

Halophytes spreading along roadsides of northern Slovakia

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Abstract: This contribution provides the first survey of vegetation with *Puccinellia distans* along the highways of northern Slovakia. Based on phytosociological relevés recorded on the route no. 18 on the section between Važec and Mengusovce settlements the vegetation corresponds with the association *Puccinellio-Chenopodietum glauci* of the alliance *Coronopodo-Polygonion arenastri*. The first record of *Spergularia salina* on road verges of the same area is also given. Our study confirmed that presence of halophytes on road verges depends strictly on the intensity of road salting. In the southern regions of Slovakia where road salting is less intensive no halophytes were recorded. Roadsides promote expansion of alien species, in the other hand, they provide refugia for rare native species as well.

Keywords: road salting, traffic, secondary habitats, expansion, *Spergularia salina*.

Introduction

Roads like many other anthropogenic habitats provide very specific environment for vegetation and are regarded as dynamic corridors for plant dispersal. Plant cover of roadsides is significantly influenced by several factors. The first is the artificial habitat itself, the raw body of the road and its verges. Another factor is the regular disturbance by mowing with heavy machinery which is usually carried out multiple times during the growing season. In the temperate zone a significant impact has the application of chemical substances (salts) and inert material (gravel) in winter (SCOTT & DAVISON 1982). Last but not least, roadside vegetation is affected also by the vehicle traffic itself which facilitates

the establishment and migration of adventive plant species (PAUCHARD & ALABACK 2004, HANSEN & CLEVENGER 2005). Roadside verges represent suitable environment for spreading alien species which have not been recorded so far in the particular country, in Slovakia for instance *Dittrichia graveolens* (KIRÁLY et al. 2014). Specific group of species of low competition ability of which secondary spread is promoted by road salting are halophytes.

In the surrounding countries there has been paid a great attention to roadside flora for a long time. In Germany, where dense road and motorway network is developed, the first studies were released already from the 1980s. There has been observed a notable expansion of alien species like *Senecio inaequidens* or salt-tolerant species like *Atriplex micrantha*, *Cochlearia danica* (BRANDES 2009) or *Plantago coronopus* (GERSTBERGER 2001). Similar phenomenon is the occurrence of native halophytic species such as *Spergularia salina* which has been recorded on road verges of Austria since the 1970s (FRIEDRICH 1979, HOHLA & MELZER 2003). Several studies are devoted to the spread of native and adventive halophytes along roads in Poland (WRÓBEL et al. 2006) and Czech Republic (ŠERÁ 2008). In addition to the long-term established roadside halophyte, *Puccinellia distans*, a notable spread of *Spergularia salina* has been observed for a long period as well (e.g. CHOCHOLOUŠKOVÁ 2013). This species, except the D1 motorway, the busiest traffic artery of the Czech Republic, is being recorded in the whole country (KAPLAN et al. 2016). On the same motorway in the broader vicinity of Brno, *Limonium gmelinii* is being observed since 2009 (KOCIÁN et al. 2016). This halophyte is native only in another countries of the Pannonian bioregion (ŘEHOŘEK & MAGLOCKÝ 1999). In Austria and Hungary it was also found on roadsides (HOHLA et al. 2015, BAUER et al. 2015). Regarding Hungarian roads, the most recent salt-tolerant newcomers are *Plantago coronopus* (SCHMIDT et al. 2016) and *Cochlearia danica* (MOLNÁR & LÖKI 2016). As much floristic data of roadsides are available the more lack is the data about their vegetation.

Within Central Europe the least information about roadside flora is from Slovakia. The most wide-spread and generally known roadside halophytic species in the country is *Puccinellia distans*. It is a good indicator of salt-affected soils, already ŠMARDA (1961) pointed out its spread in Svit around the chemical factory, as well as DOSTÁL (1991) and MAGLOCKÝ & SVOBODOVÁ (1999) who reported the species also from road verges. Secondary occurrence and vegetation of facultative halophyte *Taraxacum bessarabicum* was published from the area of Košice (MIKOLÁŠ & MIHOKOVÁ 1993) and later by DUDÁŠ et al. (2016), however, these occurrences are not related to the road maintenance. This trampled vegetation where the species grow is affected by industrial emissions from the magnesite factory in Košice and was characterized for the first time by KRIPPELOVÁ (1971). She described new association *Puccinellio-Chcenopodietum glauci* and included it to the alliance *Polygonion avicularis* (today accepted name: *Coronopodo-Polygonion arenastri* Sissingh 1969). Other studies dedicated to roadside halophytic vegetation (mainly with *Puccinellia distans*) in Slovakia are not known.

The aim of this work is to bring new information on the occurrence of halophytes along roadsides in northern Slovakia and to characterize the vegetation where they were recorded.

Material and methods

Study area

Vegetation with *Puccinellia distans* was examined along roads of 1st to 4th class in several parts of Slovakia. In the northern part of the country: Liptov, Spiš and southern Orava regions and on the D1 motorway in the section between Ivachnová and Poprad. For comparison, in central Slovakia we observed several sections of the R1 motorway around towns Banská Bystrica and Zvolen and along the highway no. 76 from Hronský Beňadik to Štúrovo and in southern Slovakia the highway no. 63 between Štúrovo and Komárno and around the town Nové Zámky on the highway no. 75.

Vegetation sampling was conducted on the highway no. 18, on a 11-km section between Važec and Mengusovce where altitude is between 815 and 920 m (Fig. 1). The second site was a 200-meter-long section under the Hybica viaduct on the motorway D1 with an altitude 710 m. This area belongs to the Liptovská and Popradská kotlina basins. The climate is slightly cool with an average annual temperature of 5-6 °C and annual rainfall of between 700 and 800 mm. There are 100 days with snow cover, the average temperature of the coldest month is -5 °C, the warmest 14 °C (MIKLÓS 2002).

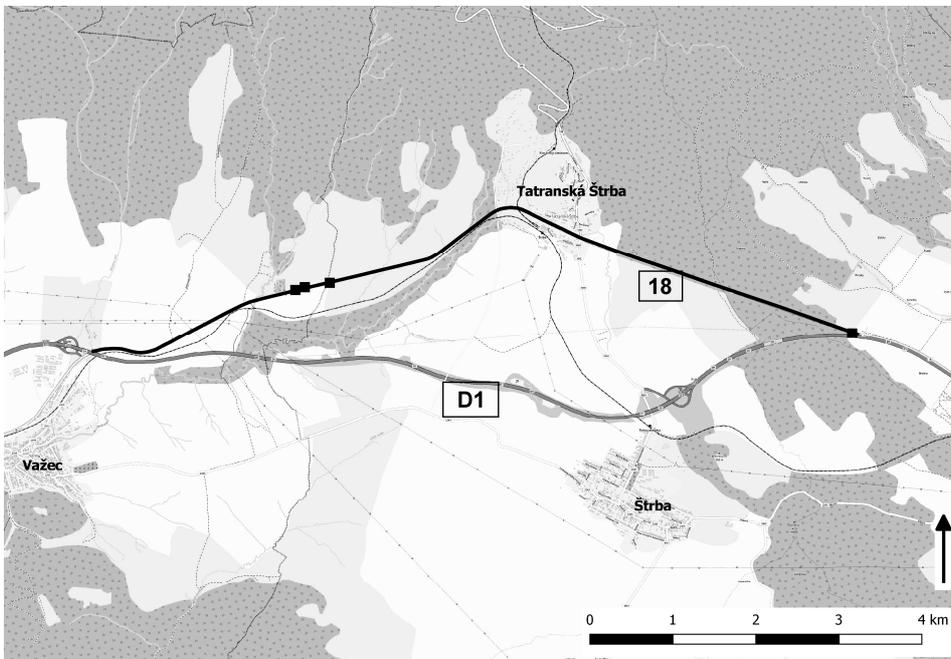


Fig. 1. Map of the sampled section of route no. 18 (black line) between Važec and Mengusovce. Black squares represent locations of *Spergularia salina*.

Data sampling

Highway no. 18 was chosen because of the fact that we detected the most developed secondary stands of *Puccinellia distans* from all the routes surveyed. Phytocenological relevés were recorded on the road shoulder edges adjoining the road surface in vegetation where stands of the targeted species reached a minimum width of 1 m. They were sampled according to the Zürich-Montpellier approach using the adapted nine-grade Braun-Blanquet's scale (BARKMAN et al. 1964). Taxonomy and nomenclature of vascular and non-vascular plants follows MARHOLD & HINDÁK (1998). Phytogeographical divisions of FUTÁK (1980) are also used.

Results

During the growing seasons 2015 and 2016 we surveyed halophytes along roads in several areas of Slovakia. We found that winter chemical treatment is strongly reflected on the plant cover along motorways and roads of higher classes in the foothill and mountain areas than in lowland regions where snow and frost are less frequent. In the Podunajská nížina Lowland we did not detect stands with *Puccinellia distans* on roadsides. The most common species were there *Amaranthus retroflexus*, *Cynodon dactylon*, *Elytrigia repens*, *Eragrostis pillosa*, *Portulaca oleracea*, *Polygonum aviculare* agg. and *Hordeum murinum*. The southernmost occurrence of *Puccinellia distans* was recorded near Kozárovce (highway No. 76) in the boundary of the Carpathian a Pannonian bioregion.

On contrary, in northern Slovakia stands with *Puccinellia distans* are much more developed, mainly along roads of first class (e.g. in Ružomberok and Liptovský Hrádok). Linear stands were usually 15–50 cm-wide, therefore they were not subjected to detailed vegetation sampling. Well-developed stands were observed on the R1 motorway between Banská Bystrica and Zvolen and on the whole section of the D1 motorway from Ivachnová to Važec. From safety reasons they were not sampled.

The most representative, large stands were observed on the highway 18, especially on parking areas with larger lawns where the most relevés were recorded. The first four records (Tab. 1, rel. 1–4) are extremely species-poor stands (5 vascular species per relevé) representing pioneer vegetation dominated by *Puccinellia distans*. They were developed on rough gravel and fine soils as well. We recorded them under the motorway viaduct Hybica on places affected by water run-off from the motorway directly under the bridge. The other relevés (Tab. 1, 5–14) contain on average 10 species and are developed on broader road verges, around turns of unpaved roads and rest areas. Accompanying species except *Puccinellia distans* were diagnostic species of the class *Polygono arenastri-Poëtea annuae* Rivas-Martínez 1975 corr. Rivas-Martínez et al. 1991: *Matricaria discoidea*, *Plantago major*, *Taraxacum* sect. *Ruderalia* and *Polygonum aviculare* agg. High constancy values had *Elytrigia repens* and *Leontodon autumnalis*.

All relevés (Tab. 1) were according to the available literature classified into the class *Polygono arenastri-Poëtea annuae*, alliance *Coronopodo-Polygonion arenastri*, association *Puccinellio-Chcenopodietum glauci* Krippelová 1971.

New species to northern Slovakia is *Spergularia salina*. We have recorded this native halophyte on three sites (two several micro-sites near Važec and in Mengusovce, relevés no. 6, 9, 10 and 13, Fig. 1).

Tab. 1. Phytosociological relevés of roadside vegetation with presence of halophytes

Relevé number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rel. area in m ²	16	8	4	12	8	2	8	6	2	2	4	3	10	16
Cover E ₁ %	30	40	40	70	45	50	70	50	30	50	60	45	40	40
Cover E ₀ %	0	0	0	0	3	0	1	0	0	0	0	0	0	0
Number of species	4	2	6	8	13	10	19	8	12	10	10	11	8	8
<i>Puccinellia distans</i>	3	3	b	4	b	b	1	3	1	a	3	3	3	3
<i>Elymus repens</i>	+	+	+	+	+	+	1	1	1	a	a	+	+	+
<i>Plantago major</i>	.	.	+	+	b	+	a	a	1	1	1	1	+	+
<i>Taraxacum sect. Ruderalia</i>	+	.	.	+	1	1	+	+	.	1	+	a	+	.
<i>Spergularia salina</i>	.	.	.	.	.	a	.	.	a	a	.	.	1	.
<i>Trifolium repens</i>	.	.	.	.	+	.	1	.	.	.	.	+	.	.
<i>Matricaria discoidea</i>	.	.	.	.	+	+	+	r	+	.	.	.	.	.
<i>Polygonum aviculare</i> agg.	.	.	.	.	+	+	.	1	+	.	1	.	.	.
<i>Sonchus oleraceus</i>	.	.	.	.	.	+	.	.	1	1	1	.	.	.
<i>Achillea millefolium</i>	.	.	.	.	+	.	1	.	.	+	.	+	.	.
<i>Chenopodium glaucum</i>	.	.	.	.	.	.	.	.	+	+	1	+	.	+
<i>Chenopodium album</i>	.	.	.	.	.	.	.	.	r	.	+	.	.	+
<i>Juncus compressus</i>	.	.	+	1	.	.	.	.	.	.	.	+	+	+

Species recorded in less than two relevés:

Agrostis stolonifera + (5, 7), *Artemisia vulgaris* + (10), *Atriplex sagittata* + (1), *Bryum caespiticium* 1 (5, 7), *Carex hordeistichos* + (7), *Cynodon dactylon* 1 (7), *Daucus carota* + (5, 7), *Deschampsia cespitosa* + (7), *Echinochloa crus-galli* + (10, 15), *Juncus bufonius* 2b (3), + (4), *Lolium perenne* + (12), *Medicago lupulina* + (7), *Odontites vulgaris* + (5, 7), *Pastinaca sativa* + (11), *Pimpinella saxifraga* + (7), *Trifolium pratense* + (7), *Spergularia rubra* + (4), *Tussilago farfara* + (3).

Localities:

1. Hybe, under the motorway bridge, initial open vegetation, 49°03'21.2", 19°50'38.0", 710 m, 24. 9. 2016. **2.** Mengusovce, highway no. 18; broadened road (rest area), gravel, initial open vegetation, 49°04'27.8", 20°06'33.9", 869 m, 25. 8. 2016. **3.** Hybe, under the motorway bridge, silty soil, 49°03'20.0", 19°50'38.6", 710 m, 24. 9. 2016. **4.** Hybe, under the motorway bridge, silty soil, 49°03'20.0", 19°50'38.5", 710 m, 24. 9. 2016. **5.** Važec, highway no. 18; road verge, gravel, 49°04'14.9", 19°59'38.2", 820 m, 14. 9. 2016. **6.** Važec; highway no. 18; rest area, fine gravel, 49°04'39.3", 20°01'34.7", 868 m, 23. 8. 2016. **7.** Važec, highway no. 18; road verge, loam and gravel, 49°04'14.9", 19°59'33.2", 819 m, 14. 9. 2016. **8.** Važec; highway no. 18, turn to the unpaved road from the rest area, gravel, 49°04'38.5", 20°01'34.1", 868 m, 23. 8. 2016. **9.** Važec; highway no. 18; rest area, road verge, fine gravel, 49°04'38.2", 20°01'29.0", 868 m, 23. 8. 2016. **10.** Mengusovce, highway no. 18; broadened road (rest area) before the turn to the settlement, 49°04'21.2", 20°06'59.3", gravel, 844 m, 23. 8. 2016. **11.** Mengusovce, highway no. 18; broadened road (rest area) before the turn to the settlement, 49°04'21.5", 20°06'58.4", gravel, 844 m, 23. 8. 2016. **12.** Važec; highway no. 18; rest area, in the track at the roadside, fine gravel, 49°04'39.2", 20°01'33.8", 868 m, 23. 8. 2016. **13.** Važec; highway no. 18; roadside towards Tatranská Štrba, gravel, 49°04'41.0", 20°01'49.4", 868 m, 23. 8. 2016. **14.** Tatranská Štrba, highway no. 18; road verge, gravel, 49°04'58.4", 20°03'05.8", 888 m, 25. 8. 2016.

Discussion

KRIPPELOVÁ (1971) described the association *Puccinellio-Chenopodietum glauci* as species-poor vegetation with high dominance of *Puccinellia distans* and accessory presence of *Chenopodium glaucum* within the alliance *Coronopodo-Polygonion arenastri*. She recorded this vegetation on trampled urban lawns in the vicinity of magnesite factory strongly affected by air pollution and she pointed out its similarity with the strongly trampled vegetation of *Lolio-Plantagnetum majoris* Beger 1930. From this association she allocated the *Puccinellio-Chenopodietum glauci* since those stands have different species composition due to the magnesium pollution in the soil.

JAROLÍMEK et al. (1997) in the survey of synanthropic vegetation of Slovakia refer to the as. *Puccinellio-Chenopodietum glauci* under the name *Puccinellia distans*-community. According to these authors the plant community occurs on soils with high nutrient content and pollution originating from industrial production, partially on the edges of dung-water pits and exposed bottoms of disposal sites from sugar-making factories. They also highlight its expansion along roadsides due to road salting. They assigned the association into the alliance *Chenopodion glauci* Hejny 1974 of the class *Bidentetea tripartiti* R. Tx. et al. in R. Tx. ex von Rochow 1951. In the following survey *Puccinellia distans*-comm. was included also in the alliance *Chenopodion glauci* (JAROLÍMEK et al. 2008).

In the Czech vegetation survey (ŠUMBEROVÁ & LOSOSOVÁ 2011) the association *Puccinellio-Chenopodietum glauci* is presented under the synonym *Chenopodietum rubri* Timár 1950 (alliance *Chenopodion rubri* Tüxen 1960, class *Bidentetea tripartiti*). This association consisting of a few summer annuals occurs on wet soils around barns, dung hills, depressions along puddles in villages and on exposed bottoms of nutrient-rich fishponds. Less typical stands of *Chenopodietum rubri* with dominance of *Puccinellia distans* according to ŠUMBEROVÁ & LOSOSOVÁ (l. c.) grow on roadsides where the species composition is influenced by chemical properties of salts applied. On the contrary, in Poland WALDON (1998) following the concept of KRIPPELOVÁ (1971) included *Puccinellio-Chenopodietum glauci* in the vegetation of trampled areas (*Matricario-Polygonion avicularis*).

We also include *Puccinellio-Chenopodietum glauci* into the vegetation of trampled habitats of the *Coronopodo-Polygonion arenastri* alliance. Based on our observations, *Puccinellia distans*-community in the foothill regions has a strong mesic character against the warmer areas. Therefore its position in the class *Polygono arenastri-Poëtea annuae* is preliminary and the exact classification requires higher amount of recent phytosociological data from several regions of Slovakia.

Other interesting fact is the occurrence of *Spergularia salina*. Until now, its secondary occurrence in Slovakia was known only on the D2 motorway at the Sekule rest area near the border of the Czech Republic (GOLIAŠOVÁ 2012). It is expected that the species will expand along other road and motorway sections as a result of the effect of winter road salting, similarly as in the Czech Republic. There the species occurs most frequently along motorways of colder areas

where the application of de-icing salts is more intense, and is less abundant in warm and dry areas (KAPLAN et al. 2016).

As it is generally known, roadsides as secondary habitats promote expansion of alien species, they simultaneously provide refugia for rare native species as well, regardless to the vicinity of primary habitats where they naturally grow. In selected route sections of southern Slovakia no halophytes were detected on roadsides, however natural saline habitats are there present (DÍTĚ et al 2010). Our study confirmed that presence of halophytes on road verges depends strictly on the intensity of road salting.

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