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# 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 determinate. 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 allochtonous 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 Lijevče 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–Ljevčanica 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 20$^{th}$ 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–Ljevčanica 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 preformed 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 determinate (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

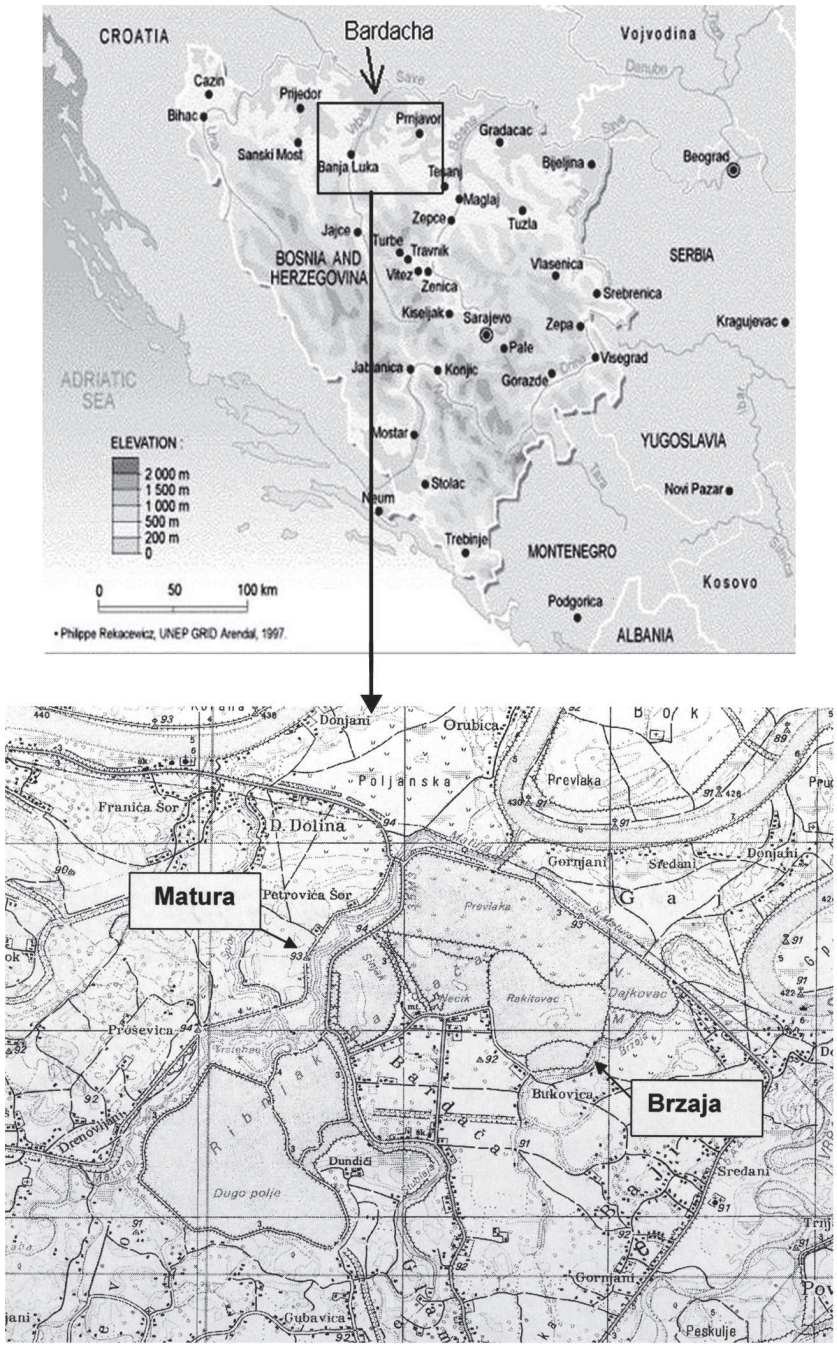


*Fig. 1. Position of Bardača area*
*Slika 1. Pozicija područja Bardače*

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 $km^2$ and the second one has an area of less than 5 $km^2$. 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 ($N/m^2$ and $g/m^2$) and volume ($N/m^3$ and $g/m^3$) of investigated stations for both rivers, Matura and Brzaja. Next elaborations are preformed 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 vrijednostima 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 | | | | Matura | | | | Brzaja | | | |
| | | W | S | SU | A | W | S | SU | A | W | S | SU | A | W | S | SU | A |
| Abramis brama danubii | Deverika/ Carp Bream | | 4,837 | 1,607 | | | 1,242 | | | | 6,74 | 9,01 | | | 5,038 | | |
| Acerina cernua | Obični balavac/Ruffe | 2,247 | 3,225 | | | 0,658 | | | 0,401 | 0,984 | 3,174 | | | 0,578 | | | 0,141 |
| Alburnus alburnus alburnus | Uklija/ Bleak | | 12,318 | 28,763 | | | 21,517 | 21,429 | | | 3,126 | 10,546 | | | 8,248 | 3,805 | |
| Blicca bjoerkna | Krupatica/ White Bream | | 5,054 | 1,071 | | | 8,077 | 6,633 | 1,152 | | 4,109 | 0,6 | | | 10,108 | 1,095 | 0,294 |
| Carassius auratus gibelio | 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 | 51,76 |
| Chalcalburnus chalcoides danubicus | Bucov/ Danube Bleak | | | | | | 0,993 | 2,041 | | | | | | | 15,995 | 0,263 | |
| Chondrostoma nasus nasus | 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 |
| Cobitis taenia taenia | 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 |
| Cyprinus carpio | Šaran/ Common Carp | | | | | 0,658 | 0,574 | | 0,842 | | | | | 4,632 | 2,083 | | 0,551 |
| Esox lucius | Štuka/ Northen Pike | | | | 0,795 | | 0,822 | 1,02 | 0,717 | | | | 7,164 | | 0,833 | 16,743 | 8,59 |
| Gobio gobio obtusirostris | Krkuša/ 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 |
| Ictalurus nebulosus | 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 |
| Lepomis gibbosus | 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 |
| Leuciscus cephalus cephalus | 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 |
| Leuciscus leuciscus | Klenić/ Common dace | | 15,317 | | | | 0,574 | | | | 3,772 | | | | 0,157 | | |
| Misgurnus fossilis | Čikov/ Weathgerfish | 2,021 | | | | | | | | 0,213 | | | | | | | |
| Perca fluviatilis fluviatilis | Grgeč/ Europen 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 |
| Pseudorasbora parva | Amurski čebačok/ Stone Moroko | | | 0,977 | | 8,882 | 3,731 | 6,122 | 14,459 | | | 0,361 | | 2,905 | 0,684 | 1,32 | 2,464 |
| Rhodeus sericeus amarus | 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 |
| Rutilus rutilus carpathorossicus | Bodorka/ Roach | 1,124 | 19,411 | 36,241 | | | 9,672 | 1,02 | 8,746 | 0,464 | 11,845 | 30,513 | | | 5,893 | 2,214 | 2,708 |
| Scardinius erythrophthalmus erythrophthalmus | Crvenperka/ Rudd | | 0,638 | | 1,101 | | 3,157 | 1,531 | 1,067 | | 0,184 | | 5,54 | | 1,294 | 0,79 | 0,329 |
| Silurus glanis | Som/ Wels Catfish | | | | | | 0,497 | | | | | | | | 3,116 | | |
| Stizostedion lucioperca | Smuđ/ Zander | 0,808 | | | | | | | | 9,313 | | | | | | | |
| Tinca tinca | 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 erythrophthalamus erythrophthalamus, 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 speceies pertain to family *Percidae* (*Perca fluviatilis fluviatilis*, *Stizostedion lucioperca* and *Acerina cernua*) and one species pertain to family *Centrachidae* (*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 | | | |
|---|---|---|---|---|---|---|
| | | | $\bar{X}$ $m^{-2}$±Sd) | $\bar{X}$ $gm^{-2}$±Sd) | $\bar{X}$ $m^{-3}$±Sd) | $\bar{X}$ $gm^{-3}$±Sd) |
| *Abramis brama danubii* | 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 |
| *Acerina cernua* | 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 |
| *Alburnus alburnus alburnus* | 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 |
| *Blicca bjoerkna* | 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 |
| *Carassius auratus gibelio* | 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 |
| | Brzaja | autumn | 0,293±0,261 | 13,766±12,152 | 0,581±0,527 | 27,26±24,511 |
| *Chalcalburnus chalcoides danubicus* | 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 |
| *Chondrostoma nasus nasus* | 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 | | | |
|---|---|---|---|---|---|---|
| | | | $\bar{X}$ $m^{-2}$±Sd) | $\bar{X}$ $gm^{-2}$±Sd) | $\bar{X}$ $m^{-3}$±Sd) | $\bar{X}$ $gm^{-3}$±Sd) |
| *Cobitis taenia taenia* | 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 |
| *Cyprinus carpio* | 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 |
| *Esox lucius* | 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 |
| *Gobio gobio obtusirostris* | Matura | spring | 0,001 | 0,01 | 0,001 | 0,006 |
| *Ictalurus nebulosus* | 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 |
| *Lepomis gibbosus* | 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 |
| *Leuciscus cephalus cephalus* | 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) |
| *Leuciscus leuciscus* | 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 |
| *Misgurnus fossilis* | Matura | winter | 0,006±0,002 | 0,017±0,006 | 0,003±0,001 | 0,009±0,003 |
| *Perca fluviatilis fluviatilis* | Matura | winter | 0,007±0,001 | 0,071±0,017 | 0,006±0,001 | 0,058±0,014 |
| | 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 |
| *Pseudorasbora parva* | Matura | summer | 0,002 | 0,012 | 0,001 | 0,01 |
| | 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 |
| *Rhodeus sericeus amarus* | 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 |
| *Rutilus rutilus carpathorossicus* | 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 |
| *Scardinius erythrophthalmus erythrophthalmus* | 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 |
| *Silurus glanis* | Brzaja | spring | 0,003 | 0,315 | 0,002 | 0,202 |
| *Stizostedion lucioperca* | Matura | winter | 0,002±0,000 | 0,725±0,110 | 0,001±0,000 | 0,382±0,058 |
| *Tinca tinca* | 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 erythrophthalamus erythrophthalamus* 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 (Maletin 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 provođeno 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–Weawerov 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

## *REFERENCES*

Bogutskaya, N. G., A. M. Naseka (2004): Catalogue of agnathans and fishes of fresh and brackish waters of Russia with comments on nomenclature and taxonomy. Russian Academy of Sciences, Moscow. Fishes Russia, 1–389, [Ref ID: 28183].

Holčik, J. (1984): Some considerations on the role of introduced species of fish in the management of inland fisheries. EIFAC Tech., 42, (2) 488–495.

Kosorić, Dj., Kapetanović, N., Guzina, N., Mikavica, D., Kačanski, D., Čanković, M., Bošnjak, Z. (1984): Ribarska osnova za ribolovno područje Sava. II/37–49, Biološki institut Univerziteta u Sarajevu, Sarajevo.

Maletin, S., Đukić, N., Miljanović, B., Ivanc, A., Pujin, V. (1997): Ocena kvaliteta vode hidrosistema Dunav–Tisa–Dunav na osnovu sastava i strukture ribljeg naselja. Zaštita voda '97, Zbornik radova, Sombor, 367–372.

Mikavica, D., Radević, M., Grujić, R., Savić, N. (1998): Ihtiofauna hidrografskog područja ribnjaka Bardača–Srbac. Ecobilten, 8/10, 9 pp.

Obratil, S. (1973): Ornitofauna ribnjaka Bardača kod Srpca. Glasnik Zemaljskog Muzeja Bosne i Hercegovine, sveska XI/XII, Sarajevo, 153–184.

Petrović, O., Matavulj, M. (2004): Water Quality. Special report of project LICENSE Local Institutional Capacity Development in Environmental Sensitive Areas [LIFE TCY/BIH/041] of Bardača area, Institute for Urbanism of Republika Srpska, Banjaluka, 80–84.

Povž, M., Sket, B. (1990): Naše slatkovodne ribe. Založba Mladinska knjiga, Ljubljana, pp 114–123, 218–221.

Vuković, T., Ivanović, B. (1971): Slatkovodne ribe Jugoslavije. Zemaljski Muzej BiH, Sarajevo, 9–245.

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