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FUNGAL PATHOGENS OF MEDICINAL PLANTS IN ARID WOODLANDS OF VAYOTS DZOR REGION OF ARMENIA

ГРИГОРЯН Н. В., АЛЕКСАНЯН А. С., НАНАГЮЛЯН С. Г. ПАТОГЕННЫЕ ГРИБЫ ЛЕКАРСТВЕННЫХ РАСТЕНИЙ АРИДНЫХ РЕДКОЛЕСИЙ ВАЙОЦ-ДЗОРСКОГО РЕГИОНА АРМЕНИИ

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Our research in arid woodlands of Vayots Dzor Region of Armenia indicates different fungal infections in separate parts of several medicinal plants that grow in this area. On 42 species of medicinal plants which belong to 38 genera and 19 families collected in researched area, a total of 39 species of micromycetes were found. Among them, fungi 31 species belonged to *Ascomycota*, 7 — to *Basidiomycota*, and 1 — to *Oomycota* divisions. *Golovinomyces* genus from powdery mildew fungi was the prevalent for 11 plants, and *Golovinomyces galeopsidis* was the dominant species on 6 host plants. The quantitative relation between collected (by population) and infected parts of medicinal plants shows that collected leaves, stems, barks, branches are largely infected, and the least of all infected are roots.

Key words: pathogenic micromycetes, medicinal plants, arid woodlands, powdery mildew, rust fungi.

Исследования, проведенные в аридных редколесьях Вайоц Дзора (Армения), показали, что различные грибные инфекции встречаются на разных частях лекарственных растений, произрастающих в обследованном регионе. На 42 видах лекарственных растений из 38 родов и 19 семейств, обнаруженных в исследуемом регионе, зарегистрировано 39 видов микромицетов. Среди них 31 вид принадлежит отделу *Ascomycota*, 7 — *Basidiomycota* и 1 — *Oomycota*. Род *Golovinomyces* из мучнисторосяных грибов был распространен на 11 видах лекарственных растений, а *Golovinomyces galeopsidis* доминировал на 6 видах растений-хозяев. Количественное сравнение зараженных и используемых населением частей лекарственных растений показывает, что в значительной степени поражаются собранные листья, стебли, кора, ветви и менее всего — корни.

Ключевые слова: патогенные микромицеты, лекарственные растения, аридные редколесья, мучнистая роса, ржавчинные грибы.

Folk medicine is used widely and has a rapidly growing economic importance. Indigenous and complementary-alternative medicine are gaining more and more respect by national governments and health providers in developing countries (World.., 2002). Medicinal plants represent an important component of biodiversity. It is essential to make the complete inventory of the medicinal plants of any country for conservation and sustainable use. In modern health care, about half of all medical products is produced from wild and cultivated medicinal plants.

Nowadays, the use of natural resources in Armenia and in many other countries is uncontrolled and sustainable management as well as the system for monitoring the status of population are absent. Especially actual problem is the preservation of medicinal plants. Medicinal plants traditionally occupied an important position in rural and urban lives of Armenia. They constitute the basis of primary health care for the majority of the population in Armenia and are a significant source of benefits for rural population. The majority of the plants are collected as a medicinal. Arid woodlands have a huge value as source of the richest gene pool of fodder, food, medicinal and melliferous plants.

Medicinal plants which are used in herbalism have certain compounds in their leaves, stems, flowers and fruits with medicinal purposes. Prepared extracts are used as inputs in the pharmaceutical and chemical industries.

Local people collect medicinal plants in both fresh and dry conditions to have opportunity to utilize during the

whole year. Different parts of plants (aerial, foliage and underground) can be used for treatment of different diseases and by various ways.

The flora of deciduous arid woodlands of Vayots Dzor Region (Darelegis floristic region) includes 753 species of plants belonging to 344 genera and 70 families. The high floristic richness for this type of vegetation proves its integrated character and presence of disturbed habitats rather than the diversity of climatic conditions (Biodiversity.., 2014).

Medicinal plants of this area are collected and used not only by locals and tourists, but also by procurers and traditional herbal drug dealers for sale purposes.

The role of fungal organisms in the nature is diverse. As one of the components of phytocenosis, fungi can on one hand promote the development of certain vascular plants, on the other — delay the phenological stages, cause debilitation and even remove some plants from phytocenosis.

The main problems for medicinal plants are numerous fungal diseases which heavily damage them. These diseases sometimes drastically reduce the crop, causing premature drying and death of the plant, which affect on their quality and quantity.

Various pathogens negatively affect on the medicinal plant biochemistry and decrease its medicinal value. It may be harmful to the human body while using these infected parts as medicine. So, identification of the infected fungi is important. Being impertant component of biocoenoses they need to be studied.

Taking into account aforementioned, we start to investigate arid woodlands of Vayots Dzor which have not been explored in mycological respect, yet. The aim of this study was to identify systematic structure of fungal biota of arid woodlands of Vayots Dzor, to reveal regularities in distribution and specialization of fungi to host plants.

Materials and methods

Area studied. Vayots Dzor is one of the most attractive and historically fascinating regions of Armenia, centered on the watershed of the Arpa River and its tributaries. The region is situated in the southern part of Armenia. In the south it borders with Nakhijevan, in the north it borders with Gegharkunik Region, in the east — Syunik Region and in the west — Ararat Region. It covers an area of 2308 km^2. Vayots Dzor is surrounded with high mountains, mountain ranges, that being original natural banks between it and adjacent territories, turn that into a geographical single whole with big and small tops, mysterious canyons, mountain passes, plateaus and concavities. The region territory is covered with a dense network of mountain rivers and their tributaries (39 rivers and 16 small rivers). The main river is Arpa (Movsisyan, 2003).

The Vayots Dzor climate is continental with cold or moderate cold winters and hot or warm summers. The highest possible air temperature reaches 40 °C in southern districts, and the exceptional minimum is –35 °C. Precipitations comprise 300—700 mm. The region has 4 climatic types — arid continental, moderately warm arid, moderately cold forest, and cold mountain climate (Valesyan, Hovsepyan, 2007).

Because of the variety of habitats, soils of Vayots Dzor are also various. There are mountain (post-forest) chernozems, mountain brown forest soil, mountain-chestnut soil, mountain meadow steppe and mountain meadow soils (Ghazaryan, 2013).

Diversity of vegetation with prevalence of the extremely xerophilous vegetation units is caused by variation in relief, climatic conditions and also soil cover. The territory of Vayots Dzor is presented by several types of vegetation: semi-deserts, steppes, subalpine and alpine meadows, arid woodlands, intra-zonal types of vegetation — phryganoid vegetation, rocky habitats (rocks, screes, placers) and wetlands. The administratively investigated territory coincides with borders of Darelegis floristic region, that is presented as one of the regions with the richest flora in Armenia (1740 species) (Biodiversity.., 2014).

Besides the above mentioned types of vegetation, weed (in the fields) and ruderal (near settlements, roadsides, in disturbed habitats) vegetation types are presented in all mountain zones.

Sample collection, detection and identification of medicinal plants. As materials for our research were used: our own collections of medicinal plants from Vayots Dzor Region of Armenia during 2010—2014, the herbarium materials of Department of Botany and Mycology (ERHM) of Yerevan State University and of the Institute of Botany of NAS RA (ERE), analysis of available literature data about medicinal plants (Grossgeym, 1952; Zolotnitskaya, 1958, 1965; Gubanov et al., 1976; Gammerman, Grom, 1976; Turova, Sapozhnikova,1984; Plant.., 1984—1993; Pastushenkov et al., 1990; Nosal, Nosal, 1991; Sokolov 1994; Tsaturyan, Gevorgyan, 2007), as well as interviews with local people. As a result we have carried out a general analysis and identified medicinal plants of deciduous arid woodlands of Vayots Dzor Region.

Sample collection, detection and identification of micromycetes. As materials for our research were used our own collections of microscopic phytopathogenic fungi, collected from Vayots Dzor Region of Armenia in the period from 2012 to 2014, the herbarium materials of YSU Department of Botany and Mycology (ERHM), as well as all available literature data. The data obtained allowed to summarize the distribution of fungi affecting on medicinal plants.

Study is based on methods of route-forwarding and laboratory studies. Route surveys were conducted during all growing season. The affiliation of the species of pathogens, the time of appearance of the symptoms of diseases, as well as the degree of susceptibility of different species of plants are studied. Infected plant parts (leaf, stem or root) were collected and placed into individually labeled paper bags and sealed. All the samples with the symptoms of disease were collected in separate bags.

Collection, identification, description and fungi microscopy were performed by standard mycological methods (Golovin, 1960; Cummins, Hiratsuka, 2003; Mueller et al., 2004; Azbukina, 2005; Popkova et al., 2005; Braun, Cook, 2012).

The names of plants, place and time of samplings were recorded accordingly. Classification and reclassification of

the taxa was conducted during the work. The taxonomic revision of fungal species, were stored in herbaria, or the process previously mentioned in the literature was carried out. Many of them are renamed in accordance with the International Code of Botanical Nomenclature (2006) and Index Fungorum (2015) database (www.indexfungorum.org).

Results and discussion

Results indicated that there are several fungal diseases, which may infect the medicinal plants, their aerial and soil parts, depending on the plant species and the fungal pathogens. Infected plants wilt in leaf and grow poorly, which leads to the decrease in quality and quantity of biologically active substances. Eventually, it can bring to a death and collapse of the plants.

During our research we investigated 289 species of medicinal plants belonging to 175 genera and 58 families. From these plants were separated 42 species from 38 genera and 19 families, on which identified fungi were found. Among investigated plants herbs are dominate — 32 species (most of them perennials). Woody plants have only 9 species, but there are dominant species such as *Amygdalus fenzliana*, *Celtis glabrata*, *Pistacia mutica*, *Rhamnus pallasii*, etc., of main formations of arid woodlands of southern Armenia (Pistacieta, Amygdaleta, Celtideta, etc.). We note that all 42 species of plants are spread not only in Vayots Dzor Region, but also in adjacent areas (Osipyan, 1967, 1975, 2013; Teterevnikova-Babayan, 1977; Teterevnikova-Babayan et al., 1983; Simonyan, 1994). This proves the importance of our research in the diseases of these plants, as they can easily be spread and become epidemic.

As a result of our mycological studies of medicinal plants of arid woodlands of Vayots Dzor we identify 39 species of microscopic fungi belonging to 20 genera, 10 orders, 9 families, 6 classes from 3 divisions and 2 kingdoms (Table 1).

As the data in the table, the largest numbers of fungal species are included in the division *Ascomycota* — 31 species, from which the order *Erysiphales* (20 species) is represented in a large number of species.

The most common species of microfungi in this territory is *Golovinomyces galeopsis* (about 15.4 % of the total) — which causes powdery mildew of medicinal plants from the family *Lamiaceae* and infects their leaves, stems and flowers.

As the data in the Table 2, the greatest number of fungi species are found on the plants from the family *Lamiaceae* (6 species), *Asteraceae* and *Rosaceae* (4 species), *Fabaceae*, *Plantaginaceae*, *Rhamnaceae* — 3 species in each, *Anacardiaceae*, *Borraginaceae*, *Ephedraceae*, *Oleaceae*, *Poaceae* and *Polygonaceae* — 2 species, mycobiota of other families are represented by a single species, which depends on wide distribution of species from these families.

Data show that powdery mildew is the most common disease on medicinal plants of this area — 69 % of infected medicinal plants. Powdery mildew disease appears on leaves and fresh stems at the end of the season and then covers the entire surface of growing parts of plants. Leaves of some medicinal plants are used for different medicinal purpose, so powdery mildew is a significant disease on these medicinal plants.

Table 1

Distribution of fungal pathogens by the main taxonomic groups

Kingdom/division	Class	Order	Family	Genera	Species number
Chromista/Oomycota	*Oomycetes*	*Peronosporales*	*Peronosporaceae*	*Peronospora*	1
Fungi/Ascomycota	*Dothideomycetes*	*Capnodiales*	*Mycosphaerellaceae*	*Ovularia*	1
				Ramularia	3
		Botryosphaeriales	*Botryosphaeriaceae*	*Phyllosticta*	1
		Pleosporales	*Pleosporaceae*	*Curvularia*	1
				Ulocladium	1
			Incertae sedis	*Phoma*	2
		Venturiales	*Venturiaceae*	*Fusicladium*	1
	Leotiomycetes	*Erysiphales*	*Erysiphaceae*	*Blumeria*	1
				Erysiphe	2
				Golovinomyces	5
				Leveillula	3
				Microsphaera	2
				Phyllactinia	2
				Podosphaera	5
	Sordariomycetes	*Hypocreales*	*Incertae sedis*	*Acremonium*	1
Fungi/Basidiomycota	*Pucciniomycetes*	*Pucciniales*	*Pucciniaceae*	*Puccinia*	4
				Uromyces	1
	Ustilaginomycetes	*Urocystidales*	*Urocystidaceae*	*Urocystis*	1
		Ustilaginales	*Ustilaginaceae*	*Ustilago*	1
In total: 2/3	6	10	9 + 2 incertae sedis	20	39

Table 2

Distribution of species of pathogenic micromycetes by host plants

Families of vascular plants	Number of plant genera	Number of plant species	Divisions			Total number of fungi species for each family
			Ascomycota	*Basidiomycota*	*Oomycota*	
Anacardiaceae	1	1	2	—	—	2
Apiaceae	1	1	—	1	—	1
Asteraceae	5	6	4	—	—	4
Berberidaceae	1	1	—	1	—	1
Boraginaceae	2	2	2	—	—	2
Campanulaceae	1	1	1	—	—	1
Convolvulaceae	1	1	1	—	—	1
Ephedraceae	1	1	2	—	—	2
Fabaceae	4	4	3	—	—	3
Lamiaceae	7	9	6	—	—	6
Oleaceae	1	1	2	—	—	2
Plantaginaceae	1	2	2	—	1	3
Poaceae	2	2	1	1	—	2
Polygonaceae	1	1	1	1	—	2
Primulaceae	1	1	1	—	—	1
Ranunculaceae	1	1	—	1	—	1
Rhamnaceae	1	1	1	2	—	3
Rosaceae	5	5	4	—	—	4
Ulmaceae	1	1	1	—	—	1

As a result of our studies we have found 20 species of powdery mildew fungi, belonging to 8 genera from division *Ascomycota*. We have identified the following genera of powdery mildew: *Golovinomyces* and *Podosphaera* (5 species for each), *Leveillula* (3 species), *Microsphaera*, *Erysiphe* and *Phyllactinia* (2 species for each), *Blumeria* (1 species).

In the study area favorable conditions exist for the development of hyphal fungi, which now belong to division *Ascomycota*. By the number of representatives the following genera should be noted: *Ramularia* (3 species), *Curvularia* (2 species), *Acremonium*, *Fusicladium*, and *Ulocladium* which are presented by one species. They include both parasitic and saprophytic forms. The parasites affect the tissue of host plants and cause dieback of its individual parts in the form of rounded, angular or irregular spots, causing an illness called spotting in vascular plants.

In saprophytic species of hyphal fungi staining can not be observed, but it develops abundant scurf, consisting of mycelium, conidiophores and conidia. Developing on the juicy, fleshy substrate, they can cause it to rot.

As we know, various fungal pathogens infect overground, foliage and underground parts of plants. We investigated all 42 species of medicinal plant in this region, which were infected by micromycetes. The comparison of the number of the plant parts which are used for medicinal purposes with the number of the infected parts of the same plant species is shown in Fig. 1. Apparently from figure,

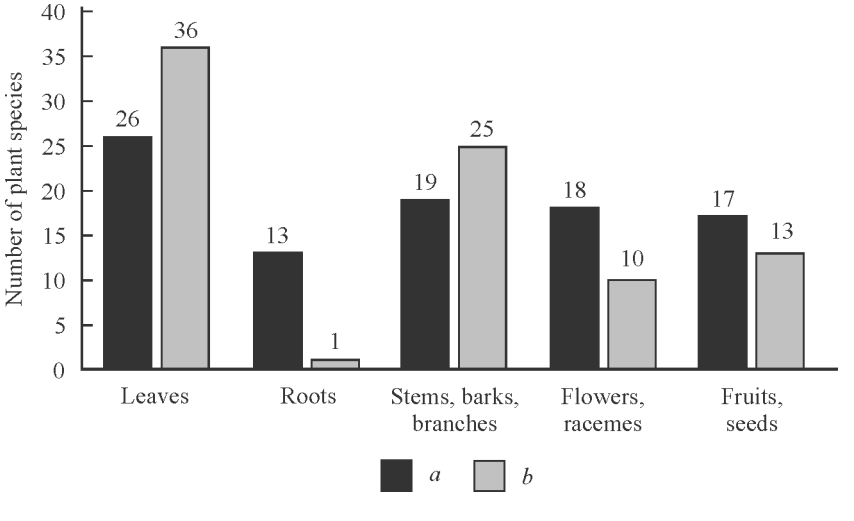

Fig. 1. The comparative analysis of used (*a*) and infected (*b*) parts of medicinal plant species.

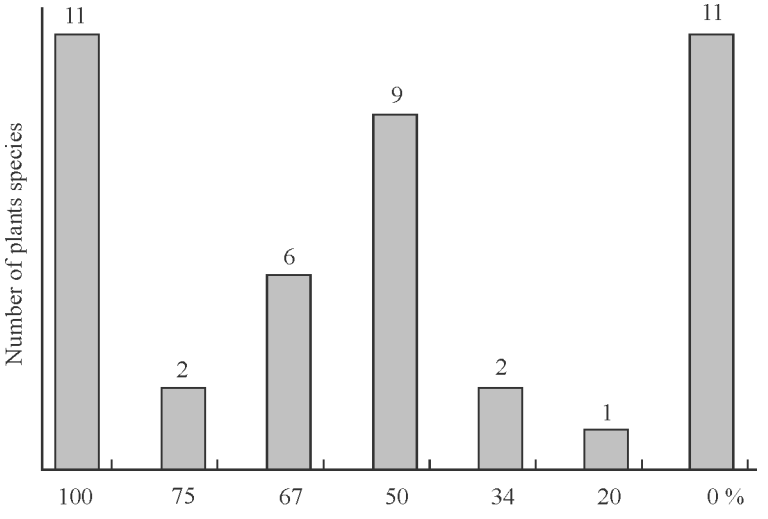

Fig. 2. Percent of identity of the collected and infected parts of medicinal plants.

leaves, stems, barks and branches are the parts of the plants, which are mostly used and infected, and the least of all are the roots.

We also tried to compare how infected and collected/used parts coincide for each plant species. For example, infected and collected/used parts of *Pistacia mutica* are the same. For fruits and seeds the matching is 100 %, but for *Campanula rapunculoides* it makes 0 %, because roots are used for medicinal purpose whereas only leaves are infected. As we can see from Fig. 2, in 11 plant species among 42 collected and infected parts do not coincide, but for most of all species, there is either a complete or partial matching.

We need to note that there are other 11 species that, despite the percentage of coincidence, have infected parts that are not used. Of course, despite the percentage of coincidence of collected and infected parts we must not forget that even if there are collected uninfected parts, all the same plants have diseases. This, if not directly then indirectly, affects the entire physiology and host plants life. That in varying degrees reduces useful characteristics of plants.

Conclusion

Currently, plant protection is seen as a problem which is of biological, economic, environmental and social significance. Long-term use of some wild economical important plants led to a reduction of their natural recourses. In this regard, one of the most urgent tasks is to record resources of wild useful plants, the development of processes for rational use and protection of collected species.

In investigated area we have found 289 species of medicinal plants belonging to 175 genera and 58 families. From these plants we separate 42 species from 38 genera and 19 families, which were infected by microscopic fungi.

We define 39 species of micromycetes belonging to 20 genera, 10 orders, 9 families, 6 classes from 3 divisions and 2 kingdoms. In addition 2 families from *Hypocreales* and *Pleosporales* orders have an *incertae sedis* status. Included in the division *Ascomycota* — 31 species, among them by large number of species is represented the order *Erysiphales* (20 species).

It should be noted that modern plant protection processes are based on a rational combination of organizational-economic and preventive measures. Undoubtedly, the above mentioned number of plants and their diseases does not exhaust all flora and mycobiota of our study territory. Unique natural conditions, the richness of the vegetation types and the relatively mild climate provide the basis to expect that further research will add more species to this list.

The results of these studies can be used in activities for the protection of cultivated and wild medicinal plants in the organization of measures to combat harmful pathogens both in the wild and artificial plant communities, as well as to inform the public, especially the local people who widely collect these plants for their own use and sale.

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