Joint Danube Survey 3

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International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

Chapter (summary report) on: Zooplankton

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1 Introduction

Zooplankton is a fundamental component of the pelagic food web. It is the main link between small phytoplankton and larger carnivores, primarily young fish.

Several studies have been organized in River Danube so far, which investigated shorter or longer sections of the river: Rotifera dominance and the similarly high proportion of nauplius and copepodit larvae among Crustacea were proved by Bothár (1974), Naidenow and Schewzowa (1990), Naidenow et al. (1991) and Gulyás (1994, 1995). The most frequent occurrence has been observed by species typical of still or slow-flowing eutrophic waters. According to earlier results, the dominant species of the river are: *Brachionus calyciflorus*, *Keratella spp.*, *Synchaeta spp.*, *Bosmina longirostris*, *Thermocyclops crassus*, *Acanthocyclops robustus* (Reckendorfer et al. 1999, Zsuga 2008). Bothár (1974) pointed out that the joining of Drava and Tisza did not have an effect on Crustacea plankton.

Naidenow (1998) laid the qualitative and quantitative proportions of the Danube zooplankton in a comprehensive work, on the grounds of the results of 164 studies. In the aspect abundance the Upper Section until Slovakia proved to be the poorest, the amount increased in Hungary, but then dropped in Croatia, Serbia and Bulgaria.

Gulyás (2002) reported the zooplankton survey made on the section between Neu-Ulm and Tulcea in summer 2001 (JDS1). According to the results the individual numbers were the lowest in the German, Austrian, Romanian and Bulgarian sections of the river, the highest on the section below Budapest and in Croatia and Serbia. Low rates of individual numbers were also observed at Neu-Ulm-Tass, as well as on the section between Iron Gate Reservoir and Danube Delta. The primary reasons for these results are the higher water flow velocity in the Upper Section, and the high turbidity in the Lower Section.

According to the surveys of Sandu and Kutzenberger (2008) in consequence of the global climate change the water level decreases and the temperature increases in Danube Delta lakes. The rise in temperature would be the cause of the increase of abundance and would grow the rate of presence of the warm stenotherm organisms.

Lovász (2012) demonstrated from the analysis of the 60 years (1950-2010) observation, that the water of the Danube is generally warmer. His conclusions: "The overall rising trend in the monthly mean temperature indicates remarkable climate change which began from the 1980s, and has been continuing to our days."

Vadadi-Fülöp (2012) demonstrated that the flow regime has an important role for the development and abundance of of the Danube.

2 Methods

During JDS3 53 sampling sites were investigated in the Danube River – from each profile from left, middle and right side zooplankton samples (sum total 159) were collected. Among of the tributaries 11 were examined in the middle profile. Out of zooplankton the three main characteristic groups, Rotifera, Cladocera and Copepoda community were investigated in details. For the analysis of zooplankton 50 litres water were filtered through plankton net with 50 µm mesh size at all three (left, middle, right) profiles. The samples were preserved in the field in formaldehyde 4-5 % concentration. The quantity and qualitative composition of zooplankton was determined with light- and stereomicroscope. For the purpose of exact identification of some Rotifera species their trophi was prepared with sodium hypochlorite solution. The abundance was given in ind/100 litres unit. We investigated the ratio of Rotifera, Cladocera, Copepoda, and the characteristic, dominant species or taxa in the different reaches of the Danube.

3 Results

In the Danube River and its tributaries 149 zooplankton taxa have been identified: 107 Rotifera, 33 Cladocera and 9 Copepoda. These values are a little higher than JDS1 and JDS2 values (Zsuga 2008; Gulyás 2002). The majority of the species maintain planktonic living, however, in some sampling areas tychoplanktonic elements, which penetrate the plankton from aquatic plant environment or from the surface of the sediment through mud-mixing, have been found.

The distribution of zooplankton in the whole longitudinal profile of the Danube presents the following features: Rotifera and Copepoda have the most numerous populations; Cladocera populations are less abundant (Fig.1-3.). Earlier Gomoiu et al. (1997) demonstrated similar abundance relations in the lower section and Iron Gate of Danube.

3.1. Quantity of the zooplankton community

3.1.1. Rotifera plankton of the Danube River

In the Upper Danube to the rkm 1800 (German, Austrian, Slovak section) the density of zooplankton is very low. From the Rotifera *Brachionus angularis*, *Br. calyciflorus*, *Keratella tecta* and *Synchaeta* spp. (Photo 1-3.) are dominant, their ratio is changing.

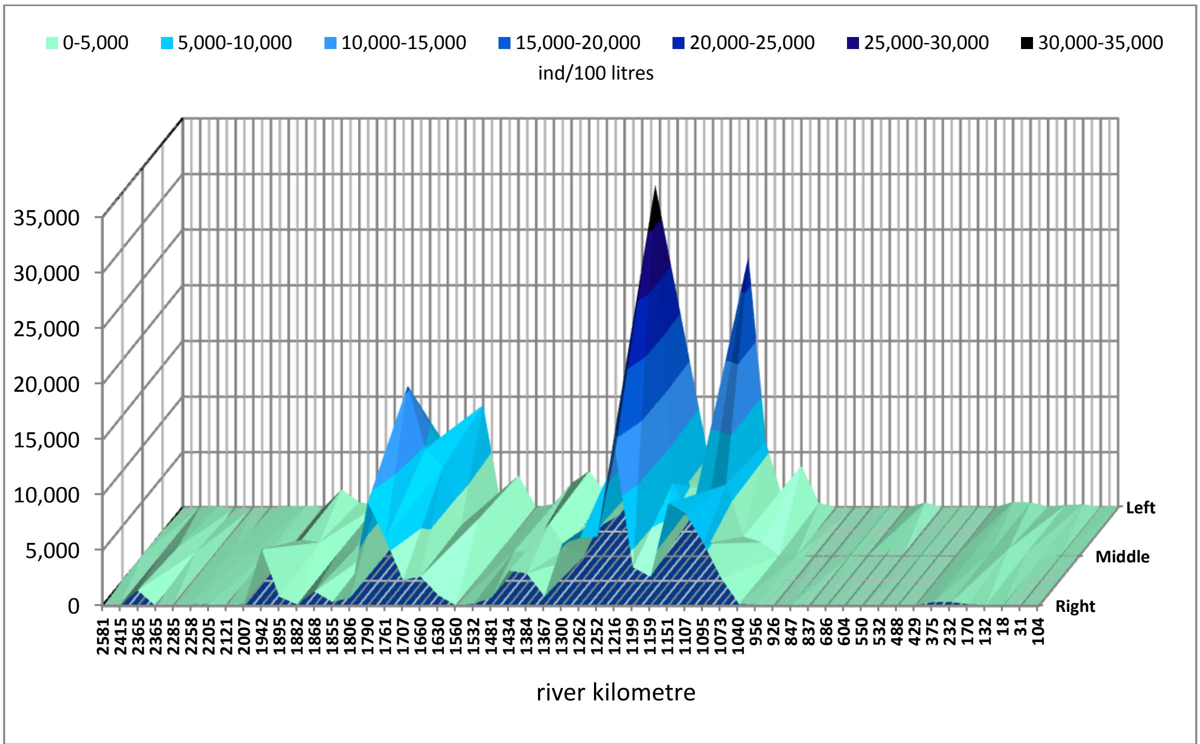


Figure 1: Rotifera abundance in the longitudinal profile of the Danube River

Between Klizska (rkm 1790) and Szob (rkm 1707) was a medium abundance of zooplankton, further downstream in the Hungarian Danube section the abundance decreases. In the Serbian reach between rkm 1300 and 1216 the increase of zooplankton abundance is observed, which is the most intensive in the area of Stari Slankamen (Fig.1). This situation corresponds to JDS2 results (Zsuga 2008). Along the whole river the highest individual numbers of Rotifera plankton density can be found in the rkm 1216 (Stari Slankamen) and rkm 1151 (Downstream Pancevo). The value of abundance measured here is about four times higher than the JDS2 values. This result calls attention to an increased nutrient load and eutrophication of this section. In the rotifers community the proportion of *Synchaeta oblonga* and *S. kitina* being 80-95 % indicates the eutrophic state of the Danube River. The main food is phytoplankton for the most rotifer species, therefore the density of rotifers is closely connected with the phytoplankton and chlorophyll-a value (compare chapter Phytoplankton). In the Iron Gate Reservoir and the Lower section of the Danube River the abundance of Rotifera plankton is low, but the diversity is higher than in the previous section. In the lateral profile of the river the middle segment has the highest abundance at most of the sites, and the Rotifera plankton of the left and right side does not differ significantly from each other (Fig.1).

3.1.2. Cladocera plankton of the Danube River

The density of cladocerans in the upper stream is very low. In the rapid streaming circumstances the conditions are not prosperous to the development of the Cladocera community. In the middle Danube section the abundance is elevated, the highest values were observed at Serbian section (rkm 1330-1073), the maximum was in the left profile at area of Pancevo (rkm 1151) (Fig.2). This value is about 1,5-2 times higher than that observed during JDS2 (Zsuga 2008). In this Danube reach the most diversified composition (9 species) can be seen. In the area of the Iron Gate Reservoir and the Lower Danube the abundance decreased, and the change of species composition can be registered. The characteristic *Disparalona rostrata* (Photo 10.) of the previous sections becomes rarer, but the high proportion of *Bosmina longirostris* (Photo 8.) is continued. At the same time the ratio of euplanktonic *Daphnia cucullata* and *Diaphanosoma brachyurum* (Photo 9.) increases in the river. In the lateral profile of the Danube the left side had the higher cladocerans density, the middle and the right side did not differ significantly from each other, and no difference was observed in the composition as well (Fig.2).

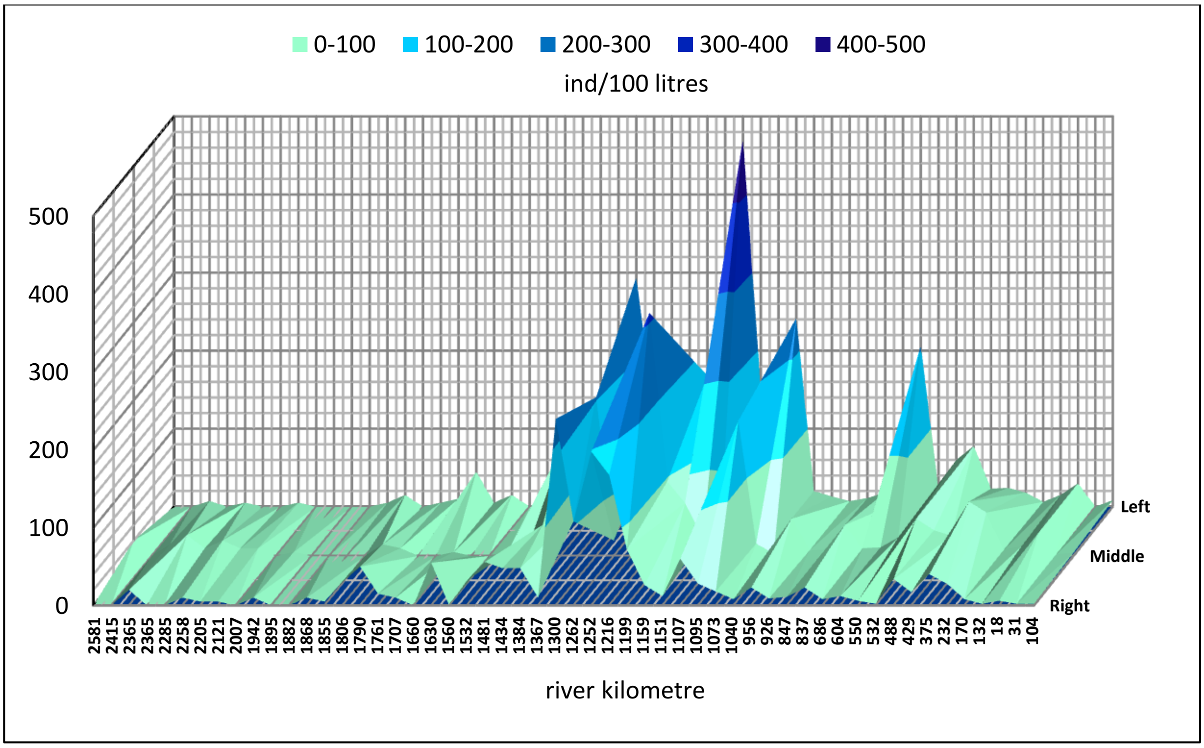


Figure 2: Cladocera abundance in the longitudinal profile of the Danube River

3.1.3. Copepoda plankton of the Danube River

In the Copepoda community the nauplii forms are dominant in the whole longitudinal section. The tendency of copepods abundance is similar to cladocerans. In the rapid streaming of the upper Danube the tychopanktonic copepodits of Harpacticoida group were also found. The highest abundance is characteristic in the middle region of the river downstream Pancevo (Fig.3) and it is higher than the value observed during JDS2. In the Lower Danube reach down to the Delta there was a significant change observed, the quantity of copepods becomes the highest among the three zooplankton groups. The adult copepods *Thermocyclops crassus* and *T. oithonoides* (Photo 11.) are characteristic species, and the *Eurytemora velox* (Photo 12.) can be found in some sections as well. In the lateral river profile the higher density in the left side can be observed, while the density of middle and right segment copepods community is similar. The reason would be for this the different hydromorphological conditions in the lateral profile of the river (different water movement, different turbulence, etc).

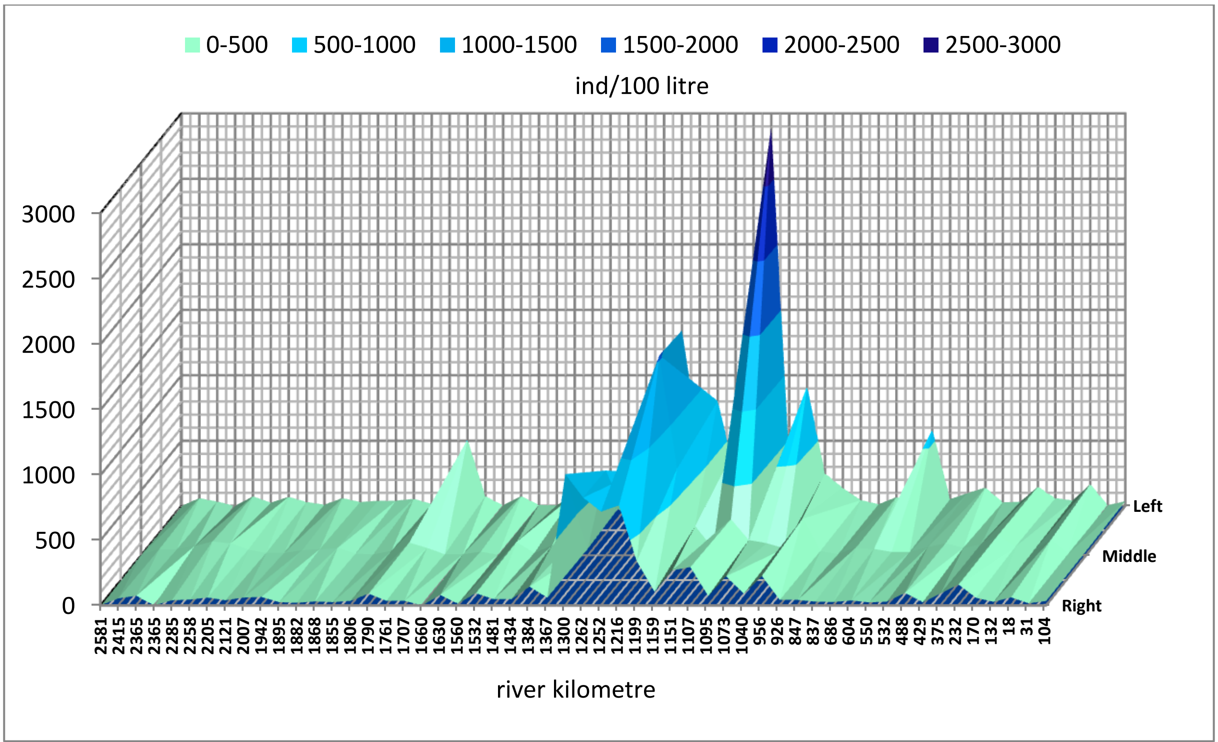


Figure 3: Copepoda abundance in the longitudinal profile of the Danube River

The density of the three main zooplankton groups is different in the lateral profile of the Danube (Table 1.). In the middle segment the Rotifera plankton species had the major abundance while the Crustacea plankton density was elevated in the left side. The reason would be for this the different hydromorphological conditions in the lateral profile of the river (different water movement, different turbulence, etc).

Table 1. Distribution of the abundance maximum in the lateral profile of the 53 sampling places of the Danube River

Lateral profile	Rotifera	Cladocera	Copepoda
Left	29.4 %	**35.6 %**	**40.5 %**
Middle	**45.6 %**	**37.3 %**	32.5 %
Right	25.0 %	27.1 %	27.0 %

3.1.4. Zooplankton abundance of the tributaries

In the tributaries the greatest diversity and highest abundance are recorded also for the group Rotifera. These results are similar to the data of Ostojic et al (2004). Only in the River Tisa the Copepoda abundance was higher than that of Rotifera, this was caused by an increased number of nauplii (Fig.4.). In the most cases the tributaries did not influence significantly neither the quantity nor the composition of the Danube zooplankton, the only exception being the Danube downstream Drava showing an increase of zooplankton diversity.

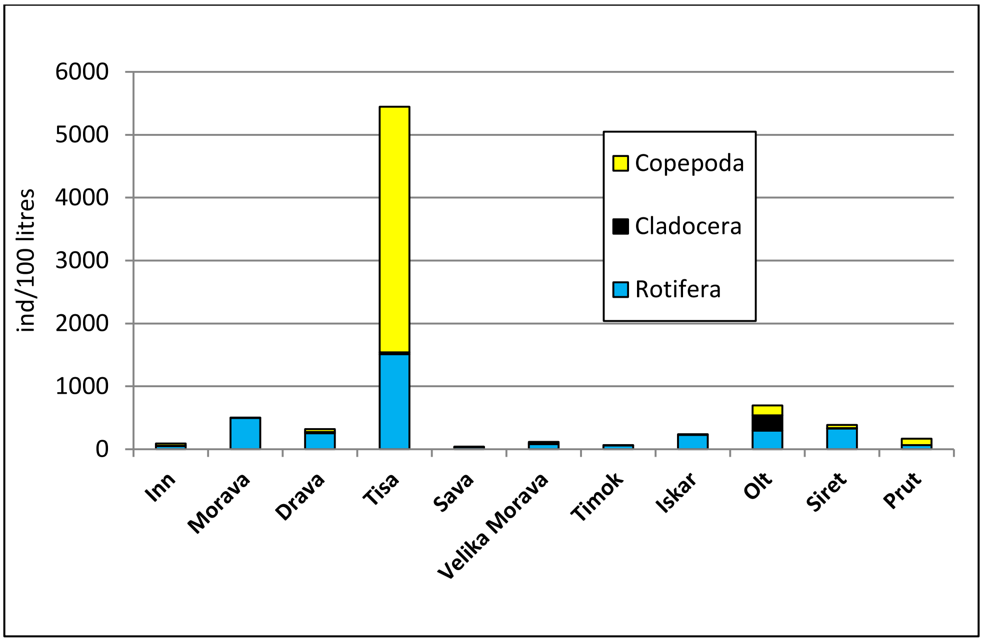


Figure 4: Abundance of the zooplankton groups in the tributaries of the Danube River

3.2. Composition of the zooplankton community

In the Danube River and its tributaries 149 zooplankton taxa have been identified: 107 Rotifera, 33 Cladocera and 9 Copepoda. These values are a little higher than JDS1 and JDS2 values (Zsuga 2008; Gulyás 2002). The majority of the species maintain planktonic living, however, in some sampling areas tychoplanktonic elements, which penetrate the plankton from aquatic plant environment or from the surface of the sediment through mud-mixing, have been found.

From the rotifers *Brachionus calyciflorus*, *Keratella tecta* and *Synchaeta oblonga* are dominant species, they live in the pelagial. The species richness was the biggest in the Croatian-Serbian section, the number of taxa changed between 24-28 (Fig.5.). Simultaneously the species diversity was very low in this reach; only 2-3 species gave the 80-90 % of the rotifers community.

There were some rare rotifers above common species, which were found only 1-2 sampling places. They are mainly methaphytic elements, and were some species which live in the shallow waters (*Lecane papuana (syn: Lecane luna presumpta*, (Segers 2007) (Photo 5.), *Lecane obtusa*, *Tripleuchlanis plicata* (Photo 7.) and other Lecane, Mytilina, Ploesoma, Cephalodella, etc. taxa). Presence of some species was surprising, because they prefer to warmer, subtropical waters: *Lecane elegans* (Photo 6.) (Bertani et al. 2011), it was found in 6 sampling places. During the previous surveys (Zsuga 2008) *Brachionus forficula* (Photo 4.) was only in some sections of the Danube, but during JDS3 this species lives almost in the whole middle and lower longitudinal profile of the Danube (21 sampling places). This is a warm stenotherm organism (Koste 1978, Kutikova 1970); its stabile presence may refer to the rise temperature. I think these result are important, in my opinion also can refer to climate change. It indicates simultaneously also organic pollution.

The composition of crustacean plankton was richest at the middle and lower section of the river, except Iron Gate reservoirs reach (Fig.5.). The dominant species are common planktonic elements, but in this group are also some tychoplanktonic species. The *Eurytemora velox*, known as an invasive species, was found a few sampling area, similarly to JDS2 (Zsuga 2008). Its rapid spreading in Danube River could not register during JDS3.

In the tributaries of the Danube River the taxa number of rotifer community is higher than crustaceans, the most species were in Morava, Drava and Tisa (Fig.6.). In some rivers cladocerans not found in the time of survey (Morava, Sava, Timok, Iskar, Prut), and here only the copepodite and nauplii larvae stages were noted from the Copepoda community.

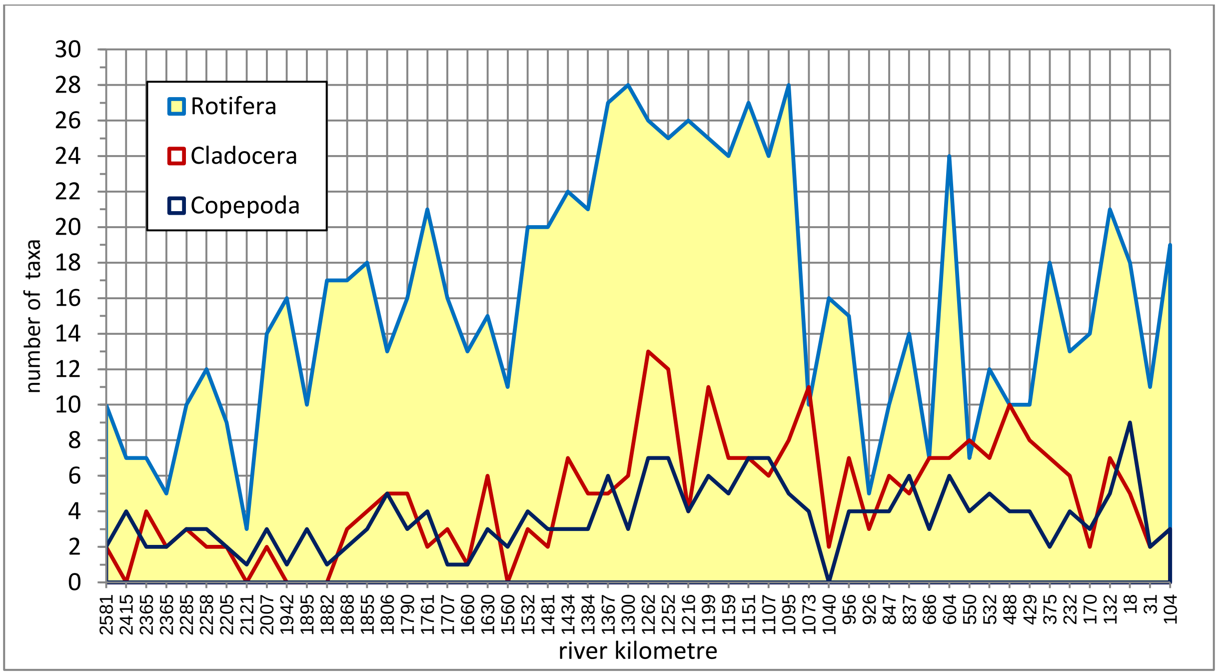
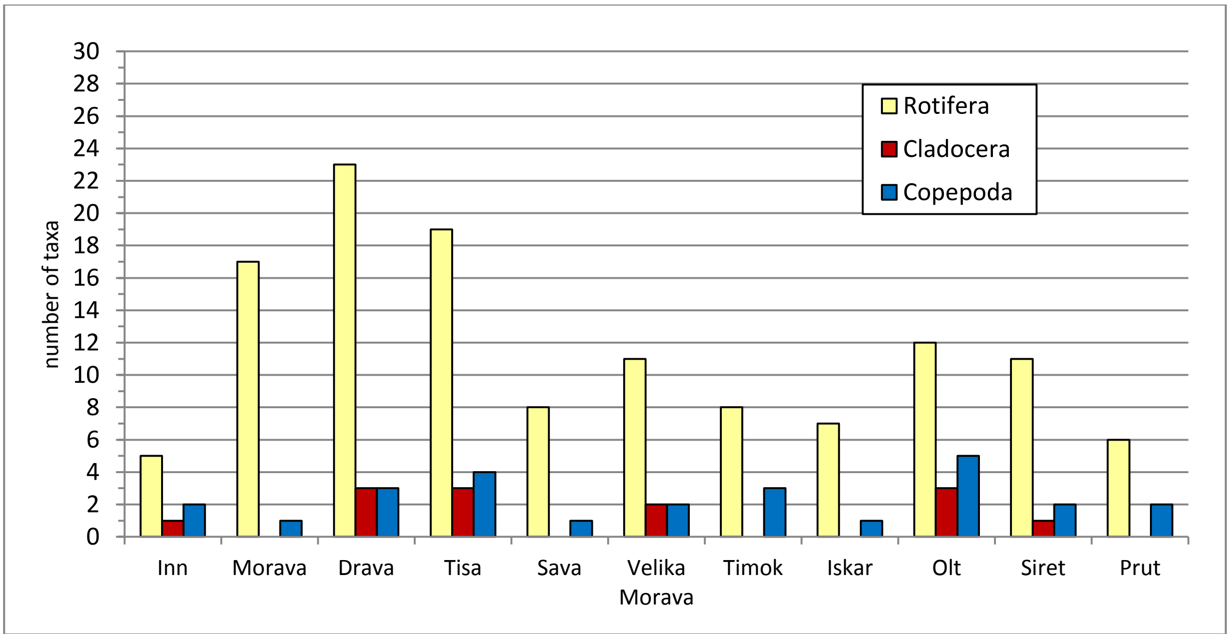


Figure 5: Change of the zooplankton taxa number in the longitudinal profile of the Danube River

Figure 6: Number of taxa of the zooplankton groups in the tributaries of the Danube River



3.5. Other organisms in the plankton of the Danube River

The characteristic *veliger larvae* (Photo 13-15.), -similarly to JDS2 -, were found in high proportion in several sections of the Danube (Fig.7.), but their species identification was not done. We suggest monitoring of the *veliger larvae* in zooplankton of the Danube River, because they can give important information about spreading of the invasive bivalve species (Bódis et al. 2012) along the Danubian water way.

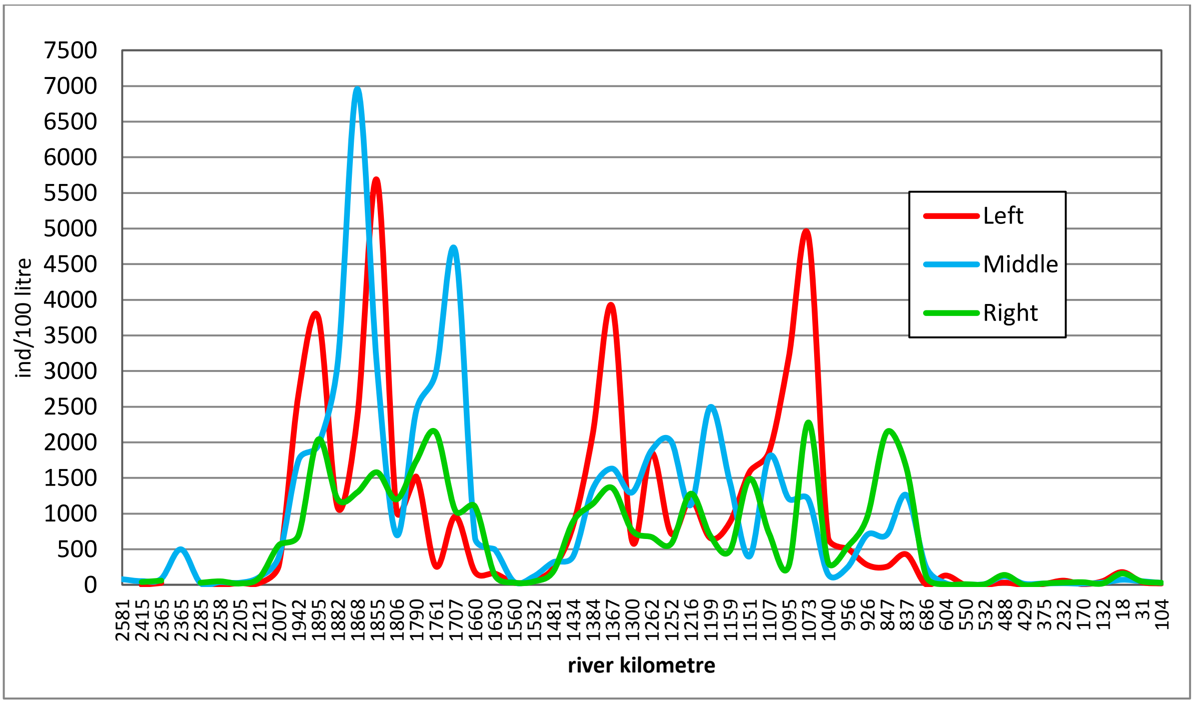


Figure 7: Abundance of the veliger larvae in the longitudinal profile of the Danube River

4. Conclusion

In the Danube River the density of zooplankton varied substantially. Water velocity and the amount of turbidity both had significant effects on the zooplankton density. The high numbers have evolved in the slow flowing Middle Danube reach. A number of sections can be identified along the river with zooplankton abundances considerably differing from each other.

In the Danube River and its tributaries 149 zooplankton taxa have been discovered, out of which 107 Rotifera, 33 Cladocera and 9 Copepoda have been registered. There are tychoplanktonic elements among planktonic community, coming from aquatic plant stocks or from the sediment. The zooplankton composition of the main branch shows that in some cases the dead arms and side arms have an effect to the Danube plankton as well (tychoplanctonic, metaphytic elements, which live mainly in the shallow waters *Macrothrix*, *Leydigia* sp.).

The proportion of the dominant species was the same as in former researches (Gulyás 1992, Zsuga 1998). The density of zooplankton was in general higher than in 2007 (JDS2), the reason would be for this the rise of temperature (global climate change), the increase of nutrient load.

The maximum individual number was registered in the Serbian reach, where the most eutrophic-polytrophic environment was found (*Brachionus calyciflorus, Keratella tecta, Synchaeta oblonga, S. tremula, Bosmina longirostris, Daphnia cucullata, Diaphanosoma brachyurum, Thermocyclops crassus, T. oithonoides)*. There was no increased abundance or species number observed in reservoir sections and in the Danube Delta.

During the previous surveys (Zsuga 2008) a Rotifera species, *Brachionus forficula* was found only in some sections of the Danube, but during JDS3 this species was found almost in the whole longitudinal profile of the Danube. This is a warm stenotherm organism (Koste 1978,Kutikova 1970); its stabile presence may refer to the rise temperature.

In the lateral profile of the Danube the density of the three main zooplankton groups is different. The reason would be for this the different hydromorphological conditions in the lateral profile of the river (different water movement, different turbulence, etc).

The tributaries did not have a significant effect neither on the quantity nor on the composition of Danube zooplankton.

The further investigation of veliger larvae in zooplankton is suggested along the River Danube, due to the importance of invasive alien Bivalvia species.

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6. Appendix

1. Brachionus calyciflorus

2. Synchaeta sp.

3. Keratella tecta

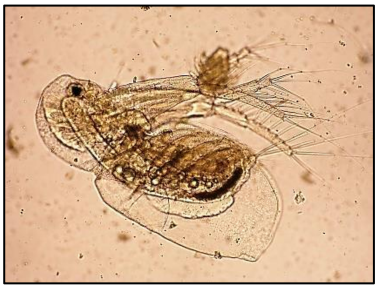
4. Brachionus forficula

5. Lecane papuana

6. Lecane elegans

7. Tripleuchlanis plicata

8. Bosmina longirostris

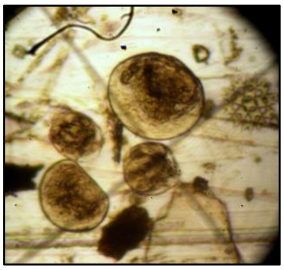


9. Diaphanosoma brachyurum

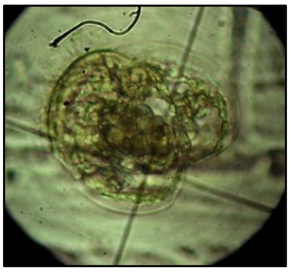
10. Disparalona rostrata

11. Thermocyclops oithonoides

12. Eurytemora velox



13-15. Veliger larvae



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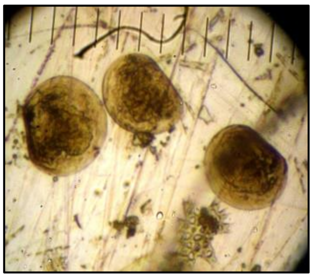

15.

Photos:

1-5; 8-9; 11; 13-15: Zsuga, K.

6.: http://rotifer.acnatsci.org/rotifer.php

7.: http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=284182

10.: http://s92.photobucket.com/user/bernhardinho/media/09_08_28_hammerst-002_2.jpg.html

12.: http://publication.nhmus.hu/NatEu/HNHM_Zoology/HNHM-CRU_Eurytemora_velox.jpg