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PATHOGENIC MYCOBIOTA OF ORNAMENTAL PLANTS FROM GREEN AREA IN THE CITY OF BUCHAREST, ROMANIA

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Abstract

The paper presents the pathogenic mycobiota associated with ornamental deciduous trees and shrubs as well as flowering plants grown in the green spaces of the city of Bucharest. The observations were carried out in 2020-2023 in the Herastrau Park, the Bazilescu Park, the Dendrological Park and the Botanical Garden on the USAMVcampus and adjoining streets. Ornamental plants are attacked by various pathogenic species of fungi from Ascomycota and Basidiomycota phyla. During the study, symptoms produced by 47 species of fungal pathogens, belonging to the phylum Ascomycota, included in 11 orders (Erysiphales, Rhytismatales, Glomerellales, Helotiales, Diaporthales, Capnodiales, Taphrinales, Mycosphaerellales, Venturiales, Myringiales, Pleosporales) were observed. From the Basidiomycota phylum, 10 species belonging to 4 orders (Pucciniales, Agaricales, Entylomatales, Polyporales) were identified. Fungal species were identified based on symptoms induced in plants and on morphological characteristics of pathogens.

Key words*: ornamental plants, pathogenic mycobiota, Romania, urban green spaces.*

INTRODUCTION

In recent years, there has been a growing interest in increasing the area of green areas in cities, as well as in their maintenance (Bărbulescu et al., 2004). Ornamental plants play a vital role in enhancing public open spaces such as city parks, gardens, urban forests and recreational areas, providing green spaces and relaxing opportunities for both residents and visitors, thus contributing to the physical and mental health of the population (Barton & Rogerson, 2017; Jimenez et al., 2021; Van den Berg & van den Berg, 2015). Green spaces in cities offer numerous benefits through aesthetic value, noise mitigation, pollution reduction, reduction of ambient temperature, creation of habitats for wildlife (Iliescu, 2003; UGREEN, 2024). However, the well-being of ornamental plants in green spaces is constantly threatened by various pathogens, pests and abiotic factors (Bălăcenoiu et al., 2020; Badea & Enescu, 2016; Ciceoi et al., 2017; Gutue et al., 2014; 2015; Vlad et al., 2006) as well as with adaptation to the effects of climate change, population growth, degradation of environmental conditions, globalisation, etc. (Ferrini & Fini, 2011).

By 2050, more than 66% of the world's population is expected to live in cities compared to 54% today (United Nations, 2018). In terms of recommended green space per inhabitant, the European Union propose a minimum of 26 square meters of green space and the World Health Organization suggest 50 square meters per inhabitant. In the city of Bucharest, according to a study conducted by the European Commission, only 7.1 square meters of green space per inhabitant was recorded (Petrescu, 2021).

With the advent of global warming, scientists are concerned about improving the environment in cities. Thus, keeping ornamental plants healthy becomes a requirement of our days. Moreover, climate change can modify the physiology of the host plant as well as the microbial community of plants. Consequently, the combination of abiotic factors and native or invasive pests and pathogens may exacerbate tree health problems in urban green spaces in the future (Fodor & Vlad, 2013; Vîrteiu et al., 2022). The impact of global warming, with changes in temperature and humidity, can affect the development and survival of pests and pathogens as well as their natural enemies, competitors and vectors.

Planting trees in close proximity to buildings, streets and concrete-covered areas often leads to reduced tree vigour due to soil compaction and

impermeability of the substrate surface, preventing adequate water and nutrient uptake. In addition, exposure to pollution from roads, factories and other sources can further weaken urban trees, making them more susceptible to pests and pathogens (Badea & Enescu, 2016).

At present, fungi are the most common pathogens on ornamental plants in green spaces (Kimic et al., 2023). Fungal diseases most commonly found in green spaces in cities are recognized by symptoms such as powdery mildew, foliar spots, necrosis, rusts, blight, cankers or various rots and molds (Fodor & Vlad, 2013; Sălcudean et al., 2020; Vlad & Iacomi, 2021). Damage caused by fungal diseases to ornamental trees and shrubs is considered high, involving additional costs of control measures or generating problems with costs related to removing dead parts or even whole plants (Kimic et al., 2023). In many urban areas, lack of proper care and maintenance of ornamental plants results in much higher rates of plant mortality (Ferrini & Fini, 2011). Therefore, our study aims to gather more information about the most important diseases affecting green spaces. These data can prioritise research in the field and knowledge transfer to those who are interested.

MATERIALS AND METHODS

A survey was performed to asses the presence of fungal pathogen on ornamental trees, shrubs, subshrubs, vines and annual, biennial and perennial flower species. Observations were carried out between 2020 and 2023, in the city of Bucharest - Bazilescu Park (B), Herastrau Park (H), USAMV Campus Park (U) and adjacent streets (S).

Fungal pathogens have been identified based on characteristic symptoms that were photograped and a microscopic examination was done for species-level identification.

Results are expressed as a list of identified species (fungal taxa) detected on ornamental species. The names of the host plants (ornamental deciduous trees, shrubs, subshrubs, lianes as well as flowering plants) followed the nomenclature proposed by USDA - Plants Database (Plant List of Attributes, Names, Taxonomy, and Symbols) and the family name was in acording with Encyclopedia Britannica.

Fungal species were identified based on symptoms induced in plants and on morphological characteristics of pathogens. Species names of identified fungal pathogens have been listed according to Index Fungorum.

RESULTS AND DISCUSSIONS

Pathogenic mycobiota associated with ornamental plants in the green spaces of Bucharest was represented by 57 fungal species classified in 15 orders and 21 families, belonging to the *Ascomycota* and *Basidiomycota* phyla.

Different fungal pathogens have been identified on 45 woody taxa and flowering plants belonging to 24 botanical families: *Araliaceae*, *Asteraceae*, *Asparagaceae*, *Balsaminaceae*, *Berberidaceae*, *Betulaceae*, *Bignoniaceae*, *Celastraceae*, *Fagaceae*, *Hypericaceae*, *Iridaceae*, *Juglandaceae*, *Liliaceae*, *Malvaceae*, *Oleaceae*, *Paeoniaceae*, *Platanaceae*, *Plantaginaceae, Rosaceae*, *Salicaceae*, *Sapindaceae*, *Solanaceae*, *Moraceae* and *Vitaceae*. Thus, 22 species of deciduous trees, 9 species of shrubs, 2 species of subshrubs, 2 species of lianas and 10 flowering plants have been monitored (Tables 1-3).

Symptoms observed in woody taxa were powdery mildew, foliar spot, rust, wood rot, basal stem rot, blossom and twig blight, scab, pocket plum, leaf curl (Figure 1).

Rosaceous plants have been the most affected by fungal pathogens, due to the large number of taxa in this family that are susceptible to attack. The representatives of the genus *Acer* (*Sapindaceae* family) showed symptoms of powdery mildew in each year of the study period.

Trees, shrubs, subshrubs, lianas and flowering plants in the green spaces of Bucharest have been attacked every year by fungal species classified in the orders *Erysiphales*, *Helotiales, Pleosporales, Polyporales, Agaricales* and *Pucciniales.*

The main symptoms observed on flowering plants were powdery mildew, foliar spot, rust, gray mold and white smut (Figure 1).

From flowering plants, the taxa from the Asteraceae family have been the most affected by fungal pathogens belonging to the *Erysiphales* and *Entylomatales* orders (Table 3).

Table 1. Pathogenic mycobiota associated with deciduous trees

Host family	Host species	Disease	Symptoms on:*	Fungal species	Reporting period	Location
Sapindaceae	*Acer campestre* L. *Acer negundo* L. *Acer platanoides* L.	Powdery mildew	L	*Sawadaea bicornis* (Wallr) Miyabe	2020-2023	B, H, U
	Acer tataricum L.	Powdery mildew	L	*Sawadaea tulasnei* (Fuckel Homma)	2020-2023	B, H, U
	Acer negundo L.	Anthracnose	S	*Colletotrichum acutatum* J.H. Simmonds	2022	U
	Acer platanoides L.	Tar spot	L	*Rhytisma acerinum* (Pers.) Fr	2021	U
	Aesculus hippocastanum L.	Basal stem rot	St	*Ganoderma applanatum* (Pers.) Pat.	2020-2023	H, S
Bignoniaceae	*Catalpa bignonioides* Walter	Powdery mildew	L	*Erysiphe elevata* (Burrill) U. Braun & S. Takam.	2020-2023	U
Betulaceae	*Corylus avellana* L.**	Powdery mildew	L	*Phyllactinia guttata* (Wallr.) Lèv.	2020-2023	H, U
Rosaceae	*Cydonia oblonga* Mill.**	Entomosporium leaf spot	L	*Diplocarpon mespili* (Sorauer) B. Sutton	2020; 2023	S
		Blossom blight	L, F, YF	*Monilinia linharthiana* (Prill. & Delacr.) Dennis	2022-2023	S
	Malus pumila Mill.**	Powdery mildew	L, F, S	*Podosphaera leucotricha* (Ellis & Everh.) E.S. Salmon	2020-2023	U
		Brown rot	Fr	*Monilinia fructigena* (Pers.) Honey	2021	U
	Malus floribunda Siebold ex Van Houtte	Powdery mildew	L, F, S	*Podosphaera leucotricha* (Ellis & Everh.) E.S. Salmon	2021	B, U
		Scab	L, Fr	*Venturia inaequalis* (Cooke) G. Winter	2021	U
	Prunus persica (L.) Batsch f. *atropurpurea* C.K. Schneid	Leaf curl	L	*Taphrina deformans* (Berk.) Tul.	2021	B
	Prunus cerasifera Ehrh. var. *pissardii* (Carrière) L.H. Bailey	Pocket plum	Fr	*Taphrina pruni* (Fuckel) Tul.	2020-2022	H, S, U
		Rust	L	*Tranzschelia pruni-spinosae* (Pers.) Dietel	2021	H, S, U
	Prunus avium L.**	Anthracnose	L	*Blumeriella jaapii* (Rehm) Arx	2020-2022	U
		Shot hole	L	*Stigmina carpophila* (Lév.) M.B. Ellis	2020-2023	U
	Prunus serrulata Lindl.	Blossom blight	Fr, L	*Monilinia* laxa (Aderh. & Ruhland) Honey	2022	U
Oleaceae	*Fraxinus excelsior* L.	Powdery mildew	L	*Phyllactinia fraxini* (DC.) Fuss	2020-2023	S
Juglandaceae	*Juglans regia* L.**	Antracnose	L, Fr	*Ophiognomonia leptostyla* (Fr.) Sogonov	2021; 2023	U
Platanaceae	*Platanus hybrida* Brot.	Antrachnose	L	*Apiognomonia veneta* (Sacc. & Speg.) Höhn.	2020-2023	S, U
		Powdery mildew	L	*Erysiphe platani* (Howe) U. Braun & S. Takam.	2020-2023	S, U
Salicaceae	*Populus nigra* L.	Rust	L	*Melampsora laricis-populina* Kleb.	2021-2022	S, U
		Powdery mildew	L	*Erysiphe aduncа* (Wallr.) Fr.	2023	S
	Salix matsudana Koidzumi "*Tortuosa*"	Anthracnose	L, S	*Marssonina salicis* (Trail) Magnus	2022-2023	U
Moraceae	*Morus alba* L.	Leaf spot	L	*Mycosphaerella mori* (Fuckel) F.A. Wolf	2021-2022	H, S
	Morus rubra L."*Pendula*"	Leaf spot	L	*Mycosphaerella mori* (Fuckel) F.A. Wolf	2021-2022	H, S, U
Fagaceae	*Quercus robur* L.	Powdery mildew	L	*Erysiphe alphitoides* (Griffon & Maubl.) U. Braun & S. Takam.	2020-2023	U
	Quercus rubra L.	Wood rot	ST	*Schizophyllum commune* Fr.	2020-2023	U

*F – flowers; Fr - fruits; L – leaves; S – shoots; ST – stems; YF – young fruits;
**These species are not typical ornamental plants, but they are found in different green spaces from Bucharest

In the case of flowering plant species, some attacks were not recorded each year of the study period (Table 3). Thus, powdery mildew attacks on *Chrysanthemum indicum* (*Golovinomyces chrysanthemi*) and *Impatiens balsamina* (*Podosphaera balsaminae*), white smut symptoms (*Entyloma ploysporum*) on *Gaillardia aristata*, and gray mold (*Botrytis paeoniae*) on *Paeonia officinalis* were recorded only in 2021. In 2023, the climatic conditions were favorable for *Botrytis tulipae* attack on *Tulipa gesneriana* plants.

Table 2. Pathogenic mycobiota associated with deciduous shrubs, subshrubs and lianas

Host family	Host species	Disease	Symptoms on:*	Pathogens	Reporting period	Location
Berberidaceae	*Berberis vulgaris* L.	Powdery mildew	L, S	*Erysiphe berberidis* DC.	2020-2023	B, H, S, U
	Mahonia aquifolium (Pursh) Nutt.	Powdery mildew	L	*Erysiphe berberidis* DC.	2020-2023	B, U
		Rust	L	*Cumminsiella sanguinea* (Peck) Arthur	2020-2023	B, U
		Anthracnose	L	*Colletotrichum karsti* You L. Yang, Zuo Y. Liu, K.D. Hyde & L. Cai	2021	S
Rosaceae	*Chaenomeles japonica* (Thund.) Lindl. ex Spach	Blossom blight	F, L	*Monilinia laxa* (Aderh. & Ruhland) Honey	2021-2023	B, U
	Pyracantha coccinea M. Roem.	Scab	L	*Fusicladium pyracanthae* (Thüm.) O. Rostr.	2023	U
	Rosa spp.	Powdery mildew	L, S, F	*Podosphaera pannosa* (Wallr.) de Bary	2020-2023	B, H, S, U
		Black spot	L	*Diplocarpon rosae* (Lib.) F.A. Wolf	2020-2023	B, H, S, U
		Rust	L	*Phragmidium mucronatum* (Pers.) Schltdl.	2021	H
		Anthracnose	L, P	*Elsinoe rosarum* Jenkins & Bitanc.	2020-2023	B, H, S, U
		Gray mould	FB, P	*Botrytis cinerea* Pers.	2021	S
		Sooty mould	L	*Capnodium citri* Berk. & Desm.	2021	S
Celastraceae	*Euonymus fortunei* (Turcz.) Hand. - Mazz.	Powdery mildew	L, S	*Erysiphe euonymi-japonici* U. Braun & S. Takam.	2020-2023	S
Oleaceae	*Forsythia* x *intermedia* Zabel	Twig blight	L, F, S	*Sclerotinia sclerotiorum* (Lib.) de Bary	2021-2023	B, U
	Syringa vulgaris L.	Powdery mildew	L	*Erysiphe syringae* Schwein.	2020-2023	B, H, S, U
Araliaceae	*Hedera helix* L.	Anthracnose	L	*Colletotrichum trichellum* (Fr.) Duke	2021	U
Hypericaceae	*Hypericum calycinum* L.	Rust	L	*Melampsora hypericorum* (DC.) J. Schröt.	2020-2021	U
Solanaceae	*Lycium barbarum* L.	Powdery mildew	L, S	*Arthrocladiella mougeotii* (Lèv.) Vassilkov	2020-2023	U
Vitaceae	*Vitis vinifera* L.**	Powdery mildew	L, G	*Erysiphe necator* Schwein.	2023	S
		Antracnose	L, S, G	*Elsinoe ampelina* Shear	2021	S
Asparagaceae	*Yucca filamentosa* L.	Brown leaf spot	L	*Coniothyrium concentricum* (Desm.) Sacc.	2020-2023	B, S, U

*F – flowers; FB – flower buds; G – grapes; L – leaves; P – petiols; S – shoots;
**These species are not typical ornamental plants, but they are found in different green spaces from Bucharest

Table 3. Pathogenic mycobiota associated with some flowering plants

Host family	Host species	Disease	Symptoms on:*	Pathogens	Reporting period	Location
Malvaceae	*Althea rosae* L.	Rust	AP	*Puccinia malvacearum* Bertero ex Mont.	2020-2023	S
Plantaginaceae	*Antirrhinum majus* L.	Rust	L, ST	*Puccinia antirrhini* Dietel & Holw.	2020-2023	S
Asteraceae	*Chrysanthemum indicum* L.	Powdery mildew	L, S	*Golovinomyces chrysanthemi* (Rabenh.) M. Bradshaw, U. Braun, Meeboon & S. Takam.	2021	S
	Cosmos bipinnatus Cav.	Powdery mildew	L	*Podosphaera fusca* (Fr.) U. Braun & Shishkoff	2020-2023	S
	Dahlia pinnata Cav.	Powdery mildew	L	*Golovinomyces cichoracearum* (DC.) V.P. Heluta	2020-2023	B, U
	Gaillardia aristata Pursh	White smut	L	*Entyloma polysporum* (Peck) Farl.	2021	U
Balsaminaceae	*Impatiens balsamina* L.	Powdery mildew	L	*Podosphaera balsaminae* (Wallr.) U. Braun & S. Takam.	2021	S
Iridaceae	*Iris germanica* L.	Leaf spot	L	*Heterosporium pruneti* Nicolas & Aggéry	2020-2023	S, U
Paeoniaceae	*Paeonia officinalis* L.	Leaf blotch	L, P, ST	*Dichocladosporium chlorocephalum* (Fresen.) K. Schub., U. Braun & Crous	2020-2023	U
		Gray mold	FB	*Botrytis paeoniae* Oudem.	2021	U
Liliaceae	*Tulipa gesneriana* L.	Gray mold	L, F	*Botrytis tulipae* (Lib.) Lind	2023	U

*AP - all aerial parts; F – flowers; FB – flower buds; L – leaves; P – petiols; S – shoots; ST - stems

One explanation for this situation may be that climatic conditions have varied so that in some years they have favoured the development of fungal diseases. Also, some of the monitored plant species, such as *Impatiens balsamina,* are annuals, and not planted every year.

The pathogenic fungi identified during this study belong to the Ascomycota and Basidiomycota phyla. Most fungal species have been classified in Ascomycota phylum (82.45%), in 11 orders, 15 families, and 26 genera (Table 4). In Basidiomycota phylum (17.55%) fungal species have been classified into 4 orders, 7 families, and 8 genera (Table 5). The *Erysiphales* order was the best represented within Ascomycota phylum, with numerous species attacking both woody (82.6%) and flowering species (17.4%).

Species of this order were observed in almost each year of the study period and are well known for their negative consequences on the sustainability of urban green spaces and plant health. In 2020 and 2022, 18 host plant species that showed symptoms of powdery mildew were identified. The number of host plants with powdery mildew attack increased in 2021 to 21 species, and in 2023 to 20 species, compared to 18 species in 2020 and 2022.

Fungal species belonging to *Helotiales* order have been involved in gray mold and blossom or twig blight (*Sclerotiniaceae* family) and leaf spots (*Drepanopezizaceae* family).

From Basidiomycota phylum, the *Pucciniales* order was the best represented with numerous species involved in rust symptoms on ornamental plants, attacking both woody and flowering species.

Table 4. Fungal species from Ascomycota phylum

Order	Family	Fungal species
Capnodiales	*Metacapnodiaceae*	*Venturia inaequalis*
	Capnodiaceae	*Capnodium citri*
	Cladosporiaceae	*Heterosporium pruneti*
	Davidiellaceae	*Dichocladosporium chlorocephalum*
Diaporthales	*Gnomoniaceae*	*Ophiognomonia leptostyla*
		Apiognomonia veneta
Erysiphales	*Erysiphaceae*	*Arthrocladiella mougeotii*
		Erysiphe aduncata;E. alphitoides; E. berberidis; E. elevata; E. euonymi-japonici; E. necator; E. syringae
		Golovinomyces chrysanthemi; *G. cichoracearum*
		Phyllactinia guttata; *P. fraxini*
		Podosphaera leucotricha; P. pannosa; P. fusca; P. balsaminae
		Sawadaea bicornis; S. tulasnei
Glomerellales	*Glomerellaceae*	*Colletotrichum acutatum;C. karsti;C. trichellum*
Helotiales	*Sclerotiniaceae*	*Botrytis cinerea; B. paeoniae; B. tulipae*
		Monilinia laxa;M. linharthiana; M. fructigena
		Sclerotinia sclerotiorum
	Drepanopezizaceae	*Blumeriella jaapii*
		Diplocarpon mespili; D .rosae
		Marssonina salicis
Mycosphaerellales	*Mycosphaerellaceae*	*Mycosphaerella mori*
		Stigmina carpophila
Myringiales	*Elsinoaceae*	*Elsinoe ampelina; E. rosarum*
Pleosporales	*Coniothyriaceae*	*Coniothyrium concentricum*
Rhytismatales	*Rhytismataceae*	*Rhytisma acerinum*
Taphrinales	*Taphrinaceae*	*Taphrina deformans; T. pruni*
Venturiales	*Venturiaceae*	*Fusicladium pyracanthae*

Table 5. Fungal species from Basidiomycota phylum

Order	**Family**	**Fungal species**
Agaricales	*Schizophyllaceae*	*Schizophyllum commune*
Entylomatales	*Entylomataceae*	*Entyloma polysporum*
Polyporales	*Polyporaceae*	*Ganoderma applanatum*
Pucciniales	*Melampsoraceae*	*Melampsora hypericorum; M. laricis populina*
	Pucciniaceae	*Cumminsiella sanguinea*
		Puccinia malvacearum; P. antirhhini
	Tranzscheliaceae	*Tranzschelia pruni-spinosae*
	Phragmidiaceae	*Phragmidium mucronatum*

Figure 1. Symptoms caused by fungal pathogens on host plants examined during the study: Pg - *Phyllactinia guttata* on *Corylus avellana*; Am - *Arthrocladiella mougeotii* on *Lycium barbarum*; Pb - *Podospahera balsaminae* on *Impatiens balsamina*; Cc - *Coniothyrium concentricum* on *Yucca filamentosa*; Hp – *Heterosporium pruneti* on *Iris germanica*; Bp - *Botrytis paeoniae* on *Paeonia officinalis*; Bt - *Botrytis tulipae* on *Tulipa gesneriana*; Ss - *Sclerotinia sclerotiorum* on *Forsythia* x *intermedia*; Mla – *Monilinia laxa* on *Prunus serrulata* (a) and on *Chaenomeles japonica* (b); Ml - *Monilinia linharthiana* on *Cydonia oblonga*; Mh - *Melampsora hypericorum* on *Hypericum calycinum*; Tps - *Tranzschelia pruni-spinosae* and Tp - *Taphrina pruni* on *Prunus cerasifera* var.*pissardii*; Pa - *Puccinia antirrhini* on *Antirrhinum majus*; Cs (a, b) - *Cuminsiella sanguinea*, Ck - *Colletotrichum karsti* on *Mahonia aquifolium*; Ep - *Entyloma polysporum* on *Gaillardia aristata*; Ra - *Rhytisma acerinum* on *Acer platanoides*; Fp - *Fusicladium pyracanthae* on *Pyracantha coccinea*; Pp - *Podosphaera pannosa,* Dr - *Diplocarpon rosae*, Er - *Elsinoe rosarum,* Pm - *Phragmidium mucronatum* on *Rosa* spp.

Our study joins other studies monitoring the microbiota of ornamentals plants in green spaces (Chinan & Mânzu, 2018; Chinan, 2018; Chira et al., 2020; Florea et al., 2022; Pricop et al., 2002). The examined ornamental plants were affected by diseases that are commonly identified in urban green areas as powdery mildew, rusts, leaf spots, twig blights, leaf curl and wood rots.

In recent years there has been a growing interest in increasing the number of ornamental plants (trees, shrubs, subshrubs, lianas or flowering plants) in green spaces, in the diversification of cultivated species, and in their health in view of the benefits they bring to cities and residents. Ornamental plants are generally not selected for their resistance to fungal diseases, and this can be deduced from the observations made during this study, a large number of fungal pathogen species being detected in urban green spaces.

Therefore, there is a need for continuous monitoring of ornamentals diseases in urban green spaces in order to contribute to early detection and identification of responsible pathogens.

CONCLUSIONS

Our study inventoried the diseases of ornamental trees, shrubs, subshrubs, lianas and flowering plants in the green spaces of Bucharest (mainly Bazilescu Park, Herăstrau Park, UASVM Campus Park and adjacent streets). Fungal species that composed the studied mycobiota were classified into the phyla Ascomycota and Basidiomycota. These species are common fungal pathogens in urban green areas, responsible for powdery mildew, leaf spots, rusts, blossom and twig blights. Powdery mildews were the most recorded diseases, being detected and identified on 23 host plants. Other categories of well represented diseases were leaf spots identified on 18 host plants, rusts identified on 7 host plants, and blossom and twig blights identified on 4 host plants.

Inventoried ascomycetes fungi were better represented (26 genera) compared to basidiomycetes (8 genera).

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