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Macrofungi Inventaritation at The Pine Forest of Kragilan, Magelang

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Abstract

The pine forest of Kragilan village, Magelang, is a forested area on the west slopes of Mount Merbabu with a humid environmental condition. The conditions make this region suitable for the growth of a macrofungal community. The macrofungal inventory in Merbabu Mountain is very limited and this is inversely proportional to the increasing deforestation. Thus, the macrofungal inventory is a fundamental way of managing natural conservation in this area. The study aimed to provide information and the potency of macrofungi found in the pine forest area of Kragilan, Magelang. The method used is purposive sampling in the research area, and the fungi obtained were identified based on characteristics with some related references. This research described eight species of eight different genera, including one from the Ascomycota (Xylaria sp.), and seven others from the Basidiomycota (Auricularia auricula-judae, Lentinellus sp., Mycena sp., Skeletocutis sp., Gymnopilus sp., Coprinopsis sp., and Coprinellus disseminatus). The current study is the first report on macrofungi diversity in the research area. Further exploration is still needed to record the macrofungal diversity on the western slopes of the Kragilan pine forest.

Keywords : Ascomycota, Basidiomycota, exploration, pine forest, Merbabu Mountain.

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1. Introduction

Fungi are heterotrophic eukaryote organ-isms that have an essential role in ecosystems. Based on their size, fungi can be di-vided into macrofungi and microfungi. Macrofungi generally have a variety of forms of the fruit body, the hoods, the sur-face of the spores, the stalks, and the stipe [1, 2]. Fungi get nutrition from organic mat-ter gradients surrounding them (saprophytes) or by gaining nutrition from their host (mycorrhiza or parasite) [3]. From an ecological perspective, some fungi act as decomposers with several species of bacteria and protozoa. Fungi help in the decomposition of organic matter, so it has a role in soil fertility by providing nutrients for plants [4, 5]. Fungi have an important role in soil biogeochemical cycles, nutrients cycles, and decomposition. Fungi can have a

positive symbiosis or act as parasites on animals and plants. Fungi also act as biocontrol agents and producers for other industries, such as the pharmaceutical and food indus-tries. Several species have been used by humans as food and medicine, both traditional and modern [6, 7, 8, 9].

Mount Merbabu is one of the dormant volcanoes in Central Java Province, which is divided into three administrative areas: Magelang on the west slope; Boyolali on the south and east slopes; and Semarang on the north slope. The Pine Forest area of Kragilan Village, Magelang, is one of the well-known pine forests on the western slope of Mount Merbabu National Park. Kragilan Pine Forest is located at a height of 1261 above sea level. Pine forest is the most abundant vegetation found in Mount Merbabu National Park. According to [10], four types of plants that dominate Mount Merbabu are pine, acacia, mountain spruce, and puspa. Mount Merbabu is geographically located at 7.5º South Latitude and 110.4º East Longitude with a height ± 1000-3142 above sea level. This mountain has a type B climate with 2000-3000 mm of rainfall and 17-30ºC temperatures throughout the year [11]. High rain-

fall with low light intensity makes the forest conditions in the Mount Merbabu area humid. This is a suitable place for mushrooms to grow well. According to [12, 13], the air humidity is quite high during the rainy season, which is a good condition ideal for fungal growth. The temperature level is also closely related to the humidity of the surrounding air. The humidity will decrease when the ambient temperature rises.

Fungi exploration is one of the critical steps in managing natural resource conservation in Indonesia. Data on fungi in Indonesia is still very low, including in the Mount Merbabu forest areas; this is inversely proportional to the increasing deforestation in Indonesia. If this continues, the existence of fungi that have not been explored and identified will become extinct due to deforestation. The number of known fungi species up to date is about 70,000 of the estimated 1,500,000 species in the world [14]. Meanwhile, based on [15], the identified macroscopic fungi in the Tropical Asia region (including Indonesia) amounted to 259, and there were still 83% of fungi that had not been identified. The diversity of fungi in Indonesia is abundant, but the available data is still limited. Thus, research on the diversity of macrofungi in Indonesia still needs to be done intensively. Mushroom exploration in the Mount Merbabu area is still limited, even though it has a very large forest area, especially the pine forest area. Thus, it is still necessary to explore and identify the rich-ness of mushrooms in this area to add data on the presence of mushrooms in Indonesia, which can be used for further uses such as management, education, and research.

2. Materials and Methods

This research was conducted in the Pine Forest Area of Kragilan Village, Magelang Regency (Figure 1) in October 2021 with an environmental temperature of 21-24°C and 93-94% air humidity. The tools used in this study were paper bags, rulers, stationery, brushes, knives, shovels, digital thermometers, digital humidity meters, and digital directions. Data collection in this study was carried out by the purposive sampling meth-od [16] by directly observing the presence of the macrofungi. This method is the most widely used in qualitative research. The samples of macrofungi obtained were documented, given a sample number, morphological characteristics and habitats were record-ed, and the environmental parameters (temperature and humidity) at the sampling loca-tion were measured. The macrofungi samples obtained were described for their macroscopic morphological characteristics [17], including fruiting body size, fruiting body shape, fruiting body color, pileus edge, pile-us surface, hymenophore type, and substrate. Then, identification of the characterization results was carried out using the books The Beginners Guide to Mushrooms [18], Cali-fornia Mushrooms: The Comprehensive Identification Guide [19], A Field Guide to Mushrooms, North America [20], and Polypores of British Columbia [21].

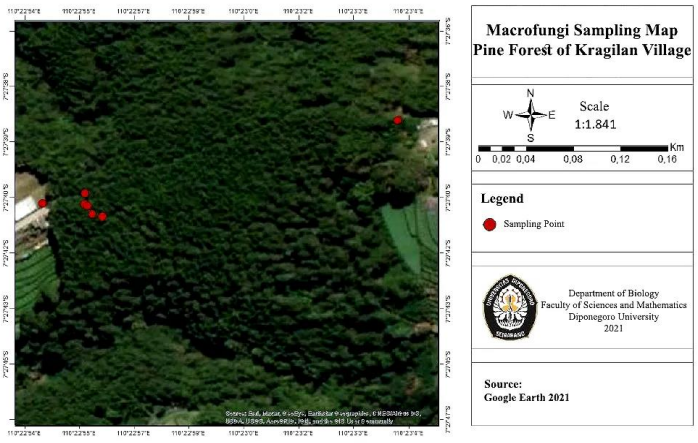

Figure 1. Macrofungi exploration location in this study (red dots).

3. Results and Discussion

Our data showed that the macrofungi found consisted of the Ascomycota and Basidiomycota phyla (Figure 2), which consists of nine species from eight different genera, seven families, and five orders (Table 1).

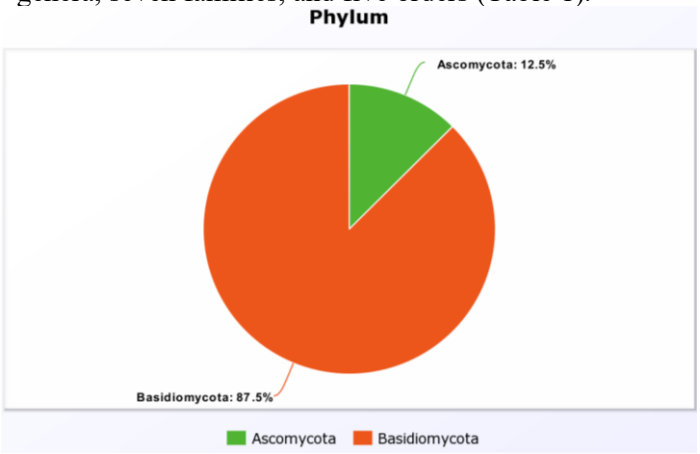

Figure 2. The distribution of macrofungi phyla in this study.

Figure 3. The percentage of macrofungi habitat in this study.

The habitat of the macrofungi found consisted of moist soil and decayed wood (Figure 3). Macrofungi are mostly found in decayed wood, where seven species live on it. Meanwhile, only one species was found in moist soil (Table 2).

Table 1. Taxonomical position of macrofungi of Kragilan pine forest

Phylum	Ordo	Family	Genus	Species
Peer-review	Xylariales	Xylariaceae	*Xylaria*	*Xylaria* sp.
Basidiomycota	Auriculariales	Auriculariaceae	*Auricularia*	*Auricularia auricula-judae*
	Russulales	Auriscalpiaceae	*Lentinellus*	*Lentinellus* sp.
	Agaricales	Mycenaceae	*Mycena*	*Mycena* sp.
	Polyporales	Polyporaceae	*Skeletocutis*	*Skeletocutis* sp.
	Agaricales	Hymenogastraceae	*Gymnopilus*	*Gymnopilus* sp.
		Psathyrellaceae	*Coprinopsis*	*Coprinopsis* sp.
			Coprinellus	*Coprinellus Disseminatus*

Table 2. Habitat distribution of macrofungi of Kragilan pine forest

Species	Habitat*	
	Moist soil	Decay wood
Xylaria sp.	-	√
Auricularia auricula-judae	-	√
Lentinellus sp.	-	√
Mycena sp.	-	√
Skeletocutis sp.	-	√
Gymnopilus sp.	√	-
Coprinopsis sp.	-	√
Coprinellus disseminatus	-	√

*Note: - (not found), √ (found)

***Xylaria* sp.**

Xylaria sp. is a member of the Xylariaceae, which belongs to the Ascomycota phyla. *Xylaria* sp. was found solitary and some scattered attached to pieces of weathered wood. Ascomata have a fruiting body shaped like a finger and have a fairly solid or hard mass. The fruit bodies found were 9 mm in size, with a thickness of about 3 mm. The fruiting body of *Xylaria* sp. is slightly grayish-white with a lighter tip. This fungus has a slightly rough surface (Figure 4A-C). Some members of the *Xylaria* can be used as anticancer drugs. This is due to their high lentinan compounds, which are suspected of being anticancer compounds [22, 23, 24]. A study conducted by [25] found that *Xylaria* can be a biological agent because it has antagonistic activity against several plant pathogenic organisms.

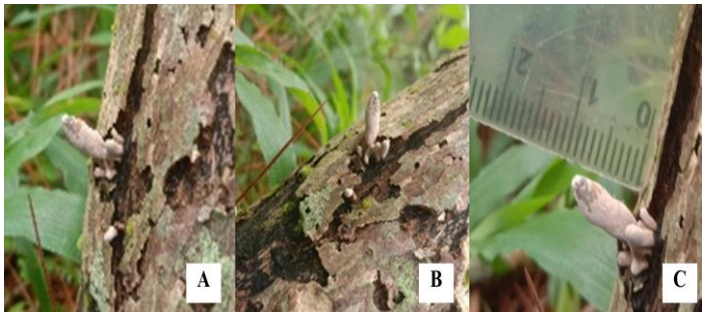

Figure 4. Morphological characteristics of *Xylaria* sp. A-C: Ascomata grow on decay trees

Auricularia auricula-judae

The basidiocarp of *Auricularia auricula-judae* are attached to rotting wood, and some grow solitary or in colonies. The basidiocarp have a gelatinous texture like jelly with a slightly shiny surface and a somewhat downy texture on the other side. Basidiocarp with brown (Fig. 5A-B) and partially black (Fig. 5C) surfaces; sometimes the outer surface is covered by gray or fairly white things. The pileus has a diameter of 2-2.5 cm. *Auricularia* is a type of mushroom that can be eaten and is commonly consumed by Indonesians. *Auricularia auricula-judae* can be used as a diabetes drug, a hypertension drug, a cancer drug, an inflammatory drug, and an antimicrobial. Its high carbohydrate, protein, and mineral content is one reason why this mushroom is widely consumed [26, 27]. Besides, research [28] showed that polysaccharides from *A. auricula-judae* have the potential to heal skin wounds.

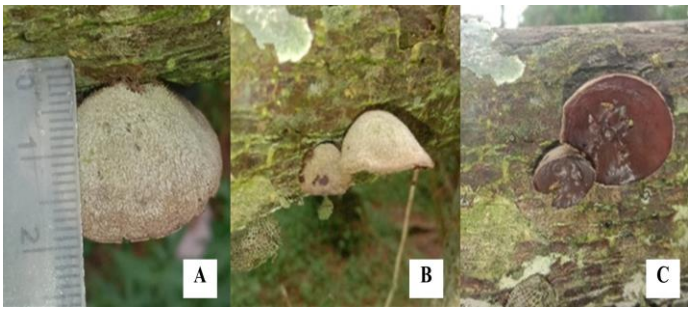

Figure 5. Morphological characteristics of *Auricularia auricula-judae*. A-B: The rough surface of the upper side of basidiocarp. C: The smooth surface of the underside of basidiocarp.

***Lentinellus* sp.**

Lentinellus sp. fruiting bodies are found sessile or attached to rotten pieces of wood, and several grow into overlap. The fruiting bodies are fan-like shaped (semicircular) with a pileus diameter of 2-5 cm. The pileus (Fig. 6A-B) is beige brown with a slightly rough and dull surface. The margins are often found to be bent inward. The lamellae have a lighter cream color than the pileus. The gill (Fig. 6C) is serrated and crowded with lamelullae (3-4 series). The basidiocarp do not have a stem/stipe (Fig. 6). This mushroom is not recommended for consumption [19]. However, research [29] showed that *Lentinellus ursinus* contains heptelidic acid and its derivatives, which have antimicrobial and antimalaria potential. *L. ursinus* also contains lentinellic acid, lactone, and an α,β-unsaturated carboxylic acid which has antimicrobial activity [30]. Besides, *L. cochleatus* can be used as an anticancer due to its antiproliferative activity in cancer cells [31].

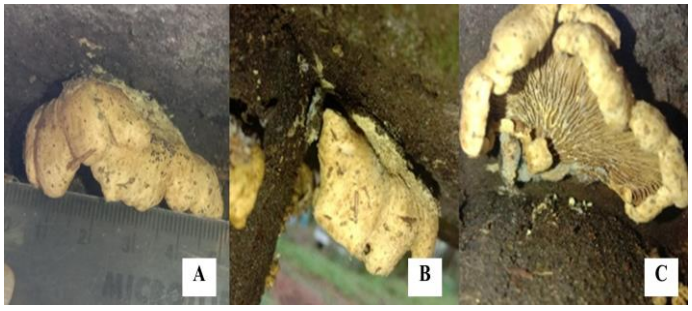

Figure 6. Morphological characteristics of *Lentinellus* sp. A-B: Pileus with beige brown. C: Gills with serrated characteristics.

***Mycena* sp.**

Mycena sp. fruiting bodies are found in pieces of wood that are starting to rot (Fig. 7A). The basidiocarp were found to have a pileus/cap with a flattened-convex shape (like a slightly flat umbrella) measuring 4 mm (Fig. 7B). The pileus surface is covered with small white granules. The pileus was thin and had a translucent-striate margin surface from the edge to the center of the pileus. The lamella is free-adnexed attached to the stem and has close-to-sub distant gills. The stipe was 21 mm long and had a cylindrical shape (Fig. 7C), which was hollow. The surface of the stem is smooth with thin white hairs, especially on the underside (Figure 7). Several species of *Mycena* (*M. alkalina, M. avenaceae,* and *M. crocata*) have secondary metabolites (chlorinate strobilurins B) that have potential as antibiotics and antifungals against respiratory pathogens [32]. In addition, laccase compounds and manganese peroxidase, which are both known as essential enzymes in lignin degradation, were discovered in some *Mycena* sp. [33, 34].

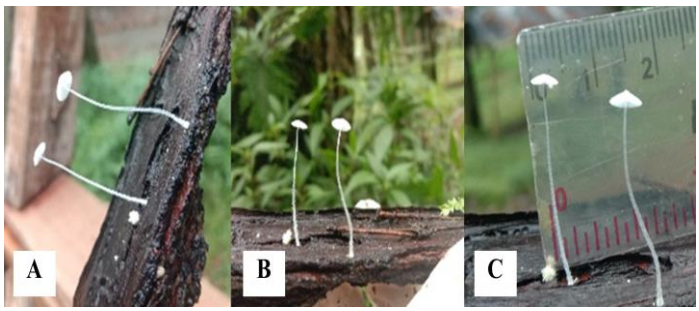

Figure 7. Morphological characteristics of *Mycena* sp. A: Basidiocarp grow on decay trees. B: Small size of basidiocarp. C: Stipe with thin hairs.

***Skeletocutis* sp.**

Skeletocutis are found attached to pieces of hard and weathered wood. The fruiting body was 4-5 cm long and shaped like a crust. The fruit body has a creamy white col-

or and has a dull, rough-textured surface. The fruiting bodies are pretty thick and fibrous, with tufted margins. The surface of the fruiting body sometimes has a bluish or greenish color (Figure 8). *Skeletocutis* produces secondary metabolites called skeletocutins M-Q, which are inhibitors of *Staphylococcus aureus* [35]. In addition, a study by [36] also found an undescribed metabolite called skeletocutins A-L inhibited S. aureus biofilm formation, and some of them moderately inhibited HCV infection.

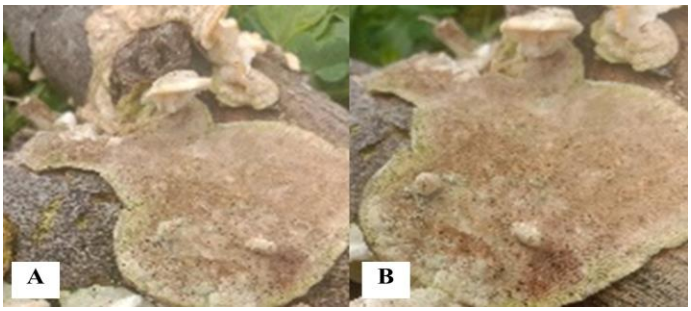

Figure 8. Morphological characteristics of *Skeletocutis* sp. A: Basidiocarp grow on decay trees. B: Basidiocarp with a bluish or greenish color.

***Gymnopilus* sp.**

Gymnopilus sp. fruiting bodies are found in moist soil with a lot of wood and rotting leaves (Fig. 9A). The pileus measures 2.9 cm and is shaped like an umbrella with raised edges (plane); the center of the pileus sinks slightly inward (Fig. 9B). Pileus was brown, with the edges slightly fading to a cream color. The pileus surface is dry and smooth. The lamellae are cream with adnexed attachments to the stem (Fig. 9C). The gills are close to one another. The basidiocarp have light-brown-beige colored stems with a cylindrical shape and a smooth surface. The species of *Gymnopilus* can be an antioxidant and an antibacterial agent. For example, methanol extract produced from *Gymnopilus junonius* showed better activity against *Enterococcus faecalis, Eggerthella lenta*, and *Vibrio parahaemolyticus* than amoxicillin [37]. In addition, [38] proved that *G. pampeanus* could be a biological treatment in the degradation of *Populus* sawdust.

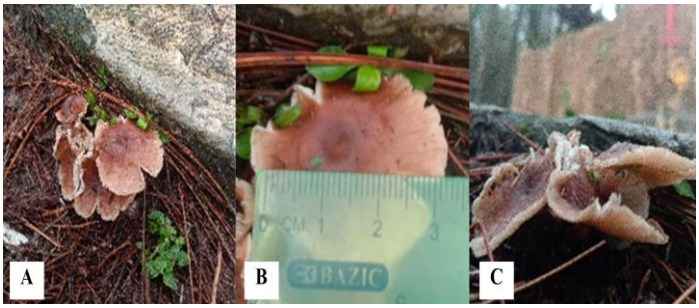

Figure 9. Morphological characteristics of *Gymnopilus* sp. A: Basidiocarp grow in groups. B: Pileus characters. C: Gills characters.

***Coprinopsis* sp.**

Coprinopsis sp. fruiting bodies are attached to pieces of rotting wood and grow solitary (Figs. 10A-C). The pileus (Fig. 10A) was 2 - 2.8 cm long. The pileus is shaped like a bell (conic) with the edges or margins raised upwards. Pileus has a gray color, is dry, and has thin white to gray hairs. The cap is a translucent-striate margin surface. The lamellae were the same color as the upper surface and were free attached to the stem. The gills in this mushroom have a crowded distance. The stem measures 3-4 cm and is cylindrical and hollow. The stem is white with a smooth and dry surface from the tip to the base (Fig. 10B-C). *Coprinopsis cinerea* has antifungal components that can be used as biological agents against pathogens like *Fusarium* spp. [39], and has also shown antibacterial activity [40]. Besides, [41] proved that *C. atramentaria* contains active compounds in the form of p-coumaric (CoA), cinnamic (CA), and p-hydroxybenzoic (HA), which have potential as antioxidants and anticancer agents.

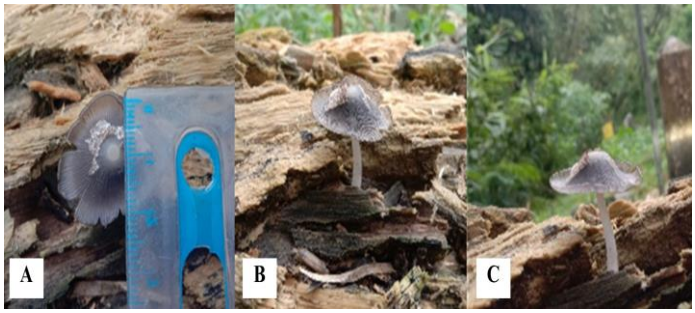

Figure 10. Morphological characteristics of *Gymnopilus* sp. A: Basidiocarp grow in groups. B: Pileus characters. C: Gills characters.

Coprinellus disseminatus

Coprinellus disseminates fruiting bodies attached to rotting wood in colonies. The pileus measures 4-8 mm and has a parabolic shape. Pileus is cream to white, smooth on the surface, and has a translucent-striate margin surface. Hymenophores had blackish (old) or white (young) lamellae. The attachment of the lamellae is adnate and the gill distance is crowded. The stipe has a size of 3-4 cm with white color. The stem has a cylindrical shape that is hollow and easily brittle (Figure 11). *Coprinellus disseminatus* is a saprophytic fungus that can be used as food with some nutritional content, such as protein, amino acids, fatty acids, and mineral components [42]. Besides, it can be used as an anti-cancer [43, 44]. [45] also showed that *C. disseminatus* has antioxidant and anti-proliferative effects.

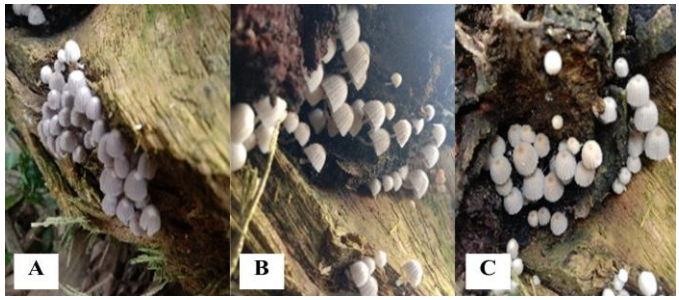

Figure 11. Morphological characteristics of *Coprinellus disseminatus*. A: Old Basidiocarp with a grayish color. B-C: Young basidiocarp with white to cream color

4. Conclusion

Based on research already done, eight species of macrofungi have been found from eight different genera. Including the Ascomycota (*Xylaria* sp.), and seven others from the Basidiomycota (*Auricularia auricula-judae, Lentinellus* sp*., Mycena* sp*., Skeletocutis* sp*., Gymnopilus* sp*., Coprinopsis* sp*.,* and *Coprinellus disseminatus*).

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