TAF Journal of Advances in Technology and Engineering Studies JATER
2017, **3**(1): 19-26

PRIMARY RESEARCH

Survey the composition and distribution of fungi species in the natural reserve Wetland Lung Ngoc Hoang, Vietnam

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Index Terms
Fungi Distribution
Lung Ngoc Hoang
Biodiversity

Received: 3 June 2016
Accepted: 15 July 2016
Published: 12 February 2017

***Abstract*—** The study was conducted at the natural reserve wetland, named Lung Ngoc Hoang, from August to December, 2015 to build the database on the current status of distribution and diversity of fungi groups. The results provide useful information to assess the biodiversity at Lung Ngoc Hoang and build a list of fungi species. In addition, species distribution, frequency and diversity index were assessed. The study results showed that 63 species have identified, belonging to 42 genera, 27 families, 12 orders, 6 classes, and 2 phyla. In which, Basidiomycota phylum dominated with 98.97%, while Ascomycota phylum accounted for 1.03% in total. Besides, Agaricomycetes class prevailed with 93%, followed by the class Basidiomycetes with 86.67%. In 12 orders, Agaricales was the most dominant, followed by the Polyporales and the Auriculariales. Moreover, Polyporaceae family occupied the highest percentage of 83.33% with the most dominance of genus Pycnoporus. In 63 fungi species, species Pycnoporus sanguineus had the highest diversity with 23 individuals collected, accounting for 7.87% in total. This species was dominant with 43.33% frequency of appearance. Besides, there were 18 species that were found rarely with the proportion of 1.67% in total. These species had the lowest frequency of appearance, having 0.70% compared to other identified species.

I. INTRODUCTION

Biodiversity degradation in Vietnam is going on with an accelerating speed. Many endemic species are exploited. The value of biodiversity is very essential to the existence and development of biology. The natural reserve wetland Lung Ngoc Hoang was established on the basis of forest land. This is the final legacy of famous natural ecosystems of Phung Hiep District, in the southwestern province of Can Tho in the Mekong Delta of Vietnam. It is the vast flood plain and considered as one of the important wetlands in Vietnam. Lung Ngoc Hoang has about 206 animal species, including species in the Red Book of Vietnam, for example the hairy-nosed otter, cap turtles and cobra. Besides, flora is equally abundant with 330 species, belonging to 224 genera and 92 families [1]. Because of being less affected by human factors, Lung Ngoc Hoang became a biodiversity reserve. This area is the appropriate environment for many species, especially the fungi species.

Fungi are very important in human life, having practical roles in the economy, science and physical processes and natural energy [2]. Fungi are widely used in the life and production [3], [4] and [5]. Many fungi species are used in the food industry, medicine and biological production [6], [7], [8] and [9]. Besides, fungi also play a very important role in the ecosystem. Along with bacteria, fungi are the decomposed organisms in most terrestrial ecosystems, so they keep a critical role in the biogeochemical cycle in many food webs. While living in the form of necrotic or symbiotic, fungi decompose the organic matter into inorganic molecules, then these substances will be assimilated in plants or other organisms [10]. Therefore, the study was conducted in order to provide useful information about the

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current diversity and the distribution of fungi. This would help the biodiversity conservation manegement. In addition, results would be useful database in teaching, studying and doing scientific research.

II. LITERATURE REVIEW

The natural reserve wetland Lung Ngoc Hoang is located in the province of Phung Hiep District, Hau Giang, that has the geographic coordinates from 09,041' to 09,045' North latitude and from 105 039' to 105 043' East longitude [11]. This area is located at the junction between the two ecoregions, namely West of Hau River and Ca Mau Peninsula. This area is formed from the process of regression and deposition of silt and sediment at coastal and wetlands, forming a topographic and relatively flat land, with an average elevation from 0.3 to 1.5 meters Statistical Yearbook, 2013. According to the Statistical Yearbook 2013, Lung Ngoc Hoang was influenced by tropical monsoon climate with the average difference of humidity from 10-11%. Average rainfall was 1700-1800 mm/ year. The annual average number of rainy days ranged from 120 - 135 days.

III. METHODOLOGY

The survey was conducted from 6/2015 to 11/2015. The survey method was selected, including direct surveys, observations, field sampling for target groups surveyed. Based on topographic maps of the area, 30 selected sites were investigated. At each site of the survey, conducted the line transect through representative sampling points as shown in Figure 1. Collect the samples in 10m radius at each point.

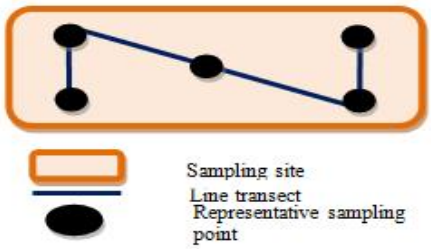

Fig. 1 . The line transect at each site through representative sampling points

According to [12], collect all different stages of fungus. Rare samples were kept in the laboratory. Fungus could be stored in the alcoholic solution of formalin (30-50% or 4%) or soaked in 25g zinc sulfate mixed with 10ml formalin in 1 liter of distilled water for 24 hours. Use the classification and description of published authors [13] and [14].

The method analyzes various indicators:

The frequency of occurrence is calculated according to the formula of [15]:

$C = \frac{p}{P} * 100$

Where C is the frequency of occurrence of species, p is the number of sampling points found species; P is the total number of sampling points.

According to the value of C, the levels of occurrence were presented in the following table (Table 1):

TABLE 1
Different levels of frequency of appearance [17]

Frequency of occurrence (C%)	Level
1–20	Rare
21–40	Average
41–80	High
81 – 100	Very high

The biodiversity Shannon index is calculated according to the formula of [16]:

$H^{'} = \sum_{i=1}^{n} pi^{ln} Pi \; Pi = \frac{ni}{N}$

$H^{,}$:Diversity index

$P_i$number of species i /total number of species

IV. RESULTS

A. The Checklist of Fungi Species at the Natural Reserve Wetland Lung Ngoc Hoang

The survey at the natural reserve wetland Lung Ngoc Hoang has obtained 313 samples and identified 63 species, belonging to 42 genera, 27 families, 12 orders, 6 classes and 2 phyla (Basidiomycota and Ascomycota) (table 1).

Regarding the number of individuals, in 63 species collected at Lung Ngoc Hoang, Pynoporus sanguineus had the highest number of individuals collected with 7.35% in total, having 53.33% frequency of occurrence, followed by Amauroderma rugosum and Coprinus disseminates with 46.67% and 40% frequency of occurrence, respectively. However, some species were discovered only once, having the smallest frequency of occurrence, such as Geastrum fimbriatum, Tyromyces chioneus, Marasmius pulcherripes, Marasmius oreades, Entoloma sinuatum, Lentinus crini-

ISSN: 2414-4592
DOI: 10.20474/jater-3.1.4

tus, Dictyophora multicolor. Moreover, from the results, 52 species occurred rarely in Lung Ngoc Hoang, with their frequency ranging from 6.67% to 20%. This figure was about 6 times higher than the number of fairly common species found in Lung Ngoc Hoang, having 9 species from 26.67% to 40% frequency. Only 2 common species with high frequency of occurrence (46.67% and 53.33%) were found in the surveyed sites.

Beside species occurrence, the diversity index was calculated to find out which species was the most diverse in surveyed area of Lung Ngoc Hoang. In 63 fungi species, Pynoporus sanguineus had the highest diversity index, with 29.82. In addition, Amauroderma rugosum and Pynoporus cinnabarinus dominated with 23.03 of Shannon index. The species Coprinus disseminates was dominant with smaller diversity index of 13.62. Three species Marasmius haematocephalus, Marasmius rotula and Ganoderma lucidum followed closely with 10.75 (table 1). Other species were reported with small diversity index, fluctuating between 0.70 and 5.55.

B. Occurrence and Diverisity Values

Survey the current distribution of fungi species at the natural reserve wetland Lung Ngoc Hoang to complete the fungi checklist in this area. 63 species were found, belonging to 2 phyla, Basidiomycota and Ascomycota. In which, the phylum Basidiomycota was dominant with 282 individuals, representing 98.97%, whereas the phylum Ascomycota had 3 individuals, accounting for 1.03% (table 3).

Although having the high frequency of occurrence, the phylum Basidiomycota had small diversity index with 0.01022. This was true to the second phylum Ascomycota when the number of fungus collected was very small. This led to the diversity index of phylum Ascomycota that was extremely small at 0.00011 (table 3).

Regarding the fungi class, from the surveyed results at Lung Ngoc Hoang, six classes were identified (Agaricomycetes, Basidiomycetes, Sordariomycetes, Heterobasidiomycetes, Dacrymycetes, Pezizomycetes), belonging to 2 branches Basidiomycota and Ascomycota. The most dominant class Agaricomycetes had 203 individuals, accounting for 93% while Basidiomycetes with 73 individuals accounted for 86.67% frequency of occurrence. However, the diversity indices were opposite with the highest 0.35 of Basidiomycetes phylum and the second 0.25 of Agaricomycetes. Four other fungi classes, namely Sordariomycetes, Heterobasidiomycetes, Dacrymycetes and Pezizomycetesco had the frequency from 3.33% to 23.33% and Shannon index from 0.02 to 0.09 (table 3).

TABLE 2
THE DIVERSITY INDEX AND FREQUENCY OCCURRENCE OF FUNGI ACCORDING TO PHYLUM AND CLASS THAT WERE SURVEYED IN LUNG NGOC HOANG

No.		Shannon index (H)	C (%)
Phylum			
1	Basidiomycota	0.01022	98.97
1	Ascomycota	0.00011	1.03
Class			
1	Agaricomycetes	0.25	93
2	Basidiomycetes	0.35	86.67
3	Dacrymycetes	0.08	16.67
4	Heterobasidiomycetes	0.09	23.33
5	Pezizomycetes	0.03	6.67
6	Sordariomycetes	0.02	3.33

TABLE 3
THE DIVERSITY INDEX AND FREQUENCY OF OCCURRENCE OF ORDERS THAT WERE SURVEYED IN LUNG NGOC HOANG

No	Order	Shannon index (H)	C (%)
1	Agaricales	0.36	96.67
2	Auriculariales	0.14	43.33
3	Boletales	0.10	20.00
4	Cantharellales	0.03	3.33
5	Dacrymycetes	0.08	16.67
6	Geastrales	0.02	3.33
7	Pezizales	0.03	6.67
8	Polyporales	0.37	90.00
9	Phallales	0.05	10.00
10	Russulales	0.02	3.33
11	Thelephorales	0.09	20.00
12	Xylariales	0.02	3.33

In 12 orders, Agaricales was the most dominant, followed by the Polyporales and the Auriculariales. Agaricales was the most dominant with 128 individuals, representing 96.67% frequency of occurrence, followed by the order Polyporales with 120 individuals, accounting for 90%. The order Auriculariales occupied 43.33%; Moreover, order Boletales reported 8 individuals, accounting for 20%. Other orders Cantharellales, Geastrales, Russulales, Phallales, Pezizales, Xylariales, Dacrymycetales, and Thelephorales had smaller occurrence frequency, from 3.33% to 20% (table 4).

The Shannon indices of two dominant orders were

ISSN: 2414-4592
DOI: 10.20474/jater-3.1.4

different with the higher value belonging to order Polyporales (0.37). Agaricales came second with 0.36. In contrast, the smallest diversity values were reported in order Geastrales and Xylariales (table 4).

TABLE 4
THE DIVERSITY INDEX AND FREQUENCY OF OCCURRENCE OF ORDERS THAT WERE SURVEYED IN LUNG NGOC HOANG

No	Order	Shannon index (H)	C (%)
1	Agaricaceae	0.19	46.67
2	Amanitaceae	0.02	3.33
3	Auriculariaceae	0.14	43.33
4	Cantharellaceae	0.03	3.33
5	Cortinariaceae	0.06	10.00
6	Dacrymycetaceae	0.08	16.67
7	Diplocystaceae	0.03	6.67
8	Entolomataceae	0.02	3.33
9	Ganodermataceae	0.27	60.00
10	Geastraceae	0.02	3.33
11	Inocybaceae	0.06	13.33
12	Lepiotaceae	0.02	3.33
13	Marasmiaceae	0.29	76.67
14	Meripilaceae	0.02	3.33
15	Mycenaceae	0.15	40.00
16	Nidulariaceae	0.06	13.33
17	Pluteaceae	0.05	10.00
18	Polyporaceae	0.36	83.33
19	Psathyrellaceae	0.12	30.00
20	Pyronemataceae	0.03	6.67
21	Phallaceae	0.05	10.00
22	Russulaceae	0.02	3.33
23	Sclerodermataceae	0.08	16.67
24	Schizophyllaceae	0.12	20.00
25	Strophariaceae	0.10	20.00
26	Thelephoraceae	0.09	20.00
27	Xylariaceae	0.02	3.33

In 27 families identified, the Polyporaceae family occupied the highest occurrence percentage of 83.33% with 81 individuals. There were 2 families which had high frequency of occurrence, namely Marasmiaceae (76.67%) and Ganodermataceae (60%). The Shannon index of the Polyporaceae family was greatest with 0.36, being slightly higher than the family Marasmiaceae (0.29) and Ganodermataceae (0.27) (table 5). Fungi species obtained were varying from incompleted forms to completed fruiting forms. The common form is the form of fan shape, funnel-shaped or star shape. Fruiting forms were colorful with the most common color of white, gray and grayish white. There were also other colors such as brown, yellow, red and orange. Sometimes the fruits may be 2-color or multi-color (Figure 2 and 3).

(Schizophyllum commune)

(Guepiniopsis spathularia)

Fig. 2 . Schizophyllum commune and Guepiniopsis spathularia collected at Lung Ngoc Hoang

The top and bottom of one fungus can be of different or same colors. The same species could have different colors in different landscapes and the different stages of growth (Figure 2). The top of a fungus can be smooth or smooth with alternating ridges... but sometimes it changes its shape and color in the process of living. Some fungi representing the average frequency of appearance:

ISSN: 2414-4592
DOI: 10.20474/jater-3.1.4

Fig. 3 . Ganoderma fulvellum with the top (A) and the bottom (B)

Fig. 4 . Pycnoporus sanguineus with the top (A) and the bottom (B)

Fig. 5 . Chaetocalathus columellifer with the top (A) and the bottom (B)

Fig. 6 . Pycnoporus cinnabarinus with the top (A) and the bottom (B)

Some fungi representing the small frequency of appearance:

Fig. 7 . Favolus brasiliensis with the top (A) and the bottom (B)

Fig. 8 . Cyathus striatus with the top (A) and the bottom (B)

Fig. 9 . Amauroderma rugosum with the top (A) and the bottom (B)

Fig. 10 . Daldinia Concentrica(A), Scleroderma nitidum (B), Trametes cervina (C)

ISSN: 2414-4592
DOI: 10.20474/jater-3.1.4

V. DISCUSSION

Our study found the phylum Basidiomycota was common in the natural reserve wetland Lung Ngoc Hoang. According to [18] on the phylum Basidiomycota, this phylum appeared fairly common around the world, including three sub-sectors Basidiomycota, 16 classes (of which 6 classes were not identified), 52 orders, 177 families, 1,589 genera, and 31,515 species found in Asia with tropical monsoon climate. On the other hand, according to the study of the [19], the phylum Ascomycota was representing soil ecosystems in Italy, Eastern Europe and the Antarctic. However, due to contrast climatic conditions, this phylum was found rarely in the tropical monsoon area such as Vietnam. This research explained the reason why the phylum Ascomycota was reported rarely in our surveyed sites.

In 12 orders discovered, the orders Agaricales and Polyporales were the most dominant. The order Agaricales is distributed at places with high humidity and habitats mainly forest land and pasture. Besides, the order Polyporales found that this order is distributed in low-lying areas with high humidity, for example on the dead tree or on the biodegradable slime plant. According to the research of [19] and [18], the orders Geastrales, Russulales, Phallales, Pezizales, Xylariales, Cantharellales, Dacrymycetales, and Thelephorales had different habitats. They are distributed in a well-ventilated area, high terrain or in areas with animal feces. Those orders represented for fungi species in dried season. Our research focused on two rainy seasons and habitats of forest land and agricultural land. That's why we could not find more species in these orders.

According to the report "Atlas Cat Tien mushroom" by [18], the species Pynoporus sanguineus and Chaetocalathus columellifer were two fairly common fungi in cooler climate areas in Europe and North America, tropical South America and Asia. They adapted well to the temperature from 270C to 280C and humidity between 70 and 80%. They lived mainly on the hard wooden trunk near water sources. The conditions mentioned were quite consistent with ecosystem conditions in Lung Ngoc Hoang. This explained the high diversity of two species in Lung Ngoc Hoang.

Lung Ngoc Hoang reported 63 species, accounting for 4.5% of the total number of 1400 fungi species published in Vietnam in 2010. In addition, comparing results with some published works about mushrooms in Vietnam with 31 species, the fungi checklist at the natural reserve wetland Lung Ngoc Hoang showed 63 species, being more diverse.

VI. CONCLUSION

From the research results, some conclusions about the large mushrooms at the natural reserve wetland Lung Ngoc Hoang were concluded: The total number of samples collected had identified 63 species, belonging to 42 genera, 27 families, 12 orders, 6 classes, and 2 phyla.

In particular, the species Pycnoporus sanguineus was dominant, accounting for 7.34% in total; Chaetocalathus columellifer species had the highest frequency of occurrence at 53.33%. Besides, some species Amauroderma rugosum, Dictyophora indusiata, Favolus brasiliensis, Ganoderma fulvellum, Guepiniopsis spathularia, Gymnopilus penetrans, Inocybe rimosa, Leucocoprinus birnbaumii, Marasmius oreades, Parasola conopilus, Pycnoporus sanguineus, Pycnoporus cinnabarinus and Scleroderma nitidum had the smallest number of individuals, representing 6.67%.

VII. SUGGESTION

Conduct research to identify more fungi species and add to the list of Vietnamese fungus. In addition, conduct an assessment of biomass of the species and fungi values. These studies will contribute completed data about fungi in Vietnam.

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ISSN: 2414-4592
DOI: 10.20474/jater-3.1.4

TABLE 5
THE CHECKLIST OF FUNGI SPECIES COLLECTED AT LUNG NGOC HOANG

No	Phyllum	Class	Order	Family	Genus	Species	H	C %
1	Ascomycota	Pezizomycetes	Pezizales	Pyronemataceae	Scutellinia	Scutellinia scutellata	1.39	13.33
2		Sordariomycetes	Xylariales	Xylariaceae	Daldinia	Daldinia concentrica	0.70	6.67
1				Agaricaceae	Coprinus	Coprinus disseminates	13.62	40.00
2				Agaricaceae	Leucocoprinus	Leucocoprinus birnbaumii	0.70	6.67
3					Lycoperdon	Lycoperdon pyriforme	5.55	26.67
4				Amanitaceae	Amanita	Amanita virgineoides	0.70	6.67
5					Cortinarius	Cortinarius violaceus	0.70	6.67
6				Cortinariaceae	Cortinarius	Gymnopilus penetrans	0.70	6.67
7						Gymnopilus zenkeri	1.39	6.67
8				Entolomataceae	Entoloma	Entoloma sinuatum	0.70	6.67
9				Inocybaceae	Inocybe	Inocybe rimosa	1.39	13.33
10				Lepiotaceae	Macrolepiota	Macrolepiota procera	3.30	6.67
11						Marasmius haematocephalus	10.75	20.00
12						Marasmius oreades	0.70	6.67
13				Marasmiaceae	Marasmius	Marasmius oreades	0.70	6.67
14						Marasmius rotula	10.75	26.67
15					Agaricales	Marasmius pulcherripes	0.70	6.67
16					Filoboletus	Filoboletus manipularis	0.70	6.67
17	Basidiomycota	Agaricomycetes		Mycenaceae	Mycena	Mycena chlorophos	3.30	13.33
18						Mycena galericulata	5.55	26.67
19				Nidulariaceae	Cyathus	Cyathus striatus	1.39	13.33
20					Pynoporus	Crucibulum laeve	0.70	6.67
21				Pluteaceae	Pluteus	Pluteus petasatus	0.70	6.67
22					Volvarialla	Volvarialla volvacea	0.70	6.67
23				Psathyrellaceae	Psathyrella	Psathyrella gricilis	0.70	6.67
24					Parasola	Parasola auricoma	0.70	6.67
25						Parasola plicatilis	5.55	26.67
26						Parasola conopilus	1.39	6.67
27				Schizophyllaceae	Schizophyllum	Schizophyllum commune	5.55	20.00
28				Strophariaceae	Hypholoma	Hypholoma fasciculare	5.55	20.00
29			Auriculariales	Auriculariaceae	Auricularia	Auricularia fuscosuccinea	1.39	13.33
30						Auricularia tenuis	1.39	13.33
31			Boletales	Sclerodermataceae	Scleroderma	Scleroderma nitidum	0.70	6.67
32						Scleroderma citrinum	1.39	13.33
33				Diplocystaceae	Astraeus	Astraeus hygrometricus	1.39	6.67
34			Cantharellales	Cantharellaceae	Cratelellus	Craterellus cornucopioides	3.30	6.67
35			Geastrales	Geastraceae	Geastrum	Geastrum fimbriatum	0.70	6.67
36			Phallales	Phallaceae	Phallus	Phallus multicolor	0.70	6.67
37						Phallus aurantiacus	0.70	6.67
38						Phallus indusiatus	0.70	6.67
39					Polyporaceae	Microporus	Microporus flabelliformis 3.30	20.00
40					Lenzites	Trametes hirsuta	1.39	13.33
41					Favolus	Favolus brasiliensis	0.70	6.67
42				Ganodermataceae	Ganoderma	Ganoderma sp1	0.70	6.67
43						Ganoderma fulvellum	3.30	20.00
44						Ganoderma lucidum	10.75	40.00
45						Ganoderma multipileum	5.55	26.67
46			Polyporales			Ganoderma subresinosum	1.39	13.33
46				Meripilaceae	Grifola	Grifola frondosa	0.70	6.67
47				Polyporaceae	Lenzites	Lenzites palisoti	8.05	20.00
48					Trametes	Trametes cervina	3.30	6.67
49					Earliella	Earliella scabrosa	0.70	6.67
50					Lentinus	Lentinus crinitus	0.70	6.67
51					Microporus	Microporus xanthopus	1.39	13.33
52					Tyromyces	Tyromyces chioneus	0.70	6.67
53			Russulales	Russulaceae	Lactarius	Lactarius salmonicolor	0.70	6.67
54			Thelephorales	Thelephoraceae	Thelephora	Thelephora griseozonata	3.30	20.00
55			Agaricales	Marasmiaceae	Chaetocalathus	Chaetocalathus columellifer	5.55	26.67
56				Ganodermataceae	Amauroderma	Amauroderma rugosum	**23.03**	**46.67**
57					Hexagonia	Hexagonia apiaria	3.30	20.00
58		Basidiomycetes	Polyporales	Polyporaceae	Pycnoporus	Pynoporus sanguineus	**29.82**	**53.33**
59						Pynoporus cinnabarinus	23.03	26.67
60		Dacrymycetes	Dacrymycetes	Dacrymycetaceae	Guepiniopsis	Guepiniopsis spathularia	3.30	20.00
61	Heterobasidiomycetes	Auriculariales	Auriculariaceae	Auricularia	Auricularia	Polytricha	3.30	20.00

ISSN: 2414-4592
DOI: 10.20474/jater-3.1.4