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EFFECTS OF URBANIZATION ON THE OCCURENCE OF ANURA ASSEMBLAGES IN THE CITY OF SZEGED (HUNGARY)

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Abstract. Nowadays, rapidly expanding urbanization influences the existence of many plant and animal species. The amphibian decline is largely related to habitat loss, in which expansion of urban areas and the degradation of aquatic habitats within the city play a significant role. There were 18 study sites involved in our study, all within the administrative area of Szeged. Their state was different regarding the adverse impacts of urbanization. In our study we seek to answer which amphibian species occur in Szeged and what are the environmental parameters that affect the community of amphibians living in urban areas. Our results clearly show that *Pelophylax esculentus* complex is fully dominating the heavily polluted, affected and also the most seminatural aquatic habitats. Moreover, regarding the environmental parameters, we detected negative correlation between the length of the main roads, the total area of the study sites and its vegetation cover and water transparency. However, according to our results, there is positive correlation between the locally occurring amphibian community and the coastal water depth and the linear extent of the surrounding concrete and dirt roads.

Keywords: urbanization, environmental parameters, amphibian community, species richness, aquatic habitats

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Introduction

Worldwide, the number of amphibian species shows a persistent decline (Houlahan *et al.* 2000). That progression has different reasons such as degradation (Blaustein *et al.* 1994; Corn, 2000) and fragmentation (Hartel *et al.* 2007) of habitats, environmental pollution and excessive use of chemicals (Berill *et al.* 1997; Harte and Hoffman 1989), respectively climate change (Pounds *et al.* 1999) and inter alia some disease like chytridiomycosis (Berger *et al.* 1998; Daszak *et al.* 1999; Pessier *et al.* 1999). The amphibian decline is largely related to the general decline in biodiversity, whose current rate is faster than that of any time in the last 10,000 years (Eldridge 1998). Urbanization exerts an influence on a number of animal species thus amphibians are also affected by it. The aquatic habitats, which are indispensable for the reproduction of amphibians, are often drained in the cities or they are highly degraded that they become unsuitable for the amphibians to maintain viable populations. Due to their extremely sensitive skins, amphibians play an important role as indicator species in the detection of environmental and ecological changes (Piotr 2006; Price *et al.* 2008). The amphibians have to adapt to the altered habitat conditions occurring in urban environments. Some species can keep up with the changes in their habitat easier while some species hardly can, thus such changes can lead to local extinction (Drinnan 2005). In urban areas breeding places are often separated from hibernating places by different infrastructure elements like roads. Thus the latter form physical barriers which are usually hostile for anurans to cross, during springtime (Puky 2006; Puky and Vogel 2003). For some species like the Green frogs, which are hibernating in mud, roads are less dangerous than they are for toads (*Bufo* spp.) that die in great quantities while reaching the breeding sites. However, earlier studies show the migrating behavior of Green frogs in Lake Fertő (Frank and

Pellinger 1988). Finally many aquatic habitats are transformed into fishponds where predator fish species negatively affect the composition of the amphibian community (Smith *et al.* 1999). Amphibians sensitively indicate the perturbations listed above as well as to the loss and fragmentation of habitats.

Habitat degradation can be traced by the presence or absence of the amphibian species living there, but the main goal of our study is the monitoring of aquatic habitats. The herpetofauna of Szeged and its surroundings has already been the topic of several previous studies (Marián 1963; Ilosvay 1974). According to those studies 11 of the 18 Hungarian amphibian species occur in the region. Among the anurans Fire-bellied Toad (*Bombina bombina*, Linnaeus, 1761), Common Spadefoot (*Pelobates fuscus*, Laurenti, 1768), Common Toad (*Bufo bufo*, Linnaeus, 1758), Green Toad (*Bufo viridis*, Laurenti, 1768), European Tree Frog (*Hyla arborea*, Linnaeus, 1758), Moor Frog (*Rana arvalis*, Nilsson, 1842), Agile Frog (*Rana dalmatina*, Bonaparte, 1840), Marsh Frog (*Pelophylax ridibundus*, Pallas, 1771) and the Edible Frog (*Pelophylax* kl. *esculenta*, Linnaeus, 1758) were described.

The aims of the present study were (1) to assess the amphibian fauna of Szeged and compare the present data with the results of former faunistical surveys (Marián 1963, Ilosvay 1974) and (2) identify the environmental parameters that influence the composition of the amphibians living in urbanized habitats.

Materials and methods

Study sites

Our surveys have been done in 17 permanent and 1 temporary aquatic habitats between April and September 2011. All habitats are located within the administrative area of Szeged and they show a considerable variation in perturbation and pollution. The exact location of sampling sites is given in Fig. 1. The only temporary aquatic habitat is located in a fenced off area in the centre of the city — hereinafter Centrum — which lies 2-3 meters below the street

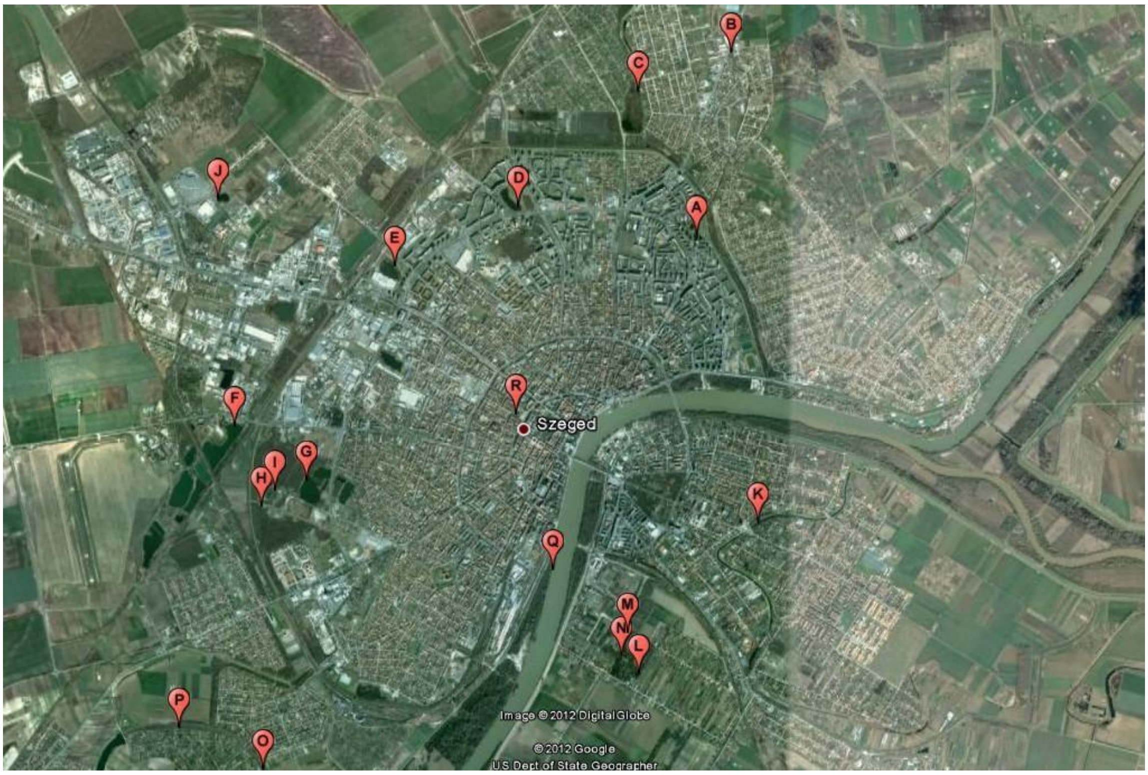

Fig. 1. Study sites. A: Zápor Garden (1); B: Szillér Baktó main channel (2); C: Lake Bika (3); D: Vértó (4); E: Lake Búvár (5); F: Lake Keramit (6); G: Sancer ponds (7); H: Marsh near "Pantanal" (8); I: "Pantanal" (9); J: Zápor-tározó (10); K: Dead Maros (11); L: Botanic Garden outer pond (12); M: Botanic Garden inner pond (13); N: Canals within Botanic Garden (14); O: Gyála Oxbow black water (15); P: Gyála oxbow middle section (16); Q: Boszorkánysziget (17); R: Centrum (18).

level. Many Green Toads reproduce and lay eggs during spring time in that quick warming habitat. Around the end of June the entire water dries out, consequently the tadpoles that could not metamorphose die and the juvenile specimens hive off seeking shelter in the surrounding downtown areas. The oxbow of Gyála is the only aquatic habitat located outside the city, where two sampling sites were selected. One at the more polluted part, which is called "Black water" and the other is in the middle section of the water body. The water quality is less polluted in the latter section of the aquatic habitat, which is surrounded by houses and gardens. Among the study sites Lake Bika is in the most advanced in the eutrophication process and has the largest surface, although 90% of the water body is covered by the reeds belt. The ponds of the Botanical Garden, where we set up 3 sample places, belong to those which are less exposed to disturbance. The Sancer ponds in the Szeged Zoo are less disturbed too and the same applies to the other two sampling sites we set in the area of the Zoo. Regarding the nature of the study sites, Boszorkánysziget is the only one which is connected to a River. It is situated a floodplain of the River Tisza. Zápor Garden, Vértó and Lake Búvár are located in densely populated areas. Finally Lake Keramit, the Maros oxbow and the Zápor-tározó (rain reservoir) are used for fishing activities. Sample sites are shown on the map (Fig. 1) edited with the software Google Earth Plus v6.0.3.2197.

Sampling methods

Samplings were performed 4 times at each study site (from April to September). We performed our survey in daytime and used two methods; visual identification combined with fishing out with scoop net and acoustic monitoring (Anthony and Puky 2001). The latter was just an additional method to identify those species which are difficult to locate visually (e.g.: *H. arborea*). Above the adult linked methods, a spawn and tadpoles study was also carried out, although we only found spawn in two study sites (Centrum and Maros oxbow). The collected adult specimens were released nearby the capturing places right after the morphological identification and registration.

Environmental Parameters

The following 10 environmental parameters were chosen to characterize the aquatic habitats and the impact of urbanization: the total area of the study site (m^2), the surface of water (m^2), the surface of the reed belt (m^2), the vegetation cover (%), water transparency (cm), average water depth alongside the shore (cm), the length of the main roads (m), the length of the concrete roads (m), the length of the dirt roads (m), the proportion of residential areas (%). The length of the main roads, concrete roads, dirt roads and the proportion of residential areas were determined within a radius of 300m. Google Earth Plus and ArcView (ArcGIS 9.1, ESRI) softwares were used to determine the size of the habitats, the water surface, the size and coverage of the reed belt and the vegetation, the main roads, concrete roads, dirt roads and the proportion of residential areas. All asphalt roads, which had more than two lanes was categorized as a main road. The transparency of aquatic habitats was measured with Secchi disk. The Secchi transparency is the quantity of the water where the disk vanishes and reappears. The average water depth was measured ten times at each study site at one meter from the shore.

Statistical analysis

We used Generalized Linear Models with Poisson error distribution term to determine the correlation between the number of species and individuals and the measured environmental parameters. Stepwise selection was applied for model selection. The non-metric multidimensional scaling (NMDS) was used to visualize the similarity of the amphibian assemblages of the study sites. Similarity matrices based on Bray-Curtis distance measure were used. The data was log-transformed ($\log(x+1)$) prior to the analyses to avoid distortion due to the high number of individuals of *Pelophylax esculentus* complex. We took into consideration only permanent aquatic habitats, thus Centrum was not included in the NMDS (Figure 2). Data analysis was performed with R software package (R Development Core Team 2009) and vegan package (Oksanen *et al.* 2006).

Results

During the present study we found the following 6 species (Table 1); Fire-bellied Toad, Common Toad, Green Toad, European Tree Frog, Moor Frog, Agile Frog and the Green frog group (*Pelophylax* spp., Ranidae) all of the identified species were recorded formerly from Szeged (Marián 1963, Ilosvay 1974). We did not separate the individuals of the Green frog group, which consist of three species in Hungary: *P. ridibundus, P. lessonae* and *P.* kl. *esculenta*; due to a high hybridization rate. Thus they are mentioned as *Pelophylax esculentus* complex. We could not find any Common Spadefoot, since that species is more active at night, although they probably occur in Szeged and its surroundings (Solomampianina and Molnár 2011). The highest

Table 1. The occurrence of amphibians in each study sites. Investigated ponds: 1: Zápor Garden; 2: Szillér Baktó main canal; 3: Lake Bika; 4: Vértó; 5: Lake Búvár; 6: Lake Keramit; 7: Sancer ponds; 8: Marsh near „Pantanal"; 9: „Pantanal"; 10: Zápor-tározó; 11: Dead Maros; 12: Botanic Garden outer pond; 13: Botanic Garden inner pond; 14: Canals within Botanic Garden; 15: Gyála oxbow black water; 16: Gyála oxbow middle section; 17: Boszorkánysziget; 18: Centrum Species: BOBO=*Bombina bombina*; BUBU=*Bufo bufo*; BUVI=*Bufo viridis*; HYAR=*Hyla arborea*; PESC=*Pelophylax esculentus* complex; RDAL=*Rana dalmatina*; RARV=*Rana arvalis*

	Study sites																	
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
BOBO	×											×	×		×	×		
BUBU											×	×						
BUVI	×																	×
HYAR		×									×	×	×			×	×	
PESC	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	
RDAL													×				×	
RARV												×						

species richness was found in the Botanical Garden, where in the outer pond four species and a species group occurred (Fire-bellied Toad, Common Toad, European Tree Frog, Moor Frog, Green frog group) and in the inner pond we found three species (Fire-bellied Toad, European Tree Frog, Agile Frog) and the Green frog group. As mentioned above, Boszorkánysziget was the only one study site which is directly connected to the Tisza River. We found a few individuals of Agile Frogs there, not surprisingly, where the breeding sites are surrounded by wooded areas (Boszorkánysziget, inner pond of the Botanical Garden) (Table 1).

The *Pelophylax esculentus* complex had an undisputable dominancy in the aquatic habitats of urbanized areas. Within more than half of the study sites, the members of the *Pelophylax esculentus* complex were the only one dominant species. We found them in heavily polluted habitats or ponds with significantly simplified structure as well as in near-natural water bodies. Marsh Frog was the least typical species, which occurred only in the outer pond of the Botanical Garden (Table 1).

Table 2. Explanatory variables influencing number of species

	beta-value (β)	z-value	p-value
Length of main roads	-0.001169	-2.095	0.0362

We used Generalized Linear Models to determine the correlation between number of species and individuals and the environmental parameters. Only the main roads had a significant impact on the number of species. Negative correlation occurred between the number of species and the length of the main roads in the vicinity of the aquatic habitats (Table 2). Regarding the number of species, the total area of the study sites, the vegetation cover and the water transparency were proved to have a significantly negative effect, while the water depth, the length of concrete roads and dirt roads show positive correlation (Table 3). Interestingly the main roads, which have exclusive effect on the number of species, showed no significant effect on the number of individuals.

Table 3. Explanatory variables influencing number of individuals

	beta-value (β)	z-value	p-value
Total area	-1.882e-05	-9.179	< 0.001
Vegetation cover	-1.649e-02	-9.474	< 0.001
Transparency	-7.641e-02	-13.365	< 0.001
Water depth	2.652e-02	5.613	< 0.001
Length of main roads	1.847e-04	1.518	0.129
Length of concrete roads	3.025e-04	6.443	< 0.001
Length of dirt roads	7.528e-04	12.035	< 0.001

NMDS was used to plot the similarity between the aquatic habitats (Figure 2). The biplot shows that the aquatic habitats in Szeged are characterized by the members of Green frog complex. At the habitat 3, 4, 5, 6, 7, 8, 9, 10 and 14 the only recorded species was the *Pelophylax esculentus* complex. The habitat 12 and 13 in the Botanical Garden is moderately disturbed so this may be the reason why we found there the individuals of *B. bufo, R. arvalis* and *H. arborea*.

Discussion

The habitat properties of urban environments, fragmentation (Hartel *et al.* 2007) and habitat degradation (Blaustein *et al.* 1994; Corn, 2000) also cause problems in the aquatic habitats of Szeged. Our faunistical results match all results of previous studies (Marián 1963; Ilosvay 1974). Among previously described anurans, Common Spadefoot was the only one species that we could not find, although former studies recorded their occurrence in Szeged and its surroundings (Solomampianina and Molnár 2011). It is possibly due to the nocturnal activity of the species. We detected six species and the *Pelophylax esculentus* complex.

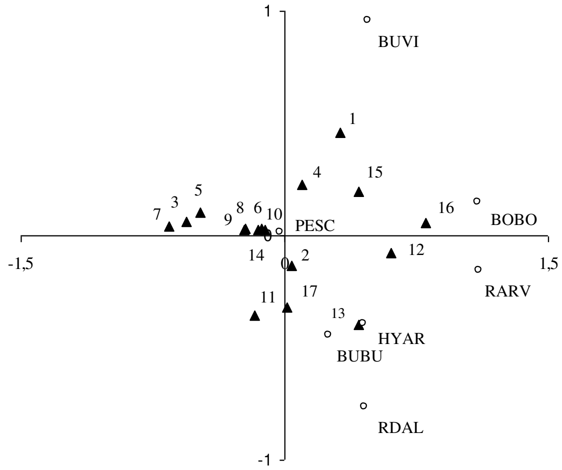

Fig. 2. The result of NMDS ordination in terms of study sites and the occurring species drawn as biplot (stress: 9.43759). The study sites and the name of species are shown in Table 1. ○ - Species; ▲ - Study sites

In terms of species diversity, we reached the similar conclusion as earlier studies in similar urban environments (Mollov 2011; Rácz *et al.* 2009). Together with the Green frogs, European Tree Frog is also a species, which – although in our study not in large numbers – does occur in urban environments (Pellet *et al.* 2004). Numerous individuals of Green frogs occurred in heavily polluted water bodies as well as in less perturbed, seminatural aquatic habitats. The dominance of Green frogs in these ponds is caused by the wide tolerance against the human perturbation and water pollution (Mollov 2011). Among the study sites, in six cases we found European Tree Frogs and in five cases Fire-bellied Toads, these species were comparatively occurred in more aquatic habitats or their surroundings. The Common Toad is usually frequent in urban areas (Mazgajska 2009) but we only found these species in two sampling sites, and also a small number of individuals. Compared to other amphibians the Common Toads often make apart far from the breeding sites (Reading *et al.* 1991) so the traffic is threatening them in the centre of the city. That could be the reason why we found Common Toads in those aquatic habitats, which were surrounded by less traffic roads. As for the species richness, the Botanical Garden raises above the study sites, where we found four species and the *Pelophylax esculentus* complex. The above mentioned species richness can be explained by the fact that the aquatic habitats of the Botanical Garden are less perturbed by human activity. Moreover, among the environmental parameters, the coastal water depth, the concrete and dirt roads have positive effect on the amphibian community. The deeper coastal water secures the eggs against the dehydration when the weather turns dry and the ponds have no water supply. The deeper water provides safer environment for growing eggs so it could be the adequate explanation why we found correlation between the number of individuals and the water depth. Negative correlation can be demonstrated between the length of the main roads and the following parameters: total area, the vegetation cover and the water transparency of aquatic habitats. The linear extension of the main roads within 300 meters radius, the fewer the species that occurred in the given aquatic habitat. The roads, especially the busy ones, like the main roads, form strong physical barriers for amphibians, while migrating from hibernation sites to breeding and feeding sites during the springtime and back to the hibernation sites in the autumn (Frank and Pellinger 1988, Puky 2006, Puky and Vogel 2003). For those aquatic habitats, which are surrounded by main roads, the vast majority is dominated by one species group less frequently two species can occur. Adequate explanation for that phenomenon is the fact that the life of Green frogs is closely linked to water throughout the year. In the case of Secchi transparency when the value is low, the ponds organic matter content is high or pollution level is massive. Except the Green frog complex the inland species can moderately tolerate the polluted water bodies what our survey clearly showed. The other negatively correlated environmental parameters were the extension of the total area and the cover of the coastal vegetation. In the case of Green frogs the excessively rich coastal vegetation prevents the animals to go back quickly the water when something suddenly disrupts their resting period at the shore. The bigger the habitat the more negative human impact it can be exposed to and these impacts negatively correlate with the number of individuals. Based on the results of NMDS, it can be concluded that no grouping between the above mentioned species can be detected regarding the similarity of the amphibian assemblages on the studied habitats. It can be established that several amphibian species are able to form and maintain a relatively stable population in urban areas, however, only the species of the *Pelophylax esculentus* complex can tolerate human disturbance and changed habitat conditions.

Acknowledgement

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References

Anthony, B. and Puky, M. (2001): Kétéltűek hang alapján történő monitorozása (Amphibian monitoring by sound). Varangy Akciócsoport Egyesület, pp 2-18.

Berger, L., Speare, R., Daszak, P., Green, D.E., Cunningham, A.A., Goggin, C.L., Slocombe, R., Ragan, M.A., Hyatt, A.D., Mcdonalds, K.R., Hines, H.B., Lips, K.R., Marantelli, G. and Parkes, H. (1998): Chytridiomycosis causes amphibian mortality associated with population declines in the rain forests of Australia and Central America. Proceedings of the National Academy of Science, USA 95:9031-9036.

Berrill, M., Bertram, S. and Pauli, B. (1997): Effects of pesticides on amphibian embryos and tadpoles. — In: Green, D.M. (Ed.), Amphibians in Decline: Canadian Studies of a Global Problem. Society for the Study of Amphibians and Reptiles, St. Louis, MO, pp. 233–245.

Blaustein, A.R., Wake, D.B. and Sousa, W.P. (1994): Amphibian declines: judging stability, persistence, and susceptibility of populations to local and global extinctions. Conservation Biology 8, 60–71.

Corn, P.S. (2000): Amphibian declines: review of some current hypotheses. In: Sparling, D.W., Linder, G., Bishop, C.A. (Eds.), Ecotoxicology of Amphibians and Reptiles. SETAC Press, Pensacola, Florida, pp. 633–696.

Daszak, P., Berger, L., Cunningham, Hyatt, A., Green, D.E. and Speare, R. (1999): Emerging infectious diseases and amphibian population declines. Emerging Infectious Diseases 5(5).

Drinnan, I. N. (2005): The search for fragmentation thresholds in a southern Sydney suburb. Biological Conservation 124: 339–349.

Eldridge, N. (1998): Life in the balance: humanity and biodiversity crisis. Princeton University Press, Princeton, New Jersey, USA.

Frank T. and Pellinger A. (1988): Kétéltűek és hüllők védelme a Fertő-menti úton (Amphibian and reptilian protection along the road near Lake Fertő). EFE, Sopron. pp 72.

Harte, J. and Hoffman, E. (1989): Possible effects of acidic deposition on a Rocky Mountain population of the tiger salamander Ambystoma tigrinum. Conservation Biology 3, 149–158.

Hartel, T., Öllerer, K. and Nemes, S. (2007): Critical elements for biologically based management plans for amphibians in the middle section of the Târnava Mare basin. Biologia Acta Scientiarum Transylvanica 15(1): 109-132.

Houlahan, J.E., Findlay, C.S., Schmidt, B.R., Meyer, A.H. and Kuzmin, S.L. (2000): Quantitative evidence for global amphibian population declines. Nature 44: 752-755.

Ilosvay Gy. (1974): Szeged környéke herpetofaunája (Herpetofauna of Szeged and its surroundings). Thesis, Juhász Gyula Tanárképző Főiskola Állatani Tanszék, Szeged (in Hungarian), pp. 127.

Marián, M. (1963): Közép-Tisza kétéltű és hüllő világa (Amphibians and reptiles of the Middle Tisza region). Móra Ferenc Múzeum Évkönyve, Szeged (in Hungarian), 207-231.

Mazgajska, J. (2009): Amphibians in the Wawer district of the Warsaw agglomeration. Fragmenta Faunistica 52(1): 33–42.

Mollov, I. (2011): Habitat distribution of the amphibians and reptiles in the city of Plovdiv, Bulgaria. Biharean Biologist, 5(1): 25-31.

Oksanen, J., R. Kindt, P. Legendre and R.B. O'Hara. (2006): VEGAN: Community Ecology Package. R package ver. 1.8-3. URL http://cran.r-project.org/.

Pellet, J., Guisan, A. and Perrin, N. (2004): A concentric analysis of the impact of urbanization on the threatened European Tree Frog in an agricultural landscape. Conservation Biology, 18: 1599-1606.

Pessier, A.P., Nichols, D.K., Longcore, J.E. and Fuller, M.S. (1999): Cutaneous chytridiomycosis in Poison Dart Frogs (Dendrobates spp.) and White's Tree Frog (Litoria caerulea). Journal of Veterinary Diagnostic Investigation 11:194-199.

Piotr, T. (2006): Is body size of the water frog Rana esculenta complex responding to climate change? Naturwissenschaften, 93, 110–113.

Pounds, J.A., Fogden, M.P.L. and Campbell, J.H. (1999): Biological response to climate change on a tropical mountain. Nature 398, 611–615.

Price, S.J., Howe, R.W., Hanowski, J., Regal, R.R., Niemi, G.J. and Smith, C.R. (2008): Are Anaurans of Great Lakes coastal wetlands reliable indicators of ecological condition? Journal of Great Lakes Research. 33 (Special Issue 3): 211-223.

Puky, M. (2006): Amphibian road kills: a global perspective. pp 325–338. In: Irwin CL, Garrett P, McDermott KP (eds) Proceedings of the 2005 international conference on ecology and transportation. Center for transportation and the environment, North Carolina State University, Raleigh, NC, USA.

Puky, M. and Vogel, Zs. (2003): Amphibian mitigation measures on Hungarian roads: design, efficiency, problems and possible improvement, need for a co-ordinated European environmental education strategy. Habitat Fragmentation due to Transportation Infrastructure – IENE: 1-13.

R DEVELOPMENT CORE TEAM (2009): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.Rproject.org

Reading, C.J., Loman, J. and Madsen, T. (1991): Breeding pond fidelity in the common toad, Bufo bufo. Journal of Zoology, 225(2): 201-211.

Rácz, M.J., Kiss, I. and Sály, P. (2009): Kétéltűállományok összehasonlító vizsgálata Budapest különböző vizes élőhelyein (Comparative study of amphibian assemblages in different wetland habitats at Budapest). Állattani Közlemények, 94(1): 103-121.

Smith G.R., Rettig J.E., Mittelbach G.G., Valiulis L.J. and Schaack S.R. (1999): The effects of fish on assemblages of amphibians in ponds: a field experiment. Freshwater Biology 41(4): 829–837.

Solomampianina, G. and Molnár, N. (2011): Occurrence of True Frogs (Ranidae L.) in the region of Szeged as related to aquatic habitat parameters. - Tiscia 38, 11-18.

TISCIA 39, 9-15

ASSESSMENT OF RIVERINE DRAGONFLIES (ODONATA: GOMPHIDAE) AND THE EMERGENCE BEHAVIOUR OF THEIR LARVAE BASED ON EXUVIAE DATA ON THE REACH OF THE RIVER TISZA IN SZEGED

G. Horváth

Horváth, G. (2012): Assessment of riverine dragonflies (Odonata: Gomphidae) and the emergence behaviour of their larvae based on exuviae data on the reach of the river Tisza in Szeged. — *Tiscia 39, 9-15*

Abstract. Abundance, phenology, sex ratio, emergence pattern, mortality and larval emergence behaviour of riverine dragonflies (Odonata: Gomphidae) were studied at the Lower-Tisza reach at Szeged (168–173 rkm) during the emergence period in 2011. Three 20 meter long sampling sites were chosen and searched systematically for exuviae, dead specimens and dragonfly wings, which were left behind by bird predators. At the studied reach of the river two species form stable populations: *G. flavipes* and *G. vulgatissimus*. *G. flavipes* was much more abundant than *G. vulgatissimus*. Exuviae indicated the excess of females in the *G. vulgatissimus* population (altough there were no significant difference between sexes), while in the case of *G. flavipes* the number of individuals in both sexes were almost the same. *G. vulgatissimus* started to emerge first as a 'spring species', while *G. flavipes* started to emerge about a month later showing the characteristics of a 'summer species'. The rate of mortality in the *G. flavipes* population during emergence was slight and quite normal compared to the abundance of the species. Selection of emergence support of *G. flavipes* showed that the significant majority of the larvae chose soil, but this could have been caused by the notable minority of other types of substrates at the sampling sites. The distance crawled by the larvae from the water-front to the emergence site differed significantly between the two species, *G. vulgatissumus* crawled further, and in the case of *G. flavipes* the effect of the measured background variables to the distance had not been proven.

Key words: Gomphus flavipes, G. vulgatissimus, collections of exuviae, abundance, emergence pattern, sex ratio.

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Introduction

If we want to examine Odonata (in this particular case Gomphidae) populations, there are three different methods to carry out the work:

The most difficult way is the imago based examination because of the excellent manoeuvring skills and hiding behaviour of the adults. The collection of larvae is also not easy, sampling can be problematic in large watercourses. In the case of these two methods there is another disadvantage in a conservational point of view, as imagines and larvae may die during the collection.

Knowing all those, the most reliable and the simplest method to define the population size and emergence specificity of riverine dragonflies is the regular quantitative collection of their exuviae. The best time to estimate the accurate size of the Gomphidae population is during the emergence period (Suhling and Müller – cit. Farkas *et al.* 2012a). Beside species composition and abundance, exuviae provide information about phenology, pattern of emergence, sex ratio, mortality during the emergence, we could make statement about morphological features or even about the moult-strategy of the larvae (Berzi-Nagy 2011, Farkas *et al.*

2009, 2011, 2012a,b; Jakab 2006). The application of the method is highly recommended, because it does not require the collection of living animals so it is not objectionable in a conservational point of view either. Furthermore, exuviae of Anisopterans remain intact for a long time, even under unsuitable weather conditions (Jakab 2006) so there is no need for daily collection.

During the past few years, many studies were published about the riverine dragonfly populations of the Upper- and Middle-Tisza regions (Bánkuti *et al.* 1997; Mátyus 2006 – cit. Berzi-Nagy 2011; Berzi-Nagy 2011; Farkas *et al.* 2009; Farkas *et al.* 2012a; Jakab 2006). Nevertheless, this present study is the first to discuss the Gomphid assemblages of the Lower-Tisza region.

According to literature two Gomphidae species, the River Clubtail (*Gomphus flavipes*) and the Common Clubtail (*Gomphus vulgatissimus*) were expected to occur with abundance big enough to form stable populations along this region. In the light of the current Gomphidae based works my goals were to reveal the sex-ratio and emergence characteristics (phenology, emergence pattern) of the riverine dragonflies that inhabit the reach of the river Tisza near Szeged. I also examined the emergence behaviour (the distance larvae crawled from the waterfront and correlation with the variables, and substrate preference) and mortality during the emergence.

Materials and Methods

Study sites and sampling

Sampling was carried out at the bank of the river Tisza within the administrative territory of Szeged (between 168-173 river kilometers).

I chose 3 different sampling sites, one on the left bank [L.I. (46°12'46.71"N, 20° 7'42.43"E)], and two on the right bank of the river [R.II. (46°14'25.53"N, 20°8'57.53"E); R.III. (46°13'31.74"N, 20°8'23.20"E)], each site was 20 m long.

Each sampling site differed from the others in their characteristics. L.I. site was sunny, cover of vegetation was low, and the inclination angle of the riverbank was little. The R.II. site was shaded the whole day, cover of vegetation was low, and the inclination angle of the riverbank was high. The R.III. site had sunny and always shaded parts too, cover of vegetation was relatively high, the inclination angle of the riverbank was medium compared to the other two sites.

Sampling was performed between 6 May and 18 August in 2011 twice a week, usually in the third and the fifth day.

I checked the bank of the river carefully twice (the soil and the vegetation) in a 4-5 m zone from the water-front. I recorded the emergence support and the distance crawled from the water-front to the emergence support, then I collected the exuviae with tweezers and stored them in boxes in dry conditions.

To study the substrate-preference I determined 8 different support-types (artificial objects in the watercourse, dead fallen leaves, exuviae, green leaves, objects washed up by the river, roots, soil and thin branches).

To study the mortality during the emergence, I recorded data of individuals that were captured by predators (wings near the exuviae indicate bird predation), or died during the emergence due to other reasons (e.g. abnormal moulting or abnormal wing decompression). To determine total mortality, I also paid attention to young adult dragonflies that were damaged. These individuals would not live enough to mate, they usually die shortly after emergence. I did not count these imagines in the total number of individuals, because in most cases I found their exuviae next to them.

Processing of the exuviae took place at the laboratory of the Department of Ecology of the University of Szeged. Identification of the specimen to species and gender level had been carried out with a stereomicroscope. I used the keys and descriptions of Askew (1988), Gerken and Sternberg (1999) and Raab *et al.* (2006). To separate the sexes I used the work of Berzi-Nagy (2011).

The water level and water and air temperature data came from the on-line database www.vizadat.hu, data of the measure station in Szeged (173,6 river kilometer) were used as background variables.

Statistical analysis

PAST (Hammer *et al.* 2001) and R (R Development Team 2009) softwares were used to the statistical analysis of the dataset.

To the comparison of the sex ratio of *G. vulgatissimus* and *G. flavipes*, $\chi 2$ test was used.

To compare the distance crawled from the waterfront to the place of emergence by *G. vulgatissimus* and *G. flavipes* larve, Kruskal-Wallis test was used.

The number of *G. vulgatissimus* larvae was so low that if the data of this species were used by ANOVA and linear regression the results would be quite questionable, so during the following statistical methods I used only the data of *G. flavipes* exuviae.

Linear regression was used to examine the relationship between the amount of emerged *G. flavipes* specimens and that of captured by birds.

The analysis of the substrate-preference of *G. flavipes* was carried out with one-way ANOVA, and Tukey-test was used to the pairwise comparisons.

Multiple linear regression was used to reveal the connection between the distance crawled by *G. flavipes* larvae and the background variables (water level, water temperature and air temperature) and between the number of the exuviae and the background variables. The best model had been chosen with Stepwise models election based on Akaike information criterion (AIC).

Results

Abundance of species

During the examination period, 1217 exuviae were found. Thirty two (2,6%) of them were *G. vulgatissimus*, 1183 (97,2%) *G. flavipes* and 2 (0,2%) were Green Snaketail (*Ophiogomphus cecilia*). The 1217 exuviae come from 3 study sites, so the average number on a 20 meter long study site is 406. In the case of *G. vulgatissimus* exuviae this number is 11 and the *G. flavipes* is 394. In the case of *O. cecilia,* there is no point talking about population density, because of their low number.

In the case of *G. vulgatissimus*, there was no big difference between the number of the individuals at the three study sites. However, in the case of *G. flavipes*, the number of the exuviae in the L.I. site exceeded the combined number of the individuals of the R.II. and R.III. (Fig. 1.).

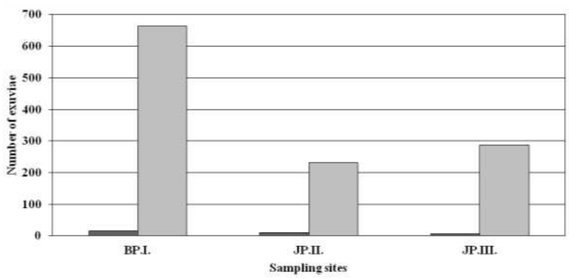

Figure 1. Distribution of *G. vulgatissimus* (dark grey columns) and *G. flavipes* (light grey columns) exuviae between the sampling sites.

Sex ratio

From the 32 *G. vulgatissimus* exuviae there were 19 (59,4%) female and 13 (40,6%) male specimens. In the case of the 1183 *G. flavipes* exuviae, there were 590 (49,8%) female and 591 (49,9%) male, while the sex of 2 individuals were uncertain. There was no significant difference between the ratio of sexes either in case of *G. vulgatissimus* ($\chi 2$=0,0008; df=1; p=0,98) or *G. flavipes* ($\chi 2$=1,125; df=1; p=0,29).

Pattern of the emergence

G. vulgatissimus started to emerge on the 6th May. The emergence of *G. flavipes* started on the 25th May.

The pattern of the emergence is fundametally different between the two Gomphid species (Fig. 2.). In the case of *G. vulgatissimus* the whole population emerged within a month (19 days), the EM50 value (the time needed for the 50% of the population to emerge) is 4 days, the curve of the emergence is steep – the species act as a 'spring species'. In the case of *G. flavipes*, however, the emerging of the total population took more than two months (72 days), the EM50 value is 17 days – the species act as a 'summer species'.

If we examine the pattern of the emergence on the basis how many exuviae had been found each day, two peaks can be seen in the case of *G. flavipes* (Fig. 3.).

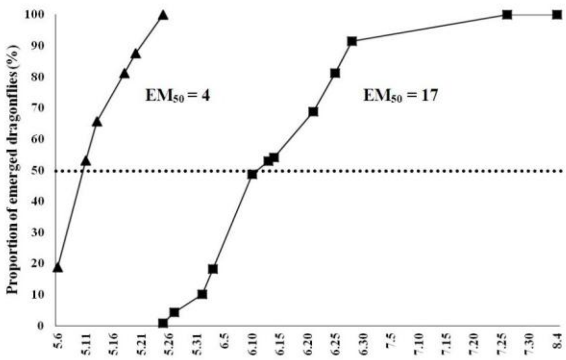

Figure 2. The emergence curve of *G. vulgatissimus* and *G. flavipes* at the investigated reach of the river Tisza at Szeged in 2011 (EM50 :the time needed for the 50% of the population to emerge; ▲–*G. vulgatissimus* ■–*G. flavipes*).

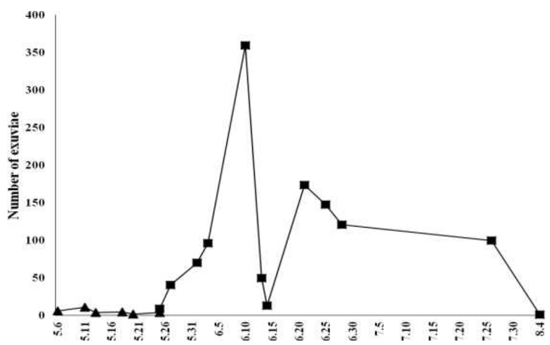

Figure 3. The emergence pattern of *G. vulgatissimus* and *G. flavipes* at the investigated reach of the river Tisza at Szeged in 2011 (▲–G.vulgatissimus ■–G.flavipes).

Mortality of G. flavipes during the emergence

Total mortality of *G. flavipes* during the emergence period was 5,58%. According to the literature (Farkas *et al.* 2011, 2012b) this is a normal value by this abundance of the species. Larvae consumed by predators (4,9%) make up the largest proportion of the total value, and within predation birds are liable for the most consumed larvae (4,48%). These specimens can be easily distinguished from those that were consumed by other, unknown predators (0,42%) in most cases. When birds eat the emerging dragonflies they leave the uneatable wings of the insects behind, so if the wings are found nearby the exuviae that refers to bird predators. Linear regression shows that there is a significant and positive correlation between the amount of emerged dragonflies and mortality caused by birds (β=0,52; F=15,4; df=1 and 12; p=0,002, n=12).

The remaining proportion of mortality was caused by abnormal moulting (0,34%) and the abnormal decompression of the wings (0,34%).

Substrate pereference of G. flavipes

I used data of 763 specimen of *G. flavipes* exuviae to the examination of substrate preference, because the original support could be identified without doubts by that many exuviae (in the other 420 case the exuviae were found lying on their back, or due other reasons I could not identify the original support). According to one-way ANOVA there is a significant difference between the support choice (F=7,832; df=7,16; p<0,0003), the majority of the larvae chose soil as an emergence support (Table 1.). Tukey's pairwise comparison shows (Table A.1.) that soil is significantly differ from any other supports and between other support types there are no significant difference in terms of preference.

Table 1. Substrate types chosen by *G. flavipes* larvae at the reach of the river Tisza in Szeged.

support type	number of individuals	percentage of individuals
fallen leaves	14	1,83
exuviae	5	0,66
roots	6	0,79
artificial object	10	1,31
washed up objects	7	0,92
soil	687	90,04
branches	12	1,57
green leaves	22	2,88
Total	763	100

Distance crawled from waterfront, number of exuviae and connection with background variables

According to the distance data crawled by larvae, there is a significant difference between *G. vulgatissimus* and *G. flavipes* populations (Kruskal-Wallis-test: H=13,35; Hc=13,35; p<0,0005). *G. vulgatissimus* crawl greater distance (horizontal+vertical) from the waterfront than the other species, although there was no vertical movement observed of *G. vulgatissimus* specimens. (Figure 4. and Table 2.).

Water level, water temperature and air temperature (investigated their effects individually) have no significant effect on the distance crawled by *G. flavipes* larvae (Linear regression: β=-0,24; F=0,35; df=7,3; p=0,79; n=12), and they have no significant effect if we assume interaction between them either (Linear regression: β= 0,07; F=1,11; df= 7,3; p=0,51; n=12). None of the models were supported by the AIC.

Nevertheless, marginally significant positive connection was found between water temperature and the number of exuviae (Linear regression: β=0,52; F=14,1; df= 1,11; p=0,003; n=13).

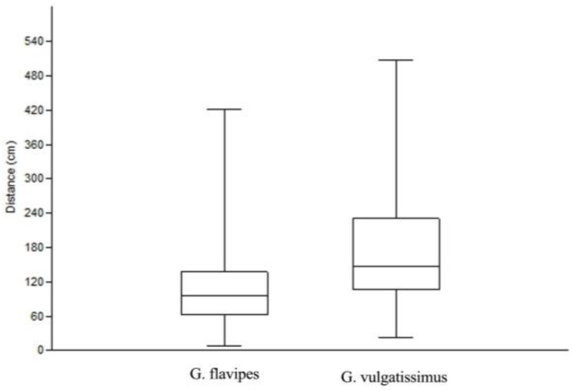

Figure 4. Distance crawled by the larvae of *G. flavipes* and *G. vulgatissimus* from the waterfront to the emergence substrate at the reach of the river Tisza in Szeged.

Discussion

At the investigated reach of the river Tisza *G. vulgatissimus* and *G. flavipes* seem to form stable populations. Although there is a huge difference between the abundance of the two species this phenomenon seems to be normal along the river Tisza and every other places where the two species occur together. (Jakab and Dévai 2008). In 2011 at Szeged the abundance of *G. flavipes* was 36 times bigger than *G. vulgatissimus*, many authors inform about a similar result, nevertheless, the differences in

Table 2. The mean, standard deviation and maximum values of distances (horizontal, vertical and total) crawled by the larvae of *G. flavipes* and *G. vulgatissimus*.

Species	Horizontal distance		Vertical distance		Total distance		N
	Mean±SD	Max.	Mean±SD	Max.	Mean±SD	Max.	
G.flavipes	104 ± 63	420	1 ± 6	72	105 ± 62	420	763
G.vulgatissimus	174 ± 114	506	0	0	174 ± 114	506	26

abundance quoted by these papers are greatly variable. According to Jakab (2006) at the reach between Tiszafüred and Tiszacsege in 2001 the abundance of *G. flavipes* was 8 times greater, during the following years the abundance of *G. flavipes* was much more greater than the abundance of *G. vulgatissimus*: 11 times greater in 2002; 23 times greater in 2003 and 26 times greater in 2012 (Farkas *et al.* 2012a). At Vásárosnamény in 2008 the abundance of *G. flavipes* was 2 times greater than the abundance of *G. vulgatissimus* (Farkas *et al.* 2008). As we can also see the differences increase toward the south greatly, it could be possible that the southern regions of the river Tisza can provide better conditions for the populations of *G. flavipes*, as this species, in his paper Berzi-Nagy (2011) made the same conclusions.

In the case of *O. cecilia* it is quite sure that the species has no stable population at the investigated reach of Tisza. This species, as well as the Small Pincertail (*Onychogomphus forcipatus*), the fourth occurring Gomphid in Hungary, prefers small rivers and streams with high oxygen level and moderate flow (Raab *et al.* 2006). The two specimens might have drifted from the river Maros, where they form populations (Jakab and Dévai 2008).

The result of the investigation shows that in 2011 at Szeged there was no significant difference between the ratio of sexes either in case of *G. vulgatissimus* or *G. flavipes*. In the case of *G. flavipes* the number of individuals in both sexes are almost the same. Although, for the subgenus Anisoptera it is general that the number of females is higher than the number of males (Berzi-Nagy 2011; Farkas *et al.* 2009; Jakab 2006) similar result may occur (Jakab 2006). It is also an example that the sex ratio of a certain species differ at the same reach of a river between years (Corbet 1999 – cit. Farkas *et al.* 2009), so it is possible that next years the sex ratio of the *G. flavipes* also will change.

In 2011 at Szeged the *G. vulgatissimus* acted as a 'spring species' (the species emerged strongly synchronized within a short time) the *G. flavipes* as a 'summer species'. (the emergence was less synchronized and stretched in time) This phenomenon can be observed at other regions of the river Tisza during the last decade as well. According to Berzi-Nagy (2011) the emergence pattern of *G. flavipes* showed the trait of a 'spring species' at the Middle-Tisza region near Szolnok. Jakab (2006) reported the same phenomenon from that region, but during his three year long investigation the pattern of the emergence of *G. flavipes* varied between years, too, and the differences were significant. Similarly to sex ratio, the pattern of emergence can vary between years, and also between different reaches of one certain river. Variability could be caused by water temperature: lower water temperature in winter and higher one during summer caused more synchronized emergence (Suhling 1995 – cit. Jakab 2006).

The emergence pattern of *G. flavipes* shows two peaks, but this cannot be explained with weather conditions, because these peaks do not coincide with the highest air temperatures. So in this case, cohort splitting seems to be the best explanation to the emergence pattern as cohort splitting and unsuitable weather conditions can cause a long-drawn emergence period too. The reason of cohort splitting is that females lay eggs during the entire emergence period and some larvae winter in the final (F0) larval, while some in the penultimate (F-1) larval stage. Those that winter in F-1 stage will emerge a few days or weeks later and they cause the second peak in the emergence pattern.

The fact that more than 90% of the larvae chose soil as emergence support does not necessarily mean that there is a specific attachment to the soil as substrate. 92% of the 763 *G. flavipes* larvae emerged within 2 meters from the waterfront and 78% of them within 1,5 metres. There is a possibility that the over-representation of the soil has caused this phenomenon, as during most of the emergence period there were no – or was in very low proportion of – other substrates in the first 1,5-2 meter zone from the waterfront. Former studies (Farkas *et al.* 2009, 2011) claim that in the case of *G. flavipes* larvae there is no substrate-specific attachment, but they choose supports that are available within a certain distance from the waterfront. This idea is supported by the observation that larvae that chose green leaves (second most frequently chosen emergence support) did not crawl further than the mean distance but most of them emerged in late June and July, when the vegetation had grown in this zone too (68% of them emerged within 2 metres; 68 % emerged in July and 54% of them emerged within 2 metres in July).

During the emergence period in 2011 there were 66 *G. flavipes* exuviae, larvae or young imagines found consumed by predators or wounded mortally at the investigated reach of the river. This proportion at this density is quite normal (Farkas *et al.* 2011, 2012a,b). Due to the emergence strategy of the species [larvae emerge close to the waterfront and the entire process takes 15-59 minutes, which is very short compared to other Anisoptera taxa (Farkas et al 2012b)] the major factor for mortality is predators, especially birds as common blackbird (*Turdus merula*) and white wagtail (*Motacilla alba*) (personal observation and Farkas *et al.* 2012a,b).

Results of the present study shows that *G. vulgatissimus* larvae crawl greater distances from the waterfront than *G. flavipes* larvae, as there is a strong significant difference between the crawled distance (from the waterfront to the emergence support) of the two species. This seems to be general along the river Tisza (Farkas *et al.* 2009, 2011, 2012a,b), and the explanation is that *G. vulgatissimus* starts emerging in late April or early May when greater fluctuations of the water-level is possible, while in late May or early June, when the *G. flavipes* starts the emergence, there is a less chance of the fluctuation of the water level (Farkas *et al.* 2012b).

The background variables could have a strong effect to the emergence of the Gomphidae species: Berzi-Nagy (2011) claims that the level and temperature of water could influence the rate of synchronization and the timing of emergence. Moreover, according to former studies (Farkas *et al.* 2009) water level has a positive and water temperature has a negative effect on the crawled distance. In the case of this present study, the fact that none of the background factors showed to effect the distance, might be due to the low sample size.

Aknowledgement

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References

Askew, R. R. (1988): The Dragonflies of Europe. – Harley Books, Colchester, 291 pp.

Bánkuti, K., Dévai, Gy., Miskolczi, M. (1997): Faunistical data on dragonfly (Odonata) exuvia from the active floodplain of river Tisza between Tiszabercel and Gávavencsellő (NE-Hungary). – Studia odonatol. hung. 3:43-47.

Berzi-Nagy L. (2011): A sárgás szitakötő (*Gomphus flavipes flavipes* Charpentier, 1825) jellemzése és Tisza-menti populációinak összehasonlító elemzése (Characterization of river clubtails (*Gomphus flavipes flavipes* Charpentier, 1825) and comparative analysis of their populations along the river Tisza). – Debreceni Egyetem, Hidrobiológiai Tanszék, Debrecen, 50 pp.

Farkas, A., Jakab, T., Dévai, Gy. (2009): Assessment of riverine dragonfly (Odonata: Gomphidae) on the basis of exuviae on the reach of the river Tisza at Vásárosnamény. – Acta Biol. Debr. Oecol. Hung. 20:65-78.

Farkas, A., Jakab, T., Dévai, Gy. (2011): Emergence behaviour of riverine dragonfly (Odonata: Gomphidae) larvae along the Tisza river system based on exuviae surveys. – Acta Biol. Debr. Oecol. Hung. 26:53-66.

Farkas, A., Jakab, T., Dévai, Gy. (2012a): Emergence characteristics of riverine dragonflies (Odonata: Gomphidae) along the river Tisa between Tiszacsege and Tiszafüred. – Acta Biol. Debr. Oecol. Hung. 27:39-50.

Farkas, A., Móra, A., Dévai, Gy. (2012b): Mortality during emergence in *Gomphus flavipes* and *G. vulgatissimus* (Odonata: Gomphidae) along the Danube. – Acta Biol. Debr. Oecol. Hung. 28:65-82.

Gerken, B., Sternberg, K. (1999): Die Exuvien Europäischer Libellen (Insecta Odonata) (Exuviae of european dragonflies (Insecta Odonata)). – Arnika & Eisvogel, Höxter & Jena, VI + 354 pp.

Hammer, Ø., Harper, D. A. T., Ryan, P. D. (2001): PAST: Paleontological Statistics Software Package for Education and Data Analysis. – Paleontologica Electronica 4/1: 1-9 pp. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Jakab T. (2006): A Tisza-tó és a Közép-Tisza szitakötő-fajegyütteseinek (Insecta: Odonata) összehasonlító elemzése (Comparative analysis of dragonfly assemblages (Insecta: Odonata) of Tisza-lake and Middle-Tisza region). – Doktori Értekezések 23. Debreceni Egyetem Kossuth Egyetemi Kiadója, Debrecen, 131 pp.

Jakab, T., Dévai, Gy. (2008): The occurrence of the riverine dragonfly-species (Odonata: Gomphidae) in Hungary according to data of larvae and exuviae. – Acta Biol. Debr. Oecol. Hung. 18: 53-65.

Raab, R., Chovanec, A., Pennerstorfer, J. (2006): Libellen Österreichs (Dragonflies of Austria). – Springer, Wien/New York. 355 pp.

R Development Core Team (2009): R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.Rproject.org

Appendix

Table A.1. Tukey's pairwise comparisons for the substrate types (* marks the significant differences).

	fallen leaves	exuviae	roots	artifical ob.	washed ob.	soil	branches	green leaves
fallen leaves	–	1	1	1	1	0,001*	1	1
exuviae	0,1053	–	1	1	1	0,0009*	1	1
roots	0,0936	0,0117	–	1	1	0,0009*	1	1
artifical ob.	0,0468	0,0585	0,0468	–	1	0,0009*	1	1
washed ob.	0,0819	0,0234	0,0117	0,0351	–	0,0009*	1	1
soil	7,877	7,982	7,97	7,923	7,959	–	0,001*	0,0011*
branches	0,0234	0,0819	0,0702	0,0234	0,0585	7,9	–	1
green leaves	0,0936	0,199	0,1873	0,1404	0,1756	7,783	0,117	–

TISCIA 39, 17-21

NEW LOCALITIES OF PROTECTED AND RARE PLANTS IN SOUTHERN HUNGARY

L. Erdős, V. Cseh and Z. Bátori

Erdős, L., Cseh, V. and Bátori, Z. (2013): New localities of protected and rare plants in southern Hungary. – *Tiscia 39, 17-21.*

Abstract. Data on protected and rare plants may be important from a nature conservation point of view, and can be used to secondary data analysis, to reveal broad-scale spatial patterns. As recent publications indicate, several floristic novelties can be found even in well-studied areas. In this article, we give data about occurrences of 28 species, among them 19 protected and 3 strictly protected ones. The focus of the paper is on the Maros-angle and the Villány Mts, but other areas from South Hungary are also represented. In two cases, coenological relevés are also provided. Knowledge on the localities of the strictly protected *Astragalus dasyanthus*, *Ephedra distachya* and *Ophrys sphegodes* reported here, accompanied by localities of other protected and rare species may be used for designating protected areas and performing more effective conservation measures.

Keywords: Astragalus dasyanthus, Ephedra distachya, Ophrys sphegodes, floristic data, Maros-angle, Villány Mts

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Introduction

Although data on new localities of plant species are often neglected, they play an important role in nature conservation, and can be used in revealing broad-scale spatial patterns (Horváth 1997, Király 2005, Molnár V. 2005, Fekete 2010). Recent publications suggest that there are several unknown occurrences of plants, even in well-studied areas, and even for the relatively well-known taxa (e.g. Penksza and Malatinszky 2010, Erdős et al. 2011, Riezing 2012). In the present paper, we give data about occurrences of 28 species, including 22 protected and strictly protected ones. We also provide some coenological relevés.

Methods

Species are listed in alphabetical order in this article. All localities are given according to the small landscape units of Hungary (Marosi and Somogyi 1990), and according to settlements as well. Topographic maps were used to give local geographic names. Codes of the Central European Flora Mapping System (CEU) are given in brackets (Király and Horváth 2000). Nomenclature follows Simon (2000). For the small landscape units, we used the following abbreviations:

B: Bugac-sand ridge
D: South-Tisza-valley
DM: Dorozsma-Majsa sand ridge
I: Illancs
M: Maros-angle
NH: Nyárád-Harkány-plain
V: Villány Mts

Results

Asplenium javorkeanum VIDA

NH: Nagyharsány (on a stonewall in the village) [0176.3]. It occurs on some parts of the neighbouring Villány Mts (Bátori et al. 2010, Erdős et al. 2011), thus it can be assumed that the species arrived from the nearby Mt Szársomlyó.

Asplenium scolopendrium L.

D: Szeged (on the wall of the Bolyai-building of the university,under a gutter) [9786.4]. It has not been known from Szeged before, although some ferns have been reported from the city, from unusual habitats: *Pteridium aquilinum* from stone-walls (Lányi 1915) and *Dryopteris carthusiana* from a tree hollow in Újszeged (Tímár 1948).

Astragalus dasyanthus PALL.

DM: Kisszállás (Jánosteleki-forest, in open sand grasslands) [9783.2]. The investigated population is taxonomically problematic. Only a small proportion of the individuals could be identified as typical *Astragalus dasyanthus* according to the species identification keys (cf. Bátori et al. 2011). Presumably, most individuals are hybrids of *Astragalus dasyanthus* and *Astragalus exscapus*. Location of the two parent species have been known from the region (Szujkó-Lacza et al. 1993). Other valuable, protected plants occurring in the grasslands are *Achillea ochroleuca, Adonis vernalis, Alkanna tinctoria, Colchicum arenarium, Centaurea arenaria, Corispermum nitidum, Dianthus serotinus, Gypsophila fastigiata, Iris humilis* ssp. *arenaria*, *Onosma arenaria, Stipa borysthenica, Vinca herbacea.*

Botrychium lunaria (L.) SW. in SCHRAD.

DM: Ásotthalom (Emlékerdő, under hawthorn shrubs and white poplar trees) [9784.4] (K. Lukács and G. Pászty, ined.). It has not been reported from Ásotthalom previously (cf. Lányi 1915, Lengyel 1915, Bodrogközy 1957, Farkas 1999). According to Király (2009), it is rare on the Great Hungarian Plain, but Farkas (1999) states that new localities are expected to be discovered. Coenological relevé: A1 (%): *Populus alba* 15; B (%): *Crataegus monogyna* 80, *Ligustrum vulgare* 1, *Populus alba*: 20; A1 + B cover (%): 90; A1 height (m): 15; B height (m): 4; C (%): *Achillea* sp. 0.1, *Anthriscus cerefolium* 0.1, *Asparagus officinalis* 0.1, *Berberis vulgaris* 0.1, *Botrychium lunaria* 0.1, *Bromus sterilis* 2, *Calamagrostis epigeios* 0.1, *Carex liparicarpos* 3, *Celtis occidentalis* 0.1, *Chondrilla juncea* 0.1, *Crataegus monogyna* 0.5, *Cynoglossum officinale* 0.1, *Dactylis polygama* 0.1, *Eryngium campestre* 0.1, *Euphorbia cyparissias* 0.1, *Fallopia convolvulus* 0.1, *Festuca valesiaca* 15, *Galium aparine* 0.1, *Galium verum* 0.1, *Hedera helix* 0.1, *Ligustrum vulgare* 1, *Myosotis stricta* 0.1, *Phleum phleoides* 0.1, *Poa pratensis* agg. 0.1, *Populus alba* 0.1, *Potentilla arenaria* 0.1, *Quercus robur* 0.1, *Rhamnus catharticus* 0.5, *Salvia pratensis* 0.1, *Scirpoides holoschoenus* 0.1, *Seseli* sp. 1, *Silene latifolia* ssp. *alba* 0.1, *Stellaria media* 0.1, *Taraxacum officinale* 0.5, *Thymus pannonicus* 0.1, *Tragopogon* sp. 0.1, *Verbascum lychnitis* 0.1, *Viola rupestris* 0.1; C cover (%): 30; C height (cm): 25; date: 24.05.2011. Relevé was made by K. Baráth., Z. Bátori and L. Erdős. Size: 5 m × 5 m.

V: Máriagyűd (Mt Tenkes, near the blue tourist route, two specimens in 2010, three specimens in 2012) [0175.2] (A. Mészáros, ined.). It has not been known from the Villány Mts (cf. Dénes 2000).

Cephalanthera rubra (L.) RICH.

DM: Kisszállás (Jánosteleki-forest, in a sand poplar forest, about 25 specimens) [9783.2]. It has not been mentioned from the area previously (Szujkó-Lacza et al. 1993).

Clematis integrifolia L.

M: Szeged (on the dike, near the mouth of River Maros, abundant) [9787.3]. It was reported from the same locality by J. Erdős (in Soó and Máthé 1938).

Crocus reticulatus STEV.

DM: Kisszállás (Jánosteleki-forest, in the edges of black locust and poplar plantations, several hundred individuals) [9783.2]. It is not rare on the southern part of the Danube-Tisza Interfluve Area (Farkas 1999).

Dryopteris filix-mas (L.) SCHOTT

B: Bugacpusztaháza (Deszkás-dűlő, in a pine plantation) [9384.1]. It is relatively rare on the Great Hungarian Plain (Szerdahelyi 1999, Simon 2000).

Ephedra distachya L.

I: Hajós (former shooting range of the Hungarian Army, a few hundred individuals in a small patch) [9681.1]. Szalczer and Szalczer (2009) reported the species in the same CEU-quadrat, about 2 km from the cellars of Hajós away, on a small sand dune surrounded with tree plantations; that locality is not identical with the occurrence on the former shooting range. The species is rare in the region and in the whole Carpathian basin as well (Szujkó-Lacza et al. 1993, Dobay 1999). It is assumed that military activity supported the species by creating and maintaining open sand surfaces (cf. Dobay 1999). Due to the decline of the species, every new locality can be important from a nature conservation perspective (Dobay 1999).

Euphorbia maculata L.

M: Szeged (abundant in the park of the biological building of the university) [9787.3]. It is established in Szeged (Tímár 1948).

Galanthus nivalis L.

V: Csarnóta (Mt Kis, near to a deserted wine-cellar cottage, abundant) [0175.1]. It is likely that the population was planted, as it is restricted to the area around the cottage. Other localities in the Villány Mts are listed in Erdős et al. (2011).

Helleborus odorus W. et K. f. *purpureiformis* HORV.

V: Diósviszló (Cserkó-dűlő, near the forester's lodge) [0174.2], Villány (Mt Somsich) [0176.2]. Only one specimen in both locality. Horváth (1942) mentions this form only from the Mecsek Mts.

Iris spuria L.

M: Magyarcsanád (Bekai-meadow, on a hay-meadow) [9889.2]. Neither Dragulescu (1995) nor Farkas (1999) mentioned it from the lower section of River Maros, but Penksza et al. (2001) listed it among the protected plants of the area. Coenological relevé: *Allium* sp. 0.1, *Alopecurus pratensis* 5, *Capsella bursa-pastoris* 1, *Carex distans* 0.1, *Carex praecox* 25, *Cirsium arvense* 0.1, *Convolvulus arvensis* 1, *Elymus repens* 40, *Galium verum* 25, *Geranium pusillum* 0.1, *Iris spuria* 15, *Lactuca serriola* 0.5, *Lamium amplexicaule* 1, *Myosotis arvensis* 5, *Ornithogalum umbellatum* 0.1, *Poa pratensis* agg. 10, *Rumex* sp. 0.1, *Taraxacum officinale* 0.1, *Valerianella locusta* 0.1, *Veronica arvensis* 0.1, *Vicia angustifolia* 5; cover (%): 110; height (cm): 90; date: 16.05.2012. Relevé was made by Z. Bátori and L. Erdős. Size: 2 m × 2 m.

Jovibarba globifera (L.) J. PARNELL ssp. *hirta* (L.) J. PARNELL

V: Csarnóta-Harkány (Mt Nagy, in an open rock sward) [0175.1]. Lehmann (1975) mentioned the species from Mt Szársomlyó, based on the notes of Zs. L. Vöröss, but this occurrence was never confirmed later. Thus the Mecsek Mts were considered its only locality in the region (cf. Farkas 1999, Király 2009). It is possible that it was planted to Mt Nagy, as *Opuntia* individuals live in the immediate proximity.

Lamium album L.

M: Magyarcsanád (in a willow-poplar forest of River Maros near Bökény) [9889.4]. It is rare on the Great Hungarian Plain (Simon 2000), its nearest known locality is Csordajárás next to Makó (Makra 2002).

Marchantia polymorpha L. emend BURGEFF.

M: Deszk (on the Maros bank, on open soil surface) [9787.4]. Although it is wide-spread in most of the Carpathian basin (Hazslinszky 1885), it is rare on the Great Hungarian Plain, occurring mostly in artificial habitats (Soó 1964, Orbán és Vajda 1983).

Ophrys sphegodes MILL.

V: Harkány (Mt Nagy, 60 specimens) [0175.1]. From the Villány Mts, it was known from the Csukma-dűlő near Siklós (Dénes 1996, also see Kevey 2004).

Orchis morio L.

V: Csarnóta-Harkány (Mt Kis, 4 specimens) [0175.1]. Formerly, it was known from the Felső-legelő near Máriagyűd and from the Akasztófa-hill near Siklós (Dénes 1996).

Orchis tridentata SCOP.

V: Csarnóta-Harkány (in the shrubforests of Mt Nagy) [0175.1]. It was reported from the following localities in the Villány Mts previously: Mt Tenkes (Kevey 1980), Felső-legelő, Mt Fekete, Mt Szársomlyó, Akasztófa-hill, Csukma-dűlő (Dénes 1996), and Szabolcsi-dűlők near Máriagyűd (Erdős et al. 2010).

Polygonatum latifolium (JACQ.) DESF.

V: Villány (northern slope of Mt Templom, in a degraded oak-hornbeam forest) [0176.2]. It is sporadic in the Villány Mts (Erdős et al. 2011).

Prunus padus L.

V: Villány (northern slope of Mt Templom, in a degraded oak-hornbeam forest) [0176.2]. It has not been reported from the Villány Mts (cf. Horvát 1942, Lehmann 1975, Dénes 2000).

Ranunculus ficaria L.

M: Deszk [9787.3, 9787.4], Maroslele [9787.4] (N. Darányi, ined.), Szeged [9787.1, 9787.3] (along River Maros, in willow-poplar forests and hybrid poplar plantations and oak plantations). It is sporadic along the river (Soó and Máthé 1938).

Ruscus aculeatus L.

V: Csarnóta (Mt Nagy, in the black locust plantation of the northern slope) (Kovács and Erdős, ined.) [0175.1], Villány (in the Deák Ferenc street and in the park of the student hostel of the Teleki Vocational School) (Kovács and Erdős, ined.) [0176.2]. It is wide-spread in the Villány Mts, its known localities are listed in Kevey and Bartha (2010).

Salvinia natans L.

M: Szeged (near the mouth of River Maros, in the inundated area) [9787.3] (D. Tolnay and L. Erdős, ined.). It was known from this section of River Maros (Gaskó 1999), as well as from Algyő (Kováts F. in Soó and Máthé 1938) and from the

Szeged section of River Tisza (Zsák 1941).

Scilla vindobonensis SPETA

M: Magyarcsanád (in a willow-poplar forest of River Maros near Bökény) [9889.4]. It is rare east of River Tisza, its nearest known locality is the Landori-forest of Makó (Farkas 1999).

Sempervivum tectorum L.

V: Csarnóta-Harkány (Mt Nagy, in an open rock sward) [0175.1]. The only occurrence of the species in Hungary is known from Mt Szársomlyó (Farkas 1999). It is probable that it was planted to Mt Nagy, for the population is near to the planted Opuntia individuals.

Spiranthes spiralis (L.) CHEVALL

V: Harkány (Mt Nagy, only a few specimens) [0175.1]. It is rare in the Villány Mts, and has not been found west of Mt Tenkes so far (Dénes 1996, 2000, Erdős et al. 2010).

Thalictrum aquilegiifolium L.

V: Csarnóta (Mt Nagy, in the edge of the degraded forest of the northern slope, about 10 individuals) [0175.1] (D. Tolnay and L. Erdős, ined.). It was not known from Mt Nagy; its former localities are given by Erdős et al. (2011).

Trapa natans L.

M: Szeged (near the mouth of River Maros, in the inundated area) [9787.3] (D. Tolnay and L. Erdős, ined.). It was known from Algyő (Gaskó 1999).

Viola reichenbachiana JORD.

M: Szeged (near River Maros, in a willow-poplar forest) [9787.3]. It is rare on the Great Hungarian Plain (Király 2009).

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References

Bátori, Z., Bock, Cs. and Erdős L. (2010): Florisztikai adatok a Dél-Dunántúlról (Floristic data from South Transdanubia). – Kitaibelia 15, 95-100.

Bátori, Z., Kelemen, A., Aradi, E. and Zalatnai, M. (2011): A new population of *Astragalus dasyanthus* Pall. in the Southern Kiskunság (Hungary) – Tiscia 38, 19-27.

Bodrogközy, Gy. (1957): Die Vegetation der Weisspappel-Haine in dem Reservat „Emlékerdő" bei Szeged-Ásotthalom. – Acta Biol. Szeged. 3, 127-140.

Dénes, A. (1996): Adatok a Villányi-hegység flórájához (Data to the flora of the Villány Mts). – A Janus Pannonius Múz. Évk. 40, 5-8.

Dénes, A. (2000): A Villányi-hegység flóra- és vegetációkutatásának története, eredményeinek összefoglalása, különös tekintettel a védett és ritka fajok előfordulására (History of the floristic and vegetational research of the Villány Mts, its main results, with special regard to the protected and rare species). Dunántúli Dolgozatok Természettudományi Sorozat 10, 47-77.

Dobay, P. (1999): Csikófark-*Ephedra distachya* L. – Tilia 7, 7-15.

Draglescu, C. (1995): The flora and vegetation of the Mures (Maros) valley. – Tiscia Monograph Series 1, 47-111.

Erdős, L., Dénes, A., Kovács, Gy., Tóth, V. and Pál, R. (2010): Adatok a Villányi-hegység flórájának ismeretéhez (Contributions to the flora of the Villány Mts). – Bot. Közlem. 97, 97-112.

Erdős, L., Tolnay, D. and Tóth, V. (2011): Kiegészítések a Villányi-hegység flórájához (Data to the flora of the Villány Mts). – Bot. Közlem. 98, 117-128.

Farkas, S. (ed.) (1999): Magyarország védett növényei (Protected plants of Hungary). – Mezőgazda Kiadó, Budapest.

Fekete, G. (2010): Florisztika ma és holnap (Floristic research now and tomorrow). – Kitaibelia 15, 13-23.

Gaskó, B. (1999): Csongrád megye természetes és természetközeli élőhelyeinek védelméről III (On he natural and near-natural habitats of Csongrád county III). – Studia Naturalia 2, 1-282.

Hazslinszky, F. (1885): A magyar birodalom moh-flórája (Mosses of the Hungarian empire). – K. M. Természettudományi Társulat, Budapest.

Horvát, A. O. (1942): A Mecsekhegység és környékének flórája (Flora of the Mecsek Mts and its surroundings). – Ciszterci Rend, Pécs.

Horváth, F. (1997): Milyenek a flórakutatás kilátásai a Kárpát-medencében? (Perspectives of the floristic research in the Carpathain basin). – Bot. Közlem. 84, 33–40.

Kevey, B. (1980): Adatok Magyarország flórájának és vegetációjának ismeretéhez I (Data to the flora of Hungary). – Bot. Közlem. 67, 179-181.

Kevey, B. (2004): Dél-Dunántúl fokozottan védett növényei (Strictly protected plants of South Transdanubia). – Kitaibelia 9, 67-83.

Kevey, B. and Bartha, D. (2010): Szúrós csodabogyó (*Ruscus aculeatus*). – Tilia 15, 271-301.

Király, G. (2005): Mivel foglalkozzon a magyar botanikus? (What should be in the focus of a Hungarian botanist?) – Kitaibelia 10, 207-209.

Király, G. (ed.) (2009): Új magyar füvészkönyv (New herbal of Hungary). – Aggteleki Nemzeti Park Igazgatóság, Jósvafő.

Király, G. and Horváth, F. (2000): Magyarország flórájának térképezése: lehetőségek a térképezés hálórendszerének megválasztására (Flora mapping of Hungary: possible grid systems). – Kitaibelia 5, 357-368.

Lányi, B. (1915): Csongrádmegye flórájának előmunkálatai (Preliminary results on the flora of Csongrád county). – Magyar Botanikai Lapok 13, 232-274.

Lehmann, A. (1975): A nagyharsányi Szársomlyó-hegy és növényzete (Mt Szársomlyó, its lora and vegetation). – MTA Dunántúli Tud. Int. Közlem. 20, 1-185.

Lengyel, G. (1915): A királyhalmi m. kir. Külső erdészeti kísérleti állomás területe növényzetének ismertetése (Vegetation of the forestry research area of Királyhalom). – Erdészeti Kísérletek 17, 50-73.

Makra, O. (2002): A makói Csordajárás természetvédelmi szempontú botanikai értékelése. Diplomamunka (Botanic survey of the Csordajárás area near Makó. MsC theses). – SZTE Ökológiai Tanszék, Szeged.

Marosi, S. and Somogyi, S. (eds.): Magyarország kistájainak katasztere I-II (Cadaster of the small landscape units of Hungary I-II). – MTA Földrajztudományi Kutató Intézet, Budapest.

Molnár, V. A. (2005): 10 éves a Kitaibelia (Ten years of the journal Kitaibelia). – Kitaibelia 10, 204-206.

Orbán, S. and Vajda, L. (1983): Magyarország mohaflórájának kézikönyve (Handbook of the mosses of Hungary). – Akadémiai Kiadó, Budapest.

Penksza, K., Herczeg, E., Gubcsó, G., Joó, K., Barczi, A., Nemes, B. and Pintér, B. (2001): A KMNP Mágor-pusztai és Maros-ártéri területi egységeinek állapotfelvétele. Kutatási jelentés (Present state of the Mágor-puszta and Maros inundation subunits of the Körös-Maros National Park. Report). – SZIE KGI Tájökológiai Tanszék, Gödöllő.

Penksza, K. and Malatinszky, Á. (2010): Adatok a Bódva-völgy edényes flórájához (Data to the vascular flora of the Bódva valley). – Bot. Közlem. 97: 151-158.

Riezing, N. (2012): Adatok a Győr-Tatai Kisalföld flórájához és vegetációjához (Data to the flora and vegetation of the Győr-Tata Plain). – Bot. Közlem. 99, 83-104.

Simon, T. (2000): A magyarországi edényes flóra határozója (Key of the vascular plants of Hungary). – Nemzeti Tankönyvkiadó, Budapest.

Soó, R. (1964): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve I (Systematic-geobotanical manual of the Hungarian flora and vegetation). – Akadémiai Kiadó, Budapest.

Soó, R. and Máthé, I. (1938): A Tiszántúl flórája (Flora of the area east of River Tisza). – Instituti Botanici Universitatis Debreceniensis, Debrecen.

Szalczer, A. and Szalczer, B. (2009): Az *Ephedra distachya* L. új állománya Hajós mellett (New locality of *Ephedra distachya* L. in southern Hungary). – Flora Pannonica 7, 81.

Szerdahelyi, T. (1999): Pteridophyte flora research in the Kiskunság National Park in 1976-80. In: Lőkös, L. and Rajczy, M. (eds.): The flora of the Kiskunság National Park II. – Magyar Természettudományi Múzeum, Budapest, 415-424 pp.

Szujkó-Lacza, J., Kováts, D. and Tölgyesi, I. (1993): Flowering plants in the Kiskunság National Park and the other region between the Danube and Tisza Rivers: Check-list. In: Szujkó-Lacza, J. and Kováts, D. (eds.): The flora of the Kiskunság National Park I. – Magyar Természettudományi Múzeum, Budapest, 66-438 pp.

Tímár, L. (1948): A Tisza- és Marosmente új növényei (New plants of the Tisza- and Maros-region). – Borbásia 8, 58-61.

Zsák, Z. (1941): Florisztikai adatok a hazai növényvilág ismeretéhez (Floristic data to the flora of Hungary). – Bot. Közlem. 38, 12-33.