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Oligochaeta of the Danube River – a faunistical review

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Abstract: The aim of this work is to discuss the distribution of Oligochaeta (Annelida) in the Danube River using the collections made by the Joint Danube Survey 2007 (JDS2) on more than 2800 km of the river. The basic faunistical features of the oligochaete assemblages were analysed with regard to three main sectors of the Danube (upper, middle and lower reaches, the last with the Danube Delta). A total of 52 oligochaete taxa have been recorded. Most of the observed species are typical of the potamon-type rivers in the region, and are well adapted to moderate-to-high organic load. The highest taxa richness and frequency of occurrence were observed among the Tubificidae family. Naididae, Propappidae, Enchytraeidae and Haplotaxidae had also low frequency. The upper reach of the Danube showed the lowest species richness, while the middle reach is characterised by its highest species richness. Construction of dams and regulation of the riverbed have resulted in an increase of limno(rheo)philic taxa which prefer slow-flowing and lentic zones.

Key words: Oligochaeta; Annelida; large lowland rivers; longitudinal distribution; river section types

Introduction

Oligochaeta are an important component of the communities of aquatic macroinvertebrates, especially in large lowland rivers (Šporka 1998; Moog 2002; Jakovcev-Todorovic et al. 2005; Atanacković et al. 2011). In potamon-type rivers, oligochaetes are typically one of the most diverse and abundant macroinvertebrate groups (Paunović et al. 2005). In aquatic habitats that are under the impact of nutrient and organic pollution and/or increased sedimentation, oligochaetes may reach a high density, which changes the community structure and function. Due to their potentially high densities, wide distribution, and indicator value, aquatic oligochaetes can be important for water management (Verdonschot 1989). They can also be indicative of a variety of environmental conditions other than pollution. Influence of stream hydrology and physical and chemical factors on aquatic Oligochaeta have been studied by many authors (Elexová 1998; Šporka & Nagy 1998; Moog 2002; Timm et al. 2001; Đukić et al. 1996; Jakovčev-Todorović et al. 2005; Martinovic-Vitanovic et al. 2006; Paunovic et al. 2003).

The present paper analyzes the data regarding the structure of oligochaete fauna obtained during The Second Joint Danube Survey (JDS 2), from sampling sites distributed throughout the entire stretch of the Danube River.

The Danube, one of Europe's most important waterways, traverses 2,857 km from the Black Forest to the Black Sea. The Danube River basin is divided into three sub-regions: the upper, the middle and the lower basin with the Danube Delta (Literáthy et al. 2002; Robert et al. 2003; Liška et al. 2008). The Upper Basin extends from the source (Germany) to Bratislava (Slovakia). The Middle Basin is the largest and comprises the part from Bratislava to the Iron Gate dams (Serbia/Romania). The Lower Basin extends from the Iron Gate to Sulina (mouth of the Danube to the Black Sea) including a huge river delta (Paunovic et al. 2007).

Along the main stream of the Danube, 69 dams have been built and 30% of its total length is impounded. Upstream of Bratislava, only about 15% out of ~1,000 rkm remain free-flowing. The largest dams are the Iron Gate dams I and II at rkm 943 and rkm 842, respectively, which have significantly changed the sediment transportation and groundwater regime (Sommerwerk et al. 2009).

Detailed limnological investigations of the Danube main course, its floodplain waters and main tributaries have been undergoing for a long time and continue to the present (Liepolt 1967; Banu 1967; Cousteau Equipe 1993; Russev 1998; Janković & Jovičić 1994; Paunović et al. 2005, 2007; Moog 2002; Nagy & Šporka 1990; Elexová 1998; Šporka 1998; Oertel 2000; Nosek 2002; Oertel et al. 2005; Literáthy et al. 2002; Csányi & Paunović 2006; Graf et al. 2008; Sommerwerk et al. 2009; Simonovic et al. 2010). Three international expeditions have been completed (the Joint Danube Survey in 2001 – JDS, the Aqua Terra Danube Survey in

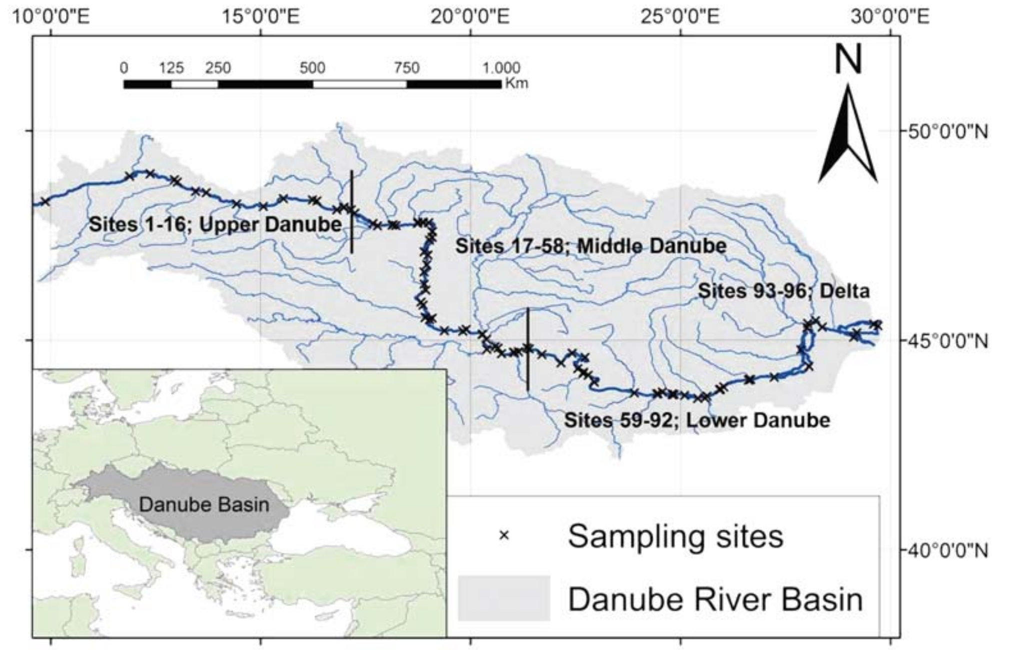

Fig. 1. The position of the Danube basin and sampling sites along the Danube.

2004 – ADS and Joint Danube Survey 2 in 2007 – JDS 2). These expeditions provided comparable data of the biota, chemistry and hydromorphology of the Danube River. Besides intensive ship traffic, the river is under the influence of hydromorphological alterations, industrial "hot-spots", as well as agriculture (for details see: Literáthy et al. 2002; Csányi 2002; ICPDR WFD Roof Report 2004; SCG ICPDR National Report 2004, Teodorović et al. 2000; Djukić et al. 2000). According to these considerable pressures in the past decades, the biodiversity of the Danube has significantly changed, affecting all of the river biota, the populations and communities of the river bank, as well as in the deeper zone.

Material and methods

The study is based on material collected during JDS 2, from 13 August to 26 September 2007. During the survey, 96 sites were sampled along the 2,600 km stretch of the Danube, of which 24 sites were in the mouth portion of tributaries or side arms (Fig. 1). The sampling sites are presented in Table 1. The discussion on sampling sites selection is presented in Liška et al. (2008).

In order to collect representative material for each sampling point, a combination of sampling techniques was performed. Samples were collected using air-lift sampling (cylinder diameter 23 cm, height 40 cm, sampling area 434 cmň), the multicorer technique (sampling device consists of 3 corers with a diameter of 9 cm each), multihabitat sampling – MHS (6 single kick-samples, 25×25 cm each subsample, AQEM/STAR net sampler mesh size 500 μm), kick and sweep multihabitat sampling, or K&S – EN 27828 (1994) (FBA hand net, mesh size 500 μm) and dredging. Sampling by air-lift was applied at the majority of sampling sites. At each site, 6 sampling units (3 on the left and 3 on the right river bank) were taken and pooled to one sample. The multicorer technique (in the case of soft sediments) and MHS (in the case of all other substrate types) were used on sites where air-lift was impossible due to low water level (the vessel with the sampler installed could not approach the site). The K&S technique was performed at each sampling site, and dredging was performed in the deeper sections as an additional technique.

The material collected by air-lift/multicorer/MHS was rinsed through a net with a 100 μm mesh-size, while the material collected with K&S and dredging was rinsed through a net with a 500 μm mesh-size. At each sampling site, two set of samples were collected, one rinsed through a net with a 100 μm, the other with 500 μm, which make the data sets comparable in regards to recorded species richness. The material was preserved in formaldehyde (4%).

Nomenclature was used according to the Fauna Europaea, (http/www.faunaeur.org.), based on the comments on the taxonomy of Oligochaeta provided by Timm (2012).

Basic faunistic features of the oligochaete assemblages were analysed with regard to the three main sectors of the Danube (upper, middle and lower reach, the last together with the Danube Delta). In order to analyse differences between the sites and sectors, frequency analyses were performed. The frequencies of occurrence for each species (the percentage of samples comprising specimens of a given species) were calculated for the entire watercourse (F_1) and for the three different sectors of the Danube River (F_2). The following scale was used in the evaluation of constancy: $F_1 = 0$–0.25 – accidental species, $F_1 = 0.25$–0.50 – accessory taxa, $F_1 = 0.50$–0.75 – constant, $F_1 = 0.75$–1 – euconstant.

Additionally, the faunistic similarity of the three investigated sectors of the Danube, based on the oligochaete taxa, was determined according to Sørensen's (1948) Quotient of Similarity.

The work discusses the main ecological features of the recorded communities with respect to its qualitative composition. The autecological data are taken from AQEM (2002) and Hörner et al. (2002), while the Asterics software 3.1.1. (AQEM 2002) was used for calculating relationships between the functional groups within the community, including the characterisation of the species with regard to sapro-

Table 1. List of sampling sites.

JDS2	Site	rkm	JDS2	Site	rkm
1	Upstream Iller	2600	49	Tisa (rkm 1.0)	1215
2	Kelheim – gauging station	2415	50	Downstream Tisa/Upstream Sava (Belegis)	1200
3	Geisling power plant	2354	51	Sava (rkm 7.0)	1170
4	Deggendorf	2285	52	Upstream Pancevo/Downstream Sava	1159
5	Niederalteich	2278	53	Downstream Pancevo	1151
6	Inn, rkm 4.2	2225	54	Grocka	1132
7	Jochenstein	2204	55	Upstream Velika Morava	1107
8	Upstream dam Abwinden-Asten	2120	56	Velika Morava	1103
9	Upstream dam Ybbs-Persenbeug	2061	57	Downstream Velika Morava	1097
10	Oberloiben	2008	58	Starapalanka – Ram	1077
11	Upstream dam Greifenstein	1950	59	Banatska Palanka/Bazias	1071
12	Klosterneuburg	1942	60	Irongate reservoir (Golubac/Koronin)	1040
13	Wildungsmauer	1895	61	Donji Milanovac	991
14	Upstream Morava (Hainburg)	1881	62	Irongate reservoir (Tekija/Orsova)	954
15	Morava (rkm 0.08)	1880	63	Vrbica/Simijan	926
16	Bratislava	1869	64	Iron Gate II	865
17	Gabčikovo reservoir	1852	65	Upstream Timok (Rudujevac/Gruia)	849
18	Medvedov/Medve	1806	66	Timok (rkm 0.2)	845
19	Moson Danube Arm – end (rkm 0.1)	1794	67	Pristol/Novo Selo Harbour	834
20	Komarno/Komarom	1768	68	Calafat	795
21	Vah (rkm 0.8)	1766	69	Downstream Kozloduy	685
22	Iža/Szony	1761	70	Upstream Iskar (Bajkal)	640
23	Štúrovo /Esztergom	1719	71	Iskar (rkm 0.3)	637
24	Hron (rkm 0.5)	1716	72	Downstream Iskar	629
25	Ipoly (rkm 0.7)	1708	73	Upstream Olt	606
26	Szob	1707	74	Olt (rkm 0.4)	605
27	Upstream end of Szentendre Island	1692	75	Downstream Olt	602
28	Upstream end of Szentendre Island (arm)	1692	76	Downstream Turnu-Magurele/Nikopol	579
29	Budapest upstream	1659	77	Downstream Zimnicea/Svishtov	550
30	Budapest (old Danube) end of S.arm	1658	78	Jantra (rkm 1.0)	537
31	Rackeve-Soroksar Danube Arm – start	1642	79	Downstream Jantra	532
32	Budapest downstream	1632	80	Upstream Ruse	500
33	Adony/Lórév	1605	81	Russenski Lom	498
34	Rackeve-Soroksar Danube Arm – end	1586	82	Downstream Ruse/Giurgiu	488
35	Dunafoldvar	1560	83	Upstream Arges	434
36	Paks	1533	84	Arges	432
37	Sio (rkm 1.0)	1497	85	Downstream Arges, Oltenita	429
38	Baja	1481	86	Chiciu/Silistra	378
39	Hercegszanto	1434	87	Upstream Cernavoda	295
40	Batina	1424	88	Giurgeni	235
41	Upstream Drava	1384	89	Braila	167
42	Drava (rkm 1.4)	1379	90	Siret (rkm 1.0)	154
43	Downstream Drava (Erdut/Bogojevo)	1367	91	Prut (rkm 1.0)	135
44	Dalj	1355	92	Reni	130
45	Ilok/Backa Palanka	1300	93	Vilkova – Chilia arm/Kilia arm	18
46	Upstream Novi-Sad	1262	94	Bystroe canal (to be confirmed)	8
47	Downstream Novi-Sad	1252	95	Sulina – Sulina arm	0
48	Upstream Tisa (Stari Slankamen)	1216	96	Sf.Gheorghe – Sf.Gheorghe arm	0

bic preference, current, substrate type and general river zonation.

Results

As a significant component in the macrozoobenthic communities of the Danube (11.79% of the total number of macroinvertebrate taxa), aquatic oligochaetes were represented by 52 taxa belonging to 8 families, and are found to be one of the most diverse group besides Diptera.

The qualitative composition of oligochaete fauna is presented in Table 2. The highest taxa richness was observed among Tubificidae (27 species), followed by the families of Naididae (13), Lumbriculidae (6) and Lumbricidae (2).

Table 3 shows the participation (%) of Oligochaeta species in the total number of bottom fauna taxa in the assemblages of the three different parts of the Danube's course, in the range from 12% – part I to 18% – part III.

Table 4 gives the Quotient of Similarity (QS) according to Sørensen (1948) for the Oligochaeta in three different parts of the course of Danube, in the range from 73% (between I and III) to 81% (between II and III).

According to the frequency analyses (occurrence of the taxa in all samples/sampling sites, Table 2), one constant species was recorded – *Limnodrilus hoffmeisteri* (F_1 = 0.50–0.75) and nine accessory taxa (F_1 = 0.25–0.50) – *Isochaetides michaelseni*, *L. claparedeanus*, *Potamothrix moldaviensis*, *Psammoryc-*

Table 2. Qualitative composition of the Oligochaeta fauna and frequencies of species in the entire water course (F_1) and in three different sectors of the Danube River (F_2). "+" taxa present; "*" unidentified taxa.

Taxa	F_1	Upper Danube (F_2)	Middle Danube (F_2)	Lower Danube (F_2)	Arms	Tributaries
Oligochaeta gen. sp.		*	*	*		*
Naididae						
Dero obtusa d'Udekem, 1835	0.05		0.03	0.1	+	+
Nais alpina Sperber,1948	0.01		0.03			
Nais bretscheri Michaelsen,1899	0.02	0.08	0.03			
Nais christinae Kasprzak,1973	0.01			0.03		
Nais communis Piguet, 1906	0.02		0.03	0.03		
Nais pardalis Piguet, 1906	0.02		0.03	0.03	+	
Nais pseudobtusa Piguet, 1906	0.01		0.03			
Nais simplex Piguet, 1906	0.01		0.03			
Nais sp.	0.01					
Ophiodonais serpentina (Müller, 1773)	0.05		0.03	0.1		+
Piguetiella blanci (Piguet, 1906)	0.01					+
Stylaria lacustris (L., 1767)	0.04	0.08	0.03	0.07		
Tubificidae						
Aulodrilus japonicus Yamaguchi, 1953	0.02			0.03		+
Aulodrilus pluriseta (Piguet, 1906)	0.05	0.15	0.06	0.03		
Aulodrilus limnobius Bretscher, 1899	0.05		0.06	0.07		+
Bothrioneurum vejdovskyanum Štolc, 1888	0.01			0.03		
Branchiura sowerby Beddard, 1892	0.27	0.08	0.23	0.03		+
Embolocephalus velutinus (Grube,1879)	0.03			0.1		
Isochaetides michaelseni (Lastočkin, 1936)	0.47	0.23	0.4	0.73		+
Limnodrilus claparedeanus Ratzel, 1868	0.41	0.54	0.71	0.37	+	+
Limnodrilus hoffmeisteri Claparède, 1862	0.59	0.62	0.71	0.4	+	+
Limnodrilus profundicola (Verrill, 1871)	0.31	0.46	0.34	0.13		+
Limnodrilus sp.	0.4				+	+
Limnodrilus udekemianus Claparède, 1862	0.37	0.23	0.49	0.23	+	+
Potamothrix bavaricus Oschmann,1913)	0.01	0.08				
Potamothrix danubialis (Hrabě, 1941)	0.18	0.08	0.2	0.27	+	+
Potamothrix hammoniensis (Michaelsen, 1901)	0.08	0.08	0.11	0.1		
Potamothrix isochaetus (Hrabě, 1941)	0.16	0.31	0.2	0.07	+	+
Potamothrix moldaviensis Vejdovský & Mrázek, 1902	0.38	0.46	0.51	0.27	+	+
Potamothrix sp.	0.07					*
Potamothrix vejdovskyi (Hrabě, 1941)	0.12		0.09	0.2		
Psammoryctides albicola (Michaelsen, 1901)	0.22	0.31	0.34	0.07	+	+
Psammoryctides barbatus (Grube, 1861)	0.38	0.46	0.63	0.13	+	+
Psammoryctides moravicus (Hrabě, 1934)	0.16		0.17	0.2	+	+
Psammoryctides sp.	0.09				+	
Rhyacodrilus coccineus (Vejdovský, 1875)	0.01	0.08				
Tubifex ignotus (Štolc,1886)	0.02		0.06			
Tubifex tubifex (Müller, 1774)	0.22	0.31	0.31	0.07		+
Tubificidae gen. sp.					*	*
Enchytraeidae						
Enchytraeidae gen. sp.	0.03		0.03			+
Propappidae						
Propappus volki (Michaelsen, 1916)	0.06	0.15		0.13		+
Lumbriculidae						
Lumbriculidae gen. sp.	*					*
Lumbriculus variegatus (Müller, 1774)	0.01	0.08				
Rhynchelmis limosella Hoffmeister,1843	0.01	0.08				
Stylodrilus lemani (Grube, 1879)	0.01	0.08				
Stylodrilus heringianus Claparède, 1862	0.29	0.69	0.46	0.03	+	+
Stylodrilus sp.	0.03					+
Lumbricidae						
Lumbricidae gen. sp.	*					
Eiseniella tetraedra (Savigny, 1826)	0.14	0.38	0.14	0.1		
Criodrilidae						
Criodrilus lacuum Hoffmeister, 1845	0.35	0.15	0.43	0.47	+	+
Haplotaxidae						
Haplotaxis gordioides (Hartmann, 1821)	0.05		0.11	0.03		
No. of taxa		32	40	37	16	28

tides barbatus, *L. udekemianus*, *Criodrilus lacuum*, *L. profundicola*, *Stylodrilus heringianus* and *Branchiura sowerbyi,* while the rest (39) could be characterised as accidental species (F_1 = 0–0.25). The frequency of species belonging to the families Naididae, Propappidae, Enchytraeidae and Haplotaxidae is particularly low (F_1 ranged from 0.01 to 0.06).

Taking into consideration all recorded species

Table 3. Percentage of oligochaete taxa in the zoobenthos in the investigated parts of the Danube in relation to the total number of benthic taxa recorded in I – Upper Danube (294); II – Middle Danube (257); III – Lower Danube (195).

Parts of the Danube course	I		II		III	
	No. of taxa	%	No. of taxa	%	No. of taxa	%
Oligochaeta	36	12.25	39	15.16	37	18.97
Tubificidae	23	7.82	22	8.56	24	12.31
Naididae	3	1.02	10	3.89	6	3.08
Lumbriculidae	6	2.04	3	1.17	2	1.03
Lumbricidae	1	0.34	1	0.39	2	1.03
Criodrilidae	1	0.34	1	0.39	1	0.51
Propappidae	1	0.34	–		1	0.51
Enchytraeidae	1	0.34	1	0.39	–	
Haplotaxidae	–		1	0.39	1	0.51

Table 4. Values of the Sørensen's Quotient of Similarity (QS) (Sørensen, 1948) based on Oligochaeta in the investigated parts of the Danube course.

Parts of the Danube course	I	II	I	III	II	III
No. of taxa	36	39	36	37	39	37
No. of common taxa	28		27		31	
QS (%)	75.67		73.97		81.58	

within the investigated area, the majority could be considered as tolerant to a high organic load. Thus, according to the ecological classification of the taxa, with regard to saprobic conditions (saprobic valence) of Hörner et al. (2002), 28.24% of the identified species belong to the alpha-mesosaprobic group, while 24.14% of the taxa could be characterized as beta-mesosaprobic. Species adapted to high organic load (polysaprobic) were represented by 15.64% of the total number of taxa. Only 6.97% of the recorded taxa are classified as sensitive to organic pollution (xenosaprobic and oligosaprobic taxa). For the rest of the species (25%), there is no data to classify them in regard to saprobic tolerance.

Furthermore, according to Hörner et al. (2002) and the AQEM (2002) classification with regard to a preferred zone within the river continuum (longitudinal zonation), the greatest part (36.80%) of the recorded species is characteristic to the lower stretches of a river (potamal species). A lower proportion of the taxa belong to those of the rhithral type (14.58%).

With regard to flow preference, the recorded community is characterized by domination of rheolimnophilous taxa (Type RL–43.38% of the total number of recorded species) and limno-rheophilous taxa (Type LR–26.42%). Those types of species prefer slow-flowing streams and lentic zones. A smaller amount (5.73%) of species were indifferent to current conditions, while 19% of the taxa could not be classified with regard to current preference, due to a lack of relevant data.

Majority of the identified species (63.98%) are adapted to the substrate types of large lowland rivers (pelal, psammal and argillal). Thus, pelophilous taxa are represented with 35.64%, psammophilous with 26.26% and argillophilous with 2.08% of the total number of recorded Oligochaeta taxa.

The species that prefer fine-to-medium-sized gravel were represented by 11.12% of the Oligochaeta assemblages. The taxa that prefer particulate organic matter such as woody debris were represented by 7.59%, and the lithophilous species by 6.46% of the total number of species. A smaller number of taxa (2.58%) were characterized as phytophilous, while for the rest there is not enough information about microhabitat preference (AQEM 2002).

Upper reach of the Danube

A total of 14 sites were sampled, 13 in the main channel and one in a tributary (the Inn River). Oligochaeta were found at all sampling sites in the upper reach, but showed the lowest taxa richness since a total of 32 taxa were identified. The most frequent species in the main channel were *Stylodrilus heringianus* (F_2 = 0.69), *Limnodrilus hoffmeisteri* (F_2 = 0.62) and *L. claparedeanus* (F_2 = 0.54). The species *Potamothrix moldaviensis*, *Psammoryctides barbatus* and *L. profundicola* also had high frequency (Table 2). The highest taxa richness was found at the sampling site JDS5 where 11 species were recorded.

Nine taxa were found in the Inn, the only tributary sampled on this reach. *L. hoffmeisteri* and *Aulodrilus limnobius* were found to be the most abundant species. The Naididae species *Piguetiella blanci* was found at this locality only.

The six taxa recorded only in this sector of the Danube are: *P. blanci* (at locality JDS6), *Potamothrix bavaricus*, *Rhyacodrilus coccineus*, *Stylodrilus lemani*, *Lumbriculus variegatus* and *Rhynchelmis limosella* (at locality JDS1).

Middle reach of the Danube (excluding the Iron Gate)
In the middle reach of the Danube 44 sites were sampled, 35 of them in the main channel and nine in the tributaries. Oligochaeta were recorded at 30 sites; altogether 40 taxa were identified. The highest species richness was observed in this sector of the Danube River (Table 2). In terms of frequency and abundance, the most dominant in the main channel was the Tubificidae family – *Limnodrilus hoffmeisteri*, *L. claparedeanus*, *Psammoryctides barbatus* and *Potamothrix moldaviensis*, followed by *Stylodrilus heringianus* (Lumbriculidae) and *Criodrilus lacuum* (Criodrilidae). Species belonging to other families were less frequent and abundant. Naididae (10 species in total) were found only at eight sampling sites and in low abundance. At localities JDS41 and JDS96 only one taxon was found (*Isochaetides michaelseni*). The highest number of taxa was found at sampling site JDS52, where 20 species were recorded.

In total, 22 taxa were recorded from the nine tributaries investigated. The dominant taxa regarding frequency and abundance were *Limnodrilus hoffmeisteri, L. claparedeanus, L. udekemianus, L. profundicola* and *Branchiura sowerbyi*.

Four species were found only in the Middle Danube: *Nais alpina*, *N. pseudobtusa*, *N. simplex* and *Tubifex ignotus*.

A characteristic (typical) species, which occurs only in the upper and middle reaches, is *Stylodrilus heringianus*. On the other hand, characteristic species from the middle and also lower reaches of the main channel were *Criodrilus lacuum* and *Isochaetides michaelseni* (see in Graf et al. 2008).

Lower reach of the Danube (including Iron Gate)
In the lower reach, 37 sampling sites were investigated; 30 sites were located in the main channel and 7 in the tributaries. Oligochaeta were recorded from all sampling sites. In total, 37 taxa were identified. The most dominant and frequent was *Isochaetides michaelseni* ($F = 0.73$), followed by *Criodrilus lacuum* ($F = 0.46$). Other Tubificidae species, as well as *Eiseniella tetraedra* (Lumbricidae) and *Propappus volki* (Propappidae), had low frequency. The Tubificidae species *Embolocephalus velutinus* and *Bothrioneurum vejdovskyanum* were found only in the lower reach. Naididae species (6 in total) were found like in the middle reach only at a few of sampling sites and in small numbers. The species *Nais christinae* was recorded only in this sector of the Danube.

Altogether 12 taxa were found in tributaries, with the highest frequency *Isochaetides michaelseni*, *Limnodrilus hoffmeisteri* and *L. udekemianus*, $F = 0.43$.

Discussion

In the course of the investigation, 441 macroinvertebrate taxa were identified (Graf et al. 2008). Oligochaetes were found to be one of the principal components of the macrozoobenthos in regards to species richness and community density (11.79% contribution to the total bottom fauna).

Our results are in agreement with those of other authors – aquatic oligochaetes were one of the main groups and their community was typical of European large lowland rivers (Dumnicka 1987; Šporka 1998; Moog et al. 2000; Timm et al. 2001; Atanacković et al. 2011). The typical oligochaete assemblages of the Danube are dominated by representatives of the Tubificidae family (the highest taxa richness and frequency). According to Paunović et al. (2007) oligochaetes and molluscs were found to be the principal components of the community along 588 km of the Serbian stretch of the Danube River (part of the Middle and Lower Danube) with regard to number of recorded taxa, frequency of occurrence, as well as with regard to relative abundance.

A high degree of faunistic similarity according to Sørensen (1948) between the oligochaete assemblages of the observed three parts of the Danube was found. The presence of ubiquitous species (of the genera *Limnodrilus*, *Potamothrix*, *Psammoryctides*, as well as *Tubifex tubifex*, *Isochaetides michaelseni*, *Branchiura sowerbyi*, *Aulodrilus pluriseta*, *Stylaria lacustris*) affects the values of QS and contributes to the faunistic similarity of the observed parts of the Danube. According to our results, the majority of recorded species are considered as tolerant to high organic load (Hörner et al. 2002), with considerable participation of alpha-, beta-mesosaprobic, as well as polysaprobic species. Only a few of the recorded taxa are classified as sensitive to organic pollution (xenosaprobic and oligosaprobic taxa). These results correspond with previous investigations of the water quality of the Danube. Austrian and Slovakian stretches of the river were characterized by β-mesosaprobity (Moog et al. 2000; Elexová 1998); the saprobic status in Serbia, according to bottom fauna, corresponds to mesosaprobic conditions (β-meso to α-mesosaprobity) (Paunović et al. 2005).

Construction of dams and regulation of the riverbed in certain parts of the Danube has resulted in a slowing down of the current and more intensive sedimentation in the zones of backwater effect. The consequence is an increase in limno(rheo)philic taxa, which prefer slow current and lentic zones. Impounding, heating, accumulation of organic matter and bed load, all lead to the “potamalization” of faunal structure (Moog 2002), and thereby the observed domination of potamal species. The large share of Tubificidae indicates the existence of well-developed silted zones. Damming has a marked influence on the oligochaete fauna, favouring species that require a slower current and fine-grained bottom (Dumnicka 1987).

The upper reach of the Danube showed the lowest species richness in comparison to the other stretches, probably due to the influence of damming and consequent low hydromorphological status of the majority of the river stretch belonging to the Upper Danube, but could be also the consequence of the lesser number of examined sampling sites within the stretch. An increase in current velocity produces an increased drift of organisms and can produce impoverishment of the bottom fauna (Russev 1970). The stretch of the Danube in Austria represents a transition zone between hyporhithral and epipotamal (Moog et al. 2000). Having in mind the water type of the Upper Danube, a higher participation of rheophilous taxa is expected. According to Litheráthy et al. (2002), the Upper Danube is characterized by reaches of alpine type and a transition zone between alpine-type and lowland river is situated in the stretch between the Gabčikovo Reservoir (river km 1816) and Budapest (upstream the city, river km 1659). Robert et al. (2003) also pointed out the peculiarity of the Upper Danube in comparison to other general Danube sections.

On the contrary, during our investigation, a similar pattern in comparison with other Danube stretches was recorded, with a domination of potamophilous taxa belonging mostly to the family Tubificidae. This is probably due to the damming influence in the section, the backwater effect and the more intensive sedimentation that is evident in a considerable stretch of the Upper Danube. Lumbriculidae were also frequent in this sector and this is expected since many lumbriculids prefer cool habitats (springs, mountain brooks and underground water bodies).

The middle reach of the Danube is characterised by the highest species richness. The macrozoobenthos community composition in the Slovakian stretch of the Danube River was influenced by the species diversity in the Slovak left side tributaries (Elexová 1998). A typical species, which occurs only in the upper and middle reach, is *Stylodrilus heringianus*. On the other hand, characteristic species from middle and lower reaches of the main channel are *Criodrilus lacuum* and *Isochaetides michaelseni*. The lower reach of the Danube shows high species richness (37 taxa). The typical species of the main channel were *C. lacuum, B. sowerbyi, I. michaelseni, Limnodrilus claparedeanus, L. udekemianus, Potamothrix danubialis* and *P. hammoniensis.*

Rare species that were recorded only from one sampling site were *Rhyacodrilus coccineus* and *Rhynchelmis limosella* (JDS1)*, Piguetiella blanci* (JDS6), *Nais alpina* (JDS33)*, Nais christinae* (JDS69) and *Bothrioneurum vejdovskyanum* (Iron Gate II – JSD64). With regard to overall environmental conditions, sampling site JDS1 is different from all the other sites. In the Upper stretch, the Danube is faster, the bottom characteristics are different from other section types, with a significant participation of larger bottom substrate fractions (Liška et al. 2008). Further, *B. vejdovskyanum* that was recorded within the lower stretch only, typically can be found in sediments rich in organic matter (Dumnicka & Poznanska 2006), and according to Timm (2009), this species is common particularly in cases of thermal pollution. Also rare was *Tubifex ignotus*, found only in the middle reach.

According to Šporka (1998), the factors which determine the distribution of macroinvertebrates are numerous and interrelated. The most important factor influencing the species composition of Oligochaeta in the main channel of the Danube is the structure of bottom sediment which is strongly linked to current velocity (for details see: Liška et al. 2008). A good example is *Stylodrilus heringianus,* which prefers coarse gravel and is therefore absent in the lower reach of the Danube, where coarse sediments are lacking. In contrast, *Isochaetides michaelseni* and *Criodrilus lacuum* prefer fine sediments and therefore occur only in the middle and lower reaches.

As a tolerant species in terms of organic pollution, *Limnodrilus hoffmeisteri* occurs along the whole stretch of the Danube, but prefers fine sediments rich in organic matter.

Compared with the first survey, JDS 1 (in 2001), where a polyp grab was used for sampling, the number of identified benthic species in JDS 2 (in 2007) increased and the main changes were in Oligochaeta. During the JDS 1, Oligochaeta were identified to a small degree only, so that the number of recorded species was low compared to this dataset. The total qualitative composition of fauna depended on the employed sampling techniques and on the level of determination.

Comparison of data sets showed a predominance of Oligochaeta when air-lift and MHS were used. On the other hand, kick-sampling and sweep/dredging seems to be less effective in documenting this faunistic group. This fact reveals that, regarding diversity, a combination of both air-lift/MHS, kick-sampling and sweep/dredging is useful (Graf et al. 2008). Having this in mind, the JDS 2 was the most comprehensive survey, providing comparable biological and chemical data along the Danube in the main river channel and in the major tributaries. This is important in order to obtain reliable and comparable results.

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