Morphological diversity of Agaricomycetes in Kuningan Botanical Garden, West Java, Indonesia

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Abstract. Fungi are common organisms in natural forests as well as human-made ecosystem such as botanical gardens. Likewise forest, botanical gardens provide lignocellulose substrates and other organic media for fungi to grow and develop especially fungal species which belong to class Agaricomycetes. Regarding those roles, it is necessary to do more research on fungal exploration in Indonesia to provide taxonomy and diversity on fungi which belong to Agaricomycetes. This research is conducted to study Agaricomycetes fungi in Kuningan Botanical Garden based on their macroscopic morphology. The fungal collection was conducted in July 2017. Fungal samples were collected from four sampling areas, then the samples were identified based on morphology such as the character of cap, stalk, gill, veil, and spore print. Based on morphological observation, fungal samples found in botanical garden were grouped in to twelve families, i.e./namely: Polyporaceae, Ganodermataceae, Stereaceae, Sclerodermataceae, Russulaceae, Schizophyllaceae, Auriculariaceae, Amanitaceae, Tricholomataceae, Irpicaceae, Auriculariaceae, and Agaricaceae. The fungal genera that were identified are: Auricularia, Scleroderma, Collybia, Russula, Stereum, Lycoperdon, Schizophyllum, Coprinellus, Limacella, Lentinus and Leucopaxillus.

1. Introduction

Some number of a mega-diverse group of bacteria, fungi, nematode, and insects are often unrecognized. Those data are significant for determining biodiversity pattern in ecology [1, 2]. Estimation of fungal diversity worldwide is 1.5 billion organisms, yet, only five percent of species are successfully identified [3, 4]. Their recognition is significant because their existences are related to agriculture, medicine, industry, ecology, and conservation [5].

Agaricomycetes is one out of four classes with Dacrymycetes, Tremellomycetes and Walleomyces under subdivision Agaricomycotina [6, 7]. Approximately twenty-one thousand species or twenty percent of the worldwide fungi Agaricomycetes have been described [8].

Agaricomycetes is the most distinctive fungal group which has species with prominent fruiting bodies and functions [9]. Some fungal species are edible and can be cultivated such as Auricularia auricula, Agaricus bisporus and Pleurotus ostreatus whereas wild fungal species that are edible are Lactarius deliciosus, Boletus edulis, Cantharellus tubaeformis, Tuber aestivum, etc. Additionally, some species such as Schizophyllum commune are commonly used in studies of mating genetics [10]. Agaricomycetes is macrofungi that have important role in nutrient cycling of various elements such as carbon, nitrogen, and oxygen [11].
In Indonesia, there are about eighty thousand species of Basidiomycetes and Ascomycetes [12]. Generally, fungal diversity in tropical countries has not sufficiently been explored, and the results of some previous studies were confused and misidentified with subtropical fungi [13]. The explorations of macroscopic fungi were conducted in France, Brazil and Indonesia [13–15]. However, there is still a lack of data regarding fungi class Agaricomycetes in Kuningan Botanical Garden. Thus, this research is conducted to explore and study morphological diversity of Agaricomycetes fungi in Kuningan Botanical garden.

2. Materials and methods

2.1. Fungal sampling

Fungal specimens were collected in four sampling areas in Kuningan Botanical Garden (figure 1). The method used in this research was by exploring and observing through soil surface, alive and dead trees or log while collecting mushroom bodies. Each sampling area was explored for about 3-4 hours. Mushroom bodies that were found on soil or dead trees subsequently were taken and wrapped with brown paper and then labeled.

2.2. Identification of Agaricomycetes fungi

Identification was conducted on the spot after sampling work since some of the fungal samples were rotten-easy mushrooms. Collected fungi were characterized and described until genus level based on morphological characteristics such as size, color, color changes, texture, cap, gills, stalk, veil, annulus, volva, spore prints and chemical characteristic with KOH 5% [16].

![Figure 1. A map of West Java Island, Indonesia (left) and the sampling sites, Kuningan Botanical Garden (right). Notes: 1. Black soil area, 2. Pinus site, 3. Pond site, 4. Main office’s surrounding plantation.](image)

3. Results and discussion

This study was conducted to explore fungal samples belong to class Agaricomycetes in Kuningan Botanical Garden. Previously, there was no study regarding documentation of morphological diversity of fungi in the area. Thus, this research is likely the first study to reveal the morphological diversity of Agaricomycetes in Kuningan Botanical Garden. The following are the results of fungal collection and information about the location where the fungi were collected (table 1). Additionally, the key identification containing morphological characteristic leading to identification until the genus level is provided.

From table 1, it can be seen that the pond site had the most number variety of fungi since there were eight fungal families found. Meanwhile, the least number of the fungal family (only three families) were discovered in Pinus site. The availability of water and variety of food resources are presumably the reason. In the Pond site, water and trees are more abundant and various than in the Pinus site.

Among the identified fungal family, Polyporaceae and Ganodermataceae were predominantly found in Kuningan Botanical Garden. Member of those fungal families is closely related with the degradation of lignocellulosic materials such as wood and/or log which is dominant in natural or man-made plantations including botanical gardens. The key identification shows that Agaricomycetes fungi in
Kuningan Botanical Garden have various fruiting bodies characteristics from the round shape with and/or without a stalk, ear-like, and common umbrella-shaped fungi. Those diverse shapes of mushroom bodies are depicted in the pictures below (figure 2).

In this study, most collected fungi were associated with wood substrates (namely Polyporaceae, Stereaceae, Amanitaceae, Schizophyllaceae, and Ganodermataceae) except for *Lycoperdon*, *Scleroderma* and *Russula* which were found on ground or soil. *Lycoperdon* can be found on the deciduous and tropical forest where their soil is enriched with mulch and leaf litter [20]. *Scleroderma* is mostly found in humus, sand, and soil while *Russula* is found in the soil under hardwoods and conifers [16]. Both *Scleroderma* and *Russula* are ectomycorrhizal (ECM) fungal species and their existences relates to certain trees. In Southeast Asia, some genera of ECM fungi such as *Russula*, *Scleroderma*, *Laccaria*, *Amanita*, *Cortinarius*, etc are associated with the family tree of Dipterocarpaceae [21].

Previous exploration study revealed that in Batam Botanical Garden, besides Polyporaceae and Ganodermataceae, there were fungal samples which belong to Agaricomycetes other than. Compared to fungi in Batam Botanical Garden, fungal samples collected in Kuningan Botanical Garden were mostly different. However, some fungal genera such as *Lentinus* and *Collybia* were identified in both areas [17]. Pezizaceae, Tremellomycetes, and Sordariomycetes class were also observed namely Pezizaceae, Tremellaceae family, and fungal genus *Xylaria*, respectively.

The most striking point of fungal genera that were found in Kuningan Botanical Garden is *Limacella* and *Leucopaxillus*. Illinitone A was detected in fungal species *Limacella illinita* of which shows moderate activity to nematode *Caenorhabditis elegans* [22]. Meanwhile, species of *Leucopaxillus giganteus* synthesize clitocine that has antitumor capability [23].

**Table 1.** Identification and location of fungi collected in Kuningan Botanical Garden.

| Sampling area                  | Total fungal sample | Identification (Family, Class)                                                                 |
|-------------------------------|---------------------|-------------------------------------------------------------------------------------------------|
| Black soil area               | 19                  | Polyporaceae, Agaricomycetes                                                                   |
|                               |                     | Ganodermataceae, Agaricomycetes                                                                 |
|                               |                     | Stereaceae, Agaricomycetes                                                                     |
|                               |                     | - *Stereum*                                                                                   |
|                               |                     | Sclerodermataceae, Agaricomycetes                                                               |
|                               |                     | - *Scleroderma*                                                                                |
| Pinus site                    | 11                  | Polyporaceae, Agaricomycetes                                                                  |
|                               |                     | Ganodermataceae, Agaricomycetes                                                                 |
|                               |                     | Russulaceae, Agaricomycetes                                                                    |
|                               |                     | - *Russula*                                                                                     |
| Main office’s surrounding plantation | 14                | Polyporaceae, Agaricomycetes                                                                  |
|                               |                     | Ganodermataceae, Agaricomycetes                                                                 |
|                               |                     | Schizophyllaceae, Agaricomycetes                                                                |
|                               |                     | - *Schizophyllum*                                                                               |
|                               |                     | Stereaceae, Agaricomycetes                                                                     |
|                               |                     | - *Stereum*                                                                                     |
|                               |                     | Pezizaceae, Pezizomycetes                                                                      |
|                               |                     | Xylariaceae, Sordariomycetes                                                                    |
|                               |                     | - *Xylaria*                                                                                    |
|                               |                     | Auriculariaceae, Agaricomycetes                                                                 |
|                               |                     | - *Auricularia*                                                                                 |
|                               |                     | Amanitaceae, Agaricomycetes                                                                     |
|                               |                     | - *Limacella*                                                                                  |
|                               |                     | Tremellaceae, Tremellomycetes                                                                   |
|                               |                     | Tricholomataceae, Agaricomycetes                                                                |
|                               |                     | - *Collybia*                                                                                     |
|                               |                     | Agaricaceae, Agaricomycetes                                                                     |
|                               |                     | - *Lycoperdon*                                                                                  |
| Pond site                     | 21                  | Polyporaceae, Agaricomycetes                                                                  |
|                               |                     | Schizophyllaceae, Agaricomycetes                                                                |
|                               |                     | - *Schizophyllum*                                                                               |
|                               |                     | Xylariaceae, Sordariomycetes                                                                    |
|                               |                     | - *Xylaria*                                                                                    |
|                               |                     | Auriculariaceae, Agaricomycetes                                                                 |
|                               |                     | - *Auricularia*                                                                                 |
|                               |                     | Amanitaceae, Agaricomycetes                                                                     |
|                               |                     | - *Limacella*                                                                                  |
|                               |                     | Tremellaceae, Tremellomycetes                                                                   |
|                               |                     | Tricholomataceae, Agaricomycetes                                                                |
|                               |                     | - *Collybia*                                                                                     |
|                               |                     | Agaricaceae, Agaricomycetes                                                                     |
|                               |                     | - *Lycoperdon*                                                                                  |
Key identification of Agaricomycetes in Kuningan Botanical Garden:

1. a. Mushroom body is round, ball-like, no cap and stalk.............................. *Scleroderma*
b. Fruiting bodies are round, shelf-like, and/or umbrella-like, with or without stalk....................2
2. a. Fruiting bodies are round with stalk. Mostly found on soil.......................... *Lycoperdon*
b. Fruiting bodies contain cap with or without stalk........................................3
3. a. No stalk, underside caps are not lamellate.................................................................4
   b. Stalks are apparent even though they are small, underside caps are *lamellate*..................5
4. a. Mushroom bodies are ear-like fungi................................................................. *Auricularia*
b. Underside caps are vein-like fungi........................................................................Stereum
5. a. Stalks are very small, the lengths are approximately or less than 0.5 cm ........... *Schizophyllum*
b. The stalk length is more than 0.5 cm..................................................................6
6. a. No *volva* or universal veil.........................................................................................7
   b. Appear to have *volva*, caps are slimy or viscid.......................................................Limacella
7. a. The stalks are fragile, and it breaks, snapped like a piece of chalk.......................... *Russula*
b. The stalks and caps are pliant......................................................................................8
8. a. Stalk’s core is hollow ...............................................................................................Collybia
   b. Stalk’s core is not hollow.................................................................................................9
9. a. Stalks’ thickness is more than 1 cm............................................................... *Leucopaxillus*
b. Stalks’ thickness is less than 1 cm.............................................................................10
10. a. Mushroom bodies are evanescent.............................................................. *Coprinellus*
b. Mushroom bodies are not evanescent............................................................................... *Lentinus*

Figure 2. Diversity of fruiting bodies collected from Kuningan Botanical Garden. a. *Lycoperdon*,
b. *Leucopaxillus*, c. *Limacella*, d. *Collybia*, e. *Auricularia*, f. *Coprinellus*, g. *Lentinus*, h. *Scleroderma*,
i-j. Stereum, k. *Xylaria* (Sordariomycetes).

Explorations of fungal samples from natural habitat and plant reservations such as in botanical
gardens are important since deforestation, climate changes, habitat loss, and land conversion
significantly lead to the transformation of Agaricomycetes biota in the past and will consistently do so
in the future. Many countries realize the importance of fungal data collection to record-keeping the rare
and endangered fungi [18, 19]. Therefore, the continuation of exploration and data collecting on fungi
are vital especially in Indonesia where land conversions massively happen.
4. Conclusion

Twelve fungal families were found in Kuningan Botanical Garden, West Java, Indonesia. Among those fungi, eleven fungal genera were identified, namely Auricularia, Scleroderma, Collybia, Russula, Stereum, Lycoperdon, Schizophyllum, Coprinellus, Limacella, Lentinus and Leucopaxillus. Identification of fungal samples belongs to Polyporaceae and Ganodermataceae until genus and/or species level is ongoing.

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5. References

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