



Original Scientific Paper

The distribution of alien species *Geranium sibiricum* in Slovakia

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ABSTRACT:

The paper presents data on the distribution and spread of the alien vascular plant species *Geranium sibiricum* in Slovakia. Greater attention should be given to the existing data on its chorology and habitat preferences in the country. Some pertinent records are dispersed in various local literature sources and herbaria. In Slovakia, this alien species was recorded for the first time in 1924, but the significant increase in localities started after 1980. *G. sibiricum* has been found in 67 localities scattered irregularly throughout the Pannonian and Carpathian phytogeographical regions. It has been noted in a wide range of anthropogenic habitats at low to middle elevations. Recently, it has spread mainly in urban areas in eastern Slovakia and along railway tracks in northern and western Slovakia.

Keywords:

Central Europe, chorology, introduction, neophyte, Siberian Cranesbill, spreading, synanthropic habitats, traffic

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INTRODUCTION

Rapid advances in the availability of data regarding the diversity and ecology of alien plants and their distribution patterns have been observed in Europe over the last several decades. The improvement of theoretical knowledge has also led to the discovery of numerous new species records. The accumulated distribution data of alien species were thus subsequently revised and used in alien plant checklists published from local (national) to regional levels. For example, PYŠEK *et al.* (2017) reported 4,139 naturalized alien plant taxa in Europe, posing a potential threat to biodiversity. The first comprehensive revision of non-native plants in Slovakia comprised 916 vascular plant taxa, including 282 archaeophytes and 634 neophytes (MEDVECKÁ *et al.* 2012). This list has been continuously updated by numerous new records of neophyte species (MÁJEKOVÁ *et al.* 2021a; DUDÁŠ *et al.* 2022; ELIÁŠ *et al.* 2023).

Alien species originate mainly from cultivations of ornamental plants (PERGL *et al.* 2016a), but many others are unintentionally introduced into new territories through traffic and the transport of goods. The historical role of ship and railway transport in introducing and spreading species non-native to Europe has been gradually replaced by the dominant effect of road traffic (JEHLÍK 1998). Roads represent permanently disturbed human-made habitats. They favour the dispersal of alien plant species, including typical roadside species, such as *Atriplex micrantha* Ledeb., *A. oblongifolia* Waldst. et Kit., *A. sagittata* Borkh., *Dittrichia graveolens* (L.) Greuter and *Senecio inaequidens* DC. (GRIESE 1998; HOHLA & MELZER 2003; VERLOOVE 2006; BRANDES 2009, 2010; KOCIÁN 2014). There are also typical railway species (e.g. *Geranium purpureum* Vill.) which recently spread in some regions due to railway transport (MELZER 1990; RŮŽIČKA & KOBLÍŽEK 2009; ELIÁŠ 2011). However, these aforementioned alien species can gradually penetrate

other synanthropic and semi-natural habitats within the countryside. The distribution pattern of several alien species has been critically revised in Slovakia to date, e.g. *Sisyrinchium montanum* Greene (DUDÁŠ 2022) and *Xanthium spinosum* L. (DUDÁŠ & ELIÁŠ 2021); however, the historical and current chorology of Siberian Cranesbill (*Geranium sibiricum* L.) was largely ignored.

Geranium sibiricum (Geraniaceae) Sp. Pl.: 683, 1753, is a perennial densely hairy herb with a height of up to 60 cm and violet flowers accompanied by darker veins (TUTIN *et al.* 1968). Its natural range includes the temperate zone of Kazakhstan, Central Asia, southern Siberia, Mongolia, and northern Pakistan, and extends eastwards to China, Korea and northern Japan (MEUSEL & JÄGER 1992). It is also considered native to Eastern Europe (the Baltic countries, Belarus, and Ukraine), Romania, Turkey and the Caucasus, while in central, northern and western Europe, it is categorised as a naturalised neophyte (AEDO 2009). Its vegetation affinity in native regions includes forest margins, scrub and meadows, but this herb species also grows in anthropogenic sites (XU & AEDO 2008).

In Slovakia, the oldest record of *G. sibiricum* (Table 1) was published by JÁVORKA (1924). Subsequent findings were reported only sporadically (JASIČOVÁ 1982), with an increasing number of localities observed after 1980 (DOSTÁL 1980, 1985 and others). MEDVECKÁ *et al.* (2012) evaluated it as a naturalised neophyte with less than 15 known localities. However, the chorology of *G. sibiricum* in Slovakia remains poorly recognised and most of the relevant distribution data are dispersed in different literature sources and/or herbarium collections.

Therefore, we aimed to (i) present the current distribution of the species *G. sibiricum* in Slovakia using herbarium specimens, published records and data collected in the field, (ii) characterise its habitat preferences, and (iii) outline the trends of its spread.

MATERIALS AND METHODS

The recent distribution of *G. sibiricum* in Slovakia was revised in 2020–2022. The species occurrence was mapped using herbarium specimens deposited in most of the public Slovak and Czech herbaria. Herbarium specimens collected from the territory of Slovakia were found only in BBZ, HLO, KO, MOP, MPS, NI, and SAV. Floristic records from GJO (Germany) and W (Austria) were obtained from the JACQ – Virtual herbaria database (www.jacq.org). The herbarium acronyms follow THIERS (2023), and the acronyms of small local museum collections were unified according to VOZÁROVÁ & SUTORÝ (2001). All the studied herbarium records were completed by available public sources, such as wild nature photographic databases (FotoNet – www.fotonet.sk; www.nahuby.sk), the Central Phytosociological Database of Slovakia (CDF, <http://ibot.sav.sk/cdf>), published studies and relevant unpublished works or manuscripts

Table 1. The first records of alien *Geranium sibiricum* introduced and naturalised in several Central European countries.

Country	Year of first reliable record	Literature source
Austria	1873	WIESBAUER 1873
Czech Republic	1850	PYŠEK <i>et al.</i> 2022
Hungary	1947	SCHMIDT 2004
Poland	1840	TOKARSKA-GUZIĆ 2005
Slovakia	1924	JÁVORKA 1924

(mainly stored at the Institute of Botany, Plant Science and Biodiversity Center, Slovak Academy of Sciences, Bratislava, Slovakia). The substrate type was visually estimated during field research. The distribution map was prepared using ArcGis, version 9.2. The mapping grid follows the CEBA (Central European Basic Area) grid template described by NIKLFELD (1971), divided into quadrants of 5×3 arc minutes (corresponding to approximately 5.5×5.9 km).

List of localities. The localities are arranged according to their affiliation to phytogeographical districts (FUTÁK 1984). The name of the city (or village) is followed by its city part (if existing), the name of the street (abbreviated as “St.”), habitat, altitude (in m a.s.l.), and other available relevant information. The collectors (name and surname), year of collection, and acronyms of the herbarium collection for the herbarium specimens are given in parentheses. For published data, the author of the publication, journal abbreviation, and its volume is followed by a *G. sibiricum* record and year of publication. Recent findings without a specimen collection are shown with the name of the collector, the year of observation, and the abbreviation “not”.

RESULTS

In total, 67 localities of *G. sibiricum* have been recorded in Slovakia to date (Fig. 1). The species was recorded in four phytogeographical districts of the Pannonian (*Pannonicum*) and eight districts of the Carpathian (*Carpathicum*) regions. The elevation of the recorded localities ranged from 101 m to 570 m a.s.l. The species was reported only in a few localities (mainly railway stations) of western and north-western Slovakia (Bratislava, Hlohovec, and Martin), where it inhabited railway embankments and tracks or their nearest surroundings such as roadsides. Most of the localities for *G. sibiricum* were documented in eastern Slovakia, with many records situated in larger cities (e.g. Humenné, Košice, Michalovce, Prešov, and Spišská Nová Ves). The species mainly occurred in semi-natural and man-made habitats such as city lawns between blocks of flats and parks, fences and walls, roadsides, the edges of paths, road ditches,

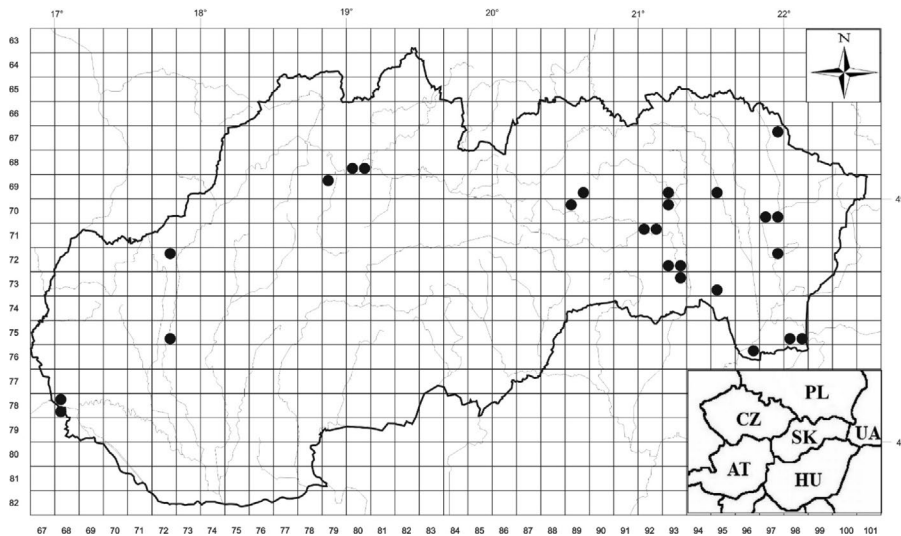


Fig. 1. Distribution map of *Geranium sibiricum* in Slovakia. The mapping grid follows the CEBA grid template. International country codes are abbreviated as follows: AT – Austria, CZ – Czech Republic, HU – Hungary, PL – Poland, SK – Slovakia, UA – Ukraine).

railway tracks, as well as various abandoned and ruderal sites. The analysis of habitat affinity indicated the preference of *G. sibiricum* for roadsides, the margins of paths, and road ditches (29%), followed by sunny and shaded lawns, gardens and orchards (25%) (Fig. 2). In contrast, it was rarely found in abandoned and ruderal habitats (3%) such as construction waste dumps, cracks in concrete, abandoned gardens or other types of ruderal sites (Fig. 2). The species usually grew in gravel and clay soil. The increasing number of localities observed in the last two decades (Fig. 3) originated primarily from eastern Slovakia (Fig. 1).

List of localities with *G. sibiricum* occurrence in Slovakia

Pannonicum

(*Eupannonicum*) **Devínska Kobyla Mts.:** Bratislava, Karlova Ves, Líščie údolie St. (Feráková, Acta Bot. Univ. Comenianae 50: 44, 2015). – Bratislava, Patrónka, Dúbravská cesta St., Institute of Botany SAS, garden (M. Jasičová 1979 SAV). **Podunajská nížina Lowland:** Hlohovec, Železničná St., the foot of the wall, 146 m (V. Feráková & R. Vavro 2010 HLO; Feráková in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 36/2: 252, 2014). – Nové Mesto nad Váhom, an old apple orchard near the dormitory of Slovlik company and behind the fence in the nearby area (Svobodová, Rosalia 14: 62, 1999). **Košická kotlina Basin:** Košice, Sever, St. Čermel'ská cesta 23a, a lawn near the roadside, 228 m (Dudáš, Bull. Slov. Bot. Spoločn. 43/1: 78, 2021). – Košice, Sever, Národná trieda Avenue no. 38, 214 m (V. Mikoláš 2007 W). – Košice, Sever, St. Obrancov Mieru 3, roadside (M. Dudáš 2022 KO). – Košice, Sever, the Vodárenská bus stop, lawn (Dudáš 2022 not.). – Košice, Sever, Pod Šiancom St., roadside (Dudáš 2022 not.). – Košice, Dargovských hrdinov, Jaltská St. 11,

lawn (Dudáš 2021 not.). – Košice, Rampová St., by the fence, 206 m (M. Dudáš 2022 KO). – Košice, railway station, 205 m (Májeková et al., Thaiszia – J. Bot. 26/2: 180, 2016). – Košice, Staré Mesto, Slovenskej Jednoty St., near the edge of Tyršovo nábrežie, lawn, 210 m (Dudáš 2022 not.). – Košice, Staré Mesto, Mestský park, lawn, frequent, 210 m (Dudáš 2021 not.). – Košice, Staré Mesto, Svätoplukova St., between the post office and railway station, 203–205 m (V. Mikoláš 2009 KO, W). – Košice, Staré Mesto, Thurzova St., near post office, 200 m (V. Mikoláš 2009 GJO, KO, W). – Košice, Staré Mesto, Bosákova St., near the school SOU Železničná, roadside, 206 m (M. Dudáš 2020 KO; Dudáš, l. c.). – Košice, Staré Mesto, Továrenská/Štefániková St., bus stop, 208 m (V. Mikoláš 2009 W, 2013 KO). – Košice, Staré Mesto, Protifašistických bojovníkov St., the Jakabov palác bus stop, 207 m (V. Mikoláš 2009 W). – Košice, Západ, Kremnická St., an abandoned area (J. Koperdákova 1997 KO; Koperdákova, Bull. Slov. Bot. Spoločn. 26: 58, 2004). – Košice, Juh, Rastislavova St., Old Hospital, on a fence in the park area, 205 m (V. Mikoláš 2009 GJO, W). – Košice, Juh, Žižkova St., opposite Tábořská St., 220 m (V. Mikoláš 2006 MOP, 2009 KO, W). – Košice, Juh, Nerudova St., under Winter Stadium, 218 m (V. Mikoláš 2009 W). – Košice, Krásna, Krásna gravel pit, a construction waste dump on the shore of the gravel pit, 194 m (M. Dudáš 2020 KO; Dudáš, l. c.). – Košice, Nad Jazerom, the edge of Dneperská St., next to the lake, the edge of the path under a hedge, 197 m (M. Dudáš 2020 KO; Dudáš, l. c.). – Košice, Vyšné Opátske, between the church and the orchard (V. Mikoláš 1999 KO). **Východoslovenská nížina Lowland:** Michalovce, Park Mieru, lawn, 117 m (M. Dudáš & J. Májeková 2022 KO). – Streda nad Bodrogom, gas storage (V. Mikoláš 1990 KO). – Dobrá, railway trans-shipment yard and cereal silo, 101 m (Jehlík et al., Tuexenia 37, Supplement 1, 2017). – Čierna nad Tisou, railway station, 102 m (Jehlík et al., l. c.).

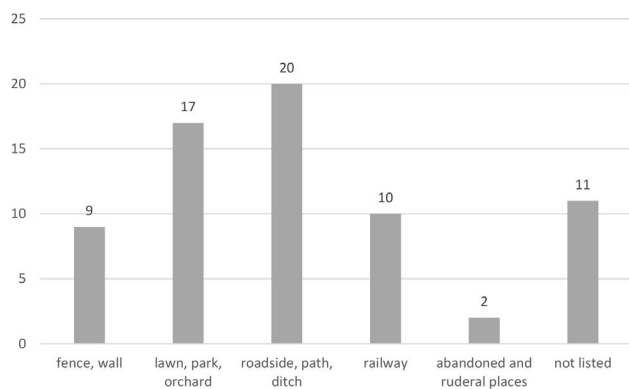


Fig. 2. The habitat preferences of *Geranium sibiricum* in Slovakia.

Carpathicum occidentale

(*Praecarpathicum*) **Malé Karpaty Mts.:** Bratislava, Révová St., the garden of the Department of Botany of Comenius University (D. R. Letz 1995 SAV). **Slovenské rudohorie Mts.:** Košice, Horný Bankov, the Horný Bankov bus stop, park area, 405 m (M. Dudáš 2022 KO). – Košice, Sever, Botanical Garden, near the path from the pool with a fountain towards the lower ponds, 225 m (Dudáš 2021, 2022 not.). **Stredné Pohornádie Region:** Margecany, railway station, 335 m (Prach in Mráz & Mrázová (eds), Bull. Slov. Bot. Spoločn. 25, Suppl. 9: 53, 2003; Kollár & Palaj in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 44/1: 110, 2022). – [former flooded village] Ružín, roadside (L. Dostál 1985 MPS; Dostál, Zborn. Východoslov. Múz. v Košiciach, príř. vedy 26: 162, 1985). – Malá Lodina, roadsides between the Ružín I. and Malá Lodina water reservoirs, 290–300 m (M. Dudáš 2022 KO). – Malá Lodina, the Ružín II hydroelectric power plant, roadside, 300 m (M. Dudáš 2022 KO). – Malá Lodina, the east end of the village, roadside, 270 m (M. Dudáš 2022 KO). **Slanské vrchy Mts.:** Veľký Šariš, Kanaš, Lúčna St., roadside, 277 m (M. Dudáš 2022 KO). – Hanušovce nad Topľou, roadside (Dostál, Zborn. Východoslov. Múz. v Košiciach, príř. vedy 25: 28, 1984). – Zemplínska Teplica, 0,7 km NE of the center, road ditch, 180 m (V. Mikoláš 2009 W).

(*Intracarpaticum*) **Turčianska kotlina Basin:** Martin, railway station, 397 m (R. Hrivnák 2011 SAV; Hrivnák in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 35/1: 80, 2013). – Turany, near the railway station, 400 m (J. Kochjarová 2011 BBZ; Kliment et al. in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 41/1: 94, 2019). – Krpeľany, railway station, 413 m. – Krpeľany, above the power plant at the roadside towards Nolčovo, 437 m (both data Škovirová in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 34/1: 112, 2012). – Krpeľany, road ditch near the church, 415 m (Koutecký in Kochjarová (ed.), Bull. Slov. Bot. Spoločn. 42, Suppl. 1: 77, 2020). **Spišské kotliny Basins:** Spišská Nová Ves, railway station, 465 m (Májeková et al., l. c.; Dudáš, l. c.). – Levoča, town walls, 566 m (R. Hrivnák 2012 SAV; Hrivnák in Eliáš jun., l.c.; Kerbčárová 2022

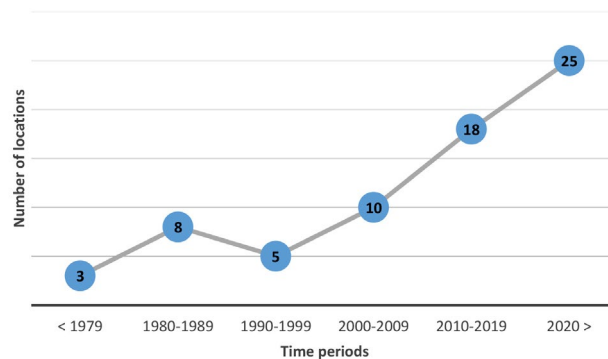


Fig. 3. The number of new localities of *Geranium sibiricum* in Slovakia in selected decades.

not.). – Levoča, parking space near the town walls, 570 m (Zaliberová & Májeková in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 36/1: 100, 2014). – Levoča, church of Saint Jakub. – Levoča, railway station. – Levoča, bus station. – Levoča, Ružová St. (all data Chrték & Chrtková, Čas. Nár. Múz. – řada příř. 151/4: 198, 1982). – Levoča, Kukučínova St., town walls near the crossroads with Sirotinská St., 560 m (P. Eliáš jun. 2017 NI).

(*Beschidicum orientale*) **Šarišská vrchovina Mts.:** Veľký Šariš, at the crossroads of Sabinovská and Staničná streets, lawn at the roadside, 266 m (M. Dudáš 2022 KO). – Prešov, Svätoplukova St., by the fence of an abandoned garden, 259 m (P. Eliáš jun. 2019 NI; Eliáš jun. in Eliáš jun. (ed.), Bull. Slov. Bot. Spoločn. 42/1: 94, 2020). – Prešov, Centre, Južný park, under a shrub, 258 m (M. Dudáš & M. Slezák 2021 KO). – Prešov, Lesík delostrelcov, lawn, 262 m (Dudáš & Slezák 2021 not.). – Prešov, St. Antona Prídavka, lawn, 251 m (M. Dudáš 2022 KO). – Prešov, railway station, rare, 240 m (Dudáš & Slezák 2021 not.). **Nízke Beskydy Mts:** Medzilaborce, railway station, 316 m (D. R. Letz 2014 SAV; M. Dudáš 2021 KO). – Humenné, Československej Armády St. 20, lawn (Dostál, Biológia 35/10: 759, 1980; L. Dostál 1986 MPS). – Humenné, Fidlíkova St., roadside (Dostál, Zborn. Východoslov. Múz. v Košiciach, príř. vedy 19: 43, 1978; Dostál, l. c. 1980). – Humenné, Hviezdoslavova St. (Dostál, Zborn. Východoslov. Múz. v Košiciach, príř. vedy 25: 28, 1984; Dostál, Biológia, ser. A 40/1: 91, 1985). – Humenné, at the crossroads of Školská and 1. mája streets, lawn, 155 m (Dudáš 2022 not.). – Humenné, Mestský cintorín, lawn between graves, 175 m (M. Dudáš 2022 KO). – Humenné, Lackovce, west of the village, on the left bank of the River Laborec near the bridge, exposed gravel banks and benches, 205 m (D. R. Letz 2014 SAV).

General data (not mapped):

Bratislava (Wiesbauer 1873, Jávorka 1924). – Humenné (L. Dostál 1977 SLO).

DISCUSSION

The genus *Geranium* consists of a total of 423 species (AEDO *et al.* 1998). Slovak flora currently comprises 19 species (LETZ *in litt.* 2023), including 11 native species, three naturalised archaeophytes (*G. dissectum* L., *G. molle* L., *G. pusillum* Burm. f.), three naturalised neophytes (*G. purpureum*, *G. pyrenaicum* Burm. f., *G. sibiricum*) and one casual neophyte (*G. tuberosum* L.; MEDVECKÁ *et al.* 2012). The most recent finding of *G. macrorrhizum* L. corresponds to the casual neophyte (ELIÁŠ *et al.* 2023). MEDVECKÁ *et al.* (2012) also mentioned *G. rotundifolium* L. as a species with uncertain residence status, but MÁJEKOVÁ *et al.* (2021b) re-evaluated it as native. Compared with other *Geranium* species, *G. sibiricum* is easily determined by its leaves deeply cleft into 3 to 5 palmate, lance-elliptic, sharply pointed lobes with sparsely hairy surfaces and coarsely toothed edges. Its flowers are single, white to light pink with darker lines radiating from the base. In its native range, *G. sibiricum* is classified as an apophyte (XU & AEDO 2008). The first record in Central Europe was reported from Poland in 1840 (TOKARSKA-GUZIĆ 2005). This perennial species is considered to be a naturalised neophyte (kenophyte) with the ability to penetrate various plant communities developed in urban areas (TOKARSKA-GUZIĆ *et al.* 2014; ZAJĄC & ZAJĄC 2019). The same species category is also reported from Hungary (BALOGH *et al.* 2004) and the Czech Republic (PYŠEK *et al.* 2022). It was included in the Czech Grey list, which grouped alien species with a limited negative impact on the environment (PERGL *et al.* 2016b). The first finding of *G. sibiricum* in the wild in Austria dates back to 1873 (Tab. 1), but the species was cultivated in a botanical garden from 1850 (WIESBAUER 1873). The species is naturalised in this country with a spreading tendency but low invasive potential (DRESCHER *et al.* 2012). It was originally considered indigenous to some Eastern European regions, especially in Romania, Ukraine, and southwestern Russia. However, its native occurrence in Ukraine was recently updated, where the species is considered an epocophyte due to its invasive spread throughout the country in ruderal and semi-natural or natural habitats (DOBROCHAJEVA 1955; PROTOPOPOVA *et al.* 2006). A similar situation was recognised in Romania, i.e. the previous classification of *G. sibiricum* in the extinct category was re-considered and newly interpreted in line with neophytic invasion following its reappearance (ANASTASIU & NEGREAN 2006). This species was also introduced to various states of the USA (AEDO 2001).

The earliest but unclear occurrence data of *G. sibiricum* in Slovakia was recorded from Bratislava (WIESBAUER 1873). Since the author provided no further description of plant origin or locality, the possibility of this record being from cultivation cannot be ruled out. Moreover, we admit that the locality of Bratislava

could also correspond to the affiliation of the collector Mr. Schneller, which was the standard format used in botanical studies at that time (for more details, see WIESBAUER 1873). The first reliable record of the species is thus ascribed to JÁVORKA (1924). Although he did not specify the habitat of the locality near Bratislava, DOSTÁL (1950) cited this record with a note about its supposed escape from cultivation. The increase in the number of new populations started in the towns of eastern Slovakia in the 1980s. New observations were documented, for example, in the cities of Humenné (DOSTÁL 1980), Levoča (CHRTEK & CHRTEKOVÁ 1982), Hanušovce nad Topľou (DOSTÁL 1984) and near the flooded village of Ružín (DOSTÁL 1985). In Košice, the first plants were collected by Koperdáková in 1994 (see KOPERDÁKOVÁ 2004). Recently published records are almost exclusively related to urban areas and railway junctions in eastern Slovakia (MRÁZ & MRÁZOVÁ 2003; JEHLÍK *et al.* 2017; DUDÁŠ 2021 and others cited herein), with only a few isolated reports in the Turčianska kotlina basin in central Slovakia (KLIMENT *et al.* 2019) and in Bratislava in the southwest of the country (FERÁKOVÁ 1999).

Our results suggest that the current chorology of *G. sibiricum* in Slovakia is most likely a consequence of spontaneous spread, as it usually occurs in synanthropic habitats in settlements or along anthropogenic landscape elements such as roads and railways. Our results thus coincide with the study of MEDVECKÁ *et al.* (2012), who evaluated it as a species of accidental introduction in Slovakia, occurring in human-made habitats. For example, the species grows in the area of the Botanical Garden of Pavol J. Šafárik in Košice, but there is no direct evidence that *G. sibiricum* was intentionally planted in the area (MÁRTONFI & MÁRTONFIOVÁ 2020). Although horticulture is the most important source and pathway for introducing alien plants (PERGL *et al.* 2016a), we are not aware of *G. sibiricum* cultivation in the horticulture trade for ornamental purposes in Slovakia and a similar situation has also been recognised in other European regions. PYŠEK *et al.* (2022) listed it as a species deliberately introduced to the Czech Republic, but TOKARSKA-GUZIĆ (2005) reported both unintentional and intentional introduction in Poland.

The habitat affinity of *G. sibiricum* in Slovakia follows the general patterns observed in other European countries. More specifically, there are numerous reports of railway habitats in Austria, the Czech Republic, Germany, Poland, and Ukraine (HOHLA *et al.* 1998, 2002, 2005; ŚWIĘS & WRZESIEŃ 2002; WRZESIEŃ 2006; HLISNIKOVSKÝ & KOCIÁN 2014; WRZESIEŃ *et al.* 2016; DENISOW *et al.* 2017; MAMCHUR *et al.* 2017), from where it can effectively spread to the surrounding habitats (WRZESIEŃ & DENISOW 2017). In addition to the man-made habitats reported from Austria (e.g. new ruderal areas, hedgerows, and mowed lawns), this species was also found in the countryside in alluvial forests (ESSL

& RABITSCH 2002). In Germany, it grows on the edges of hedges, and as an ornamental plant (HEGI 1924; JÄGER 2016). The spread of the species by road transport in southern Poland is indicated by its abundant occurrence along roads and adjacent ditches or garden fences (MIREK 1981). In Hungary, it occurs at various ruderal sites in settlements (e.g. by fences, along roads, railway lines, lawns and gardens) and sometimes in degraded forests (SCHMIDT 2004; SOMLYAY & CSÁBI 2019). It has also been recorded in various synanthropic habitats (including railway stations) and cultivated in several botanical gardens in the Czech Republic and Austria (SLAVÍK 1997; DRESCHER *et al.* 2012).

We concluded that *G. sibiricum* is rarely cultivated, but manages to escape into the wild. It has become naturalised in many countries and began its spread most often by railway and road transport. Its spreading tendency along the east-to-west gradient recognised in our study has also been found in other European regions (HOHLA *et al.* 1998, 2005; DRESCHER *et al.* 2012). The species reproduces and spreads by seed dispersal, indicating the possible spread via endo- and epizoochory (SCHMIDT 2004). Similarly, it shows great ecological adaptability; for example, it can withstand frequent mowing in cultivated lawns. The removal of seeds before ripening and mechanical weeding seems to be an effective approach to prevent its spread (DRESCHER *et al.* 2012). Despite the fact that the species is found in several European countries as a non-native species, it appears here as a naturalised species. It has not yet shown a tendency to behave invasively, and therefore does not pose a threat to the original flora/biodiversity in the near future.

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REFERENCES

- AEDO C. 2001. The genus *Geranium* L. (Geraniaceae) in North America. II Perennial species. *Anales del Jardín Botánico de Madrid* **59**: 3–65.
- AEDO C. 2009. *Geranium*. In: AEDO C, ESTÉBANEZ B & NAVARRO C (eds.), with contributions from RAAB-STRAUBE E VON & PAROLLY G. *Geraniaceae*. Euro+Med Plantbase – the information resource for Euro-Mediterranean plant diversity.
- AEDO CF, MUÑOZ GARMENDIA F & PANDO F. 1998. World checklist of *Geranium* L. (Geraniaceae). *Anales del Jardín Botánico de Madrid* **56**(2): 211–252.
- ANASTASIU P & NEGREAN G. 2006. Alien vascular plants in Dobrogea (Romania) and their impact on different types of habitats. In: IVANOVA D (ed.), *Plant, fungal and habitat diversity investigation and conservation*, pp. 590–596, Proceedings of IV BBC, Sofia.
- BALOGH L, DANCZA I & KIRÁLY G. 2004. A magyarországi neofitonok időszerű jegyzéke, és besorolásuk inváziós szempontból. In: MIHÁLY B & BOTTA-DUKÁT Z (eds.), *Biológiai inváziók Magyarországon: Özönnövények*, pp. 61–92, Természet BÚVÁR Alapítvány Kiadó, Budapest.
- BRANDES D. 2009. Autobahnen als Wuchsorte und Ausbreitungsweg von Ruderal- und Adventivpflanzen. *Braunschweiger Naturkundliche Schriften* **8**(2): 373–394.
- BRANDES D. 2010. *Geranium sibiricum* als Neophyt in Osttirol. *Floristische Rundbriefe* **43**: 52–64.
- CHRTEK J & CHRTEKOVÁ A. 1982. Další lokalita *Geranium sibiricum* na Slovensku. *Journal of the National Museum (Prague), Natural History Series* **151**(4): 198.
- DENISOW B, WRZESIEŃ M, MAMCHUR Z & CHUBA M. 2017. Invasive flora within urban railway areas: a case study from Lublin (Poland) and Lviv (Ukraine). *Acta Agrobotanica* **70**(4): 1727.
- DOBROCHAIEVA DM. 1955. *Geranium* L. In: KLOKOV MV & VISULINA OD (eds.), *Flora of Ukrainian SSR* **7**, pp. 6–32, the USSR Academy of Sciences Press, Kyiv.
- DOSTÁL J. 1950. *Květena ČSR*. Nakl. Přírodovědec, Praha.
- DOSTÁL L. 1980. *Geranium sibiricum* L. v Humennom. *Biológia* **35**(10): 759–760.
- DOSTÁL L. 1984. K výskytu niektorých adventívnych druhov flóry východného Slovenska. *Zborník Východoslovenského Múzea v Košiciach, Prírodné Vedy* **25**: 25–34.
- DOSTÁL L. 1985. Floristické poznámky z okolia Ružinskej priehrady. *Zborník Východoslovenského Múzea v Košiciach, Prírodné Vedy* **26**: 161–164.
- DRESCHER A, LECHNER M & BERG C. 2012. Pflanzen mit invasivem Potenzial in Botanischen Gärten III: *Geranium sibiricum* (Geraniaceae). *Carinthia II* **202**(122): 33–46.
- DUDÁŠ M. 2021. Komentovaný prehľad zaujímavejších floristických nálezov z východného Slovenska II. *Bulletin Slovenskej Botanikkej Spoločnosti* **43**(1): 75–89.
- DUDÁŠ M. 2022. Naturalisation of Strict blue-eyed grass *Sisyrinchium montanum* Greene (Iridaceae) in Slovakia. *BioInvasions Records* **11**(2): 312–319.
- DUDÁŠ M & ELIÁŠ P JR. 2021. Alien weed *Xanthium spinosum* in Slovakia I: distribution and habitats. *Journal of Central European Agriculture* **22**: 305–316.
- DUDÁŠ M, KIRÁLY G, KOBIV Y & PLISZKO A. 2022. New floristic records from Central Europe 9 (reports 122–133). *Thaiszia – Journal of Botany* **32**(1): 81–90.
- ELIÁŠ P JR. 2011. *Geranium purpureum* Vill. – new alien species to the Slovak flora. *Thaiszia – Journal of Botany* **21**: 21–28.
- ELIÁŠ P JR, MÁJEKOVÁ J, HEGEDŮŠOVÁ K, DUDÁŠ M, LETZ DR, MEREĎA P JR, BAKAY L, ČEJKA T, DÍTĚ D, DÍTĚ Z, ĎURIŠOVÁ L, GREGOREK R, KIRÁLY G, MÁRTONFIOVÁ L, MÁRTONFI P, SPANYIK F, SVITKOVÁ I & HRIVNÁK R. 2023. New alien vascular plants of Slovakia: records from 2008–2021. *BioInvasions Records* **12**: 1–30.
- ESSL F & RABITSCH W. 2002. *Neobiota in Österreich*. Umweltbundesamt, Wien.
- FÉRÁKOVÁ V. 1999. Invázne a expanzívne druhy vyšších rastlín v Bratislave (s dôrazom na chránené územia). In: ELIÁŠ P (ed.), *Invázie a invázne organizmy* **2**, pp. 135–147, SEKOS, Nitra.
- FUTÁK J. 1984. Fytogeografické členenie Slovenska. In: BERTOVIČ L (ed.), *Flóra Slovenska IV/I*, pp. 418–420, Veda, Bratislava.
- GRIESE D. 1998. Die viatische Migration einiger neophytischer Pflanzensippen am Beispiel norddeutscher Autobahnen. *Braunschweiger Geobotanische Arbeiten* **5**: 263–270.

- HEGI G. 1924. *Illustrierte Flora von Mittel-Europa*. Band 4, Teil 3, München, J. F. Lehmanns Verlag.
- HLISNIKOVSKÝ D & KOČIÁN P. 2014. Poznámky k adventivní flóře severní Moravy a Slezska 3. *Geranium rotundifolium*. *Acta Musei Beskidensis* 6: 69–76.
- HOHLA M, KLEESADL G & MELZER H. 1998. Floristisches von den Bahnanlagen Oberösterreichs. *Beiträge zur Naturkunde Oberösterreichs* 6: 139–301.
- HOHLA M, KLEESADL G & MELZER H. 2002. Neues zur Flora der oberösterreichischen Bahnanlagen – mit Einbeziehung einiger Bahnhöfe Bayerns – Fortsetzung. *Beiträge zur Naturkunde Oberösterreichs* 11: 507–578.
- HOHLA M, KLEESADL G & MELZER H. 2005. Neues zur Flora der oberösterreichischen Bahnanlagen. *Beiträge zur Naturkunde Oberösterreichs* 14: 147–199.
- HOHLA M & MELZER H. 2003. Floristisches von den Autobahnen der Bundesländer Salzburg, Oberösterreich, Niederösterreich und Burgenland. *Linzer Biologische Beiträge* 35(2): 1307–1326.
- JÄGER EJ. (ed.) 2016. *Rothmaler – Exkursionsflora von Deutschland. Gefäßpflanzen: Grundband* 21. Springer-Verlag, Berlin, Heidelberg.
- JASIČOVÁ M. 1982. Geraniaceae Juss. Pakostovitě. In: FUTÁK J & BERTOVÁ L (eds.), *Flóra Slovenska* 3, pp. 476–508, Veda, Bratislava.
- JÁVORKA S. 1924. *Magyar flóra*. Budapest.
- JEHLÍK V. (ed.) 1998. *Cizí expanzivní plevele České republiky a Slovenské republiky*. Academia, Praha.
- JEHLÍK V, ZALIBEROVÁ M & MÁJEKOVÁ J. 2017. The influence of the Eastern migration route on the Slovak flora – a comparison after 40 years. *Tuexenia* 37: 313–332.
- KLIMENT J, BERNÁTOVÁ D & KOCHJAROVÁ J. 2019. *Geranium sibiricum* [report], p. 94. In: ELIÁŠ P JR (ed.), *Zaujímavější floristické nálezy*. *Bulletin Slovenskej Botanickéj Spoločnosti* 41(1): 89–98.
- KOCIÁN P. 2014. Nezpozorované a rýchle šírenie lebedy rúznosemenné (*Atriplex micrantha*) a omanu smradlavého (*Dittrichia graveolens*) na dálnicích Moravy a Slezska (Česká republika). *Acta Musei Beskidensis* 6: 27–47.
- KOPERDÁKOVÁ J. 2004. Príspevok k synantropnej flóre mesta Košice. *Bulletin Slovenskej Botanickéj Spoločnosti* 26: 53–60.
- MÁJEKOVÁ J, JAROLÍMEK I, ZALIBEROVÁ M & MEDVEČKÁ J. 2021a. Alien (invasive) vascular plants in Slovakia – a story of successful plant immigrants. *Environmental & Socio-economic Studies* 9: 23–31.
- MÁJEKOVÁ J, LETZ DR & MEREĎA P JR. 2021b. Zaujímavější nálezy cievnatých rastlín na území Bratislavy. Časť 1. *Bulletin Slovenskej Botanickéj Spoločnosti* 43: 21–73.
- MAMCHUR Z, CHUBA M & DRACH YU. 2017. Mosses and vascular plants on railway tracks in the Lviv city. *Visnyk of Lviv University – Biological Series* 75: 54–65.
- MÁRTONFI P & MÁRTONFIOVÁ L. 2020. *Catalogue of plant collections*. No. 7. Košice, Slovakia. Available at: <https://www.upjs.sk/public/media/13235/catalogue-of-plant-collections-2020.pdf> [Accessed 10 November 2022]
- MEDVEČKÁ J, KLIMENT J, MÁJEKOVÁ J, HALADA L, ZALIBEROVÁ M, GOJDIČOVÁ E, FERÁKOVÁ V & JAROLÍMEK I. 2012. Inventory of the alien flora of Slovakia. *Preslia* 84: 257–309.
- MELZER H. 1990. *Geranium purpureum* Vill., der Purpur-Storchschnabel – neu für die Flora von Österreich und *Papaver confine* Jord., ein neuer Mohn für die Steiermark. *Verhandlungen des Zoologisch-Botanischen Vereins in Wien* 127: 161–164.
- MEUSEL H & JÄGER EJ. 1992. *Vergleichende Chorologie der zentraleuropäischen Flora*. Band 3. Gustav Fischer Verlag Jena, Stuttgart.
- MIREK Z. 1981. *Geranium sibiricum* L. – rzadki w Polsce gatunek synantropijny. *Fragmenta Floristica et Geobotanica* 26: 251–257.
- MRÁZ P & MRÁZOVÁ V. 2003. Flóra Volovských vrchov a príľahlej časti Braniska, Čiernej Hory a Hornádskej kotliny. *Bulletin Slovenskej Botanickéj Spoločnosti* 25 (Suppl. 9): 1–76.
- NIKLFIELD H. 1971. Bericht über die Kartierung der Flora Mitteleuropas. *Taxon* 20: 545–571.
- PERGL J, SÁDLO J, PETŘÍK P, DANIHELKA J, CHRTEK J JR, HEJDA M, MORAVCOVÁ L, PERGLOVÁ I, ŠTAJEROVÁ K & PYŠEK P. 2016a. Dark side of the fence: ornamental plants as a source of wildgrowing flora in the Czech Republic. *Preslia* 88: 163–184.
- PERGL J, SÁDLO J, PETRUSEK A, LAŠTŮVKA Z, MUSIL J, PERGLOVÁ I, ŠANDA R, ŠEFROVÁ H, ŠÍMA J, VOHRALÍK V & PYŠEK P. 2016b. Black, Grey and Watch Lists of alien species in the Czech Republic based on environmental impacts and management strategy. *NeoBiota* 28: 1–37.
- PROTOPOPOVA VV, SHEVERA MV & MOSYAKIN MS. 2006. Deliberate and unintentional introduction of invasive weeds: A case study of the alien flora of Ukraine. *Euphytica* 148: 17–33.
- PYŠEK P, PERGL J, ESSL F, LENZNER B, DAWSON W, KREFT H, WEIGELT P, WINTER M, KARTESZ J, NISHINO M & ANTONOVA LA. 2017. Naturalized alien flora of the world: species diversity, taxonomic and phylogenetic patterns, geographic distribution and global hotspots of plant invasion. *Preslia* 89: 203–274.
- PYŠEK P, SÁDLO J, CHRTEK J JR, CHYTRÝ M, KAPLAN Z, PERGL J, POKORNÁ A, AXMANOVÁ I, ČUDA J, DOLEŽAL J, DŘEVOJAN P, HEJDA M, KOČÁR P, KORTZ A, LOSOSOVÁ Z, LUSTYK P, SKÁLOVÁ H, ŠTAJEROVÁ K, VEČEŘA M, VÍTKOVÁ M, WILD J & DANIHELKA J. 2022. Catalogue of alien plants of the Czech Republic (3rd edition): species richness, status, distributions, habitats, regional invasion levels, introduction pathways and impacts. *Preslia* 94: 447–577.
- RŮŽIČKA V & KOBLÍŽEK J. 2009. Kakost nachový (*Geranium purpureum*), nový druh pro květenu České republiky. *Zprávy České Botanické Společnosti* 44: 23–27.
- SCHMIDT D. 2004. A szibériai gólyaorr (*Geranium sibiricum* L.) előfordulása Magyarországon. *Flora Pannonica* 2(2): 57–67.
- SLAVÍK B. 1997. Verbreitung von *Geranium*-Arten (subgen. *Geranium*) in Tschechien. *Preslia* 68: 305–321.
- SOMLYAY L & CSÁBI M. 2019. Adatok Budapest környéke flórájának ismeretéhez III. *Kitaibelia* 24(2): 227–237.
- ŚWIĘS F & WRZESIEŃ M. 2002. Rare vascular plants of the railway areas in Central-Eastern Poland. I. Lublin Upland, eastern part, Roztocze, Volhynia Upland. *Annales Universitatis Mariae Curie-Skłodowska, Sectio C* 57: 95–117.
- THIERS B. 2023. *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium, New York. Available at: <http://sweetgum.nybg.org/ih> [Accessed 25 October 2022]
- TOKARSKA-GUZIĆ B. 2005. *The establishment and spread of alien plant species (kenophytes) in the flora of Poland*. Wydawnictwo Uniwersytetu Śląskiego, Katowice.
- TOKARSKA-GUZIĆ B, DAJDOK Z, ZAJĄC M, ZAJĄC A, URBISZ A, DANIELEWICZ W & HOŁDYŃSKI C. 2014. *Rośliny obcego pochodzenia w Polsce ze szczególnym uwzględnieniem gatunków inwazyjnych*. Generalna Dyrekcja Ochrony Środowiska, Warszawa.

- TUTIN TG, HEYWOOD VH, BURGESS NA, MOORE DM, VALENTINE DH, WALTERS SM & WEBB DA. (eds) 1968. *Flora Europaea* 2. Cambridge University Press.
- VERLOOVE F. 2006. *Atriplex micrantha*, een nieuwe neofyt langs belangrijke verkeerswegen in België. *Dumortiera* 88: 15–20.
- VOZÁROVÁ M & SUTORÝ K. 2001. Index herbariorum Reipublicae bohemicae et Reipublicae slovacae. *Bulletin Slovenskej Botanickéj Spoločnosti* 23(Suppl. 7): 1–95.
- WIESBAUER J. 1873. Zur Flora von Niederösterreich. *Verhandlungen der Zoologisch-Botanischen Gesellschaft in Österreich* 23: 543–546.
- WRZESIEŃ M. 2006. Kenophytes chorologically related to the habitats of railway grounds in central eastern Poland. *Biodiversity Research and Conservation* 1–2: 92–94.
- WRZESIEŃ M & DENISOW B. 2017. Factors responsible for the distribution of invasive plant species in the surroundings of railway areas. A case study from SE Poland. *Biologia* 72(11): 1275–1284.
- WRZESIEŃ M, DENISOW B, MAMCHUR Z, CHUBA M & RESLER I. 2016. Composition and structure of the flora in intra-urban railway areas. *Acta Agrobotanica* 69(3): 1666.
- XU L & AEDO C. 2008. Geraniaceae. In: WU Z & RAVEN PH (eds.), *Flora of China* 11: Oxalidaceae through Aceraceae, pp. 7–30, Missouri Botanical Garden Press, Beijing.
- ZAJĄC A & ZAJĄC M. (eds.) 2019. *Distribution Atlas of Vascular Plants in Poland: Appendix*. Institute of Botany, Jagiellonian University, Kraków.

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SERBICA

Rasprostranjenje strane vrste *Geranium sibiricum* u Slovačkoj

Matej DUDÁŠ, Jana MÁJEKOVÁ i Michal SLEZÁK

U radu su prikazani podaci o rasprostranjenosti i širenju strane vrste *Geranium sibiricum* u Slovačkoj. Podatke o njenoj horologiji i preferencijama staništa u zemlji treba još uvek bolje upoznati. Neki relevantni zapisi postoje u lokalnim literaturnim izvorima i herbarijumima. U Slovačkoj je ova strana vrsta prvi put zabeležena 1924. godine, ali je značajan porast lokaliteta počeo posle 1980. *Geranium sibiricum* je pronađen na 67 lokaliteta nepravilno raspoređenih u panonskom i karpatskom fitogeografskom regionu. Zabeležen je na širokom spektru antropogenih staništa na niskim do srednjim nadmorskim visinama. Nedavno se proširio uglavnom u urbanim područjima istočne Slovačke i duž železničkih pruga u severnoj i zapadnoj Slovačkoj.

Ključne reči: Srednja Evropa, horologija, introdukcija, neofite, sibirski geranium, širenje, sinantropna staništa, saobraćaj