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## Species Diversity of the Genus *Amanita* Dill. Ex Boehm. (1760) in Chu Yang Sin National Park, Daklak, Vietnam

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**Abstract** The genus *Amanita* is one of the genera which is diverse in shapes, colors, species and biological characteristics. The species are valuable in medicine and nutritious for human health. However, there are some species belonging to this genus are toxic, especially the species belonging to *Amanita* Dill. Ex Boehm. The investigation of the species was carried out in Chu Yang Sin national park. The results showed that 15 species of *Amanita* Dill. Ex Boehm were recorded: (1) *Amanita abrupta*; (2) *Amanita amanitoides*; (3) *Amanita caesareoides*; (4) *Amanita caesarea*; (5) *Amanita cokeri*; (6) *Amanita concentrica*; (7) *Amanita flavoconia*; (8) *Amanita levistriata*; (9) *Amanita multisquamosa*; (10) *Amanita pantherina*; (11) *Amanita phalloides*; (12) *Amanita pilosella*, (13) *Amanita solitaria*; (14) *Amanita subcokeri*; (15) *Amanita vaginata*. Within 15 species were identified, eight species were newly added to the list of predominant fungi in the Central Highlands of Vietnam included: *Amanita abrupta*, *Amanita amanitoides*, *Amanita concentrica*, *Amanita flavoconia*, *Amanita levistriata*, *Amanita multisquamosa*, *Amanita pilosella*, *Amanita solitaria*. Most of the collected *Amanita* species showed bright colors with a base or fungal rings. They live in areas with high moisture (>85%), at altitude from 800 – 1200 m above sea level, annually occur from June to November and are saprotrophic on soil, under tree shades, especially coniferous, semi-evergreen trees and on greensward or shrubs.

**Keywords** *Amanita* Dill. Ex Boehm genus, Chu Yang Sin National Park

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### 1. Introduction

In nature, most toxic fungi live on the decomposing non-living materials on soil or plant residues. Therefore, they play an important role in the environmental cycles. However, *Amanita* has little value to human due to its causing poisonous to human and animals. Until now, there are only a few information on this fungal genus. Chen and Nicholas [1] studied on chemical components of *Amanita*. Vetter [2] reported on the toxins of *Amanita phalloides* in Europe and Central Europe. Recent works have demonstrated that *Amanita* containing mushrooms are a rare, however it shows significant cause of acute fulminant liver failure [3, 4]. The species diversity and fungi were also reported, Ryvardeen and Johansen [5] examined on fungal system of Eastern Africa; however, there have been only three species belonging to *Amanita* focusing on saprotrophic fungi living on wood in this study. Regarding macro-fungi, there are some families of poisonous fungi, mainly located in the region of South America and the effects of physical factors on Amanitaceae family and isolated the active compounds of Amanitaceae [6, 7]

Vietnam is located in tropical and subtropical country; therefore, fungi are much diversified. However, very few works have been conducted on the diversity of fungi. Some reports were published on few fungal species and their diversity as well as contributions in Vietnam which included the poisonous *Amanita* species [8]. In central highlands of Vietnam, macro-fungi species were reported and identified six poisonous *Amanita* species.



Recently, Nguyen [9] identified 18 poisonous fungal species in Nam Ka reservoir, Daklak province, including 8 species of Amanitaceae family. Up to now, *Amanita* in Central Highlands in particular, and in Vietnam, in general is not very common to the researchers. Therefore, the study of the diversity of *Amanita* species in Central Highlands is necessary to provide local citizens with the information of fungi and how to use them properly.

## 2. Natural conditions

Chu Yang Sin national park has a total area of 58,947 ha, including three zones – strict protection zone (19,401 ha), ecological restoration zone (39,526 ha), and administrative service zone (20 ha). In addition, the garden also has a buffer zone of 183,479 ha. It locates in the final point of Truong Son mountains of Southern Highlands. Chu Yang Sin National Park has a diverse, unique and endemic botanical ecosystems which has distributed into 9 main forest types: evergreen tropical rain forest, moist evergreen subtropical low type of evergreen tropical moist montane average, sparse coniferous forest subtropical dry steam, alpine dwarf forest types, evergreen forest semi-deciduous, bamboo and cork carpet style pure, pure style le carpets, scrub and grassland types scattered trees. These are favorable natural conditions for the growth and development of fungi in general and fungal species of *Amanita* in particular.

## 3. Materials and Methods

### 3.1. Materials

Fungal species of genus *Amanita* collected at 15 points in Chu Yang Sin National Park, Daklak province as shown in Figure 1.



Figure 1: Location of fungal collection at Chu Yang Sin National Park

### 3.2. Methods

#### 3.2.1. Collection of fungal samples:

The process of collecting samples was carried out following the fish-bone pathway. The analysis of fungal samples was done following the procedures of Teng [10], Kiet [8], Singer [6], Ryvarden [5] with some modifications.

The principle of the method:

+ Collect samples on different habitats (types of forests).



- + Analyze ecological characteristics, morphology, microscopic structures of the collected samples. Identify growing time, distribution and value of the samples.
- + Define the characteristics of the researched species.

### 3.3.3. Analysis and identification of the samples

**Analyzing biological and ecological characteristics:** We have analyzed microscopic and morphological characteristics of the samples in the laboratory of Biology Department, Tay Nguyen University. For analyze the morphology: it was selected based on phenotypic of samples such as color boards, KOH etc.

**Analyzing microscopic characteristics:** spores, basidia, hyphae were analysed by use of Olympus microscopes.

**Species identification:** Identify by morphology, anatomy based on some previous reports [8, 6, 5, 10, 11].

## 4. Results

### 4.1. Classification of *Amanita*

After analyzing biological characteristics of *Amanita*, we have had some results on this fungal genus as follows:

- They are diverse in colors: red, orange, yellow etc
- The cap of the mushroom is fleshy, usually umbrella-shaped
- The stem is fleshy, attached with the cap in the center and can be easily separated from the cap
- The spore is colorless, spherical or elliptical, and smooth
- The dimensions of a spore is around 5-7 x 10-12  $\mu\text{m}$
- They live as saprotrophs
- Germinating pores are 20 – 30<sup>0</sup> deviated
- When the fruit body is immature, the universal veil covers the cap and the stem. The universal veil is then ruptured by growing mushroom, creating the volva and the mushroom ring – a highlighted feature of *Amanita* species.

### 4.2. Predominant species of *Amanita* in Chu Yang Sin national park

Throughout the investigations and surveys carried out to collect predominant species of *Amanita* in Chu Yang sin national park from June 2015 to November 2016, we have collected 107 samples. In the first steps, we have identified 15 species of *Amanita* as shown in Table 1.

**Table 1:** List of predominant *Amanita* species in Chu Yang Sin national park

No.	Species	Habitats				
		PF	EF	SEF	MF	S&G
1	<i>Amanita abrupta</i> (Peck 1897)	+++		+	+	++
2	<i>Amanita amanitoides</i> (Beeli Bas 1969)	+		+		++
3	<i>Amanita caesarea</i> (Gillet 1874)	+			++	+++
4	<i>Amanita caesareoides</i> (Lj.N. Vassiljeva 1950)	+++			+	++
5	<i>Amanita cokeri</i> (E.-J. Gilbert & Kühner ex E.-J. Gilbert 1940)	++		+	++	+
6	<i>Amanita concentrica</i> (T. Oda, C. Tanaka & Tsuda 2002)			+	+++	++
7	<i>Amanita flavoconia</i> (G.F. Atk. 1902)	++				++
8	<i>Amanita levistriata</i> (D.T. Jenkins 1988)			+	+++	++
9	<i>Amanita multiscapula</i> (Peck 1901)	+++				
10	<i>Amanita pantherina</i> (D.T. Jenkins 1977)	+++			++	+
11	<i>Amanita phalloides</i> (Fr.) Secr. 1833	+	+	+	+	
12	<i>Amanita pilosella</i> (Corner & Bas 1962)	+			++	++
13	<i>Amanita solitaria</i> (sensu NCL 1960)	+++			+	+
14	<i>Amanita subcokeri</i>	+++				+
15	<i>Amanita vaginata</i> (Bull. Lam. 1783)			+	+++	+

(PF: Pine forest; EF: Evergreen forest; SEF: Semi-evergreen forests; MF: Mixed forest of coniferous and broad-leaved forests; S&G: Shrubs and greenswards). Symbol: “+” not commonly found; “++”: commonly found; “+++”: very commonly found.



As can be seen in Table 1, we found out that a big part of *Amanita* species collected usually live and grow in places where the moisture is higher than 85%, altitude is about 800 – 1200m above sea level. These species usually grow from June to November annually and are saprotrophs that live on the ground, under shades and mainly in coniferous forests, semi-evergreen forests, on greenswards and under shrubs.

#### 4.3. Descriptions of big *Amanita* species in Chu Yang Sin national park

##### *Amanita abrupta* (Peck 1897)

For a mature *Amanita abrupta*, the cap has a diameter of 4 to 9 cm and has a broadly convex to flat shape. The cap surface is white and covered with white warts. The fruit body is about 0.4 – 0.7 cm. The margin is not lined (Figure 2(1) & 3(1)).

The gills are free from the stem or slightly attached to it, close to each other and is often white to cream. The stem is 6 – 12 cm long with a diameter of 0.5 – 1.5 cm and is tapering slightly to apex with an abrupt basal bulb on the bottom. The stem is shaggy with white warts covering the whole stem. The mushroom ring is thick and double-edged (1 upper line and 1 thin membrane beneath). The mushroom flesh is white, does not change color when being cut and can be easily separated from the gills. The mushroom has an unpleasant odor. The hyphae is transparent and is 4-5  $\mu\text{m}$ . The spores are elliptical or spherical, have dimensions of 7-9 x 8-12  $\mu\text{m}$  and are amyloid. The germinating pores are 25<sup>0</sup> deviated. Biology, ecology: the mushroom usually lives in dry and sunny places, with the coordinates of N12<sup>0</sup>26.701; E 108<sup>0</sup>20.445, at the altitude of 780 m, moisture 86%, medium slope, thickness of the litter about 0.3 – 0.5 cm mainly composed of pine nuts and leaves.

Distribution: *Amanita abrupta* grows mainly in pine forests and in semi-evergreen forests.

Present value: This species of *Amanita* is toxic and dangerous to human and animals.

##### *Amanita amanitoides* (Beeli Bas 1969)

Fruit body: the cap of *A. amanitoides* has a plano-convex shape with slight umbo, white with yellowish stains at the center. It is about 7 cm wide and has yellowish color. The cap is completely floccose-pulverulent, with a nonsulcate margin (Figure 2(2)&3(2)).



Figure 2: Fruit bodies of *Amanita* species



**Note:** (1) *Amanita abrupta*; (2) *Amanita amanitoides*; (3) *Amanita caesareoides*; (4) *Amanita caesarea*; (5) *Amanita cokeri*; (6) *Amanita concentrica*; (7) *Amanita flavoconia*; (8) *Amanita levistriata*; (9) *Amanita multisquamosa*; (10) *Amanita pantherina*; (11) *Amanita phalloides*; (12) *Amanita pilosella*, (13) *Amanita solitaria*; (14) *Amanita subcokeri*; (15) *Amanita vaginata*.

The gills are white or cream, are curved from the stem to the margin, have shallow furrows and line closely next to each other. The stem is cylindrical, white or cream. It is about 10.5 cm long and has a diameter of about 0.8 cm. There are zigzag lines covering the mushroom from the base to the top of the stem. These are the remnants of the volva. The base of the mushroom is white or gray and has the shape of a lotus petal. One to two thick petals of the base cover the mushroom stem. The flesh is white, thin and soft, is 0.4 – 0.7 cm thick and can be separated from the gills easily. The hyphae captured light blue-green color, measures 4-6  $\mu\text{m}$ . The spores have the shape of a sphere or elongated ellipse, measure 5-7 x 9-11  $\mu\text{m}$  and are amyloid. The germinating pores are about 15 – 25 $^{\circ}$ . The spores are ubiquitous in the basidium of the mushroom.

Biology, ecology: grow individually, and develop strongly in raining seasons, usually live in dry, sunny conditions. Coordinates: N12 $^{\circ}$ 26.601'; E108 $^{\circ}$ 20.345'; altitude: 880 m; moisture: 86%; medium slope; litter about 0.3 – 0.5 cm thick, mainly composed of pine nuts and leaves.

Distribution: in pine forests, on greensward and under shrubs.

Present value: toxic and dangerous to human and animals.

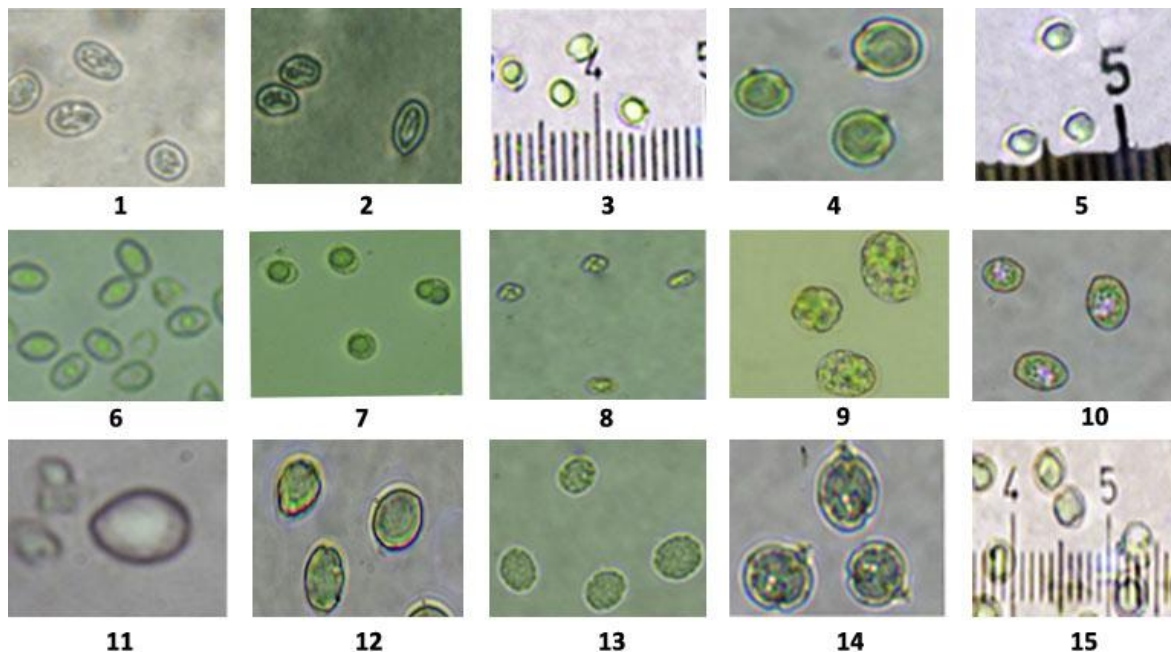


Figure 3: Spores of *Amanita* species

**Note:** (1) *Amanita abrupta*; (2) *Amanita amanitoides*; (3) *Amanita caesareoides*; (4) *Amanita caesarea*; (5) *Amanita cokeri*; (6) *Amanita concentrica*; (7) *Amanita flavoconia*; (8) *Amanita levistriata*; (9) *Amanita multisquamosa*; (10) *Amanita pantherina*; (11) *Amanita phalloides*; (12) *Amanita pilosella*, (13) *Amanita solitaria*; (14) *Amanita subcokeri*; (15) *Amanita vaginata*.

#### ***Amanita caesarea* (Gillet 1874)**

As shown in Figure 2(3) and Figure 3(3), the fruit body is red-orange to yellow. The gills, the stem and universal veil are also yellow. Only the base of this fungus is white. The cap of *A. caesarea* is nearly oval or round at first, becoming convex, then broadly convex to flat in age. It is red, red-orange to yellow, smooth, flat and a little sticky when being wet. The margin is lined and somewhat has the white remnants of universal veil. The cap can be easily separated from the stem. The cap is 6-14 (20) cm wide. The flesh is white-yellow and has aromatic smell. The gills are initially yellow, free from the stem and are short or long. The stem is bright yellow to white, tapering to apex with a swollen base. It is 10-16 cm long, 0.6-1.4 cm wide, solid when young and



hollow when age. There is a skirt-like ring covering 1/3 of the stem. The base lies inside the white universal veil material. The hyphae has not septa, with a diameter of about 2.5 – 3  $\mu\text{m}$ .

Biology, ecology: The fungus is usually encountered in summer and fall; on wet, spongy soil; coordinates N 12°24.109'; E 108°21.165'; altitude: ~1200 m, temperature: 22°C, moisture 87%, slope topography, thick litter.

Distribution: in semi-evergreen forests.

Present value: in Vietnam, people rarely consume this mushroom as food because they are afraid that it's poisonous; however, this mushroom is well-known for its tastefulness from ancient Roman time.

***Amanita caesareoides* (Lj. N. Vassiljeva 1950)**

The fruit body has the shape of a bell with red color when young. When the mushroom is mature, the cap has the shape of an umbrella with yellow-orange color, with a large broad yellow umbo. The cap of *A. caesareoides* is 10 – 14 cm. *A. caesareoides* has prominently pectinate-striate inward margins **Figure 2(4) & 3(4)**

The gills are white or cream and are curved from the stem to the margin, with crowded shallow furrows.

The stem is tapering upward. It is usually ochraceous-yellow, with yellow, zigzag lines running around the stem. When being cut, the inside of the stem is white and is slightly hollow. The stem is about 19 cm long, with a diameter of 2 – 2.1 cm. The stem is somewhat slimy. Ring on the upper part of the stem is white or yellow, skirt-like and membranous. The bulb is saccate and lobate, embracing the base of the mushroom. The flesh is white, soft and thin – about 0.3 cm thick. The hyphae is not transparent with a diameter of 3 – 4  $\mu\text{m}$ . The spores are broadly ellipsoid and measure 6-8 x 8-11  $\mu\text{m}$ . The spores are in amyloid. Germinating pores are 15 – 20°. The spores are ubiquitous in the basidium of the mushroom.

Biology, ecology: grow individually, best in rainy seasons, live in dry, sunny conditions. Coordinates: N 12°26.511'; E 108°20.215', altitude 690 m, moisture 85.99%, medium slope, thickness of litter about 0.3 – 0.5 cm, composed mainly of pine leaves and nuts.

Distribution: in pine forests, on greensward and under shrubs.

Present value: toxic and dangerous to human

***Amanita cokeri* (E.-J. Gilbert & Kühner ex E.-J. Gilbert 1940)**

The fruit body has a cap and a stem. The stem has a ring and volva. The cap is hemispherical or convex, white and covered with fairly large, pointed, white warts. The cap is 6 – 8 cm. The gills are free from the stem, close to each other and white. The flesh is white and thick. The stem is white, measures 5-10 x 0.5-1 cm. The universal veil hangs from the top of the stipe. The base is swollen and is bulb-a-like and has irregular patches. The hyphae is transparent, has no septa with a diameter of 5 – 7  $\mu\text{m}$ . Spores are white and elliptical to nearly spherical, measure 8-10  $\mu\text{m}$  and feel smooth. The content is colorless. The basidium is single-celled, looks like a mace, measures 7-10 x 20-30  $\mu\text{m}$ , contains yellow granules and has 4 spore-bearing structures on each basidium (Figure 2(5) & Figure 3(5)).

Biology, ecology: grows on spongy, wet soil; from May to October. Coordinates: N 12°24.101'; E 108°20.152'; altitude: 1350m, temperature: 22°C, moisture: 86.9%, slope topography, thick litter with high amounts of litter.

Distribution: mainly in semi-evergreen forests and pine forests

Present value: toxic and dangerous to human and animals

***Amanita concentrica* (T. Oda, C. Tanaka & Tsuda 2002)**

The fruit body is hemispherical when young with warts creating striae covering the whole fruit body. The warts are white when young and cream when age. The fruit body, stem and base are dingy white. The base is bulblike. At maturity, the cap is convex and is 2.5 – 8 cm wide. The cap is white or cream at the center. From the center to the edge of the cap the flesh is white cream to white. The skin is smooth, shiny and slippery. The fruit body is about 0.7 cm. The margin is slightly striate. The gills are white and curved to the stem with a minutely fibrillose edge. The gills are close to each other. The stipe is cylindrical and white. It is about 7 cm long with a diameter of 0.2 -0.4 cm and is stuffed inside. On the upper stipe are rings of firm, recurved scales tipped with volva material. The flesh is white, stuffed and soft. The hyphae is transparent with septa, diameter 4-5  $\mu\text{m}$ . The spores have two clear rings. They are nearly spherical or elliptical, measure 6-8 x 8-12  $\mu\text{m}$ . The spores are in amyloid. Germinating pores are about 15 – 20° deviated. The spores are ubiquitous in the basidium (Figure 2(6). Figure 3(6)).



Biology, ecology: grow in clusters, coordinates: N12<sup>o</sup>24.301'; E108<sup>o</sup>23151', temperature: ~19.5<sup>o</sup>C, altitude: about 1700 m, moisture: relatively high, about 93%, complicated differentiated topography, thick litter.

Distribution: mainly in coniferous forests

Present value: toxic and dangerous to human

***Amanita flavoconia* (G.F. Atk. 1902)**

The fruit body of *A. flavoconia* is bell-like, yellow, smooth and slippery when young. The cap is about 3 – 6.3 cm wide and is concave in age. The center of the cap is dark grey. There are scattered grey patches from the center to the margin of the cap. The skin of the cap is sticky and slimy when young or wet. The fruit body is about 3 mm thick. The margin is lined.

The gills are white cream and curved to the stem with deep grooves. The thin gills are packed close together. The stem is cylindrical, yellow, slimy and slippery. The skin is easily unattached from the stem when being affected by the environment or when collecting. The stem is about 4.5 – 10.5 cm long, with a diameter of 0.3 – 1.1 cm and is tapering upward from a small rounded bulb at the base. The base is less yellow than the stem but still yellow. The stem has a membranous cream skirt-like ring. The ring sometimes has yellow volval fragments on its underside, 1.8 – 2 cm long. The flesh is white, soft, thin and easily unattached from the gills. The thickness of the cap flesh is 0.25 – 0.45 cm. The hyphae is transparent with septa, diameter 3-5  $\mu$ m. The spores are spherical or elliptical, have dimensions of 5-7 x 8-10  $\mu$ m and are amyloid. Germinating pores are 15 – 20<sup>o</sup> (Figure 2(7) & Figure 3(7)).

Biology, ecology: appear in the beginning of rainy seasons, grow alone or gregariously. Coordinates: N 12<sup>o</sup>23.151'; E 108<sup>o</sup>20.343'; altitude: 630 m; moisture: 86%, medium slope, thickness of litter about 0.3, mainly composed of pine leaves and nuts.

Distribution: in pine forests, on greensward and under shrubs.

Present value: toxic and dangerous to human

***Amanita levistriata* (D.T. Jenkins 1988)**

The cap is a yellow hemisphere at first. At maturity, the cap is 2.2 -3.7 cm wide, convex and becomes concave in age. The center of the cap is dark grey. There are grey and brown patches scattering from the center to the margin. The skin of the cap is not smooth when young. The fruit body is about 0.3 – 0.4 cm thick. The margin is not lined when young but lined in age. The gills are olive yellow or cream, curved to the stem and have deep grooves. The gills are closely packed together. The stem cylindrical and pale yellow or cream. The stem is 2.9 – 6.5 cm, diameter 0.4 – 0.5 cm with fuzz on the base and is stuffed inside. On the upper stem is the typical ring which is dingy cream. The ring is membranous, skirt-like, thick-margined and is distant from the gills. This is the remnant of the volva. The base is bulblike, covers around the stem in a turnip shape. The flesh is white, stuffed and soft. The hyphae is transparent, with a diameter 3-4  $\mu$ m. The spores are nearly spherical or elliptical, measure 5-7 x 8-10  $\mu$ m. They are in amyloid. Germinating pores are 10-15<sup>o</sup> (Figure 2(8) & Figure 3(8)).

Biology, ecology: grow alone, best in rainy seasons. Coordinates: N12<sup>o</sup>25.811'; E 108<sup>o</sup>19.613'; altitude: 890 m, moisture: 86.2%, medium slope, thickness of litter is 0.5 cm, composed mainly of pine leaves and nuts.

Distribution: mainly in pine forests

Present value: toxic and dangerous to human

***Amanita multisquamosa* (Peck 1901)**

At first, the cap has a convex shape and is white with a basal bulb. At maturity, the cap is about 3 -11 cm wide, hemispherical, flat or concave. The cap of *A. multisquamosa* is tan. The center is brow and paler to the margin. The skin is smooth, shiny with white warts scattering above. The fruit body extrudes out of the stem. The gills are cream and are curved to the stem with shallow grooves. The stem is cylindrical and pale yellow. Its length is about 3.5 -13 cm and diameter about 0.3 – 1.2 cm with a basal, spongy and smooth bulb. There are white scales covering the stem and the stem is hollow and tapering to apex. There is a high, skirt-like, whitish ring, distant from the gills, which are the remnants of the volva.

The basal bulb has a pinched-off bottom and features an adherent white volva that fold over to form a collar-like rim on the upper edge of the bulb. It measures 2 cm. The flesh is white and soft. The hyphae is transparent with no septa, diameter 4-5  $\mu$ m. The spores are elongated eclipse, measure 5-8 x 9-12  $\mu$ m and are in amyloid. Germinating pores are 20-25<sup>o</sup> (Figure 2(9), Figure 3(9)).



Biology, ecology: appear in the beginning of rainy seasons, live symbiotically with coniferous or broad-leaved trees. The fungus usually grows in dry, sunny places, coordinates: N12<sup>o</sup>25.578'; E 108<sup>o</sup>21.692'; altitude: 900 m, moisture: 85.9%, medium slope, thickness of litter about 0.4 cm, composed mainly of pine leaves and nuts.

Distribution: mainly in pine forests and semi-evergreen forests

Present value: toxic and dangerous to human

***Amanita pantherina* (D.T. Jenkins 1977)**

The cap has a diameter of 3 – 12 cm, convex or flat and sticky. From the center to the margin brown color become paler to brown-yellow or yellow. The cap is adorned with white warts. The flesh extrudes from the stem about 5 mm. The margin is clearly lined. The gills are free from the stem, crowded and white. The stem is white, somewhat scaly or fairly bald, tapering upward and ending in a basal bulb. The stem is 4 – 20 cm long, with a diameter of 2 – 4 cm, swollen at the base, hollow inside. In the upper part of the stem is a skirt-like, whitish ring and concentric rings of volval material. The flesh is white to yellowish, not discoloring on exposure. The hyphae is yellowish, with a diameter of 4-6 µm. The spores are oval or egg-like, measure 6-8 x 8-10 µm and are in amyloid. Germinating pores are about 20-25<sup>o</sup> deviated (Figure 2(10) & Figure 2(11)).

Biology, ecology: appear in the beginning of rainy seasons. Live symbiotically with coniferous trees. Grow alone, scattered or in groups. Occur in summer and fall, coordinates: N 12<sup>o</sup>22.160'; E 108<sup>o</sup>20.236'; altitude: 800 m; temperature: 22<sup>o</sup>C, moisture: 85%, slope topography, thin litter about 0.3 cm, less amount of litter.

Distribution: mainly in pine forests

Present value: toxic and dangerous to human

***Amanita phalloides* (Fr.) Secr. 1833**

The cap is bell-like at first, becomes broadly convex in age with a diameter of 3 -15 cm. Its color ranges from grey to brown-grey. *A. phalloides*'s cap margin is lined, sticky when wet, shiny when dry. The margin is torn when old. The stem is long and round, diameter 1-2 cm, 6-14 cm tall, swollen 3-4 cm at the bottom. At maturity, the stem is hollow inside. The outside of the stem is scaly. The ring is white, skirt-like, persistent and slightly striate. The gills are free from the stem, thin, white and are close to each other. The flesh is white, soft when young, a little spongy when mature. The fungus has no distinct odor. The hyphae is yellowish, diameter 3-4 µm. The spores are oval or egg-like, measure 6-8 x 8-10 µm. Germinating pores are 15-20<sup>o</sup> deviated (Figure 2(11) & Figure 3(11)).

Biology, ecology: grow alone or in groups. Occur in summer and fall, on wet spongy soil, coordinates: N 12<sup>o</sup>17.89'; E 108<sup>o</sup>25.65', altitude: about 1100 m, temperature: 22<sup>o</sup>C, moisture: 87%, slope topography, thick litter, high amounts of litter.

Distribution: in broad-leaved forests, on greensward and in coniferous forests.

Present value: toxic and dangerous to human and animals

***Amanita pilosella* (Corner & Bas 1962)**

The cap appears when the fungus is still young. At maturity, the cap is about 2.5 – 7 cm, convex to plane, or somewhat concave, sometimes slightly umbonate, dry, umber, fuliginous or grayish brown, paler on expansion. The skin of the cap is smooth, bald and flat, with white scales scattering around, concentrating in the center. The margin is lined. The gills are white with shallow grooves. The stem is white, brown or grey. Its length is about 4-11 cm, diameter about 0.35 -0.6 cm. The stem is swollen at base and is solid inside. On the upper part of the stem is the typical white ring. At the base of the mushroom are shaggy rings which are the remnants of volva. The flesh is white and soft and can be easily separated from the gills. The hyphae is greenish with a diameter of 4-6 µm. The spores are round or elongated elliptical, measure 7-9 x 10-12 µm. The spores are in amyloid. Germinating pores are 25-30<sup>o</sup>. The spores are ubiquitous in the basidium; therefore, we can easily find them (Figure 2(12) & Figure 3(12)).

Biology, ecology: usually appear in the beginning of rainy seasons. Coordinates: N12<sup>o</sup>25.601; E 108<sup>o</sup>22.445, altitude: 780 m, moisture 86%, medium slope, thickness of litter about 0.4 cm, composed mainly of pine leaves and nuts.

Distribution: in pine forests and semi-evergreen forests

Present value: this toxic fungal species can cause harm to human





***Amanita solitaria* (sensu NCL 1960)**

At first, the fungus is globose. The basidio carp is artichoke-like. The fruit body inside the basidio carp is white. When the fruit body extrudes out of the basidiocarp, it has the shape of a bowl. At maturity, the cap of *A. solitaria* is 5 -16 cm wide, is convex at first and become plano-convex to flat with a slightly depressed center. The cap is cream to pale brownish grey with scattered grey or black-white patches from the center to the margin. The fruit body is thick. The margin is lined. The gills are white, pale yellow or cream and are curved to the stem with deep grooves. The stem is cylindrical, white, sometimes has a few shades of purple. Its length is about 6 – 14 cm, diameter 1.5 – 2.5 cm. The stem ends with a stuffed bulbous base and is hairy above the typical ivory ring. The rings are made up of upturned scales towards the base and are distant from the gills. These are the remnants of the universal veil which covers the mushroom in its earliest stages. The flesh is white, cream, stuffed and soft, can be easily separated from the gills. The hyphae is transparent with septa, diameter 4-5  $\mu\text{m}$ . The spores broadly ellipsoid to elongate, measure 6-9 x 8-11  $\mu\text{m}$  and are amyloid. Germinating pores are 15 – 22° deviated (Figure 2(13) & Figure 3(13)).

Biology, ecology: grow in dry places, usually appear in the beginning of rainy seasons. Coordinates: N12°26.701; E 108°20.445, altitude 780 m, moisture 86%, medium slope, thickness of litter about 0.3 – 0.5 cm, composed mainly of pine leaves and nuts.

Distribution: mainly in pine forests, greensward and shrubs.

Present value: toxic and dangerous to human.

***Amanita subcokeri***

At maturity, the cap of *A. subcokeri* is 7.1 – 13.7 cm wide has the shape of a convex. The cap is white, spherical, then become bell-like. The skin of the cap is grey-brown and is brown-black at the center. The edge of the cap is decurved to incurved and is usually thin and flat. This species tends to be especially moveable in wet weather, sometimes sliding off the cap in groups. They are not easily removed when the mushroom is dry. There are scattered grey warts from the center to the margin. The skin of the cap is easily unattached from the flesh. The gills are soft, cream, close to each other and are straight to the stem with shallow grooves. There are about 12 gills on 1 mm. The stem is cylindrical, dingy white with a diameter of 0.7 – 1.5 cm and is swollen at base with remnants of shaggy rings. Right beneath the cap is a curtain-like extension of the cap's skin which is grey, white or cream. The bulbous base is white with white rings decorated by thin, wavy margins. The flesh is white and soft. The spores are round or ellipsoid, measure 6-8 x 9-11  $\mu\text{m}$  and are amyloid. Germinating pores are about 30° deviated. The spores are easily found in the basidium because they are stacked together (Figure 2 (14) & Figure 3(14)).

Biology, ecology: appear in the beginning of rainy seasons. Grow in dry sunny places, coordinates: N12°24.209; E 108°23.120, altitude 780 m, moisture 86%, medium slope, thickness of litter about 0.3 – 0.5 cm, composed mainly of pine nuts and leaves.

Distribution: in pine forests and semi-evergreen forests

Present value: toxic and dangerous to human

***Amanita vaginata* (Bull. Lam. 1783)**

The fruit body has a clear cap and lined margin. The gills are white, free. The stem is long with a sack-like base. The cap is 3 – 9 cm wide, oval at first, then as it matures it becomes progressively conical, convex and eventually flattened, sometimes with a small umbo. The cap is grey to greyish-brown. The margin is prominently lined or grooved. The volva is present as more or less membranous patches on the cap. The cap's skin is smooth, sticky when young, shiny and bald when dry and sunny. The gills are free, crowded, close to each other and is always white. The stem is tinged with the cap color, sometimes paler, easily broken, and tapering upward. The stipe is stuffed at first and becomes hollow as the fruit body matures. The stem can be smooth, bald with a few white or greyish scales. The base enclosed in a sack-like, white volva that fits loosely and sometimes discolors greyish or reddish brown. The stem measures 8-15 x 0.5-2.5 cm. The flesh is white, watery, easily crushed, has no distinct odor, sweet taste. The basidium is mace-like, carrying four spore-bearing structures. The spores are broadly ellipsoid to roughly spherical, bald, non-amyloid; measure 8-12  $\mu\text{m}$ . The hyphae has septa, no locks, diameter 2.5 – 5.5  $\mu\text{m}$ . The membranous scales on the stem are made up of large fibers (diameter 5 -10  $\mu\text{m}$ ) with very few or no septa (Figure 2(15) & Figure 3(15)).



Biology, ecology: occur from June to September, on dry, sunny lands. Grow alone, coordinates: N12<sup>o</sup>24.301'; E108<sup>o</sup>23151', temperature about 19.5<sup>o</sup>C, altitude about 1700 m, moisture relatively high about 93%, complicated differentiated topography; thick litter.

Distribution: mainly in coniferous forests.

Present value: toxic, dangerous to human and animals.

## 5. Discussion

After collection and investigation, 15 *Amanita* species in Chu Yang Sin national park were identified. We found out that species of *Amanita* in Chu Yang Sin national park are quite more diverse, comparing to several other researches in Central Highlands of Vietnam such as Dung [12] who identified six poisonous *Amanita* species and Hien et al. [13] reported to determined eight poisonous *Amanita* species in Nam Ka reservoir, Daklak province. This proves that Chu Yang Sin national park has higher numbers of *Amanita* species than the previous reports. As the result shown in this study, eight *Amanita* species can be added to the list of predominant fungal species in Central Highlands, Vietnam, including: *Amanita abrupta*, *Amanita amanitoides*, *Amanita concentrica*, *Amanita flavoconia*, *Amanita levistriata*, *Amanita multisquamosa*, *Amanita pilosella*, *Amanita solitaria*.

Throughout the investigation period, it can be observed clearly that most of *Amanita* species usually grown and developed in areas with high moisture (> 85%), at altitude from 800 – 1200 m above sea level, occur from June to November and are saprotrophic on soil, under tree shades, especially coniferous, semi-evergreen trees and on greensward or shrubs. This study may provide useful information in *Amanita* species for further study in this country.

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## References

- [1]. Chen, L., Nicholas, H.O. (2005). The most widely recognized mushroom: chemistry of the genus *Amanita*. Life Science, 78:532-538.
- [2]. Vetter, J. (1997). Toxins of *Amanita phalloides*. Toxicon, 36(1): 13-24.
- [3]. Horowitz, B.Z., Gossman, G.W. (2017). Toxicity, mushroom, Amatoxin. Treasure Island (FL): StatPearls Publishing.
- [4]. Santi, L., Maggioli, C., Mastroroberto, M., Tufoni, M., Napoli, L., Caraceni, P. (2012). Acute liver failure caused by *Amanita phalloides* poisoning. International Journal of Hepatology. Article ID: 487480, 6 pages.
- [5]. Ryvarden .L, (1991), Genera of Polypores: Nomenclature and Taxonomy, Fungiflora, Oslo.
- [6]. Singer R. (1986) The Agaricales in modern Taxonomy K. Sc. Books.
- [7]. Poliwoda, A., Zielinska, K., Halama, M., Wieczorek, P.P. (2014). Determination of muscimol and ibotenic acid in mushrooms of Amanitaceae by capillary electrophoresis. Electrophoresis, 35: 2593-2599.
- [8]. Kiet, T.T. (2012) Macro-fungi in Vietnam, vol 1, Hanoi- Agriculture Publishing (in Vietnamese).
- [9]. Nguyen, V.T (1985), Central highland – the natural climate and nature resouces. Hanoi, Science and Technology Publisher (in Vietnamese).
- [10]. Teng (1964), Fungi, China (Zhong Guo De Zhen Jun).
- [11]. Jiri Baier (1991), Mushroom & Toadstools, Bohumil Vancura – Slovakia , pp1-184.
- [12]. Dung, L.B. (2003). Macro- Fungi in central highland of Vietnam. Hanoi- Scientific Techology Publishing (in Vietnamese).



- [13]. Hien, T.T.T., Thai, T.H., Dung, L.B., Nguyen, N.P.D. (2015). Diversity of species of Amanit in National Kon Ka, Gia Lai, Vietnam. 7<sup>th</sup>National proceeding of ecology and plant resources, Vietnam.