Oligochaeta community of the main Serbian waterways

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Abstract

The aim of this paper is to present a checklist and the distribution of Oligochaeta in Serbia's major rivers: the Danube, the Sava, and the Tisa. The data presented serve as principal inputs for the design of an effective biomonitoring system, as a part of routine monitoring of water status under the EU Water Framework Directive. The rivers under investigation flow through numerous industrial and urban centers and receive significant amounts of pollution. The effects of pollution and hydromorphological alterations are important for the distribution of Oligochaeta, which are one of the principal members of the macroinvertebrate community. A total of 52 taxa of aquatic worms from 32 genera, belonging to 9 families, have been recorded. Most of the observed species are typical of potamon-type rivers in the region, adapted to high and moderate organic loads. The recorded community is dominated by limnophylous and limno to rheophilous, as well as pelophylous, argillophylous and psammophylous taxa. Although the investigated river stretches are considered to be of similar water types, characterized as large lowland rivers, a certain differences within the Oligochaeta species composition has been identified.

Key words: Oligochaeta, biological quality elements, water status, watercourses, large rivers,

Introduction

This paper provides a list of recorded taxa and discusses the distribution of Oligochaeta (aquatic worms, oligochaetes) species in three large rivers in Serbia: the Danube, the Sava, and the Tisa. The results are especially interesting because aquatic worms were found to be among the principal members of the macroinvertebrate community in the investigated rivers (Paunovic, 2004; Paunovic *et al.,* 2008; Paunovic *et al.,* 2007). The community in the investigated rivers, which are similar with regard to their overall characteristics (SCG ICPDR, 2004), is highly complex. Data on the Oligochaeta community in substantial stretches of large rivers in the region are scarce, generally limited to descriptions of relatively small reaches (Paunovic, 2004).

The results presented below constitute an important input for the design of an effective approach to ecological status assessment. After the EU Water Framework Directive (European Commission, 2000) came into the force, biological investigations of aquatic ecosystems became an important component of water management. According to the EU Water Framework Directive (WFD), biological status assessment is primarily based on analyses of aquatic communities – Biological Quality Elements (BQEs). In particular, BQEs including aquatic macroinvertebrates, and oligochaetes as their principal member, were underscored as the most important element for water status assessment. Thus, the aim of this paper is to present the data needed to contribute to the knowledge of the aquatic worm community and its potential use in ecological status assessment.

The Danube River Basin is the second largest river basin in Europe, with a surface area of some 800,000 km^2. The basin extends into 17 countries. The total length of the Danube River is 2,857 km.

The Serbian stretch of the Danube is 588 km long and includes the middle and a part of its lower, 220 km long, course. A major portion of this stretch of the Danube (358 km) lies within the Pannonian Basin. In Serbia, the Danube is a typical lowland river, with a gradient of

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0.05-0.04‰. The largest tributaries of the Danube in Serbia are the Tisa and Sava rivers. The Danube River Basin is considered to be a “hot spot” for European freshwater biodiversity, due to its geographical location, extent and history (Sommerwerk *et al.,* 2009).

The catchment area of the Tisa River (157,186 km²) is the largest sub-basin of the Danube River Basin. The Tisa is the longest tributary (966 km) of the Danube; it comes from Hungary and empties into the Danube in Serbia, near Slankamen (at km 1215). Only 5% of its catchment area lies within the territory of Serbia, and this 164 km long stretch of the Tisa is a typical lowland river (Lower Tisa). In Serbia, the Tisa receives the Begej River directly and a number of smaller tributaries indirectly, via the Danube-Tisa-Danube Canal System (HS DTD). The main structure of the HS DTD is a dam erected at the 63rd km of the Tisa River. The dam has increased low and average water levels, whose effects are felt beyond the Serbian/Hungarian border.

The Sava River rises from the Sava Dolinka and the Sava Bohinjka in Slovenia. With numerous tributaries along its 940km-long course to the Danube, it represents one of the most significant basins in the region (surface area 95,419 km^2). The lower course of the Sava (206 km long) flows through Serbia. This stretch is a typical lowland watercourse: it is located at an altitude of less than 80 m , its gradient is 0.098 ‰, the river channel is up to 1000 m wide, and there are relatively thick deposits dominated by small fractions of sand and silt. The long-term average water discharge at Sremska Mitrovica (about 100 km upstream from the mouth) is nearly 1500 m^3 s^{-1}. The Sava River joins the Danube at Belgrade (km 1170).

The Danube, the Sava and the Tisa are important waterways, not only for Serbia, but also for other countries in the region. Besides intensive ship traffic, the rivers are under the influence of hydromorphological alterations, settlements, industrial “hot-spots”, and agriculture (for details see: Csanyi, 2002; ICPDR WFD Roof Report, 2004; Literathy *et al.,* 2002; Paunovic, 2004; SCG ICPDR, 2004).

One of the most important problems which affect the Danube is river engineering. In Serbia, the erection of a dam on the Danube near Sip (km 943), has resulted in the creation of a large artificial lake, the Iron Gate Reservoir, which is 100 km long and extends to Golubac. Following damming, the flow rate of the Danube decreased upstream all the way to Slankamen (km 1215), and resulted in intensified sedimentation.

The investigated rivers are affected by urban wastewater originating from numerous settlements, as well as wastewater from industrial facilities and agricultural activities. Radioactive contamination has been detected in sediments sampled from the Sava River (Ajdacic and Martic, 1989) and in groundwater (Jankovic, 1989).

Material and Methods

The study is based on the results of investigations of Oligochaeta fauna in large potamon-type rivers in Serbia during the period from 2001 to 2005. The material was collected at 25 sampling sites on the Danube River, 6 on the Sava River, and 5 on the Tisa River (Figure 1), using a Hydraulic Polyp Grab, FBA hand net (mesh size 500 μm), benthological dredge (mesh size 250 μm), and Van Veen grab (270 cm^2), mostly in the riverbank region. In the case of samples collected with Polyp and Van Veen grabs, animals were separated from the sediment by sieving (mesh size 200 μm).

The samples were preserved with a 4% formaldehyde solution. Sorting and identification were carried out using a binocular magnifier (5-50) and a stereomicroscope (10x10 and 10x40).

Characterization of the species with regard to saprobic condition, substrate and current preference was performed using AQEM software (AQEM, 2002).

A correspondence analysis (CA, Statistica 6.0) was performed on a matrix of 52 (taxa) x 3 (presence/absence of taxa in material from three river stretches). A correlation analysis was also carried out in order to quantify the relations between the rivers based on Oligochaeta compositions (presence/absence data).

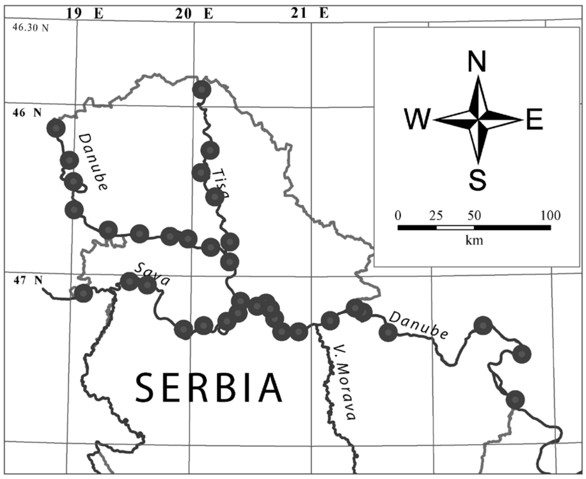

Figure 1: Sampling sites along the Danube, Sava and Tisa Rivers

Results

A total of 52 taxa of aquatic worms from 32 genera, belonging to 9 families, were identified (Table 1).

For the duration of the investigation, a total of 37 taxa of Oligochaeta were found in the Danube River. The families Naididae and Tubificidae (16 species each), were found to be the principal members of the community in terms of species richness. The families Enchytraeidae (*Enchytraeus albidus*) and Propappidae (*Propappus volki*), were detected only in the Danube River.

In the Sava River, 21 Oligochaeta taxa were identified. Out of these taxa, 10 belong to the Tubificidae and 8 to the Naididae family, while other families were found to be less diverse. *Criodrilus lacuum* and *Haplotaxis gordioides* were detected only in the Sava River.

During investigation of the Tisa River, 27 taxa of aquatic worms were recorded. The family Tubificidae, with 17 identified species, was found to be the most diversified group of aquatic worms. Other families were less diverse – Naididae 6, Lumbriculidae 2, and Lumbricidae and Pristinidae 1 taxon each. The Tisa River is characterized by the presence of 11 taxa that were not recorded in the other investigated rivers (Table 1).

The species that were recorded only in one out of the three investigated river stretches comprise rare taxa (*Aulophorus furcatus, Aulodrilsu limnobius, Dero nivea, Specaria josinae, Potamothrix moldaviensis, C. lacuum*), according to previous investigations (JDS-ITR National Report, 2002; JDS-ITR National Tisa Report, 2002; Jurca and Miljanović, 2006; Paunovic *et al.,* 2008; Paunovic *et al.,* 2007; Paunovic *et al.,* 2005; Vojinović-Miloradov *et al.,* 2003), or those not previously recorded (*Tubifex montanus, Isochaeta baicalensis, Stylodrilus lemani, Pepsidrilus pusillus, H. gordioides*) in the investigated area.

Taking into consideration all the species recorded in the investigated area, the majority could be considered as tolerant to high organic load. Thus, according to AQEM classification (AQEM, 2002) of the taxa, in terms of saprobic conditions (saprobic valence), 27.11% of the identified species belong to the beta-mesosaprobic group (adapted to or tolerant of medium-level organic pollution), while 27.50% of the taxa could be characterized as alpha-mesosaprobic (adapted to or tolerant of considerable organic pollution). Species adapted to high organic load (poly-saprobic) contributed 6.73% to the total number of taxa. Only 7.88% of the recorded taxa were classified as sensitive to organic pollution (xeno-saprobic and oligo-saprobic taxa). The remaining species (30.77%) could not be classified in terms of saprobic tolerance due to a lack of data.

Further, according to the AQEM classification (AQEM, 2002) with regard to the preferred zone within the river continuum (longitudinal zonation), a major portion (43.65%) of the recorded species are characteristic of lower river courses (barbell and carp region), while 22.31% of the taxa recorded are typical of standing waters. A minor proportion of the taxa belong to those of the rhithral type (14.61%).

With regard to salinity preference, 36.15% of the recorded taxa are typical freshwater organisms. Out of the identified species, 11.92% were characterized as oligohaline and 1.92% belong to mesohaline taxa, while half of the taxa could not be classified into salinity preference groups due to insufficient data.

In terms of current preference, the recorded community is dominated by limnophylous (36.54% of the total number of recorded species) and limno to rheophilous (15.38%) taxa. A minor proportion of the species (11.54%) was characterized as indifferent to current conditions, while 23.08% of the taxa could not be classified in terms of current preference due to a lack of relevant data.

The majority of the identified species are adapted to the bottom substrate which is typical of large lowland rivers in the region (37): 43.35% of the taxa belong to pelophylous (19.42%), argillophylous (4.23%), and taxa that prefer sandy substrates (psammophylous, 17.69%). The taxa that could be characterized as phytophylous contributed 15.19% to the total number of the species, while for the remainder there was not enough information about microhabitat preference (AQEM, 2002).

The positions of the river stretches (squares) and species groups (circles), obtained by CA, are shown on Figure 2. The CA procedure yielded the positions of the species and the river stretches in the form of an ordination diagram. According to the CA, the species are grouped at seven positions. The species from the same position on the ordination diagram (Figure 2) are considered to be species groups (SG) and the SG qualification of each species is shown in Table 1.

According to correlation analyses, a significant negative correlation exists between the Tisa and the Danube based on the presence/absence of the Oligochaeta taxa. This difference between the two stretches revealed by CA is mostly due to the taxa belonging to SG 1, which comprises taxa that were found only at the Tisa River, and SG 4 (species recorded only in the Danube River). Two species belonging to SG 7 were found only in the Sava River. Other SGs are either represented in all the investigated rivers (SG 2), or present in two of the investigated rivers (SGs 3, 5, 6).

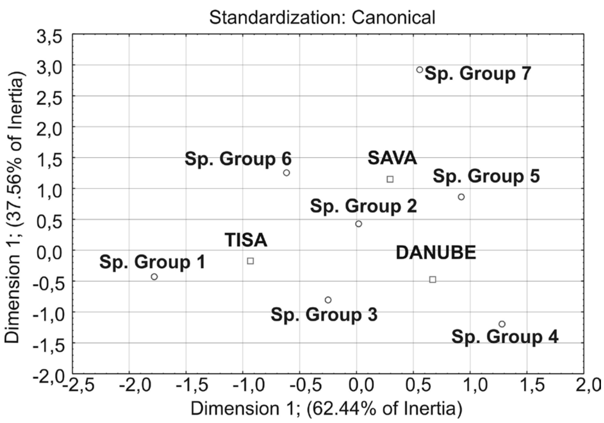

Figure 2: The position of the river stretches and species groups (SG) obtained by CA

Table 1: List of Oligochaeta taxa and species groups (SG) recorded in Serbian waterways

Sampling site (river)	Danube	Sava	Tisa	Species Group
Naididae				
1. *Amphichaeta rostrifera* Akinschina, 1984	*		*	3
2. *Aulophorus furcatus* (Müller, 1773)	*			4
3. *Chaetogaster* sp.	*		*	3
4. *Nais barbata* (Müller, 1773)	*			4
5. *Nais communis* Piguet, 1906	*	*		5
6. *Nais pseudobtusa* Piguet, 1906	*	*		5
7. *Nais elinguis* Müller, 1773	*	*	*	2
8. *Ophidonais serpentina* (Müller, 1773)	*	*		5
9. *Paranais frici* (Hrabe, 1941)	*	*		5
10. *Uncinais uncinata* (Oersted, 1842)	*	*		5
11. *Stylaria lacustris* (Linnaeus, 1767)	*	*		5
12. *Dero obtusa* d'Udekem, 1855	*		*	3
13. *Dero dorsalis* Ferroniere, 1899			*	1
14. *Dero digitata* (Mueller, 1773)			*	1
15. *Dero nivea* Aiyer, 1929	*			4
16. *Specaria josinae* (Vejdovski, 1883)	*			4
17. *Vejdovskyella intermedia* (Bretscher, 1896)	*			4
18. *Vejdovskyella comata* (Vejdovski, 1883)	*	*		5
Pristinidae				
19. *Pristina aequiseta* Bourne, 1891	*			4
20. *Pristina longiseta* Ehrenberg, 1828	*			4
21. *Pristina rosea* (Piguet, 1906)			*	1
Tubificidae				
22. *Aulodrilus pluriseta* (Piguet, 1906)	*	*		5
23. *Aulodrilus limnobius* Bretscher, 1899	*			4
24. *Aulodrilus* sp.			*	1
25. Branchiura *sowerbyi* Beddard, 1892	*	*	*	2
26. *Embolocephalus velutinus* (Grube, 1879)	*			4
27. I*sochaeta baicalensis* (Michaelsen, 1901)			*	1
28. *Isochaetides michaelseni* (Lastockin, 1936)		*	*	6
29. *Limnodruilus claparedeanus* Ratzel, 1868	*	*	*	2
30. *Limnodrilus hoffmeisteri* Claparede, 1862	*	*	*	2
31. *Limnodrilus udekemianus* Claparede, 1862	*	*	*	2
32. *Limnodrilus profundicola* (Verrill, 1871)	*	*	*	2
33. *Peloscolex* sp.			*	1
34. *Pepsidrilus pusillus* (Timm, 1977)			*	1
35. *Psammoryctides albicola* (Michaelsen, 1901)	*	*	*	2
36. *Psammoryctides barbatus* (Grube, 1861)	*		*	3
37. *Psammoryctides moravicus* (Hrabe, 1934)	*		*	3
38. *Potamothrix hammoniensis* (Michaelsen, 1901)	*	*	*	2
39. *Potamothrix isochaetus* (Hrabe, 1941)	*			4
40. *Potamothrix moldaviensis* (Vejdovsky and Mrazek, 1902)			*	1
41. *Potamothrix vejdovskyi* (Hrabe, 1941)	*			4
42. *Spirosperma ferox* (Eisen, 1879)	*			4
43. *Tubifex montanus* (Kowalewski, 1919)			*	1
44. *Tubifex tubifex* (Müller, 1774)	*	*	*	2
Lumbriculidae				
45. *Stylodrilus lemani Grube*, 1879			*	1
46. *Trichodrilus* sp.			*	1
Lumbricidae				
47. *Eisenniella tetraedra* (Savigny, 1826)		*	*	6
48. *Lumbricidae* spp.	*			4
Enchytraeidae				
49. *Enchytraeus albidus* (Henle, 1837)	*			4
Propappidae				
50. *Propappus volki* (Michaelsen, 1916)	*			4
Criodrilidae				
51. *Cryodrilus lacuum* Hoffmeister, 1845		*		7
Haplotaxidae				
52. *Haplotaxis gordioides* (Hartmann, 1821)		*		7
No. of taxa	**37**	**21**	**27**	

Discussion

During this investigation, a rich Oligochaeta community was detected, with 52 identified taxa, belonging to 9 families. A total of 37 taxa were recorded in the Danube, while fewer species were detected in its tributaries (Tisa 27, Sava 21), mostly due to a smaller number of examined sites.

Aquatic worms were one of the principal members of the macroinvertebrate community in the investigated rivers, with regard to species richness. In previous investigations of these rivers, Oligochaeta were also recognized as one of the most distinguished members of the macroinvertebrate community (Djukic and Karaman, 1994; Jakovcev, 1987, 1988; Jakovcev-Todorovic *et al.,* 2005; JDS-ITR National Report, 2002; JDS-ITR National Tisa Report, 2002; Jurca and Miljanović, 2006; Martinovic-Vitanovic *et al.,* 1999, 2006; Paunovic *et al.,* 2005, 2007, 2008; Simic *et al.,* 1997; Simic and Simic, 2004; Simonovic *et al.,* 2010; Vojinović-Miloradov *et al.,* 2003).

Oligochaeta were found to be one of the principal members of the benthic community, not only in the Serbian stretch of the Danube, but also along a considerable portion of the river (Csányi and Paunović, 2006; Elexová, 1998; Russev,1970; Sommerwerk *et al.,* 2009), as well as in the investigated tributaries: the Sava (Mihaljevic *et al.,* 1998; Paunovic, 2004; Paunovic *et al.,* 2008) and the Tisa (Csanyi, 2002).

Most of the observed species are typical of potamon-type rivers in the region and well adapted to high organic load and soft sediment. Representatives of the Tubificidae family, adapted to high organic load (Moog, 2002), which are taxa characteristic of a soft substrate (pelophilous taxa, Timm *et al.,* 2001), were observed in all of the investigated river stretches: *Branchiura sowerbyi* (alien invasive species), *Limnodrilus hoffmeisteri, L. claparedeanus, L. udekemianus, L. profundicola, Potamothrix hammoniensis, Psammoryctides albicola* and *Tubifex tubifex.* Apart from pelophilous species, taxa characteristic of other substrates were found to be the psammophilous *Psammoryctides barbatus* (Danube and Tisa rivers) or phytophilous representatives of the Naididae family.

A similar community structure was observed in the Slovakian stretch of the Danube (Elexová, 1998; Sommerwerk *et al.,* 2009; Šporka and Nagy, 1998). The thermophilous species *A. furcatus* was recorded in the Serbian stretch of the Danube (Timm, 1999), which could be indicative of a local (intra-microhabitat) disturbance, resulting from altered hydrological conditions along a considerable portion of the stretch due to damming, and the subsequent change in thermal conditions.

Most of the macroinvertebrates in the Serbian stretch of the Sava River have been observed in the Belgrade area (Jakovcev, 1988, 1989, 1991; Martinovic-Vitanovic *et al.,* 1999; Paunovic, 2004). The identified Oligochaeta community is typical of large lowland rivers in the region. The detection of *H. gordioides* in the Sava River is especially interesting because this species is not typical of lowland rivers (Csanyi, 2002; Jakovcev-Todorovic *et al.*, 2006). Šporka (1998) reported finding this species in a gravel substratum in Slovak/Hungarian portions of the Danube River. In Serbia, *H. gordioides* has previously been collected only in highland streams (Kalafatic *et al.,* 1999; Paunovic *et al.,* 2003; Simić *et al.,* 1993).

Several rheophilous species of Ponto-Caspian origin have spread upstream, most likely with ships: *Isochaetides michaelseni, P. moldaviensis,* and *Psammoryctides moravicus.* In addition, *Paranais frici*, a brackish-water species (Timm *et al.,* 2001), was found in the Danube and the Sava. These findings support the belief that the Ponto-Caspian area is an important spreading centre for alien species in Europe (Arbaciauskas *et al.,* 2008; Panov *et al.,* 2009).

Although the investigated stretches are considered to be of similar water types (belonging to large lowland rivers), certain differences within the Oligochaeta species composition have been identified. The positions of the investigated stretches shown in Figure 2 suggest that the Tisa River is distinct in some characteristics associated with the composition of the Oligochaeta fauna. Representatives of the Lumbriculidae family were recorded in the Tisa River only. The finding of *Trichodrilus* sp. was interesting, because it is comprised of taxa typical of cold-water streams (Timm *et al.,* 2001).

The greater species richness recorded in the Danube River could be attributed to different lengths of the investigated river stretches, and consequently different numbers of studied sampling sites.

Further, 11 taxa not found in the other rivers are present in the Tisa River, suggesting a certain peculiarity of the investigated stretch. This was confirmed by previous investigations; *P. moldaviensis* was found to be one of the principal taxa within the benthic community of the Tisa River (Vojinović-Miloradov *et al.,* 2003).

The difference between the stretches explained by CA (Figure 2) and correlation analyses is mostly generated by the presence of rare taxa. The species that were recorded in only one out of three investigated stretches (SG 1, 4 and 7) comprise species that are, according to previous investigations (JDS-ITR National Report, 2002; JDS-ITR National Tisa Report, 2002; Jurca and

Miljanović, 2006; Paunovic *et al.,* 2005, 2007; Vojinović-Miloradov *et al.,* 2003), rare (e.g. *Trichodrilus* sp., *Tubifex montanus, Pepsidrilus pusillus*), or not previously recorded (*T. montanus H. gordioides.*) in the investigated area.

Uncommon taxa for this river type, and also rare in general (Timm, 2009), have reached the Tisa River from its Carpathian Basin tributaries. The finding of these taxa as well is indicative of the influence of the tributaries which, according to our data, is more pronounced in the case of the Tisa River, compared to the Danube and the Sava.

Conclusions

Oligochaetes are one of the principal members of the macroinvertebrate community in Serbia's major watercourses with regard to species richness. The observed community is typical of large lowland rivers in the region. The recorded species, dominated by the Tubificidae family, are well adapted to high organic load and soft sediment. The observed differences in species composition between the investigated rivers are caused by the presence of uncommon and rare taxa. Thus, the Tisa River is under the influence of the Carpathian Basin, and the Danube is under the influence of the Ponto-Caspian region. This paper indicates that Oligochaeta, which is one of the principal members of macroinvertebrate community, should be part of ecological status assessment.

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