

Diversity, taxonomic structure of subalpine and alpine vegetation of Caucasus (Azerbaijan and border countries)

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Abstract: It was determined that the diversity of alpine and subalpine vegetation of Azerbaijan consist of 975 plant species and subspecies belonging to six classes, 66 families and 321 genera which makes up 22% of the country's flora. Among the families Asteraceae (143 species), Poaceae (66 species), Fabaceae (61 species), Rosaceae (53 species), Caryophyllaceae (49 species), Lamiaceae (47 species) are dominant families richer in species. The 25 families (36 species) found in the area are sensitive and are represented by only 1-2 species. Eight of these species are subendemics distributed in the North and South Caucasus, Iran and Turkey. The *Polygala alpicola* (Polygalaceae) is described from the North and South Caucasus, *Axyris caucasica* (Chenopodiaceae), *Festuca skvortsovii* from the South Caucasus only. In total, we have identified 432 endemic species for alpine and subalpine flora in the Caucasus ecoregion. The originality of vegetation is 10% of the total flora, and 44% of the alpine and subalpine flora. The leading families in terms of the number of endemic species are Asteraceae (60 species), Caryophyllaceae (29), Fabaceae (28), Apiaceae (26), Rosaceae (25), Brassicaceae (24), Lamiaceae (24). Eight of them are real Azerbaijani endemics.

Key Words: biodiversity, endemism, family, flora, genus, species, subendemics

INTRODUCTION

In modern times, the development of applied ecology and botany, the organization of long-term forecasting and control over the components of the natural environment on a global and regional scale are very important issues. Recently, the conservation of the environment, protection of ecosystems and natural resources has increased at a high level. Deforestation due to lack of energy carriers, especially fuels, unplanned grazing of agricultural animals in the

areas, hard anthropogenic impacts on nature have led to the destruction-degradation of soil and vegetation [Babakishiyeva et al., 2021]. In particular, as a result of deforestation due to the use of trees in furniture making and as fuel, disturbance of the water-protective role of landscapes, the process of erosion has intensified. For this reason, the protection of the flora and fauna of the republic, implementation of monitoring to study and forecast anthropogenic changes in the environment and biosphere as well as preservation of existing natural complexes without change and transmission to future generations are of special importance for the creation of state reserves, national parks [Seyidov et al., 2014].

Although the terrestrial flora has deep historical roots, it has undergone a complex natural-historical development process, and subjected to changes at times as a result of various physical and anthropogenic influences and has reached its present state. According to A.A. Grossheim the history of the development of the Caucasian flora and came to the conclusion that the development of xerophytic vegetation in the Transcaucasia formed as a result of narrowing of the Sarmatian Sea, which covers most of the land in the Caucasus, to Iran and its drying up [1936]. The formation of a continental climate in the area, the presence of seasonal continentality, although not so much affected the subalpine and alpine, created conditions for the formation of desert plants in the area. According to A.A. Grossheim, the formation of xerophytic plants in the territory of Iran occurred at the same time and with little difference from Central Asia. The physical and geographical conditions of Transcaucasia have led to the gradual migration of Central and Central Asian elements in the area [Grossheim, 1939]. In the fourth period, climate change led not only to a shift in the boundaries of vegetation zones in the territory, but also to the narrowing and expansion of these boundaries at times. In particular, as a result of the advance and retreat of glaciers, these boundaries have sometimes risen to high altitudes, and in some cases, the stiffening of the climate has led to the descent of these boundaries to the plains.

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Received 12.04.2022; Received in revised form 26.04.2022; Accepted 18.05.2022

Beginning in the middle of the Tertiary period, the migration of Asian and Mediterranean elements to the area continued to increase. During this period, the elements belonging to the northern flora were weakly visible in the area, but the migration of European elements began in the middle of the Sarmatian period and continued to increase [Talibov, 2001].

One of the main features of the formation of xerophytic vegetation in the area is the occurrence of park-like forests in mountainous areas, which sometimes rise to the subalpine. It should be noted that the forests of this period were mainly composed of oak, hawthorn, wild pear and other trees. Other species of trees are also found in the Greater Caucasus and Talysh forests.

In the Tertiary period, the hardening of the climate led to significant changes in the life of broad-leaved forest plants. Thus, these plants were either completely destroyed or gradually migrated to the plains. V.J. Hajiyev [2004] shows that the water of the Sarmatian Sea slowly began to recede between the ponts, as a result, the territory of the East Caucasus merged with the low mountainous zone of Iran, creating conditions for the migration of xerophytic plant elements into the area. The glacial period has led to the migration of northern and arctic elements to the area. In particular, the migration of wetland plants took place during this period. The migration of boreal elements can be considered as a product of the glacial age. The changing conditions of the Tertiary period, weakening of mountain formation processes, changing of the physical and geographical conditions, migration of elements from Central Asia, the Mediterranean, East Asia and Europe to the area, the inclusion of northern species to a greater or lesser extent played a special role in the formation of the territorial flora.

From this perspective, the biological diversity of subalpine and alpine zone is of particular interest from an ecological and physiological point of view. Since these organisms live in a relatively harsh climate and their ranges are relatively small, changes in climatic factors are reflected in the size of the populations of these organisms. As a result, it is possible to study the regularities of the impact of climate change on the living populations. Subalpine and alpine vegetation are under the strongest pressure. The vegetation of this area is used as summer pastures and hayfields. Overgrazing, the impact of invasive species introduced by domestic animals, has a direct impact on the biodiversity of the territory, and an indirect negative occurs when landscape

changes.

Currently, there are certain materials on the study of alpine and subalpine landscapes of Azerbaijan. These studies cover the entire ecoregion of the Caucasus in general, or general plant formations vegetation types, specific species of flora [Hajiyev, 2004; Ibrahimov et al., 2013; Khalilov et al., 2015; Mammadova et al., 2013].

To preserve, conserve and restore all these processes, especially natural complexes located on the territories, protect rare and endangered species of flora characteristic of mountain slopes, and study their ecological state, prevent erosion processes occurring on mountain slopes, especially for the study of biological objects that are valuable for these regions and conduct monitoring studies through observations, the studies were launched taking into account the fact that the alpine-supalp areas rich in flora have not yet been studied in detail during the last years.

MATERIAL AND METHODS

The materials were collected during expeditions in 2013-2020 and scientific literature were searched. In assessing the biological diversity of alpine and subalpine, the results of environmental monitoring studies by various scientists and specimens stored in the herbarium (BAK) of the Institute of Botany of ANAS were used.

According to the literature, 4745 plant species have been identified in Azerbaijan, which makes up 67% of the Caucasian flora. For comparison, number of species in neighboring Georgia is 4100 species and in Armenia - 3260 species [Askerov, 2016; Gagnidze, 2000; Fifth Nati. Rep..., 2000]. However, according to the monitoring carried out in recent years and calculations adapted to the latest classifications, the flora of vascular plants in Azerbaijan includes 2 species belonging to club-moss, 6 species to horsetails, 55 species to ferns, 11 species to gymnosperms, 5 species to gnetophyta, 956 species to monocotyledons, 3343 species to dicotyledonous and we conclude that 4378 species are distributed in Azerbaijan.

In the Greater Caucasus, including Azerbaijan, the subalpine zone covers altitudes of 1800-2000 and 2500-2700 m, depending on the relief and climatic features of the area, and the alpine zone 2500 and 3000-3200 m, sometimes 3500 m. In the Lesser Caucasus, including the Zangezur and Daralaaz ranges that fall into the territory of Nakhchivan, subalpine and alpine meadows cover heights of 2350-3000 m. Zangezur

mesophytic subalpine meadows are found in the form of narrow strips in areas of the high-mountain belt, where mountain-meadow turfy soils of the northern, northwestern and northeastern directions are spread. In harder and rockier areas, these meadows appear as dry subalpine meadows. Mesophytic subalpine meadows form numerous transformations in the form of clearings in the area at the foot of the Batabat, Takali and Salvarti mountains. These meadows are well covered with turf due to numerous turf-forming grass. The subalpine meadows of this area were formed as a result of the influence of existing climate, soil and other environmental factors, numerous formations and associations with various specific features. These meadows are distinguished by the richness of their floral composition. Subalpine and alpine belts are more represented by mixed cereal meadows. The main components of these meadows are such plants as *Phleum alpinum* L., *Alopecurus textilis* Boiss., *Melica taurica* C.Koch, *Bromus japonicus* Houtt., *Anthoxanthum odoratum* L. In these areas, *Dactylis glomerata* L. forms colorful associations and groupings with different species of plants. *Arrenatherum elatius* (L.) P.Beauv. ex J.Presl & C.Presl., *Festuca valesiaca* Rchb., *Trifolium medium* L. are one of these plants. *Hordeum bulbosum* L., *H. vulgare* L. species form a mixed association with legumes- miscellaneous herb in the territory of Batabat.

Alpine and subalpine vegetation extend from the Main and Lateral Range of Caucasus in the north of the Greater Caucasus to the Meysari, Niyaldagh, Dubrar ranges in the south. This covers the Karabakh volcanic plateau in the Lesser Caucasus, the high mountainous areas of the Murovdagh, Zangazur and Daralayaz ranges.

Brief physical-geographical characteristics of alpine-subalpine landscapes. The alpine and subalpine zones of Azerbaijan can be conventionally divided into four parts: 1. Main and Lateral Range of Caucasus of the Greater Caucasus Mountain System; 2. Part of the Lesser Caucasus mountain system; 3. Karabakh range of the Lesser Caucasus mountain system; 4. Part of the Zangazur and Daralayaz ranges.

The climate is formed under the influence of processes characteristic of a free atmosphere and is characterized by short cool summers and long cold and snowy winters. In this regard, the entire range occupied by this type of landscape belongs to the high-mountain climatic zone. The temperatures of the coldest month are 8-12°C, the warmest 7-12°C, respectively, the average annual temperature ranges from 2-2.5°C in the

subalps to -2.5°C in the alps. In addition, the minimum temperature in some areas falls on February, and the maximum on August, although “oceanicity” is often expressed only in one of the seasons. Temperature fluctuations are lower in alpine landscapes, but here the maximum temperatures of the warm period do not reach 10°C. The amount of precipitation generally ranges from 600 to 1800 mm per year. The proportion of precipitation falling in cold weather, compared with the lower landscapes, is maximum both in absolute and relative terms: 360 mm (30%) in the subalps and 530 mm (51%) in the alps. The climate of this zone, which belongs to the high mountainous climate zone, is characterized by short and humid summers, long cold and snowy winters.

In the subalpine and alpine meadows of Azerbaijan, mainly turfy mountain-meadow, primitive and turfy mountain-meadow, bare rocks, clayey rocks exposed to surface are spread [National Atlas, 2014]. This zone, where volcanic, denudative, erosional and karst reliefs are common and consist of complexes of various rocks, has a unique geomorphological structure, consisting mainly of Mesozoic and Paleogene sedimentary and volcanic-sedimentary rocks.

RESULTS AND DISCUSSION

The alpine and subalpine zone is very diverse. 21 landscape types belonging to 1 class, 1 type, 2 subtypes and forms are described [Geography..., 2015]. This area, which belongs to the type of alpine, subalpine meadows and meadow-steppe landscapes of intensely fragmented high mountains, sub-type of mountain-meadow landscapes with temperate-humid climate is conditionally divided into 2 groups: 1) subalpine forest-shrub-meadow landscapes of the highlands and 2) alpine shrub-meadow landscapes of the highlands. Vegetation of subalpine meadows is mainly divided into 3 groups: 1. Low trees belonging to *Salix* L., *Pyrus* L., *Quercus petraea* subsp. *pinnatiloba* (K. Koch) Menitsky, *Fagus orientalis* Lipsky, *Cephalotaxus harringtonii* (Knight ex J. Forbes) K.Koch (*Taxus baccata* L.), *Acer* L., *Betula* L., *Juniperus* L., *Amygdalus* L., *Crataegus* L., *Laurocerasus* Tourn. ex Duhamel, *Viburnum* L. genera that are distributed sparsely; 2. Bushes belonging to genera *Sorbus* L., *Daphne* L., *Pyracantha* M. Roem., *Lonicera* L., *Cotoneaster* Medik., *Rosa* L., *Rhododendron* L., *Acantholimon* Boiss., *Juncus* L., *Rhamnus* L., *Rubus* L.; 3. In general, various species of higher plants, dominated by the Asteraceae, Fabaceae, Brassicaceae, Poaceae, Apiaceae, Lamiaceae families, are widespread.

As a result of our research on alpine-subalpine landscapes, it was determined that 975 species of 66 families, 321 genera, belonging to the general Caucasian flora, are distributed. Table 1 presents the taxonomic structure and comparative indicators of flora diversity of alpine and subalpine of the mentioned areas. Table 2 shows the dominant families of flora diversity, comparative analysis of their characteristics. For example, the family Asteraceae (Compositae) has the largest number of species on the landscape and is represented by 143 species. This makes up 15% of the total number of species (975 species) found in the alpine-subalpine landscape. At the same time, 25% of the species belonging to the family Asteraceae (143/572) are found in the flora of the area. The families indicated in Table 3 are in the development stage and are safe due to their rich species and subspecies diversity. The taxonomic structure of the dominant genera is presented in Table 4. Of the 321 plant genera found in the area, 63 are represented by 5 or more species, which makes up 20% of the species diversity in the subalpine and alpine belts. As can be seen from the table, the richest genera - *Campanula* L. (Campanulaceae) is represented by 25 species, *Carex* L. (Cyperaceae) by 20 species, *Veronica* L. (Plantaginaceae) by 16 species, *Senecio* (Asteraceae) by 15 species and *Silene* (Caryophyllaceae) by 15 species. On the other hand, the vast majority of species belonging to the genera *Saxifraga* L. (Saxifragaceae), *Senecio* L. (Asteraceae) and *Alchemilla* L. (Rosaceae) are distributed in the alpine-subalpine zone.

Representatives belonging to 19 sensitive families, represented by 1-2 species were identified in the area, 12 of which consist of only one genus and one species. These families are: Lycopodiaceae (*Huperzia selago* (L.) Bernh. ex Schrank & Mart.), Selaginellaceae (*Selaginella helvetica* (L.) Spring), Ophioglossaceae (*Botrychium lunaria* (L.) Sw.), Ephedraceae (*Ephedra*

major subsp. *procera* (C.A.Mey.) Bornm.), Taxaceae (*Taxus baccata* Thunb.), Asphodelaceae (*Asphodelus tenuifolius* Cav.), Melanthiaceae (*Veratrum lobelianum* Bernh.), Aceraceae (*Acer trautvetteri* Medw.), Anacardiaceae (*Linum hypericifolium* Salisb.), Celastraceae (*Parnassia palustris* L.), Resedaceae (*Reseda luteola* L.), Urticaceae (*Urtica dioica* L.).

From the main shrubs, evergreen species *Juniperus communis* var. *saxatilis* Pall., three species of the genus rhododendron (*Rhododendron* L., Ericaceae), three species of the genus bilberry (*Vaccinium* L., Ericaceae), from deciduous species, three species of the genus buckthorns (*Rhamnus* L., Rhamnaceae) and six species of the genus daphne (*Daphne* L., Thymelaceae) are found in alpine-subalpine landscapes. *H. selago*, *S. helvetica*, *Polypodium vulgare* L., *Ceterach officinarum* Willd., *B. lunaria*, *T. baccata*, *Helleborus caucasicus* A. Braun found in the area are relics of the Tertiary (Neogene) period and *Saxifraga flagellaris* Willd., *Campanula saxifraga* M.Bieb. of the Ice Age.

Seven species of broomrapes from parasitic herbaceous plants belonging to the Orobanchaceae family are found on the territory. *Orobanche alba* Stephan ex Willd. mainly parasitizes on the roots of species belonging to the genera *Salvia* L., *Thymus* L., *Hypericum* L., *Orobanche grossheimii* Novopokr. on the roots of species belonging to the genus *Cephalaria* L., *O. kurdica* Boiss. & Hausskn on the roots of species belonging to the genera *Tanacetum* L., *Carduus* L., *Phlomis* L., *O. alba* Stephan ex Willd. (*O. raddeana*) on the roots of species belonging to the genus *Campanula* L., *O. gracilis* Sm. on the roots of leguminous plants, *O. reticulata* Wallr. on the roots of the species *Knautia montana* DC.

Alpine meadows. Alpine meadows with a relatively poor plant diversity (mainly 15-30 species and less) are found in the Greater Caucasus and Lateral Range, Zangazur

Table 1. Comparative analysis of the taxonomic structure of flora diversity of alpine and subalpine zone of Azerbaijan with the general flora.

№	Class	Family		Genus		Species	
		<i>alpine and subalpine/flora</i>	<i>In %</i>	<i>alpine and subalpine/flora</i>	<i>In %</i>	<i>alpine and subalpine/flora</i>	<i>In %</i>
1	Lycopodiopsida	2/2	100	2/2	100	2/2	100
2	Equisetopsida	0/1	-	0/1	-	0/6	-
3	Polypodiopsida	4/6	67	10/24	42	18/55	33
4	Gnetopsida	1/1	100	1/1	100	1/5	20
5	Pinopsida	2/3	67	2/3	67	6/11	55
6	Liliopsida	12/25	48	64/213	30	201/956	21
7	Magnoliopsida	45/95	47	242/771	31	747/3343	21
Total		66/133	50	321/1015	32	975/4378	22

Note: The numbers after slash (/) belong to the flora of Azerbaijan.

Table 2. Dominant families of flora diversity of alpine and subalpine zone and their taxonomic structure (Total 975 species).

№	Family	Genus		Species		In % by landscape and family	
		<i>Alpine-subalpine</i>	<i>Flora</i>	<i>Alpine-subalpine</i>	<i>Flora</i>	<i>On landscape</i>	<i>On family</i>
Liliopsida class: 12 families; 64 genera; 201 species							
1	<i>Poaceae</i>	27	113	66	469	6.8	14
2	<i>Cyperaceae</i>	3	19	23	116	2.4	20
3	<i>Orchidaceae</i>	10	20	27	62	2.8	44
4	<i>Liliaceae</i>	4	4	13	55	1.3	24
5	<i>Asparagaceae</i>	6	14	21	55	2.2	38
6	<i>Amaryllidaceae</i>	3	4	19	51	2.0	35
7	<i>Iridaceae</i>	4	5	14	36	1.3	36
8	<i>Juncaceae</i>	2	2	10	29	1.0	34
Magnoliopsida class: 45 families, 242 genera, 747 species							
1	<i>Asteraceae</i>	53	121	143	572	15.0	25
2	<i>Fabaceae</i>	15	43	61	293	6.4	19
3	<i>Rosaceae</i>	16	33	53	216	5.6	21
4	<i>Caryophyllaceae</i>	14	34	49	191	5.1	25
5	<i>Brassicaceae</i>	20	82	38	245	4.0	14
6	<i>Lamiaceae</i>	17	37	47	219	5.0	20
7	<i>Ranunculaceae</i>	12	23	33	101	3.5	30
8	<i>Apiaceae</i>	17	70	29	182	3.1	15
9	<i>Orobanchaceae</i>	6	16	28	73	3.0	37
10	<i>Campanulaceae</i>	2	7	25	58	2.6	41
11	<i>Plantaginaceae</i>	3	12	22	101	2.3	23
12	<i>Primulaceae</i>	5	8	17	27	1.8	62
13	<i>Gentianaceae</i>	3	6	16	22	1.7	73
14	<i>Polygonaceae</i>	4	6	13	54	1.4	24
15	<i>Crassulaceae</i>	4	7	13	31	1.4	42
16	<i>Saxifragaceae</i>	1	1	11	14	1.2	79
17	<i>Scrophulariaceae</i>	2	2	10	58	1.0	17
18	<i>Caprifoliaceae</i>	4	9	10	63	1.0	16

Table 3. Developing and safe species of flora diversity of alpine and subalpine zone.

№	Name of genus	Family it belongs	Number of species		
			In flora	Belt	In %
Liliopsida class: 64 genera; 201 species					
1	<i>Carex</i>	<i>Cyperaceae</i>	63	20	32
2	<i>Allium</i>	<i>Amaryllidaceae</i>	42	14	33
3	<i>Juncus</i>	<i>Juncaceae</i>	29	11	38
Magnoliopsida class: 241 genera, 741 species					
4	<i>Campanula</i>	<i>Campanulaceae</i>	55	25	45
5	<i>Veronica</i>	<i>Plantaginaceae</i>	40	16	40
6	<i>Senecio</i>	<i>Asteraceae</i>	22	15	68
7	<i>Silene</i>	<i>Caryophyllaceae</i>	49	15	31
8	<i>Astragalus</i>	<i>Fabaceae</i>	34	14	41
9	<i>Alchemilla</i>	<i>Rosaceae</i>	22	14	64
10	<i>Rosa</i>	<i>Rosaceae</i>	46	13	28
11	<i>Cirsium</i>	<i>Asteraceae</i>	33	11	21
12	<i>Saxifaga</i>	<i>Saxifragaceae</i>	14	11	79
13	<i>Ranunculus</i>	<i>Ranunculaceae</i>	32	10	31
14	<i>Gentiana</i>	<i>Gentianaceae</i>	10	10	100
Total			491	-	

Range of the Lesser Caucasus, at altitudes of 2900-3200 m, in the upper reaches of the alpine belt, around snowy areas that do not melt in summer, in sunny and high-water, stony-gravelly areas in the form of small spots. Plants of alpine meadows grow strongly underground, and a short aboveground part completely covers the surface (Fig. 1A). They rationally use sunlight through large, chloroplast-rich leaves (in conditions of short vegetation and low sunlight), enhance transpiration, and protect the root system from frost. Usually, along with species diversity in alpine meadows, there is also population diversity with a predominance of one species (consisting mainly of species belonging to the genera *Alchemilla* L., *Carum* L., *Sibbaldia* L., *Epilobium* L., *Senecio* L.). About 50 species belonging to 20 families are distributed here. These are representatives of Apiaceae, Asparagaceae, Asteraceae, Brassicaceae, Boraginaceae, Campanulaceae, Caryophyllaceae, Crassulaceae, Cyperaceae, Fabaceae, Gentianaceae, Onagraceae, Orobanchaceae, Plantaginaceae, Poaceae, Primulaceae, Ranunculaceae, Rosaceae, Saxifragaceae, Valerianaceae families.

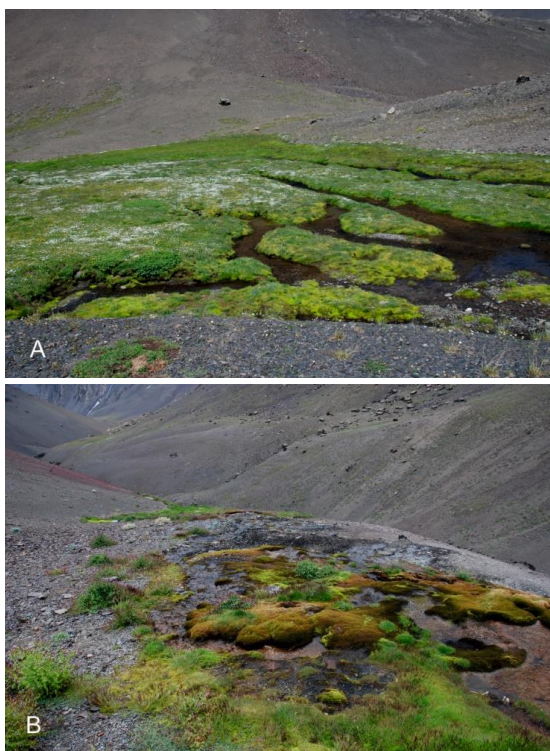


Figure 1. The photos belong to the territory of Azerbaijan. A. Alpine meadows with the dominance of *Cerastium multiflorum* and *Taraxacum stevenii* (the foot of Bazaryurd mountain, 3500 m); B. *Epilobium alpinum* species (the foothills of Bazarduzu Mountain, 3520 m).

Tundra-type alpine meadows are found in ecotones where alpine landscapes pass into subnival ones, and in areas with a predominance of the mountain-tundra climate type (Fig. 1B).

Of the 975 species of plants found in the area, 543 species have wide range and 432 species are endemic species of various categories distributed within the Caucasus ecoregion: Stenoendemics (endemics with a very narrow habitat. They are spread over a very narrow, concrete small area of the planet); Evriendemic (a species distributed over a relatively large area) (for example endemics of the South Caucasus and Azerbaijan); Subendemics (species distributed outside the study area (for example, Azerbaijan) (North and South Caucasus, Whole Caucasus, Turkey and Iran). These are conditional groupings [Tab. 4, 5].

The mentioned 432 endemic species belong to the entire Caucasus ecoregion (North Caucasus, South Caucasus, Iran and Turkey). 151 endemic species mentioned in the article belong to the Caucasus (North Caucasus and South Caucasus). This indirectly indicates that only 151 among these endemic species belong to the Caucasus region. Russian experts divide it into different groups: West Caucasus, Middle Caucasus, East Caucasus, Whole Caucasus, Eucaucasus, etc. [Ivanov, 2019]

Vegetation with wide range mainly belongs to the families Asteraceae (82 species), Poaceae (51 species), Fabaceae (34 species), Lamiaceae (21 species), Rosaceae (26 species), Orchidaceae (21 species), Cyperaceae (22 species). *H. selago* (Lycopodiaceae), *S. helvetica* (Selaginellaceae), *B. lunaria* (Ophioglossaceae), *E. major* subsp. *procera* (Ephedraceae), *C. harringtonii* (Taxaceae), *A. tenuifolius* (Asphodelaceae), *V. lobelianum* (Melanthiaceae), *Chenopodium foliosum* Asch. (Amaranthaceae), *P. palustris* (Celastraceae), *Fagus orientalis* Lipsky (Fagaceae), *Alcea rugosa* Alef. (Malvaceae), *Polygala anatolica* Boiss. & Heldr. (Polygalaceae), *R. luteola* (Resedaceae), *U. dioica* (Urticaceae) are wide-range species represented by 1 species.

Endemism of alpine and subalpine vegetation. The number of endemic species in the flora of any area is an indicator of the specificity and uniqueness of the vegetation of that area. Endemism is the result of relief, geographical and climatic indicators of the area and is formed in a limited range in the certain area. The originality of the nature of the area is determined by the special abundance of endemic species there. Phylogenetic, chorological, coenoecological features of

Table 4. Distribution of dominant families of endemism of alpine and subalpine flora by subregions.

Subendemic ranges	Total number of species	Number of endemic species by family									
		<i>Asteraceae</i>	<i>Apiaceae</i>	<i>Ranunculaceae</i>	<i>Fabaceae</i>	<i>Brassicaceae</i>	<i>Lamiaceae</i>	<i>Campanulaceae</i>	<i>Rosaceae</i>	<i>Caryophyllaceae</i>	<i>Orobanchaceae</i>
Species with wide range	543 (56%)	82	3	11	34	15	21	7	26	21	15
North Caucasus and South Caucasus	151 (35%)	24	12	6	10	10	11	8	9	14	4
North Caucasus and South Caucasus, Turkey	121 (28%)	19	3	4	5	7	3	6	10	8	5
North Caucasus and South Caucasus, Iran, Turkey	98 (23%)	9	10	8	6	1	9	1	4	5	2
South Caucasus	35 (8%)	7	1	-	4	4	2	1	3	2	1
North Caucasus and South Caucasus, Iran	28 (6%)	3	1	4	2	1	1	2	1	-	1
Total	432 (44%)	61	26	22	27	23	26	18	27	28	13

Table 5. Taxonomic structure of stenoendemic species of alpine and subalpine vegetation found in the South Caucasus.

Family	Species
Liliopsida (monocotyledons) class: 5 species	
Iridaceae	<i>Iris caucasica</i> var. <i>multiflora</i> , <i>I. grossheimii</i> , <i>I. winogradowii</i>
Poaceae	<i>Festuca skvortsovii</i>
Magnoliopsida (dicotyledonous) class: 39 species	
Apiaceae	<i>Carum komarovii</i>
Asteraceae	<i>Centaurea acmophylla</i> , <i>Jurinea grossheimii</i> , <i>J. praetermissa</i> , <i>J. spectabilis</i> , <i>Lactuca kirpicznikovii</i> (<i>Cephalorrhynchus kirpicznikovii</i>), <i>Psephellus karabaghensis</i> , <i>P. transcaucasicus</i> , <i>Tanacetum zangezuristicum</i>
Brassicaceae	<i>Alyssum globosum</i> (<i>Takhtajaniella globosa</i>), <i>Isatis karjaginii</i> , <i>Neurotropis armena</i>
Campanulaceae	<i>Campanula saxifraga</i> subsp. <i>meyeriana</i>
Caprifoliaceae	<i>Cephalaria armeniaca</i>
Caryophyllaceae	<i>Dianthus kusnezowii</i> (<i>D. abchazicus</i>), <i>Silene depressa</i>
Fabaceae	<i>Anthyllis vulneraria</i> subsp. <i>subscaposa</i> (<i>A. caucasica</i>), <i>Astragalus kubensis</i> , <i>Lathyrus atropatanus</i> (<i>L. nivalis</i> subsp. <i>atropatanus</i>), <i>L. ciliatidentatus</i>
Orobanchaceae	<i>Euphrasia daghestanica</i>
Papaveraceae	<i>Papaver zangesurum</i>
Plantaginaceae	<i>Linaria schelkownikowii</i>
Rosaceae	<i>Alchemilla epipsila</i> , <i>A. jaroschenkoi</i> , <i>Rosa karjaginii</i>
Rubiaceae	<i>Galium valentinae</i> , <i>Asperula azerbaijanica</i>
Thymelaceae	<i>Daphne axilliflora</i>

endemic species in the area allow obtaining fundamental-theoretical information about the origin and formation of biodiversity, determining the category and status of species, and choosing conservation strategies. In modern times, 1600 species belonging to 13 endemic genera have been described in the Caucasian flora, which makes up about 25% of the total flora. Most of these species are found in high mountainous landscapes [Shulkina, 2015]. It should be noted that there are various figures about the floristic endemic richness of the Caucasus ecoregion as a whole, including Azerbaijan, and their habitat [Murtazaliev et al., 2012; Askerov, 2014; Ibadullayeva et al., 2014; 2008]. One

reason for this is the recent permanent taxonomic and nomenclature changes in plant taxonomy. The second reason is the discovery of new habitats by specialists. Of course, the consistent approach of specialists in this field will provide more accurate information. Our analysis revealed 432 endemic species for alpine and subalpine flora. Of these, one species belongs to the Polypodiopsida class (*Woodsia caucasica*; Aspleniaceae), 65 species (9 families, 29 genera) to the Liliopsida class, and 366 species (40 families, 151 genera) to the Magnoliopsida class. Based on these calculations, it is determined that the originality of plant diversity in the alpine and subalpine flora of Azerbaijan

makes up 10% of the total flora, and 44% of the landscape flora. On the class Liliopsida Poaceae (66 species; 14 endemics), Amaryllidaceae (19;12), Asparagaceae (21; 10), Iridaceae (14; 10), Liliaceae (13; 10) families are the dominant families of endemic plant species in the alpine and subalpine flora of Azerbaijan (Fig. 2).



Figure 2. Endemics of different status and plants with wide range of alpine and subalpine flora: A-B. Whole Caucasus: *Dianthus vladimirii*, *Campanula lezgina*; C. Caucasus, Turkey: *Linum hypericifolium*; D. Caucasus, Iran: *Delphinium spesiosum*.

On the class Magnoliopsida Asteraceae (143; 61), Caryophyllaceae (49; 28), Fabaceae (61; 27), Apiaceae (29; 26), Rosaceae (53; 27), Lamiaceae (47; 24), Brassicaceae (38; 23), Ranunculaceae (33; 22), Campanulaceae (25; 18), Orobanchaceae (28; 13) families are the dominant families of endemic plant species of alpine and subalpine flora on the general region.

These species differ in their geographical area and habitat. Some of them are stenoendemic (Azerbaijan and South Caucasus), some are evriendemic (North Caucasus and South Caucasus) and the third part is subendemic species. It should be noted that stenoendemic species found in a relatively narrow range are objects of first class protection. Because they are very rare and unique gene pool carriers. Subendemic species, in turn, have habitat differences.

They can be conventionally divided into subendemic plants of the Caucasus Ecoregion (North, South Caucasus, Iran, Turkey), Iran (North, South Caucasus, Iran) and Turan (North, South Caucasus and Turkey) (Fig. 3).

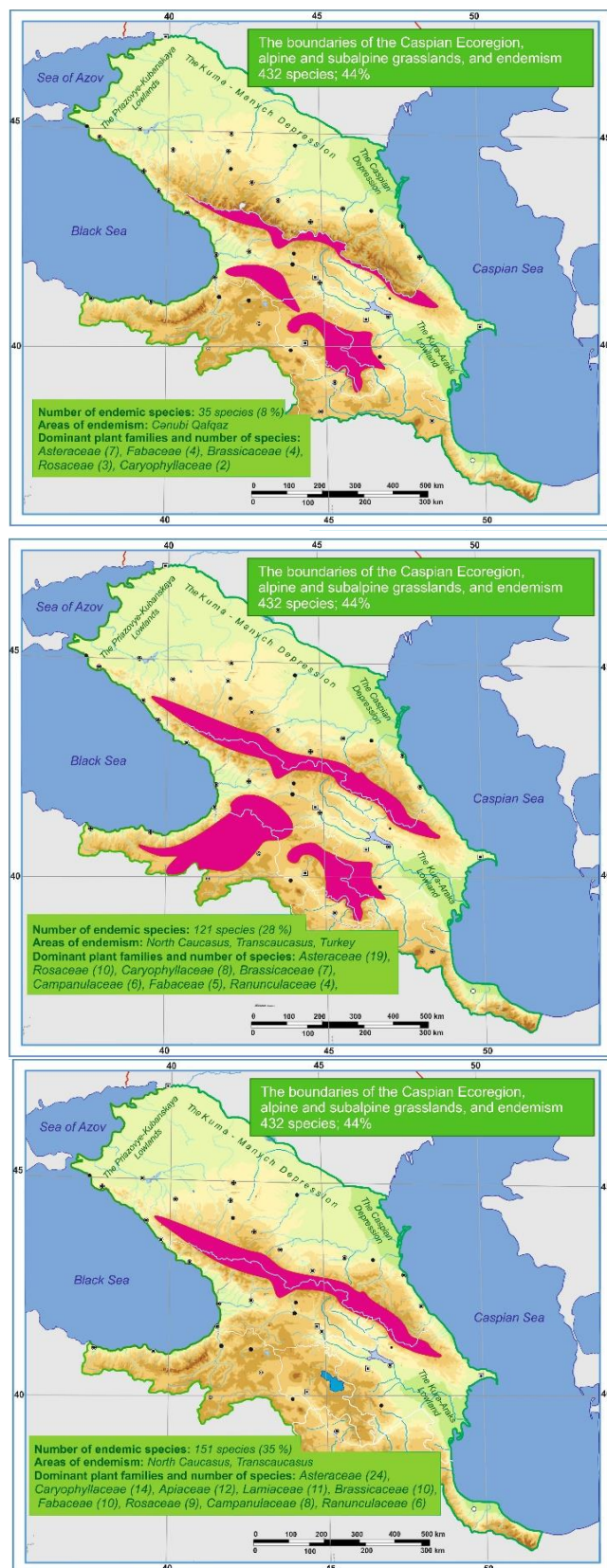


Figure 3. Main speciation centers and endemic ranges in alpine and subalpine vegetation on the Caucasus ecoregion.

As can be seen from table 4, the leadership in the absolute indicator of endemism belongs to the Asteraceae family (61 endemic species). Due to the endemism of the common species in the family, the Apiaceae family dominates. Thus, 26 out of 29 species belonging to the family spread in the landscape are endemic species with different status. The following table provides the characteristic properties of endemism of the Caucasian ecoregion. As can be seen, the maximum number of endemic species occurs in the entire Caucasus region (151 endemic species). This indicates that the Caucasus is the center of speciation.

As can be seen from table 5, *Iris caucasica* var. *multiflora* Grossh., *Jurinea spectabilis* Fisch. & C.A.Mey., *Psephellus karabaghensis* Sosn., *Astragalus kubensis* Grossh., *Euphrasia daghestanica* Juz., *Alchemilla jaroschenkoi* Grossh., *Rosa karjaginii* Sosn. and *Asperula azerbaijanica* Mam., Shach. & Velib. are endemic species of Azerbaijan.

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Qafqazın subalp və alp bitkiliyinin müxtəlifliyi və taksonomik quruluşu (Azərbaycan və sərhədyanı ölkələr)

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Müəyyən edilmişdir ki, Azərbaycanın alp və subalp bitkiliyinin müxtəlifliyi 6 sinif, 66 fəsilə və 321 cinsə aid olan 975 bitki növü və alt-növlərindən ibarətdir ki, bu da ölkə florasının 22%-ni təşkil edir. Fəsilələr arasında Asteraceae (143 növ), Poaceae (66), Fabaceae (61), Rosaceae (53), Caryophyllaceae (49), Lamiaceae (47) növcə daha zəngin olan dominant fəsilələrdir. Ərazidə rast gəlinən 25 fəsilə (36 növ) həssas fəsilələr olub yalnız 1 - 2 növlə təmsil olunur. Bu növlərdən 8-i

subendem növlər olub Şimali və Cənubi Qafqaz, İran və Türkiyə ərazilərində yayılmışdır. *Polygala alpicola* (Polygalaceae) Şimali və Cənubi Qafqaz, *Axyris caucasica* (Chenopodiaceae) və *Festuca skvortsovii* isə yalnız Cənubi Qafqazdan təsvir edilmişdir. Ümumilikdə Qafqaz ekoregionunda alp və subalp florası üçün tərkibimizdən 432 endemik növ müəyyən edilmişdir. Bitkiliyin orijinallığı ümumi floranın 10%-ni, alp və subalp florasının isə 44%-ni təşkil edir. Endemik növlərin sayına görə aparıcı fəsilələr bunlardır: Asteraceae (60 növ), Caryophyllaceae (29), Fabaceae (28), Apiaceae (26), Rosaceae (25), Brassicaceae (24), Lamiaceae (24). Bunlardan 8 növ əsl Azərbaycan endemikləridir.

Açar sözlər: *biomüxtəliflik, endemizm, fəsilə, flora, cins, növ, subendemik*

Разнообразие и таксономическая структура субальпийской и альпийской растительности Кавказа (Азербайджан и приграничные страны)

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Установлено, что разнообразие альпийской и субальпийской растительности Азербайджана представлено 975 видами и подвидами растений, относящихся к 6 классам, 66 семействам и 321 роду, что составляет 22% флоры страны. Доминирующими семействами являются Asteraceae (143 вида), Poaceae (66 видов), Fabaceae (61 вид), Rosaceae (53 вида), Caryophyllaceae (49 видов), Lamiaceae (47 видов). 25 семейств (36 видов) являются уязвимыми и представлены всего 1-2 видами, 8 из которых – субэндемики, распространенные на Северном и Южном Кавказе, в Иране и Турции. Так *Polygala alpicola* (Polygalaceae) описана с Северного и Южного Кавказа, *Axyris caucasica* (Chenopodiaceae), *Festuca skvortsovii* только с Южного Кавказа. Всего выявлено 432 эндемичных вида для альпийской и субальпийской флоры Кавказского экорегиона. Свообразие растительности составляет 10 % всей флоры, а 44 % альпийской и субальпийской флоры. Ведущими по количеству эндемичных видов являются семейства Asteraceae (60 видов), Caryophyllaceae (29), Fabaceae (28), Apiaceae (26), Rosaceae (25), Brassicaceae (24), Lamiaceae (24), включающие 8 видов эндемиков Азербайджана.

Ключевые слова: *биоразнообразие, эндемизм, семейство, флора, род, вид, субэндемики*