

## Dominant species of the flora of alpine landscapes of the surrounding areas of Shahdag mountain, their ecological analysis and endemism

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**Abstract:** Greater Caucasus has high endemism. This area is considered one of the important speciation centers. As a result of study 103 plant species belonging to two classes, 31 families and 72 genera were described in the alpine landscapes of the flora of the surrounding areas of Shahdag (eastern part of the Greater Caucasus). Based on the recorded species, the families of Asteraceae (15), Caryophyllaceae (8), Fabaceae (7), Boraginaceae (7), Ranunculaceae (6) are the dominant. Five families found in the area (Caprifoliaceae, Apocynaceae, Amaranthaceae, Geraniaceae, Orobanchaceae, Valerianaceae) are represented by single species. Among them, *Vincetoxicum rehmannii* Boiss. is a subendemic to the north and south Caucasus and *Erodium fumarioides* Steven is distributed only in the south Caucasus. The local flora has a high (60%) endemism. Out of 103 species distributed here, 42 are wide range, the remaining 61 species are endemic of different status. From those, 24 could be characterized as macroendemic (regional endemic) species and are distributed in the Caucasus, Iran and Turkey, and 35 species endemic to the Caucasus, one species to the south Caucasus (*Erodium fumarioides* Steven), and one species to Azerbaijan (*Astragalus kubensis* Gross.). The southern slopes of the Eastern Caucasus are still not fully explored.

**Keywords:** biodiversity, distribution, geobotanical studies, plant, species

### INTRODUCTION

The alpine landscapes of the eastern part of the Greater Caucasus in Azerbaijan are characterized by high biological diversity and endemism [Hajiyev, 2004, Askerov, 2014, Ibadullayeva et al., 2014, Ibadullayeva, Huseynova, 2021, Ibadullayeva, Yusifov 2022, Yusifov, 2022].

The relatively small number of species in the high mountainous areas and the harshness of the climatic conditions make it easier to study the regularity of interaction between biocoenoses. The lack of biotic and abiotic components makes it possible to study the influence of climatic factors on plant formation. On the other hand, the flora diversity of these areas is still not fully and systematically studied.

The flora and endemism of the northern slopes of the Greater Caucasus have been widely studied [Murtazaliev, 2012; Astamirova et al., 2020; Musa Taysumov et al., 2017]. The flora of the southern slopes of the western and central part of the Greater Caucasus is also studied [Nakhutsrishvili et al., 2022]. The geobotanical studies conducted in the south of the eastern part of the Greater Caucasus are fragmentary in nature. From this point of view, the complex study of the mentioned area is of interest. The purpose of this study was to analyse the flora, dominant species, ecology and endemism of the Shahdag mountain.

### MATERIAL AND METHODS

According to the generally accepted methods, plant specimens were collected, identified [Flora..., 1953] and correctness of Latin names were checked on WFO [2023].

The studied areas include Shahdag, Tufandag and Bazaryurd mountains, areas between Khinalig (Guba) and Laza (Gusar) villages, Shahyaylag, Yatygchay valley, surrounding areas near the source of Shahnabat river. In the Azerbaijani borders of the Greater Caucasus, the alpine zone covers heights of 2500 and 3000-3200m, sometimes 3500 m, depending on the position of the slopes [Ibadullayeva, 2021].

The climate of this zone is characterized by short and humid summers and long cold and snowy winters. The materials were collected in the early spring (May) and late summer (August) periods during 2019-2022. Researches were conducted in the Shahdag district of the eastern part of the Greater Caucasus, and herbarium materials were collected. To clarify the endemism of the species floras of the neighbouring countries were considered.

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## RESULTS AND DISCUSSION

The study area presents grassy mountain-meadow, primitive and peaty mountain-meadow, bare rocks, exposed clayey rocks [National Atlas, 2014].

The taxonomic structure and comparative indicators of the background species of the flora diversity found in the alpine landscapes of the area is presented in Table 1. The predominant families of the plant diversity of the area and their characteristic indicators is given in Table 2. Plant diversity of the area is rich and belongs to 75 genera found in the area, six genera are represented by three or more species, which is 8% of the genus diversity in the belt. As can be seen from the table, the richest genera – *Campanula* L. (*Campanulaceae*), *Silene* L. (*Caryophyllaceae*) and *Astragalus* L. (*Fabaceae*) are represented by four species each.

However, five sensitive families represented by one species. These are *Caprifoliaceae* (*Scabiosa caucasica* M. Bieb.), *Apocynaceae* (*Vincetoxicum rehmannii* Boiss.), *Amaranthaceae* (*Chenopodium foliosum* Asch.), *Geraniaceae* (*Geranium gymnocaulon* DC), *Orobanchaceae* (*Euphrasia amblyodonta* Juz), *Brassicaceae* (*Cardamine uliginosa* M. Bieb.). The area

is rich in endemic species (Fig. 1).

Shahyaylag situated at an altitude of 3200 m a.s.l., in the upper part of the alpine belt covered by alpine carpet in a large territory. The structure of the plant growing area in Girkhbulag is gravelly and watterich (Fig. 2 a, b). The main species of carpet are *Cardamine uliginosa* M. Bieb., *Taraxacum stevenii* (Spreng.) DC., *Cerastium multiflorum* C.A. Mey. and *Phleum alpinum* L.

Ecotones of the alpine landscapes transit into the subnival landscape, at an altitudes of 2800-3100 m a.s.l. which is dominated by the mountain-tundra climate type, tundra-type plant formations with the participation of the species *Epilobium anagallidifolium* Lam. and *Cirsium macrocephalum* C.A. May (Fig. 2 c, d).

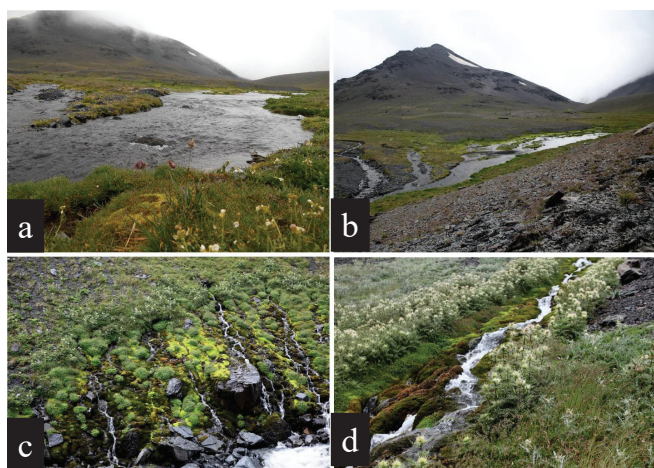
*Endemism of area vegetation.* Of the 103 background species found in the area, 42 are species with wide-range, and 61 species are endemic of different status distributed within the Caucasus Ecoregion. Among them, one species (*Astragalus kubensis* Gross.) is endemic to Azerbaijan, one species (*Erodium fumarioides* Steven) is endemic to the South Caucasus, and 36 species are endemic to the Caucasus. As a result of the analysis, 61 endemic species belonging to the Magnoliopsida class

**Table 1.** Comparative quantitative analysis of the plant diversity of alpine landscapes with the diversity of the flora of country.

№	Class	Families		Genera		Species	
		№ of species alpine /flora	%	№ of species alpine/flora	%	№ of species alpine/flora	%
1.	Liliopsida	3/25	12	6/213	3	7/956	0.7
2.	Magnoliopsida	28/95	29	68/771	1	108/3348	3.2
	Total:	31/120	26	75/1015	7	103/4378	2.3

**Table 2.** Taxonomic structure of the predominant families of the alpine landscapes of the surrounding areas of Shahdag Mountain.

Liliopsida families (genera: species)	<i>Poaceae</i> (4:6), <i>Cyperaceae</i> (1:1), <i>Amaryllidaceae</i> (1:2)
Magnoliopsida families (genera: species)	<i>Asteraceae</i> (8:15), <i>Caryophyllaceae</i> (4:8), <i>Fabaceae</i> (4:7), <i>Boraginaceae</i> (4:7), <i>Ranunculaceae</i> (4:6), <i>Lamiaceae</i> (5:5), <i>Rosaceae</i> (3:5), <i>Apiaceae</i> (3:4), <i>Campanulaceae</i> (1:3), <i>Crassulaceae</i> (2:3), <i>Polygonaceae</i> (2:3), <i>Plantaginaceae</i> (1:3), <i>Brassicaceae</i> (2:2), <i>Primulaceae</i> (1:2), <i>Gentianaceae</i> (2:2), <i>Saxifragaceae</i> (1:2), <i>Scrophulariaceae</i> (2:2), <i>Rubiaceae</i> (2:2), <i>Onagraceae</i> (1:2), <i>Geraniaceae</i> (2:2), <i>Brassicaceae</i> (1:2), <i>Apocynaceae</i> (1:1), <i>Orobanchaceae</i> (1:1), <i>Amaranthaceae</i> (1:1), <i>Caprifoliaceae</i> (1:1), <i>Tamaricaceae</i> (1:1), <i>Urticaceae</i> (1:1), <i>Violaceae</i> (1:1)
Total:	31 families, 68 genera, 103 species



**Figure 1.** Characteristic landscapes of alpine carpet (a, b) and tundra-type vegetation (c, d) found in the area.

were identified for the area. This is 60% of the total number of background species found in the area. Such a high value of endemism is an indicator of the originality of the local flora. Table 3 shows the taxonomic structure of endemic species of different status found in the area.

The distribution of species in the area varies depending on the altitude and terrain. *Cerastium multiflorum* C.A. Mey., *Dianthus vladimirii* Galushko., *Silene caucasica* (Bunge) Boiss., *S. humilis* C.A. Mey., *S. lacera* Steven. syn. *Oberna lacera* (Steven) Ikonn, *Nonea daghestanica* Kusn., *Vincetoxicum rehmannii* Boiss., *Sempervivum caasicum* Rupr. Ex Boiss, *Dracocephalum botryoides* Boiss. and other species of plants are mainly distributed in humid places of the subalpine belt and alpine meadows at altitudes of 1800-2500 m a.s.l., along river banks.

*Anthemis sosnovskyana* Fed. syn. *A. marschalliana* ssp. *sosnovskyana* (Fed.) Grierson, *A. caucasica* Chanjian. (Syn.: *Archanthemis marschalliana* subsp. *pectinata*, *Senecio taraxacifolius* (M. Bieb.) DC. (Syn.: *Turanecio taraxacifolius* (M. Bieb.) Hamzaoğlu), *Taraxacum stevenii* (Spreng.) DC., *Cynoglossum holosericeum* Steven., *Nonea alpestris* (Steven) G. Don, *N. versicolor* (Steven) Sweet, *Trigonocaryum involucreatum* (Steven) Medw., *Campanula collina* Sims., *Scabiosa caucasica* M. Bieb. syn. *Lomelosia caucasica* (M. Bieb.) Greuter & Burdet, species of plants spread up to 3000-3200 m a.s.l. altitude.

Species such as *Chamaescidium acaule* (M. Bieb) Boiss, *Sympholoma graveolens* C.A. Mey., *Cirsium obvallatum* M. Bieb., *C. macrocephalum* C.A. Mey,

*Senecio sosnowskyi* (Syn.: *S. leucanthemifolius* subsp. *caucusus* (DC.) Greuter, *Pseudovesicaria digitata* (C.A. Mey.) Rupr spread up to 3500-4000 m altitude. Species such as *Dracocephalum botryoides* Boiss, *Nepeta supine* Steven, *N. daghestanica* Kusn. (Caucasian endemic), *Delphinium caasicum* C.A. Mey. (Caucasian endemic), *Ranunculus arachnoideus* C.A. Mey., *Alchemilla sericea* Willd, *Scrophularia minima* M. Bieb (Caucasian endemic), *Viola somchetica* K. Koch., *Primula ruprechtii* Omelcz. (Caucasian endemic) are spread mainly on stony gravelly and rocky slopes and avalanches.

The characteristic indicators of the dominant families of the endemism of the alpine landscapes of the area are Apiaceae, Lamiaceae, Asteraceae, Boraginaceae, Caryophyllaceae, Campanulaceae families. The predominant genera of the area include *Cirsium* (Asteraceae, 3 species), *Campanula* (Campanulaceae,



**Figure 2.** A. Caucasian endemics: a. *Angelica sachokiana* (Karjagin) Pimenov & V.N. Tikhom; b. *Anthemis sosnovskyana* Fed. B. Subendemic species of Azerbaijan: c. *Nonea alpestris* (Steven) G. Don; d. *Taraxacum stevenii* (Spreng.) DC. Native to North Caucasus and South Caucasus. C. Rare species of the area: e. *Vavilovia formosa* (Steven) Fed. f. *Pseudovesicaria digitata* (C.A. Mey.) Rupr.

**Table 3.** Endemic species of different status found in the area.

Endemism	Species
North and South Caucasus	<i>Angelica sachokiana</i> (Karjagin) Pimenov & V.N. Tikhom., <i>Astrantia trifida</i> Hoffm., <i>Sympholoma graveolens</i> C.A. Mey, <i>Vincetoxicum rehmannii</i> Boiss., <i>Achillea ptarmicifolia</i> (Willd.) Rupr. ex Heimerl, <i>Anthemis sosnovskyana</i> Fed., <i>C. macrocephalum</i> C.A. Mey, <i>S. sosnowskyi</i> syn. <i>S. leucanthemifolius</i> subsp. <i>caucasus</i> (DC.) Greuter, <i>Taraxacum stevenii</i> (Spreng.) DC, <i>Myosotis schistose</i> A.P. Khokhr., <i>Nonea alpestris</i> (Steven) G. Don, <i>N. daghestanica</i> Kusn., <i>Trigonocaryum involucreatum</i> (Steven) Medw., <i>Pseudovesicaria digitata</i> (C.A. Mey.) Rupr, <i>Campanula ciliate</i> Steven., <i>C. petrophila</i> Rupr., <i>Cerastium multiflorum</i> C.A. Mey., <i>Dianthus vladimirii</i> Galushko., <i>Silene humilis</i> C.A. Mey., <i>S. lacera</i> Steven. syn. <i>Oberna lacera</i> (Steven) Ikonn, <i>Sedum stevenianum</i> Rouy & E.G. Camus, <i>Sempervivum caucasicum</i> Rupr. Ex Boiss, <i>Astragalus beckerianus</i> Trautv., <i>Betonica nivea</i> Steven, <i>Veronica petraea</i> Steven, <i>V. caucasica</i> M. Bieb, <i>Calamagrostis caucasica</i> Trin., <i>Delphinium caucasicum</i> C.A. Mey., <i>Pulsatilla albana</i> Bercht. & J. Presl, <i>Ranunculus arachnoideus</i> C.A. Mey., <i>Sibbaldia semiglabra</i> , <i>Rhinanthus subulatus</i> (Chabert) Soó, <i>Scrophularia minima</i> M. Bieb, <i>Scilla armena</i> Grossh., <i>Primula ruprechtii</i> Omelcz.
Caucasus, Turkey, Iran	<i>Chamaescidium acaule</i> (M. Bieb) Boiss., <i>C. obvallatum</i> M. Bieb., <i>Scabiosa caucasica</i> M. Bieb, <i>Vicia alpestris</i> Steven., <i>Alchemilla sericea</i> Willd., <i>Astragalus incertus</i> Ledeb.
Caucasus, Turkey	<i>Anthemis caucasica</i> Chanjian., <i>Erigeron caucasicus</i> Steven., <i>Senecio taraxacifolius</i> (M. Bieb.) DC., <i>Cynoglossum holosericeum</i> Steven., <i>Nonea versicolor</i> (Steven) Sweet, <i>C. collina</i> Sims., <i>Silene caucasica</i> (Bunge) Boiss., <i>Geranium gymnocaulon</i> DC, <i>Dracocephalum botryoides</i> Boiss., <i>Nepeta supine</i> Steven., <i>Thymus caucasicus</i> Willd. ex Benth., <i>Euphrasia amblyodonta</i> Juz, <i>Veronica minuta</i> C.A. Mey., <i>Bistorta carnea</i> Kom., <i>Corydalis alpestris</i> C.A. Mey, <i>Alchemilla caucasica</i> Buser., <i>Potentilla ruprechtii</i> Boiss.
Caucasus, Iran	<i>Viola somchetica</i> K. Koch.
South Caucasus	<i>Erodium fumarioides</i> Steven
Azerbaijan	<i>Astragalus kubensis</i> Gross.

4), *Silene* (Caryophyllaceae, 4), *Astragalus* (Fabaceae, 4), *Nonea* (Boraginaceae, 3), *Veronica* (Plantaginaceae, 3). Wide range vegetation, mainly belong to Asteraceae (6), Poaceae (4), Fabaceae (3), Caryophyllaceae (3), Boraginaceae (2), Lamiaceae (1), Rosaceae (1), Cyperaceae (1), Primulaceae (1), etc.

Taxonomic composition of stenoendemic and subendemic species found in the alpine landscapes of the surrounding areas of Shahdag includes 33 species from 17 families. These are represented by Poaceae (*Calamagrostis caucasica* Trin.), Amaryllidaceae (*Allium pseudostrictum* Albov., *Scilla armena* Grossh.), Apiaceae (*Angelica sachokiana* (Karjagin) Pimenov & V.N. Tikhom, *Astrantia trifida*, *Sympholoma graveolens* C.A. Mey), Apocynaceae (*Vincetoxicum rehmannii* Boiss.), Asteraceae (*Achillea ptarmicifolia* (Willd.) Rupr. ex Heimerl, *Anthemis sosnovskyana* Fed., *Cirsium macrocephalum* C.A. Mey, *Senecio*

*sosnowskyi* Sofieva, *Taraxacum stevenii* (Spreng.) DC.), Boraginaceae (*Myosotis schistose* A.P. Khokhr., *Nonea alpestris* (Steven) G. Don., *N. daghestanica* Kusn., *Trigonocaryum involucreatum* (Steven) Medw.), Brassicaceae (*Pseudovesicaria digitata* (C.A. Mey.) Rupr.), Campanulaceae (*Campanula ciliate* Steven., *C. petrophila* Rupr.), Caryophyllaceae (*Cerastium multiflorum* C.A. Mey., *Dianthus vladimirii* Galushko., *Silene humilis* C.A. Mey., *S. lacera* Steven.), Crassulaceae (*Sedum stevenianum* Rouy & E.G. Camus., *Sempervivum caucasicum* Rupr. ex Boiss), Fabaceae (*Astragalus beckerianus* Trautv., *A. kubensis* Gross.), Geraniaceae (*Erodium fumarioides* Steven), Lamiaceae (*Betonica nivea* Steven), Ranunculaceae (*Delphinium caucasicum* C.A. Mey., *Pulsatilla albana* (Steven) Bercht. & J. Presl., *Ranunculus arachnoideus* C.A. Mey., *R. oreophilus*), Primulaceae (*Primula ruprechtii* Kusnez.), Rosaceae (*Potentilla ruprechtii* Boiss.,

*Sibbaldia semiglabra* C.A. Mey.), Scrophulariaceae (*Rhinanthus subulatus* (Chabert) Soó, *Scrophularia minima* M. Bieb).

The flowering period of the species such as *Achillea nobilis* L., *Myosotis alpestris* F.W. Schmidt, *Chenopodium foliosum* Asch., *Dracocephalum botryoides* Boiss., *Urtica dioica* L., *Caltha polypetala* Hochst., *Cruciata glabra* (L.) Ehrend. (*Galium verum* Scop.) occurs in April and May. The fruiting phase of most species was observed in April-May. But some species (*Scrophularia minima* M. Bieb, *Saxifraga hirculus* L., *Epilobium algidum* M. Bieb., *Delphinium caucasicum* C.A. Mey., *Thymus caucasicus*, *Cardamine uliginosa*, *Senecio taraxacifolius* (M. Bieb.) DC. bear fruit in August and September.

The vast majority of species found in the local flora are perennial species. These species *Anthemis sosnovskyana* Fed., *S. sosnowskyi*, *Trigonocaryum involucreatum* (Steven) Medw., *Nonea versicolor* (Steven) Sweet, *Lomatogonium carinthiacum* A. Braun., *Euphrasia amblyodonta* Juz. are perennials. *Pseudovesicaria digitata* (C.A. May.) Rupr. is biennial plant found in the area.

Some plants in the study area possess useful features, of them *Achillea ptarmicifolia* (Willd.) Rupr. ex Heimerl, *A. nobilis* L., *Anthemis sosnovskyana* Fed., *Cruciata glabra* (L.) Ehrend. are medicinal importance, some of them used for food *Vicia alpestris* Steven - fodder, (*Urtica dioica* L., *Rumex alpinus* L.) - for dyeing, (*Chenopodium foliosum* Asch., *Cruciata glabra* (L.) Ehrend.) - and for decorative, (*Anthemis sosnovskyana* Fed., *Betonica nivea* Steven, *Sempervivum caucasicum* Rupr. Ex Boiss).

## CONCLUSION

As a result of the research, it was determined that alpine-subalpine landscapes have a very high endemism compared to low landscapes from a hypsometric point of view. There are several reasons for this. The most important reason is the high frequency of mutations due to high solar radiation at the top. We believe that the advantage of stony and gravelly landscapes is one of the abiotic mutagenic factors. The sparseness of populations and the diversity of the landscape create favorable conditions for the preservation of these mutations. Radicality of climatic conditions and diversity of relief create different microclimate habitats. In our opinion, the primitive-peat soils that prevail in the area also have a certain role here.

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### Şahdağın ətraf ərazilərinin alp landşaftlarının florasının dominant növləri, onların ekoloji təhlili və endemizmi

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Tədqiqat nəticəsində Şahdağın (Böyük Qafqazın şərq hissəsi) ətraf ərazilərinin florasının alp landşaftlarında 2 sinif, 31 fəsilə və 72 cinsə aid 103 bitki növü təsvir edilmişdir. Qeydə alınmış növlərə əsasən Asteraceae (15), Caryophyllaceae (8), Fabaceae (7), Boraginaceae (7), Ranunculaceae (6) fəsilələri üstünlük təşkil edir. Ərazidə rast gəlinən beş fəsilə (Caprifoliaceae, Apocynaceae, Amaranthaceae, Geraniaceae, Orobanchaceae, Valerianaceae) tək növlə təmsil olunur. Onların arasında *Vincetoxicum rehmannii* Boiss. Şimali və Cənubi Qafqaz üçün subendemikdir və *Erodium fumarioides* Steven yalnız Cənubi Qafqazda yayılmışdır. Yerli flora yüksək (60%) endemizmə malikdir. Burada yayılmış 103 növdən 42-si geniş areala malikdir, qalan 61 növ isə müxtəlif statuslu endemiklərdir. Bunlardan 24-ü makroendemik növ kimi xarakterizə oluna bilər və Qafqazda, İranda və Türkiyədə yayılmışdır, 35 növ Qafqaz, bir növ Cənubi Qafqaz (*Erodium fumarioides*

Steven) və bir növ Azərbaycan (*Astragalus kubensis* Gross.) üçün endemikdir.

**Açar sözlər:** biomüxtəliflik, yayılma, geobotaniki tədqiqatlar, bitki, növ

### Доминирующие виды флоры альпийских ландшафтов окрестностей горы Шахдаг, их экологический анализ и эндемизм

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В результате изучения флоры в альпийских ландшафтах окрестностей Шахдага (восточная часть Большого Кавказа) описано 103 вида растений, относящихся к 2 классам, 31 семейству и 72 родам. Среди зарегистрированных видов доминируют представители семейств Asteraceae (15), Caryophyllaceae (8), Fabaceae (7), Boraginaceae (7), Ranunculaceae (6). Пять семейств, встречающихся на обследуемой территории (Caprifoliaceae, Apocynaceae, Amaranthaceae, Geraniaceae, Orobanchaceae, Valerianaceae), представлены единичными видами. Среди них *Vincetoxicum rehmannii* Boiss. является субэндемиком Северного и Южного Кавказа, а *Erodium fumarioides* Steven распространен только на Южном Кавказе. Местная флора отличается высоким (60%) эндемизмом. Из 103 распространенных здесь видов 42 имеют широкий ареал, остальные 61 вид – эндемики с различным статусом. Из них 24 вида могут быть охарактеризованы как макроэндемичные виды, распространенные на Кавказе, в Иране и Турции, 35 видов являются эндемичными для Кавказа, один вид для Южного Кавказа (*Erodium fumarioides* Steven) и один вид (*Astragalus kubensis* Gross.) для Азербайджана.

**Ключевые слова:** биоразнообразие, распространение, геоботанические исследования, растение, вид