The macrophyte-floodplain habitat relationship: indicator species, diversity and dominance

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1 Introduction

Floodplain water bodies are essential, yet vulnerable and endangered habitats along European rivers. Little work focused on their macrophyte composition in relationship with the typology of floodplain waters, and especially not on those located in the riparian corridor of large rivers (Amoros & Bornette 2002, Bornette et al. 1998, Dos Santos & Thomasz 2004). The connectivity of floodplain habitats with the main river channel were described by Amoros & Roux (1988), and Ward & Stanford (1995). Relationships between several elements of aquatic fauna and floodplain habitats were reported for the Danube River corridor by Chovanec et al. (2005), who also developed a 'Floodplain Index'. Since aquatic macrophytes were not considered so far with respect to this index a preliminary study was carried out in the Eastern Reach of the Austrian Danube.

2 Methods

Macrophyte occurrence and abundance were assessed following the European Standard 14184 and the procedure published by Kohler & Janauer (1995), which was also applied during the Joint Danube Surveys 1 and 2, carried out in 2001 and 2007, respectively, by the International Commission for the Protection of the Danube River (Janauer et al. 2008). Macrophyte data used in our approach on macrophyte – Floodplain Index relationships were provided by Reckendorfer, whose data base was stocked by different contributors (Janauer 2003, Kum et al. 2003, Pall & Kum 2004, Schiemer & Reckendorfer 2004).

We distinguished five Habitat Types (HT) based on the connectivity with the main channel (C^d, for details see Reckendorfer et al. 2006) and water depth (derived from the Digital Terrain Model). The order of HTs parallels the description of habitats as classified by Ward & Stanford (1995) and by Chovanec et al. (2005), but relates directly to physical environmental components. The macrophyte data set was related directly to the HTs.

Our data set consisted of 601 individual survey units, recorded in 10 different water body ensembles in the Lobau area, a UNESCO Biosphere Reserve, and in the floodplains on the left and right side of the Danube River between Vienna and Hainburg, which are located mainly within the boundaries of the Danube National Park.

We used Indicator Species Analysis (Dufrêne & Legendre 1997) and Monte Carlo simulation test for determining the significance (McCune & Grace 2002), as well as Simpson's Index of Diversity and Berger-Parker index of dominance, for the statistical treatment of data (Magurran 2004). Multi Response Permutation Procedure (MRPP, Bray-Curtis distance measure) was used to test for differences between Habitat Types (McCune & Mefford, 2006).

The extensive table of Indicator Species Analysis is part of the data collected for the "Danube River Water Engineering project East of Vienna" (held, in part, by the Department of Limnology, University of Vienna), and is too large for including it in this publication (3 full pages in print, 8pt font size). Authors may be personally contacted in case of interest in some details.

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3 Results

A total of 119 macrophyte species had occurred in the 601 survey units. 49 species were observed in only a single Habitat Type (HT), whereas 31, 19, and 19 were recorded in two, three and four HTs, respectively. The only species found in all five HTs was *Stuckenia pectinata* (Kaplan 2008; syn. *Potamogeton pectinatus* L.), but in a wide range of abundance.

Our statistical analysis of Indicator Species revealed very low total species numbers, as well as low Indicator Species numbers for the most dynamic HTs, the main river channel of the Danube (HT-1) and side channels with through-flow of 120 to 330 days (HT-2, Fig.1). An increase in species number occurred with the reduction of disturbance by water flow in the other HTs.

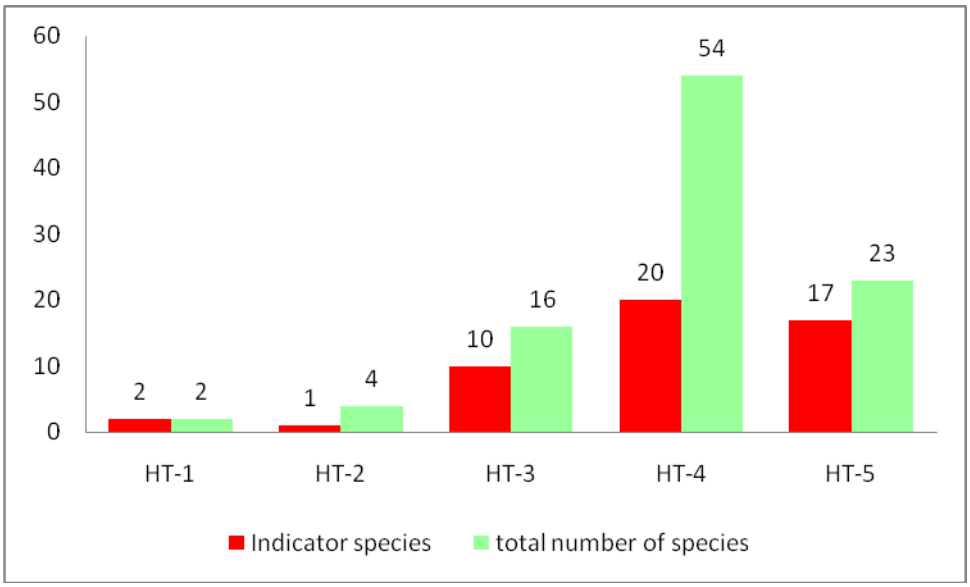

Figure 1. *Number of Indicator Species and total number of aquatic species recorded in the Floodplain Habitat Types. HT-1: Connectivity/C^d > 330 days; HT-2: C^d < 330 days; HT-3: C^d < 120days; HT-4: C^d < 5 days; HT-5: temporary waters.*

Table 1. *Multi-Response Permutation Procedure (MRPP) between Habitat Types: T-statistic describes the size of separation between Habitat Types: the more negative the T-statistic, the better the separation. The A-statistic describes how similar the survey units are. The multiple comparisons confirm the extremely high significance of all differences.*

Habitat Types	T	A	p
1 vs. 2	-27.86231926	0.16333319	<0.00000001
1 vs. 3	-46.21084743	0.06826439	<0.00000001
1 vs. 4	-59.51816262	0.03891881	<0.00000001
1 vs. 5	-22.00489047	0.21476034	<0.00000001
2 vs. 3	-24.78012187	0.03188525	<0.00000001
2 vs. 4	-95.36727018	0.0555638	<0.00000001
2 vs. 5	-28.38973469	0.11817932	<0.00000001
3 vs. 4	-155.717993	0.06912194	<0.00000001
3 vs. 5	-39.04108063	0.05088505	<0.00000001
4 vs. 5	-10.03077893	0.0063358	0.00000105

All HTs were significantly different to each other (much beyond p = 0.05), as based on species composition and abundance of species (Tab.1).

When studying the diversity of aquatic plants in the HTs we found an increase along a gradient of diminishing hydrological disturbance, from the main river channel into the floodplain, but the most distant floodplain water bodies, representing HT-5, revealed a slightly lesser diversity than HT-4, which is characterised by a higher connectivity with the main channel of the Danube River (Fig.2).

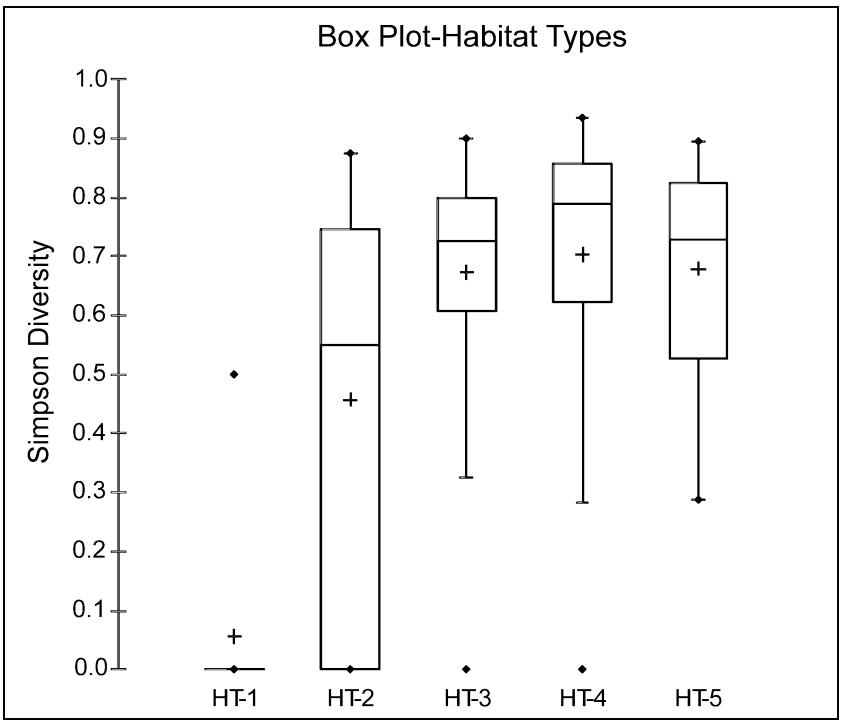

Figure 2. *Simpson Diversity values in the five Habitat Types.*

4 Discussion

In the water bodies of the Danube floodplain the overall species number (119) is at a high level, even when compared with other sections of the river. In the section of the main channel forming the basis for the present study only two species of bryophytes were detected, which is much lower than e.g. near Deutsch-Altenburg (river-km 1884.3 – 1885.4; unpublished data. 20 bryophytes were recorded). Yet, the restriction of mosses to the main river channel, and to their preferred substrate, the rip-rap along the river banks and the groynes, is a well known fact (Janauer et al. 2008), but records of vascular plants also exist from the main channel. Therefore the next step in characterising HT-1 in the main channel needs a survey of a larger number of lotic locations (HT-1was represented by only 17 units). 41% of the species recorded inhabited a single HT only, but the rest was distributed over more than one HT. This indicates the wider ecological adaptation exhibited by many aquatic macrophytes. Future studies will allocate habitat ranges for each species in this part of the Danube River floodplain corridor.

Regarding the characterisation of HTs by their macrophyte species composition and abundance it was possible to delineate Indicator Species (IS) for each of the five HTs. With decreasing impact of running water conditions both IS and total species numbers increased, except for the most remote HT, which represents the largest distances to the main channel and the lowest impact of water flow (see also: White & Jentsch 2001). The most preferred HT is located where no direct continuous water flow exists and, especially in our case, macrophytes seem to benefit from groundwater influx originating from the adjacent landscape behind the flood protection dam, whenever the river water level is low (Rezabek et al. 2003). Our study confirmed that the macrophyte vegetation can be used as an indicator that separates all the HTs from each other (Tab.1). Our study also revealed HT-4 as the macrophyte

habitat with the highest species diversity (Fig. 2). But even more interesting are the ranges listed for the five HTs in the box-plots. The survey units allocated to HT-2, the HT of side channels, exhibit the widest range of diversity. The second largest range was detected for HT-5, which is dominated by still water conditions during most of the year. A promising investigation will be a deeper look into the assemblage of not only species, but also growth form types, which structure the macrophyte vegetation.

The role of aquatic plants in the river floodplain still holds some questions and shall be investigated with a larger set of locations. The authors hope to widen this knowledge in the near future and to surpass the still premature character of our present study.

5 Conclusion

With respect to the EC Water Framework Directive (WFD) authors provided some progress in filling the gap which is still present as regards the deeper knowledge of macrophyte composition in floodplain waters. We also gave numerical proof to the common knowledge that there is a rather great diversity in floodplain water vegetation, determined by connectivity with the main river channel. This study also provides a basis for further work on "what could the reference status be" for the biological quality element macrophytes in floodplains. Yet, as recent discussions in our interdisciplinary, abiotic/biotic group working on this Danube reach have shown, two major difficulties still need solutions: (i) as hydrologists and eco-hydraulic experts pointed out, the present status of "semi-separated oxbows" is not comparable with that of the original, active side channels, and (ii) full implementation of river restoration according to WFD would crash with the prime objective of the EC "Habitat Directive", Natura 2000 areas and IUCN National Park regulations, as the present water bodies are typical results of the river regulation: in the pre-regulation floodplain similar macrophyte-rich oxbow types were located at much larger distance from the main channel, were less persistent in historical dimensions, and today their old locations are fully extinct due to flood protection levees, and agricultural development in the areas beyond. Reaching "good ecological status" may have to lead to a compromise between two competitive EC regulations - as the quest for primate of restoration over conservation will exterminate these last refuges of abundant floodplain macrophyte vegetation.

References

Amoros, A., Bornette, G. (2002): Connectivity and biocomplexity in waterbodies of riverine floodplains, Freshwater Biology 47: 761–776.

Amoros, A., Roux, A.L. (1988): Interaction between water bodies within the floodplains of large rivers: function and development of connectivity. Münstersche Geographische Arbeiten 29: 125-130.

Bornette, G., Amoros, C., Lamoroux, N. (1998): Aquatic plant diversity in riverine wetlands: the role of connectivity. Freshwater Biology 39:267-283.

Chovanec, A., Waringer, J., Straif, M., Graf, W. Reckendorfer, W., Waringer-Löschenkohl, A., Waidbacher, H., Schultz, H. (2005): The floodplain index – a new approach for assessing the ecological stats of river/floodplain systems according to the EU Water framework Directive. Archiv für Hydrobiologie 155: 169-185.

Dos Santos, A.M., Thomaz, S.M. (2004): The role of connectivity in structuring aquatic macrophyte assemblages. In: Agonstinho, A.A., Rodrigues, L., Gomes, L.C., Thomaz, S.M., Miranda, L.E. (Eds.) Structure and functioning of the Parana River and its floodplain – LTER-Site 6: 226-232.

Dufrêne, M., Legendre, P. (1997): Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 67: 345-366.

Janauer, G.A. (2003): Makrophyten der Augewässer. In: Janauer, G.A., Hary, N. (Eds.) Ökotone – Donau – March. Veröffentlichungen des Österreichischen MAB-Programms, Österreichische Akademie der Wissenschaften. Universitätsverlag Wagner, Innsbruck. pp.156-200.

Janauer, G.A., Schmidt, B., Greiter, A. (2008): Macrophytes. In: Liska, I., Wagner, F., Slobodnik, J. (Eds.). Joint Danube Survey 2 – Final Scientific Report. International Commission for the Protection of the Danube River, Vienna (Austria). 63-67.

Kaplan, Z. (2008). A taxonomic revision of *Stuckenia* (Potamogetonaceae) in Asia, with notes on the diversity and variation of the genus on a worldwide scale. Folia Geobotanica 43: 159-234.

Kohler, A., Janauer, G. A. (1995): Zur Methodik der Untersuchung von aquatischen Makrophyten in Fließgewässern. – In: Steinberg, Ch., Bernhardt, H., Klapper, H. (Eds), Handbuch Angewandte Limnologie. Ecomed, Landsberg/Lech. pp.3–22.

Kum, G., Gätz, N., Schiemer, F., Reckendorfer, W. (2003): Das Donau-Restaurierungsprojekt. Gewässervernetzung Regelsbrunn. Zoologisch-Botanische Gesellschaft Österreich. Abhandlungen 33: 63-76.

Magurran, A. E. (2004): Measuring biological diversity. Blackwell Publishing, Oxford. 256pp.

McCune, B., Grace, J. B. (2002): Analysis of ecological communities. MjM Software Design, Gleneden Beach, OR, U.S.A.

McCune, B., Mefford, M. J. (2006): PC-ORD. Multivariate Analysis of Ecological Data, Version 5.18. MjM Software, Gleneden Beach, Oregon, U.S.A.

Pall, K., Kum, G. (2004): Makrophytenvegetation in den Gewässern der Unteren Lobau zwischen Kreuzgrundtraverse und Mündung des Mannsdorfer Hagels. In: Nationalpark Donau-Auen GmbH (Ed.) Gewässervernetzung und Lebensraummanagement Donauauen. 62pp.

Reckendorfer W., Baranyi C., Funk A., F. Schiemer (2006): Floodplain restoration by reinforcing hydrological connectivity: expected effects on aquatic mollusc communities. Journal of Applied Ecology 43: 474-484.

Rezabek, H.R., Hladej, M., Halbritter, T., Stritzinger, W., Stepan, C. (2003): Hydrologicsche Rahmenbedingungen für Ökotone in Donauauen. In: Janauer, G.A., Hary, N. (Eds.) Ökotone Donau – March. Veröffentlichungen des österreichischen MaB-Programms 19: 309-319..

Schiemer, F., Reckendorfer, W. (2004): Das Donau-Restaurierungsprojekt. Ökologische Auswirkungen. Zool. Bot. Ges. Österreich. Abhandlungen. 185pp.

Ward, J.V. Stanford, J.A. (1995): Biodiversity of floodplain river ecosystems : ecotones and connectivity. Regulated Rivers: Research and Management 15: 125-139.

White, P.S., Jentsch, A. (2001): The search for generality in studies of disturbance and ecosystem dynamics. Progress in Botany 62: 399-450.