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FUNGAL DIVERSITY OF HERBS IN QUSAR DISTRICT OF AZERBAIJAN

D.N. Aghayeva, T.B. Mailova, L.V. Abasova,
A.A. Alimammadova, A.J. Bakhshiyeva, A.N. Aliyeva
Institute of Botany, Azerbaijan National Academy of Sciences
Badamdar highway 40, Baku, AZ1004, Azerbaijan
E-mail: a_dilzara@yahoo.com

The study reports the fungi occuring on herbs in Qusar district collected and investigated during 2017-2019 and specimens kept at the Mycological Herbarium of the Institute of Botany. In total 14 taxa of six genera belonging to Oomycota, 57 taxa of 22 genera belonging to Ascomycota and 84 taxa of nine genera belonging to Basidiomycota have been determined, which all together cover 155 species and infraspecific taxa. Taxonomic structure of 152 host plants belonging to five groups, 17 orders, 31 families and 116 genera has been investigated. Mass majority of fungi are obligate pathogens on the representatives of Asterales, Poales and Fabales. According to the results of the monitoring, the ratio of grass and fungal taxa not significantly different from 1:1. The affect of the climate condition to the development and abundance of fungi are different depending on the taxonomic and ecological groups. Thus the development of several fungi (*Albugo, Alternaria, Bremia, Hyaloperonospora, Peronospora, Pseudoperonospora, Pustula* etc.) depends on the temperature and humidity, but abiotic factors are not very important for development of the representatives of few genera (*Claviceps, Colletotrichum, Phyllachora* etc.). Species variation and consistent trend along the elevational gradient was observed starting from the low mountain zone. But some species were recorded at various elevations. *Colletotrichum malvarum*, various taxa of the genera *Erysiphe, Golovinomyces, Puccinia calcitrapae, P. graminis, Tranzschelia pruni-spinosae* were found in the middle and upper elevations. *Monilia altaica* on *Hippophae rhamnoides* was found in the lowest elevation, along the Samur river and *Puccinia caricina* in higher elevation, in the vicinity of Sudur village. The number of species was maximum in June, July and September. But the number of genera and species decreases slightly in August, which can be explained by heat and low humidity.

Keywords: fungi, species, taxon, elevation, seasonality

INTRODUCTION

The problem of protection and conservation of biodiversity on the Earth is of high priority. Despite of the studies conducted for centuries, data about the biotic components from the gene to ecosystem level are still scarce [Rudolph et al., 2018].

Fungi as an other living organisms are important components of different ecosystems and perform many vital functions. These include symbiotic interactions with plants, participation in the circulation of nutrient turnover, biological control, etc. [Heilmann-Clausen, 2014; Fraiture, Otto, 2015]. Fungi are among poorly documented organisms and therefore it is very difficult to understand their phylogenetic relations [Branco, 2011; Hawksworth, Lücking, 2017]. Traditionally this group are classified based on the morphological and ultrastructural features. In the past few decades molecular biological approaches to the study of fungal diversity have gained particular importance. Molecular data allows for the most accurate classification and better understanding of the interactions between fungi in this system. Studies based on various approaches altogether shed light on the history of fungal evolution [Bellemain et al., 2010; Bridge et al., 2005; James et al., 2006; Hibbet et al., 2011]. Monitoring is very important for studying the abundance of fungi in a certain area, which allows a large-scale assessment of the fungal species and making certain conclusion [Andrew et al., 2017; Danielsen et al., 2005; Hawksworth, 2003].

Qusar district located in the north-eastern border of the Republic on the southern slopes of

the Greater Caucasus and is mainly characterised by mountainous relief, abundant precipitation and moderate climate. From aesthetic point of view, landscape prevailed by mountain peaks, slopes and meadows that are rich with herbs. Humidity due to moderate climate and abundant precipitation provides favourable condition for the growth of fungi from different groups [Aghayeva, 2016].

Fungal diversity in the country had been systematically and consistently studied since the mid of the last century and nevertheless information on fungi of Qusar district is scarce. This is limited to the fragmentary studies and Ph.D thesises on different ecological or taxonomic groups of fungi [Aghayeva, Abasova, 2018; Aliyeva et al., 2019; Bakshiyeva et al., 2019; Ulyanishchev, 1960, 1962, 1967].

Summarizing the above mentioned, fungal composition of the district cannot be considered complete. The purpose of the study was to determine fungal diversity of Qusar district, to compile a species checklist. In this article we present the results of study as brief analysis of the taxonomic composition and species richness of fungi, as well as the host plant range, elevational pattern and seasonality of fungal diversity based on the available knowledge and current investigation.

MATERIAL AND METHOD

Fungal sampling. More than 300 herbarium specimens collected in Qusar district from the 40s of last century and kept at the Mycological Herbarium of the Institute of Botany of ANAS (BAK) were morphologically investigated. Inspection and monitoring were held in the villages of Anig, Chilagir, Duztahir, Hazra, Khuray, Lagar, Laza, Suvachal, Tahirjal, Urva and Zindanmurug during the field surveys organized in 2017-2019 (Fig. 1). Fungal samples in association with plants were collected and identified. Samples were taken from various parts of plants, such as live and shed leaves, branches, young shoots, fruits, and all necessary data including GPS coordinates were recorded.

Identification of fungi. Specimens were identified based on classical morphological approach by using light microscope (Carl Zeiss, Axio Imager, Göttingen, Germany). Shape and size of fungal structures were considered. About 20-25 measurements were performed for each

Figure 1. Map of Qusar district. Red marks display the sampling areas.

important diagnostic features and the results are expressed as (min-) (mean - sd) - (mean + sd) (-max). The necessary monographs and publications were used for the identification of the species [Braun, Cook, 2012; Ulyanishchev, 1960, 1962, 1967; Vánky, 1994]. Where species occurrence is considered ambiguous, information (coordinates, elevation) was analyzed further and compared with published plant data. The species status was inspected in Index Fungorum.

Identification of plants. Identification of the plant specimens was done according to the available literature, and mainly local flora guides and data lists were used [Alizade et al., 2019; Flora of Azerbaijan, 1950, 1952, 1953, 1954, 1955, 1957, 1961]. Species status was also checked following the World Flora Online [WFO]. Angiosperm Phylogeny Group classification was used for plant taxa above family [APG IV, 2016].

Statistical analyses. The relationships between the ratio of genera belonging to the different phyla and seasonality was analyzed using the Venn diagram [Venn, 1880]. Part of the analyses was carried out on the basis of a set of all possible classifications of three operational seasonal units (OSU). A presence/absence data matrix of three OSU was calculated according to the Jaccard similarity index (SJ = a/(a+b+c)) where, SJ - Jaccard similarity coefficient; a, b, c - represent the number of genera occurring in spring, summer and autumn respectively. Raw presence/absence data based on values that measure how similar three OSUs are based on the number of genera shared. This is a triangular matrix, because common data brought from three halves. A similarity matrix was used to construct a dendrogram that displays the relationship among OSUs based on similarity values.

RESULTS AND DISCUSSION

Taxonomic composition of fungi. Fungal herbarium samples, including samples collected and identified during the field trips to Qusar district in recent years have been inspected. Modern taxonomic and nomenclatural updates have been taken into account. Specimens belonging to the three phyla – Ascomycota, Basidiomycota and Oomycota (Chromista) were revised and identified (Tab. 1). Altogether 14 taxa belonging to the Peronosporea of Oomycota, 57 taxa belonging to the Dothideomycetes, Leotiomycetes, Sordariomycetes and Incertae sedis of Ascomycota and 84 taxa belonging to Pucciniomycetes, Ustilaginomycetes of Basidiomycota have been investigated.

In total, two species of each genus of *Albugo, Hyaloperonospora,* one species of each genus *Bremia, Pustula, Hyaloperonospora, Pseudoperonospora* and six *Peronospora* species were determined from phylum Oomycota.

Inspected specimens of Ascomycota belong to the orders Botryosphaeriales, Capnodiales, Pleosporales of the Dothideomycetes. Botryosphaeriales includes only the genus *Phyllosticta;* Capnodiales comprises *Cercosporella, Ovularia* with one species per genus, *Ramularia* represented with five and *Septoria* with six taxa. The order Pleosporales encomposes the following genera with one species per each: *Massarina* from the family *Massarinaceae*, *Alternaria, Macrosporium, Pyrenophora,* from the family Pleosporaceae; *Hendersonia, Stagonospora* and *Vagicola* from the family *Phaeosphaeriaceae*.

Leotiomycetes was represented with the family *Erysiphaceae* (Erysiphales) including genera *Blumeria* with one, *Golovinomyces* with 10, *Erysiphe* with eight, *Neoerysiphe* with one and *Podosphaera* with six taxa. This group is prevailing among ascomycetes in quantity of taxa.

Sordariomycetes was recorded with *Glomerellaceae* including *Colletotrichum*, *Clavicipitaceae* including *Claviceps* with two and *Epichloë* with one species, *Phyllachoraceae* including *Phyllachora*. Only *Septocyta martiniae* (Syn.: *Septoria martiniae*) of the ascomycetes was Insertae sedis in all taxonomic levels under Peziziomycotina [Index

Table 1.Taxonomic composition of fungi of Qusar district.

Orders	Families	Genera	Taxa	
			Nos	%
		OOMYCOTA		
Albuginales	*Albuginaceae*	*Albugo, Pustula*	3	1.9
Peronosporales	*Peronosporaceae*	*Bremia, Hyaloperonospora, Peronospora*, *Pseudoperonospora*	11	6.9
		ASCOMYCOTA		
Botryosphaeriales	*Phyllostictaceae*	*Phyllosticta*	4	2.5
Capnodiales	*Mycosphaerellaceae*	*Cercosporella*, *Ovularia, Ramularia, Septoria*	13	8.1
Pleosporales	*Massarinaceae*	*Massarina*	1	0.6
	Pleosporaceae	*Alternaria, Pyrenophora*, *Macrosporium*	3	1.9
	Phaeosphaeriaceae	*Hendersonia, Stagonospora*, *Vagicola*	3	1.9
Erysiphales	*Erysiphaceae*	*Blumeria, Erysiphe, Golovinomyces, Neoerysiphe*, *Podosphaera*	26	19.4
Glomerellales	*Glomerellaceae*	*Colletotrichum*	2	1.2
Hypocreales	*Clavicipitaceae*	*Claviceps, Epichloë*	3	1.9
Phyllochorales	*Phyllachoraceae*	*Phyllachora*	1	0.6
Incertae sedis	Incertae sedis	*Septocyta*	1	0.6
		BASIDIOMYCOTA		
Puccinales	*Coleosporiaceae*	*Coleosporium*	1	0.6
	Melampsoraceae	*Melampsora, Pucciniastrum*	3	1.9
	Phragmidiaceae	*Phragmidium, Trachyspora*	3	1.9
	Pucciniaceae	*Puccinia*, *Uromyces*	72	45.0
	Incertae sedis	*Aecidium*	4	2.5
Urocystidales	*Glomosporiaceae*	*Thecaphora*	1	0.6
Total	18	37	155	100

fungorum].

Inspected specimens of Basidiomycota belongs to the order Puccinales and include the genus *Aecidium* with four taxa, *Coleosporium* with one, *Melampsora* with two and *Pucciniastrum* with one species. The family *Phragmidiaceae* represented with *Phragmidium* containing two and *Trachyspora* one species. *Puccinia* dominates with 57 species and *Uromyces* with 15 species among the genera. Other genera are relatively small in number of registered species. During the study totally 84 taxa belonging to the various genera of rust fungi were recorded on 71 host plants. *The caphora* of the *Glomosporiaceae* was recorded with single species.

Host plant groups. The following plant groups have been revealed: the Monocots encomposes the families *Melanthiaceae* (Liliales), *Amaryllidaceae, Asparagaceae, Iriridaceae* and *Orchidaceae* (Asparagales), *Cyperaceae, Juncaceae* and *Poaceae* (Poales); the Eudicots with the family *Ranunculaceae* (Ranunculales), the Rosids with the families *Vitaceae* (Vitales), *Fabaceae* (Fabales), *Rosaceae, Urticaceae* (Rosales), *Euphorbiaceae*, *Violaceae* (Malpigiales), *Malvaceae* (Malvales), *Brassicaceae* and *Resedaceae* (Brassicales), the Superasterids with *Caryophillaceae, Polygonaceae* (Caryophyllales), the Asterids with *Boraginaceae* (Boraginales), *Convolvulaceae* (Solonales), *Lamiaceae*, *Plantaginaceae*, *Scrophulariaceae* (Lamiales) and *Asteraceae* (Asterales) (Tab. 2).

Maximum fungal taxa are recorded on the representatives of the genera belonging to the families *Apiaceae* (*Anthriscus, Bupleurum, Chaerophyllum, Heracleum, Laser, Libanotis, Prangos*), *Asteraceae* (*Achillea, Anthemis, Arctium, Artemisia, Bidens, Carduus, Cirsium, Centaurea, Echinops, Inula, Hieraceum, Lampsana, Senecio, Serratula, Silene, Rhagadiolus, Willemetia, Xeranthemum*), *Boraginaceae* (*Cerinthe, Lithospermum, Myosotis, Nonnea, Symphytum*) and *Lamiaceae* (*Calamintha, Marrubium, Origanum, Salvia, Scrophularia, Stachys*).

Host plants according to fungal phyla. Host range of Oomycota fungi is relatively limited,

Table 2. Taxonomic structure of host plants assosiated with fungi.

Orders	Families	Genera	Taxa	
			Nos	%
Apiales	*Apiaceae*	*Anthriscus, Bupleurum,Chaerophyllum, Falcaria, Heracleum, Laser, Pimpinella, Prangos, Seseli*	10	8.6
Asparagales	*Amaryllidaceae*	*Allium, Ornithogalum*	2	1.3
	Asparagaceae	*Polygonatum*	1	0.6
	Iridaceae	*Crocus,Gladiolus*	2	1.3
	Orchidaceae	*Dactylorhiza, Traunsteinera*	2	1.3
Asterales	*Asteraceae*	*Achillea, Anthemis, Arctium, Artemisia, Bidens, Carduus, Centaurea, Cirsium, Echinops, Inula, Hieraceum, Lampsana, Leotodon, Rhagadiolus, Senecio, Serratula, Silene, Sonchus,Taraxacum, Tussilago, Willemetia, Xeranthemum*	23	15.1
Boraginales	*Boraginaceae*	*Lithospermum, Myosotis, Nonea, Symphytum*	4	2.6
Brassicales	*Brassicaceae*	*Brassica, Cardamine, Cerinthe, Erysimum, Lepidium, Raphanus*	11	7.2
	Resedaceae	*Reseda*	1	0.6
Core eudicots Caryophyllales	*Amaranthaceae*	*Beta, Chenopodium*	2	1.3
	Caryophillacea	*Agrostemma, Dianthus*	2	1.3
	Polygonaceae	*Bistorta, Fallopia, Polygonum, Rumex*	4	2.6
Dipsacales	*Caprifoliaceae*	*Cephalaria, Dipsacus, Lonicera, Valerianella*	9	6.0
Fabales	*Fabaceae*	*Galega, Lathyrus, Onobrychis, Securigera, Trifolium, Vicia*	13	8.5
Gentiniales	*Apocynaceae*	*Vinca, Vincetoxicum*	2	1.3
	Gentiniaceae	*Gentiana*	1	0.6
	Rubiaceae	*Cruciata, Galium*	4	2.6
Lamiales	*Lamiaceae*	*Calamintha, Marrubium, Origanum, Salvia, Stachys*	6	3.9
	Plantaginaceae	*Plantago*	2	1.3
	Scrophulariaceae	*Scrophularia, Verbascum*	3	2.0
Liliales	*Melanthiaceae*	*Veratrum*	1	0.6
Malpigiales	*Euphorbiaceae*	*Euphorbia*	3	2.0
	Violaceae	*Viola*	1	0.6
Malvales	*Malvaceae*	*Althaea, Alcea, Malva*	3	2.0
Poales	*Cyperaceae*	*Carex*	3	2.0
	Juncaceae	*Luzula*	1	0.6
	Poaceae	*Aegilops, Agropyron, Agrostis, Avena, Bothriochloa, Bromus, Calamagrostis, Dactylis, Elymus, Festuca, Hordeum, Lolium, Melica, Phragmites, Poa, Sorghum, Triticum, Zerna*	22	14.4
Ranunculales	*Ranunculaceae*	*Aconitum, Clematis, Elymus, Ranunculus, Thalictrum*	5	3.3
Rosales	*Rosaceae*	*Alchemilla, Potentilla, Sanguisorba*	5	3.3
	Urticaceae	*Urtica*	1	0.6
Solonales	*Convolvulaceae*	*Convolvulus*	3	1.9
17	31	116	152	100

and this may be explained by the small number of collected samples. These fungi are found on plants of 10 different families belonging to eight orders: Asterales, Boraginales, Brassicales, Caryophyllales, Dipsacales, Fabales, Lamiales and Rosales.

Host plant association of Ascomycota is very rich. The host range of this group involves 16 orders, 21 families, that are Apiales, Asterales, Brassicales (*Brassicaceae*), Boraginales, Caryophyllales (*Amaranthaceae*, *Polygonaceae*), Dipsacales, Fabales, Gentiniales (*Apocynaceae*), Lamiales (*Lamiaceae*), Malpighiales (*Euphorbiaceae*), Malvales, Poales (*Poaceae*), Ranunculales, Rosales (*Urticaceae*) and Solonales (*Convolvulaceae*).

The host range of Basidiomycota fungi represented with 23 families belonging to 14 orders, which include Apiales, Asparagales, Asterales, Boraginales, Caryophyllales (*Polygonaceae*), Dipsacales, Fabales, Gentiniales (*Gentiniaceae, Rubiaceae*), Lamiales (*Lamiaceae, Scrophulariaceae*), Liliales, Malpigiales, Poales, Ranunculales and Rosales (*Rosaceae*).

Some fungi are found on more than one host plant, in the same plant family and sometimes on the species belonging to the same genus. For example, the rust species *Puccinia urticae-carices* is found on *Carex tristis*, *C. aggegata* (*Cyperaceae*), and *Puccinia graminis* on *Avena sativa, Phleum pretense*, *Triticum aestivum* (*Poaceae*).

Results of the analyses of the richness of the

host plants has shown that herbs belonging to different taxonomic groups may host the same fungi, or single fungal species have different hosts. *Phyllosticta libanotidis, Septoria libanotidis, Massarina* sp., *Pyrenophora* sp. was recorded on *Seseli transcaucasicum* (Syn.: *Libanotis transcaucasica*) of the family *Apiaceae*; *Aecidium inulae-helenii, Coleosporium inulae* and *Golovinomyces inulae*, on *Inula helenium* from the family *Asteraceae*; *Puccinia recondite* and *Pucciniastrum symphyti* on *Symphytum caucasicum* of the family *Boraginaceae*; *Cercospora beticola* and *Erysiphe betae* on *Beta vulgaris*, of the family *Amaranthaceae*; *Peronospora viciae, Uromyces ervi* and *Uromyces fabae* on *Vicia sepium* of the family *Fabaceae*.

Species diversity according to seasonality and elevation. Fungi highly depend on environmental condition that determines their growth period. Fungi are generally recorded starting from April (*Aecidium*, *Puccinia*), and the number is gradually increasing, which is linked to the onset of vegetation and active development period of plants. The most fungal diversity is observed during the summer (Fig. 2).

Number of observed genera was highest in June and July (Fig. 3). But in August, the number of genera and species decreases slightly, which

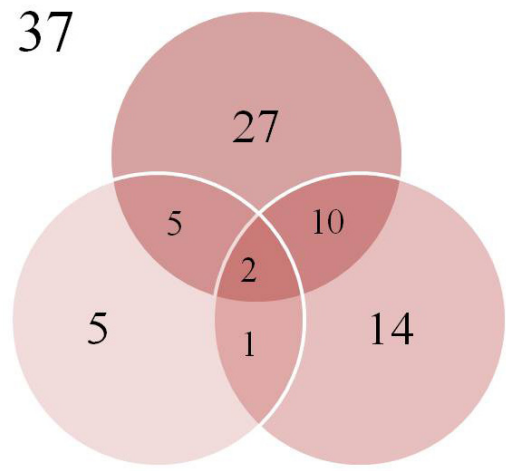

Figure 2. The number of fungal genera recorded across seasons: 37 total number of genera; a, b, c.: number of genera in spring, summer and autumn respectively.

can be explained by the heat and low humidity. In September, an increase in the number of genera and species is again observed. Starting from October herbs are partially disappear and in this month two species belonging to one genus (*Erysiphe*) have been recorded. Oomycetes was recorded during spring and summer months. Number of Ascomycetes prevailed starting from summer till the end of September. Basidiomycetes was observed from April till October.

Some species were found in forests, grasslands

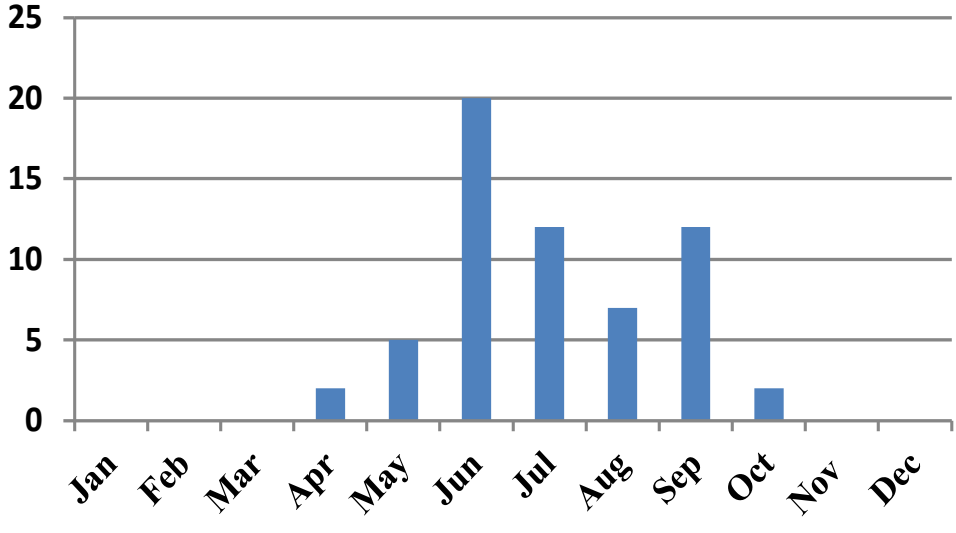

Figure 3. The number of fungal genera recorded across months.

and cultivated areas. Species variation and a consistent trend along the elevation gradient was observed starting from the low mountain zone. Some species were recorded at various elevations. *Colletotrichum malvarum*, various forms of the genus *Golovinomyces, Puccinia calcitrapae, Puccinia graminis, Tranzschelia pruni-spinosae* were found in the middle and upper elevation. *Monilia altaica* on *Hippophae rhamnoides* was found in the lowest elevation, along the Samur river 310 m a.s.l. and *Puccinia caricina* at the higher elevation, 1794 m a.s.l. in the vicinity of Sudur village.

CONCLUSION

The study of fungi of different regions has been of great importance in recent years. This generally requires long-term tedious monitoring of the study area, this may provide important information about species distribution. The article totally provides information about 155 fungal taxa on 152 herbs. The study of the fungi is a great importance in terms of protecting the plant diversity in nature, as well as protecting plants that are widely used by indigenous people for food and medicinal purposes. During the study a number of hyphomycetes, rust, smut fungi have been found on the plant species with importance of food (*Avena sativa, Avena sterilis* (Syn.: *A. ludoviciana*), *Betae vulgaris, Brassica oleracea, Chenopodium album, Hordeum vulgare, Urtica dioica*), medicinal (*Carduus crispus, Elymus repens, Plantago major, Mentha longifolia*), forage (*Dactylis glomerata, Hordeum murinum, Trifolium pratense*) and ornamental (*Artemisia absinthium, Festuca rubra, Gladiolus italicus, Inula helenium, Lithospermum purpurocoeruleum, Nonea lutea, Viola silvestris*).

Currently limited knowledge on fungal diversity makes it difficult to determine the protection status of fungi, and it also complicates demographic registration of fungi [Andrew et al., 2019; Branco, 2011]. The lack of adequate methods to quickly calculate the impact of environment to the fungal diversity is also a problem that needs to be considered. There is another possibility of incomplete information on fungal endophytes of plants. The specificity of the host plants, different species found on the same plant, or the same fungal species found on different species may pose a complication of interpreting the obtained data. Implementation of the work towards the study of fungal diversity in different regions taking account the above mentioned problems across the country will be considered in future researches.

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Azərbaycanın Qusar rayonunun otlarının göbələk müxtəlifliyi

D.N. Ağayeva, T.B. Mailova, L.V. Abasova, A.A. Əliməmmədova, A.C. Baxşiyeva, A.N. Əliyeva
AMEA Botanika İnstitutu,
Badamdar şossesi 40, Bakı, AZ1004, Azərbaycan

Tədqiqat işində 2017-2019-cu illərdə Qusar rayonunda ot bitkilərindən toplanmış, həmçinin Botanika İnstitutunun Mikoloji Herbarisində saxlanılan və araşdırılmış göbələk nümunələri barədə məlumat verilir. Oomycota 6 cinsə aid 14, Ascomycota 22 cinsə aid 57 və Basidiomycota 9 cinsə aid 84 takson ilə bütövlükdə 155 növ və növ daxili takson olaraq təyin edilmişdir. 152 sahib bitkinin taksonomik strukturu tədqiq edilmiş və onların 5 qrup, 17 sıra, 31 fəsilə və 116 cinsə aid olması müəyyənləşdirilmişdir. Göbələklərin böyük əksəriyyəti Asterales, Poales və Fabales sıralarının nümayəndələrinin obliqat törədiciləridir. Monitorinqin nəticələrinə görə ot bitkilərinin və göbələk taksonlarının nisbəti 1:1-dən əhəmiyyətli dərəcədə fərqlənmir. İqlim şəraitinin göbələklərin inişafına və sayına təsiri taksonomik və ekoloji qruplardan asılı olaraq fərqlənir. Beləliklə bəzi göbələklərin (*Albugo, Alternaria, Bremia, Hyaloperonospora, Peronospora, Pseudoperonospora, Pustula* və s.) inkişafı temperatur və rütubətdən asılıdır, lakin bəzi cinslərin (*Claviceps, Colletotrichum, Phyllachora*) nümayəndələri üçün abiotik faktorlar bir o qədər əhəmiyyət kəsb etmir. Düzənlikdən yüksəkliyə qalxdıqca növ dəyişkənliyi tendensiyası nəzərə çarpır. Lakin müxtəlif yüksəkliklərdə təsadüf edilən növlər də qeyd edilmişdir. *Colletotrichum malvarum, Erysiphe, Golovinomyces* cinslərinin nümayəndələri, *Puccinia calcitrapae, P. graminis, Tranzschelia pruni-spinosa* orta və yuxarı dağ qurşaqlarında müşahidə edilmişdir. *Monilia altaica* və *Hippophae rhamnoides* aşağı dağ qurşağında, Samur çayı boyu və *Puccinia caricina* yüksək qurşaqda, Sudur kəndi ətrafında aşkar edilmişdir. Növlərin sayı iyun, iyul və sentyabr aylarında maksimal olmuşdur. Lakin avqust ayında cins və növlərin sayında azalma qeyd edilib ki, bu da yüksək temperatur və aşağı rütubətlə izah edilə bilər.

Açar sözlər: göbələk, növ, takson, yüksəklik, mövsümilik

Грибное разнообразие трав в Гусарском районе Азербайджана

Д.Н. Агаева, Т.Б. Майлова, Л.В. Абасова, А.А. Алимамедова, А.Дж. Бахшиева, А.Н. Алиева
Институт ботаники НАНА
Бадамдарское шоссе 40, Баку, AZ1004, Азербайджан

В данной работе сообщается о грибах, встречающихся в разнотравье Кусарского района, которые были собраны и исследо-

ваны в течение 2017-2019 годов на основе материалов, хранящихся в микологическом гербарии Института ботаники. Всего было определено 14 таксонов в шести родах, принадлежащих к Oomycota, 57 таксонов в 22 родах, принадлежащих к Ascomycota, и 84 таксона в девяти родах, принадлежащим Basidiomycota, которые в целом охватывают 155 видов и внутривидовых таксонов. Была исследована таксономическая структура 152 растений-хозяев, относящихся к пяти группам, 17 отрядам, 31 семействам и 116 родам. Подавляющее большинство грибов являются облигатными возбудителями у представителей Asterales, Poales и Fabales. По результатам мониторинга соотношение травяных и грибных таксонов существенно не отличается от 1:1. Влияние климатических условий на развитие и численность грибов различается в зависимости от таксономических и экологических групп. Таким образом, развитие некоторых грибов (*Albugo, Alternaria, Bremia, Hyaloperonospora, Peronospora, Pseudoperonospora, Pustula* etc.) зависит от температуры и влажности, но абиотические факторы не очень важны для развития родов (*Claviceps, Colletotrichum, Phyllachora* etc.). Видовая изменчивость и устойчивая тенденция вдоль градиента высоты наблюдались, начиная с низкогорной зоны. Но некоторые виды были зарегистрированы на разных высотах. *Colletotrichum malvarum,* различные таксоны *Erysiphe, Golovinomyces, Puccinia calcitrapae, P. graminis, Tranzschelia prunispinosa* были обнаружены в средних и верхних высотах. *Monilia altaica* на *Hippophae rhamnoides* были обнаружены в самой нижней возвышенности, вдоль реки Самур и *Puccinia caricina* в более высокой возвышенности, в окрестностях деревни Судур. Количество видов было максимальным в июне, июле и сентябре. Однако число родов и видов в августе несколько уменьшается, что можно объяснить высокой температурой и низкой влажностью.

Ключевые слова: грибы, вид, таксон, высота, сезонность