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DIVERSITY CHARACTERISTICS OF THE FISH SPECIES IMPORTANT FOR FISHERY IN THE WATERS OF SERBIA

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Abstract

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Diversity of the fish species important for fishery on the territory of Serbia has changed both spatially and temporally. Temporal changes are connected with historical and anthropogenic factors, while spatial changes are mostly the results of anthropogenic activity. Based on the analysis of the „BAES-ex situ" national database, there are two temporal and spatial periods. The first period (from 1860 to 1950) is characterised by great diversity of the fish species important for fishery in natural ecosystems, above all in rivers. The second period (from 1950 until today) is characterised by reduction in the diversity of the fish species important for fishery, especially sturgeon species, in natural ecosystems, predominantly rivers, and the increasing diversity in anthropogenic water ecosystems. The increasing diversity in accumulations is predominantly related to Cyprinidae and Percidae species.

The reduction in diversity in natural ecosystems is most often the result of irrational fishery, habitat degradation, prominent anthropogenic influence and presence of introduced species. Many species important for fishery are, according to the newest legal regulations of the Republic of Serbia, classified in the category of strictly protected and protected species, and the permanent close hunting season or close season in certain periods and ban on hunting for individuals below prescribed size was declared for many of them. Taking into consideration prominent reduction in diversity, some of the fish species important for fishery are also in „The preliminary list of species for the Serbian red list of vertebrates" because they are in danger of being extinct.

Key words: fish, diversity, fishery, Serbia

Introduction

The data on the number of fish species important for fishery in the Republic of Serbia are, together with regular monitoring or hydro-biological and ichthyological research, collected and recorded by authorised national institutions and institutions for scientific research. Therefore, starting from 2003, establishment of „BAES *ex situ*" data base on biodiversity of aquatic ecosystems of Serbia began (Simić et al., 2006), and its goal was systematisation of data and easier monitoring of species diversity of fish and other water organisms, as well as taking measures for conservation of endangered species including both in situ and *ex situ* conditions.

Information on the number and structure of fish communities that are shown in the data base are signifi-

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cant both from the point of view of biodiversity and its conservation, and from the point of view of sustainable use of fish resources in the meaning of commercial and sport fishing.

According to a great number of reference data from different authors, of which Budakov et al. (1997) and Simonović (2001) should be emphasized, predominantly in flood areas of the Danube, but also in other water ecosystems, the presence of 55 fish species has been registered.

Since the beginning of 1990s, on the territory of the Republic of Serbia, the legislation has been actively updated to address issues of wild life protection, including ichthyofauna. Some fish species are in particular listed as natural rarities (OJ of the Republic of Serbia, 50/1993), and later they were also placed on the preliminary list of species for the Red List of Vertebrates for Serbia (Janković and Krpo-Ćetković, 1995). Protection and preservation of the fish fund of the Republic of Serbia are regulated with the Law on Fisheries and Law on By-Laws (OJ of RS 17/2009, OJ of RS 5/2010).

In the light of legislative regulations, and based on species that have been registered at certain sites, many areas on the territory of AP Vojvodina have acquired certain protection status by the end of 20th century and the beginning of 21st. Concerning ichthyofauna, the following stand out, six Special Nature Reserves: „Gornje Podunavlje“, „Koviljsko-Petrovaradinski Rit“, „Ludaš“, „Obedska Bara“, „Stari Begej-Carska Bara“ and „Zasavica“, five Nature Parks: „Palić“, „Stara (Mrtva) Tisa“, „Jegrička“, „Begečka Jama“and „Ponjavica“ and Natural Monument „Bara Trskovača“. These protected ecosystems receive special attention in order to preserve biodiversity, because endangerment or extinction of certain species make gene pool of a particular area poorer.

In contrast to Vojvodina, in the rest of Serbia there are no protected areas that are particularly related to diversity of water ecosystems, but there are water ecosystems that are located within protected areas (National Parks, Reserves, etc.).

Material and Methods

The ichthyological material was collected in the waters of the Republic of Serbia in periods of high, low and medium water levels using standard equipment for electrofishing and nets of various mesh diameters. Determination was done by using the keys Vuković and Ivanović (1971) and Simonović (2001).

The data that are related to Vojvodina, given that they exist since 1979, are more systematised when compared to the remaining data, therefore they were more used for statistical analysis in this paper.

Statistic processing of the data was done by using MS Office Excel 2010 and SigmaXL workbook. For determining if data for proportional composition of the fish species important for fishery are normally distributed, the Shapiro-Wilk test was used. The Kruskal-Wallis test was applied during the determination of significance levels between the year of catch and the site. Pearson product-moment correlation coefficient was used to determine correlation between the fish species important for fishery and invasive species.

Results

After analyzing Table 1, it can be concluded that out of six listed fish species important for fishery: *Tinca tinca, Cyprinus carpio, Esox lucius, Silurus glanis, Sander lucioperca* and *Acipenser ruthenus*, in the waters of Vojvodina during the period of thirty years, the most significant presence is that of a pike – *Esox lucius*. Proportional contribution of this species moved from 56.4% in 1980 (Budakov et al., 1983 a) at the „Koviljsko-Petrovaradinski Rit“ to 0.37% in 1996 (Maletin et al., 1997) at „Begečka Jama“.

At the second place, according to proportional contribution in natural and anthropogenic water ecosystems in Vojvodina, among fish species important for fishery is common carp – *Cyprinus carpio*. Proportional contribution was up to 100% at „Koviljsko-Petrovaradinski Rit“ in 1980 (Budakov et al., 1983 a). The presence of common carp at certain areas of the channel network of the Danube-Tisa-Danube Hydrosystem (Maletin and Neatnica, 2006) is the result of repopulation. It is important to stress the presence of this species in the catch at the „Gornje Podunavlje“ during the 1980s and 1990s (Maletin and Kostić, 1988; Budakov et al., 1997), as well as at the „Stari Begej-Carska Bara“ (Kostić and Maletin, 1992; Popović et al., 2007).

Table 1
Qualitative and quantitative proportional distribution of the fish species important for fishery in Vojvodina

Site	Point	Date of the catch	References	*Tinca tinca*	*Cyprinus carpio*	*Esox lucius*	*Silurus glanis*	*Sander lucioperca*	*Acipenser ruthenus*
1	2	3	4	5	6	7	8	9	10
Dunav		1986-1987	Maletin et Kostić, 1988	4.56					
		1996	Maletin et al., 1997		0.5	3.48	0.5	0.5	0.5
Apatinski rit		1986-1987	Maletin et Kostić, 1988						
		1996	Budakov et al., 1997	+					
Begečka jama		1996	Maletin et al., 1997		0.37	0.37	0.74	0.74	
		1996-1997	Budakov, 1999	+	+	+	+	+	
		1999	Vučković et al., 2002	0.23	3.26	9.32		0.93	3.5
Koviljski rit		1979	Budakov, 1979	+					
		II 1980	Budakov i sar., 1983 a	4.22		56.4			
		III 1980	“	0.67		10.3		50	
		IV 1980	“		100				
		V 1980	“			12.8			
		VI 1980	“	0.36		6.32		50	
		ukupno	“	0.52					
		1986-1987	Maletin et Kostić, 1988	0.82	3.28	1.49 24.59	- 0.82	- 10.11	
		1996	Maletin et al., 1997	0.06	3.28	3.22	0.06	0.38	
		1999	Popović et al., 2000		0.47	0.47			
	Šlajz	2000	Maletin i sar., 2001			17.59			
	Tonja	“	“		6.66				
	Arkanj	“	“			2.69			
	Ukupno	“	“		0.24	6.49			
	Arkanj	2006	Popović i sar., 2006			+			
	Dunavac	“	“			+			
	Tonja	“	“			+			
	Arkanj	VI 2007	Popović i sar., 2007			2.56		1.46	
	“	XI 2007	“			49.52			
	Okruglica	VI 2007	“			1.83			
	Arkanj	VII 2008	Popović i sar., 2008		0.66	5.3			

Table 1
Continued

1	2	3	4	5	6	7	8	9	10
	"	X 2008	"		20.83	5.55			
	Dunavac	VII 2008	"			5.46			
	Okruglica	X 2008	"			12.5			
	Šlajz	X 2008	"			37.16		0.68	
Kanal D-T-D	Jegrička	1983	Budakov i sar., 1984		4.01	8.92	1.33	3.12	
	"	2006	Maletin i Neatnica, 2006	2.40					
	Bajski kanal	1988-1989	Pujin i sar., 1990	+	+	0.5		3.0	
	"	1996	Maletin i sar., 1997				4.07	3.39	
	Vrbas-Bezdan	1991	Maletinn i sar., 1992	+	+	+	+	+	
	" - Crvenka	1996	Maletin i sar., 1997	0.22	0.22	0.94	0.79	1.3	
	" - Vrbas	2006	Maletin i Neatnica, 2006		20.6		5.9	2.9	
	" - Mali Stapar	"	"			1.2			
	Odzaci-Sombor	1996	Maletin i sar., 1997	0.23	0.47		0.47	1.65	
	N.Sad-Savino Selo (B.Petrovac)	1996	Maletin i sar., 1997				2.64	2.05	
	N.Sad-Savino Selo (N.Sad)	1999-2001	Kostić et al., 2002			3.95	0.19	1.51	8.29
	Bečej-Bogojevo (Odzaci)	2006	Maletin et Neatnica, 2006		6.3	0.6	0.9	0.6	
	Bački Petrovac-Karavukovo (Bač)	"	"		4.9	1.2			
	Banatska Palanka-Novi Bečej (Kajtasovo)	"	"			4.5		4.5	
	Banatska Palanka-Novi Bečej (Melenci)	"	"	4.20		8.3	4,2	8.3	
	Kikindski kanal (Novo Miloševo)	"	"	1.70	3.4	1.7	1.7	1.7	
	Begej (Stajićevo)	"	"		17				
Palić		1981-1990	Djukić i sar., 1991	+	+	+	+		
		1991-1992	Budakov, 1996 a	+	+	+	+	+	
Ludoš		1986-1987	Pujin i sar., 1988	+	+			+	

Table 1
Continued

1	2	3	4	5	6	7	8	9	10
		1981-1990	Djukić i sar., 1991	+	+		+	+	
Mrtva Tisa	Biserno ostrvo	1987	Kostić et Maletin, 1992		0.37	10.78	0.37	3.34	
	„	1988	„	0.37	1.11		0.74	0.37	
	“	1996	Maletin i sar., 1996	+					
	“	2006	Sekulić, 2007		+	+	+	17	
Beljanska bara		2007-2008	Sekulić, 2008	+	+	+	+	+	
Obedska bara		1976	Budakov i sar., 1983 b	11.06	57.39	2.94			
		1977	„	7.34	10.53	6.54			
		1979	„	4.16	5.26	1.4			
		1980	„	6.94		16.82			
		1981	„	8.47		52.8			
		1982	„	1.36	26.3	14.48			
		1986-1987	Pujin i sar., 1988	+	+	+			
Bara Trskovača		2006	Branković, 2008; 2011	4.95		+			
Carska bara		1984	Kostić et Maletin, 1992	0.68					
		1985	„						
		1988	„	0.74					
		2007	Popović i sar., 2007						
		2009	Sekulić, 2010		+	+	+	+	
Stari Begej	10 RKM	VII 2007	Popović i sar., 2007						
	„	X 2007	„						
	13 RKM	VII 2007	„						
	„	X 2007	„						
	10 RKM	VII 2008	Popović i sar., 2008						
	„	X 2008	„						
	13 RKM	VII 2008	„					1.47	
	„	X 2008	„						
Tamiš		1977-1986	Pujin i sar., 1987	+					
		1998	Maletin i sar., 1988	+					
	Sečanj	VIII 2009	Šipoš i sar., 2010		+	+			

Table 1
Continued

1	2	3	4	5	6	7	8	9	10
	“	X 2009	„						
	“	IV 2010	„						
	Banatski Despotovac	VIII 2009	„		+			+	
	“	X 2009	„						
	“	IV 2010	„						
	Opovo	VIII 2009	„						
	“	IV 2010	„						
Ponjavica		1991-1993	Budakov, 1994	+	+	+	+	+	
Zobnatica		1981-1990	Djukić i sar., 1991	+	+	+	+	+	
Provala		1996	Maletin i sar., 1999		1.53				
Borkovac		1981-1990	Djukić i sar., 1991	+	+		+	+	
Sot		1981-1990	Djukić i sar., 1991		+		+		
Zasavica		1995-1996	Budakov, 1996 b	+	+	+			
	Valjevac	1998	Kostić i sar., 2000	7.38	0.82	8.19			
	Šumareva Ćuprija	„	„	3.15		7.87			

+ : only the presence of the species

The maximum recorded proportional contribution for catfish – *Silurus glanis* was 5.9 % in the channel Vrbas-Bezdan near the town of Vrbas in 2006 (Maletin and Neatnica, 2006) which is also the result of repopulation, while at the remaining sites this species has had proportional contribution less than 1 %.

Zander – *Sander lucioperca* was, during the above mentioned research period, registered with maximum proportional contribution of 50 % at the „Koviljsko-Petrovaradinski Rit“ in 1980 (Budakov et al., 1983 a), and with significantly lower contribution in later researches.

Once a very important fish species for fishery, which is today almost extinct, tench – *Tinca tinca* with significant proportional contribution during the 1970s and 1980s, was present in Obedska Bara (Budakov et al., 1983 b), and lately it was found in Nature Monument „Bara Trskovača“ (Branković, 2008) as well as in some channels of the Danube-Tisa-Danube Hydrosystem (Maletin and Neatnica, 2006). In 1998, it was registered in „Zasavica“ at the „Valjevac“ site with 7.38 % of the total catch (Kostić et al., 2000).

Out of all researched sites in Vojvodina from the end of 1970s to 2011, sterlet was registered only in the Danube in 1996 (Maletin et al., 1997), in the Nature Park „Begečka Jama“ in 1999 (Vučković et al., 2002) and in the channel „Novi Sad-Savino Selo“ near the city of Novi Sad in the period between 1999 and 2001 (Kostić et al., 2002), wherein the highest proportional contribution of 8.29 % was recorded at the last site.

In contrast to Vojvodina, which is predominantly flat, the rest of Serbia is characterised with mountainous areas and plains in the valleys of larger rivers, like the Velika Morava River.

In mountainous areas, the dominant species is brown trout – *Salmo trutta* with contribution between 56 % and 100 %. In large rivers of West Serbia, like the Drina and Lim, apart from brown trout, grayling – *Thymallus thymallus* is also present (average 12.4–34.2%), as well as huchen – *Hucho hucho* (up to 8.3%). In lowland rivers, common nase – *Chondrostoma nasus*, barbell – *Barbus barbus* and chub – *Leuciscus cephalus* are dominant with the contribution of over 50 %, while white-eye beam – *Abramis brama*, common carp, and other whitefish are present

with 34.5 %. The remaining part consists of predators: catfish, pike and zander (Simić et al., 2006).

The Danube, Sava and Tisa are the biggest and the most important rivers for fishery in Serbia (apart from sport fishing, there is also commercial fishing), in which significant temporal and spatial changes regarding ichthyofauna have occurred during the researched period. Two significant periods can be singled out, the first one being the period up to 1970, followed by the period after construction of the large dam at the Danube: „Đerdap I" and later „Đerdap II". Contribution of the fish species important for fishery in the Danube before and after 1970 is given in Table 2.

It can be clearly seen from the table that proportional contribution of almost all fish species important for fishery drops after 1970, especially Acipenserida. At the same time, proportional contribution of allochthonous species like Prussian carp and silver carp has increased.

Shapiro-Wilk test for the data from the territory of AP Vojvodina has shown that values for proportional contribution of the fish species important for fishery are not placed within the normal distribution ($p < 0.001$).

Kruskal-Wallis test has shown that the differences in proportional contribution of the fish species important for fishery between the catches are significant ($p = 0.001$). The differences between the period up to 1990 and the period between 1990 and 2000, and after 2000 are statistically significant ($p < 0.05$ and $p < 0.001$ respectively), while for the period between 1990 and 2000, and after 2000 there is no significant difference ($p = 0.0612$). Differences between sites are also significant (Kruskal-Wallis, $p < 0.001$).

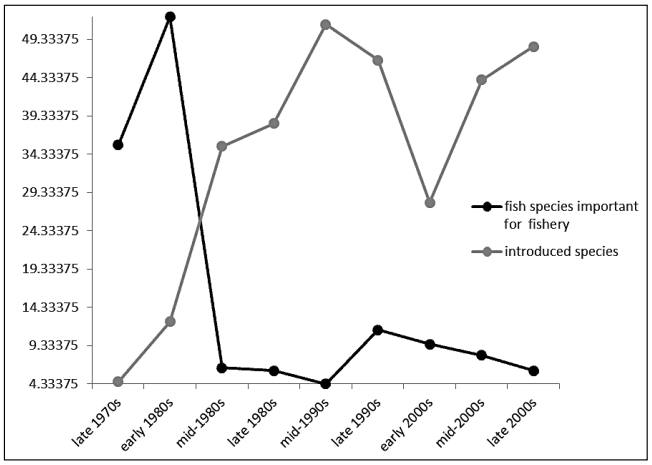

Fig. 1. Overlay running chart presenting proportional contribution of fish species important for fishery and introduced species during the research period

Pearson product-moment correlation coefficient has shown negative correlation between fish species important for fishery and introduced species ($r = –0.315$). The strongest negative correlation with the fish species important for fishery has Prussian carp – *Carassius gibelio* ($r = –0.33$) (Figure 1).

Discussion

It can be concluded from the presented results that the number of the fish species important for fishery decreases both in natural and anthropogenic water ecosystems in Vojvodina. Their survival is endangered due to irrational fishing, habitat degradation and other anthropogenic influences that have been most prominent in the „Koviljsko-Petrovaradinski Rit" Special Nature Reserve in late 1990s. Irrational fishing consists of disrespect of fishing seasons and excessive fishing of mostly juvenile individuals, which can be seen, in the results on age, weight, length and sex structure over past decades. Degradation of habitat is manifested in destruction of the areas in which fish spawn. One other important cause for decrease in number of the fish species important for fishery is the increased number of introduced species (Figure 1). This claim is also supported by correlation analysis.

Among introduced species that have changed the composition of the indigenous ichtyofauna largely, above-mentioned Prussian carp – *Carassius gibelio* should be singled out. It is one of the five species that have been introduced to the waters of Serbia from the Far East. Due to gynogenesis as a specific form of propagation, it populated the waters very fast, and since it is very resilient to oxygen deficit and increased pollution, in competition for food, it suppressed common carp and crucian carp – *Carassius carassius*. This introduced species was dominant in the most watercourses of Vojvodina, but not in Central Serbia.

The above mentioned data are confirmed by correlation analysis which determined the greatest negative correlation in relation to the number of Prussian carp

Table 2
Proportional contribution of the fish species important for fishery in the catch in the Danube before and after 1970 (Simić et al., 2006)

Fish species	Before 1970	After 1970
Huso huso	12.2%	2.4%
Acipenser sp.	11.7%	1.4%
Acipenser ruthenus	28.4%	7.3% further dicrease
Silurus glanis	13.5%	12.5% stagnation
Sander lucioperca	15.3%	8.1% slight dicrease
Esox lucius	8.2%	7.3%
Cyprinus carpio	23.5%	8.1% further dicrease
Abramis brama	26.7%	13.7%
Carassius gibelio	18.3%	36.9%
Hypophthalmichtys molitrix	less than 2%	around 10%

and the analysed fished species important for fishery (r = –0.33).

Fish species important for fishery, whose presence in the waters of Vojvodina over the last 30 years is presented in this paper deserve special attention. According to the „Rulebook on declaration and protection of protected and strictly protected wild species of plants, animals and fungi“ (Official Journal of the Republic of Serbia, no. 5 from 2010), tench – *Tinca tinca* is a strictly protected species, while common carp – *Cyprinus carpio*, pike – *Esox lucius*, catfish – *Silurus glanis*, zander – *Sander lucioperca* and sterlet – *Acipenser ruthenus* are listed as protected. Grayling and huchen are also listed as protected. Based on the „Law on Fisheries“ published in the Official Journal of the Republic of Serbia, No. 17 from 2009, the permanently closed fishing season was declared for tench, and closed season in certain periods and ban on fishing for individuals below prescribed size for the rest of the above mentioned species. Given that, after analysing above-mentioned results, tench is present with very small contribution, or it is extinct, the Ministry of Education and Science of Serbia, and Provincial Secretariat for Science of AP Vojvodina support the project of repopulation of this significant indigenous species, both in fishponds and open waters.

Among the analysed species, in the „Preliminary list of species for the Serbian red list of vertebrates“ are: *Cyprinus carpio*, *Esox lucius*, *Sander lucioperca* and *Acipenser ruthenus*, *Huso huso,* fam. Acipenseridae*, Thymallus thymallus* because their numbers are so small that there is danger of their extinction (Janković and Krpo-Ćetković, 1995; Budakov, 2000; Simonović, 2001; Lenhardt et al., 2004; Simić et al., 2006).

Beside this, sterlet – *Acipenser ruthenus* is a subject to the Law on Ratification of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), ANNEX II and it falls into a category of species that can be in danger of extinction. Furthermore, it can be found on the IUCN red list of endangered species of the International Union for Conservation of Nature – VU, which means that it is marked as vulnerable.

According to the results of the republic agency for environment, over the long period, the constant increase in fishing of carp, catfish and zander has been recorded when compared to other fish species important for fishery. According to the Agency Report from 2010 (Report, 2010), the trend of reduction of fishing of all species, apart from carp, can be seen to a smaller or greater degree. In Serbia, for a long period, commercial fishing was much more prominent than sport fishing. Only in 2010, has the Agency recorded increase in the intensity of sport fishing, which is the result of the control and monitoring of national authorities and reduced poaching. According to some assumptions, the

intensity of fishing was up to 3 times higher than in earlier years (Reports 2009, 2010).

The given data on presence of the fish species important for fishery in the waters of Vojvodina show that they should receive even more attention in order to preserve biodiversity, especially in Special Nature Reserves and Nature Parks.

Conclusions

Based on the analysis of the published data in the period between 1979 and 2011, the contribution of six fish species important for fishery is shown: tench – *Tinca tinca*, common carp – *Cyprinus carpio*, pike – *Esox lucius*, catfish – *Silurus glanis*, zander – *Sander lucioperca* and sterlet – *Acipenser ruthenus* in natural and anthropogenic water ecosystems in Vojvodina, as well as huchen – *Hucho hucho* and grayling – *Thymallus thymallus* in waters of mountainous areas of Serbia.

The number of above mentioned fish species in the waters of Serbia is decreasing due to inappropriate „tools", irrational fishing, presence of allochthonous species, uncontrolled emission of agricultural, industrial and other waste, as well as general habitat degradation.

Above-mentioned species deserve special attention. According to the „Rulebook on declaration and protection of protected and strictly protected wild species of plants, animals and fungi" from 2010, in Serbia, *Tinca tinca* is strictly protected species, while *Cyprinus carpio*, *Esox lucius*, *Silurus glanis*, *Sander lucioperca*, *Thymallus thymallus*, *Hucho hucho* and *Acipenser ruthenus* are listed as protected.

Acipenser ruthenus is subject to the Law on Ratification of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) ANNEX II and it falls into category of species that can be in danger of extinction. Furthermore, it can be found on the IUCN red list of endangered species of the International Union for Conservation of Nature – VU, which means that it is marked as vulnerable.

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