

An Investigation of the Family Ganodermataceae in the Yok Don National Park in the Central Highlands of Vietnam

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ABSTRACT: The Yok Don National Park, with an area of 115,545 ha, stretches from 12°45' -13°10' North latitude and from 107°29'30"-107°48'30" East longitude. The ecosystem is diverse, with six different zones, each with abundant fauna, flora and fungi. The conditions are ideal for the development of the Ganodermataceae Donk family. The survey at Yok Don revealed 12 species which belong to Ganodermataceae Donk: *Ganoderma lucidum* (Curtis) P. Karst. 1881, *Ganoderma applanatum* (Pers.) Pat. 1887, *Ganoderma multiplicatum* (Mont.) Pat. 1889, *Ganoderma oroflavum* (Lloyd) C.J. Humphrey 1931, *Ganoderma steyaertanum* B.J. Sm. & Sivasith. 2003, *Ganoderma gibbosum* (Blume & T. Nees) Pat. 1897, *Ganoderma tropicum* (Jungh.) Bres. 1910, *Ganoderma* sp.1, *Amauroderma niger* (Lloyd).1919., *Amauroderma subresinosum* (Murrill) Corner 1983, *Amauroderma rugosum* (Blume & T. Nees) Torrend 1920, *Amauroderma* sp.1. Four species are used for medicinal purposes: *Ganoderma lucidum*, *Ganoderma applanatum*, *Ganoderma tropicum*, and *Amauroderma niger*. Most species of the Ganodermataceae Donk family are saprophytic, and some are parasite on either living or dead wood.

KEY WORDS: Ganodermataceae, *Ganoderma*, *Amauroderma*, Yok Don National Park, Viet Nam.

INTRODUCTION

The Ganodermataceae Donk is saprophytic or parasite on wood or plant remains, and plays a crucial role in the natural cycling of forest materials. Some are used for food and valuable medicine.

Worldwide research on mushrooms in general, and on the Ganodermataceae Donk family in particular, has been carried out by many

authors: Iarevskii (1913), Kuhner (1953), Khincova (1986), Vuledzani (2009), in study in Pretoria, South Africa, presented and analyzed some characteristics of the natural morphology of some species belonged to genus *Ganoderma* and used molecular biology as a standard to classify species of the genus *Ganoderma*. Bhosle *et al.* (2010) specifically described and constructed a classification key for 18 species of the genus *Ganoderma* in some Western parts of Maharashtra (India). Alcindo

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Da *et al.* (2011) studied two families in Pará-Brazil: Ganodermataceae and Hymenochaetaceae. They specifically described three species: *G. australe*, *G. multiplicatum* and *G. stipitatum* among the 10 species investigated. Few studies have been done in Vietnam. Trinh Tam (1980), Le Ba (2003), Le Xuan (2005), and Ngo (2007) mainly focused on the medical value of some species of the Ganodermataceae family. Research has often been focused on nutritional value, but there has been no systematic study or the construction of a classification key for the Ganodermataceae family.

Natural conditions

There are many National Parks and Natural Reserves in the Central Highlands of Vietnam, including Chu Yang Sin, Yok Don, Kon Ka Kinh, and Chu Mom Ray. The Yok Don National Park with an area of 115,545 ha is located within the administrative boundaries of Dak Lak province. It was established by decision 39/2002/QĐ-TTg of the Prime Minister. The park stretches from 12° 45' to 13° 10' North latitude and from 107° 29' 30" to 107° 48' 30" East longitude.

Yok Don National Park is located in the Mekong River Basin with Serepok as the tributary river flowing through the Park. Its length is about 60 km. The National Park has a tropical monsoon climate. The rainy season is from April to October with the average rainfall of about 1,588 mm, which is 93.5% of the annual

rainfall. The dry season is from November to March. Dry season rainfall is insignificant, and there is often drought by the end of the dry season. The average temperature is 25.5°C (the highest is 29.5°C, the lowest is 15°C), and the average humidity is 82%.

The Yok Don ecosystem is very diverse with six different forest types: evergreen tropical rain forest, deciduous tropical forest, semi-deciduous tropical forest, mixed bamboo forest, shrub land and grassland. This ecosystem diversity has led to the variety of the fauna, flora and fungi. According to published statistics, the flora includes 566 species which belong to 108 families and 209 genera. The fauna includes 74 mammals, 245 birds, 48 reptiles, 16 amphibians, 78 fish species and 65 species of butterfly. Fungi have not been studied or listed and may include many species listed as threatened globally. The conditions in the central highlands are very advantageous for the development of fungi in general, and Ganodermataceae Donk, in particular.

MATERIALS AND METHODS

Sampling

The sampling and sample analysis were conducted by following the methods of Teng (1964), Trinh Tam (1981), Singer (1986) and Ryvardeen (1991).

The samples were collected in the wild. All the characteristics including colour, the morphology of the basidiocarp, context and way of growth (clusters or separate bases), were recorded and photographs were taken.

Sample Analysis and Identification

Analysis of biological and ecological characteristics

The description of external morphological characteristics, and microscopic analysis, was done in the laboratory of the Biology Department, Tay Nguyen University, Vietnam.

The microscopic analysis of spores, hymenium, mycelium and basidium, was carried out with a loupe, a light microscope with magnifications of x400 to x1000, and a scanning electron microscope at the Institute of Hygiene and Epidemiology.

Species Identification

Specimens were identified by the method of morphological comparison following Furtado (1962), Teng (1964), Steyaert (1972), 1980), Perreau (1973). Ryvarden (1991,

2000), Singer (1986), Trinh Tam (1981), Vinicius (2009) and Bhosle (2010).

RESULTS

After analysis and classification we have identified 12 species in the Yok Don National Park that belong to Ganodermataceae.

The characteristics of the Ganodermataceae Donk family

The species composition of this family is rather diverse.

Basidiocarp: thick, with a cap, and pedunculate. The stalk is often lateral or sessile. The cap is brightly coloured in shades of red, brown, red/brown, or gray.

The spores have two layers: the outer layer is smooth, the inner layer is slightly thorny and is the colour of rust.

Most fungi which belong to Ganodermataceae grow from May to December each year, some are perennial. They grow in clusters or have separate bases on living wood or plant remains.

Identification Keys

Species belonging to the Ganodermataceae family often have woody fruiting bodies, rarely with a tough derm. They are saprophytic on wood and are rarely parasitic. The Basidiocarp has a cap that may be sessile or pedunculate. The stem is lateral or central, brown or black/brown. The outer crust of the basidiocarp is often thick and polished. The spore membrane has two layers, the outer layer is smooth, the inner layer is slightly thorny.

1A. The basidiocarp often has a smooth bright crust. The spore has two layers of crust, is ovoid in shape and indented at one end-

..... Genus *Ganoderma*

1B. The basidiocarp often has a hard crust and is unpolished. The spore has two layers of crust, is ovoid shape and not indented-

..... Genus *Amauroderma*

Table 1. List of the family Ganodermataceae Donk in the Yok Don National Park – Vietnam. Evergreen forest (EF), Semi-deciduous forest (SDF), Deciduous forest (DF); Unknown (Unk), Medicinal (M).

Ord	Species names	Forest Type			Remark
		EF	SDF	DF	
1	<i>Ganoderma lucidum</i> (Curtis) P. Karst. 1881	7	2		M
2	<i>Ganoderma applanatum</i> (Pers.) Pat. 1887	5	3		M
3	<i>Ganoderma multiplicatum</i> (Mont.) Pat. 1889		2	2	Unk
4	<i>Ganoderma oroflavum</i> (Lloyd) C.J. Humphrey 1931	1		1	Unk
5	<i>Ganoderma steyaertanum</i> B.J. Sm. & Sivasith. 2003		2		Unk
6	<i>Ganoderma gibbosum</i> (Blume & T. Nees) Pat. 1897	2	3		Unk
7	<i>Ganoderma tropicum</i> (Jungh.) Bres. 1910	4	1	2	M
8	<i>Ganoderma</i> sp.	2	1		Unk
9	<i>Amauroderma niger</i> (Lloyd)	6	2	4	M
10	<i>Amauroderma subresinosum</i> (Murrill) Corner 1983	2	1		Unk
11	<i>Amauroderma rugosum</i> (Blume & T. Nees) Torrend 1920	3	5	6	Unk
12	<i>Amauroderma</i> sp.	2	1	2	Unk

Species descriptions

1. *Ganoderma lucidum* (Curtis) P.

Karst, 1881

Figs. 1 & 13

Basidiocarp (Fig. 1): red or red-brown, 2-2.5 x 3-20 cm, 0.5-1.5 cm thick. Pileus: a round lump when immature, kidney-shaped at maturity. Upper surface: concentric circles and radiating ridges with red/yellow, brown, red/brown, pink/brown, bright shiny skin. Margin: thin to slightly obtuse, waved, lobate. Context: corky, white when immature, changing to light yellow, yellow/brown, homogeneous tissue with no

stratification. Hymenium: small tubes, 4-5 or 6 tubes/mm, 0.2-0.7 cm deep. Tube rim: circular, white when young, light yellow when older. Stalk: long or short, sometimes sessile, attached to the concave side of the cap, the same color as the pileus or polished crust, cylindrical or slightly flattened, 0.5-1.5(2) x 3-17 cm. The tissue of the stem and the cap is homogeneous. Basidia: Unicellular, short claviform type, 7-10 x 12-14 μ m, the membrane is a thin layer, colourless and transparent cytoplasm, each basidium has 3-4 sterigmata

bearing spores. Spore: ovoid, indented at one end, 5.0-6.5 x 8.5-11.5 μm (Fig. 13); the membrane has two layers, the outer is smooth and colorless, the inner: is slightly thorny and rust brown.

It grows well on artificial culture medium (PGA), on the living and/or dead trunks of many timber species, and has been commonly found on legume species. This species has a wide distribution in the Central highlands and causes wood to rot in brown bars.

G. lucidum is cultured by its commercial value in traditional medicine of many countries in the world such as China, Thailand, Japan, Korea, Russia, and Viet Nam.

2. *Ganoderma applanatum* (Pers.)

Pat, 1887

Figs. 2 & 14

Basidiocarp (Fig. 2): grey/brown or brown, unpolished, 18-20 x 28-30 cm, 0.5-2.0 cm thick. Pileus: a round lump at an early age and fan shaped at maturity. Upper surface: concentric circles and radiating ridges. Margin: obtuse, waved and lobate. The surface grows into many layers, gray or light gray, with a rough surface. Context: corky, white at an early age, gray/brown at maturity with homogeneous tissue and no stratification. Hymenium: small tubes with 4-6 tubes/mm, 0.2-1.0cm deep. Tube rim: circular, white when young, dark

yellow or light brown when older. Stalk: Sessile with a separate base, dimitic system including skeletal hyphae and binding hyphae, 2.0-7.0 μm . Thick membrane, cytoplasm almost transparent. Hyphae system: white at the beginning on agar cultural medium (pure medium), then changing to light yellow. Basidia: unicellular, clavate, 7-10x12-14 μ . The membrane is a thin layer, colorless and transparent cytoplasm, each basidium has 3-4 sterigmas bearing spores. Spore: ovoid, indented at one end, 4.0-6.5 x 7.0-9.0 μm (Fig. 14). The membrane has two layers, the outer is smooth and colourless, the inner is slightly thorny, and rust brown.

It grows well on artificial culture medium (PGA), on the living and/or dead trunks of many timber species, and is commonly found on legume species (*Erythrophleum fordii*, *Peltophorum dasyrhachis*, and *Delonix regia* etc.). It is widely distributed in the Central Highlands of Viet Nam. and causes wood rot with a brown colour.

G. applanatum is well known in traditional medicine and is used as a food source.

3. *Ganoderma multiplicatum*

(Mont.) Pat, 1889 Figs. 13&15a-b

Basidiocarp (Fig. 13): grayish-brown, 9-11 x 15-17 cm, 1.5-3.5 cm thick.

Pileus: a round white lump when young changing to become fan shaped. Upper surface: concentric circles with no radiating ridges. Margin: obtuse, lobate (each lobe: 5-6 cm) and not wavy. Surface: not flat, rough, rugged and brown. Context: corky, 0.4-0.5 cm thick, heterogeneous tissue, clear stratification (2-3 layers), blackish-brown, changing to black under NaOH treatment. Hymenium: small tubes, one layer, the tube layer surface is not flat, 4-5 tubes/mm, 1.0-1.5 cm deep. Tube mouth: polygonal or circular, dull white when young, rapeseed yellow when older. Hymenium surface: light yellow/white. Sessile, saprophytic on rotten wood, causing red/brown wood rot. Hyphae system: dimitic including skeletal hyphae and binding hyphae, 3-4 μm , thick membrane, light yellow cytoplasm. On the agar cultural medium, the hyphae is white in color initially, then changes to yellow. Basidia: unicellular, clavate, 7-11 μm . The membrane is a thin layer, with transparent and colorless cytoplasm. Each basidia has 3-4 sterigmas bearing spores. Spore: ovoid, indented at one end or oval, sometimes nearly circular, 4.0-6.0 x 6.5-9.0 μm (Figs 15a-b); membrane has two layers, the outer is smooth and colorless: the inner layer has some horns. The cytoplasm is a rust brown color.

Grows well on artificial culture medium (PGA). It often appears from May to December in the Central Highlands. It is highly destructive of the wood on which it grows.

4. *Ganoderma oroflavum* (Lloyd)

C.J. Humphrey, 1931 Figs. 4&16

Basidiocarp (Fig. 4): reddish brown or soil-brown, 14-15 x 28-30 cm, 2-3 cm thick. Pileus: a round white lump with a yellow rim at an early age, then changing to become fan shaped. Upper surface: rough, soil-brown, with concentric circles and radiating ridges. Margin: obtuse, waved and lobate (each lob is about 4-10 cm). Context: corky, white when young, changing to soil-brown in colour. The colour is stable under NaOH treatment. Hymenium: small tubes, 1.0-1.5cm deep, flat tube surface, dull white, 3-5 tubes/mm; Tube rim: white at an early age, changing to dull white when older, polygonal. Stalk: sessile, separate base, attached beside saprophytic fungi on rotten wood, causing white wood rot. Hyphae system: dimitic including skeletal hyphae and binding hyphae, 2-3 μm , thick layer, light yellow cytoplasm. On pure cultural medium, hyphae are white, changing to light yellow. Spore: ovoid, indented at one end, 6.0-8.0 x 10.0-12.0 μm (Fig. 16). Membrane has two layers, the outer is smooth and colourless, the inner is slightly thorny. The

cytoplasm is rust brown. Basidia: unicellular, short clavate, 7-12 μm , the membrane is a thin layer, transparent and colorless cytoplasm, each basidium has 3-4 sterigmas bearing spores.

It is used for medicine. It grows widely in the Central Highlands from May to December each year.

5. *Ganoderma steyaertanum* B.J. Sm. & Sivasith. 2003

Figs. 5 & 17a-b

Basidiocarp (Fig. 5): soil-yellow, 15-17 x 20-24 cm, 1-3cm thick. Pileus: a round lump at an early age then develops into a fan or kidney shape. Upper surface: clear concentric circles and radiating ridges. Margin: thin, waved, non-lobed. The pileus surface: rough, soil-yellow. Context: corky, light yellow when young, then changing to soil-yellow. The colour is stable colour under NaOH treatment. Hyphae: dimitic including non-septa hyphae and binding hyphae, 2-3 μm , thick membrane, light yellow cytoplasm. In pure culture, the hyphae is white, changing to carrot-yellow and dark brown when older.

Hymenium: small tubes type, multiple layers, each layer is about 0.5 cm thick, tube layer surface is flat, 6-8 tubes/mm, 0.5 cm deep. The tube rim: light yellow when young,

rapeseed-yellow when old, polygon. The hymenium surface is rapeseed yellow.

Spore: ovoid, indented on one side or oval, sometimes nearly round, 6.0-7.0 x 8.0-11.0 μm (Figs. 17a-b); the membrane has two layers: the outer is smooth, the inner is slightly thorny, rust brown cytoplasm. Basidia: unicellular, short clavate shape, 7-12 μm , the membrane is a thin layer, transparent and colorless cytoplasm; each basidium has 3-4 sterigmas bearing spores. Sessile, separate bases, lateral attachment, parasite (it lives by the way of decomposing wood for nutrition) on wood, causing brown rotten wood, perennial. It destroys wood and may cause the death of a tree. It grows well on artificial culture medium (PGA).

6. *Ganoderma gibbosum* (Blume & T. Nees) Pat. 1897 Figs. 6 & 18

Basidiocarp (Fig. 7): soil-brown, 14-16 x 26-28 cm, 2-3 cm thick. Pileus: a round lump at an early age, then develops into a fan shape. Upper surface: no concentric circles with non-radiating ridges. Margin: obtuse, waved and lobed (each lobe: 4-5 cm). The pileus surface is rough, soil-brown. Context: corky, white when young, then changing to dark brown, heterogeneous tissue, no stratification, changing to green under NaOH treatment.

Hyphae: dimitic including non-septa hyphae and binding hyphae, 2-4 μm , thick membrane, light yellow cytoplasm. In pure culture, the hyphae is white at the beginning, then changes to light yellow. Hymenium: small tube type, tube layer surface is flat, 4-6 tubes/mm, 1.0-1.5 cm deep. The tube rim: white when young, dark yellow or light brown when old, polygonal. The hymenium surface is dark yellow. Spore: ovoid, indented at one end, 5.0-7.0 x 7.0-9.0 μm (Fig. 18). The membrane has two layers: the outer is smooth, the inner is slightly thorny. The outer rim of the cytoplasm is rust brown, the inner is blue. Basidia: unicellular, short clavate shape, 7-14 μm , the membrane is a thin layer, transparent and colorless cytoplasm; each basidium have 3-4 sterigmas bearing spores. Sessile, separate bases, lateral attachment, parasite on wood, causing white rotten wood.

It grows widely in many provinces of the Central Highlands, and destroys wood. It grows well on artificial culture medium (PGA).

7. *Ganoderma tropicum* (Jung.)

Bres. 1910 Figs. 7 & 19a-b

Basidiocarp (Fig. 7): dark red, 4.0-16.0 cm, 1.0-3.0 cm thick. Pileus: a white round lump with a red rim at an early age then develops into a fan or

circular shape. Upper surface: bright red or polished purple/red, concentric circles. Margin: obtuse, slightly waved and lobed (each lobe: 2-8 cm). Context: corky, 1.0-2.0 cm thick, white when young, changing to brown, with stable colour under NaOH treatment.

Hyphae: dimitic including non-septa hyphae and binding hyphae, 2-5 μm , thick membrane, light yellow cytoplasm. In pure culture, the hyphae is white at the beginning, then changes to light yellow. Hymenium: small tube type, tube layer surface is flat, 3-5 tubes/mm. The tube rim: white when young, yellow-brown when old, polygonal or oval. Spore: ovoid, indented at one end or oval, 4.0-6.0 x 6.0-8.0 μm (Figs 19a-b); the membrane has two layers: the outer is smooth, the inner is slightly thorny, rust brown cytoplasm. Basidia: unicellular, short clavate shape, 7-12 μm , the membrane is a thin layer, transparent and colourless cytoplasm. Each basidium has 3-4 sterigmas bearing spores. Pedunculate, lateral stalk, 3.0-7.0 cm long, lateral attachment, the stalk surface is polished and has the same color as the fruiting body or is darker. It grows in many provinces of the Central Highlands. It has medical value and is used in the a treatment of heart disease.

8. *Ganoderma* sp. Figs. 8 & 20

Basidiocarp (Fig.8): soil-brown, 4-6 x 5-7 cm, 0.5-0.7 cm thick. Pileus: a round white lump when young then develops into a fan shape. Upper surface: concentric circles and non-radiating ridges. Margin: obtuse, unwaved and not divided into lobes. The surface is not flat, with a soil-brown rim mixed with a black rim. Context: corky, 0.1-0.15 cm thick, homogeneous tissue with no stratification, soil-brown, becomes blue/black under NaOH treatment. Hymenium: small tubes, 0.3-0.4 cm deep, one layer, layer surface not flat. Tube rim: white when young, then changing to black, polygonal or circle. The hymenium surface: white when young and soil-brown when older, 4-6 tubes/mm, scattered. Stalk: pedunculate, short and slightly flat, 4-5cm, diameter about 1.5 cm, soil-brown, attached on one side of the cap, the stalk crust attaches tightly to the stalk's context. Causes wood to rot with a white colour, changing to light brown. Basidia: unicellular, short clavate shape, 7-12 μ m, membrane is a thin layer, colorless and transparent cytoplasm; each basidium has 3-4 sterigmas bearing spores. Spore: ovoid, indented at one end or oval, sometimes circular 5.0-7.0 x 7.0-9.0 μ m (Fig. 20). Membrane has two layers, the outer is smooth, the inner layer is slightly thorny, rust brown cytoplasm. It

grows from May to December each year, and is highly destructive of wood. It grows well on artificial culture medium (PGA).

Species description of genus *Amauroderma* (Pat.) Murr

9. *Amauroderma niger* (Lloyd)

Figs. 9 & 21

Basidiocarp (Fig. 9): dark brown to black/brown, dry with a black rim. Pileus: round, waved, diameter: 2.0-5.0 cm and 0.3-1.0 cm thick. The upper surface is rugose. The cap has many layers overlapped on each other with rugose grooves. Stalk: completed, ramification or not, centric, diameter: 1.0-4.0 cm. The stalk crust is hard, 0.2 x 6.0 mm thick, black/brown. Context: 1-5 mm thick, corky, black brown to black. Hymenium: tubes gray, 0.2-0.7 mm deep, 5-7 tubes/mm. Tube rim: white when moist, changing to black/brown when dry. Spore: globose or ellipsoidal, 4.0-7.0 x 8.0-10.0 μ m; rust colour, cytoplasm light brown (Fig. 21). Hyphae system: dimitic, 2.0-3.0 μ m. Basidia: unicellular, short clavate shape, 5-9 μ m, membrane is a thin layer, cytoplasm is colourless, transparent. It often grows in clusters, with a separate base on the remnants of plants on the ground, in the Central Highlands from May to December every year.

10. *Amauroderma subresinosum***Murr.****Figs. 10 & 22**

Basidiocarp (Fig. 10): bright black, 18-20 cm, 2-3 cm thick. Pileus: a round white lump when young, changing to fan shaped. Upper surface: rugose, concentric circles, no radiating ridges. Margin: obtuse, waved and lobate. Context: corky, 1-2 cm thick, white when young, changing to light yellow. The colour is stable under NaOH treatment. Hymenium: small tubes, 3-5 tubes/mm, 1.0-1.5 cm deep, flat tube surface. Tube rim: white when young, changing to dull white or rapeseed yellow when older, polygonal. Stalk: sessile, separate base, attaching beside satrophic mushrooms on rotten wood, causing white rot. Spore: ovoid, 9.0-12.0 x 14.0-16.0 μm (Fig. 22). The membrane has two layers, light yellow cytoplasm. Hyphae system: dimitic including skeletal hyphae and binding hyphae, 2-3 μm , thick membrane, light yellow cytoplasm. Basidia: unicellular, short clavate shape, 7-10 μm , membrane is a thin layer, transparent and colorless cytoplasm; each basidia has 2-4 sterigmas bearing spores. It grows separately in the Central Highlands, on wood, on the remnants of plants, or from beneath of the ground to the surface, from May to December each year.

11. *Amauroderma rugosum* (Blume & T. Nees) Torrend, 1920**Figs. 11 & 23**

Basidiocarp (Fig. 11): gray color with a bright black rim, 5.0-8.0 x 7-9 cm and is 1 cm thick. A round white lump with a black rim when young, changing to kidney or fan shape. Upper surface: rugose, concentric circles, radiating ridges. Margin: obtuse, waved and lobate. Stalk: completed, flat, 7-10 cm long, lateral. The stem crust is very hard and about 2 mm thick, gray. Context: corky, 1-3 mm thick, white to yellow. Hymenium: small tubes, 5-7 tubes/mm; tube rim: white when fresh, gradually changing to rapeseed yellow when dry, and black when handled. Spore: ovoid, 4.0-6.0 x 6.0-8.0 μm (Fig. 23), including two layers with dark yellow, rust brown cytoplasm. Hyphae system: dimitic including skeletal hyphae and binding hyphae, 2-3 μm , thick membrane, light green cytoplasm. Basidia: unicellular, short clavate shape, 7-10 μm , membrane is a thin layer, transparent and colourless cytoplasm; each basidia has 3-4 sterigmas bearing spores. It grows separately on the remnants of plants or from the ground in the Central Highlands from May to December each year. It grows very well on artificial culture medium.

12. *Amauroderma* sp. Figs. 12 & 24

Basidiocarp (Fig. 12): gray colour, completed stalk. Pileus: conical, diameter about 5-15 cm, 0.9-2.1 cm thick. Upper surface: rough, thin cover, gray/brown with smooth fur. The cap has many layers overlapping each other (each layer is about 1 year old), clear concentric zones and rugose grooves, concentric circles. Stalk: circular, thick, centric, hollow in the middle, 5-16 cm long, diameter: 0.8-1.8 cm. The stem crust is very hard and thick (about 2 mm) and is black/gray, smooth, and fur-like. Context: thin, corky, 3-4 mm thick, gray brown in color like the stalk context, very solid when dry. Hymenium: tubes, gray, 3-9 mm deep, 3-5 tubes/mm. Tube rim: light white or gray when fresh, changing to black/gray when dry. Spore: globose, rather large, diameter: 12.5-16.5 μm (Fig. 24); light yellow to light green, germ pore is just a convex nodule with diameter about 2.0-2.5 μm , thick membrane: 1-2 μm . The spore has two layers, the outer layer is smooth, the inner layer is slightly thorny and dark yellow. The cytoplasm has such fine grains that it's hard to see. Hyphae system: dimitic, 2.2-3.5 μm . Basidia: unicellular, short clavate shape, 7-12 μm . It grows separately under the forest canopy of the Central Highlands. It grows and develops very well on artificial culture medium. It is used for medicine.

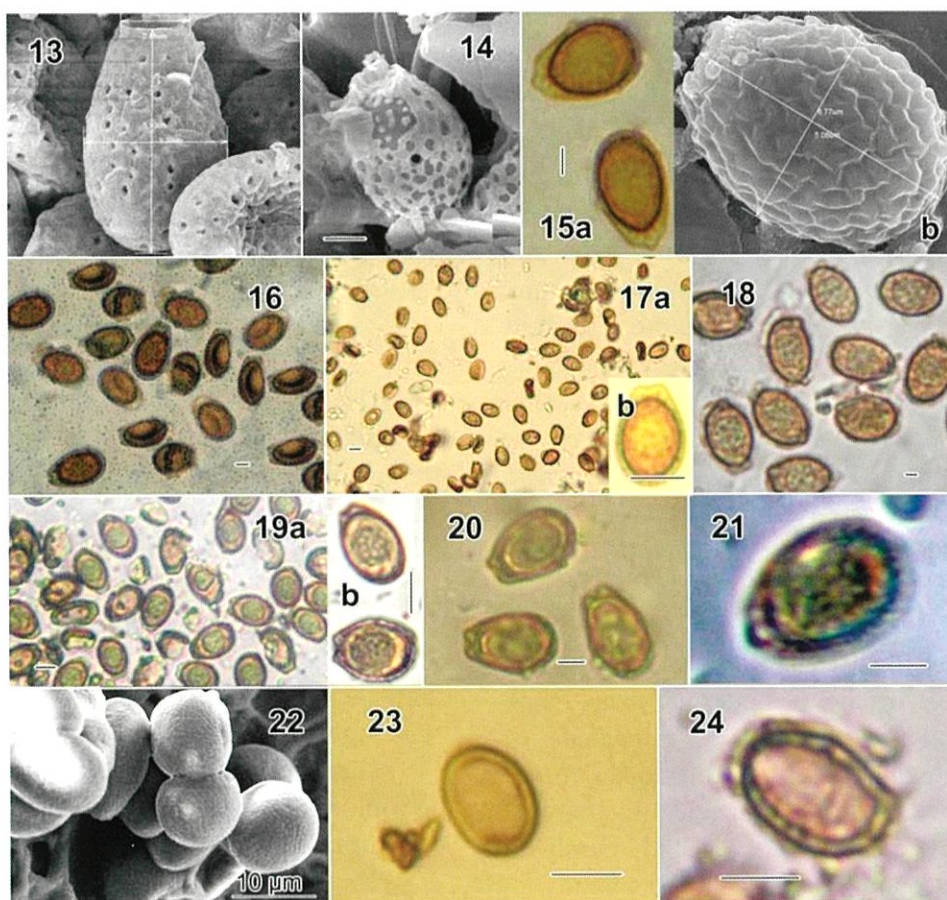
Twelve species have been identified. *Ganoderma lucidum* (Curtis) P. Karst. 1881, *Ganoderma applanatum* (Pers.) Pat. 1887, *Ganoderma multiplicatum* (Mont.) Pat. 1889, *Ganoderma oroflavum* (Lloyd) C.J. Humphrey 1931, *Ganoderma steyaertanum* B.J. Sm. & Sivasith. 2003, *Ganoderma gibbosum* (Blume & T. Nees) Pat. 1897, *Ganoderma tropicum* (Jungh.) Bres. 1910, *Ganoderma* sp., *Amauroderma niger* (Lloyd).1919, *Amauroderma subresinosum* (Murrill) Corner 1983, *Amauroderma rugosum* (Blume & T. Nees) Torrend 1920, *Amauroderma* sp. Twelve species were collected in the Yok Don National Park in the Central Highlands of Vietnam, in comparison with the 86 species of the Ganodermataceae Donk family collected in the North of Vietnam by Trinh Tam Kiet (2012), the 16 species found in Cat Tien National Park by Le Xuan Tham (2005), and the 13 species found by Le Ba Dung (2003) in Vietnam. There are four species newly recorded *Ganoderma steyaertanum* B.J. Sm. & Sivasith. 2003, *Ganoderma multiplicatum* (Mont.) Pat. 1889, *Amauroderma subresinosum* (Murrill) Corner 1983, and *Amauroderma rugosum* (Blume & T. Nees) Torrend 1920.

Since there had not been a previous study of the Ganodermataceae Donk family in the Central Highlands of

Vietnam, this study contributes to the knowledge of the species diversity of the Ganodermataceae Donk family in the Central Highlands of Vietnam.



Figures 1-12. Morphology of basidiocarps: 1. *Ganoderma lucidum* showing the crust cortex (a) and hymenium (b); 2. *G. applanatum*; 3. *G. multiplicatum*; 4. *G. oroflavum*; 5. *G. steyaertanum*; 6. *G. gibbosum*; 7. *G. tropicum*; 8. *Ganoderma* sp.; 9. *Amauroderma niger*; 10. *A. subresinosum*; 11. *A. rugosum*; 12. *Amauroderma* sp.; All scale bars = 2 cm.



Figures 13-24. Basidiospores: 13. *Ganoderma lucidum* (SEM); 14. *G. applanatum* (SEM); 15a&b. *G. multiplicatum* (Fig 15b. SEM); 16. *G. oroflavum*; 17a&b. *G. steyaertanum*; 18. *G. gibbosum*; 19a&b. *G. tropicum*; 20. *Ganoderma* sp.; 21. *Amauroderma niger*; 22. *A. subresinosum* (SEM); 23. *A. rugosum*; 24. *Amauroderma* sp.; All scale bars = 2 µm, exc. Fig. 22.

DISCUSSION

Twelve species have been identified. *Ganoderma lucidum* (Curtis) P. Karst. 1881, *Ganoderma applanatum* (Pers.) Pat. 1887, *Ganoderma multiplicatum* (Mont.) Pat. 1889, *Ganoderma oroflavum* (Lloyd) C.J. Humphrey 1931, *Ganoderma steyaertanum* B.J. Sm. & Sivasith. 2003,

Ganoderma gibbosum (Blume & T. Nees) Pat. 1897, *Ganoderma tropicum* (Jungh.) Bres. 1910, *Ganoderma* sp.1, *Amauroderma niger* (Lloyd).1919, *Amauroderma subresinosum* (Murrill) Corner 1983, *Amauroderma rugosum* (Blume & T. Nees) Torrend 1920, *Amauroderma* sp.1. Twelve species were collected in the Yok Don National Park in the

Central Highlands of Vietnam, in comparison with the 86 species of the Ganodermataceae Donk family collected in the North of Vietnam by Trinh Tam Kiet (2012), the 16 species found in Cat Tien National Park by Le Xuan Tham (2005), and the 13 species found by Le Ba Dung (2003) in Vietnam. There are four species newly recorded *Ganoderma steyaertanum* B.J. Sm. & Sivasith. 2003, *Ganoderma multiplicatum* (Mont.) Pat. 1889, *Amauroderma subresinosum* (Murrill) Corner 1983, and *Amauroderma rugosum* (Blume & T. Nees) Torrend 1920.

Since there had not been a previous study of the Ganodermataceae Donk family in the Central Highlands of Vietnam, this study contributes to the knowledge of the species diversity of the Ganodermataceae Donk family in the Central Highlands of Vietnam.

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