# Geographical distribution, habitats and current state of the *Galanthus elwesii* (*Amaryllidaceae*) populations in Ukraine

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**Abstract.** Geographical distribution, habitats and current state of populations of a rare species in the Ukrainian flora, *Galanthus elwesii* (*Amaryllidaceae*), are considered. Populations of this species grow near the northeastern limits of its range in the southwestern part of Ukraine, in Odessa and Mykolaiv regions. Along with single Moldavian and Romanian localities, the Ukrainian sites of *G. elwesii* are formed in the Bessarabian Upland and the Black Sea Lowland northeastern exclave of the Black Sea shore range, and are separated from the main part of the range in the Balkan Mountains by a disjuncture in the Lower Danube Lowland. Eight out of 11 known sites of *G. elwesii* in Ukraine are contributed now as new floristic records.

The localities of *G. elwesii* in Ukraine are associated with extrazonal oak, elm, elm-maple, and ash-maple forests of *Quercetalia roboris* ordo, and poplar forest of *Salicetalia purpurea* ordo, resulting from the shrub and forest plantations in the steppe zone. The optimal coenotical conditions for *G. elwesii* are in the anthropogenically undisturbed forests, where it formed homeostatic populations. Cutting of forest trees in the steppe zone of Ukraine has led to substitution of forests by shrubs, replacement by steppe communities and degradation of *G. elwesii* populations. Recommendations are proposed for the improvement of *G. elwesii* conservation *in situ* and *ex situ* in Ukraine.

**Kew words:** conservation, exclave, forest, range, rare species, steppe zone

## Introduction

Development of a scientific background for floristic diversity conservation is the actual problem of botanical investigation. The rare and endangered species of natural floras need special attention. Investigation of their conservation is possible, when based on a comprehensive study of their geographical distribution, habitats and current state of populations. According to the plant protection strategy (Corlett 2016) in terms of intensive anthropogenic pressure on the ecosystems, the actual task is monitoring of the small populations of rare, endangered, relic, and endemic species. Such monitoring should cover the whole diversity of rare fractions of natural floras, including the species of different geographical elements.

The authors have studied here a rare species of the Balkan element in the Ukrainian flora. The Balkan element in the flora of Ukraine comprises species with a major part of their ranges on the Balkan Peninsula and in insular localities near the boundaries of the areas in Ukraine. According Kleopov (1990), *Fritillaria montana* Hoppe, *Polygonatum latifolium* Desv., *Helleborus purpurascens* W.K., *Coronilla elegans* Panc, *Lathyrus venetus* (Mill.) Wolf., *Tilia tomentosa* Moench., and *Galanthus elwesii* Hook. fil. belong to the Balkan element in the Ukrainian flora. *Galanthus elwesii* is the rarest species within the Balkan element in the Ukrainian flora.

*Galanthus elwesii* is a rare species in the European flora and is included in the IUCN Red List (Walters & Gillet 1997), European Red List (Bilz & al. 2011), Appendix 2 of CITES, Red Data Books of Bulgaria, Moldova, Serbia, Ukraine (Stevanović 1999; Dediu 2002; Negru 2001; Diduh 2009; Peev & al. 2015), and Red List of Romania (Oltean 1994).

The purpose of our investigation was to establish the patterns of *G. elwesii* geographical distribution, habitats and current state of populations in Ukraine.

## Materials and methods

The investigation is based on materials from the field research conducted in 1986–2021 in Odessa and Mykolaiv regions of Ukraine. Geographical distribution of this species in Ukraine has been established in the result of our field investigations, literary and herbarium data. The authors have studied herbarium specimens stored in the herbaria of M.G. Cholodnyj Institute of Botany, National Academy of Sciences of Ukraine in Kyiv (KW), M.M. Gryshko National Botanical Garden, National Academy of Sciences of Ukraine in Kyiv (KWHA), T.G. Shevchenko Kyiv National University (KWU), I.I. Mechnikow Odessa National University (MSUD), Botanical Garden of the Academy of Sciences of Moldova in Kishinev (CHIS), Kishinev State University, Botanical Garden of Kluzh-Napoka University (CL), V.L. Komarov Botanical Institute of the Russian Academy of Sciences in St. Petersburg (LE), Kew Royal Botanic Garden (K), University of Cambridge (CGE), and University of Palermo (PAL).

A distribution map of *G. elwesii* in Ukraine has been drawn by the point method. In the process of map-drawing of the range of *G. elwesii,* data have been used from the herbariums, A. Davis's (1999) monograph and publications of the new records of this species (Barina & al. 2015; Jovanović & al. 2016; Hashani & al. 2019; Joannitis & al. 2019).

Habitats and structuring of the *G. elwesii* populations have been studied, according to the methodology described by Rabotnov (1983). Ontogenesis of *G. elwesii* has been studied across the years by observing the development of living plants in the M.M. Gryshko National Botanical Garden NASU. The authors have established stages of the ontogenesis (age stage) and have determined diagnostically its morphological features. According to these features, age groups of plants have been differentiated in each studied population of *G. elwesii*. The number of individuals in each age group has been calculated in plots of 1 $m^2$. During field investigations, 10–15 plots have been outlined for every population. Field research has been carried out during the flowering period of *G. elwesii* in March and April.

Herbarium specimens of *G. elwesii* from the new localities have been stored in the herbariums of M.M. Gryshko National Botanical Garden, National Academy of Sciences of Ukraine and M.G. Cholodnyj Institute of Botany, National Academy of Sciences of Ukraine.

## Results and discussion.

### Geographical distribution of *Galanthus elwesii* in Ukraine

The natural range of *G. elwesii* extends from the western part of Asia Minor (Taurus Mountains and Western Anatolian Plateau) to the Aegean Islands (Chios, Lesbos, Samos, Thassos), the Balkan Mountains and the northwestern part of the Black Sea shore (Albania, Bulgaria, Greece, Moldova, Romania, Serbia, Turkey, and Ukraine, Fig. 1) (Davis 1999; Melnyk & Didenko 2013; Hashani & al. 2019). The Ukrainian populations are located near the northeastern limits of the range. Along with single Moldavian in Gagausia and Romanian in the Dobrudja Upland localities, the Ukrainian sites of *G. elwesii* have formed a northeastern exclave, separated from the main range in the Balkan Mountains by disjuncture in the Lower Danubian Lowland.

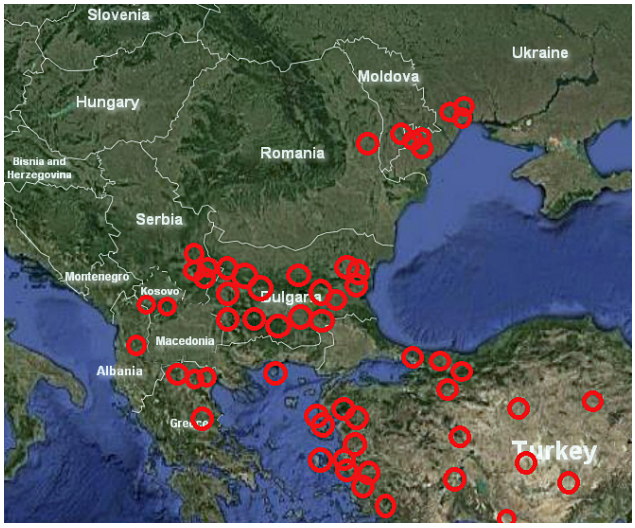


**Figure 1.** The range of *Galanthus elwesii*. – locality

In Ukraine, *G. elwesii* was first reported by Zachariady (1958) under the name *G. graecus*. He found it in 1938 in South Bessarabia (now southwestern part of Ukraine, the Odessa region). Artushenko (1970) rejected the plants from South Bessarabia as *G. elwesii*. In *Flora Europaea,* it was Webb (1980) who mentioned *G. elwesii* for Ukraine and for all Europe, and regarded *G. graecus* as a synonym of *G. elwesii*. The authors agree with this viewpoint and consider the name under which it was firstly described by Hooker (1885) as priority name.

Zachariadi (1958), Kozhura & Shaposhnikova (1969), Bakanova (1970), Geideman & Nikolaeva (1973) have described three localities of *G. elwesii* in the Odessa region. The authors of the present article have found nine new localities of this species in the Odessa and Mykolaiv regions (Fig. 2).

The range of *G. elwesii* in Ukraine is divided into two parts: the first one comprising six localities in the Bessarabian Upland, and the second – five localities in the Black Sea Lowland. A list of the localities of *G. elwesii* in Ukraine is given below.

## Bessarabian Upland

**Odessa region:** 1. Bolgradskij district (former Tarutyne district), 4 km from Berezine village, Berezinska Gorge (Zakhariadi 1958; Bakanova 1970), Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA; 2. Bolgradskij district, Pidhirne, Kulm villages, Kulminska Gorge, Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA; 3. Bolgradskij district, 3.5 km to the southwest of Maly Yaroslavets-2 village, Maly Yaroslavets Tract, Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW; 4. Bolgradskij district, 2.5 km from Annivka village, Annivskij Forest (Fig. 3), Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA; 5. Bolgradskij district, Lisove village, square IV of the Borodino Forestry, Staromanzyrskij Forest, Dibrova Manzyrska Reserve (Fig. 4), Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA; 6. Bolgradskij district, Borodino and Ivanchanka villages, Borodinska Gorge (Fig. 5) (Zakhariadi 1958; Bakanova 1970; Heideman & Nikolaeiva 1973), Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA.

## Black Sea Lowland

**Odessa region:** 1. Kominternivskij district, Kalinivka and Cairy villages, a gorge on the bank of the Tiligul estuary (Kozhura & Shaposhnikova 1969), Melnyk, 1991, KW; 2. Kominternivskij district, Solovyivka and Petrivka villages, a gorge on the bank of the Tiligul estuary, Melnyk, 1991, KW; 3. Berezivskij district, near Ryasnopil village , Bayrak Gorge (Fig. 6), Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA;

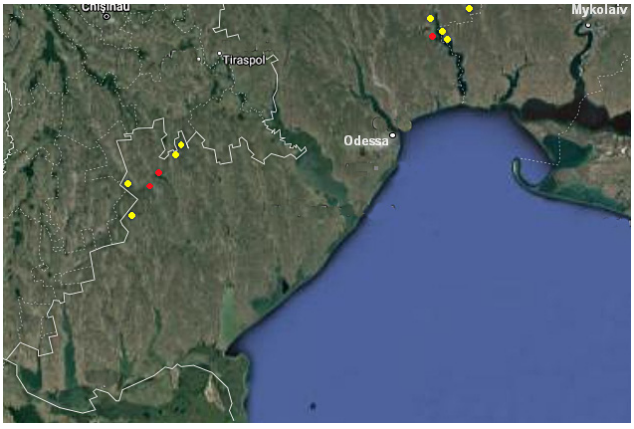


**Fig. 2.** Geographical distribution of *Galanthus elwesii* in southwestern Ukraine. ● – known locations ; ● – knew floristic records

**Fig. 3.** *Galanthus elwesii* population in silvicultural plantation of *Gleditsia triacantos* (Annivka village, Odesa region).western Ukraine.

**Fig. 4.** *Galanthus elwesii* in oak forest in reserve Dibrova Manzyrska (Lisove village, Odesa region).

**Fig. 5.** *Galanthus elwesii* and relict species *Gymnospermium odessanum* in Borodinska gully (Odessa region).

**Fig. 6.** *Galanthus elwesii* in steppe community in Bayrak gully near Ryasnopil village (Odesa region).

**Mykolaiv region:** 1. Berezanskij district, Progressivka village, Melnyk, 1991, Melnyk, Didenko, Rak, 2006, KW, KWHA; 2. Berezanskij district, Tashyne village, Hlyboka Gorge (Fig. 7), Didenko, 1996; Melnyk, Didenko, Rak, 2006, KWHA.

Thus, in two sections of the range of *G. elwesii* in the southwestern part of Ukraine, 11 locations are known, eight of which have been discovered by the authors for the first time (Odessa region: Bolgradskij district: Pidhirne, Kulm villages; 3.5 km to the southwest of Maly Yaroslavets-2 village; 2.5 km from Annivka village; Lisove village, square IV of the Borodino Forestry; Kominternivskij district: Solovyivka and Petrivka villages; Berezivskij district, near Ryasnopil village; Mykolaiv region: Berezanskij district, Progressivka village; Tashyne village). Apparently, the range of *G. elwesii* at its eastern line of distribution used to be tapered, as the species on the northern Black Sea shore have been confined to ravine and plakor forests.

**Fig. 7.** *Galanthus elwesii* in ravine forest in Hlyboka gully near Tashino village (Odessa region).

Their destruction brought insularization of habitats, which led to formation of small local populations of the species. Earlier, the continuous boundary of the range has been divided into two sections on the Bessarabian Upland and on the Black Sea Lowland on the banks of the Tiligul estuary.

Except for local populations, in different parts of the Odessa region, the authors have found patches of single growth of *G. elwesii*: in the forest near Bessarabskij House Hotel in Tarutine town and in a forest near the cemetery of Lisove village in the Bolgrad district. The individuals in each of these localities did not number more than 10 clones. These localities suggest a wider distribution of the species in the Odessa region in the past.

## Habitats and current state of populations

According to Webb (1980), *G. elwesii* grows in woods, scrubs and rocky pastures. In the Taurus Mountains in Turkey, it grows in the subalpine pastures at altitudes from 800 to 1600 m (Yüzbaşıoğlu 2012). In Greece, it is a component of the temperate and sub-Mediterranean grasslands (Joanitis & al. 2019). In Serbia, *G. elwesii* grows commonly on slopes, in montane forest ass. *Fagetum montanum,* at altitudes above 1000 m, and has been recorded in oak forests and in upland calcareous meadows, as well as among bushes, in pastures and among rocks, from 400 m to 1300 m a.s.l. In Kosovo, it grows in the subalpine pastures, from 1500 to 1780 m a.s.l., often in moist meadows (Jovanović & al. 2016; Hashani & al. 2019).

In the northeastern exclave of *G. elwesii,* phytocoenotical amplitude of this species is narrower. In that part of its range, it grows only in forest and scrub

habitats. In Moldova and in Romania, it occurs in light oak forests (Geideman & Nikolaeva 1973).

All Ukrainian localities of *G. elwesii* lie in the steppe zone. However, *G. elwesii* is a forest species by its coenotical nature. Forests in the steppe zone of Ukraine are extrazonal communities. It occupies small areas on the slopes and thalvegs of gullies (ravine forests), floodplains and river terraces (arena forests) and is found occasionally in insular forest ecosystems of flat interfluve (placor) forests. The habitats of *Galanthus elwesii* in Southwest Ukraine are set in natural insular plain (placor) forests, ravine forests, and in shrubs and forest plantations derived from them.

Single habitats in the placor forests have been found in the Dibrova Manzyrska (Manzyr Oak Forest) Botanical Reserve in Borodinskij Forestry. The Reserve covers 101 ha. That massive oak forest (*Quercatalia roboris* ordo) is one of the largest in the steppe zone of Ukraine.

The first layer in the forest is formed by *Quercus robur* L. trees, 200–300 years old, up to 25 m tall, with trunk diameters of 80–100 cm. The second layer consists of *Ulmus carpinifolia* Mill., *Acer campestre* L., *A. tataricum* L., *A. platanoides* L., and *Tilia cordata* Mill. The average height of the trees in the second layer is 15 m, the average diameter of the trunks is 20 cm. In the undergrowth, *Euonymus europaea* L., *Sambucus nigra* L. and *Prunus fruticosa* Pall. predominate on the edges of the forest massive. *Galanthus elwesii* (45 %) and *Gymnospermium odessanum* (DC.) Takht. (30 %) dominate in the early spring synusia of the herb layer. In early spring, the synusia of the herb layer also comprise *Bellevalia sarmatica* (Georgi) Woronow., *Gagea villosa* (M. Bieb.) Duby, *Ornitogalum boucheanum* (Kunth) Asch., *O. kochii* Parl., *Scilla bifolia* L., *S. siberica* Andrews, *Sternbergia colchiciflora* Waldst. & Kit., *Corydalis solida* (L.) Clairv., *C. cava* Schweigg. & Korte., *Ficaria verna* Huds., *Anemone ranunculoides* L., *Colchicum ancyrense* B.L. Burtt, *Tulipa biebersteiniana* Schult.f. s.l., *Glechoma hederacea* L., *Mercurialis ovata* Sternb. & Hoppe, *Adonis vernalis* L., *A. wolgensis* DC., *Crocus reticulatus* Adams, and *Iris variegata* L. on the forest massive edges.

The population density of *G. elwesii* in the Manzyr Forest is 160 individuals per $m^2$. The population is normal, with a full-member spectrum in the ontogenetic stage, homeostatic, with a significant predominance of juvenile individuals (Table 1, Fig. 8). A significant portion of young plants in the age spectrum (70 individuals per $m^2$) suggests an ability of the population for self-support by seed and high seed germination. A study of the structure of clones has shown that the species also reproduces well vegetatively (Table 2). The species forms full-member but small clones, with domination of young (both immature and juvenile) individuals.

The vegetation of ravine forests with *G. elwesii* in the early spring synusia is represented by elm, elm-maple and ash-maple forests of *Quercetalia roboris* ordo, and poplar forests of *Salicetalia purpurea* ordo.

A maple-elm forest with *G. elwesii* population in the early spring synusia is located in the Black Sea

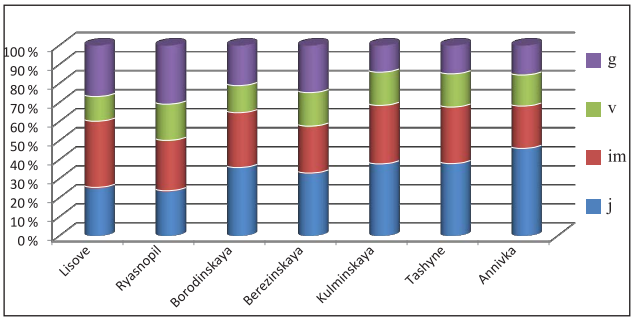


**Fig. 8.** The spectrum of age states of *Galanthus elwesii* populations in Ukraine.

**Table 1. Density and age spectrum of *Galanthus elwesii* populations in Ukraine.**

| Location | Number of individuals per 1 $m^2$ | Spectra of ontogenetic states | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | j* | | im** | | v*** | | g**** | |
| | | ind/$m^2$ | % | ind/$m^2$ | % | ind/$m^2$ | % | ind/$m^2$ | % |
| Lisove (Manzyrskaya Dibrova) forest | 116 | 29 | 25.1 | 41 | 35.3 | 15 | 12.9 | 31 | 26.7 |
| Ryasnopil (Bayrak Gorge), shrub | 98 | 23 | 23.5 | 26 | 26.5 | 19 | 19.4 | 30 | 30.6 |
| Borodinskaya Gorge, shrub | 186 | 67 | 36.0 | 54 | 29.0 | 24 | 14.0 | 41 | 21.0 |
| Berezinskaya Gorge, forest | 61 | 20 | 32.8 | 15 | 24.6 | 11 | 18.0 | 15 | 24.6 |
| Kulminskaya Gorge, forest | 634 | 240 | 37.8 | 194 | 30.6 | 112 | 17.7 | 88 | 13.9 |
| Tashyne (Hlyboka Gorge), shrub | 182 | 69 | 37.9 | 54 | 29.7 | 32 | 17.6 | 27 | 14.8 |
| Annivka, Annivsky Forest | 139 | 64 | 46.0 | 31 | 22.3 | 23 | 16.6 | 21 | 15.1 |

**Notes**: * – juvenile individuals; ** – immature individuals; *** – virginal individuals; **** – generative individuals.

**Table 2. Number and structure of *Galanthus elwesii* clones.**

| Location | Number of clones per 1 m² | g | v | im | j | Total |
|---|---|---|---|---|---|---|
| | | (individuals in the clone) | | | | |
| Lisove (Manzyrskaya Dibrova) forest | 4–7 | 5 | 3 | 6 | 7 | 21 |
| Ryasnopil (Bayrak Gorge), shrub | 2–6 | 7 | 5 | 13 | 11 | 36 |
| Borodinskaya Gorge, shrub | – | – | – | – | – | – |
| Berezinskaya Gorge, forest | – | – | – | – | – | – |
| Kulminskaya Gorge, forest | 3–5 | 4 | 3 | 31 | 53 | 91 |
| Tashyne (Hlyboka Gorge), shrub | 2–5 | 5 | 3 | 2 | 1 | 11 |
| Annivka, Annivskiy Forest | 9–12 | 5 | 3 | 6 | 12 | 26 |

Lowland. This forest massive occupies the Bayrak Gorge near Rasnopil village, Beresivzkyij district, Odessa region.

The Gorge is located northwards of Ryasnopil village. It stretches for 3 km from north to south. The width of the Gorge is 30–50 m. The slopes are steep and their upper parts are covered by steppe vegetation. The lower part of the Gorge, on the floor of which flows a stream, is covered by a maple-elm forest. The backbone of the stand is formed by 60-year-old trees of *Ulmus wyssotzkvi* Kotov and *Acer tataricum*. The average height of the trees is 15 m, the average diameter of their trunks is 20 cm. Crown density is 0.8. In some places, there are elm individuals more than one hundred years old. The grass layer is quite rich and mosaic. It consists of patches with domination of *Asparagus tenuifolius* Lam., *Polygonatum odoratum* (Mill.) Druce, *Bellevalia sarmatica*, *Bulbocodium versicolor* (Ker Gawl.) Spreng., *Corydalis cava*, *C. solida*, *Crocus reticulatus*, *Ficaria verna*, *Gagea villosa*, *G. elwesii*, *Gymnospermium odessanum*, *Hyacinthella leucophaea* (C. Koch) Schur., *Ornithogalum boucheanum*, *Scilla bifolia*, and *Tulipa biebersteiniana*. In some places in this forest massive, forest communities are replaced by thorny thickets of *Prunus spinosa*, which along with hawthorn bushes (*Crataegus* spp.) and dogrose (*Rosa* spp.) form impassable thickets with depleted grass cover dominated by adventive plants *Capsella bursa-pastoris* L., *Daucus carota* L., *Viola canina* L., *Urtica dioica* L., and *Glechoma hederacea*. The synusia of the early spring ephemeroids are represented by *Bulbocodium versicolor*, *Ficaria verna*, *Gymnospermium odessanum*, *Scilla bifolia,* and *G. elwesii*.

Population options of *G. elwesii* in the Bayrak Gorge depend on the degree of anthropogenic impact on the ecosystems. At the border of the Bayrak Gorge, the habitats of snowdrops are severely disturbed as a result of human activity in this forest massive. Population of *G. elwesii* has low density of 28 individuals per m². The age spectrum of the population is right-sided. Soil on the Gorge borders is sod, preventing seed germination and seedling survival is very low. Clones are not formed (Table 2). Regressive population is not capable of self-support. Higher up on the slopes the anthropogenic impact is less marked. There snowdrops grow under bushes and in the ecotones and *G. elwesii* populations here have high density and a high rate of young individuals in the age spectrum (Table 2). Clones contain plants of all ages.

There are three localities of *G. elwesii* in the ravine forests of Bessarabian Upland: Borodinska, Berezinska and Kulminska gorges, near Tarutyno town in the Odessa region.

Borodinska Gorge is covered by an oak-ash forest, but the latest natural vegetation in some places has been displaced by forest plantations of *Robinia pseudacacia* L. and *Gleditsia triacanthos*. So far, only some old trees of *Quercus robur* and *Fraxinus exelsior* L. and small patches of forest vegetation have remained there. Elimination of natural vegetation has contributed to sod soils and prevalence of steppe plants, namely: *Pulsatilla nigricans* Storck, *Adonis vernalis*, *A. wolgensis*, *Ornithogalum fimbriatum* Willd., and *O. boucheanum*. The population of *G. elwesii* occupies 5 ha. Density of population is 185 individuals per m². Population is normal, full-membered in the age spectrum (Table 1, Fig. 8). However, a study of the structure of clones has shown (Table 2) that self-support of the population occurs mainly vegetatively.

The floor of the small Berezinska Gorge is covered by an elm-maple forest. The tree layer is formed by *Acer campestre, A. tataricum* and *Ulmus carpiniifolia*. The average height of the trees is 18 m, the average trunk diameter is 20 cm, crown density is 0.8. The shrub layer is formed by *Crataegus monogyna* Jacq., *Euonymus europaea, Sambucus nigra,* and *Viburnum lantana* L. The grass layer is sparse. *Galium verum* (50 %) and *Stellaria holostea* (30 %) dominate. In the

early spring synusia, along with *G. elwesi,* also grow *Anemone ranunculoides*, *Corydalis cava*, *Scilla bifolia*, *Ornithogalum fimbriatum*, *O. boucheanum*, *Gagea villosa*, *Ficaria verna*, *Muscari neglectum* Ten., and *Polygonatum odoratum*. The population density of *G. elwesii* in the Berezinska Gorge is 60 individuals per $m^2$. The population is normal, with a full-member spectrum, homeostatic. Young individuals predominate (Table 1, Fig. 8).

A sparse poplar grove is preserved in the Kulminskaya Gorge, along the Anchokrak stream. The tree layer is formed of *Populus alba* L., with *Salix purpurea* L. There is a dense layer of shrubs formed by *Sambucus nigra,* with *Euonymus verrucosa* Scop. The upper parts are covered by dense impassable thickets of *Prunus spinosa,* with *Rosa canina* L. and *Crataegus monogyna.* The grass layer is sparse. *G. elwesii* is dominant in the spring synusia. These synusia also contain *Scilla bifolia*, Crocus *reticulatus*, *Corydalis cava, C. solida, Ficaria verna*, *Gagea lutea* (L.) Ker-Gawl., and *Gagea villosa*. The population of *G. elwesii* occupies 15 ha. It is normal, with a full-member age spectrum at the ontogenetic stage. Young plants dominate (640 individuals per $m^2$). There are 3–5 clones per 1 $m^2$ (Table 2). Young plants claim a significant share, with a high self-supporting ability of the population by seeds and bulbs.

In the Black Sea Lowland, *G. elwesii* grows mainly in dense thickets of shrubs in the gullies. The narrow strip of shrubs (2–3 m wide) stretches along the floor at the left bank of the Tiligul estuary, near Tashine village. This is a typical habitat of *G. elwesii* in that part of the range. Dense thickets of shrubs (with crown density of 0.9) are formed by *Crataegus monogyna, Rosa canina*, *R. tomentosa* Sm., *Euonymus europaea*, and *Ligustrum vulgare.* The grass layer is very sparse. *Corydalis solida*, *Glechoma hederacea*, *Galium verum* L., *Gymnospermium odessanum*, *Ficaria verna,* and *G. elwesii* grow in the bush thickets. The population density of *G. elwesii* is quite high: 180 individuals per $m^2$ (Table 1, Fig. 8). The population is normal, full-membered, with a left-sided age spectrum. *G. elwesii* also reproduces well by bulbs (Table 2).

The *Galanthus elwesii* population near Annivka village in the Bessarabian Upland is connected with a cultivated coenose of *Gleditsia triacantos* and *Robinia pseudoacacia*. That is a 70-year-old plantation. Some *Ulmus carpinifolia* and *Acer negundo* trees grow in the second layer. The soil is sod. The grass layer is dominated by *Stellaria holostea*. In the early spring synusia are represented *G. elwesii*, *Anemone ranunculoides*, *Gagea villosa*, *Gymnospermium odessanum*, *Ficaria verna*, *Scilla bifolia*, and *Tulipa biebersteiniana*. The population of G. *elwesii* is with a left-sided age spectrum of the ontogenetic stage and an average density of 160 individuals per $m^2$ (Table 1, Fig. 8). The species forms numerous clones (9–12 individuals per $m^2$). A study of the structure of clones has shown that vegetative reproduction predominates, self-seeding is practically not observed, and juvenile individuals dominate in the clones (Table 2).

Analysis of the current state of *G. elwesii* populations in Ukraine shows that the coenotical optimum for this species is in the anthropogenically undisturbed extrazonal placor and ravine forests. In these habitats, the populations are homeostatic, with high density, complete spectrum of ontogenesis and prevalence of young individuals. Cutting of the forest trees in the steppe zone in Ukraine has led to substitution of forest by shrubs, where *G. elwesii* populations form with low density, incomplete ontogenetic spectrum and absence of young individuals of the plants.

Consequently, shrubs have been replaced by steppe communities, with predominance of grasses. As a result, sod surface prevents penetration of seeds into the mineral soil, their germination and seedling formation (Melnyk & Didenko 2013). Thus, populations without recruitment of new generations are eliminated.

Before intensive deforestation in the steppe zone in the $18^{th}$ century, ravine forests ran as long narrow strips along the gorges. The network of ravine forests in the southwestern part of the steppe zone of Ukraine was destroyed by intensive cutting of the trees from the $19^{th}$ century onwards (Melnyk 2000). Only small insular forest patches have remained in gorges. In other places of the gorge network, human activities induced substitution of forests by shrub and steppe communities.

Thus, the forest plant species in the steppe zone have been timed mainly to ravine forests. They had tape (linear) populations. The northeastern exclave of the *G. elwesii* range consists of tape (linear) populations. Intensive cutting of ravine forest has led to fragmentation of the extended tape (linear) populations into isolated local populations. These populations, which occupied the most humid places of

the steppe zone, are relict. The process of fragmentation of the populations continues ever since. There are two local populations of *G. elwesii* in the Berezynska and Kulminska Gorges in Bessarabian Upland at a distance of 1 km from each other. According to local residents, in the recent past these two local populations were a single tape (linear) population.

Sylvicultural plantations of *Robinia pseudoacacia* and *Gleditsia triacanthos* are secondary but suitable forest ecotopes for *G. elwesii* in the steppe zone of Ukraine, where its new local populations are formed.

### Conservation

*Galanthus elwesii* is rare in all European parts of its range, including Ukraine. The reasons for this rarity of the species in Ukraine are felling of forests in the steppe zone and their substitution by shrub and steppe communities, recreational load, digging of bulbs and collection of the flowers.

In recent years, *G. elwesii* has diminished its range in Asia Minor, where the main resourced of this species are concentrated. In the period 2000–2015, five million bulbs of *G. elwesii* have been harvested annually there for the extraction of bioactive alkaloids. Since 2016, quotas have decreased to four million bulbs annually. As a result of overexploitation, populations of *G. elwesii* have been decreasing and severely fragmented in the Taurus Mountains (Rapport… 2017).

*Galanthus elwesii* is included in IUSN Red List of Threatened Plants, European Red List and Appendix II of the CITES Convention (Walter & Gillet 1997; Bilz & al. 2011). The species is included in the Red Data Books of Ukraine, Bulgaria, Moldova, Serbia, and the Red List of Romania (Oltean 1994; Stefanović 1999; Negru 2001; Diduch 2009; Peev & al. 2015). It is also included in the list of plant species requiring protection in Greece (Goulimis 1959).

A large population of *G. elwesii* near Lisne village in the Bolgrad district, Odessa region in Ukraine is under protection in the Dibrova Manzyrska Botanical Reserve. Three populations of *G. elwesii* in the Berezivskij district, Odessa region are under protection of the Tiligulskij Regional Landscape Park. Considering the high phytosociological status of *G. elwesii* at the northeastern limits of its range, all populations in Ukraine are in need of protection.

In so far as the habitats of *G. elwesii* in Ukraine are also habitats of other species included in the Red Data Book of Ukraine (Diduh 2009), namrely, *Adonis vernalis*, *Bulbocodium versicolor*, *Crocus reticulatus*, *Gymnospermium odessanum*, *Ornithigalum boucheanum*, *Sternbergia colchiciflora*, and *Tulipa quercetorum,* organization of new protected territories in the extrazonal forests of the steppe zone will significantly improve conservation of rare species in the Ukrainian flora.

*Galanthus elwesii* has ability to form populations in the secondary habitats of sylvicultural plantations. Thus, modeling on populations of this species in cultivated forest coenoses may offer a promising method of *ex situ* plant protection.

## Conclusions

A rare species in the European flora, *Galanthus elwesii* Hook.fil. (*Amaryllidaceae*), grows near the northeastern limits of its range in Ukraine. Along with single localities in Moldova in Gagausia, and in Romania in Dobrudja Upland, the Ukrainian sites of *G. elwesii* form a distinct exclave in the range at the northern shore of the Black Sea, separated from the main Balkan part of its area by disjuncture in the Danubian Lowland. The Ukrainian part of the *G. elwesii* range consists of two sections: the first one is located in the Bessarabian Upland, and the second in the Bleak Sea Lowland. Eight out of 11 sites of G. *elwesii* in the Odessa and Mykolaiv regions in Ukraine are now new floristic records.

All localities of *G. elwesii* in the northeastern exclave lie in the steppe zone, though it is a forest species by its coenotical nature. In Southwest Ukraine, *G. elwesii* times with the extrazonal insular plain (placor) and riparian forests, shrubs derived from them and forest plantations.

An analysis of the current state of *G. elwesii* populations in Ukraine has shown that the coenotical optimum for this species is in anthropogenically undisturbed placor and ravine oak, elm, elm-maple, and ash-maple forests *Quercetalia roboris* ordo, and in poplar forests of *Salicetalia purpurea* ordo. In these habitats, the populations are homeostatic, with high density, complete ontogeneic spectrum and prevalence of young individuals of *G. elwesii.*

Cutting of forest trees in the steppe zone in Ukraine has led to substitution of forests by shrubs, where *G. elwesii* populations are of low density and incomplete ontogenetic spectrum (absence of young

individuals). Consequently, shrubs are replaced by steppe communities with predominance of grasses, where populations of *G. elwesii* are eliminated.

The relict populations of *G. elwesii* in Ukraine were initially tape (linear) populations. They were distributed as long narrow strips, mainly in the ravine forests of a ramified network of gorges. Intensive cutting of the ravine forests has led to fragmentation of the extended tape (linear) populations and their transformation into local isolated populations.

Insofar as sylvicultural plantations of *Robinia pseudoacacia* and *Gleditsia triacanthos* are secondary but suitable for *G. elwesii* habitats in the steppe zone, where new populations are formed, modeling on those populations in the cultivated forest coenenoses may offer a promising method of the *ex situ* plant conservation.

All local populations of *G. elwesii* in the gene pool of the northeastern exclave of its range in Ukraine are in need of protection.

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## References

**Artushenko, Z.T.** 1970. *Amaryllidaceae* of USSR. Morphology, Systematics and Utilization. Leningrad (in Russian).

**Bakanova, V.V.** 1970. *Galanthus elwesii* in Ukraine. – Bulletin of Main Botanical Garden, Academy of Sciences of USSR, **77**: 46-48 (in Russian).

**Barina, Z., Pifko, D. & Rakuj, M.** 2015. Contributions to the flora of Albania. – Stud. Bot. Hung., **46**(2): 119-140.

**Bilz, M., Kell, S.P., Maxted, N. & Lansdown, P.V.** 2011. European Red List of Vascular Plants. Luxemburg.

**Corlett, R.T.** 2016. Plant diversity in a changing world: Status, trends and conservation needs. – Plant Diversity, **38**: 10-16.

**Davis, A.P.** 1999. The genus *Galanthus*. A Botanical Magazine Monograph. Portland.

**Dediu, J.** (ed.). 2002. Red Data Book of Moldova. Chisinau (in Moldavian).

**Diduh, J.P.** (ed.) 2009. Red Data Book of Ukraine. Kyiv (in Ukrainian).

**Geideman, T.S. & Nikolaeva, L.P.** 1973. *Amaryllidaceae* of the flora of Moldova. – News of the Academy of Sciences of Moldavian SSR. Ser. Biological and Chemical Sciences, **3**: 3-8 (in Russian).

**Goulimis, C.** 1959. Report on species of plants requiring protection in Greece and measures for securing their protection. – Proc. IUCN 7th Technical Meeting, **5**: 168-188.

**Hachani, Z., Maxhuni, Q., Ferizi, R., Abdurahmani, A. & Mala., X.** 2019. *Galanthus elwesii* (*Amaryllidaceae*) in the flora of Kosovo. – Hacquetia, **18**(1): 137-142.

**Hooker, J.D.** 1875. *Galanthus elwesii*. – Curtis's Bot. Mag., **31**: 61-66.

**Joanitis, V., Deulkeriodou, D., Kautis, K. & Strid, A.** 2019. Reports 37-78. – In: **Vladimirov, V. & al.** (comp.), New floristic records in the Balkans: 39. – Phytol. Balcan., **25**(2): 211-215.

**Jovanović, F., Obratov-Petković, D., Niketić, M. & Vukojičić, S.** 2016. Distribution of the genus *Galanthus* (*Amaryllidaceae*) in Serbia. – Botanica Serbica, **40**(1): 69-81.

**Kleopov, J.D.** 1990 Analysis of the Flora of Broad-Leaved Forests of the European Part of USSR. Kyiv (in Russian).

**Kozhura, M.G. & Shapochnicova, L.A.** 1969. *Galanthus elwesii* – new species of snowdrop in Ukraine. – Ukrainian Bot. J., **29**(5): 115-117 (in Ukrainian).

**Melnyk, V.I.** 2000. Rare Species of Plain Forests of Ukraine. Kyiv (in Russian).

**Melnyk, V.I. & Didenko, S.Ja.** 2013. The Species of the Genus *Galanthus* L. (*Amaryllidaceae*) in Ukraine. Kyiv (in Ukrainian).

**Oltean, M.** (coord.) 1994. Red list of higher plants in Romania. – In: Studies, Syntheses, Ecology Documentations. Romanian Academy, Institute of Biology Bucharest, **1**: 1-52 (in Romanian).

**Peev, D. & al.** (eds) 2015. Red Data Book of the Republic of Bulgaria. Vol.**1.** Plants and Fungi. Sofia.

**Rabotnov, T.A.** 1983. Phytoceonology. Moscow (in Russian).

**Rapport sur les combinaisons espèces/pays sélectionnées pour étude par le Comité pour les plants suivant la CoP16. 2017**. Cambridge.

**Stevanović, V.** (ed.). 1999. The Red Data Book of the Flora of Serbia. **1**. Extinct and Critically Endangered Taxa. Belgrade (in Serbian).

**Walters, K.S. & Gillet, H.J.** 1997. IUCN Red List of Threatened Plants. Gland.

**Webb, D.A.** 1980. *Calanthus* L. – In: **Tutin, T.G. & al.** (eds), Flora Europaea. Vol. **5**, pp. 77-78. Cambridge Univ. Press, Cambridge.

**Yüzbaşıoğlu, S.** 2012. Morphological variations of *Galanthus elwesii* in Turkey and difficulties on identification. – Bocconea, **24**: 335-339.

**Zachariadi, K.** 1958. Morphology and taxonomy of some species of genus *Galanthus* from USSR and RPR. – Second Delegate Congress of All-Union Botanical Society. Report of Foreign Scientists, pp. 9-13. Leningrad (in Russian).