

# Distribution and habitat preferences of *Polygonum arenarium* subsp. *arenarium* (*Polygonaceae*) in Slovakia

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**Abstract.** The paper presents data on the distribution and habitat preferences of *Polygonum arenarium* subsp. *arenarium* in Slovakia. The study showed a rapid decrease in the number of localities in Slovakia in recent decades, due to destruction of sandy habitats. At present the taxon is considered to be very rare. We recorded it in stands of pioneer vegetation of the *Festucetea vaginatae* class developed on open sandy dunes, in the associations *Festucetum vaginatae* and *Bassio laniflorae-Brometum tectorum*.

**Key words:** Central Europe, extinction, pioneer vegetation, *Polygonum*, rare plants, sandy habitats

## Introduction

According to Grulich et al. (2012) the genus *Polygonum* is represented by four species in Slovakia: *Polygonum arenarium*, *P. aviculare*, *P. graminifolium* and *P. patulum*. While *P. aviculare* is very common, other three taxa are rare (Eliáš et al. 2015). This paper is intended to clarify the past and recent distribution of one of those uncommon taxa – *Polygonum arenarium* – and to describe the plant communities in which it occurs.

## Material and methods

A field survey was done in 2006–2015 in the Burda Hills, Podunajská nížina Lowland and Východoslovenská nížina Lowland. As most of the literature data are unreliable, the occurrence of *P. arenarium* was studied using specimens deposited in 17 herbaria of the Czech Republic, Hungary and Slovakia: BP, BRA, BRNU, BRNM, LTM, MMI, NI, KO, OL, OLM, PMK, PR, PRA, PRC, SAV, SLO and ZV. Localities recorded since 2001 are considered recent; all others are considered historical. Herbarium acronyms follow Thiers (2018). A list of revised specimens was compiled according to the guidelines of Flóra Slovenska VI/3 (Goliašová & Michalková 2012). If names of settlements given by collectors are different from the current form, we include the original name in quotation

marks. The localities are shown on a grid map drawn in ArcGis ver. 9.2. Coordinates of historical localities were taken from Google Earth. Coordinates of recent finds were measured in field work with a Garmin CS 60 GPS. The phytogeographical divisions of Futák (1984) are also used.

The taxonomy and names of flowering plants follow Marhold & Hindák (1998). Names of syntaxa follow Jarolímek et al. (2008) and Borhidi et al. (2012). The phytosociological relevés were sampled using the Zürich-Montpellier method and graded on the modified (nine-grade) Braun-Blanquet scale from Westhoff and van der Maarel (1973).

## Results and discussion

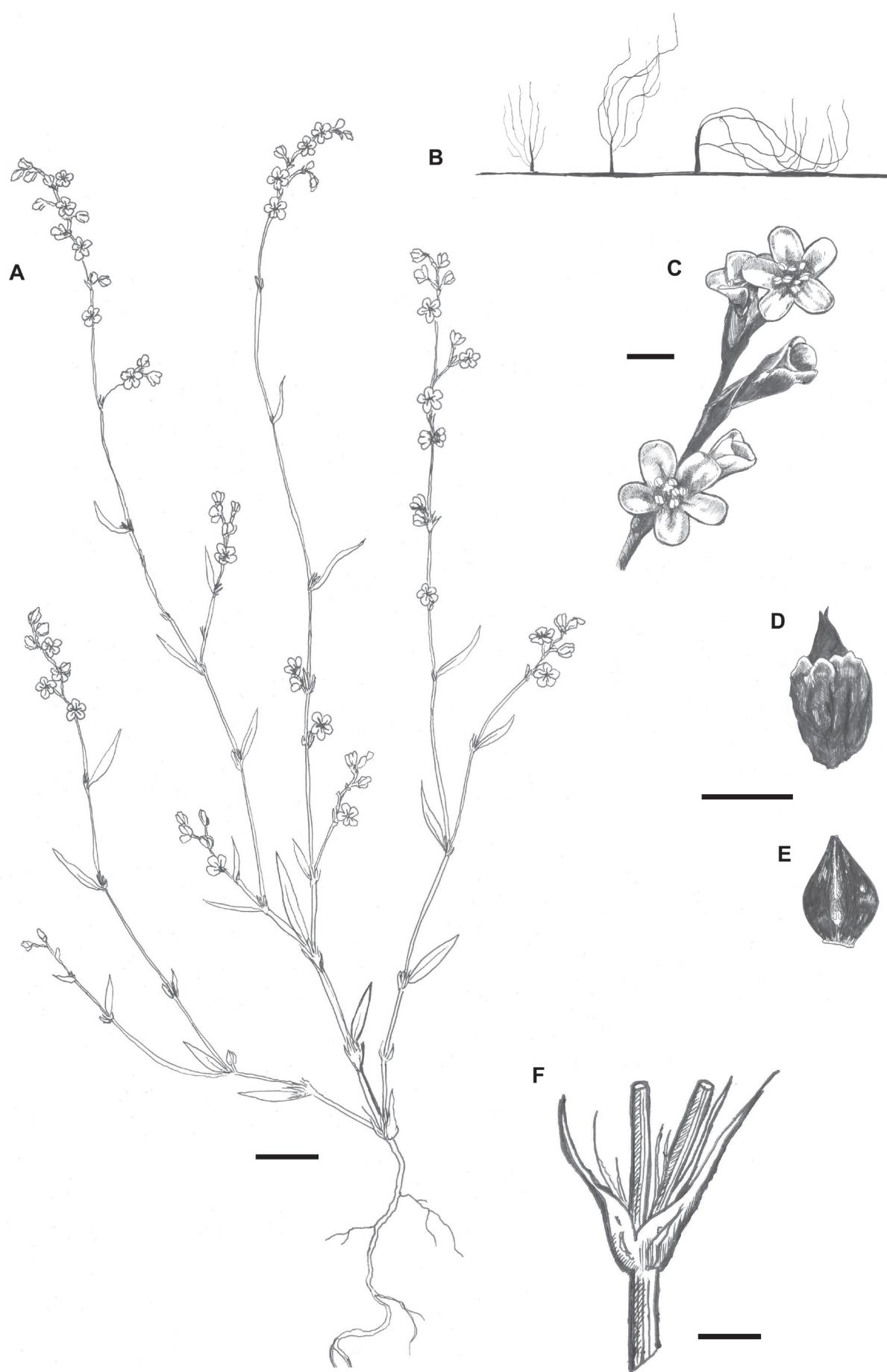
**Taxonomy and distribution range.** The taxon *Polygonum arenarium* (syn. *P. janatae*, *P. pseudoarenarium*, *P. venantianum*) includes two subspecies, of which only the nominate *P. arenarium* subsp. *arenarium* (Fig. 1) is present in Central Europe (Dostál 1990; Király 2009; Grulich et al. 2016). This subspecies has a Eurasian range reaching from Slovakia, Hungary and Romania in the west to as far as central Ukraine, Greece, Turkey, SW Russia and the Caucasus in the east, and to Lebanon and Syria in the south (Jalas & Suominen 1979; Uotila 2011; Tzvelev 2012). A disjunct area in France near Toulon has been reported (Chrtek 1958; Wagenitz 1981), but this information is now regarded as mistaken (Tison & Foucault 2014). It is reported as an alien from Germany (Wisskirchen 2016, ex verb.), Poland (Rostański & Sowa 1984), Estonia (Kukk 1999) and central Russia (Tzvelev 2006). The other subspecies, *P. arenarium* subsp. *pulchellum*

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**Figure 1.** *Polygonum arenarium* subsp. *arenarium*. A – general habit of a flowering plant; B – growth form schemes; C – upper part of inflorescence; D – achene in perianth; E – achene; F – ochrea (drawn by L. Bakay from herbarium specimens stored in NI). Scale bars: A = 2 cm; C–F = 2 mm.

(syn. *P. pulchellum*), has a Mediterranean distribution (Webb et al. 1993) and was introduced to the British Isles (Lousley & Kent 1981; Stace 2010; Akeroyd 2014), Germany (Wagenitz 1981), Belgium (Verloove 2006) and Scandinavia (Bengt 2000). It differs from *P. arenarium* subsp. *arenarium* by having flowers in lax cymes and with glossy, irregular warty achenes (Webb et al. 1993). Both taxa have sometimes been confused with *Polygonum patulum*, and *P. bellardii* (Akeroyd 2014).

**Occurrence in Slovakia.** We found that the species has occurred at 25 localities in total (Appendix 1), situated in the Burda Hills, Podunajská nížina Lowland and Východoslovenská nížina Lowland (phytogeographical division of Pannonicum, SW and SE Slovakia) at 108–250 m a.s.l. The occurrence of *P. arenarium* subsp. *arenarium* in Slovakia was first documented in the mid-19th century from SW Slovakia (Grundl 1857, SLO), while the earliest specimens from SE Slovakia were collected some 70 years later (Margittai 1928, BP, PRC). During our recent field survey, the presence of *P. arenarium* subsp. *arenarium* was confirmed at only 9 localities, all situated in SW Slovakia (Fig. 2). At these localities it survived mostly in multiple populations, each numbering tens to hundreds of individuals; at two sites (Mašan Nature Reserve; Nesvady, dune with a chapel) we saw only a few individuals. As is known for many species of annual psammophytes such as *Androsace septentrionalis* (Symonides 1979), the population size of the *Polygonum arenarium* subsp. *arenarium* populations undergoes large inter-annual fluctuations, associated particularly with vegetation succession and/or weather conditions. We did not confirm the presence of *P. arenarium* at any of its former sites in SE Slovakia during our field survey; this is in agreement with findings of other researchers (Mártonfi et al. 2014; Fig. 2). The

last reports of it came from the surroundings of Streda nad Bodrogom village about 30 years ago [Bogoly 1985; V. Grulich 1988 (MMI), J. Šmiták 1988 (BRNM)]. Its decline is related mainly to human activities, especially sand mining and afforestation of sand dunes, and also secondary succession, mainly invasion of *Robinia pseudoacacia*.

*Polygonum arenarium* subsp. *arenarium* belongs to a group of vanishing annual psammophytes (e.g. *Allysum desertorum*, *Apera interrupta*, *Corispermum nitidum*, *Bassia laniflora*, *Syrenia cana*), two of which show an almost identical distribution (sandy areas in W, SW and SE Slovakia) and a decreasing trend in the number of localities as well. Only 14 sites of *Bassia laniflora* (19% of all of its sites) have been confirmed recently, while in some areas (Počipie region) it has completely disappeared (Eliáš et al. 2016). Similarly, *Corispermum nitidum* Waldst. et Kit. has not been confirmed for nearly 15 years in the Východoslovenská nížina Lowland (SE Slovakia), and more than a quarter of the localities in SW Slovakia have disappeared (Eliáš 2016).

Although the distribution of *Polygonum arenarium* subsp. *arenarium* in SW and SE Slovakia has been published in relative detail (Chrtek 1958; Maglocký 1999), the occurrence of the taxon in the western part of the country is questioned.

There were published records from the Záhorská nížina Lowland (e.g. Šmarda 1953; Dostál 1954; Dostál & Červenka 1990). As we found during revision of herbarium specimens, all those records are based on misidentified taxa of *P. aviculare*. The absence of *P. arenarium* subsp. *arenarium* in adjacent sandy habitats in NE Austria (Marschfeld) and SW Moravia (Chrtek 1990; Walter 2008) corroborate our findings. The populations of *P. arenarium* subsp. *arenarium* in SW and SE Slovakia constitute an

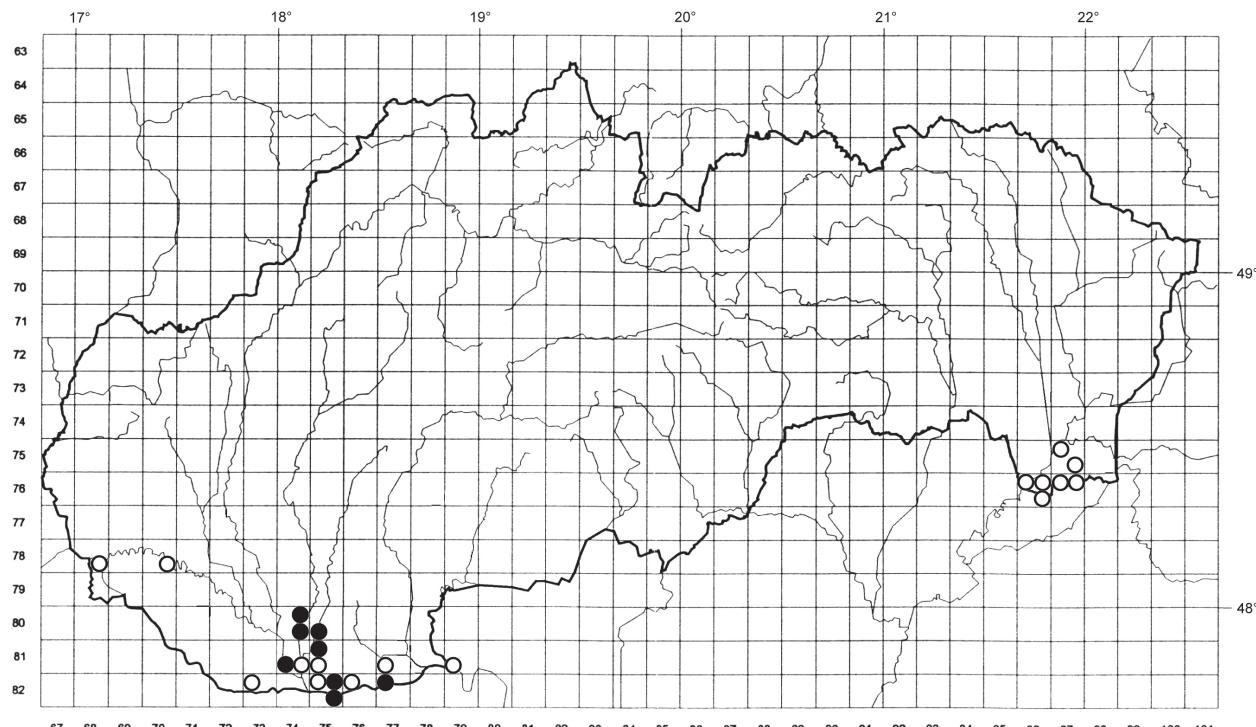


Figure 2. Historical (○) and recent (●) localities of *Polygonum arenarium* subsp. *arenarium* in Slovakia.

extension of its rather continuous distribution in Hungary (Király 2009; Bartha et al. 2015) and also the absolute northwestern limit of its distribution range.

**Status in the Slovak flora.** The distribution data from 17 herbaria and our field research demonstrate the conspicuous retreat of *Polygonum arenarium* subsp. *arenarium* in Slovakia. The taxon is extinct in the southeast part of the country, and in the southwest the number of sites has fallen by half. Our findings confirm the classification of *P. arenarium* subsp. *arenarium* as endangered (EN) on the red list of ferns and flowering plants of Slovakia (Eliáš et al. 2015). It is even rarer in Croatia, where it is classified as critically endangered (Nikolić & Topić 2007); it is rather common in other parts of Central and Southeastern Europe (Ciocárln 2009; Király 2009).

**Habitat preferences and coenology.** Our research shows that *Polygonum arenarium* subsp. *arenarium* occupied only open sandy places (Fig. 3) where different successional stages of pioneer vegetation of the class *Festucetea vaginatae* developed (Table 1). Relevé 1 represents an area with recently removed (in the year of sampling) vegetation cover of compact *Festucetum vaginatae*, done as part of the restoration of Pannonian sand habitats within the framework of the Life project of Daphne (Institute of Applied Ecology), which successfully led to the development of species-poor pioneer vegetation with dominance of *P. arenarium* subsp. *arenarium* and co-dominance of annual weedy grasses such as *Bromus sterilis* and *Setaria glauca*. This *P. arenarium* subsp. *arenarium* stand cannot be identified with any association of psammophytic vegetation reported in Slovakia (Valachovič et al. 1995, Jarolímek et al. 2008) or

from Central and most of Southeastern Europe (Soó 1938, 1980; Borhidi 2003; Borhidi et al. 2012; Sanda et al. 2008; Trinajstić 2008). The presence of the perennial *Tithymalus seguierianus* suggests that this stand is probably only an ephemeral stage of the association *Festucetum vaginatae*.

Similarly, relevés 4 and 7 represent communities of exposed sand dunes with dominance of *Corispermum nitidum*, which are usually assigned to the association *Brometum tectorum* in Slovakia (Valachovič et al. 1995). In Serbia, however, the association *Corispermo nitidi-Polygonetum arenariae* was described from large sandy areas of Deliblatska peščara in the southern part of the Pannonian Basin in NE Serbia (Stjepanović-Veselićić 1953). The community covered naturally open, air-exposed sandy dunes and surfaces of sandy dunes after fires. According to Stojšić & Dinić (2009) this community was very short-lived. It developed in the first year after a fire; in the second year the association *Festucetum vaginatae* already began to develop. As compared to stands of *P. arenarium* recorded in Serbia, the stands in Slovakia are more species-rich and occupy smaller patches. Also different is the geomorphological situation of this habitat in Slovakia, which usually developed on steep slopes of sand pits of secondary origin. Further research is needed to determine whether the stands recorded in Slovakia and also in other parts of the Pannonian Basin can be assigned to the *Corispermo-Polygonetum arenariae* association.

Other *Polygonum arenarium* subsp. *arenarium* stands in Slovakia represent the associations *Festucetum vaginatae* (rels. 2, 5) and *Bassio laniflorae-Brometum tectorum* (Soó 1938) Borhidi 1996 (rels. 3, 6). While the former is well documented in Slovakia (e.g. Valachovič et al. 1995), the latter was found only recently (Eliáš



Figure 3. Open sandy slopes of sand pits, typical secondary habitat of *Polygonum arenarium* subsp. *arenarium* in Slovakia.

**Table 1.** Phytosociological table of *Polygonum arenarium* relevés from Slovakia sampled during the study.

| No. of relevé  | 1  | 2  | 3  | 4  | 5  | 6  | 7  |
|--|----|----|----|----|----|----|----|
| Relevé plot size (m <sup>2</sup> )                           | 10 | 16 | 16 | 10 | 16 | 16 | 16 |
| E <sub>0</sub> (%)   | 0  | 0  | 0  | 0  | 60 | 0  | 0  |
| E <sub>1</sub> (%)   | 25 | 30 | 30 | 30 | 80 | 40 | 45 |
| No. of species   | 8  | 24 | 18 | 15 | 22 | 14 | 19 |
| <b>Characteristic species of <i>Festucetea vaginatae</i></b> |    |    |    |    |    |    |    |
| <i>Cynodon dactylon</i>                                      | .  | +  | 1  | 2a | 2a | +  | .  |
| <i>Festuca vaginata</i>                                      | .  | 1  | 1  | .  | 3  | +  | 1  |
| <i>Silene otites</i> agg.                                    | .  | +  | +  | .  | 1  | +  | .  |
| <i>Tithymalus seguierianus</i>                               | +  | .  | +  | .  | +  | .  | .  |
| <b>Other species</b>   |    |    |    |    |    |    |    |
| <i>Polygonum arenarium</i>                                   | 2a | 2a | 2a | +  | 1  | 2a | 1  |
| <i>Bromus tectorum</i>                                       | .  | 1  | 2a | 1  | 1  | .  | +  |
| <i>Tithymalus cyparissias</i>                                | .  | .  | +  | +  | 2b | +  | +  |
| <i>Chenopodium album</i> agg.                                | .  | 1  | r  | r  | .  | 1  | .  |
| <i>Conyza canadensis</i>                                     | .  | .  | 1  | .  | 1  | 1  | +  |
| <i>Bassia laniflora</i>                                      | .  | .  | +  | .  | 1  | +  | +  |
| <i>Erysimum diffusum</i>                                     | .  | +  | .  | +  | .  | +  | .  |
| <i>Corispermum nitidum</i>                                   | .  | .  | .  | 2a | .  | 1  | 2a |
| <i>Acosta rhenana</i>  | .  | .  | .  | .  | 2a | +  | +  |
| <i>Psyllium arenarium</i>                                    | .  | 1  | +  | .  | .  | .  | .  |
| <i>Tribulus terrestris</i>                                   | 1  | .  | .  | .  | .  | r  | +  |
| <i>Petrorhagia prolifera</i>                                 | .  | .  | .  | .  | +  | .  | 1  |
| <i>Salsola kali</i>  | .  | .  | .  | +  | .  | .  | 1  |
| <i>Crepis foetida</i>  | .  | .  | +  | .  | .  | .  | +  |
| <i>Erodium cicutarium</i>                                    | .  | +  | .  | +  | .  | .  | .  |
| <i>Medicago minima</i>                                       | .  | .  | .  | +  | +  | .  | .  |
| <i>Poa bulbosa</i>   | .  | .  | .  | +  | +  | .  | .  |
| <i>Setaria pumila</i>  | .  | +  | +  | .  | .  | .  | +  |
| <i>Silene conica</i>   | +  | .  | .  | .  | +  | .  | .  |
| <i>Stipa capillata</i>                                       | .  | .  | .  | .  | +  | +  | .  |
| <i>Xeranthemum annuum</i>                                    | .  | +  | +  | .  | .  | .  | .  |
| <i>Carduus acanthoides</i>                                   | .  | +  | r  | .  | .  | .  | .  |

**In one relevé only:** E<sub>0</sub> – *Ceratodon purpureus* 5: 4, E<sub>1</sub> – *Botriochloa ischaemum* 7: 2a, *Cota austriaca* 2: 2a, *Echium vulgare* 5: 2a, *Thymus praecox* 5: 2a, *Amaranthus retroflexus* 2: 1, *Bromus squarrosum* 3: 1, *Bromus sterilis* 1: 1, *Elytrigia repens* 2: 1, *Gypsophila paniculata* 2: 1, *Lappula squarrosa* 2: 1, *Setaria glauca* 1: 1, *Stipa borysthenica* 7: 1, *Thymus pannonicus* 7: 1, *Tragus racemosus* 7: 1, *Vicia villosa* 2: 1, *Ambrosia artemisiifolia* 4: +, *Alyssum alyssoides* 2: +, *Arenaria serpyllifolia* 4: +, *Astragalus onobrychis* 4: +, *Berteroa incana* 5: +, *Camelina microcarpa* 2: +, *Chondrilla juncea* 5: +, *Eryngium campestre* 7: +, *Erysimum repandum* 3: +, *Geranium pusillum* 2: +, *Oenothera biennis* agg. 4: +, *Poa angustifolia* 5: +, *Polygonum aviculare* agg. 2: +, *Robinia pseudoacacia* juv. 5: +, *Screllochloa dura* 2: +, *Syrenia cana* 6: +, *Fallopia convolvulus* 2: r, *Tripleurospermum perforatum* 2: r.

**Explanations.** Localities of relevés (for relevés, the header data are listed in the following order: number of relevé, locality, exposition, elevation, coordinates, altitude, sampling date): 1 – Nesvady, Liščie diery Nature Reserve, demolished slope, exp. NW, elevation 20°, 47°55'25.99"N, 18°9'28.84"E, 112 m, 26 June 2015; 2 – Nesvady, Liščie diery Nature Reserve, demolished slope, exp. W, elevation 5°, 47°55'25.10"N, 18°9'29.72"E, 112 m, 26 June 2015; 3 – Nesvady, Liščie diery Nature Reserve, open sand on top of dune, exp. –, elevation –, 47°55'25.83"N, 18°9'29.07"E, 112 m, 26 June 2015; 4 – Kameničná, Balvany farmstead, elevation point 120 m, exp. NW, elevation 10°, 47°50'26.66"N, 18°0'19.11"E, 115 m, 13 Sept. 2015; 5 – Nesvady, top of dune near cemetery, exp. NW, elevation 5°, 47°55'56.55"N, 18°7'34.54"E, 112 m, 13 Sept. 2015; 6 – Nesvady, dune near cemetery, mined slope, exp. NE, elevation 50°, 47°55'56.87"N, 18°7'35.55"E, 111 m, 26 Aug. 2007; 7 – Imel, abandoned sand pit, exp. SEE, elevation 25°, 47°54'36.37"N, 18°9'43.50"E, 118 m, 12 Sept. 2014.

et al. 2016). Stands of *Bassio-Brometum* are developed as secondary seminatural vegetation on steeper slopes in pastures on sandy soils. According to Soó (1938) they are characterized by the co-dominance of *Bassia laniflora* and *Bromus tectorum* (coverage 5–75%); in addition, *Anthemis ruthenica*, *Acetosella vulgaris*, *Botriochloa ischaemum*, *Cynodon dactylon* and *Polygonum arenarium* were present with higher coverage (5–25%). Stands found in Slovakia have a very similar species composition (including ruderal species and weeds) but the coverage of both

dominants is lower, ranging from 5 to 25% (Table 1, and Eliáš et al. 2016).

Besides the above-mentioned phytosociological units, *Polygonum arenarium* is reported from a wide range of psammophytic communities of inland sand dunes in other parts of Central and Southeastern Europe. It is also reported in weedy vegetation developed in stubble fields on sandy soils (Borhidi 1996; Borhidi et al. 2012; Sanda et al. 2008; Tab. 2). Based on that information, we conclude that *Polygonum arenarium* has no specific affinity

**Table 2.** Phytocoenoses with the presence of *Polygonum arenarium* reported from Central and Southeastern Europe.

| Alliance  | Association   |
|---|---|
| <i>Festucion vaginatae</i> Rapaics ex Soó 1929                    | <i>Galio veri-Holoschoenetum vulgaris</i> (Hargitai 1940) Borhidi 1996<br><i>Festucetum beckeri</i> Sanda & Popescu 1997      |
| <i>Bassio laniflorae-Bromion tectorum</i> (Soó 1957) Borhidi 1996 | <i>Kochio laniflorae-Secalietum sylvestris</i> Mitelu et al. 1973<br><i>Secali sylvestris-Brometum tectorum</i> Hargitai 1940 |
| <i>Festuco-Mollugion</i> Borza 1961                               | <i>Molluginetum cervianaee</i> Borza 1963   |
| <i>Tribulo-Eragrostion minoris</i> Soó & Timár in Timár 1957      | <i>Vicio-Polygonetum arenariae</i> Timár 1957   |

to a particular psammophilic plant association and that it occurs in a wide range of pioneer psammophytic vegetation of wind-blown sandy dunes and in semi-ruderal stands in abandoned sandy fields and sand pits.

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## References

- Akeroyd, J. R. 2014. *Docks and Knotweeds of Britain and Ireland*. 2 ed. Botanical Society of Britain & Ireland, London.
- Bengt, J. 2000. *Flora Nordica*. Vol. 1: 273. The Bergius Foundation, The Royal Swedish Academy of Sciences, Stockholm.
- Bogoly, J. 1985. Prehľad odborných výsledkov IX. TOP-u – botanika. In: Voskár, J. & Rencík, J. (eds), IX. *Východoslovenský tábor ochrancov prírody Borša – 1985. Prehľad odborných výsledkov*, pp. 21–32. OVN a SZOPK Trebišov, Trebišov.
- Borhidi, A. 2003. *Magyarország növénytársulásai*. Akadémiai Kiadó, Budapest.
- Borhidi, A., Kevey, B. & Lendvai, G. 2012. *Plant communities of Hungary*. Akadémiai Kiadó, Budapest.
- Bartha, D., Király, G., Schmidt, D., Tiborcz, V., Barina, Z., Csíky, J., Jakab, G., Lesku, B., Schmotzer, A., Vidéki, R., Vojtkó, A. & Zólyomi, Sz. (eds) 2015. *Atlas florae Hungariae*. University of West Hungary Press, Sopron.
- Ciocarlan, V. 2009. *Flora Ilustrata a Romaniei. Pteridophyta et Spermatophyta*. Edit. Ceres, Bucureşti.
- Dostál, J. 1954. *Klíč k úplné květeně ČSR*. Nakladatelství ČSAV, Praha.
- Dostál, J. & Červenka, M. 1991. *Velký klíč na určovanie vyšších rastlín I*. Slovenské pedagogické nakladatelstvo, Bratislava.
- Eliáš, P. jun. 2016. *Corispermum L.* In: Goliašová, K. & Michalková, E. (eds), *Flóra Slovenska* 6/4: 130–143. Veda, Bratislava.
- Eliáš, P. jun., Dítě, D., Kliment, J., Hrvínak, R. & Feráková, V. 2015. Red list of ferns and flowering plants of Slovakia, 5th edition (October 2014). *Biologia* 70: 218–228.
- Eliáš, P. jun., Dítě, D., Melečková, Z. & Eliášová, M. 2016. Distribution and ecology of the genus *Bassia* in Slovakia 2: *Bassia laniflora* (S. G. Gmel.) A. J. Scott. *Thaiszia* 26: 125–138.
- Goliašová, K. & Michalková, E. (eds) 2012. *Flóra Slovenska* 6(3). Veda, Bratislava.
- Grulich, V., Májeková, J., Eliáš, P. jun. & Dítě, D. 2016. *Polygonum L.* In: Goliašová, K. & Michalková, E. (eds), *Flóra Slovenska* 6(4): 502–515. Veda, Bratislava.
- Chrtek, J. 1958. Poznámky k rozšíření *Polygonum arenarium* W. et K. *Přírodovědecký sborník Ostravského kraje* 19: 409–418.
- Chrtek, J. 1990. *Polygonum L.* In: Hejný S. & Slavík B. (eds), *Květena České republiky* 2, pp. 266–280. Academia, Praha.
- Jalas, J. & Suominen, J. (eds) 1979. *Atlas Flora Europaea. Distribution of Vascular Plants in Europe. 4. Polygonaceae*. The Committee for Mapping the Flora of Europe & Societas Biologica Fennica Vanamo, Helsinki.
- Jarolímek, I., Šibík, J., Tichý, L., Kliment, J., Šibíková, I., Hegedűšová, K., Valachovič, M., Michálková, D., Škodová, I., Sadlonová, J., Zaliberová, M. & Májeková, J. 2008. *Diagnostic, constant and dominant species of the higher vegetation units of Slovakia*. Veda, Bratislava.
- Király, G. 2009. *Polygonum L.* s. str. In: Király, G. (ed.), *Új magyar flóráskönyv. Magyarország hajtásos növényei*. Határozókulcsok, p. 111. Aggteleki Nemzeti Park Igazgatóság, Jósvafő.
- Kukk, T. 1999. *Eesti taimestik*. Teaduste Akadeemia Kirjastus, Tallinn.
- Lousley, J. E. & Kent, D. H. 1981. *Docks and knotweeds of the British Isles*. Botanical Society of the British Isles, London.
- Maglocký, Š. 1999. *Polygonum arenarium* W. et K. In: Čerovský, J., Feráková, V., Holub, J., Maglocký, Š. & Procházka, F. (eds), *Červená kniha ohrozených a vzácných druhov rastlín a živočichov ČR a SR*, vol. 5 (Výšsие rastliny), p. 289. Príroda, Bratislava.
- Marhold, K. & Hindák, F. (eds) 1998. *Checklist of nonvascular and vascular plants of Slovakia*. Veda, Bratislava.
- Margittai, A. 1929. Szomotor homokjának flórája. *Botanikai Közlemények* 26: 26–32.
- Margittai, A. 1935. Flóra Tarbucky pri V. Kevežde. *Sborník Prirodovedného Klubu Košice* 2(1933–1934): 84–90.
- Nikolić, T. & Topić, J. (eds) 2005. *Red Book of Vascular Flora of the Republic of Croatia. Categories EX, RE, CR, EN and VU*. Ministry of Culture, State Institute for Nature Protection, Zagreb.
- Rostanski, K. & Sowa, R. 1984. Alphabetical list of the ephemeroephites of Poland. *Fragmenta Floristica et Geobotanica* 31–32: 151–205.
- Sanda, V., Öllerer, K. & Burescu, P. 2008. *Fitocenoze din România – sintaxonomie, structură, dinamică și evoluție*. Ars Docendi. Universitatea din Bucureşti, Bucureşti.
- Soó, R. 1938. Homokpusztai és sziki növényszövetkezetek a Nyírségen. *Botanikai Közlemények* 36: 90–108.
- Soó, R. 1980. *A magyar Flóra és vegetáció rendszertaninövényföldrajzi kézikönyve. Synopsis systematico-geobotanica florae vegetationisque Hungariae. VI*. Akadémiai Kiadó, Budapest.
- Stace, C. A. 2010. *New flora of the British Isles*, 3rd ed. Cambridge University Press, Cambridge.
- Stjepanović-Veselić, L. 1953. Vegetacija Deliblatske peščare. *Monographies* 216, Institut d'écologie et de biogéographie 4: 1–113.
- Stojić, V. & Dinić, A. 2009. Dinamika i distribucija biljnih vrsta u sukcesiji peščarske vegetacije na požarištu Deliblatske peščare. *Zaštita Prirode* 60: 305–312.
- Symonides, E. 1979. The structure and population dynamics of psammophytes on inland dunes: I. Populations of initial stages. *Ekologia Polska* 27: 3–37.

- Šmarda, J. 1963. Příspěvek k poznání rostlinných společenstev přesypových písků na jižním a jihozápadním Slovensku. *Biologia* 8: 497–525.
- Thiers, B. 2018. Index Herbariorum: *A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium, New York. <http://sweetgum.nybg.org/ih/>
- Tison, J.-M. & de Foucault, B. (eds) 2014. *Flora Gallica. Flore de France*. Biotope, Mèze.
- Trinajstić, I. 2008. *Biljne zajednice Republike Hrvatske*. Akademija šumarskih znanosti, Zagreb.
- Tzvelev, N. N. (ed.) 2006. *Flora of Russia: The European Part and Bordering Regions. Vol. 9*. CRC Press, Boca Raton, London, New York & Washington D.C.
- Tzvelev, N. N. 2012. *Polygonum* L. In: Takhtajan, A. L. (ed.), *Konspekt flory Kavkaza* 3(2): 262–268. Tovariščestvo naučnykh izdanijj KMK, Sankt-Peterburg & Moskva.
- Uotila, P. 2017. *Polygonaceae. Euro+Med Plantbase – the information resource for Euro-Mediterranean plant diversity*. <http://www.emplantbase.org/home.html>
- Verloove, F. 2006. Catalogue of neophytes in Belgium (1800–2005). *Scripta Botanica* 39: 1–89.
- Wagenitz, G. 1981. *Polygonum*. In: Conert, J. H. (ed.), *Gustav Hegi: Illustrierte Flora von Mitteleuropa, 3rd edition, Band III, Teil 1*. pp. 403–434. Verlag Paul Parey, Berlin & Hamburg.
- Walter, J. 2008. *Polygonum* (s. str.). In: Fischer, M. A. (ed.), *Exkursionsflora für Österreich, Liechtenstein und Südtirol. 3., verbesserte und erweiterte Auflage*, pp. 376–378. Land Oberösterreich, OÖ Landesmuseen, Linz.
- Webb, D. A., Chater, A. O. & Akeroyd, J. R. 1993. *Polygonum* L. In: Tutin, T. G., Burges, N. A., Chater, A. O., Edmondson, J. R., Heywood, V. H., Moore, D. M., Valentine, D. H., Walters, S. M. & Webb, D. A. (eds), *Flora Europaea (2nd ed.)*, Vol. 1, pp. 91–97. Cambridge University Press, Cambridge.
- Westhoff, V. & van der Maarel, E. 1973. The Braun-Blanquet approach. In: Whittaker, R. H. (ed.), *Handbook of vegetation science, part 5, Classification and ordination of communities*, pp. 617–726. Junk, The Hague.

**Appendix 1.** List of localities based on revised herbarium specimens of *Polygonum arenarium* subsp. *arenarium* from Slovakia.

| No. | Locality  | Source   |
|-----|---|--|
|     | <b>Burda Hills</b>  |  |
| 1   | Chľaba “Helemba”  | <i>I. Grundl</i> 1857 (SLO), <i>F. Nábělek</i> 1935 (SAV)  |
|     | <b>Podunajská nížina Lowland</b>                                      |  |
| 2   | Bratislava, sands of Danube islands (“Pressburg”)                     | <i>A. Richter</i> sine data (SLO)  |
| 3   | Malý Máger (“Kismagyár”)  | <i>K. Mergl</i> 1901 (SAV)   |
| 4   | Between Tôň and Klížska Nemá  | <i>J. Májovský</i> 1951 (SLO)  |
| 5   | Komárno, Malé Písky farmstead   | <i>F. Weber</i> 1935 (BRA)   |
|     | Kameničná, Velké Písky farmstead                                      | <i>F. Weber</i> 1935 (BRNM), <i>F. Černoch</i> 1959 (BRNM), <i>V. Skřivánek</i> 1959 (BRNM)  |
|     | Kameničná, Balvany farmstead  | <i>V. Krist</i> 1938 (BRNU), <i>F. Weber</i> 1935 (PR), <i>J. Májovský &amp; J. Michalko</i> 1957 (SLO), <i>F. Černoch</i> 1959 (BRNM), <i>P. Eliáš jun. et al.</i> 2004 (NI), <i>P. Eliáš jun.</i> 2010, 2015 (NI)  |
| 6   | Between Bajč and Imeľ, sandy dunes                                    | <i>Š. Mihálik</i> 1964 (SAV), <i>F. Čvančara</i> 1971 (BRNU, PR), <i>P. Eliáš jun., D. Dítě &amp; Z. Melčková</i> 2014 (NI)  |
| 7   | Imeľ, in the village  | <i>E. Krippel</i> 1953 (SLO), <i>J. Dostál</i> 1954 (PR), <i>A. Žertová &amp; J. Chrtek</i> 1954 (NI, PRC)   |
| 8   | Nesvady, dune with chapel   | <i>P. Eliáš jun. &amp; A. Szabóová</i> 2006 (NI)   |
| 9   | Nesvady, dune at cemetery   | <i>M. Takáč</i> 1959 (BRA), <i>P. Eliáš jun. &amp; M. Sádovský</i> 2004 (NI), <i>P. Eliáš jun.</i> 2009 (BRA, NI, SAV), <i>P. Eliáš jun.</i> 2012 (SAV)  |
| 10  | Nesvady, Líšcie diery Nature Reserve                                  | <i>V. Osvalčilová</i> 1954 (NI), <i>J. Dostál</i> 1954 (PR), 1955 (PR, PRC), <i>J. Chrtek, B. Křísa &amp; B. Slavíková</i> 1970 (PRC), <i>Z. Svobodová</i> 1990 (NI), <i>M. Vozárová</i> 1994 (BRA), <i>P. Eliáš jun.</i> 2012 (NI)  |
| 11  | Svätý Peter, Lúčka site   | <i>P. Eliáš jun. &amp; A. Szabóová</i> 2006 (NI)   |
| 12  | Chotín  | <i>F. Weber</i> 1935 (BRNM), <i>V. Krist</i> 1937 (BRNU), <i>J. Futák &amp; D. Magic</i> 1948 (SLO), <i>J. Šmarda</i> 1951 (BRNM), <i>E. Krippel</i> 1952 (SLO)  |
| 13  | Radvaň nad Dunajom  | <i>F. Weber</i> 1935 (BRA)   |
| 14  | Marcelová, sandy sites near the village                               | <i>F. Weber</i> 1935 (PR), <i>Č. Deyl</i> 1977 (OLM)   |
|     | Marcelová, Marcelovské piesky Nature Reserve                          | <i>J. Májovský</i> 1960 (SLO), <i>M. Unarová</i> 1981 (BRNU), <i>Z. Svobodová</i> 1987 (NI), <i>V. Grulich</i> 1987 (MMI), <i>B. Trávníček</i> 1989 (OL)   |
| 15  | Marcelová, Bašov kopec site   | <i>P. Eliáš jun.</i> 2009 (NI)   |
| 16  | Virt, Mašan Nature Reserve  | <i>P. Eliáš jun. &amp; M. Sádovský</i> 2004 (NI)   |
| 17  | Čenkov, Čenkovský les area  | <i>F. Weber</i> 1936 (BRA), <i>V. Knebllová</i> 1951 (PR), <i>J. Šourek</i> 1954 (PR), <i>J. Vicherek</i> 1972 (BRNU), <i>S. David</i> 1986 (LTM)  |
| 18  | Čenkov farmstead  | <i>V. Krist</i> 1937 (BRNU), 1938 (BRNM, BRNU), <i>V. Valenta</i> 1938 (BRA), <i>J. Futák</i> 1948 (SLO), <i>V. Skřivánek</i> 1950 (BRA, BRNM, PR), <i>E. Mencel</i> 1951 (PRC), <i>M. Smejkal</i> 1951, 1965 (BRNU), <i>F. Černoch</i> 1951 (BRNM), <i>V. Jedlička</i> 1951 (BRNU), <i>J. Šmarda</i> 1952 (BRNM), <i>J. Chrtek &amp; A. Žertová</i> 1954 (PRC), <i>V. Osvalčilová</i> 1954 (NI), <i>V. Valenta</i> 1958 (BRA), <i>J. Májovský</i> 1959, 1962 (SLO), <i>A. Chrtková</i> 1968 (PR), <i>Z. Svobodová</i> 1968 (NI), <i>F. Dvořák</i> 1972 (BRNU), <i>J. Vicherek</i> 1972 (BRNU), <i>V. Hodoval</i> 1976 (BRA), <i>J. Dvořák</i> 1980 (BRA), <i>V. Grulich</i> 1985, 1987 (MMI), <i>M. Zajac</i> 2008, 2011 (ex verb.) |
|     | <b>Východoslovenská nížina Lowland</b>                                |  |
| 19  | Streda nad Bodrogom, Čipkés Hill                                      | <i>J. Májovský</i> 1965 (SLO), <i>J. Šmiták</i> 1988 (BRNM)  |
| 20  | Streda nad Bodrogom, vineyards above the village                      | <i>J. Májovský &amp; J. Kytká</i> 1980 (SLO)   |
|     | Between villages of Streda nad Bodrogom and Malý Kamenc, in vineyards | <i>J. Záborský</i> 1959 (SLO)  |
| 21  | Streda nad Bodrogom, W slopes of Tarbucka hill E of the village       | <i>V. Grulich</i> 1988 (MMI)   |
|     | Malý Kamenc, Tarbucka Hill, 120–250 m                                 | <i>A. Margittai</i> 1935, <i>J. Futák</i> 1949 (SLO), <i>J. Šourek</i> 1950 (PR), <i>J. Záborský</i> 1959, 1960 (SLO)  |
| 22  | Svätuše (“Sentés”)  | <i>J. Futák</i> 1949 (SLO), <i>J. Šourek</i> 1957 (PR)   |
| 23  | Hrušov, mound of sand quarry  | <i>J. Holub</i> 1958 (PRA)   |
| 24  | Between villages of Malý Horeš and Veľký Horeš                        | <i>A. Margittai</i> 1928 (BP, PRC), <i>S. Hejný</i> 1948 (PR); <i>V. Opluštílová</i> 1948 (SLO)  |
|     | Malý Horeš, sandy site  | <i>F. Černoch</i> 1957 (BRNM)  |
|     | Malý Horeš, dune near <i>Robinia</i> woods                            | <i>J. Májovský</i> 1964 (SLO)  |
| 25  | Strážne   | <i>A. Margittai</i> 1928 (BP), <i>J. Holub</i> 1958 (PRA)  |
|     | <b>Doubtful site (not mapped)</b>                                     |  |
|     | Vráble  | <i>J. Futák, T. Hejná, J. Ružička</i> 1949 (SLO); this apparently applies to some sites south of that town   |