



DISTRIBUTION AND VARIABILITY OF MORPHOPARAMETERS OF SPECIES OF THE GENUS *GALANTHUS* L. IN THE REPUBLIC OF ADYGEA

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The paper presents the results of a study of the distribution of species of the genus *Galanthus* on the territory of Adygea and the variability of individual morphological characteristics of individuals in natural populations. The study of intrapopulation variation of a number of parameters made it possible to identify stable and variable characteristics of species and to assess the polymorphism of populations.

Keywords: *Galanthus woronowii*, *Galanthus alpinus*, *Galanthus lagodechianus*, monitoring, locations, cenopopulations, morphoparameters, intrapopulation variability, ecological plasticity.

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1 INTRODUCTION

The diminishing biodiversity occupies a special place among the main environmental problems of our time, which can lead to the destabilization of the biota, the loss of the integrity of the biosphere and its ability to maintain the most important characteristics of the environment. As a result of the irreversible transition of the biosphere to a new state, it might be unsuitable for human life.

Rare and endangered species of animals, plants and fungi are particularly at risk due to the increasing impact of economic and other human activities on the natural environment. The protection priorities of such species are determined by the Russian environmental legislation, in particular, the "Strategy for the Conservation of Rare and Endangered Species of Animals, Plants and Fungi of the Russian Federation for the period up to 2030" [*Strategy for the Conservation of Rare and Endangered species of animals, plants and fungi of the Russian Federation for the period up to 2030*, 2014]. The strategy is aimed at ensuring the conservation and restoration of the most vulnerable part of Russia's biological diversity and habitats.

The works on the conservation of biological diversity of the plant world include the study of intraspecific variability of structural and functional characteristics of plants in natural cenopopulations. Intraspecific variability of organisms is defined by the variation of a number of factors, including genotype, stage of development and environmental parameters [*Korochkin, 1999; Lutova et al., 2000*] and its analysis in natural conditions is a difficult task [*Zlobin, 1989*]. It is considered important in population studies to study individual forms of intraspecific variability, while keeping in mind a certain conditionality of their differentiation due to the possibility of interpenetration and overlaying [*Mamaev, 1975*].

2 OBJECT OF STUDY AND METHODS

The conservation of biodiversity is most relevant for the mountainous territories of the country, which, due to the exceptional diversity of natural landscapes, are of great importance for the process of microevolution. The Republic of Adygea is located in the central part of the North-Western Caucasus, in the river basins Kuban, Laba, Belaya, Pshish and Psekups. The Republic occupies a unique geographical position, which determines

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the presence on its territory of several geographical zones and vertical vegetation belts, considerable landscape, phytocoenotic and floral diversity, as well as a high level of endemism and relict. About a third of the territory is occupied by protected areas where 14% of its land is classified as UNESCO World Natural Heritage Site “Western Caucasus” [Zhane, 1999].

Geographical location, high degree of compartmentalization, complex geological structure and considerable distribution of limestone rocks create conditions on the territory of Adygea that contribute to local morphogeny, the development of endemism and the emergence of isolated foci of plant species diversity. Thus, 1209 species were identified in the alpine flora of the Fisht-Oshten massif and the Black Sea chain, including 925 species in the alpine flora of the Fisht-Oshten massif and the Lagonaki plateau. The level of endemism of alpine species is one of the highest in the Caucasus – 43.2%. The special physical and geographical conditions in the mountains also turns out to be favorable for the preservation of relict species in refugiums. For example, the relict level among alpine species is one of the highest in the Caucasus – 52.8% [Timukhin and Tuniev, 2019].

The objects of the study are species of the genus *Galanthus* of the family Amaryllidaceae J. St.-Hil., one of the most vulnerable components of plant communities in Adygea. Species of the genus *Galanthus* are perennial herbaceous, oligocarpous bulbous ephemerals, geophytes. These phytocoenotic patients grow in forests and undergo a generative period of development in winter and early spring under a snow cover before the appearance of foliage on trees.

The genus *Galanthus* includes 18 species and two hybrids of natural origin. The range of the genus covers Central and Southern Europe, the Crimea, the Caucasus and Asia Minor. There is the greatest species diversity of snowdrops in the Caucasus – 16 species, on the northern coast of the Mediterranean Sea – two species, on the coast of the Tyrrhenian Sea – four, the Aegean Sea – three, the Sea of Marmara – one species [<http://www.theplantlist.org>].

Species of the genus *Galanthus* are relics of the ancient Mediterranean mesophytic flora [Kemularia-Natadze, 1947] and belong to the Eastern Mediterranean group [Maleev, 1941]. Nine species of the genus grow on the territory of Russia, of which seven species are listed in the Red Book of the Russian Federation [Trutnev, 2008]: *Galanthus angustifolius* G. Koss, *G. bortkewitschianus* G. Koss, *G. caucasicus* (Baker) Grossh., *G. lagodechianus* Kem.-Nath., *G. platyphyllus* Traub et Moldenke, *G. plicatus* Bieb., *G. woronowii* Losinsk.

Galanthus woronowii, *G. alpinus* and *G. lagodechianus* are found on the territory of the Republic of Adygea (Figure 1). *G. lagodechianus* was first found on the territory of the Republic in the southern outskirts of the city of Maykop in the Nagiezh-Uashkh Ridge in 2019 [Akatova et al., 2021]. Two species are included in the Red Book of the Republic of Adygea [Red Book of the Republic of Adygea 2nd ed. parts 1, 2012]: *Galanthus woronowii* and *G. alpinus*. *Galanthus lagodechianus* is recommended for inclusion in the new third edition of the Red Book of the Republic of Adygea.

The literary sources and herbarium collections of the Caucasian State Natural Biosphere Reserve named after H. G. Shaposhnikov (CSR) and Adygea State University (MAY) were used in the study. The collection of factual material was carried out in 2017–2021 during expeditionary surveys of the territory in the vicinity of Maykop and in the Maykopsky, Giaginsky and Koshekhablsky districts of the Republic. Intrapopulation variation of morphological features of generative and vegetative organs of plants was investigated by the method of S. A. Mamaev [Mamaev, 1975]. The coefficient of variation (Cv, %) was used as a measure of variability. The material for determining intrapopulation variation was taken from 30 individuals in one population of each species during one season.

3 RESULTS AND DISCUSSION

Galanthus alpinus (Figure 1a) is endemic to the Caucasus, which grows in forests and on the edges of broad-leaved forests, in shrubby thickets in the lower and middle mountain belts [Lozina-Lozinskaya, 1935]. In the Red Book of the Russian Federation, the species is classified as category 2 – a rare species with a limited range, part of which is located on the territory of Russia [Trutnev, 2008]. It is found within the North Caucasus in Russia. In the Republic of Adygea, *G. alpinus* was recorded in the Maykopsky district, namely, in Pshekish and Abago mountains, the gorge of the Kisha River, the Polkovnitskaya River Valley, and the outskirts of the Tabachny village. In the Koshekhablsky district, it was found in the outskirts of the villages of Khodz and Volnoye, in the Takhtamukaysky district – in the outskirts of the villages of Krasnoarmeysky and Otradny [Red Book of the Republic of Adygea 2nd ed. parts 1, 2012].

The new locations of *G. alpinus* have been found in the Maykopsky, Giaginsky and Koshekhablsky districts. In the Maykopsky district, one location of the species was found in the vicinity of the village of Tulsy, the western slope with a degree of slope 35°; 44°29'15.14" N, 40°11'04.55" E, 301 m above sea level; habitat is a maturing oak-hornbeam forest.

(a) *Galanthus alpinus*;(b) *Galanthus woronowii*;(c) *Galanthus lagodechianus*.**Figure 1:** Species of the genus *Galanthus* in the Republic of Adygea

Three locations of the species have been found in the Giaginsky district: 1) the vicinity of Giaginskaya village, the left bank of the Ulka River, 44°52'45.03" N, 40°09'30.44" E, 144 m above sea level; a small number of individuals were found in the flood plain oak-hornbeam forest; 2) the vicinity of Giaginskaya village, the right bank of Giga River, 44°50'38.95" N, 40°05'53.77" E, 156 m above sea level; there is a population field of 20×10 cm with the number of 57 individuals in a broken forest of *Robinia pseudoacacia* L., *Prunus divaricata* Ledeb. and shrubs; 3) the vicinity of Lesnoy village, the left bank of the Ulka River, 44°47'47.39" N, 40°10'48.01" E, 173 m above sea level; the cenopopulation of the species is not numerous, plants are placed unevenly, form isolated clones of vegetative and generative individuals in the broken middle-aged flood plain oak forest.

Two locations have been found in the Koshekhabsky district: 1) the vicinity of Krasny village (Figure 2), the left bank of the Chehrak River, 44°46'26.98" N, 40°31'20.10" E, 196 m above sea level; habitat is a broken forest of *Robinia pseudoacacia*, *Prunus divaricata* and shrubs; 2) the vicinity of Maysky village, the left bank of the Chehrak River, 44°47'14.77" N, 40°31'07.83" E, 218 m above sea level; habitat of *Galanthus alpinus* is a broken hornbeam-oak forest.

Galanthus woronowii (Figure 1b) is endemic to the Caucasus that grows in forests, along the edges of broad-leaved forests and in shrubs of the lower and middle mountain belts [Lozina-Lozinskaya, 1935]. In the Red Book of the Russian Federa-

tion, it is classified as category 2 – a species that is decreasing in number as a result of excessive human use [Trutnev, 2008]. In Russia, it grows in the Krasnodar [Litvinskaya, 2017] and Stavropol krai [Red Book of Stavropol Krai Plants, 2013] and in the Republic of Adygea [Red Book of the Republic of Adygea 2nd ed. parts 1, 2012]. In Adygea, the species was recorded in the vicinity of Maykop at the Lesnaya station; in the Maykopsky district – tract Goreloye on the Belaya River, the vicinity of Guzeripl village, the right bank of the Belaya River, the Polkovnitskaya River Valley and in the vicinity of Dagestanskaya village [Red Book of the Republic of Adygea 2nd ed. parts 1, 2012].

Galanthus woronowii was found in four locations during the monitoring in the Maykopsky district: 1) the vicinity of Guzeripl village, the left bank of the Belaya River, steep eastern slope, 44°59'55.52" N, 40°08'06.22" E, 670 m above sea level; *Galanthus woronowii* cenopopulation (Figure 3) is represented in the flood plain beech forest by all ontogenetic groups, density is up to 100 S/m²; 2) the vicinity of Dagestanskaya village, the right bank of the Kurdzhips River, 44°23'16.22" N, 40°02'22.49" E, 302 m above sea level, the cenopopulation in the young flood plain oak forest is represented by ten clones with individuals of all ontogenetic states and single individuals (60 generative individuals along the riverbed); 3) the vicinity of Dagestanskaya village, the left bank of the Khakodz River, 44°21'34.68" N, 40°01'29.62" E, 363 m above sea level; habitat is a broken flood plain oak forest; 4) the Una-Koz Ridge, SPNR (specially protected natural reser-



Figure 2: *Galanthus alpinus* in the vicinity of Krasny village



Figure 3: Cenopopulation of *Galanthus woronowii* on the left bank of the Belaya River

vation) “Meshoko Gorge” [Sirotyuk et al., 2020], slope of the southern exposure, 44°16'44" N, 40°11'12" E, 450 m above sea level; the species is represented in the oak forest by single vegetative and generative plants.

Galanthus lagodechianus (Figure 1c) is a rare endemic of the Caucasus with a limited range, part of which is located on the territory of Russia. In Russia, until recently, the locations of the species were found in the Karachay – Cherkess Republic [Red Book of the Karachay – Cherkess Republic, 2013], the Kabardino – Balkarian Republic [Red Book of the Kabardino – Balkar Republic, 2018], the Republic of North Ossetia – Alania [Red Book of the Republic of North Ossetia – Alania: Rare and endangered species of plants and animals, 1999], the Chechen Republic [Red Book of the Chechen Republic, 2020], the Republic of Ingushetia [Red Book of the Republic of Ingushetia: Plants Animals, 2007] and the Republic of Dagestan [Red Book of the Republic of Dagestan,

2020]. Outside of Russia, the species is found in the Republic of Georgia and the Republic of Azerbaijan [Trutnev, 2008].

In 2019, we confirmed the location of *G. lagodechianus* (Figure 4) in the southern outskirts of Maykop on the Nagiezh-Uashkh Ridge, eastern slope, 44°35'09.61" N, 40°06'49.56" E, 327 m above sea level; habitat is a oak-hornbeam forest.

Intrapopulation variation of morphoparameters of *Galanthus alpinus* plants was studied in a cenopopulation growing in the vicinity of Lesnyy village. Most plant characteristics have an average level of variation (Figure 5): bulb width, ovary width, and inner circle petal width, lower leaf length, bract length, flower spike length and pedicel length (Cv = 16.0–21.1%). Outer circle petal length (Cv = 3.6%) showed a very low level of variation and inner circle petal length and width, as well as outer circle petal width (8.4–14.0%)



Figure 4: The population of *Galanthus lagodechianus* in the vicinity of Maykop

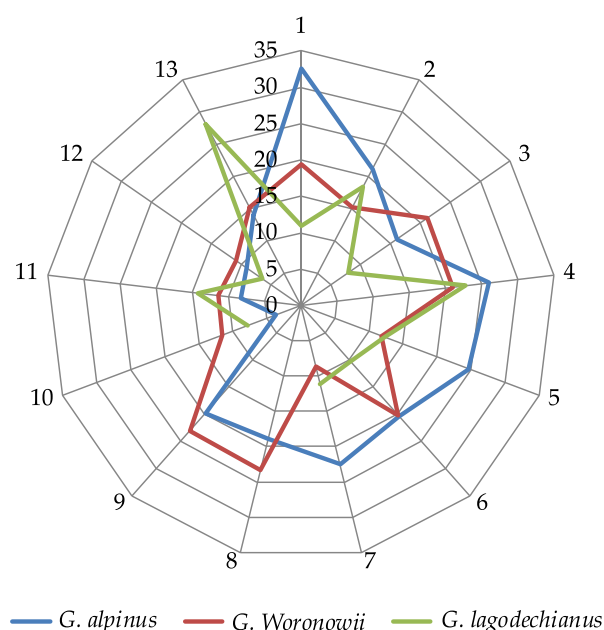


Figure 5: Coefficients of variation of morphoparameters of species of the genus *Galanthus*: 1 – bulb length; 2 – bulb width; 3 – lower leaf length; 4 – lower leaf width; 5 – bract length; 6 – flower spike length; 7 – pedicel length; 8 – ovary length; 9 – ovary width; 10 – outer circle petal length; 11 – outer circle petal width; 12 – inner circle petal length; 13 – inner circle petal width

showed a low level. Lower leaf width and bulb length have an increased level of variability ($Cv = 26.0$ and 32.6% , respectively). Thus, the most stable level of intrapopulation variation in the studied population of *G. alpinus* is demonstrated by outer circle petal length ($Cv = 3.6\%$) and the most variable feature is bulb length ($Cv = 32.6\%$).

The intrapopulation variation analysis of morphological features of *Galanthus woronowii* was carried out in a population growing in the flood plain of the Kurdzhips River in the vicinity of

Dagestanskaya village. The results of the study show that most of the features have an average level of variability: bulb length and width, inner circle petal width, flower spike length, lower leaf length and width, ovary length and width ($Cv = 10.8$ – 23.0%). The other features have a low level of variation: pedicel length ($Cv = 8.6\%$), inner circle petal length ($Cv = 10.8\%$), outer circle petal length ($Cv = 11.5\%$) and width ($Cv = 11.6\%$), bract length ($Cv = 11.9\%$). Thus, the most stable feature of *Galanthus woronowii* in the studied population is pedicel length ($Cv < 10\%$) and the most variable ones are ovary width and length ($Cv = 23.0$ – 23.3%).

The results of the study of intrapopulation variation of *Galanthus lagodechianus* morphoparameters in a single location in the vicinity of Maykop show that most plant characteristics in the population have a low level of variation: bulb length, lower leaf length, bract length, flower spike length, peduncle length, outer circle petal length and width ($Cv = 7.8$ – 14.3%). A very low level of variability has one characteristic: inner circle petal length ($Cv = 6.4\%$), the average level of variability is bulb width ($Cv = 18.4\%$) and lower leaf width ($Cv = 22.7\%$). The most stable characteristic of *G. lagodechianus* on the territory of the Republic of Adygea is inner circle petal length ($Cv = 6.4\%$), the most variable is inner circle petal width ($Cv = 28.2\%$).

4 CONCLUSION

The monitoring of rare plant species during expeditionary surveys of the territory of the Republic makes it possible to identify new locations of their populations and to compare the variability of various features in populations. Most morphological parameters show a low level of variability in the studied populations of *Galanthus woronowii* and *G. lagodechianus*, and average one is in *Galan-*

thus alpinus. Very high and high levels of variation of the studied morphological features were not observed in the populations of all species. Two features in *G. alpinus* show an increased level of variability and one is in *G. lagodechianus*. A very low level of variability of one feature was found in *Galanthus alpinus* and *G. lagodechianus*. In general, the population of *Galanthus alpinus* turned out to be the most polymorphic of the studied populations, which indicates a higher ecological flexibility of the species and the ability to maintain homeostasis in various environmental conditions.

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