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Geographical Analysis of Upper-Alpine Rock-Scree Flora of Central And Eastern Caucasus

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***Abstract* – Species of plants, forming upper-alpine rock-scree vegetation of Central and Eastern Caucasus, have different habitats, in most cases exceeding the limits of the studied area. Analysing these habitats enables to discover the chorological nature of the researched flora, determine dominating geoelements, which provides the basis for, first, correcting the schemes of biogeographic zoning, as well as solving the issues, related with the history of flora. Upper-alpine rock-scree plants of Central and Eastern Caucasus belong to caucasian-holarctic-irano-turanian. The head part of the geographical range corresponds with the sequence of families *Apiaceae – Cyperaceae – Poaceae,* sequence of geni – *Campanula – Carex – Ranunculus* and *Minuartia.* It follows from the above said that the studied flora does not contain tertiary relicts, although ancient species, which may date as far back as the tertiary, exist. These include all ferns and gymnosperms, evergreen bush *Rhododendron caucasicum*, evergreen shrubs *Vaccinium vitis-idaea, Empetrum caucasicum, Daphne glomerata,* wintergreen subshrub *Dryas caucasica.* Also, there are no xerothermic relicts, as in highlands there are no arid areas where the remains of xerophiles could survive. In terms of xerothermic relicts, they can include only one species - *Cirsium cephalotes,* transcaucasian-asiatic species, having within the researched region a relict area up the river Baksan.**

Keywords – flora; Central and Eastern Caucasus; geoelements; rocks and scree; zoning.

I. INTRODUCTION

High-mountain plants of the Russian Caucasus is described as extraordinary, representing a unique gene pool rich in endemic species. This flora includes highland complexes, characterized as endolithic, having distinctive floristic composition. One of such regions is the highland area of the northern macroslope in Central and Eastern parts of the Russian Caucasus, where vast territories remain virtually unexplored due to the remoteness of most mountainous regions. This flora is noteworthy as an indicator of intensive speciation, which is proved by the existence of local endemic species and representatives of monotypical endemic geni, research of which can considerably contribute to improving the model of the florogenesis of high-mountain Caucasian plants.

Solution of this issue lies within resolving another current global problem – research and conservation of biodiversity that has ever increasing relevance. Description and analysis of this regional vegetation represents the foundation for evaluating the state of phytobiota, determining the trends of its change and influence on the environmental integrity of its habitats, making various theoretical and practical forecasts.

Studying the flora of this region in this perspective is vital for developing guidelines to use the plant resources in a rational way, as well as predicting the effects of human activities on the phytobiota of the mountains. In this view, this dissertation research is relevant.

II. METHODS AND MATERIALS

The research material is based on the floral and geobotanical data of the upper-alpine rock-scree vegetation of Central and Eastern Caucasus, collected by the author for seven years (2010-2017) during en-route and semi-stationary research. The results include more than 300 geobotanical descriptions and a herbarium of over 1500 thousand pages, which is stored among the herbarium collections of Ecology Faculty of CSPU, as well as Caucasian department of BIN.

Field studies were carried out in different seasons: early and late spring, summer, at the end of summer and in some areas – autumn. The region under study is covered with the network of paths, prepared in advance. The material was collected both en-route and on-site, using various methods. Paths and basic sites were selected with the view of fully accounting for different environments and variety of plant associations, which were formed by cryophytes.

III. RESULTS

The geographical analysis is based on the geographical range of vegetation, relying on the hierarchy of species, related with the corresponding geographical element. Every species, inhabiting a certain area, and in the scheme of biogeographic zoning of the earth, can be presented as a geographical element, the habitat of which is characterized by a set of various divisions of these zones. Moreover, it has a certain position in the hierarchy of those divisions [1], i.e. geoelements that are characteristic for certain biotic provinces, regions, phyla and kingdoms, coincide with the positions of phytochories in the system of biogeographic zonation.

To classify species, belonging to a certain geographical element, we refer to the system of biogeographic zoning by A.L. Tahtadzhyan [2,3], which is based on the concept of phytochories, developed in a number of previous research papers [4,5,6] and others.).

As a classification scheme we apply the system of geoelements by N.N. Portenier [7,8,9], suggested for the vegetation of Caucasus, based on the correlation of geoelements, similarly to phytochories, where every geographical element is a typical representative of flora for a certain phytochory, the territory of which covers most of its habitat. The exception is so-called pluri-regional geoelements that grow in areas belonging to various floral kingdoms.

In the researched flora we classify 11 geoelements, presented in the geographical range (table 9).

Caucasian geoelement. This is the dominating geoelement, comprising 274 species (71,4%). It includes species with the habitat mostly within Caucasian floral region. This geoelement is worth making a detailed analysis, as among these species can be found endemic and subendemic ones.

The most interesting species are endemic, whose areas remain within the boundaries of the studied region – local and regional. They serve as absolute measure for uniqueness of flora. Among them the local endemic species, whose habitats are limited to a single floral region, 22 (5,7%). These are *Ranunculus tebulosicus, Viola meyeriana, Erysimum subnivale, E. babadagensis, Sempervivum ingwersenii, Saxifraga dinnikii, Vicia larissae, Bupleurum subnivale, Cruciata valentinae, C. elbrussica, Galium pseudopolycarpon, Pedicularis balkharica, Veronica bogosensis, Campanula galushkoi, C. valentinae, C. nefedovii, C. besenginica, Erigeron schalbusi, Pyrethrum galushkoi, Allium samurense, Festuca inguschetica, Poa primae*.

Larger areas are occupied by regional endemics that can be found in two or more regions, 11 species (2,9%): *Papaver lisae, Gypsophila imbricata, Sobolewskya truncata, Saxifraga columnaris, Alchemilla chlorosericea, Potentilla ghalghana, Astragalus supinus, Jurinea filicifolia, Pyrethrum daghestanicum, Melica minor, Festuca primae.*

TABLE I. GEOGRAPHICAL RANGE OF UPPER-ALPINE ROCK-SCREE FLORA OF CENTRAL AND EASTERN CAUCASUS

№	Geoelement	Number of species	%
Group of boreal geoelements - 343 (89.3%)			
1	Caucasian	274	71.4
2	Holarctic	30	7.8
3	Euro-Caucasian	15	3.9
4	Euro-Siberian	7	1.8
5	Boreal	6	1.6
6	Euxine	6	1.6
7	Palaearctic	5	1.3
Group of Ancient Mediterranean geoelements – 38 (9.9%)			
8	Irano-Turanian	30	7.8
9	Common Ancient Mediterranean	5	1.3
10	Armeno-Iranian	3	0.8
Group of pluri-regional geoelements – 3 (1.3%)			
11	Pluri-regional	3	0.8
	TOTAL	384	100

Habitats of subendemic species (pseudo-endemic) exceed the limits of the region under study, but they are within Greater Caucasus. These are 73 (19,0%), among them Delphinium caucasicum, Ranunculus arachnoideus, Arenaria holostea, Minuartia biebersteinii, Silene lychnidea, Apterigia pumila, Dentaria bipinnata, Draba ossetica, Pseudovesicaria d*igitata, Saxifraga pseudolaevis, Astragalus levieri, Vavilovia formosa, Trigonocaryum involucratum, Thymus caucasicus, Jurinea coronopifolia, Elymus buschianus, Poa caucasica* and others.

1. **Holarctic geoelement.** It includes species, typical for three and more phyla of Holarctic kingdom of both hemispheres. There are 30 species (7,8%). Among them 5 are ferns - *Asplenium ruta-muraria, A. septentrionale, Athyrium alpestre, Gymnocarpium robertianum, Polystichum lonchitis.* The rest are angiosperms: *Thalictrum alpinum, Minuartia verna, Oxyria digyna, Saxifraga hirculus, Astragalus alpinus, Gentiana aquatica, Juncus triglumis, Luzula spicata, Allium schoenoprasum, Carex obtusata, Eriophorum vaginatum, Deschampsia caespitosa, Poa badensis, Phleum alpinum* and others.

2. **Irano-Turanian geoelement.** Presented by the species, spread in two or more provinces of Irano-Turanian region. It includes 30 species (7,8%): *Pulsatilla violacea, Ranunculus brachylobus, Arenarua rotundifolia, Silene chlorifolia, Primula algida, Viola oreades, Arabis caucasica, Epilobium gemmascens, Astragalus fragrans, Scrophularia variegata, Taraxacum stevenii, Allium oreophilum, Carex kotschyana, Kobresia persica, Catabrosella variegata, Sesleria phleoides* and etc.

3. **Euro-Caucasian geoelement.** The areas of these species cover Caucasian, Euxine and European provinces of Euro-Siberian region, forming Euro-Caucasian subregion [10] of European broad-leaved region E.M. Lavrenko [11]. Its number is 15 (3,9%). *Ranunculus oreophilus, Saxifraga moschata, Potentilla multifida, Trifolium spadiceum, Myosotis alpestris, Rhinanthus minor, Erigeron alpinus, Leontodon hispidus, Carex huetiana, C. melanthiphormis, Festuca ruprechtii, F. saxatilis, Trisetum. Ovatipaniculatum,*

4. **Euro-Siberian element.** Presented by the species that are typical for Euro-Siberian region (Tahtadzhyan, 1970, 1978). In total, there are 7 geoelements (1,8%): *Cerastium cerastioides, Vaccinum myrtillus, Saxifraga flagellaris, Cruciata glabra, Euphrasia hirtella, Carex capillaris, Nardus stricta*

5. **Boreal geoelement.** Related with this geoelement species are wide spread within Boreal phylum of both hemispheres. These are 6 species (1,6%): *Gymnocarpium dryopteris, Woodsia alpina, Gentiana nivalis, Aster alpinus, Coeloglossum viride, Poa glauca.*

6. **Euxine geoelement.** Species of this geoelement are spread mostly in Euxine province (Tahtadzhyan, 1978) [1, 2]. There are also 6 species (1,6%): *Draba hispida, Daphne glomerata, Trifolium rytidosemium, Lupinaster polyphyllum, Nonea intermedia, Pedicularis nordmanniana.*

7. **Palaearctic geoelement.** Belonging to this geoelement species cover all three phyla of Holarctic kingdom of the Old World without special affiliation to any of them, 5 species (1,3%). *Aconitum confertiflorum, Dichodon cerastoides,*

Polygonum aviculare, Lomatogonium carianthiacum, Lloydia serotina.

8. **Common Ancient Mediterranean geoelement.** It includes species, spread across Mediterranean and Irano-Turanian regions of Ancient Mediterranean phylum (Tahtadzhyan, 1978) [1, 2], 5 species (1,3%): *Ceterach officinarum, Juniperus depressa, Rumex hastifolius, Rhynchocorys elephas, Doronicum oblongifolium.*

9. **Armeno-Iranian geoelement.** The distribution areas are situated in Armeno-Iranian province of Persian subregion in Irano-Turanian region, 3 species (0,8%): ***Didymophysa*** *aucheri, Thymus transcaucasicus, Carex oreophila.*

10. **Pluri-regional geoelement.** Here can be found species, whose habitats exceed the boundaries of Holarctic kingdom. There are only 3 (0,8%) of them. These are *Asplenium trichomanes, Botrychium lunaria, Carex cinerea.*

The table 6 demonstrates that the overwhelming majority in the flora under study belongs to boreal geoelements (343 species, 89,3%), among which Caucasian ones prevail (274 species, 71,4%). The second position belongs to Common Ancient Mediterranean geoelements (38 species, 9,9%), most of which are Irano Turanian (30 species, 7,8%). Pluri-regional geoelements seem insignificant (3 species, 0,8%). According to the leading geoelements, the upper-alpine rock-scree plants of Central and Eastern Caucasus are caucasian-holarctic-irano-turanian. These three dominating geoelements account for 334 species which make 87,0% of all vegetation, but with the obvious lead of Caucasian geoelements. The proportion of geoelements among the first three - 1:0,1:0,1, i.e. Caucasian geoelements significantly prevail.

The indicative geographical characteristic of regional flora ought to be the representation of geographical elements in the classification range. The proportion of leading geoelements in the classification range is given in table 10. The table shows that, according to the percentage of Caucasian geoelement, the classification range of families looks like this: *Apiaceae* (100%) – *Campanulaceae* (91,7%) – *Rosaceae* (88,9%) – *Scrophulariaceae* (83,3%) – *Saxifragaceae* (81,3%) – *Asreraceae* (81,1%) – *Brassicaceae* (80,0%) – *Fabaceae* (77,8%) – *Caryophyllaceae* (74,3%) – *Ranunculaceae* (72,7%) – *Gentianaceae* (70,0%) – *Poaceae* (66,7%) – *Cyperaceae* (42,1%). Fully «Caucasian» seems *Apiaceae*, over three quarters of Caucasian species are found among 8 more families, the rest contains more than half of species, except for *Cyperaceae*. Among the first three families Caucasian geoelements do not dominate.

The sequence of the first three families in percentage of Holarctic geoelement is: *Cyperaceae* (26,3%) – *Poaceae* (8,3%) – *Campanulaceae* (8,3%), in terms of Irano Turanian geoelement - *Poaceae* (13,9%) – *Ranunculaceae* (13,6%) – *Asteraceae* (10,8%). In other words, in terms of contents of Caucasian geoelement the first three families, having a considerable number of species of this geoelement, do not lead in percentages. When it comes to other dominating geoelements, then the first three include *Poaceae* (Holarctic and Irano Turanian elements) and *Asteraceae* (Irano Turanian geoelement).

TABLE II. REPRESENTATIVES OF DOMINATING GEOELEMENTS IN THE CLASSIFICATION RANGE OF FAMILIES OF UPPER-ALPINE ROCK-SCREE FLORA OF CENTRAL AND EASTERN CAUCASUS

family/number of species	**quantity indicators**	**geoelement**		
		Caucasian	***Holarctic***	***Irano Turanian***
Asteraceae/37	number	30	1	4
	%	81.1	2.7	10.8
Poaceae/36	number	24	3	5
	%	66.7	8.3	13.9
Caryophyllaceae/35	number	26	2	4
	%	74.3	5.7	11.4
Fabaceae/27	number	21	1	1
	%	77.8	3.7	3.7
Brassicaceae/25	number	20	-	2
	%	80.0	-	8.0
Scrophulariaceae/24	number	20	-	1
	%	83.3	-	4.2
Ranunculaceae/22	number	16	1	3
	%	72.7	4.5	13.6
Cyperaceae/19	number	8	5	2
	%	42.1	26.3	10.5
Rosaceae/18	number	16	1	-
	%	88.9	5.6	-
Saxifragaceae/16	number	13	1	1
	%	81.3	6.3	6.3
Campanulaceae/12	number	11	1	-
	%	91.7	8.3	-
Apiaceae/10	number	10	-	-
	%	100	-	-
Gentianaceae/10	number	7	1	-
	%	70	10	-

Thus, caucasian-holarctic-irano-turanian upper-alpine rock-scree vegetation of the studied area, according to the classification of the representatives among the dominating geoelements, is characterized by the sequence of families *Apiaceae* – *Cyperaceae* – *Poaceae*, i.e. «the most» Caucasian is *Apiaceae*, Holarctic – *Cyperaceae*, and Irano Turanian – *Poaceae*.

In the classification range of larger geni, which accounts for more than one fifth of all species, Caucasian geoelements also dominate (table 11). These geni form the following sequence: *Campanula* (100%) – *Ranunculus* (81,8%) - *Saxifraga* (81,3%) – *Astragalus* (80,0%) – *Draba* (70%) – *Minuartia* (63,5%) – *Carex* (30,8%). «The most» Caucasian is *Campanula* (100%), Holarctic – *Carex* (23,1%), Irano Turanian – *Ranunculus* and *Minuartia* (each 18,2%) [13-17].

TABLE III. REPRESENTATIVES OF DOMINATING GEOELEMENTS IN THE CLASSIFICATION RANGE OF GENI OF UPPER-ALPINE ROCK-SCREE FLORA OF CENTRAL AND EASTERN CAUCASUS

Genus/number of species	**quantity indicators**	**geoelement**		
		Caucasian	***Holarctic***	***Irano Turanian***
Saxifraga/16	number	13	1	1
	%	81.3	6.3	6.3
Carex/13	number	4	3	1
	%	30.8	23.1	7.7
Campanula/11	number	11	-	-
	%	100	-	-
Ranunculus/11	number	9	-	2
	%	81.8	-	18.2
Minuartia/11	number	7	1	2
	%	63.5	9.1	18.2
Draba/10	number	7	-	1
	%	70	-	10
Astragalus/10	number	8	1	1
	%	80	10	10

IV. CONCLUSION

Therefore, according to the dominating geographical elements, the upper-alpine rock-scree flora of Central and Eastern Caucasus is caucasian-holarctic-irano-turanian. The head part of the geographical range corresponds with the sequence of families *Apiaceae – Cyperaceae – Poaceae*, sequence of geni – *Campanula –Carex – Ranunculus* and *Minuartia.*

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