembles an umbrella, textured	Long stalks white	striped	Colored white	Colony	Animal waste
Pycnoporus cinnabarinus	There is not any	There is not any	There is not any	Yes, it is porous	Orange and flat	Colony	Weathered wood, bamboo
Coprinellus disseminatus	Yes, it is partitioned	Yes, conical striped	Yes, small	Yes, it is white	Colored white	Colony	Rotten wood, damp places
Agaricus placomyces	There is	Yes, it resembles an umbrella	Yes, small	There are, in the form of plates or gills	Brownish white	Individual	Clay (moist) soil

The identification results related to macrofungi diversity were found to have 377 individuals. Of the 10 types found, there are 2 divisions, namely Ascomycota, with 5 individuals, and Basidmycota. The macrofungi diversity index of the Paciran limestone mining area is presented in Table 3.

Table 3: Macrofungi diversity index in the Paciran limestone mining area

Division	Species	Number of Individuals (ni)	Diversity Index (H')	Category
Ascomycota	*Nectria cinnabarina*	5	0.06	Low
	Amount	**5**	**0.06**	**Low**
Basidmycota	*Schizophyllum commune*	10	0.10	Low
	Phallus indusianus	156	0.37	Low
	Ganoderma lucidium	12	0.11	Low

Division	Species	Number of Individuals (ni)	Diversity Index (H')	Category
	Lentinus tigrinus	74	0.32	Low
	Auricularia auricula	1	0.02	Low
	Psilocybe cubensis	6	0.07	Low
	Pycnoporus cinnabarinus	3	0.04	Low
	Coprinellus disseminatus	108	0.36	Low
	Agaricus placomyces	2	0.03	Low
	Amount	**372**	**1.40**	**Medium**

The diversity of fungi in the limestone area was 10 different species. Morphological observations of the 10 fungal species can be seen in Figure 1. Some of the species found were *Schizophyllum commune*, *Nectria cinnabarina*, *Phallus indusianus*, *Ganoderma lucidium*, *Lentinus tigrinus*, *Auricularia auricula*, *Psilocybe cubensis*, *Pycnoporus cinnabarinus*, *Coprinellus disseminatus*, *Agaricus placomy*. Each of these species has different morphological characteristics from each species, which are listed in Table 2. and has differences in the substrate. The substrate is a place for fungi to live. According to Anjella et al. (2023), fungi can live on dead organisms such as wood, grass, and soil. There are 2 divisions of the ten species found in limestone mining areas with diversity data in Table 3. Each division has a diverse number of individuals. The diversity and many individual macrofungi in limestone mining areas are supported by environmental conditions such as shady places and fallen trees that can grow well with wood fungi. These lighting conditions are exposed to indirect sunlight and low soil pH. This aligns with research conducted by Yenie and Utami (2018) that shows that environmental pH and temperature can influence fungal growth. A bad environment will affect the development of fungi in a habitat (Djuku et al., 2022).

The first species identified was *Schizophyllum commune*, which has a brownish-white body, insulated hyphae, a cap resembling a fan, and a small stalk. This fungus also has striped lamellae in folds that are neatly arranged at the bottom of the cap. This serrated fungus lives in colonies attached to rocks and wood substrates. The serrated fungus (*Schizophyllum commune)* is known to have a small, flat body with a stalk that needs to be better developed (Nurlita et al., 2021). The next species, namely *Lentinus tigrinus*, is a fungus that lives on the roots and trunks of fallen trees. This fungus has a bone-white color with a round head shape that looks like a funnel. This fungus is found in very large colonies. This fungus has insulated hyphae, a round head cap, and a short stalk that grows on a wood substrate. *Lentinus tigrinus* has uneven body edges and a brownish-white color when the mushroom ages. This fungus grows on rotting wood and lives attached to living trees (Suryani & Istiqomah, 2018).

The Phallus indusianus species is a bamboo fungus with a flat, serrated cap. This bamboo mushroom has a small, brownish-white body and a small stalk. There are striped lamellae, and this fungus grows in colonies in very large numbers on the roots of fallen bamboo groves. This *Phallus indusianus* fungus can be found anywhere, including in rotting wood or soil rich in nutrients (Norfajrina et al., 2021). The number of individuals found in the limestone mining area was 156, and the diversity index of this fungus is still relatively low. *Ganoderma lucidium* is a wood fungus. The *Ganoderma lucidum* fungus belongs to the Polyporales order and the Polyporaceae family. This wood mushroom is known as *Lingzi or Reishi mushroom*. The research showed that wood fungi had several colors; some were whitish brown and orange, both found attached to dead tree trunks. Observations on *Ganoderma lucidium*: This fungus has a flat, grooved body shape and a hard texture. The top of the mushroom has a smooth and shiny surface. This fungus has a sturdy stem to live on its substrate, one of which is hard and damp wood (Fitriani et al., 2017). The environment is very influential in the growth of this fungus, requiring hot and humid environmental conditions between 26-27°C (Wardhani, 2017).

The species *Nectria cinnabarina* is a coral fungus. This mushroom is unique compared to other mushrooms, where it has a bright red color, holes resembling coral in the basidiocarp, and a textured and porous mushroom body. This coral fungus lives attached to damp rotting wood, and this fungus is found living individually and not in colonies. This coral fungus has a mottled, pimply, disc-shaped, or cylindrical body and has a height of up to 250–800 mm (Hirooka et al., 2011). *Auricularia auricula:* This species is locally known as the ear fungus. The research showed that the *Auricularia auricula fungus* has a body like an ear and a brown color. This fungus was found to be an individual that does not have colonies and does not have a stalk, and it was found directly attached to the trunk of a fallen tree. This ear fungus has insulated hyphae and has an ear-shaped basidiocarp; this fungus does not have a cap, stalk, or lamella. Ear fungus has a jelly-like, purplish-brown texture and lives in colonies or solitary on wood (Tristina et al., 2022). Ear fungus can grow in various environmental conditions, with a tolerance temperature of around 16-36°C with an ideal environmental temperature of 26-28°C (Namidya et al., 2023).

Psilocybe cubensis is called the *Magic Mushroom.* The results show that this fungus is found in colonies and grows on cow dung. This mushroom is bone white. This mushroom has a stalk that is long and grows on cow dung. It also has a cap with spots and an upward-curved edge. This fungus also has hyphae insulated, but this fungus does not have lamellae or basidiocarp. This fungus has characteristic flat oval spores (Wardani & Novianto, 2017). The *Psilocybe cubensis* mushroom belongs to the Psilocybe genus and is a group of hallucinogenic mushrooms (Suaniti et al., 2018). Research on the number of individuals in this limestone

mining area has a low diversity index of 6 species. *Pycnoporus cinnabarinus Pycnoporus cinnabarinus* This fungus has a flat body and a light orange color. This fungus does not have hyphae, caps, or stalks. This fungus lives directly attached to the substrate, namely rotting wood and damp bamboo. *Pycnoporus cinnabarinus* fungus was found living in colonies. According to Pardosi et al. (2020), the habitat of *Pycnoporus cinnabarinus* jamjur can be found in dead wood in open areas exposed to sunlight. This fungus is found in small numbers in limestone mining areas, with 3 individuals classified as having a low diversity index.

The data obtained for the species *Coprinellus disseminatus* shows that this fungus has insulated hyphae, a cap resembling a conical umbrella, and looks striped. There is a small stalk on its body, and it has mycelium and a white mushroom body. *Coprinellus disseminatus* has a white body color when it is young. Over time, this fungus will change from gray to brown when it is old and in damp areas. It is called a hygrophyte (Putra et al., 2021). The *Coprinellus disseminatus* fungus was attached to damp, rotten wood substrates and lived in clusters (colonies). The number of individuals found in this study was 108, and they were found in clusters attached to the substrate. Data obtained from *Agaricus placodes* shows that this fungus has been identified as having small hyphae; the stem of this fungus resembles an umbrella and is brownish-white. This mushroom also has a small stalk. This fungus is found individually in moist soil. The number of fungi in this limestone area is 2, with a low diversity index.

The science with learning resources related to living things is biology. One learning resource can be utilized is the surrounding environment, where interaction is close to daily life. We can find macrofungi in the environment around us, with various types, characteristics, colors, and variations in number can be utilized in education. From the research that has been done, the results of macrofungi diversity in the limestone area are obtained and each fungus has diversity related to differences in characteristics, size and quantity, so that macrofungi as local potential can be used as a contextual learning resource in lower plant botany courses through their contribution to education by providing knowledge, understanding, insight and adding contextual knowledge related to macrofungi diversity for biology education students. Utilization as a contextual learning resource certainly needs further research in developing contextual learning resources by utilizing the diversity of macrofungi that have been identified. Utilization of macrofungi diversity as a contextual learning resource is expected to provide concrete and contextual learning experiences.

CONCLUSION

Based on the results of the study, it can be concluded that the macrofungi identified in the Paciran limestone mining area were 10 species belonging to two divisions, namely Ascomycota

and Basidmycota with a total of 377 individuals. The Ascomycota division has a low diversity level with a value of 0.6 while the Basidiomycota division has a medium diversity level with a value of 1.40. The identification shows that the diversity of macrofungi in the Paciran limestone mining area can be utilized as a contextual learning resource for the botany of low plants course.

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