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Short communication: Macrofungi assemblage in Rawa Bento Forest, Kerinci Seblat National Park, Indonesia

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Abstract. *Sayuti I, Zulfarina, Rahayu Z. 2023. Short communication: Macrofungi assemblage in Rawa Bento Forest, Kerinci Seblat National Park, Indonesia. Biodiversitas 24: 1224-1230.* This study deals with macrofungi in the peat swamp forest of Rawa Bento, Kerinci Seblat National Park, Indonesia and their utilization. The forest region is dominated by banto grass or swamp rice grass (*Leersia hexandra*) with high humidity and rainfall which favors macrofungi growth and fruiting body formation. Furthermore, the sampling sites were chosen based on the accessibility of the area and the conditions for occurrence of macrofungi. About 36 macrofungi species were documented from 29 genera and 20 families, where 33 species belonged to Basidiomycota and only 2 species were Ascomycota. The dominant fungal group in the forest region was the Polypores and wood-inhabiting macrofungi. Eleven species were recognized as edible *including Auricularia auricula-judae, Cantharellus subalbidus, Cookeina tricholoma, Dacryopinax spathularia, Galiella rufa, Ganoderma lucidum, Pleurotus cornucopiae, Pluteus fenzlii, Lentinus arcularius, Psilocybe cubensis*, and *Schizophyllum commune*. Based on the scientific evidence, the majority of macrofungal species have medicinal properties except Pluteus fenzlii. The result provided preliminary information regarding use of macrofungi by the surrounding population, as well as knowledge development for researchers in the food and medical fields.

Keywords: Macrofungi, peatland, Rawa Bento, Sumatra

INTRODUCTION

Mushrooms, also known as macromycetes, are the fungi that produce large visible fruiting bodies or sporocarps and live in a variety of environments. Examples of well-known macrofungi include bracket fungi, magic mushrooms, puffballs, and toadstools. The macrofungi belong to both phylum Basidiomycota and Ascomycota. Indonesia is known for its unique biodiversity, including mushrooms or macrofungi. Fungi are important decomposers, mutualists, and parasites in forests, that enable nutrient cycling, provide food for animals, and create habitat diversity for various organisms (Dutta et al. 2011a,b; Dighton and White 2017). The importance of macrofungi has been demonstrated since ancient times and traditionally, several Asian countries have used wild edible mushrooms as nutritious foods and medicine (Dutta et al. 2011c; Tapwal et al. 2013), as they are valued for their flavor, texture, as well as their chemical and nutritional properties particularly low on fat, high on minerals, proteins, and vitamins (Valverde et al. 2015). In addition, dietary fiber, specifically chitin and α-/β-glucans, also contributes to their functional bioactivities (Cerletti et al. 2021), however, more than 93% of the world's fungal species are currently unknown (Cannon et al. 2018).

Several studies have investigated the diversity of Indonesian macrofungi and their potential in their respective contexts from different natural sites. According to Arini et al. (2019), the local community around Tangale Nature Reserve, Gorontalo, utilized 4 species as food including *Auricularia auricula, Pleurotus ostreatus, Polyporus arcularius*, and *Ramaria formosa*, and 11 others as traditional medicines. Izati et al. (2020) discovered 12 species on Mount Picis and Mount Sigogor Nature Reserves in East Java, which have food and medicine potential as discussed in scientific literatures. Also, Yusran et al. (2021) identified 172 species in Lore Lindu National Park, Sulawesi, and their presence varied with elevation. The local communities rely on certain species as traditional food and medicine such as *Agaricus* sp., *Auricularia auricula-judae, Ganoderma lucidum, Pleurotus ostreatus, Xylaria* sp., etc.

Kerinci Seblat National Park or *Taman Nasional Kerinci Seblat* (TNKS) is a tropical rain forest that contributes to nature conservation efforts in Indonesia and it is used for various purposes including research, education, tourism, and recreation (Karyadi et al. 2018). Literature survey reveal lack of information on the diversity of macrofungi in several National Parks, including in Rawa Bento Forest which is a part of TNKS. The collection and identification of macrofungi in the wild promote and conserve mushroom biodiversity. Furthermore, the Rawa Bento Forest is an undisturbed ecosystem and a unique natural landscape. The peat swamp forests or peatlands consist of massive dead logs and partially decayed organic matter are favourable environmental conditions for growth of macrofungi (Barreto and Lindo 2018). But, studies on macrofungal assemblage on such unique peatland forest ecosystem is neglected and limited. This study aims to generate baseline information on macrofungi assemblage in Rawa Bento Forest with information on their potential value as food and medicine.

MATERIALS AND METHODS

Study site

The Rawa Bento Forest is a peat swamp forest located within Kerinci Seblat National Park (TNKS), Jernih Jaya Village, Gunung Tujuh District, Kerinci Regency, Jambi, Indonesia (Figure 1). Meanwhile, the forest area (±1,000 ha) is located at an altitude of 1,375 m and it is categorized as the highest peat swamp in Sumatra. The study site receives high annual rainfall and humidity of >2,900 mm and >77%, respectively. In addition, it is categorized as a type A climate with a dry month of less than two months and a temperature range between 16º and 28ºC. The area is dominated by grasses (*Leersia hexandra* Sw.), weeds, and small trees of the genera: *Ficus*, *Elaeocarpus*, *Eugenia*, *Palaquium*, *Syzygium*, etc.

Macrofungi collection and identification

The sampling sites were selected based on the area's accessibility and the macrofungi occurrence (Paloi et al. 2016; Kinge et al. 2017). The study was conducted from November 2020 to April 2021 (mid-to-end of the rainy season), in 10 observation plots with a 20×20 m^2 size and a maximum distance of 100 m between them. The macrofungi were studies and photographed from their substrates, which include decomposing litter (DL), dung (D), soil (S), and wood debris (WD). Furthermore, the fruiting body of each specimen was differentiated into morphotypes, carefully packed in wax paper, and transferred to the laboratory for identification. The specimens were identified based on their macro- or morphological characteristics using an identification guidebook such as Arora (1986), McKnight (2021), and an online tool (https://www.mushroomexpert.com/).

RESULTS AND DISCUSSION

The study on macrofungal diversity of Rawa Bento Forest yielded 36 species belonging to 29 genera and 24 families (Figure 2, Table 1). The macrofungal community was dominated by Basidiomycota, having 32 species, with only three members of Ascomycota viz. *Cookeina tricholoma* (Sarcoscyphaceae), *Daldinia concentrica* (Xylariaceae), and *Galiella rufa* (Sarcoscyphaceae). Figure 3 shows the number of species in each macrofungal family, where the largest member was obtained from Polyporaceae (8 species), followed by Hypoxylaceae (3 species), Crepidotaceae (2 species), Incrustoporiaceae (2 species), Marasmiaceae (2 species), Pleurotaceae (2 species), Strophariaceae (2 species) and one species of remaining families. About 26 species occupied the wood debris (WD) as substrate, while two members of *Psilocybe* grew on animal dung (D). There are three major functional groups of terrestrial fungi in forests that can be distinguished by trophic status such as (i) ectomycorrhizal which is terrestrial and grows in association with living roots of ectomycorrhizal partner trees, (ii) wood-inhabiting which grow on rotten logs and wood debris, (iii) terricolous saprotrophs which grow on dead substrates on soil (Shuhada et al. 2020). The wood-inhabiting fungi are vital to the forest ecosystems (Abrego 2021) and the organisms that use the wood substrate are known as saproxylics, hence polypores were the dominant macrofungi in this study. Generally, polypores are flat, grow in clusters, have mostly coriaceous or pithy texture, and have a high tolerance to hot and open environments. The results showed that the path used for collection is an open area, where parts of the living trees were cut down and the debris were left. This is in line with Noverita and Setia (2019), who reported the dominant assemblage of polypores in the peat swamp forest of West Kalimantan, Indonesia. Furthermore, the forest is rich in macrofungi diversity and can be used as a bioindicator to monitor the possibility of a human-altered environment and land cover dynamics (Shuhada et al. 2017).

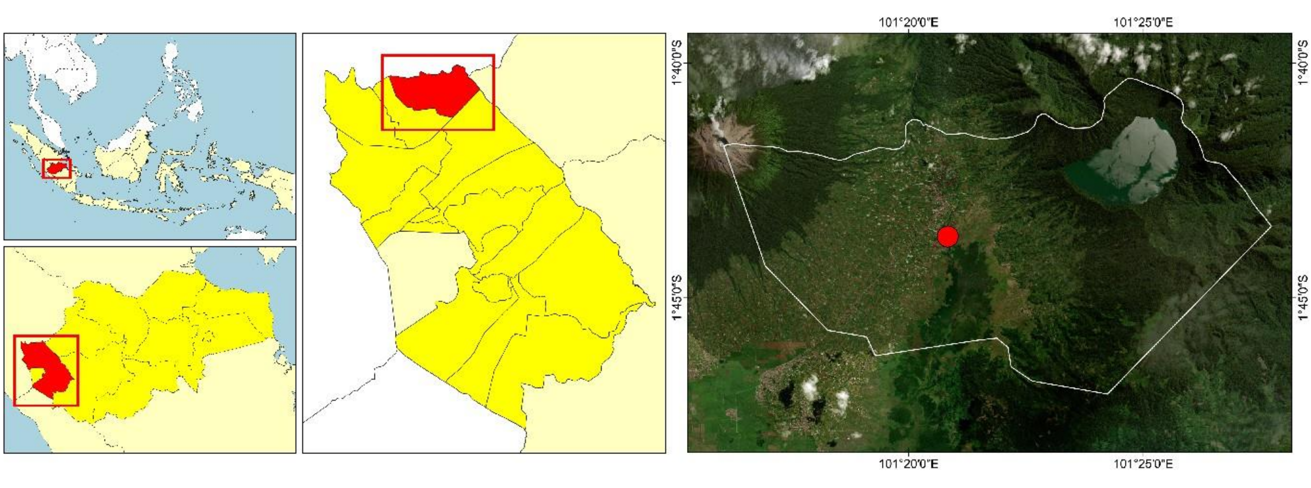

Figure 1. Study site at Rawa Bento Forest in Kerinci Seblat National Park, Indonesia

Figure 2. Macrofungi in Rawa Bento Forest, Kerinci Seblat National Park, Indonesia. A. *Alnicola escharioides*, B. *Auricularia auricula-judae*, C. *Baorangia* sp., D. *Cantharellus subalbidus,* E. *Cookeina tricholoma,* F. *Crepidotus* sp., G. *Dacryopinax spathularia*, H. *Daldinia concentrica*, I. *Galiella rufa*, J. *Ganoderma lucidum*, K. *Laccaria* sp., L. *Lentinus arcularius*, M. *Lycoperdon marginatum*, N. *Trogia* sp., O. *Mycena* sp., P. *Panus* sp., Q. *Parasola* sp., R. *Pleurotus cornucopiae,* S. *Pluteus fenzlii,* T. *Polyporus* sp., U. *Psilocybe cubensis*, V. *Pycnoporus* sp.1, W. *Schizophyllum commune*, X. *Simocybe* sp., Y. *Stereum* sp., Z. *Trametes* sp.1, AA. *Tricholoma* sp., AB. *Tyromyces* sp.

Although 11 species of macrofungi are known to be edible, the majority of them (22 species) are unknown due to a lack of accurate species information, and a small number (2 species) are inedible for humans such as *Alnicola escharioides*, *Lentinus arcularius,* and *Marasmius androsaceus* (Table 1). The edible macrofungi have at least one pharmacological activity including the magic mushroom, *Psilocybe cubensis*, and reishi, *Ganoderma lucidum*, as seen in Table 2, with the exception of *Pluteus fenzlii*. The majority of the pharmacological potential was obtained from in vitro studies, hence requires validation in clinical trials to determine their safety and other risk factors. *Ganoderma lucidum* and *Psilocybe cubensis* are recognized species that could be valuable for the community of Rawa Bento in terms of economy and health care. The availability of *Ganoderma*-based products is supported by its bioactive compounds, including the anti-tumor polysaccharides such as beta 1,3/1,6 glucan and proteoglycan, which have been documented and isolated from the fruiting-bodies of *G. lucidum* (Rossi et al. 2018). Currently, the *G. lucidum* bioactive component has been formulated into various cosmeceutical and nutraceutical products including body lotion, creams, face masks, health drinks (tea), and serum, and sold in many countries from North America to Europe, especially in South Asia (Sheikha 2022). Meanwhile, psilocybin in *Psilocybe cubensis* is the most desirable and safest psychedelic compound for human use. The vast amount of evidence-based data on psilocybin showed that it is the most effective psychedelic drug for treating mood and anxiety disorders, despite the lack of studies comparing the efficacies of psilocybin and psychedelic drugs for the treatment of such disorders (Lowe et al. 2021).

Table 1. List of macrofungi collected in Rawa Bento Forest, Kerinci Seblat NP, Indonesia with its substrate of growth and edibility status

Species	**Family**	**Division**	**Substrate(s)**	**Edibility (yes/no/un-known)**
Alnicola escharioides (Fr.) Romagn.	Bolbitiaceae	Basidiomycota	DL	No
Auricularia auricula-judae (Bull.) Quél.,	Auriculariaceae	Basidiomycota	WD	Yes
Baorangia sp.	Boletaceae	Basidiomycota	S	Unknown
Cantharellus subalbidus A.H. Sm. & Morse	Hydnaceae	Basidiomycota	S	Yes
Cookeina tricholoma (Mont.) Kuntze	Sarcoscyphaceae	Ascomycota	WD	Yes
Crepidotus sp.	Crepidotaceae	Basidiomycota	WD	Unknown
Dacryopinax spathularia (Schwein.) G.W. Martin	Dacrymycetaceae	Basidiomycota	WD	Yes
Daldinia concentrica (Bolton) Ces. & De Not.	Hypoxylaceae	Ascomycota	WD	Unknown
Galiella rufa (Schwein.) Nannf. & Korf	Sarcosomataceae	Ascomycota	S	Yes
Ganoderma lucidum (Curtis) P. Karst.	Ganodermataceae	Basidiomycota	WD	Yes
Laccaria sp.	Hydnangiaceae	Basidiomycota	WD	Unknown
Lentinus arcularius (Batsch) Zmitr.	Polyporaceae	Basidiomycota	WD	Yes
Lentinus sp.1	Polyporaceae	Basidiomycota	WD	Unknown
Lycoperdon marginatum Vittad.	Lycoperdaceae	Basidiomycota	S	Unknown
Trogia sp.	Marasmiaceae	Basidiomycota	DL, WD	No
Marasmius sp.	Marasmiaceae	Basidiomycota	DL, WD	Unknown
Mycena sp.	Mycenaceae	Basidiomycota	WD	Unknown
Panus sp.	Panaceae	Basidiomycota	WD	Unknown
Parasola sp.	Psathyrellaceae	Basidiomycota	DL	Unknown
Pleurotus cornucopiae (Paulet) Quél.	Pleurotaceae	Basidiomycota	WD	Yes
Pleurotus sp.	Pleurotaceae	Basidiomycota	WD	Unknown
Pluteus fenzlii (Schulzer) Corriol & P.-A. Moreau	Pluteaceae	Basidiomycota	WD	Yes
Polyporus sp.	Polyporaceae	Basidiomycota	WD	Unknown
Psilocybe cubensis (Earle) Singer	Strophariaceae	Basidiomycota	D	Yes
Psilocybe sp.	Strophariaceae	Basidiomycota	D	Unknown
Pycnoporus sp.1	Polyporaceae	Basidiomycota	WD	Unknown
Pycnoporus sp.2	Polyporaceae	Basidiomycota	WD	Unknown
Schizophyllum commune Fr.	Schizophyllaceae	Basidiomycota	WD	Yes
Simocybe sp.	Crepidotaceae	Basidiomycota	WD	Unknown
Stereum sp.	Stereaceae	Basidiomycota	WD	Unknown
Trametes sp.1	Polyporaceae	Basidiomycota	WD	Unknown
Trametes sp.2	Polyporaceae	Basidiomycota	WD	Unknown
Trametes sp.3	Polyporaceae	Basidiomycota	WD	Unknown
Tricholoma sp.	Tricholomataceae	Basidiomycota	S	Unknown
Tyromyces sp.	Incrustoporiaceae	Basidiomycota	WD	Unknown

Note: D: dung, DL: decomposing litter, S: soil, WD: wood debris.

Table 2. Medicinal prospects of 11 edible macrofungal species found in Rawa Bento Forest, Kerinci Seblat National Park, Indonesia

Species	**Medicinal properties**	**References**
Auricularia auricula-judae	Anti-oxidant, anti-coagulation, anti-diabetes, anti-hyperlipidemic, anti-tumor, bacteriostatic, hepatoprotective, and immuno-stimulant	Liu et al. (2021)
Cantharellus subalbidus	Anti-bacterial activity against *Helicobacter pylori*	Na et al. (2022)
Cookeina tricholoma	Antinociceptive activity against harmful and toxic chemicals, mechanical injuries, and neurogenic pains to human body	Moreno et al. (2016)
Dacryopinax spathularia	Anti-bacterial, anti-hyperlipidemic, hepatoprotective, nephroprotective	Kumar et al. (2019a), Kumar et al. (2019b), Kumar et al. (2019c), Kumar et al. (2020)
Galiella rufa	Anti-cancer, anti-tumor, HIV-1 inhibitor, immuno-modulatory, nematicidal against *Caenorhabditis elegans* and *Meloidogyne incognita*	Kopcke et al. (2002), Perez et al. (2014)
Ganoderma lucidum	Multifunctional bioactivities such as anti-acetylcholinesterase, anti-diabetes, anti-inflammatory, anti-oxidant, anti-tumor, anti-viral, immuno-stimulant, etc.	Cor et al. (2018), Lu et al. (2020)
Lentinus arcularius	Anti-microbial and anti-oxidant	Yen et al. (2022)
Pleurotus cornucopiae	Anti-oxidant, anti-tumor, immuno-stimulant, nephroprotective	Wang et al. (2013), Zhang et al. (2014), Lee et al. (2017), Minato et al. (2017)
Pluteus fenzlii	Not yet discovered	-
Psilocybe cubensis	Neuro-therapeutic and psychedelic	Lowe et al. (2021)
Schizophyllum commune	Anti-bacterial, anti-cancer, anti-fungal, anti-infective, anti-viral, hepato-protective, immuno-stimulant, prebiotic	Hobbs (2005), Chen et al. (2021), Vu et al. (2022)

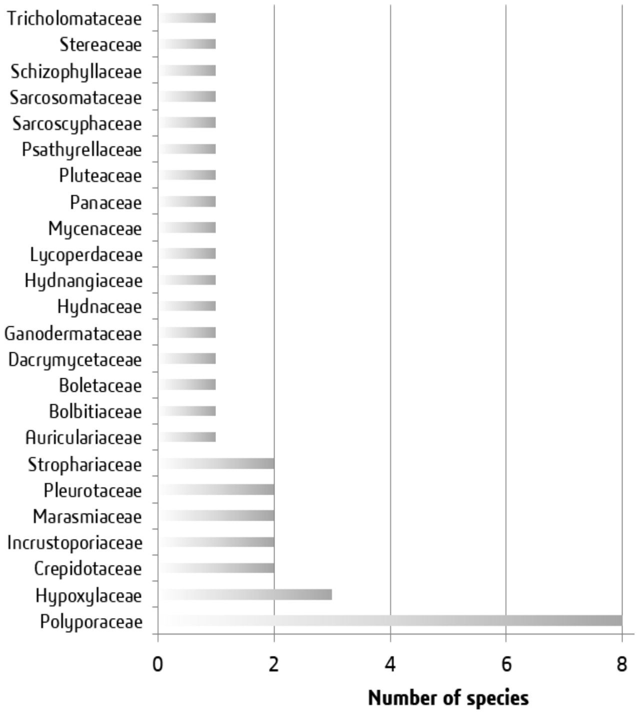

Figure 3. Distribution of macrofungi species in different families

Auricularia auricula-judae is the third most cultivated edible fungi globally, though its demand is relatively more in Asia, compared to Europe and America. The water-soluble polysaccharides in the fungus exert pharmacological properties and protect the fruiting bodies from drought stress (Liu et al. 2021). Both *Dacryopinax spathularia* and *Schizophyllum commune* have been studied on experimental animals and pathogenic microbial cultures, which exerted some biological activities (Kumar et al. 2019a,b,c, Kumar et al. 2020). Furthermore, *D. spathularia* is cultivated as natural preservatives in drinks and as an ingredient in vegetarian Chinese dishes such as Buddha's delight due to its resemblance to osmanthus (*Osmanthus fragrans*) flowers (EFSA 2021; Meuninck 2017). The species, *S. commune*, has been commercialized in a region of tropical Mexico and proven to increase the informal economic practices by the locals (Ruan-Soto 2006).

In Malaysia, *S. commune* has been initiated to be commercialized and cultivated for potential mushroom industry (Rosnan et al. 2019). *Galiella rufa* contains galiellalactone, which exerts anti-tumor and immuno-modulatory properties as a dual inhibitor to NF-κB/STAT3 and it is a promising lead compound for the synthesis of novel drugs against cancer, inflammatory diseases, and HIV-1 (Perez et al. 2014). *Schizophyllum commune* is a white-rot fungus that synthesizes hydrolytic enzymes and bioactive metabolites. The fungus is known for its exopolysaccharide or schizophyllan derived from glucose metabolism and stored in its leathery fruiting bodies. Similar to *G. lucidum* and *A. auricula-judae*, the polymer was prepared for cosmetic products and pharmaceuticals (Kumar et al. 2022). *Cookeina tricholoma* stored polysaccharides as water-insoluble beta 1,3/1,6 glucans, similar to *Lactaria rufus*, and demonstrated nociception in treated experimental rats (Moreno et al. 2016). Wang et al. (2013) reported four novel monoterpenoids and sesquiterpenoids from *Pleurotus cornucopiae* with moderate nitric oxide (NO) inhibitory activities and potential cancer cell inhibition. In addition, purified polysaccharides from *P. cornucopiae* fruiting bodies in the form of intracellular zinc polysaccharides (IZPs) showed a potential antioxidation through the upregulation of enzymes and served as scavengers against DPPH radicals (Zhang et al. 2014).

The initial examination of the edible and medicinal mushrooms in Rawa Bento Forest suggests the need for additional research to be conducted (Valverde et al. 2015). Economic utilization and cultivation of specific mushroom species such as *Auricularia auricula-judae*, *Pleurotus cornucopiae*, and *Schizophyllum commune* have been identified. Furthermore, the forest serves as a source for wild mushrooms, which local researchers use to conduct exploratory studies on bioactive ingredients and pharmacological activities, particularly in unknown species. However, the current method for identifying macrofungal species, which relies on visible fruiting body characteristics, is limited and may require the use of microscopy and DNA analysis. Additionally, the community surrounding Rawa Bento may be interested in conducting recurring surveys of wild edible mushrooms as a result of the knowledge gained from this study on the bioprospection of mushroom species. This study showcases the possible contribution of traditional ecological knowledge (TEK) from local communities in their dependence on and appreciation of macrofungi as a sustainable resource that may be discovered in further studies (Pacheco-Cobos et al. 2015). The study highlights the importance of peat swamp forests, particularly in Rawa Bento, in supporting the diversity of macrofungi. Finally, the macrofungal species list obtained through this study provides the first database for future research on the utilization of specific species for food and medicine.

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