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**Research Article**

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## **Macrofungi of Imbak Canyon - Batu Timbang Area, Sabah**

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### **Abstract**

Macrofungi survey was carried out from 21<sup>st</sup> to 26<sup>th</sup> of August, 2017 during the Imbak Canyon Conservation Area (ICCA) Scientific Expedition at Batu Timbang Area, Imbak Canyon, Sabah. The purpose of the study was to survey the diversity of mushroom forming-fungi or macrofungi because such study and information is poorly documented and limited in Malaysia. In this scientific expedition, we obtained a total of 106 species from 13 different families within Basidiomycota and Ascomycota. The most dominant family found was Polyporaceae with 25 species were collected, 23% of the total samples collected. We identified four different species of edible mushrooms and two deadly poisonous mushrooms. About 47% unidentified group will be subjected for DNA analysis. Apart from that, we characterized some of the polypore till genus or species level. The most interesting species from this study area were *Earliella scabrosa* and *Panus similis* that were recorded to have a medicinal properties. A glowing mushroom, *Mycena illuminans* is a new record for the Imbak Canyon region. Diversity of the ectomycorrhizal mushrooms which are specific to dipterocarp trees in Batu Timbang should be explored. Endemic and IUCN red listed species like *Buglossoporus* sp. found in the study area should be preserved for DNA. Future studies are needed in order to conserve the hidden knowledge of undescribed groups of mushroom from this region.

**Keywords:** macrofungi diversity, gill mushrooms, polypores, conservation

## Introduction

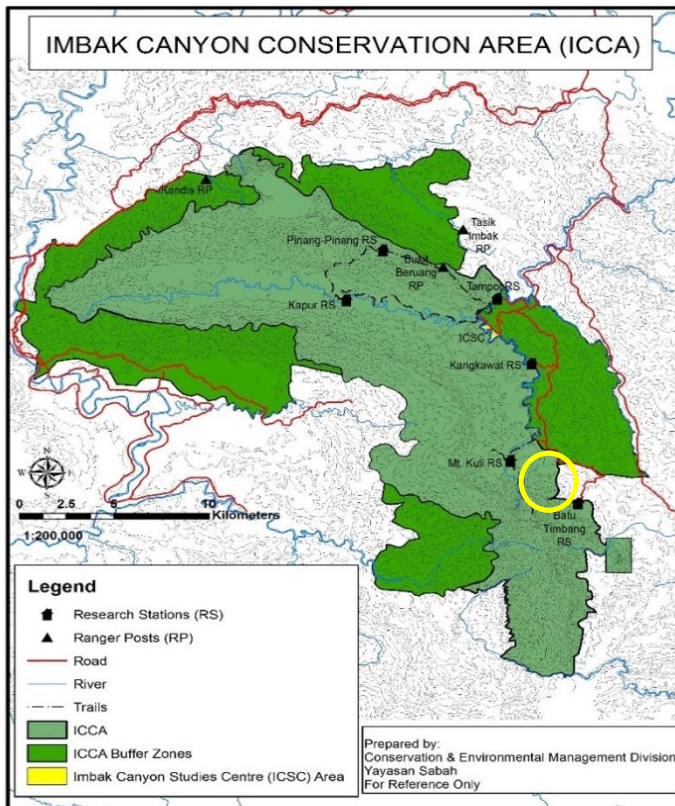
Mushroom-forming fungi or macrofungi are a group of mushrooms that are visible to our naked eye. They play an important role in our ecosystem as part of the terrestrial ecosystems, forming a large share of their species diversity, and are key players in ecosystem processes (Chang & Miles, 2004; Senn-Irlet et al., 2007). They are good decayers, pathogens, parasites, and mutualistic symbionts of both plants and animals. The main macrofungi includes some of the ascomycetes and basidiomycetes with large, easily observed spore-bearing structures. This includes mushrooms, bracket fungi (polypores), puffballs, truffles, cup fungi, resupinate or corticioids and etc. Global distribution of macrofungi have been compiled and it is estimated that tropical Asia contains about 400 described species (Mueller et al., 2007). The number seems to be very low for a high biodiversity hotspot area such as Malaysia. This is because the study of macrofungi and their species diversity in this region, especially in Borneo, is still lacking (Chang & Lee, 2011; Hyde, 2003). Thus, the main objective of this study was to survey macrofungi (different forms) distributed within the Batu Timbang area of Imbak Canyon. In this scientific expedition, we compiled data from different group of mushrooms based on their nutritional modes and segregated them according to their closest families, genus and species level. All of the collections that were made from this expedition were described and identified in order to produce a checklist for the Batu Timbang Area. This study will serve as baseline information for future researchers who are interested to study the specific genus or species. In addition, research findings or information from this study especially endemic mushroom species known to this area, will be incorporated to enhance this area as a Class I Forest Reserve.

## Methods and materials

### *Study Area*

Imbak Canyon, approximately 30,000 hectares in size and encompassing two ridge top Virgin Jungle Reserves is probably Sabah's last frontier of pristine tropical rainforest and is located between longitude 117°2'0"E and latitude 5°5'30"N. It was gazetted as a Class I (Protection) Forest Reserve by the Sabah State Government in 2009. Unlike Danum Valley and Maliau Basin Conservation areas, Imbak Canyon Conservation Area ICCA is located near 48 villages in the district of Tongod, with a combined population of 30,000. ICCA is reachable by road from Kota Kinabalu to Tongod on a journey of approximately 10 hours, and a four-wheel drive is essential as the latter part of the journey is on logging roads. The scientific expedition was conducted from the 16<sup>th</sup> to 26<sup>th</sup> of August,

2017 and was divided into two sessions, and we joined the second session that was conducted from 21<sup>st</sup> to 26<sup>th</sup> of August, 2017. The Imbak Canyon Conservation Area (ICCA) Scientific Expedition was organized by Yayasan Sabah in collaboration with Sabah Forestry Department and sponsored by PETRONAS. The expedition was participated by numerous agencies and academic institutions such as Universiti Malaysia Sabah (UMS), Sabah Parks, Sabah Museum, Universiti Kebangsaan Malaysia (UKM), Universiti Malaya (UM), Universiti Sains Malaysia (USM), Sabah Foundation and Ryukyus University, Japan. ICCA is located almost right in the heart of Sabah, just north of the famous Maliau Basin with unique heterogenous biodiversity in terms of the geological and geomorphic characteristic and studded with many stunning waterfalls.



**Figure 1.** Sampling location of Batu Timbang Scientific Expedition Site

### *Sample Collections*

Fresh macrofungi samples were collected based on their fruiting body occurrence on the substrates, mostly on fallen rotting branches, twigs, and dead trees. During the time of this trip, it was the rainy season. Photographs were taken for each specimen, including the top, side, and bottom view of the fungi. The specimens were then cut or carefully dug out using a knife or a trowel to any avoid damages. All specimens were properly tagged and wrapped appropriately in a paper bag to avoid drying. The habitat, substrate and their fresh morphological characteristics of the fungi were recorded. For each habitat, Global Positioning System (GPS) were recorded. Photographs were taken with DSLR Nikon D3200.

### *Macrofungi Identification*

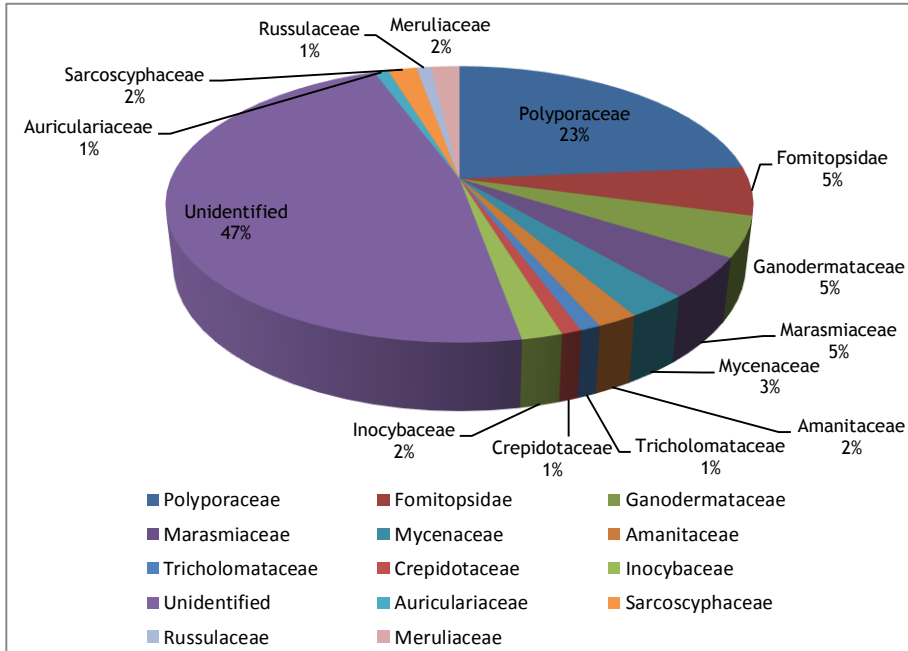
Spore prints were prepared from fresh samples and chemical reaction tests were done using potassium hydroxide (KOH). A small piece of the mushrooms tissues were kept in KOH for further study. The identification based on the morphology and some microscopic characteristic of the macrofungi was accomplished with the aid of current keys, descriptions and references (Evans & Kibby, 2004; Pegler, 1994; Zainuddin et al., 2010). When specimens could not be matched to known species descriptions, they were assigned to a genus and given a species number, for example, *Hyphodontia* sp. 1. The taxonomic status and description of these species will be examined and identified later using more advance method like molecular identification for further use. The specimens were brought back and dried in an incubator or oven at 45°C for 24-48 hours. The dried specimens were deposited in the BORNEENSIS Herbarium (BORH) at the Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah for further study.

## **Results and Discussion**

In this study, we recorded macrofungi taxa that belongs to two major division of the fungi kingdom namely (i) Basidiomycota and (ii) Ascomycota. Most of the collections that were collected from Batu Timbang, were Basidiomycetes and one species of *Cookeina* (Ascomycota, Sarcoscyphaceae). The total families and genus of macrofungi are presented in Table 1. The total number of 56 species of macrofungi found during the survey on Batu Timbang, Imbak Canyon were from 13 families within Basidiomycotina (Figure 2). The highest distribution of macrofungi for Batu Timbang were Polyporaceae (23%), followed by Fomitopsidae (5%), Ganodermataceae (5%) and Marasmiaceae (5%).

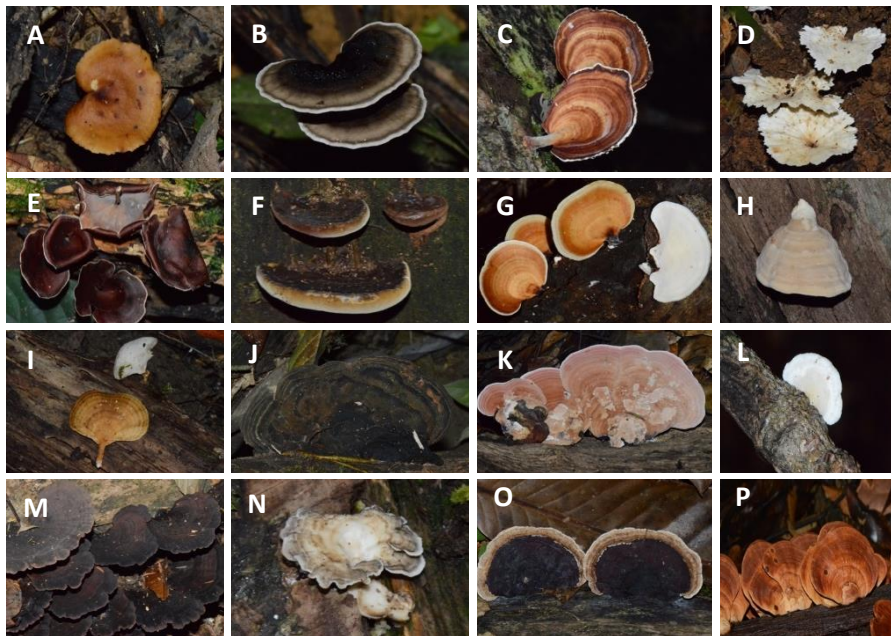
About 47% of the collected fungi were unidentified as they lacked morphological references and need further identification using molecular analysis which is costly and time consuming.

In this survey, we discuss some of the interesting collections from Batu Timbang.



**Figure 2.** Percentage of macrofungi occurrence by families at Batu Timbang, Imbak Canyon

Polyporaceae, the wood decay fungi, was the dominant group around this area (Figure 3). We recorded 25 species within Polyporaceae family. Batu Timbang is an old growth forest area covered with dead logs and dead woods. This area may be accompanied with humidity and the high moisture content for the abundant polypore's to grow on the cellulose-rich substrates (Svrcek, 1997). Most of the polypores are white rot and favour dead wood and dead trees as their main substrate. We recorded two edible polypores, *Polyporus badius* and *Hexagonia tenuiculus*. Apart from that, an interesting finding of *Buglossoporus sp.* from Batu Timbang is considered as a new record for this area since this species only occurs at higher elevations of more than 2500m in montane regions like Mount Tambuyukon, Crocker Range and Sayap National Park, Kundasang. (Figure 5).



**Figure 3.** List of some interesting polypore mushrooms. A. *Polyporus badius*; B. *Amouroderma rugosum*; C. *Microporus xanthopus*; D. *Microporellus* sp.; E. *Favolus* sp.; F. *Fomitopsis dochmia*; G. *Microporus affinis*; H. *Piptoporus* sp.; I. *Favolus emericii*; J. *Ganoderma australe*; K. *Rhodofomitopsis feei*; L. *Tyroformes* sp.; M. *Coriopsis* sp.; N. *Microporus vernicipes*; O. *Earliella scabrosa*; P. *Microporus* sp.

Agaricales are fleshy gill mushrooms. In this study, we were able to record at least 14 species from different families such as Mycenaceae, Russulaceae, Marasmiaceae, Amanitaceae, Thelephoraceae, Meruliaceae and Crepidotaceae. Among the Agaricales, Amanitaceae, Russulaceae, Thelephoraceae were ectomycorrhizal species which were associated with tree species like Dipterocarpaceae, Fagaceae, *Castanotiopsis* and etc. Ectomycorrhizal species are usually dependent on their host plants and in this study, we did not record any of the symbiotic relationship information due to time constraints. In addition, we recorded two deadly poisonous mushrooms, *Amanita similis* and *Trogia venenata* (Figure 4 - J & M). *A. similis* is a common tropical species that is widely distributed along the Javan and Bornean islands. Morphologically, the cap of *Amanita similis* ranges between 80 - 90 mm wide, convex then expanded and somewhat umbonate, viscid at first, innately streaked, bronze to honey yellow, darkest in the centre, with a sulcate-striate margin (30 - 50% of the radius). The flesh is pale yellow, bright yellow underneath the cap skin especially under the umbo. The Javan and the Bornean species are almost the same in terms of their spore structures. The spores size is  $7.5 - 10.5 \times 5.5 - 7.5$

$\mu\text{m}$  with broadly ellipsoid and inamyloid shape. On the other hand *Trogia venenata* is one of the tropical species that was recorded poisonous and this species is lethal to human due to their toxic amino acids.



**Figure 4.** List of some interesting Agaricales mushrooms. A. *Mycena illuminans*; B. *Mycena* sp.; C. *Crepidotus* sp.; D. *Gerronema* sp.; E. *Russula* sp.; F. *Marasmius rotalis*; G. *Marasmius* sp.; H. *Inocybe* sp.; I. *Cymatoderma elegans*; J. *Amanita similis*; K. *Russula nigricans*; L. *Inocybe* sp. (pink); M. *Trogia venenata*.; N. *Thelephora* sp.

The distribution of Polypores were more abundant in this area than the Agaricales (Table 1). This might be due to the climate and seasonal factors that needs to be observed throughout the year (Svrcek, 1997). The fruiting of mushrooms sometimes needs to be monitored yearly. During the expedition, it was rainy and most of the gill mushrooms or fleshy mushrooms were damaged because of the wet environment and could not be dried well for storing. Spore prints for some of the fleshy mushrooms were restricted because some of the fruiting bodies were too moistured and damaged. However, we were able to identify the edible ones based on the records from previous studies done by Seelan et al. (2015).

**Table 1.** List of Macrofungi collections by family at Batu Timbang, Imbak Canyon (Sabah).

Family / Species	Number of samples	Habitat/Substrate	Remarks
<b>Order: Polyporales</b>			
<b>Family: Polyporaceae</b>			
<i>Polyporus badius</i>	1	Dead log/Saprophytic	Edible
<i>Trametes versicolor</i>	1	Dead wood/Saprophytic	Medicinal
<i>Microporus xanthopus</i>	6	Dead wood/Saprophytic	Medicinal

<i>Microporus vernicepes</i>	1	Dead wood/Saprophytic	
<i>Microporus affinis</i>	4	Dead log/Saprophytic	
<i>Microporus</i> sp.	2	Dead log/Saprophytic	
<i>Trametes</i> spp.	4	Dead wood/Saprophytic	
<i>Hexagonia tenuiculus</i>	1	Dead log/Saprophytic	Edible
<i>Skeletocutis</i> sp.	1	Dead log/Saprophytic	
<i>Panus similis</i>	1	Dead wood/Saprophytic	Edible
<i>Earliella scabrosa</i>	1	Dead tree	
<i>Favolus emericii</i>	1	Dead log/Saprophytic	
<i>Favolus</i> sp.	1	Dead log/Saprophytic	
<b>Family: Fomitopsidae</b>			
<i>Fomitopsis</i> spp.	3	Dead log/Saprophytic	
<i>Piptoporus</i> sp.	1	Dead log/Saprophytic	
<i>Coriolopsis</i> sp.	1	Dead log/Saprophytic	
<i>Buglossoporus</i> sp.	1	Dead log/Saprophytic	
<b>Family: Ganodermataceae</b>			
<i>Ganoderma australae</i>	2	Dead log/Parasitic	Pathogenic
<i>Ganoderma lucidum</i>	1	Dead log/Saprophytic	Medicinal
<i>Amouroderma rugosum</i>	1	Soil/Saprophytic	Medicinal
<i>Ganoderma</i> sp.	1	Dead log/Saprophytic	
<b>Family: Meruliaceae</b>			
<i>Podoscypha</i> sp.	1	Dead wood/Saprophytic	
<i>Cymatoderma elegans</i>	1	Dead wood/Saprophytic	
<b>Order: Agaricales</b>			
<b>Family: Mycenaceae</b>			
<i>Mycena</i> spp.	3	Dead wood/Saprophytic	Glowing
<b>Family: Marasmiaceae</b>			
<i>Marasmius</i> spp.	4	Dead wood/Saprophytic	
<i>Gerronema</i> sp.	1	Dead branch	
<b>Family: Tricholomataceae</b>			
<i>Trogia venenata</i>	1	Dead wood/Saprophytic	Toxic
<b>Family: Amanitaceae</b>			
<i>Amanita similis</i>	2	Soil/Ectomycorrhizal	
<b>Family Crepidotaceae</b>			
<i>Crepidotus</i> sp.	1	Dead wood/Saprophytic	
<b>Family Inocybaceae</b>			
<i>Inocybe</i> sp.	2	Soil/Ectomycorrhizal	
<b>Order: Auriculariales</b>			
<b>Family Auriculariaceae</b>			
<i>Auricularia</i> sp.	1	Dead wood/Saprophytic	Edible
<b>Order: Pezizales</b>			
<b>Family Sarcoscyphaceae</b>			
<i>Cookeina sulcipes</i>	1	Dead log/Saprophytic	
<i>Cookeina tricholoma</i>	1	Dead log/Saprophytic	



Order: Russulales		
Family: Russulaceae		
<i>Russula</i> spp.	1	Soil/Ectomycorrhizal
<i>Unidentified</i>	50	
TOTAL	106	

The ten days study in pristine forest of Imbak Canyon also recorded three interesting species of macrofungi which are the *Earliella scabrosa*, *Panus similis* and *Buglossoporus* sp. (Figure 5). *Earliella scabrosa* is a monotypic genus which comprises a single species and was described by Murril (1905) from Cuba. This species provides a conducive habitat for many beetle groups. Their fleshy hymenophores provide food sources and habitat for many arthropods especially beetles and are also recorded pathogenic to humans (Hong et al., 2018). The others species is *Panus similis*, which is the lentinoid fungi and is a saprophytic fungi. It was distributed only in Southeast Asia, Latin Americas and Australasia (Gunasekaran, 2015). The species was described by Corner in 1964 and rediscovered in Batu Timbang, Imbak Canyon in 2017. *Buglossoporus* sp. is recorded as one of the vulnerable species by the IUCN Red List and recorded as very rare distribution as it is only found in Tambuyukon so far. The species is annually grown, usually on lowland and montane forest distribution (Hattori, 2017).

## Conclusion

The preliminary work will undoubtedly be valuable to those interested in studying fungi in the lowland and upland mixed dipterocarp forests of Imbak Canyon - Batu Timbang Area, Sabah. It is hoped that this work will act as a catalyst to increase and promote more studies on fungi, especially in Sabah.



Figure 5. List of some interesting mushroom from Batu Timbang. A. *Earliella scabrosa*; B. *Panus similis*; C. *Buglossoporus* sp.

## Acknowledgements

We are grateful to Yayasan Sabah under the coordination of Dr Yap Sau Wai, who heads the Conservation and Environmental Management Division, Rita S. Galid, Dr Hamzah Tangki, Jadda Suhaimi and their team from Yayasan Sabah for their support throughout the expedition. We also wish to thank the then Chief Conservator of Forests, Datuk Sam Mannan, who is also the Chairman of Imbak Canyon Management Committee, Deputy Chief Conservators, Frederick Kugan and Dr Lee Ying Fah, for their support in this expedition. Sincere gratitude also goes to the Dipterocarp's team from Sabah Forestry Department headed by Mr. Richard Majapun and his team Martin Tuyok, Sandy Tsen and Lee Yew Leung for their invaluable help during the field work. We also wish to thank Dr Arthur Chung Yaw Chyang for his comments and suggestion on the manuscript.

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