DOI:10.24394/NatSom.2011.19.41

Natura Somogyiensis	19	41-50	Kaposvár, 2011

Botanical survey of Southern Transdanubian oxbow lakes and the changes of the last 10 years

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Balázs, A. & Erdős, L.: *Botanical survey of Southern Transdanubian oxbow lakes and the changes of the last 10 years.*

Abstract: We studied six oxbow lakes along the River Drava with the Kohler-method. Oxbow lakes were chosen, in which occurences of *Nymphaea alba* were mentioned earlier. In comparison to the former studies, the quantity of *Nymphaea alba* has decreased dramatically in most oxbow lakes. Moreover, several other water-weeds have disappeared. Probably, this problem is caused by the settlement of *Ctenopharyngodon idella*, the grubbing-up of water-weeds, the pollution from the nearby cultivated fields and the fact that nature conservational aspects are not considered in the management of the lakes. The invasive weed species have mostly spread at Bresztik and Zalátai Ó-Dráva while at the other oxbow lakes, their quantity has been found generally low. Among the invasive species, *Solidago gigantea* seems to be the most dangerous.

Keywords: Bresztik, Vájási-tó, Zalátai Ó-Dráva, Mailáthpusztai-tó, Hótedra, Kovácshidai tavak, River Drava, *Nymphaea alba*, Kohler-method.

Introduction

The Drava plain was once rich in natural values. However, due to the river canalizations, the landscape suffered severe changes (Ortmann-né Ajkai 2004). By now only some small pieces of the forests, wet fields and oxbow lakes have remained. Unfortunately, after the establishment of Danube-Drava National Park, only a few areas became protected, although many areas can be found in Drava plain which are valuable from a nature conservation point of view (Dénes et al. 1998).

The Drava plain has been studied during the last few decades. Floristical data on the region are given by Klujber et al. (1963), Vöröss (1964, 1965) and Ortmann-né Ajkai and Dénes (1997). Vegetation of the oxbow lakes was studied by Klujber et al. (1963), Vöröss (1965), Kovács and Kárpáti (1973, 1974), Ortmann-né Ajkai (1997a, 1997b) and Dénes and Ortmann-né Ajkai (1999, 2006).

We made a survey of six oxbow lakes of River Drava (Bresztik, Vájási-tó, Zalátai Ó-Dráva, the northern lake of Mailáthpusztai-tó, Hótedra, Új-tó in Kovácshida) with the Kohler-method. These oxbow lakes were last examined in 1999 and in 2006. So our aim was to point out the changes during the last years and to compare our records to the former examinations. We laid special emphasis on the degree of dispersion of the pro-

ISSN 1587-1908 (Print); ISSN 2062-9990 (Online)

tected species, the water-weeds and the invasive species and on the changes of their quantity during the last years. A detailed description about the dispersion of these invasive species at the shore of these oxbow lakes has not been given so far, so we would like to fill this gap with our survey. We would like to point to the aspects which endanger the oxbow lakes: the lack of forested buffer zones, the pollution from the angling activity, the introduction of the adventive herbivorous fish species and, in the case of the Új-tó, the problem caused by the high water-level.

Material and methods

All of the oxbow lakes under study are situated on the Drava plain, in Southern Transdanubia. Mean annual temperature of the study area is 10.2-10.8 °C (AMBRÓZY and KOZMA 1990). Mean annual precipitation is 680-750 mm (AMBRÓZY and KOZMA 1990). The Drava plain belongs to the phytogeographic province Pannonicum, region Eupannonicum, district Titelicum (BORHIDI and SÁNTA 1999).

Six oxbow lakes were chosen for our study, in which occurence of *Nymphaea alba* was recorded in earlier studies. Below we give a brief characterization of the oxbow lakes under study, based on the data of DÉNES and ORTMANN-NÉ AJKAI (1999, 2006) and PECZE (2001).

Bresztik: This oxbow lake can be found on the flood-protected area, it is privately owned and its angling exploiter is the Angler Association of Sellye. Water supply originates from underground water. It is visited frequently by anglers and its vegetation along its shores is interrupted by stages. The oxbow lake is surrounded by cultivated fields from the north and by reed beds from the south.

Vájási-tó: This oxbow lake is situated on the flood-plain. Its exploiter is the Angler Association of Drávasztára. It is surrounded by cultivated and uncultivated fields, secondary dry sand steppe and a dry oak forest patch.

Zalátai Ó-Dráva: It can be found on the flood-protected area and it is owned by 342 private people. Its exploiter is the Angler Association of Zaláta and Surroundings. It has no connection with any water-supply systems, thus its water supply comes from the precipitation and the ground-water. This oxbow lake is surrounded by treelines and narrow forest stripes.

Mailáthpusztai-tó: It is located on the flood-protected area, its owner and exploiter is the Angler Association of the Worker of Ormánság. It can be filled from the ditch in Kisszentmárton and its water can be drained off to the River Drava. Along its shore, several stages have been built. The oxbow is bordered by narrow forest stripes, behind which cultivated fields can be found.

Hótedra: It is situated in the inundation area. Its owner is the Hungarian State and its exploiter is the Angler Association of Siklós and Surroundings. This oxbow lake has connection with the River Drava when the river has high water-level, but it also gets water supply from ground-water flow. A lot of stages can be found on its eastern shore. Also, angling is allowed from boats. It is surrounded almost entirely by cultivated fields.

Új-tó (part of the Kovácshida lake-system): This oxbow lake originates from a former turf-pit and it is situated on the flood-protected area. It is owned by the Beremend Cement-works Angler Association. It is bordered from all sites by settlements, a highway and cultivated fields.

Table 1: The 5-graded scale and its explanation according to KOHLER (1978).

Scale-values	Explanation
1	very rare
2	rare
3	spread
4	frequent
5	abundant

All oxbows were examined during the summer 2008 or 2009. We divided the oxbow lakes into different length sections, which was based on the variety of the habitats. The species on each sections were valued with a 5-graded scale according to KOHLER (1978) (Table 1.), and the scale-values were cubed according to MELZER (1988).

We applied RPM% (Relative Plant Mass) to the data evaluation (KOHLER and JANAUER 1995, PALL and JANAUER 1995, SZALMA 2007). RPM% is the percentage of the quantity of a plant species in the ratio of the quantity of all observed plant species. This parameter gives us information about the dominance relationships. The formula of RPM% is:

$$RPM[\%] = \frac{\sum_{i=1}^{n}\left(M_i^3 \times L_i\right) \times 100}{\sum_{j=1}^{k}\left[\sum_{i=1}^{n}\left(M_{ji}^3 \times L_i\right)\right]}$$

where *RPM* is the relative plant mass, M_i is the scale-value of a plant species on the „i"-th section, L_i is the lenght of the „i"-th section, j is a constant of a plant species.

Plant species names are used according to SIMON (2000).

Results

Evaluation of the actual state of the oxbow lakes

First, we characterize the actual state of the oxbow lakes based on the dominant species, other water-weeds, protected and adventive species. Among the dominant species, *Phragmites australis* was the most typical in each one of the six oxbow lakes. *Utricularia vulgaris* was found in the highest quantity in the Vájási-tó, *Nymphaea alba* reached a considerable mass only in Mailáthpusztai-tó, *Thelypteris palustris* and *Typha angustifolia* were dominant in Hótedra.

We found a total of seven non-protected water-weed taxa, six protected species and five adventive species (Table 2). It is worth mentioning that Mailáthpusztai-tó possesses the most protected species. Among the adventives, *Solidago gigantea* proved to be the most wide-spread.

Below we give a comparison of the different shore sections of the oxbow lakes under study. We evaluate all six oxbows, but only the results of the Zalátai Ó-Dráva are illustrated (Fig. 1), due to space limitations.

If dominant species are considered, no remarkable differences exist between the left and right shores. For example, *Nymphoides peltata* and *Phragmites australis* are dominant on both shores of Zalátai Ó-Dráva (Fig. 1).

Table 2: Occurences of non-protected water-weeds, protected species and adventive plants in the oxbow lakes under study

Plant species	Bresztik	Vájási-tó	Zalátai Ó-Dráva	Mailáth-pusztai-tó	Hótedra	Új-tó
Non-protected water-weeds						
Hydrocharis morsus-ranae	+	+	-	-	+	-
Lemna spp.	-	+	+	+	+	-
Myriophyllum spicatum	-	-	-	+	-	-
Myriophyllum verticillatum	-	-	-	+	-	-
Nuphar lutea	+	+	+	+	+	-
Ranunculus trichophyllus	+	-	-	+	-	-
Utricularia vulgaris	-	+	+	+	+	-
Protected species						
Nymphaea alba	-	+	+	+	-	-
Nymphoides peltata	+	+	+	+	-	-
Salvinia natans	+	+	+	+	+	-
Trapa natans	-	-	-	+	+	-
Thelypteris palustris	-	-	-	-	+	-
Urtica kioviensis	-	-	+	+	-	-
Adventive and invasive species						
Ambrosia artemisiifolia	+	-	-	-	-	-
Amorpha fruticosa	+	-	+	+	-	+
Echinocystis lobata	+	+	+	-	-	-
Parthenocissus quinquefolia	-	-	+	-	-	-
Solidago gigantea	+	+	+	+	+	+

We found characteristic differences between certain sections of the shores in the case of some protected or valuable species. For instance, *Urtica kioviensis* can be found mainly in the northern part of Mailáthpusztai-tó. *Nymphaea alba* is also especially frequent in the northern part of the oxbow lake although it is present along the eastern (left) shore, too. *Thelypteris palustris* is abundant in the right part of Hótedra. *Cladium mar-*

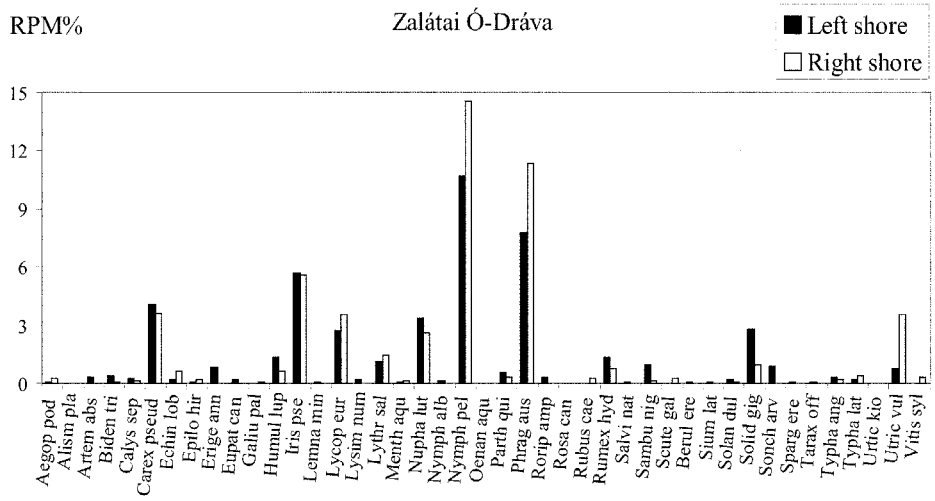

Fig. 1: The RPM% diagram of the left and right shores of Zalátai Ó-Dráva

iscus, occuring only in Új-tó, reaches a high quantity on some sections in the middle of the left shore.

Moreover, we found considerable differences between the individual sections in the case of disturbance-tolerants and invasive species. Invasive species and other plants indicating degradation can be found mainly on the left shore in the case of Bresztik, Vájási-tó and Zalátai Ó-Dráva. For example, *Solidago gigantea* is much more abundant on the left shore of Zalátai Ó-Dráva (Fig. 1). The explanation of this phenomenon is that the roads and cultivated fields are very close to the left shores of the oxbow lakes mentioned above, and a protective forest buffer zone is lacking. In contrast, the Új-tó is surrounded by a stripe of *Phragmites australis*, supporting a protective belt from every direction. Thus we found no considerable differences between the two shores regarding the weed and invasive species. In the case of Mailáthpusztai-tó, a narrow protective forest buffer zone lies along the left shore while on the right shore there is a much wider forestzone. As this oxbow lake contains hardly any weed and invasive species, the narrow forestzone seems to be enough to prevent the penetration of these species. Despite the fact that there is only a narrow buffer zone around Hótedra, we found hardly any weed and invasive species in this lake. A lot of other species can be found mainly on the right shore.

Changes of the last 10 years

We compared our data with the results of DÉNES and ORTMANN-NÉ AJKAI (1999) and CZIROK et al. (2000, 2002, 2003, 2004) to reveal possible changes. The results are as follows:

Bresztik: This oxbow lake had rich water-weed vegetation 10 years ago. Unfortunately, the vegetation has suffered a considerable impoverishment: we could find only 5 water-weed species in 2009. The stands of *Typha latifolia* and *Thelypteris palustris* have disappeared from the southern shore and the quantity of *Nuphar lutea* has decreased much due to the dredging in 2002. On the other hand, *Nuphar lutea* has recovered fastly since it was already very frequent when our study was carried out (Table 3). *Nymphoides peltata* turned up in this oxbow lake in 2004 and it became dominant by 2009. *Nymphaea alba* was not present in this oxbow lake between 2002 and 2004 and we did not find it in 2009, either (Table 3). The decrease of the quantity of *Nymphaea alba* is due to the dredgings and *Ctenopharyngodon idella*, this herbivorous fish species. During our survey, *Solidago gigantea* proved to be the most dangerous invasive species and it was wide-spread along both shores of Bresztik (Table 3).

Vájási-tó: Fortunately, the number of water-weed species has not decreased during the years analysed. *Nuphar lutea* has already been dominant since 1999. The quantity of *Nymphoides peltata* was fluctuating and it was frequent in 2003 and 2009. The number of water-weed species is low, but these few species reach high RPM% values. *Utricularia vulgaris* was frequent on the right shore in 2004 and it was wide-spread in the whole oxbow lake by 2009. However, *Nymphaea alba* could be found only in a few sections and in low quantity. The reason of this could be the dominance of *Nuphar lutea* in this oxbow lake (cf. BORHIDI and SÁNTA 1999) and the introduction of *Ctenopharyngodon idella*. Also, this fish may be responsible for the disappearance of other water-weed species. The invasive species reached only low RPM%.

Zalátai Ó-Dráva: Unfortunately, we found that both species number and abundance of most water-weed species have decreased, for example we could not find *Ceratophyllum demersum, Utricularia minor, Trapa natans, Myriophyllum spicatum, Ranunculus circinatus* and *Potamogeton crispus*, all of which were present previously. *Nymphaea alba* was present only in low numbers in the south-eastern part of the oxbow lake, which is

Table 3: The changes in the vegetation of Bresztik between 1999 and 2009
+: the species or association is present in the oxbow lake, -: not present, +: abundant, n.a.: data not available

Plant species and associations	1999	2000	2002	2003	2004	2009
Ceratophyllum demersum	+	+	n.a.	n.a.	n.a.	-
Hydrocharis morsus-ranae	+	+	n.a.	n.a.	n.a.	+
Lemna minor	+	+	+	n.a.	+	-
Myriophyllum spicatum	-	+	-	-	-	-
Nuphar lutea	+	+	D+	D+	D+	+
Nymphaea alba	-	+	-	-	-	-
Nymphoides peltata	-	-	-	-	+	+
Ranunculus trichophyllus	n.a.	n.a.	n.a.	n.a.	n.a.	+
Salvinia natans	+	+	+	n.a.	+	+
Spirodela polyrrhiza	+	+	n.a.	n.a.	n.a.	-
Utricularia vulgaris	+	+	n.a.	n.a.	n.a.	-
Phragmitetum communis	É+, D+	É+, D+	É+, D+	É-,D-	É-,D-	D+
Thelypteris palustris	D+	D+	D+	n.a.	D+	-
Typhetum latifoliae	D+	D+	D+	D-	D-	-
Salicetum cinereae	É+, D+	É+, D+	É+, D+	É-,D+	É-	D+
Ambrosia artemisiifolia	n.a.	n.a.	n.a.	n.a.	n.a.	+
Amorpha fruticosa	n.a.	n.a.	n.a.	n.a.	n.a.	É+
Echinocystis lobata	n.a.	n.a.	n.a.	n.a.	n.a.	ÉNy+
Solidago gigantea	n.a.	n.a.	n.a.	n.a.	n.a.	+

relatively undisturbed. *Nymphoides peltata* was dominant in the northern part of the oxbow lake in 2000. Since 2000, it has spread in the whole oxbow lake. The disappearance of the water weed species is not due to the *Ctenopharyngodon idella* according to a local angler, because this fish species has not been introduced to this oxbow lake for years. He said that chemicals had been applied for the eradication of the water-weeds. We found a few individuals of *Urtica kioviensis* in a section.

The invasive *Amorpha fruticosa* was present in low quantity in the south-western and eastern part of the oxbow lake. These sections are near to the cart-road and contain a lot of stages. *Solidago gigantea* was considerable only on the eastern shore.

Mailáthpusztai-tó: This oxbow lake has the most water-weed species among the six oxbox lakes, although most of them have only low RPM%. *Nymphoides peltata* has been dominant since 1999. We could find only 1-2 individuals of *Nuphar lutea. Nymphaea alba* has been present in the most quantity in the northern part of the oxbow lake since 2002 but it can be found along the eastern part of the oxbow lake, too. It was reported in 2004 (CZIROK et al. 2004) that *Nymphaea alba* was only present in a few quantity in the northern part. However, it was quite abundant in 2009, with scale-values reaching 3-5. *Urtica kioviensis* has an RPM% value of about 2%. Moreover, it could be found also in the northern part of the oxbow lake in a few sections in low quantities. Also, some other valuable water-weed species were found in Mailáthpusztai-tó, for example *Trapa natans, Nuphar lutea, Ranunculus trichophyllus, Myriophyllum spicatum* and *M. verticillatum*.

There were hardly any invasive species on the shores, we found only a few individuals of *Amorpha fruticosa* and *Solidago gigantea*. This oxbow lake is the most appreciative one from a nature conservation perspective as the quantity of the invasive species is very low and the quantity and the number of the protected species are comparatively high.

Hótedra: The number of the water-weed species and individuals has changed negatively. *Ctenopharyngodon idella* may be responsible for this tendency. *Nymphaea alba* could be found in great numbers in this oxbow lake earlier but we could not find it in

2008. *Ceratophyllum demersum* was dominant in 2002, whereas it has disappeared by 2008. *Lemna trisulca* and *Spirodela polyrrhiza* have also disappeared. *Lemna minor, Hidrocharis morsus-ranae, Salvinia natans, Utricularia vulgaris* and *Trapa natans* became extremely rare. *Nuphar lutea* is the only water-weed species which was frequent both earlier and in 2008. Fortunately, *Typha angustifolia* and the protected species *Thelypteris palustris* were frequent on the eastern shore.

We found only some individuals of *Solidago gigantea* in this oxbow lake.

Új-tó: The greatest changes have happened at this oxbow lake. We could not find any water-weed species during our studies. 10 years ago, *Nymphaea alba* was frequent and also *Trapa natans* was found here (DÉNES and ORTMANN-NÉ AJKAI 1999). *Phragmites australis* was the only dominant species in 2009, surrounding the shores with a dense stripe, the other species reached only low RPM%. *Cladium mariscus* was found in this oxbow lake in more sections.

Due to the dense reed-bed around the lake, invasive and weed species (e. g. *Solidago gigantea* and *Amorpha fruticosa*) were found only in small numbers in Új-tó.

Conclusions

We found 6 protected species in the six oxbow lakes. *Nymphaea alba* was found in all oxbow lakes earlier but now it is present only in three oxbow lakes, reaching a greater abundance only in one of them. On the other hand, the quantity of *Nymphoides peltata* has risen or remained stable in four oxbow lakes. *Urtica kioviensis* was found only in two oxbow lakes in small numbers.

From a nature conservation point of view, Mailáthpusztai-tó proved to be the most valuable, since number of protected species was found to be high whereas number of invasive and weed species is low. *Trapa natans, Nuphar lutea, Ranunculus trichophyllus, Myriophyllum spicatum* and *M. verticillatum* have not been reported from this oxbow lake previously (cf. DÉNES and ORTMANN-NÉ AJKAI 1999, CZIROK et al. 2000, 2002, 2003, 2004). At the other end of the scale, Új-tó can be found, where no protected species occur, neither are there any water-weed species. Although the number of invasive species is very low at this oxbow lake, Új-tó is undoubtedly in the worst condition of the six oxbow lakes studied.

Compared to the earlier years, not only the quantity of protected species has changed but also the quantity of the water-weeds has decreased and many plants have disappeared. This is caused by the settlement of the adventive herbivorous fish species *Ctenopharyngodon idella* and the chemicals used for the eradication of the water-weeds. In addition, in the case of Új-tó, the water-level may not be appropriate, since several water-weeds can not tolerate deep waters (on some parts, Új-tó is as deep as 4 m) (cf. BORHIDI and SÁNTA 1999). The grass carp (*Ctenopharyngodon idella*) does not make great demands upon its habitat, it tolerates the low solute O_2 concentration well, it tolerates both shallow and deep waters with bushy water-weeds or without them, so grass carp could find appropriate habitats in these oxbow lakes. It feeds most intensively during the hot summer months, when it is already two years old. The quantity of the grass carp is decreasing, because of the law no. LIII. of 1996 on nature conservation, which banned the settlement of all adventive fish species in the natural waters (FÜSTÖS 2003).

In the case of three oxbow lakes, the indicator species of degradation spread because protection zone was either lacking or too narrow. In contrast, where there was a wider forest or reed protection buffer zone along the shores, degradation-tolerating species

were rare or completely absent. DÉNES and ORTMANN-NÉ AJKAI (1999) also emphasized the importance of protective buffer zones. Unfortunately, nothing has been done about this problem for 10 years. These oxbow lakes are privately owned and they are utilized as angling lakes, so it is hard to take the necessary conservation measures.

ORTMANN-NÉ AJKAI and DÉNES (1999) emphasized the threat presented by the invasive species and they also listed the invasive plants of the Drava plain. However, detailed data about the occurences and quantity of invasive species around the oxbow lakes have not been published so far. We detected five invasive species in the six oxbow lakes examined. *Solidago gigantea* seemed to be the most wide-spread. Most invasive species were found at Bresztik and Zalátai Ó-Dráva (Table 2).

At present, of the six oxbows, only Vájási-tó belongs to the area of the Danube-Drava National Park. All of them, except for Új-tó, are Natura 2000 areas (Wágner László, ex litt.). However, nature conservation does not have any influence on the utilization. Therefore, it is very difficult to check the building of the stages, the introduction of fish species, the dredging and to keep the water quality (DÉNES and ORTMANN-NÉ AJKAI 2006). Since some of the oxbows support considerable conservation values, we suggest that the Danube-Drava National Park should manage these oxbow lakes, or at least it should check the management regularly.

Acknowledgement

The authors are indebted to Attila Czirok, Adrienne Ortmann-né Ajkai, Elemér Szalma and Eszter Falusi for their help in collecting the cited articles.

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