

# Wild mushrooms diversity in tropical rainforest

Nabilla Hapsari Wijaya, Annisa Dwi Savitri, Ayu Tri Wahyuni, Eva Salsabila Alhadad, Nikolas Edo, Afrah Shabrina, Muhammad Ardiansyah Farid, Sarah Shafaanissa Basri, Amalia Rizky Febrianti, Diajeng Aulia Rahma Putri and Intan Ayu Pratiwi\*

*Department of Biology, Faculty of Science and Technology, Universitas Airlangga, Surabaya, Indonesia*

(Received 10 August, 2020; Accepted 30 October, 2020)

## ABSTRACT

Tropical rainforests are well-known as the habitat of various organisms, each housing a very complex yet different vegetation communities based on the biogeographical region. One of these organisms which prevails the most in tropical rainforest are fungi, especially the macroscopic ones. This research aims to analyze and compare the diversity especially of Basidiomycota between 4 location, 2 located in Indonesia while the other 2 in another country. In Indonesia, West Bali National Park, the exactly in Ambyarsari and the other one is in Block Cisela Lowland Forest Nature Reserve Bojonglarang Jayanti, Cianjur, West Java. For the location in other country, one in Colombian Amazon forests and the last one is Central Cardamom Protected Forest (CCPF) in Koh Kong province of Cambodia.

*Key words* : Bali, Basidiomycota, Mushroom, Diversity, Rainforest

## Introduction

Tropical rainforest, mostly found near the equator, have high average temperatures and humidity. The characteristic of tropical rainforest is very high annual rainfall, so this forest is also called evergreen forest. This type of forest provides good environment for many flora and fauna to grow so it increased the organism diversity around. Tropical rainforests are spread on more place in the world, one of them is West Bali National Park (TNBB) in Ambyarsari. West Bali National Park is one of flora and fauna conservation areas in Bali, Indonesia. The area of TNBB is 19,002.89 ha and in 2005 the forest area was only 5-10 thousand ha. In Ambyarsari minimum annual rainfall is 1,750 mm (69 in) and 2,000 mm (79 in), while the temperature averages months are above 18 °C all year round (Woodward, 2004, 2013). The humidity is high, as well as the rainfall, while rainy days are evenly distributed

throughout the year (Walter, 1971).

Tropical rainforests are also dominated by large trees that form a canopy with a solid and tight layer. The more solid and dense canopy, the less intensity of light that received by forest floor and humidity levels will be higher. Cisela Nature Forest Reserve Bojonglarang Jayanti, located in West Java, is one of a typical tropical rain-forest. Apart from Indonesia, tropical rainforest can be found in other country, one of the most famous is The Amazonian rainforest. This forest is arguably the most species-rich terrestrial ecosystem in the world (Hoorn *et al.*, 2010). The Amazonian rainforest can be found in several place, one of them is in Colombia. In the northwestern part of the Amazon area, the forests cover 42% of the area of Colombia. Two locations near the Caquetá and Amazonas rivers were selected because of the availability of data on plant diversity, soils and climate, as well as accessibility.

Forest Areas in Cambodia, such as The Central

Cardamom Protected Forest (CCPF) in Koh Kong province also have a forest type as tropical rainforest also called evergreen forest. CCPF is located in the center of the Cardamom Mountains Range, covers an area of 401,313 ha, an important constituent of the Indo-Burma Biodiversity Hotspot. The Cardamom Mountains cover approximately 2 million ha of contiguous forestland with significant biodiversity and watershed values. Rainfall is relatively heavy, averaging around 3,000 mm annually. Temperatures show little seasonal change, averaging 25-30 °C, and March, April, and May are the hottest months (Kim, 2017). One of the most organism found in Tropical rainforest is mushroom. Mushroom are components that have important functions in terrestrial ecosystems as decomposers, symbionts and pathogens.

Mushroom is one of organisms that have a most wide biodiversity after Insects (Roosheroe, 2006). Fungi spread worldwide is estimated at 1.5 million, but only 70,000 species have been identified and about 1.43 million (95%) undescribed species (Hawksworth and Rossman, 1997; Hawksworth, 2001). Hawksworth and Rossman (1997) explained that studies to describe fungi in unexplored habitats need to be done especially in the tropics. Although tropical habitats occupy only 25.7% of the Earth's land, they housed most of the world's species (Deshmukh, 1986). Numerous taxa have been described from the tropics in the past decade, there may be 1 million species of fungi in tropical plants alone that have not been found (Hawksworth, 1993). The difference of substrates causes different types of mushroom, as well as the difference of environmental conditions such as soil moisture, temperature, pH of soil, and sunlight intensity.

### Methods

This study to compare and provide information data on the diversity of mushroom in two locations in Indonesia and other countries using data and information form along all season.

### Results

The diversity of mushrooms in tropical forest are presented in Table 1.

### Discussions

#### Physico-chemical parameters

Fungi are components that have an important func-

tion for terrestrial ecosystems as decomposers, symbionts and pathogens (Mueller, 2007). Mushroom availability in nature highly depends on the environmental conditions. The spread and growth of an organism including mushroom in the world is also influenced by any environmental factors (Suin, 2002). Environmental parameters that support the growth of mushroom are such as pH and soil moisture, air humidity, temperature, light intensity and substrate. Each mushroom has a habitat with a different type of substrate depending on the enzymes owned by the mushroom to utilize nutrients. Tropical rainforest types conduct diversity of mushroom in that forest types. TNBB (Wahyuni *et al.*, 2019) and Nature Reserve Bojonglarang Jayanti (Marzuki, 2017), Colombian Amazon forests (López-Quintero, 2012) and CCPF (Kim, 2017). The differences of geographic locations caused different types of mushroom to grow, as well as differences in environmental conditions which greatly affect the fruiting bodies of mushroom (Roosheroe, 2006). Ambyarsariin TNBB area which has 96% air humidity level and 25.5°C, located at an altitude of 0–1.414 meter above sea level. In Ambyarsari area, finds 10 genus of mushroom which lived on soil, weather wood, and fallen leaf. Meanwhile, Bojonglarang Forrest Jayanti Nature Preserve in Cianjur, West Java has 81.3% air humidity level. Bojonglarang Forrest Jayanti has a temperature from 26.5 – 30.1°C. That nature preserve is included lowland area which altitude from 49.4 until 77.1 meter above sea level. From 5 station which being observed, founds 13 Genus of mushrooms. That 13 mushroom has a habitat in wood. Colombian Amazon Forest has air humidity level on 88% with 25 °C temperature. Colombian Amazon Forest also include in highlands area, which have 200 – 300 meter above sea level altitude. Tropical forests, such as rainforests, are productive forests with tropical climates, which are located between 230 27 'LU and 230 27' LS. Tropical rainforests have very high humidity and lower temperatures with evenly distributed rainfall throughout the year (Walter, 1971). The four locations have a temperature range of 25 °C which is still within tolerance limits. Woodward (2016) states that the average monthly temperature in tropical rainforests is above 18°C (64°F) throughout the year. Humidity at the four locations shows a different range. It ranged between 81.3% - 96% at 3 locations, while the CCPF had low humidity. Tropical rainforest had the average of air humidity between 80%.

**Table 1.** Mushroom diversity

No	Genus	Ambyarsari, West Bali National Park	Cisela Nature Forest Reserve Bojonglarang Jayanti, Western Java	Colombian Amazon Forests	Central Cardamom Protected Forest (CCPF)
1	<i>Abortiporus</i>				V
2	<i>Agaricus</i>			V	
3	<i>Albatrellus</i>				V
4	<i>Alboleptomia</i>				V
5	<i>Amanita</i>				V
6	<i>Auriscalpium</i>				V
7	<i>Auricularia</i>		V	V	V
8	<i>Austroboletus</i>			V	
9	<i>Bjerkandera</i>				V
10	<i>Boletinellus</i>		V		
11	<i>Calocera</i>				V
12	<i>Campanella</i>		V		V
13	<i>Cantharellus</i>				V
14	<i>Cheimono</i>	V			
15	<i>Clavaria</i>			V	V
16	<i>Collybia</i>			V	
17	<i>Coltricia</i>				V
18	<i>Coprinellus</i>				V
19	<i>Coprynus</i>	V			
20	<i>Coriolopsis</i>				V
21	<i>Cordyceps</i>			V	
22	<i>Crinipellis</i>				V
23	<i>Crustodontia</i>				V
24	<i>Cyathus</i>				V
25	<i>Cyclomyces</i>				V
26	<i>Cymatoderma</i>			V	
27	<i>Dacryopinax</i>				V
28	<i>Daedalea</i>				V
29	<i>Daedaleopsis</i>				V
30	<i>Dentipellicula</i>				V
31	<i>Earliella</i>				V
32	<i>Elmerina</i>				V
33	<i>Entoloma</i>			V	
34	<i>Exidia</i>				V
35	<i>Favolaschia</i>		V		
36	<i>Fomes</i>				V
37	<i>Funalia</i>			V	
38	<i>Ganoderma</i>		V		V
39	<i>Geastrum</i>				V
40	<i>Gloeophyllum</i>				V
41	<i>Gymnopilus</i>				V
42	<i>Gymnopus</i>				V
43	<i>Gyroporus</i>				V
44	<i>Hygrocybe</i>	V			V
45	<i>Hexagonia</i>			V	V
46	<i>Hydnellum</i>			V	
47	<i>Hydnophlebia</i>				V
48	<i>Hydnum</i>				V
49	<i>Hymenochaetopsis</i>				V
50	<i>Hymenopellis</i>				V

Table 1. Continued ...

No	Genus	Ambyarsari, West Bali National Park	Cisela Nature Forest Reserve Bojonglarang Jayanti, Western Java	Colombian Amazon Forests	Central Cardamom Protected Forest (CCPF)
51	<i>Hypholoma</i>				V
52	<i>Inocybe</i>	V			V
53	<i>Inonotus</i>				V
54	<i>Irpex</i>				V
55	<i>Laccaria</i>				V
56	<i>Laxitextum</i>				V
57	<i>Leccinellum</i>				V
58	<i>Leiotrametes</i>				V
59	<i>Lentinus</i>	V		V	V
60	<i>Lenzites</i>				V
61	<i>Lepiota</i>			V	V
62	<i>Loweporus</i>				V
63	<i>Lycoperdon</i>			V	
64	<i>Marasmiellus</i>		V		V
65	<i>Marasmius</i>	V		V	V
66	<i>Megacollybia</i>				V
67	<i>Microporus</i>		V		V
68	<i>Mycena</i>				V
69	<i>Panus</i>				V
70	<i>Phaeoclavulina</i>				V
71	<i>Phellinus</i>		V		V
72	<i>Phlebia</i>				V
73	<i>Phylloporus</i>				V
74	<i>Pisolithus</i>				V
75	<i>Plicaturopsis</i>				V
76	<i>Podoscypha</i>			V	V
77	<i>Polyporoletus</i>			V	
78	<i>Polyporus</i>		V	V	V
79	<i>Porodisculus</i>				V
80	<i>Postia</i>	V			
81	<i>Pulberoboletus</i>				V
82	<i>Psathyrella</i>				V
83	<i>Pycnoporus</i>	V		V	V
84	<i>Retiboletus</i>				V
85	<i>Rigidoporus</i>				V
86	<i>Rimbhacia</i>	V			
87	<i>Russula</i>				V
88	<i>Schizophyllum</i>		V		V
89	<i>Serpula</i>				V
90	<i>Skeletocutis</i>				V
91	<i>Stereopsis</i>				V
92	<i>Stereum</i>				V
93	<i>Tephrocybe</i>	V			
94	<i>Tetrapyrgos</i>			V	V
95	<i>Thelephora</i>				V
96	<i>Trametes</i>		V	V	V
97	<i>Tremella</i>				V
98	<i>Trichaptum</i>				V
99	<i>Turbinellus</i>				V
100	<i>Tyromyces</i>		V		

Table 1. Continued ...

No	Genus	Ambyarsari, West Bali National Park	Cisela Nature Forest Reserve Bojonglarang Jayanti, Western Java	Colombian Amazon Forests	Central Cardamom Protected Forest (CCPF)
100	<i>Xeromphalina</i>				V
101	<i>Xerula</i>				V
103	<i>Xylaria</i>		V		
104	<i>Xylobolus</i>				V

### Genera diversity

Based on the data obtained, the diversity of mushrooms found in Ambyarsari were found 10 genera of fungi, namely the genus *Tephrocybe*, *Postia*, *Cheimono*, *Inocybe*, *Rimbachia*, *Higrocybe*, *Lentinus*, *Coprinus*, *Marasmius*, and *Pycnoporus*. The following is the research data regarding various species of herbal medicine found in the Bojonglarang Jayanti forest area. Based on result of observations was found 13 genera of fungi which are *Auricularia*, *Boletinellus*, *Campanella*, *Favolaschia*, *Ganoderma*, *Marasmiellus*, *Marasmiellus*, *Microporus*, *Phellinus*, *Polyporus*, *Polyporus*, *Polyporus*, *Polyporus*, *Schizophyllum*, *Trametes*, *Tyromyces*, and *Xylaria*. As previously explained, tropical rainforest habitat is a suitable habitat for fungal growth. One of them is the Amazon forest in Colombia. The following data is the diversity of mushrooms found in the Colombian Amazon forest. Based on result of observations was found 21 genera of fungi which are *Agaricus*, *Auricularia*, *Austroboletus*, *Cheimono*, *Clavaria*, *Cordyceps*, *Cymatoderma*, *Entoloma*, *Funalia*, *Hexagonia*, *Hydnellum*, *Lentinus*, *Lepiota*, *Lycoperdon*, *Marasmius*, *Podoscypha*, *Polyporoletus*, *Polyporus*, *Pycnoporus*, *Tetrapyrgos*, and *Trametes*. The last forest that will be discussed regarding mushroom diversity is forest areas in Cambodia including several forests that are used as research sites for mushroom diversity, one of them is CC PF in Koh Kong province, 84 genera specimens were collected, which are *Daldinia*, *Microporus*, *Pycnoporus*, and *Stereum* were commonly distributed in all ranges of elevation, while the distribution of *Ceratomyxa*, *Panus*, *Schizophyllum*, *Trametes*, and *Tyromyces* were limited in the elevation under 500 m. While *Amauroderma*, *Bjerkandera*, *Trichaptum*, and *Tyromyces* were collected only in Cardamom forests, while 20 species including *Auricularia*, *Coriolopsis*, *Rigidoporus*, and *Xylaria* were collected only in Seima and Mondulkiri forests. Then, *Ganoderma*, *Mycena*, *Marasmius*,

*Microporus*, *Phellinus*, and *Russula* were dominant species in both the eastern and western Cambodia. Mushrooms in Cambodia because of the absence of references or the survey reports on mushroom collection and identification. Species diversity of mushrooms in south-eastern Asian countries was quite different from that in northeastern countries as well as north America and Europe (Imazeki and Hongo, 1989).

### Habitat distribution

There are a lot of factors that can affect the distribution of fungal biodiversity, both internally and externally. Some of them are the environmental condition, humidity, temperature, rainfall, soil type, measure, size, morphological, and anatomical of the fungus itself. The only certain fungus can live in a specific habitat. Consequently, habitat can determine fungal distribution in a certain place. The research in Ambyarsari. The region has a high level of rainfall and humidity. Reviewed from the place, the average fungi that have habitat in humid soil are *Hygrocybe*, *Marasmius*, *Lentinus* and *Comprynus*. Other types of a genera that naturally grow in dead wood are *Cheimono*, *Inocybe*, *Pycnoporus*, and *Rimbachia*. Mostly fungus found grow in an area with condition 25.5 C and level of air humidity 96%. The macroscopic fungi can live in arctic up to tropical habitat. The data obtained the number and types of fungi that were found in the Bojonglarang Jayanti nature reserve, have so many varieties based on environmental conditions especially in the habitat where the fungus grows. These 13 genera of fungi grow and thrive in a plank of rotted wood or dead tree, with a 78-85% level of air humidity, the average temperature is 28 C, and light intensity that supports fungal growth. Some of the fungi that dominated in this place are *Trametes*, *Polyporus*, and *Xylaria*. There also part of the forest that still has grown tree has lesser fungi, it because there no rot-

ted wood or dead tree that become fungi habitat. Among all of the mushrooms that are founded in the Cambodian forest, the most species-rich families are Ployporaceae, Marasmiaceae, Ganodermataceae, Hymenochaetaceae, Mycenaceae, and comprised. One of the factors is in the Cambodian Forest, which has a low level of air humidity. Each one types of fungi, Ascomycota and Basidiomycota own their unique characteristic features and different habitat (Gomez-Hernandes *et al.*, 2012). Commonly most of the fungi are breeds in a dead tree, for example, *Coprinellus*, *Elmerina*, and *Trichaptum*. A few of fungus was found in humid soil, fallen leaves, and in a dead rotten tree. The reason is that they have big features and invulnerability with environmental condition depend on the habitat.

## Conclusion

Most of the differences in diversity catalog and index between the 4 locations were due to the sampling effort, which consists of the time it takes to do the sampling and other resources involved, made at each 4 locations. Ten genera were found in Ambyarsari, 13 genera found in Block Cisela Lowland Forest Nature Reserve Bojonglarang Jayanti, Cianjur, West Java, 21 genera found in Colombian Amazon forests, and 84 genera was found in Central Cardamom Protected Forest (CCPF) in Koh Kong province of Cambodia.

## References

- Deshmukh, I. 1986. Ecology and Tropical Biology. Blackwell Scientific Publications.
- Gomez-Hernandez, M., Williams-Linera, G., Guevara, R., and Lodge, D. J. 2012. Patterns of macromycete community assemblage along an elevation gradient: options for fungal gradient and metacommunity analyses. *Biodiv. and Conservation*. 21(9): 2247- 2268.
- Hawksworth, D. 1993. Priorities for biosystematic research in support of biodiversity in developing countries: microorganisms and invertebrates. *Biodiversity and biosystematic priorities: microorganisms and invertebrates*.
- Hawksworth, D. and Rossman, A. 1997. Where are all the undescribed fungi? *Phytopathology*.
- Hawksworth, D. L. 2001. The magnitude of fungal diversity: the 1,5 million species. *Mycological Research*.
- Hoorn, C., Wesselingh, F.P., Ter Steege, H., Bermudez, M.A., Mora, A., Sevink, J., Sanmartín, I., Sanchez-Meseguer, A., Anderson, C.L., Figueiredo, J.P. and Jaramillo, C. 2010. Amazonia through time: Andean uplift, climate change, landscape evolution, and biodiversity. *Science*. 330(6006): 927-931.
- Imazeki, R. and Hongo, T. 1989. *Genshoku Nihon Shin Kinrui Zukan [New Colored Illustrations of Mushrooms of Japan]*, Vol. 2. 316 pp. Osaka, Japan: Hoikusha Publishing Co., Ltd.
- Kim, N. K., Lee, J. H., Jo, J. W. and Lee, J. K. 2017. A Checklist of Mushrooms of Cambodia. *Journal of Forest and Environmental Science*. 33 (1): 49-65.
- López-Quintero, C. A., Straatsma, G., Franco-Molano, A. E. and Boekhout, T. 2012. Macrofungal diversity in Colombian Amazon forests varies with regions and regimes of disturbance. *Biodiversity and Conservation*. 21(9) : 2221-2243.
- Marzuki, B. M., Rossiana, N. and Normanita. 2017. *Diversity of Macrofungi on Wood in Forest Nature Reserve of Bojonglarang Jayanti, Cianjur, West Java*.
- Mueller, G.M., Schmit, J.P. and Leacock, P.R. 2007. Global diversity and distribution of macrofungi. *Biodivers. Conserv.* 16 : 37-48.
- Roosheroe, I. G., Sjamsuridzal, W. and Oetari, A. 2006. *Mikologidasar dan terapan*. Jakarta: Yayasan Obor Indonesia.
- Suin, N. M. 2002. *Metoda Ekologi*. Padang: Penerbit Universitas Andalas.
- Wahyuni, N., Nuswantara, Eka Narendra, Farida, Yuni., Putra, Gading Gunawan, Indriyarsari, Khudrotul Nisa., Ikmala, Nur Laily Fachira, Islamatasya, Ufairanisa, Nariswari, Anindya., Permatasari, Fadhila, Ni'matuzahroh, Pratiwi and Intan Ayu. 2019. Basidiomycota diversity in Tegal Bunder and Ambyarsari, West Bali National Park, Bali, Indonesia. *In Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia* (Vol. 5, No. 2, pp. 280-285).
- Walter, H., Mueller-Dombois, D. and Burnett, J.H. 1971. *Ecological of Tropical and Subtropical Vegetation*. New York: Van Nostrand Reinhold Company.
- Woodward, F. I., Lomas, M. R. and Kelly, C. K. 2004. Global climate and the distribution of plantbiomes. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*. 359(1450) : 1465-1476.
- Woodward, R.B. and Hoffmann, R. 2013. *The Conservation of Orbital Symmetry*. Elsevier.
- Woodward, Bessie M., Arantes, Marina Donaria Chaves., Arango, Rachel A., França, Frederico Jose Nistal., França, Tamara Suely Filgueira Amorim. 2016. Natural Resistance of Plantation Grown African Mahogany (*Khaya ivorensis* and *Khaya senegalensis*) from Brazil to Wood-Rot Fungi and Subterranean Termites. *Inter. I. Biodeterioration and Biodegradation*. 107: 88-91.