

ICHTHYOFAUNA OF THE WETLAND ECOSYSTEM IN THE BARDAČA AREA (BOSNIA AND HERZEGOVINA)

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Summary

The ichthyofauna composition of the wetland ecosystem in the Bardača area (Bosnia and Herzegovina) was described with the aim of indication on the richness and necessary protection of the biodiversity of this sensitive swamp region. During 2004, qualitative and quantitative fish samplings were carried out, according to seasons, in Matura and Brzaja rivers, the main tributaries of the drainage area around the Sava River. Fish samplings were carried out using an electro-generator pulse and removal method. Analysis of the sampled fishes consisted of species determination and estimation of yield for average density and biomass (N/m^2 or m^3 and g/m^2 or m^3). It could be said that during one year examinations, the presence of 24 fish species from 7 families has been determined. In addition, the analysis of fish diversity was carried out by means of species richness, Shanon–Weiner index, evenness and Simpson index. According to analyzed data, it could be observed that 2 allochthonous pest species, *Carassius auratus gibelio* and *Ictalurus nebulosus* presents the most dominant fish species in these waters in almost all sampling seasons.

Key words: Bardača wetland, ichthyofauna, qualitative–quantitative structure, biodiversity

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INTRODUCTION

The Bardača wetland (Fig. 1) is located in the northwest of Bosnia and Herzegovina, near the Croatian border. Bardača lies northeast of the Lijevo Polje, which is bounded by the River Sava in the north, Rivers Vrbas and Brzaja in the east, and River Matura in the west. To the south, in the close vicinity there is the Osorna–Borna–Ljevanica Canal, while to the southwest are the hillsides of the Kozara Mountain. Bardača covers 2810 hectares of surface area (810 hectares of water area and 2000 hectares of land area).

The marshland ecosystem in which the Bardača fishpond is located is merely a fraction of what was once a huge complex of marshes in the north Bosnia. Until the beginning of the 20th century, what is today's Bardača used to be covered in marshland vegetation with the prevalence of flood-plain forests. The construction of dykes and fishponds and forests cutting changed the landscape and gave to Bardača marshland its today's appearance (Obratil, 1973).

Considering extraordinary rich birds fauna, the area of Bardača has been declared as a special natural sanctuary what placed it under protection of the law.

The wider hydrological area of Bardača consists of the Bardača fishpond basins (surface around 670 hectares), surrounding rivers Brzaja, Matura and Stublaja, the Osorna–Borna–Ljevanica Canal and smaller drainage canals. The overall hydrological status is also significantly affected by the Rivers Sava and Vrbas.

Relevant scientific data about qualitative and quantitative content of ichthyofauna of hydrographical area of Bardača are very thin. According to the 1984 data, when the fishing basis for the »Sava« fishing area was built it was established that a part of the Matura River was inhabited by 14 economically valuable species of fish (Kosorić et al., 1984).

The only detailed investigation was performed in 1989 on a few marginal canals around Bardača fishpond, in the fishpond basins and on river Matura when 26 fish species from 6 different families were determined (Mikavica et al., 1998).

The main aim of this paper is to analyze composition and structure of the existing fish fund what referred to analyses of fish settlement at representative localities in respect of type of mass and number and to indicate on the richness and necessary protection of the biodiversity of this wetland area, specially the diversity of ichthyofauna populations and their habitats.

According to the aim of this research which is to provide a qualitative and quantitative analysis of the indigenous ichthyofauna, the Rivers Matura and Brzaja were selected as the most representative sites for this

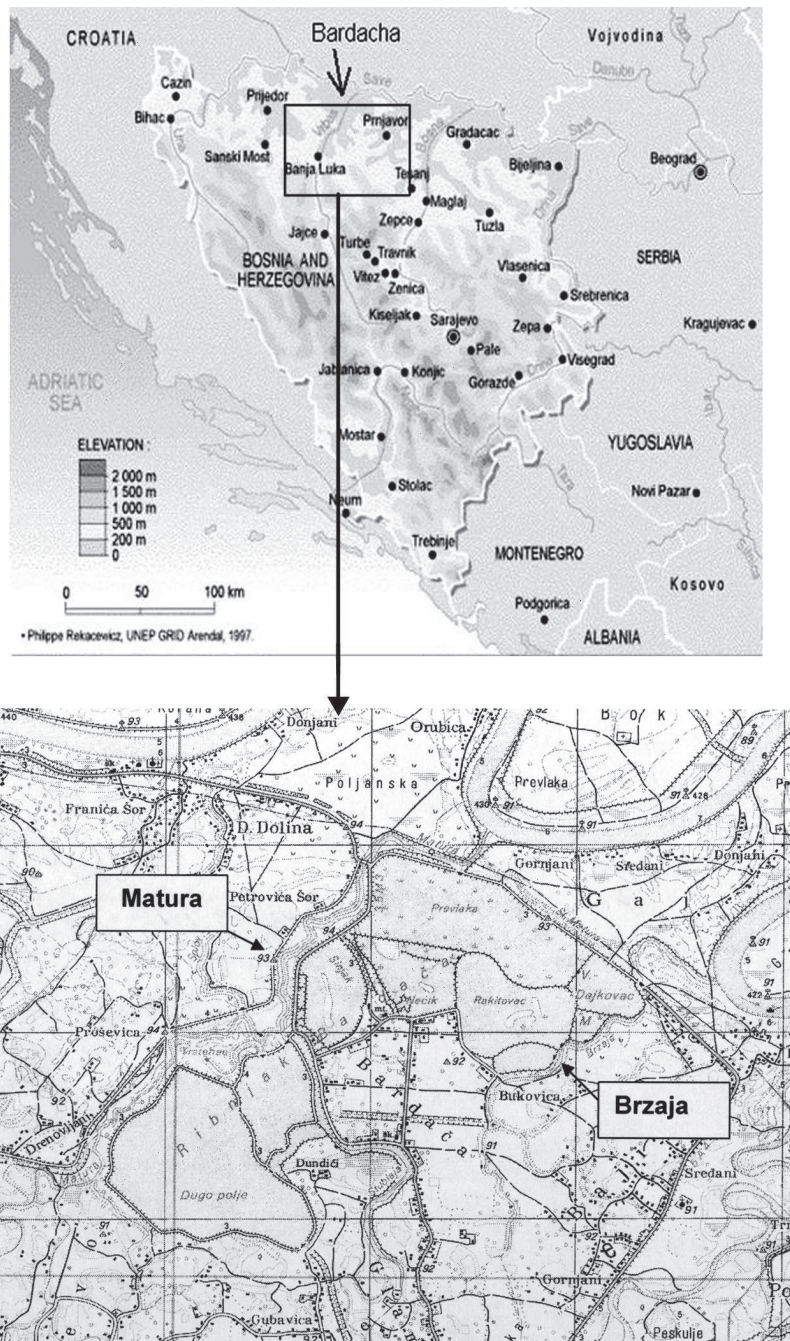


Fig. 1. Position of Bardača area
Slika 1. Pozicija područja Bardače

research. The Matura River rises at the Razboj–Karajizovac site and empties into the River Sava. During the construction of the main canal, the River Matura was intercepted and divided into two rivers by the crossing of the Osorna–Borna canal. The upstream one has an area of 40 km² and the second one has an area of less than 5 km². The headwaters of the Brzaja River are in the area of the Glamočani village, while it empties into the Sava River. The entire length of the river is around 5100 m. The water quality in these rivers was found to be generally satisfactory given that they belong to I–II to II class (Petrović & Matavulj, 2004).

MATERIALS AND METHODS

Ichthyofauna sampling in the area of Bardača was carried out on the two rivers Matura and Brzaja that represent the most important natural watercourses of this swamp complex. Two sampling stations were selected on each of the rivers where catch was carried out. Sampling was made in all seasonal aspects, in other words, there were four catches at all localities and sampling stations, one in spring, summer, autumn and winter of 2004. During ichthyofauna sampling an electric generator for fish catching was used. Since at the time of sampling a removal method was used, at each locality and each station within those localities two catches were carried out with a pause of about half an hour between them. All fish species caught when sampling firstly were determined then all individuals were counted and then their total and individual mass were determined in order to analyse species composition in these two rivers. Values for number of specimens and mass of those specimens of all determinate species in rivers Matura and Brzaja are presented and also calculated in terms of yield as density and biomass regarding of surface (N/m² and g/m²) and volume (N/m³ and g/m³) of investigated stations for both rivers, Matura and Brzaja. Next elaborations are performed in a conception of calculations of some indices of biodiversity (species richness, Shannon–Weaver index, evenness and Simpson index).

RESULTS

All caught fish species (Table 1) were determined by means of the keys for fish determination, (Vuković & Ivanković, 1971; Povž & Sket, 1990). Determination was made on the basis of morphometric and meristic characteristics. Regarding the nomenclature, above mentioned key and data from the Internet — www.fishbase.org (Bogutskaya & Naseka, 2004) was used.

Table 1. Species composition with values of density index (Nm^{-3}) and biomass index (gm^{-3}) (*w*–winter, *s*–spring, *su*–summer, *a*–autumn)
Tablica 1. Sastav vrsta s vrjednostima indeksa gustoće (Nm^{-3}) i biomase (gm^{-3}) (*w* — zima, *s* — proljeće, *su* — ljeto, *a* — jesen)

Vrsta/Species	Domestic name/ English name	Density index Nm^{-3} (%) — indeks gustoće						Biomass index gm^{-3} (%) — indeks biomase								
		Matura		Brzaja		W		Matura		Brzaja		W				
		S	SU	A	W	S	SU	A	W	S	SU	A	W	S	SU	A
<i>Abramis brama</i> <i>danubii</i>	Deverika/ Carp Bream	4,837	1,607			1,242				6,74	9,01			5,038		
<i>Acerina cernua</i>	Obični balavac/Ruffe	2,247	3,225		0,658			0,401	0,984	3,174			0,578			0,141
<i>Alburnus alburnus</i>	Ukljija/ Bleak	12,318	28,763			21,517	21,429			3,126	10,546			8,248	3,805	
<i>Blicca bjoerkna</i>	Krupatica/ White Bream	5,054	1,071			8,077	6,633	1,152		4,109	0,6			10,108	1,095	0,294
<i>Carassius auratus</i> <i>gibelio</i>	Babuška/ Prussian Carp	47,087	6,603	2,481	4,404	16,118	25,651	18,367	19,585	73,046	16,822	7,224	7,801	18,309	26,193	37,636
<i>Chalcalburnus</i> <i>chalcoides</i> <i>danubicus</i>	Bucov/ Danube Bleak					0,993	2,041							15,995	0,263	
<i>Chondrostoma</i> <i>nasus nasus</i>	Škobalj/ Sneep	1,124	3,056	2,096	0,979	0,658	4,175		0,842	0,266	1,414	2,037	0,376	0,329	4,02	0,368
<i>Cobitis taenia</i> <i>taenia</i>	Badelj/ Spined Loach	2,829	1,825	3,779	0,795		0,745		0,45	0,267	0,48	0,749	0,09	0,258		0,188
<i>Cyprinus carpio</i>	Šaran/ Common Carp					0,658	0,574		0,842					4,632	2,083	0,551
<i>Esox lucius</i>	Štuka/ Northern Pike			0,795		0,822	1,02	0,717					7,164	0,833	16,743	8,59
<i>Gobio gobio</i> <i>obtustirostris</i>	Krkaša/ Gudgeon	0,638								0,285						

cont. Table 1 — nastavak Tablice 1

Vrsta/Species	Domestic name/ English name	Density index Nm ⁻³ (%) — indeks gustoće						Biomass index gm ⁻³ (%) — indeks biomase										
		Matura			Brzaja			Matura			Brzaja							
		W	S	SU	A	W	S	SU	A	W	S	SU	A	W	S	SU	A	
<i>Ictalurus nebulosus</i>	Američki somić/ Brown Bullhead	33,575	15,206	13,855	69,266	67,434	6,288	27,551	20,237	13,236	18,049	22,13	49,139	69,836	4,275	29,198	19,344	
<i>Lepomis gibbosus</i>	Sunčanica/ Pumpkinseed	5,253	1,914	1,118	4,037	1,974	0,854	4,082	3,836	0,803	1,273	0,429	2,24	0,828	0,526	2,74	1,004	
<i>Leuciscus cephalus</i>	Klen/ European chub	4,837	4,937	4,679	0,658	3,229	2,551	0,763			24,303	15,467	7,547	1,056	9,652	1,645	0,519	
<i>Leuciscus leuciscus</i>	Klenić/ Common dace	15,317					0,574				3,772				0,157			
<i>Misgurnus fossilis</i>	Čikov/ Weatherfish	2,021								0,213								
<i>Perca fluviatilis</i>	Grgeč/ European Perch	3,933	1,276	1,955	1,713	1,316		1,531	22,847	1,408	1,893	0,722	0,199	1,104		1,37	11,09	
<i>Pseudorasbora parva</i>	Amurski čebačok/ Stone Moroko			0,977		8,882	3,731	6,122	14,459				0,361		2,905	0,684	1,32	2,464
<i>Rhodeus sericeus</i>	Gavčica/ Amur Bitterling	2,233	1,118	0,795	1,645	8,202	6,122	4,056			0,306	0,213	0,042	0,422	1,625	1,18	0,65	
<i>Rutilus rutilus</i>	Bodorka/ Roach	1,124	19,411	36,241							9,672	1,02	8,746	0,464	11,845	30,513		
<i>carpathorossicus</i>																		
<i>Scardinius erythrophthalmus</i>	Crvenperka/ Rudd		0,638		1,101		3,157	1,531	1,067		0,184		5,54		1,294	0,79	0,329	
<i>Silurus glanis</i>	Som/ Wels Catfish						0,497										3,116	
<i>Stizostedion lucioperca</i>	Smud/ Zander	0,808								9,313								
<i>Tinca tinca</i>	Linjak/ Tench		1,612		2,691						2,225						7,05	

It could be said that during one-year examination and sampling of ichthyofauna in the area of natural water courses of Bardača, more precisely on the rivers Matura and Brzaja, the presence of 24 fish species from 7 different families has been determined. One species (*Esox lucius*) belong to family *Esocidae*, 17 species belong to family *Cyprinidae* (*Leuciscus cephalus cephalus*, *Leuciscus leuciscus*, *Rutilus rutilus carpathorossicus*, *Scardinius erythrophthalmus erythrophthalmus*, *Chalcalburnus chalcoides danubicus*, *Alburnus alburnus alburnus*, *Abramis brama danubii*, *Blicca bjoerkna*, *Tinca tinca*, *Chondrostoma nasus nasus*, *Rhodeus sericeus amarus*, *Carassius auratus gibelio*, *Cyprinus carpio*, *Gobio gobio obtusirostris* and *Pseudorasbora parva*) and 2 species belong to family *Cobitidae* (*Cobitis taenia taenia* and *Misgurnus fossilis*). Family *Siluridae* was presented with one species, *Silurus glanis*, and also the family *Ictaluridae* (*Ictalurus nebulosus*). Three species pertain to family *Percidae* (*Perca fluviatilis fluviatilis*, *Stizostedion lucioperca* and *Acerina cernua*) and one species pertain to family *Centrarchidae* (*Lepomis gibbosus*). Out of that number, 22 fish species were found in the river Matura, and 21 species were determined in the river Brzaja.

In order to get the more clear perspective, the density and biomass indexes of ichthyofauna species composition in rivers Matura and Brzaja are presented on following tables (Table 2).

In order to accurately describe the structure of fish communities in rivers Matura and Brzaja, it was necessary to analyse certain diversity indices. Besides the species richness (number of determinate fish species), the first elaborated index of species diversity in those communities of was the Shannon–Weiner biodiversity index. Given the obtained values, there was a need to also analyse the index of equitability, i.e. evenness, and to determine how evenly individuals are distributed among the determined fish species. In order to determine to which extent a certain species (or more of them) is dominant in relation to other species, the Simpson index was established. All the indexes were calculated for the both investigated rivers, namely Matura and Brzaja, in different seasons of the year (Tables 3 & 4).

The lowest values in terms of the number of species were recorded in wintertime in both rivers alike. We identified 10 different fish species in Matura and 10 in Brzaja. This situation changed significantly during spring sampling, when the number of identified species almost doubled. In spring we identified 17 different species of fish in Matura and 18 in Brzaja. The number of species drops in summer, when we determined 13 fish species in Matura and 13 in Brzaja. It should be noted here that the sampling conditions in summer were quite difficult due to the thick aquatic vegetation. The number of fish species in autumn is almost the same in Matura (12 species), while a slight increase has been increased in Brzaja, in which we identified 15 species.

Table 2. Species composition with average values of density and biomass in Matura and Brzaja River during all season

Tablica 2. Sastav vrsta s prosječnim vrijednostima gustoće i biomase u rijeci Maturi i Brzaji tijekom svih sezona

Species / vrsta	Locality / lokalitet	Season / sezona	Yield			
			$\bar{X} \text{ m}^{-2} \pm \text{Sd}$	$\bar{X} \text{ gm}^{-2} \pm \text{Sd}$	$\bar{X} \text{ m}^{-3} \pm \text{Sd}$	$\bar{X} \text{ gm}^{-3} \pm \text{Sd}$
<i>Abramis brama danubii</i>	Matura	spring	0,006±0,000	0,153±0,058	0,005±0,000	0,136±0,051
	Matura	summer	0,002±0,001	0,223±0,167	0,002±0,001	0,244±0,236
	Brzaja	spring	0,006±0,005	0,509±0,261	0,004±0,003	0,327±0,167
<i>Acerina cernua</i>	Matura	winter	0,004	0,05	0,003	0,04
	Matura	spring	0,004	0,072	0,004	0,064
	Brzaja	winter	0,002	0,018	0,001	0,011
	Brzaja	autumn	0,006±0,002	0,038±0,016	0,012±0,003	0,074±0,030
<i>Alburnus alburnus alburnus</i>	Matura	spring	0,016±0,016	0,08±0,040	0,014±0,015	0,063±0,043
	Matura	summer	0,052±0,045	0,359±0,332	0,042±0,035	0,286±0,262
	Brzaja	spring	0,105±0,096	0,827±0,982	0,069±0,060	0,535±0,625
	Brzaja	summer	0,028±0,011	0,066±0,043	0,048±0,020	0,113±0,074
<i>Blicca bjoerkna</i>	Matura	spring	0,008±0,005	0,112±0,052	0,006±0,004	0,083±0,042
	Matura	summer	0,002±0,000	0,02±0,017	0,002±0,000	0,016±0,012
	Brzaja	spring	0,036±0,011	0,992±1,092	0,026±0,005	0,655±0,682
	Brzaja	summer	0,009±0,001	0,019±0,003	0,015±0,002	0,033±0,006
	Brzaja	autumn	0,017±0,009	0,078±0,029	0,034±0,018	0,155±0,061
<i>Carassius auratus gibelio</i>	Matura	winter	0,084±0,087	3,739±4,159	0,068±0,071	2,994±3,436
	Matura	spring	0,012±0,009	0,476±0,163	0,007±0,005	0,339±0,177
	Matura	summer	0,004±0,003	0,172±0,091	0,004±0,002	0,196±0,122
	Matura	autumn	0,008±0,003	0,512±0,256	0,006±0,002	0,366±0,245
	Brzaja	winter	0,041±0,006	0,575±0,046	0,024±0,003	0,338±0,027
	Brzaja	spring	0,105±0,103	2,323±1,265	0,083±0,089	1,698±0,974
	Brzaja	summer	0,024±0,025	0,648±0,721	0,041±0,042	1,118±1,243
<i>Chalcalburnus chalcoides danubicus</i>	Brzaja	spring	0,005	1,617	0,003	1,037
	Brzaja	summer	0,003±0,002	0,005±0,002	0,005±0,003	0,008±0,004
<i>Chondrostoma nasus nasus</i>	Matura	winter	0,002	0,013	0,002	0,011
	Matura	spring	0,004±0,003	0,036±0,021	0,003±0,003	0,028±0,023
	Matura	summer	0,003±0,003	0,066±0,080	0,003±0,002	0,055±0,060
	Matura	autumn	0,002	0,032	0,001	0,018
	Brzaja	winter	0,002	0,01	0,001	0,006
	Brzaja	spring	0,02±0,023	0,401±0,561	0,013±0,014	0,261±0,357
Brzaja	autumn	0,013	0,097	0,025	0,194	

cont. Table 2 — nastavak Tablice 2

Species / vrsta	Locality / lokalitet	Season / sezona	Yield			
			$\bar{X} \text{ m}^{-2} \pm \text{Sd}$	$\bar{X} \text{ gm}^{-2} \pm \text{Sd}$	$\bar{X} \text{ m}^{-3} \pm \text{Sd}$	$\bar{X} \text{ gm}^{-3} \pm \text{Sd}$
<i>Cobitis taenia taenia</i>	Matura	winter	0,008±0,005	0,021±0,013	0,004±0,002	0,011±0,007
	Matura	spring	0,002±0,001	0,012±0,007	0,002±0,001	0,01±0,007
	Matura	summer	0,004	0,015	0,005	0,02
	Matura	autumn	0,001±0,000	0,006±0,002	0,001±0,001	0,004±0,003
	Brzaja	spring	0,004±0,002	0,026±0,005	0,002±0,001	0,017±0,003
	Brzaja	autumn	0,007±0,005	0,052±0,033	0,013±0,011	0,099±0,061
<i>Cyprinus carpio</i>	Brzaja	winter	0,002	0,146	0,001	0,086
	Brzaja	spring	0,002	0,162	0,002	0,135
	Brzaja	autumn	0,013±0,009	0,145±0,042	0,025±0,018	0,29±0,083
<i>Esox lucius</i>	Matura	autumn	0,001±0,000	0,476±0,064	0,001±0,001	0,337±0,138
	Brzaja	spring	0,003±0,001	0,071±0,030	0,003±0,001	0,054±0,032
	Brzaja	summer	0,001	0,288	0,002	0,497
	Brzaja	autumn	0,011±0,007	2,304±2,384	0,021±0,014	4,524±4,798
<i>Gobio gobio obtusirostris</i>	Matura	spring	0,001	0,01	0,001	0,006
<i>Ictalurus nebulosus</i>	Matura	winter	0,08±0,045	0,908±0,618	0,049±0,018	0,543±0,273
	Matura	spring	0,021±0,015	0,432±0,457	0,017±0,014	0,363±0,421
	Matura	summer	0,015±0,004	0,438±0,160	0,02±0,005	0,599±0,220
	Matura	autumn	0,12±0,061	3,127±1,722	0,087±0,060	2,309±1,661
	Brzaja	winter	0,171±0,126	2,194±1,738	0,1±0,074	1,29±1,022
	Brzaja	spring	0,025±0,026	0,335±0,407	0,02±0,022	0,277±0,341
	Brzaja	summer	0,036±0,015	0,503±0,357	0,062±0,026	0,867±0,616
	Brzaja	autumn	0,307±0,199	5,173±3,866	0,601±0,405	10,187±7,860
<i>Lepomis gibbosus</i>	Matura	winter	0,014±0,002	0,063±0,002	0,008±0,001	0,033±0,001
	Matura	spring	0,004	0,044	0,002	0,026
	Matura	summer	0,002±0,000	0,012±0,007	0,002±0,000	0,012±0,003
	Matura	autumn	0,008±0,007	0,186±0,210	0,005±0,004	0,105±0,115
	Brzaja	winter	0,005	0,026	0,003	0,015
	Brzaja	spring	0,004±0,003	0,052±0,056	0,003±0,002	0,034±0,035
	Brzaja	summer	0,005	0,047	0,009	0,081
	Brzaja	autumn	0,059±0,049	0,273±0,265	0,114±0,092	0,529±0,501
<i>Leuciscus cephalus cephalus</i>	Matura	spring	0,006	0,553	0,005	0,489
	Matura	summer	0,008±0,003	0,516±0,461	0,007±0,001	0,419±0,352
	Matura	autumn	0,009±0,002	0,565±0,501	0,006±0,001	0,355±0,254
	Brzaja	winter	0,002±0,000	0,033±0,004	0,001±0,000	0,02±0,002
	Brzaja	spring	0,016±0,002	0,976±0,562	0,01±0,001	0,626±0,360
	Brzaja	summer	0,003±0,003	0,028±0,018	0,006±0,005	0,049±0,030
Brzaja	autumn	0,012	0,145	0,023	0,273	

cont. Table 2 — nastavak Tablice 2

Species / vrsta	Locality / lokalitet	Season / sezona	Yield			
			\bar{X} m ⁻² ±Sd)	\bar{X} gm ⁻² ±Sd)	\bar{X} m ⁻³ ±Sd)	\bar{X} gm ⁻³ ±Sd)
<i>Leuciscus leuciscus</i>	Matura	spring	0,019±0,007	0,086±0,008	0,017±0,006	0,076±0,007
	Brzaja	spring	0,002	0,012	0,002	0,01
<i>Misgurnus fossilis</i>	Matura	winter	0,006±0,002	0,017±0,006	0,003±0,001	0,009±0,003
	Matura	winter	0,007±0,001	0,071±0,017	0,006±0,001	0,058±0,014
<i>Perca fluviatilis fluviatilis</i>	Matura	spring	0,002	0,065	0,001	0,038
	Matura	summer	0,004	0,025	0,003	0,02
	Matura	autumn	0,003±0,001	0,014±0,006	0,002±0,001	0,009±0,004
	Brzaja	winter	0,003	0,035	0,002	0,02
	Brzaja	summer	0,002±0,001	0,024±0,028	0,003±0,002	0,041±0,047
	Brzaja	autumn	0,341±0,322	2,934±2,941	0,678±0,648	5,841±5,912
	Brzaja	autumn	0,002	0,012	0,001	0,01
<i>Pseudorasbora parva</i>	Brzaja	winter	0,023±0,022	0,091±0,093	0,013±0,013	0,054±0,055
	Brzaja	spring	0,014±0,005	0,053±0,022	0,012±0,004	0,044±0,018
	Brzaja	summer	0,008±0,008	0,023±0,021	0,014±0,013	0,039±0,037
	Brzaja	autumn	0,221±0,111	0,669±0,318	0,429±0,210	1,298±0,598
<i>Rhodeus sericeus amarus</i>	Matura	spring	0,004±0,004	0,01±0,011	0,002±0,002	0,006±0,006
	Matura	summer	0,002±0,000	0,006±0,005	0,002±0,000	0,006±0,002
	Matura	autumn	0,001±0,000	0,003±0,001	0,001±0,001	0,002±0,002
	Brzaja	winter	0,004±0,004	0,013±0,012	0,002±0,002	0,008±0,007
	Brzaja	spring	0,032±0,032	0,127±0,131	0,026±0,027	0,105±0,110
	Brzaja	summer	0,008±0,002	0,02±0,007	0,014±0,003	0,035±0,012
	Brzaja	autumn	0,061±0,097	0,172±0,306	0,12±0,195	0,342±0,612
<i>Rutilus rutilus carpathorossicus</i>	Matura	winter	0,002	0,023	0,002	0,019
	Matura	spring	0,03±0,015	0,34±0,218	0,021±0,012	0,238±0,158
	Matura	summer	0,041±0,034	0,649±0,512	0,053±0,050	0,826±0,760
	Matura	autumn	0,018±0,013	1,003±0,990	0,011±0,006	0,602±0,522
	Brzaja	spring	0,045±0,021	0,563±0,411	0,031±0,010	0,382±0,241
	Brzaja	summer	0,001	0,038	0,002	0,066
	Brzaja	autumn	0,131±0,129	0,719±0,644	0,26±0,259	1,426±1,298
<i>Scardinius erythrophthalmus erythrophthalmus</i>	Matura	spring	0,001	0,006	0,001	0,004
	Matura	autumn	0,002	0,312	0,001	0,26
	Brzaja	spring	0,012±0,011	0,101±0,108	0,01±0,009	0,084±0,090
	Brzaja	summer	0,002±0,001	0,014±0,012	0,003±0,002	0,023±0,020
Brzaja	autumn	0,016±0,011	0,087±0,060	0,032±0,022	0,173±0,122	
<i>Silurus glanis</i>	Brzaja	spring	0,003	0,315	0,002	0,202
<i>Stizostedion lucioperca</i>	Matura	winter	0,002±0,000	0,725±0,110	0,001±0,000	0,382±0,058
<i>Tinca tinca</i>	Matura	spring	0,002	0,051	0,002	0,045
	Matura	autumn	0,004±0,003	0,467±0,072	0,003±0,003	0,331±0,142

The values of Shannon–Weiner index for the river Matura were the lowest during autumn and winter, which indicated the lowest diversity level, while a higher diversity level was observed in summer and especially in spring. The situation in Brzaja was as follows: the lowest diversity values were observed in wintertime, while they rose in other seasons, being rather similar in summer and autumn and highest in spring. As values varied between 1,109 and 2,411, we can say that the diversity in rivers Matura and Brzaja fits within the standard range, although it cannot be considered too high.

After analysis of the evenness results we came to the conclusion that the index values for the Matura River, which varied between 0,505 and 0,851 across seasons, indicated comparatively uneven number of individuals in certain species, especially in autumn and winter. The index values for the Brzaja River varied between 0,482 and 0,797, which also indicated an uneven distribution of individuals within species, especially in winter when these values were the lowest.

Since the elaboration of evenness indicated the existence of one or more fish species which stand out from the rest in terms of population density, we had to calculate the Simpson index, which is used for determining most dominant species in a community in terms of population density. The highest index values were determined in autumn and winter in Matura and during winter sampling in Brzaja. In other words, it is in these periods of the year that some species can be defined as dominant in the said communities due to their intensive density and it is in these periods that the diversity of the fish community was at the lowest level.

On the basis of all samplings and data elaboration results, two allochthonous species are determinate as a most dominant: *Carassius auratus gibelio* and *Ictalurus nebulosus*, and investigations of influence of these non-native species on the total and especially on the autochthon ichthyofauna of Bardača hydrographical area natural waters shows negative and dangerous impact.

DISCUSSION AND CONCLUSIONS

This paper aims to contribute to an overview of biodiversity in the Bardača ecosystem, while it focuses more specifically on the studying of qualitative and quantitative composition of ichthyofauna in natural water streams, namely rivers Matura and Brzaja. This is the first time that the fish community in these two rivers have been studied so comprehensively and in accordance with the standard, scientifically approved and necessary methodology. Consequently, these data represent a very important contribution to biological and environmental sciences, especially in

Bosnia and Herzegovina, and it is certain to serve in the future as a basis for related studies in this region. This is especially important because Bardača is under the direct human influence, which makes these water ecosystems quite certain to be exposed to further changes and successions.

During sampling that was conducted in 2004 in rivers Matura and Brzaja, we identified 24 species of fish from 7 different families, most of which belong to the family *Cyprinidae*.

It can be concluded from the two aforementioned pieces of research, however, that the composition of ichthyofauna in the river Matura has undoubtedly changed. The sampling that was conducted in 2004 as part of the present research failed to identify as many as 9 species of fish (*Barbus barbus*, *Rutilus pigus*, *Vimba vimba*, *Acipenser ruthenus*, *Leuciscus idus*, *Hypophthalmichthys molitrix*, *Ctenopharyngodon idella*, *Aspro streber* and *Acerina chraetser*) that inhabited the river Matura between 1984 and 1989. Moreover, we determine 6 species (*Rhodeus sericeus amarus*, *Gobio gobio obtusirostris*, *Cobitis taenia taenia*, *Misgurnus fossilis*, *Scardinius erythrophthalmus erythrophthalmus* and *Leuciscus leuciscus*) that can be defined as »new« because no source before did not proclaim them as a members of Matura and Brzaja fish fauna.

On the other hand, despite the inconclusive results of previous researches, one can notice that the domination of species in terms of density and biomass has also changed. In comparison with the results from 1984 and 1989, it is only *Ictalurus nebulosus* that remained unchanged, whereas other species such as *Cyprinus carpio*, *Tinca tinca*, *Stizostedion lucioperca*, *Silurus glanis*, etc. are nowadays sparsely distributed in the two rivers, while some of the aforementioned species were not found at all. We can also conclude that the distribution of commercially important species such as *Cyprinus carpio*, *Tinca tinca* and all autochthonous predatory species was at a very low level.

It is important to emphasise here the sparse distribution of the abovementioned autochthonous predatory species such as *Silurus glanis*, *Esox lucius*, and *Stizostedion lucioperca*.

Possible causes of the low number of predatory species primarily include excessive and uncontrolled fishing and change of hydrological conditions in waters they inhabit (Holčik, 1984).

It should be emphasised here that a number of pumps have been built over the last few years along rivers Matura and Brzaja for the purpose of supplying water to nearby fishponds and that the course of the river Matura was physically obstructed due to similar works. These hydrological undertakings surely had a negative impact on autochthonous predators, especially in terms of the reduced spawning area.

Table 3. Indices of fish biodiversity in river Matura
 Tablica 3. Indeksi diverziteta ribljeg naselja u rijeci Maturi

River/rijeka Matura					
Season / sezona	Species richness S	Simpson's index Λ	Shannon — Weiner index H'	Evenness J	
Winter	10	0,341	1,408	0,611	
Spring	17	0,115	2,411	0,851	
Summer	13	0,239	1,783	0,695	
Autumn	12	0,495	1,255	0,505	

Table 4. Indices of fish biodiversity in river Brzaja
 Tablica 4. Indeksi diverziteta ribljeg naselja u rijeci Brzaji

River/rijeka Brzaja					
Season / sezona	Species richness S	Simpson's index Λ	Shannon — Weiner index H'	Evenness J	
Winter	10	0,490	1,109	0,482	
Spring	18	0,144	2,266	0,784	
Summer	13	0,171	2,044	0,797	
Autumn	15	0,164	2,027	0,749	

Our interviews with anglers revealed that it is these species they see as most attractive catch, which leads to the conclusion that there is a constant fishing pressure on these fish species without any restock efforts.

On the other hand, during sampling we noticed the constant presence of another two introduced fish species, namely *Lepomis gibbosus* and *Pseudorasbora parva*, whose population density fluctuates across different seasons.

Moreover, it is important to mention that we also noticed the complete absence of herbivorous fish species that had been introduced into the waters of Bosnia and Herzegovina, but from the point of view of ichthyofauna production, complete water ecosystem and water quality, this has proved to be a very positive process (Maletić et al., 1997).

When we compared the results for the population density of all the identified fish species in both rivers across all seasons, we came to the conclusion that it is *Carassius auratus gibelio* and *Ictalurus nebulosus* that constitute the most dominant species in terms of both population density and biomass in these fish communities. It can be said that the occurrence of these two species shows negative influence reflecting upon the competition for reproduction, food and habitat.



Based on all the aforementioned facts, and in connection with the species composition in rivers Matura and Brzaja, we can say that the ichthyofauna of these two rivers is characterised by a relatively unfavourable composition. The dominant species are non-native weed fishes which, due to their density and feeding habits, contributed significantly to the expelling of autochthonous species of fish that used to be much more widely distributed in these two rivers just two decades ago. Very rare in terms of distribution are commercially important species and autochthonous predatory species.

The main actions to be undertaken with the aim of improving the current situation and protecting the two rivers and fish communities living in them include restocking with autochthonous species and artificial breeding of these native species, stricter and more adequate fishing control, and harsher penalties on fishermen who use illegal fishing tools and who are active during closed season. Also necessary is the continuous monitoring of these water ecosystems, for which purpose one should consider establishing a specialised service to be in charge of such monitoring.

Sažetak

IHTIOFAUNA MOČVARNOG EKOSUSTAVA BARDAČA (BOSNA I HERCEGOVINA)

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U ovom je radu opisan sastav ihtiofaune močvarnog ekosustava Bardače (Bosna i Hercegovina), i to radi identifikacije bogatstva i prijeko potrebne zaštite biodiverziteta ove osjetljive močvarne regije. Tijekom godine 2004. izvršena je kvalitativno–kvantitativna analiza ribljeg naselja iz dviju rijeka, Mature i Brzaje, koje su pritoci rijeke Save na ovom području. Uzorkovanje riba provedeno je elektroagregatom za lov ribe, a izlovi su obavljani tijekom svih

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godišnjih doba. Analiza ulovljenih riba sastojala se od determinacije vrsta i proračuna njihove prosječne biomase i abundance (N/m^2 ili m^3 i g/m^2 ili m^3). Može se reći da je tijekom ovoga jednogodišnjeg ispitivanja utvrđena prisutnost 24 riblje vrste iz sedam porodica. Analiza diverziteta spomenutih ribljih vrsta utvrđena je računanjem sljedećih indeksa diverziteta: bogatstvo brojnosti vrsta (*richness*), Shanon–Weaverov indeksa, indeks ravnomjernosti distribucije vrsta (*evenness*) i Simpsonov indeks. Prema dobivenim podacima, zaključeno je da su dvije introducirane »korovske« vrste riba, *Carassius auratus gibelio* i *Ictalurus nebulosus*, bile najdominantnije vrste u ovim vodama, i to u gotovo svim godišnjim dobima.

Ključne riječi: močvara Bardača, ihtiofauna, kvalitativno–kvantitativna struktura, biodiverzitet

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Received: 3. 4. 2008.
Accepted: 16. 6. 2008.