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RESEARCH ARTICLE

Distribution patterns of *Dactylis glomerata* subsp. *slovenica* (*Poaceae*) in the Ukrainian Carpathians

Volodymyr M. BILONOHA *, **Volodymyr H. KYYAK**, **Volodymyr I. KOZLOVSKYY**
Institute of Ecology of the Carpathians, National Academy of Sciences of Ukraine,
4 Kozelnytska, Lviv 79026, Ukraine
* Author for correspondence: *v_bilonoha@ukr.net*

Abstract. *Dactylis glomerata* subsp. *slovenica* (*Poaceae*) is widespread in the Alps, Carpathians, Sudetes, the Giant Mountains (Krkonoše), and adjacent foothills. Some localities are also known in the northern Apennines, in the foothills of the French Pyrenees, Balkans, and the Caucasus, and occasionally outside the mentioned mountain systems in Poland, Germany, France, and Ukraine. In the Ukrainian Carpathians, it occurs in isolated populations in all main mountain ranges up to 1620 m above sea level, preferring tall herbaceous communities of the subalpine belt. Relatively strong restriction of *D. glomerata* subsp. *slovenica* to habitats with neutral or sub-acidic soils limits its advance on new areas in the Carpathians. The primary threats to the taxon are its geographical isolation, substrate requirements, and secondary successions associated with the expansion of *Alnus alnobetula* (*A. viridis*). Instead, reduced grazing or haymaking may have a positive impact on population size within existing localities or dispersal into areas with suitable soil conditions.

Keywords: Carpathians, *Dactylis slovenica*, distribution, ecology, Ukraine

Introduction

Dactylis glomerata subsp. *slovenica* (Domin) Domin is a vigorous grass with strong and thick arched flower culms. In contrast to *D. glomerata* subsp. *glomerata*, it is often up to 2 m tall, mostly smooth or slightly rough, bright or pale green, with swelling of the culm base and spread loose tuft. The differences between these two subspecies have been thoroughly described by Doroszewska (1961) and Mizianty (1988a).

Dactylis glomerata subsp. *slovenica* occasionally occurs throughout the Ukrainian Carpathians from the Beskydy Mts in the west to the Hryniava and Chyvchyny mountain ridges in the east (Prokudin et al., 1977; Mizianty, 1988b; Malinovski et al., 2002; Antosyak et al., 2009). Additionally, some specimens have been found in the foothills at much lower altitudes (Mizianty 1988b; KRAM herbarium; https://www.gbif.org/uk/species/5940394). In Ukraine, under the latest assessment of the conservation status, the taxon was evaluated as "Endangered" or "Data

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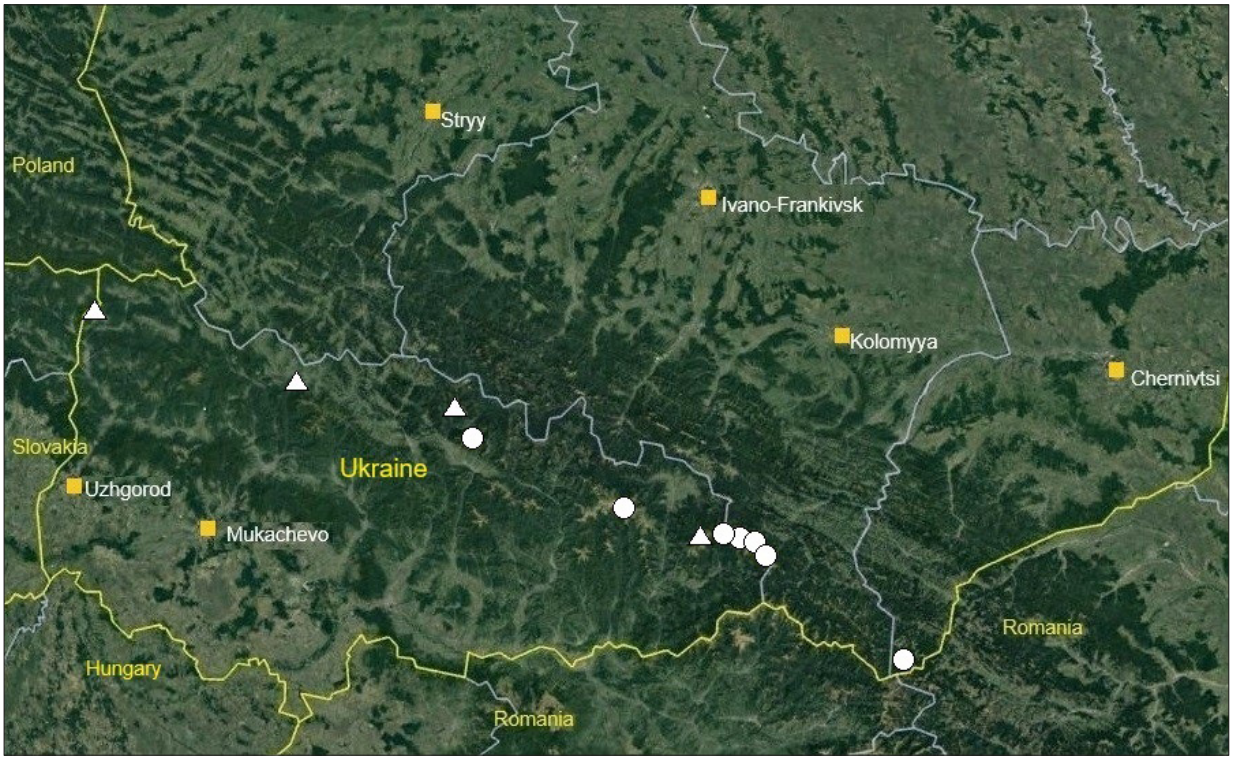

Fig. 1. Distribution of *Dactylis glomerata* subsp. *slovenica* in the Ukrainian Carpathians (circles — confirmed records, left to right — Mt. Nehrovets, Mt. Rebro, Mt. Hoverla, Mt. Breskulets, Mt. Pozhyzhevska, Mt. Dantser, Sarata; triangles — herbarium and literature data, left to right — Mt. Stinka, Volovets, Synevir, Mt. Pietros)

Deficient" (Malinovski et al., 2002). Previously, for Transcarpathia, according to Kricsfalusy (1999), *D. glomerata* subsp. *slovenica* was classified as a IV (rare) category of rarity and included in the Regional Red List. However, since new records are regularly reported (e.g. Mt. Pozhyzhevska, Mt. Rebro, Mt. Nehrovets), the current data on distribution of this taxon in the Ukrainian Carpathians and its ecological and coenotic characteristics need to be updated and supplemented.

Moreover, the spread of many rare and rarely reported species of plants and plant communities in the Carpathians has been significantly affected by the recent decline in grazing intensity and ongoing climate change (Hlásny et al., 2016; Kobiv et al., 2017; Kobiv, 2018; Kobiv, Kobiv, 2020; Kyyak et al., 2022). Another threat to *D. glomerata* subsp. *slovenica* is the colonizing of its habitats by *Alnus alnobetula* (Ehrh.) K. Koch (*A. viridis* (Chaix) DC.) due to secondary successions (Blažkova, Březina, 2003; Kyyak et al., 2018) that often results in reduced population viability or even its local extirpation.

These factors emphasize the importance of comprehensive studies on the current distribution and abundance of *D. glomerata* subsp. *slovenica* in the Ukrainian Carpathians, its vulnerability, and implementing the relevant conservation measures, wherever needed. Therefore, the aim of this article is to provide data on the distribution patterns, ecological and coenotic characteristics, and some demographic parameters of the populations of *D. glomerata* subsp. *slovenica*.

Materials and Methods

The objects of the present study were the habitats of *D. glomerata* subsp. *slovenica*, those known from earlier publications and the new ones discovered during our field research in the Ukrainian Carpathians (Fig. 1).

To study the distribution patterns, ecological and coenotic features, and existing threats to the habitats of *D. glomerata* subsp. *slovenica* were surveyed in the subalpine zone and at the upper forest

line in the Gorgany, Svydivetska, Chornohora, and Chyvchyny mountain ranges.

The research materials were collected in habitats of *D. glomerata* subsp. *slovenica* at Mt. Nehrovets, Mt. Rebro, Mt. Hoverla, Mt. Breskulets, Mt. Pozhyzhevska, Mt. Dantser, and near the village of Sarata. The specimens and observations were collected in one-time and long-term stationary surveys. The general contours of habitats, altitude, and exposure were determined. A list of associated vascular plants was compiled.

In the Chornohora Mts, the trial plots were established for a more detailed study of the main population parameters in localities on the slopes of Mt. Danzer, Mt. Breskulets, and Mt. Pozhyzhevska. To study the peculiarities of individual development, tufts of varying sizes and ages were excavated, the ramets werer counted, and the presence or absence of connections between them was assessed. The ratio of vegetative to reproductive plants in the population of *D. glomerata* subsp. *slovenica* was studied using the ontogenetic approach when every ramet was considered as a separate individual (Kyyak, 2013).

In small populations, a continuous count of individuals was carried out and their reproductive status was determined. In populations with an area of more than 500 m², the density and proportion of reproductive individuals were estimated on quadrats of 1 × 1 m in size in total of 10–14 units. To determine the prevailing mode of reproduction in the population, all seedlings and ramets were calculated on 0.25 m² quadrats. The sample size in each studied population was 8 to 10 quadrats.

To evaluate its dependence on soil parameters, 10 pre-reproductive (v) and 10 reproductive (g) individuals of *D. glomerata* subsp. *slovenica* were relocated outside the habitat with a substrate with a subacid or neutral pH to a similar elevation with a typical acidic brown forest soil (pH 3.5–3.7). The main physicochemical properties of the soils in the sample plots were studied using standard methods (Nikitin, 1972; Antonova et al., 1984; Mineev et al., 2001). The accepted names of associated vascular plants found in communities of *D. glomerata* subsp. *slovenica* are mainly given according to *Plants of the World Online* (https://powo.science.kew.org/).

Results and Discussion

Under the studied conditions, *D. glomerata* subsp. *slovenica* forms loose tufts with relatively short and slow-growing rhizomes. The integrity of the tuft is maintained at least until the plant reaches a reproductive state. Over time, the central part of the tuft gradually dies off, which leads to its partitioning. Subsequently, such parts function autonomously for an indefinitely long period, retaining the ability to vegetative and seed reproduction. The seed recruitment in most of the habitats found in the subalpine zone is episodic and during the observation period did not have a significant impact on the demographic parameters of *D. glomerata* subsp. *slovenica*. In the population near the village of Sarata (47°45'50.64"N, 24°59'30.68"E) seed reproduction is limited by regular hay cutting and it is fragmented and propagates mainly clonally. Seed reproduction is successful along small streams and wet ditches only.

The habitat on Mt. Pozhyzhevska is located in a narrow snowbed, has an elongated shape, and extends for 30 m along the southeast slope (48° 8'36.44"N, 24°31'43.02"E). Its width does not exceed 7 m. Most individuals of *D. glomerata* subsp. *slovenica* are concentrated in 2 loci measuring 9.0 × 1.5 m and 6 × 3 m. The latter one, for example, stably contains only 5 clones. The largest of them reaches almost 1 m in diameter with up to 52 vegetative ramets with an average value of 22.4 per clone in locus. The rest are fragments of old degrading clones or individuals of seed origin. Aging clones are often empty in the central part with weak shoots located mainly concentrically.

Dactylis glomerata subsp. *slovenica* in a plant community is most often accompanied by *Achillea millefolium* L., *Calamagrostis villosa* (Chaix) J.F. Gmel., *Cirsium waldsteinii* Rouy, *Cirsium erisithales* (Jacq.) Scop., *Deschampsia cespitosa* (L.) P. Beauv., *Epilobium angustifolium* L., *Filipendula ulmaria* (L.) Maxim., *Geranium sylvaticum* L., *Hypericum richeri subsp. grisebachii* (Boiss.) Nyman, *Luzula luzuloides* (Lam.) Dandy & Wilmott, *Rumex rugosus* Campd., *Senecio nemorensis* L., etc. (Table 1). Tree and shrub species — *Alnus viridis*, *Juniperus communis* subsp. *nana* (Baumg.) Syme., *Picea abies* (L.) H. Karst., and *Pinus mugo* Turra, are concentrated mainly on the periphery of the habitat.

According to the exposure and slope steepness, the habitat of *D. glomerata* subsp. *slovenica* at Mt. Rebro (48°15'36.60"N, 24°10'42.60"E) is similar to the habitat at Mt. Pozhyzhevska. The difference is that the area is subject to pastoral influence. The core of the population is located in the upper part of a narrow snowbed. The site is strictly bounded by

topographic, ecological, and coenotic conditions, which limits the population's possibilities for increasing its area and numbers.

The floristic composition of the plant community is typical for subalpine tall herb vegetation with a clear trend to increase the canopy thickness of *Alnus alnobetula* both in the central and peripheral zones of the habitat. Under such circumstances, the population of *D. glomerata* subsp. *slovenica* is divided into separate fragments. Seed and vegetative propagation are weakened here. Due to the current graze and secondary succession, the population is under threat of extinction.

In contrast to the previous two localities, the habitats of *D. glomerata* subsp. *slovenica* at Mt. Breskulets (48°9'21.50"N, 24°31'23.14"E) and Mt. Hoverla (48°9'38.13"N, 24°30'56.78"E) (in the Chornohora range) occupy a much larger area (about 21 ha in total) and cover almost the entire their southeast steep slope within the altitude range of 1400–1560 m a.s.l. The spatial structure of the population is determined by the features of the nano relief, the thickness of the topsoil cover, the size and configuration of rubble patches, snow accumulation, and groundwater outflow as well as occurrence of *Pinus mugo* and *Alnus alnobetula*. The most frequently occurring herbaceous plants in the habitat are *Adenostyles alliariae* (Gouan) A. Kern., *Calamagrostis villosa*, *Cirsium waldsteinii*, *Deschampsia cespitosa*, *Epilobium angustifolium*, *Hypericum richeri* subsp. *grisebachii*, *Luzula luzuloides*, *Pulmonaria filarszkyana* Jáv., and *Rumex alpinus* L.

The population on the southeastern slope of Mt. Dantser (48°8'33.10"N, 24°32'35.73"E) is located in the leveled area under the rocky ledges where interlayer waters enriched with compounds with an alkaline reaction come to the surface. Thus, in terms of humidity and soil parameters, it is similar to the Mt. Breskulets habitat. However, it is significantly smaller and amounts to about 0.1 ha.

Accompanying species of plants in the phytocenosis are *Achillea millefolium*, *Aconitum moldavicum*, *Alnus viridis*, *Calamagrostis villosa*, *Cirsium waldsteinii*, *Cirsium erisithales*, *Deschampsia cespitosa*, *Epilobium angustifolium*, *Filipendula. ulmaria*, *Geranium sylvaticum*, *Hypericum richeri* subsp. *grisebachii*, *Luzula luzuloides*, *Pinus mugo*, *Senecio nemorensis*, and others.

At Mt. Negrovets, the population of *D. glomerata* subsp. *slovenica* is located below the mountaintop (1620 m a.s.l.) in the upper part of the snowbed on the eroded northeastern slope (48°29'50.75"N, 23°43'2.23"E). In general, this habitat is comparable to those in Pozhyzhevska and Rebro Mts. This population is one of the smallest in terms of numbers and area (0.01 ha) and is under threat of soil erosion. As compared to other habitats, this habitat differs most in the species composition of the plant community.

The shape and size of the studied populations, in our opinion, are mainly determined by the soil properties, in particular, the low pH level of the soil outside the habitat.

To confirm this, a comparison of the main physicochemical parameters of soils within two different types of habitats of *D. glomerata* subsp. *slovenica* on the Pozhyzhevska and Breskulets mountains and outside these habitats was carried out (Table 2).

The soils inside the habitats of *D. glomerata* subsp. *slovenica* differs significantly in their physical and chemical properties from the widespread typical mountain brown soils (Dystric Cambisols) of the Chornohora range. Actual acidity (pH of aqueous solution) is 1.30–1.76 pH units lower with hydrolytic acidity 3.1–4.4 mg-eq/100 g, and the degree of base saturation is up to 13 times higher at average than in the typical brown soil. The amounts of absorbed bases in terms of quantitative content are similar. However, in terms of qualitative composition, the studied soils contain 5–10 times less exchangeable Al and, accordingly, several times more exchangeable Ca and Mg than typical brown soils in the Chornohora range in general (Table 2). It can be assumed that the soils on the test sites belong to the subtype of poorly developed loamy saturated soils (Eutric Regosols). This type of sub-acidic soil with a pH of 5–6 occupies small areas and is limited to the sites with increased migration of ground and/or interlayer waters enriched with neutral or alkaline compounds (Skiba et al., 2006).

Such differences in substrate parameters have a substantive impact on *D. glomerata* subsp. *slovenica*. Within the habitat, under optimal conditions (an open, reasonably moist site with a relatively deep soil and a neutral or alkaline reaction), an adult plant can have up to 20–40 vegetative and generative ramets in total. On acidic soils, the ontogenesis of *D. glomerata* subsp. *slovenica* is intensively simplified, and plants lose the ability to acquire characteristics typical of adult individuals. In particular, plants transplanted outside the habitat on acidic soils (Dystric Cambisols) quickly reduced

Table 1. **List of plant species in the localities of *Dactylis glomerata* subsp. *slovenica***

Taxon \ Location	Mt. Breskulets 1400–1560 m a.s.l.	Mt. Pozhyzhevska 1610 m a.s.l.	Mt. Dantser, 1520 m a.s.l.	Mt. Rebro 1370–1450 m a.s.l.	Mt. Nehrovets 1630 m a.s.l.
Alchemilla glabra Neygenf.	+	+	+	+	+
Achillea millefolium L. s. l.	+	+	+		
Aconitum moldavicum Hacq.	+				
Aconitum bucovinense Zapał.	+	+			
Adenostyles alliariae (Gouan) A. Kern.	+		+		
Agrostis capillaris L.	+		+		
Alnus alnobetula (Ehrh.) K. Koch (*A. viridis* (Chaix) DC.)	+	+	+	+	+
Angelica sylvestris L.	+				
Aquilegia vulgaris L.	+				+
Astrantia major L.	+		+	+	
Calamagrostis villosa (Chaix) J.F. Gmel.	+	+	+	+	+
Carduus kerneri Simonk.	+			+	
Centaurea kotschyana Heuff.					+
Centaurea maramarosiensis (Ják.) Czerep.	+	+	+		
Chaerophyllum hirsutum L.	+	+	+		+
Cicerbita alpina (L.) Wallr.	+				
Cirsium arvense (L.) Scop.				+	
Cirsium erisithales (Jacq.) Scop.	+			+	
Cirsium waldsteinii Rouy	+	+	+		+
Cotoneaster integerrimus Medik.				+	
Daphne mezereum L.				+	
Deschampsia cespitosa (L.) P. Beauv.	+	+	+	+	+
Digitalis grandiflora Mill.				+	
Doronicum austriacum Jacq.	+		+		
Epilobium alpestre (Jacq.) Krock.	+		+		
Epilobium angustifolium L.	+	+	+		+
Filipendula ulmaria (L.) Maxim.	+	+	+	+	+
Galium intermedium Schult.				+	
Gentiana acaulis L.	+				
Gentiana asclepiadea L.	+		+		+
Gentianella praecox (A. Kern. & Jos. Kern.) Dostál ex E.Mayer	+			+	
Geranium sylvaticum L.	+	+	+	+	+
Geum rivale L.				+	
Heracleum sphondylium subsp. *transsilvanicum* (Schur) Brummitt	+				
Homogyne alpina (L.) Cass.	+	+	+		
Hylotelephium vulgare (Haw.) Holub	+		+	+	
Hypericum richeri subsp. *grisebachii* (Boiss.) Nyman	+	+	+	+	
Jacobaea subalpina (W.D.J. Koch) Pelser & Veldkamp	+		+		
Juniperus communis subsp. *nana* (Baumg.) Syme.	+	+	+	+	+
Knautia dipsacifolia Kreutzer	+			+	
Lactuca alpina (L.) A. Gray	+		+		
Laserpitium krapfii Crantz	+		+		
Leucanthemum vulgare Lam.				+	
Leucopoa carpatica (F. Dietr.) H. Scholz	+		+		

Table 1 **(continued)**

Taxon \ Location	Mt. Breskulets 1400–1560 m a.s.l.	Mt. Pozhyzhevska 1610 m a.s.l.	Mt. Dantser, 1520 m a.s.l.	Mt. Rebro 1370–1450 m a.s.l.	Mt. Nehrovets 1630 m a.s.l.
Lilium martagon L.	+	+	+		+
Linum extraaxillare Kit				+	
Lolium apenninum (De Not.) Ardenghi & Foggi			+		
Luzula luzuloides (Lam.) Dandy & Wilmott	+	+	+		+
Myosotis alpestris F.W. Schmidt				+	
Parnassia palustris L.			+	+	
Picea abies (L.) H. Karst.	+	+	+		
Pinus mugo Turra	+	+	+		
Pleurospermum austriacum (L.) Hoffm.	+				
Poa chaixii Vill.	+		+		
Polygonatum verticillatum (L.) All.	+				
Potentilla aurea L.	+				
Prunella vulgaris L.				+	
Pulmonaria filarszkyana Jáv.	+		+		
Ranunculus platanifolius L.	+		+		
Rubus idaeus L.	+	+	+		+
Rumex acetosa L.				+	
Rumex alpinus L.	+			+	
Rumex rugosus Campd.	+	+	+		
Salix caprea L.	+	+	+	+	
Salix silesiaca Willd.	+	+	+	+	
Sambucus racemosa L.	+		+	+	
Scabiosa lucida subsp. *barbata* Nyár.	+				
Senecio nemorensis L.	+	+	+	+	
Silene dioica (L.) Clairv.	+		+	+	
Silene pusilla Waldst. & Kit.		+		+	
Solidago virgaurea subsp. *minuta* (L.) Arcang.	+	+			
Symphytum cordatum Waldst. & Kit. ex Willd.	+	+	+		
Symphytum tuberosum L.					+
Tanacetum corymbosum (L.) Sch. Bip.				+	
Taraxacum sect. *Taraxacum* (*Taraxacum officinale* F.H. Wigg. agg.)	+	+	+	+	
Tephroseris papposa (Rchb.) Schur				+	
Thalictrum thalictroides (L.) A.J. Eames & B. Boivin	+				
Thymus alpestris Tausch ex A. Kern.				+	+
Traunsteinera globosa (L.) Rchb.	+				
Tussilago farfara L.	+	+	+	+	+
Urtica dioica L.	+	+	+		
Vaccinium myrtillus L.	+	+	+	+	+
Valeriana dioica subsp. *simplicifolia* (Rchb.) Nyman	+				
Valeriana tripteris L.	+	+	+		+
Veronica urticifolia Jacq.				+	
Viola declinata Waldst. & Kit.	+				+

Table 2. **Physicochemical properties of soil inside and outside habitats of *Dactylis glomerata* subsp. *slovenica* in the Chornohora Mts.**

Location	Soil	Depth, cm	pH H_2O	C organic, %	Sum of exchangeable bases	Hydrolytic acidity	Base saturation, %
					mg-eq/100 g		
Mt. Pozhyzhevska	Eutric Regosols	0–7	5.25	6.00	18.00	4.50	80.00
Mt. Breskulets	Eutric Regosols	0–5	5.70	2.30	18.10	3.10	85.50
Mt. Pozhyzhevska	Dystric Cambisols	0–7*	3.94*	14.33*	3.92*	56.96*	6.44*

* According to Kozlovskyy (2017)

the activity of vegetative renewal and did not form rhizome daughter plants, lost the ability to produce generative shoots, and died within 2–3 years.

Conclusion

Dactilis glomerata subsp. *slovenica* in the Ukrainian Carpathians occurs as isolated populations in all main mountain ranges up to 1620 m a.s.l. Optimal for *D. glomerata* subsp. *slovenica* are the phytocoenotic conditions of tall herb communities of the subalpine belt at the altitudes of 1400–1600 m a.s.l., which Malynovski and Kricsfalusy (2002) attributed to the class *Mulgedio-Aconitetea*. Most populations are self-sustainable with an adequate proportion of generative individuals, and regular fruiting, but with the predominance of vegetative reproduction. The sites with access to groundwater seeps, snowbeds, banks of streams, and rivers are typical. The distribution and size of each separate population are limited to sub-acidic or neutral pH and sufficiently moistured soils. The predominance of acidic soils in the region explains the characteristics and relatively limited distribution of *D. glomerata* subsp. *slovenica* in the Ukrainian Carpathians, and the conservativeness of the size and shape of the population area. Since *D. glomerata* subsp. *slovenica* is strongly confined to moist habitats, the decrease in groundwater and the duration and thickness of the snow cover in the winter period may pose a threat to a population. The main threat to populations of *D. glomerata* subsp. *slovenica* are the secondary successions caused by a complex of natural and man-induced (anthropic) factors that decrease grazing and climate change, reduce atmospheric precipitation, and, in some cases, also soil erosion.

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The first two authors, Volodymyr Bilonoha and Volodymyr Kyyak, dedicate the final version of this article to our late co-author Volodymyr Kozlovskyy, who sacrificed his life for the freedom of Ukraine in a battle against Russian aggressors (see Stone, 2024). He died in action on 19 June 2023 during a combat mission near the village of Yampolivka, Donetsk Region, southeastern Ukraine. By the Decree of the President of Ukraine of 8 November 2023, Volodymyr Kozlovskyy was awarded (posthumously) with the Order for Courage for his personal courage in protecting the state sovereignty and territorial integrity of Ukraine and his selfless performance of military duties.

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ETHICS DECLARATION

The authors declare no conflict of interest.

ORCID

V.M. Bilonoha: https://orcid.org/0000-0003-0387-6828
V.H. Kyyak: https://orcid.org/0000-0002-0364-4157
V.I. Kozlovskyy: https://orcid.org/0000-0002-2401-3178

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Особливості поширення *Dactylis glomerata* subsp. *slovenica* (*Poaceae*) в Українських Карпатах

В.М. БІЛОНОГА, В.Г. КИЯК, В.І. КОЗЛОВСЬКИЙ
Інститут екології Карпат НАН України,
Козельницька 4, Львів 79026, Україна

Реферат. *Dactylis glomerata* subsp. *slovenica* (*Poaceae*) поширений в Альпах, Карпатах, Судетах, Карконошах та прилеглих передгір'ях. Окремі місцезнаходження відомі також на півночі Апеннін, у передгір'ях Французьких Піренеїв, на Балканах і Кавказі, а також зрідка за межами згаданих гірських систем у Польщі, Німеччині, Франції та Україні. В Українських Карпатах підвид представлений ізольованими популяціями в усіх основних гірських масивах висотою до 1620 м н.р.м., надаючи перевагу високотравним угрупованням субальпійського поясу. Приуроченість *D. glomerata* subsp. *slovenica* до нейтральних або слабокислих ґрунтів обмежує його поширення на нові території за межі існуючих оселищ. Основними стримуючими чинниками для таксона є географічна ізоляція, параметри субстрату та вторинні сукцесії, які пов'язані з експансією *Alnus alnobetula*. Натомість, зменшення випасу чи інтенсивності сінокосіння можуть мати позитивний вплив на чисельність популяцій у межах існуючих локалітетів або сприяти його поширенню на території з відповідними ґрунтовими умовами.

Ключові слова: *Dactylis slovenica*, екологія, Карпати, поширення, Україна