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The Effect of Hydromorphological Changes on Habitat Composition of the Szigetköz Floodplain

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Abstract: Impacts of river engineering, particularly effects of channelisation were studied by analysis of historical maps from the early 19th century in the Szigetköz floodplain of the Danube River. Different hydrogeomorphological situations were investigated at a study site (Bodaki-branch system), where several deficiencies of altered river ecosystems (areal decline of aquatic habitats, change of bed load transport, decrease of lateral river-floodplain connectivity, etc.) can be recognised. Prior to extensive regulations, the Szigetköz floodplain was a highly dynamic braided and anabranching channel system. Alteration of the hydrogeomorphological processes by engineering lead to aggradation of river-floodplain ecosystem, formation of several abandoned channels and significant decline of the ecological rejuvenation of the aquatic habitats. Our results indicate long-term changes of landscape dynamics and fragmentation of the river ecosystem from the pre-regulation period up to the present situation.

Keywords: landscape ecology, landscape history, river regulation, historical habitat change

Introduction

The Szigetköz section of the Danube River is one of the last extensive inundated floodplains in Central Europe. The hydrological regime and the hydrogeomorphological processes are the most important landscape-forming factors in its evolution (Erdélyi 1994, Göcsei 1979, Pécsi 1959). The natural geomorphological processes have been altered by river engineering since the end of the 19th century. Further modifications of the landscape dynamics was caused by the operation of the Gabčikovo hydropower dam at the end of the 20th century. Historical analysis of the river- floodplain ecosystem are important in order to recognise the main controlling factors affecting the long-term changes of the floodplain habitats, as well as the role of human activity in the development of the fluvial landscape. The assessment of the pre- regulation conditions helps to identify the deficiencies of the hydrogeomorphological and ecological processes in the recent situation. Furthermore, it highlights the potential constraints for the restoration of river ecosystem functions. The interpretation of the historical references and factors influencing the river landscape dynamics may be essential for various stakeholders, managers and policy- makers who are interested in the identification of the management options for the Szigetköz floodplain (Guti *et al.* 2010, Potyó, Guti 2010).

Study Area

The Szigetköz floodplain is in the upper part of the Hungarian-Slovak section of the Danube River, within the Kisalföld region (*i.e.* Little Danube Plain). It is situated on the right side of the extensive alluvial cone stretching from Rajka to Gönyü (between rkm 1850 and rkm 1794). In the pristine conditions, the river formed a braided and anabranching riverbed characterised by multiple channels, bars and unstable islands. At the end of the 19th century (from 1886 to

1896), a unified and straigntened main channel was created for the improvement of navigability. At this period, the flood controlling dyke system was developed and it resulted in the restriction of the floodplain inundations to 20% of the historical floodplain (375 km^2). One hundred years later, the construction of the Gabčikovo hydropower dam led to further alterations. Its operation (from 1992) resulted in two to three meter drop of the water level in the floodplain branch-system because 85 % of the river discharge was diverted to its bypass canal. Since the middle of the 1990s, artificial water replenishment from the main arm of the Danube River has been providing permanent water supply for the branch-system with the capacity of 40-180 m^3 s^{-1}, but the major connections between the main arm and the branches have been blocked by weirs (Guti 2002). The more thorough historical habitat analysis of the present study has been focused to the Bodaki branch-ystem (rkm 1832-1827) in the upper part of the anabranching sector of the Szigetköz floodplain.

Methods

In the habitat assessments, several historical maps and river engineering plans were collected and evaluated to describe the geomorphological conditions in the pristine pre- regulation conditions of the Szigetköz floodplain. The typology of the habitat analysis was mainly based on the 'functional sets' concept (Amoros *et al.* 1987). In addition, the definitions used in the Austrian section of the Danube River (Hohensinner *et al.* 2005) were followed with minor modifications (Table 1).

The habitat structure of the river- floodplain ecosystem was studied from maps of military surveys and aerial photographs from the early 19th century to the beginning of the 21th century. Vectorisation of the georeferenced maps was performed by using the ArcGIS 10 software in WGS-84 coordinate system. The spatial data were inserted in an attribute table to analyse the habitat changes in three situations: before the extensive regulations from 1830, after the channelisation and the development of flood controlling system in 1946 and after the installation of the Gabčikovo hydropower plant in 2004.

In the analysis of the historical changes of the riverine landscape, the main habitat types were distinguished on the basis of their geomorphological features. For example, in the area of the eupotamon-A habitats, the shape of the islands is usually elongated in longitudinal direction and their longest diameter is parallel to the thalweg (*i.e.* line of the lowest points along a watercourse), whereas the less elongated islands are rather typical for the area of the eupotamon-B habitats. For the lentic water bodies with fluvial origin, parapotamon, plesiopotamon and paleopotamon habitat types can be distinguished according to their distance from the main river bed and their assumed connectivity to the lotic habitats (Ward *et al.* 2002). The parapotamon type arms are situated close to the eupotamon type arms. The plesiopotamon type backwaters are also situated close to the eupotamon habitats, but their recognisable characteristic is the temporal disconnectivity at their upstream and downstream ends. The paleopotamon type dead channels are located far from the flowing waters and their permanent separation is quite obvious.

Results

In the first half of the 19th century, some small and local engineering works had been carried out in the Bodaki branch-system, without significant modification of the natural geomorphological processes, which were characteristic to the pre- regulation state of the river-floodplain ecosystem. According to the analysis of the map published in 1830, the dominance of eupotamon- A and -B type arms can be clearly established. The proportions of their estimated areas

Table 1. Definitions of the fluvial origin habitat types in the Szigetköz floodplain

Habitat type	Definition
Eupotamon-A	Main stream
Eupotamon-B	Always connected side channels, with permanent flow
Parapotamon-A	Highly dynamic side arms, intact downstream connection, blocked upstream by bare gravel/ sand deposits
Parapotamon-B	Less dynamic side arms, intact downstream connections, blocked upstream by vegetated deposits
Plesiopotamon	Isolated water bodies, close to the main channel, often connected
Paleopotamon	Isolated water bodies (oxbows in the meandering sector), seldom connected

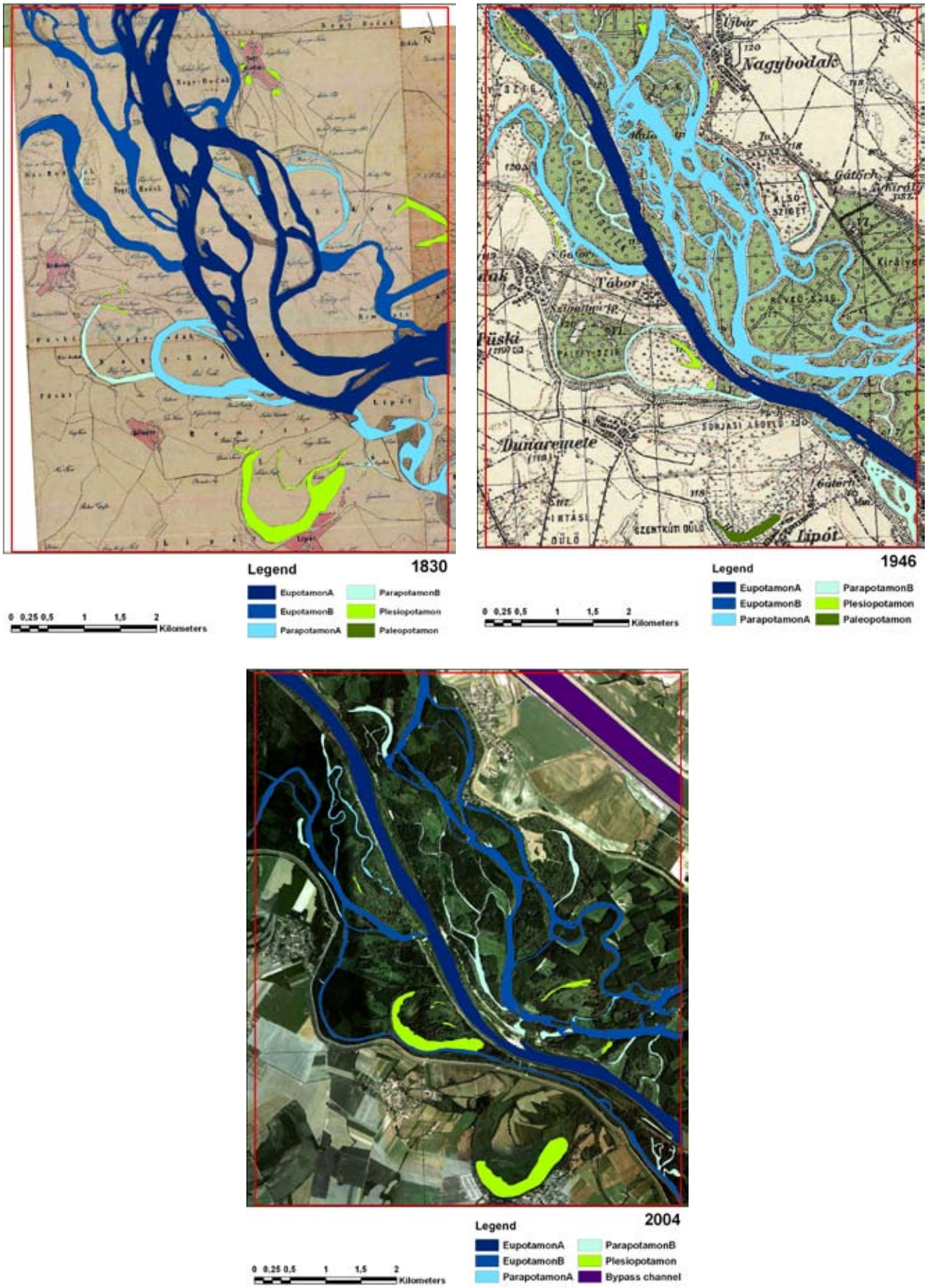

Fig. 1. Indication of the aquatic habitat distribution on the historical maps from 1830 and 1946 and in the recent (2004) situation

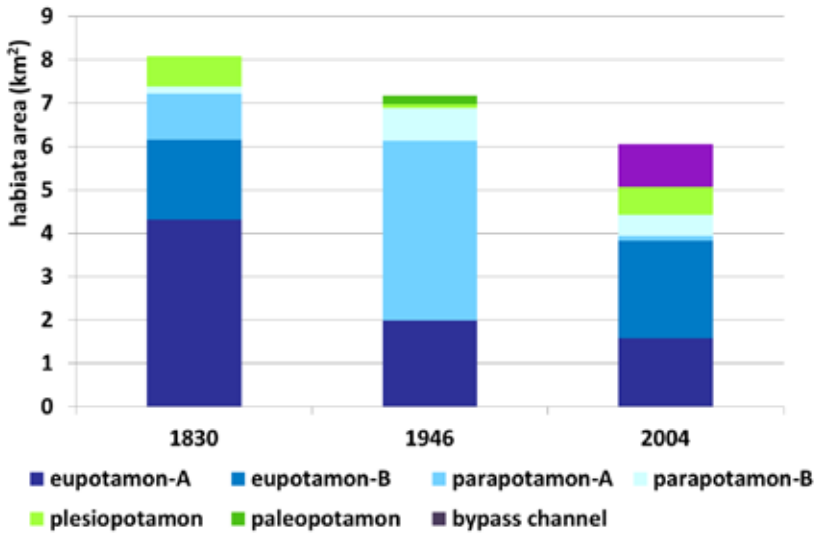

Fig. 2. Changes of the aquatic habitat composition between 1830 and 2004 in the Bodaki side arm system

were 53% and 23%, correspondingly. The shares of the semi-lotic arms and the lentic backwaters were smaller in the dynamic system: the parapotamon- A and -B and plesiopotamon were 13%, 2% and 9%, correspondingly. The total area of the aquatic habitats in the study area was about 810 hectares during this period.

After the 19th century extensive regulation of the Szigetköz section of the Danube River, the longitudinal and lateral connectivity of the Bodaki side arm system became fragmented by cross weirs and rip-rap embankments that were stabilising the main channel. The fragmentation resulted in the transformation of the significant proportion of the former eupotamon- A and -B type branches into parapotamic side arms and this process eliminated the earlier dominance of the eupotamic branches. In the middle of the 20th century, the proportion of the eupotamon-A habitats declined to 28% and the eupotamon-B habitats disappeared in the Bodaki side arm system. The shares of the semi-lotic parapotamon- A and - B habitats increased to 58% and 11%, correspondingly. The proportion of the plesiopotamic water bodies decreased to 1%. The former river branches and abandoned oxbows on the flood-protected side of the floodplain have lost their direct connections with the lotic arms, and their paleopotamic features became predominant. The proportion of the paleopotamon type habitats was about 3%. The total area of the aquatic habitats in the studied area decreased by 9% to 717 hectares during the first half of the 20th century.

In the beginning of the 1990s, when the Danube River was diverted to the Gabčikovo bypass canal, 80% of the side arms in the Szigetköz floodplain dried out. However, their permanent water supply has been provided by the water replenishment from the main arm since the middle of the 1990s. This remedial measure resulted in the rising proportion and dominance of the eupotamon type habitats as opposed to the parapotamic side arms. The estimated proportions of eupotamon- A and - B type arms were 26% and 37%, correspondingly. The former area of the semi- lotic branches decreased by 88%, and the recent shares of parapotamon- A and -B habitats became 2% and 8%. The area of the lentic backwaters slightly increased and the proportion of the plesiopotamon habitats reached about 11%. The paleopotamon habitats have been transformed to plesiopotamon type water bodies due to their direct water supply from the active floodplain since the extension of the water replenishment system to the flood protected area. The total area of the aquatic habitats in the study site is reduced by an additional 15% and it is around 606 hectares, but about 100 hectares of the total area is part of the man-made bypass channel.

Conclusions

Historical habitat analysis is a useful tool in the determination of the hydrogeomorphological conditions in the pristine situation of the river-floodplain ecosystem (Hohensinner *et al.* 2005) and the identi-

fication of the processes shaping the recent deficiencies of the fluvial landscape.

The map of the pre-regulation state of the Bodaki branch system indicated the dominance of the eupotamon type habitats and the dynamic changes of the side arms. The extensive engineering at the end of the 19th century, such as the creation of navigation channel (main arm) and the blocking of upstream inlets of the branch system, has transformed the natural structure of the aquatic habitats. The construction of rip-rap embankments and wing-dams along the straightened main arm has altered the inshore formations of gravel bars and has reduced the lateral erosion of the river banks. The construction of cross-dykes in the side arms has reduced their gradient and flow velocity. The proportion of the eupotamon type of the side arms was decreased significantly by the blocking of the upstream inlets of the side arms, and thus the extent of the temporal stagnant semi-lotic channels increased. The restriction of the dynamic hydrogeomorphological processes resulted in a change in the aquatic habitat distribution and the advanced stages of habitat succession, causing parapotamon-A and -B habitats to become characteristic in the branch system.

Since the operation of the Gabčikovo hydropower plant, the flow regime, the bed load transport, as well as the longitudinal and lateral connectivity of the river-floodplain ecosystem has been heavily modified in the Szigetköz section of the Danube River. Most of the cross dykes were opened to improve the flow conditions within the branch systems, whereas the floodplain side arms and the main arm of the Danube River were separated by the blocking of the tributaries which served as inlets and outlets of the branch systems. The permanent artificial water supply to the floodplain branches resulted in the increase in the proportion and the dominance of the eupotamon-B type side arms. Therefore, the recent habitat composition became more similar to the pre- regulation situation. However, the incidence of the temporal flushing of the branches had diminished owing to the alteration of the natural flow regime. Because of this a gradual sedimentation process began with the lack of regular floods which maintained the gravel substrate. The growing fine sediment layers along the shorelines provided good substrate for aquatic and semi-aquatic macrophytes, and thereafter for spontaneous forestation. These processes led to the narrowing of the side arms and the overall degradation of the aquatic habitats.

Several environmental problems can be recognised in the long-term dynamics of the aquatic habitat structure in the Szigetköz floodplain. Interpretation of the altered landscape triggered by various hydrogeomorphological processes and the prediction of the future state of the fluvial habitats may be essential information for the managers and decision-makers of the river restoration programmes.

References

Amoros C., A. L. Roux, J. L. Reygrobellet, J. P. Bravard and G. Pautou 1987. A method for applied ecological studies of fluvial hydrosystems. – *Regulated Rivers,* **1**: 17-36.

Erdélyi M. 1994. The hydrogeology of the Hungarian upper Danube section (before and after damning the river), – *Földrajzi értesítő,* **44**: 1-279.

Göcsei I. 1979. A Szigetköz természetföldrajza. – *Akadémiai Kiadó*, Budapest, 120 p.

Guti G. 2002. Changes in the Szigetköz floodplain of the Danube and its fish communities after river diversion by the Gabčikovo Dam. – *Verh. Internat. Verein. Limnol.,* **28**: 840-844.

Guti G., I. Potyó, T. Gaebele and A. Weiperth 2010. Ecological benchmarking of the aquatic habitat changes in the Szigetköz floodplain of the Danube. Proceeding Volume of the 38th Conference of the IAD, Dreseden, (http://www.iad.gs/index.php?item=materials).

Hohensinner S., M. Jungwirth, S. Muhar and H. Habersack 2005. Historical analyses: a foundation for developing and evaluating river-type specific restoration programs. – *Int. J. River Basin Management,* **3** (2): 87-96.

Pécsi M. 1959. A magyarországi Duna-völgy kialakulása és felszínalaktana. – *Akadémiai Kiadó*, Budapest, 346 p.

Potyó I., G. Guti 2010. 1D hydrological model as a predictive tool for the assessment of aquatic habitat changes in floodplain rivers. Proceeding Volume of the 38th Conference of the IAD, Dreseden, (http://www.iad.gs/index.php?item=materials).

Ward J.V., K. Tockner, D. B. Arscott and C. Claret 2002. Riverine landscape diversity, – *Freshwater Biology*, **47**: 517-539.