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Monitoring the species diversity of medicinal plants typical for the south slope of Hissar Ridge / Tajikistan /

D.S. Sattarov[1,*], S.Kh. Vyshegurov[2] and R.R. Galeev[2]

[1]Tajik Academy of Agricultural Sciences, National Republican Center for Genetic Resources, Rudaki Avenue, 21/1, TJ734000 Dushanbe, Tajikistan
[2]Federal State Budgetary Educational Institution of Higher Education "Novosibirsk State Agrarian University", Street Dobrolyubova, 160, RU630039 Novosibirsk, Russia
[*]Correspondence: jamshed.hvilya@mail.ru

Abstract. This paper is a summary of literature reviews concerning the diversity of medicinal plants and the results of our many years studies. It includes scientific and practical justifications of the importance of monitoring species diversity of the studied object. Results of monitoring the species composition of wild medicinal plants in some areas of the southern slope of the Gissar Range are specified. As a result of studying 11 gorges (Gazhne, Safedchashma, Gusgarf, Shamal, Obi-Zugora, Gulobod, Yos, Yavroz, Semiganch, Odzhuk, Magov), 174 species of medicinal plants were found that belong to different botanical taxa. This number of plants includes representatives of 106 genera belonging to 46 families, among which representatives of the aster family predominate: Asteraceae (36 species), Rosaceae (19 species), Lamiaceae (16 species), etc. Compared with the number of known plants growing within the territory of the Republic of Tajikistan, the number of species found was 11.6%. In relation to the number of plants that are recognized as medicinal in the world, species diversity of the southern slopes of Gissar Range is less than one percent. However, the number of species is comparable to locations with similar climatic conditions.

Key words: biodiversity, medicinal plants, family, species, Gissar Range, agriculture.

INTRODUCTION

The problem of rapidly declining biological diversity, including species diversity, is global concern rather widely discussed in modern scientific community (Altukhov, 1995; Iaconay et al., 2018). The number of species in an ecosystem determines its stability as of a functional unit over a long time period (Landscape Indicators, 2011). The more species inhabit an ecosystem, the greater their number is concentrated on the performance of similar functions what, in turn, is a kind of guarantee for maintaining ecosystem stability if any species suddenly becomes extinct (Markov, 2010). Some scientists believe that ecosystem stability is based on the laws of thermodynamics, in particular, on the concept of self-regulating mechanisms (Rosenberg & Zinchenko, 2014). Self-sustaining systems are thought to be the prerogative of living organisms (May, 1973). It is believed that the very fact of life appearance is a logical end to the formation of a global biochemical metabolism. Moreover living organisms are a peculiar

conservation factor due to the possibility of encoding hereditary information with the help of nucleic acids. It is also important that due to the appearance of living organisms, it is possible to use in biosphere more effective catalysts, such as enzymes (Markov, 2010; Moelling, 2016). Any biological species is an important, and sometimes irreplaceable, element of global biochemical mechanism – based on the fact that everything that is irrelevant sooner or later loses its competitive ability, and, accordingly, the extinction of such species due to natural selection is just about timing (Markov & Naimark, 2015). After all, as you know, freedom ends where it infringes on the freedom of others, and therefore, selfish, genetically determined desire of species for personal progress is limited by complex interspecific interactions where excessive egoists are at a disadvantage (Dawkins, 1978). Each biological species is a unique genetic reservoir; the total of them is a global allele pool of biosphere stability. Quantitative ratio of different species is also an evolutionarily developed mechanism. It is not for nothing that people thought about different concepts of the conservation of biological diversity what is specified in the provisions of different international conventions (Convention on Biological Diversity. Rio De Janeiro, 1993). In particular, the mountains of Central Asia are recognized as one of the most important global biological resources for the conservation of mountain biodiversity (Khan et al., 2013).

Wild medicinal plants are a meaningful part of biocenoses. In particular, the symbiosis of at least some of them with endophytic actinobacteria enriches biocenoses with various sodium compounds what is estimated as a valuable resource for chemical industry and agriculture (Golinska et al., 2015; Karlsons & Osvalde, 2019). It was demonstrated that the species composition of plants, including those used for medicinal purposes, closely correlates with the number of insects pollinators which, in turn, increase the efficiency of pollination, and therefore, reproduction (Gailis et al., 2017). It is well known that the biological diversity of wild medicinal plants is a fairly informative criterion for assessing the overall environmental situation. In particular, species composition of biocenosis is a rather informative visual tool for assessing the content of heavy metals (Ozyigit et al., 2018; Imeri et al., 2019; Salama et al., 2019). Their qualitative and quantitative composition is determined by a number of environmental factors (Khan et al., 2013). Medicinal plants are an integral part of high mountain ecosystems that are directly involved in stabilizing the functioning of lowland ecosystems where the most part of the planet's population is concentrated (Geist, 2005).

In addition, despite the development of biomedical technologies, medicinal plants are still a valuable resource for pharmacological industry (Sofowora et al., 2013). In developing countries up to 80% population use traditional system of medicine i.e. herbal formulations derived from plants (Navaneethan et al., 2011; Nautiyal et al., 2015). In the global volume of medicines, the number of herbal drugs is up to 5%, and investments in this industry amount to hundreds of millions of dollars (Dutra et al., 2016). Thus, monitoring the biological diversity of medicinal plants is a very important scientific and practical issue.

Tourism development, over population, as well as intensification of industrialisation are well-known factors in increasing the anthropogenic load by first decades of the 21st century. Expansion of agricultural land that reduces the area of unique natural ecosystems gives cause for special concern (Khan et al., 2013). In combination with changing climatic conditions, this is a risk of the decrease in species composition of flora and fauna. In particular, biodiversity of resources and the influence

of different environmental factors on the seed productivity of wild medicinal plants in the Republic of Tajikistan were studied (Sattarov et al., 2017, 2018, 2018a). In addition, geographical and species analysis of the flora of Central Pamir-Alai was carried out (Safarov, 2013, 2013a). Number and age composition of coenopopulations of *Thermopsis dolichocarpa* under conditions of Vakhsh and Gissar ranges (Rakhimov, 2010), and the productivity of high-mountain pastures of Gissar (Madaminov, 2010). Due to favorable climatic conditions, more than 1,500 species of wild medicinal plants grow in the Republic of Tajikistan (Khojimatov, 1989). Fortunately a number of measures are being taken to protect wild flora in the Republic of Tajikistan (http://www.portali-huquqi.tj/publicadliya/view_qonunhoview.php?showdetail=&asosi_id=2866).

The aim of this research is to study the species composition of wild medicinal plants on the southern slope of Gissar Range, which is the natural buffer zone of the city of Dushanbe from the north, northwest, northeast, and east.

RESEARCH OBJECTS AND METHODS

Studies were carried out in 2012–2017, on the southern slope of Gissar Range, on the territory of the Ramitsky gorge zone: sites (Semiganch, Safedchashma, Obi-Zugora, Magov, Yos, Yavroz), Varzob gorge zone (Gusgarf, Odzhuk, Gulobod, Gazhne) and Shamal gorge (Almasy river basin). Surveys of the sites were carried out to the upper limit of the middle-altitude belt, i.e. to an altitude of 2,500 m above sea level through visual counting during hiking expeditions (Fig. 1). Vegetation analysis of ethnomedical plants was carried out according to the method of stratified random sampling. The area of square plots was 100 m^2 for trees, and inside the main squares there were two plots of 25 m^2 for shrubs and four plots of 1 m^2 for grass.

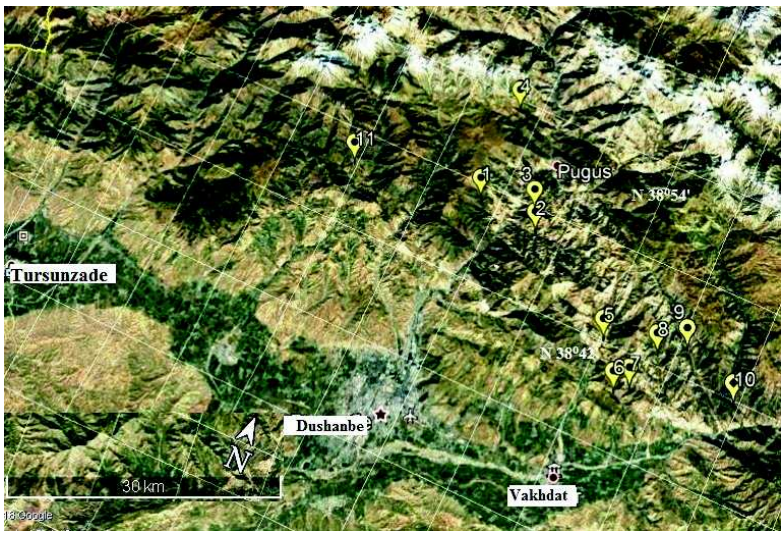

Figure 1. Study area of Gissar Range: 1 – Gusgarf; 2 – Odzhuk; 3 – Gulobod; 4 – Gazhne; 5 – Semiganch; 6 – Safedchashma; 7 – Obi-Zugora; 8 – Magov; 9 – Yos; 10 – Yavroz, 11 – Shamal.

Processing and verification of herbarium material for determining plant species was carried out according to the reference book (Flora of the Tajik SSR, 1991), as well as an to online plant guide (www.plantarium.ru). Taxon systematic affiliation was established according to the accepted classifier (Takhtadzhyan, 1987). It should be noted that Ramitsky and Varzbsky gorge zones are the most recreational areas of the Republic of Tajikistan, and are subject to great anthropogenic stress in the form of tourism and outdoor activities in the spring-summer and summer-autumn seasons.

RESULTS AND DISCUSSION

As a result of studies performed, it was revealed that 174 species of medicinal plants that belong to different taxonomic groups were found on the territory of the abovementioned sites. Belonging to groups, classes, families, genera, and species was determined in accordance with the existing phylogenetic classification (Takhtadzhyan, 1987). It was found (Table 1) that medicinal plants of Varzob and Ramitsky gorge zones are represented by the groups of angiosperms, gymnosperms and fern-like plants. The group of angiosperms is represented by monocotyledonous and dicotyledonous plants. The class of monocotyledonous plants is formed by representatives of 9 families: Liliaceae, Hyacinthaceae, Asphodelaceae, Alliaceae, Asparagaceae, Convallariaceae, Amaryllidaceae, Iridaceae, Araceaea and 14 genera, and the class of dicotyledons is formed by representatives of 35 families and 90 genera. The group of gymnosperms is represented by only one species of ephedra horsetail – *Ephedra equisetina* Bunge that belongs to the joint-fir class (Gnetopsida) and the coniferous family (Ephedraceae). The Group of fern-like plants is represented by one species, *Cystopteris filix-fragilis* (L.) Borbas that belongs to the family of ferns (Polypodiaceae R. BR.). As expected, most species belong to the world's largest taxon – group of angiosperms (Markov, 2010).

Table 1. Systematic affiliation of medicinal plants found on the southern slopes of Gissar Range

Group	Class	Number of families	Number of genera	Number of species
Fern-like – Polypodiophyta	Polypodiaceae – Polypodiopsida	1	1	1
Gymnosperms – Pinophyta	Joint-fir –Gnetopsida	1	1	1
Angiosperms – Magnoliophyta	Monocotyledons –Liliopsida	9	14	33
	Dicotyledons –Magnoliopsida	35	90	139
Total		46	106	174

This is 11.6% in relation to the total number of species typical for the Republic of Tajikistan. Samples found include representatives of 106 genera belonging to more than 40 families. The most numerous were representatives of *Rosaceae* (19 species), *Asteraceae* (36 species), and *Lamiaceae* (16 species). According to the economic and practical classification, found plant species were distributed as follows. 20 species belonged to commonly recognized medicinal plants (Table 2), 56 species are used in the medicine of local peoples (Table 3). In addition, monitoring revealed several rare and endangered species; 8 of them are specified in the Red Book of the Republic of Tajikistan (Table 4), and another 18 species are unique to the Pamir-Alai flora (Table 5).

Representatives of four plant species were observed, which are a food resource regularly used by the local population (gray blackberry – *Rubus caesius L.* and *R. turkestanicus* Pavl., *Rheum gissaricum* Losinsk. and *R. maximowiczii* Losinsk). However, samples of plants commonly used as medicinal products were also taken, for example, of herb-Robert – Geranium robertianum L, common plantain – *Plantago major*, common dandelion – *Taraxacum officinale* Wigg., L., and chamomile – *Matricaria recutita* L.

Table 2. List of widely recognized medicinal plants

No	Name of plant	No	Name of plant
1	Marsh-mallow – Althaea officinalis L.	11	Rosa korshinskyana – *Rosa korshinskyana* Bouleng.
2	Elecampane – Inula helenium L.	12	Rosa canina – *Rosa canina* L.
3	St John's wort – *Hypericum perforatum* L.	13	Rosa ovchzinnikovii – *Rosa ovchzinnikovii* Koczk.
4	Common dandelion –*Taraxacum officinale* Wigg.	14	Rosa foetida – *Rosa foetida* Herrm.
5	Broadleaf plantain – *Plantago major* L.	15	Rosa divina – *Rosa divina* Sumn.
6	Wormwood – *Artemisia absinthium* L.	16	Rosa maracandica – *Rosa maracandica Bunge*
7	Chamomile – *Matricaria recutita* L.	17	Rosa corymbifera – *Rosa corymbifera Borkh.*
8	Licorice – *Glycyrrhiza glabra* L.	18	Fedchenko's rose – *Rosa fedtschenkoana* Regel
9	Rosa achburensis – *Rosa achburensis* Chrshan.	19	Rosa ecae – *Rosa ecae* Aitch.
10	Begger's rose – *Rosa beggeriana* Schrenk	20	Horsetail ephedra – *Ephedra equisetina* Bunge

Table 3. List of found medicinal plants that are used in traditional medicine

No	Name of plant	No	Name of plant
1	Arctium leiospermum – *Arctium leiospermum* Jus. et Serg.	29	Achillea biebersteinii – *Achillea biebersteinii* Afan.
2	Arum korolkowii – *Arum korolkowii* Regel	30	Achillea filipendulina – *Achillea filipendulina* Lam.
3	Berberis heterobotrys – *Berberis heterobotrys* E.L. Wolf	32	Amygdalus bucharica – *Amygdalus bucharica* Korsh .
4	Crataegus pontica – *Crataegus pontica* C. Koch	33	Asian mint – *Mentha asiatica* Boriss.
5	Crataegus turkestanica – *C. turkestanica* Pojark.	34	Brittle bladder-fern – *Cystopteris filix-fragilis* (L.) Borbas
6	Datisca cannabina - *Datisca cannabina* L.	35	Clary sage – *Salvia sclarea* L.
7	Dianthus baldshuanicus – *Dianthus baldshuanicus* Lincz.	36	Common chicory – *Cichorium intybus* L.
8	Dianthus seravschanicus – *Dianthus seravschanicus* Schischk.	37	Common mugwort – *Artemisia vulgaris* L.
9	Dianthus tetralepis – *Dianthus tetralepis* Nevski	38	Echinops maracandicus - *Echinops maracandicus* Bunge (2)
10	Erigeron Gissaricus – *Erigeron Gissaricus* Botsch.	39	Eremurus ambigens – *Eremurus ambigens* Vved.

Table 3 (continued)

11	Gentiana olivieri – *Gentiana olivieri* Griseb.	40	Ferula kuhistanica – *Ferula kuhistanica* Korov.
12	Gymnospermium albertii – *Gymnospermium albertii* (Regel) Takht.	41	Handelia trichophylla – *Handelia trichophylla* (Schrenk) Heimerl
13	Heracleum lehmannianum – *Heracleum lehmannianum* Bunge	42	Pedicularis olgae – *Pedicularis olgae* Regel
14	Hypericum elongatum – *Hypericum elongatum* Ledeb.	43	Polychryzum tadshikorum – *Polychryzum tadshikorum* (Kudr.) Kovalevsk.
15	Hypericum scabrum – *Hypericum scabrum* L.	44	Prangos pabularia – *Prangos pabularia* Lindl.
16	Inula macrophylla – *Inula macrophylla* Kar. et Kir.	45	Pseudohandelia umbellifera – *Pseudohandelia umbellifera* (Boiss.) Tzvel.
17	Lemon balm – *Melissa officinalis* L.	46	Pyrethrum parthenium – *Pyrethrum parthenium* (L.) Smith
18	Lychnis coronaria – *Lychnis coronaria* (L.) Desr.	47	Rhaponticum integrifolium – *Rhaponticum integrifolium* C. Winkl.
19	Megacarpaea gigantea – *Megacarpaea gigantea* Regel in Bull.	48	Ribwort plantain – *Plantago lanceolata* L.
20	Origanum tyttanthum – *Origanum tyttanthum* Gontsch.	49	Rumex paulsenianus – *Rumex paulsenianus* Rech. f.
21	Phlomis cashmeriana – *Phlomis cashmeriana* Royle ex Benth.	50	Salvia turcomanica – *Salvia turcomanica* Pobed.
22	Polygonum Gissaricum – *Polygonum Gissaricum* M. Pop.	51	Sicilian sumac – *Rhus coriaria* L.
23	Potentilla canescens – *Potentilla canescens* Bess.	52	Tanacetum pseudoachillea – *Tanacetum pseudoachillea* C. Winkl.
24	Potentilla kulabensis – *Potentilla kulabensis* Th.Wolf.	53	Thermopsis dolichocarpa – *Thermopsis dolichocarpa* V. Nikit.
25	Verbascum songaricum – *Verbascum songaricum* Schrenk	54	Ungernia victoris – *Ungernia victoris* Vved.
26	Vinca erecta – *Vinca erecta* Regel	55	White nettle – *Lamium album* L.
27	Ziziphora brevicalyx – *Ziziphora brevicalyx* Juz.	56	Wild carrot – *Daucus carota* L.
28	Ziziphora pamiroalaica – *Ziziphora pamiroalaica* Juz.	57	Wild chamomile – *Matricaria suaveolens* (Pursch) Buch.

Table 4. List of found medicinal plants included in the Red Book of the Republic of Tajikistan

No	Name of plant	No	Name of plant
1	Allium rosenbachianum – *Allium rosenbachianum* Regel	5	Paeonia intermedia – *Paeonia intermedia* C.A. Mey.
2	Allium stipitatum – *Allium stipitatum* Regel	6	Eremurus aitchisonii – *Eremurus aitchisonii* Baker
3	Allium suworowii – *Allium suworowii* Regel	7	Ungernia victoris – *Ungernia victoris* Vved.
4	Ostrowskia magnifica – *Ostrowskia magnifica* Regel	8	Juno nicolai – *Juno nicolai* Vved.

Based on the fact that the number of widely recognized medicinal plants in the world is 13,787 species (Que et al., 2018), the proportion of medicinal plants found on the southern slopes of Gissar Range is 0.15%, however, the total number of species found is 1.27% of global fund. According to some estimates (Dasti et al., 2007), the biological diversity of the Iran-Turan region bordering Gissar range is 19,000 plant species. Simple calculations show that the number of plants found during expedition is less than one percent, even in comparison with the diversity of the neighboring region. However, it is worth considering that only plants somehow used for medical purposes were included in our study.

Table 5. List of found plants that are endemic to Central Asia and the Pamir-Alai

No	Name of plant	No	Name of plant
1	Astragalus macropodium – *Astragalus macropodium* Lipsky	10	Oxytropis roseiformis – *Oxytropis roseiformis* B. Fedtsch.
2	Astragalus heterotrichus – *Astragalus heterotrichus* Gontsch.	11	Rheum Gissaricum – *Rheum Gissaricum* Losinsk.
3	Anemone verae –*Anemone verae* Ovcz. et Scharip.	12	Asparagus bucharicus – *Asparagus bucharicus* Iljin
4	Iris hoogina – *Iris hoogina* Dykes	13	Thermopsis dolichocarpa – *Thermopsis dolichocarpa* V. Nikit.
5	Cousinia tomentella – *Cousinia tomentella* C. Winkl.	14	Tulipa praestans – *Tulipa praestans* Hoog
6	Cousinia grigoriewii – *Cousinia grigoriewii* Juz.	15	Chesneya Gissarica – *Chesneya Gissarica* Boriss.
7	Potentilla kulabensis – *Potentilla kulabensis* Th.Wolf.	16	Rosa achburensis – *Rosa achburensis* Chrshan.
8	Pseudosedum condensatum – *Pseudosedum condensatum* Boriss.	17	Rosa korshinskyana – *Rosa korshinskyana* Bouleng.
9	Oxytropis baldshuanica – *Oxytropis baldshuanica* B. Fedtsch.	18	Eremurus brachystemon – *Eremurus brachystemon Vved.*

As a comparison, we quote some monitoring data on the biodiversity of medicinal plants found in literary sources. In relatively neighboring Pakistan, 106 species of medicinal plants were identified, only 4% of them grew in mountainous areas (Akhtar et al., 2013). However, the diversity of the southern slope of Gissar Range was somewhat inferior to the diversity of families found (46 vs. 54). Up to 1,700 species of medicinal plants have been reported to grow in Indian Himalayas (Bhat et al., 2013), but not only angiosperms were taken into account for this study. In the vicinity of the capital of Colombia, Bogota, 409 species of medicinal plants were found (Bussmann et al., 2018). Only 100 species of medicinal plants were found in Dagala region (Bhutan) (Wangchuk et al., 2016). In Algeria, 90 species were reported belonging to 42 families (Bouasla & Bouasla, 2017). Global monitoring of the biological diversity of plant communities in high mountain regions indicates that Gissar Range is a location with one of the highest concentrations of species (Khan et al., 2013). This study generally confirms this point. Taking into account that monitoring was carried out earlier than 2013, it can be stated that over the past 5 years, the species diversity of the southern slopes of Gissar Range has undergone no significant changes (Khan et al., 2013).

The number of widely recognized medicinal plants was 11.49% of the number of species found. Almost every species is a fairly significant phytopharmacological resource. For example, the extract of *Althaea officinalis* has a coating property and is applied in the treatment for stomach diseases. Galenical preparations with this herb are used to treat for bronchitis and asthma (Sakovich et al., 1997). Elecampane is acknowledged to be an expectorant. It is also used for gastrointestinal diseases including inflammation of duodenum and gastric ulcers (Butko, 2013). Tincture of *Hypericum perforatum* proved to be an antifungal drug (Hovsepyan & Ghazaryan, 2019). Common dandelion, chamomile, wormwood, as well as various types of wild rose and licorice are perhaps the most well-known and widely used medicinal plants from among those found (Table 2). Common dandelion is a rather effective antidote to the poisons of insects and arachnids (Karomatov & Davlatova, 2018). Its presence in the ecosystem of Gissar Range, taking into account that there are species posing a danger to humans in the Middle Asia, is a rather significant resource for ensuring the safety of the local population to arthropod poisons. Dried parts of this herb compose a part of some gastric teas (Sukhanov, 2000). Antiseptic properties of common plantain are well-known; that's why for many centuries it served people as an alternative to all kinds of adhesives even after they were invented. In medicine, it is also used in the treatment for cancer and inflammatory diseases (Moiseev, 2009; Korepanov & Openko, 2012). Wormwood is used for a number of morpho-physiological systems of humans and animals: nervous, endocrine, urinary, respiratory, etc. (Karomatov & Kakhkhorova, 2018). Chamomile has proved to be an effective diaphoretic and antidote. It is also used to treat eczema, eye, ear, nose diseases, jaundice and yellow fever (Karomatov et al., 2018). Licorice root is used for making alcohol tinctures. Being sweet, it is an element of different herbal teas in order to improve their taste. This plant is used as an expectorant, general stimulant for tuberculosis, stomach diseases, allergic diseases. It is used for liver echinococcus, emphysema, bronchial asthma, and blood diseases (Karomatov, 2013). Different types of roses are known due to the high content of vitamin C. Plants are used as a diaphoretic in the treatment for colds and liver diseases (Baimurodov et al., 2017)

CONCLUSION

As a result of the studies it was found that 174 species of medicinal plants belonging to 45 different families, including 35 dicotyledonous plants and 9 monocotyledonous plants are mainly distributed in some parts of Varzob and Ramit gorges, which are located in close proximity to the capital of the Republic –Dushanbe city and are its natural buffer zones.

Considering that the number of researched sites is less than 3% of the total area of Varzob and Ramit gorges and despite the fact that the researched sites are under rather high recreational and anthropogenic pressure, the presence of the above mentioned number of medicinal plants indicates relatively favorable growing conditions. Therefore, by organizing appropriate economic measures to protect and promote their natural renewal, the biological diversity of medicinal plants in this area can be significantly improved.

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