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New records of rare species on exposed river banks and pools in southern Slovakia

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Abstract: We present new phytosociological and chorological data of five rare and endangered plant species of Slovakia: *Chlorocyperus glomeratus*, *Dichostylis micheliana*, *Lindernia procumbens*, *Heleochloa alopecuroides* and *Scirpus radicans*. All of them are characteristic species of periodical wetland habitats. We observed them in 2015, when optimal wheather circumstances (humid early-vegetation period followed by very dry and warm summer) were present. As they were recorded in new locations within the Podunajská and Východoslovenská nížina lowlands, brief characteristics of the new sites are provided as well. We also point out the negative trend of eutrophication in the natural mudflat vegetation in Slovakia.

Keywords: Danube River, Váh River, Latorica River, Hron River, Zemplínska Šírava, dwarf annual swards, *Isoëto-Nanojuncetea, Chenopodion rubri*, *Scirpetum radicantis*.

Introduction

Ephemeral vegetation of periodically desiccating water bodies is divided into two types of habitats: oligotrophic to mesotrophic standing waters with pioneer low-herb amphibian vegetation of the *Littorelletea uniflorae* and *Isoëto-Nanojuncetea* (Natura 2000 habitat code 3130). In Slovakia, the most typical is the vegetation of the *Elatino-Eleocharition ovatae* which is a Central-European-

Eurasiatic alliance including short-lived assemblages of exposed pond bottoms and emerging river banks (DEIL 2005). The other habitat (3270) gathers also amphibian pioneer vegetation from lowland to submontane levels, but it is developed on sites with higher nutrient accumulation. These nitrophilous plant communities in Slovakia are represented by the alliances *Chenopodion rubri* and *Bidention tripartitae* which belong to the class *Bidentetea tripartitae*.

Both habitats appear in years, when specific weather conditions are given: humid spring followed by very dry and warm late-summer, which results in long-lasting decrease of water levels. Since such circumstances are not repeating regularly, the vegetation does not develop in each growing season. River regulations, succession of river banks by willows and direct habitat destruction have reduced these habitats. Therefore recently they are very rare and fragile, especially the oligotrophic vegetation of the habitat 3130. Their substitute, secondary vegetation can be found on shallow field depressions where several species of exposed bottoms occur (ELIÁŠ et al. 2011).

The most recent local or regional studies about the vegetation of pond bottoms and river banks in Slovakia published RUŽIČKOVÁ et al. (2014), DÍTĚ et al. (2015) and KOCHJAROVÁ et al. (2015). On community level, the most up-to date survey provided ŠUMBEROVÁ & HRIVNÁK (2013) who gave a detailed description of ecology, dynamics, and distribution of the classes *Bidentetea tripartitae* and *Isoëto-Nanojuncetea*. In contrary, there is a poor knowledge about the recent occurrence and vegetation of annual swards in primary periodical habitats, as dried river oxbows or natural ponds.

The late vegetation season of the year 2015 was characterized by extremely high temperatures in Central Europe. Due to the persistent droughts the water level of the Danube River decreased to a very low level and from July until October the most islands and gravel bars were easily accessible. The same phenomenon was observed on the lower courses of the Danube tributaries Váh and Hron as well as in SE Slovakia, where a significant portion of the waterbeds (e. g. oxbows of the Latorica River and the banks of the Zempínska Šírava dam) became dry. The prolonged low water retreat enabled the development of natural mudflat vegetation and several rare species typical to periodically wet habitats appeared: *Chlorocyperus glomeratus* in the Podunajská nížina, *Heleochloa alopecuroides* and *Scirpus radicans* in the Východoslovenská nížina lowland, *Dichostylis micheliana* and *Lindernia procumbens* in both regions.

This work presents new localities of these species, provides data on their phytosociology and it is also aimed to draw up the current stage of the vegetation in their natural habitats (river oxbows and water reservoirs).

Material and methods

Our study was carried out during the year 2015. For each species, a brief description of the new sites, habitat and vegetation characteristics and mostly also phytosociological relevés are provided. The relevés were sampled according to the Zürich-Montpellier approach using the adapted nine-grade

Braun-Blanquet's cover abundance scale (BARKMAN et al. 1964). Nomenclature of higher plants follows MARHOLD & HINDÁK (1998), names of syntaxa are according to JAROLÍMEK et al. (2008), the names not included in this checklist are provided by the author abbreviations. The phytogeographical division of Slovakia is in accordance with FUTÁK (1980). The collected herbarium specimens are deposited in the Herbarium of the Institute of Botany SAS, Bratislava (SAV) and in the Herbarium of the Department of Botany, Slovak University of Agriculture in Nitra (NI). Results of the study are presented on the grid maps. The maps were designed by program ArcGis, version 9.2. The grid follows one that was described by NIKLFELD (1971). List of sites is processed according to the rules of Flóra Slovenska project (GOLIAŠOVÁ & MICHALKOVÁ 2012).

Results and discussion

We present new or long-time not confirmed localities of five species of periodical wetlands by enclosing 15 phytosociological relevés. The species order is according to the number of the relevés in which they were sampled.

1. *Dichostylis micheliana* is a typical therophyte of periodical wet habitats in warm lowland areas. In the Red List of Slovakia it is classified as EN and is protected by the law (ELIÁŠ et al. 2015). While in the Czech Republic it is bounded especially to dried bottoms of extensively used fishponds (DANIHELKA et al. 1995), in Slovakia it is rather known from the inundation area of the Morava, Danube and Latorica rivers (PROCHÁZKA et al. 1999a). *D. micheliana* indicates habitats not impacted by eutrophication, which is evidenced by the fact that it does not occur on rice fields as the majority of species of the class *Isoëto-Nanojuncetea* (HEJNÝ 1960; PINKE et al. 2014).

Numerous localities published HEJNÝ (1960) from the Borská, Podunajská and Východoslovenská nížina lowlands. In the following decades the species was not reported at all, until 1988 it was considered as a missing species in Slovakia (PROCHÁZKA et al. 1999a). The historic sites in the Podunajská nížina lowland (e.g. Komárno, Štúrovo) were not confirmed up to now, there were documented only some scattered locations, e.g. Kľúčovské rameno (SUCHÁ 1992) or Chotín (DÍTĚ 2004). The species was more frequently observed on the Východoslovenská nížina lowland by BOGOLY (1994). Its recent distribution in the Borská nížina lowland provided KOCHJAROVÁ et al. (2013). We add several data on the recent occurrence of *D. micheliana* in the Danube and Latorica regions.

We recorded the species on the historic site in Štúrovo (firstly reported by FEICHTINGER 1899, later observed by HEJNÝ 1960) and on several locations along the left bank of the Danube River and on the right bank of the Váh River on different types of exposed bottoms from gravel to silt, with the greatest affinity to sandy substrates. In SE Slovakia we have found the species on the muddy banks of the Zemplínska Šírava dam and on exposed muddy bottoms of the Latorica River oxbow near Zatín and Boľ settlements (Fig. 1).

List of the new localities:

1. Burda: Kamenica nad Hronom, gravel shore of the Danube River, 102 m a.s.l. (P. Eliáš jun., D. Dítě, Z. Melečková 2015 NI).

6. Podunajská nížina: Číčov, near the Danube bank, desiccating muddy pool on the southernmost part of the Číčovské mŕtve rameno dead arm, outside of the Nature Reserve – Klížska Nemá, left bank of the Danube, exposed gravel bottom, 110 m. – Klížska Nemá, shores of large pond in the village, 110 m (both data P. Eliáš jun., D. Dítě, Z. Melečková 2015 NI). – Zlatná na Ostrove, Veľký Lél settlement, left bank of the Veľkolélske rameno river branch of the Danube, 110 m (D. Dítě, Z. Dítětová, not. 2015). – Kolárovo, left and right sandy banks of the Váh River south from the road bridge, 116 m (P. Eliáš jun. 2015 NI). – Komárno, left bank of the Danube River E of the railway bridge at the SW edge of the town, exposed sandy loam bottom, 107 m. – Komárno, part Malá Ižа, left bank of the Váh River at its confluence with the Danube, exposed sandy bottom, 108 m (both data E. Michalková, D. R. Letz 2015 SAV). – Iža, Leányvár, exposed gravel shore of the Danube, S of the village, 104 m. (P. Eliáš jun. 2015 NI). – Radvaň nad Dunajom, part Žitava, left bank of the Danube, S of the settlement, exposed sandy bottom, 105 m. – Radvaň nad Dunajom, left bank of the Danube, S of the village, exposed sandy bottom, 107 m. – Moča, left bank of the Danube at the SE edge of the village, exposed sandy loam bottom, 104 m. – Kravany nad Dunajom, left bank of the Danube, SE of the village, exposed sandy loam bottom, 105 m. – Mužla, part Čenkov, left bank of the Danube, 0,5 km SE of the settlement, exposed sandy loam bottom, 104 m. (all data D. R. Letz 2015 SAV). – Štúrovo, east from the village near the confluence of rivers Danube and Hron, 103 m (D. Dítě, Z. Dítětová, P. Eliáš jun. 2015 not.).

8. Východoslovenská nížina: Michalovce, Biela Hora recreation area, exposed bottom of the Zemplínska Šírava dam, 110 m – Kusín, NE bank of the Zemplínska Šírava dam near the church, 105 m. – Jovsa, SE bank of the Zemplínska Šírava dam, 105 m. – Streda nad Bodrogom, Stredský les site, dry bottom of the Bodrog River oxbow, 101 m (all data P: Eliáš jun., D. Dítě, Z. Melečková 2015 NI). – Zatín, dried bottom of the Latorica River oxbow, 99 m. – Boľ, exposed muddy bottom of the Latorica River oxbow, 99 m (both data P. Eliáš jun., D. Dítě, Z. Melečková, A. Šimková 2015 NI).

We document the vegetation with *D. micheliana* by the following relevés:

Relevé no. 1.

Podunajská nížina, Klížska Nemá, left bank of the Danube, exposed gravel bottom, 112 m, N 47°44´37.3˝, E 17°50´15.4˝, slope 0°, relevé plot 16 m^2, E_1: 60%, E_0: 5%, 22. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš jun.

E_1: *Portulaca oleracea* 2b, *Rorippa sylvestris* 2b, *Agrostis stolonifera* 1, *Echinochloa crus-galli* 2a, *Salix fragilis* juv. 2a, ***Dichostylis micheliana*** **1**, *Eragrostis minor* 1, *Limosella aquatica* +, *Bolboschoenus maritimus* agg. +, *Chenopodium rubrum* +, *Cirsium arvense* +, *Cyperus fuscus* +, *Eragrostis pilosa* +, *Juncus articulatus* +, *Lycopus europaeus* +, *Plantago uliginosa* +, *Rorippa*

amphibia +, *Rumex maritimus* +, *Stenactis annua* +, *Tripleurospermum perforatum* +, *Veronica peregrina* +.
E_0: *Physcomitrium pyriforme* 2a.

Relevé no. 2.

Podunajská nížina, Zlatná na Ostrove, part Veľký Lél, left bank of the Veľkolélske rameno river arm of the Danube river, above the bridge, exposed gravel bottom, 110 m, N 47°45´16.6˝, E 17°56´56.0˝, slope 0°, rele vé plot 16 m^2, E_1: 85%, 4. 9. 2015, D. Dítě, Z. Dítětová.
E_1: ***Dichostylis micheliana* 4**, *Cyperus fuscus* 2b, *Persicaria lapathifolia* 2a, *Rorippa amphibia* 2a, *Butomus umbellatus* +, *Chenopodium rubrum* +, *Echinochloa crus-galli* +, *Filaginella uliginosa* +, *Oenanthe aquatica* +.

Relevé no. 3.

Podunajská nížina, Kolárovo, right bank of the Váh River, south of the road bridge, sand, 116 m, N 47°54´47.44˝, E 18°0´46.88˝ , slope 5°, relevé plot 16 m^2, E_1: 75%, 3. 9. 2015, P. Eliáš jun.
E1: *Plantago uliginosa* 3, *Echinochloa crus-galli* 2a, *Eragrostis pilosa* 2a, *Persicaria lapathifolia* 2a, *Portulaca oleracea* 2a, *Cyperus fuscus* 1, *Lythrum salicaria* 1, *Rorippa sylvestris* 1, *Salix alba* juv. 1, *Amaranthus emarginatus* +, *Bidens tripartita* +, ***Dichostylis micheliana* +**, *Chenopodium album* agg. +, *Ch. ambrosioides* +, *Ch. rubrum* +, *Setaria viridis* +.

Relevé no. 4.

Východoslovenská nížina, Michalovce – Biela Hora recreation area, W bank of the Zemplínska Šírava dam, exposed silt bottom, deep polygonal rifts, 110 m, N 48°46´54.3˝, E 21°57´16.6˝, slope 0°, relevé plot 16 m^2, E_1: 25%, E_0: 5%, 10. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš jun.
E_1: *Chenopodium rubrum* 2a, *Bidens frondosus* 1, *Cyperus fuscus* 1, *Filaginella uliginosa* 1, *Persicaria lapathifolia* 1, *Amaranthus blitum* agg. +, *Agrostis stolonifera* +, *Bidens cernuus* +, *Cirsium arvense* +, *Chenopodium polyspermum* +, ***Dichostylis micheliana* +**, *Echinochloa crus-galli* +, *Juncus compressus* +, *Leersia oryzoides* +, *Lythrum salicaria* +, *Plantago uliginosa* +, *Rorippa amphibia* +, *R. sylvestris* +, *Rumex maritimus* +, *Salix fragilis* juv. +, *Stenactis annua* +, *Veronica anagallis-aquatica* +, *Artemisia vulgaris* r, *Lycopus europaeus* r, *Urtica dioica* r, *Xanthium strumarium* r.
E_0: *Leptobryum pyriforme* 2a.

Relevé no. 5.

Východoslovenská nížina, Kusín, NE bank of the Zemplínska Šírava dam, exposed silt bottom, clay, 110 m, N 48°48´36.2˝, E 22°03´55.1˝, slope 0°, relevé plot 16 m^2, E_1: 98%, 10. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš.
E_1: ***Dichostylis micheliana* 4**, *Persicaria lapathifolia* 2b, *Chenopodium rubrum* 2a, *Echinochloa crus-galli* 2a, *Bidens cernuus* 1, *Cyperus fuscus* 1, *Filaginella uliginosa* +, *Leersia oryzoides* +, *Lythrum salicaria* +, *Potentilla supina* +, *Rorippa sylvestris* +, *Stenactis annua* +, *Solanum nigrum* r.

In the relevés no. 1 and 4, *Dichostylis micheliana* created sporadic, small populations in open, relatively species-rich stands. We recorded more than 20 species per relevé, usually semi-ruderals, while neither of the species reached higher cover than 20%. These pioneer stands correspond to the association *Polygono brittingeri-Chenopodietum rubri* within the alliance *Chenopodion glauci*, class *Bidentetea tripartiti* (sensu JAROLÍMEK et al. 1997). Relevé no. 3 has the same character with higher total cover and lower richness. This type of ruderal nitrophilous vegetation occurs in warm areas of alluvial habitats: banks of large rivers, oxbows, less frequently on dried bottoms of fishponds (ŠUMBEROVÁ & LOSOSOVÁ 2011). It is a relatively widely frequent association in Slovakia, but it was published only from a few regions (cf. JAROLÍMEK et al. 1997).

In the relevés no. 2 and 5 (localities Zlatná na Ostrove and Kusín), *D. micheliana* dominated, the total cover was high and the species richness was low (under 13 species per relevé). They are identical with the *Cyperetum micheliani* association (alliance *Elatino-Eleocharition ovatae*, class *Isoëto-Nanojuncetea*). The association occurs on periodically flooded river banks, oxbows and bottoms of fishponds or water reservoirs. It is better adapted to substrate desiccation than other associations within the alliance, and it prefers soils rich in calcium carbonate (ŠUMBEROVÁ 2011). Several nitrophilous taxa were present, e.g. in the relevé no. 5, where the silty ground had better nutrient supply. This corresponds to the variant *Cyperetum micheliani* var. *Rumex maritimus* described by ŠUMBEROVÁ (l.c.).

In Slovakia, there is only a few data available on the vegetation where *Dichostylis micheliana* occurs. Three relevés were provided by SUCHÁ (1992) from the Kĺúčovské rameno, 13 km westwards from Klížska Nemá (the relevé area was not larger than 10 m^2). She recorded the species in natural low-herb vegetation of the *Isoëto-Nanojuncetea* class, in the association *Eleocharito acicularis-Limoselletum aquaticae* (alliance *Elatino-Eleocharition ovatae*). VALACHOVIČ et al. (2001) re-classified it into the *Cyperetum micheliani* association. The relevés 2 and 5 had similar species composition. *Cyperetum micheliani* is an ephemeral plant community rarely observed in Slovakia (VALACHOVIČ et al. 2001). On the other hand, the species itself was found more or less on the entire ca. 80 km length of the Danubian bank between Klížska Nemá and Kamenica nad Hronom in 2015, in some places it was present even on a mass scale (e.g. at Veľký Lél and Malá Iža). We recorded the species at 21 localities in several types of vegetation (the further 7 localities with relevés are listed below at other species).

2. *Chlorocyperus glomeratus* is included in the actual Red List of the Slovak flora as critically endangered (CR) species (ELIÁŠ jun. et al. 2015). In the past it was known from the Žitný ostrov in the Danube region near Bratislava, where it was observed on sandy bank and fosses of the Danube River (CSÁDER 1856). Very much later it was found at the town of Štúrovo on the Danube bank by HEJNÝ (1960). During the same period, it was stated also from East Slovakia (DOSTÁL 1989), but this record is doubtful. After 54 years in 2014 it was

confirmed at Štúrovo on the same site and also another site (Mužla, part Čenkov, gravel pit) was discovered as a new locality (MELEČKOVÁ et al. 2016).
In 2015 we repeated our field observations along the left bank of the Danube on potential sites with suitable conditions for the species. *C. glomeratus* was found ca. 7 km NE of the location found in 2014 near Štúrovo in the confluence area of the Hron River with the Danube. Moreover, 5 new localities were discovered along the Danube bank (Fig. 1).

List of the new localities:

1. Burda: Kamenica nad Hronom, E of the confluence of the Hron and Danube rivers, outer side of the Danubian island „Veľký ostrov", exposed gravel bottom, 103 m (P. Eliáš, D. Dítě, Z. Melečková 2015 NI).

6. Podunajská nížina: Radvaň nad Dunajom, part Žitava, left bank of the Danube, S of the settlement, exposed sandy bottom, 105 m. – Radvaň nad Dunajom, left bank of the Danube, S of the village, exposed sandy bottom, 107 m. – Moča, left bank of the Danube at SE edge of the village, exposed sandy loam bottom, 104 m. – Kravany nad Dunajom, left bank of the Danube, SE of the village, exposed sandy loam bottom, 105 m. – Mužla, part Čenkov, left bank of the Danube, 0,5 km SE of the settlement, exposed sandy loam bottom, 104 m. (all data D. R. Letz 2015 SAV). – Štúrovo, W of the confluence of the Hron and Danube rivers, outer side of an unnamed Danubian island, exposed gravel bottom, 103 m (P. Eliáš, D. Dítě, Z. Melečková 2015 NI).

After the last warmer years this thermophilous species grew at 9 localities on a 35 km long section of the southernmost Slovakian part of the Danube River between Komárno and Štúrovo. On the higher section of the river it was not reported, however, on the Hungarian side (e.g. Gönyü, opposite to Klížska Nemá village) it is known for a longer time (POLGÁR 1941, SCHMIDT & BAUER 2005). Its occurrence was scattered, usually solitary plants were observed in low-herb stands of *Salix fragilis*-shoots on gravel or sand sometimes covered with thin silt. The vegetation is represented by the following relevés:

Relevé no. 6.

Podunajská nížina, Štúrovo, ca. 100 m W of the confluence of the Hron and Danube rivers, outer side of an unnamed Danubian island, exposed gravel bottom, 103 m, N 47°48´58.2˝, E 18°44´29.0˝, slope 3°, exposition SE, relevé plot 16 m^2, E_1: 70%, 28. 8. 2015, D. Dítě, Z. Dítětová.
E_1: *Salix fragilis* juv. 4, *Cyperus fuscus* 1, *Dichostylis micheliana* 1, *Rorippa amphibia* 1, *R. sylvestris* 1, *Agrostis stolonifera* +, *Bidens tripartitus* +, *Echinochloa crus-galli* +, *Chenopodium rubrum* +, ***Chlorocyperus glomeratus* +**, *Oenanthe aquatica*, + *Lycopus europaeus* +, *Lythrum salicaria* +, *Persicaria lapathifolia* +, *Plantago uliginosa* +, *Potentilla supina* +, *Solidago gigantea* r, *Urtica dioica* r.

Relevé no. 7.

Podunajská nížina, Štúrovo, ca. 400 m SW of the confluence of the Hron and Danube rivers, upper point of an unnamed Danubian island, exposed gravel

bottom with thin silt, 103 m, N 47°48´51.6˝, E 18°4 4´16.8˝, slope 0°, relevé plot 16 m^2, E_1: 20%, 30. 8. 2015, D. Dítě, Z. Dítětová.
Cyperus fuscus 1, *Epilobium tetragonum* agg. juv. 1, *Persicaria lapathifolia* 1, *Rorippa amphibia* 1, *R. sylvestris* 1, *Salix fragilis* juv. 1, *Agrostis stolonifera* +, *Bidens tripartitus* +, *Dichostylis micheliana* +, ***Chlorocyperus glomeratus* +**, *Echinochloa crus-galli* +, *Limosella aquatica* +, *Lycopus europaeus* +, *Plantago uliginosa* +, *Polygonum aviculare* agg. +, *Portulaca oleracea* +, *Pulegium vulgare* +, *Sonchus oleraceus* +, *Solidago gigantea* +, *Typha angustifolia* +, *Oenanthe aquatica* r.

Relevé no. 8.

Podunajská nížina, Štúrovo, ca. 100 m W of the confluence of the Hron and Danube rivers, inner side of an unnamed Danubian island, exposed wet silty bottom, 103 m, N 47°49´00.6˝, E 18°44´26.2˝, slope 0°, relevé plot 16 m^2, E_1: 40%, 21. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš.
Cyperus fuscus 2a, *Bidens frondosus* 1, *Dichostylis micheliana* 1, *Alisma plantago-aquatica* 1, *Echinochloa crus-galli* 1, *Persicaria lapathifolia* 1, *Sagittaria sagittifolia* 1, *Rorippa amphibia* 1, *R. sylvestris* 1, *Typha latifolia* 1, *Agrostis stolonifera* +, *Amaranthus emarginatus* subsp. *pseudogracilis* +, ***Chlorocyperus glomeratus* +**, *Hottonia palustris* +, *Myosotis palustris* +, *Oenanthe aquatica* +, *P. hydropiper* +, *Leersia oryzoides* +, *Limosella aquatica* +, *Lindernia procumbens* +, *Lythrum salicaria* +, *Plantago uliginosa* +, *Portulaca oleracea* +, *Ranunculus sceleratus* +, *Rumex maritimus* +, *Salix fragilis* juv. +, *Stenactis annua* +, *Veronica peregrina* +, *Aster lanceolatus* r.

Relevé no. 9.

Burda, Kamenica nad Hronom, ca. 100 m E of the confluence of the Hron and Danube rivers, outer side of the Danubian island „Veľký ostrov", exposed gravel bottom, 103 m, N 47°49´02.2˝, E 18°44´40.0˝, slope 0°, relevé plot 16 m^2, E_1: 15%, 21. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš.
Salix fragilis juv. 2a, *Dichostylis micheliana* 1, *Artemisia vulgaris* +, *Bidens tripartitus* +, *Cirsium arvense* +, *Cyperus fuscus* +, ***Chlorocyperus glomeratus* +**, *Chenopodium rubrum* +, *Celtis occidentalis* juv. +, *Leersia oryzoides* +, *Persicaria hydropiper* +, *P. lapathifolia* +, *Plantago uliginosa* +, *Pulegium vulgare* +, *Rorippa sylvestris* +, *Rumex maritimus* +, *Solanum nigrum* +, *Solidago gigantea* +.

The vegetation had open structure with total cover between 15–70%. In each relevé, *Chlorocyperus glomeratus* was recorded in low cover, always less than five specimens per relevé. The number of species was between 18 and 29, *Salix fragilis* juv. was the most dominant. The species composition in each case had strong transition character. In similar proportion, there were present diagnostic species of three different classes: *Bidentetea tripartiti*, *Isoëto-Nanojuncetea* and *Phragmito-Magnocaricetea*. We consider all these relevés as a less typical, initial stage of the *Cyperetum micheliani* association with a high extent of ruderalization. The most optimal vegetation for *C. glomeratus* was recorded in the relevé no. 8 where *S. fragilis* was less dominant and more hygrophytes were

present (*Alisma plantago-aquatica, Sagittaria sagittifolia, Hottonia palustris*). The site is located on the inner side of a small island on the Danube, where the river flow is slower. After the river retreats, fine-grained muddy sediments are deposited and they remain wet for a longer time than the rough gravel.

Syntaxonomically, *C. glomeratus* belongs to the class *Isoëto-Nanojuncetea* (BRULLO & MINISSALE 1998). The recent data from the larger region of Central Europe highlight its tolerance against the expansion of ruderal and alien species. On the right side of the Danube in Hungary, RIEZING (2012) reported the species from secondary wetland habitats. On the lower section of the river, in Harta, it was also observed in artificial depressions. In Slovakia (Štúrovo) it was also recorded in an artificial depression with a very slight presence of characteristic *Isoëto-Nanojuncetea* species (MELEČKOVÁ et al. 2016). The species richness was there two-times lower compared to the sites found in 2015. The new localities are situated in natural habitats, less influenced by anthropogenic disturbance.

C. glomeratus, as other species of annual amphibian swards, is threatened by redirection of river beds and liquidation of suitable habitats. Under the natural courses of succession, these alluvial pioneer habitats tend to transfer quickly into willow shrubberies of the association *Polygono hydropiperi-Salicetum triandrae* (KEVEY 2008) within the class *Salicetea purpurae*. We believe that the species was apparently overlooked; the recent occurrence suggests that in favorable years it has been continuously present and we expect additional records along the Danube in the future.

3. *Heleochloa alopecuroides* is also a typical species of periodically exposed muddy bottoms, banks of water reservoirs and watercourses. Due to its higher ecological plasticity it occupies secondary habitats as well, e.g. flooded fields of warm lowland areas (HOLUB & GRULICH 1999). According to the Red List of Slovakia it is evaluated as (VU) vulnerable (ELIÁŠ et al. 2015) and it is included in the Red Book of Slovakia (ČEŘOVSKÝ et al. 1999).

Its occurrence is well documented in the Východoslovenská nížina and the larger area of the Podunajská nížina lowland (HOLUB & GRULICH 1999, DÍTĚ 2004, RUŽIČKOVÁ et al. 2014). In 2010, when optimal conditions were available for ephemeral vegetation, it was observed at numerous locations through the Podunajská nížina, mainly in field depressions (ELIÁŠ et al. 2011; FEHÉR & FEHÉR-PINDEŠOVÁ 2011) and occasionally in natural subhalophytic habitats (ELIÁŠ et al. 2008). Within the Východoslovenská nížína lowland, the localities are concentrated around the Latorica and Tisa Rivers (HOLUB & GRULICH 1999; BOGOLY 1994). In 2015, thanks to the extreme droughts in SE Slovakia, we have found rich populations of *Heleochloa alopecuroides* on the dried banks of the Zemplínska Šírava dam (Fig. 2).

List of the new localities:

8. Východoslovenská nížina: Michalovce – Biela Hora recreation, W bank of the Zemplínska Šírava dam, exposed silt bottom, 110 m. – Kusín, NE bank of the Zemplínska Šírava dam, exposed loamy bottom around the small stream, 110 m. –

Jovsa, E bank of the Zemplínska Šírava dam, exposed gravel bottom, 110 m (all data P. Eliáš, D. Dítě, Z. Melečková 2015 NI).

The species was not recorded earlier from this area (HOLUB & GRULICH 1999), therefore we provide three phytosociological relevés:

Relevé no. 10.

Východoslovenská nížina, Jovsa, E bank of the Zemplínska Šírava dam, exposed gravel bottom, 110 m, N 48°48´17.4˝, E 22°0 4´43.9˝, slope 0°, relevé plot 16 m^2, E_1: 80%, 10. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš.

E_1: ***Heleochloa alopecuroides* 5,** *Persicaria lapathifolia* 3*, Chenopodium polyspermum* 1, *Ch. rubrum* 1, *Cyperus fuscus* 1, *Leersia oryzoides* 1, *Digitaria sanguinalis* +, *Echinochloa crus-galli* +, *Filaginella uliginosa* +, *Myosoton aquaticum* +, *Plantago uliginosa* +, *Portulaca oleracea* +, *Rumex maritimus* +, *Stenactis annuua* +, *Setaria pumila* +, *Solanum nigrum* +, *Trifolium repens* +, *Sonchus oleraceus* r.

Relevé no. 11.

Východoslovenská nížina, Jovsa, eastern bank of the Zemplínska Šírava dam, exposed gravel bottom, 110 m, N 48°48´12.6˝, E 22°0 4´46.9˝, slope 0°, relevé plot 16 m^2, E_1: 40%, 10. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš.

E_1: *Cyperus fuscus* 2a, ***Heleochloa alopecuroides* 2a**, *Persicaria lapathifolia* 2a, *Chenopodium rubrum* 1, *Dichostylis micheliana* 1, *Leersia oryzoides* 1, *Echinochloa crus-galli* 1, *Agrostis stolonifera* +, *Bidens cernuus* +, *B. frondosus* +, *Bolboschoenus maritimus* agg. +, *Cirsium arvense* +, *Ch. polyspermum* +, *Digitaria sanguinalis* +, *Filaginella uliginosa* +, *Lycopus europaeus* +, *Myosoton aquaticum* +, *Plantago uliginosa* +, *Portulaca oleracea* +, *Rumex maritimus* +, *Salix fragilis* juv. +, *Solanum nigrum* +, *Sonchus oleraceus* +, *Stenactis annua* +, *Trifolium repens* +, *Lythrum hyssopifolia* r, *Urtica dioica* r.

Relevé no. 12.

Východoslovenská nížina, Kusín, NE bank of the Zemplínska Šírava dam, exposed loamy bottom around the small stream, 110 m, N 48°48´36.2˝, E 22°03´34.3˝, slope 0°, relevé plot 16 m^2, E_1: 50%, E_0: 5%, 10. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš.

E_1: *Cyperus fuscus* 2a, *Eleocharis palustris* 2a, *Lemna minor* 2a, *Alisma plantago-aquatica* 1, *Batrachium circinatum* 1, *E. acicularis* 1, *E. ovata* 1, *Lindernia procumbens* 1, *Persicaria lapathifolia* 1, *Typha latifolia* 1, *Chenopodium glaucum* +, *C. rubrum* +, *Echinochloa crus-galli* +, *Filaginella uliginosa* +, ***Heleochloa alopecuroides* +**, *Juncus articulatus* +, *Potentilla supina* +, *Rorippa sylvestris* +, *Stenactis annua* +, *Salix fragilis* juv. +.

E_0: *Physcomitrium pyriforme* 2a.

In the relevé 10, prostrate forms of *Heleochloa alopecuroides* created carpet-like stands, in the upper layer dominated *Persicaria lapathifolia*. The cover of nitrophilous species was high. Therefore we place this relevé within the alliance *Chenopodion glauci*, class *Bidentetea tripartitae*. Relevé 11 is similar, but the vegetation is more species-rich and *H. alopecuroides* has low cover. Both

relevés from Jovsa correspond to the association *Chenopodio rubri-Heleochloëtum alopecuroidis* (Timár 1950) Borhidi 2003 which was described in Hungary on the drying sandy to muddy banks of the Tisza River. This plant community is first recorded here for Slovakia.

Vegetation of the relevé 12 from Kusín is different, *H. alopecuroides* is only sporadic, many wetland species are present and the cover of nitrophilous species is low. We assign it to the class *Isoëto-Nanojuncetea*, alliance *Elatino-Eleocharition ovatae*, association *Polygono-Eleocharitetum ovatae.* This is the most moisture-demanding and acidophilous association of the alliance*,* it occupies places with deep layer of mud (ŠUMBEROVÁ 2011). In such vegetation, *H. alopecuroides* was not recorded in Slovakia so far.

High cover (more than 50%) of *H. alopecuroides* was reported by RUŽIČKOVÁ et al. (2014), who published a relevé from the bottom of water reservoir near Pezinok in the *Eleocharito acicularis-Limoselletum aquaticae* association. They also recorded the species (with low cover) in the *Cyperus fuscus*-community. Both relevés were ranked to the class *Isoëto-Nanojuncetea*. Regarding species composition indicating higher eutrophication (*Persicaria lapathifolia*, *Bidens tripartita* or *Chenopodium rubrum*), their relevés are rather identical with the class *Bidentetea tripartiti*. ELIÁŠ et al. (2011) recorded the species also in this class, in the *Echinochloo-Polygonetum lapathifolii* association within the *Chenopodion glauci* alliance. According to VALACHOVIČ et al. (2001) *H. alopecuroides* occurs in several associations of the class *Isoëto-Nanojuncetea*: *Cyperetum micheliani*, *Eleocharito acicularis-Limoselletum aquaticae* and *Juncetum bufonii*. It shows that the optimum of *H. alopecuroides* is on the interface between these two classes.

In Hungary, *H. alopecuroides* is well documented in both classes. In the *Bidentetea tripartitae* (except the above mentioned association *Chenopodio rubri-Heleochloëtum alopecuroidis*) it occurs in the association *Echinochloo-Heleochloetum alopecuroidis* Bodrogközy 1982 which was described on flooded corn fields (BAGI & BODROGKÖZY 1984). In Slovakia it was not observed.

In the *Isoëto-Nanojuncetea* class *H. alopecuroides* occurs in the association *Dichostylido-Heleochloëtum alopecuroidis* (Timár 1950) Pietsch 1973 and at on European scale, it is a characteristic species of the alliance *Verbenion supinae* Slavnić 1951 which groups nitrophilous vegetation of clayey alkaline soils (BRULLO & MINISSALE 1998).

In the Pannonian Basin, *H. alopecuroides* is mentioned in a third class as well (*Crypsietea aculeatae*), as a vegetation of annual graminoids in periodically flooded saline habitats of the association *Heleochloëtum alopecuroidis* within the alliance *Cypero-Spergularion salinae* (SOÓ 1980, BORHIDI et al. 2012). DÍTĚ et al. (2014) invalidated the existence of this association, since it was not properly described as being part of the Pannonian halophytic vegetation.

4. *Lindernia procumbens* has similar ecological requirements as *Heleochloa alopecuroides*. Besides fishponds and natural riverbeds, it prefers also flooded shallow depressions of croplands and water ditches (PROCHÁZKA et al. 1999b).

This ephemeral plant germinates in late-summer, therefore is not affected by the herbicide treatment (KIRÁLY et al. 2008). Its occurrence is not regular, it can be missing for several years and re-appear after a long time. According to the Red List *L. procumbens* is vulnerable (VU) (ELIÁŠ et al. 2015) and it is included in the Red Book of Slovakia (ČEŘOVSKÝ et al. 1999).

L. procumbens was a typical weed on rice fields in the 1950s and 1960s in south Slovakia (HEJNÝ 1960; ZÁHRADNÍKOVÁ & OŤAHELOVÁ 1997). After the termination of rice growing it became less frequent, e.g. in the Ipeľsko-Rimavská brázda it is recently known only from a few localities – Veľká Ves nad Ipľom (ELIÁŠ jun. 2013) and Lučenec, Ľadovo (KOŠŤÁL & VOJTEKOVÁ 2014). Most records of *L. procumbens* (mainly older than 20 years) are from the Východoslovenská nížina lowland in the Latorica River catchment area and at the Zemplínska Šírava dam (PROCHÁZKA et al. 1999b; ŠUVADA 2015). The second one we confirmed in 2015 in Kusín (Fig. 2, see relevé 12 above). The species is less frequent in the Borská nížina (OŤAHELOVÁ 1992), more records are from the Podunajská nížina lowland, e.g. at the Hron River in Zalaba (ZAHRADNÍKOVÁ & OŤAHEĽOVÁ 1997), NE of Hronovce in the Vozokanský luh Nature Reserve (KUBALOVÁ 2003, ŠUVADA 2015) or in Iža, Konopište in shallow depression in the corn field together with *Heleochloa alopecuroides* and *Schoenoplectus supinus* (ELIÁŠ et al. 2011).

List of the new localities:

1. Burda: 6. Kamenica nad Hronom, 1,6 km E from the confluence of Hron and Danube rivers, „Veľký ostrov" island, exposed river branch, wet silty bottom, 103 m (P. Eliáš jun., D. Dítě, Z. Melečková 2015 NI).

6. Podunajská nížina: Klížska Nemá, left bank of the Danube, exposed gravel bottom, 110 m. (P. Eliáš jun., D. Dítě, Z. Melečková 2015 NI). – Pohronský Ruskov, ESE of the parish church on the bank of the Hron River oxbow, drying pool with stagnant water, exposed gravel bottom, 127 m (D. R. Letz 2015 SAV).

8. Východoslovenská nížina: Kusín, NE bank of the Zemplínska Šírava dam, exposed loamy bottom around a small stream, 110 m (P. Eliáš jun., D. Dítě, Z. Melečková 2015 NI). – Boľ, 2 km N of the village, left silty bank of the Latorica oxbow, 100 m (P. Eliáš jun., D. Dítě, Z. Melečková, A. Šimková 2015 NI).

In 2015 we found *L. procumbens* on the bank of the Hron River at Pohronský Ruskov and also on its lower reaches in the confluence area with the Danube at Kamenica nad Hronom. The record at Kamenica nad Hronom confirmed the locality of Domin (1921 ined.). The species was there present sporadically in the side branch of the Danube with stagnant water. The wet bottom was deposed by silt thanks to the surrounding small islands which protect the side branches from fast currents. The vegetation is described by the following relevé:

Relevé no. 13.

Burda, Kamenica nad Hronom, 1,6 km E of the confluence of the Hron and Danube rivers, „Veľký ostrov" island, exposed river arm, wet silty bottom, 103 m, N 47°49´17.6˝, E 18°45´51.7˝, slope 0°, relevé plot 16 m^2, E_1: 30%, 21. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš jun.

***Lindernia procumbens* 2a,** *Cyperus fuscus* 1, *Rorippa amphibia* 1, *R. sylvestris* 1, *Lythrum salicaria* 1, *Agrostis stolonifera* +, *Bidens tripartitus* +, *Bolboschoenus maritimus* agg. +, *Dichostylis micheliana* +, *Echinochloa crus-galli* +, *Leersia oryzoides* +, *Limosella aquatica* +, *Persicaria lapathifolia* +, *Plantago uliginosa* +, *Pulegium vulgare* +, *Stenactis annua* +, *Salix fragilis* juv. +, *Stachys palustris* +, *Tripleurospermum perforatum* +.

The stand of the relevé no. 13 had open, pioneer character enriched with synanthropic species. *L. procumbens* had the highest cover. The vegetation was transient between the classes *Bidentetea tripartitae* and *Isoëto-Nanojuncetea*, not assignable to a particular association.

In the Východoslovenská nížina lowland *L. procumbens* is more frequent, there are known at least 6 localities (PROCHÁZKA et al. 1999b). The most recent distribution was published by ZLACKÁ et al. (2006) from field depressions and rural roads in the vegetation of the associations *Limosella aquatica*-community and *Polygono-Eleocharitetum ovatae* (class Isoëto-*Nanojuncetea*). We present a relevé from natural habitat, on the exposed bottom of the Latorica oxbow to compare it with the vegetation recorded at the Danube:

Relevé no. 14.

Východoslovenská nížina lowland, Boľ, 2 km N of the village, left bank of the Latorica oxbow, silt, 100 m, N 48°29´40.7˝, E 21°55 ´53.2˝, slope 0°, relevé plot 16 m^2, E_1: 85%, E_0: 2%, 9. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš jun., A. Šimková.

E_1: *Cyperus fuscus* 3, *Dichostylis micheliana* 3, ***Lindernia procumbens* 2b,** *Eleocharis palustris* 2a, *Trapa natans* 1, *Bidens frondosus* +, *Echinochloa crus-galli* +, *Filaginella uliginosa* +, *Limosella aquatica* +, *Persicaria hydropiper* +, *P. lapathifolia* +, *Rorippa sylvestris* +, *Cirsium arvense* r.

E_0: *Physcomitrium pyriforme* 1.

The stand of the relevé no. 14 is less impacted by eutrophication; the cover of *Isoëto-Nanojuncetea* species is higher than in the relevé no. 13. We classify it to the *Cyperetum micheliani* association. This vegetation represents optimal conditions for *L. procumbens*, as it is a characteristic species of the alliance *Elatino-Eleocharition ovatae* (BRULLO & MINISSALE 1998). Since the species tolerates higher nutrient content in the soil, its second optimum is in the association *Elatini-Lindernietum procumbentis* Ubrizsy (1948) 1961 (alliance *Elatini-Lindernion* Pietsch 1973) within the same class. The latter association is reported only in the rice fields of Hungary (BORHIDI et al. 2012).

5. *Scirpus radicans* is a very rare species in Slovakia. It was confirmed only in the Podunajská nížina lowland in the Kľúčovské rameno oxbow (SUCHÁ 1992) and the Východoslovenská nížina lowland between Veľké Kapušany and Kráľovský Chlmec (OŤAHELOVÁ 1995; ZALIBEROVÁ et al. 2000). A single locality (Šajdíkove Humence) in the Borská nížina lowland was found in the last years (DÍTĚ & ELIÁŠ 2013). According to the Red List of Slovakia it is endangered (ELIÁŠ et al. 2015).

As a pioneer species of disturbed habitats affected by fluctuating groundwater and surface water, *Scirpus radicans* takes part in the succession of stagnant water banks of oxbows and water reservoirs. Under favourable conditions pure stands of the *Scirpetum radicantis* association develop. The plant community belongs to the alliance *Oenanthion aquaticae* (class *Phragmito-Magnocaricetea*) and is considered as a pioneer vegetation of helophytes which develops after the water retreats (OŤAHELOVÁ et al. 2001). While in the Czech Republic this plant community is bounded to moderately warm or chill foothill areas with higher precipitation (HROUDOVÁ et al. 2011), in Slovakia it was found only in the warmest and driest lowland areas. Such stands were found in the Latorica oxbow in two locations close to each other between the Boľ and Zatín villages (Fig. 2).

List of the new localities:

8. Východoslovenská nížina: Zatín, exposed bank of the Latorica oxbow, 99 m – Boľ, 2 km N of the village, material pit near the Latorica oxbow, silt, 100 m (both data P. Eliáš jun., D. Dítě, Z. Melečková, A. Šimková 2015 NI).

These locations were not known so far. Several polycormons of *S. radicans* were observed within the dense stands of *Schoenoplectus lacustris*. We enclose the following relevé:

Relevé no. 15.

Boľ village, material pit near the Latorica oxbow system 2 km N of the village, silt, 100 m, N 48°29´30.9˝, E 21°56´04.0˝, slope 0°, rele vé plot 16 m^2, E_1: 90%, 9. 9. 2015, D. Dítě, Z. Dítětová, P. Eliáš jun., A. Šimková.

***Scirpus radicans* 5**, *Glyceria maxima* 2a, *Alisma plantago-aquatica* +, *Butomus umbellatus* +, *Carex acutiformis* +, *Eleocharis acicularis* +, *E. palustris* +, *Galium palustre* +, *Rorippa amphibia* +, *Xanthium strumarium* r.

The relevé is species-poor and it corresponds to typically developed association of *Scirpetum radicantis*, with high abundance of *Oenanthion aquaticae* species and small presence of low-herb mudflat vegetation. Similar mono-dominant stands were recorded by OŤAHELOVÁ (1995) and ZALIBEROVÁ et al. (2000) from this region. Same vegetation was published by SUCHÁ (1992) from the Danube where *S. radicans* was found in low cover, in the association of *Oenantho aquaticae-Rorippetum amphibiae* and in stands dominated by *Schoenoplectus triqueter*. DÍTĚ & ELIÁŠ (2013) reported the species in initial stage of less typical association of *Scirpetum radicantis* on the bank of a sand pit in Šajdíkove Humence. Their relevé contained competitively stronger species such as *Phragmites australis* and *Calamagrostis epigejos*. Although *S. radicans* can develop vital stands, due to its ephemeral character and dependence on continuous disturbance its populations are threatened by expansion of high sedges or willows. Its presence is often transient and the number of recent locations is low. According to our observation, the Latorica inundation area provides optimal conditions for the species, therefore we do not exclude that other new locations can be found there.

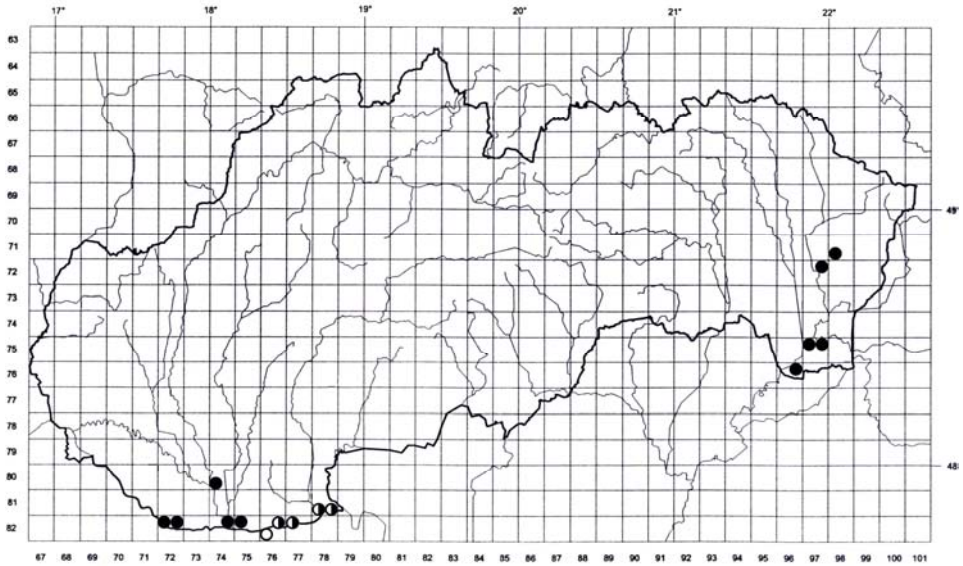

Fig. 1. Localities of *Dichostylis micheliana* (●), *Chlorocyperus glomeratus* (○) and *Dichostylis micheliana* + *Chlorocyperus glomeratus* (◑) found in 2015 in Slovakia.

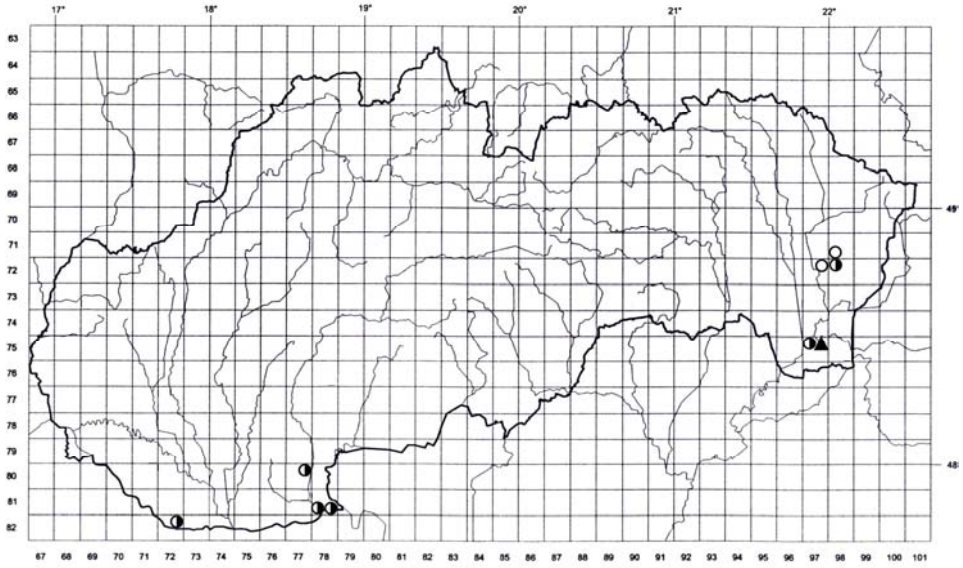

Fig. 2. Localities of *Heleochloa alopecuroides* (○), *Lindernia procumbens* (◑) and *Scirpus radicans* (▲) found in 2015 in Slovakia.

Conclusion

Although *Chlorocyperus glomeratus*, *Dichostylis micheliana*, *Lindernia procumbens* and *Heleochloa alopecuroides* are characteristic species of the class *Isoëto-Nanojuncetea* (BRULLO & MINISSALE 1998), the vegetation where they were recorded was less typical. Only eight relevés were assigned to this class (alliance *Eleocharition ovatae*). The accompanying species of the visited sites were other, more frequent species like *Cyperus fuscus, Limosella aquatica, Filaginella uliginosa, Chenopodium rubrum*, *Persicaria lapathifolia, Leersia oryzoides* or *Echinochloa crus-galli* and numerous indifferent, ruderal species were there present as well.

Under the impact of permanent denudation or eutrophication the stands of *Eleocharition ovatae* transfer into nutrient-rich vegetation of the *Bidentetea tripartitae* class as an advanced stage of succession (ŠUMBEROVÁ & LOSOSOVÁ 2011). The vegetation on the discovered sites reflects this situation. The recorded species are not mentioned in the Slovak and Czech syntaxonomical surveys of the class *Bidentetea tripartitae* (JAROLÍMEK et al. 1997, ŠUMBEROVÁ & LOSOSOVÁ 2011), only under the vegetation of the class *Isoëto-Nanojuncetea* (VALACHOVIČ et al. 2001, ŠUMBEROVÁ 2011). We have found them in almost each case with a very strong transition to the class *Bidentetea tripartitae.* Several diagnostic species of the *Isoëto-Nanojuncetea* (e.g. *Eleocharis ovata*) were observed also very rarely compared to the earlier studies from the Východoslovenská nížina lowland (BOGOLY 1994, ZLACKÁ et al. 2006). In addition, *Carex bohemica* or *Schoenoplectus triqueter*, other rare species of the same habitat were recorded in nutrient-rich vegetation (DÍTĚ et al. 2015, 2016). In the past, vegetation of the class *Bidentetea tripartitae* was mainly recorded in places with high nutrient level, for instance around sewage water flows (TIMÁR 1950; JAROLÍMEK et al. 1997), today it can be found almost everywhere along the natural watercourses. This calls the attention to the increasing eutrophication of the landscape.

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