Spatial differences of the zooplankton assemblages and chemical characteristics of water in a plesiopotamal side arm of the active floodplain at the Danube (rkm 1442-1440)

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1 Introduction

River-floodplain landscapes are dynamic areas exhibiting a high biodiversity. The exchange of matter and energy between the different landscape elements of these areas is facilitated by the hydrological connectivity. Floodplains are keystone ecosystems characterised by a high level of habitat heterogeneity and by a diverse biota adapted to the high spatio-temporal heterogeneity (Tockner & Stanford 2002).

The Gemenc and Béda-Karapancsa Danube floodplains (Duna-Dráva National Park, Hungary) represent an exceptional example of river-floodplain systems in Europe with big meanders, oxbow lakes, marshlands and extended hardwood forests. Due to the river regulation works in the 19th century this area has changed, the floodplain remained more or less isolated from the main stream and the length of the side arms has been shortened. Currently numerous side arms and backwaters with various hydromorphological characteristics are still located completely in the active floodplain. The water-supply of this area is totally determined by the Danube.

The detailed investigation of this typical near natural active floodplain zone started in 2002 by examinig the differences between the water bodies (Schöll & Kiss 2008; Schöll et al. 2008). In this paper the results of the hydrobiological monitoring focusing on the plesiopotamal Mocskos-Duna are summarized. This was the first hydrobiological survey in this side arm with high nature conservation value, which included the monitoring of zooplankton assemblages and of chemical characteristics of the water.

2 Materials and methods

The Mocskos-Duna side arm (rkm 1442-1440) is situated in the active floodplain of Karapancsa area (Hungarian Lower Danube valley), approximately 3.4 km long, 60 meter wide, with shallow water (average depth: 1.5 m) and very dense macro-vegetation. There were two sampling occasions on 22 June and on 28 July of 2009. The side arm is connected with the Danube by an artificial channel. The Danube starts to overflow into the floodplain after it reaches a water level of 550 cm at Mohács in the main channel of the river; during the sampling, there was no connection with the main stream (the water level was 359 cm on 22 June and 508 cm on 28 July). The following sampling sites were examined:

Main stream (D1437) (N 45º 55’ 58,00”, E18º 46’ 26,00”) — At this reach of the Danube the mean discharge is about 2449 m^3 sec^{-1}, the slope is 5 cm km^{-1}, the mean velocity is 0.5-1.2 m sec^{-1}. The difference between the minimum and maximum water level fluctuation is near 9 m.

Mocskos-Duna (1, 2, 4 and 7 sites: longitudinal transect of the side arm)

1. (N 45º 57’ 24,78” E18º 46’ 24,67”) — Open water site in the southern end of the side arm.

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2. (N 45º 57’ 35,27” E18º 46’ 38,22”) — Open water area with dense *Ceratophyllum* stands 20-30 cm below the water surface.

3. (N 45º 57’ 36,87” E18º 46’ 36,25”) — Special habitat with *Salix* trees and emergent *Typha* stands. Water depth: 30 cm.

4. (N 45º 57’ 58,65” E18º 46’ 43,94”) — Open water area with dense *Ceratophyllum* stands 20-30 cm below the water surface.

5. (N 45º 58’ 06,20” E18º 46’ 37,07”) — Vegetated area with *Ceratophyllum demersum* L. and *Trapa natans* L. The coverage of macrophytes is 100%. Water depth: 120 cm.

6. (N 45º 58’ 06,95” E18º 46’ 17,85”) — Open water area at the end of the shorter side arm of the Mocskos-Duna with emergent *Phragmites* stands on the banks. Water depth: 35-40 cm, the coverage of macrophytes is 5% (*Polygonium amphibium* L.).

7. (N 45º 58’ 18,26” E18º 45’ 57,13”) — The northern end of the side arm with *Hydrocharis morsus-ranae* L. and *Trapa natans*. The coverage of macrophytes is 100%. Water depth: 100-120 cm

The measurement of hydrochemical parameters (temperature, pH, conductivity, dissolved oxygen and oxygen saturation) was performed *in situ* using WTW Multiline-P4 portable meter (WTW, Germany). The cation and anion concentrations we analyzed in the laboratory, with Dionex DX-120 ion-chromatograph after filtration (0.2 μm).

Suspended matter, CO_3^{2-}, HCO_3^- and chlorophyll-a concentrations were determined using standard analytical methods (Golterman et al. 1978). The composition and coverage of macro-vegetation was estimated with a 1 m^2 quadrate according to Braun-Blanquet (1951). Rotifers were sampled with a plankton net (mesh size 40 µm), by filtering 20 litres of water. Crustaceans were concentrated on a 70µm mesh and fixed in 5% formaldehyde solution. Microcrustacean abundance including the developmental stages of copepods (copepodids) was evaluated by enumerating individuals in the whole sample. Data were analysed by hierarchical cluster (HC) and non-metric multidimensional scaling (MDS) method with Euclidean distance by using the PAST program-package (Hammer et al. 2001).

3 Results and discussion

3.1 Water chemistry

The examined sampling habitats differed especially in their vegetation cover, water depth, oxygen saturation and chlorophyll-a content. The oxygen saturation, the chlorophyll-a content and the suspended matter content were higher in the open water habitats than in the vegetated areas (Table 1).

The hydrochemical parameters slightly differed in the two sampling times; however, the site 7 in July was remarkably different from the other sites in terms of extremely high water temperature (32^0 C) and sites 2 in June and 7 in July in very high (217 %) oxygen saturation (Figure 1).

There were no significant differences in the chemical parameters of the main stream and the side arm, with the exception of the NO_3^- concentrations, which were notably higher in the Danube, than in the Mocskos-Duna side arm.

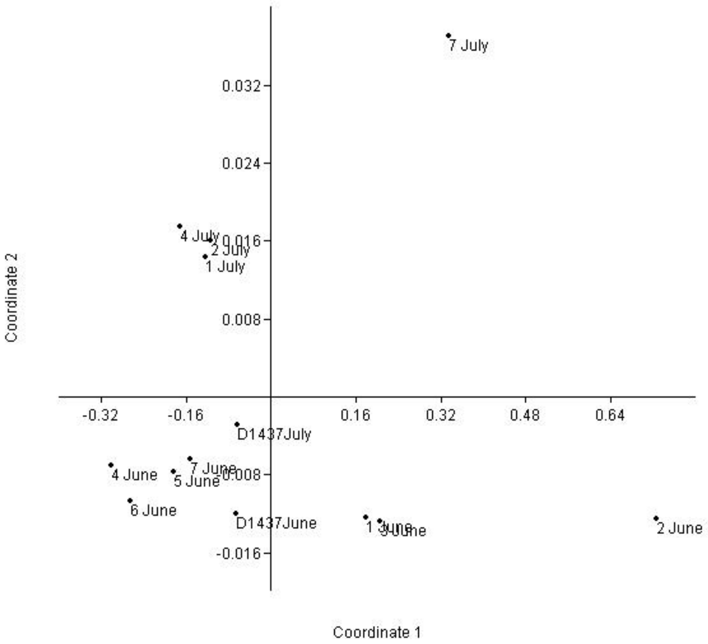

Figure 1. *The NMDS plot of the examined habitats on the basis of the hydrochemical parameters in the two sampling days (22 June and 28 July, 2009)*

3.2 Zooplankton

18 *Cladocera,* 9 *Copepoda*, 3 *Ostracoda* and 35 *Rotifera* taxa were recorded in the Mocskos-Duna; *Synchaeta pectinata* Ehrenberg (Rotatoria) and *Disparalona rostrata* (Koch) (Cladocera) were found only in the main stream. In the Danube mostly rotifers (especially *Synchaeta pectinata* Ehrenberg, *Anuraeopsis fissa* (Gosse), *Keratella cochlearis* (Gosse)) dominated the zooplankton assemblages with an average of 98.7% of total abundance.

The zooplankton assemblages in the Mocskos-Duna, similarly to the main stream, were clearly dominated by rotifers, which in the open water (sites 1, 2, 3, 4 and 6) made up to 86.3-99.6% and in the vegetated areas 63.5-66.1% of the total abundance. In the open water habitats the rotifer assemblages were characterized by euplanktonic taxa, especially *Keratella cochlearis* (Gosse) (29.4%), *K. tecta* (Gosse) (29.6%) and *Polyarthra dolichoptera* Idelson (17.7%) and *Brachionus* spp. (11.3%). The highest Rotifera, tychoplanktonic Rotifera taxon number and the highest Shannon-diversity were recorded in the vegetated habitats (Table 1).

Table 1. *Minimum and miximum values of selected abiotic and biotic parameters in the Danube and the longitudinal transect of the Mocskos-Duna (sites 1, 2, 4, 7) measured on 22 June and 28 July, 2009*

	D1437		1		2		4		7	
	min	max	min	max	min	max	min	max	min	max
Temperature (C^o)	19.4	21.6	19.6	25.9	20.1	26.4	20.4	26.7	20.7	32.0
pH	7.9	8.4	7.7	8.6	7.4	7.9	7.5	7.7	7.7	8.6
Conductivity ($\mu S\ cm^{-1}$)	349	352	333	401	324	325	383	386	333	349
O_2 (mg L^{-1})	8.5	10.3	8.4	15.1	8.5	25.1	4.5	7.3	7.3	15.8
O2 saturation (%)	117	118	102	178	105	315	58	90	95	217
Suspended matter (mg l^{-1})	24.4	41.8	10.9	23.6	2.9	5.6	4.4	5.4	2.8	6.9
NO_3-N (mg l^{-1})	1.20	1.30	0.10	0.30	0	0.30	0.10	0.10	0.20	0.20

PO_4-P (µg l^{-1})	10	45	21	240	36	50	43	64	6	55
TP (µg l^{-1})	97	123	98	701	103	152	110	146	83	177
Water depth (cm)	359	508	35	40	190	200	190	200	100	120
Coverage of macrophytes (%)	0	0	0	5	0	0	0	0	100	100
Chlophyll-a (µg l^{-1})	10	52	30	118	25	51	30	35	21	25
Rotifera taxon number	5	6	8	11	13	16	10	13	16	16
Tychoplanktonic taxon number	0	0	2	0	4	6	3	4	9	8
Rotifera density (ind l^{-1})	22.5	32.5	245	3460	137.5	722.5	677.5	1010	227.5	457.5
Rotifera Shannon diversity	1.48	1.68	1.43	1.48	1.95	2.14	1.27	1.53	2.19	2.25
Crustacea taxon number	2	7	1	6	3	7	2	15	15	18
Tychoplanktonic taxon number	1	5	0	6	2	2	2	10	14	14
Crustacea density (ind l^{-1})	0.2	0.7	0.1	12.4	1.7	4.3	0.1	3.2	19.9	20.5
Crustacea Shannon diversity	0.45	1.29	0	1.37	0.41	1.60	0.64	1.84	1.09	1.13

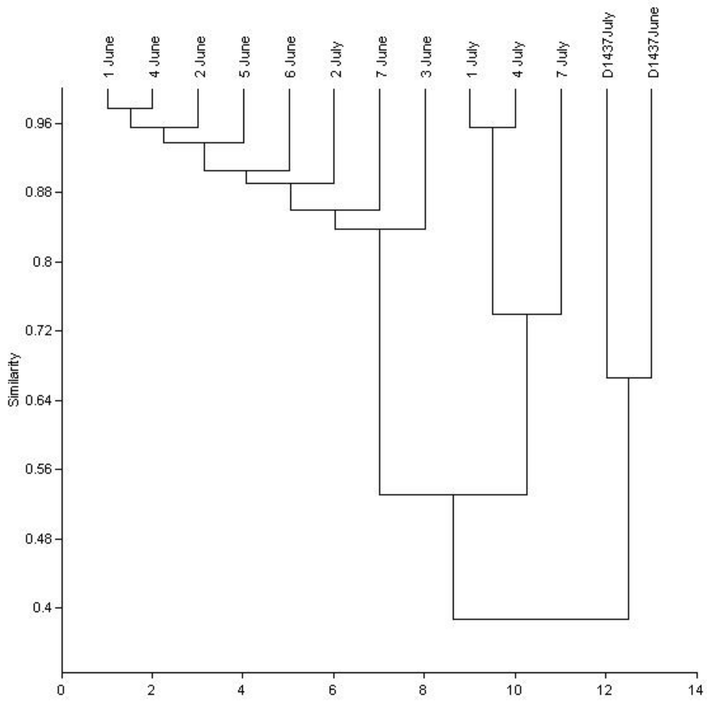

Figure 2. *Cluster analyses of rotifer abundances in the two sampling days (22 June and 28 July, 2009)*

Maximum abundance of rotifers (7450 ind l^{-1}) was found at site 6. Besides the frequent species mentioned above, *Anuraeopsis fissa* (Gosse), *Brachionus angularis* Gosse, *Filinia terminalis* (Plate) and *Trichocerca birostris* (Minkiewitz) reached high densities in this habitat. The average rotifer density was highest in open water habitats (3718 ind l^{-1}) and decreased notably in the vegetated sites (343 ind l^{-1}).

Samples taken from the main stream and from the side arm in June and July (with the exception of site 2 in July), were clearly separated from each other (Figure 2). The rotifer abundance and chlorophyll-*a* concentration were positively correlated (y = 476.83x-8674.4, R^2 = 0.81). This relationship was also described in other floodplain waters (Schöll et al. 2006, Pithart et al. 2007). This can be explained by either less top-down control (absence of large filtrators) easing competition (Lampert & Rothhaupt 1991), or increased bottom-up control (elevated concentration of suitable food, Merriman & Kirk 2000).

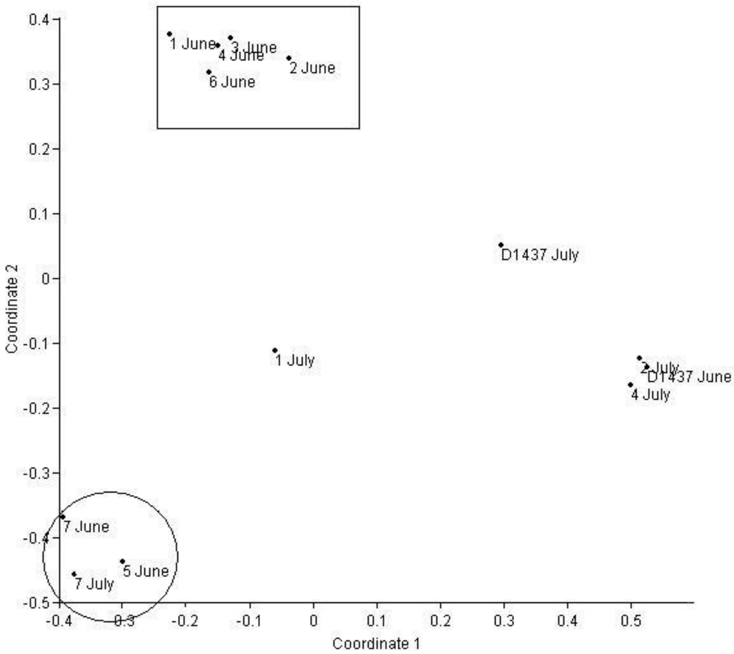

Figure 3. *Comparison of sampling sites based on crustacean assemblages (NMDS) in the two sampling days (22 June and 28 July, 2009)*

The crustacean dynamics in the sampled habitats varied extremely in term of abundance and species composition (Figure 3). The open water habitats and the vegetated areas (sites 5 and 7) differed significantly, but the several open water habitats were similar (sites 1, 2, 3, 4, 6). There were no significant differences in the crustacean assemblages among the different macrophyte types. In the open water habitats the crustacean taxon number and abundance slightly decreased in July. Highest densities of crustaceans were detected at site 5 (*Ceratophyllum* and *Trapa stands*) with over 88.5 ind l^{-1}. In the open water habitats the average density of crustaceans was low (4.5 ind l^{-1}), copepodids accounting for over 45-83% of the total abundance the number of euplanktonic taxa (*Bosmina longirostris* (O. F. M.), *Moina brachiata* (Jurine), *Acanthocyclops robustus* (Sars), *Eurytemora velox* (Lilljeborg), *Thermocyclops crassus* (Fischer)) was high. The taxon number (R^2 = 0.581), total abundance of microcrustaceans (R^2 = 0.598) and the abundance of cladocerans (R^2 = 0.618) were significantly higher in the vegetated sites than in open water, mostly due to higher densities of *Chydorus sphaericus* (O. F. M.) (R^2 = 0.644), *Simocephalus vetulus* (O. F. M.) (R^2 = 0.908), ostracods (R^2 = 0.889) and *Graptoleberis testudinaria* (Fischer). Many studies showed that aquatic macrophytes may contribute to the increase in microcrustacean abundance but only a few focused on river-floodplain system (Basu et al. 2000, Grenouillet et al. 2001). Protection from predators and availability of food are the two main factors generally invoked to explain the high density of zooplankton in vegetated habitats (Carpenter & Lodge 1986). In unregulated river sections with well-developed floodplains the zooplankton of the main arm is imported from adjacent slow flowing or lentic areas depending on the hydrological connectivity with the river (Reckendorfer et al. 1999).

4 Conclusion

This short hydrobiological survey carried out on the Mocskos-Duna, little known side arm of the Béda-Karapancsa floodplain-system, confirmed other results on river-floodplain systems focusing on the role of macrophytes. The different macrophyte beds in the side arm increasing habitat heterogeneity enhance the zooplankton diversity by providing food and shelter against predation and the taxon number (including tychoplanktonic taxa) and diversity were significantly higher in the vegetated habitats than in the open water. Our results showed that zooplankton studies of floodplains demand extensive monitoring and a detailed survey of the different floodplain habitats.

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