New recorded species of polypore for Indonesia found in Universitas Indonesia Depok Campus

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Abstract. The polypore mushrooms or polypores are distinguished by their binding and skeletal hyphae and typical poroid hymenophore. Huge beneficial ecological and anthropocentric values can be obtained from them. The taxonomy information about of this group of mushrooms in Indonesia is very limited and very difficult to find. This study was aimed to collect, characterize, and identify the polypores in Universitas Indonesia Depok Campus which has forest area. Sampling was conducted using broad survey method. Characterization, identification, and species description were performed based on morphological data, both macroscopic and microscopic examination. Seventy specimens which were collected consisted of 34 species from 22 genera, 7 families (1 incertae sedis), and 4 orders. Polyporales Gáum is the largest order (82.35% from all species found) with Polyporaceae and Trametes as the largest family and genus, respectively. This study discovered 17 new recorded species polypores for Java and 11 new recorded species polypores for Indonesia.

Keywords: Morphology, new record, polypore mushroom, taxonomy, Universitas Indonesia Depok Campus

1. Introduction
Polypore mushrooms, or polypores, classified to the phylum Basidiomycota characterized by their poroid hymenophores and tough sporocarps [1, 2]. The vegetative hyphae, consist of skeletal and binding hyphae, is the typical anatomical character that can be found in polypores and the reason of the carp toughness [3]. They are also known as bracket or shelf fungi with various forms of sporocarps: pileate-sessile, pileate-stipitate, resupinate and effuso-reflexed [1, 4]. The “polypores” is an informal group and has gone through dynamic history of classification. It was first classified by Rea [5] under one order of Aphyllophorales based on their gill absence. Then modern classification shows that polypore can be found spread across at least 12 orders of the class Agaricomycetes [6, 7].

Polypores are usually found growing on the tree trunks [4], though some species can be found inhabiting soil forming symbiotic relationship with surrounding higher plants [8]. Their important role
as wood decaying fungi is due to their high lignocellulolytic activity [9], thus making them as one of the main decomposer in the tropical forest ecosystem. The polypores have been taken benefit by human for food, medicine, ritual, even their biochemical properties can be used for substitute in manufacturing [10-14]. The polypores also reported can be used in biopulping and reducing the manufacture cost. Studies on bioremediation, enzyme development, and new chemical substance discovery also can be obtained from these mushrooms [11].

Polypores are commonly found in pantropics which has higher relative temperature, humidity, and rainfall frequency [15]. Although Indonesia is one of the region included, the taxonomy information on this group in this country is very limited and very difficult to find. Generally speaking, studies on tropical polypores are very rare as stated by Lindblad [16], Lonsdale et al. [17], and Gibertoni et al. [18]. The study about polypores diversity in Indonesia is usually under one title as “macrofungi” or “mushroom diversity” [19-24]. As a further matter, there has been no national mushroom diversity annotated checklist ever found. But still, there are huge chances of progress and new polypore species discovery as proven by Stayaert [25] and Susan et al. [26].

Universitas Indonesia Depok Campus (UI Depok Campus) is a 320 Ha green campus located between the Jakarta and Depok, in West Java, Indonesia. Approximately 25% of the campus area is the urban forest with 75% of the remaining area is utilized for academic building and green spaces [27]. The university’s urban forest and green spaces have important role in maintaining ecological values [28].

Since the university establishment in 1987, biodiversity recording and monitoring have been conducted and still ongoing to these days by the Herbarium of Department of Biology. Even so, not a single data about university’s mushroom diversity can be found. Regardless, it could be predicted that the area is suitable for mushroom biodiversity studies. The area has annual mean temperature of 27°C and 85% for relative humidity [29] thus suitable for mushroom growth. As stated by Huhndorf et al. [30] that the area of vegetation is directly proportional to the number of mushrooms that can be found.

The urgency of the taxonomical work on polypore diversity in UI Depok Campus is heightened by the fact that campus facility development has taken over some of the green spaces. The chance of losing valuable species is cannot be avoided for the majority of the polypores depend on the existence of the host plant. Therefore, the accurate taxonomy information about each species is needed for effective and efficient fungal conservation strategy and optimal utilization.

The aim of this study to collect, characterize, and identify the polypores that can be found in UI Depok Campus area, i.e. the urban and forest area. It is hoped that the data obtained from this study can be used for recommendation of *in-situ* conservation of polypore mushrooms in UI campus and provide to the list of species record for the national fungal species database.

2. Materials and methods

The study had conducted from July to December 2018. Sampling of specimen was done in two types of area, e.g. forest area and urban area. The forest area includes the location designated as Wales Barat, Wales Timur, and Vegetasi Alam Forest. Thus the remaining area (academic buildings and green spaces) is categorized as urban area. Macroscopic characteristics examination was done directly on field before and after sampling, then completed in Herbarium Collection Room at Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Indonesia. Microscopic characteristics examination was done in Cryptogam Laboratory, Botany Division, Research Centre for Biology, Indonesian Institute of Sciences, and Bioimaging Laboratory in Universitas Indonesia.

2.1. Sampling of Polypore specimens

The sampling was done by exploring the entire area of UI Depok campus using broad survey method. The method requires tracking all of the possible sampling site thoroughly [32, 33]. Before sampling, photograph must be taken. Polypores are sampled by cutting the host plant parts or digging the surrounding soil without bruising the carp [31]. The single sample then tagged with label and wrapped
by the aluminium foil or newspaper. The wrap then put into the basket. Re-exploration and monitoring was done two months later as suggested by Huhndorf et al. [30] and Lodge et al. [32].

Macroscopic characterization, including growth habit can be done before or directly after sampling. The data then completed in the lab for further examination. During sampling, abiotic data should be taken, such as air temperature, relative air humidity, light intensity, altitude, and pH if the sample inhabits soil. The measure of pH was done by dipping the indicator into the 2:1 aquadest-soil sample mix [34].

2.2. Preservation and Collection Management
Samples were preserved by dry-heating using oven at the temperature of 40-60°C. The preservation takes days to weeks depending on the sample condition. The drying can take shorter duration of time if the specimen is cut longitudinally (as it is recommended for bigger sized sample). The specimen then put into the labeled ziplock plastic bags. The specimens then stored in the container box in the 20°C room [31, 36] and checked frequently.

2.3. Characterizations of the specimens
Characterizations of the specimens was done by describing the entire macroscopic and macroscopic features of the sampled polypores thoroughly. All of the procedure and character nomenclature refers to Largent [35] and Ryvarden & Johansen [1].

2.3.1. Macroscopic morphological characterizations. All the macroscopic features i.e. pileus, pore or other form of hymenium, and stipe should be noted in detail from shape, size, texture, and color. The measurement was done using ruler or caliper and noted in range from the smallest to biggest, illustrated in figure 1. Context thickness, tube width and length, and pores can be observed and measured in detail using dino lite microscope and its program, as illustrated in figure 2.

![Figure 1](image_url)

**Figure 1.** Measurement of various polypore (A) sessile, (B) and (C) pileate-stipitate (p=length; l=width; t=thickness; and R=radius).

2.3.2. Microscopic morphological characterizations. The cross section preparation from various parts of the sample is needed for microscopic character observation as illustrated in figure 3. There are three types of preparation needed for each part. First, the section was dripped by KOH solution. Second, the same as the first one but then the solution absorbed by tissue. After that, the sample was dripped by
Phloxine, absorbed, then dripped by KOH again. Third, the sample was dripped by the Melzer’s reagent [36].

Types of hyphae, including generative hyphae (basidiole and basidium) and vegetative hyphae (binding and skeletal hyphae), and basidiospores were observed under the microscope and measured using the program. The measurement was repeated five times for hyphae while twenty times for basidiospores.

![Figure 2](image2.png)

**Figure 2.** Measuring (A) context and tube, (B) pores (p=length; t=thickness; d=diameter; and Δ=pore distance).

![Figure 3](image3.png)

**Figure 3.** Parts of polypore needed for preparation: 1. Pileus surface to upper context; 2. context; and 3. Lower context to tubes

2.4. Identification and species description

The specimens were identified using the guide from *A Preliminary Polypore Flora of East Africa* by Ryvarden and Johansen [1] and “Hymenochaetaceae (Basidiomycota) in China” by Dai [37]. The identification were done by identification key guidance, comparing descriptions and illustrations. The specimens were also compared to the herbaria from Herbarium Bogoriense. The results then compiled
and the nomenclature was validated using Index Fungorum (http://www.indexfungorum.org). Plant substrates were identified using the guide from *A Guide to The Urban Plants of Universitas Indonesia – Spermatophytes* [38] and the result was validated by Tropicos (https://www.tropicos.org).

The description of the species was arranged from complete accepted name; synonym; and basionym; continued by description content: macroscopic (carp, pileus, stipe, pore surface, and context) and microscopic characters (hyphae and spores); habitat; distribution; notes; specimen data; and documentation. All of the specimens were stored in Biota Collection Room in Department of Biology, Universitas Indonesia. All of the specimens were stored in Biota Collection Room in Department of Biology, Universitas Indonesia.

3. Results and discussion

3.1. Identification of polypores found in UI Depok Campus

Seventy specimens of polypores were collected in this study. The specimens were sampled from the field in June 4th – 28th, 2018 and September 4th – 30th, 2018. The polypores collected belong into 34 species, 7 families (1 incertae sedis), and 4 orders. Data are shown in table 1. The polypores that were collected in this study were found growing in range temperature of 27.1-36.3°C, relative air humidity of 49-98%, light intensity of 320-10,000 lux, and soil pH of 5-6.

The diversity of polypore in UI Depok Campus can be assumed as quite diverse. It is indicated by the discovery of four orders in the total area: *Agaricales* Underw., *Gloeophyllales* Thorn, *Hymenochaetales* Oberw., and *Polyporales* Gäum, compared to the majority of studies that had done before in different area shows that only one or two genus-era of polypore can be found [19-23]. The study shows that taxonomical diversity is higher in forest area compared to urban area. It was possible due to the differences in plant availability as substrate and abiotic factors those affect polypores dispersion and growth.

| No. | Order                | Family            | Genus                  | Species                                           |
|-----|----------------------|-------------------|------------------------|--------------------------------------------------|
| 1   | Agaricales Underw.   | Schizophyllaceae  | Schizophyllum          | S. commune Fr.                                   |
| 2   | Gloeophyllales Thorn | Gloeophyllaceae   | Gloeophyllum           | G. subferrugineum (Berk.) Bondartsev & Singer    |
| 3   | Hymenochaetales Underw. | Hymenochaetaceae | Inonotus               | I. pachyphloeus (Pat.) T. Wagner & M. Fisch.     |
|     |                      |                   |                        | I. tabacinus (Mont.) G. Cunn.                     |
| 4   |                      |                   | Hymenochaeta           | H. luteobadia (Fr.) Höhn. & Litsch.              |
| 5   |                      |                   |                        |                                                  |
| 6   | incertae sedis       | Trichaptum        |                        | T. byssogenum (Jungh.) Ryvarden                  |
| 7   | Fomitopsidaceae      | Rhodofomes        |                        | R. carneaes (Blume & T. Nees) B.K. Cui, M.L. Han & Y.C. Dai |
| 8   | Polyporales Gäum.    | Amauroderma       |                        | A. leptopus (Pers.) J.S. Furtado                 |
|     |                      |                   |                        | A. rugosum (Blume & T. Nees) Torrend             |
| 9   |                      |                   |                        |                                                  |
| 10  |                      |                   |                        | G. australe (Fr.) Pat.                           |
| 11  |                      |                   |                        | G. colossus (Fr.) C.F. Baker, Brotéria           |
Table 1. Continued

| No. | Family         | Genus                   | Species                                      |
|-----|----------------|-------------------------|----------------------------------------------|
| 12  |                | G. lucidum-group sensu  | Ryvarden & Johansen (1980)                   |
| 13  | Meripilaceae   | Rigidoporus             | R. ulmarius (Sowerby) Imazeki                 |
| 14  | Cellulariella  | C. acuta (Berk.)        | Zmitr. & Malyseva                             |
| 15  | Cerrena        | C. unicolor (Bull.)     | Murrill 1903                                 |
| 16  | Earliella      | E. scabrosa (Pers.)     | Gilb. & Ryvarden                             |
| 17  | Favolus        | F. grammacephalus       | (Berk.) Imazeki                               |
| 18  | Funalia        | F. aspera (Jungh.)      | Zmitr. & Malyseva                             |
| 19  |                | F. caperata (Berk.)     | Zmitr. & Malyseva                             |
| 20  |                | F. sp.                  |                                              |
| 21  | Lentinus       | L. fasciatus Berk.      |                                              |
| 22  |                | L. tigrinus (Bull.)     | Fr.                                           |
| 23  | Microporellus  | M. obovatus (Jungh.)    | Ryvarden                                      |
| 24  | Microporus     | M. affinis (Blume & T. | Nees) Kuntze                                  |
| 25  |                |                         |                                              |
| 26  | Neofomitella   | N. rhodophaea (Lév.)    | Y.C. Dai, Hai J. Li & Vlasák                 |
| 27  | Panus          | P. cf. neostrigosus     | Fr.                                           |
| 28  | Perenniporia   | P. martia (Berk.)       | Ryvarden                                      |
| 29  | Pycnoporus     | P. sanguineus (L.)      | Murrill                                       |
| 30  | Trametes       | T. modesta (Kunze ex Fr.) | Ryvarden                                    |
| 31  |                | T. socotrina Cooke     |                                              |
| 32  |                | T. strumosa (Fr.)       | Zmitr., Wasser & Ezhov                       |
| 33  |                | T. vespacea (Pers.)     | Zmitr., Wasser & Ezhov                       |
| 34  |                | T. cf. villosa (Sw.)    | Kreisel                                       |

Most of the species (82%) belong to the order Polyporales Gäum. This order is mentioned to be one of the biggest polypore order, besides Hymenochaetales Oberw., as mentioned by Miettinen [39]. It is likely possible because of its general preference on plant host. It is supported by their high lignocellulolytic enzyme activity and variation, including their carbohydrate binding molecule [40]. The biggest family and genus found in this study are Polyporaceae and Trametes, respectively. The reason of it remained unknown.

Around 862 fruiting bodies of Schizophyllum commune Fr. (Agaricales; Schizophyllaceae) were found, making it the most abundant polypore known to this study. This species is known as cosmopolitan species and has widely distributed in South East Asia. The species possesses huge variety of mating type [41] and 99% chance of mating compatibility [42]. In contrast, the least abundant species is Amauroderma leptopus (Pers.) J. S. Furtado (Polyporales; Ganodermataceae) which only
one fruiting body was found in this study. The reason is remain unknown due to the lack of information about its growth and distribution.

All polypores found in this study are known to be not poisonous, supported by the fact that *Hapalopilus* is the only poisonous polypore [43]. Though, the information about the edibility of each species is limited. Bisema [44] has listed 51 edible mushrooms in Indonesia. *Schizophyllum commune* Fr. is the only edible polypore among the other in this study.

Majority of polypores in this study (32 out of 34 species) were found inhabiting living plants or dead, or both. The plants identified are *Artocarpus altilis* (Parkinson) Fosberg (sukun; breadfruit), *Enterolobium cyclocarpum* (Jacq.) Griseb. (sengon buto; guanacaste), *Hevea brasiliensis* (Willd. ex A.Juss.) Müll.Arg. (karet; rubber tree), *Swietenia macrophylla* King (mahoni; mahogany), and *Tectona grandis* L.f. (jati; teak). Some remaind unknown due to the lack of diagnostic characters, e.g. flowers and leaves. Most of polypores grow on a stump and/or main trunk, approximately 40-200 cm above the ground. The base of the tree is known to have higher humidity and lower light intensity. Moreover, that part is the oldest part of the tree which cracks are commonly found [45]. The cracks are thought to be the mushroom’s spore entry to inhabit the plant. *Amauroderma leptopus* (Pers.) J.S. Furtado and *A. rugosum* (Blume & T. Nees) Torrend are the only two that inhabit soil.

### 3.2. New record polypore species in Java and Indonesia

During the study conducted, no annotated checklist of Indonesian polypore was found. Therefore, species distribution information was known by compiling data from Herbarium Bogoriense (BO) database and various publications. In the end, it is known that some of the species are new record to Java and Indonesia. Seventeen species are new to Java and among them, eleven are new to Indonesia, as listed in table 2 and documented from figure 4 to 21.

**Table 2.** New record species list for Java and for Indonesia

| New Record in Java     | New Record in Indonesia       |
|------------------------|-------------------------------|
| 1. Gloeophyllum subferrugineum (Berk.) Bondartsev & Singer | 1. Gloeophyllum subferrugineum (Berk.) Bondartsev & Singer |
| 2. Inonotus tabacinus (Mont.) G. Cunn. | 2. Inonotus tabacinus (Mont.) G. Cunn. |
| 3. Hymenochaete luteobadia (Fr.) Höhn. & Litsch. | 3. Hymenochaete luteobadia (Fr.) Höhn. & Litsch. |
| 4. Trichaptum byssogenum (Jungh.) Ryvarden | 4. Amauroderma leptopus (Pers.) J.S. Furtado |
| 5. Rhodofomes carneus (Blume & T. Nees) B.K. Cui, M.L. Han & Y.C. Dai | 5. Ganoderma colossus (Fr.) C.F. Baker, Brotéria |
| 6. Amauroderma leptopus (Pers.) J.S. Furtado | 6. Rigidoporus ulmarius (Sowerby) Imazeki |
| 7. Amauroderma rugosum (Blume & T. Nees) Torrend | 7. Cellariella acuta (Berk.) Zmitr. & Malycheva |
| 8. Ganoderma colossus (Fr.) C.F. Baker, Brotéria | 8. Cerrena unicolor (Bull.) Murrill 1903 |
| 9. Rigidoporus ulmarius (Sowerby) Imazeki | 9. Funalia caperata (Berk.) Zmitr. & Malycheva |
| 10. Cellariella acuta (Berk.) Zmitr. & Malycheva | 10. Funalia sp. |
| 11. Cerrena unicolor (Bull.) Murrill 1903 | 11. Perreniporia martia (Berk.) Ryvarden |
| 12. Funalia aspera (Jungh.) Zmitr. & Malycheva | |
| 13. Funalia caperata (Berk.) Zmitr. & Malycheva | |
| 14. Funalia sp. | |
| 15. Lentinus tigrinus (Bull.) Fr. | |
| 16. Microporellus obovatus (Jungh.) Ryvarden | |
| 17. Perreniporia martia (Berk.) Ryvarden | |
**Figure 4.** *Gloeophyllum subferrugineum* (Berk.) Bondartsev & Singer. 
A. Fruiting bodies; 
B. Specimen from (a) top and (b) bottom view; 
C. Microscopic characters (a) cystidia, (b) spore, (c) gill pattern.

**Figure 5.** *Inonotus tabacinus* (Mont.) G. Cunn. 
A and B. Fruiting bodies; 
C. Specimen from (a) top and (b) bottom view; 
D. Pore surface; 
E. Cross section; 
context (indicated by red line) and tube (blue line) and black line along the context (arrows); 
F. Microscopic characters: (a) vegetative hyphae, (b) setae, and (c) spores.

**Figure 6.** *Hymenochaete luteobadia* (Fr.) Höhn. & Litsch. 
A and B. Fruiting bodies; 
C. Specimen from (a) top and (b) bottom view; 
D. Cross section; 
context (indicated by red line) and tube (blue line) and black line along the context (arrows); 
F. Microscopic characters: (a) vegetative hyphae, (b) spore, and (c) setae.
Figure 7. *Trichaptum hyssogenum* (Jungh.) Ryvarden A. Fruiting bodies; B. Specimen from (a) top and (b) bottom view; C. Dentate pore surface; D. Microscopic characters (a) cystidia, (b) generative (top) and vegetative (bottom) hyphae, (c) spores.

Figure 8. *Rhodofomes carneus* (Blume & T. Nees) B.K. Cui, M.L. Han & Y.C. Dai. A. Fruiting bodies; B. Specimen from (a) top and (b) bottom view; C. cross section; context (indicated by red line) and tube (blue line); D. Pore surface; E. Microscopic characters (a) spores and (b) branching generative hyphae.
Figure 9. *Amauroderma leptopus* (Pers.) J.S. Furtado. A. Fruiting body; B. Specimen from (a) top and (b) bottom view; C. cross section; context (indicated by red line) and tube (blue line); D. Pore surface.

Figure 10. *Amauroderma rugosum* (Blume & T. Nees) Torrend Fruiting bodies A. old B. young; B. Specimen C. Pore surface.

Figure 11. A. Hyphae and B. Spores comparison: (a) arboriform hyphae and spores of *A. leptopus* (Pers.) J.S. Furtado; (b) *aciculiform* hyphae, spores, and (c) cystidia of *A. rugosum* (Blume & T. Nees) Torrend.
Figure 12. *Ganoderma colossus* (Fr.) C.F. Baker A. Fruiting body; B. Specimen from perpendicular view; C. (a) top and (b) bottom view.

Figure 13. *Rigidoporus ulmarius* (Sowerby) Imazeki. A. Fruiting bodies; B. Specimen from top view; C. cross section; context (indicated by red line) and tube (blue line); D. Pore surface; E. Microscopic characters (a) generative hyphae, (b) setae, (c) spores.

Figure 14. *Cellulariella acuta* (Berk.) Zmitr. & Malyshева Keterangan: A. and B. Fruiting bodies; C. from the youngest to the oldest (left to right); D and E. Hymenophore surface; F. cross section; context (indicated by red line) and tube (blue line); F. Microscopic characters (a) generative hyphae, (b) skeletal hypha, and (c) spores.
Figure 15. *Cerrena unicolor* (Bull.) Murrill. A. and B. Specimens; C. Spores.

Figure 16. *Funalia aspera* (Berk.) Zmitr. & Malysheva. A. and B. Fruiting bodies; C. Specimen from (a) top and (b) bottom view.
Figure 17. *Funalia caperata* (Berk.) Zmitr. & Malysheva A. Fruiting bodies; B. Specimen from (a) top and (b) bottom view; C. Pileus surface; D. C. cross section; context (indicated by red line) and tube (blue line); E. Pore surface.

Figure 18. *Funalia* sp. A. Fruiting bodies; B. Specimen from (a) top and (b) bottom view; C. Pore surface; D. cross section; context (indicated by red line) and tube (blue line) also hairs (arrow); E. Spores.
Figure 19. *Lentinus tigrinus* (Bull.) Fr. A. Fruiting bodies; B. Specimen from (a) top and (b) bottom view; C. Microscopic characters (a) generative hyphae, (b) skeletal hypha, and (c) spores and (d) basidium.
Figure 20. *Microporellus obovatus* (Jungh.) Ryvarden. A. Fruiting body from the oldest to youngest (left to right); B. Specimen from (a) top and (b) bottom view; C. Cross section; context (indicated by red line) and tube (blue line); D. Pore surface; E. Microscopic characters (a) skeletal hyphae, (b) generative hyphae and (c) spore.
Figure 21. *Perenniporia martia* (Berk.) Ryvarden. A. Fruiting bodies; B. Specimen; C. Microscopic characters: (a) cystidia and (b) spores.

4. Conclusion
Seventy specimens of polypores were collected in UI Campus Depok. The identification results showed that the polypores specimens collected belong into 34 species, 7 families (1 incertae sedis), and 4 orders. *Polyporales* Gäum is the largest order (82.35% from all species found) with *Polyporaceae* and *Trametes* as the largest family and genus, respectively. It is known that some of the species are new record to Java and Indonesia. Seventeen species are new to Java and among them, eleven are new to Indonesia.
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