Hacquetia 15/1 • 2016, 93–100 DOI: 10.1515/hacq-2016-0007

Cyperus glomeratus L. – rediscovered in Slovakia

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Keywords: *Eleocharition ovatae*, Danube, Pannonian lowland, temporary wetland habitats, eutrophication.

Ključne besede: *Eleocharition ovatae*, Donava, Panonska nižina, občasni mokriščni habitati, eutrofikacija.

Abstract

Two new and one historical site of *Cyperus glomeratus* were discovered in SW Slovakia along the left bank of the river Danube. After 60 years, this is the second record of the species in the country. We provide details about the historical and current distribution of *C. glomeratus* in Slovakia based on herbarium revision and field survey on the Slovak section of the river Danube. According to the phytosociological data collected from the new locality (Čenkov) and from the confirmed historic locality (Štúrovo), the stands with *C. glomeratus* were identified with less developed, ruderalized form of the association *Cyperetum micheliani*.

Izvleček

Odkrili smo novo in potrdili že znano rastišče vrste *Cyperus glomeratus* na levem bregu Donave na jugozahodu Slovaške. Po 60 letih je to drugo nahajališče te vrste v državi. Na osnovi revizije herbarijskega materiala in terenskih pregledov območja ob Donavi na Slovaškem smo prikazali nekdanjo in trenutno razširjenost vrste *C. glomeratus* na tem območju. Sestoje z vrsto *C. glomeratus* smo uvrstili v asociacijo *Cyperetum micheliani* na osnovi fitocenoloških popisov z novega rastišča (Čenkov) in potrjenega znanega nahajališča (Štúrovo).

Received: 13. 3. 2015
Revision received: 4. 11. 2015
Accepted: 7. 11. 2015

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Introduction

The concept of the genus *Cyperus* L. is very diverse; therefore the number of species is not fixed. The genus contains many species, in the European flora there are recognized 27 species (DeFilipps 1980). According to Marhold & Hindák (1998) in Slovakia six species are known: *C. flavescens*, *C. fuscus*, *C. glomeratus*, *C. longus*, C. *michelianus* (syn. *Dichostylis micheliana*) and *C. pannonicus* (syn. *Acorellus pannonicus*).

Cyperus glomeratus L. [syn. *C. aureus* Georgi, *Chlorocyperus glomeratus* (L.) Palla, *Pycreus glomeratus* (L.) Hayek] is an annual, rarely perennial short-lived flatsedge (galingale) species from the *Cyperaceae* family. Rhizomes are absent or they are rarely creeping, stems 10-80 cm, mainly solitary or rarely caespitose. Leaves are 2-10 mm wide, shorter than to exceeding the stems. Bracts are 2-6, exceeding the inflorescence. Inflorescence is a compound umbel or a sessile, dense head; rays up to 10 cm. Spikelets 5-12 × 1-1.5 mm, linear, with 8-20 flowers, ascending to patent. Glumes (1.5-)2-2.3 × 0.5 mm, linear or linear-lanceolate, obtuse, pale- or reddish-brown, with greenish keel. Stamens are 3. Nuts are 3/5 as long to as long as the glumes, linear-oblong, dark brown (DeFilipps 1980).

Cyperus glomeratus is thermophilous, pioneer plant of lowland river banks, lakeshores, marshes, rarely wet meadows (Dostál & Červenka 1992). It grows secondarily on rice fields and ditches. The species prefers raw gravel or sandy soils with muddy surface resulting from periodical inundation. In paleobotanical studies it is an indicator of former warm areas of the interglacial periods in Eurasia as it was found in several macrofossils (Bińka & Nitychoruk 2003, Durnikin & Zinovyeva 2014) including sites north of the present northern limit of its distribution range (Łańcucka-Środoniowa 1979, Lesniak 1994).

The distribution range of *C. glomeratus* covers SE part of central Europe (Hungary, Slovakia), SE Europe (the former Yugoslavia, Romania, Bulgaria, Greece and Turkey), Ukraine, the western part of Russia, Caucasus, NW Iran, Turkmenistan, Uzbekistan, Pakistan, N China and Japan (Schulze-Motel 1980). In Central, SW and W Europe the species is considered as a casual alien (Spain, France – Verloove 2014, the Nederland – Stolwijk 1991, Switzerland, Germany – Schulze-Motel 1980, Austria – Essl & Rabitsch 2002, the Czech Republic – Dostál & Červenka 1992, Pyšek et al. 2012) or invasive (Italy – Celesti-Grapow et al. 2009).

In the Pannonian lowland *C. glomeratus* is autochtonous; it occurs sporadically: in Hungary it is more frequent in the western part of the country along larger rivers like Danube, Rába, Drava and Mura and in the eastern part of the country along the lower sections of Tisza and Maros rivers (Király et al. 2009). *C. glomeratus* in lowland Serbia (Vojvodina) is common along the Danube and Sava rivers. Outside of the Pannonian lowland, Zlatković et al. (2005) report it only from a few localities on sandy river banks of Južna Morava and beside the moderate number of floristic data (Jovanović & Bartula 1997, Petrić et al. 2010, Stojković 2012) and field observations it is more widespread than it can be concluded from the literature (Perić in litt.). More to the north, like in Slovakia it is rather rare.

In this contribution we present historic and recent occurrence of *Cyperus glomeratus* in Slovakia. As the species is frequently reported from more locations on the right side of the Danube, e.g. in Győr, Hungary (Polgár 1941, Schmidt & Bauer 2005), we compare the vegetation composition of the stands with this species on each side of Danube within the NW part of the Pannonian lowland.

Material and methods

The field observation was carried out along 82 km section of the left bank of the Danube river (from 1792 to 1710 fluvial kilometers) in Slovakia (Podunajská nížina lowland) in year 2014 and the survey was repeated in 2015. Special attention was given to active and former gravel pits and open gravel beaches with potential habitats of semi-aquatic pioneer vegetation of flat depressions in Kližská Nemá, Veľké Kosihy, Zlatná na Ostrove, Čenkov, Štúrovo and Chľaba. Phytosociological relevés were sampled according to the Zürich-Montpellier approach using the adapted nine-grade Braun-Blanquet's scale (Barkman et al. 1964) and were stored in the TURBOWIN database (Hennekens & Schaminée 2001). The nomenclature of plant taxa are according to the database of Euro+Med plantbase (2006).

Data regarding the distribution of the species in Slovakia were obtained from herbaria BP, BRA, BRNU, NI, PR, PRC, OLM, SAV, SLO and from the Database of vascular plants deposed in the Institute of Botany, Slovak Academy of Sciences in Bratislava. Herbarium abbreviations are according to Vozárová & Sutorý (2001).

Results and discussion

Historical occurrence of *Cyperus glomeratus* in Slovakia

In Slovakia, the exact distribution of *Cyperus glomeratus* is not clarified, since most of the data are published in determination keys on the Czechoslovak flora and the source data are not available. The oldest literature mentions that

C. glomeratus was found in some years in sandy bottoms of the Danube in the Žitný ostrov area near Bratislava ("Schütt Insel"), but without exact locality (Csáder 1856). The second reference gives Pantocsek (1907) from large surroundings of Bratislava city and later Polívka et al. (1928) from the Podunajská nížina lowland („Veľký Žitný ostrov"), but exact data are not given in these reports.

Dostál (1958) confirms the species from the same area but also without closer localisation. Doubtful data provides Májovský (1959) from SE Slovakia. He reports *C. glomeratus* from the Tice oxbow near Hrušov settlement on the Východoslovenská nížina lowland in the Tisa river basin (Database of vascular plants deposed in the Institute of Botany). The locality was documented by two herbarium specimens (Májovský & Záborský 1961 SLO). This data was used in the actualized Czechoslovak determination key (Dostál 1989) where two locations are mentioned: Streda nad Bodrogom, still in the Východoslovenská nížina lowland (SE Slovakia) and Štúrovo in the Podunajská nížina lowland (SW Slovakia). Herbarium material of *C. glomeratus* collected from SE Slovakia (Streda nad Bodrogom and Keresztúr settlements) by Májovský & Záborský we revised as *Bolboschoenus maritimus* agg. and *Cyperus michelianus*. To the second cited site (Podunajská nížina) Dostál (l.c.) notes that this observation was valid until 1953 originating from Hejný (1960) who observed the species in 1953 on the Danube river bank in Štúrovo by the Boží kopec (in different part of the text Hejný stated this location as Obid near Štúrovo). The latest determination key (Dostál & Červenka 1992) includes only Podunajská and Východoslovenská nížina lowlands in general, without closer data. In the following years there was not paid attention to the confirmation of these localities. Recent floristic studies from the above mentioned areas (e.g. Jehlík et al. 2005, Mártonfi et al. 2014) have not reported the species.

Recently confirmed locations

We found *Cyperus glomeratus* in the town of Štúrovo (locality "Boží kopec"), on the left bank of the Danube in a former gravel depot (Fig. 1). This is a confirmation of the first reliable record in Slovakia found by Hejný in 1953. Artificial shallow depressions approx. 20 m from the shoreline were flooded and at the beginning of September the muddy pools were occupied by pioneer semi-ruderal stands of annual hygrophytes. *Cyperus glomeratus* was developed sporadically in three shallow ponds each with an average area of 20 m^2. The estimated population of the species was up to two hundred fertile individuals. The vegetation can be characterized by the following two relevés:

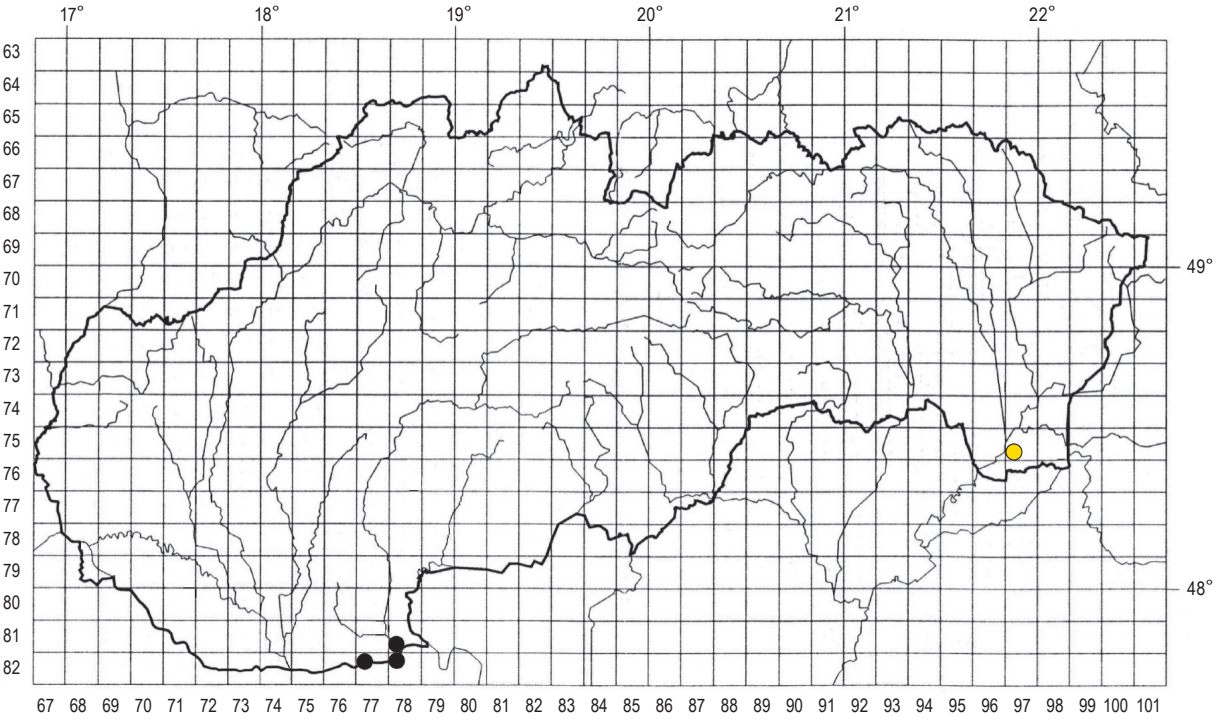

Figure 1: Historical and recent occurrence of *Cyperus glomeratus* L. in Slovakia: ○ – doubtful location, ● – recently confirmed locations.
Slika 1: Nekdanja in recentna nahajališča pojavljanja vrste *Cyperus glomeratus* L. na Slovaškem: ○ – dvomljiva lokacija, ● – nedavno potrjeno nahajališče.

Relevé 1: Štúrovo, Boží kopec, left bank of the Danube river, former gravel depot, shallow pool, water depth 10 cm, 16m^2, E_1: 20% E_0: 0; open water: 90%; 112 m a. s. l., 47°46'55.0"; 18°42'20.4", Melečková, Dítě & Eliáš jun., 16. 9. 2014.

E_1: *Trifolium repens* 2a, ***Cyperus glomeratus*** 1, *Echinochloa crus-galli* 1, *Juncus articulatus* 1, *Ambrosia artemisiifolia* +, *Conyza canadensis* +, *Cyperus fuscus* +, *Chenopodium ambrosioides* +, *Persicaria lapathifolia* +, *Plantago major* +, *Populus alba* juv. +, *P. canadensis* juv. +, *Potentilla supina* +, *Setaria viridis* +, *Solidago gigantea* +, *Tripleurospermum inodorum* +.

Relevé 2: Štúrovo, Boží kopec, left bank of the Danube river, former gravel depot, shallow pool, water depth 5 cm, 16m^2, E_1: 25% E_0: 0; open water: 100%; 112 m a. s. l., 47°46'55.0"; 18°42'20.4", Melečková, Dítě & Eliáš jun., 16. 9. 2014.

E_1: *Cyperus fuscus* 2a, *Echinochloa crus-galli* 1, *Juncus articulatus* 1, *Veronica anagallis-aquatica* 1, *Typha angustifolia* 1, *Ambrosia artemisiifolia* +, ***Cyperus glomeratus*** +, *Epilobium tetragonum* +, *Lemna minor* +, *Persicaria lapathifolia* +.

The second, new site to Slovakia was found 12 km west of Štúrovo, between the settlements Mužla and Čenkov in the area of active, extensively used gravel pit on the left bank of the Danube. The population was poor: two robust fertile specimens were observed on raw gravel with thin silt exposed in the last year. The following relevé was recorded:

Relevé 3: Mužla, Čenkov, left bank of the Danube, active gravel pit, shallow dried depression, 16m^2, E_1: 20%, E_0: 10%; 105 m a. s. l., 47°46'16.54"; 18°32'57.10", Melečková & Dítě, 16. 10. 2014.

E_1: *Echinochloa crus-galli* 2a, *Agrostis stolonifera* 1, *Plantago major* 1, *Salix fragilis* 1, *Sonchus arvensis* 1, *Cyperus fuscus* +, ***Cyperus glomeratus*** +, *Persicaria lapathifolia* +, *Poa annua* +, *Polygonum aviculare* +, *Populus* × *canadensis* juv. +, *Ranunculus sceleratus* r.

In presented relevés the stands are two-layered, on the surface are typical dwarf plants like *Cyperus fuscus* and *Trifolium repens*, in the upper layer besides *Cyperus glomeratus*, ruderal hygrophytes prevail (*Persicaria lapathifolia* and *Echinochloa crus-galli*). Each recorded species composition is regarded as an early succession stage of desiccating pools after the river retreats.

We identified these relevés as a transition vegetation between the classes *Isoëto-Nano-Juncetea* Br.-Bl. et Tüxen ex Br.-Bl. et al 1952 and *Bidentetea tripartitae* Tüxen et al. ex von Rochow 1951 (Šumberová 2011). Regarding the heterogeneity and the high amount of ruderal nitrophilous species the vegetation cannot be determined to an exact association, it can be considered as a strongly ruderalized stage of the association *Cyperetum micheliani* (Horvatić 1931) within the alliance *Eleocharition ovatae* Philippi 1968. The vegetation reported by Hejný (1960) on the same locality had similar initial and ruderal character which he considered as a coenosis of *Rorippa sylvestris-Rumex crispus*.

In 2015, when large parts of river shores were exposed during extreme droughts, we found a new location of *Cyperus glomeratus* in the vicinity of Štúrovo, in Kamenica nad Hronom settlement. It created sporadical micro-populations in the dense stands of young *Salix fragilis*-shoots in the vegetation of *Cyperetum micheliani* association. We assume that *Cyperus glomeratus* was in years of favorable climatic and ecological conditions continuously present on these localities in the last decades as well.

Coenological and ecological remarks to *Cyperus glomeratus*

C. glomeratus is not a major diagnostic species for particular syntaxonomical unit. It is a component of a large variety of azonal vegetation and it occurs in more associations belonging to even different classes. Yet, the optimum of the species is found in the vegetation of the alliances *Nano-Cyperion* Koch ex Libbert 1932, *Eleocharition ovatae* and *Verbenion supinae* Slavnić 1951 of the order *Nanocyperetalia* Klika 1935, class *Isoëto-Nanojuncetea* (Brullo & Minissale 1998).

Within this order and class, Csiky & Purger (2008) include stands with *C. glomeratus* along the Drava river in SW Hungary into the association *Polygono-Eleocharitetum ovatae* Eggler 1933; in the Tisza river basin in SE Hungary Bodrogközy (1982) includes the species in the associations *Cypero fusci-Juncetum bufonii* Soó et Csűrös 1944 and *Cyperetum micheliani*, each community belongs into the alliance *Eleocharition ovatae*.

The alliance *Eleocharition ovatae* is oligotrophic amphibious vegetation in temporary pools on river deposits or fishponds, characterized by therophytes, rarely accompanied by hemicryptophytes and dwarf geophytes which grow on periodically flooded soils (Šumberová 2011). Crucial factors for development are the short vegetation period and the periodically moist habitat. After floods, raw alluvial deposits and organic silty material are left behind. In desiccating habitats due to gradual evaporation large amount of carbonate accumulate (Borhidi et al. 2012). *Cyperus glomeratus* is well adapted to the fluctuating ecological circumstances. Such habitat conditions were present in our sites, but the eutrophication was high.

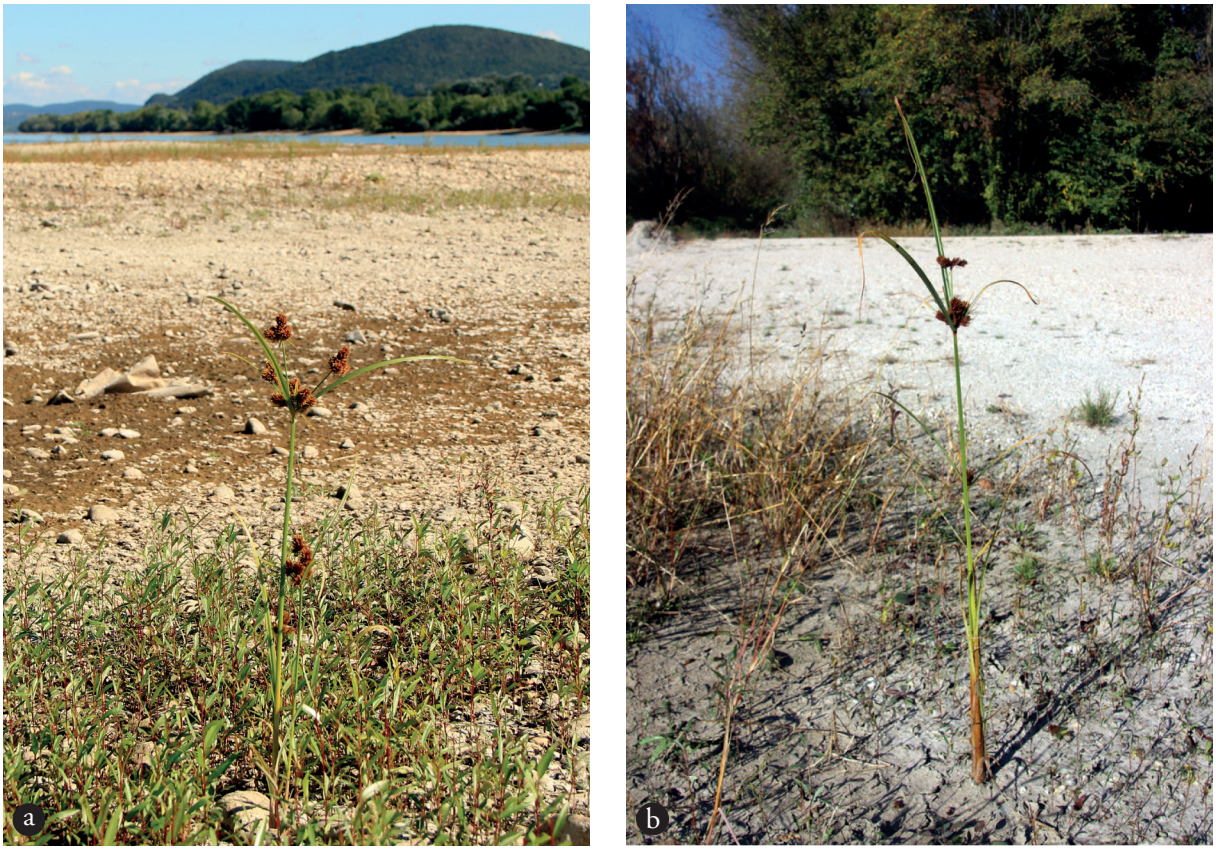

Figure 2: Vegetation of desiccating pools with *Cyperus glomeratus* L. in Štúrovo (**a**) and Čenkov (**b**) in SW Slovakia on the left bank of the Danube
Slika 2: Vegetacija izsušenih uleknin z vrsto *Cyperus glomeratus* L. na nahajališčih Štúrovo (**a**) in Čenkov (**b**) na jugozahodnem Slovaškem na levem bregu Donave.

On the opposite side of the Danube in Hungary, where are analogous ecological circumstances, *C. glomeratus* is relatively common in the favourable years (Barina & Schmidt 2004, Schmidt 2014). We present the following relevé from Győr from a nonstandard area of 2 × 2 m for the purpose of comparison the vegetation with the newly discovered locations in Slovakia.

Relevé 4: Győr, between Likócs and Bácsa settlements on the muddy bank of the Mosoni-Duna river, 2 × 2 m, E_1: 70%, E_0: 0; 47°43'33"; 17°41'08", 111 m a. s. l. ; Schmidt. 9. 9. 2003.

E_1: *Salix alba* juv. 4, *Persicaria dubia* 3, *Cyperus fuscus* 2, *Chenopodium rubrum* 2, ***Cyperus glomeratus*** 1, *Rorippa palustris* 1, *Potentilla supina* 1, *Bidens frondosus* 1

Ranunculus sceleratus 1, *Atriplex patula* +, *Chenopodium glaucum* +, *Dichostylis michelianus* +, *Gnaphalium uliginosum* +, *Veronica beccabunga* +, *Amaranthus blitum* +, *Urtica dioica* +, *Digitaria sanguinalis* +, *Plantago major* +, *Capsella bursa-pastoris* +,

Poa annua +, *Rumex obtusifolius* +, *Barbarea stricta* +, *Butomus umbellatus* +, *Amaranthus albus* +, *Batrachium trichophyllum* +.

Vegetation sampled in Hungary is more species-rich. These stands are enriched with several *Nanocyperion* species such as *Cyperus michelianus* or *Gnaphalium uliginosum*. Species of trampled, wet habitats are also abundant, together with nitrophilous plants of the alliance *Bidention tripartitae*. Other accompanying species of *Cyperus glomeratus* outside of the relevé area were *Limosella aquatica*, *Potamogeton pectinatus* and *Potentilla supina*. The species composition is heterogeneous due to the rough terrain and high amount of organic silt. Like relevés from Slovakia, this relevé can be also regarded as a less typical association of *Cyperetum micheliani*. High cover of young *Salix alba* shoots and the higher species richness indicate latter stages of succession. In Slovakia, observed vegetation had more pioneer character, since the total cover of vascular plants did not reach higher than 25%, in two relevés stagnant water was still present.

Nitrophilous and ruderal species are frequent in both sides of the Danube, since stands are developed in anthropogenic, sometimes eutrophic habitats. Extraction of gravel and sand from the river terraces, like in Čenkov is suitable for *Cyperus glomeratus*, as it needs constant distur-

bance in order to create pioneer surface without high plant cover. In such sites ruderalisation is high, but according to our observations the species is resistant to this stress.

Succession of these temporal communities is fast, the pioneer stands usually alters to the vegetation of the alliances *Salicion triandrae* or *Phragmition australis* (Valachovič et al. 2001). *Cyperus glomeratus* has short life cycle and it is not adapted to the strong competition of perennials and in these communities is less typical (Borhidi et al. 2012). However, the understory of willow gallery forests can offer suitable conditions, as it occurs in such places along the lowland section of Drava river (Kevey et al. 2008). In southern parts of Europe, for instance in Italy, it is quite abundant in vegetation with *Phragmition australis* (Biondi et al. 2009).

Cyperus glomeratus has strong spreading potential if ecological conditions are optimal (humid early-vegetation period followed by dry and warm late-summer). If the circumstances are not suitable, the vegetation does not develop at all within the growing season (Csiky & Purger 2008).

Distribution and threats

Barina and Riezing (in litt.) report *Cyperus glomeratus* from at least five locations on the right bank of the Danube in Hungary between the towns Komárom and Esztergom, very close to the discovered localities. Despite the relatively frequent occurrence in Hungary along the whole section of the Danube (Barina & Schmidt 2004, Schmidt 2014), the species is far rarer on the opposite side, in Slovakia.

Rivers are important transporters of diasporas in cultivated landscape (Jehlík et al. 2005) where several exotic species can spread, for instance *Cyperus strigosus* in Bulgaria (Tzonev et al. 2003) or *Cyperus eragrostis* in Slovenia (Dakskobler & Vreš 2009). Except such neophytes, river-banks often provide places for rare native species. To similar habitats as of *C. glomeratus* are bound other rare species of *Cyperaceae*, which are reported in Slovakia very rarely (e.g. Dostál 1989, Dostál & Červenka 1992). Here belong *Scirpus radicans* (Dítě & Eliáš 2013), *Schoenoplectus triqueter* (Suchá 1992, Dítě et al. 2016), *Schoenoplectus pungens* (Ondrášek 2006) and *Carex bohemica* (Dítě et al. 2015) which recent distribution is restricted to one or two localities. About *Schoenoplectus mucronatus* and *Cyperus longus*, another species of periodically flooded habitats, are no recent data at all.

Redirection of river beds and their consecutive erosion and eutrophication and invasion of alien species in riparian habitats reduce the suitable conditions of *C. glomeratus*. In the IUCN Red List of threatened species it is classed as least concern (LC) (Kavak 2014). In the actual Red List of the Slovak flora *C. glomeratus* is included as critically endangered (CR) (Eliáš jun. et al 2015) like in Switzerland (Welten & Sutter 1982). In the surrounding countries, *C. glomeratus* is regarded either as common species and it is not included in Red lists (Hungary – Király 2007, Ukraine – Didukh 1999) or casual alien (Austria – Essl & Rabitsch 2002, the Czech republic – Pyšek et al. 2012). In Croatia it is classed as vulnerable (VU) (Nikolić & Topić 2005) and in Slovenia as rare (R) (Anonymus 2002). It is protected by law only in Serbia (Anonymus 2010).

Acknowledgements

We thank to Zoltán Barina, Dániel Pifkó, Norbert Riezing, Ranko Perić, Filip Verloove and Laura Celesti-Grapow for their comments on the distribution of *Cyperus glomeratus* in South and Central Europe, to the staff of visited herbaria for their technical help. The study was supported by the grants VEGA No. 2/0003/12 and 1/0083/16.

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