Arch. Biol. Sci., Belgrade, 60 (2), 265-271, 2008 DOI:10.2298/ABS0802265P

RESULTS OF THE 2006 SAVA SURVEY – AQUATIC MACROINVERTEBRATES

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Abstract — The paper presents some results of the 2006 Sava survey. The investigation was carried out at four locations along 188 km of the Serbian stretch of the Sava River (206 km of the river belongs to Serbia). Among other things (physical and chemical properties of water and sediment, phytoplankton, and phytobenthos), the study included investigation of aquatic macroinvertebrates. Sixty-two taxa were identified in this typical lowland river. Mollusks and oligochaetes were the most diverse groups of macroinvertebrates. Our results support the hypothesis that the Sava River is an important bio-invasion trajectory, a part of the Southern Invasive Corridor of Europe. Five alien macroinvertebrate taxa were identified, some of which (*Corbicula fluminea*, *Branchyura sowerbyi*, and *Anodonta woodiana*) were found to be important components of the community.

Key words: Sava River, aquatic macroinvertebrates, Serbia

UDC 592(49711 SAVA)"2006":502.51:504.5

INTRODUCTION

The aim of this paper is to present the macroinvertebrate community along the Serbian sector of the Sava River.

The Sava River arises from the Sava Dolinka in Slovenia. With numerous tributaries along its 940-km course to the Danube, the Sava represents one of the most significant basins in the region (with a drainage area of 95,419 km^2). The lower part of the river (206 km long) flows through Serbia. This section of the Sava is a typical lowland watercourse: it is located at an altitude lower than 80 m with 0.098‰ declination, the river channel being up to 1.000 m wide and having relatively thick depositions dominated by small fractions of sand and silt. The long-term average water throughut at Sremska Mitrovica (about 100 km upstream from the mouth) is close to 1.500 m^3 s^{-1}. The Sava reaches its confluence with the Danube in Belgrade.

The Sava River is an important waterway, not only for Serbia, but also for other countries in the region. In addition to heavy boat traffic, the river is under the influence of hydro-morphological alterations, industrial "hot-spots", and agriculture (for details see: SCG ICPDR National Report, 2004). The Serbian part of the Sava has been influenced by numerous pollution sources from municipal and industrial facilities, as well as by agricultural activities. The most damaging pollution derives from communal waste water and discharges from the metallurgical, chemical, leather, textile, food, and pulp and paper industries (Jovičić et al., 1989). According to previous investigations (Petrović 1983, 1989; Janković, 1989), this sector of the watercourse is endangered by relatively high nutrient content, BOD values, and inorganic pollutant loads, as well as by thermal pollution. Radioactive contamination was detected in the sediment (Ajdačić and Martić, 1989) and in ground water (Janković, 1989).

The most complete investigation of macroinvertebrates of the Sava River was performed by Matoničkin et al., (1975). Macroinvertebrates of the Serbian stretch of the Sava River have been observed intensively only in the region of Belgrade (Jakovčev, 1988, 1989, 1991; Martinović-Vitanović et al., 1999; Paunović, 2004). Previously published results of investigations con-

ducted in the Serbian part of the Sava River mostly presented only limited data on aquatic macroinvertebrates.

MATERIAL AND METHODS

The study is based on material collected in August of 2006. The research vessel Argus was used for the investigation, which was carried out at four sampling sites along the banks of the main channel, covering 188 km of the Serbian stretch of the Sava River (Table 1, Fig. 1).

Macroinvertebrate samples were taken using an FBA hand net (mesh size 250-500 μm; kick and sweep technique) and a benthological dredge (mesh size 250 μm). In addition, diving was performed at depths between 0.4 and 7 m to obtain specimens of the malacofauna. In the case of collection of mollusks by diving, their abundance was evaluated by collecting and counting individuals within randomly selected square areas of 0.5 m^2. The diver sampled all specimens from a chosen quadrant and removed them to the shore for identification.

Coordinates of the sampling sites were measured by GPS ("Garmin Etrex") and charted using ArcView software (map 1:300,000, system WGS_1984).

Species richness (total number of species and number of species within selected groups), relative abundance (percentage participation), frequency of occurrence (F), the Shannon-Weaver diversity index (H – Shannon-Weaver, 1949), The Pielou evenness index (Pielou, 1984), the ASPT and BMWP indices (Armitage et al., 1983), the number of sensitive taxa (AQEM, 2002), and the EPT index (AQEM, 2002) were used to describe the community.

RESULTS

Table 1. Sampling sites.

Nº	Site	River km	X	Y	elevation
1.	Jamena	195.0	44°52'41,6"	19°05'21,0"	84 m
2.	Sremska Mitrovica	136.4	44°57'55,4"	19°36'01,4"	80 m
3.	Šabac	103.6	44°46'17,2"	19°42'16,1"	79 m
4.	Ostružnica	17.0	44°43'19,5"	20°18'15,5"	78 m

Sixty-two macroinvertebrate taxa were observed in the course of the investigation (Table 2). Mollusks were found to be the principal community component, with 23 species (Gastropoda 12 and Bivalvia 11). Among Oligochaeta, 16 species were identified. Other macroinvertebrate groups were characterized by lower numbers of taxa.

The number of species per sample ranged from five (site 3, right bank) to 27 (site 1, left bank). The number of taxa per sample at sites 4 and 5 ranged from 22 to 25. Site 5 was characterized by 14 and 15 species per sample.

Mollusca and Oligochaeta were found to be the principal components in regard to relative abundance, also. Percentage participation of mollusks and oligochaetes in the total macroinvertebrate community ranged from 10.45 to 97.75% (mean

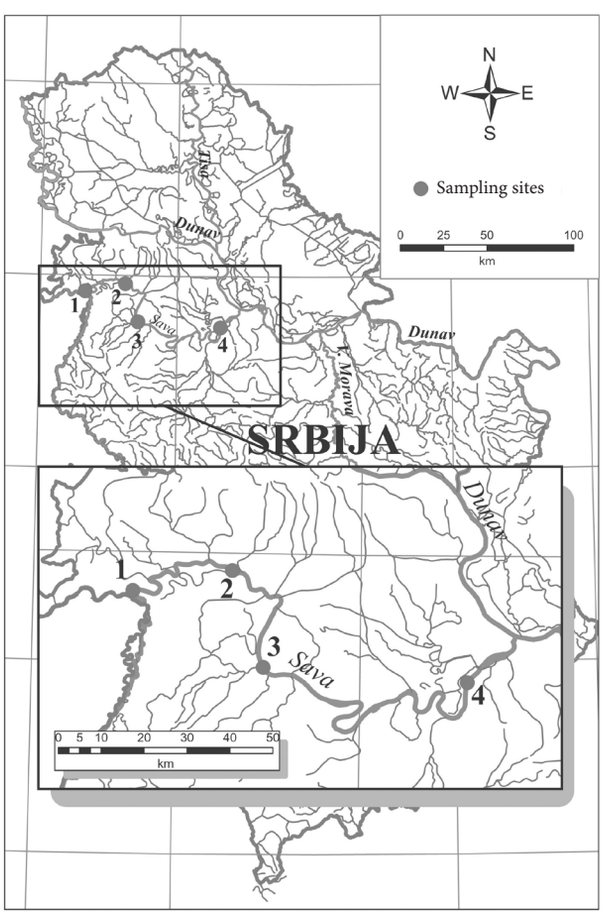

Fig. 1. Sampling sites.

Table 2. List of taxa (neobionts are marked with an asterisk).

NEMATODA
TURBELLARIA
Planaria torva O. F. Müller, 1773
POLYCHAETA
**Hypania invalida (*Grubě, *1860)*
OLIGOCHAETA
Nais pseudooptusa Piguet, 1906
Stylaria lacustris (Linnaeus, 1767)
Aulodrilus pluriseta (Piguet, 1906)
**Branchyura sowerby* Beddard, 1892
Limnodrilus claparedeanus Ratzel 1868
L. hoffmeisteri Claparede, 1862
L. udekemianus Claparede, 1862
L. profundicola (Verrill, 1871)
Psammoryctides albicola (Michaelsen, 1901)
P. barbatus (Grubě, 1891)
Potamothrix hammoniensis (Michaelsen, 1902)
Tubifex tubifex, Müller 1774
Spirosperma velutinus (Grubě, 1879)
Isochaetides michaelseni (Lastockin, 1937)
Criodrilus lacuum Hoffmeister, 1845
Enchytraeidae
HIRUDINEA
Glossiphonia complanata (Linnaeus, 1758)
Piscicola geometra (Linnaeus,1761)
GASTROPODA
Viviparus acerosus (Bourguignat, 1862)
*V. viviparus (*Linnaeus, 1758)
V. contectus (Millet, 1813)
Valvata naticina (Menke, 1845)
Bythinia tentaculata (Linnaeus, 1758)
Acroloxus lacustris (Linnaeus, 1758)
Physa fontinalis (Linnaeus, 1758)
Litoglyphus naticoides (C. Pfeiffer, 1828)
Esperiana (Fagotia) acicularis (Ferussac, 1823)
E. esperi (Ferussac, 1823)
Theodoxus danubialis (C. Pfeiffer, 1828)
T. fluviatilis (Linnaeus, 1758)
BIVALVIA
Sphaerium rivicola (Lamarck, 1818)
Mysculium (Sph.) lacustre (Müller, 1774)
Pisidium sp.
**Corbicula fluminalis* (Müller, 1774)
**C. fluminea* (Müller, 1774)
Dreissenia polymorpha (Pallas, 1771)
Unio pictorum (Linnaeus, 1758)
U. tumidus Philipsson, 1788
Pseudanodonta complanata (Rossmasser, 1835)
Anodonta anatina (Linnaeus, 1758)
**A. (Sinanodonta) woodiana* (Lea, 1834)
ISOPODA
Jaera istri Vieuille, 1979
Asellus aquaticus (Linnaeus, 1758)
AMPHIPODA
Gammaridae
Corophium curvispinum (Sars, 1895)
C. robustum (Sars, 1895)
MYSIDACEA
Mysidae
ODONATA
Gomphus vulgatissimus (Linaeus, 1758)
Platicnemis pennipes (Pallas, 1771)
EPHEMROPTERA
Ecdyonurus venosus Fabricius, 1775
TRICHOPTERA
Hydropsyche bulgaromanorum Malicky, 1977
Polycentropus flavomaculatus (Pictet, 1834)
Ecnomus tenellus (Rambur, 1842)
DIPTERA
Chironomidae
Tipulidae
Dolichopus sp.
COLEOPTERA
Limnius sp.

value of 64.13%) and from 1.50 to 89.02% (mean value of 29.91%), respectively.

In regard to frequency of occurrence, the most important species were *C. fluminalis* (Bivalvia) – F=1.00, *B. sowerbyi* and *L. claparedeanus* (Oligochaeta) – F=0.91, and *L. profundicola* (Oligochaeta) – F=0.82, *P. albicola* (Oligochaeta) – F=0.73, *P. hammoniensis* (Oligochaeta) – F=0.73, *T. tubifex* (Oligochaeta) – F=0.64, *I. michaelseni* (Oligochaeta) – F=0.45, *F. acicularis* (Gastropoda) - F=0.64, *E. esperi* (Gastropoda) - F=0.54, *T. danubialis* (Gastropoda) - F=0.54, *M. lacustre* (Bivalvia) - F=0.45, and *C. curvispinum* (Corophidae) - F=0.45. Other species were found to be less frequent.

Table 3. Mean values of selected community parameters.

Sample code	1	2	3	4
BMWP Score	28	13	39	45
ASPT	3,968	2,833	4,110	4,415
Evenness	0,550	0,390	0,690	0,525
No. of sensitive taxa	1,250	0,667	2,000	1,500
EPT-Taxa [%]	0,398	0,000	0,000	0,125
H'	1,620	0,832	2,190	1,636

Diversity index values ranged from H'=0.43 to H'=2.15.

Mean values of analyzed parameters of the community are presented in Table 3. Sample site 2 is characterized by lower mean values of H', BMWP, ASPT, and EPT in relation to sites 1, 3, and 4.

During the investigation, five alien invasive species were detected (Table 2, taxa marked with an asterisk) which is 8.06% of total number of identified macroinvertebrate species. Some alien species were found to be frequent and abundant. Thus, *C. fluminea* (Asiatic clam) was found at all sampling sites. The frequency of occurrence of *B. sowerbyi* (Oligochaeta) was found to be F=0.91, which indicates that the species is one of the dominant taxa in the community. *A. woodiana* (Chinese pond mussel) was collected only by diving. The species was abundant in bottom habitats with predominance of sand, fine sand, and mud.

DISCUSSION

Sixty-two macroinvertebrate species were identified in the course of the investigation. The recorded community is typical of large lowland rivers in the region (Simić et al., 1997; Csanyi, 2002; Simić and Simić, 2004; Paunović, 2004). Similar faunistic structure, with dominance of Oligochaeta and Mollusca, was recorded in the Tisa River (Csanyi, 2002) and along the Serbian stretch of the Danube River (Paunović et al., 2005, 2007). The number of taxa identified during the 2006 Sava survey is higher than that recorded at the same number of sampling sites on the Serbian sector of the Tisa River (42 taxa – Csanyi, 2002), but lower than those obtained in investigations of the Danube River (84 taxa – Paunović et al., 2005; 74 taxa – Paunović et al., 2007).

Lower mean values of analyzed community parameters (H', BMWP, ASPT, and EPT) at sampling site 3 indicate habitat degradation. Descriptive analysis in regard to specific stress performed with the AQEM program (AQEM, 2002) indicates general degradation and the presence of organic pollution.

During the investigation, five alien species were identified. Some of them were found with high frequency (*C. fluminea* and *B. sowerbyi*) and abundance (*A. woodiana*), which supports the premise that the Sava River is part of the Southern Invasive Corridor of Europe (Bij de Vaate et al., 2002; Galil et al., 2007).

CONCLUSIONS

A total of 62 macroinvertebrate species were identified, which is close to the number of taxa recorded in other large rivers in the region (the Tisza and the Danube).

The recorded community structure, with dominance of Mollusca and Oligochaeta, is typical of potamon-type rivers in the Danube basin.

The community's structure indicates habitat degradation and the presence of organic pollution, which are indicated for sampling site 3 by values of the analyzed community structure parameters (H', BMWP, ASPT, and EPT).

The Sava is under the influence of biological invasions, and the river is part of one of the most important trajectories of neobiont spreading, the so called "Southern Invasive Corridor".

Acknowledgments – This work was supported by the Ministry of Science of the Republic of Serbia (Grants Nos. 143023B and

143035B) and the European Commission's sixth framework program - Integrated Project ALARM (contract GOCE-CT-2003-506675). We would also like to thank the Ministry of Environmental Protection of the Republic of Serbia for enabling us to use the research vessel Argus.

REFERENCES

Ajdačić, N., and *M. Martić* (1989). Kontaminacija donjeg toka reke Save radioaktivnim elementima, In: *Zbornik radova, Savetovanje "Rijeka Sava, zaštita i korišćenje voda",* (Ed. M. Meštrov), 1987, 389-392. JAZU, Zagreb.

AQEM (2002). Manual for the application of the AQEM system. A comprehensive method to assess European streams using benthic macroinvertebrates, developed for the purpose of the Water Framework Directive. Contract No: EVK1-CT1999-00027).

Armitage, P. D., Moss, D., Wright, J. F., and *M. T. Furse* (1983). The performance of a new biological water quality scores system based on macroinvertebrates over a wide range of unpolluted running-water sites. *Water Res.* **17**, 333-347.

Bij de Vaate, A., Jazdzewski K., Ketelaars, H. A. M., Gollasch S., and *G. Van der Velde* (2002). Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe. *Can. J. Fisheries Aquatic Sci.* **59**, 1159–1174.

Csanyi, B. (2002). Joint Danube Survey: Investigation of the Tisza River. International Commission for the Protection of the Danube River, 1-135.

Galil, B. S., Nehring, S., and *V. E. Panov* (2007). Waterways as invasion highways – Impact of climate change and globalization, In: *Biological Invasions. **Ecological Studies***, 193 (Ed. W. Nentwig), 59-74. Springer, Berlin.

Jakovčev, D. (1988). Zustand der Benthalfauna der Flusses Sava im Region Belgrad. - *27. Arbeitstagung der IAD, SIL, Limnologische Berichte Donau 1988*, 259-263, Mamaia, Rumänien.

Jakovčev, D. (1989). Saprobiološka analiza reke Save na osnovu faune dna u okviru beogradskog regiona, In: *Zbornik radova, Savjetovanje "Rijeka Sava - zaštita i korišćenje voda"* (Ed. M. Meštrov), 1987, 442-445. JAZU, Zagreb. [Saprobiological analysis of the Sava River in the Region of Belgrade, based on bottom fauna].

Jakovčev, D. (1991). Saprobiologische Analyse der Sava im Belgrader Gebiet Anhand der Bodenfauna. - *29. Arbeitstagung der IAD, SIL, Wissenschaftliche Referate*, 250-254 Kiew, Ukrainien.

Janković, D. (1989). Specifičnost ekosistema donjeg toka reke Save od Jamene do ušća u Dunav. In: *Zbornik radova, Savjetovanje "Rijeka Sava - zaštita i korišćenje voda"* (Ed. M. Meštrov) 1987, 421-425. JAZU, Zagreb.

Jovičić, M., Bogdanović, B., Popović, L., Marjanović, Z., and *N. Marjanović* (1989). Prognoza kvaliteta vode reke Save, In: *Zbornik radova, Savjetovanje "Rijeka Sava- zaštita i korišćenje voda"* (Ed. M. Meštrov), 1987, 373-377. JAZU, Zagreb.

Martinović-Vitanović, V., Kalafatić, V., Martinović, J. M., Paunović, M., and *D. Jakovčev* (1999). Saprobiological analysis of benthic communities in the Danube in the Belgrade region. - 1st Congress of Ecologists of the Republic of Macedonia with International Participation. *Special Issues of the Macedonian Ecological Society* **5**, 504-516, Skopje.

Matoničkin, I., Pavletić, Z., Habdija, I., and *B. Stilinović* (1975). Prilog valorizaciji voda ekosistema rijeke Save. *Sveučilišna Naklada Liber* **95**, Zagreb.

Paunović, M. (2004). Qualitative composition of the macroinvertebrate communities in the Serbian sector of the Sava River. *Inter. Assoc. Danube Res.* **35**, 349-354.

Paunović, M., Simić, V., Jakovčev-Todorović, D. and *B. Stojanović* (2005). Results of macroinvertebrate community investigation in the Danube River on the sector upstream from the Iron Gate (1083-1071 km). *Arch. Biol. Sci. (Belgrade)* **57 (1)**, 57-63.

Paunović, M., Jakovčev-Todorović, D., Simić, V., Stojanović, B., and *P. Cakić* (2007). Macroinvertebrates along the Serbian section of the Danube River (stream km 1429-925). *Biologia (Bratislava)* **62 (2)**, 1-9.

Petrović, G. (1983). Beitrag zur hydrochemischen Erforschung der Donau und der Sava im Einzugsgebeit von Beograd. *Hidrobiologia (Bucharest)* **17**, 218-228.

Petrović, G. (1989). Hidrohemijska proučavanja kvaliteta vode reke Save u njenom donjem toku, In: *Zbornik radova, Savetovanje "Rijeka Sava, zaštita i korišćenje voda"* (Ed. M. Meštrov), 1987, 412-420. JAZU, Zagreb.

Pielou, E. C. (1984). *The Interpretation of Ecological Data - A Primer on Classification and Ordination,* 265 pp. Wiley-Interscience Publication, New York – Chichester – Brisbane – Toronto - Singapore.

SCG ICPDR National Report (2004). National Report of Serbia and Montenegro – ICPDR Roof Report, Part B. www.icpdr.org

Shannon, C. E., and *W. Weaver* (1949). *The Mathematical Theory of Communication*. The Univ. of Illinois Press, Urbana, IL.

Simić, S., Ostojić, A., Simić, V., and *D. Janković* (1997). Changes in structure of plankton and benthos in the part of the Danube from Veliko Gradište to Prahovo (Serbia, Yugoslavia) during the summer period. *Ekologija* **32 (2)**, 65-80.

Simić, V., and *S. Simić* (2004). Macroinvertebrates and fishes in the part of the Danube river flowing through the Iron Gate National Park and possibilities of their protection under *in situ* and *ex situ* conditions. *Arch. Biol. Sci. (Belgrade)* **56 (1-2)**, 53-57.

РЕЗУЛТАТИ ИСТРАЖИВАЊА РЕКЕ САВЕ (2006) - АКВАТИЧНИ МАКРОБЕСКИЧМЕЊАЦИ

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Циљ рада је да се прикаже део резултата истраживања на реци Сави током 2006. Истраживање је вршено на четири локалитета дуж 188 км речног тока Саве кроз Србију (од 206 км укупне дужине тока). Поред истраживања осталих параметара (анализа физичких и хемијских карактеристика воде, седимента, фитопланктона и фитобентоса) вршена су и истраживања акватичних макроинвертебрата. Укупно је забележено 62 таксона. Најразноврсније групе су Oligochaeta и Mollusca. Добијени резултати потврђују претпоставку да је река Сава важан инвазивни пут и да представља део јужноевропског инвазивног коридора. Укупно је забележено 5 алохтоних врста макроинвертебрата, од којих неке представљају важне компоненте заједнице - (*Corbicula fluminea*, *Branchyura sowerbyi*, и *Anodonta woodiana*)