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인왕산에 서식하는 담자균류의 다양성

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Diversity of Basidiomycetous Fungi in Mt. Inwang

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ABSTRACT

The diversity of basidiomycetous macrofungi was investigated in Mt. Inwang. The fruit bodies were collected from September to August in 2014 and they were identified using morphological and molecular methods. A total of 91 specimens were collected and they were identified and classified as 71 species 45 genera, 30 families, and 7 orders. Most of the species were observed in August and only 10 species of wood decay fungi were found in September or October which were in drier conditions. Only two species, *Hyphodontia tropica* and *Irpex lacteus* were observed from all three survey months.

Key words : Basidiomycetes, diversity, Mt. Inwang

Introduction

Mt. Inwang is located in Seoul, South Korea. It is 338 m high in altitude and the area is about 1.8 km^2. The vegetation of the forest consists of coniferous and deciduous trees and the major tree species are *Pinus densiflora* Siebold & Zucc. and *Robinia pseudoacacia* L., and there are also *Querqus acutissima* Carruth., *Sorbus alnifolia* (Siebold & Zucc.) K. Koch, *Populus tomentiglandulosa* T. B. Lee, and *Alnus hirsuta* (Spach) Rup. in small patches (Cho *et al*. 1999). Although the forest is fragmented, it could be beneficial for humans not only by its scenic views, but also by improving the quality of air, controlling rainwater runoff, and providing habitats for diverse organisms (Kuser 2007). Among the organisms in the forest, fungi perform diverse ecological roles (Deacon 2006). Saprotrophic fungi decompose organic matters such as plant litter and contribute to nutrient cycling. Wood decay fungi could utilize wood which is otherwise recalcitrant to the other organisms. There are also mycorrhizal fungi which have symbiotic relationships with trees and

they help plant growth in nutrient poor conditions.

In the previous studies, the diversity of macrofungi was investigated from mountainous areas in Seoul and they gave insight into the diversity of macrofungi in urban areas (Jang *et al*. 2012, 2014; Jung 1991). However, Mt. Inwang was not included there and the diversity of fungi in this area is still not known. In this study, the diversity of basidiomycetous macrofungi in Mt. Inwang was investigated by the collection and identification of fungal fruit bodies.

Materials and Methods

1. Study Site

Field surveys were carried out in Mt. Inwang (37°34-35'N, 126°57'E), Seoul from August to October, 2014. The meteorological information of the study site during the survey period was collected from Korea Meteorological Administration (http://www.kma.go.kr/weather/climate/past_cal.jsp) and shown in Table 1.

2. Morphological Analysis

The collected specimens were observed macroscopically according to Largent (1977). Microscopic features were examined under the Olympus BX51 microscope using slide preparations according to Largent *et al*. (1977). The studied specimens were deposited in the Korea University Culture Collection, South Korea (KUC).

3. Molecular Analysis

To extract DNAs from the collected specimens, Accuprep Genomic DNA Extraction Kit (Bioneer, Korea) was used. PCR reactions were performed to amplify nuclear large subunit ribosomal DNA using the primers of LR0R/LR5 and internal transcribed spacer region sequences with the primers, ITS1F/ITS4 according to Jang *et al*. (2012). The amplified products were visualized using agarose gel electrophoresis and purified using Accuprep PCR Purification Kit (Bioneer, Korea). The sequencing of the purified products was performed in the Macrogen, Ltd. (Seoul, Korea). A BLASTn search was carried out with the obtained sequences (http://blast.ncbi.nlm.nih.gov/Blast.cgi). Phylogenetic analysis was performed according to Jang *et al.* (2012).

Table 1. The meteorological information of Seoul from August to October, 2014

	Monthly mean temperature (°C)	Mean monthly maximum temperature (°C)	Mean monthly minimum temperature (°C)	Precipitation (mm)
Aug.	25.2	29.0	22.1	172.8
Sep.	22.1	27.0	18.0	88.1
Oct.	15.6	21.4	11.1	52.2

Table 1. The list of basidiomycetous macrofungi in Mt. Inwang

Species	Representative specimen	Ecologya	Aug	Sep	Oct
Agaricales					
Agaricaceae					
Agaricus abruptibulbus Peck	KUC20140822-40	Sa	○		
Agaricus sp.	KUC20140823-04	Sa	○		
Agaricus subrutilescens (Kauffman) Hotson & D.E. Stuntz	KUC20140823-19	Sa	○		
Lepiota jacobi Vellinga & Knudsen	KUC20140822-03	Sa	○		
Amanitaceae					
Amanita flavipes S. Imai	KUC20140822-55	Ec	○		
Amanita pantherina (DC.) Krombh.	KUC20140822-02	Ec	○		
Amanita sp. 1	KUC20140822-43	Ec	○		
Amanita sp. 2	KUC20140823-20	Ec	○		
Amanita sp. 3	KUC20140823-21	Ec	○		
Amanita vaginata (Bull.) Lam.	KUC20140822-32	Ec	○		
Amanita virgineoides Bas.	KUC20140822-13	Ec	○		
Amanita virosa Bertill.	KUC20140822-39	Ec	○		
Entolomataceae					
Entoloma album Hiroë	KUC20140822-06	Uk	○		
Entoloma praegracile Xiao L. He & T.H. Li	KUC20140822-11	Uk	○		
Entoloma sp. 1	KUC20140822-30	Uk	○		
Entoloma sp. 2	KUC20140822-50	Uk	○		
Hydnangiaceae					
Laccaria amethystea (Bull.) Murrill	KUC20140822-57	Ec	○		
Laccaria laccata (Scop.) Cooke	KUC20140823-08	Ec	○		
Laccaria vinaceoavellanea Hongo	KUC20140822-56	Ec	○		
Incertae sedis					
Plicaturopsis crispa	KUC20140925-03	Wd		○	
Inocybaceae					
Crepidotus sp.	KUC20140823-07	Wd	○		
Inocybe sphaerospora Kobayasi	KUC20140822-59	Ec	○		
Lyophyllaceae					
Gerhardtia incarnatobrunnea (Ew. Gerhardt) Bon	KUC20140822-47	Sa	○		
Marasmiaceae					
Marasmius siccus (Schwein.) Fr.	KUC20140822-23	Sa	○		
Mycenaceae					
Mycena pura (Pers.) P. Kumm.	KUC20140823-16	Sa	○		
Omphalotaceae					
Gymnopus sp. 1	KUC20140822-18	Sa	○		
Gymnopus sp. 2	KUC20140822-33	Sa	○		
Physalacriaceae					
Cyptotrama asprata (Berk.) Redhead & Ginns	KUC20140823-13	Wd	○		
Hymenopellis chiangmaiae (R.H. Petersen & Nagas.) R.H. Petersen	KUC20140822-36	Sa	○		
Coprinellus radians (Desm.) Vilgalys, Hopple & Jacq. Johnson	KUC20140822-19	Wd	○		
Pterulaceae					
Pterula sp.	KUC20140822-24	Sa	○		
Schizophyllaceae					
Schizophyllum commune Fr.	KUC20140925-06	Wd		○	○

Table 1. Continued

Species	Representative specimen	Ecologya	Aug	Sep	Oct
Strophariaceae					
Hypholoma fasciculare (Huds.) P. Kumm.	KUC20140822-60	Wd	○		
Pholiota multicingulata E. Horak	KUC20140823-01	Wd	○		
Pholiota terrestris Overh.	KUC20140823-11	Wd	○		
Tricholomataceae					
Clitocybe sp.	KUC20140822-22	Sa	○		
Singerocybe alboinfundibuliformis (Seok, Yang S. Kim, K. M. Park, W. G. Kim, K. H. Yoo & I. C. Park) Zhu L. Yang, J. Qin & Har. Takahashi	KUC20140822-25	Sa	○		
Tricholoma sp.	KUC20140822-58	Ec	○		
Boletales					
Boletaceae					
Heimioporus japonicus (Hongo) E. Horak	KUC20140822-46	Ec	○		
Strobilomyces confusus Singer	KUC20140822-41	Ec	○		
Strobilomyces sp.	KUC20140822-14	Ec	○		
Xerocomus sp. 1	KUC20140822-15	Ec	○		
Xerocomus sp. 2	KUC20140822-44	Ec	○		
Sclerodermataceae					
Scleroderma areolatum Ehrenb.	KUC20140822-20	Ec	○		
Suillaceae					
Suillus bovinus (L.) Roussel	KUC20140822-48	Ec	○		
Suillus granulatus (L.) Roussel	KUC20140822-27	Ec	○		
Geastrales					
Geastraceae					
Geastrum lageniforme Vittad.	KUC20140823-03	Sa	○		
Gloeophyllales					
Gloeophyllaceae					
Gloeophyllum sepiarium (Wulfen) P. Karst.	KUC20140822-38	Wd	○		
Hymenochaetales					
Schizoporaceae					
Hyphodontia tropica Sheng H. Wu	KUC20140822-05	Wd	○	○	○
Polyporales					
Fomitopsidaceae					
Postia sp.	KUC20140822-16	Wd	○		
Ganodermataceae					
Ganoderma applanatum (Pers.) Pat.	KUC20140822-28	Wd	○		
Meruliaceae					
Irpex lacteus (Fr.) Fr.	KUC20140822-01	Wd	○	○	○
Loweomyces fractipes (Berk. & M.A. Curtis) Jülich	KUC20140823-09	Wd	○		
Phlebia tremellosa (Schrad.) Nakasone & Burds.	KUC20140823-02	Wd	○		
Phanerochaetaceae					
Phanerochaete sp.	KUC20140925-05	Wd		○	
Polyporaceae					
Cerrena consors (Berk.) K.S. Ko & H.S. Jung	KUC20140823-18	Wd	○		
Daedaleopsis confragosa (Bolton) J. Schröt.	KUC20141028-01	Wd			○
Lopharia mirabilis (Berk. & Broome) Pat.	KUC20140822-37	Wd	○		

Table 1. Continued

Species	Representative specimen	Ecologya	Aug	Sep	Oct
Perenniporia fraxinea (Bull.) Ryvarden	KUC20140822-04	Wd	○		
Trametes versicolor (L.) Lloyd	KUC20140925-02	Wd		○	○
Russulales					
Peniophoraceae					
Peniophora incarnata (Pers.) P. Karst.	KUC20140925-09	Wd		○	
Russulaceae					
Lactarius hatsudake Nobuj. Tanaka	KUC20140822-10	Ec	○		
Lactarius hygrophoroides Berk. & M.A. Curtis	KUC20140822-29	Ec	○		
Lactarius sp.	KUC20140822-51	Ec	○		
Lactarius subzonarius Hongo	KUC20140822-54	Ec	○		
Russula pectinatoides Peck	KUC20140823-10	Ec	○		
Russula sororia Fr.	KUC20140823-06	Ec	○		
Russula sp. 1	KUC20140822-07	Ec	○		
Russula sp. 2	KUC20140822-31	Ec	○		
Stereaceae					
Stereum hirsutum (Willd.) Pers.	KUC20140823-23	Wd	○	○	
Stereum peculiare Parmasto, Boidin & Dinghra	KUC20141028-06	Wd			○

[a]Ec: Ectomycorrhizal fungi, Sa: Saprotrophic fungi, Wd: Wood decay fungi, Uk: Unknown.

Results

During the field surveys, a total of 91 specimens were collected from August to October in 2014 in Mt. Inwang. By the morphological and molecular analyses, all the specimens were identified to genus or species level. As results, 71 species were recognized and they were classified in 45 genera, 30 families, and 7 orders (Table 1). In order level, more than half of the species belonged to the Agaricales (53.5%). In addition, Polyporales (15.5%), Russulales (15.5%) and Boletales (11.3%) accounted for more than 10% of the total species (Fig. 1A). In family level, Amanitaceae (11.3%), Russulaceae (11.3%), Boletaceae (7.0%), Polyporaceae (7.0%), Agaricaceae (5.6%), Entolomataceae (5.6%) accounted for more than 5% of the total species. The 12 genera which had more than two species were *Amanita, Entoloma, Lactarius, Russula, Agaricus, Laccaria, Gymnopus, Pholiota, Stereum, Strobilomyces, Suillus,* and *Xerocomus* and the rest 33 genera had only one species. Morphologically, the majority of the species were agaricoid fungi (69%), followed by polyporoid fungi (14.1%) and corticioid fungi (8.5%) (Fig. 1B). Ecologically, most of them were categorized as ectomycorrhizal fungi (40.8%), wood decay fungi (33.8%), and saprotrophic fungi (19.7%) except the genus *Entoloma* which comprised of both ectomycorrhizal and saprotrophic species (Tedersoo *et al.* 2010) (Fig. 1C). 64 species of all three ecological groups including *Entoloma* were observed in August (90.1%) (Fig. 1D). However, in September and October, only 10 species of wood decay fungi (8 species in September, 6 species in October) - *Daedaleopsis confragosa*, *Hyphodontia tropica*, *Irpex lacteus, Peniophora incarnata, Phanerochaete* sp., *Plicaturopsis crispa, Schizophyllum commune, Stereum hirsutum, Stereum*

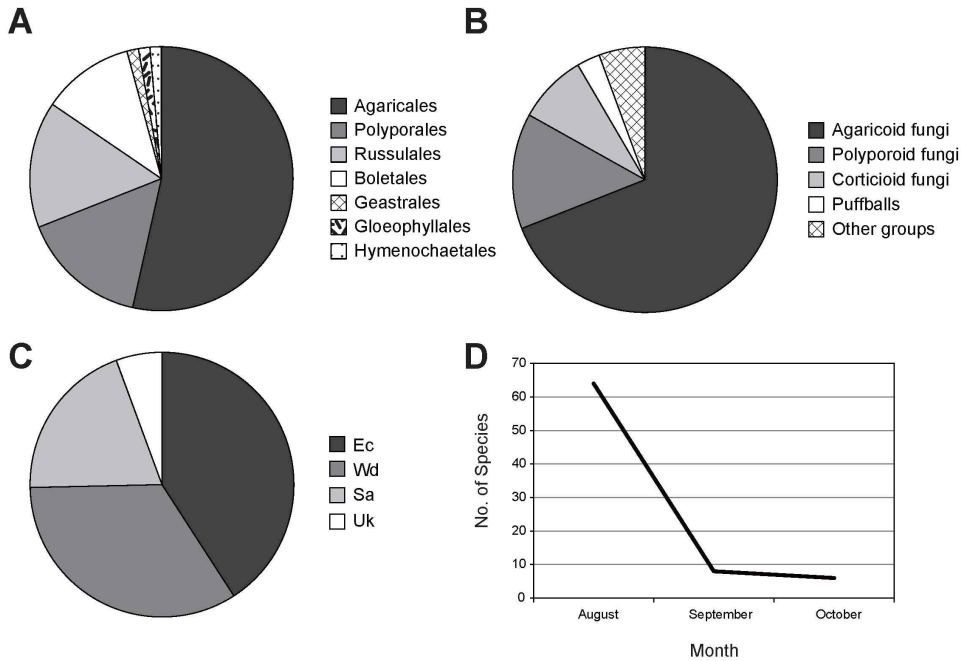

Fig. 1. A. The proportion of species in each taxonomic group. B. The proportion of species in each morphological group. C. The proportion of species in each ecological group. Ec: Ectomycorrhizal fungi; Wd: Wood decay fungi; Sa: Saprotrophic fungi; Uk: Unknown. D. The number of species observed in August to October, 2014.

peculiare, and *Trametes versicolor* were found. Among them, two species, *Hyphodontia tropica* and *Irpex lacteus* were observed from all three survey months.

Discussion

In Mt. Inwang, field surveys were carried out from August to October in 2014. A total of 71 species were recognized, but 20 species could not be identified to species level through morphological and molecular analyses due to their deviated morphological characters from the previously described species and no closely related sequence information available in GenBank.

The occurrence of fungal fruit bodies is related to climatic factors such as precipitation and temperature. According to Jang (2014) and Jang and Hur (2014), most of the fungi preferred higher temperatures and precipitation for the formation of fungal fruit bodies and the highest species occurrence was observed in July and August when the highest temperature and rainfall were observed, and it decreased in September and October. As shown in Table 1, the monthly mean temperature, mean monthly maximum temperature, mean monthly minimum temperature, and precipitation of Seoul were the highest in August and they gradually decreased until October. Here, most of the species were observed in August except 7 wood decay

fungi which were *Daedaleopsis confragosa, Trametes versicolor, Stereum peculiare, Phanerochaete* sp., *Peniophora incarnata, Schizophyllum commune,* and *Plicaturopsis crispa,* and only a small number of species was found in September and October. The species which were observed in October and September had relatively low water contents compared to agaricoid fungi and it seemed that they could form fruit bodies even in drier conditions.

Although diverse species were observed by the surveys, it is not certain whether a species is common or rare in terms of occurrence. We observed that some ectomycorrhizal fungi such as *Amanita* spp. and *Suillus* spp. were abundant and widespread in the study site in August, but their exact occurrence was not measured. For the better understanding, plot-based analysis is needed.

This study shows the diversity of basidiomycetous fungi in Mt. Inwang for the first time. Although the forest is fragmented, diverse fungi were found including currently undetermined species. Further studies are needed to identify them and to properly understand the distribution of each species in terms of season and location.

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요 약

본 연구에서는 인왕산에 서식하는 버섯의 다양성을 조사하였다. 2014년 8월부터 10월까지 버섯 채집을 실시한 결과, 총 91점의 표본을 채집하였다. 이는 형태학적인 분석방법과 분자생물학적인 분석방법을 통해 71종, 45속, 30과, 7목으로 동정되었다. 확인된 대부분의 종은 8월에 발생하였으며, 더 건조한 9월과 10월에는 10종의 목재부후균만을 확인하였다. *Hyphodontia tropica*와 *Irpex lacteus* 두 종만이 8월부터 10월까지 모두 확인되었다.

검색어 : 다양성, 담자균, 버섯, 분류, 생태, 인왕산