Key environmental variables affecting the distribution of *Elatine hungarica* in the Pannonian Basin

Faktory prostředí ovlivňující rozšíření *Elatine hungarica* v Panonské pánvi

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Elatine hungarica Moesz is a small wetland ephemerophyte that occurs and is classified as extinct, data deficient or a very rare and endangered taxon in most countries in eastern and central Europe. Based on literature and herbarium data, supplemented by 160 field records collected between 1998 and 2011, we present the currently known distribution of this species in the Pannonian Basin, which mostly but not exclusively includes Hungary. Within the Pannonian Basin this species is distributed throughout Hungary, with sporadic occurrences in Romania, Serbia and Slovakia. The temporal distribution of floristic records is very uneven. This species was recorded only in 27 years during the last 213 years (1798–2011). When examining presence/absence data for most of the 20th century, we found a significant correlation between the number of records of this species in a given year and two key, but not independent, environmental variables: rainfall and the extent of the area inundated in the same year. In the more intensively documented period between 1998 and 2010, there is only a significant correlation between the numbers of records of this species and the extent of flooding, which is because there is a delay in the effect of an increase in rainfall. The peak occurrence of records in the 1940s and 1950s is associated with extensive rice production in Hungary. Today, most records are for agricultural fields that are subject to flooding and becoming temporary wetlands. The comparison of recent and past distributions of *E. hungarica* reveals a consistent and marked regional difference; whereas this species is not rare along the Tisza river and its tributaries, it is markedly scattered in similar habitats near the Danube.

K e y w o r d s: ephemerophyte, flooding, Hungary, inland water, *Isoëto-Nanojuncetea*, *Elatinaceae*, mapping, rainfall, rice weeds, Romania, Serbia, Slovakia, temporary ponds

Introduction

All members of the family *Elatinaceae* are poorly known, especially in terms of their taxonomy and phytogeography (Popiela & Łysko 2010, 2011, Popiela et al. 2011, 2012). *Elatine hungarica* Moesz is probably one of the most data deficient vascular plant species in Europe, which is indicated by the low number of localities documented by herbarium specimens. A further telling fact is that, to our knowledge, no photographs of this species were published before that in Molnár V. et al. (1998). This species was described by Gusztáv Moesz (1908) and the lectotype for this name has recently been designated (Molnár V. et al. 2013). The only illustration of *E. hungarica* by Moesz (1908) appeared later as a redrawn figure in numerous other works (e.g. Hegi 1927, Jávorka & Csapody 1929–1934, Ţopa 1955, Felföldy 1990, Dihoru & Negrean 2009).

Elatine hungarica is an ephemerophyte growing on wet mud or on the bottom in shallow water. The individuals are minute, reaching only a few centimeters in diameter, but under favourable conditions dense colonies may arise that are up to 60–70 cm in diameter. Shoots are branched, rooting at nodes and creeping on the mud. The most remarkable differentiating characters of this species are seed curvature and testa reticulation (Molnár V. et al. 2013). The measurements reported indicate that the seeds of the lectotype of *E. hungarica* are much more curved (n = 50, mean ± SD = 188 ± 22°, range: 144–236°) than those of *E. orthosperma* (n = 30, mean ± SD = 40 ± 20°, range: 0–76°), but somewhat less curved than those of *E. hydropiper* (n = 40, mean ± SD = 230 ± 20°, range: 171–276°). The seed testa of *E. hungarica* is characterized by regular hexagons. In this respect *E. orthosperma* and *E. hydropiper* are very different from *E. hungarica* because the reticulation on their seed is characteristically covered by long-hexagons.

Elatine hungarica is reported occurring in central Europe in Hungary (Moesz 1908), Romania (Moesz 1908, Oprea 2005), Serbia (Jávorka 1924–1925) and Slovakia (Margittai 1927, 1939, Ťavoda & Goliašová 2008). Outside central Europe this species is known from Moldova (Gejdeman 1986), Ukraine (Prokudin 1987, Kricsfalusy et al. 1999, Mosyakin & Fedoronchuk 1999, Shapoval 2006) and Russia, where it grows from the coastal area of the Black Sea to western Siberia (Gorshkova 1949). In Portugal, it is recorded as an introduced (naturalized) species (Walters 1968, Uotila 2009), although data in Flora Europaea are highly unreliable for evaluating the invasive status of species at the country level (Pyšek 2003). In most of the countries where *E. hungarica* occurs it is listed in national Red Lists or in Red Data Books. The threat status varies between the countries and includes e.g. "critically endangered" (Romania; Dihoru & Negrean 2009) or "vulnerable" (in Transcarpathian Ukraine; Kricsfalusy et al. 1999), though in some cases Red List data do not reflect the real status of this species (e.g. in Slovakia, see Holub et al. 1999). In the IUCN Red List *E. hungarica* is categorized as a Data Deficient (DD) taxon (Bilz et al. 2011). The threat status and exact distribution of *E. hungarica* are insufficiently known for the eastern part of its distribution; although the species is listed in the Red Data Book of Ukraine (Mosyakin 2009) the published photograph of the species shows *E. triandra* Schkuhr.

Elatine hungarica grows only in periodically flooded habitats (i.e. temporarily inundated arable fields, rice paddy fields and natural marshes). In Hungary, this species, together with *Alisma lanceolatum*, *Alopecurus aequalis*, *Echinochloa crus-galli*, *Elatine alsinastrum*, *Lindernia procumbens*, *Peplis portula*, *Ranunculus sardous*, *Schoenoplectus*

supinus and *Typha latifolia* are classified as diagnostic species of waterlogged arable fields with characteristic *Isoëto-Nanojuncetea* vegetation (Lukács et al. 2013). The specific habitat of *E. hungarica* (3130: Oligotrophic to mesotrophic standing waters with vegetation of *Littorelletea uniflorae* and/or of *Isoëto-Nanojuncetea*) is considered to be of community interest in the European Union (Annex I of Habitats Directive), which implies the designation of special areas for the conservation of this species (Council of the European Communities 1992). Hence, investigations on the distribution and ecology of *E. hungarica*, identification of threatening factors and revision of the IUCN threat status are desirable.

This paper has four main aims: (i) to summarize the data on its distribution scattered in the literature and herbaria in the Pannonian Biogeographic Region; (ii) to present data collected in the field between 1998–2011, which is a significant contribution to the present distribution of this species; (iii) to examine environmental factors influencing its erratic appearance; and (iv) to evaluate threats to this species.

Materials and methods

Study area

The study area is located in the Pannonian Basin, which corresponds to the Pannonian Biogeographic Region of the EU (EEA 2008) (Fig. 1). Basically the region extends over eight countries (Austria, Czech Republic, Croatia, Hungary, Slovakia, Serbia, Ukraine and Romania), with the overwhelming majority of the region in Hungary. This country is in the centre of the basin and has the largest area of lowland in central Europe. Located in the temperate zone it is at the border of three climate zones and experiences a very variable climate (Mezősi 2011). The annual average temperature is ~10°C, but partly because it is in a basin the amplitude of the temperature fluctuation is high (24.5°C in the central part). Annual precipitation decreases from 800 mm in the west to 500 mm in the east, depending on oceanic, orographical and Mediterranean influences (Péczely 1979). The area is rich in surface and ground water and the main rivers are the Danube and Tisza. Before the rivers were regulated in the 19th century the area was mostly flooded and swampy (Ihrig 1973). Nowadays, river regulations prevent large-scale flooding but a significant part of Hungary is still subject to inland water inundation caused mainly by a significant increase in ground water level. Two-thirds of the region is lowland (< 200 m), with most of the remaining area at mid-altitudes (200–500 m) and only a small proportion in the submontane region (> 500 m). This lowland area functions as a real basin where the incoming large rivers (Danube, Tisza and its tributaries) create large, alluvial river valleys with restricted active floodplains due to extensive river regulations.

Distribution of the species

The distribution of *Elatine hungarica* presented here is based on recent (1998–2011) field observations (n = 160), critically evaluated herbarium data (n = 30, from herbaria BP, DE, CL – herbarium acronyms according to Holmgren & Holmgren 1998) and published floristic records (n = 79) for 21 of which there were voucher specimens.

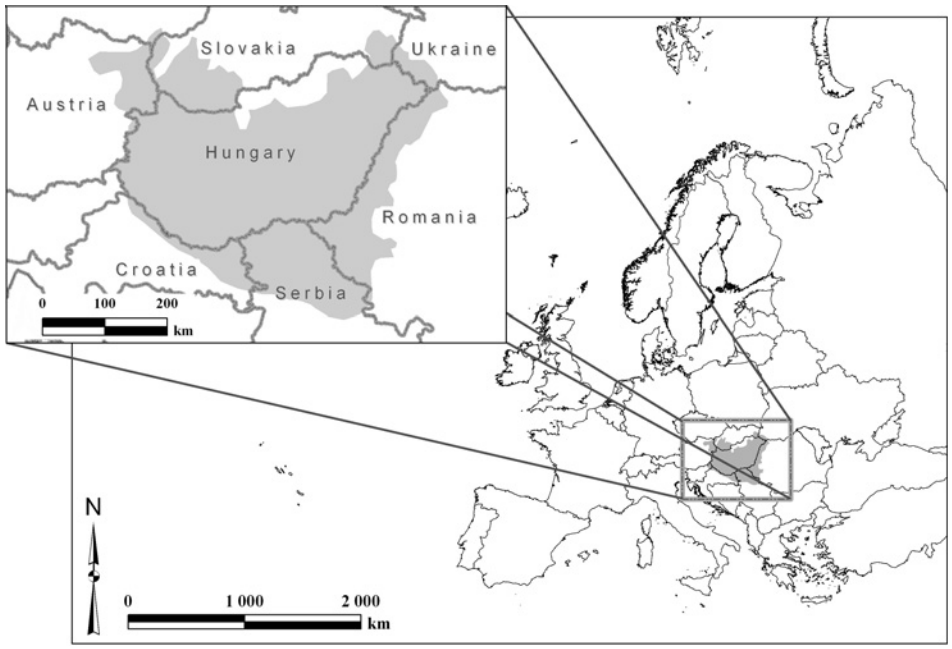

Fig. 1. – The location of the study area.

The taxonomic identity of herbarium specimens and data collected by the authors were verified based on seed morphology. Only records that could be located unequivocally were used to prepare the distribution map. The complete list of localities is given in Electronic Appendix 1.

Distribution data are displayed on a map using the central-European floristic mapping system (Niklfeld 1971). The distribution map summarizing all records for this species in the region is presented in combination with the map (Hydrographic Institute 1938) of waters and wetlands in the Pannonian Basin before the large-scale regulation of the rivers (i.e. before 1860s) to visualize the possible coincidence between the extent of historical wetlands and the species' distribution. The nomenclature of vascular plants follows Király (2009).

Environmental data

To evaluate the possible effects of environmental factors on the occurrence of *E. hungarica* we used rainfall data (including snowfall) measured between 1951 and 2010 by the Lower Tisza Regional Water and Environmental Directorate, Hungary (Pálfai 2011). The maximum extension of the area inundated each year (between 1936 and 2010) was obtained from hydrological sources (Szlávik 2003, Hungarian Hydrological and Environmental Central Directorate 2011). As the increase in the area used for producing rice in Hungary might have influenced the distribution of this species, data on rice production obtained from Hajdú (2006) was used to indicate possible effects.

Statistical analysis

Long-term inundation and rainfall data available for Hungary, which are representative for the entire region, were used to statistically evaluate the role of these factors in influencing the occurrence of *E. hungarica.* Since there were many years with no records (i.e. this variable was strongly zero-inflated), we coded each year based on whether *E. hungarica* was recorded or not. This variable was used to test the null hypothesis (by means of ANOVA) that rainfall and inundation do not differ between years with or without records of *E. hungarica*. The variable "inundation" was log-transformed to improve normality.

Since there were fewer years with zero records after 1997 (5 out of 13), we also tested whether there is a correlation between the number of records, and inundation and rainfall, in the period 1998–2010. This analysis allowed us to evaluate the effect of these two environmental variables on the population size of *E. hungarica* (not only its presence/absence, as in the first analysis). Since the number of records per year was not normally distributed Spearman rank correlation was employed. Analyses were done in the R Statistical Environment (R Development Core Team 2010).

Results

Altogether, 269 floristic records for 105 mapping grid units from Hungary, Romania, Serbia and Slovakia were collected. The earliest record was for 1798, the latest 2011. The recent and historical distribution of *E. hungarica* is shown in Figs 2 and 3 (see Electronic Appendix 1 for source data). The majority of all the records (86%) of *E. hungarica* are for Hungary, but within the Pannonian Basin the species is more widespread occurring in Romania, Slovakia and Serbia, at least in the areas bordering on Hungary (Fig. 3).

The distribution of *E. hungarica* records over time in the region is very uneven (Figs 4, 5). Over a period of 213 years between 1798 and 2011 *E. hungarica* was recorded only in 27 years. Between the 1790s and 1930s the species was recorded only in 10 years in 13 grid units. Between 1940 and 1960 it was collected in 13 years, mostly in rice paddy fields. In Hungary, disregarding the artificially flooded rice paddy fields, the plant was found only in 18 years. Between 1951 and 2010 *E. hungarica* was recorded only in 9 years, mostly after 1998 (Fig. 3).

Annual rainfall and the maximum extent of the area inundated were significantly higher in years when *E. hungarica* was recorded (Table 1). The annual number of records between 1998 and 2010 correlated with the maximum extent of yearly inundated area (Spearman rank correlation, $n = 13$, $\rho = 0.82$; $P < 0.001$), but not with annual rainfall ($\rho = 0.41$; $P = 0.17$).

The distribution of this species shows a notable geographic disparity in the Pannonian Basin (Fig. 3). Although most of the basin is a large floodplain formed by the rivers Danube and Tisza, the majority of the records of *E. hungarica* are for the eastern part of the area, in the region of Tisza and its (sub)tributaries (Bodrog, Berettyó, Zagyva, Körös; Figs 2, 3). Although suitable habitats and typical accompanying species, such as *Schoenoplectus supinus, Lindernia procumbes, Elatine alsinastrum* and *Eleocharis acicularis,* are relatively common along the Danube river *E. hungarica* is a rather rare species there.

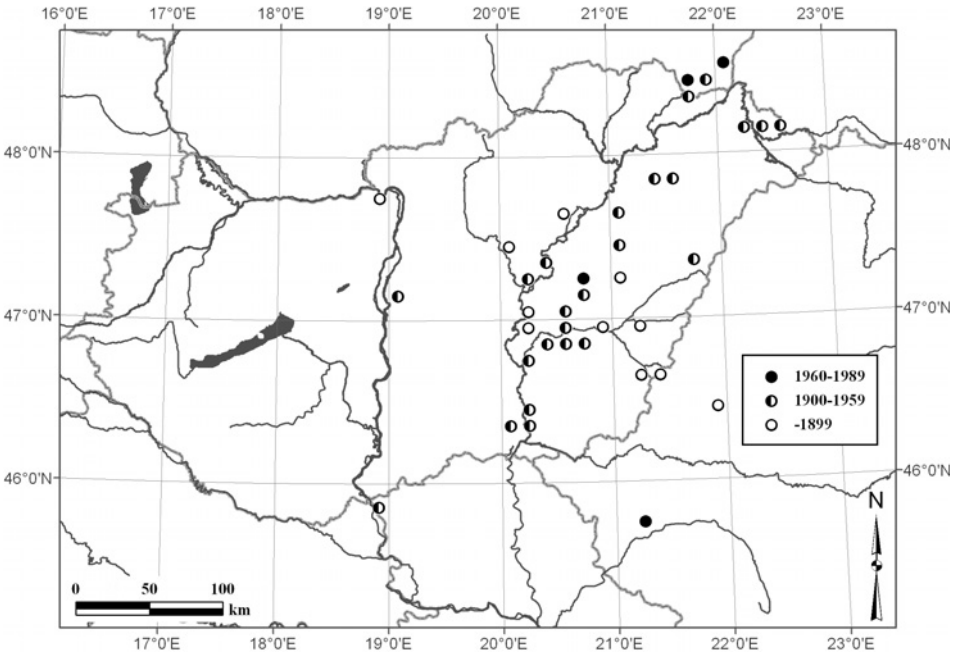

Fig. 2. – Records of *Elatine hungarica* in the Pannonian Basin before 1989. In the case of multiple records in the same grid the symbol displayed is for the latest record. Note that between 1900 and 1959 in Hungary, the species was recorded mostly in rice paddy fields.

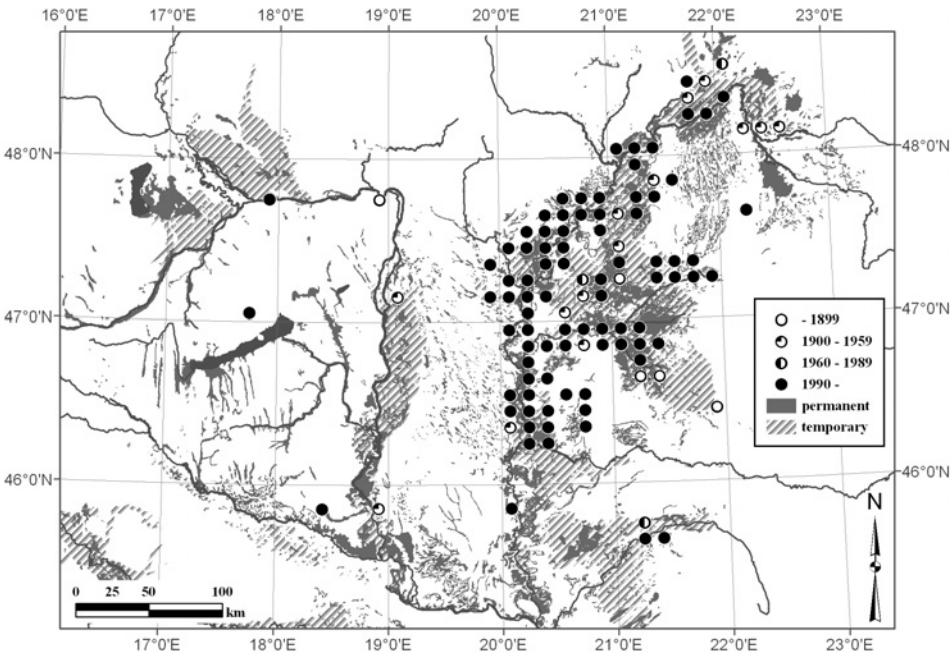

Fig. 3. – Complete distribution of *Elatine hungarica* based on records from several periods, overlaid with the pattern of inundation. Areas covered permanently or temporarily with water in the Pannonian Basin before the rivers were regulated are distinguished (according to the Hungarian Hydrographic Institute 1938). In the case of multiple records in the same grid the symbol displayed is for the latest record.

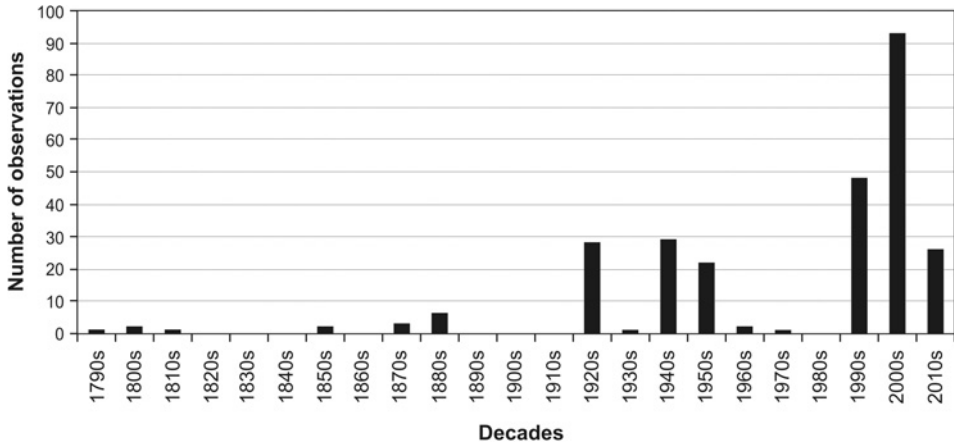

Fig. 4. – The number of records of *Elatine hungarica* in the Pannonian Basin recorded in each decade.

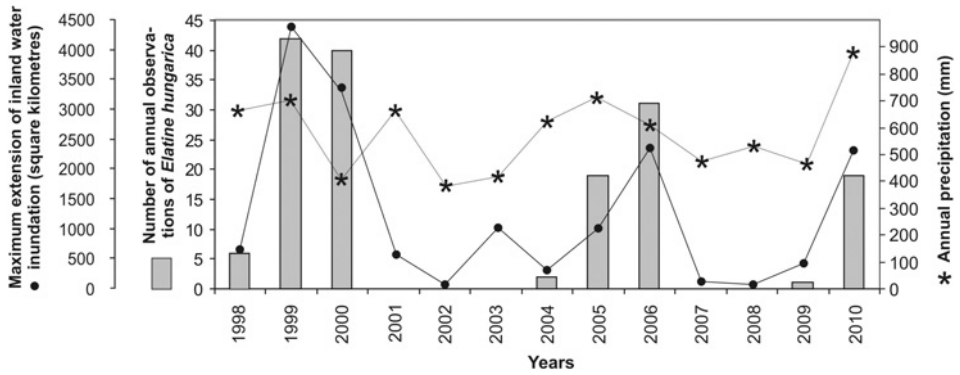

Fig. 5. – The annual number of records of *Elatine hungarica* recorded in the Pannonian Basin between 1998 and 2010, related to annual rainfall and maximum area inundated in Hungary. Note that records from rice fields are

Table 1. – Comparison of the annual rainfall (1951–2010) and the maximum area inundated yearly (1936–2010) in Hungary between years with and without records of *Elatine hungarica* in the Pannonian Basin.

	Records of *Elatine hungarica*	n	Mean	Median	SE	ANOVA
Annual rainfall (mm/year)	Yes	9	638	665	46	$F_{1,58}$=8.0;
	No	51	536	522	13	P = 0.006
Maximum area inundated each year	Yes	13	231	186	50	$F_{1,74}$=14.611;
(1000 hectares)	No	63	78	42	12	P < 0.001

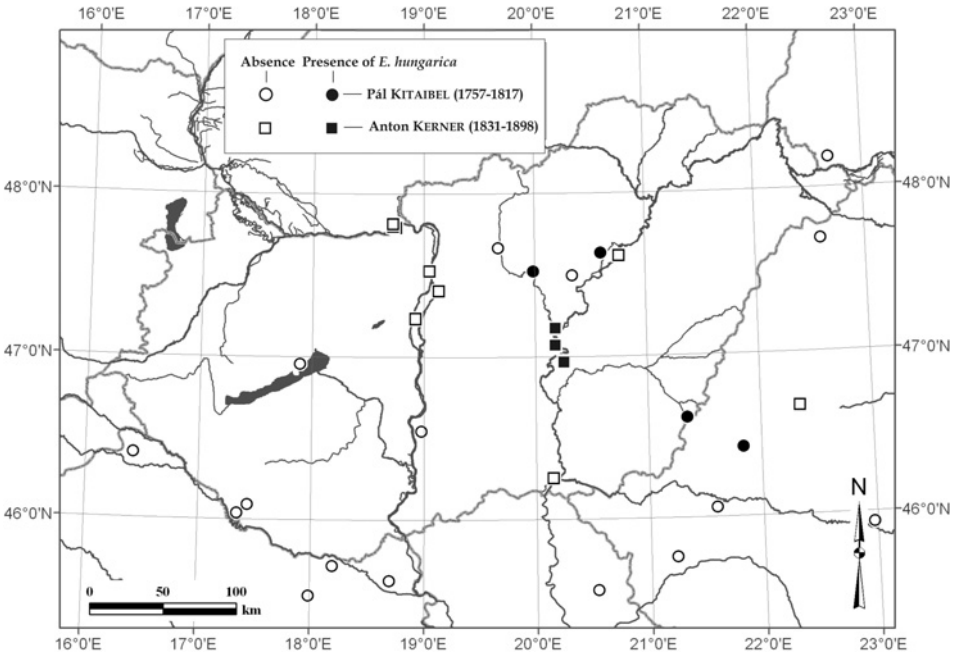

Fig. 6. – Records of *Elatine hungarica* (full symbols) and other *Isoëto-Nanojuncetea* species (empty symbols) recorded by Pál Kitaibel (circles) and Anton Kerner (squares) before the beginning of the regulation of the Tisza river in the 1860s.

The historical longevity of this geographic disparity can be proven by the historical data on this species' occurrence. *Elatine hungarica* was recorded long before the regulation of the Tisza river in the1860s at four and three localities by two botanists, Pál Kitaibel and Anton Kerner, respectively. All these localities are on the Tisza floodplain. Nonetheless, other *Isoëto-Nanojuncetea*-species (e.g. *Cyperus fuscus*, *Dichostylis micheliana*, *E. alsinastrum*, *Eleocharis acicularis*, *Gnaphalium uliginosum*, *Juncus bufonius*, *Limosella aquatica*, *Lythrum hyssopifolia*, *Marsilea quadrifolia*, *Peplis portula*) were also reported by these authors from 12 and six localities, respectively, including the Danube floodplain (Fig. 6).

Discussion

Our paper describes the geographic distribution of the poorly known Red Listed species *Elatine hungarica* in the Pannonian Biogeographic region. We present its current and historical distribution based on the literature, herbarium data and 160 field records reported here, which significantly enhance our knowledge of this species distribution. The erratic distribution of *E. hungarica* may be influenced by several factors. Danihelka et al. (2009) suggest that the number of botanists specialized on a certain group of plants has an indisputable role in determining the extent of the knowledge of a species distribution and

ecology. This might be especially pronounced in the case of aquatic plants, for which the number of experts is relatively low (Kaplan 2010). Nevertheless, we think that the differences in the intensity of floristic research cannot be the only reason for the conspicuous temporal unevenness we have documented in this study (Figs 4, 5) as climatic conditions in the region, such as highly fluctuating annual rainfall and annual extent of the area inundated, also play an important role in determining the occurrence of *E. hungarica*.

Our results indicate that the occurrence of *E. hungarica* significantly increased with increase in annual rainfall and extent of the area inundated. These two key environmental variables are not independent as the former factor evidently influences the latter and due to the basin's geographic characteristics large-scale inundations by direct flooding and lift in the level of ground water are usually associated with increased rainfall. Therefore, the indirect effect of annual rainfall may be crucial. However, in order to understand why we failed to find a correlation between annual rainfall and records of this species in 1998–2010 we need to understand the inundation dynamics of the region. Within this period the rainfall in the wettest year in Hungary (2010: 876 mm) was more than twice that in the driest year (2002: 388 mm). *E. hungarica* was recorded in relatively wet years in which the average rainfall was 141 mm greater than in years when it was not recorded. But, rainfall also has a delayed effect on the extent of the area inundated that significantly contributes to the appearance of *E. hungarica*. This can be exemplified by the period 1998–2002 (Fig. 5), in which the annual rainfall in the first two years, was relatively high (~700 mm) and caused an expansion in the area temporarily inundated to about 350,000–450,000 hectares, which provided suitable habitats for mudflat species, hence the number of records of *E. hungarica* suddenly increased in 1999 and 2000. In the third year (2000) rainfall decreased to only 411 mm, which implied there should have been a decrease in the occurrence of *E. hungarica* in 2001. In 2000, annual rainfall was far below the average, but the number of records was still high because conditions for this plant continued to remain favourable. In contrast, despite the significant rainfall (623 mm) in 2001 there was no extensive flooding causing an absence of records for this plant. In summary, we conclude that the lack of a significant correlation between annual rainfall and the occurrence of this species is caused by the delayed effect of rainfall on the extent of inundation.

An additional limiting factor that is supposed to affect the distribution and occurrence of *E. hungarica* is change in land-use. The species was often recorded in rice fields, which provided an adequate depth of water for a sufficient length of time for it to complete its life cycle. The Pannonian Basin is situated at the northern limit of rice production. From the 16th century onwards sporadic attempts at rice cultivation were made in different countries. The practice of cultivation was established and the main production areas in Hungary determined before World War II. Rice production had a strong political priority in the 1950s and the area under rice cultivation rapidly increased (from ~ 20,000 hectares in 1949 to 87,500 hectares in 1955; Hajdú 2006). Fortunately, the weed flora of rice fields was thoroughly investigated during this period (Soó 1948, Ubrizsy 1948, 1961, Csapody 1953) and *E. hungarica* was recorded at numerous locations. Rice was also cultivated in Serbia (Vojvodina) and Slovakia in the past (Hejný 1960, Tošić 1970) but to a much less extent than in Hungary. Although the presence of rice paddy fields had a similar effect on the flora of Slovakia, e.g. the increase in the number of localities of *Beckmannia eruciformis* was related to experimental rice cultivation (Dítě et al. 2011), *E. hungarica* was not recorded in rice paddy fields in Slovakia or Serbia. The area under rice was

quickly reduced in Hungary after 1970. Nevertheless, the decrease in the number of records of *E. hungarica* cannot be explained only by the decline in rice cultivation. In Hungary there is no documented record of this species in 1960–1998 (Molnár V. et al. 1998, 1999). In this period the intensity of floristic research in Hungary, especially in the potential habitats of *E. hungarica* (e.g. inundated arable fields) was probably too low. Similarly, apparent rarity is recorded for other ephemeral wetland species in the Czech Republic (Šumberová 2003, Šumberová et al. 2012) and Slovakia (Zlacká et al. 2006, Eliáš et al. 2011). After 1998, as a consequence of surveys that focused on inundated areas, unprecedented numbers of localities were recorded.

In Hungary, *E. hungarica* was recorded early mostly in rice paddy fields and in the last decade most frequently in arable fields, which are, at least in certain years, subject to inland inundation and become temporary wetlands (Lukács et al. 2013). Most of these areas are used for agricultural crop production. The presence of this species in wet arable fields can be explained at least in three ways: (i) the seeds are transferred from natural habitats to agricultural land by waterfowl (epi- and/or endozoochory), (ii) by human activities or (iii) the species is a relict of the former natural wetland flora, whose seeds survive in the soil in unfavourable dry years. Transmission by waterfowl is documented for some *Isoëto-Nanojuncetea* species. For instance, seeds of *Carex bohemica* in mud attached to the feet of mallards (Hohensee & Frey 2001) and propagules of 21 plant species in mud attached to the body of waterfowl (Kerner 1868, 1895). In addition, recent studies emphasize the importance of epizoochorous (Vivian-Smith & Stiles 1994) and endozoochorous (Charalambidou & Santamaría 2002, Green et al. 2002, Mueller & van der Valk 2002, Charalambidou et al. 2003, Chang et al. 2005, Wongsriphuek et al. 2008, Brochet et al. 2009, 2010, Figuerola et al. 2010) transport of marsh plants and aquatic macrophytes. Nevertheless, some ecologists (e.g. Clausen et al. 2002) are sceptical about the real importance of ornithochory in long-distance dispersal of seed. In a similar vein, the conspicuous fact that *E. hungarica* has not been recorded in the floodplains of the Danube, Sava and Drava rivers argues against effective dispersal by water birds. If small seeded plants like *Elatine* have conspicuous gaps in their distributions it is much more probable that they are habitat- rather than dispersal limited. This is also clear from the huge but usually scattered distribution range of many wetland annuals, e.g. *Tillaea aquatica*, *Coleanthus subtilis* and some *Elatine* species (Hultén & Fries 1986). However, this phenomenon may be explained by other ecological factors (such as soil characteristics), which needs to be addressed in future investigations.

There is evidence that human vehicles (including soles of boots) and other technical equipment greatly contribute to the dispersal of plant propagules (e.g. Clifford 1959, Bakker et al. 1996). Seed dispersal between isolated ponds carried on vehicles and boots is reported for the Czech Republic for some *Elatine* species (Šumberová et al. 2012). It is probable that vehicles used in farming might also disperse large numbers of propagules. However, this mode of dispersal is limited to local or regional scales.

On the other hand, seed of the genus *Elatine* retain the ability to germinate for a long period (e.g. Margittai 1939, Deil 2005), e.g. *E. triandra* for more than 50 years (Kasahara et al. 1967). Relevant also is that there had been a relatively large area of permanently inundated land in the Pannonian Basin. Until the middle of the 19th century, when the regulation of rivers started in this region, 20.5% of area had been permanently and an additional 17.8% periodically covered by water (Hydrographic Institute 1938). Nonetheless,

Pálfai (2003) reports a potential excess of temporary water on 60% of the plains in Hungary even after the regulation of the rivers was completed.

Conservation outlook

The relative abundance of *E. hungarica* is connected with the availability of suitable temporary wet habitats, especially in agricultural fields. Intensive agricultural cultivation (e.g. ploughing, treading) and inundation creates hundreds of hectares of optimally wet, exposed surfaces. However, local and regional scale drainage of inundated arable fields, which is in the interest of farmers, causes this habitat to dry out before this species can germinate. In addition, *E. hungarica* (and other dwarf mud dwellers) is threatened by the abandonment of traditional extensive cultivation methods, and the general application of advanced agrotechnology and herbicides. According to Timár & Ubrizsy (1957) 2,4-dichlorophenoxyacetic acid and MCP (2-methyl-4-chlorophenoxyacetic acid), which are widely used chemicals in agriculture are known to be harmful to this species.

Elatine hungarica is evaluated as missing (possibly extinct) in the Slovak Republic (Holub et al. 1999: 414, Feráková et al. 2001, Ťavoda & Goliašová 2008). However, it was recently recorded at two localities in Slovakia (Molnár V. et al. 1999, Király & Eliáš 2011), hence the species must be considered as critically endangered (CR). The same happened in Hungary, where Bagi (1998) presumed that the species was extinct, even though protected in this country since 1993 but without specified level of threat (Király 2007).

Overall, this study has a clear conservation message. Because of the general rarity of this species, and the strong correlation of its occurrences with annual rainfall and the area of land inundated, the best strategy for conservation is the hydrographical rehabilitation of selected sites or creation of suitable habitats and inclusion of the species in a vulnerable legislation category. The success of the former strategy is ensured by the ability of *E. hungarica* to create a long lasting seed bank. Because of the latter we propose for *E. hungarica* the category Least Concern (LC) on the global scale and Vulnerable (VU) on a regional scale according to Bilz et al. (2011). This may result in *E. hungarica* being given a preferred role in nature conservation projects.

See www.preslia.cz for Electronic Appendix 1

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Souhrn

Elatine hungarica Moesz, drobný mokřadní efemerofyt s centrem výskytu ve střední a východní Evropě, je ve většině zemí Panonského ekoregionu považován za taxon vyhynulý (EX) nebo velmi vzácný a ohrožený (EN), nebo je hodnocen jako druh s nedostatečnými údaji výskytu (DD). Stanoviště tohoto druhu patří mezi biotopy evropského významu (tj. jsou uvedeny v Příloze I. směrnice o stanovištích EU). V předloženém příspěvku představujeme historické i aktuální rozšíření tohoto druhu v Panonském ekoregionu zpracované na základě dat získaných studiem literatury a herbářových údajů, doplněných o 160 terénních záznamů získaných v letech 1998 a 2010. V rámci ekoregionu se druh vyskytuje roztroušeně ve velké části Maďarska, zatímco v Srbsku a na Slovensku byl zaznamenán pouze ojediněle. Časové rozložení floristických záznamů je velmi nerovnoměrné. *Elatine hungarica* byla zaznamenána v průběhu posledních 213 let (mezi lety 1798–2011) pouze v 27 případech/letech. Analýzou dat jsme zjistili pozitivní korelaci mezi přítomností druhu a množstvím srážek, jakož i mezi přítomností druhu a velikostí oblasti zaplavení. Vrchol jeho výskytu ve čtyřicátých a padesátých létech minulého století souvisí s tehdejším velkoplošným pěstováním rýže v Maďarsku. Dnes je většina nálezů soustředěna v zemědělských oblastech, které jsou v letech s vysokým úhrnem srážek vystaveny periodickým záplavám vytvářejícím dočasné mokřady. Historické i současné rozšíření *E. hungarica* vykazuje rovněž nápadné regionální rozdíly: ačkoliv druh bývá v blízkosti řeky Tisy a její přítoků nalezen dosti často, na obdobných lokalitách v blízkosti Dunaje se vyskytuje velmi roztroušeně až vzácně.

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