ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., Suppl. 7, 2014: 185-190

Effect of Some Environmental Parameters on the Composition of Fish Communities in the Riparian Zone of the Bulgarian Danube River Section

Milena Pavlova, Yavor Rabadjiev

Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, 2 Gagarin Str., Sofia 1113, Bulgaria;
E-mail: mnp.iber@gmail.com

Abstract: Sixteen sites were surveyed from August to September 2013 along the Bulgarian part of the Danube River. Fishes were sampled by electricity using portable fishing device, and by seine net. A total of 22 fish species were found. Basic physical and chemical parameters (water temperature, dissolved oxygen and saturation, pH, COD, conductivity, concentrations of ammonium, nitrate and nitrite nitrogen, phosphate phosphorus, and total nitrogen and phosphorus) in both the water and sediments were measured. Some other abiotic (composition of the substrate) and biotic factors (percent macrophyte coverage) were also used. The concentrations of heavy metals (Cd, Mn, Cu, Pb, Zn, and Ni) and of As in both the water and sediments were also examined according to the standardised methods. Statistical packages Canoco 4.5 and Primer v 6 were used for analyses of the raw data. The percent coverage of macrophytes, water temperature, substrate features, concentration of As, Ni, Mn, and the content of nitrates in the sediments were identified as the main statistically significant factors for the distribution of fish according to the Monte Carlo test. The analysis of the number-biomass ratio suggests significant pressure on the fish community. These preliminary results contribute to the studies of the ichthyofauna of the riparian area of the Bulgarian Danube River section under anthropogenic pressure and impact. Further studies on the community are necessary regarding the high importance of the habitats in the riparian zone for the surviving and growing of the young fishes.

Introduction

The species composition of fish fauna in the Bulgarian Danube wetlands is well described (Kalchev *et al.* 2010, Pehlivanov *et al.* 2011). As for the Lower Danube River itself the recent data are scarce. The publications discuss distribution features of certain species, for example the sturgeon (Vassilev, Pehlivanov 2003), the gibel carp (Trichkova *et al.* 2008), and the gobies *Neogobius* spp. (Polačik *et al.* 2008a, Brandner *et al.* 2013). The last overall study of the fish communities' composition in the ripal zone was conducted in 2005-2007 (Polačik *et al.* 2008b). Recently the whole Lower Danube River has been considered anthropogenically affected stretch. The development of indices and metrics for ecological quality assessment of waters and the intercalibration of the methods according to the Common Implementation Strategy of the Water Framework Directive require analyses of the accumulated data for the composition, distribution and population parameters of the fish communities as a Biological Quality Element. The analysis of the anthropogenic pressure and impact is an integral part of this process and contains evaluation of the environmental parameters's effect on the composition of fish communities. This study aimed to define the recent main environmental parameters which effect the composition and distribution of the ichthyofauna in the riparian area of the Bulgarian Danube River section.

Material and Methods

The samples were collected in the period August 19th – September 1st 2013 at 16 sampling sites (Table 1) which covered the entire Bulgarian Danube River section following the west-to-east direction. The quantitative fish samples were collected by using two methods. Sampling with electricity according the Standard EN 14011 was applied at 10 points, where large areas overgrown by submerged macrophytes occurred. Sampling was done by wadding in shallow waters covering 1000 m^2 in each sampling site. Ten meters long seine net (0.5 cm mesh size) on area of 1500 m^2 was used in areas free of vegetation. The fish were identified *in situ* after Vassilev, Pehlivanov (2005), Vassilev *et al*. (2012), Kotelat, Freihof (2007). Catch-per-unit effort (CPUE = number of fish per 100 m) and frequency of occurrence were calculated. The values of the environmental variables were measured according to the standardised methods. The heavy and toxic metals in the water and sediment samples were measured according to Bulgarian national standard БДС 16777 and ISO 11466, ISO 11047, БДС EN ISO 11969, and БДС EN ISO 1483. Distributional plots with Primer v6 (k-dominance) (Warwick 1986) was used to identify the potential points with or without minimal anthropogenic pressure over the ichthyocenoses. The partial dominance curves (Clarke 1990) were applied to avoid false impression of disturbance, because a large number of species with small biomass was studied. Principal component analysis, redundancy analysis, and response curves by Canoco 4.5 were performed for defining the correlations of the fish abundance and the environmental factors.

Results and Discussion

Species composition and abundance

Twenty two fish species from 8 families were recorded (Tables 1 and 2). The spined loach was the most abundant species (Table 2). The bleak, the roach, the bighead goby, and the monkey goby were the most frequent species (Table 2). The *Neogobius* spp. group was represented at all of the sampled sites. Jepsen *et al.* (2008) points that the *Neogobius* spp. group is native downstream the Iron Gate and their abundance are low mainly due to the much lower hydromorphological pressure in the river.

In the present study significant abundances and frequency of occurrence of the bighead goby, round goby, racer goby, and monkey goby were found. Increasing abundance downstream was observed, more strongly expressed in the round goby. The tubenose goby was found more frequently in comparison with the previous study of Polačik *et al*. (2008b). The stellate tadpole goby was found at only one of the sampled sites (Table 1). Amocoetes of the Ukrainian brook lamprey were recorded at 2 sites where the bottom substrate corresponded to their known preference for detritus rich sand and clay sediments, according to Freyhof (2011). The white-finned gudgeon was of very low abundance in our catches. This result was attributed not to its population declining as it occurs in the Upper Danube River (Jepsen *et al*. 2008), but rather to the distribution of young-of-the-year to the deeper boundary areas between the ripal and the medial (about 6-8 meters), which are not suitable for sampling with the standard electrofishing devices. The occurrence and abundance of the pumpkinseed, reported as invasive for Bulgaria (Simonović *et al.* 2013), was found to be relatively low into the riparian zone. Furthermore, the Chinese sleeper – also considered as invasive – was not found at all at the studied sites. The reason for this is probably the low water level in the period of sampling, when the riprap areas stay out of the water.

Indication for disturbances in the riparian ichthyocenose

The abundance/ biomass comparison curves method of Warwick (1986) showed only three sites where the biomass was dominated by one or a few species (Figs. 1a, c, and e) and the biomass curve lied above the abundance. These three sites were preliminary considered as relatively reference points with minimal anthropogenic pressure over the fish communities in the riparian area. Using the partial dominance curve method (Clarke 1990), it was found (Figs. 1 b, d, and f) that there were no sites even close to the reference conditions with regard to the fish fauna in the riparian area only. Thus it was assumed that there

Table 1. Sampling points and fish species sampled. Legend: Rkm – River kilometer; Fish species: *Eluc – E. lucius, Saba – S. abaster, Celo – C. elongatoides, Emar – E. mariae, Cgib – C. gibelio, Scep – S. cephalus, Lgib – L. gibbosus, Pflu – P. fluviatilis, Aalb – A. alburnus, Nkes – N. kessleri, Nmel – N. melanostomus, Nflu – N. fluviatilis, Ngym – N. gymnotrachelus, Rama – R. amarus, Bbjo – B. bjoerkna, Pmar – P. marmoratus, Ralb – R. albipinnatus, Abal – A. ballerus, Abra – A. brama, Rrut – R. rutilus, Bste – B. stellatus, Aasp – A. aspius*

№	Sampling point	Rkm	Fish species
1	Downstream the Timok River confluence	844	Abal, Abra, Cgib, Celo, Nkes, Nflu, Ngym, Pflu, Rrut
2	Upstream the Novo Selo village	835	Abal, Abra, Aalb, Celo, Eluc, Nmel, Nflu, Pflu, Rrut, Saba
3	Downstream the Vidin town	785	Cgib, Eluc, Nkes, Nmel, Pflu, Saba
4	Upstream the Dolni Tzibar village	719	Celo, Eluc, Nkes, Nmel, Nflu, Nmel,Ngym, Psem, Pflu, Rrut
5	Downstream the Ogosta River confluence	684	Aalb, Eluc, Nkes, Nmel, Nflu, Nmel, Psem, Pflu
6	Upstream the Iskar River confluence	641	Aab, Celo, Cgib, Emar, Pflu, Scep
7	Downstream the Iskar River confluence	636	Aab, Celo, Emar, Lgib, Nflu, Ngym, Psem, Pflu, Rrut
8	Downstream the Olt River confluence	602	Abra, Aasp, Bste, Cgib, Celo, Eluc, Nflu, Ngym, Psem, Pflu, Rrut, Saba
9	Upstream the Svishtov town	571	Eluc, Lgib, Pflu
10	In front of the head of the Vardim Island	548	Aalb, Eluc, Nkes, Nmel, Pflu, Rrut
11	Downstream the Yantra River confluence	534	Aalb, Eluc, Nkes, Nflu, Nmel, Ngym, Rrut, Ralb
12	Upstream the Ruse Town	501	Aalb, Nkes, Nmel, Nflu, Ngym, Psem, Rrut
13	Downstream the Rusenski Lom River	498	Lgib, Pflu
14	Downstream the Ruse Town	484	Aalb, Nkes, Nmel, Nflu, Nmel, Psem, Rama, Saba
15	Downstream the Ardjesh River confluence	431	Abal, Abra, Aalb, Bbjo, Celo, Nkes, Nmel, Psem, Rama, Rrut, Saba
16	Upsteram the Silistra town	385	Nkes, Nflu, Nmel, Psem, Rama, Rrut

Table 2. Composition of the ichthyofauna in the riparian zone of the Bulgarian Danube River stretch. Mean CPUE ± SE, Frequency of occurrence (pF)

Taxa	**Common name**	**Mean CPUE**	**SE**	**pF**
Cyprinidae				
Abramis ballerus (Linnaeus, 1758)	Zope	0.34	0.13	18.75
Abramis brama (Linnaeus, 1758)	Bream	0.37	0.07	25
Alburnus alburnus (Linnaeus, 1758)	Bleak	2.91	0.74	62.5
Aspius aspius (Linnaeus, 1758)	Asp	0.06	0.01	6.25
Blica bjoerkna (Linnaeus, 1758)	White bream	0.10	0.05	6.25
Carassius gibelio (Bloch, 1782)	Gibbel carp	0.28	0.02	25
Rhodeus amarus (Bloch, 1782)	Bitterling	0.62	0.35	18.75
Romanogobio albipinnatus (Lukasch, 1933)	White-finned gudgeon	0.06	0.01	6.25
Rutilus rutilus (Linnaeus, 1758)	Roach	1.58	0.83	62.5
Squalius cephalus (Linnaeus, 1758)	Chub	0.92	0.70	12.5
Cobitidae				
Cobitis elongatoides Băcescu & Mayer, 1969	Spined loach	21.11	0.16	43.75
Esocidae				
Esox lucius Linnaeus, 1758	Pike	0.44	0.01	43.75
Eudontomyzonidae				
Eudontomyzon mariae (Berg, 1931)	Ukrainian lamprey	0.18	0.05	12.5
Centrarchidae				
Lepomis gibbosus (Linnaeus, 1758)	Pumpkinseed	0.23	0.03	18.75
Gobiidae				
Bentophilus stellatus (Sauvage, 1874)	Stellate tadpole goby	0.07	0.01	6.25
Neogobius kessleri (Günther, 1861)	Bighead goby	1.09	0.22	62.5
N. melanostomus (Pallas, 1814)	Round goby	1.71	0.58	56.25
N. fluviatilis (Pallas, 1814)	Monkey goby	2.07	0.55	62.5
N. gymnotrachellus (Kessler, 1857)	Racer goby	1.10	0.23	50
Proterorhinus semilunaris (Heckel, 1837)	Tubenose goby	0.79	0.16	50
Percidae				
Perca fluviatilis Linnaeus, 1758	Perch	1.27	0.26	81.25
Syngnthidae				
Syngnathus abaster Risso, 1827	Black-striped pipefish	1.20	0.56	25

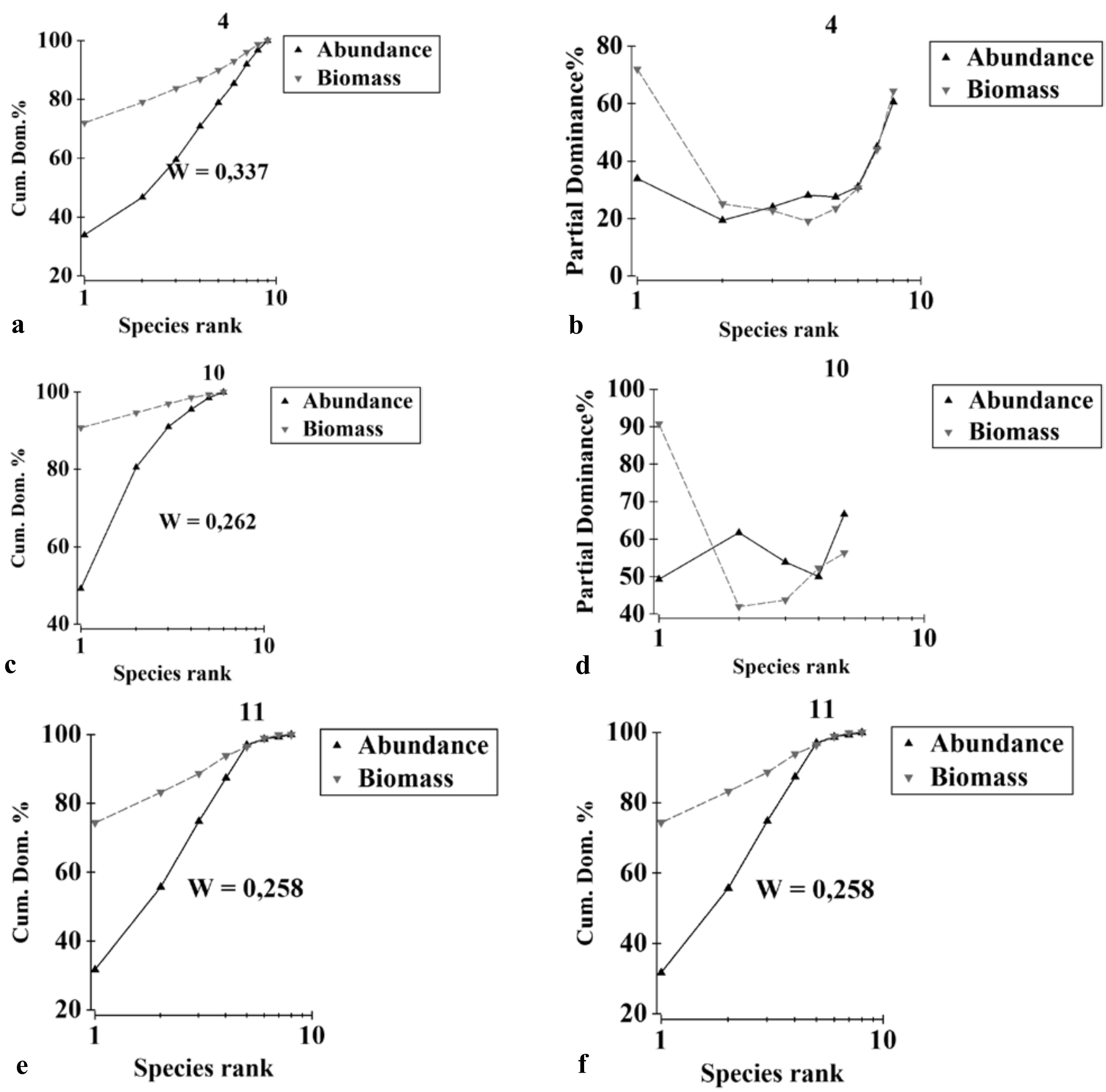

Fig. 1. Standard K-dominance (a, c, e) and Partial dominance curves (b, d, f) for the three points, assumed as points with slight or without anthropogenic pressure

is a prevalence of the anthropogenic factors over the natural ones.

Influence of the natural and anthropogenic factors on the fish communities in the riparian area

The bottom substrate was considered a natural factor, as far as along the Bulgarian Danube River section the riprap and concrete bank reinforcement cover only a few percentage of the total river length, mainly in the settlements (Schwarz, Kraier 2008). Furthermore, according the PCA analysis, the bottom substrate was found to be one of the most important among the natural factors influencing the fish communities. The first two axes (λ_1=0.892, λ_2=0.420; p=0.002) both explain 64% of the variance. The sum of all eigenvalues reaches 3.86. The first principal component (abscise) was defined with the sand and felt predomination in the substrate and with the water temperature. The gradient divides the sampling sites into two groups– coarse and fine, which were characterised by different particle size of the substrate. It is interesting trend that the coarse particle sediments are associated with high concentration of As, Ni, and Mn. It is generally known that high concentrations of the heavy and toxic metals are associated with smaller particle-size (Biksham *et al.* 1991), but

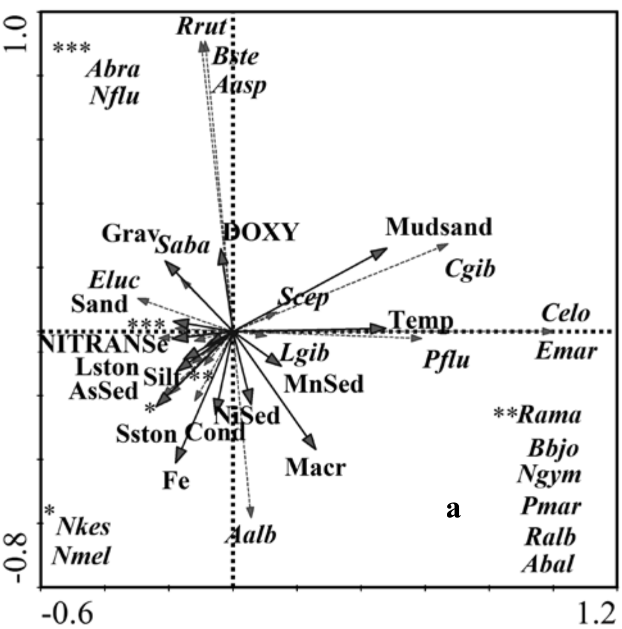

Fig. 2. Correlation biplot based on redundancy analysis (RDA) and depicting the statistical significant relation between the physical and chemical characteristics of the water and sediments and the CPUE of the fish species. Legend: *Measured values of the environmental variables*: NITRANSe – nitrate nitrogen in the sediments [mg/l], DOXY – dissolved oxygen concentration [mg/l], Temp – water temperature [^{o}C]; *Measured values of the trace metals and As* [µg/kg]: AsSed – arsenic concentration in the sediments, NiSed – nickel, Mnsed – manganese, Fe – iron concentration in the water; Cond –conductivity [µS/cm]; Macr – percent macrophyte coverage of the transect; *Fine sediments*: Mudsand – percent coverage of the muddy sand in the substrate, Sand – percent coverage of the sandy sediment, Silt – silt, Grav – gravel, Felt – felt; *Coarse sediments*: Sston – small stones, Lston – large stones. For abbreviations of the *fish species* names please refer to Table 1. (Eigenvalues: Axis 1 – 0.892; axis 2 – 0.420; p=0.002 for both)

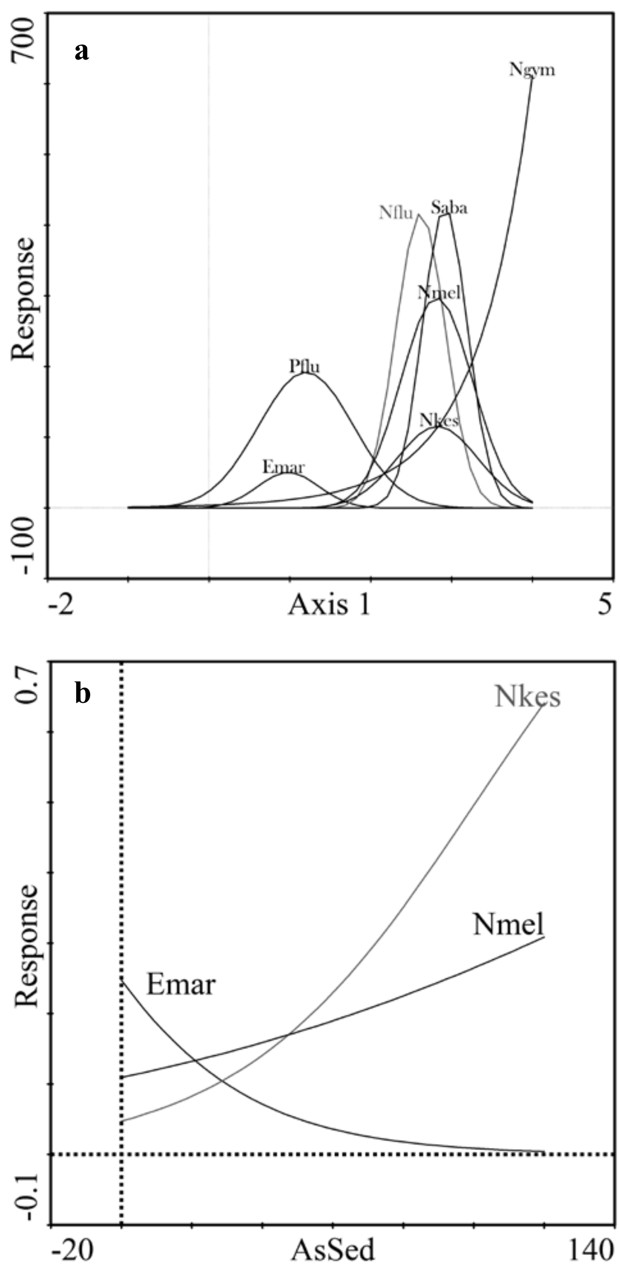

Fig. 3. Response curves of 7 fish species fitted using generalised additive models (a – response to the substrate gradient and b – response to the As concentration in the substrate). Legend: for abbreviations of the *fish species* names please refer to Table 1

some opposite cases are also described in the literature. Parizanganeh (2008) reported anomalously high concentration of trace metals in coarse-grain sediments in Caspian Sea and ascribed it to the winning function of the water. In our case a similar explication could be proposed. As the river flow induced mixing in the riparian zone and wash down the fine-grain material, the pollutants discharged in that area are transported downstream. The coarse particles have longer residence time in the oxygenated riparian areas, what often leads to developing of oxide coating, attracting and absorbing more trace metals (Parizanganeh 2008).

The first two axes (λ_1 =0.989, $\lambda_{2=}$0.0.03, p=0.002, sum of all eigenvalues reaches 1.00) explained 99.2% of the variance (Fig. 2).

Patterns of the spatial distribution in a significant part of the fish species demonstrated strong relation with the high concentration of the trace metals in the sediments. The strongest correlation was observed between the abundance of the bighead goby, the racer goby, and the round goby and the As concentration (Fig. 3). The data are in agreement with Milenkovic *et al.* 2005, who considered the sediment loading with heavy and toxic metals to be crucial for the riverine biota. Furthermore, RDA was used for ordination of abundance in the fish species in such environmental situation. Most probably, the As content in subletal concentrations is involved in the trophic web in the riparian area. The response curve in the amocoetes of the Ukrainian brook lamprey showed a significant sensitivity of the species to the content of this trace metalloid (Fig. 3 b).

Conclusions

The bottom substrate is considered the leading natural environmental factor for the distribution of fish community within the riparian zone as far as there are no significant hydromorphological changes along the Bulgarian Danube River section. The population characteristics of the fish fauna in the riparian area indicate a significant anthropogenic impact. The parameters of the anthropogenic pressure and impact over the fish communities strongly need a thorough analyses and evaluation. Therefore, the establishment of permanent monitoring sites for the overall ecological quality/ potential assessment is advisable taking into account that the data expected would be beneficial for the scientifically based management of the Danube River basin.

Acknowledgements. This study is part of the project *„Survey for establishing the level of water contamination in the Danube River with heavy metals and organic products*", funded by the National Agency of Fishery and Aquaculture at the Ministry of Agriculture and Food (Project BG0713EFF-514-220262). The authors are grateful to the anonymous reviewers, for their valuable notes and comments.

References

Biksham, G., V. Subramanian, A. L. Ramanathan, and R.V.Grieken 1991. Heavy Metal distribution in the Godavari River Basin. – *Environmental Geology and Water Sciences*, **17**: 117-126.

Brandner, J., J. Pander, M. Mueller, A. F. Cerwenka and J. Geist, 2013. Effects of sampling techniques on population assessment of invasive round goby *Neogobius melanostomus*. – *Journal of Fish Biology* **82**: 2063–2079.

Clarke K. R. 1990 Comparisons of dominance curves. – *Journal of experimental marine biology and ecology,* **138**: 143-157.

Freyhof J. 2011. *Eudontomyzon mariae*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2.

Jepsen N. C. Wiesner and N. Schotzko 2008. Fish. In: Liљka I., F. Wagner and J. Slobodník (eds.), Joint Danube Survey. Final Scientific Report, ICPDR, Wien, 72-81.

Kalchev R., V. Beshkov, T. Bogdanović, A. Coman, M. Edinger, T. Hein, B. Ivanov, D. Krasić, M. Mihaljević, V. Nikolov, L. Pehlivanov, S Puzović, C. Sandu, S. Shmutz, N, Stojnić, M. Vasilev and A. Vujić 2010. Vertebrate species distribution in selected wetlands of the Danube River Basin. – *Transylv. Rev. Syst. Ecol. Res, The Wetlands Diversity*, **10**: 151-168.

Kottelat M., J. Freyhof 2007. Handbook of European Freshwater Fishes: 646.

Milenković N., M. Damjanović and M. Ristić 2005. Study of heavy metal pollution in sediments from the Iron Gate (Danube River), Serbia and Montenegro. – *Polish J. of Env. Stud.*, **14**: 781-787.

Parizahganeh A. 2008. Grain size effects on Trace Metals incontaminated Sediments along the Iranian coast of the Caspiansea. – In: Segupta M., R. Dalwani (eds.), Proceedings of Taal 2007: the World Lake Conference: 329-336.

Pehlivanov L., T. Stefanov, S. Mihov, V. Biserkov, M. Vassilev, A. Apostolou and B. Velkov. 2011 Recent ichthyofauna in the wetlands along the Bulgarian section of the Danube. – *Sc. Annals of DDI*, Tulcea – Romania, **17**: 83-88.

Polačik M., M. Janáč, T. Trichkova, M. Vassilev and H. Keckeis 2008a.The distribution and abundance of the *Neogobius* fishes in their native range (Bulgaria) with notes on the non-native range in the Danube River. – *Fundamental and Applied Limnology/ Archiv für Hydrobiologie, 166 (1-2) Large Rivers,* **18** (1-2): 193–208.

Polačik M, T. Trichkova, M. Janáč, M. Vassilev and P. Jurajda 2008b.The ichthyofauna of the shoreline zone in the longitudinal profile of the Danube River, Bulgaria. – *Acta zoologica bulgarica*, **60** (1): 77-88.

Simonovic´ P., A. Tošic´, M. Vassilev, A. Apostolou, D. Mrdak, M. Ristovska, V. Kostov, V. Nikolic´, D. Škraba, L. Vilizzi and G. H. Copp 2013. Risk assessment of non-native fishes in the Balkans Region using FISK, the invasiveness screening tool for non-native freshwater fishes. – *Medit. Mar. Sci.*, **14 (2)**: 369-376.

Trichkova T., M. Zivkov, and A. Apostolou 2008. Some biological characteristics of gibel carp (*Carassius gibeli*o) from three localities in the Bulgarian stretch of the Danube River. –*Ecology & Safety, International Scientific Publications*, **2** (2): 385-394 (In Bulgarian, English summary)

Vassilev M., A. Apostolou, B. Velkov, D. Dobrev and V. Zarev 2012. Atlas of the Bulgarian Gobies (Gobiidae). Pensoft Publ., Sofia, 112 p.

Vassilev M., L. Pehlivanov 2003. Structural changes of sturgeon catches in the Bulgarian Danube Section. – *Acta zoologica bulgarica,* **55** (3): 97-102.

Vassilev M., L. Pehlivanov 2005. Checklist of the Bulgarian freshwater fishes. – *Acta zoologica bulgarica*, **57** (2): 161-190.

Warwick R. M. 1986. A new method for detecting pollution effects on marine macrobenthic communities. – *Mar. Biol.,* **92**: 557-562.