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Species Diversity Of Ganodermataceae Fungi In Yok Don National Park, Central Highlands Of Vietnam

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Abstract
Yok Don National Park, spanning 115,545 hectares and situated between 12°45'-13°10' north latitude and 107°29'30"-107°48'30" east longitude, hosts a richly diverse ecosystem comprising six distinct types. The propitious natural conditions within this region foster the flourishing of the Ganodermataceae family. A comprehensive survey within the Tay Nguyen region's Yok Don National Park revealed the presence of 10 species affiliated with the Ganodermataceae family. Remarkably, six species (Ganoderma balabacense, Ganoderma tornatum, Ganoderma multiplicatum, Amauroderma niger, Amauroderma subresinosum, and Amauroderma rugosum) were newly documented in the Tay Nguyen regions. Additionally, three species (Ganoderma multiplicatum, Amauroderma niger, and Amauroderma rugosum) were identified as novel macrofungi within Vietnam. Notably, Ganoderma lucidum, Ganoderma applanatum, and Amauroderma elmerianum among the species exhibit valuable medicinal properties. Predominantly saprophytic, the Ganodermataceae mushrooms thrive on decaying wood or plant debris beneath the forest canopy from May to December. Our findings may provide useful information to further analyze the roles of those species in this region.
Keywords: *Yok Don National Park, Macrofungi, Ganodermataceae mushrooms*

INTRODUCTION

Ganodermataceae is a group of fungi that live as saprophytes or parasites on wood or plant debris; therefore, they have important significance in the natural cycle. Some are used as valuable food and medicinal resources. Research on macrofungi in general and the Ganodermataceae in particular has been conducted by numerous authors worldwide. Iarevskii (1913) [22], Khincova et al. (1986) [23] focused on studying the fundamental characteristics of the Ganodermataceae mushroom family. Muthelo (2009) [26] investigated and described species belonging to the Ganodermataceae in South Africa. Bhosle S, Ranadive K et al. (2010) [15] studied the diversity of the Ganoderma genus in Maharashtra, India. Stéphane Welti and Courtecuisse Régis (2010) [45] surveyed the species composition of the Ganodermataceae family in the western region of France. Additionally, other authors such as Ryvarden L, Johansen I (1980, 1991, 2000) [34, 35, 36], Torres-Torres & Guzmán-Dávalos (2012) [47], Alcindo et al. (2011) [13], Stéphane & Régis (2010) [45], Bhosle et al. (2010) [15], Muthelo (2009) [26], Campacci & Gugliotta (2009) [14], Dong-Mei & Sheng-Hua et al. (2009) [17], Dine et al. (2008) [18], Zhou et al (2007) [48], Foroutan et al. (2007) [19], Fleischmann et al. (2007) [20], Loguercio-Leite et al. (2005) [25], Lai Tim et al. (2004) [24], Smith et al. (2003) [44], Ryvarden (1991, 2000, 2004) [33, 34, 35], Ryvarden & Johansen (1980) [36], Gottlieb et al. (1999) [21], Steyaer (1977, 1972, 1962) [38, 39, 40], Shaffer (1975) [37], Teng (1986) [46], Singer (1960, 1986) [41, 42], Pegler et al. (1973) [31], Bessey (1950) [16], Patouillard (1897, 1923, 1927, 1928) [27, 28, 29, 30] have contributed to the research on the diversity of the Ganodermataceae family in various countries. However, there have been very few authors who have studied the Ganodermataceae family in Vietnam.

Yok Don National Park is one of the largest special-use forests in Vietnam, located in the provinces of Dak Lak (including Krong Na commune in Buon Don district, Ea Bung and Chu M'Lanh communes in Ea Sup district) and Dak Nong (including Ea Po commune in Cu Jut district) of Vietnam. In Yok Don National Park, evergreen forests and semi-evergreen forests make up a very small proportion, while the predominant forest type is deciduous forests. This national park is the only one in Vietnam that conserves this type of deciduous forest. This area has a tropical monsoon climate with two distinct seasons. The rainy season occurs from May to November, while the dry season lasts from December to April. Yok Don National Park is situated within the coordinates of 12°45'-13°10' north latitude and 107°29'30"-107°48'30" east longitude. It is located in the

Mekong River basin, with the Srepok River running through the park for approximately 60 kilometers. The park is within a region characterized by a tropical monsoon climate. The rainy season, from May to November, accounts for 93.5% of the annual rainfall, with an average precipitation of 1.588mm. The dry season, from December to April, experiences negligible rainfall, particularly towards the end of the dry season. The average annual temperature is 25.5°C, with an average humidity of 82%.

The majestic forests within the deciduous forest ecosystem display the characteristic features of Southeast Asian tropical forests, with lush greenery and diverse vegetation, including valuable timber species such as agarwood, catechu, eaglewood, rosewood, and purpleheart. These natural conditions are highly favorable for the development of macrofungi in general and the Ganodermataceae in particular [4].

In Vietnam, there have been relatively few research studies on macrofungi, mainly focusing on the investigation of the medicinal value of the Ganodermataceae. Authors such as Trinh (2012) [9], Dung (2003) [7], Tham (2005, 2009) [11, 12], Anh (2007) [1], and Phan and Anh (2004) [6] have conducted research in this area. In addition, authors Nguyen and Kien have researched the diversity of the Ganodermataceae. Nguyen (2015) [3] studied on "Species diversity of the Ganoderma genus in Kon Ka Kinh National Park, Gia Lai" and identified at least 25 species of Ganoderma [30]. Nguyen et al (2013) [4] have also studied the ecological characteristics and distribution of the Ganodermataceae in the Central Highlands [4]. In 2019, Nguyen and Kien conducted an investigation on the composition of black Linhzhi (genus Amauroderma (pat.) Murill) in Chu Yang Sin National Park, Dak Lak, identifying and providing detailed descriptions for 9 species [5]. However, there has yet to be an author who has studied the diversity of the Ganodermataceae in the ecosystem of Yok Don National Park. Therefore, this research is a comprehensive study focusing on the diversity of the Ganodermataceae in Yok Don National Park from 2019 to 2023.

MATERIALS AND METHODS

Sampling

The collection and analysis of samples were conducted using the methods described by Teng (1964) [46], Trinh (2012) [9], Singer (1986) [41], and Ryvarden (1980, 1991, 2000) [34, 35, 36]. Sampling Period: From the previous May to February of the following year for the years 2019 to 2023. Principles of the method: Collecting specimens from different habitats within Yok Don National Park. Recording detailed information, including sampling locations, climate, temperature, humidity, elevation, forest types, and characteristics of the Ganodermataceae using appropriate equipment.

Sample Analysis and Identification

Analyzing biological and ecological characteristics and species identification

Analyzing microscopic and external morphological features in the laboratory of the Biology Department, Tay Nguyen University. Microscopic analysis: fungal spore, mycelium, spore morphology, etc., using an Olympus microscope (Japan), a scanning electron microscope S-4800 (Hitachi), and an Olympus magnifying glass (Japan) at the electron microscopy and ultrastructural imaging room of the Central Institute of Epidemiology. The mushroom samples were collected and identified using a comparative morphological approach based on the original references of Furtado Teng (1964) [46], Ryvarden L (1991, 2000) [34, 35], Singer (1986) [41], Kiet (2012) [9], Campacci and Silva (2009) [14], Bhosle (2010) [15], and Pegler (1973) [31].

Total DNA Extraction

In this study, we use the extraction method with CTAB with some minor modifications to extract DNA of the samples. In brief, prepare a CTAB extraction buffer solution at 60°C. Grind 0.3 grams of the mushroom sample into a fine powder using a sterile porcelain mortar and pestle in liquid nitrogen (previously kept at -80°C). Dissolve the finely ground sample in 800 µl of CTAB buffer and 60 µl of 10% SDS. The composition of the extraction buffer solution includes 100 mM Tris base, 20 mM EDTA, 1.4 M NaCl, and 2% CTAB. Incubated the sample at 65°C in a heat block for 60 minutes, then added chloroform, gently shaking until the mixture turned into a milky emulsion. Centrifuge at 10,500 rpm for 30 minutes at 4°C. Transfer the upper aqueous phase to a new tube. Repeat the extraction using chloroform to obtain the DNA-containing extraction solution. Precipitate DNA by adding chilled isopropanol. Keep at -20°C for 1 hour. Centrifuge the precipitated DNA at 10,500 rpm for 15 minutes at 4°C. Wash the DNA pellet with 70% ethanol, centrifuge

to collect the pellet, air-dry, and dissolve it in TE buffer. RNA removal: Add RNase to the DNA sample and incubate at 37°C for 1 h. The DNA product on a 1% agarose gel was finally checked under UV light.

Agarose Gel Electrophoresis Method

Added 0.4 g of agarose to 40 ml of 1X TAE buffer. Heat the mixture until boiling to completely dissolve the agarose. Add 2.5 µl of Ethidium Bromide after cooling to 45-50°C and pour it into a prepared gel mould. After 30-60 minutes, when the gel has cooled and solidified, transfer the gel tray into the electrophoresis apparatus. Fill the chambers with 1X TAE buffer, ensuring that the buffer covers the gel by about 0.5-1 cm. Loading Samples: Mix the PCR product with 4 µl of loading dye and load it into the wells of the gel. Electrophoresis: Once the samples have been loaded, connect the electrophoresis apparatus to the power supply and set it to 130 V. Observation: The gel is visualized under ultraviolet light, and DNA fluoresces due to its binding with Ethidium Bromide. The Qiagen Gel Extraction Method was performed following the company's instructions.

Sequencing and Data Analysis

The purified PCR ITS product is sequenced at the Institute of Biotechnology, Vietnam Academy of Science and Technology. The sequence results are compared to similar sequences on NCBI. Subsequently, the sequences are aligned and analyzed using MEGA v5.1 software to construct a species phylogenetic tree.

RESULTS AND DISCUSSION

After conducting the collection, analysis, and classification, we have identified 20 taxa belonging to the Ganodermataceae distributed in Yok Don National Park in the Central Highlands region (Table 1 and Figure 1).

Characteristics of the Ganodermataceae Donk

The species composition of this fungal family is quite diverse. The fruiting body is thick, consisting of a cap and a stipe. The stipe of the mushroom is often eccentric or absent, while the cap is glossy and commonly exhibits light colors such as red, orange, brown, reddish-brown, gray, etc. The spores have two membrane layers: an outer smooth membrane and an inner membrane with small spines, often showing a rust-colored tint. Most mushrooms belonging to the Ganodermataceae grow from May to December, forming clusters attached to or detached from the substrate, which can be wood or plant debris beneath the forest canopy (Table 1 and Figure 1).

Classification at the genus level within the Ganodermataceae family

The fruiting bodies are woody, rarely fleshy, and primarily saprophytic, rarely parasitic. The fruiting bodies consist of a cap and a stipe, with the stipe often eccentric or absent. The color of the fruiting body is usually brown or black, and the outer surface is typically covered with a thick, glossy layer. The spores have two membrane layers, with the outer membrane being smooth and the inner membrane adorned with small spines (Table 1 and Figure 1).

1A. The fruiting body usually has a hard and glossy surface; the spores have two membrane layers shaped like a blunt-ended eggshell... ..... Genus Ganoderma.

1B. The fruiting body usually has a less glossy, hard surface; the spores have two membrane layers, egg-shaped without a blunt end... ..... Genus Amauroderma.

1C. The fruiting body usually has a hard and glossy surface; the spores have two membrane layers, egg-shaped with a blunt end, and the surface of the fruiting body has fissures resembling the segments of a pomelo..... Genus Haddowia.

Characteristics of the genus Ganoderma Donk:

The fruiting body has or lacks a stalk and grows on wood. The cap of the mushroom is glossy and often kidney-shaped or fan-shaped, sometimes round. The flesh of the mushroom is brown, woody to fibrous. The pore layer is mostly single-layered, with a few double-layered. The spores are egg-shaped with a blunt end. The spore wall consists of two layers, with a smooth outer layer and a lightly spiny inner layer with a rusty color (Table 1 and Figure 1).

Characteristics of the genus Amauroderma (Pat.) Murr:
The fruiting body has a stalk and grows on wood or on the ground, with the surface of the cap having a layered texture, often not glossy. The flesh of the mushroom is nearly white or brown, woody to fibrous, but always firm in the center. The pore layer is single-layered. The spores are spherical or nearly spherical, usually pale in color, with a smooth outer surface and a rough inner surface.
Characteristics of the genus Haddowia Steyaert 1972:
The fruiting body has a long stalk and grows on wood or on the debris on the ground, with the surface of the cap having a layered texture, usually not very glossy. The flesh of the mushroom is nearly white or yellowish, with a woody to fibrous texture, but always firm in the center. The spores are egg-shaped, with a rough outer surface that is not smooth and resembles pomelo segments, and a rough inner surface.
Table 1: Catalog of mushroom species belonging to the Ganodermataceae in Yok Don National Park.

Order N	Code	Species	Notes
1	YD18	Ganoderma applanatum (Pers.) Pat. 1887	Medicinal material
2	YD12	Ganoderma calidophilum JDZhao, LWHsu & XQZhang 1979	NA
3	YD06	Ganoderma orbiforme (Fr.) Ryvarden	NA
4	YD09	Ganoderma lucidum (Curtis) P. Karst. 1881.	Medicinal material
5	YD22	Ganoderma philippii (Bres. & Henn. ex Sacc.) Bres. 1932	NA
6	YD20	Ganoderma sinense J.D. Zhao, L.W. Hsu & X.Q. Zhang 1979	Medicinal material
7	YD08	Ganoderma tornatum (Pers.) Bres. 1912	NA
8	YD21	Ganoderma fornicatum (Fr.) Pat. 1889	NA
9	YD25	Ganoderma amboinense (Lam.) Pat. 1887	NA
10	YD02	Ganoderma australe (Fr.) Pat. 1889	NA
11	YD05	Ganoderma gibbosum (Blume & T. Nees) Pat 1897	NA
12	YD17	Ganoderma sp.1	NA
13	YD11	Ganoderma sp.2	NA
14	YD27	Ganoderma sp.3	NA
15	YD10	Amauroderma subresinosum (Murrill) Corner 1983	Medicinal material
16	YD32	Amauroderma rugosum (Blume & T. Nees) Torrend 1920	NA
17	YD47	Amauroderma exile (Berk.) Torrend 1920	NA
18	YD19	Amauroderma sp.1	NA
19	YD62	Amauroderma sp.2	NA
20	YD26	Haddowia sp.	NA

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Figure 1: Fruit bodies of Ganodermataceae mushroom species in the deciduous Forest of Yok Don National Park.
(a) Ganoderma applanatum; **(b)** Ganoderma calidophilum; **(c)** Ganoderma orbiforme; **(d)** Ganoderma lucidum; **(e)** Ganoderma philippii; **(f)** Ganoderma sinense; **(g)** Ganoderma tornatum; **(h)** Ganoderma fornicatum; **(i)** Ganoderma amboinense; **(k)** Ganoderma australe; **(l)** Ganoderma gibbosum; **(m)** Ganoderma sp.1; **(n)** Ganoderma sp.2; **(o)** Ganoderma sp.3; **(p)** Amauroderma subresinosum; (q) Amauroderma rugosum; (r) Amauroderma exile; **(s)** Amauroderma sp.1; **(t)** Amauroderma sp.2; (u) Haddowia sp.; Scale bars **(a-q)** = 2cm

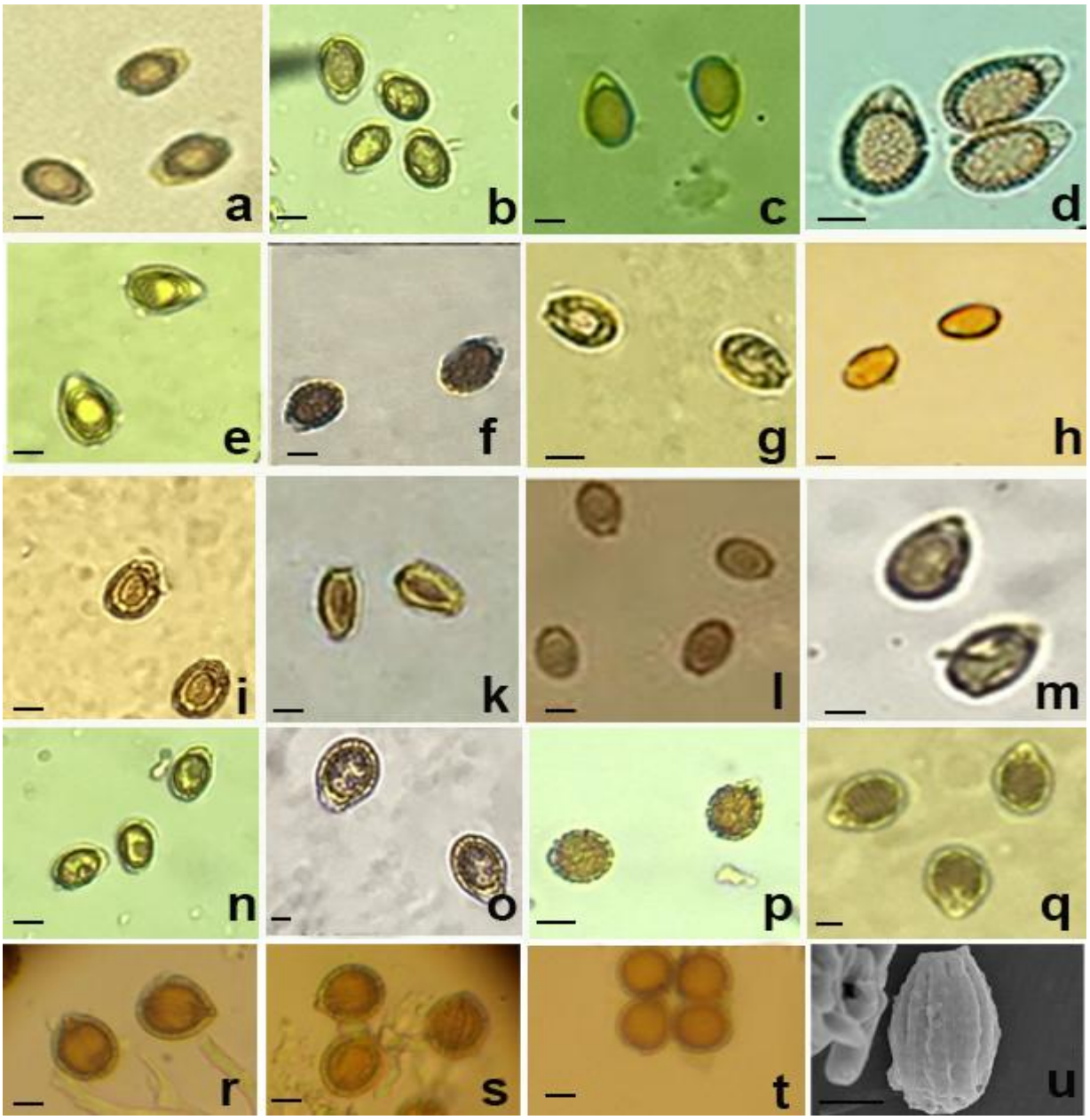

Figure 2: Spores of the Ganodermataceae in the deciduous Forest of Yok Don National Park.
(a) Ganoderma applanatum; **(b)** Ganoderma calidophilum; **(c)** Ganoderma orbiforme; **(d)** Ganoderma lucidum; **(e)** Ganoderma philippii; **(f)** Ganoderma sinense; **(g)** Ganoderma tornatum; **(h)** Ganoderma fornicatum; **(i)** Ganoderma amboinense; **(k)** Ganoderma austral; **(l)** Ganoderma gibbosum; **(m)** Ganoderma sp.1; **(n)** Ganoderma sp.2; **(o)** Ganoderma sp.3; **(p)** Amauroderma subresinosum; (q) Amauroderma rugosum; (r) Amauroderma exile; **(s)** Amauroderma sp.1; **(t)** Amauroderma sp.2; (u) Haddowia sp.1; Scale bars **(a-q)** = 5µm

Analysis of amplification products

After performing the PCR reaction, the amplified products using the ITS1/ITS4 primer pair were subjected to agarose gel electrophoresis on a 1.5% gel, resulting in a single band with an approximate size of 750 bp. The amplified PCR products were then purified using a Sigma GenElute TM Agarose Spin column (USA) to obtain specific PCR products. The results are presented in Figure 3.

Figure 3. Electrophoresis profile of PCR products using the ITS1/ITS4 primer pair on 20 samples of mushrooms with a size standard marker: 100bp.

Size of sequence fragments of the studied Ganodermataceae mushrooms

PCR products with the ITS1/ITS4 primer pair, after purification, were directly analyzed on an ABI PRISM 3100 DNA Analyzer (Applied Biosystems) at the Institute of Biotechnology, Vietnam Academy of Science and Technology, using the MEGA v6 software. The results produced a chromatogram with peaks of four different colors corresponding to the four types of nucleotides, representing the sequence of nucleotides (Figure 3). The obtained results yielded 20 ITS sequence fragments from 20 mushroom samples, each with a different number of nucleotides.

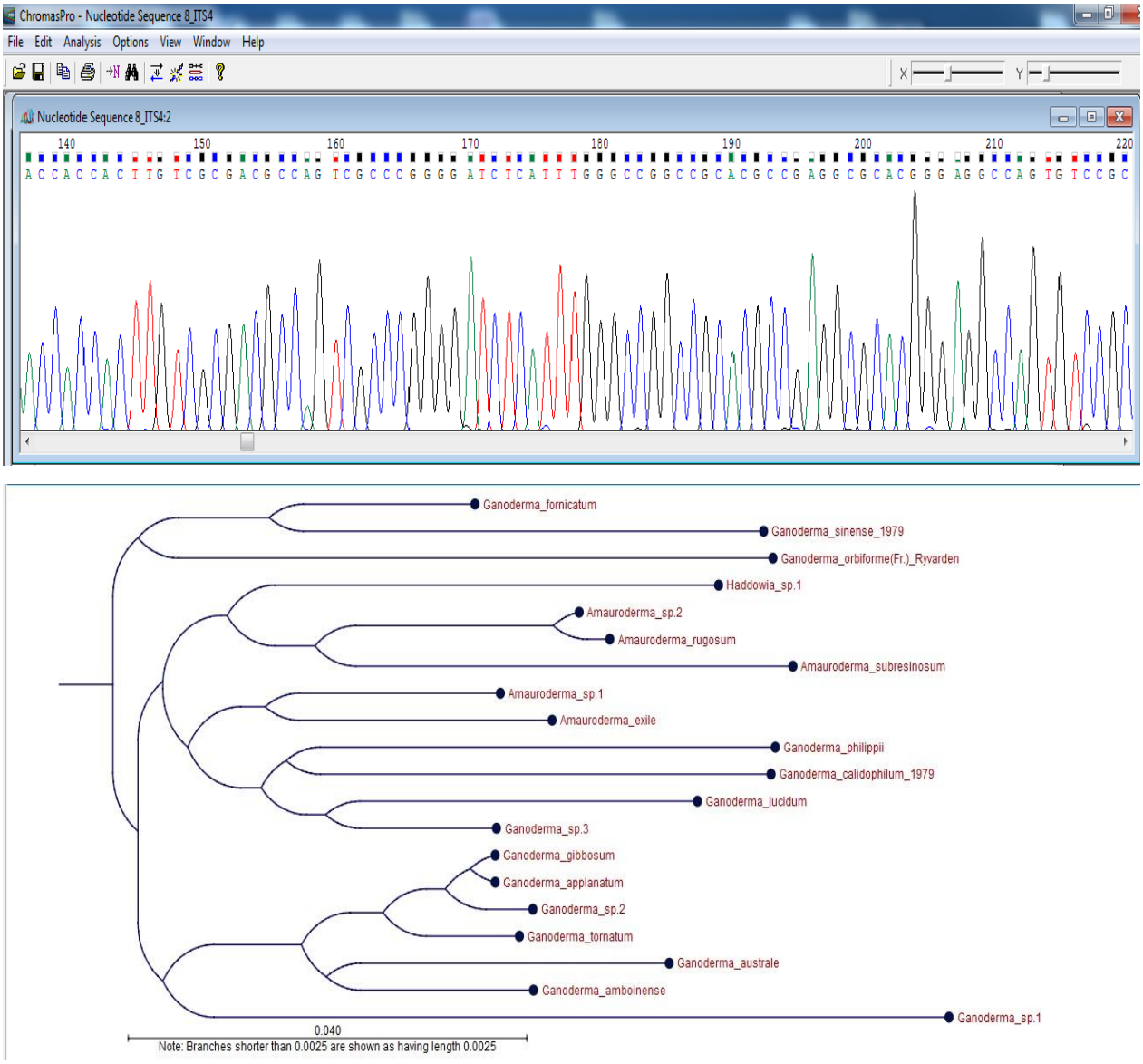

Figure 5. Phylogenetic tree of 20 fungal samples based on ITS-rDNA sequence comparison.

Multivariate regression model for predicting the frequency of occurrence of fungal species with ecological factors.

Studying the relationship between the frequency of occurrence of fungal species and ecological factors helps identify important ecological combinations or factors, serving the determination of distribution areas, development, protection, and related techniques.

Table 2. Identifying the ecological factors and the distribution of the mushroom species

Stt	Scientific name	Density	Altitude (m)	Temperature (0C)	Humidity (%)	Light (Lux)	Forest type	Forest type
1	Ganoderma tornatum	9	215	27	89	400	RTX	3
2	Ganoderma tornatum	8	215	27	89	400	RTX	3
3	Ganoderma lucidum	7	215	27	88	420	RTX	3
4	Ganoderma sinense	7	214	27	88	450	RBTX	2
5	Ganoderma sp.3	7	213	27	86	450	RBTX	2
6	Ganoderma lucidum	6	212	28	85	450	RBTX	2
7	Ganoderma philippii	6	211	28	85	450	RBTX	2
8	Ganoderma amboinense	6	210	28	81	450	RBTX	2
9	Amauroderma subresinosum	6	210	28	81	470	RBTX	2
10	Ganoderma philippii	5	210	28	81	470	RK	1
11	Ganoderma australe	5	208	29	81	470	RK	1
12	Ganoderma sp.2	5	208	29	80	470	RK	1
13	Amauroderma sp.1	5	208	29	80	470	RK	1
14	Amauroderma sp.2	5	208	29	79	490	RK	1
15	Haddowia sp	5	206	29	78	500	RK	1
16	Ganoderma orbiforme	4	206	29	77	500	RK	1
17	Ganoderma lucidum	4	205	30	76	500	RK	1
18	Ganoderma lucidum	4	204	30	76	500	RK	1
19	Ganoderma lucidum	4	204	30	76	500	RK	1
20	Ganoderma fornicatum	4	204	30	76	500	RK	1
21	Ganoderma fornicatum	4	204	30	76	500	RK	1
22	Ganoderma sp.1	4	202	31	76	500	RK	1
23	Amauroderma exile	4	202	31	76	500	RK	1
24	Ganoderma applanatum	3	202	31	76	500	RK	1
25	Ganoderma applanatum	3	202	31	76	500	RK	1
26	Ganoderma calidophilum	3	201	31	76	500	RK	1
27	Ganoderma calidophilum	3	201	31	76	510	RK	1
28	Ganoderma philippii	3	200	31	76	540	RK	1
29	Ganoderma sinense	3	199	31	76	550	RK	1
30	Ganoderma gibbosum	3	199	31	75	550	RK	1

Stt	Scientific name	Density	Altitude (m)	Temperature (0C)	Humidity (%)	Light (Lux)	Forest type	Forest type
31	Amauroderma subresinosum	3	199	31	75	550	RK	1
32	Amauroderma subresinosum	3	199	31	75	550	RK	1
33	Amauroderma rugosum	3	199	31	75	550	RK	1
34	Amauroderma sp.2	3	199	31	75	550	RK	1
35	Ganoderma applanatum	2	199	32	75	550	RK	1
36	Ganoderma orbiforme	2	198	33	75	550	RK	1
37	Ganoderma amboinense	2	198	33	75	570	RK	1
38	Ganoderma gibbosum	2	198	33	75	590	RK	1
39	Ganoderma gibbosum	2	198	33	75	590	RK	1
40	Ganoderma sp.2	2	198	33	75	600	RK	1
41	Ganoderma sp.3	2	198	33	74	600	RK	1
42	Amauroderma subresinosum	2	198	33	73	600	RK	1
43	Amauroderma subresinosum	2	198	33	73	600	RK	1
44	Amauroderma exile	2	198	33	71	600	RK	1
45	Haddowia sp	2	194	33	71	600	RK	1
46	Ganoderma applanatum	1	192	30	73	650	RK	1
47	Ganoderma applanatum	1	202	28	75	600	RK	1
48	Ganoderma australe	1	192	28	89	550	RK	1
49	Ganoderma sp.1	1	194	28	88	450	RK	1
50	Ganoderma sp.1	1	198	31	75	450	RK	1
51	Amauroderma subresinosum	1	198	29	76	400	RK	1
52	Amauroderma subresinosum	1	202	29	75	550	RK	1
53	Amauroderma rugosum	1	210	27	89	540	RK	1
54	Haddowia sp	1	208	27	86	420	RK	1

With data collected from 54 survey locations and compiled in Excel, the software Statgraphics Centurion XV was used to establish multiple regression models and analyze the relationship between the frequency of occurrence of Ganodermataceae Donk species and ecological factors. With a sample size of 54 locations, regression analysis was conducted with five important ecological factors. Variables that did not satisfy the condition for a significant relationship with the frequency of occurrence were excluded at a significance level of $P > 0.05$. The exploration of relationships ranged from simple to complex functions, from single variables

to combinations of variables and transformed variables. The results yielded multiple regression models, as shown in the following Table 3.

Table 3: Relationship models between the frequency of occurrence of Ganodermataceae Donk family and ecological factors.

Order N	Equation	Coefficient of determination(R^2 %)	P-value
1	Density = -48,9829 + 0,333072* Temp + 1,4972* Foresttype + 0,144422*(Altitude+Humidity)	70.4353	0.0000
2	Density = -61,5747 + 3,90267*sqrt(Temp + 1,49179*Foresttype + 0,148779*(Altitude+Humidity)	70.7627	0.0000
3	Density = -90,8281 + 0,339408*(Temp) + 1,50966* Foresttype + 4,90573*sqrt(Altitude+Humidity)	70.6451	0.0000
5	Density = -243,419 + 0,345385*(Temp + 1,52312* Foresttype + 41,6156*log(Altitude+Humidity)	70.8495	0.0000
6	Density = -286,848 + 11,7557*log(Temp) + 1,51774* Foresttype + 44,0696*log(Altitude+Humidity)	71.5434	0.0000
7	sqrt(Density) = -91,2448 + 4,3833*log(Temp) + 0,312725* Foresttype + 13,7878*log(Altitude+Humidity)	61.9195	0.0000

With 05 ecological variables investigated, it was found that 04 variables significantly influenced the frequency and distribution of the fungal species, as represented by the following equation:
Density = N + alog(Temp) + bForestType + c*log(Altitude+Humidity)
With n = 54 and all variables tested using the t-test with the condition $P < 0.05$, it was discovered that 4 factors, namely Forest Type (Foresttype), Air Humidity (Humidity), Altitude relative to sea level (Altitude), and Air Temperature (Temp), had a pronounced impact on the frequency and occurrence of the fungal species. Additionally, with R2 = 71.5434% and $P < 0.05$, it was evident that the relationship between the frequency of the fungal species and the 4 ecological factors was tightly linked, and they mutually influenced each other. Specifically, the density of fungal species showed a positive correlation with Forest Type, Humidity, Light intensity, and Altitude relative to sea level. The regression model aids in understanding the initial ecological requirements of the fungal species. It serves as a basis for identifying the distribution areas of the species and for cultivation and development purposes of the aforementioned mushrooms.
Through the process of investigation and sampling of the Ganodermataceae in the Yok Don National Park, we have observed a high abundance and diversity of species compared to other regions reported by different authors. This is also the first publication on the species diversity of the Ganodermataceae in the deciduous forest ecosystem of the Central Highlands in Vietnam. This publication provides comprehensive information on each species of the Ganodermataceae, including their morphology, ecological conditions, and biological characteristics. Species identification was determined using two methods: comparative anatomy and molecular biology. Based on the natural ecological factors influencing the growth and development of fungal species in the deciduous forest ecosystem, a multiple regression equation was developed to predict the occurrence of these fungal species in the Yok Don National Park, which can also be applied to other ecological areas.

CONCLUSIONS

In conclusion, through the investigation and study of the Ganodermataceae in the deciduous forest ecosystem of Yok Don National Park, we have identified 54 locations and determined 20 species belonging to the Ganodermataceae, including 3 genera (Ganoderma, Amauroderma, and Haddowia) using comparative morphology, anatomy, and molecular identification methods. The researchers identified the ecological requirements of the 20 fungal species belonging to the Ganodermataceae and developed a multiple regression

equation to predict the influence of ecological factors on the occurrence of these fungal species. The predictive equation is as follows: Density = N + alog(Temperature) + b*Foresttype + c*log(Height + Humidity). By establishing this equation, we have gained insights into the ecological requirements of the Ganodermataceae and their occurrence in the Yok Don National Park. This information can also be applied to other ecological areas in this country.

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Conflict of interest: The authors would like to declare that there is no conflict of interest in this work.

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