The Population Ecology of *Gentiana oschtenica* (Kusn.) Woronow in the Highlands of the Republic of Adygea

EMILIYA A. SIROTYUK

Maykop State Technological University, 385000, Maykop, Russia
E-mail: emiliya09@yandex.ru

Received 18 June 2019 │ Accepted by V. Pešić: 20 September 2019 │ Published online 16 October 2019

Abstract

The article presents the results of the study of the ecology of *Gentiana oschtenica* by population-ontogenetic methods. Most coenopopulations have normal ontogenetic right-sided spectra with a maximum on the group of virginile or generative individuals. The state of coenopopulations is pessimal. The level of the ecological and geographical variability is significantly lower than the level of the intrapopulation variability. The data on the variability of morpho-parameters support the species independence of *G. oschtenica*.

**Key words:** ontogenetic structure, morphological variability, phytocenotic and ecological optima, phenotypic plasticity, taxonomy, Western Caucasus.

Introduction

*Gentiana oschtenica* is a rare endemic of the Western Caucasus from the Cyclostigma Griseb. section of the Gentianaceae Juss. family, genetically related to the northwestern extremity of the Main Caucasus Range and having minor irradiations in Ciscaucasia (Ivanov 2013) and the western part of the Central Caucasus (Vorobieva & Onipchenko 2001; Tsepkova 2011). The species is in the Red Lists of the Republic of Adygea (2012) and the Stavropol Territory (Ivanov 2013).

*G. oschtenica* is a close relative of the Eurasian *G. verna* L. and Caucasian gentians — *G. angulosa* Bieb., which dominate in the eastern part of the Western Caucasus, and *G. pontica* Soltok, which is found in the Lesser Caucasus. All species are included in the cycle of forms combined in *G. verna* s. l. (Maleev 1941).

The Republic of Adygea is located in the central part of the North-West Caucasus in the basins of two tributaries of the Kuban River – Laba and Belaya. The mountains Fisht, Oshten and Pshekha-Su form here limestone Fisht-Oshtensky mountain site, located on the territory of the Caucasus State Natural Biosphere Reserve named of H.G. Shaposhnikov. The height of Oshten is 2804 m, above sea level the snow line descends to a height of 2737 m above sea level. In the subnival zone, and in some places in the subalpine, the vegetation of rocks, scree and glacial seas is widespread. Below are alpine meadows, but they form a continuous strip only on the western slope of the mountain. The Lago-Naki Plateau is located under Fisht, Oshten and Pshekha-Su between Belaya river and Pshekha river at an altitude of 1800 to 2200 m.
above sea level. Subalpine and alpine meadows are widespread here, and the subalpine belt occupies much wider spaces on the plateau than the alpine.

*G. oschtenica* – herbaceous perennial plant with a thin branched rhizome and tetrahedral stem 2-3 cm high (Fig. 1). The lower leaves are elliptical, obtuse, rough at the edges due to small glands, collected in a dense basal rosette. Stem leaves (1-2 pairs), ovate-lanceolate or lanceolate, fused into a short vagina. Upper leaves more narrow, are under a flower. The flower is large, single, apical. Corolla tubular, lemon-yellow. Corolla blades are rhombic-ovate, obtuse, three times shorter than the tube. The inter-blade folds are triangular, 6-7 times shorter than the blades. Stamens are free. Ovary is sessile, pistil is short, stigma is disc-shaped. Cup tubular, five-membered. Teeth calyx identical, lanceolate, sharp, 2-3 times shorter than calyx tube. Cup tubular, five-membered. Calyx teeth are lanceolate, sharp, 2-3 times shorter than Calyx tube. Propagated by seeds and vegetatively. Fruit – oblong-lanceolate, odnezhnaya box on the leg. Seeds are small, yellow-brown, egg-shaped. The weight of 1000 – seeds is 85.5 ± 1.5 mg. The surface of the seeds is mesh-cellular. *G. oschtenica* blooms in June – July, fruits in July – August.

**Figure 1.** Photo of *G. oschtenica*.

**Material and methods**

The materials for the study were the collections of the herbariums of the Botanical Institute of the Russian Academy of Sciences, the Kh.G. Shaposhnikov Caucasus Nature Reserve, the Adyghe State University and our own collections from Lago-Naki Plateau (Fig. 2) and Oshten Mount (Fig. 3) in the Republic of Adygea. Research methods are population-ontogenetic methods, based on the classic works of T.A. Rabotnov, A.A. Uranov, and their followers. The intraspecific variability of morpho-parameters was studied by the method of S.A. Mamaev (1975). The measure of variability was the coefficient of variation (Cv, %.). Quantitative data analysis was conducted in Microsoft Excel 2007.
Results

In the surveyed area, *G. oschtenica* is found on meadows, rocky slopes, rocks, and screes in the alpine and subalpine belts. Individuals are found in singles and in groups. The average density of coenopopulations is 1.5 pieces/m² with the abundance of sp. Heliophyte, Calciphile, and Psychrophyte (which prefers conditions after melting of snow).

Figure 2. The location of Lago-Naki Plateau populations of *G. oschtenica*.

Figure 3. The location of Oshten Mount populations of *G. oschtenica*. 
The following ontogenetic groups of *G. oschtenica* of the seed and vegetative origin were identified: juvenile (j), immature (im), virginile (v), generative (g), and senile (s). The ontogenetic structure of coenopopulations: 18v:13g; 1im:18v:13g; 1im:14v:13g; 3im:14v:9g; 4im:19v:5g; 1j:6im:23v:9g:1s; 1j:2im:8v:9g; 1im:12v:15g. For clarity, the ontogenetic structure of coenopopulations is shown in Fig. 4.

**Figure 4.** Ontogenetic structure of coenopopulations *G. oschtenica*: 1-4 – subalpine cenopopulation; 5-8 – alpine cenopopulation; 7-8 – rocky-scree cenopopulations.

In the coenopopulations growing in the alpine rock-scree groupings, the group of generative individuals prevails, in the others – the group of virginile individuals. Juvenile plants are present only in alpine phytocenoses. Most of the studied coenopopulations have normal, right-sided ontogenetic spectra with a maximum on the group of virginile or, more rarely, generative individuals. The state of coenopopulations is pessimal.

The intrapopulation variability of the majority of vegetative traits in all coenopopulations of *G. oschtenica* has a high level of variation (Cv int. = 29.6-63.9%). The length of the shoot is subject to the strongest variation (63.9%), other traits are less variable (Fig. 5).

Traits of the generative sphere of a plant demonstrate relative stability: the coefficients of intrapopulation variability have low values (Cv int. = < 15%). The smallest coefficient of variation is noted for the length of the cup (Cv int. = 10.6%), the largest – for the width of the wing of the cup (Cv int. = 40.8%).

Analysis of the ecological and geographical variability of *G. oschtenica* showed that by all metric features, its level is low. The ratio of the length of the cup to the length of the tooth can be considered the most constant intraspecific trait. Figure 5 shows that the level of the ecological-geographical variability is significantly lower than the level of intrapopulation variability. Only two traits (the length of the cup and the length of the corolla) have approximately the same amplitude of variation.

**Discussion**

According to some authors, *G. oschtenica* is found outside the Caucasus, but not further than Asia Minor and the Balkans (Fedorov 1952). However, according to P.H. Davis (1978), it is absent in the flora of Asia Minor and the Balkans. Other researchers believe that *G. oschtenica* is a typical representative of the limestone mountains of the Western Caucasus (Syrotyuk & Akatova 2001).

Throughout the Western Caucasus, *G. oschtenica* is characterized by low local and regional occurrences. All known localities of the species are in the subalpine and alpine zones. A.L. Ivanov (2013) notes that in the Stavropol Territory the species lives not only in the subalpine and alpine belts of the
mountains, but also occasionally it is found in the middle and upper mountain forest belts. The author also indicates that *G. oschtenica* reproduces only by seeds, which causes considerable doubts. According to T.G. Bahareva (2004), *G. oschtenica* reproduces by seeds and vegetatively. Vegetative reproduction of *G. oschtenica* is due to short hypogeogenic rhizomes. Therefore, in the composition of plant alpine communities, individuals are usually found in the loose turf-like clones, where the boundaries of individual ramets are quite distinct.

Thus, the species forms clones, manifesting the tactics, which is characteristic of sitters (Herben et al. 1994): it never forms widely distributed ramets, all individuals are located within a short distance from the mother plants. The predominance in the ontogenetic spectra of the species of adult vegetative individuals is possible precisely as a result of vegetative reproduction, which begins in the virginile. Seed renewal is present only in alpine phytocenoses, which may be associated with a more efficient seed renewal under these conditions (Bahareva 2004).

Significant variation in the width of the wing of the cup has been noted by some authors who studied the variability of plants (Zlobin 1989; Ilyushko & Kartavtsev 2001). We assume that this is due to the small absolute values of its size, so this feature as a diagnostic one should be used with caution.

The stability of the ratio of the length of the cup to the length of the tooth of *G. oschtenica* indicates the existence of certain differences in the mechanisms of formation and maintenance of the intrapopulation and intraspecific variability of absolute and relative indicators of morphological traits. According to the

---

**Figure 5.** Intrapopulation and ecological-geographical variability of *G. oschtenica*: 1 – the length of the calyx; 2 – the length of the prong cup; 3 – the ratio of calyx length to the length of the prong; 4 – cup wing width; 5 – the length of the corolla limb; 6 – the diameter of the rim at the limb; 7 – the length of the blade of the limb; 8 – length of escape to the base of the cup; 9 – the length of the rosette leaf; 10 – width of rosette leaf; 11 – length of penultimate sheet; 12 – the width of the penultimate leaf; 13 – length of the last sheet; 14 – the width of the last sheet.
researchers (Bondareva 1994; Trubina 2001), the variability of relative values is less dependent on the conditions of the microenvironment.

European and some Russian botanists doubt the species status of G. oschtenica (Korotkov, 1989; Vorobyova & Onipchenko, 2001), considering it as a subspecies – G. verna L. subsp. oschtenica (Kusn.) Halda. From literary sources it is known that G. verna is distinguished by the strong variability of many morphological parameters. Thus, the authors of the review of European species of gentians (Anchisi et al., 1989) give four subspecies for G. verna, which differ only in the shape of rosette leaves. According to our data (Sirotyuk & Bakhareva 2001; Sirotyuk 2005, 2006), G. oschtenica differs from G. verna in vertical distribution, ecology features, and some morphological features: lemon-yellow flower color (Fig. 4), short pistil column; rhombic and egg-shaped vanes of the limb of the corolla. Its leaves of the rosette is of elliptical shape and rough at the edges due to small glands. In a typical G. verna, the color of the flower is azure; the column is long; corolla limb vanes are egg-shaped or round-egg-shaped; rosette leaves are elliptic-lanceolate and sharp.

All three species of the G. verna s. l. group, inhabiting the Caucasus, are plants of the alpine and subalpine belts. It can be assumed that they have a common origin, being closely related, geographically and ecologically substituting for each other in different regions of the Caucasus and adjacent territories.

Regarding the origin of this group of Caucasian gentians from the section Cyclostigma Griseb., V.P. Maleev (1941, page129) wrote: "As regards the cycle of forms, united in Gentiana verna s. l., then, the double migration of forms of this cycle to the Caucasus is very likely: from the south, leading to the formation of G. pontica in the Lesser Caucasus, and from the north, resulting in the formation of G. angulosa and G. oschtenica in the Greater Caucasus".

It is not yet possible for us to understand the origin and kinship of these species, but the following is clear: they separated from G. praverna earlier than G. verna and replace each other in different parts of the Caucasus. This is indirectly indicated by the lack of pronounced intraspecific polymorphism, which is characteristic of G. verna. Of course, the presence of intraspecific differentiation alone does not give grounds to consider it a more progressive type than G. angulosa and G. oschtenica. Intraspecific polymorphism of the European species could have arisen earlier: before or at the beginning of the Pleistocene. In addition, the wider range of the variability of G. verna in Europe may be associated with both a larger territory and with a significant movement of the species to the north, and into the lower altitude zones than in the Caucasus.

Conclusions

The altitudinal limits of the distribution of G. oschtenica in the Republic of Adygea are 1800-2600 m above the sea level. The phytocenotic optimum of the species is formed in the alpine belt, the ecological optimum is formed in the subalpine belt. The stability of coenopopulations in phytocenoses is ensured by the plasticity of the ontogenetic structure and density. Coenopopulations are normal, which indicates that the ecological conditions of habitats correspond to the biological needs of G. oschtenica. The level of the ecological and geographical variability is significantly lower than the level of the intrapopulation variation, which confirms the low phenotypic plasticity and independence of the species.

References

Anchisi E., Bernini A., Cartasegna N. and Polani F. (1989) Genziane d'Europa (Gentianes d'Europe). Gruppo Naturalistico Oltero pavese, Milano, 152 pp.

Bakhareva T. G. (2004) The structure of populations of the species of the genus Gentiana L. in the high-mountain phytocenoses of the North-West Caucasus. Maykop State Institute of Technology, Maykop, 143 pp.

Bondareva N. A. (1994) Population morphological variability of the intraspecific structure of Caragana pygmaea (Fabaceae) in Siberia. Botanical Journal, 79 (6), 84–87.

Davis P. H. (1978) Flora of Turkey and the East Aegean Islands. University Press, Edinburgh, 6, 825 pp.

Fedorov A. A. (1952) The history of the alpine flora of the Caucasus in the Quaternary as an example of the autochthonous development of the tertiary floristic base. In: Materials on the Quaternary period of the USSR. Academy of Sciences of the USSR, Moscow, 3, 49–86.
Herben T., Marshall C. and Soukupova L. (1994) Plant clonality: Biology and diversity. *Geobotanica et Phytotaxonomica*, 29, 2, 113-122.

Ilyushko M. B. and Kartavtsev Yu. F. (2001) Variability of morphological features of *Iris setoza* (Iridaceae) in the Russian Far East. *Botanical Journal*, 86 (3), 60–71.

Ivanov A. A. (2013) *Gentiana oschitena*. In the book: *Red Book of the Stavropol Territory*, v. 1. Andreev Igor Vladimirovich, Stavropol, 211.

Korotkov K. O. (1989) Floristic analogies between the highlands of the Caucasus and Western Europe. *Bulletin of the Moscow Society of Naturalists, Department of Biology*, 94 (5), 119–137.

Maleev V. P. (1941) Tertiary relics in the flora of the Western Caucasus and the main stages of the Quaternary history of its flora and vegetation. In the book: *Materials on the history of flora and vegetation of the USSR*. Academy of Sciences of the USSR, Moscow; Leningrad, 1, 61–144.

Mamaev S. A. (1975) The basic principles of the study of intraspecific variability of woody plants. In the book: *Individual and ecological-geographical variability of plants*. Academy of Sciences of the USSR, Sverdlovsk, p. 3-14.

Sirotyuk E. A. (2005) On the origin and kinship of some gentians of the Western Caucasus. *Fundamental science*, 10, 89–90.

Sirotyuk E. A. (2006) *The bio-ecology of Gentianaceae in the Western Caucasus*. LLC “Quality”, Maykop, 182 pp.

Sirotyuk E. A. and Akatova T. V. (2001) The local and regional occurrence of some species of the family Gentianaceae in the high-mountainous zone of the Western Caucasus. In: *Collection of scientific work of the Maykop State Institute of Technology*. Maykop State Institute of Technology, Maykop, 286–293.

Sirotyuk E. A., Bakhareva T. G. (2001) The ordination of price populations of a gentian Oshten in the North-West Caucasus. In: *Materials of the international scientific-practical conference "Actual problems of ecology in the conditions of the modern world"*. Maykop State Institute of Technology, Maykop, 20–23.

*The Red Book of the Republic of Adygea* (2012) Part 1. LLC “Quality”, Maykop, 340 pp.

Trubina M. R. (2001) Ecological and genetic structure of variability in populations of roofing skerdy (*Crepis tectorum* L.). *Ecology*, 1, 38–43.

Tsepkova N. L. (2011) Additions to the Red Book of the Kabardino-Balkarian Republic (Central Caucasus). *Proceedings of the Samara Scientific Center of the Russian Academy of Sciences*, 13 (1-6), 1529-1532.

Vorobyova F. M. and Onipchenko V. G. (2001) *Vascular plants of Teberdinsky Reserve (Annotated list of species)*. 99. “Grif and Co”, Moscow, 100 pp.

Zlobin Yu. A. (1989) *Principles and methods of studying coenotic plant populations*. Kazan State University, Kazan, 146 pp.