Agaricales: the most dominated macroscopic fungi in Tahura Pocut Meurah Intan Forest Park

H I Kusuma\textsuperscript{1, a}, E Harnelly\textsuperscript{2, b} and Z Thomy\textsuperscript{2, c}

\textsuperscript{1} Master Program of Biology, Biology Department, Faculty of Mathematics and Natural Sciences, Syiah Kuala University, Jl. Tgk. Syech Abdul Rauf No. 3, Banda Aceh 23111, Indonesia.
\textsuperscript{2} Biology Department, Faculty of Mathematics and Natural Sciences, Syiah Kuala University, Jl. Tgk. Syech Abdul Rauf No. 3, Banda Aceh 23111, Indonesia.

E-mail: \textsuperscript{a} hendrikkusuma.hk@gmail.com; \textsuperscript{b} essyharnelly@unsyiah.ac.id; \textsuperscript{c} zairinthomy@unsyiah.ac.id

Abstract. Agaricales is a group of fungi from the \textit{Basidiomycota} division which is widely known by the public because it easily grows on various substrates and is widely distributed, especially in the tropics. Most members of this order have an important role in the environment as well as a great economic value. However, research on the Agaricales fungi diversity in Aceh is still rare, especially in Pocut Meurah Intan Forest Park (Tahura PMI). This research contributes to the knowledge about this fungi biodiversity found in Aceh and mainly the PMI Tahura. The aim of this research was to record the diversity of the order Agaricales in the Tahura PMI area. Samples were collected through exploration along the track and identification was carried out based on the morphological and ecological characters. The results obtained showed that 50 species from the order Agaricales were included in 16 families out of 30 genera which were dominated by the \textit{Marasmiaceae} family and the \textit{Marasmius} genus. Nine samples were known to have the potential of being used as food, while 6 of them as medicines. This research shows that the Tahura PMI area has a high diversity of Agaricales with potentials that can be utilized for the benefit of mankind in the future.

1. Introduction

Agaricales are the most familiar fungi recognized by the public of which the term fungi refer to this type. Furthermore, this fungus is easily recognized because of its characteristic soft fruiting body, generally shaped like an umbrella with a bottom that resembles a sheet (gills). Agaricales are considered to be a cosmopolitan fungus which can easily grow in a variety of habitats, from the Arctics to the Tropics. Furthermore, some grow in a limited, specific or over a wide geographical area. The wide variety of habitats and substrates colonized by this fungus indicates that the fungal group of Agaricales includes saprophytic, symbiotic, and parasite types in various shapes, sizes, and colors[1].

Agaricales have a very important role, especially in degrading organic ingredients, nutrient cycling, soil structure and retention, food sources for wildlife, pathogens in plants, and as mycorrhizae. This order, including several families in it (especially the \textit{Agaricus} genus), presents significant economic value because it provides benefits such as food and medicine. Furthermore, it has 33 extant families, 413 genera, and more than 13,200 described species, along with six extinct genera known only from the fossil record [2]. Despite their enormous diversity, Agaricales and fungi have been the subject of very little research in Aceh. Several studies on fungi in Aceh have been carried out, but this is not enough,
especially on the progress in the exploration of fungi originating from Aceh's forests and the Agaricales order. This research was conducted to contribute to the knowledge about the biodiversity of fungi in Aceh, especially the Basidiomycetes species from the Agaricales order in the Pocut Meurah Intan Forest Park Area (Tahura PMI).

The difficulty in determining the type of fungus is large due to polymorphism. The same fungus can look different depending on climatic conditions and age. Furthermore, different species may look the same at first but are actually different in terms of details (macroscopic or microscopic) that may not be seen directly [3]. Therefore, the aim of this research was to study the diversity of basidiomycetes species from the order Agaricales found in the Tahura PMI Area. Furthermore, it specifically includes the following objectives: i) to make an inventory of the order Agaricales species in the study area, and ii) to develop a list of fungi belonging to the order Agaricales (data will be stored on the Biodiversity of Aceh website).

2. Method

2.1. Description of the research site
Tahura PMI is one of the nature conservation areas located 05°26'00"-05°26'60" North Latitude and 95°44'80"-95°45'45" East Longitude. It serves the purpose of collecting natural or artificial plants or animals, native or non-native species, which are used for research, science, education, cultivation support, tourism culture, and recreation. This combined form of nature conservation is at the same time a display case for biodiversity which is becoming scarce and its existence is threatened as a result of extraction and exploitation of forest resources that trigger degradation of natural forest ecosystems or their natural habitat.

2.2. Time and sample collection
This research was conducted in 2018-2019 and fungi samples were collected from along the track in the Tahura area. The samples found were photographed in their natural habitat and then taken for further observation. The morphological characteristics were recorded before being stored in bottles containing 70% alcohol to prevent bias due to morphological changes (especially color) during storage. In addition, agro-climatic conditions (temperature, humidity, and light intensity) and fungi growing media were recorded.

2.3. Identification
The morphological characteristics of the hood (color, shape, surface, edge), lamella (shape, density), stalk (surface, color), ring, or volva were used as references to identify fungi to the species level. The next sample identification was carried out by matching morphological features with the images contained in several identification books and cross-checking some literature.

3. Results and discussion

3.1. Diversity of species
A total of 50 species were identified as the order Agaricales belonging to 30 genera. The species name, family, genus, substrate, and potency of the Agaricales fungi found are presented in Table 1.

| Family         | Genus       | No. | Species                    | Substrate    | Potency  |
|----------------|-------------|-----|----------------------------|--------------|----------|
| Clavariaceae   | Clavulinopsis | 1   | Clavulinopsis fusiformis    | Soil         | Non edible |
|                | Clavaria    | 2   | Clavaria acuta              | Soil         | Non edible |
| Hygrophoraceae | Hygrocybe   | 3   | Hygrocybe ceracea           | Soil, litter | Non edible |
| Marasmiaceae   | Baeospora   | 4   | Baeospora myosura           | Pines cone   | Non edible |
| Family          | Genus          | No. | Species                  | Substrate     | Potency         |
|-----------------|----------------|-----|--------------------------|---------------|-----------------|
| Marasmiellus    | Marasmiellus   | 5   | Marasmiellus candidus    | Leaf litter,  | Non edible      |
|                 | candidus       | 6   | Marasmiellus nigripes    | Leaf twigs,   | Non edible      |
|                 | Marasmiellus   | 7   | Marasmiellus ramealis    | Twigs         | Non edible      |
| Marasmius       | Marasmius      | 8   | Marasmius rotula         | Leaf twigs,   | Non edible      |
|                 | haematocephalus| 9   |                          | Leaf twigs,   | Non edible      |
|                 | Marasmius      | 10  | Marasmius siccus         | Leaf twigs,   | Non edible      |
|                 | oreades        | 11  |                          | Leaf twigs,   | Non edible      |
|                 | nummularius    | 12  |                          | Leaf twigs,   | Non edible      |
|                 | araucariae     | 13  |                          | Leaf twigs,   | Non edible      |
|                 | guyanensis     | 14  |                          | Leaf twigs,   | Non edible      |
|                 | sp. 2          | 15  |                          | Leaf twigs,   | Non edible      |
| Trogia          | Trogia         | 16  | Trogia infundibiliformis | Twigs         | Non edible      |
| Agaricaceae     | Lepiota        | 17  | Lepiota helveola         | Soil          | Non edible      |
|                 | Agaricus       | 18  | Agaricus sp.             | Soil          | Non edible      |
|                 | Leucocoprinus  | 19  | Leucocoprinus sp.1       | Living tree   | Non edible      |
|                 | Calvatia       | 20  | Leucocoprinus brebissonii| Soil, litter  | Edible,         |
|                 | Mycenaceae     | 21  | Calvatia craniiformis    | Soil          | Medicinal       |
| Mycena          | Mycena         | 22  | Mycena rosea             | Soil          | Non edible      |
|                 | Mycena         | 23  | Mycena manipularis       | Twigs         | Non edible      |
|                 | Mycena         | 24  | Mycena vitilis           | Leaf litter,  | Non edible      |
|                 | Mycena         | 25  | Mycena albicocapilaris   | Leaf litter,  | Non edible      |
| Psathyrellaceae | Parasola       | 26  | Parasola plicatilis      | Log wood      | Non edible      |
|                 | Coprinopsis    | 27  | Coprinopsis fragilisimus | Twigs         | Non edible      |
|                 | Coprinellus    | 28  | Coprinellus disseminates | Log wood      | Non edible      |
|                 | Flammulina     | 29  | Flammulina velutipes     | Stump, log    | Edible,         |
|                 | Lyophyllaceae  | 30  | Termitomyces microcarpus | Termites      | Medicinal       |
|                 | Termitomyces   | 31  | Termitomyces umkowaan    | Termites      | Edible          |
|                 | Termitomyces   | 32  | Termitomyces sp. 2       | Termites      | Edible          |
| Physalacriaceae | Oudimansella   | 33  | Oudimansella sp.         | Log wood,     | Non edible      |
|                 | Cyptotrama     | 34  | Cyptotrama asprata       | Log wood      | Non edible      |
The families with the highest number of species were Marasmiaceae (24%) followed by Agaricaceae, Schizophyllaceae, and Tricholomataceae (10%), Mycenaceae and Psathyrellaceae (8%), Lyophyllaceae and Physalacriaceae (6%), Clavariaceae (4%), and Hygrophoraceae, Inocybaceae, Nidulariaceae, Amylocorticiaceae, Pterulaceae, Crepidotaceae and Cortinariaceae (2% of each). In the Marasmiaceae family, Marasmius was the largest genus collected (with 8 species), followed by Mycena (with 4 species), then Termotimyces, Lycoperdon, and Marasmiellus with 3 species respectively (Figure 1). The samples collected showed that the substrate was commonly found as a saprophyte on rotting wood or twigs (36) followed by soil (13) and in living plants (1). Subsequently, three of the thirteen species found growing on the ground are a group of fungi from the genus Termotimyces. This fungus is known for been a specie in symbiosis with termites and is specially planted by termites in a special part of their nest as a food reserve. They will form fruit bodies and appear on the ground surface a few days after the rain falls. Pictures of several species of fungi that represent the order Agaricales can be seen in Figure 2.

The diversity of Agaricales fungi species found in Tahura PMI is high compared to several similar studies in various regions of Indonesia. Furthermore in the research done in Tangale Nature Reserve, Gorontalo, out of the 28 species of fungi found, 8 of them were Agaricales [4]. Another Research in the Mount Ambang Nature Reserve in North Sulawesi showed that out of 29 species, 11 of which were Agaricales [5]. Furthermore similar results obtained in Mount Merapi National Park (TNGM) showed 51 species belonging to the order Agaricales on the southern slopes and 19 species on the northern slope [6]. This similar level of diversity is due to the similarities in the environmental conditions between Tahura PMI and TNGM.
The *Marasmiaceae* genus was found to be the most dominant in the Tahura PMI Area. This genus is generally small in size and easy to grow even in the litter of rotting leaves. The same result was also found that the *Marasmiaceae* family was the largest number in the Educational Forest of the University of North Sumatra, Tongkoh Village, Karo Regency and North Sumatra with 10 species [7]. However, for other areas, this family type is only found in small number, such as in the KPHP South Sorong Protected Forest Area where only one specie is found, namely *Marasmius rotula* [8], one specie in the Peat Swamp Forest of Teluk Bakung Village, Ambawang Subdistrict, Kubu Raya Regency, as well as five species in the Sumatran Lowland Tropical Forest [9]. The difference in the number of species found at each location is because fungi have different abilities to live for each type and the required environmental factors vary [10].

![Figure 1](image-url)

**Figure 1.** Family composition and number of per family species of the Agaricales order found in Tahura PMI, Saree.

### 3.2. Habitat and ecology

Tahura PMI have large tree vegetations with a wide canopy, as well as several fallen and dead trees. Furthermore their soil condition is mostly covered in leaf litter and rotten twigs. Environmental conditions measured in the study area can be seen in Table 2.
Table 2. Conditions of physical environmental factors in the Tahura area of Pocut Meurah Intan, Saree, Aceh Besar Regency.

| No. | Environmental Physical Factors | Measurement results | Unit |
|-----|--------------------------------|---------------------|------|
| 1.  | Air temperature                | 27-37               | °C   |
| 2.  | Humidity                       | 70-82               | %    |
| 3.  | soil pH                        | 4.9-5.8             |      |
| 4.  | Soil moisture                   | 67-100              | %    |
| 5.  | Light intensity                | 250-951             | Lux  |

Generally, the fungal growth substrate is divided into 2, ligneous (wood), and terrestrial (soil). Fungi that grow on substrates in the form of deadwood or twigs are saprophytic fungi working as decomposers by decomposing and rotting wood. The research by Ye et al., showed that specific tropical areas are dominated by wood-degrading fungi or litter (litter) [11]. This is due to the high availability of substrates in the tropics which is as a result of a favorable climate, high vegetation diversity, and an ideal environment. Furthermore, high temperatures and rainfall rates also provide a suitable environment for enzyme activity and fungal growth, thereby supporting a large and diverse fungal community. Besides acting as saprophytes, those that grow in the soil are also suspected of being a group of ectomycorrhizal fungi that are symbiotic with tree roots. This symbiosis between trees and fungi is mutually beneficial (mutualism). Naturally, most of the higher plants in forest ecosystems are associated with ectomycorrhizal fungi. These fungi serves as benefits to plants by increasing their nutrient absorption capacity of roots and providing protection against various types of pathogens and abiotic stress around the rhizosphere, while it obtains carbon compounds from photosynthesis [12]. Furthermore, the research conducted by Gómez-Hernández et al., showed that mycorrhizal fungi are mostly found in forests with mature trees [13].

3.3. Potential of the order Agaricales

The results of the literature review also showed the potentials possessed by the samples collected and they include 9 species that can be used as food and 6 species with potentials of being used as medicines. Furthermore, the fungi group from the order Agaricales that can be used as medicine includes the genus *Calvatia, Schizophyllum, and Lycoperdon*, while those that can be used as food includes the genus *Pleurotus, Flammulina* and *Termotomycetes* (table 1). *Calvatia craniformis, Schizophyllum communae, and Lycoperdon perlatum* have both of these benefits at once. In addition to being edible they also contain medicinal properties. According to Miles & Chang, fungi have been used for thousands of years as food (edible fungi) and a source of ingredients for traditional medicines (medicine fungi) [14]. This is because it contains components that are needed by the body, such as protein, essential amino acids, essential fatty acids, carbohydrates, fiber, vitamins, and minerals [15]. Apart from its nutritional content, fungi are also consumed because of its pleasant taste. The *Termotomycetes* genus is a fungus that has a very delicious taste and has become a unique culinary delicacy in various mainland Asia such as China and Thailand. Several other Agaricales that are also excellent for food commodities are oyster mushrooms from the *Pleurotus* genus and they are currently been cultivated.

The use of mushrooms as medicine has actually been carried out since 600 years BC by the Chinese community. The development in science shows that fungi have various metabolite compounds that can be used as anti-cancer, anti-bacterial, immunomodulatory, antioxidant, anti-inflammatory, and anti-allergic properties. Furthermore, they can regulate blood sugar and cholesterol levels, blood pressure, and help in preventing diabetes, hypertension, and cardiovascular disease [16]. Several species of Agaricales found in Tahura PMI such as *Schizophyllum communae, Flammulina velutipes* are known to have anti-tumor, anti-hepatitis, antiviral, anti-microbial, and immunomodulatory properties[17][18]. The use of fungi as medicine is due to their very low toxicity when consumed regularly, even in high doses [19].
Figure 2. Representation of fungi from the Agaricales order based on family. a). Clavulinopsis fusiformis (family: Clavariaceae), b). Hygrocybe ceracea (Hygrophoraceae), c). Marasmius haematocephalus (Marasmiaceae), d). Agaricus sp. (Agaricaceae), e). Mycena vitilis (Mycenaceae), f). Coprinellus disseminates (Psathyrellaceae), g). Termitomyces microcarpus (Lyophyllaceae), h). Cytotrama asprata (Physalacriaceae), i). Inocybe rimoso (Inocybaceae), j). Cyathus striatus (Nidulariaceae), k). Schizophyllum commune (Schizophyllaceae), l). Plicaturopsis crispa (Amylocorticiaceae), m). Pterula subulata (Pterulaceae), n). Crepidotus sp. (Crepidotaceae), o). Gymnopilus sapineus (Cortinariaceae), and p). Pleurotus djamor (Tricholomataceae).

4. Conclusion
A total of 50 species were identified as members of the order Agaricales which belongs to 16 families of the 30 genera. It is dominated by the Marasmiaceae family and the Marasmius genus. This high diversity is a very good opportunity considering the fact that some of the fungi have the potential of being used for food and medicine. It is necessary to develop and conduct further research on these fungi for community benefits, especially around the Tahura PMI.
References

[1] Rosa L H and Capelari M 2009 Braz. J. Microbiol. 40 846–51
[2] Kirk P M, Cannon P F, Minter D W and Stalpers J A 2008 Dictionary of the Fungi 10th ed. (Wallingford, UK: CAB) p 782
[3] Khady N, Maimouna K, Adidja M W, Abdalah F and Kandioura N 2018 Annu. Res. Rev. Biol. 29 1–12
[4] Arini D I D, Christita M and Kinho J 2019 Berita Biologi 18 109–115
[5] Arini D I D and Christita M 2016 Proc. Seminar Nasional Biodiversitas VI (September) 49–59
[6] Prasetyaningsih A and Rahardjo D 2015 The 2nd University Research Colloquium 471–81
[7] Tampubolon S D B M, Utomob B and Yunafsi 2013 Peronema For. Sci. J. 2 176–82
[8] Khayati L and Warsito H 2016 Proc. Symbion (Symposium on Biology Education) 213–22
[9] Wahyudi T R, Prasetyaningsih S R and Azwin A 2016 Wahana Forestra: Jurnal Kehutanan 11 21–33
[10] Nasution F, Prasetyaningsih S R and Ikhwan M 2018 Wahana Forestra: Jurnal Kehutanan 13 64–76.
[11] Ye L, Li H, Mortimer P E, Xu J, Gui H, Karunarathna S C, Kumar A, Hyde KD and Shi L 2019 Forests 10(10) 824
[12] Smith S E and Read D 2008 Mycorrhizal Symbiosis Vol. 137 Soil Science (New York: Academic Press) p 800
[13] Gómez-Hernández M, Ramírez-Antonio KG and Gándara E 2019 Fungal Ecology 39 109–16
[14] Miles P G and Chang S-T 2004 Mushrooms: Cultivation, nutritional value, medicinal effect, and environmental impact (USA : CRC Press) p 480
[15] Fitra M A, Thomy Z, Samingan, Harnelly E and Kusuma H I 2020 IOP Conf. Ser.: Earth and Environmental Science 425 012058
[16] Pohleveln J, Korosec T and Gregori A 2015 Medicinal Mushrooms (Slovenia: Mycomedica)
[17] Yi C, Zhong H, Tong S, Cao X, Firempong CK, Liu H, Fu M, Yang Y, Feng Y, Zhang H, Xu X and Yu J 2012 Int. J. Nanomedicine 7 5067–5078
[18] Mirfat A H S, Vikineswary S, Ahmad M, Salahuddin H, Abdullah N and Sabaratnam V 2014 Am. J. Res. Commun. 2 113.
[19] Wasser S P 2014 Biomed. 37(6) 345–356

Acknowledgment
The authors are grateful to Mr. Samingan in borrowing his book for identification. In addition, this research was funded by Syiah Kuala University, Ministry of Research, Technology and Higher Education, according to the 2020 Master Thesis Research Contact, Number: 62 / UN11.2.1 / PT.01.03 /DPRM/2020.