ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., Suppl. 7, 2014: 45-50

Analysis of Structure, Composition, Spatial and Temporal Changes of Juvenile Fish Community in a Danube-Tributary System in the Middle Danube River Basin

András Weiperth

MTA Centre for Ecological Research, Danube Research Institute, H-2131 Göd, Jávorka Sándor u. 14., Hungary;
E-mail: weiperth@gmail.com

Abstract: Juvenile fish assemblages were surveyed by electrofishing once in each season along five sections at the lower reaches of the Ipoly River from Ipolytölgyes to the mouth, and five sections along both banks of the Danube River downstream of the mouth of the Ipoly River, in 2012 and 2013. A total of 6235 individuals of 41 fish species were caught, with 6023 individuals of 37 species being juveniles. Ten of the species were non-native. Bleak (*Alburnus alburnus*) and other juvenile cyprinid species (*e.g. Abramis brama*, *Aspius aspius, Barbus barbus* and *Chondrostoma nasus*), which are present in large populations in the Hungarian Danube stretch, are the most abundant and frequent in the lower reaches of the Ipoly River contributing to 61% of the total catch. In the mouth section of the Ipoly River, the invasive Ponto-Caspian goby species are the most abundant fishes (47%). Large woody debris and flooded terrestrial vegetation were identified as the most important habitat structures to the riverine cyprinids, while ripraps were preferred by gobies. These results demonstrate that not only the different habitats in a river estuary, but also the distant spawning and nursing zones of the tributaries are especially important for the fish community of the Danube River.

Keywords: tributary, juvenile fish assemblage, habitat preference, Danube River, Ipoly River

Introduction

River regulation has influenced the hydrological conditions and morphological dynamics of the Danube River as well as its tributaries and floodplain areas since the end of the 19th century. Owing to the confinement of the inundated area, the closure of side arms and tributary entrances, the degradation of the main channel of the Danube River and other interventions, ecological conditions have changed considerably in the 20th century (Guti 1998, 2002, Pracheil *et al.* 2009, 2013, Schmutz, Jungwirth 1999). In recent decades, there has been a growing demand for the versatile utilisation of the Danube River and some tributaries, which affects the ecological status of the rivers in a negative way. The ecological status and protection of natural values is an expectation of the EU outlined in different guidelines and the Water Framework Directive, but in many cases it is not clear what interventions can be effective in realising these aims. Fishes are very good indicators for river habitat diversity (Schiemer, Reckerendorfer 2004) because their habitat demand changes significantly during their ontogeny (Balon 1975, 1981, Erős 2005). In many cases, the lack of certain habitats utilised by juvenile fishes, which have a narrower tolerance range in comparison with adults, is a limiting factor for certain fauna elements (Leclere *et al.* 2011, Wolter, Arlinghaus 2003). The research of spatial distribution and structure, composition and seasonal dynamics of juvenile fish communities deliver information about the nursery potential of a river section and the limiting factors of natural aftergrowth (Copp 1989, Sindilariu *et al.* 2006).

The importance of habitat structures of estuary and riparian habitats of tributaries were demonstrated by previous studies on the Danube River (*e.g.* Schmutz, Jungwirth 1999). The authors proved that juvenile fish assemblages living along shallow banks, eroded steep walls and ripraps are well separated from the community of vegetation bordered sand and gravel-bed river sections. The knowledge of habitat use and dynamics of juvenile fish assemblages is incomplete in the Hungarian section of the Danube River and its tributaries. Our study, carried out in the upper reaches of the Ipoly River and the Danube River at Szob, aimed to compare the seasonal dynamics of fish assemblages and the influence of different habitat variables on them, as well as to describe the relationship between the inshore habitat patterns, which change with the water level fluctuation, and the spatial distribution of juvenile fish population.

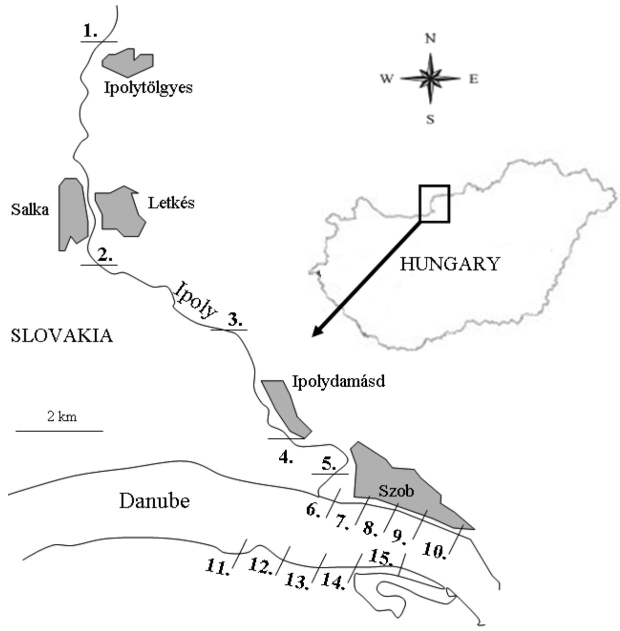

Fig. 1. Sampling sites in the Ipoly River from Ipolytölgyes to Szob and in the Danube River along both banks

Material and Methods

The Ipoly River is a medium size river regulated along the border of Hungary and Slovakia. Its source is at 1020 m a.s.l. in Slovakia and its mouth is at Szob, at the 1708 river km of the Danube River. The length of the river is 257.4 km, its catchment area is 5108 km^2 and its mean discharge is 20.6 m^3 s^{-1}. The first efforts of river regulation dated back to the 17^{th} and 18^{th} centuries. In the 1980s, one modern dam was constructed between Ipolytölgyes and the river mouth, at the lower stretch of the river (Kabay 2007). The interventions resulted in channel incision and a decrease in the mean and low water levels. The lower section of the river is protected in the Danube-Ipoly National Park since 1997, the adjacent floodplain being designated as a NATURA 2000 site in 2004, and an increasing effort has been made to restore its ecosystem in the recent years (Weiperth *et al*. 2010). In the study area, the river beds of the River Ipoly and the Danube River are quite stable and the interventions mentioned above resulted in the development of diverse microhabitats; natural (sand and gravel) and artificial banks (ripraps, barriers, etc.).

A total of 15 sampling sections with a length of 120-150 m were selected: in the Ipoly River from Ipolytölgyes to Szob between rkm 18 and 2 (sampling sites 1-5), along the left side of the Danube River downstream of the mouth of the Ipoly River between rkm 1708 and 1705 (sampling sites 6-10), and along the right side of the Danube River between river km 1709 and 1706 (sampling sites 11-15) (Fig. 1).

The sampling sites were characterised by 11 environmental variables: distance from the bank, current velocity, aquatic and terrestrial plant cover (0%, <10%, 10-50%, >50%), woody debris, coverage of shading trees (0%, <10%, 10-50%, >50%), water depth, and sediment composition (rocks, boulders >10 cm, pebbles 10 -0.2 cm, sand-mud 2 – 0.004 mm, clay 0.004 – 0.00024 mm) (Bogárdi 1971, Gaebele, Guti 2009, 2010, Gaebele *et al*. 2013). Two-day surveys were carried out once a season (April – December) in 2012 and 2013. The juvenile fish assemblages were sampled by electrofishing using the “point abundant” sampling method (Copp 1989) with a portable electrofishing equipment (DEKA 3000) collecting 30-30 point-samples. The fish determined on the site were released immediately after the necessary measurements were made. The fish too small to be determined properly on the site were preserved in 4% formaldehyde and taken to the laboratory for microscopic examination and measurements (Pinder 2001). A statistical analysis was made using the SYN-TAX 2000 software (Podani 2001). Principal component analyses (PCA) were used to carry out spatial and temporal dynamics, while redundancy analyses (RDA) were used to identify habitat characteristics explaining the distribution of fish species (Podani 1997). Series of daily water level data in the period of study and local water level fluctuation calculations were gathered from the Internet (www.hydroinfo.hu/Html/archivum/archiv_tabla.html).

Results

A total of 6235 individuals of 41 fish species were caught, with 6023 individuals of 37 species being juveniles, and ten of them were non-native. In 2012 five adults of *Ballerus sapa*, two adults of *Rutilus virgo* and six adults of *Sander volgensis*, while in 2013 four adults of *Ameiurus melas* were collected without any juveniles from the respective species. Altogether ten non-native fish species were detected and in 2013 a new fish species (*Gasterosteus gymnurus* Cuvier, 1829) was reported for the Hungarian section of the Ipoly River and the Danube River at sampling sites 5, 6 and 7. The list and individual number of juvenile fish species are presented in Table 1.

The water level of the Ipoly River at Ipolytölgyes fluctuated from 66 to 177 cm in 2012, and from 90 to 510 cm in 2013; the water level of the Danube River at Nagymaros was in the range from 12 to 362 cm in 2012 and from 9 to 750 cm in 2013. The data on catches indicate that juvenile cyprinids, such as *Alburnus alburnus* and *Leuciscus idus*, have appeared first already in spring in both rivers (Table 1). During summer, autumn and winter samplings of the year with a lower water level (2012), the reophil spe-

Table 1. The number of individuals of juvenile fish species recorded along the lower stretch of the Ipoly River and the adjacent Danube section in 2012-2013 (the first value indicates the number of individuals sampled in 2012/ the second value is the number of individuals sampled in 2013

Species	Code	Ipoly 2012/2013				Danube 2012/2013			
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
Abramis brama	abbr	12/5	45/46	100/73	72/36	28/81	5/60	7/3	1/ -
Alburnoides bipunctatus	albi	0/20	2/ -	12/4	8/1	- / -	- / -	3/5	- / -
Alburnus alburnus	alal	45/26	161/45	161/187	138/86	66/109	65/118	49/52	11/19
Aspius aspius	asas	7/1	42/13	19/26	11/15	- / -	3/ -	14/6	2/4
Babka gymnotrachelus	bagy	- / -	1/ -	5/1	4/ -	- / -	2/ -	16/3	2/ -
Barbus barbus	baba	- / -	17/3	15/11	7/6	- / -	- / -	3/2	1/ -
Blicca bjoerkna	blbj	5/13	54/46	56/104	69/50	20/83	12/63	13/5	6/2
Carassius gibelio	cagi	- / -	4/82	4/24	15/19	- /1	- /142	- / -	1/ -
Chondrostoma nasus	chna	3/ -	39/9	54/10	25/8	- / -	8/1	3/3	2/ -
Cobitis elongatoides	coel	- / -	12/1	9/4	3/1	- / -	- / -	2/1	- / -
Cyprinus carpio	cyca	- / -	2/77	1/3	- / -	- / -	- /98	- / -	- / -
Esox lucius	eslu	- / -	4/2	7/2	1/ -	- / -	- /3	- / -	- / -
Gasterosteus gymnurus	gagy	- / -	- /6	- /1	- / -	- / -	- /6	- / -	- / -
Gobio gobio komplex	gogo	- / -	10/1	16/2	5/ -	- / -	1/ -	- / -	- / -
Gymnocephalus cernua	gyce	- / -	3/ -	2/1	- / -	- / -	6/ -	3/ -	- / -
Gymnocephalus schraetser	gysc	- / -	- / -	- / -	- / -	- / -	- / -	2/ -	1/ -
Lepomis gibbosus	legi	- / -	3/1	7/3	1/ -	- / -	- / -	- / -	- /1
Leuciscus idus	leid	20/6	33/50	68/16	25/6	12/16	10/19	21/1	8/2
Leuciscus leuciscus	lele	8/11	44/4	16/12	14/2	- / -	- /3	2/1	- / -
Lota lota	lolo	3/ -	1/ -	- / -	- / -	- /1	2/ -	3/ -	- / -
Neogobius fluviatilis	nefl	- / -	23/2	43/7	22/2	- / -	16/ -	27/5	6/ -
Neogobius melanostomus	neme	- / -	22/ -	59/9	33/8	- / -	23/ -	39/14	5/ -
Perca fluviatilis	pefl	5/ -	12/1	4/1	7/ -	1/ -	1/2	1/ -	- / -
Ponticola kessleri	poke	- / -	5/ -	14/ -	19/ -	- / -	12/ -	27/3	3/ -
Proterorhinus semilunaris	prse	- / -	6/-	19/2	1/ -	- / -	- /1	2/1	- / -
Pseudorasbora parva	pspa	- / -	- / -	- /3	170/34	- / -	- /1	- / -	118/46
Rhodeus amarus	rham	- / -	35/5	64/11	62/3	- / -	- / -	7/ -	1/ -
Romanogobio vladykovi	rovl	- / -	16/ -	8/6	6/ -	- / -	3/ -	3/ -	1/ -
Rutilus rutilus	ruru	41/19	73/47	45/72	79/22	9/37	7/8	3/2	2
Sabanejewia balcanica	saba	- / -	4/ -	1/1	- / -	- / -	- / -	- / -	- / -
Sander lucioperca	salu	- / -	7/ -	1/1	- / -	- / -	2/ -	- /1	- / -
Scardinius erythrophthalmus	scer	- / -	15/5	25/2	3/2	- / -	- / -	- /1	- / -
Silurus glanis	sigl	- / -	1/2	- / -	- / -	- / -	- / -	5/ -	- / -
Squalius cephalus	sqce	5 / -	12/5	54/29	61/24	- / -	13/ -	9/11	5/ -
Vimba vimba	vivi	- / 1	14/7	25/15	4/3	- / -	2/ -	7/4	1/ -
Zingel streber	zist	- / -	5/2	7/1	5/ -	- / -	- / -	- / -	- / -
Zingel zingel	zizi	- / -	4/1	5/ -	2/ -	- / -	- / -	- / -	- / -
Total number of species		11/9	35/25	32/32	29/19	136/328	193/526	271/128	178/75
Total number of individuals		154/84	731/461	926/646	872/328	6/7	19/13	25/20	19/6

cies (*e.g*. *Barbus barbus* and *Chondrostoma nasus)*, and non-native species (*e.g*. the Ponto-Caspian gobies) dominated in the fish communities, while in the following year with a higher water level juveniles of common Danube cyprinids became more abundant in the juvenile fish community of the Danube River, as well as in the lower reaches of the Ipoly River (Fig. 2). In the year with lower water level, the juveniles of Ponto-Caspian gobies made up 10% and 23% of the whole catch in the Ipoly River and the Danube River, respectively. This rate decreased to 2% and 3% in the following year with a higher water level. Comparing the two years, a similar decrease can be observed in reophilic and semi-reophilic fish species: the rate of fish species breeding on gravel banks was reduced from 23% to 10% in the Ipoly River and from 12% to 4% in the Danube River. The proportion of eurytopic fish species (*e.g*. *Blicca bjoerkna, Carassius gibelio* and *Cyprinus carpio*) changed from 53% to 73% in the Ipoly River and from 46% to 88% in the Danube River during the same period (Table 1). As an important aspect of the water level increase, the shoreline moved with the rising water level towards the edge of the riparian forest along the sampling sites by 2013. As a consequence, the sediment composition, the frequency of woody debris, as well as the presence of terrestrial vegetation and shading trees were becoming more significant by the end of 2013 (Fig 3).

The analysis of the effect of environmental variables on fish species separated two groups in the two years, but the fish species of the two groups were divided by different environmental variables in 2012 and 2013. Reophilic fish species preferred rocky habitats with high velocity in the year with the low water level (2012), while in the year with the higher water level, they were also found in medium or fast flowing gravel habitats with a higher water depth. Juvenile semi-reophilic, eurytopic and limnotic fish species belonging to the other group were

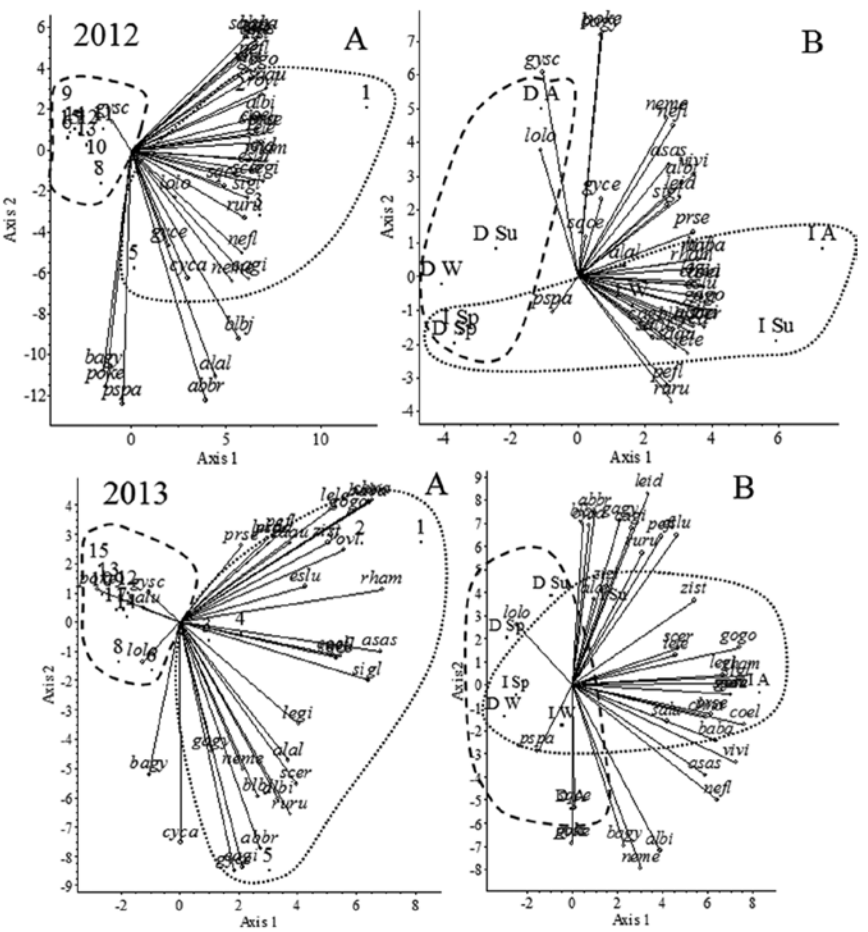

Fig. 2. PCA analysis of spatial (A) and temporal (B) samples in the Ipoly River (marked by dotted line) and Danube River (marked by dashed line). 2012(A): 55 and 25, 2012(B): 52 and 19, 2013(A): 32 and 19, 2013(B): 38 and 25 percent of the total variance can be explained by the first and second axis. Fish codes are given in Table 1. Codes of sampling sites are given in Fig. 1. Codes of water bodies: I: Ipoly River, D: Danube River. Codes of seasons: Sp: spring, Su: summer, A: autumn, W: winter

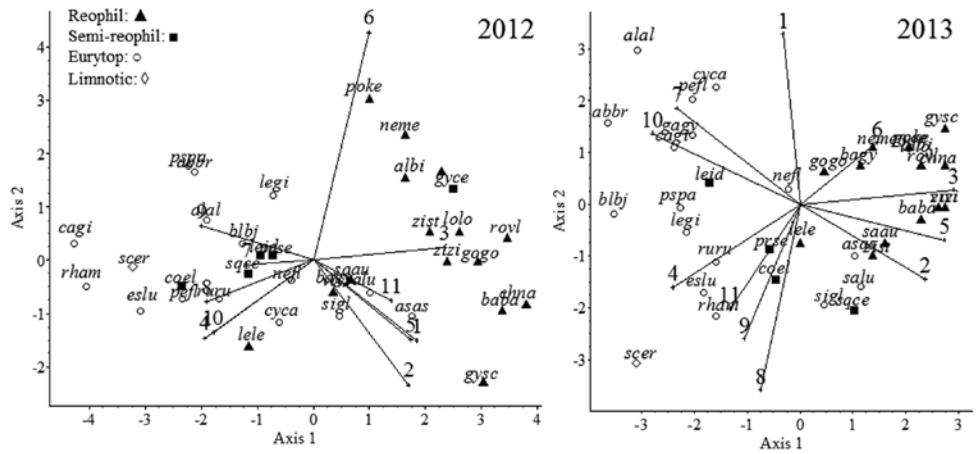

Fig. 3. Effect of environmental variables on the habitat use of juvenile fish species in the Ipoly River and the Danube River in 2012 and 2013 (RDA). 2012: 46 and 12 and 2013: 39 and 17 percent of the total variance can be explained by the first and second axis, respectively. Fish codes are given in Table 1. Legend: 1= distance from the bank (m), 2= water depth (m), 3= current velocity (zero, slow, medium, fast), 4= mud-sand, 5= pebbles, 6= rocks, boulders, 7= clay, 8= woody debris, 9= aquatic macrophytes, 10= terrestrial plants, 11= shading trees

found on muddy-sand river banks with high cover of different plants in 2012, while in the high water level year (2013) they preferred clay and sand bottom river banks with a considerable amount of terrestrial plants, woody debris and standing trees (Fig. 3).

Discussion

Some recent works have demonstrated that tributary inputs are important community reorganisation points for river biota. This fact is also proved by high environmental pollution and disasters, *e.g.* the cyanide spill in the Tisza River in 2000 (Antal *et al.* 2013). The analysis of the distribution and abundance of fish species and ecological guilds in regulated rivers allows us to determine the fish community conservation targets in river-tributary complexes (Hladík, Kubečka 2003, Zalewski *et al.* 1998,). However, only a few studies have examined the long-term effects of tributary inputs on fish populations in large rivers so far (Guti 2002, Pracheil *et al.* 2009, 2013). Our research in 2012-2013 showed that the riparian ecotones along the lower section of the Ipoly River and the natural banks of the Danube River downstream the Ipoly estuary played an important role in the reproduction of several Danubian fish species. The structure of the juvenile fish communities in the two rivers considerably changed spatially and temporarily under different water level conditions. In autumn and winter, the juveniles and adults of native (*e.g. Sander lucioperca*) and non-native (*Pseudorasbora parva*) fish species drifted naturally from the upper section of the Ipoly River and adjacent water bodies (side arms and tributaries) to the lower reaches influencing the composition and structure of the fish assemblages within the over-the-estuary section of the Ipoly River (sampling sites 4 and 5) and the section downstream of the mouth in the Danube River (sampling sites 6-8) (Table 1).

Juveniles of several fish species are known to respond differently to changes in current velocity and sediment composition caused by water level fluctuations (Jackson *et al.* 2001, Wolter, Arlinghaus 2003). The current velocity, sediment structure of habitats and the presence of different types of vegetation also played an important role for the scale patterns of juvenile fish communities in a river tributary system in our study. The spreading of non-native species in the Middle Danube River Basin and some connected waters has been presented in several reviews (*e.g.* Bódis *et al.* 2012, Weiperth *et al.* 2013), but the driving forces of these changes, biotic and abiotic processes that promote the spreading of non-native fish species in a river-tributary system are still unclear. The analysis of the juvenile fish community composition at the sampling sites revealed that the fish community of sampling site 5 on the Ipoly River is similar to those of the Danube sampling sites in low-water periods inasmuch as they are both dominated by three Ponto-Caspian goby species (*Neogobius fluviatilis, Neogobius melanostomus* and *Ponticola kessleri*). At the same time, the communities of the upper sampling sites along the Ipoly River significantly differed from those from the Danube, except in spring. During the summer flood in 2013 the Danube dammed the Ipoly River as far as Ipolydamásd (sampling site 3), thus providing optimal spawning conditions for several litophilic and phyto-litophilic fish species (*e.g. Abramis brama, Carassius gibelio* and *Cyprinus carpio*), and the ecotone zone between the two rivers largely increased.

The results show that not only the estuary habitats but also the far-lying natural nursing zones of tributaries may be of increased importance in the conservation of the fish fauna in the Middle Danube River Basin.

Acknowledgements: The author thanks Dr. Miklós Puky and the anonymous reviewers for improving an earlier version of the manuscript.

References

Antal L., B. Halasi-Kovács and S.A. Nagy 2013. Changes in fish assemblage in the Hungarian section of River Szamos/Someş after a massive cyanide and heavy metal pollution. – *North-Western Journal of Zoology,* **9** (1): 131-138.

Balon K. E. 1975. Reproductive guild of fishes: A proposal and definition. – *Journal of Fisheries Research Board of Canada,* **32** (6): 821-864.

Balon K. E. 1981. Additions and amendments to the classification of reproductive styles in fishes. – *Environmental Biology of Fishes,* **6** (314): 377-389.

Bódis E., P. Borza, I. Potyó, M. Puky, A. Weiperth and G. Guti 2012. Invasive molluscs, crustacean, fish and reptile species along the Hungarian Danube stretch and some connected waters. – *Acta Zoologica Academiae Scientiarum Hungaricae,* **58** (Suppl.1): 13-29.

Bogárdi J. 1971. Vízfolyások hordalékszállítása [Sediment transport in alluvial streams]. Akadémia Kiadó, Budapest. 320 p.

Copp G. H. 1989. Electrofishing for fish larvae and 0+ juveniles: equipment modifications for increassed efficiency with short fishes. – *Aquatic Fisheries Management,* **210**: 117-186.

Erős T. 2005. Life-history diversification in the Middle Danubian fish fauna. – *Archiv für Hydrobiologie, Supplement Large Rivers,* **16** (1-2): 289-304.

Gaebele T., G. Guti 2009. Halivadék élőhelyek vizsgálata a Dunán a Gödi-sziget térségében (1671-1669 fkm) [Habitat survey of juvenile fish at the Göd island (rkm 1671-1669) of the Danube]. – *Hidrológiai Közlöny,* **89** (6): 199-201.

Gaebele T., G. Guti 2010. Halivadék fajegyüttesek élőhelyhasználata a gödi Duna-szakaszon [Habitat use of juvenile fish assemblages in the Danube at Göd]. – *Pisces Hungarici,* **4**: 9-16.

Gaebele T., I. Potyó, A. Weiperth, G. Guti G. and M. Puky 2013. Abundant prey or optimal microhabitat? *Natrix tessellata* stays hidden in safe areas in a diverse floodplain along the Danube at Göd, Hungary. – *North-Western Journal of Zoology,* **9** (2): 374-382.

Guti G. 1998. Ecological impacts of the Gabčikovo River Barrage System on fish in the Szigetköz floodlpain in Hungary. *Verhandlungen der Internationale Vereinigung Für Theoretische und Angewandte Limnologie,* **26** (5): 2251-2254.

Guti G. 2002. Significance of side-tributaries and floodplains for Danubian fish populations. – *Archiv für Hydrobiologie Supplement of Large Rivers,* **13** (1-2): 151-163.

Hladík M., J. Kubečka 2003. Fish migration between a temporate reservoir and its main tributary. – *Hydrobiologia,* **504**: 251-266.

Jackson D. A., P. R. Peres-Neto and J. D. Olden 2001. What controls who is where in freshwater fish communities – the roles of biotic, abiotic and spatial factors. – Canadian Journal of Fischeries and Aquatic Scienses, 58: 157-170.

Kabay S. 2007. Jelentős Vízgazdálkodási Kérdések, 1-5 Ipoly tervezési alegység, Közép-Duna-völgyi Környezetvédelmi és Vízügyi Igazgatóság, Budapest 10 p.

Leclere J., T. Oberdorff, J. Belliard and F. Leprieur 2011. A comparison of modeling techniques to predict juvenile 0+ fish species occurrences in a large river system. – *Ecological Informatics,* **6** (5): 276-285.

Pinder A. C. 2001. Keys to larval and juvenile stages of coarse fishes from fresh waters in the British Isles. Freshwater Biological Association, Scientific Publication, 60: 136 p.

Podani J. 1997. Bevezetés a többváltozós biológiai adatfeldolgozás rejtelmeibe. Scientia Kiadó, Budapest. 412 p.

Podani J. 2001. SYN-TAX 2000. Computer Program for Data Analysis in Ecology and Systematics. Scientia Kiadó, Budapest. 53 p.

Pracheil B. M., M. A. Pegg and G. E. Mestl 2009. Tributaries influence recruitment of fish in large rivers. – *Ecology of Freshwater Fish,* **18**: 603-609.

Pracheil B. M., P. B. McIntyre and J. D. Lyons 2013.Enhancing conservation of large-river biodiversity by accounting for tributaries. – *Frontiers in Ecology and the Environment,* **11**: 124-128.

Schiemer F., W. Reckerendorfer 2004. Das Donau-Restaurierungprojekt Ökológische Auswirkungen. – *Verlag der Zoologisch-Botanischen Gesellschaft in Österreich,* **34**: 185 p.

Schmutz S., M. Jungwirth 1999. Fish as indicators as large rivers connectivity: the Danube and its tributaries. – *Archiv für Hydrobiologie Supplement of Large Rivers,* **11** (3): 329-348.

Sindilariu P-D., J. Freyhof and C. Wolter 2006. Habitat use of juvenile fish in the lower Danube and the Danube Delta: implication for ecotone connectivity. – *Hydrobiologia,* **571**: 51-61.

Weiperth, A., T. Gaebele, I. Potyó and G. Guti 2010. Long-term changes of fish fauna in the Hungarian section of the Ipel River. – Proceedings Volume of the 38th Conference of the IAD, 1-6 p.

Weiperth A., Á. Staszny and Á. Ferincz 2013. Idegenhonos halfajok megjelenése és terjedése a Duna magyarországi szakaszán – Történeti áttekintés [Occurrence and spread of non-native fish species in the Hungarian section of River Danube – A historical review]. – *Pisces Hungarici,* **7**: 103-112.

Wolter C., R. Arlinghaus 2003. Navigation impacts on freshwater fish assemblages: the ecological relevance of swimming performance. – *Reviews in Fish Biology and Fisheries,* **13**: 63-89.

Zalewski M., B. Bis, M. Lapińska, P. Frankiewicz and W. Puchalski 1998. The importance of the riparian ecotone and river hydraulics for suitable basin scale restauration scenarios. – *Aquatic Conservation: Marine and Freshwater Ecosystems,* **8**: 287-307.