

Systematic Analysis Towards Highland Alpine Rocky-Scree Vegetation of Central and Eastern Caucasus

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Abstract – The paper provides the systematic analysis on highland Alpine rocky-scrub vegetation of the Central and Eastern Caucasus. In taxonomy the vegetation under consideration is characterized with domination of dicotyledonous, specific family-species spectrum (*Caryophyllaceae*-species and *Fabaceae*-subspecies), a great number of pseudomonotypic genera in the main plant families and emuotypic genera, and a low plant genus index. Over half plant genus in the vegetation includes one species – 90 (57.0% of total genus species, whereas, genuinely monotypic there are 4 plant genera: *Pseudovesicaria*, *Symphyloloma*, *Trigonocaryum* and *Pseudobetckea*, referred to endemic Caucasus plant genera. The main index in the vegetation taxonomy is the ratio between monotypic plant genera in the spectrum of the main plant families that highlights the prominent role in formation of the highland Alpine rocky-scrub vegetation of big plant families, namely *Asteraceae*, *Poaceae* and *Brassicaceae*. In the Central and Eastern Caucasus vegetation the big and medium plant families have the determined order: *Asteraceae* → *Poaceae* → *Brassicaceae* → *Ranunculaceae* → *Caryophyllaceae* → *Fabaceae* → *Apiaceae* → *Gentianaceae* → *Scrophulariaceae* → *Cyperaceae* → *Rosaceae* → *Campanulaceae* → *Saxifragaceae*.

Keywords — *flora; systematics; Central and Eastern Caucasus analysis.*

I. INTRODUCTION

Rocky scree plant species take big spaces in the Central and Eastern Caucasus, particularly in the high part of it. In the principal work "Caucasus Flora" [4] academician A. Grossheim wrote: 'a wide development is typical to rocky and scree vegetation in the Big Caucasus, particularly in its central parts where in highland mountains the rocky-stone places are in domination. For more in-detail descriptions on the vegetation situation in rocky and scree places do not exist for these regions'.

Although more than 4–5 decades have passed since this work was published, this issue still remains far from being resolved, since the attention of researchers was first and foremost paid to studying the highland cryophilic meadows that were of great national economic importance. Another reason of not less importance is the inaccessibility of rocky-stone places during the whole year. All this has led to the fact that this original species of vegetation on a vast area has remained so far little studied, and in some areas not studied at all. At the same time, one of the topical challenges in phytocenology is a

comprehensive study of this, truly little studied vegetation, with the aim at understanding the caenogenesis regularities, identifying the gene pool of rare, endemic and relict species and studying their ecology with the ultimate goal of developing their rational use.

Grossheim's words [4] echo in the statement of V.I. Vasilevich [3], who speaks about the 'poverty' of data in our botanical literature towards non-zonal plant species (weed, rock-slope, etc.) vegetation. Therefore, nowadays when multivolume work publishing "Synopsis on the Caucasus" is under design, the study of non-zonal vegetation species is one of the main tasks for botanists.

As part of the rock-stone vegetation, there are many different high-quality forage grasses that can be used in the national economy, if cultivated pastures are created, as well as to increase productivity and restore disturbed high-mountain pastures through additional grass seeding. In addition to forage grasses, the flora of rocks and screes holds a reserve of ornamental, prone-fixative and other groups of useful plants that are promising as the original maternal forms in selection works. In this regard, the rock-stone vegetation is of considerable practical interest.

The value of the vegetation in rocks and slope-screes is also of high importance for solving a number of theoretical questions.

The peculiar edaphic and microclimatic conditions of the rocks and screes contributed to the survival and preservation here of many species of the past climatic times. Like some other high-mountain ecotopes, rocks and screes became shelters (micro-refugiums) for relict plants when climatic conditions were adverse. The study on these plants (their biology, ecology, taxonomy) both in nature and in culture can shed light on the sources and evolution paths towards the flora and the climate characteristics of the past eras.

One of the main issues in the modern botany is the issue on speciation, and, as known, the highlands of the Central and Eastern Caucasus are one of the sources of this process. To solve the issue, much can be given by studying the biology of endemic plants. The particular interest in this regard lies in studying young species (neoendems), most often they are region-oriented endems with high-intensity range, which are the products of today evolutionary process. No less valuable are

the species with broken habitats. There are a great number of such species growing on our rocks and screes: they are mainly associated with the high-mountainous regions of the Western Asia (Iran, Turkey, and the South Caucasus).

Since the phytocaenogenesis processes remain many unresolved issues, we suggest that solving some of them should be started with a study on “non-soil” primary-naked formations, what rocky scree substrates are.

However, as it will be seen from further research, the rock-scrree vegetation in the Caucasus has been studied very little; there are only fragmentary data about the floristic composition in various areas, but synthesis-based works in this field are absent.

II. METHODS AND MATERIALS

As material we used floristic and geobotanical data of the vegetation of the highland Alpine rock-scrree flora of the Central and Eastern Caucasus, collected by the author during seven years (2010-2017) in the course of the route and semi-stationary studies. As a result, more than 300 geobotanical descriptions were made and a herbarium was collected, accounting to more than 1,500 thousand leaves, which are stored in the herbarium repositories of the Department of Ecology of CSPU, as well as the Caucasian Department of Botanical Institute.

Field studies were conducted at different times: in early and late spring, in summer, in late summer, and at some time in autumn. The study area was covered by a map of the predetermined routes. The collection of material was carried out with a route-based method, and in special facilities through applying different techniques. The choice of routes and base areas were carried out by taking into account the full coverage of various environmental conditions and the diversity of plant associations, in the formation of which xerophytes took part.

III. RESULTS

The analysis is based on the pre-compiled compendium about the flora, in which for each species the above listed characteristics are identified. The methodology of the analysis was tested in numerous studies in the Caucasus, starting with the work of A.A. Grossheim "Analysis on Caucasus Vegetation" [5]. In relation to the floras that were identified by the ecological characteristics, according to this methodology, at the end of last century and at the beginning of ongoing one, the petrophytes of some mountain systems were studied (Lafishev, Teymurov [8, 11], as well as of the Western part of the Central Caucasus (Shkhagapsoev) [14], of the Russian Caucasus (Ivanov, Kovalev) [7]; the flora of the Terek-Kumsky lowland (Abdurzakov) [1]; the halophytes of the Pre-Caucasus (Nagalevsky) [9], the xerophytes of the Russian Caucasus (Taysumov, Magomadova) [10] and of the Predgorny Dagestan (Tsakhueva) [13]. The same method we used in the analysis of highland Alpine vegetation of rocky-scrree plants of the Central and Eastern Caucasus.

The systematic structure of the flora is characterized by a certain number and ratio of taxa of higher species, which is its specific feature and differs from other floras. Our research has

concluded that the highland Alpine rock-scrree vegetation of vascular plants of the Central and Eastern Caucasus includes 384 species of vascular plants belonging to 158 genus and 42 families.

Table 1 presents the proportions of the studied vegetation. It follows that the gymnosperm plants are represented by a smallest number of taxa (1 family, 1 genus, 1 species). Also, one division of the Polypodiophyta is represented by higher spore ones, including 4 families, 9 genera, and 13 species. Angiosperms dominate (96.4% among species, 93.7% among genera and 88.2% among families), where most taxa belong to the class of dicotyledons (80%). The divisions of Lycopodiophyta and Equisetophyta are not represented. The ratio of monocots and dicots is 1: 4.9, which is significantly lower than for the entire vegetation of petrophytes of the Russian Caucasus, where the ratio is 1: 9.1 [7].

In general, the comparative proportions of these two floras indicate a smaller participation of taxa belonging to a family rank in the composition of the highland Alpine rock-scrree vegetation of the Central and Eastern Caucasus. The main indicator of the taxonomic structure of the flora is a systematic spectrum, which is viewed through ranked series of families and genera. There are no largest families with 50 or more species in the studied flora, in contrast to the same spectrum of the flora of the Russian Caucasus, which counts 7 largest families [7].

TABLE I. PROPORTIONS TOWARDS HIGHLAND ALPINE ROCKY-SCREE VEGETATION IN THE CENTRAL AND EASTERN CAUCASUS

Taxa	Number of species	%	Number of genera	%	Number of families	%	Proportions	Genus index
Polypodiophyta	13	3,4	9	5,7	4	8,7	1:2,3:3,3	1,4
Pinophyta	1	0,3	1	0,6	1	2,2	1:1:1	1
Magnoliophyta	370	96,4	148	93,7	37	88,2	1:4:10	2,5
Inter alia:								
<i>Magnoliopsida</i>	307	80,0	123	77,8	31	73,8	1:4,0:9,9	2,5
<i>Liliopsida</i>	63	16,4	25	15,8	6	13,0	1:4,2:10,5	2,5
Total	384		158		42		1:3,8:9,1	2,4

Large families, including from 20 to 49 species - 7 (table 2), in total they comprise 205 species, which is more than half the flora (53.4%). The average families with a number of species from 10 to 19 - 6, quantitatively accounts to 85 species, equals to 22.1%. Together, large and medium-sized families comprise 290 species and make up 75.5% of the rocky-scrree vegetation.

In general, at the spectrum top part, the features of the Holarctic flora are appeared, namely, by locating families *Asteraceae* and *Poaceae* at the first positions. The third position in the spectrum indicates that the studied flora belongs to the Caryophyllaceae-type, which is typical for the Arctic

territories and high mountains with no specific localization, whereas the Fabaceae-subtype speaks of its Mediterranean origins [12]. But the distinctive feature of the proper Mediterranean floras, where the Fabaceae family takes the second place, is its position as the fourth. Also as the difference from the Mediterranean floras can be noted the absence in the list of the first ten families such families as *Lamiaceae* and *Boraginaceae* and the presence of such a boreal family as *Cyperaceae*. A similar spectrum was found for the petrophyte flora of the Western part of the Central Caucasus [14], where the sequence of the first ten families is: *Asteraceae* — *Fabaceae* — *Caryophyllaceae* — *Poaceae* — *Rosaceae* — *Lamiaceae* — *Apiaceae* — *Ranunculaceae* — *Saxifragaceae* — *Campanulaceae*; but in contrast to the spectrum that we obtained such families as *Scrophulariaceae* and *Cyperaceae* were not found but *Lamiaceae* family is present.

TABLE II. SYSTEMATIC SPECTRUM OF HIGHLAND ALPINE ROCKY-SCREE VEGETATION OF THE CENTRAL AND EASTERN CAUCASUS

Family	Number of species	%
Large		
1. Asteraceae	37	9,6
2. Poaceae	36	9,4
3. Caryophyllaceae	35	9,1
4. Fabaceae	27	7,0
5. Brassicaceae	25	6,5
6. Scrophulariaceae	24	6,3
7. Ranunculaceae	22	5,7
Total	205	53,4
Medium		
8. Cyperaceae	19	4,9
9. Rosaceae	18	4,7
10. Saxifragaceae	16	4,2
11. Campanulaceae	12	3,1
12. Apiaceae	10	2,6
13. Gentianaceae	10	2,6
Total	85	22,1
TOTAL	290	75,5

The remaining families include from 1 to 9 species and are divided into small (5 to 9 species) and oligotype (from 1 to 4 species). Small families are 9; their composition includes 58 species (15.1%), in descending order they are arranged in the following sequence: *Primulaceae* (9 species), *Lamiaceae* (8), *Polygonaceae*, *Crassulaceae* (7 species), *Aspidiaceae*, *Rubiaceae* (6 species each), *Aspleniaceae*, *Valerianaceae*, *Boraginaceae* (5 species each). Oligotype families are 20: *Violaceae*, *Juncaceae* (4 species each), *Fumariaceae*, *Ericaceae*, *Onagraceae*, *Alliaceae* (3 species each), *Papaveraceae*, *Salicaceae* (2 species each), *Ophioglossaceae*, *Pteridaceae*, *Cupressaceae*, *Empetraceae*, *Cistaceae*, *Thymelaeaceae*, *Geraniaceae*, *Polygalaceae*, *Dipsacaceae*, *Plantaginaceae*, *Liliaceae*, *Orchidaceae* (1 species).

The taxonomic spectrum at the genus level is presented in Table 4. These include the large genera, counting 10 or more

species, and the medium genera, from 6 to 9 species. In total, there are 13 such genera, which account to 32.6% of the species of the entire vegetation.

Most in the studied flora spectrum there are oligotype genera. From their number the genera that count from 5 to 2 species are 55: 5 species are included into 8 genera, 4 in 11 genera, 3 in 13 genera, and 2 in 23 ones. They contain 169 species (44%).

Clearly, the quantitative and percentage ratio of families and species of the highland Alpine rock-scrée flora are presented in Table 3.

TABLE III. QUANTITATIVE RATION BETWEEN FAMILIES AND SPECIES OF HIGHLAND ALPINE ROCKY-SCREE VEGETATION OF THE CENTRAL AND EASTERN CAUCASUS

Families	Large	Medium	Small	Oligotype with species number			
				4	3	2	1
(number of species)	20-49	10-19	5-9	4	3	2	1
Number of families	7	6	9	2	4	2	12
% of total number of families	16,7	14,3	21,4	4,8	9,5	4,8	28,6
Number of species	205	85	58	8	12	4	12
% of total number of species	53,4	22,1	15,1	2,1	3,1	1,0	3,1

More than half the genera in the studied flora contain per one species - 90 (57.0% of the total number of genera), while the truly monotype species represented with one species in the global flora are four genera: *Pseudovesicaria*, *Symphyloma*, *Trigonocaryum* and *Pseudobetckea*, belonging to the endemic Caucasian genera. The quantitative ratio of genera is presented in Table 5.

Another important indicator of the taxonomic composition of the flora is the ratio of monotypic genera in the spectrum of leading families. According to this indicator, large and medium-sized families line up in the following sequence: *Asteraceae* (12), *Poaceae* (11), *Brassicaceae* (11), *Ranunculaceae* (6), *Caryophyllaceae* (5), *Fabaceae* (5), *Apiaceae* (4), *Gentianaceae* (2), *Scrophulariaceae* (1), *Cyperaceae* (1), *Rosaceae* (1), *Campanulaceae* (1), *Saxifragaceae* (0). This sequence emphasizes the prominent role in the formation of the highland Alpine rock-scrée vegetation of large families, especially, *Asteraceae*, *Poaceae* and *Brassicaceae*. The phenomenon of a monotype in highlands and of a specific substrate, which provides taxon isolation, can serve as a basis for the beginning towards the isolation of the endemic genus, as in the case with the eumonic types such as: *Pseudovesicaria*, *Symphyloma*, *Trigonocaryum*, *Pseudobetckea*.

TABLE IV. SPECTRUM OF LARGE AND MEDIUM GENERA OF HIGHLAND ALPINE ROCKY-SCREE VEGETATION IN THE CENTRAL AND EASTERN CAUCASUS

Genus	Number of species	% of total number of species
1. Saxifraga	16	4,2
2. Carex	13	3,4
3. Campanula	11	2,9
4. Ranunculus	11	2,9
5. Minuartia	11	2,9
6. Draba	10	2,6
7. Astragalus	10	2,6
8. Festuca	9	2,3
9. Potentilla	8	2,1
10. Alchemilla	7	1,8
11. Pedicularis	7	1,8
12. Silene	6	1,6
13. Scrophularia	6	1,6
Total	125	32,6

TABLE V. QUANTITATIVE RATION BETWEEN GENERA OF HIGHLAND ALPINE ROCKY-SCREE VEGETATION IN THE CENTRAL AND EASTERN CAUCASUS

Genera	Large	Medium	Oligotype with number of species:					
			10-19	6-9	5	4	3	2
Number of species								
Number of genera	7	6	8	11	13	23	90	
% of total number of genera	4.4	3.8	5.1	7.0	8.2	14.6	57.0	
Number of species	82	43	40	44	39	46	90	
% of total number of species	21.4	11.2	10.4	11.5	10.2	12.0	23.4	

Completing the taxonomic analysis, it is worth dwelling on the genus index, which shows what number of species is per genus. In the highland Alpine rock-scrub vegetation of the Central and Eastern Caucasus this index equals to 2.4, i.e. one genus accounts to 2.4 species. To compared with other region parts, as for instance, in the vegetation of petrophytes of the Western part of the Central Caucasus this index equals to 2.7 [14]; in the Russian Caucasus – 3.3 [7]. The genus index serves as an indirect indicator of the intensity in competition between closely related species growing in various environmental conditions [6]. This indicates the peculiarities of the physiographic environment in which the vegetation was evaluated. The index is always lower in the floras formed in

condition of non-changing climate and relief [3] that is related to highlands and naturally identified in the proportions of the studied flora.

IV. CONCLUSION

The highland Alpine rocky-scrub vegetation of vascular plants in the Central and Eastern Caucasus includes 384 species of vascular plants belonging to 158 genus and 42 families.

Systematically, the studied vegetation is characterized with domination of dicotyledonous, specific family-species spectrum (Caryophyllaceae-species and Fabaceae-subspecies), a great number of pseudomonotype genera in the main plant families, with the presence of emuotypic genera, and a low plant genus index.

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