



**Spatio-temporal dynamics of planktonic crustacean  
assemblages in the Danube River near Budapest and in the  
Ráckeve-Soroksár Danube**

*PhD dissertation thesis*

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## **Introduction**

Research on the Danube River has been in the focus of limnology for a long time in Hungary due to the activity of the Hungarian Danube Research Station of the Hungarian Academy of Sciences and the Environmental and Water Research Institute „VITUKI”. This continuous research program made Hungary one of the most powerful centers of Danube research among the countries lying along the river. Research on rivers (and also potamoplankton), however, lagged behind research on lakes due to some methodological difficulties. Zooplankton of the Hungarian reach has been investigated for a long time, however, a number of studies have been restricted to the area of Göd, included only short periods or has been carried out with sampling frequency beyond the biweekly level. Research on side arms of the Danube River rather focused on the area of Gemenc and Szigetköz, whereas the side arm of Szentendre remained rather poorly studied. As the Ráckeve-Soroksár Danube (hereafter referred to as RSD) has not got so much interest, its side arms remained almost completely unexplored.

In these days, RSD research is entitled to great attention since the complex water quality improvement project of the RSD aimed to improve water quality and increase its water management function and conservation value on the basis of a 35 billion HUF based budget expectedly co-financed by the EU. Findings of the present study may provide a firm basis to assess the ecological status of RSD in times to come. With the sewage farm of Csepel, expected to put into operation in summer 2010, some 95 % of wastewater of Budapest is expected to reach the river after being cleaned. Exploring the possible (favourable) effects of the operation of the sewage farm on the zooplankton assemblage promises an exciting challenge in the future. Present work may serve as a reference.

Within the framework of a two-year study, microcrustacean plankton was sampled in the main channel of the Danube River upstream and downstream of Budapest and in the RSD together with its two side arms of different types. Sample taking in winter and at a daily frequency and transversal sampling procedure (left bank, streamline, right bank) were considered rather important, which have often been neglected in limnological practice.

Goals of the study included:

1. Description of the seasonal dynamics of cladoceran and copepod assemblages taking into consideration the hydrological regime as well.
2. Investigation of spatial dynamics of microcrustacean plankton including the following:
  - 2.1. Contrasting microcrustacean plankton assemblages of the main channel and the RSD both from qualitative and quantitative points of view.

- 2.2. Contrasting samples taken from the streamline and from the river bank both in the main channel and in the RSD.
- 2.3. Contrasting samples taken upstream and downstream of Budapest.
3. Sample taking with daily frequency at one sampling station. Analysis of population dynamics of the most abundant species. Contrasting the results of daily sampling frequency with those of biweekly data. Assessment the effects of sampling effort and sampling frequency on the observation of the composition of the planktonic crustacean assemblage.

## **Materials and Methods**

Sampling stations included:

**Dunaharaszti** (transversal sampling) (44.5 rkm) (RSD)

**Sport-sziget side arm** (RSD) (it has a permanent connection to the RSD and is enclosed downstream)

**Molnár-sziget side arm** (RSD) (it has a permanent connection to the RSD through its upper and lower mouth)

**Újpest-Békásmegyer** (transversal sampling) (1657 rkm) (Danube)

**Tököl-Százhalombatta** (transversal sampling) (1623 rkm) (Danube)

Crustacean plankton was sampled biweekly from 2nd October 2006 to 8th November 2008. Throughout this period the author collected and analyzed a total of 522 samples. In summer of 2007, between 13rd June and 21st July, crustacean plankton was sampled at a daily frequency in the Sport-sziget side arm. These daily samples were collected always around 4 p.m. so as to eliminate possible diel variation in some parameters. This 39-day long period seemed to be capable of analyzing daily variation in population dynamics due to the high abundance and its remarkable fluctuation. In the Danube River and in the main channel of the RSD, 100 litres of water (in the Sport-sziget side arm and Molnár-sziget side arm 50 litres of water) was filtered through a plankton net (50  $\mu\text{m}$  mesh size) and the collected material was preserved *in situ* in 4-5 % formaldehyde solution. Samples were taken from the open water in the Sport-sziget and Molnár-sziget side arms, whereas from left bank, streamline and right bank in the Danube River and main channel of the RSD. Cladocerans and copepods (Cyclopoida, Calanoida) were identified to species level, Ostracoda and Harpacticoida were not identified to this level. Water temperature and conductivity were measured *in situ* and in the lab of the Environmental and Water Research Institute „VITUKI” (with HANNA HI 4521), respectively, whereas water discharge and water level data were obtained from the data bank

of „VITUKI”. Water residence time was calculated with the formula of Soballe & Kimmel (1987). In order to analyze the spatio-temporal dynamics of crustacean plankton assemblages, multivariate analyses, classical statistics and the bootstrap method were used. Diversities were calculated with Shannon and Berger-Parker indices. Shannon diversity t-test was used to contrast diversities among sampling stations. Linear correlation was used to detect any possible significant association between hydrological regime and crustacean plankton. A single index was introduced (Potential Dynamic Information loss; PDI) (Vadadi-Fülöp et al. 2010) to determine the potential loss of information (%) when sampling frequency is reduced.

## Theses

1. 40 species of cladocerans and 16 species of copepods were found in the Danube River near Budapest and in the RSD between 2nd October 2006 and 8th November 2008. Two species (*Diaphanosoma mongolianum*, *Pleuroxus denticulatus*) were new to the fauna of the RSD and one species (*Diacyclops crassicaudis*) was first recorded in the Hungarian section of the Danube River. A total of 20 species was only identified in the RSD (and in its side arms), only one species (*Diacyclops crassicaudis*) was recorded in the Danube River without occurrence in the RSD. The number of tychoplanktonic elements reached its maximum (71 %) in the main channel of the RSD, and its minimum in the main channel of the Danube River (58 %). In the Sport-sziget and Molnár-sziget side arms, the proportions of tychoplanktonic taxa were 59 % and 68 %, respectively.
2. Present study was the first survey on the Sport-sziget and Molnár-sziget side arms, with record of 39 and 40 species of microcrustaceans, respectively, including also *Diaphanosoma mongolianum*, *Alona intermedia*, *Paracyclops affinis*, *Eurytemora velox*.
3. It was evidence of increasing occurrence of *Thermocyclops crassus*, decreasing record of *Cyclops* spp. and expansion of *Eurytemora velox* both in the main channel of the Danube River and in the RSD.
4. The main channel – and the side arm of Szentendre – was relatively poor in plankton, species number and densities increased considerably in the RSD, whereas its side arms were characterized by high species number and high dominance of some species.
5. Contrasting diversities in the main channel of the Danube, in the RSD and in its side arms, there was evidence of significant variation among these water bodies. On the basis of microcrustacean assemblages, the main channel of RSD can be characterized

- by higher diversities compared with its side arms, where species number was similarly high, but evenness reached low values due to the powerful dominance of some species. Microcrustacean assemblages in the Danube River have dominance values similar to those of the main channel of the RSD, but diversities lagged behind those of the RSD.
6. Based on the qualitative and quantitative composition of planktonic crustacean assemblages, RSD and the Danube River differed significantly, however, RSD samples taken from the streamline showed much more similarity to those collected in the Danube River as long as quantitative points are considered.
  7. In the streamline, abundance of microcrustaceans and number of taxa were both lower compared with the river bank and this finding was true for the Danube River and the RSD as well.
  8. In the main channel of the Danube River, there was a negative relationship between crustacean plankton density and water residence time and a positive correlation between density and discharge.
  9. There were remarkable longitudinal (upstream vs. downstream of Budapest) and transversal (streamline vs. river bank; left bank vs. right bank) variations in the abundance of the major crustacean plankton groups (adult copepods, copepodites, nauplii, cladocerans) and dominant species (*Thermocyclops crassus*, *Bosmina longirostris*, *Moina micrura*), however, these variations were dependent on the examined objects. Samples taken from the RSD differed significantly from those of the Danube River.
  10. Microcrustacean assemblage structure displayed seasonal patterns, however, these differed among water bodies. There were statistically significant seasonal and interannual differences in the abundance of major microcrustacean groups, these variations differed among taxa and developmental stages though. In the year of 2008, microcrustacean abundance reached higher values at all sampling stations, although it was not so remarkable in the main channel of the Danube River.
  11. Crustacean plankton was sampled throughout 39 days at a daily sampling frequency in the Sport-sziget side arm. Abundance experienced notable fluctuation within the 39-day long period. Samples taken on the daily basis showed higher diversities compared to those of monthly samples. The male/female and copepodite/adult ratios and also the proportion of egg-carrying individuals were determined for the population of *Thermocyclops crassus*.

12. On the basis of samples taken at daily frequency (a case study of the Sport-sziget side arm) the optimal sample size was tested with two different methods and it resulted in a sample size (1000 and 300 l, respectively) beyond those applied in the studies of riverine plankton.
13. In order to evaluate the effect of sampling frequency, a single index (PDI) was introduced, which determines the potential loss of information when sampling frequency is reduced. Results suggest that abundances may experience notable fluctuations even within one week as do number of taxa, diversities and adult/larva ratios, thus some variation remain unobserved at a biweekly sampling frequency.

## Conclusions

Dominant species found in the main channel of the Danube River (*Acanthocyclops robustus*, *Bosmina longirostris*) are consistent with the findings of Bothár (1975, 1985, 1988, 1994) and Gulyás (1994a, 1994b, 1995, 2002), however, the relatively large contributions of *Thermocyclops crassus* and harpacticoid copepods are something new. *Eucyclops serrulatus* and particularly *Cyclops vicinus* were not found to be dominant or frequent and, therefore, not supported the findings of Bothár (1985, 1988) and Bothár & Kiss K. T. (1990), although Bothár (1996) reported *Acanthocyclops robustus* to experience increasing contribution at the expense of *Eucyclops serrulatus*. Minor contributions of *Cyclops vicinus* and *Mesocyclops leuckarti* deserve attention as well.

In the RSD, neither average nor maximal individual numbers varied markedly since the 70s (Bothár 1973, Just et al. 1998). Temporal variations in the composition of planktonic crustacean assemblages include appearance and increasing contribution of *Eurytemora velox*, and increasing dominance of *Thermocyclops crassus* and *Acanthocyclops robustus*.

Minor species number recorded in the streamline can be attributed to the favourable conditions of the river bank (inshore habitats provide microcrustaceans refugia and nutrients) and also hydrological conditions, water flow differ among inshore and offshore habitats. Looking at diversities, it seems to be a paradox, i.e. relatively low species number vs. relatively high diversity, but this is due to the higher evenness in the streamline. Quantitative distribution of microcrustaceans can be explained with a similar story. The stagnant water character is supposed to support high abundance in the side arms of RSD, as was the case effectively.

In the main channel of the Danube River, there was a negative relationship between crustacean plankton density and water residence time and a positive correlation between

density and discharge, thus, densities do not peak when water level is low (low discharge, long residence time), but mostly on the contrary. This suggests that zooplankton production in the main channel is of minor importance, floodplain areas and adjacent water bodies seem to be rather important sources of plankton biomass (Reckendorfer et al. 1999, Saunders & Lewis 1989, Kiss 2006, Schöll et al. 2006). Positive correlation between microcrustacean density and water level and the relatively high number of tychoplanktonic elements observed in the main channel also support this hypothesis.

There were remarkable variations among water bodies based on the qualitative and quantitative compositions of microcrustacean assemblages, however, it is worth mentioning that samples taken from the side arm of Szentendre did not show much difference from samples collected in the main channel. In author's opinion, it is due to the fact, that shoreline configuration and hydrological regime of the side arm is rather similar to those of the Danube. The rich planktonic crustacean fauna of the RSD, both from qualitative and quantitative points of view, can be attributed to decreased velocities, habitat heterogeneity and presence of macrophytes.

Although significant differences were demonstrated between upstream (Újpest-Békásmegyer) and downstream (Tököl-Százhalombatta) sections considering densities of some groups of microcrustaceans, all in all, there was no considerable variation in qualitative and quantitative composition of crustacean plankton between upstream and downstream profiles. As a result, it can be concluded, that the capital and its wastewater load poorly affects microcrustaceans, likely due to the buffering capacity of the large volume of water.

Results of processing samples taken on the daily basis in the Sport-sziget side arm pointed out that sampling effort and sampling frequency can have a significant impact on the observation of the qualitative and quantitative composition of the planktonic crustacean assemblage at least within the framework of the case study. The author, however, stresses that the Sport-sziget side arm has a stagnant water character and these findings cannot be extrapolated to the main channel without references, what is more, results are based on a dataset of 39 days, which does not consider seasonal dynamics.

Results of the two-year study indicated that the biweekly sampling strategy does not adequate definitely. Partly, it is likely due to the relatively short generation time of cladocerans. Sensibility of the method is strongly dependent upon the duration of the period when samples are collected at a daily frequency. Ideally, one should collect samples throughout the year, i. e. throughout 365 days, so as to get a very clear picture of the information loss and to consider

seasonal variations. Failure of the method increases with fast population growth not happened within the daily sample taking procedure.

## References

- Bothár, A. 1973. Crustacea-Planktonuntersuchungen im Donauarm von Soroksár. *Danubialia Hungarica* LXV. *Annales Universitatis Scientiarum Budapestinensis Sectio Biologia* 15: 129-144.
- Bothár, A. 1975. Die Änderungen der Crustacea-Gemeinschaften des Planktons aufgrund der im Donauabschnitt von Göd (Stromkm 1669) durchgeführten Untersuchungen. *Danubialia Hungarica* LXXVIII. *Annales Universitatis Scientiarum Budapestinensis Sectio Biologia* 17: 137-146.
- Bothár, A. 1985. Die qualitative und quantitative Verbreitung der planktonischen Crustaceen im ungarischen Donauabschnitt von 1965-1985. 25. Arbeitstagung der IAD, Bratislava, Wissenschaftliche Kurzreferate 283-287.
- Bothár, A. 1988. Quantitative und qualitative Zooplanktonuntersuchungen im Donauabschnitt oberhalb und unterhalb von Budapest I. J. 1987. 27. Arbeitstagung der IAD, Mamaia/Romania, Wissenschaftliche Kurzreferate 179-182.
- Bothár, A. 1994. Qualitative und quantitative Planktonuntersuchungen in der Donau bei Göd/Ungarn (1669 Strom km) II. Zooplankton. 30. Arbeitstagung der IAD, Zuoz/Schweiz, Wissenschaftliche Kurzreferate 41-44.
- Bothár, A. 1996. Die lang- und kurzfristigen Änderungen in der Gestaltung des Zooplanktons (Cladocera, Copepoda) der Donau – Probeentnahmestrategien. 31. Arbeitstagung der IAD, Baja/Ungarn, Wissenschaftliche Referate 1: 201-206.
- Bothár, A. & Kiss, K. T. 1990. Phytoplankton and zooplankton (Cladocera, Copepoda) relationship in the eutrophicated river Danube. (*Danubialia Hungarica* CXI.) *Hydrobiologia* 191: 165-171.
- Gulyás, P. 1994a. Studies on the Rotatorian and Crustacean plankton in the Hungarian section of the Danube between 1848,4 and 1659,0 riv. km. In: Kinzelbach, R. (ed.) *Biologie der Donau*: 49-61. Gustav Fischer, Stuttgart.
- Gulyás, P. 1994b. Hydrobiological research of the Danube between Rajka and Budapest. II. Rotatorian and crustacean plankton. XVII<sup>th</sup> Conference of the Danube Countries on Hydrological Forecasting and Hydrological Bases of Water Management, Budapest, 1994, pp. 721-725.



- Gulyás, P. 1995. Rotatoria and Crustacea plankton of the River Danube between Bratislava and Budapest. *Miscellanea Zoologica Hungarica* 10: 7-19.
- Gulyás, P. 2002. A Rotatoria és Crustacea plankton minőségi és mennyiségi vizsgálata a Dunán. *Vízügyi Közlemények* 84: 601-620.
- Just, I., Schöll, F. & Tittizer, T. (eds.) 1998. Versuch einer Harmonisierung nationaler Methoden zur Bewertung der Gewässergüte im Donauarm am Beispiel der Abwasser der Stadt Budapest. Umweltbundesamt, Berlin, pp. 65.
- Kiss, A. 2006. Cladocera, Ostracoda and Copepoda assemblages in different side-arms of the Danube in Gemenc floodplain (Danube-Dráva National Park, Hungary). *Proceedings 36th International Conference of IAD. Limnological Reports* 36: 250-254.
- Reckendorfer, W., Keckeis, H., Winkler, G. & Schiemer, F. 1999. Zooplankton abundance in the River Danube, Austria: the significance of inshore retention. *Freshwater Biology* 41: 583-591.
- Saunders, J. F. & Lewis, W. M. 1989. Zooplankton abundance in the lower Orinoco River, Venezuela. *Limnology and Oceanography* 34: 397-409.
- Schöll, K., Dinka, M., Berczik, Á., Kiss, A., Ágoston-Szabó, E., Schmidt, A., Fehér, G. 2006. Hydrobiological differences in the Danubian water system with periodically connections with the Danube (Gemenc floodplain, Danube-Dráva National Park, Hungary). *Proceedings 36<sup>th</sup> International Conference of IAD. Limnological Reports* 36: 338-342.
- Soballe, D. M. & Kimmel, B. L. 1987. A large-scale comparison of factors influencing phytoplankton abundance in rivers, lakes, and impoundments. *Ecology* 68: 1943-1954.

#### **Articles published in the topic**

- Mészáros, G., **Vadadi-Fülöp**, Cs., Udvari, Zs. & Hufnagel, L. 2007. Analysis of spatial and temporal changes of the zooplankton fauna in the Ráckeve-Soroksár Danube arm. *Tájökológiai Lapok* 5: 333-345.
- Vadadi-Fülöp**, Cs. & Mészáros, G. 2007. A Ráckevei-Soroksári Dunával kapcsolatos zooplankton és makrogerinctelen kutatások áttekintése. *Hidrológiai Közöny* 87 (3): 60-63.
- Vadadi-Fülöp**, Cs., Mészáros, G., Jablonszky, Gy. & Hufnagel, L. 2007. Ecology of the Ráckeve-Soroksár Danube - a review. *Applied Ecology and Environmental Research* 5 (1): 133-163.
- Vadadi-Fülöp**, Cs. 2008. Planktonikus rák vizsgálatok a Ráckevei (Soroksári)-Duna felső szakaszán. *Hidrológiai Közöny* 88 (3): 49-51.

- Vadadi-Fülöp**, Cs., Mészáros, G., Jablonszky, Gy. & Hufnagel, L. 2008. The zooplankton of the Ráckeve-Soroksár Danube: spatio-temporal changes and similarity patterns. *Applied Ecology and Environmental Research* 6 (4): 121-148.
- Vadadi-Fülöp**, Cs. 2009. Zooplankton (Cladocera, Copepoda) dynamics in the River Danube upstream and downstream of Budapest, Hungary. *Opuscula Zoologica Budapest* 40 (2): 87-98.
- Vadadi-Fülöp**, Cs., Hufnagel, L., Jablonszky, Gy. & Zsuga, K. 2009. Crustacean plankton abundance in the Danube River and in its side arms in Hungary. *Biologia* 64: 1184-1195. Impakt faktor: 0,406
- Vadadi-Fülöp**, Cs., Zsuga, K. & Hufnagel, L. 2009. Mintavételi gyakoriság hatása a rákplankton közösségi összetételének észlelésére: dunai esettanulmány. *Hidrológiai Közlöny* 89 (6): 72-75.
- Vadadi-Fülöp**, Cs., Hufnagel, L., Zsuga, K. 2010. Effect of sampling effort and sampling frequency on the composition of the planktonic crustacean assemblage: a case study of the river Danube. *Environmental Monitoring and Assessment* 163: 125-138. Impakt faktor: 1,035

#### **Conference abstract**

- Vadadi-Fülöp**, Cs., Hufnagel, L. & Mészáros, G. 2007. Planktonikus rák fajgyűttesek kompozíciós viszonyai különös tekintettel a Ráckevei-Soroksári Dunára. XLIX. Hidrobiológus Napok, Tihany, Abstract: 49.