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Coprinellus sect. *Disseminati*: Source of Gastropod Mycophagy in Bogor-Indonesia

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Abstract

Mycophagy is the process of the organism consuming fungi. Fungal tissue considered as valuable resource with high nutritional content for organisms which have the metabolic abilities to digest it. To date, there is no previously published record of animal mycophagy in Indonesia. Field observations in IPB University Campus Forest has been done to monitor mycophagy activity by any animals in sampling site. Only 1 of the 4 observasion period showed the evidence of animal mycophagy in sampling site. Mycophagous gastropod found to consume *Coprinellus* sect. *Disseminati* fruit body as diet source. Macrofungi fruit body was eaten within two to three minutes. The snail only consume the pileus part of fruit body of *Coprinellus* sect. *Disseminati*. It showed to use it's anterior tentacles to pick the stages of fruit body. The gastropod tend to prefer mature fruitbody, yet the the reasons are still not clear. This is the first report of animal mycophagy evidence in Indonesia.

Keywords: ***Coprinellus* sect. *Disseminati*, Macrofungi, Mycophagy, Gastropod, IPB University.**

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Introduction

Macrofungi plays an important role in both natural or man-made ecosystem in Indonesia (Putra *et al*, 2017, 2018, 2019a, 2019b; Putra, 2020; Solle *et al*, 2018). Fungal mycelia recognized to decompose and recycle variety of organic materials during their life cycles. Being paramount parts of the ecosystem, fungal mycelia known to represent a stable and huge nutrient resource (Chang & Miles, 2004), and also interact symbiotically with other organisms (Lilleskov & Bruns, 2005). The term of mycophagous is appealed to animals which consume of fungi as part of their diets (Merritt, 2010). Many kind of animals are well known to ingest fungi, including birds (Simpson, 2000; Trappe *et al*, 2009; Tanney & Hutchison, 2011), invertebrates (Moore, 1996; Boddy & Jones, 2008), mammals (Fogel & Trappe, 1978; Claridge, 2002), Reptile (Elliot *et al*, 2019) and turtles (Vasco-Palacios *et al*, 2008).

However, in the term of mycophagy, invertebrates such as molluscs has not been studied in Indonesia, despite of its huge diversity of gastropod and macrofungi. Apparently, gastropod and slugs are able to consume ascospores, basidiospores, and spermatia. Some reports on mycophagy, especially on macrofungi has provided by (Trappe *et al*, 2009; Trierveiler-Pereira*et al*, 2016; Keller & Snell, 2002). Many mollusc species, especially those in the genus *Arion*, are present in litter (Hoffman & Rao, 2013). The preferences of the mollusc species on consuming stromata seem based on which fungi are a part of their diet (Hoffman & Rao, 2013).

Taxonomically, the white-rot fungus, *Coprinellus* belongs to the family of Coprinaceae (order Agaricales). Generally, *Coprinellus* species main substrates are straw, litter, animal carcasses, excrement, and humus, and they frequently grow on humus-rich soil (Desjardin *et al*, 2014). It is a common macrofungi species which the fruitbody live in large troops on stumps, buried wood, and logs in Indonesia (Tampubolon *et al*, 2013; Lestari *et al*, 2019). Till date, no study clarifies the mycophagy of animal on macrofungi in Indonesia. Here, author report first fungivorous involving gastropod observed in the field, in order to improve the knowledge about mycophagy knowledge in Indonesia.

Research methods

I. Observation Areas

Present report is based on direct observation of animal fungivorous occurance. Event was observed in IPB University Campus Forest (IPBUCF) (Fig. 1). Four times of weekly observations were done in IPBUCF. Observations were made from 08.00 am until 16:00 pm, on June 2017. The place where the observation occurred was under natural recovery and is dominated by *Shorea* sp. Also, several spots of forest floor colonized by common macrofungi as reported by Putra *et al*, (2019b) and Putra (2020).

II. Taxonomic Identification and Biological Properties of Macrofungi

The gastropod spesies was not identified. Macrofungi identification based on macroscopic and microscopic parameters including : how to grow, fruit body shape, hygrophanous, cap color when young and mature, cap diameter, upper and lower shape of cap, cap surface, cap edge, cap margin, wetness level, himenophore type (lamellae, pores, teeth) including: how to attach to the stipe, length, distance between rows,and margins. Other characters observed were stipe shape, stipe color (young and mature stage), stipe diameter and length, stipe surface, attachment position, stipe attachment type on the substrate, stipe cross section, partial veil and universal veil, fruit body texture, odor, and taste. Microscopic examination including : pileipellis, basidia, spores, and clamp connection. Mushroom sample identified using several identification references including Arora (1986), Maekawa *et al*, (2013), Desjardin *et al*, (2014), and Læssøe *et al*, (2019). The current taxonomical position is following *indexfungorum* and Wächter & Melzer (2020). Information on its biological properties was done with literature studies.

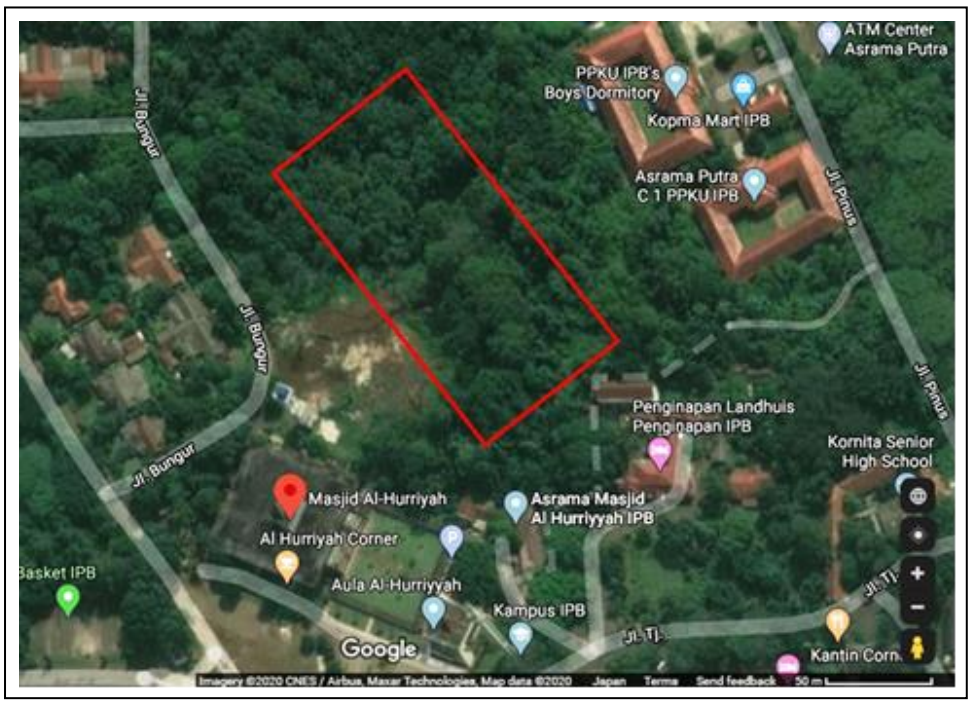

Figure 1. Field observation site (red line). Image was modified from google image.

Result and Discussion

I. Macrofungi Identification and Biological Properties of Macrofungi

Coprinellus sect. *Disseminati* found to grow on humus soil with caespitose pattern in young and mature stage (Figure 2.A). Pileus of mushroom found are high conical to semiglobose, round shape from underside view, white to cream in colour (young stage) and gray to brown in matuge stage, and the colour changed after time (hygrophanous). Cap characteristics are 3-6 mm in diameter, radially

thread like surface, entire edge, decurved margin, and moist at wetness level. The hymenophore is lamella (Figure 2.B), 5 mm in length, crowded rows, and entire type of margins. The stipe are white in colour, rooting in form, 12 mm in length, and smooth surface (Figure 2.C). The stipe has hollow stipe cross section without partial veil. This mushroom has a soft and fleshy fruit body texture and has distinctive odor like the smell of vegetables and with butter taste. Spores (Figure 3.B) 6-7.17 x 4-4.13 µm, elliptical, and smooth. Basidia (Figure 3.C-D) 4-sterigmate, pleurocystidia absent. Pileipellis (Figure 3.A) an epithelium with lageniform to subglobose layer. Clamp connections was absent.

Coprinellus is a small fungal species known as "fairies bonnets" or "trooping crumble cap" which belongs to the phylum Basidiomycota and family Psathyrellaceae. Same as other coprinoid species, its basidiocap deliquesce (dissolve into black ink) in very maturity stage (Desjardin *et al,* 2014). Several researchers in Indonesia, reported the distribution of this genus in North Sumatra and West Java, colonized soil mixed with litter (Tampubolon *et al,* 2013; Lestari *et al,* 2019). However the use of taxonomical name of *C. disseminatus* in Indonesia should be revisited based on work of Wächter & Melzer (2020). The *Coprinellus* species in Indonesia are consider as undescribed species and should be placed under the *Disseminati* section for time being.

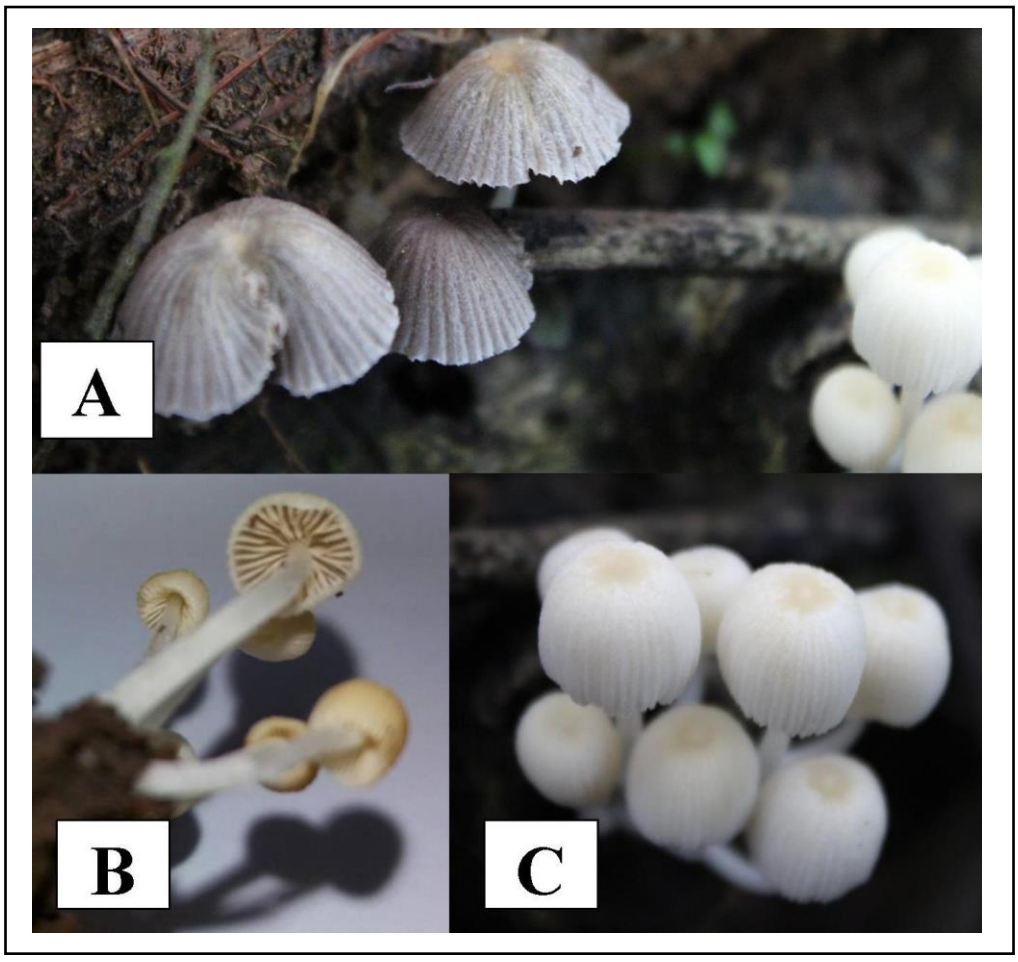

Figure 2. Macroscopic identification characters of *Coprinellus* sect. *Disseminati* Wächter & A. Melzer, sect. nov. in this study. A: Young and mature fruiting body. B: The hymenophore. C: The upper surface of pileus.

Based on literature studies, it appears that *Coprinellus* has paramount properties to be used as a food diet for animals. However, only few published studies regarding *Coprinellus* which species possess antioxidant properties (Han *et al*, 1999). Another work showed that crude extracts of *Coprinellus* also possessed high antibacterial properties (Gu and Leonard, 2006). Furthermore, Novakovic *et al*, (2018) has done a huge contribution in information of *Coprinellus* biological properties. They reported that this macrofungi contain : amino acid (arginine, alanine, cysteinand glutamic acid) and fatty acid composition (linoleic acid, palmitic acid, and oleic acid). For the example, the most abundant macroelement in *C. disseminatus* is K (followed by Ca and Mg), among microelements Fe is the most abundant element (followed by Zn, Mn and Cu), and forty-five phenolic compounds were identified in *C. disseminatus* (Novakovic *et al*, 2018). Based on manifested bioactivities, the *C. disseminatus* could be considered as a good potential alternative source for nutraceuticals and biologically active compounds (Novakovic *et al*, 2016; Novakovic *et al*, 2018). Till time, there is no previous report on biological properties of *Coprinellus* in Indonesia as well as its utilization.

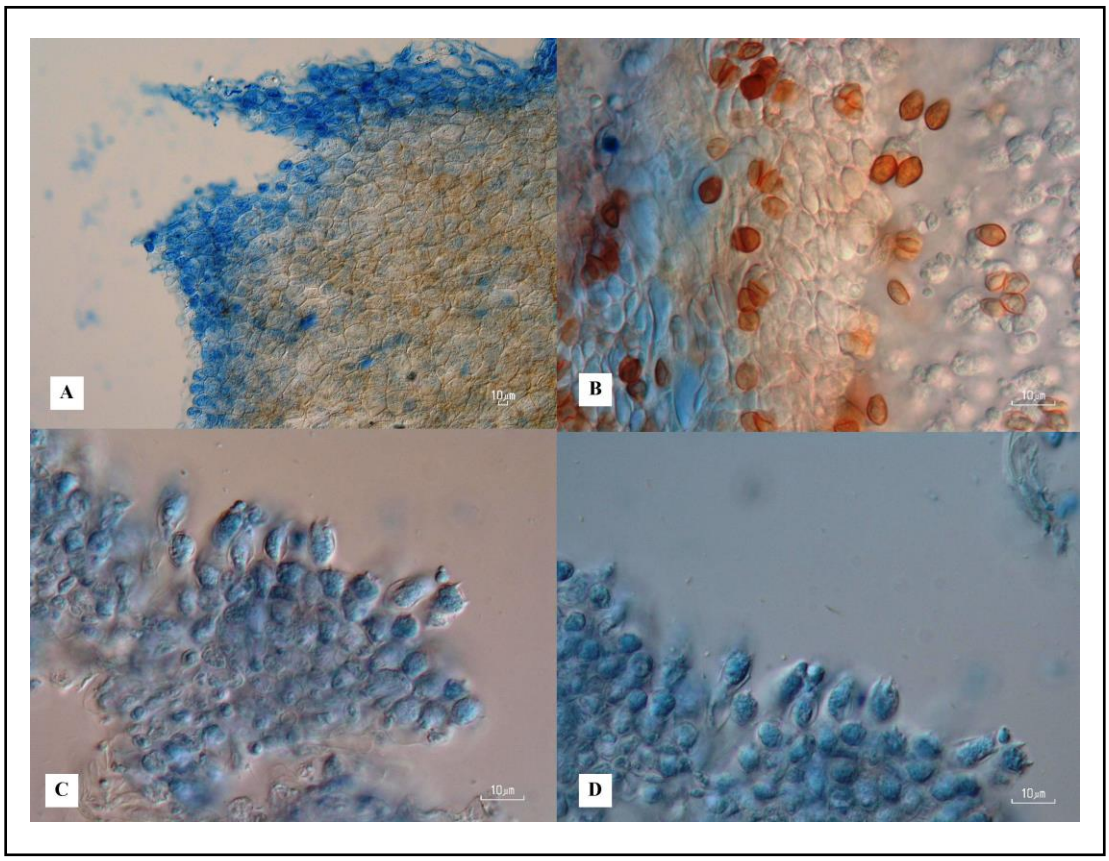

Figure 3. Microscopic identification characters of *Coprinellus* sect. *Disseminati* Wächter & A. Melzer, sect. nov. in this study. A: Pileipellis (bar: 10 um). B: Spores (bar: 10 um). C-D : Basidia (bar: 10 um).

II. Gastropod Mycophagy

Conditions of IPBUCF were ideal for macrofungi and slug because of the heavy rains and saturated condition of the ecosystem in monitoring time span. However, Only 1 of the 4 observasion showed the evidence of gastropod mycophagy in sampling site. Most gastropods species are generalists, feeding on a broad spectrum of plant tissues in nature such as green leaves from living plants, lichens, mushrooms, decaying vegetation, and even carrion (Keller and Snell 2002). The gastropod

in this study have a spiral-shaped shell which is wound around a spindle (Figure 4).To note, in this study, the gastropod reacted to flashlight and camera flash during documentation. Many times, the anterior tentacles were quickly withdrawn and feeding was postponed. One of the fungal fruit body was eaten within two up to three minutes (Figure 4). Ademolu *et al*, (2013), reported that amylase, α-glucosidase, cellulase, lipase, and protease, were detected on the gut regions (oesophagus, crop, stomach and intestine) of land snail. Furthermore, they found that the stomach recorded the highest enzyme activities of all the gut regions. Macrofungi are imponant in the diet of many animals and in some cases comprise the major foodsource. In fact, they are source of food for numerous species (Lundgren, 2009) since they represent rich sources of nutraceuticals (Ribeiro *et al*, 2009).

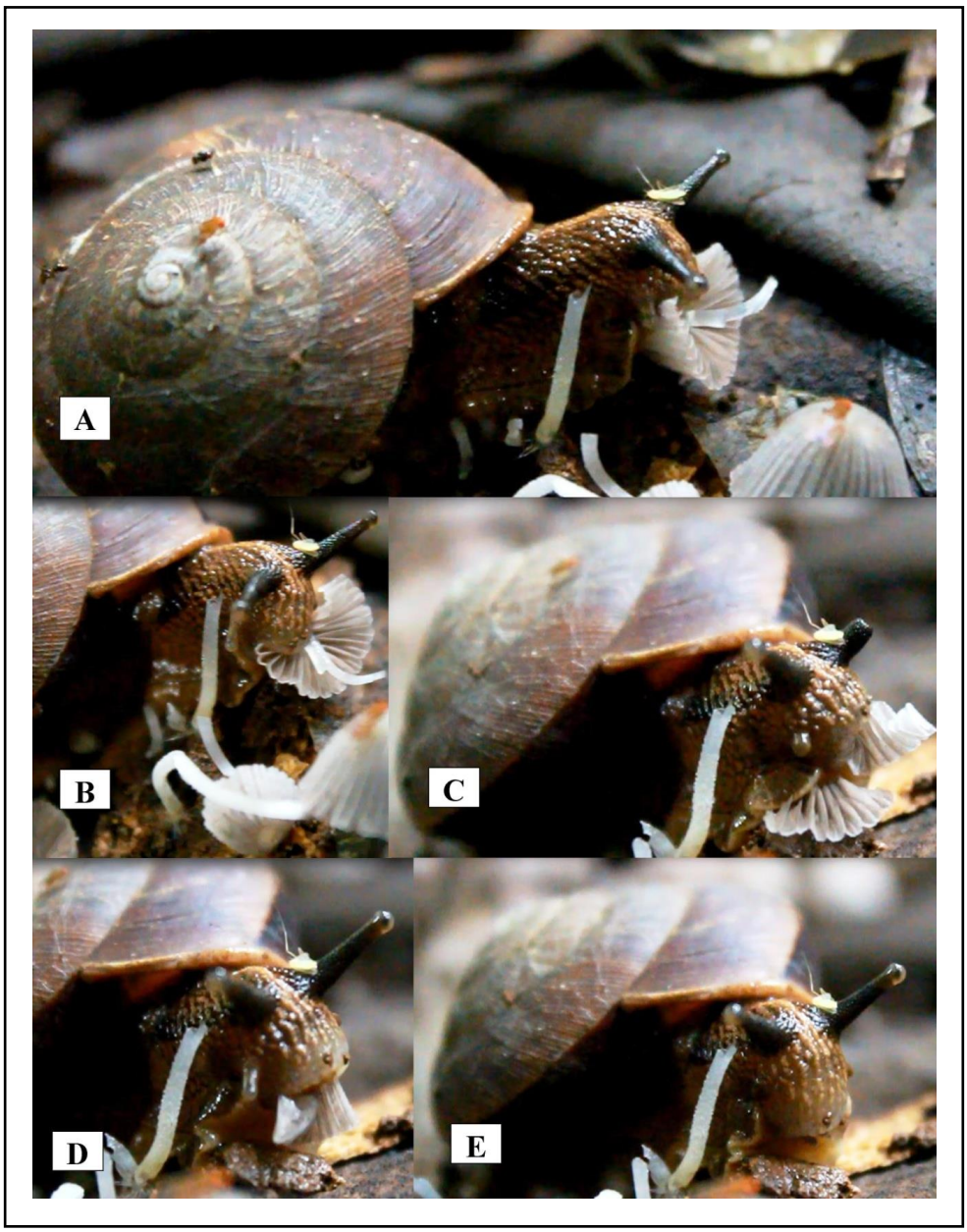

Figure 3. Gastropod feeding on basidiocarp of *Coprinellus* sect. *Disseminati*. A: start feeding; B: after 1 minute and 30 second ; C: after 2 minutes; D: after 2 minutes and 30 second; E: after 3 minutes

In this study, the gastropod only ate the pileus part of mushroom fruitbody. It appeared to use it's anterior tentacles to detect the stages of fruit body. Gastropod tend to prefer mature fruitbody with darker spores colour, but the the reasons are still vague. Fogel and Trappe (1978) described that spores presumably contain concentrated energy sources, as indicated by the relatively high caloric values of gills or rubes of mushrooms as compared to the somatic parts. However, the mechanisms which make certain *Coprinellus* basidiocarp specifically attractive to mycophagous gastropod remain largely unknown. One prime reason may be that no one ever studied it in Indonesia. Mycophagy can be classified regarding to the dependence on basidiomata for nourishment: obligate, preferential, casual or opportunistic and accidental (Claridge and Trappe, 2005). However, in this study, it is still uncertain which type of mycophagy possed by the gastropod. Longer monitoring interval is considerably needed in order to obtain the detail information.

Mycophagy is presumably a major means of spore dispersal for epigeous and hypogeous fungi. Previously, Keller and Snell (2002) reported the feeding activities on basidiocarp by *Ariolimax columbianus* on two species of macrofungi, namely : *Pleurotus ostreatus* and *Boletus edulis* which might also act as spore spreading of this particular macrofungi. In line with that, Lilleskov and Bruns (2015) confirmed that fungal spore disperse also involving spore-based food webs. They showed wide variety of invertebrates including arthropods to be primary spore dispersal vectors for the terricolous mushroom *Tomentella sublilacina*, via both internal transport (in the digestive tract) and external transport (on the integument). Therefore, mycophagy might not only important for animals as a food source, but it is also important for fungal dispersal. Additionally, no information on poisoning of animal by fungi in previous reports. Even so, it is obscure in this study, whether the gastropod which consume mushroom also contribute to the spread of *Coprinellus* spores or not in the sampling site. Following research is needed to clarify it.

To the best of our knowledge, this is the first report of mycophagy in Indonesia. The work that author report here is preliminary and poses many questions, particularly on the symbiotic interaction between animal and macrofungi in Indonesia. Future studies involving zoologists and ecologists are needed in order to detailed feeding and foraging data, aimed to better understand the mycophagous behaviour, fungal spore disperse, and to estimate how significant the fungal species are for the diet of Indonesian animals.

Conclusion

This research provide the information of animal mycophagy in Indonesia. Mycophagous gastropod found to eat *Coprinellus* sect. *Disseminati* fruit body as diet source in IPBUCF. Macrofungi fruit body waseaten within two up to three minutes. The snail only consume the pileus part of fruit body. Its howed to use it's anterior tentacles to pick the stages of fruit body. The gastropod tend to prefer mature fruitbody, yet the the reasons are still not clear. Further study should be done frequently (with longer time) and in variety of ecosystems to reveal more information on mycophagy aspect in Indonesia.

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