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Railway stations vs. thermophilous species (example from Eastern Slovakia)

JANA MÁJEKOVÁ[1], VLADIMÍR JEHLÍK[2] & MARICA ZALIBEROVÁ[1]

[1]Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 9, 845 23 Bratislava, Slovak Republic; jana.majekova@savba.sk, maria.zaliberova@savba.sk

[2]V Lesíčku 1, 150 00 Praha 5 – Smíchov, Czech Republic

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Abstract: Railway habitats host a multitude of plant taxa – both native and alien, including threatened, synanthropic and invasive species. Thermophilous species are also often present at many railway stations due to the high temperature of rails and gravel. The aims of this study are: (i) to document past and current vascular plant flora identified at Košice and Spišská Nová Ves railway stations in Eastern Slovakia (ii) to compare species composition at these stations and (iii) to evaluate species' temperature preferences at the different climatic regions (at Košice, Spišská Nová Ves, Plaveč and Čierna nad Tisou stations). Recorded plant taxa were; 207 at Košice railway station and 204 at Spišská Nová Ves. Archaeophytes prevailed over neophytes at both stations and the most frequent plant families were *Asteraceae*, *Poaceae* and *Brassicaceae*. Despite the different climates, similar species structure was identified at all studied railway stations.

Keywords: vascular plants, distribution, climate, species thermophility, Ellenberg indicator values, Borhidi indicator values, railway, Slovakia.

Introduction

Anthropogenic influences have a significant role in species spread throughout a country. In addition to deliberate plant and animal introduction for agricultural, medical and ornamental purposes, there is also accidental spread by increasing

globalization, international traffic and trade (VAN KLEUNEN et al. 2015). Plant diaspores are imported on road vehicles and with transported material, so railway has become a major factor in flora synanthropization (RABITSCH & ESSL 2006, WIŁKOMIRSKI et al. 2012). JEHLÍK (1998, 2013) pioneered research in plant spread by railway and ship traffic in Slovakia and in former Czechoslovakia. His work revealed that freight transport was more important than passenger traffic in spreading adventives.

Apart from Jehlík, only marginal attention has been devoted to flora and vegetation research at Slovak railway habitats (e.g. SCHIDLAY 1944, FRANTOVA 1947, ELIÁŠ 1977, 1979a, b, c, 1981, JEHLÍK & DOSTÁLEK 1989, 2008, ELIÁŠ jun. 2011, ELIÁŠ jun. et al. 2013, JEHLÍK el al. 2013, MÁJEKOVÁ et al. 2013, 2014, ZALIBEROVÁ & MÁJEKOVÁ 2014 and MÁJEKOVÁ & LIMÁNEK 2016).

Study on this topic in adjacent Central European countries has also been performed in the Czech Republic (JEHLÍK 1986, 1995, HOSKOVEC 2009, RŮŽIČKA & KOBLÍŽEK 2009, STAŘECKÁ 2010), Poland (PISKORZ & CZARNA 2006, NOWINSKA & CZARNA 2008, GALERA et al. 2012, 2014), Austria (HOHLA et al. 2000, 2002, 2005), Ukraine (SHEVERA et al. 2015) and Germany (cf. www.ruderal-vegetation.de/epub/#eisenbahn). BRANDES (1983) concentrated on flora and vegetation at Central European railway stations and published his Bibliography on railway vegetation in Europe (BRANDES 2008).

Although railway habitats are often neglected by botanists, they are very interesting biotopes. JEHLÍK (1986, 1998) characterised synanthropic stands in the following adjacent railway areas: (1) many fields without vegetation – with reduced native species competition; (2) very young soils; (3) drying stands; (4) temperature elevated by dark substrate surface and (5) constant anthropogenic impacts on the soil surface.

Railyards, platforms and banks offer a refugium for many species; especially for both native and alien synanthropic plants, but threatened species also find these conditions suitable (cf. HUBER 1992, HOHLA et al. 2000, 2002, 2005, NOWIŃSKA & CZARNA 2008, MÁJEKOVÁ et al. 2014, MÁJEKOVÁ & LIMÁNEK 2016). These sites also provide a convenient corridor for alien and invasive plant spread (JEHLÍK 1995, RABITSCH & ESSL 2006), where some species bind to these biotopes in their initial introduction to a new country (cf. ELIÁŠ jun. 2011, ZALIBEROVÁ & MÁJEKOVÁ 2014). Thermophilous species are especially suited to the extreme train rail and gravel temperatures, because soil temperature increase above air temperature enhances their germination (BRANDES 1983); and this is also noted in reports of several thermophilous plants at railway stations in different countries (ELIÁŠ 1977, BRANDES 1983, ELIÁŠ jun. et al. 2013, GALERA et al. 2014, MÁJEKOVÁ et al. 2014, MÁJEKOVÁ & LIMÁNEK 2016).

The above research inspired us to investigate the extent to which the proportional representation of thermophilous species is dependent on railway station climate. Here, we chose the following 4 railway stations in Eastern Slovakia in different climatic regions, altitudes and phytogeographical districts: Košice, Spišská Nová Ves, Plaveč and Čierna nad Tisou. In addition to Jehlík's past railway biotope research in Eastern Slovakia (JEHLÍK & DOSTÁLEK 2008, JEHLÍK et

al. in press), he also collected data from Košice and Spišská Nová Ves stations, but his species lists are incomplete. Our comprehensive field-work therefore detailed the flora at these two stations to complete the study. In addition, Plaveč station species composition was published by MÁJEKOVÁ & LIMÁNEK (2016), and our study of Čierna nad Tisou populations is in press (JEHLÍK et al. in press).

The aims of this study are: (1) to document and evaluate past and present vascular plant flora at Košice and Spišská Nová Ves railway stations; (2) to compare species composition at these sites and (3) to compare species' temperature preferences at Košice, Spišská Nová Ves, Plaveč and Čierna nad Tisou Eastern Slovak railway stations.

Material and methods

Study area

Field research was performed at Košice and Spišská Nová Ves railway stations. These are situated in different Eastern Slovak climatic regions; Košice lies in the southern warm climatic region near the Slovak-Hungarian border, while Spišská Nová Ves is more northern in moderately warm climatic region (LAPIN et al. 2002). Phytogeographically (FUTÁK 1980), Košice is part of the Košická kotlina district (Eupannonicum, Pannonicum) and Spišská Nová Ves is in the Spišské kotliny district (Intracarpaticum, Carpaticum occidentale). Flora at these stations has been studied both recently and in the past.

Characteristics of the individual localities: the size and locality of the four railway stations are illustrated in Fig. 1 and Tab. 1; where station size is determined by the number of rails in the station (www.vlaky.net).

(1) Košice: railway station, altitude: 205 m a.s.l.; number of square and subsquare on the Slovak flora grid map (JASIČOVÁ & ZAHRADNÍKOVÁ 1976): 7293d; visited 1968–2013 (by Jehlík: 31.7.1968 and 13.7.1974; by Jehlík, Zaliberová and Májeková: 25.8.2012, 30.4.2013 and 16.7.2013).

Košice is an important rail junction with the following lines; number 180 to the North-west (Žilina – Košice); 190 to the East (Košice – Čierna nad Tisou); 160 to the West (Zvolen – Košice); 169 South to Hungary (Košice – Hidasnémeti) and 188 North to Poland (Košice – Plaveč – Muszyna). The railway station began operation in 1871 and the lines were opened between 1860 and 1890 (KUBÁČEK et al. 2013).

(2) Spišská Nová Ves: railway station, 465 m a.s.l; 7089a; visited in 1973–2013 (by Jehlík: 12.7.1973; by Jehlík, Zaliberová and Májeková: 2.5.2013, 17.7.2013).

Station lies on the Žilina – Košice 180 line and rail traffic began here in 1871. Passenger traffic on a local Spišská Nová Ves – Levoča 186 line commenced in 1892, was stopped in 2003 (KUBÁČEK et al. 2013).

(3) Plaveč station lies in North-eastern Slovakia in the moderately warm climatic region. It serves as a passenger and freight station, and connects to the 185 Poprad-Tatry and 188 Košice lines; this line previously continued into Poland (cf. MÁJEKOVÁ & LIMÁNEK 2016).

(4) Čierna nad Tisou lies in the warm climatic region of South-eastern Slovakia. It is the largest and the most important Slovak railway trans-shipment yard and also serves as a passenger railway station. The station is connected to Košice line 190 and to the Ukrainian rail network (cf. JEHLÍK et al. in press).

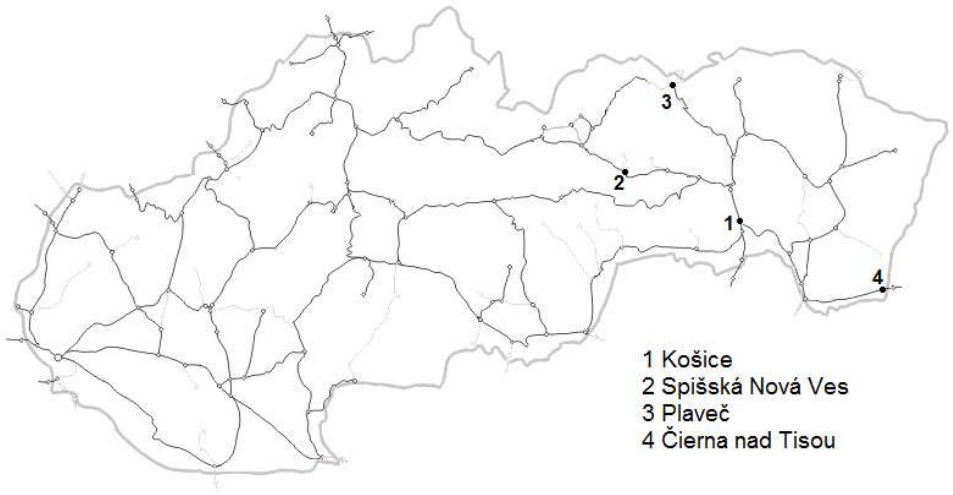


Fig. 1. Map of railway network in Slovakia with studied stations.

Tab. 1. Comparison of studied railway stations' size, the number of recorded species and available values (% of all taxa) in Ellenberg and Borhidi species temperature values.

Railway station	Number of rails	Number of recorded species	Ellenberg	Borhidi
Košice	119	207	148 (71%)	193 (93%)
Spišská Nová Ves	38	204	143 (70%)	191 (94%)
Plaveč	11	202	141 (70%)	189 (94%)
Čierna nad Tisou	173	582	383 (66%)	481 (83%)

Field research

Previous species lists from Košice and Spišská Nová Ves were incomplete, with only species presence/absence documented, therefore we recorded all vascular plant species identified at these railway stations; with abundance on a 5-degree scale: a – rare, b – occasional, c – scattered, d – frequent and e – abundant (cf. JEHLÍK 2013, JEHLÍK et al. in press).

Plant taxa nomenclature follows MARHOLD (1998) or is cited with the author's name, particular IUCN threat categories are according to ELIÁŠ jun. et al. (2015) and their origin and invasiveness are as in MEDVECKÁ et al. (2012). Specimens are deposited in the herbarium at the Institute of Botany, Slovak Academy of

Sciences in Bratislava (SAV) and in the herbarium of the Institute of Botany, Academy of Sciences of the Czech Republic in Průhonice (PRA).

Data analysis

Comparison of species' temperature preferences was from Košice, Spišská Nová Ves, Plaveč (MÁJEKOVÁ & LIMÁNEK 2016) and Čierna nad Tisou (JEHLÍK et al. in press) species lists. Ellenberg and Borhidi temperature indicator values were used and compared (ELLENBERG et al. 1992, BORHIDI 1995), and species' temperature values at the stations were presented as Box-Whisker plots in Statistica program.

Results and discussion

Košice

A total of 207 plant taxa were recorded at Košice railway station (Tab. 2); comprising 192 current taxa and 72 from past records; and featuring 97 native taxa and 99 alien with 10 uncertain residence status. Archaeophytes (with 63 taxa) were more abundant than neophytes (36). Plants belonged to 46 families, the most abundant were: *Asteraceae* (28 taxa), *Poaceae* (22), *Brassicaceae* (15), *Cichoriaceae* (14) and *Fabaceae* (10).

While *Lactuca saligna* (VU), *Chenopodium murale*, *Tribulus terrestris* (NT) and *Draba nemorosa* (LC) are recently recorded threatened species, comparison between past and recent species lists is impossible because of incomplete previous monitoring.

The discovery of *Tribulus terrestris* at Košice station documents a new distribution locality because it had only previously been recorded in dry natural and synanthropic habitats in south-western Slovakia (ZAHRADNÍKOVÁ 1982, ELIÁŠ & FERÁKOVÁ 1999). Nowadays, species is spreading northwards by railway traffic to the secondary habitats, specifically railway stations (ELIÁŠ 1977, MÁJEKOVÁ et al. 2014). Košice is beside the most eastern Čierna nad Tisou station the second species location in Eastern Slovakia (JEHLÍK et al. in press).

In addition, although *Draba nemorosa* is generally spread throughout Slovakia, our finding is the first in the Košická kotlina phytogeografical district (cf. PENIAŠTEKOVÁ & KLIMENT 2002, MÁJEKOVÁ et al. 2014).

Spišská Nová Ves

A total of 204 taxa were recorded at the Spišská Nová Ves railway station (Tab. 2); 56 from past lists and 191 recent additions. The 112 native plant taxa prevailed over 83 aliens, and 58 archaeophytes over 25 neophytes, with an additional 9 species having uncertain residence status.

Species are divided into 42 plant families, with the following most abundant: *Asteraceae* (24), *Poaceae* (24), *Brassicaceae* (22), *Fabaceae* (13) and *Rosaceae* (12); while threatened species comprised the recently recorded *Papaver dubium* subsp. *austromoravicum* (NT) and *Draba nemorosa* (LC).

Tab. 2. List of recorded taxa at Košice and Spišská Nová Ves railway stations. Historical data comes from Jehlík (1968–1974) and recent data from Jehlík, Zaliberová and Májeková (2012–2013). Annotations: x = taxa presence and a–e = taxa abundance.

Taxon	Košice		Spišská Nová Ves	
	historic	recent	historic	recent
Acer campestre		a		
Acer platanoides		a		a
Acetosa thyrsiflora	x	c		b
Acinos arvensis		a		
Acosta rhenana	x	b		
Aegopodium podagraria				a
Aethusa cynapium subsp. *cynapioides*		a		
Achillea millefolium agg.	x	c		c
Ailanthus altissima		a		
Alliaria petiolata				a
Amaranthus albus	x	a-b	x	
Amaranthus powellii		c		
Amaranthus retroflexus	x	c-d	x	c
Ambrosia artemisiifolia		b-c		
Anchusa officinalis	x		x	b
Anthriscus cerefolium		a		
Anthriscus sylvestris				b-c
Apera spica-venti			x	
Arabidopsis thaliana		b		c
Arctium lappa	x	b		b
Arctium minus	x			
Arctium tomentosum		a-b	x	b
Arenaria serpyllifolia		c		a-c
Armoracia rusticana			x	a
Arrhenatherum elatius		d		c-d
Artemisia absinthium	x	a-b		a
Artemisia vulgaris	x	c	x	c
Astragalus glycyphyllos				a
Atriplex patula		a-b		a
Atriplex tatarica	x	a-c		
Ballota nigra subsp. *nigra*		b		a-b
Barbarea vulgaris				a
Bassia scoparia subsp. *scoparia*	x	c		
Berteroa incana		a-b		b
Betula pendula		a		
Bidens frondosa		a-c		a
Brassica napus subsp. *napus*	x	b-c		a-b
Bromus hordeaceus		b		a-b
Bromus inermis	x		x	
Bromus japonicus		b		
Bromus sterilis		a		b
Bromus tectorum	x	a-c	x	b-c

Tab. 2. – cont.

Taxon	Košice		Spišská Nová Ves	
	historic	recent	historic	recent
Bunias orientalis			x	a
Calamagrostis epigejos	x	b-c	x	c
Calystegia sepium				b
Camelina microcarpa		a		
Camelina microcarpa subsp. *sylvestris*			x	
Capsella bursa-pastoris		b-c		c
Cardaminopsis arenosa				a
Cardaria draba			x	a
Carduus acanthoides	x	b	x	b
Carex hirta	x			
Carex spicata			x	
Cerastium glutinosum				a
Cerastium holosteoides		b		b
Cerastium semidecandrum		c		c
Cerasus avium				a
Chaerophyllum aromaticum				a
Chamerion angustifolium			x	a
Chelidonium majus		a-b		a-b
Chenopodium album	x	b		b
Chenopodium glaucum	x	b		
Chenopodium murale		a		
Chenopodium pedunculare Bertol.				a
Chenopodium strictum		d		
Chorispora tenella				a
Cichorium intybus	x	a-c	x	c
Cirsium arvense	x	b-c		b
Cirsium vulgare subsp. *vulgare*	x			a
Citrullus lanatus		a		
Consolida regalis	x	a	x	a
Convolvulus arvensis	x	c-d		b-c
Conyza canadensis	x	b-c	x	b-c
Crepis sp.		b		
Crepis tectorum		a		a
Cruciata glabra				a
Dactylis glomerata		a		a
Dalanum angustifolium		a		
Daucus carota	x	c		a-c
Descurainia sophia			x	
Digitaria sanguinalis		c-d		c
Draba nemorosa		a		c
Echinochloa crus-galli		b		a
Echium vulgare	x	b-c	x	c
Elytrigia repens	x	c		c
Epilobium collinum		a		a
Epilobium hirsutum		a		a
Epilobium tetragonum		a		a

Tab. 2. – cont.

Taxon	Košice		Spišská Nová Ves	
	historic	recent	historic	recent
Equisetum arvense	x	c		b-c
Eragrostis minor	x	c	x	b
Erigeron acris		a		
Erodium cicutarium		a	x	
Erophila verna		b		b
Erysimum cheiranthoides				a
Falcaria vulgaris	x			
Fallopia convolvulus		c		c
Festuca pratensis				a
Festuca rubra		b		b
Fragaria vesca		a		a
Galinsoga parviflora	x	a-c	x	a
Galinsoga urticifolia		a-b		
Galium album		b-c		b-c
Galium aparine		b		
Galium odoratum				a
Galium spurium		a		
Galium verum	x	b		a
Geranium pratense	x		x	b
Geranium purpureum Vill.		a		
Geranium pusillum		a-b		
Geranium robertianum		b		b
Geranium sibiricum		a		a-c
Glechoma hederacea				b
Helianthus annuus var. *macrocarpus* (DC.) Cockerell	x			a
Heracleum sphondylium				b
Hieracium sabaudum		a		
Hordeum murinum		a		a
Humulus lupulus		a		
Hypericum perforatum		b-c		a-b
Impatiens parviflora		b		c
Iva xanthiifolia	x	a		
Juglans regia		a		
Lactuca saligna		b		
Lactuca serriola	x	b-c	x	b-c
Lamium album				b-c
Lamium amplexicaule		a		a
Lamium purpureum		b		
Lappula squarrosa		a		
Lapsana communis				a
Lathyrus pratensis				a
Lathyrus tuberosus	x	a	x	a
Leontodon autumnalis		a-b		a
Lepidium campestre	x		x	
Lepidium densiflorum (incl. *L. neglectum*)	x	b	x	a

Tab. 2. – cont.

Taxon	Košice		Spišská Nová Ves	
	historic	recent	historic	recent
Lepidium ruderale	x	b	x	b
Libanotis pyrenaica		a	x	c
Linaria vulgaris	x	a-c		c
Lithospermum arvense		b		a
Lolium perenne	x	a-c		c
Lotus corniculatus	x	b-c		
Lycopersicon esculentum		a		
Malus domestica	x	b		a
Malva neglecta				a
Matricaria discoidea		a	x	b
Medicago falcata			x	a
Medicago lupulina		c		c
Medicago sativa	x	a-c		
Medicago × varia		a-b		b
Melilotus albus	x	a-b	x	a
Melilotus officinalis	x	b-c	x	b
Microrrhinum minus	x	a-c		a
Myosotis arvensis				b
Myosotis sparsiflora				a
Myosotis stricta		c		b
Negundo aceroides		b-c		
Oenothera biennis	x	a-b		a
Oenothera rubricaulis		a		
Oenothera villosa	x	b	x	a
Onopordum acanthium	x		x	a
Origanum vulgare subsp. *vulgare*				a
Panicum capillare subsp. *barbipulvinatum* (Nash) Tzvel.		c		
Papaver dubium subsp. *austromoravicum*				a
Papaver rhoeas		b		a
Parthenocisus inserta (A. Kern.) Fritsch		a		a
Pastinaca sativa subsp. *sativa*	x	b-d	x	a-b
Persica vulgaris	x			
Persicaria lapathifolia			x	
Persicaria maculosa	x	a-b		b
Picris hieracioides	x	b-c	x	b-c
Pilosella officinarum		a-b		a
Pimpinella saxifraga		b		a
Pinus sylvestris				a
Plantago lanceolata		c		c
Plantago major	x	b-c		b
Plantago media				a
Poa annua		a		b
Poa bulbosa subsp. *vivipara*				a
Poa compressa		a-b	x	a-b
Poa palustris				a
Poa pratensis		d		c

Tab. 2. – cont.

Taxon	Košice		Spišská Nová Ves	
	historic	recent	historic	recent
Polygonum aviculare agg.	x	d		c
Populus alba		a		
Portulaca oleracea		b-c		b
Potentilla anserina				a
Potentilla argentea		b-c	x	b-c
Potentilla intermedia				b-c
Potentilla recta			x	a
Potentilla reptans		c		b
Potentilla supina			x	a
Prenanthes purpurea				a
Puccinellia distans	x	a-b	x	a
Ranunculus repens				a
Reseda lutea	x	a-b	x	a
Rorippa sylvestris		a		
Rosa canina		a-b		a-b
Rubus caesius		b-c		b-c
Rubus idaeus		a		a
Rumex confertus	x			
Rumex crispus	x			a
Rumex obtusifolius		b		
Rumex patientia		a		
Salix caprea		b		a-b
Salix cinerea		a		a
Salix silesiaca				a
Salvia verticillata		a	x	a
Sambucus nigra	x	a-c		a-c
Saponaria officinalis	x	a-c	x	a-b
Scrophularia nodosa		a		
Securigera varia		a	x	b
Sedum acre		b		b
Senecio ovatus				a
Senecio vernalis		b		b
Senecio viscosus	x	a-b		a
Senecio vulgaris		b		a-b
Setaria verticillata	x	a		
Setaria viridis (L.) P. B. subsp. *pycnocoma* (Steud.) Tzvelev				a
Setaria viridis subsp. *viridis*		c-d		b
Silene latifolia subsp. *alba*		b-c		b-c
Silene noctiflora		a		
Silene vulgaris		a		a
Sisymbrium altissimum	x		x	
Sisymbrium loeselii		a	x	
Sisymbrium officinale			x	
Solanum nigrum		b		
Solanum nigrum subsp. *schultesii*		a		

Tab. 2. – cont.

Taxon	Košice		Spišská Nová Ves	
	historic	recent	historic	recent
Solanum tuberosum			x	
Solidago canadensis		b-c		b
Solidago gigantea				a
Sonchus arvensis	x			
Sonchus asper		a		
Sonchus oleraceus		b-c		c
Stachys annua		b		
Stellaria graminea		a		
Stellaria media		c		b
Stenactis annua		a-c		b
Swida sanguinea		a-b		a
Symphytum officinale				a
Tanacetum vulgare	x	a-c	x	a-b
Taraxacum sect. *Ruderalia*		b-d		b-d
Thlaspi arvense		b		
Thlaspi perfoliatum		a		
Tilia cordata				a
Tilia platyphyllos		a		a
Tithymalus cyparissias		b		a
Tithymalus helioscopia				b
Torilis japonica		b		
Tragopogon dubius		c		
Tragopogon orientalis		c		c
Tribulus terrestris		a-b		
Trifolium pratense		c		c
Trifolium repens		b-d		b-c
Tripleurospermum perforatum	x	b-c	x	b-c
Tussilago farfara	x	a		a
Ulmus glabra				a
Urtica dioica		b-c		b
Valerianella locusta		b		a
Verbascum blattaria		a		
Verbascum lychnitis			x	a-b
Veronica arvensis		b		b
Veronica hederifolia		b		a
Veronica persica				a
Veronica polita				b
Vicia cracca				b
Vicia villosa				a
Viola arvensis		a-b		b-c
Viola cf. *odorata*		b		
Viola odorata				b
Viola tricolor		a		a
Vitis vinifera		a		
Xanthoxalis stricta		a		

Comparison of the species structure

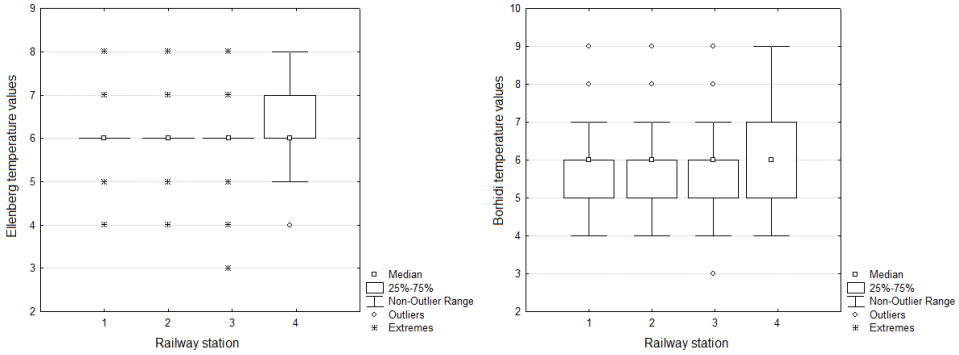
Tab. 1 highlights that although Košice's 119 tracks makes it a much larger railway complex than Spišská Nová Ves with its 38 tracks, the number of recorded species is quite similar at 207 compared to 204; and 192 to 191 in recent listing. Specifically, there is uniformity of occurrence of the following large group of thermophilous species at these stations: *Amaranthus albus*, *A. retroflexus*, *Anchusa officinalis*, *Artemisia absinthium*, *Bromus tectorum*, *Consolida regalis*, *Conyza canadensis*, *Digitaria sanguinalis*, *Echium vulgare*, *Eragrostis minor*, *Onopordum acanthium*, *Portulaca oleracea*, *Setaria viridis*, *Sisymbrium altissimum* and *S. loeselii*. However, differences in populations were also noted; where the following thermophilous species were recorded only at Košice: *Ambrosia artemisiifolia*, *Amaranthus powellii*, *Atriplex tatarica*, *Geranium purpureum*, *Iva xanthiifolia*, *Lactuca saligna*, *Lappula squarrosa*, *Rumex patientia*, *Setaria verticillata* and *Tribulus terrestris*.

The most novel finding was *Chorispora tenella*'s presence at Spišská Nová Ves station. This is not only a new locality for this species but also its northernmost sighting in Slovakia; as it was previously recorded mainly at a few South-western and eastern Slovak locations (MICHALKOVÁ 2002). Its presence at Spišská Nová Ves can be explained as introduction by railway traffic from southern warmer areas. The species was recorded, for example, in Dobrá and Čierna nad Tisou South-eastern Slovak railyards (JEHLÍK et al. in press).

Archaeophytes prevailed over neophytes at both Košice and Spišská Nová Ves railway stations; supporting CHYTRÝ et al.'s (2008) finding that archaeophytes have higher affinity for open vegetation at dry or mesic sites and neophytes prefer wet habitats and woodlands. Representation of dominant plant families at these two sites is also similar to that at south-eastern stations (JEHLÍK et al. in press).

We employed the different Ellenberg and Borhidi indicator scales to evaluate species temperature preferences, and we also included the further two Čierna nad Tisou and Plaveč railway stations to supplement Košice and Spišská Nová Ves results. Many more species were recorded at the southern-most Čierna nad Tisou station because this is the largest rail area with the greatest railway trans-shipment yard in Slovakia, and therefore it has the highest diaspore introduction rates (Tab.1); moreover this area was researching for the longest time. We found the same median value (6) on the thermophilous scale at all four stations, and Ellenberg and Borhidi indicator values returned similar results (Fig. 2). While Košice and Spišská Nová Ves have the same value range and Plaveč is very similar with only small deviation in the lower values, the Čierna nad Tisou value range is higher.

While our research shows similar thermophilous species representation at the four studied railway stations and climate has no distinguishing role, the heated rail and gravel substrate in these railway vicinities provide a fruitful location for thermophilous species which do not thrive so well in less suitable temperatures at native biotopes in colder areas.



a) b)

Fig. 2. Box and Whiskers plots of species temperature preferences by a) Ellenberg, b) Borhidi scales at studied railway stations (1 – Košice, 2 – Spišská Nová Ves, 3 – Plaveč, 4 – Čierna nad Tisou).

Use of environmental indicator values

Our research revealed differences in practical use of the indicator scales. The Ellenberg scale was proposed for Central Europe and most often used in analyses. However, this scale determined more species with missing values in our dataset (Tab. 1) than the Borhidi indicator values proposed for Hungary and whose proximity to our study area proved more reliable for our data. Since this differentiation is supported by KOCHJAROVÁ et al.'s (2015) results, it is advisable to test these scales before analysis.

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