THE IMPACT OF ALIEN SPECIES ON MACROZOOBENTHOS COMMUNITIES AND ASSESSMENT OF WATER QUALITY BY BIOTIC INDICES

Vladimir Razlutskij[1*], Katarina Zorić[2], Jelena Đuknić[2], Mihail Moroz[1], Bojana Tubić[2], Stefan Anđus[2], Nikola Marinković[2], Momir Paunović[2]

[1]Scientific and Practical Center for Bioresources, National Academy of Sciences of Belarus, Akademicheskaya 27, Minsk, BELARUS

[2]University of Belgrade, Institute for Biological Research "Siniša Stanković", 142 Despota Stefana Boulevard, Belgrade, SERBIA

[*]*vladimirrazl@gmail.com*

Abstract

Invasion of alien species can effects ecological state of water bodies through changes of composition and structure of macrozoobentos communities. We assessed bio-contamination (SBCI index) and water quality by biotic indices at 12 sites along the Danube River in Serbia and at 17 sites including the Neman, Narew and Western Bug river basins in Belarus for different years. The correlation analyses show that SBCI was weakly correlated with biotic indices in Danube River. Also, during the time Corophium sp. disappeared from macrozoobenthos community in the presence of Dikerogammarus villosus what could be a possible reason for the increase in the number of species and of the values of biotic indices. SBCI and densities of Orconectes limosus at sampling sites at Neman River are negatively correlated with biotic indices. At other sites in Belarus, SBCI metrics showed positive correlation with biotic indices. Differences in the impact of alien species on the assessment of water quality may be related to the intensity of biological pollution and the duration of the invasion.

Keywords: macroinvertabrates, alien species, biocontamination, water quality assessment

INTRODUCTION

Great number of alien species, especially macroinvertabrates, invaded the major European river basins due to human activities and related impacts [1]. Besides, domination of non-native species along the numerous European large rivers is confirmed [2,3]. Invasion of alien species can effects native communities due to direct predation and competition [4, 5]. Benthic macroinvertebrates are one of five biological quality elements of WFD used to assess of ecological status of European aquatic ecosystems. Changes in macroinvertebrate community structure due to pressures of invasive species may influence assessment of water quality [3,6].

To establish possible impact of aliens on native macroinvertabrates and assessment of water quality by biotic indices we conducted analysis of data from Serbian part of Danube River and Belorussian part of Neman River and its tributaries and rivers of Narew and Western Bug basins for different years. The Danube River is a part of Southern Invasive Corridor of Europe [7] and the Neman River is the main pathway for invaders from the Baltic Sea regions. The other rivers are part of the Ponto-Caspian Basin.

MATERIALS AND METHODS

Sampling of aquatic macroinvertebrates in the Danube River was carried out at 12 sites in 2014, 2015 and 2018. Sampling in Belarus was cried out at 17 sites in 2007, 2015 and 2018. Macroinvertebrates were collected using benthic hand nets with mesh size 500 μm, using Kick and Sweep multihabitat method in proportion to the evaluated habitat percentage at the sampling section. Material was preserved using 95% ethanol.

To assess biocontamination by alien species we used the site-specific biocontamination index (SBCI) [2]. It was calculated from two metrics: an abundance contamination index (ACI) and a richness contamination index (RCI). The sampling site classifies by obtained SBCI into one of four classes ranging from 0 (no contamination) to 4 (severe contamination).

Water quality was assessed using Biological Monitoring Working Party Index (BMWP) [8] and Altered Indice Biotico Esteso (IBE AQEM) [9]. To calculate biotic indices and other metrics we used Asterics Software Version 4.0.4.

Pearson correlation coefficient was used to test relationships between biocontamination indices and biological metrics.

RESULTS AND DISCUSSION

The 12 alien species were observed at sites along the Danube: *Hypania invalida* (Grube, 1860), *Dikerogammarus villosus* (Sowinsky, 1894), *Dikerogammarus bispinosus* Martynov, 1925, *Echinogammarus ischnus* (Stebbing, 1899), *Obesogammarus obesus* (Sars, 1894), *Limnomysis benedeni* Czerniavsky, 1882, *Dreissena bugensis* Andrusov, 1897, *Dreissena polymorpha* (Pallas, 1771), *Paramysis lacustris* (Czerniavsky, 1882), *Corbicula fluminea* (Müller, 1774), *Physella acuta* (Draparnaud, 1805) and *Orconectes limosus* (Rafinesque, 1817). The most abundant among them were *D. villosus* and *L. benedeni*.

Table 1 *Correlation coefficients between biocontamination and biotic indices and abundances of Dikerogammarus vilosus at sites of Danube River*

Index	ACI	RCI	SBCI	*D. villosus*
BMWP	-0.112	-0.119	0.061	**0.424**
IBE AQEM	0.085	-0.070	0.212	**0.510**

The most sites of Danube River had a high biocontamination level, which is in concordance with previous investigations [2,3]. The correlation analyses showed that SBCI metrics were weakly correlated with biotic indices (Table 1). The lasts were positively related with numbers of species in macrozoobentos communities ($r = 0.744$ for BMWP and $r = 0.697$ for IBE AQEM, $P<0.05$) and densities of *D. villosus* ($r = 0.570$, $P<0.05$).

Regarding certain amphipods species detected in the Danube River, we can see that during the time corophiid species were disappeared in the presence of *D. villosus* (Figure 1).

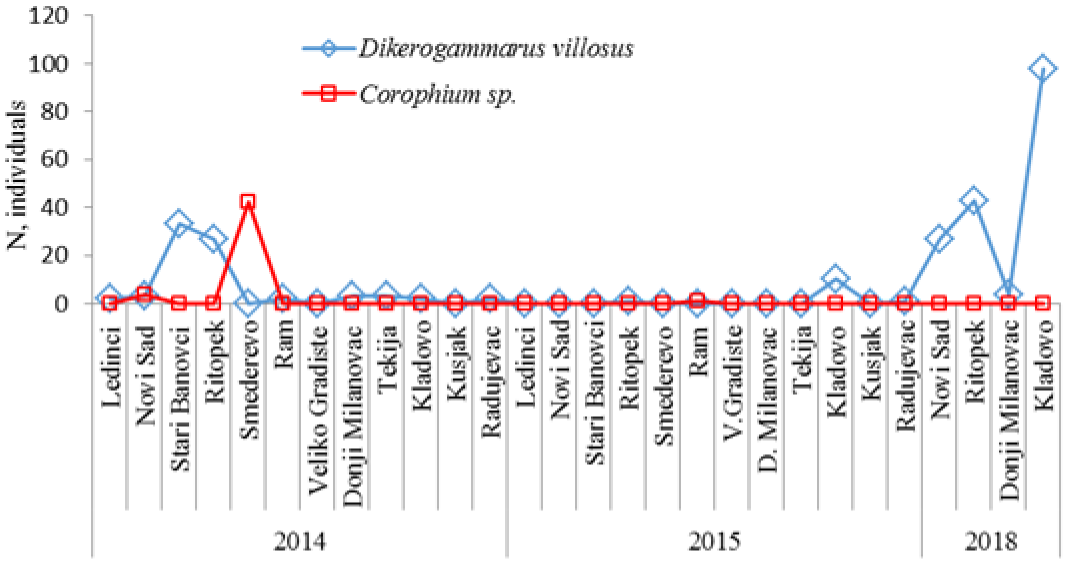

Figure 1 *The densities of Dikerogammarus vilosus and Corophium sp. at different sites of Danube River*

Decrease of *Corophium* sp. densities could be a reason for the increase in the number of species and values of biotic indices. Same situation was observed in Rhine River when *D. villosus* decreased abundance of *Corophium curvispinum*, resulting in a reduction of mud on the stone substrate, leading to an increased diversity of other macroinvertebrates [10].

Only 3 alien species were found at Belorussian river sites: Neman - *Lithoglyphus naticoides* (Pfeiffer, 1828), *Dreissena polymorpha* (Pallas, 1771) and *Orconectes limosus* (Rafinesque, 1817). Different metrics of biocontamination index and densities of *O. limosus* show negative correlation with biotic indices (Table 2). Another analyses showed that biotic indices were positively correlated with the proportions (%) of EPT taxa (Table 3).

Table 2 *Correlation coefficients between biocontamination and biotic indices and abundances of Orconectes limosus at sites of Neman River*

Index	ACI	RCI	SBCI	*O.limosus*
BMWP	-0.064	**-0.605**	-0.415	**-0.562**
IBE AQEM	-0.177	**-0.555**	-0.455	**-0.552**

Table 3 *Correlation coefficients of different groups of macroinvertebrates with biotic indices and the numbers of Orconectes limosus for study sites of Neman River*

taxa	BMWP	ASPT	BBI	IBE Aqem	N *O.limosus*
Gastropoda	-0.147	0.074	-0.315	-0.325	0.405
Oligochaeta	-0.231	-0.021	-0.370	-0.364	0.351
Hirudinea	0.006	-0.403	-0.132	-0.135	0.122
Crustacea	0.023	-0.166	0.046	0.049	-0.022
Ephemeroptera	0.072	-0.128	0.173	0.228	-0.285
Odonata	-0.298	**-0.663**	**-0.504**	-0.341	0.453
Plecoptera	**0.558**	0.446	**0.527**	**0.514**	-0.316
Heteroptera	0.459	0.365	0.459	0.374	-0.342

***Table 3** continued*

Trichoptera	0.337	**0.492**	**0.581**	0.364	**-0.549**
Coleoptera	0.083	-0.355	0.001	0.239	0.172
Diptera	0.174	0.363	0.358	0.266	-0.298
Hydrachnidia	0.466	**0.578**	**0.575**	0.449	-0.389
EPT/OL	-0.334	**-0.504**	-0.270	-0.145	0.266
- EPT (abundances)	**0.549**	**0.782**	**0.813**	**0.572**	**-0.799**

In contrast, biocontamination index positively correlated with biotic indices at sites along Narew and Western Bug basins rivers and Neman tributaries (Table 4). Biotic indices are negatively correlated with proportion of Oligochaeta, but have positive correlation with EPT taxa. Density of *Orconectes limosus* tends negative relation with proportion of Oligochaeta and are positively correlated with Ephemeroptera (Table 5).

***Table 4** Correlation coefficients between biocontamination and biotic indices and abundances of Orconectes limosus at sites of Neman tributaries and Narew and Western Bug basins rivers*

Index	ACI	RCI	SBCI	*O. limosus*
BMWP	0.418	**0.855**	**0.825**	**0.797**
IBE AQEM	0.326	**0.707**	**0.686**	**0.680**

***Table 5** Correlation coefficients the proportions (%) of different groups of macroinvertebrates with biotic indices and the numbers of Orconectes limosus for study sites of different rivers of Narew and Western Bug basins and Neman tributaries*

taxa	BMWP	ASPT	BBI	IBE AQEM	N *O. limosus*
Oligochaeta	-0.594	**-0.729**	**-0.836**	**-0.695**	-0.406
Hirudinea	-0.194	-0.399	-0.518	-0.196	-0.385
Crustacea	0.274	0.452	0.271	0.187	0.546
Araneae	**0.681**	0.584	0.459	0.612	**0.700**
Ephemeroptera	0.520	**0.708**	**0.694**	0.635	**0.695**
Odonata	0.337	0.551	0.407	0.263	0.560
Plecoptera	-0.036	0.231	0.408	0.198	0.060
Heteroptera	0.486	0.535	0.347	0.439	**0.713**
Trichoptera	-0.049	0.132	0.173	0.240	-0.217
Coleoptera	-0.061	0.093	0.419	0.252	-0.164
Diptera	0.170	-0.130	-0.069	0.109	-0.185
Hydrachnidia	0.032	0.061	0.056	0.018	-0.001
EPT/OL	0.528	**0.729**	0.603	0.531	**0.853**
- EPT (abundances)	-0.380	-0.360	-0.327	-0.529	-0.322

CONCLUSION

Differences in the impact of alien species on the assessment of water quality may be related to the intensity of biological pollution and the duration of the invasion. The study sites of Danube River have high level of biocontamination and predation of *D. villosus* on *Corophium* sp. possibly promotes increase of the number of species and values of biotic indices. Data from Belorussian river sites presuppose that *O. limosus* can influence macroinvertebrate communities through decreasing of EPT and Oligochaeta taxa, which has already been proven in our experiments [6]. From one hand, a decrease of Oligochaeta abundance increases values of biotic indices, but decrease of EPT taxes tends to decrease biotic indices and in that way, *O. limosus* can influence an assessment of water quality. *O. limosus* established its populations in Neman River at the end of 1990 and in the other rivers this species appeared later [11]. It is possible, that differences in *O. limosus* impact were due to the differences in the time of invasion and in community composition of macroinvertebrates. Thus, predatory invasive invertebrates, can affect the composition of macroinvertabrate communities and an assessment of water quality by biotic indices.

ACKNOWLEDGEMENTS

Part of field studies and manuscript preparation for publication were supported by Belorussian Republican Foundation for Basic Research (B18KI-007, B18SRGB-007) and Ministry of Education, Science and Technological Development of Republic of Serbia (Project of scientific and technical cooperation between Republic of Serbia and Republic of Belarus 2018-2019).

REFERENCES

[1] A. Bij de Vaate, K. Jazdzewski, H.A.M. Ketelaars, *et al.*, Can. J. Fish Aquat. Sci; 59 (2002) 1159–1174.

[2] K. Arbačiauskas, V. Semenchenko, M. Grabowski, *et al*., Aquat. Invasions; 3 (2008) 211–230.

[3] E. Arndt, S. Fiedler, D. Böhme, Hydrobiologia; 635 (2009) 309–320.

[4] R.E. Gozlan, D. Burnard, D, Andreou, *et al.*, PLoS ONE; 8 (2013) e53200, *Available on the following link:* https://doi.org/ 10.1371/journal.pone.0053200

[5] A. Ricciardi, T.M. Blackburn, J.T. Carlton, *et al.*, Trends in Ecology & Evolution; 32 (2017) 464–474.

[6] E. Šidagytė, V. Razlutskij, A. Aklehnovich, *et al.*, Aquat Invasions; 12 (4) (2017) 523–540.

[7] B. Galil, S. Nehring, V. Panov, Waterways as Invasion Highways – Impact of Climate Change and Globalization, In: W. Nentwig, ed., Biological Invasions, Springer, Berlin, Heidelberg, (2007) pp. 59–74.

[8] P.D. Armitage, D. Moss, J.F. Wright, *et al*., MT Water Research; 17 (1983) 333–347.

[9] D. Hering, O. Moog, L. Sandin, Verdonschot PFM Hydrobiologia; 516 (2004) 1–20.

[10] G. Van der Velde, I. Nagelkerken, S. Rajagopal, *et al.*, Invasions by alien species in inland freshwater bodies in Western Europe: The Rhine Delta. In: E. Leppäkoski, S. Gollasch, S. Olenin, eds., Invasive Aquatic Species of Europe: Distribution, Impacts and Management, Kluwer Academic Publishers, Dordrecht, (2002) pp. 360–372.

[11] A. Aklehnovich, V. Razlutskij, BioInvasions Records; 2 (3) (2013) 221–225.