Preliminary impressions about some macroinvertebrate sampling methods – shallow and deep waters in the Danube

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1 Introduction

The target of a synbiological survey is frequently a detailed data collection concerning the coexistential pattern of Biota living in the investigated water body. The general goal of the macroinvertebrate survey of the series of Joint Danube Surveys was highly the same: sampling sites were checked using different sampling methods in order to determine the taxa in the spot. These faunistic data are still important because the Danubian Fauna is not completely discovered, particularly the spreading phenomenon of aquatic alien invasive elements of the organisms.

Data of such longitudinal study provide several kinds of evaluation possibilities. Basically each of the sites could be regarded as separate entities and their macroinvertebrate communities could be evaluated independently of the others. However, the sequential order of longitudinal data provides several kinds of evaluations going into different depths of interpretation. It is plausible that methodologically the former type of analysis is much easier than the later ones.

The permanent increase of empirical knowledge concerning the spatial distribution of Danubian macroinvertebrate communities provoked new sampling approaches in time. A gradual development in sampling methodology of aquatic macroinvertebrates can be observed during the series of twelve years period of three Joint Danube Surveys: the change of sampling methods shows an interesting alteration in approach in the consecutive surveys. In the beginning (2001, JDS1) the *polyp grab*, the on-board installed sampling device of ARGUS ship was applied to sample the manually unmanageable rock fills situated in the marginal zone of the Danube not correctly emphasising the importance of only that portion of habitats and macroinvertebrates. Parallel, the simple *Kick and Sweep method* was also used providing several new presence-absence data for the Unionidae species taking the more natural habitats in consideration. These particular taxa were generally absent from the taxon list provided by the polyp grab sampling.

2007 brought basic change in the sampling approach because sampling was completed by the Austrian *Air Lift method* targeting macroinvertebrates living in the navigable edge zone of the Danube, near the left and right bank. This laborious and time consuming method - applied from the ARGUS ship again using its hydraulic crane resulted in quantitative dataset but in fact that has limited validity due to the small sample size (3-3 spot samples per site). An additional sampling method, *K&S* was again simultaneously applied above the Iron Gate II Reservoir, and another one, the *dredging* had to be used downstream, due to the suddenly increased water level. Dredging was focused to the same (low water littoral) zone that was sampled upstream by K&S at lower water discharge (and water level). The two different approaches (i.e. Air Lift in the deeper and K&S or dredging in the low water littoral zone) provided very useful taxon lists having clear complementary character.

During the third survey (JDS3 in 2013) the principal sampling technique was the *Multihabitat sampling (MHS)* procedure based on the AQEM approach (taking 20 sub-samples on both littoral zones (right and left) of the Danube. *Habitat proportional K&S sampling* was also taken on both sides of the river together with detailed look at the mussel species (tactile diving method). Using this additional semi-quantitative sampling procedure the data of mussels that live in the edge zone of the Danube are more comprehensive than the MHS and the deep water dredging data.

The third parallel sampling method was the *deep water dredging* in each 53 investigated Danubian cross sections providing new information about the macroinvertebrates living in the non wadeable zone of the Danube River.

This present macroinvertebrate dataset is now referring to the much more extended spatial dimensions of the Danube River than just the shallow marginal bank side littoral zone alone. Looking at the number of detected taxa by different sampling methods it is evident that all of the three sampling procedure have their own important value regarding to the detection ability of the Danubian macroinvertebrate Fauna. Several new publications are planned to deal with those new aspects that were revealed during the JDS3 project in the near future. Therefore this CD supplement contains only a very draft evaluation of the results of K&S sampling in the wadeable zone and the deep water sampling (along the five locations per cross section) in order to show a rough insight in the tremendous dataset. In some diagrams we took the data of the Multihabitat sampling group for illustrative purposes. The data were collected and evaluated in the Final Report of JDS3 by Wolfram Graf, Patrick Leitner, Thomas Hubner, Claudia Nagy and Péter Borza. We would like to thank them for their generous work during the JDS3.

The overall methodological conclusion of the JDS3 experiences for us, macroinvertebrate experts (that most probably is highly similar to the fish expert's opinion) is that large river research should never be restricted only to the shallow part of the water body. Knowledge about the biotic characteristics of the extended deep water realm is essential also.

2 Kick & Sweep Sampling (K&S)

2.1 Community analyses based on K&S data

Based on the K&S sampling procedure, all together 282 macroinvertebrate species were identified. Number of species recorded per taxonomic group is presented at **Table 1.** Aquatic insects were found to be the dominant component of the communities, with 160 taxa recorded.

Table 1: Number of taxa recorded per taxonomic group – K&S Sampling

TAXA		Number of taxa	
		K&S	Dredging
Porifera		3	
Turbellaria		2	1
Nematoda		1	1
Annelida total		48	22
	Polychaeta	2	1
	Oligochaeta	40	22
	Hirudinea	6	7
Mollusca total		44	35
	Gastropoda	21	15
	Bivalvia	23	20
Crustacea total		24	23
	Amphipoda	13	8
	Corophiidae		4
	Isopoda	1	1
	Mysidacea	7	7
	Decapoda	3	2
	Cumaceae		1
Insecta total		160	82
Ephemeroptera		13	5
Trichoptera		25	13
Odonata		8	4
Plecoptera		1	1
Diptera total		100	58
	Chironomidae	86	54
Heteroptera		7	
Coleoptera		7	1
Total number of taxa		**282**	**172**

The most heterogeneous group among insects were Diptera (100 taxa), with the most diverse family Chironomidae (86 species), followed by Trichoptera (25 species) and Ephemeroptera (13 species). Molluscs (44 taxa, Gastropoda – 21 species, Bivalvia 23) and Oligochaeta (40 species), Crustaceans (24 species), were the most diversified taxa groups after insects.

The number of taxa per sampling site ranged from 13 (JDS32, Upstream Novi Sad) to 63 (JDS14, Gabčikovo Reservoir).

Functional community analyses (feeding preference, the general relations of organisms in relation to preferred bottom substrate and watercourse zonation, shifts in organisms with preference to particular saprobic zone) revealed gradual changes along the Danube River, that are in some stretches influenced by both, natural peculiarities of the sector and human influence, primarily damming and reservoirs. Thus, linear trend of rising participation was recorded for collectors and filterers (functional feeding groups that are generally more represented in lower stretches of the rivers – **Figure 1**) and organisms that prefer find bottom sediments (**Figure 2**). In the same time, the trend of decline of participation litophylous taxa was identified.

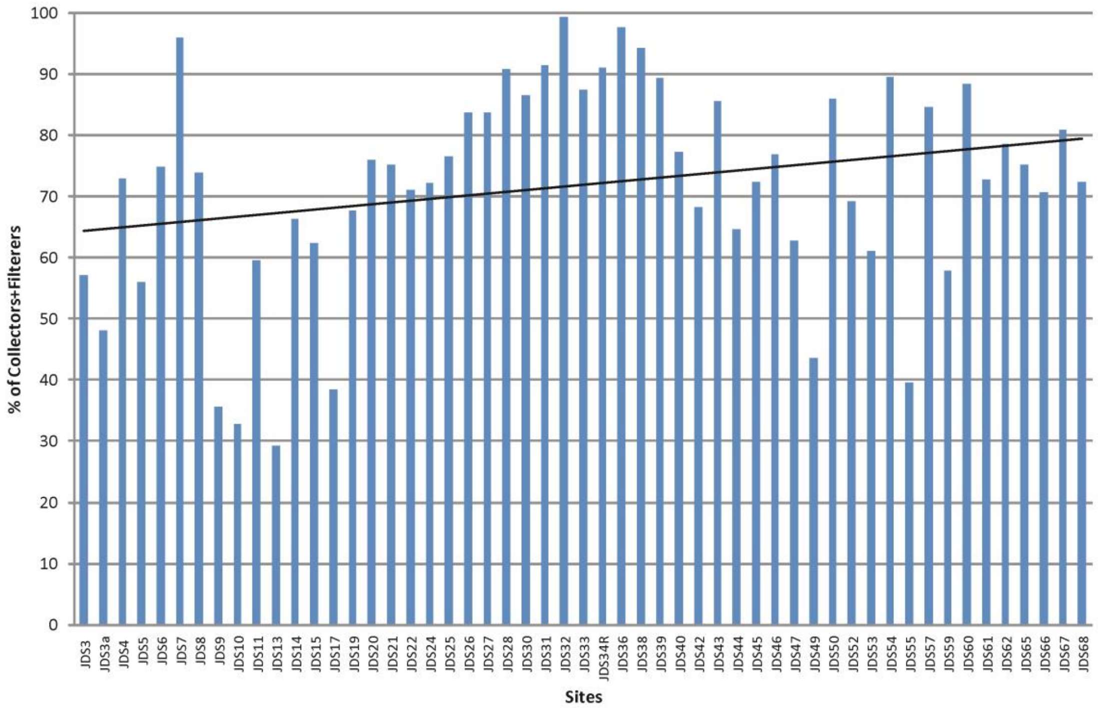

Figure. Participation of filterers and collectors feeding groups at sampling sites with rising linear trend – K&S dataset

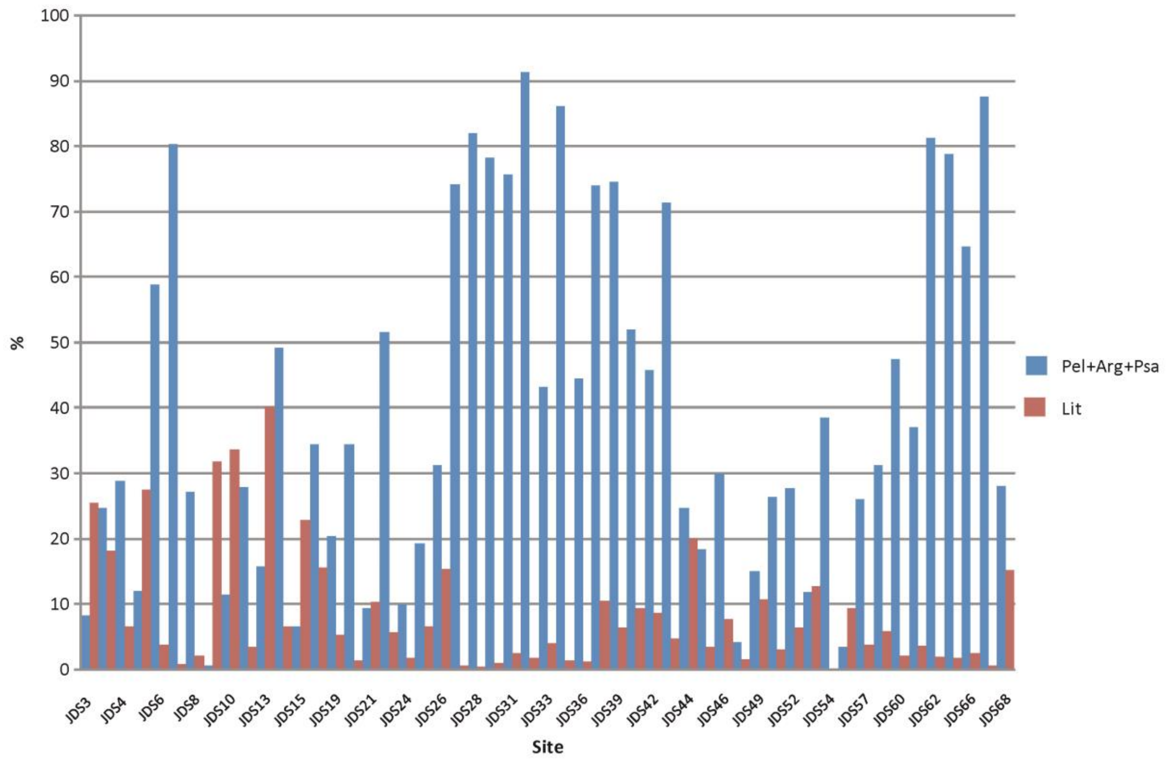

Figure 1. Participation of organisms preferring soft bottom substrates (pelal, argilal and psammal) and litophylous taxa at sampling sites – K&S dataset

K&S procedure revealed generally lower species richness in compare to MHS sampling (282 taxa in compare to 393, respectively). The highest difference in number of recorded taxa was found in the case insects of orders Diptera (K&S – 100, MHS – 160) and Ephemeroptera (K&S – 13, MHS – 24). Within other taxa groups, similar number of species is recorded, with exception of molluscs (K&S – 44, MHS – 30).

The higher number of species recorded by the MHS sampling compared to K&S clearly shows that sampling design has the major influence on the study results. MHS is more effective sampling approach for research programs, but the combination of two approaches could give the best results – e.g. to provide the most complete taxalist for large lowland rivers. Higher number of insect recorded by MHS approach indicates that specific less represented habitats that were sampled by this method, but typically not covered by K&S, represents the niche for significant number of species.

Comparing K&S results of JDS2 survey data (202 taxa identified), higher number of taxa recorded during JDS3 by applying the same technique could be explained by more favourable hydrological conditions during 2013. Namely, considerable increase of water level was recorded during JDS2, especially on the Lower Danube that influences both, capability of sampling and fauna distribution. During JDS3 more stabile hydrological conditions provided better possibility for sampling.

2.2 Sectioning of the Danube River based on K&S results

A contribution to the Danube typology by using K&S data was done applying CA analyses with Singular Value Decomposition (SVD) algorithm (KARADŽIĆ, 2013). Resulting CA diagram shows less difference within macroinvertebrate communities at sites belonging to certain stretches (**Figure 3**).

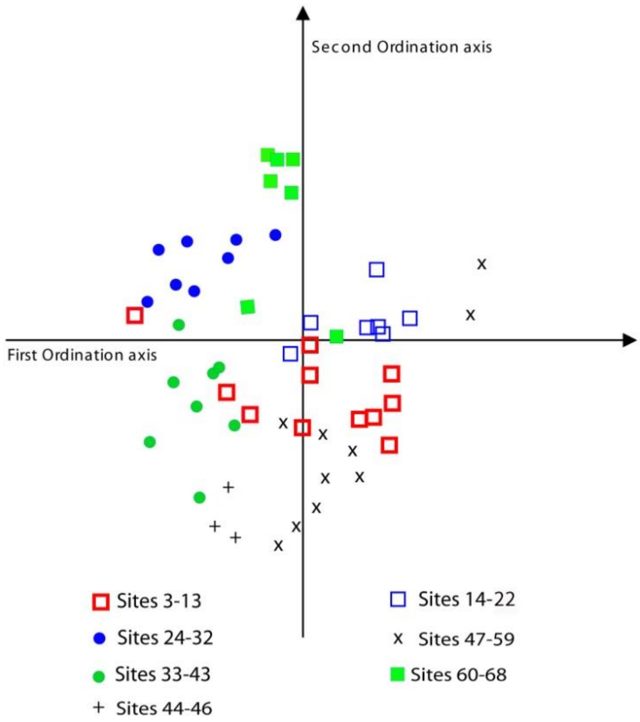

Figure 2. Resulting diagram of CA analysis based on K&S data

Presented results of K&S, as in the case of results based on MHS, show occurrence of six sectors. First one is the same in compare MHS results and could be characterised as the typical Upper Danube. The sites whose position is distinct from the group belong to reservoir sections.

Second group comprise sites from 14-22 (Gabčikovo-Downstream Budapest) and could be characterised as upper part of the Middle Danube, while the third comprise sites of the downstream sector of the Middle Danube (24, Dunaföldvár – 32, Upstream Novi Sad). In the Gabčikovo area there is a shift of general bottom substrate type and hydrological conditions that influence macroinvertebrate community characteristics.

Further downstream Novi Sad there is as zone of influence of Iron Gate (Đerdap) dam, more precise area of back water effect, which, together with natural characteristics of the area, influenced macroinvertebrate community and less difference in position of sites located in particular stretch (33, Downstream Novi Sad – 43, Banatska Palanka/Baziaš).

Below the site 43, the typical Iron Gate stretch starts (the border between the Upper and Lower Danube - LITERÁTHY et al. 2002, as well as between ecoregion 11 and 10 is located at particular site). Sites of the Lower Danube from 44-49 are situated below the x axis (together with 3 sites that belong to Iron Gate I and II area, 44-46). Only two sites from this group (Radujevac/Gruia and downstream Ruse) are positioned from the right side of the diagram, which indicates the difference of the fauna of those sites. Both sites are under significant anthropogenic pressure, which influenced macroinvertebrate community character. The first one (Radujevac/Gruia) is situated under the Iron Gate II dam and thus hydrological regime in the stretch directly depends on the regime of work of hydropower station, while the second one (Downstream Ruse) is under the influence of hydromorphological modification and urban pollution.

The sites of the lowest stretch of the Danube (60-68), based on CA analysis of K&S data, could be considered as distinct stretch. Only sites Vilkova - Chilia arm/Kilia arm (66) and St. George arm (68) are separated from the group, which is expected having in mind the influence of activities connected with navigation (works related to the improvement of waterways for the purpose of navigation, but also direct influence of ship traffic) and the vicinity of the Black Sea.

Presented results only partially go along with previous discussions on the Danube typology (e.g. LITERÁTHY et al. 2002 and the ICPDR, 2005, ‘WFD Roof Report’ ANNEX 3: Typology of the

Danube River and its reference conditions). Faunal distribution patterns are strongly connected with influence of pressures and in regards of study of relation fauna-stress factors further work is needed.

2.3 Indicative status assessment based on K&S

Results obtained by the K&S sampling are used to assess the indicative status in respect to organic pollution. In that regard, Saprobic Index (SI) was used and the same approach was used as in the case of MHS procedure, by employing ASTERIX software and related database.

The results of saprobiological analyses, as the measure of the level of organic pollution, based on K&S data are presented in **Table 3 of the Report**.

The results indicate generally moderate pressure caused by organic pollution. SI ranged from 1.87 to 3.445, with average value (AV) of 2.507 and deviation (STDEV) of 0.358. In general, saprobiological analyses by employing K&S data showed changes of saprobic conditions along the watercourse, which is partially influenced by rising organic pollution, but also reflect diverse natural conditions. Based on K&S data 3 sites are provisionally assessed to have high ecological status, 20 sites have good ecological status. Based on resulting values of SI, 19 sites could be characterised to have moderate ecological status, while the rest are assessed as to be in bad (9 sites) and poor status (2 sites).

Values of SI obtained by K&S during JDS3 expedition are higher in compare to those resulted from analyses of MHS data (AV of SI=2.256, STDEV=0.280), but also in compare to JDS2 results (both, obtained by Air Lift sampling - AV of SI=2.204, STDEV=0.272 and K&S sampling - AV of SI=2.127, STDEV=0.140).

It is evident that further work in development of SI for use in status assessment according to the recommendation of the WFD should be focused on the improvement of the lists of saprobic indicators, individual saprobic values and indicator values of listed species. Based on K&S dataset, large share of the community is not included in existing list of saprobic indicators. Thus, for used system (ASTERICS database based primarily on the Fauna Aquatica Austriaca ed. by MOOG, 1995), average proportion of specimens within community that belongs to species/taxa without saprobic characterisation (not included in the database) range from few percentages to 83.50%, with average value per sample of 27.90%. The fact that large proportion of the community is actually not included in the analyses clearly indicates necessity of further development of SI assessment system, primarily indicator lists for particular stretches.

3 Dredging

The number of taxa in the main taxonomic groups is shown on **Table 1.** for comparative purposes. Different sampling methods concentrating to different habitat types are providing very interesting and characteristic picture about the distribution and spreading ability of the aquatic macroinvertebrates.

Much less taxa were detected in the deep water region (in cross sectional points) than either by MH or K&S sampling in the littoral wadeable zone. Altogether 172 taxa were detected by the cross sectional sampling method in the Danube River in 53 different cross sections (5 dredges/site). The most abundant groups are the Insecta (82 taxa) and the Mollusca (from 35 taxa 15 Gastropoda and 20 Bivalvia). The largest taxon number characterizes Insects by the Chironomidae with 54 taxa. The Annelida group contains 22 Oligochaeta, 7 Hirudinea and one Polychaeta taxon. There are 8 Amphipoda, 7 Mysididae, 4 Coropiidae, 2 Decapoda and 1-1 Isopoda and Cumacea among the registered 23 different Crustacea taxa.

The picture is very different in terms of abundance values. **Table 2.** illustrates the list of macroinvertebrate species organized in the order of their abundances. Three groups are shown: **Taxongroup 1** (11 taxa) represents those ones that have bigger individual number than 2000 per sample, and at the same time they have more than 1 % relative frequency each. They contribute to more than 89 % of the total abundance. The total abundance almost reaches 95 % with other 9 taxa (**Taxongroup 2**). If we consider 22 additional taxa (**Taxongroup 3**) in the order of their relative frequency, it can be seen that these 42 most abundant taxa together are responsible for almost the 99 % of the total abundance of the benthic macroinvertebrates found in the Danubian dredged samples during JDS3.

Table 2. List of the most abundant macroinvertebrate taxa detected by dredging in cross sections of the Danube

Total number of individuals by dredging	189773	%				
				Chironomus nudiventris	977	0,515
Corbicula fluminea	65482	34,505		Dreissena bugensis	953	0,502
Dreissena polymorpha	18764	9,888		Rheotanytarsus sp.	809	0,426
Chelicorophium curvispinum	17510	9,227		Viviparus viviparus	745	0,393
Corophium sowinskyi	17261	9,096		Bithynia tentaculata	568	0,299
Corophium sp.	12643	6,662		Gammaridae Gen. sp.	391	0,206
Lithoglyphus naticoides	11821	6,229		Hydropsyche sp.	376	0,198
Chelicorophium robustum	6575	3,465		Fagotia esperi	349	0,184
Dikerogammarus villosus	6078	3,203		Potamopyrgus antipodarum	283	0,149
Hydropsyche bulgaromanorum	5661	2,983		Hypania invalida	232	0,122
Obesogammarus obesus	5397	2,844		Pontogammarus sarsi	208	0,110
Dikerogammarus haemobaphes	2134	1,125	89,23%	Pisidium supinum	204	0,107
Theodoxus fluviatilis	1591	0,838		Borysthenia naticina	200	0,105
Echinogammarus ischnus	1541	0,812		Brachycentrus subnubilus	170	0,090
Chironomus acutiventris/obtusidens	1286	0,678		Limnodrilus udekemianus	168	0,089
Limnodrilus hoffmeisteri	1169	0,616		Tanytarsus sp.	161	0,085
Isochaeta michaelseni	1077	0,568		Cladotanytarsus sp.	151	0,080
Jaera istri	1054	0,555		Theodoxus danubialis	150	0,079
Hydropsyche contubernalis	1046	0,551		Branchiura sowerbyi	137	0,072
Fagotia acicularis	1033	0,544		Holandriana holandrii	130	0,069
Dikerogammarus bispinosus	1017	0,536	94,92%	Potamothrix moldaviensis	119	0,063
				Chironomus plumosus-Gr.	119	0,063

3.1 Longitudinal change of taxon number and abundance in main taxonomic groups

The two first groups of taxa (first column) indicates mostly invasive taxa (*by italics*, 14 out of 20). It should be noted that most of them are Ponto-Caspic species meaning that their presence on the Lower Danube should be regarded as natural (native species on that reach). Only two taxa are new in the Danubian Fauna: *Theodoxus fluviatilis* was firstly reported from the Budapest section of the Danube not long ago (FRANK et al. 1990). Similarly, *Corbicula fluminea* was found at first in the lower Hungarian Danube in 1998 (CSÁNYI 1998-1999) as a new species.

Looking at the abundance and longitudinal distribution of the most frequent species, the introduction of abundance values is more illustrative in many cases on *logarithmic scale* because then both low and high individual numbers are well seen together. However, small abundance values are often hidden *normal scale* n on the diagram. This is why the longitudinal distribution of some taxa is illustrated in the forthcoming chapter sometimes on both scales.

Discussing the longitudinal distribution of taxa in their order of abundances the invasive *Corbicula fluminea* is the first species to be investigated (**Figure 4**). It is well shown on normal scale that the really large populations exist on the middle (Slovakian-Hungarian) and the lower (Bulgarian-Romanian stretches, including the Iron Gate I Reservoir. Abundance values almost reach 10 thousand/sample upstream Velika Morava, Radujevac and Ruse-Oltenita. The logarithmic scale is able to show that this mussel species is significantly present along the entire Danube, including the upper German section, as well.

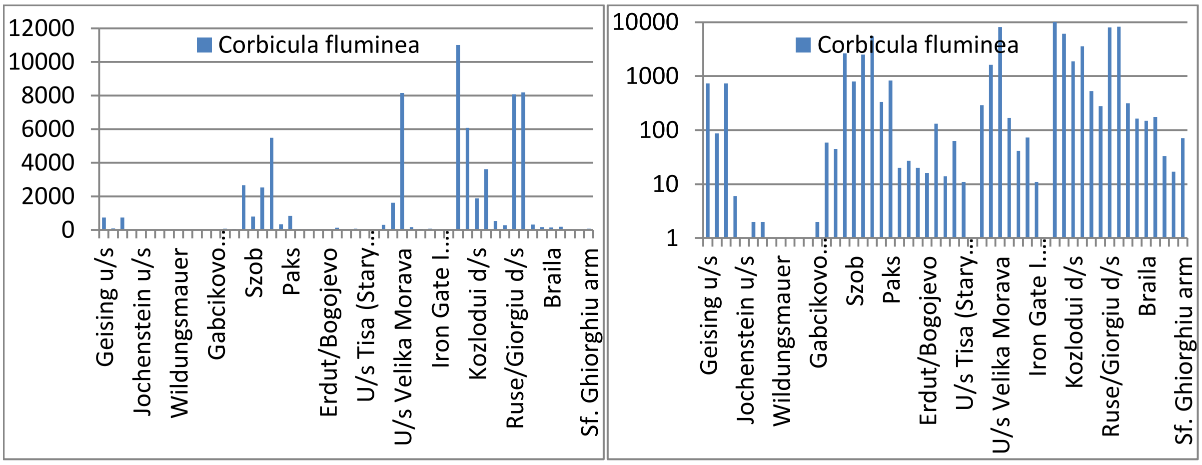

Figure 3. Longitudinal abundance values of *Corbicula fluminea* along the Danube River (JDS3)

Dreissena polymorpha has the peak abundance (and biomass) in the Novi Sad section where the mussels were detected in very large number in the whole cross section (**Figure 5**). Logarithmic scale illustrates again that the species together with the newly spreading *D. bugensis* are present along the whole investigated Danube section. We were not able to detect these animals along the upper stretch where the reservoirs/barrages together with particularly deep river bed are situated.

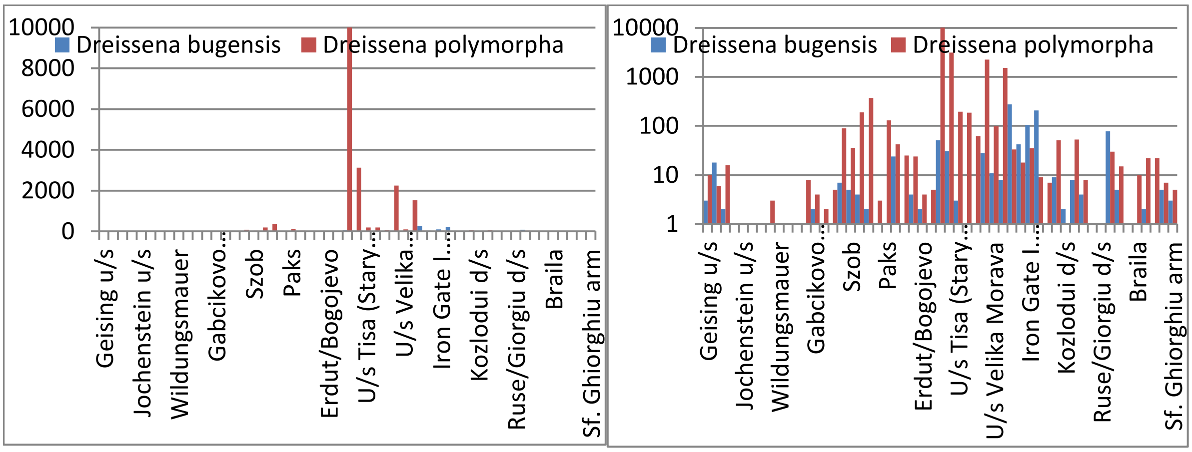

Figure 4. Longitudinal abundance values of *Dreissena bugensis* and *D. polymorpha* (JDS3)

Similar abundant group is formed by the species of Corophiidae. The most dominant populations are found on the Lower Danube where *Chelicorophium curvispinum, C. robustum* and *Corophium sowinsky* are all commonly occurring (**Figure 6**).

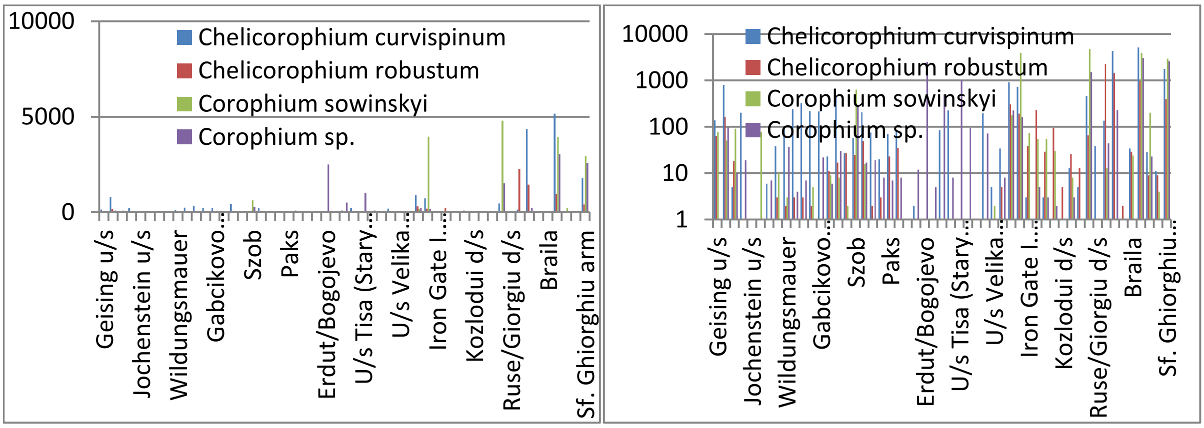

Figure 5. Longitudinal abundance values of Coropiidae along the Danube River (JDS3)

One aquatic snail is very abundant, too, principally in the middle section (from Pancevo to the Iron Gate section) and the Lower Danube. The abundance of *Lithoglyphus naticoides* exceeds 3500 ind/sample at the upstream of the Veika Morava tributary (**Figure 7**).

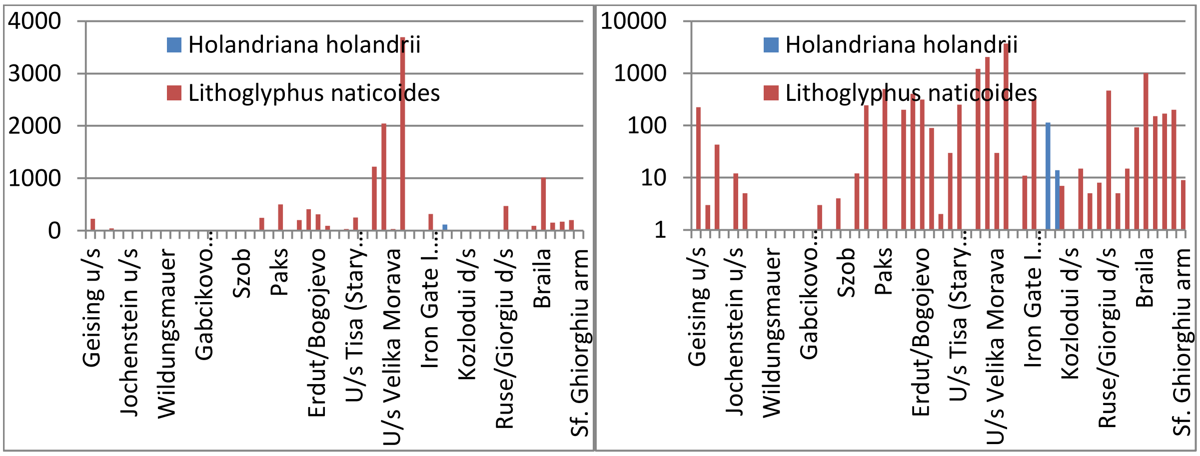

Figure 6. Longitudinal abundance values of *Holandriana holandrii* and *Lithoglyphus naticoides* along the Danube River (JDS3)

Gammaridae form the richest group of Crustacea. *Dikerogammarus villosus*, *Obesogammarus obesus* and *D. haempbaphes* are the most frequently found and most abundant species (**Figure 8**). The largest individual numbers /deep water dredged sample were detected mostly on the middle and lower section. *O. obesus* almost reached 2800 ind/sample downstream Jantra.

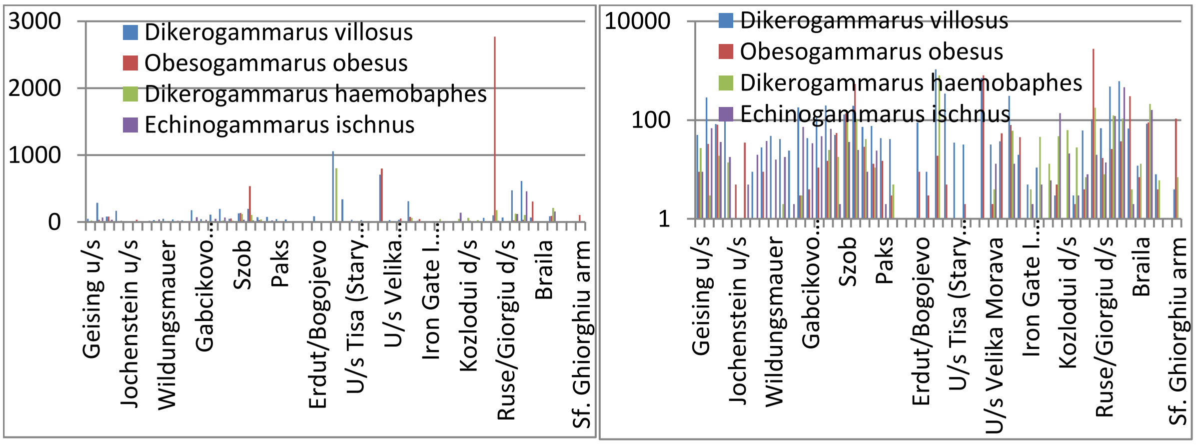

Figure 7. Longitudinal abundance values of four Gammaridae species along the Danube River (JDS3)

However, two Gammaridae species have totally disjunctive distribution along the Danube River. *Dikerogammarus bispinosus* was found only on the upper and middle stretches (downstream until Stary Slankamen), *Pontogammarus sarsi* occurred only on the Lower Danube from Kozlodui until to the Delta (**Figure 9**).

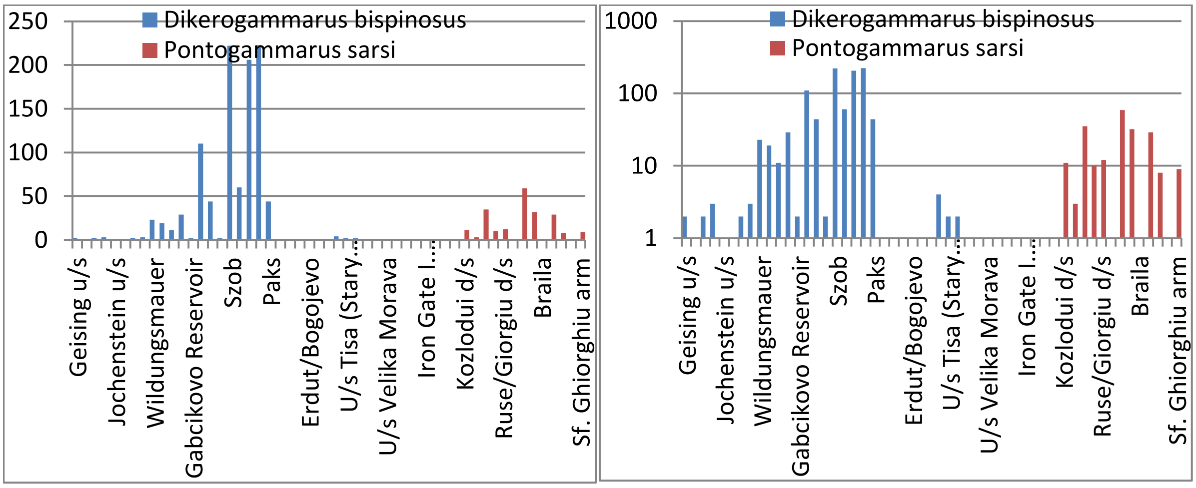

Figure 8. Longitudinal abundance values of two Gammaridae species along the Danube River (JDS3)

The most abundant species of the Trichoptera group are Hydropsyche species all along the Danube (**Figure 10**). They are more common on the Upper Danube; the real mass production was experienced at Klosterneuburg in the deep water river bed. Similar abundances were found on the Slovakian-Hungarian and Hungarian section. From Croatia and Serbia the individual numbers decrease below 100 ind/sample, except d/s Jantra (220 ind/sample). It can be clearly seen that *H. bulgaromanorum* is the dominant species; the second one in the order of abundance is *H. contubernalis* with higher values on the upper section, too. The other four detected species distribute strictly the upper-middle Danube section (lower Austrian-Slovakian-Hungarian part).

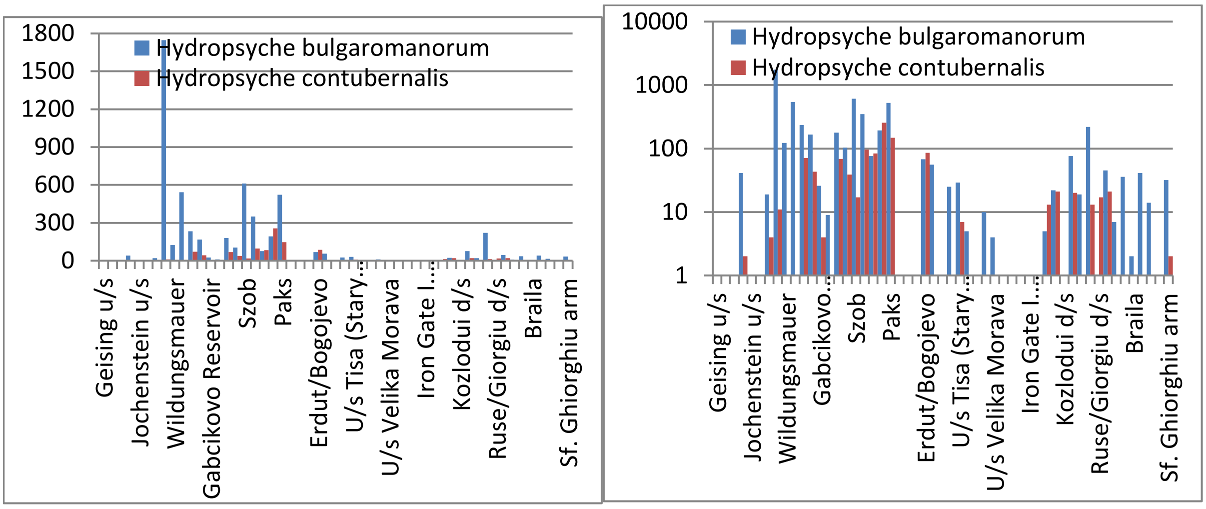

Figure 9. Longitudinal abundance values of Hydropsychidae along the Danube River (JDS3)

Three common Danubian insect larvae have special distribution along the river in the deep water dredges (**Figure 11**). *Ephoron virgo* is abundant on the Upper Danube (mostly in Germany but at Abwinden-Asten also). Downstream it becomes rare on the Slovakian-Hungarian section where its typical occurrences were registered in Kliska Nema and downstream Budapest. Recently mass emergences were reported from the upstream section of Budapest, principally on the Szentendre arm (Tahi bridge). It seems that this Ephemeropteran species is re-populating the Middle Danube just at present (the reason is unknown).

Two river dragonfly larvae (*Gomphus flavipes*, *G. vulgatissimus*) were detected in the deeper samples during the JDS3 program. The first one is a frequent species on the Lower Danube; the second one was found only at two sites (Deggendorf, d/s Novi Sad).

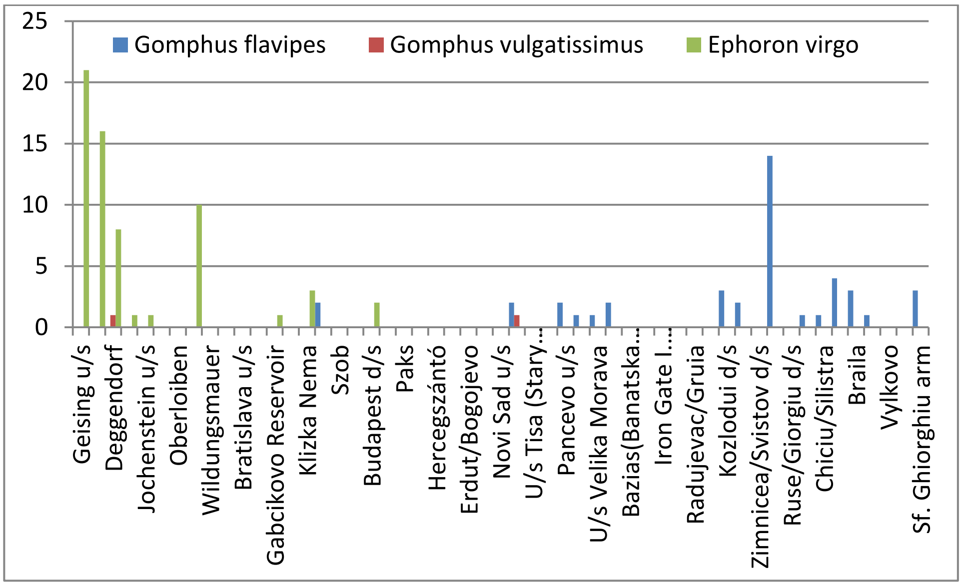

Figure 10. Longitudinal abundance values of two Gomphidae and *Ephoron virgo* along the Danube River (JDS3)

Fagotia acicularis and *F. esperi* are characteristic Danubian snails (**Figure 12**). *F. acicularis* lives on the middle Hungarian Danube (from Szob to Budapest) and could be detected around Novi Sad but after it is living only on the Lower Danube downstream the Iron Gate Reservoirs. It is commonly found between Radujevac/Gruia-Kozlodui stretch and after Oltenita (Arges tributary) until the Sf. Ghiorghiu arm in relatively large individual numbers. The highest abundance was detected upstream Budapest (>600 ind/sample). *F. esperi* is often co-occurring together with *F. acicularis*, especially on the Lower Danube. Both of them form large population size at Vylkovo (more than 200 ind/sample)

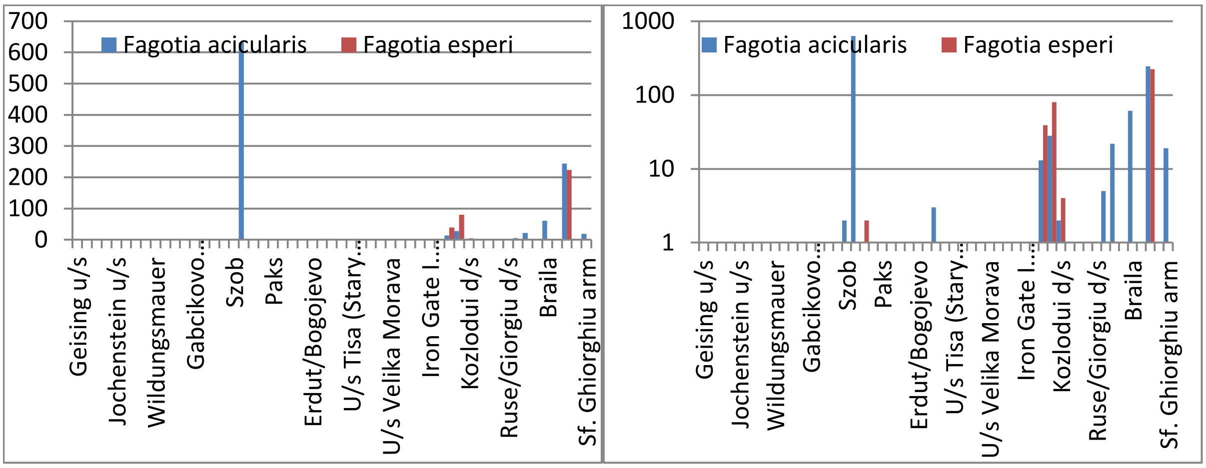

Figure 11. Longitudinal abundance values of two Fagotia species along the Danube River (JDS3)

Theodoxus fluviatilis has dense populations on the following Danube stretches: Deggendorf-Mühlau; Komárom-Paks; Novi Sad-Stary Slankamen; in the Iron Gate I. Reservoire around Banatska Palanka-Bazias. It is very widespread and abundant after the Iron Gate I and II, as well (**Figure 13**). We could detect that species almost everywhere on the Lower Danube but the highest abundances were populating the upper Bulgarian(-Romanian) stretch in Vrbica/Simian region (235 ind/sample)

It is very interesting that *Th. danubialis* was detectable in the dredged samples of the deep zones only downstream the Iron Gate I and II, until the upstream section of Kozlodui, and again from Ruse to Vylkovo (in Vylkovo there were 75 ind/sample abundance detected). The population size of *T. danubialis* – according to several recent experiences – is decreasing unfortunately.

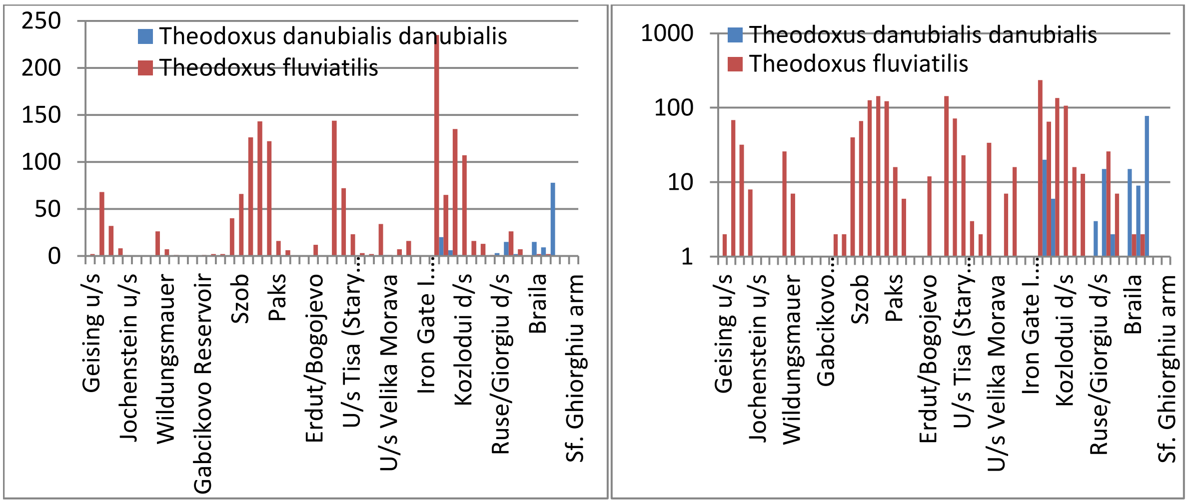

Figure 12. Longitudinal abundance values of two Theodoxus species along the Danube River (JDS3)

The most valuable and endangered Theodoxus species, *Th. transversalis* has particularly interesting distribution along the Danube: at present it is relatively common in the deep water dredged samples between Radujevac/Gruia and Chiciu/Silistra scetion. This is one of the most characteristic snail species of the Lower Danube at the moment. *Holandriana holandrii* is particularly present only around and after the Iron Gate I.and II Reservoirs, the densest populations are living at Radujevac/Gruia section (**Figure 14**).

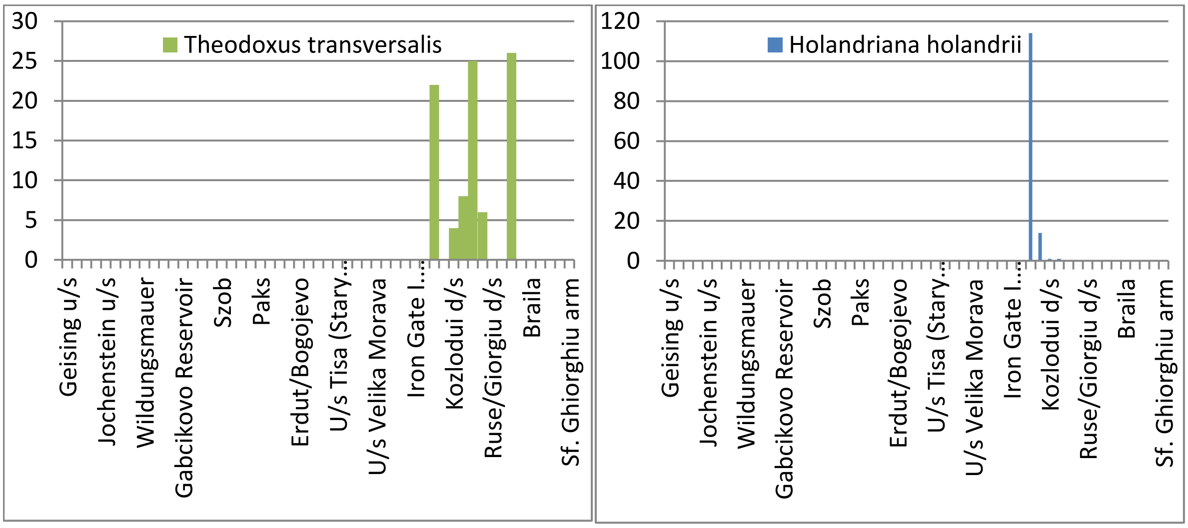

Figure 13. Longitudinal abundance values of Theodoxus transversalis and Holandriana holandrii, two Lower Danubian snails along the Danube River (JDS3)

The large mussels of the Danube are particularly interesting because it is always difficult to identify their exact location using both littoral and deep water sampling methods. According to the results of the JDS3 dredging program *Unio tumidus* is the most frequently detected Unionida sp., followed by *Anodonta anatina*, *Sinanodonta woodiana* and *U. pictorum*. *Unio crassus* having high nature conservation value is very seldom in the Danube (**Figure 15**). It is Natura 2000 species in Hungary indicating the extreme rarity of this species. Great result of the JDS3 mission is that we detected *Unio crassus* at first at the lowermost Hungarian section (Mohács) in the littoral zone. *U. crassus* in dredged sample– until JDS3 – were found only at Szob in 2012 in the real deep water zone together with *Theodoxus danubialis*. Now it was detected in Pristoil/Novo Selo cross section near the right (Bulgarian) bank, but in deep water among large gravels.

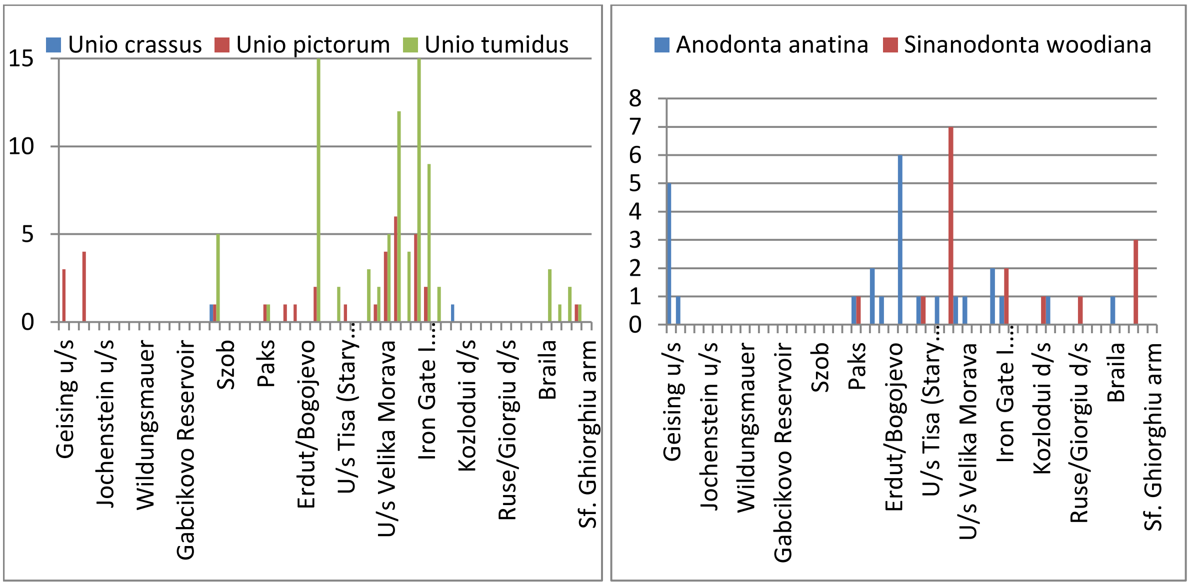

Figure 14. Longitudinal abundance values of five Unionidae species along the Danube River (JDS3)

Sphaeriidae were very rarely found during the JDS3 dredging mission (**Figure 16**). *Sphaerium solidum* is detected mainly on the upper section but its most downstream occurrence was found in Bazias. *S. rivicola* is living along the entire Danube, *S. corneum* was described only on the upper and middle streches.

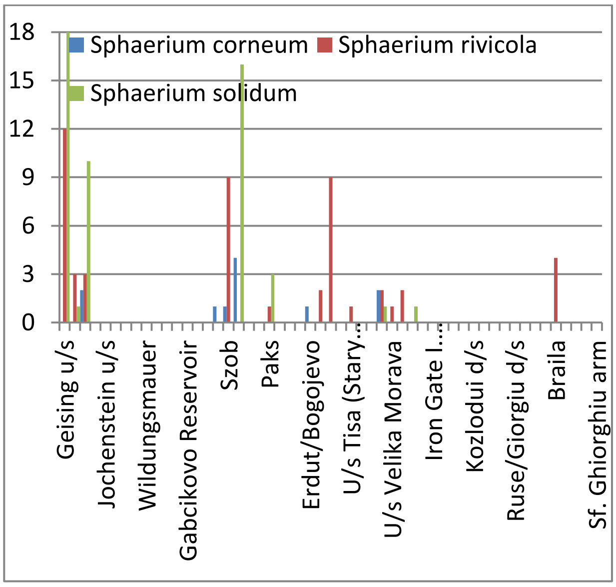

Figure 15. Longitudinal abundance values of three Sphaerium species along the Danube River (JDS3)

3.2 Sectional change of taxon number and abundance in main taxonomic groups

The following seven sections based on large scale hydromorphological characters (i.e. bed slope, bed material) were compared in terms of taxon numbers and individual numbers per sample (Table 3).

Table 3. Seven sections of the Danube River for interpretation of faunal differences of different stretches

Section 1 (Geising u/s-Abwinden-Asten u/s)	Reservoires, barrages in Germany
Section 2 (Oberloiben-Medve)	Lower end of the upper section (having high bed slope)
Section 3 (Klizka Nema-Hercegszántó)	Middle section with lower bed slope and gravel bed
Section 4 (U/s Drava-Pancevo d/s)	Middle section with lower bed slope and sandy bed
Section 5 (U/s Velika Morava-Vrbica/Simian)	Impounded section of Iron Gate I.
Section 6 (Radujevac/Gruia-Chiciu/Silistra)	Upper part of the Lower Danube (right stony/left sandy)
Section 7 (Giurgeni-Sf. Ghiorghiu arm)	Lower part of the Lower Danube (sandy)

The average values of sampling cross sections were used to compare these subsequent sections to each other based on macroinvertebrates. There are some evidences (**Figure 17**):

- The number of Annelida (mostly Oligochaeta), Gastropoda and Bivalvia taxa decreased sharply along Oberloiben-Medve due to the fast flowing character of this upper Danube stretch;
- The Crustacea taxa have usually higth taxon numbers along the whole Danube, but minimum taxon number was detected on the fourth section (Serbian stretch);
- The number of Insect taxa (mostly Chironomidae) generally decrease downstream direction.

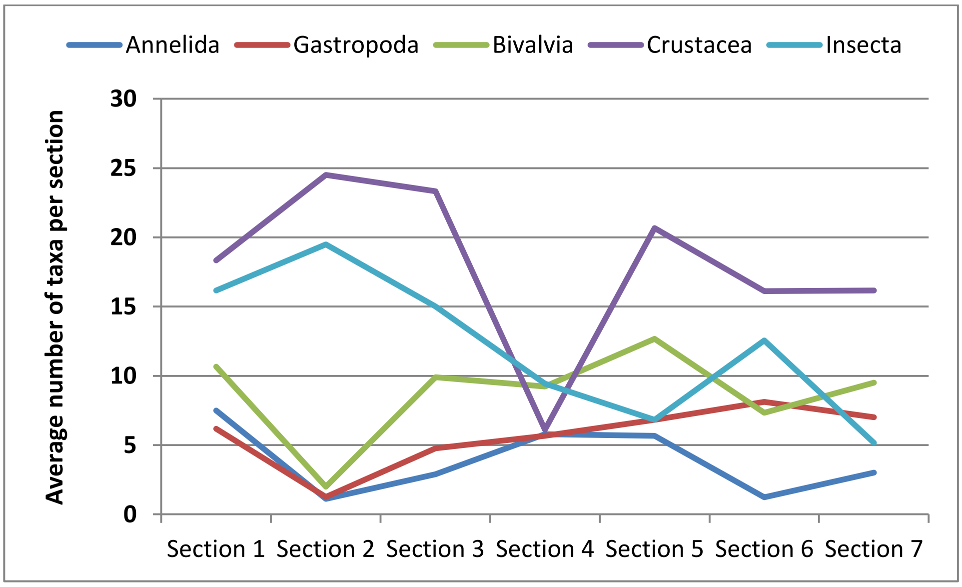

Figure 16. Average taxon number of macroinvertebrates on 7 sections along the Danube (JDS3)

Individual numbers (average numbers/section) usually increase along the river (**Figure 18**). Annelida and Insecta form exception because usually low abundances were experienced in the deep zone of the Danube downstream characterized by strong sediment transport everywhere. The increases are mainly caused by the most abundant given species (Bivalvia: Corbicula fluminea, Gastropoda: *Lithoglyphus naticoides*, Crustacea: Corophiidae).

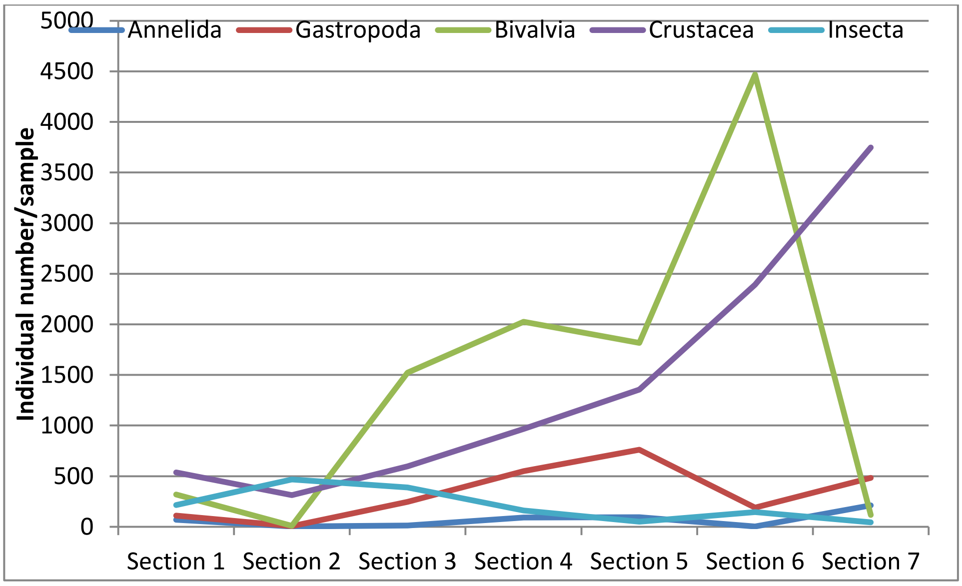

Figure 17. Individual numbers (average/section) of the main macroinvertebrate taxonomic groups along seven sections of Danube

The sectional description of given taxa is another interesting topic that needs careful analysis in the near future.

3.3 Cross sectional change of taxon number and abundance in main taxonomic groups

One of the main goals of the dredging program was to define:

- How the benthic macroinvertebrates are populating the deep water zones of the Danube?
- What are the most relevant taxa from to littoral zone to the deeper parts?
- What is the additional information collected by this –physically difficult – sampling method?

To illustrate the way of the distribution the cross sections one has to sum up the data referring to the subsequent deep water zones from site number I to V separately. For the first trial this summing up procedure was taken for three basic Danube section-types:

- Reach 1: Giesling-Gabcikovo Reservoir (13 JDS3 sites);
- Reach 2: Medve-Vrbica/Simian (24 JDS3 sites);
- Reach 3 Radujevac/Gruia-Danube Delta (16 JDS3 sites).

This very rough section typology is based on several preliminary multivariate analyses that later has to be further specified. At present we investigate how Gastropoda, Bivalvia and Crustacea taxa (the most characteristic Danubian Fauna-elements) are colonizing the given cross sections. Using the same scale on the y axis on the three subsequent diagrams it can be noticed that the Crustaceans have the largest taxon number among the three taxonomic groups.

Along Reach 1 Gastropoda have the largest taxon numbers closed to the right bank side (**Figure 19**). The second reach represents the middle section until the end of Iron Gate I where aquatic snails appeared in richer populations than on the left side. The lowest taxon numbers are always in the middle zone, the site II and IV represent an intermediate richness. Strictly the same phenomenon is observed on the Reach 3: The taxon richness is much bigger on the right than on the left. The reason of this picture is very evident: the Bulgarian stretch – together with the Lower Romanian one (from Chiciu/Silistra) – has a sedimentary elevated hilly chain on the bank side that provides very rough bed material along the cross section points I and II. Those zones are representing very diverse habitats for benthic invertebrates and fish, as well.

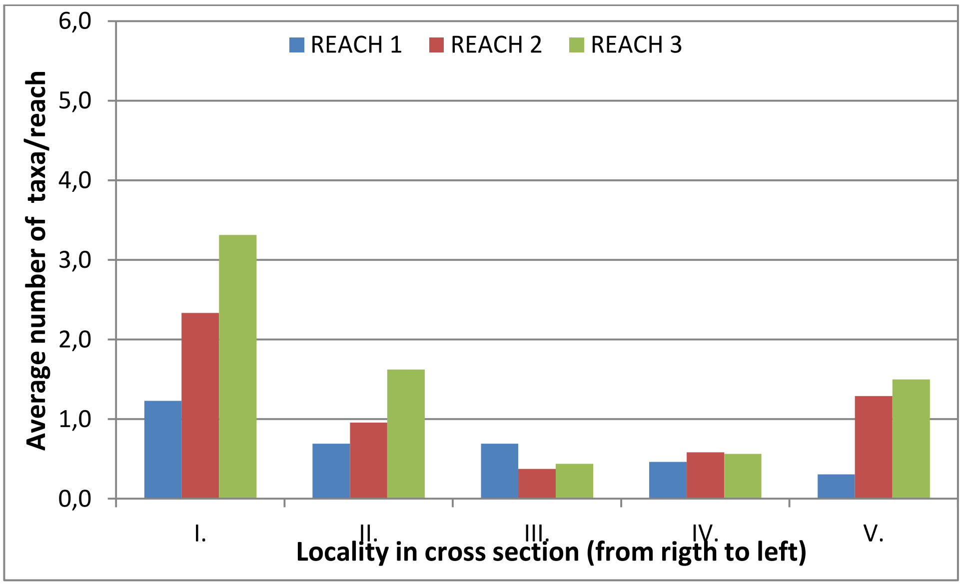

Figure 18. Average number of Gastropoda taxa along three different Danube reaches

Along Reach 1 Bivalvia (similarly to Gastropoda) have more taxa closed to the right bank side (**Figure 20**). Similar picture is characteristic on the Reach 2 but with higher taxon numbers: this stretch is obviously richer in mussel species then the Reach 1. The most diverse fauna exists on the third section (Reach 3) where the similar explanation can be given to the large taxon number of mussels on the right side places (I and II dredged zones).

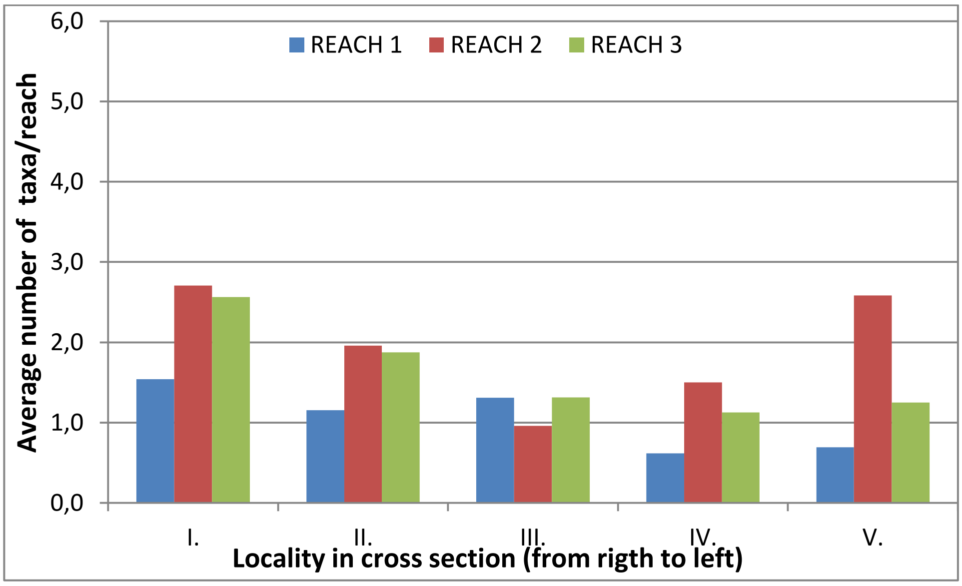

Figure 19. Average number of Bivalvia taxa along three different Danube reaches

Reach 1 has a general character: the Crustacea group also occurred in larger taxon number closed to the right side, similarly to Gastropoda and Bivalvia (**Figure 21**). This difference existing between right and left side zones is very much expressed in case of the Crustacea group.

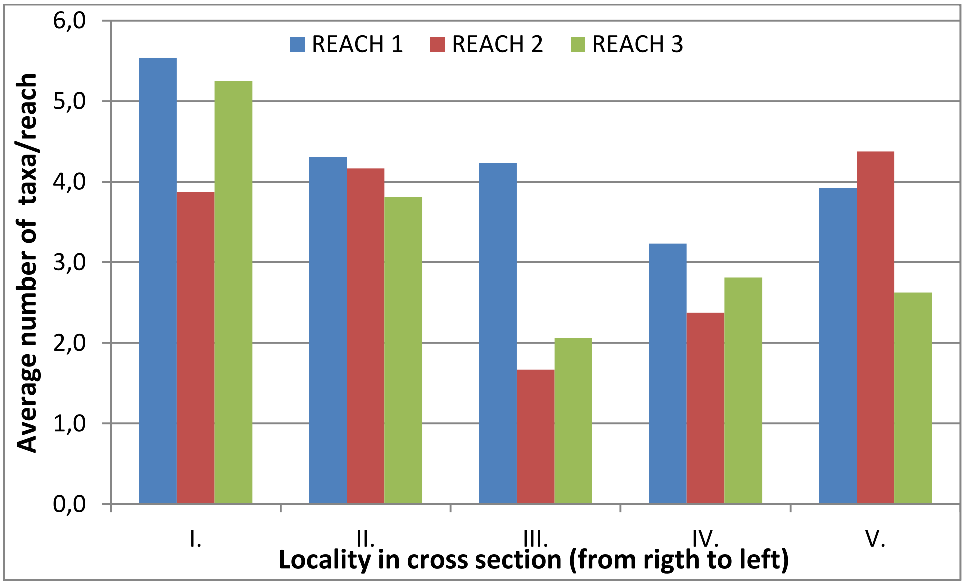

Figure 20. Average number of Crustacea taxa along three different Danube reaches

Summarizing the dredging results it is concluded that:

- It is very important to sample the deep water bottom zone of very large rivers because new Faunal character of the Danube can be detected;
- The data from the dredging have perfectly added value using them with those that are collected in the littoral zone;
- This was the very first trial when the deep water Fauna of the Danube River was taken into consideration. The detailed further evaluation later will most probably provide several interesting additional results to our present knowledge.

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