

POPULATION STATUS OF THE RARE SPECIES OF THE MUD VOLCANOES IN THE GREATER CAUCASUS

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The article describes four populations (Pop) of the rare species (*Tulipa biflora* Pall., *Ophrys apifera* Huds., *Rosa azerbaijdzhanica* Novopokr. & Rzazade, *Pyrus salicifolia* Pall.) found on mud volcanoes in the Greater Caucasus. Studying the flora of two volcanoes it has established that in the local flora of the Gyzmeidan mud volcano, were recorded 46 species belonging to 45 genera and 21 families, and in the Toragay mud volcano 23 species belonging 22 genera and 12 families. The types, density, ontogenetic condition state and demographic structure of populations have been determined. According to the spatial and demographic indicators of rare species populations has been determined that the highest average density and number of individuals of all ontogenetic states were noted in Pop 1 and the lowest in Pop 2. According to the indices Δ and ω , only Pop 4 is transitional, and the remaining populations are assigned as young type.

Key words: rare species, mud volcanoes, population, ontogenetic structure, The Greater Caucasus, demographic structure

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Introduction

Nowadays, there is an acute issue of preserving endangered species and reducing biodiversity in general. At the same time, long-term thought-out and well-grounded monitoring should be the basis of any nature conservation activity in the field of flora, associated with the collection of the necessary information regarding the general morphological state of plants, as well as their life stages. In that in terms of plant conservation, the main goal of it is to maintain viable populations of species in the long term and prevent their extinction at the local, regional or global levels (Akatov et al., 2021; Bogoslov et al., 2021; Egorova, Suleimanova, 2021; Kirillova, Kirillov, 2021; Mursal, Mehdiyeva, 2021).

Azerbaijan is located in the south-eastern part of the Caucasus region. It is bordered by Georgia and Russia (Dagestan) in the north, the Caspian Sea in the east, Iran in the south, and Armenia in the west. Azerbaijan demonstrates an extremely diverse native flora. The diversity of the Azerbaijan flora and its high endemism are due to the variable physical geography and the past geological complexity.

There are about 4500 species of vascular plants in Azerbaijan flora that represent 64% of the total species known for the Caucasus region. No less than 10% of the species are considered as rare or endangered and are subject to protection. Representatives of 125 plant families grow in Azerbaijan, or 80% of the 156 family total for the Caucasus

region; 930 genera are represented in Azerbaijan, or 72.3% of the 1286 total genera in the Caucasus. Total national endemics in Azerbaijan flora are represented 200 species, 950 species are Caucasian region endemics (Red list of the endemic plants of the Caucasus, 2014).

Studies on the flora and vegetation of the volcano have not been conducted in Azerbaijan before. Preliminary research in this area has been conducted since 2016. As a result of the study of flora and vegetation of the mud volcano in the territory of Gobustan, it was determined that the territory is dominated mainly by semi-desert vegetation and there are 30 plant species belonging 29 genera from 14 families. The surface of the mud field is inhabited by the most tolerant pioneer species *Halocnemum strobilaceum* (Pall.) Bieb., Which acts as the dominant of the cenosis, together with *Kalidium capsicum* (L.) Ung.-Sternb. and *Suaeda microphylla* Pall. forms an association. In such areas have been registered associations *Poa bulbosa* + *Calendula persica* + *Erodium cicutarium*, *Agropyrom cristatum* + *Sisymbrium runcinatum* + *Adonis aestivalis*, *Artemisia caucasica* + *Carthamus oxyacantha* and *Salsola nodulosa* + *Anthemis candidissima* (Isayeva & Mehdiyeva, 2017).

Thus, the study of flora and vegetation in Pirekyashkyul showed that the flora of the this mud volcano contains 18 species of vascular plants, from 7 families and 16 genera. The largest number of species is represented by the families Chenopodiaceae and Asteraceae (6 and 5 species, respectively). The poor flora composition could be explained by the activity of the mud volcano and difficult environmental conditions (Isayeva, 2019).

However, despite the geological and geographical studies of the mud volcano Toragay and Shamakhi regions, its vegetation cover and rare species has not yet been studied. In this regard, the aim of the investigation was to study the flora, as well as rare plant cenopopulations of the mud volcanoes of those regions.

Material and Methods

The field investigations were carried in 2016–2020 in Gobustan and Shamakhi districts of the Greater Caucasus using population-based and geobotanical methods (Fig. 1).

The characteristics of research areas. The Toragay volcano is situated 15 km west of Sangachal railway station in Gobustan districts. It is a large volcano with a numerous radially divergent gorges and ravines. It has a relative height of 280 m. Southern and eastern slopes are steep. Its crater, 500–550 m in diameter, is bordered with 8 m high bank and is broken from the west side by mud volcanic breccia flow, 1 km long and 250–300 m wide. The volcano base size is 3.8 by 2.9 km. Mud volcanic sheet area come to 754 ha, the breccia average thickness is 100 m. The volcano is confined to the zone of intersection of longitudinal and latitudinal rupal breaks in the northeastern near axial part of the Toragay fold composed of the Pliocene sediments (Abbasov et al., 2015) (Fig. 2A).

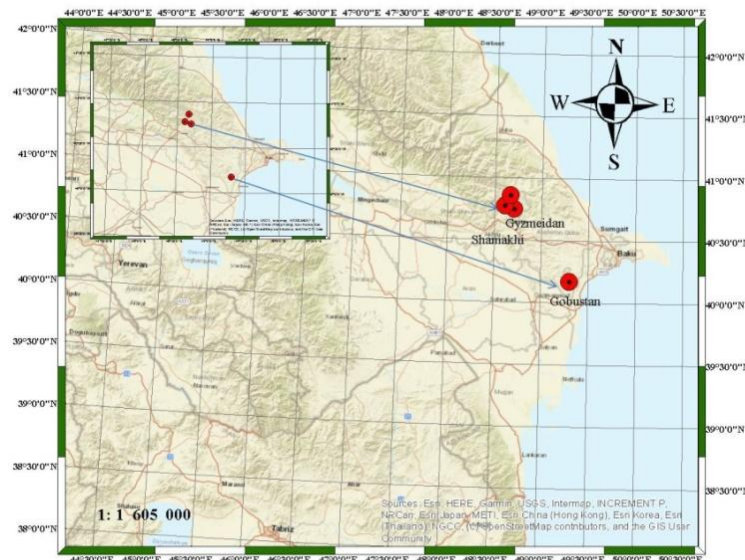


Fig. 1. The map of rare species locations studied in the mud volcanoes in the Greater Caucasus.

The Gyzmeidan volcano is placed 4–5 km northwest of the same name village in Shamakhi district. It is a slightly convex mud volcanic field reaching 1 km in diameter and look like a hummock, 20 m in relative height, dissected by gorges and scours. It is located upon the upper Cretaceous (lower Campanian-Santonian) sediments and confined to the northern slope of the same name anticline complicated by the two longitudinal thrust-type dislocations. Mud volcanic breccia area reaches 345 ha by the average thickness of 25 m (Abbasov et al., 2015) (Fig. 2B).

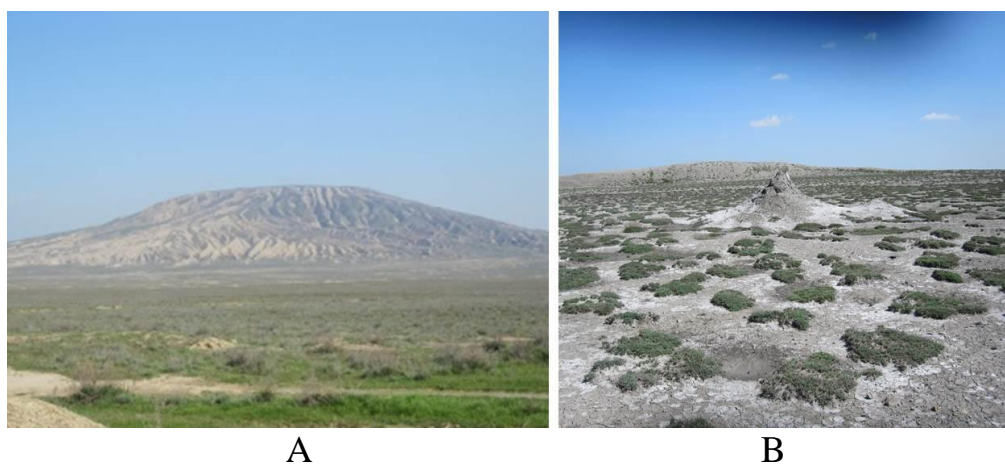


Fig. 2. Toragay (A) and Gyzmeidan (B) volcanoes.

The objects of research. The object of research is 4 taxa belonging to 3 families (Orchidaceae Juss., Rosaceae Juss., Liliaceae Hall.) and 4 genera (*Ophrys* L., *Rosa* L., *Tulipa* L., *Pyrus* L.) included in the 2nd edition of the Red Book of Azerbaijan (2013): *Ophrys apifera* Huds., *Pyrus salicifolia* Pall., *Rosa azerbaijdzhanica* Novopokr. & Rzazade, *Tulipa biflora* Pall. (Fig. 3).

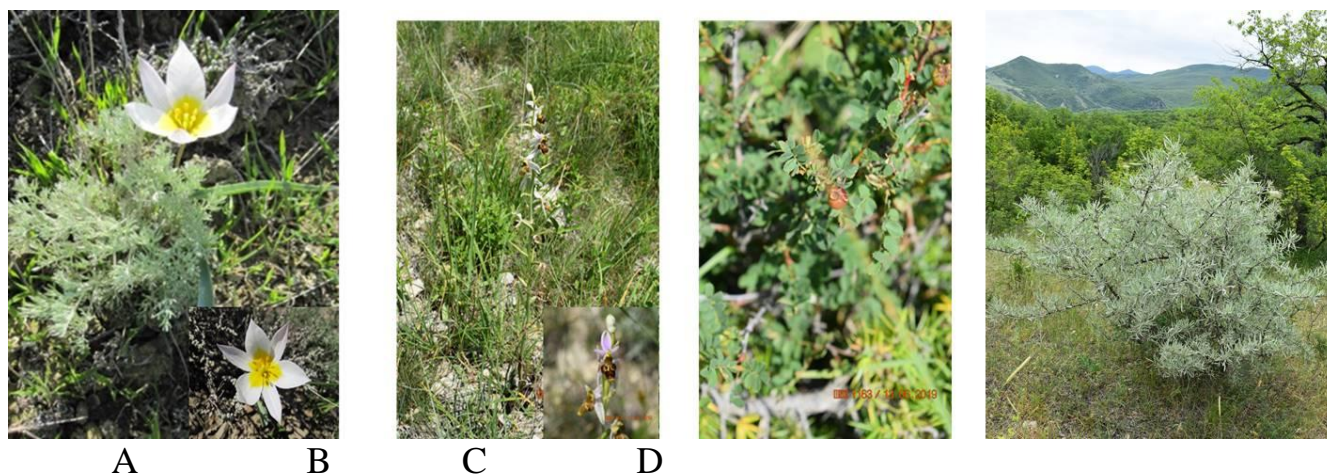


Fig. 3. Rare species found in volcanic areas A – *Tulipa biflora* Pall., B – *Ophrys apifera* Huds., C – *Rosa azerbaijdzhanica* Novopokr. & Rzazade, D – *Pyrus salicifolia* Pall.

The methods of research. The portrayal of plant communities accomplished concurring to Ipatov & Kirikova (1998) and Mirkin et al. (2001). The ontogenesis and demographic structure of populations have been studied according to Uranov (1975), Zaugolnova & Zhukova (1988), Zhukova (1995), Ishbirdin et al. (2005), Ishkinina & Ishmuratova (2007). Since the objects of research are rare species, the study of its ontogenesis was investigated out with a minimal number of individuals (10 individual per age class), photos were taken of different ontogenetic classes. We distinguished four periods (latent, pregenerative, generative and postgenerative) and eight age classes (juvenile (j), immature (im), virginile (mature vegetative) (v), young generative (g1), mature generative (g2), old generative (g3), subsenile (ss), senile (s).

To identify the main demographic parameters of populations, we studied the ontogenetic structure. To investigate the abundance and the ontogenetic structure of rare plants populations, we established 10–15 study plots (1 m²) arranged within 5–10 transects (10 m²) per each study site. To determine the age structure of each population in these locations, we measured the total number of individuals and the number of individuals of each age class. The population type was determined according to Zhivotovsky (2001) classification of normal populations «delta–omega» ($\Delta - \omega$).

New taxonomic status of species is given based on the Euro + Med PlantBase (2006–) nomenclature website. All statistical analyzes were performed in PAST 3.15 (Hammer et al., 2001) and Microsoft Excel 2010. The distribution maps of the research objects were conducted in ArcGIS 10.5 program.

Results and Discussion

In the local flora of the Gyzmeidan mud volcano, 46 species of higher tubular plants belonging to 45 genera of 21 families were recorded. 3 of them are rare, 27 species are useful (medicinal, dye, food, technical, etc.) plants. The most common species are Compositae Giseke (9 species – 19.6%), Rosaceae (7 species – 15%) and Poaceae Barnhart (5 species – 11%). In the local flora of Toragay mud volcano, 23 plant

species belonging to 12 families and 22 genera were registered. Of these, 1 species is rare and 11 species are medicinal plants (Fig. 4).

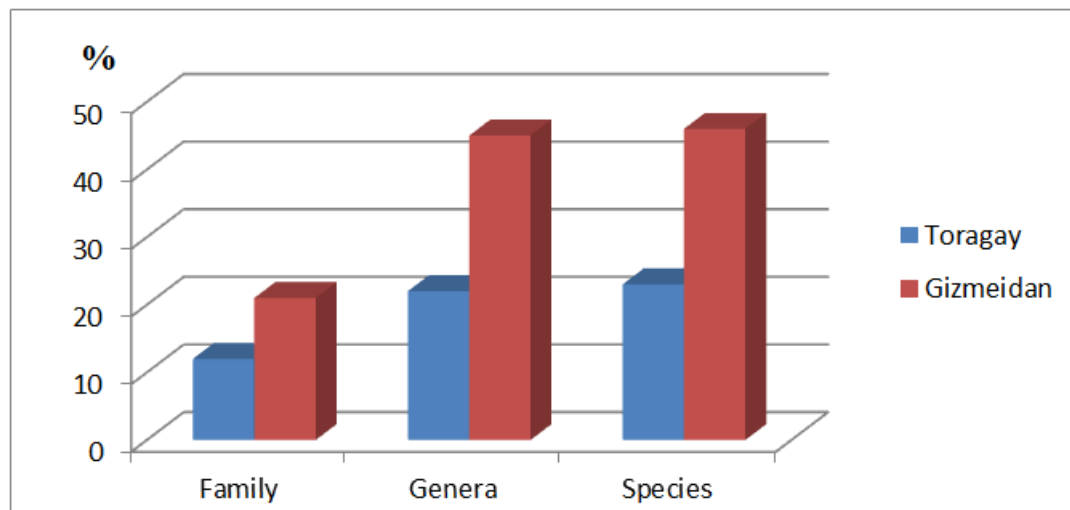


Fig. 4. Flora composition of Gyzmeidan and Toragay volcanoes.

Pop 1 – The population of *Ophrys apifera* Huds. is found in Gyzmeidan village of Shamakhi region in the territory of a soil volcano at an altitude of 1371 m (Mursal, 2020). The soil is gray and dry. The slope exposure is 30 degrees. The projective cover of grass is 80%. The height of the grass is 50–60 cm. The number of plant individuals in 1 m² area is 2–3. Along with this plant in the cenosis, *Plantago lanceolata* L., *Archanthemis fruticulosa* (M. Bieb.) Lo Presti & Oberpr., *Bromus japonicus* Thunb., *Xeranthemum cylindraceum* Sm., *Euphorbia boissieriana* (Woronow) Prokh., *Lolium rigidum* Gaudin, *Filago arvensis* L., *Teucrium polium* L., *Linum corymbulosum* Rchb., *Potentilla pedata* Willd. species have been recorded.

Pop 2 – The population of *Pyrus salicifolia* Pall. is registered in the territory of the soil volcano in Gyzmeidan village of Shamakhi region. The number of plant individuals in 1 m² area is 1–2. *Tragopogon graminifolius* Dc., *Inula aspera* Poir., *Achillea millefolium* L., *Rapistrum rugosum* (L.) All., *Arabis hirsuta* (L.) , *Astragalus bungeanus* Boiss., *Hedysarum sericeum* M.Bieb., *Briza media* L. are registered in the cenosis.

Pop 3 – *Rosa azerbaijdzhanica* Novopokr. & Rzazade population was also found in the area of the same soil volcano in Gyzmeidan village of Shamakhi region. The number of plant individuals in 1 m² area is 1–2. *Filago arvensis* L., *Artemisia alpina* Willd., *Dactylis glomerata* L., *Stipa pulcherium* K.Koch, *Thalictrum simplex* L., *Lappula barbata* (M.Bieb.) Gürke, *Anacamptis pyramidalis* (L.) Rich., *Sanguisorba officinalis* L., *Hypericum linarioides* Bosse species were also present in the cenosis.

Pop 4 – The population of *Tulipa biflora* Pall. is investigated in Gobustan region in the area of Toragay volcano located at an altitude of 332 m a.s.l. The projective cover

of the grass was 90%. The height of the grass reached 60–70 cm. The number of individual plants per 1 m² is 3–5. Here, individuals of the *Tulipa biflora* were grouped at a distance of 60–70 cm from each other. Along with this plant, *Anthemis candidissima* Spreng., *Artemisia fragrans* Willd., *Podospermum laciniatum* (L.) DC., *Calendula arvensis* (Vaill.) L., *Medicago minima* (L.) L., *Poa bulbosa* L., *Adonis aestivalis* L., *Gagea chlorantha* (M. Bieb.) Schult. & Schult. f. species were also present.

Ontogenetic structure

In the study area, the ontogenetic structures of investigated rare species show that almost all populations are normal. However, Pop 2, Pop 3, Pop 4 are incomplete due to the absence of subsenile individuals. We found the highest number of juvenile individuals in Pop 4, immature and virginile individuals in Pop 1, young generative individuals in Pop 2, mature generative, old generative, subsenile and senile individuals in Pop 1. In the four studied populations, the highest number of pregenerative and post-generative individuals was noted in Pop 1. The highest proportion of generative individuals was observed in Pop 4, the lowest proportion in Pop 1. The maximal values of individuals in postgenerative age class were detected in Pop 1, while they were absent in Pop 2 (Fig. 5).

Spatial and demographic indicators of rare species populations are presented in Table. The highest average density and abundance of individuals of all ontogenetic states were noted in Pop 1 and the lowest in Pop 2. The highest density of pregenerative individuals, generative and postgenerative individuals was observed in Pop 1.

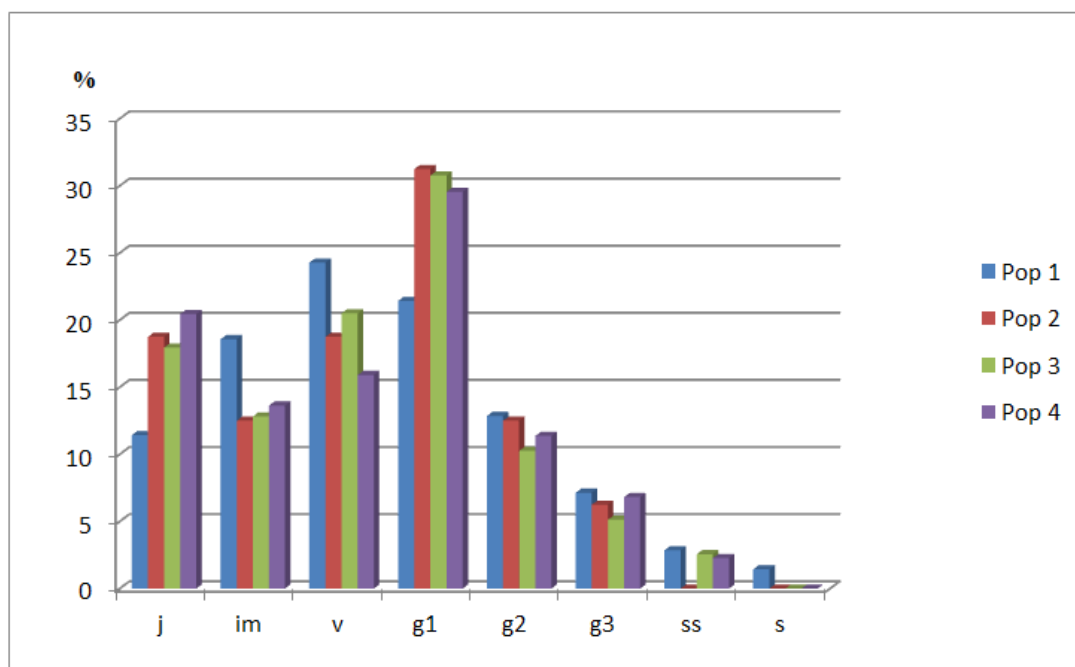


Fig. 5. Ontogenetic spectrum of rare species populations of the mud volcanoes in the Greater Caucasus (Azerbaijan) (X – axis – population, Y– axis – individual fraction in percentage %).

Table. Spatial and demographic parameters of rare species populations of the mud volcanoes in the Greater Caucasus (Azerbaijan)

Pop	n	X _a	X _{pre}	X _g	X _{post}	I _r	I _a	I _{rep}	Δ	ω	Type
Pop 1	70	4.67	2.53	1.93	0.2	1.310	0.043	1.187	0.284	0.512	Young
Pop 2	16	2	2	1	0	1	0	1	0.272	0.534	Young
Pop 3	39	2.6	1.33	1.2	0.06	1.11	0.026	1.052	0.274	0.517	Young
Pop 4	34	4.25	2.25	1.87	0.12	0.420	0.038	0.397	0.350	0.681	Transition

Note: n – number of individuals; X_a – total average density of plants (individuals / m²); X_{pre} – density of the pregenerative individuals (individuals / m²); X_g – density of generative individuals (individuals / m²); X_{post} – density of postgenerative individuals (individuals / m²); I_r – recovery index; I_a – aging index; I_{rep} – replacement index; Δ – age index; ω – efficiency index.

Recovery index showing how much of the generative proportion can regenerate undergrowth after dying, is higher in Pop 1 and low in Pop 4. The highest values of the replacement index are observed in Pop 1. According to the indices Δ and ω, only Pop 4 is transitional, and the remaining populations are assigned as young type.

Conclusion

The present investigation was dealt to the population status of the rare species of mud volcanoes in the Greater Caucasus in Azerbaijan. The location of Toragay (d.s. 332 m) and Gyzmeidan volcano (d.s. 1371 m) at different altitudes and their ecological environment also affected their plant diversity. The study of the composition of the flora revealed that the plant diversity of the two volcanoes is very different. Among them, only 1 species (*Artemisia fragrans* Willd.) was found in both volcanoes. Studies of populations of rare species have shown that all populations are normal, only Pop 2–4 is incomplete due to the absence of subsenile individuals. According to the indices Δ and ω, only Pop 4 is transitional, and the remaining populations are assigned as young type.

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ПОПУЛЯЦИОННЫЙ СТАТУС РЕДКИХ ВИДОВ ГРЯЗЕВЫХ ВУЛКАНОВ БОЛЬШОГО КАВКАЗА

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В статье описаны четыре популяции (Pop) редких видов (*Tulipa biflora* Pall., *Ophrys apifera* Huds., *Rosa azerbaijdzhanica* Novorok. & Rzazade, *Pyrus salicifolia* Pall.), обнаруженных на грязевых вулканах Большого Кавказа. При изучении флоры двух вулканов установлено, что в местной флоре грязевого вулкана Гызмейдан зарегистрировано 46 видов, принадлежащих к 45 родам и 21 семейству, а в грязевом вулкане Торагай – 23 вида, принадлежащих к 22 родам и 12 семействам. Изучены типы, плотность, онтогенетическое состояние и демографическая структура популяций. По пространственно-демографическим показателям популяций изученных видов установлено, что наибольшая средняя плотность и число особей всех онтогенетических состояний отмечена в Pop 1, а наименьшая – в Pop 2. По показателям Δ и ω только Pop 4 является переходной, а остальные являются молодыми.

Ключевые слова: редкие виды, грязевые вулканы, популяция, онтогенетическая структура, Большой Кавказ, демографическая структура