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Analysis of the morphology and growth of the fungus *Phallus indusiatus* Vent. in Cocoa Plantation, Gaperta-Ujung Medan.

Rama R Sitinjak*

Faculty of Agrotechnology, Prima Indonesia University, Medan-Indonesia.

ABSTRACT

This research aimed to analyze the morphological characteristics and growth of the *Phallus indusiatus* Vent. which belong to the group Stinkhorn fungi. The method used is survey and description. This fungi grows individually, appear twice in one year on the ground that a pile of cocoa leaves that have died, during the heavy rainy season ends. The fungi was first found growing in the area of cocoa plantations in the village Gaperta-Ujung Medan, ie on August 6, 2013, around 9.00 am. *Phallus indusiatus* have major macroscopic morphological characteristics, namely the fruiting body has a height of ± 19.13 cm, hood (cap or pileus) shaped brown cony and the side grooves with a width of ± 3 cm, and a height ± 2.6 cm, yellowish cream-colored gleba, has a white circular ring at the center of the stem, the stem (stalk or stipe) chewy white, cylindrical, cup (volva) gray that secrete mucus such as jellies, have a section that resembles roots (mycelium), has a coat or indusium such a network is creamy white and turned into golden yellow when wilting, that described from the bottom of the cap to the base of the stem. The process of growth and development of mushroom fruit body this happens starting from the egg stage (takes about 24 hours), and the budding stage, maturation stage, the stage of wilting (death) (third last stage of this only takes about 5 hours). On the cap that has gluten and odor found some flies.

Keywords: mushroom, *Phallus indusiatus* Vent., morphology, growth.

*Corresponding author

INTRODUCTION

Indonesia is rich in biodiversity, both animals and plants. This happens because of the geographical position of Indonesia that supports growth and proliferation by the biological resources. Indonesia region is a region suitable for the growth and proliferation of microorganisms such as bacteria and fungi. Bacteria and fungi including low-level plants, whose life will always be a parasite or saprophyte organisms/other objects. Mushrooms are one of the microorganisms which do not have chlorophyll so in order to survive will take energy and organic ingredients produced by green plants either still alive or already dead.

The diversity of fungi have been found and published, but due to changes in the nature and life of fungi that live as parasites or that saprophyte which makes it difficult to be found, then it is likely there are many types of fungi that are still yet to be seen or discovered by humans. Maybe mushrooms that have not seen this addition can increase the diversity of fungi in Indonesia, also can cure diseases, or may even cause harm to human life. But as human beings naturally want to know how much the diversity of fungi, especially in Indonesia. Identification of mushrooms is an activity that is very important because many types of mushrooms unknown number and type. The number of species of fungi have been known until now only about 69,000 of the estimated 1.5 million species exist in the world. It is certain that Indonesia is very rich in plant and animal diversity, also has diversity mushrooms were very high considering the environment humid and tropical climate that supports the growth of fungi [1].

Mushrooms Phallus indusiatus Vent. included in Basidiomycetes class on the group of Stinkhorns, Family Phallaceae, Genus Phallus. Because of this coat fungus has fruiting body which a large, then this fungi include in to the type of mushroom [2]. Mushroom formed from a large mass growth of the mycelium composed of hypha. Mycelium does not always exist in every mold growing. These hyphae can grow in a wide area and are similar to the roots of plants. When the hyphae grow and have a substrate for food (usually decaying organic matter), then it will form a mushroom in some places [3]. Mycelium to lektofilik fairy ring associated with a layer of straw. This type of fungi can stimulate the growth of grass, but did not damage the grass and soil layers [4].

Mushrooms *Phallus indusiatus* Vent. called Stinkhorn group because spreading the bad odor. Stinkhorn of the Phallus and Mutinus genus is commonly found in Nebraska. Stinkhorn has a spongy white stalk that may or may not have a hood (cap) is usually colored section ends [3,5]. Stinkhorns is a saprobic fungus found in areas containing organic material, or a pile of leaves. These fungi are associated with decay of stumps, was found in the Hawaiian Islands, Africa, Oceania, and many other tropical locations [4]. Stinkhorn fungi was also found along the southern coast of the Upper Peirce Reservoir in Central Watershed Nature Reserve, Singapore. In a thick layer of leaf litter after heavy rains the night before [6]. Then one species of Stinkhorn to the family Phallaceae found in the grassland, on a bamboo plantation of village Habungia, Jorhat District, Assam, India [7].

Family Phallaceae collected in French Guiana during the survey since 2005 [8]. This type of *Phallus indusiatus* fungi of Gasteromycetes found in India [2]. Then Cheyep [8] succeeded identify the type of Phallus fungi, ie *Phallus indusiatus*, *Phallus merulinus*, *Phallus atrovolvatus*, and *Phallus aff. Multicolor*. However, in 1981 the species of the Phallus genus, Phallaceae family been collected during 15 years in Costa Rica, including the species of *Phallus ravenelli*, *Phallus impudicus* {Synonyms: *Phallus roseus* Delile, *P. iosmos* Berk., *P. imperialist* Schulz., *P. foetidus* Lamarque}, *Phallus indusiatus* Vent. {Synonyms: *Dictyophora indusiata* (Vent. Ex Pers), *Dictyophora Duplicata* (Bosc.)}, *Phallus duplicatus*, Bosc. {Synonyms: *Dictyophora Duplicata* (Bosc.), *Hymenophallus duplicatus* (Bosc.), *Hymenophallus togatus*}. Regional spread of the fungus *Phallus indusiatus* are tropical and subtropical regions [9].

However, from a large number of species of fungi have been identified Stinkhorn, types of *Phallus indusiatus* fungi is description and illustrations yet widespread. This type of fungus including the ones are still rare, and they are found only in certain places or countries. In addition to be found in the country of India [2,10,11] and the Brazilian Amazonia [12], a species of the genus Phallus is also found from the subtropical forest in Xishuangbanna in the province Yunnan, China, during the rainy season of 2012. *Phallus mengsongensis* and *P. serrata* was introduced as a new species for science [13]. *Phallus atrovolvatus* found in Hawaii in 2002 [14]. Then Gogoi & Parkash [7] reported five species of the genus Phallus, which included mushrooms gasteroid along with the percentage of occurrence, namely: *Phallus indusiatus* (9.46), *Phallus*

duplicatus (3.55), *Phallus merulinus* (1:42), *Phallus cinnabarinus* (1.18), *Phallus atrovolvatus* (0.95), in Hollongapar Gibbon Wildlife Sanctuary, Jorhat, Assam, India.

Therefore, this group of Stinkhorn fungi especially species of *Phallus indusiatus* Vent is still not description and illustration of with widespread, especially in the area of Indonesia, and the type of fungus is also still includes mushrooms which a very rare and have unique characteristics, and the increasing public demand for mushrooms, especially in the world's health, hence through this research needs to be done, the analysis of the macroscopic morphology and growth of the fungus *Phallus indusiatus* Vent. who grew up in cocoa plantations in Gaperta-Ujung Medan, Indonesia.

MATERIALS AND METHODS

This study commenced in April 2013 to April 2015, in a cocoa plantation, Gaperta Ujung Medan. Indonesian regions contained in Sumatra Island, North Sumatra province. Analysis of the morphology, growth and development of this fungus *Phallus indusiatus* Vent. conducted in the cacao plantations. The tools used in this study was calipers, scales, documentation, etc. The method used in obtaining the data is a survey method and descriptive.

Parameters measured were:

Macromorphological characters of *Phallus indusiatus* fungus:

- a. High fungi; measured from the tip of the hood (cap or pileus) to the tip of stem base.
- b. Weight fungi; fresh weight per individual weighed.
- c. Long cap; measured from the top of the cap to the bottom of the cap.
- d. Cap diameter: measured at the bottom of the cap.
- e. Color, model, and location of the cap.
- f. Stem diameter (stulk or stipe) at the tip and the base of the stem, as well as color.
- g. Color, number and width of the ring on the stem.
- h. Height and color of the cup (volva): the membrane that surrounds at the stem base.
- i. The number and color of mycelium located at the stem base.
- j. Length, width, color and model of the mantle or indusium owned this type of fungi.

Growth and development of fruiting bodies of *Phallus indusiatus* Vent.: observed at the time began to emerge from the egg stage to stage wilted (death).

Implementation Procedures of this study:

To analyze macro-morphology:

- a. Cacao plantation area is observed at all times, because this fungus appears unpredictable time or its growing season.
- b. If the fungus is found among the leaves of the cocoa, soon made observations and measurements on parts of the fungus. Limited the growth of this fungus, which appear only twice a year and usually grows per individual. To obtain accurate data is required at least 5 mushroom.

To analyze the growth and development of mushroom fruit body: This activity began in fungal growth is at the initial growth stage namely the egg stage, later stage of germination, maturation, and wilting stage (death). To obtain this data is required 5 *Phallus indusiatus* fungi.

RESULTS AND DISCUSSION

Mushrooms *Phallus indusiatus* Vent., Basidiomycetes class who belong to the group Stinkhorn fungus, have been found the first time around 9 am on Tuesday, August 6, 2013 in cocoa plantations which are about 30 m above sea level in the region Gaperta-Ujung, Medan. *Phallus indusiatus* found in cocoa plantations are in the month of August 2013, November 2014 and April 2015. This fungus is found in soil that was on the sidelines of the cocoa leaf litter that had rotted or decayed, after continuous heavy rains started over. Based

on observations in the field, this type of *Phallus indusiatus* Vent. fungus has macro-morphological characteristics as follows:

1. Having a hood (cap or pileus) brown with the grooved sides and spreading odors such as the smell of animal waste, and if the surface of the cap is touched, it will leave brown adhesive. This cap is shaped conical, has a length of about 2.6 cm and a diameter of about 3 cm. At the top of the cap there is a white hole that is the end of the channel from the mushrooms stem.
2. Having a coat like network called white indusium and change color to golden yellow when wilting, has a diameter of about 13 cm, about 10 cm long. This coat decomposes starting from the bottom of the hood (cap) up to the base of the stem, and shaped like a net that covered almost the entire body of the fungus. Because of this characteristic, the author in the beginning calls this type of fungus is a coat fungal.
3. Having a white ring on the stem, which is located about 2 cm below the cap. This ring has a width of about 2 cm.
4. Having a section that resembles a white stems. In the middle of the stem there is a hole or channel that penetrates stems to the top of the cap. Stems ridged like foam, spongy. The base of the stem is wrapped by membranes (cup or volva) gray and soft to the touch. Volva has a length of ± 4 cm. Cup (volva) torn will discharge white mucus like jelly. Stem height ± 15.67 cm, stem diameter ± 2.6 cm, but when a section of the base end of the stems diameter ± 3.8 cm, and on the tip of the stem diameter ± 1.53 cm.
5. The final section of stems base there that resembles roots (mycelium), which consists of several strands of thread-like white (called hypha), which resembles the root is attached to the leaves of the cocoa that has been weathered.
6. All fungal fruiting body has a high ± 19.13 cm, soft and does not smell tasty, especially when mushrooms revoked taste smell are so terrible came from slime rolling down the outside of the cap. The cap section were also found some flies.

Table 1: The average of the results of morphological observation of the fruiting bodies of *Phallus indusiatus* Vent. years 2013-2015.

No	Characteristics	Average
1	Cap or pileus (hood) :	
	- The width of the cap	3,0 cm
	- High-cap	2,6 cm
	- Color	brown
	- Form	Conical, side grooved
	- Side portion	Kept moist, smelly and brown adhesive
2	Resembling a stem or stalk or stip:	
	- Diameter top	1,53 cm
	- Lower diameter	2,6 cm
	- Diameter at base	3,8 cm
	- Length of the stem	15,67 cm
	- Color	creamy white
	- Form	Cylindrical
	- The base of the stem	There cup or volva gray
- Middle part	There is a white ring with a width of 2 cm	
3	Indusium (coat):	
	- Color	- White, turns into golden yellow when wilting
	- Form	- Such as nets, surround stems decomposes from under the cap toward the bottom closer to the ground.
	- Long	10 cm
	- Width	13 cm
4	Resembling roots (mycelium):	
	-Total root	5,67
	- Long	2,5 cm
	- Color	White
5	Gleba or gills:	Yellow
6	Body of fruit:	
	- High	19,13 cm
	- Fresh weight	11,85 gram

Based on observations, the average characteristics of this fungus can be seen in **Table 1**. Typical morphology and growth of fruiting bodies this fungus can be seen in **Fig. 1**. Illustration of morphology *Phallus indusiatus* Vent. can be seen in **Fig. 1A**.

The observation on the growth and development of fruiting bodies *Phallus indusiatus* Vent. :
The process of growth and development is very short:

1. The egg stage: Starting with the emergence of the individual in the form of eggs up to a maximum magnitude of ± 3.5 cm, on the surface of the soil mixed with bundles of leaves of the cocoa plants that have died. This egg wrapped with a layer of whitish brown color (**Fig. 1B**). This stage can last up to 24 hours.
2. Stage germination: Membrane from the top of the egg torn, white mucus out of the inner crevices torn membrane. Then came the hood up, followed by growth of the hyphae (rod) slowly, followed by an emerging would indusium or coat from under the hood (cap). This process takes about 2 hours (ranging from hours 7-9 am) (**Fig. 1C**).
3. Stage of maturity: At the time of the extension of stems began to slow, it will coat which appears like white ring on the bottom of the hood (cap) began to be formed more quickly toward the bottom. Gradually this coat decomposes down while expanding and beginning to show its shape like a net, surround his stem up to the base of the stem, almost touching the ground. Along growth of this coat, is also accompanied by the appearance of creamy white rings around stems, which is located approximately 1 cm below the emergence of the coat. Along with the process of formation and development of the coat, as well as the formation and elongation of the ring around stem, stem elongation process grew very slowly. At this stage, the main activity is the process of formation and development of coat and ring. This process only takes about 60 minutes (starting at 9:15 to 10:15 am). After the process of formation and development of the coat and the ring is completed, then the process is elongated stopped. The process of growth and development here maximized to achieve climax stage (**Fig. 1D and Fig. 1E**).
4. Stage of wilt (death): Around 11:00 am, part indusium (coat) begins to wilt, which was originally white coat color turns into golden yellow. Indusium began to closes. Then about 13.00 parts cap began to droop downward, then slowly followed by the top of the stem droop to the ground. This stage takes about 3 hours. Around the clock 11:00 to 15:00 caps and stems already lay on the ground (**Fig. 1F**).

This *Phallus indusiatus* Vent. (1798) mushrooms is synonymous with *Dictyophora indusiata* (Vent. : Release) Desv. (1809), *Hymenophallus indusiatus* (Vent.) Nees (1817), *Dictyophora phalloidea* Desv., (1809), *Dictyophora tahitensis* (Schltdl.) (1886), *Phallus callichrous* (Möller) (1907) [9,8,15]. Based on the analysis of morphology and characteristics of the macroscopic in this study, the type of mushroom has a hood (cap) the grooved brownish form koni, indusium creamy white, which is in wilt stage turn into golden yellow which grew from the bottom of the cap to the base of the stem, in part stems there is a white ring, and at the base of stems there is a cup (volva) gray. This mushroom fruit body has high measure ± 19.13 cm diameter tip of the stem ± 1.53 cm and the diameter of the base of the stem ± 3.8 cm, then this type of fungi belong to the group of mushroom, the fungus can produce large fruit body, According to Velišek and Cejpek [16] the majority of this group of fungi called Basidiomycetes higher fungi known as mushrooms (fungi). Kreisel and Hausknecht [3] have identified a new species of *Phallus flavidus* Basidiomycetes group, and 19 taxa *Phallus indusiatus* with yellowish indusium and orange pileus, this taxon approached a group of tropical and subtropical species. Mushrooms *Phallus indusiatus* of tropical India is likely to have a pattern of shapes and colors that are very similar to mushrooms *Phallus indusiatus* observed in this study, but differ in size (75-100 mm tall fruiting bodies, stipe diameter 11-22 mm, length indusium 90-95 mm). *Phallus indusiatus* in this research still has a larger size. Likewise with *Phallus cinnabarinus* collected from Hawaii in 2002, which appeared on the lawns and in the compost pile of wood. According to Hemmes and Desjardin [14] this type of mushrooms is also located along the coast of Hawaii Island as *Dictyophora indusiata* in 1907. Judging from its the shape pattern, this mushrooms is similar to mushrooms *Phallus indusiatus*, but differ in color pattern. Similarly to the fungus *Phallus flavidus* of tropical India are identified by Kreisel & Hausknecht [3]. This fungus has the same form with mushroom *Phallus indusiatus* analyzed in this study, but differ in size and color. *Phallus indusiatus* has a size larger than the *Phallus flavidus* mushrooms that have fruiting bodies with a height of 50-80 mm, pileus (cap): globiferus, pale orange, and indusium length up to 50 mm. Likewise, species of *Phallus serrata* one of the collection survey results during the rainy season in 2012 in China [13]. This fungus has a shape, color, and size is almost the same as the *Phallus indusiatus* found in this study. According to Hemmes and Desjardin [14] the species of *Phallus* sometimes produces fruiting bodies with white indusium clean. *Phallus multicolor*, very

similar to a *Phallus atrovolvatus*, that his body has volva dark gray, white fluffy indusium between cap and volva, and have a habit of growing in the compost timber. The difference is that the surface of the fruit body of *Phallus atrovolvatus* black, while the fruiting bodies of *Phallus multicolor* (specimen Hawaii) gray.



Fig 1: An overview of the morphology, growth and development of fungi *Phallus indusiatus* Vent.:
A. Illustration of morphology *Phallus indusiatus* Vent.,
B. Growth of *Phallus indusiatus* Vent at the egg stage,
C. Growth of sprouting stage: the process of stem growth, initiation indusium and ring formation,
D. Stage of maturity: The process of development and refinement of indusium and rings,
E. Adult stage: Formation and development indusium and extension stems have maximum, fruiting bodies blooming,
F. Wilt (death) stage: indusium closes (wilting) and cap drooping, drooping eventually surface soil.

The occurrence of different patterns of size and color of the *Phallus* species is likely influenced by topography, be it climate, rainfall, and humidity of the environment. Küffer & Senn-Inlet [17] also reported

that the biogeographic region affect the diversity or richness of fungal species. Then Nogueira-Melo *et al.* [18] explains that to analyze the diversity of mushrooms in a number of mangrove Brazil, and its relationship to diversity, precipitation and collection areas. Overall abundance and species richness did not differ significantly between regions, but may vary according to the time, to be higher during the rainy season. In addition, fungal host and habitat specificity coupled with dispersal limitation can lead to local variation in fungal community structure [19].

Mushrooms *Phallus indusiatus* Vent. in this study generally twice a year is found in cocoa plantations in the morning, on the ground wet from rain. The process of growth and development of the mushroom fruit body was also found quite short about 24 hours for the egg stage, but the next germination stage, maturation stage, and the stage of wilting (death) only takes about 5 hours. Hence the growth of only 1-2 mushrooms and the process is very short, so that makes this study a little longer because it takes three years to obtain multiple samples in obtaining their actual characteristics. Likewise Stinkhorn fungus, Dictyophora species (Phallaceae Family, Phallales orders, Agaricomycetes class, Basidiomycota division), with distribution in Singapore, often found in the morning in the wet soil due to heavy rain [6]. According to Giesler & Haxton [5] growth fruiting bodies are younger than mushrooms Stinkhorn (white and round shaped eggs, most of which appeared in the soil or mulches) will be the fruit body of mature (structures like ovule breaks, and stalk appear) often occurs overnight, However the overall life cycle of *Phallus indusiatus* can occur for 15-30 days, including the vegetative stage (mycelium formation) and reproductive stages (formation basidiocarp). Reproduction method different from a lot of mushrooms, which uses air to spread spores. Stinkhorns produce a sticky spore mass on the end, which has a bad smell to attract bees and flies or other insects [20,5]. Tan [6] described that Stinkhorn fungus does not spread through the air. Basidiocarp produce a slimy mixture of spores called gleba, and spreading odor to attract carrion flies and other agents for the spread of spores. There are plenty of Drosophila flies (Diptera: Drosophilidae) around the cap and veil, which plays a role in the spread of spores. Some also sap beetles (Coleoptera: Nitidulidae) seem to feed on mushrooms cap. The fly landed on gleba and consuming mucus [20]. Oliveira & Morato [12] reported existence intraksi between the spread of spores of two species Stinkhorn namely *Dictyophora sp.* and *Phallus sp.* with bees. The discovery of mucilaginous mass of spores on the surface of the body of worker bees. Fungal spores as a complement to the diet for the worker bees.

Kreisel and Hausknecht [3] also reported that mushroom will produce thousands of spores to spread fungus to new areas, and when the food source is available, it will germinate and eventually produce a new mushroom. In the life cycle of basidiomycetes, mycelium explore the depths of the soil and spreads laterally, absorbing nutrients and organic matter. Sexual reproduction and sporophore production have only occurred during favorable environment and the weather is usually wet [4]. Then Lodge *et al.* [21] also reported a high content of nitrogen can inhibit the growth of mycelium. This shows that for mold growth is in addition affected by the climate, is also influenced by the soil and the nutrient content in the soil, and also influenced by ecological systems. According to De Vries *et al.* [22] biomass plants is a major carbon source for many species of fungi. Due to the complex nature of the polymer, the degradation of this biomass for monomer, digest requires a wide range of enzyme activity. Then Petre *et al.* [23] explains that this species has the ability to efficiently use the substrate, rots the macromolecular organic compounds, using all the strategies, which depending on stage of development, type of substrate and environmental factors. There is the possibility of organic content that comes from decaying leaves of cocoa, which is supported by the climatic conditions and the lay of the land, making these fungi can be grown in this area, and also makes the process of growth and development of the fruiting bodies so short and grow 1-2 times in one year. If the climate and nutrient content in the soil does not support, it is possible that the egg stage no potential to germinate (this stage can last more than 24 hours). The egg stage is the preparation conditions in the collection of a very high energy to be used in the process of germination until the end in wilting stage. The process of growth and development of the fruiting bodies of this fungus is very short (it only takes about 5 hours). To complete the whole biological cycle, mushrooms saprotrophic requires optimal quantity of nutrients, to develop a variety of strategies to occupy different ecological niches [23]. So also with the interaction between the odor derived from the mucus secreted by these fungi in the gleba with bees or flies can affect the speed of its spread to grow into a new fungus in other areas.

Characteristic unpleasant odor excreted by fungus is likely caused by the presence of the enzyme and influenced its development stages. In the egg stage, this fungus has not excrete the bad odor. At the stage of germination, unpleasant odor had begun. At the stage of maturation, unpleasant odor is increasingly stung (like the smell of animal waste), then at the stage of wilting, odor decreases. According to Pudil *et al.* [24]

there are some volatile compounds released by Stinkhorn (*Phallus impudicus* L. ex Pers.) at different stages of maturity of the fruit body. There is a qualitative difference of the major components, in accordance with the stages of maturity. Dimethyl trisulfide, cis- β -ocimene, trans- β -ocimene, 2-phenylacetaldehyde and 2-phenylethanol are volatile, which is most commonly found in the ripe fruit body is dimethyl polysulfide, most significant contributors to smell are so terrible of fruiting bodies Stinkhorn, but not found in egg-shaped stage and a more mature stage. This is likely to cause mature fruiting body of Stinkhorn can be detected from a considerable distance in the forest, and close most people find very disgusting cloying odor. In the fungal fruiting bodies that are old are not found mucus [20]. Then Stinkhorn fungus is only visible when the "blooming" with slimy cap and orange white indusium of around the stalk [6]. The bloom is a sign of maturity of the fruit body reaches maturity level with the coat or indusium that expands along with the maximum potential to produce mucus that emit a very sharp odor thereby attracting bees or flies.

CONCLUSION

Mushrooms *Phallus indusiatus* Vent. are included Basidiomycetes classes, grouped into Stinkhorn. Macroscopically, this mushroom has a cap shape conical brownish, white ring, gray cup, golden white indusium, with its height of about 19.13 cm, with an average wet weight of 11.85 grams. Living on the ground between a rotting cocoa foliage, with the growth and development of its fruit body through several stages: from the egg stage, the stage of germination, maturation, and wilting stage (death). The egg stage can take quite a long time (about 24 hours) to be able to the stage of germination. If the germination stage has already begun, then the next stage until the final stage will take place very quickly (it only takes about 5 hours). This fungus appears generally to heavy monsoon rains began to expire, usually grows each individually, and appears twice a year.

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