Macrophyte Habitat Preference, River Restoration, and the WFD: making use of the MIDCC data base.

Georg A. Janauer[1], Peter Filzmoser[2], Helena Otahelova[3], Alenka Gaberscik[4], Jasenka Topic[5], Arpad Berczik[6], Ruzica Igic[7], Vladimir Vulchev[8], Anca Sarbu[9], Alexander Kohler[10] and Norbert Exler[1]

Key words: aquatic plants, Danube River, Water Framework Directive, reference conditions

Introduction

In the Multifunctional Integrated Study Danube: Corridor and Catchment (MIDCC) important physical parameters were recorded in macrophyte habitats, in addition to the species composition of the aquatic vegetation, which reflect the abiotic conditions under which different macrophytes will grow. This information is of basic importance when planning e.g. the re-opening of oxbows as appropriate measure to rehabilitate hydrological dynamics or to reconstruct former river courses as integral parts of flood management. Prediction is then needed on how species will cope with changed flow, sediment, connectivity, and/or nutrient conditions. The same information supports expert judgement when re-constructing macrophyte reference conditions *sensu* WFD (2000). As the Danube River Corridor crosses different geo-morphological regions (ICPDR 2002, MOOG et al. 2006) the question arises, if aquatic macrophyte species have the same habitat preference throughout the whole length of the river, or not. If not, this knowledge has implications on macrophyte re-colonisation following river restoration and for expertises on reference conditions – which in turn relate to the good and moderate ecological status (WFD).

Methods

The assessment of habitat parameters was based on the visual recognition of respective features, which are shown in the figures. For a detailed description of the classification of each habitat parameter consult http://www.midcc.at. For the present publication data sets were selected for the parameters 'Flow Class' and 'Substrate Type', and for the main river channel (Eupotamon A) and large side-channels (Eupotamon B) of the Danube. The aquatic species to which we refer here are *Ceratophyllum demersum* L., loosely anchored to the substrate and the most frequent species in the Danube River Corridor, submerged *Potamogeton pectinatus* L., and *Butomus umbellatus* L., a species with predominantly amphibious character along the

[1]Department für Limnologie und Hydrobotanik, University of Vienna, Althanstrasse 14, A – 1090, Austria

[2]Institut für Statistik und Wahrscheinlichkeitstheorie, Technical University of Vienna, Wiedner Hauptstrasse 8/107, A – 1040, Austria

[3]Institute of Botany, Slovak Academy of Sciences, Dúbravská cesta 14, SK – 845 23, Bratislava, Slovakia

[4]Department of Biology, University of Ljubljana, Vecna pot 111, SI – 61000, Ljubljana, Slovenia

[5]Department of Biology, Institute of Botany, Marulicev trg 20/2, HR – 10000 Zagreb, Croatia

[6]Institute of Ecology and Botany, Hungarian Academy of Sciences, Javorka S. u. 14, H – 2131, Göd, Hungary

[7]Institute of Biology and Ecology, University of Novi Sad, Trg Dositeja Obradovica 2, SCG – 21000, Novi Sad, Serbia

[8]Institute of Botany, Bulgarian Academy of Sciences, 23 Acad. G. Bonchev Str.,BG – 1113, Sofia, Bulgaria

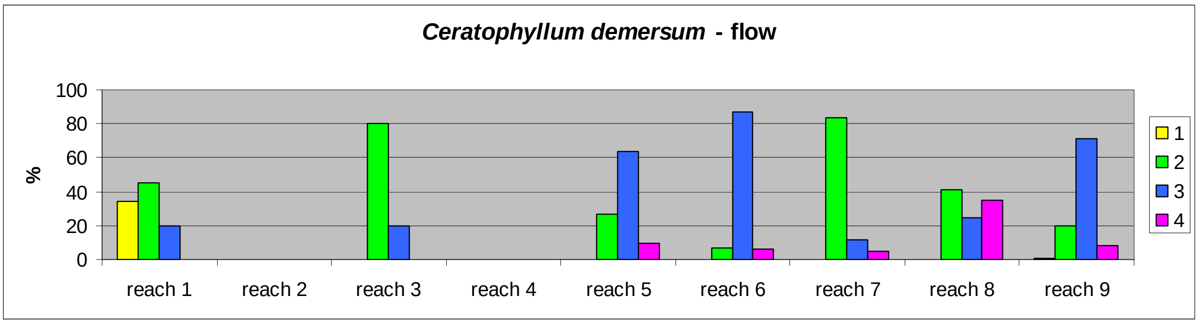
[9]Department of Botany, University of Bucharest, RO – 77206, Bucharest, Romania

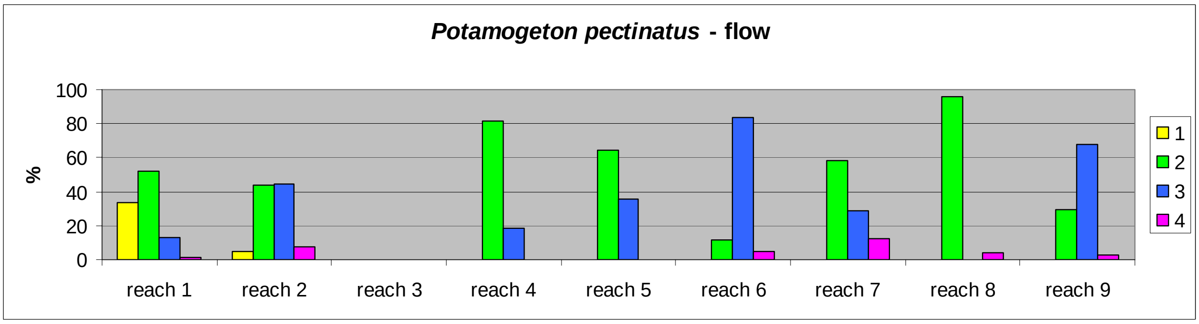
[10]Institut für Landschafts- und Pflanzenökologie, University of Hohenheim, D – 70599, Stuttgart, Germany

Danube (occurring as helophyte in most tributaries). Terminology of geo-morphological regions along the Danube River follows the classification of the First Joint Danube Survey (ICPDR 2002), but with consideration to the concept by MOOG et al (2006), see Table 1.

Table 1: Danube Reaches based on geo-morphology and anthropogenic impact (following ICPDR 2002) Related sections according to Moog et al (2006) in brackets, e.g. [M2]. River-km = rkm

Reach Nr.	Location	River km
1	Neu Ulm – Confluence with River Inn [M2]	2581 – 2225
2	River Inn – Morava River [M3 to rkm 2001 & part of M4]	2225 - 1880
3	Morava River – Gabcikovo Dam [M4]	1880 – 1816
4	Gabcikovo Dam – Budapest, end of side arm [M4 to rkm 1790 & M5]	1816 – 1659
5	Budapest – Confluence with Sava River [M5 to rkm 1497 & part of M6]	1659 – 1202
6	Sava River / Belgrade – Iron Gate Dam [M6 to rkm 1071 & M7]	1202 – 943
7	Iron Gate Dam – Confluence with Jantra River [M7 to rkm 931 & part of M8]	943 – 537
8	Jantra River – Reni [M8 to rkm 378 & M9]	537 – 132
9	Reni – Black Sea /Danube Delta (and 3 main channels) [M9 to rkm 100 & M10]	132 – 12





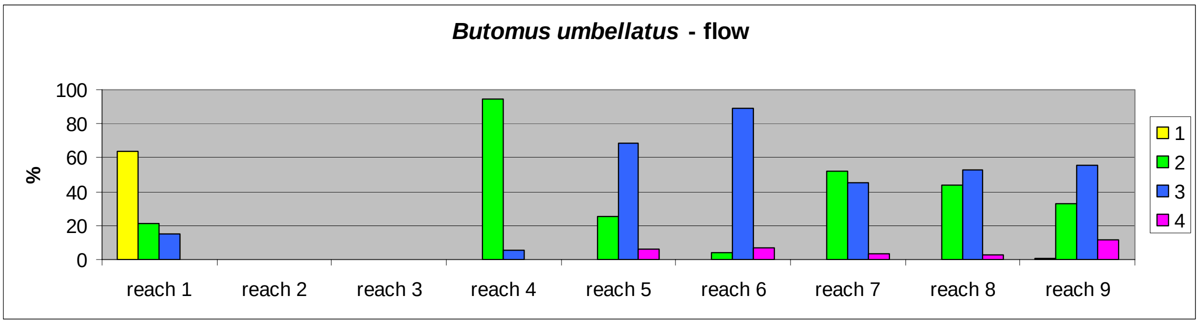


Figure 1: Percentage of river length in which macrophyte species were found to grow in one of the four flow classes: 1 = stagnant, no flow; 2 = 5 – 30 cm.s^{-1}: 3 = 35 – 65 cm.s^{-1}; 4 = > 70 cm.s^{-1}. Possible misclassification of

flow class had no impact on results as flow velocity estimates corresponded with measured data (flow meter: µP-Hoentzsch, Germany) in over 90% of the cases.

Results

Habitat preference regarding water flow velocity is shown in Figure 1; preference for substrate type is shown in Figure 2, for three frequent aquatic plant species.

With respect to water flow velocity next to the plant stands all three species occur mainly in still or slowly running conditions in the Upper Reach of the Danube (reach 1 & 2), whereas in the Middle and Lower Reach (reach 3 to 9) they alternate between slow flow and intermediately fast flow. In the Gabcikovo power plant reservoir *C. demersum* prefers 'low flow' (flow class 2), but in the Iron Gate reservoir it occurs under faster flow conditions (flow class 3), like the other two species.

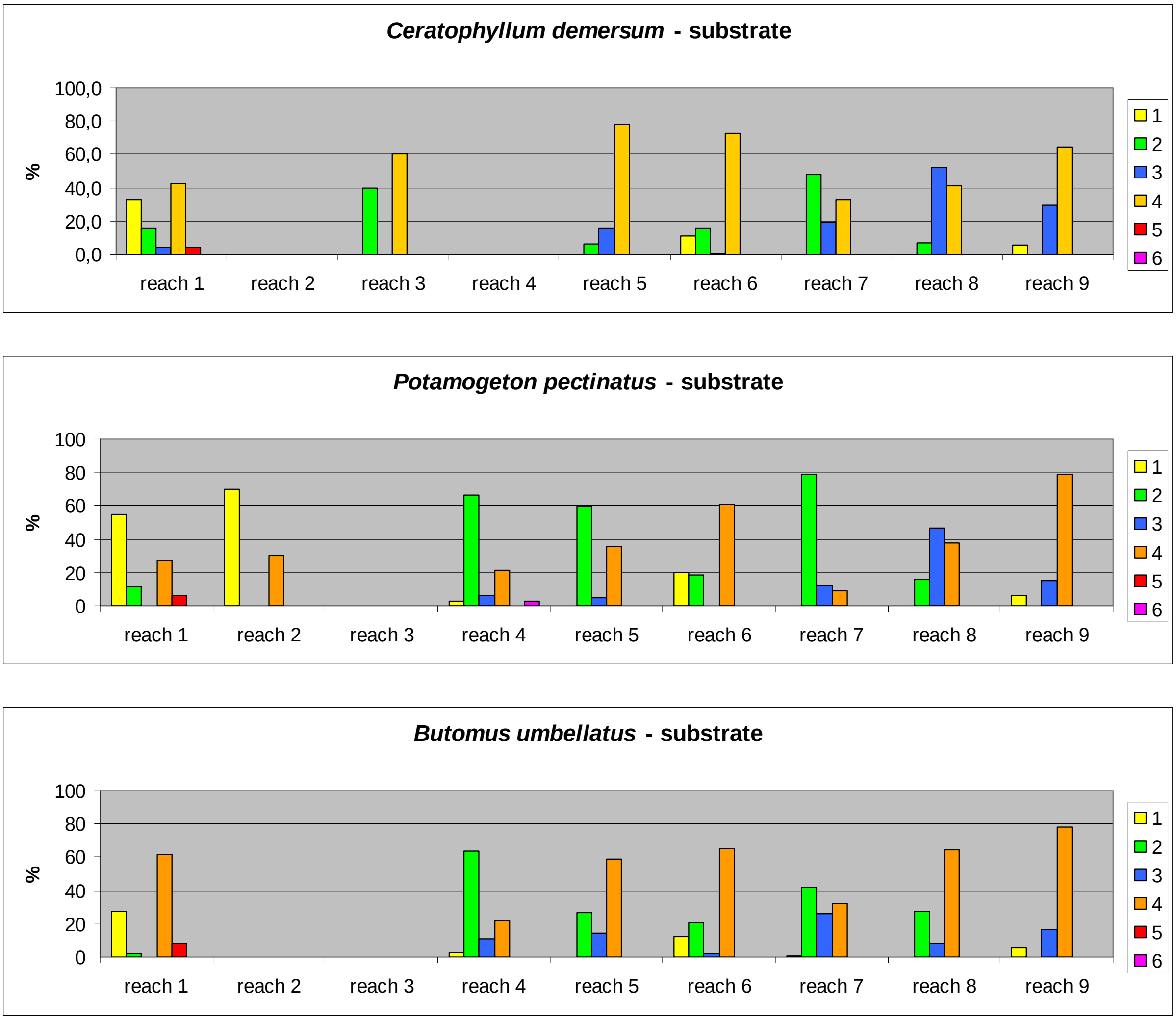


Figure 2: Percentage of river length in which macrophyte species were found to grow atop one of the six substrate types: 1 = rip-rap/rock; 2 = gravel: 3 = sand; 4 = fine, mainly inorganic; 5 = artificial (e.g. concrete, asphalt); 6 = organic.

Substrate preference shows that all three species find attachment (*C. demsersum*), or true rooting conditions (*P. pectinatus*, *B. umbellatus*), in the rip-rap that protects the river banks in the Upper Reach of the river, as well as in parts of the Danube Delta. This is especially indicated by the dominance of that substrate type for P. pectinatus between the confluence of the Inn River, and the Morava River, respectively, as in this section (reach 2) the river regulation in the late 19th century and the existing ten power plants have lead to river shores almost entirely lined with rip-rap. In short river stretches in Germany, Austria and in the Iron Gate reservoir (reach 6) rock faces are also included in the same substrate category.

Discussion

As early as 1959 AMBÜHL (1959, and referring there to even earlier information) pointed out that aquatic macrophyte species grow in specific flow conditions, often in connection with a certain substrate type. From other sources he reported that this is only true within certain regional limits, concluding that only few species are truly characteristic for either rather fast (mosses, algae), or rather low water flow velocities (Elodea canadensis Michx., Myriophyllum spicatum L.). Regarding his latter examples present knowledge shows that this is only part of the total "flow niche" of these species (JANAUER, 1999, JANAUER et al., 2006). The effect of connectivity of side channels and oxbows as the background for resulting water flow was studied in much detail by BORNETTE (e.g. BORNETTE et al., 1998) and by JANAUER (2001). However, the relationship between macrophyte species and sediment conditions appears to be highly complex (CLARKE, 2002).

The full range of habitat conditions supporting the growth of a 'Danube macrophyte species' is best presented by the sum of all conditions found along the Danube River Corridor, but local occurrence reveals regional differences in the preferred environment. Considering water flow velocities results show (i) that none of the species occurs in all reaches of the Danube, and (ii) all species tend to prefer more lentic conditions (no or slow water flow) in the Upper Reach of the Danube as compared to the Middle and the Lower Reach of this river. However, the top preference for flow conditions in the main river channel, and in the large side channels, varies for each reported species in the latter two reaches.

The relationship of aquatic macrophytes to the substrate in which they grow is complex: they may start to grow in a certain type of substrate, but while building the structure of their plant stand, they collect material from the suspended matter load of running waters, which modifies the substrate type found under their stand over a length of time. In this study the substrate under and right next to the plant stands was classified, based on the assumption that the recorded type was not in an extremely initial stage. Of course, some mixture occurs – e.g. little pockets of fine sediment between large stones or between the individual granules of the gravel: for this presentation the dominant feature of the substrate was selected.

In the Upper Danube all the three species grow in a wide range of substrate types, including the prevailing rip-rap. The existence of micro-habitats suitable for embedding propagules and establishing young plant stands is thus proved for all the substrate types recorded in this study. In the Middle and Lower Danube the three species were found on gravel, sand or fine, inorganic material as the preferred sediment types in different geo-morphological reaches. In the reservoir of the Gabcikovo Dam, and the Iron Gate Dams, either gravel or fine inorganic substrate dominated the habitats.

In any case the highly variable habitat preference shown by our results must be taken into account for different regions along the Danube. The PHABSIM approach of modelling habitat conditions for aquatic life (http://www.fort.usgs.gov/Products/Software/PHABSIM), which is in wide use, needs just as well adaptation to regional or even local conditions in the light of the present study.

With respect to the Water Framework Directive the modelling of Reference Conditions should consider this variability as the spatial resolution in the MIDCC project was the individual river-km (with at least three detailed samplings in the longitudinal assessment at about 300m distance) in the main channel and in the large side channels. For a river 2850km in length this is a very detailed report scale, and served as a discriminate basis for our study. Our results can also influence WFD classification procedures in the different river reaches, and surveyors in WFD monitoring regimes must actively search for habitats with different flow and sediment characteristics to describe comprehensively the macrophyte vegetation as a biotic element of the ecological status. Original findings should also help to improve predictive scenarios used in river rehabilitation and restoration planning, which build on habitat characteristics and need to integrate this new aspect.

Acknowledgements

The MIDCC project ('Macrophyte Inventory Danube: Corridor and Catchment') was funded in its major part by the Austrian Federal Ministry of Education, Science, and Culture. The authors much acknowledge the effort of, and thank, the numerous colleagues who, under the leadership of their national co-ordinators, helped to finish this enormous task: the inventory of macrophytes in one of the Large Rivers of the world.

References

AMBÜHL, H. (1959): Die Bedeutung der Strömung als ökologischer Faktor. Schweiz. Zeitschr. f. Hydrologie **XXI**, 133-263.

BORNETTE, G., AMOROS, C. & LAMOROUX, N. (1998): Aquatic plant diversity in riverine wetlands: the role of connectivity. Freshwater Biol. **39**, 267-283.

CLARKE, S.J. (2002): The sediment niche of riverine macrophyte species. Proc. 11th EWRS Internat. Symposium Aquati Weeds. EWRS, Moliets et Maa. Pp107-110.

ICPDR (2002): Joint Danube Survey. International Commission for the Protection of the Danube River, Vienna. 262 pp.

JANAUER, G.A. (1999): Macrophytes of the River Danube: a diversity study of the Austrian stretch. Arch Hydrobiol. **115**, 399-412.

JANAUER, G.A. (2001): Fluss- und Au-Ökotone an Donau und March. Schriftenreihe Bundesamt f. Wasserwirtschaft **12**, 23-32.

JANAUER, G.A., JOLANKAI, G.G. & EXLER, N. (2006): River restoration in the Tisza River Basin: conflicting interests and the future of the aquatic macrophyte vegetation. Arch. Hydrobiol.**158,** 525-540.

MACHATA-WENNINGER, C. & JANAUER, G.A. (1991): The measurement of current vrlocities in macrophyte beds. Aquatic Bot. **39**,221-230.

MOOG, O., SOMMERHÄUSER,M., ROBERT, S., BATTISTI, T., BIRK, S., HERING, D., OFENBÖCK, T., SCHMEDTJE, U. & VOGEL, B. (2006): Typology of the Danube River based on „top-down" and „bottom-up" approaches. In: Austrian Committee Danube Research. 36th Conference International Association for Danube Research. Vienna, 2006. Book of Abstracts, ISBN 13: 978-3-9500723-2-7. Austrian Committee Danube Research-IAD, Vienna.

WFD (2000): Directive 2000/60/EC of the European Parliament and of the Council. Establishing a framework for Community action in the field of water policy. Official Journal of the European Communities, Brussels. **L 327**, 72pp.