ICHTHYOFAUNA OF THE LOWER CATCHMENTS OF NERETVA RIVER

(Research season 2021)

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Enhancing Knowledge on Biodiversity and Assessing Ecological Status of the Lower Catchments of Neretva River in Bosnia and Herzegovina

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SALAKOVAC LAKE

1. Ecosystem of the Salakovac region

The hydrographic network in Bosnia and Herzegovina is extensively developed. It is characterised by several main river courses with a series of tributaries of I, II, III and IV order. The Neretva River basin, due to the characteristics of its origin, the appearance of certain elements of the valley terrain, its basic shape, as well as its geographical position, is a unique morphological phenomenon in the central part of the Dinaric Mountains. The Mostar valley stretches from Prigrađani and Salakovac in the north, to the Buna in the south.

Hydro-accumulation Salakovac was formed in 1981. The maximum length of the lake is 20 kilometers, the surface area is about 314 ha, the maximum depth is about 40 meters, while the water level oscillations are about 5 meters.

The geological base in the area of Salakovac consists of limestones of different geological ages, as well as dolomites and dolomitized limestones. The soils are formed from different developmental phases of dolomite and limestone soils - calcomelanosols, calcocambisols and red rocks. The climatic conditions in the Neretva Valley are quite similar to those in the southeastern Dinarides. Average annual air temperatures for the area of Mostar vary around 15℃, while the absolute minimum drops to -10.9℃, and absolute maximum during the summer months reaches values up to 40.2℃. The average air temperature of the coldest month of the year is around 1.5℃, and the warmest 28.2℃. Precipitations are mostly concentrated outside the vegetation period, in late autumn and early spring, which is why the climate is extremely arid during the summer. The vegetation period lasts from 200 to 240 days, and in the southern parts over 240 days.

2. Species of the Salakovac region

Salakovac Lake is inhabited by six species of fish from two families: Salmonidae and Cyprinidae. Family Salmonidae is represented by two species: lake trout (*Salmo trutta m. lacustris L.*), and rainbow trout (*Oncorhynchus mykiss* Wal.). Four species of the Cyprinidae family have been identified: *Leuciscus svallize svallize* Heck. Et Kn., white chub (*Leuciscus cephalus albus* Bon.), carp (*Cyprinus carpio* L.) and bleak (*Alburnus alburnus alborella* de Filippi).

The analysis of the qualitative composition shows that one autochthonous and one introduced salmonid species currently live in this ecosystem. Three indigenous cyprinid species are present. It is very clear that the number of more robust introduced species in Salakovac is gradually increasing. There is a noted change in the composition of ichthyofauna with the dominance of Cyprinid species, and certainly a much larger number of rainbow trout individuals. There seems to be a complete disappearance of soft-mouthed trout, which represented 10.31% of caught individuals in previous studies (Kosorić *et al*.1983 and 1989). In 1990, its numbers fell to 2.08% of caught individuals. No individuals of this species were observed during this study. Fishing was carried out during research seasons of 2021. Standard nets and electric fishing units were used for fishing. The fish samples were fixed in a 4% formaldehyde solution. Laboratory processing and determination were performed at the Faculty of Education in Mostar.

The rapid growth rate of introduced population and displacement of indigenous species suggests that ecological conditions of the environment coincide with ecological valences of

these fish species. The continuous and accelerated dynamics of introduced populations in Salakovac hydro-accumulation is observed. Along with the increase in population of allochthonous species, there is an obvious decrease in the population of indigenous species of *Leuciscus svallize svallize* Heck. Et Kn. and white chub (*Leuciscus cephalus albus* Bon.), as well as complete disappearance of soft-mouthed trout (*Salmothymus obtusirostris oxyrhinchus* Steind.) and marble trout (*Salmo marmoratus* Cuv.).

3. Illegal landfills on Salakovac Lake

Natural attributes of the Lake Salakovac and its immediate surroundings are largely tarnished by waste. Piles and piles of various types of litter “enrich” the landscape: discarded windows and doors with and without glass, inevitable car tyres, nylon and paper bags with contents of industrial origin, canisters of all kinds, plastic and glass bottles, cans, wardrobe, blankets, bags, construction waste, large iron barrels, remnants of old furniture were deposited about fifty meters from the shores of Lake Salakovac. However, the situation is not much better along the shore itself, where we encountered a significant amount of “fishing garbage”.

It is obvious that for a number of those who come to enjoy what this lake has to offer, the same lake serves as a garbage disposal area. In early spring, when the level of the lake reaches its maximum, the water "picks up" from the shores all discarded plastic bottles and other floating debris. At that time, huge islands of floating garbage form, and in addition to polluting the water, endanger numerous niches and habitats of Lake Salakovac.

Table 1. Current state of the ichthyiopopulation in the Salakovac Lake

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		REGIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Lake trout	*Salmo trutta. m.lacustris* (Linnaeus,1758)	Salmonidae	46	12	34	**CR**	**LC**
Californian rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)	Salmonidae	83	49	34	**LC**	**NE**
Neretvan chub	*Leuciscus svallize* (Heckel et Kner, 1852)	Cyprinidae	93	39	54	**VU**	**VU**
White chub	*Leuciscus cephalus albus* (Bonaparte, 1838)	Cyprinidae	93	43	50	**LC**	**DD**
Common Bleak	*Alburnus alburnus alborella* (De Filippi, 1844)	Cyprinidae	348	234	114	**LC**	**LC**
Eurasian carp	*Cyprinus carpio* (*Linnaeus, 1758)*	Cyprinidae	182	135	47	**LC**	**VU**

4. Floristic composition of the Salakovac basin

Flora in this area is quite diverse and hence could not have been omitted from the study. We conducted a simple inventory list to determine which plat species are commonly present. A large number of different plant species that belong to different system categories - families exist on the Salakovac site. At this locality, the vegetation levels are clearly expressed, that is: the level of trees, the level of shrubs and the level of herbaceous plants alternate. The terrain in this area consists of limestones of different geological ages. The climate is temperate. Temperatures vary from -10℃ to 40℃. Annual precipitation is just above 1500 mm. Regarding the riparian vegetation, we recorded 63 species at this locality: 13 tree species, 10 species of shrubs and 40 species of herbaceous plants. The species found belong to the families: Rosaceae, Moraceae, Coylaceae, Salicaceae, Fabaceae, Oleaceae, Aceraceae, Pinaceae, Liliaceae, Rhamnaceae, Achantaceae, Pteridaceae, Ranunculaceae, Violaceceae, Pantida. *Rusco - Carpinetum orientalis* are of the greatest importance. Results show that the Salakovac site is rich in various plant and animal species, although this area is very poorly researched.

FLORISTIC COMPOSITION	SPECIES NAME	DOMESTIC NAME
DENDROFLORA	*Salix viminalis L.* *Quercus pubescens Willd.* *Populus nigra L.* *Sorbus aucuparia L.* *Cornus mas L.* *Populus alba L.* *Pinus sylvestris L.* *Ficus carica L.* *Acer monspessulanum L.* *Quercus petraea (Matt.)* *Ostrya carpinifolia Scop.* *Frainus excelsior L.* *Acer campestre L.*	Rakita Medunac Topola crna Jerebika Drijen Topola bijela Bor bijeli Smokva Makljen javor Kitnjak Crni grab Bijeli jasen Poljski javor
SHRUBS	*Petteria ramentacea (Siebor)* *Ruscus aculeatus L.* *Asparagus acutifolius L.* *Crategus monogyna L.* *Vitis sylvestris Gmel.* *Paliurus spina – christi Mill.* *Rosa canina L.* *Colutea arboreascens L.* *Rhamnus intermedia Steud.* *Hedera helix L.*	Tilovina Veprina Beluš Bijeli glog Loza Drača Divlja ruža Pucalina Krkavina Bršljan

HERBACEOUS PLANTS	*Cichorium intybus L.*	Vodopija
	Prunella vulgaris L.	Crno zelje
	Astragalus glycyphillos L.	Orlovi nokti
	Pteridium aqvilinum L.	Orlova paprat
	Centaurea jacea L.	Različak
	Clematis vitalba L.	Pavit bični
	Agrimonia eupatoria L.	Obična turica
	Viola odorata L.	Ljubičica
	Acanthus balcanicus Heywood	Dugolisni primog
	Salvia officinallis L.	Kadulja
	Malva sylvestris L.	Šumski sljez
	Picris hieracoides L.	Runjikasti jagušac
	Equisetum sylvaticum L.	Rastavić
	Dianthus sp.	Karanfil
	Centaurea rupestris L.	Žuti različak
	Deskurainia sophia L.	Sofijin oranj
	Asplenium trichomanes L.	Paoratka
	Asplenium adiantum – nigrum L.	Sljezenica crna
	Fumana procumbens (Dunal)	Sunčac obični
	Ceterach officinarum DC.	Zlatna paprat
	Filipendula vulgaris MOENCH	Suručica
	Coronila coronata L.	Alčica žuta
	Matricaria chamomila L.	Kamilica
	Medicago sativa L.	Hmeljasta lucerka
	Cotinus coggygria Scop.	Ruj
	Clematis recta L.	Pavitac
	Rubus sp.	Kupina
	Clinopodium vulgare L.	Talac
	Peucedanum oreoselinum L.	Pukovica
	Linum austriacum L.	Lan
	Sanquisorba minor Scop.	Zelena svitica
	Punica granatum L.	Nar
	Artemisia vulgaris L.	Pelin
	Erigeron sp.	Divizma
	Verbascum thapsis L.	Mrkva
	Daucus carota L.	Muška bokvica
	Plantago lanceolata L.	Ljekoviti kokotac
	Melilotus officinalis L.	Hajdučka trava
	Achilea millefolium L.	Ptičija grahorica
	Vicia craca L.	

MOSTAR LAKE

1. Introduction

Lake Mostar is located within the City of Mostar, in the northern suburb of Vrapčići. Its coordinates are: 43°20′N 17°48′E. It is the newest lake on the Neretva River, created in 1987. The length of the lake is about 10 kilometers, and the surface area covers about 112 ha. The deepest point of the lake is at about 20 meters (Ministry of Agriculture, Forestry and Water Management FBiH).

The Neretva is the longest tributary of the Adriatic Sea from the east coast. It springs in the mountainous areas of the upper Herzegovina, below the mountain Jabuka at 1095 m altitude. In upper catchments, Neretva flows from the southeast to the northwest, thus forming the northern border of Herzegovina. The Neretva Delta (which has been under the UNESCO protection since 1992) covers an area of 12,000 hectares, bordered by the branches of the Dinaric mountains.

Bosnia and Herzegovina, as a country rich in water resources with great hydro potential, fulfils its energy requirements mainly from hydro power plants. The Neretva River Basin is energetically one of the most important regions in Bosnia and Herzegovina. In addition, export of produced electricity is a pivotal component in Bosnia and Herzegovina's foreign trade balance. With the inclusion of The Mostar hydroelectric power plant, the following plants are established on the Neretva River: HPP Mostar, HPP Salakovac, HPP Drežnica, HPP Grabovica, and HPP Jablanica.

Exploitation of water potential for energy production has an economical competitive advantage over production of electricity from fossil and nuclear fuels, making hydropower the most important renewable energy source. However, hydropower has significant technical and natural limitations. The main limitations are:

- the requirement for an abundant source of water throughout the year
- electricity storage is expensive and very harmful to the environment, since it is necessary to build dams and reservoirs to reverse the effects of water level fluctuations
- plant construction significantly increases investment requirements, has adverse environmental impacts,
- amplify devastation after earthquakes
- potential terrorist targets

1.2. Jablanica, Grabovica and Salakovac HPPs

The Jablanica hydroelectric power plant is the first and largest hydropower plant built on the Neretva River. The building is a derivation with an accumulation pool for seasonal leveling. Installed power is 180 MW (6 x 30 MW). The maximum net drop is 111.0 m. Turbine type - Francis, while the average annual production is 679 GWh.

Electricity production at HPP "Jablanica" began in February 1955. After its construction, it was the largest hydropower facility in the former SFRY. The comprehensive revitalization of the HPP (six units and part of the accompanying equipment) was completed in 2008. The revitalization has increased the installed capacity from 150 MW to 180 MW and extended the service life of HPPs for the next 30 to 40 years.

The total volume of the HPP Jablanica reservoir is 318 hm^3, and the reservoir includes the waters of the Neretva and all its tributaries upstream from Jablanica. By erecting a high arc-gravity dam, which is 85 meters high, just below the mouth of the Rama River into the Neretva, an accumulation lake with a maximum length of 30 kilometers was created, stretching along the Neretva to the town of Konjic and along the Rama River to the village of Gracac. The shortest route brings water to the turbines through two tunnels about two kilometers long, using a maximum drop of 111 meters at the Grabovica Hydroelectric Power Plant. The Grabovica hydroelectric power plant was put into operation in 1982. The location of the facility is on the Neretva River, Herzegovina-Neretva Canton (precisely, 13 km downstream from HPP "Jablanica"). The installed capacity is 114 MW (2 x 57 MW). The maximum net drop is 36.0 m. The type of turbine is Kaplan. The average annual production is 263 GWh. The total volume of the HPP "Grabovica" is 19.77 hm^3, and it was created by building a concrete dam 60 m high which stretches for about 11 km from the dam in Grabovica to the drainage canals of HPP "Jablanica" in Jablanica. The reservoir is elongated with an extremely small width, so it is mainly located in the canyon of the Neretva's middle course.

The Salakovac hydroelectric power plant was put into operation in 1982. The location of the construction is on the river Neretva, Herzegovina-Neretva Canton (precisely, 15 km upstream from Mostar). The object is a gravity dam, 70 m high. Installed power is 210 MW (3 x 70 MW). The maximum net drop is 45.0 m. The turbine type is Kaplan. The average annual production is 371 GWh. HPP "Salakovac" is included in the power system with 220 kV transmission lines: "HPP Salakovac - Kakanj" and "HPP Salakovac - Mostar 3". The total volume of the HPP "Salakovac" is 68.1 hm^3, and it was created by building a concrete dam 70 meters high (Bogut and Ivanković 2011).

2. Hydrological regime of the Mostar Lake

Natural variability of flow is the most important point of rivers and streams, which enables the maintenance of a dynamic environment and conditions conducive to great biodiversity. Construction of dams and hydroelectric power plants, impacted hydrological regime of Neretva's watercourse, with significant impacts such as:

- loss of terrestrial habitats by creating hydro accumulation and dam construction causing changes in the natural variability of water levels;
- impacts on the riparian zone, which changes microhabitat;
- invasion of allochthonous plants, which have almost completely conquered the coast;
- sewage system that overflows into the Neretva River, providing necessary mineral nutrients (primarily nitrates) that favor growth of invasive vegetation. A closer look at the composition of this group of plants shows increased abundance of plants such as *Pueraria lobata*, *Brussonetia papyrifera, Acer negundo, Phytolacca americana, Bidens subalternura, Ailanthus altissima.*
- sudden changes in water levels that occur due to direct operation of the hydropower plant upstream of the dam are not harmonized with the natural hydrological regime, which leads to degradation and disappearance of riparian vegetation;
- lowering the groundwater level downstream of the dam has negative effects on fishing and aquatic vegetation (fragmentation and / or loss of natural habitats)
- when an ecologically acceptable flow is released into the old riverbed, the areas under the originally present habitat types are proportionally reduced;
- creation of torrent waves and sudden rises in water levels (hydropeaking) are most often present in the operation of storage hydropower plants. Direct sudden release of large amounts of water has negative effects, such as washing away juveniles and small fish.

These effects are also possible with flow power plants with shorter periods of water accumulation. After such a flood event, fish can be found trapped in small pools left behind after the flood, and most often die when such habitats dry up;

- impact on water speed; upstream of the dam the former stream becomes almost stagnant (influence on the formation of bottom ice in winter);
- effects on water temperature (upstream and downstream of the dam) due to increased or decreased flow and/or depth. Water temperature is an important environmental factor for plant and animal species, and its changes affect fish spawning and fish egg survival (Federal Ministry of Environment and Tourism, 2008).
- the concentration of invasive weeds and allergenic plants is especially high in the areas of sewage outflows (of which there are approx. 40 in the urban zone) of different diameters and intensities. At these locations, the spread of ragweed, Chinese wormwood and churchweed is clearly expressed, as well as several species of bivalves (*Bidens spp.*) and similar nitrophilous weeds.

2.1. Direct impact on species

A turbine is an energy device with a constant (continuous) flow of working fluid (gas or liquid) through a system of stator and rotor blades (turbo engine) that converts potential or thermal energy of fluid flow into kinetic energy, and further rotation of the rotor into mechanical work. The obtained mechanical work is used to start electric generators, pumps, compressors and others. Turbines are a frequent source of injury to the ichthyofauna.

Species evolve by adapting to their natural habitat over a long period of time in which they create unique connections with their environment and other species. Changes in habitat disrupt the life cycles of river organisms. Torrential waves and sudden rises in water levels (hydropeaking) affect the qualitative and quantitative structure of ichthyofauna. When assessing the impact on ecological network areas, it is important to keep in mind that different impacts occur at different stages, eg during the construction, operation, maintenance, renovation and decommissioning of a hydropower plant (Bogut and Ivanković, 2011).

3. Current state of the Mostar Lake

Main factors that disrupt riparian vegetation are excavation, eutrophication and waste. During present study no aquatic insects were observed. This suggests that Lake Mostar is no longer suitable habitat for insects, ie., that it is not clean enough for their existence. The whole ecosystem is disturbed and fish population is decreasing.

Eutrophication is the aging of aquatic ecosystems. This process naturally lasts for thousands of years, while under human influence it occurs at much faster pace. Algal growth intensifies, the amount of oxygen decreases and animal species gradually die out. Aquatic ecosystems (in this case the lake) change color to dark green and brown. Lake Mostar has not reached the end point however it is threatened showing conception stages of eutrophication. Should this trend continue the lake itself could soon become highly threatened, leading up to further degradation of flora and fauna. Apart from eutrophication, there is also an active excavation process at this site. Excavation is casting, exploitation, separation or cleavage of substances from a sample. Lake Mostar is an obvious example of separation due to the constant separation of water and sand to make various building materials. It is also heavily littered.

3.1. Current state of ichthyopopulation - study results

According to the latest research and preliminary data, there are three families consistently found in Lake Mostar, namely: *Salmonidae, Cyprinidae* and *Percida*e.

During field trips, a large number of sports fishermen were noted. The vast majority of anglers catch soft-mouth trout (*Salmo obtusirostris*) as well as rainbow trout (*Oncorhynchus mykiss*). Frequent violations of the rules, use of illegal fishing equipment and taking larger quantities of fish than allowed were noticed. In sports fishing, the prescribed limit is one soft-mouthed trout longer than 30 cm per angler. Soft-mouthed trout (*Salmo obtusirostris*) is on the Red List of Fauna of the Federation of BiH, in the status of critically endangered species. Therefore, the question arises why fishing is allowed and why this endemic and relict species of fish does not have the protected and legal status it deserves.

Lake trout (*Salmo trutta morpha lacustris*) has very small scales, which rest firmly on the body and are therefore difficult to spot. The first rays in the thoracic, abdominal fins, as well as in the dorsal fin are white. The back is greenish-black, the hips of the body are silvery, and the belly is white. During the spawning period, the body color changes somewhat. There are rarely large pink x-shaped spots on the body. Specimens of this species can grow up to 100 cm, but are usually less than half a meter. They can reach a weight of up to 20 kg, and an age of up to 15 years. It has been considered quite rare as a catch in tis lake. Therefore, its status on the IUCN red list should be carefully considered.

Carp (*Cyprinus carpio*) is a fish of the family *Cyprinidae*. It has an elongated, thick body completely covered with scales. The massive head ends in a four-mustache mouth, and the mouth can be extended in the shape of a tube through which the carp searches and sucks food from the bottom. The only dorsal fin has a jagged and very sharp beam at the beginning. According to the habitat, its color varies from white gold to brown on the back, and becomes lighter with copper reflections on the hips and ends with a more or less light belly.

L*euciscus svallize svallize* Heck. Et Kn. is another of the indigenous species in the Neretva catchment area. It is characterized by a slender body, and the head and forehead are quite narrow and rounded. The morphometric and meristic features of this species have been studied in detail, while its ecology, and especially the biology of development needs to be further elucidated.

Zander (*Sander lucioperca, Stizostedion lucioperca*) is a fish from the *Percidae* family. Its slender body is covered with small scales. The head is elongated. The wide-open mouth has very developed teeth: 6 strong canines serve to injure and catch prey, other teeth, slightly weaker and directed inwards, aim to keep the caught fish. Bright eyes, special retinal structures provide them with excellent vision even at great depths and in the absence of light.

Taken as a whole, the Lake Mostar, from the aspect of qualitative composition of fish biocenosis, is a relatively preserved and young ecosystem, in which, however, one can still feel the adverse effects of the upcoming habitat changes. In the 2021 survey, the representation by species was as follows:

Table 1. Current state of the ichthyiopopulation in the Mostar Lake, family Salmonidae

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		NATIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Californian rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)	Salmonidae	38 (69,09%)	24	14	**LC**	**NE**
Soft-mouthed trout	*Salmothymus obtusirostris oxyrhynchus* (Steindachner,1882)	Salmonidae	12 (21,81%)	8	4	**CR**	**EN**
Lake trout	*Salmo trutta m. lacustris* (Linnnaeus, 1758)	Salmonidae	5 (9,090%)	4	1	**LC**	**LC**
TOTAL			55 (100%)	36 65,54%	19 34,54%		

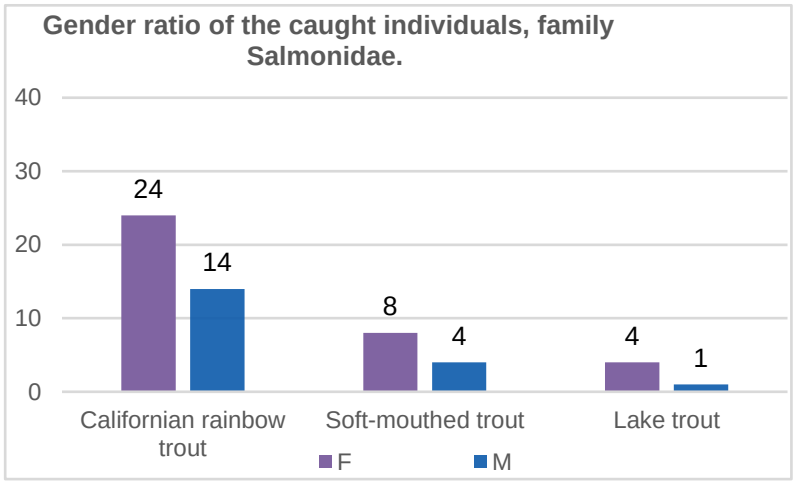
Table 2. Current state of the ichthyiopopulation in the Mostar Lake, family Cyprinidae

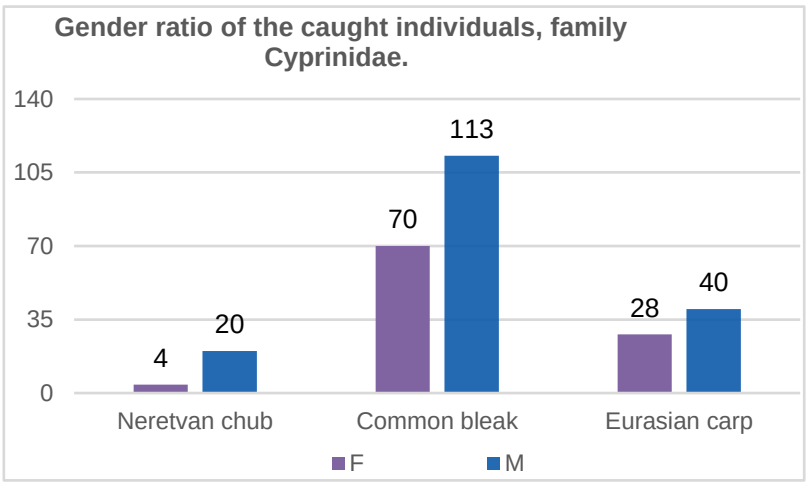
NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		NATIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Neretvan chub	*Leuciscus svallize* (Heckel et Kner, 1852)	Cyprinidae	24 (8,72%)	4	20	**VU**	**VU**
Common Bleak	*Alburnus alburnus alborella* (De Filippi, 1844)	Cyprinidae	183 (67,27%)	70	113	**LC**	**LC**
Eurasian carp	*Cyprinus carpio (Linnaeus, 1758)*	Cyprinidae	68 (24,72%)	28	40	**LC**	**VU**
TOTAL			275 (100%)	102 37,09%	173 62,9 %		

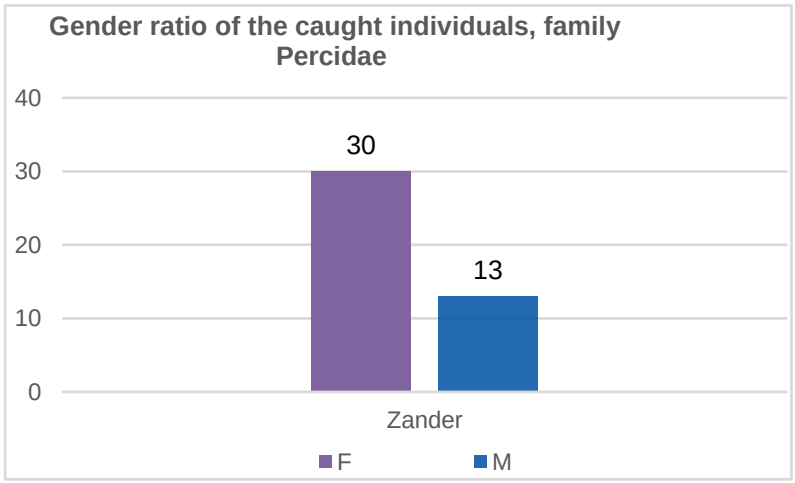
Table 3. Current state of the ichthyiopopulation in the Mostar Lake, family Percidae

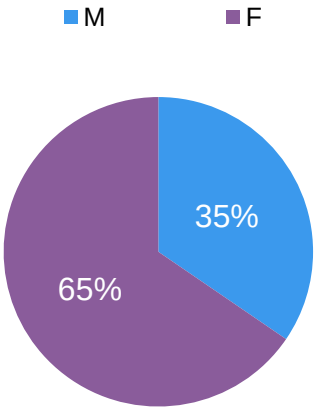
NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		NATIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Zander	*Sander lucioperca; syn. Stizostedion lucioperca* (Linnaeus, 1758)	Percidae	43 (100%)	30	13	**LC**	**LC**
TOTAL			43 (100%)	30 69,76%	13 30,23%		

GENDER RATIO

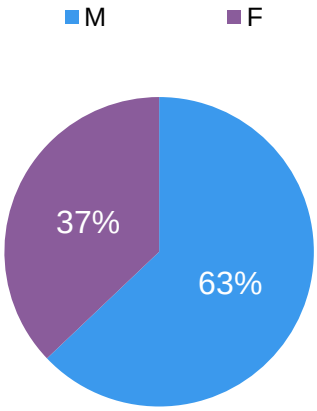




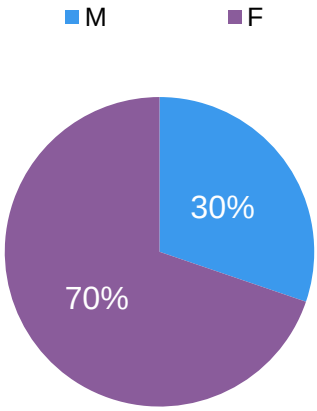




Gender ratio of the caught individuals, family Salmonidae.



Gender ratio of the caught individuals, family Cyprinidae.



Gender ratio of the caught individuals, family Percidae.

NERETVA RIVER

1. Introduction

The Neretva River is the largest river of the Adriatic basin in Bosnia and Herzegovina and in the Western Balkans. The Neretva is the longest (215 km) and richest river in the Dinaric karst (Slišković, 2014). The first 193 km are within Bosnia and Herzegovina, and the last 22 km within the Republic of Croatia (Štambuk-Giljanović, 2006). The Neretva River springs southeast of the Zelengora mountain. It arises from four permanent and one occasional spring at altitudes between 1340 and 1200 m. The main stream is formed by merging small streams of springs about one kilometer downstream (Mrđen et al., 2016).

The main features of the Neretva River basin are a large area, a highly heterogeneous basin, a large number of tributaries and altered natural hydrogeographic state caused by the construction of numerous hydropower plants (HPP Jablanica, HPP Rama, HPP Grabovica, HPP Salakovac and HPP Mostar). The construction of these structures and the formation of reservoirs completely changed the river ecosystem. The regime of operation of hydropower plants in the middle course of the Neretva causes a significant decrease in the water level during summer, which results in negative changes in aquatic habitats. The left tributaries are: Ljuta, Rakitnica, Tresanica, Kraljuščica, Neretvica, Rama, Doljanka, Grabovka, Drezanka, Radobolja, Jasenica, Trebizat, and the right are Ladjanica, Krupac, Bijela, Idbar, Glogovka, Buna, Bregava and Krupa.

Both the upper and lower course of the Neretva River abound in significant number of strong karstic springs within the riverbed and in tributaries of its tributaries. Karstic springs are fed with water from karstic fields rich in underground waters. Some of the important karstic springs along the Neretva riverbed are: Veliki and Mali Praporac, Mliječnik, Komadinovo Vrelo, Crno Vrelo, Salakovačka vrela, Studenac, Crno Oko, Arapi Vrilo and others (Slišković, 2014).

The lower course is under strong anthropogenic influence. Numerous hydroelectric power plants have been built and on the tributaries of the Neretva River: HPP Čapljina (Krupa), HPP Peć Mlini (Trebižat), HPP Mostarsko blato (Lištica and Jasenica), mHPP Bregava. The rivers Lištica and Jasenica flow from Mostarsko Blato, Buna is fed by river Zalomka from Nevesinje field, Bregava drains water from Dabar and Fatnica fields, and Trebižat drains water from Imotski and Drinovac fields. The Krupa River brings water to the Neretva from Hutovo Blato, more precisely Deran and Svitav Lakes (Mrđen et al., 2016).

The average flow at the mouth of the Rama River is 75 m^3 / s, in Konjic 63 m^3 / s, in Žitomislići 240 m^3 / s, and at the mouth of the river itself 380 m^3 / s (Slišković, 2014). The entire hydrographic basin of the Neretva River is estimated at 12,000 km^2 of surface area (Štambuk-Giljanović, 1998, 2006). The average temperature of the Neretva River is 12.8ºC (Bonacci, 1987). Increased salinity in Metković is a major problem in the summer months because water is used to irrigate crops (Štambuk-Giljanović, 1998).

1.1. Biodiversity of the Neretva River

The Neretva River as part of the Adriatic basin is a very important source of biodiversity and has a socio-economic role in electricity generation, water supply and agriculture. It is also one of the largest rivers in the Balkans and supplies various cultures, industries and nature reserves. Together with its tributaries, it provides Bosnia and Herzegovina with 40% of

running water and is of great importance for Croatia and Montenegro. The IUCN (International Union for Conservation of Nature) rated the Neretva River as one of the rivers with the largest number of endemic fish species in the entire Mediterranean.

Its ichthyofauna is very diverse, containing a fairly large number of indigenous and endemic species. Endemic species of this river belong to 4 families: Cyprinidae, Cobitidae, Salmonidae, Gobiidae (Akrap, 2016). Endemic fish species in the Cyprindae family include 3 important fish species: Strugač (Leuciscus svallize) (Heckel & Kner, 1858), *Squalius microlepis* (Heckel, 1843) and *Scardinus plotizza* (Heckel & Kner, 1858). These species are insufficiently researched and it is necessary to invest more effort in their research, with a view of preserving biodiversity. One very important part of the research is related to measuring and monitoring the length and weight of individuals of these species from which the growth, condition and age structure of fish are calculated. The inventories of fish in the Neretva River listed a total of 93 fish species; 50 of which inhabit fresh waters of the upper and middle course exclusively, and 43 species which also inhabit brackish habitats of the lower course and its wider estuary, some of which reach the confluence of the Krupa River with the Neretva and Hutovo Blato wetland (Glamuzina et al., 2013).

Due to its natural features, among which fish occupy a special place, the area of the Hutovo Blato wetland is one of the most important parts of the Neretva River. During their research, Tutman et al., (2012) recorded 25 species of fish, and with the inclusion of data from published literature, this number grows to 43, distributed in 36 genera and 19 families. Indigenous species make up more than half of the recorded number (63%), among which 15 are endemic with a very narrow range, while 15 species are allochthonous. The ichthyofauna of Hutovo Blato is also represented by a number of marine fish species that temporarily reside there. The current status of the fish fauna of the Hutovo Blato wetland and the wider area can be marked as endangered. Effective habitat protection, together with improved water management and measures to prevent the spread of alien species are particularly important to protect the high ichthyofauna value of this wetland (Tutman et al., 2012).

2. Climatic characteristics of the Neretva River

According to Köppen's classification of climate, a moderately warm rainy climate (C) is present in the lower reaches of the Neretva River. The Csa subtype or Mediterranean climate with dry and hot summers covers the part from the mouth of the Neretva River to Čapljina and the lower course of the Trebižat River. In the rest of the Neretva River basin, Cfa, i.e. moderately warm humid climate with hot summers, is present (Mrđen et al., 2016). The main climatic factors in the lower Neretva River are the proximity of the Adriatic Sea, the direction of mountain ranges, altitude and the constant change of air masses originating from the Atlantic Ocean, the Mediterranean Sea and the European mainland. The area is strongly influenced by the Mediterranean through the Neretva River valley. This influence weakens with distance from the delta and with increasing altitude. The average annual temperature is 15ºC. Annual rainfall ranges from 1000 and 1500 mm, throughout the year, with the lowest amounts in July and August and highest in the spring and autumn months (Mrđen et al., 2016). Relative humidity varies during the year (60 - 69%). In karstic fields there are frequent winds that increase evaporation and lower the temperature.

The lower course of the Neretva River basin is located in the so-called The Adriatic geomorphological belt, which abounds in numerous smaller karst fields (Slišković, 2014). Karst is a morphologically specific area built of limestone and dolomite permeable base with

a developed aboveground and underground hydrological network, resulting in a complex drainage system. One of the main features of karst hydrography is a richer underground water network than the above-ground one (Štambuk-Giljanović, 1998). Karst has been insufficiently researched globally, although the first theories on the circulation of water in karst were developed based on the experience and knowledge of the Dinaric Karst (Bonacci, 1987). Karst is a special ecosystem that is rich in numerous and very often endemic, rare and endangered species (Bonacci, 2003).

3. Ichthyofauna of the Neretva River

The course of the Neretva River and its tributaries is rich in fish families: Cobitidae, Cottidae, Gasterosteidae, Mugilidae, Clupeidae, Anguillidae, Salmonidae and Cyprinidae. Cyprinids and salmonids dominate, to which the largest number of endemic and autochthonous species of the Adriatic basin also belong. Most of them are endangered, many are critical. We have already lost some of the important populations of these Neretva species in certain areas of the river flow. It is estimated that up to 50% of the population could disappear with the construction of small hydropower plants (Riđanović et al., 2015).

The Neretva soft-mouthed trout *(Salmothymus obtusirostris oxyrhynchus)* is an endemic species of the Neretva River and its tributaries. It is distinguished by a special shape of the head with an elongated snout and accentuated bones around the eyes. Only a small number of nonprominent teeth can be seen on the specifically rounded lower and elongated upper lip. Its body is olive with tiny scales of golden sheen and is adorned with a combination of thick dark and sparse red dots ranging from gills to pigmented dorsal fins.

It feeds primarily on gamarus, a small benthic shrimp. As this reddish macroinvertebrate feeds on aquatic plants rich in beta-carotene, the result is soft, high-quality fish meat of a specific orange color, which is often compared to salmon. It spawns in the spring, from the end of February to the beginning of May when it swims upstream to find an optimal spot for spawning. Construction of reservoirs in the second half of the 20th century resulted in a drastic loss of this species in most of the Neretva basin, especially the upper catchments, where in some rivers, e.g. the Rama River, it practically disappeared completely. It used to make up over 90% of all salmonids downstream, specifically in the Buna River. It has been an endangered species on the IUCN Red List since 1996. The constant decline in population numbers is caused by uncontrolled hunting and hybridization with river trout and other stocked allochthonous species. In many lakes, soft-mouthed trout is considered extinct today (Spasojević, 2012).

Marble trout (*Salmo marmoratus*) is the largest salmonid fish species in the Adriatic basin, and the second largest salmonid species in Europe. Some specimens fished in the Neretva were up to 30 kg in weight. The natural range extends from the southwestern Alps, across the western Balkan Peninsula to the southeast and Albania. It is present in the Alpine tributaries of the Po River in Italy, the Sochi River in Slovenia, the Neretva River in Bosnia and Herzegovina, the Zeta and Moraca Rivers in Montenegro, as well as in some rivers in Albania. It spawns from the end of autumn to the beginning of winter, ie. from November to January, and sexually matures in the sixth year when it reaches a length of up to 70 cm. It is predatory and feeds on other fish.
Near Konjic there is a place Glavaticevo, named, it is believed, precisely because of the large presence of marble trout in this area (*bos. common name – glavatica*). By erecting high dams and disrupting river flows, its natural migrations have been prevented, so it is no longer present at all in Glavaticevo, as well as in most of its former spawning grounds. As

an endemic species, it has been on the IUCN Red List since 1996 and new data are needed. It is believed that the expansion of hydropower plants along the Neretva River could halve the existing population of marble trout (Spasojević, 2012).

Trout (*Salmo trutta m. fario*) is autochthonous for the Neretva River area and its tributaries. Its body is recognizable by evenly scattered small red and black dots, while the color changes depending on habitat conditions. The extremely aerodynamic body is an adaptation to fast and strong watercourses in which it prefers to swim. Its growth also depends on ecological conditions, especially the quantity and quality of food, so with limited quantities in mountain streams it reaches up to 1 kg in weight, and in larger rivers up to 6 kg. It feeds on riverbed fauna, insect larvae, shrimp, earthworms, and even smaller fish. It spawns from November to January and then also migrates upstream where it prefers gravelly shallow spaces. It is endangered by hybridization caused by uncontrolled restocking with genetically allochthonous species (of the Atlantic and Danube basins). It is interesting to mention that, apart from the morphological difference from the autochthonous Adriatic, the allochthonous Atlantic subspecies of trout once stocked in the Neretva during spawning goes downstream to the Adriatic Sea and never returns (Spasojević, 2012).

Among the allochthonous species of salmonids that reached Neretva and its tributaries by restocking (or fleeing from fish farms), the California trout (*Onchorhynchus mykiss*) and the grayling (*Thymallus thymallus*) stand out. As a rule, non-native varieties are more resistant to temperature disadvantages and lack of oxygen concentration in water, and they are often predators and a competition for endemics. It should be noted that Neretva fish farms almost regularly favor allochthonous varieties during restocking operations, which are expected to benefit more economically.

Another large fish family of the Neretva River and its tributaries are the Cyprinidae. After disappearance of a large number of salmonid populations in the upper course of Neretva and accumulation lakes, they have become the most abundant. There are six species of Neretva cyprinids that stand out as autochthonous and endemic, and most are endangered (Spasojević, 2012).

Spotted minnow (*Delminichtyes adspersus*) is an autochthonous and endemic species of the Adriatic basin. Especially recorded in the rivers Tihaljina and Trebižat. This very characteristic and rare species otherwise inhabits karst aquatic habitats and even wetlands with appropriate temperatures. During unfavorable arid conditions, it often migrates underground and spends parts of the year there. The IUCN Red List considers it vulnerable (VU). The population is decreasing and is on its way to becoming critically endangered. It is described as a sporadic species, of unknown population trend and density. However, it is known that it is endangered by the destruction of karst habitats, overexploitation and reduction of the quality of waters in which it lives, especially by harmful chemicals from agriculture. Due to its extremely tasty meat, it is overexploited. From the conservation aspect, it needs safe spaces and restrictions on partitioning of its watercourses, as well as a ban on introduction of non-native species that compete with it (Spasojević, 2012).

The Neretvan nase (*Chondrostoma knerii)* is an autochthonous and endemic species of the lower Neretva basin that inhabits Buna, Bunica, Bregava and Hutovo blato. It swims in slower streams and lakes rich in oxygen. It spends part of the year in underground streams and spawns in the shallows. It is primarily threatened by dams, but also by degradation of its natural habitats and generally increasing pollution of the lower Neretva basin. The good news is that its spawn was recently spotted in the Buna River, i.e. more precisely locality of

Kosor. The number of subspecies is otherwise extremely reduced. It is on the FBiH Red List and has the status of an endangered species (EN), while on the IUCN Red List it is listed as vulnerable (VU). In the Buna area, there were once thousands of individuals during spawning, while today it is practically non-existent in Hutovo blato, where it was also numerous. Due to the quality and taste of meat, it is highly valued, so the losses can be mostly attributed to excessive hunting (Spasojević, 2012).

The roach (*Rutilus basak*) is an endemic and indigenous species of the Adriatic basin. It is carp-like in shape and scales. It mostly inhabits lakes and moderately slow streams, and the lower courses of the Neretva, Buna, Bunica, Tihaljina, Trebizat, Trebisnjica and Bregava. It is most numerous in Hutovo blato. Apart from BiH, it is also found in Croatia. It gathers in flocks and although, unlike other cyprinids, it is relatively numerous, due to its local economic importance in some parts of the stream, it is unfortunately overfished, mostly during spawning when instinct leads it to source zones. Therefore, it has the status of a critically endangered species (CR) on the National Red List in Bosnia and Herzegovina, while on the IUCN Red List it is LC. It is gratifying that it was recently spotted again in Bunica.

Neretva chub (*Leuciscus svallize)* is another indigenous species in the Neretva catchment area. It is characterized by a slender body, and the head and forehead are rather narrow and rounded. In the literature we can find data that this subspecies inhabits (along the Neretva and its tributaries) the accumulation lakes of Herzegovina: Bilećko, Jablaničko, Ramsko, etc., in which it has adapted extremely well to the ecological conditions of "new" ecosystems. It inhabits karst waters, mostly in larger flocks. It lays its eggs on a rocky base. It lives in the waters of Zrmanja, Krka, Neretva and Trebišnjica. This species is present in river Neretva and it is endemic species. Fishermen know it as a very combative catch. It has been on the IUCN Red List since 1996 and has the status of a sensitive species (VU) and needs more research attention.

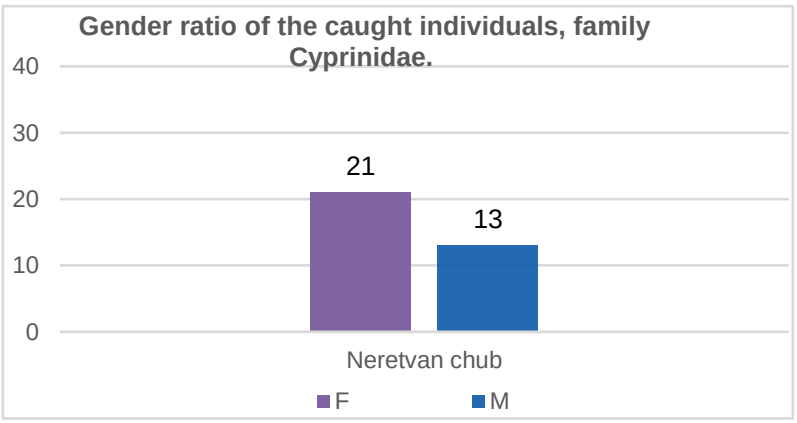
Sandpiper (*Scardinius plotizza*) is a well-known fish to Mostar fishermen, but also to those in Dalmatia. It is an autochthonous and endemic species of the lower Neretva basin. It lives in Hutovo blato, Svitavsko lake and the river Krupa. It swims in slower streams and stagnant waters of rich tributaries. It also swims towards the shallow and calm streams of the Neretva delta, where it enters the brackish water zone. It is generally an under-researched species and the available data are sparse and old. Its age, spawning period are unknown and the influence of abiotic factors on its mobility has not been determined. It is hunted mainly for sports, which is why it is assumed that it is not endangered like the other listed species, but supervision is necessary.

Table 1. Current state of the ichthyopopulation in the river Neretva, family Salmonidae

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		NATIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Trout	*Salmo trutta. m. fario* (Linnaeus,1758)	Salmonidae	27 (22,13%)	14 (11,47%)	13 (10,65%)	**CR**	**LC**
Marble trout	*Salmo marmoratus* (Cuvier, 1817)	*Salmonidae*	13 (10,65%)	9 (7,37%)	4 (3,27%)	**CR**	**LC**
Soft-mouthed trout	*Salmothymus obtusirostris oxyrhynchus* (Steindachner,1882)	Salmonidae	69 (56,55%)	32 (26,22%)	37 (30,32%)	**CR**	**EN**
Californian rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)	Salmonidae	13 (10,65%)	5 (4,09%)	8 (6,55%)	**LC**	**NE**
TOTAL			**122 (100%)**	**60 (49,18%)**	**62 (50,81%)**		

Table 2. Current state of the ichthyopopulation in the river Neretva, family Cyprinidae

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		NATIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Neretva chub	*Leuciscus svallize* (Heckel et Kner, 1852)	*Cyprinidae*	34 (100%)	21 (61,76%)	13 (38,23%)	**LC**	**VU**
TOTAL			**3 4 (100%**	**21 (61,76%)**	**13 (38,23%)**		



With reduction of biodiversity, extinction of river organisms and the disappearance of birds from coastal areas, loss of vegetation, deterioration of riverbeds and erosion of the river delta, and disruption in this case of the wetland protected area Hutovo blato - the most significant negative consequence of hydropower plants on the Neretva is a significant change in ichthyopopulation structure.

Redirection of river courses in certain places alone produce drastic disruptions to the vital functions of the entire river ecosystem. Artificial oscillations of water destroy the natural flow, which is a basic condition for the reproduction of many species. Disturbed water flow velocity complicates the migration and orientation of fish, and consequently their fertility decreases. Neretva's salmonids are specifically affected by high water levels during the spawning period. Shallow spawning grounds exposed to high water levels result in high mortality of newly hatched fish. Reducing water flow also results in the accumulation of waste sludge at

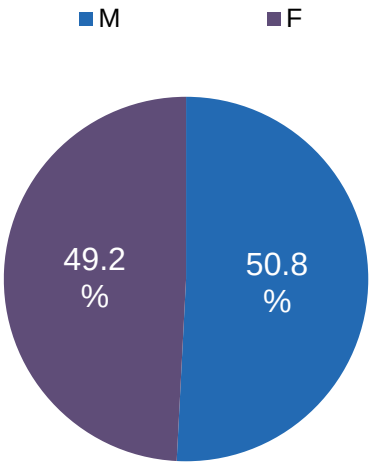


Figure 1. Gender ratio of the caught individuals, family Salmonidae.

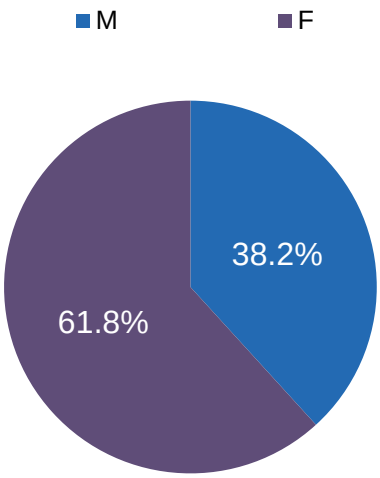
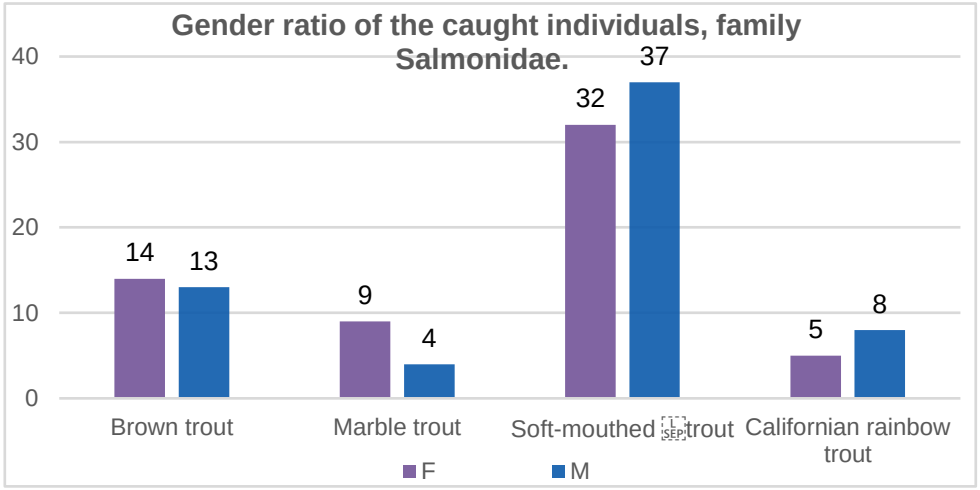


Figure 2. Gender ratio of the caught individuals, family Cyprinidae.



the bottom of the riverbed, i.e. the backfilling of habitats and hatcheries with harmful substances such as heavy metals and similar pollutants.

The fragmentation of the river habitat further destroys the genetic diversity of populations, so the inbreeding of related populations increases the risk of their extinction. In the populations of certain species, there is an accumulation of deadly mutations that can consequently reduce their size and survival. It is assumed that in Neretva some isolated populations of Neretvan humpback and soft-mouthed trout were previously extinct due to the process of mutational melting, i.e. an irreversible series of deadly mutations adopted after changes in the environment. Even the slightest disturbance of the values of physicochemical parameters can disrupt the homeostasis of ecosystems and cause these distortions.

By changing the speed of water flow and water level oscillations, the water temperature is also disturbed, to which indigenous and endemic species are most sensitive. Damage is also caused by the consequences of reduced oxygen concentration dissolved in water, as well as oxygen supersaturation caused by sedimentary faecal water. Oxygen saturation at equilibrium is at 100% (actual concentration relative to the oxygen balance in water at a given temperature). While previous research already shows a supersaturation of 130% in certain areas in the summer, it is assumed that the operation of hydropower plants could increase saturation by up to 500%, which would cause serious physical damage to fish. Changes in temperature, chemical composition, oxygen concentration, on the other hand, favor both competitive and invasive species. The operation of the hydropower plant also prevents the inflow of nutrients and sediments necessary for the natural enrichment of the ecosystem. Lack of natural sediment consequently leads to erosion of downstream banks and riverbeds which destroys the coast and vegetation and ultimately causes soil erosion, and the damage can extend all the way to the estuary. This further deepening of the riverbed would continue to reduce the amount of water available, and changes to the riverbed would destroy fish that spawns at the bottom. Tufa shores are especially important shelters and food sources. Their downfall would have drastic consequences for fish life. In addition, the middle reaches of the Neretva have a large source of pollution in wastewater that is self-purifying downstream. Raising dams would make this process impossible.

The mechanical operation of turbines on machines can injure and kill fish. Construction of the so-called fish paths that would be adequate are too complex a task, because it is necessary to know well the behavior of all local fish species, and in addition, fish paths are even less useful to other species in the river ecosystem. With the cumulative effect, research points out, the total number of machines of small hydropower plants could exceeded even the consequences of large dams.

Expert analyses call for a detailed study to assess the state of populations in the Neretva and its tributaries, and visible biomonitoring of sites suitable for fish nurseries, with the necessary regular analysis of water quality and other environmental parameters. It is necessary to supplement the existing data on the state of flora and fauna and enable more accurate assessments of possible negative impacts of the construction of small hydropower plants on the river ecosystem, especially on indigenous and endemic species.

RADOBOLJA RIVER

1. Natural characteristics of the Mostar municipality

Herzegovina is located in the south of Bosnia and Herzegovina. It stretches from the southern Adriatic coast to the highest peaks of the Dinaric Mountains in the interior the country. Its surface total area is close 10,000 km^2. It consists of two micro regions: higher (upper or mountainous) and lower (coastal or Adriatic) Herzegovina. Higher Herzegovina includes the areas of the upper and middle Neretva basins, a certain part of the Dinaric region, the mountains Velež, Volujak, Prenj, Čvrsnica and Crvanj, as well as Gatačko and Nevesinje karst fields. Low or Adriatic Herzegovina covers the lower course of the river Neretva and the basins of rivers Bregava and Trebižat. Herzegovina includes Popovo polje, Mostar field and valley, as well as Trebinje field.

In the municipality of Mostar, we notice that karstic and fluvial processes have shaped the karst and formed unique landforms. Mountains in the municipality of Mostar were formed in the Alpine orogenic phase in the late Mesozoic and Cenozoic about 250 million years BC. The area is characterised by terrains of different altitudes. The highest elevation in the municipality is 2102 meters while the lowest is 12 meters. Areas with the lowest altitudes are located along the Neretva and its tributaries. These are areas mainly in the central part, with longitudinal stretch to the south. Areas with the highest altitudes are located in the western, northwestern and eastern parts of the municipality.

The climate of Herzegovina depends on the configuration of the terrain. The climate is also affected by a gradual decline towards the Adriatic coast and river flows that allow the penetration of the Mediterranean-Adriatic climate in the interior. It is very important to point out that the climate of Herzegovina is affected by mountain massifs which change the characteristics of the Mediterranean climate, and towards the north it gradually changes to continental. In coastal Herzegovina, the climate is Mediterranean, characterized by low humidity, low clouds, more hours of sunshine, increased air currents, rains in winter, as well as long and warm summers. High Herzegovinian mountains have a sub-mountainous climate, while in the valley of the middle and upper course of the Neretva there is a significant Mediterranean influence. Mountainous Herzegovina receives about 1800 mm of precipitation.

Mostar has a temperate submediterranean climate with mild but cold winters (with little or no snow) and very hot summers, when temperatures in the shade can be up to 45°C. The highest temperature ever recorded in Mostar was measured on July 31, 1901, and it was 46.2°C. Despite that, Mostar still has a pleasant climate suitable for growing different types of fruit and vegetables. Autumn and spring can be extremely rainy.

From the hydrological aspect, Herzegovina is a very specific area. The limestone topography brought forth various phenomena of surface and underground hydrography. The area of Herzegovina abounds in large numbers of karstic springs, waterfalls, sinkholes and estavela. The main inland watercourse is the river Neretva. The rivers in Herzegovina belong to the Adriatic basin.

The Municipality of Mostar occupies areas of different altitudes, which is a very important condition for the vegetation diversity. Vegetation alternates with an increase in altitude. Deciduous forests dominate at lower altitudes, and coniferous vegetation is present at higher altitudes. With increasing altitude the climate is also changing. In the municipality of Mostar

we can see three levels of vegetation. The first belt (up to 500 meters above sea level) is rich in forests of sessile, pedunculate, common hornbeam. Other belts make up areas from 500 to 1500 meters above sea level and consists of deciduous and coniferous forests and the third the belt is over 1500 meters above sea level and consists of coniferous forests.

2. Radobolja River in Mostar

Radobolja is a river in Mostar. It is a 5 kilometers long tributary of the river Neretva. The river springs below the hill Mikuljača, on the edge of the Mostar valley. The spring is filled from the karst area of the southeastern part of the Čabulja mountain. Waters flow through limestone aquifers along two diagonal faults of the Dinaric direction of extension. It flows through Mostar and flows into the Neretva near the Old Bridge. Radobolja is a river with a short and slow flow, a small drop and low mechanical strength. The water depth ranges 50-80 cm. During more intense precipitation in some places it reaches a maximum depth of 1 m. Autumn and spring have a higher inflow of precipitation, thus, the water level of the river Radobolja are at its peak.

Water from Radobolja is used for irrigation, but also supplies drinking water to the western and part of the eastern suburbs of Mostar. In the past it was used for operation of numerous mills along the river, pillars and irrigation carts and watered gardens. It used to be a favorite destination for rowers and swimmers. After construction work throughout the riverbed, it lost its vortices. Now Radobolja is heavily polluted due to various influences: incompetent urban planners, illegal construction, faecal discharge, etc. The river Radobolja is an obvious example of endangered and destroyed water ecosystem. The City of Mostar has antique wastewater drainagesystem, where all faecal waters, through the sewage collector, are discharged directly into riverbeds. Collectors for treatment of wastewaters have been recently built, but are still not in operation.

A significant contribution to the research and assessment of the quality of the Neretva and Radobolja rivers was made by Lejla Riđanović (2012, 2017). According to research conducted at five selected sites and based on the values of bacteriological indicators: total number of bacteria, total coliforms, fecal coliforms, fecal *enterococci (streptococci*) and *Clostridium spp.* the load of Radobolja's watercourse with fecal wastewater is evident. The highest recorded values are 3500 cfu / 100 ml of coliform bacteria. From an environmental point of view, the river Radobolja is not in good condition. Analysis of water samples performed as part of scientific research showed high values of nitrogen compounds (ammonia, nitrites and nitrates) and high bacteriological load of organisms of faecal origin. These findings, supported by extremely high numbers total coliforms and the total number of aerobic mesophilic bacteria indicate the presence fecal pollution and sewage into the Radobolja River.

While the water near the Radobolja spring can be classified as a class I water, in the upper course of the river a sudden degradation of quality is noticeable, which progressively decreases on the way to the estuary. Discharge of municipal wastewater into the river Radobolja affects the entire living world of this river. Increasing turbidity of water due to intensive soil erosion and destruction of the riparian vegetation amplifies the intensity of problems facing the Radobolja River in Mostar. Radobolja riverbed is littered with various waste materials that accumulate and pose a great danger to many plants and animal species. An important factor that affects the flow of the river Radobolja as well as water quality is a change in direction and speed of flow, as well as changes in structure bottoms due to the exploitation of gravel and sand.

In the past, the river Radobolja was a very clean river with lush vegetation and species that have adapted to these living conditions. Due to the great pollution, there has been a significant decline in plant and animal populations. In the riparian area there are a number of invasive plant species, such as chicory (*Helianthus cicoka*) and ragweed (*Ambrosia artemisiifolia*), one of the strongest known allergens.

Due to the increasing pollution of this river, many species that existed in it have now been eradicated. The animal world of the river Radobolja consisted of three fish species: trout - *Salmo trutta m. fario* (Linnaeus, 1758), three-spined stickleback - *Gasterosteus aculeatus* (Linnaeus, 1758), eel - *Anguilla anguilla* (Linnaeus, 1758), as well as crustacean *Austropotamobius pallipes,* a species that is a bioindicator of water quality and purity, amphibians *Bombina variegata*, brown frog (*Pelophylax ridibundus*) and aquatic insect from the family Plecoptera *Perla marginata.*

Currently, the quality of water significantly drops from the spring to the estuary. During summer months at the large portion of the watercourse, the flow is reduced to a trickle.There are high levels of fecal bacteria that come from sewage wastewaters that led to pollution of the river Radobolja, which is particularly evident at the estuary. Plant and animal populations have been disturbed, water pollution has led to extermination of many species. Riparian biocenosis is modified, due to construction of facilities along watercourses. During our research, only *Salmo trutta m. fario* was recorded in Radobolja.

Table 1. Current state of the ichthyopopulation in the river Radobolja

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		NATIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
				F	M		
Trout	*Salmo trutta. m. fario* (Linnaeus,1758)	Salmonidae	28 (100%)	12	16	**CR**	**LC**

BUNA RIVER

1. Introduction

In freshwater ecosystems, the living communities exist in specific conditions that are exclusively related to water. The aquatic communities are inextricably linked to environmental conditions that prevail in it, namely: water flow, temperature, substrate, light, precipitation, etc. Temperature is one of the most important indicators for studying the speed of life processes in running waters. Higher temperature speeds up life processes, animals breathe faster and become more sensitive. Temperature also affects physical properties of the water. Physico-chemical characteristics of freshwaters are of great importance for the growth of aquatic communities and have a great impact on quality and useability of water in households. Variation of these parameters directly affects living conditions for aquatic communities, which has broad ecological implications.

The Buna River is one of the rarest natural phenomena in Herzegovina. It springs in the village of Blagaj, located in the vicinity of Mostar. The riverbed is usually covered with gravel, while in some parts it is rocky. The average range of the Buna riverbed is 35 m. The area around the source of Buna (Vrelo Bune) is built of Cretaceous limestone, and represents one of the oldest limestone deposits in this area (Gelenčir, 1991). The river Buna is 9 m long in total, from the source to delta in the Neretva River. The Buna spring area is characterized by the abundant flora and fauna. Due to its natural and cultural values, it is protected as a hydrological nature reserve in Bosnia and Herzegovina, with the aim of enabling condition for protection and proper use of bioresources, as well as special landscapes, cultural and historical sites. The Buna spring is also protected by a decree of the Regional Institute for the Protection of Cultural Monuments in Mostar. The Commission for Preservation of National Monuments of Bosnia and Herzegovina nominated Blagaj for the UNESCO's World Heritage List in Europe (Čaldarović, 2007).

The coastal zone, due to the illegal construction of houses, cottages and restaurants has been greatly altered and modified. This significantly contributes to reduction in diversity of habitats in Buna, which has a direct negative impact on the number of species in certain communities in this area.

2. Buna River - importance for living communities

Denis Bohm from Mostar, who lives in Great Britain, surveyed the area of Blagaj and Vrelo Bune, and according to his data, there were about 174 species of birds in this area. The most significant site is certainly the Green Cave, located on the cliffs above the spring (Hadžijahić, 1990). In the area of Blagaj, there is a large number of different plant species that belong to different taxonomic categories. However, today the vegetation in this area is endangered by anthropogenic factors. Most anthropogenic factors lead to extinction of species. It is also important to mention Griffon Vulture *Gyps fulvus* (Treer, 2001). The first data on Griffon Vulture in Herzegovina date from 1885. This bird is an indigenous species in this area. There used to be a large population of them above Blagaj and in other rugged areas of Herzegovina.

2.1. Climate of the Buna River

The climate in this area is Mediterranean, with long and warm summers and short and mild winters. The average temperature in the year is 16 °C. Summer temperatures are around 26 °C and 28 °C, and winter around 7.5 °C. The average annual rainfall is 1349 mm, with large fluctuations. The number of sunny days a year is variable, but it can reach up to 300. Such favorable conditions have created a habitat for birds, where 174 species from the bird world live in the Blagaj area during the year. Summer rains are mostly short-lived (Hasandedić, 1997). The water temperature in Buna hardly ever reaches 18°C. The climate of Herzegovina is generally influenced by the proximity of the Adriatic Sea, relief and altitude (Hasandedić, 1997).

3. Ichtyofauna of the river Buna

River Buna is famous for endemic species in this area. The Buna River has been marked as the most important spawning ground for soft-mouth trout, so it is necessary to preserve it in the future. The family *Salmonidae* belongs to the order *Salmoniformes.* The order *Salmoniformes* consists of two suborders: *Osmerideae* and *Salmonideae.* Species of the suborder *Osmeroidae* are classified into six families and are distributed in the northern parts of the Atlantic and Pacific Oceans. They live in coastal zones, from where they enter rivers during spawning. Due to their economic and sporting value, they were also introduced into the waters of South America, New Zealand and Australia (Čaldarović, 2007).

All salmonid fish species live exclusively in cold, clear and unpolluted streams, rivers or fast-flowing rivers, which are rich in dissolved oxygen, or in mountain lakes where the water temperature is around 10°C and which does not exceed 18°C even in the warmest seasons. These are all rheophilic fish species which have spindle-shaped bodies, adapted to life in fast-flowing rivers (Safner, 2001). *Salmonidae* are distinct predators, they eat live food, so their stomach is adapted to the digestion of food of animal origin, it is wide and muscular (Aganović, 1979).

Cypriniformes are an order of fish from the class of *Actinopterygii*. This line contains 8 or more families, 354 genera and more than 3250 species, with new species described every few months and new genera recognized regularly. They are most diverse in Southeast Asia, but are completely absent from Australia and South America (Treer, 2001). Representatives of the family share the common feature, the presence of a Weberian apparatus and a pharynx. They are located on the lower pharynx in one, two or even three rows. Cyprinids swallow food by mouth, and grinding occurs in the throat (Treer, 2001). They are also characterized by a large swimming bladder and a specific digestive tract (Treer, 2001).

3.1. Soft-mouthed trout (*Salmothymus obtusirostris oxirhyncus*)

It is a unique fish species, due to its specific diet, behavior, and even appearance. It is recognizable by its red dots. In the last few years, there has been a sharp decline in the Buna River, and there are many reasons for that. One of the most important impacts is due a sharp rise in poaching, and excessive hunting (Safner, 2001). This fish is most similar to the *Salmo marmoratus* (Cuvier, 1829). It is also characterized by inhabiting clean, clear and oxygen-rich waters (Safner, 2001). Due to its specific appearance, the soft-mouthed trout is called a relic of the ancient earth's past, since it has a number of "primitive" features - pleistomorphs (short jaws, small mouth, short teeth and obligatory freshwater fish) (Saner, 2001).

Four subspecies of soft-tailed trout have been singled out:

- *Salmothymus obtusirostris oxyrhynchus* Steindachner, 1882
- *Salmothymus obtusirostris salonitana* Karaman 926
- *Salmothymus obtusirostris krkensis* Karaman, 1926
- *Salmothymus obtusirostris zetensis* Karaman, 1932

Common characteristics of soft trout subspecies are:

- golden glow of the body,
- small mouth with fleshy lips,
- short jaws,
- small teeth,
- the stomach has a large number of pyloric extensions (48 - 91)
- thick dark spots behind the gills all the way to the dorsal fin,
- sparsely distributed red dots that reach the end of the body,
- fins are not pigmented, except for dorsal fins - spring spawn (Treer, 2001).

3.2. Trout (*Salmo trutta morpha fario)*

Trout as an indigenous species is found in an area from Europe and Asia to North America. It is distributed from northern Norway to the northeastern part of Russia and south to the Atlas Mountains in North Africa. The main characteristic of trout is a spindle-shaped, elongated body. It is an excellent and fast swimmer. There are numerous black dots on the hull below and above the side line. They have large mouth in which the teeth are arranged in two rows. The upper jaw reaches to the back of the eye. There are 18 to 24 branchiospins on the first gill arch, and the number of pyloric extensions varies from 40 to 100. The diploid number of chromosomes is 84, with considerable variation in intraspecific forms (Safner, 2001).

Sexual dimorphism is pronounced during spawning. Females have a rounded belly and a red swollen genital opening. It spawns in late autumn and early winter, from December to January. It lays its eggs on a rocky bottom with a fast flow of water. The diameter of the egg is very large and ranges from 4.5 to 5 mm. The incubation period depends on the water temperature, from 60 to 90 days. The larvae hatched in January or February have a large yolk sac, which allows them to feed, but at the same time makes it difficult for them to move. The active life of larvae begins with the wear of the yolk sac on 1/3 of its size. At the beginning of autumn, when the young reach a length of about 10 cm, they move downstream into calmer waters in search of food. Sexual maturity occurs at two to three years of age. In the first year, the trout grows from 10 to 14 cm. During the early life, it is marked with a dozen of black vertical spots on the sides of the body. With further growth, these characteristics are lost (Safner, 2001). Trout feed on fish, larvae of aquatic insects, caviar, insects that fly over water and fall on its surface, shrimp and other invertebrates (Mičijević, 2004).

Trout inhabit cold waters in the upper reaches of rivers of temperate continental climate, although it is also found in lowland rivers of the boreal zone, and lakes with clean, cold water of the northern hemisphere. It is extremely adaptable to different habitat conditions, and adaptability is also reflected in different morphological forms, (Mičijević, 2004). There are three different forms of trout:

- Stream form - *Salmo trutta morpha fario*
- Lake form - *Salmo trutta morpha lacustris*
- Marine form - *Salmo trutta morpha trutta*

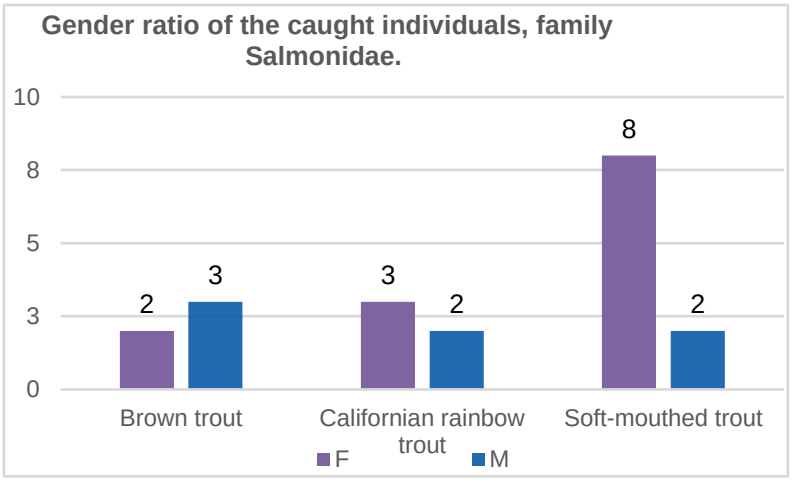
3.3. California trout (*Oncorhynchus mykiss*)

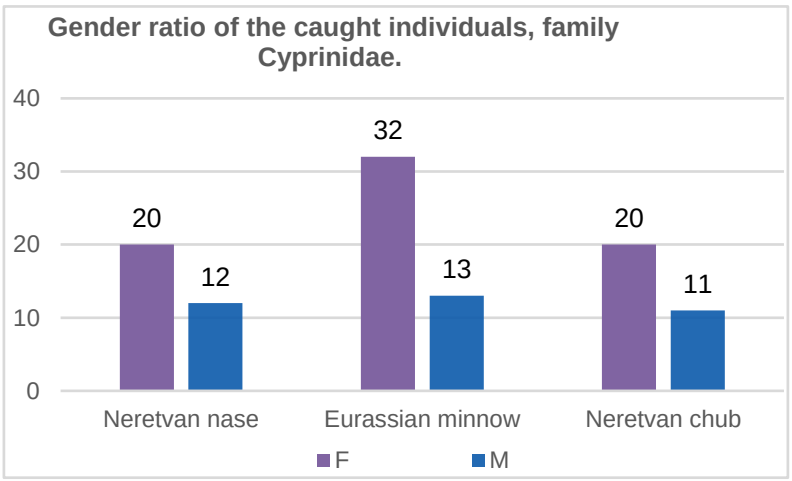
California trout originate from the west coast of North America. California trout is a very hardy and adaptable fish, so it has been successfully distributed all over the planet. It was imported to Europe at the end of the 19th century (Hršak, 2015). It tolerates far warmer waters and poorer in oxygen streams, and in addition it has a wider area of distribution. It is omnivorous and feeds on what salmonids do not normally ingest (Treer, 2001). It has a rainbow-colored stripe on its sides, which is why it is also called the rainbow trout. The back, fins and hips are marked with black spots. It does not have a strictly defined habitat, so it can live in stagnant waters, regardless of the type of bottom. It spawns in the upper reaches of rivers, at an optimal water temperature of 7°C, in March, depending on the temperature regime and other hydrological and environmental factors. The eggs are yellow-orange, 3.7-5.9 mm in diameter, and with the weight of the female of 1 kg, fertility is expressed with 3300 pieces of eggs. The female becomes sexually mature after the third year, and the male from the second year of life (Treer, 2001). Incubation of eggs, depending on water temperature, lasts from 35 to 50 days. Its growth rate is faster than river trout and it grows up to 10 kg. California trout over four years old weigh about 1 kg. In the first year of life, the California trout feeds on larvae and shrimps, and from the second year, its menu includes juveniles of other fish species. It is more voracious than brook trout and easier to catch (Safner, 2001). Buna is one of the cleanest rivers and is rich in fish. The fauna of the Blagaj area (given the specific habitat conditions and the new survival conditions of sensitive species such as soft-mouthed trout), will become endangered and must be protected in their habitat. According to the research, the current state of species in the Buna River is shown in Table 1. The Buna River is marked as the most important spawning ground for soft-mouthed trout, so it is necessary to preserve it in the future.

Table 1. Current state of the ichthyopopulation in the river Buna

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		REGIONAL IUCN CATEGORY	EUROPEAN IUCN CATEGORY
				F	M		
Trout	*Salmo trutta. M. Fario* (Linnaeus,1758)	Salmonidae	5 (3,9%)	2 (2,3%)	3 (6,9%)	CR	LC
Californian rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)	Salmonidae	5 (3,9%)	3 (3,5%)	2 (4,6%)	LC	NE
Soft-mouthed trout	*Salmothymus obtusirostris oxyrhynchus* (Steindachner,1882)	Salmonidae	10 (7,8%)	8 (9,4%)	2 (4,6%)	CR	EN
Neretvan nase	*Chondrostroma knerii* (Heckel, 1834)	Cyprinidae	32 (25%)	20 (23,5%)	12 (27,9%)	EN	VU
Eurasian minnow	*Phoxinus phoxinus* (Linnaeus, 1758)	Cyprinidae	45 (35,1%)	32 (37,6%)	13 (30,2%)	LC	LC
Neretvan chub	*Leuciscus svallize* (Heckel et Kner, 1852)	Cyprinidae	31 (24,2)	20 (23,5%)	11 (25,5%)	VU	VU
TOTAL			128 (100%)	85 (66,4%)	43 (33,5%)		

GENDER RATIO





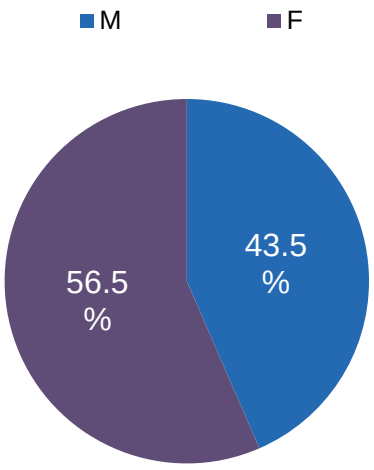


Figure X. Gender ratio of the caught individuals, family Salmonidae.

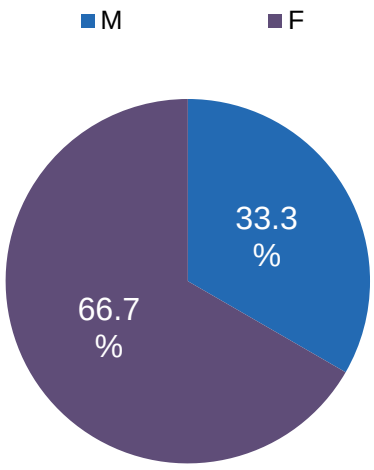


Figure X. Gender ratio of the caught individuals, family Cyprinidae.

BUNICA RIVER

1. Introduction

Biodiversity is the overall diversity of all living organisms that are integral parts of an ecosystem, and includes diversity within species, between species, living communities, and ecosystem diversity. Bosnia and Herzegovina is known for the specificity and diversity of the living world, the diversity of genes and ecosystems. Under the influence of numerous factors, a large number of different habitats developed, which led to a large species diversity. The total area of protected areas in Bosnia and Herzegovina is generally very low. It makes 2,2% of the total area, which is much lower than in the surrounding countries. Each protected area, depending on the categorization, has the opportunity to develop its own sustainable activities. Natural resources through conservation and education provide great opportunities for sustainable development.

The Blagaj area is characterized by a variety of surface and groundwater. The source of the river Buna is one of the largest and most beautiful springs in Europe. The Buna flows out of a cave below a 200-meter-high rock and creates a river that flows another 9 km to the west and flows into the Neretva near the village of Buna. The Bunica River is characterized by a high diversity of flora and fauna, with several species of endemic flora recorded. Bunica is a left tributary of the Buna. It is located 4 km from the center of Blagaj with its huge source about 40 meters in diameter and, with a course about 7 km long. The source of the river Bunica is characterized by a large lake, as well as surrounding vegetation. The climate is Mediterranean, with long and warm summers and short and mild winters. The average yearly temperature is 16°C. The area is rich in precipitation, but with irregular distribution. The number of sunny days can reach up to 300. The climate of Herzegovina is generally influenced by the proximity of the Adriatic Sea, terrain and altitude (Hasandedić, 1997). The presence of flora in this area is endangered due to anthropogenic impact, and this should be prevented because the river Bunica as well as its source is a habitat for many rare and endemic species. Heavy anthropogenic influence has all but obliterated majority of the Bunica River's watercourse and destruction of many natural habitats. Bunica is said to be a river, with a very healing effect due to high levels of iodine.

Aquatic ecosystems, in a broader sense, encompass all habitats, natural or man-made, in which water is a key environmental factor. Freshwater ecosystems can be distinguished either by their physical state (liquid, solid, gaseous), by their location (groundwater and surface water) or as liquid or standing water. Around 40% of known fish species (10,000 of the known 25,000 species) inhabit freshwaters. The number of fish species per unit volume of water is more than 5,000 times higher in freshwater than in saltwater (UN / WWAP, 2003; Millennium Ecosystem Assessment, 2005).

Although the Neretva River Basin covers only one fifth of the total area of Bosnia and Herzegovina, it is a home to more than one half of the total number of species and lower taxonomic units of flora in Bosnia and Herzegovina. There are about 4000 species and lower taxonomic units of flora in the whole of Bosnia and Herzegovina. The river basin of Herzegovina has approximately 170 endemic and relict species. Most endemic species are found in the middle and upper courses of the river basin. The largest number of species from the Red List of rare, endangered and endemic pecies in Bosnia and Herzegovina can be found in the Neretva river basin, in the middle and upper course of the stream (about 32% of species).

The problems of environmental pollution resulting from anthropogenic impacts are becoming more and more prominent, in developed countries as well as in developing countries. The only stretch of the river not affected by anthropogenic impacts is the Source of Bunica. The Bunica Recreation Center (estuary into Buna) used to record visits of up to 5,000 tourists a day. Due to human negligence, this site is now hardly used, despite its great potential for the development.

Unsystematic development of agriculture, unresolved ownership relations, usurpation of the swamp and its transformation into agricultural land, poaching, splitting of roads, water pollution, land salinization, disturbed water regime due to bad water management are some of the problems that directly threaten the natural values of this space and its future survival. Hydrotechnical interventions (construction of dams) in the upper courses of the Neretva influenced the change of water regime, which seriously disturbed the natural balance of the delta of this river. Significant qualitative reduction of certain animal groups, especially fish, has been documented (Glamuzina et al, 2013).

Data on physical and chemical variations show low nutrient concentrations, good aeration and generally oligotrophic conditions. According to the measured parameters, the water quality in the river Bunica is of high ecological status, which corresponds to the natural status without anthropogenic impact, especially in the upper course. It is very in diversity of flint algae or diatoms, the most diverse group of unicellular eukaryotic protists. They inhabit all types of aquatic habitats, as well as wet terrestrial habitats. They are responsible for approximately half of primary production and nearly a quarter of the world's carbon fixation. Diatoms are a good indicator of the quality of the environment and are often a major component of phytobenthos and phytoplankton in surface aquifers, an important element in aquatic ecosystems and one of the most important groups of algae for monitoring activities (Kelly et al., 1998). Diatomaceous environmental assessment conditions in rivers and streams have a long history and different approaches such as levels of pollution on one hand and biodiversity on the other. According to this, diatoms are used to assess environmental conditions in streams and rivers around the world.

According to the IPS, IDSE and IDG indices, the water quality at the Bunica site is I-II class (from high to good ecological status). Benthic groups of diatoms in the Bunica River were sampled at different seasons to assess the applicability of 17 diatoms indices used worldwide to assess water quality. According to the physical and chemical conditions, the waters of the river Bunica showed high oxygen saturation and water transparency, as well as low concentrations of nutrients and indicates the oligotrophic character of the river. Diatomaceous indices showed different results and indicated more variation among the localities on the Bunica River (Dedić et al, 2019).

2. Bunica as a protected natural monument

A natural monument is an individual source object or part of living or non-living nature (geomorphological phenomenon, mineralogical and peleontological sites, spring, sloap, lake, watercourse, river or locally marked example of flora, spatially small botanical or zoological locality), important in scientific and educational cultural or recreational view. In the area of Blagaj, we can define the following natural monuments:
- Geomorphological monuments of nature - Vrelo Bune with cliffs, Vrelo Bunice with cliffs, Zelena cave, Linčija kuk cave, "Šavrljica" cave.
- Hydrological monuments of nature - Vrelo Bune, Vreloo Bunice and Buna waterfalls (cascades in Blagaj).

- Dendrological monuments of nature - plantations in the courtyard of the tekke at Vrelo Bune, poplar plantations in the fish farm, pine and cypress forest on the hill around Stjepan-grad, cypress plantations near the mosque in Blagaj, cypress plantations near the Orthodox Church in Blagaj, churchyards in Orah and Ada under the noise. (Institute for the Protection of the Cultural, Historical and Natural Heritage of Bosnia and Herzegovina, 2000, p.9). For years, this river was untouched and separated from all anthropogenic influences, although it collected numerous excursionists and bathers in its lower courses. In the last 50 years, over 80% of life in freshwater has been destroyed in BiH. The appeal to the authorities to start preserving the natural resources of this country has significantly improved the condition of the flora and fauna of the river Bunica and has been placed under protection and declared a natural monument.

2.1. Assessment of the ichthyopopulations in the Bunica River

During the research conducted on the river Bunica, four fish species originating from two families were identified: Salmonidae, Cyprinidae. From the family Salmonidae the following species are present: *Salmo truta m. fario* (Linnaeus, 1758), from the family Cyprinidae: *Chondrostoma knerii* (Heckel, 1834), *Leuciscus svallize* (Heckel et Kner, 1858), P*hoxinus phoxinus* (Linnaeus, 1758).

Table 1. Current state of the ichthyopopulation in the river Bunica

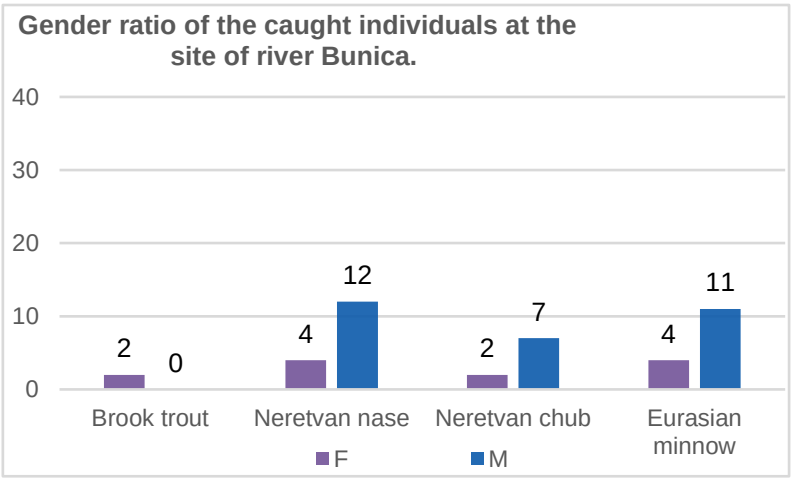
FAMILY	SPECIES	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		REGIONAL IUCN CATEGORY	GLOBAL IUCN CATEGORY
			F	M		
Salmonidae	Trout (*Salmo truta m. fario*) Linnaeus, 1758	2 (100%)	2 (100%)	0	CR	LC
Cyprinidae	Neretvan nase (*Chondrostoma knerii*) Heckel, 1834	16 (40%)	4 (25%)	12 (75%)	EN	VU
	Neretvan chub (*Leuciscus svallize*) Heckel et Kner, 1858	9 (22, 5%)	2 (22,22%)	7 (77,77%)	VU	VU
	Eurasian minnow (*Phoxinus phoxinus*) Linnaeus,1758	15 (37, 5%)	4 (26,66%)	11 (73,33%)	EN	VU

Salmo truta m. fario

Trout is a freshwater, brown form of sea trout *Salmo trutta*. In a sense, this species is a typical representative of the family Salmonidae. It is one of the most famous and widespread freshwater fish. The shape and structure, and to a large extent the color of its body, is extremely adapted to the conditions of the habitat. It is characterized by a relatively large head and large mouth. The jaws and vomer are equipped with sharp teeth. Body color is directly dependent on the place of its residence. That is why darker, lighter, olive-brown and similarly colored individuals are found. The color of the back is mostly olive brown, while the hips are yellowish-green. Dark and red spots bordered by light edges can be seen on the body. The whole body is covered with tiny, thin and round scales. It reaches sexual maturity in the second or third year of life at a body length of 25-30 cm. Females lay 500 to 3,000 eggs with a diameter of 4.5-5 mm. The average fertility is about 1,500 pieces of eggs per 1 kg of body weight. Sexual dimorphism is pronounced in trout during the spawning season (November, December, and less often in October or January). Due to its abundance, meat quality and distribution, trout is a very attractive fish species for sport fishing. In the future, great attention should be paid to maintaining the number and protection of indigenous populations of this species in Bosnia and Herzegovina.

Chondrostoma knerii

The common nase is a Central European freshwater fish from the carp family (Cyprinidae), hard cartilaginous mouth, blackish-green back, silvery-white belly. It grows up to 40 cm, weighs up to 1 kg. It forms fast streams and stays at the bottom. It feeds on small animals and plants. It spawns from March to May. The female lays up to 100,000 eggs, about 1.5 mm in diameter, in running water, and the eggs stick to the gravel at the bottom of the river.



Leuciscus svallize svallize

It is another indigenous species in the Neretva catchment area. It is characterized by a slender body, and the head and forehead are quite narrow and rounded. The morphometric and meristic properties of this species have been studied in detail, while its ecology, and especially the biology of development, has been little or not elucidated. It reaches sexual maturity in the third and fourth year. It spawns in the spring from April to June. It lays its eggs on a rocky base, and is a lithophilic species in this sense. When there are no spawning

conditions in the reservoir, the migrates into tributaries in large flocks. This species is endemic to a limited part of the waters of the Adriatic basin.

Phoxinus phoxinus

A species of fish in the family Cyprinidae of the order Cypriniformes. It is widespread in the rivers of Eurasia, and includes 21 known species. It is present in large numbers in the river Bunica, Neretva and most of its tributaries.

The proximity of the river has always influenced agriculture, settlements, trade and communication. Bunica is a natural resource that should be additionally protected, and not allowed to be slowly destroyed and disappearing. It has great human, economic and tourist potential. It is an ideal destination for those who want peace and escape from everyday life, but also for those who want an active vacation. In addition, it provides a good basis for scientific research projects and fieldwork. Every country should have a developed strategy for the protection of fish and their habitats. The basis of this regulation lies in the legislation at the municipal and state level. However, the basis of these legal implementations lies in a practice that is unfortunately poor or almost non-existent.

It is necessary to make an inventory and determine the area of individual species in order to see the general picture of the distribution of freshwater fish communities in Herzegovina. After that, it is necessary to determine in detail the area of distribution of rare and endemic species, and to determine the necessary protection measures required for implementation. In order for measures to be proposed, it is necessary for scientists to conduct biological and ecological research of the life cycle of rare and endangered species, within which the time and location of spawning, and areas where early developmental stages are of exceptional and primary importance.

As one of the measures in order to protect these species, it is possible to propose the creation of areas for their protection in the form of ichthyological reserves such as e.g. Mostarsko Blato, parts of Popovo fields, etc. Bunica has the status of protection as a natural monument, and the spawning area of many plant and animal species as well as endemics, should be further protected. In order for these measures to be implemented effectively, there is a need for greater sensitization of the general public to endemic and endangered species, which can be implemented through newspaper articles, active lectures and the like.

BREGAVA RIVER

1. Introduction

The Bregava River, with length of 31 km, is the longest left tributary of the Neretva. It originates from the permanent springs of Bitunja and Hrgud and the periodic springs of Mali and Veliki Suhavić, and flows into the Neretva near Čapljina, in the village of Klepci. Its catchment area lies between Trebišnjica in the southeast and the Neretva in the west, and its total area is 722.4 km^2. The average drop is 3.7 m/km. Downstream from Stolac, the riverbed usually dries up during summer, due to porous geological base and anthropogenic impact. Published research findings indicate presence of a large number of plant species, some of which are endemic. The world of fauna includes invertebrates (butterflies and crayfish) and vertebrates (fish, amphibians, reptiles, birds and mammals). However, the Bregava River is in great danger of becoming a dry karst valley due to the gradual expansion of underground water channels and drainage of water towards Deranski Blato, along the entire upper course and part of the middle course. Therefore, gravel and sand excavations are not recommended in this part of the watercourse, nor are any actions to deepen the riverbed. Due to all the negative impacts, the Bregava River needs to be protected through coordinated conservation efforts, due its diverse plant and animal communities, and the importance this river has for the human population.

1.2. Geographic position of the Stolac municipality

The municipality of Stolac is located in the southeastern part of Bosnia and Herzegovina, in the far east of the Herzegovina-Neretva Canton. It is located on the banks of the river Bregava, at the foot of the mountain Hrgud, in the valley of Vidova polje. At an altitude of 70 meters, there is an urban settlement, while other rural parts of the municipality are at an altitude of 230-600 m. The geographical area of the municipality is 286 km^2, located on the carbonate platform of the Dinaric Alps.

1.3. Hydrographic characteristics

The river Bregava springs in Dol. The altitude of the spring is 120 m. The catchment area of the Bregava spring covers about 396 km^2 and is divided into two areas: the zone of the mountains Hrgud and Sitnica, between Ljubomirsko polje and Stolac and, the second zone, which is the indirect basin, which consists of the Dabar field, and which includes the basins of the Trusin and Lukavic fields. From the Dabar field, all the water flows out through several large abysses, among which the largest, the Ponikva abyss, stands out. The upper course of the Bregava is a unique geographical complex thanks to its position on the border of mountainous and Mediterranean areas, various terrains karst forms and branched hydrographic system. Riverbed has been formed in a canyon, with valley sides reaching a height of up to 700 m. The extensions contain alluvial deposits, the thickness of which in the riverbed varies between 4 and 23 m. After the construction of a small dam upstream from Stolac, the alluvial deposits accumulated faster (Miošić 1995).

The Bregava river valley consists of Cretaceous and Paleogene sediments. This area has a Dinaric character. The anticline shape with which the canyon part of the watercourse was carved is the most fragile tectonic element. The anticline was interrupted by a cleft, which imposed the formation of a canyon valley from a spring near Stolac. Beneath the sediment is limestone that is permeable to water. The water quality of the Bregava River varies from

spring to estuary. At the spring, the water is oligosaprobic to weakly betamesosaprobic, while downstream from Stolac it deterioration, and at the estuary itself it is betamesosaprobic. Bregava water is, in all cases, alkaline, with moderate salt content and high oxygen content (Kosorić 1977).

1.4. Geological characteristics

Cretaceous sediments make up the largest share, more than 70%, in the geological structure of Herzegovina. From a paleontological point of view, perhaps one of the earliest explored fossil forms from Cretaceous sediments consists of ores, which have so far been best described and explored. However, in addition to ores in different levels of the Cretaceous, some very important fossils have been found in Herzegovina (Bolkay, 1925). Most of the area, according to geological structure, belongs to the Mesozoic limestones, and a smaller part was formed from Lower Cretaceous and Jurassic dolomites. According to research in the central part of Herzegovina, Eocene flysch formations and alveolinic cumulite Paleogene limestones are present (Slišković, 1962).

On the way from Buna to Stolac we notice the Turonian Senonian limestones with ores. Limestones appear as layered, white, finely crystalline forms with foraminifera. Dolomites and dolomite limestones occur in some places in the lower parts. Alveolin-numulite limestones of the Lower and Middle Eocene can be clearly distinguished (Hrvatović 1999). The Dinaric karst consists of the terrain of the western part of the Dinaric Mountains, developed on a vast carbonate platform of Mesozoic age, and at the same time represents the largest uninterrupted karst surface in Europe. The Dinaric karst is important for the development of karstology and speleology (Kranjc 2003).

1.5. Pedological characteristics

This area is known for its geological-lithological, as well as specific geomorphological characteristics of a karst area. The area is full of sinkholes and scrapes of great depth. At the bottom of the valleys, coves and sinkholes is the *terra rosa* (Ćirić, 1991). The mineral part of the soil on the karst is formed from the clay substance, which makes 1-2% of the rock mass (Hrvatović 1999).

Terra rosa is the name for the red residual soils that are especially widespread in the karst area around the Mediterranean. It is believed that red soil is a type of relict soil formed during the times when the climate was significantly warmer. In geological terms, red soil is the name for reddish, brownish-red and yellowish-red clayey-dusty soils covering limestones and dolomites. The characteristic reddish coloration is derived from amorphous iron hydroxides (Herak, 1990). In addition to red soil, black earth, sandstone and clay can also be found in this area (Selimić 2017).

1.6. Characteristics of the climate

Factors influencing the climate in Herzegovina are the proximity of the Adriatic Sea, terrain and altitude. Much of Herzegovina has a predominantly Mediterranean climate, characterized by mild winters and warm summers. During the colder seasons, extremely rainy periods occur from November to February. The proximity of the Adriatic Sea during the winter alleviates the low air temperature. During the summer months of July and August, temperatures often climb up to 40°C. Winds from the north and northeast prevail in this area. Stolac is dominated by the Mediterranean type of climate, which is characterized by

warm summers and humid winters. This type of climate is present in both low and high Herzegovina. The area of low Herzegovina, in which Stolac is located, which corresponds to the lower course of the Neretva River with the surrounding karst fields lower than 1000 meters above sea level. This type of climate in low Herzegovina occurs due to the fact that its area is under the direct influence of sea air. The average temperature in Stolac in January is 4.3°C. The impact of the Adriatic Sea in summer is negligible, due to the limestone rocks, which change the temperature of this area at the time they warm up. Summers are dry and hot. The vegetation period lasts for about or over 240 days (Federal Hydrometeorological Institute in Sarajevo).

2. The living communities on the Bregava river

Along the Bregava River and within it, throughout history, a very specific living world has settled. Although it is quite similar to the continental, it is characterized by its specific characteristics and shapes, which makes it different and special (Milanović 2021). A very important link in the protection of species is the protection of their habitats. The basic conditions for normal growth and development of life forms are: adequate conservation of habitats in unaltered or approximately original form, to whose specific circumstances the species have adapted. The Bregava River remained the largest Mediterranean watercourse in Bosnia and Herzegovina. This river is characterized by very heterogeneous communities that develop in drained riverbeds, with aliviums of different granulometric structure and occasional permanent water bodies in which submerged and emergent vegetation develops. Of special importance are habitats on gravelly deposits with herbaceous or woody vegetation, which are similar to those in the continental parts, but with Mediterranean elements (Milanović 2021).

2.1 Distribution of the European freshwater crayfish *(Austropotamobius pallipes* species complex)

It is interesting to note that Bregava River is the only site where freshwater crayfish was present during this research. Papers published in 2013 and 2014 by Zujo Zejic et al., described the distribution of the European freshwater crayfish *Austropotamobius pallipes* in Bosnia and Herzegovina. Due to taxonomic uncertainty, this species received the status of a species complex. According to recent data on the distribution of European freshwater crayfish, its distribution has been recorded in the Neretva basin. Populations determined in Bosnia and Herzegovina are characterized by variations in morphometric parameters (width and length of rostrum, length of cephalothorax, etc.) as well as populations throughout Europe. As the oldest species from the Astacidae family, due to its sensitivity to organic load, it requires urgent protection at all levels in our country.

The first species was recorded in the Neretva when Karaman pointed out its presence in 1961. Then, in 1982, Albrecht listed this species for the area of Herzegovina, while later findings (2008) indicate the presence of European freshwater crayfish in the river Bregava upstream from Stolac. Also, it was stated in the research of the study "Biomonitoring of surface waters of the Neretva and Cetina River basins in FBiH" in the period from 2008 to 2010. These studies also indicated the dominance of European freshwater crayfish at 18 sites in the Neretva Basin. In the Neretva, individuals of this species are 11 cm long, while in its tributaries the average length is about 7 cm.

In the researched areas on Bregava, European freshwater crayfish occur at altitudes of 300 m, while water temperatures were 10°C. Also, research has shown that it is present in clean

or less polluted waters. Large populations of white-legged crabs with a predominance of *Chara* and *Fontinalis antipyretic*s have been confirmed in Bregava.

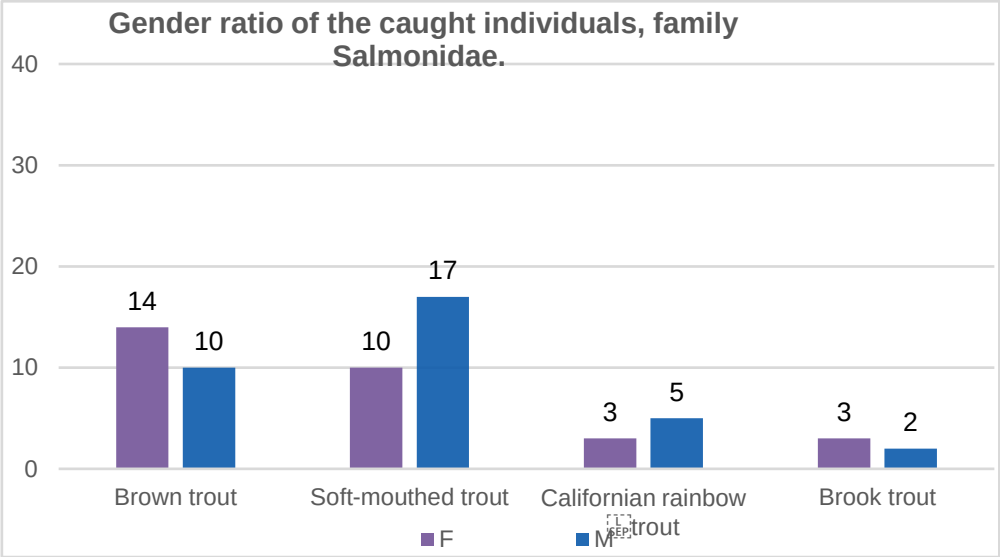
Problems in the taxonomy of the species and especially pronounced morphological characteristics require additional research on distribution in Europe, especially our country, while special emphasis is placed on ecotoxicology, because one of the important causes is the physiology and pathology of the European freshwater crayfish. Due to the indicated age of the species and its indication, this type of crayfish is protected in Appendix III of the Bern Convention and Annex V of the European Habitats Directive. Although there are certain legal regulations in Bosnia and Herzegovina, more adequate protection and concrete implementation is needed in the future (Trožić-Borovac 2011).

3. Ichthyopopulation of the river Bregava

Ichthyofauna of the river Bregava, is represented by the family Salmonidae. The following species occur within this family: *Salmo trutta morpha fario* (Linnaeus, 1758), *Salmothymus obtusirostris oxyrhynchus* (Steindachner, 1882), *Oncorhynchus mykiss* (Walbaum, 1792) and S*alvelinus fontinalis* (Mitchill, 1814).

Table 1. Distribution of the family Salmonidae in the river Bregava

NAME	SPECIES	FAMILY	NUMBER OF CAUGHT INDIVIDUALS	GENDER RATIO		REGIONAL IUCN CATEGORY	EUROPEAN IUCN CATEGORY
				F	M		
Trout	*Salmo trutta morpha fario* (Linnaeus, 1758)	Salmonidae	24 (37,5%)	14 (21,87%)	10 (15,62%)	**CR**	**LC**
Soft-mouthed trout	*Salmothymus obtusirostris oxyrhynchus* (Steindachner, 1882)	Salmonidae	27 (42,,18%)	10 (15,62%)	17 (26,56%)	**CR**	**EN**
Californian rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792)	Salmonidae	8 (12,5%)	3 (4,68%)	5 (7,81%)	**LC**	**NE**
Brook trout	*Salvelinus fontinalis* (Mitchill, 1814)	Salmonidae	5 (7,82%)	3 (4,68%)	2 (3,12%)	**LC**	**NE**
	TOTAL		**64 (100%)**	**30 (46,87%)**	**34 (53,13%)**		



Graph 1. Gender ratio of the caught individuals by species, family Salmonidae

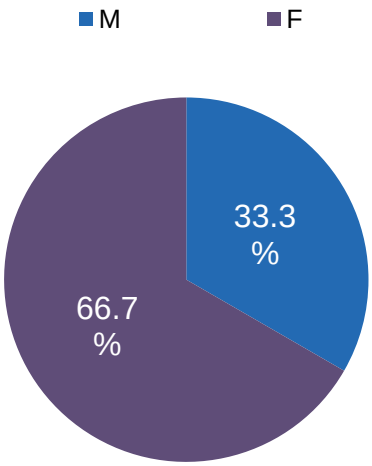


Figure 1. Gender ratio of the caught individuals in total, family Salmonidae.

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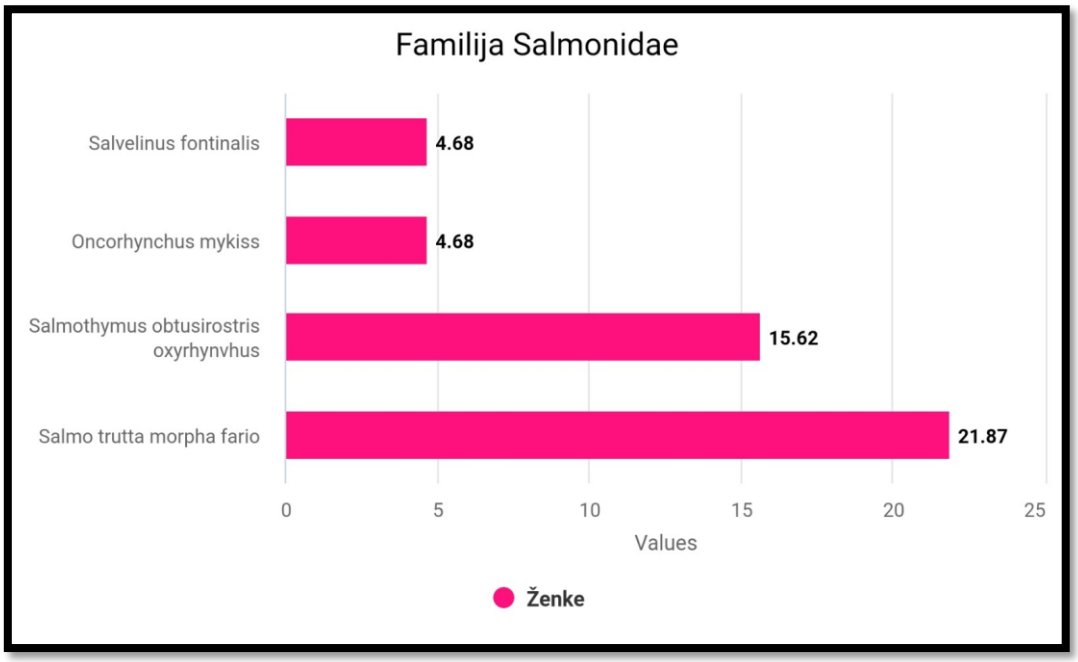
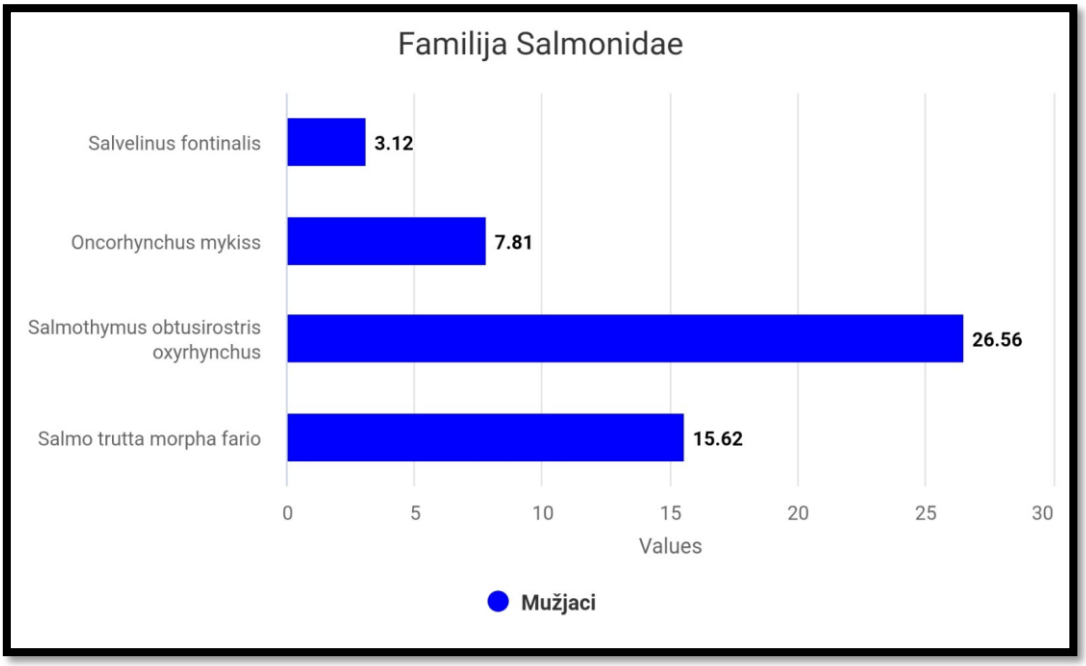


Graph 2. Numerousness of females from the family Salmonidae expressed in percentages



Graph 3. Numerousness of males from the family Salmonidae expressed in percentages

Salmo trutta morpha fario (Linnaeus, 1758) is a typical member of the Salmonidae family. This trout is an endemic species, which can be found only in the Neretva, Buna and Bunica. During the research, 24 individuals (14 females and 10 males) were caught in Bregava. With its shape and structure, and a good part of its body color, it is very well adapted to the conditions of the habitat. It is characterized by a relatively large head and large mouth, while its jaws are equipped with sharp teeth. Body color depends on the location of the habitat, and darker, lighter, olive-brown colors of individuals are encountered. The color of the back is olive brown, while the hips are yellow-green. Dark and red spots are present on the body bordered with light edges. The whole body of trout is covered with tiny, thin and round scales. The introduction of Danube and Atlantic strains into the Bregava River during restocking has caused the disappearance of the endemic river trout that was present in this river twenty years ago.

Salmothymus obtusirostris oxyrhynchus (Steindachner, 1882) is an endemic species of the Neretva basin and its tributaries. It is another typical representative of the Salmonidae family. According to the data, the population numbers are decreasing. During the research, 27 species were caught from the river Bregava, of which 10 were females and 17 were males. Soft-mouthed trout is considered a relic-remnant of the ancient land of the past, because it has a number of "primitive" characteristics-pleistomorphs (short jaws, small mouth, short teeth and is a mandatory freshwater fish). There are four subspecies of soft-mouthed trout: *Salmothymus obtusirostris oxyrhynchus* Steindachner, 1882, *Salmothymus obtusirostris salonitana* Karaman, 1926, *Salmothymus obtusirostris krkensis* Karaman, 1926, *Salmothymus obtusirostris zetensis* Karaman, 1932. The usual characteristics of the subspecies are the golden glow of the body, small mouth with big lips, short jaws, small teeth, stomach with a large number of pyloric fasteners (48-91), thick dark spots behind the gills all the way to the dorsal fin, sparsely distributed red spots reaching to the end of the body, fins not pigmented except dorsal fins, spawn in spring and small scales.

Oncorhynchus mykiss (Walbaum, 1792) has been spawning in our country since 1894. Through long-term planned restocking by local fishing associations, it was introduced in the Neretva River Basin. It is also present in the river Bregava, where 8 individuals (3 females and 5 males) were caught during the research. California trout migrate downstream to the sea. Its populations survive mainly in artificial lakes. It is similar in shape and body structure to trout. It is characterized by a relatively large head with strong jaws rich in sharp teeth. Numerous black spots are scattered on the head, back, dorsal and tail fins, while along the hips there are a number of very characteristic red-orange stripes of rainbow colors. The body color of this species is very variable. The whole body is covered with round, tiny and thin scales. This species is non-native and as such is a problem for indigenous fish species in the Neretva River, since it feeds on them and is their competitor.

Salvelinus fontinalis (Mitchill, 1814) was first described as *Salmo fontinalis* in 1814 when it was scientifically described by naturalist Samuel Latham Mitchill. According to some data, it was introduced into the Bregava River between 1980 and 1995. Later records state an escape of this species from a small fish farm owned by one of the local restaurants in the upper reaches of the Bregava River. The brook trout adapted very well in the river Bregava, where 5 species (3 females and 2 males) were caught during the research. There is no data of it spawning in Bregava.

4. Factors threatening the living world of the Bregava River

In addition to constructed hydropower plant, there are many other impacts of anthropogenic factors on the living world of the Bregava River. Among the leading negative factors are illegal construction on the river, uncontrolled garbage dumping, as well as uncontrolled hunting. Also, the lower course of the Bregava is most endangered due to the exploitation of river gravel, which has led to the devastation of the riverbed. Another problem is waste dumps in lower catchments of the river.

It is an undeniable fact that the Bregava, like other tributaries of the Neretva, is under increasing anthropogenic pressure, which results in the destruction of an increasing number of valuable habitats. In order to prevent the destruction of the river as well as the surrounding habitats around the river, it is necessary to carry out all necessary activities in order to protect them and include river protection as one of pivotal points of municipal development plans.

Another negative impact on the living world is the pollution caused by agricultural pollutants. On the river Bregava, this is especially noticeable in the middle and lower courses. In order to achieve the highest possible yields, farmers use pesticides and fertilizers, while water is pumped from the river for irrigation. Thus, pesticides are washed into water, which has a negative effect on aquatic organisms, but also on other living beings, including humans. Another problem is the inadequate disposal of pesticide packaging.

However, the greatest damage to the river is caused by the construction of hydroelectric power plant in Do. The construction and operation of hydropower plants disrupt environmental conditions that result in the reduction or extinction of certain organisms. The natural riverbed has been modified as well as riparian vegetation belt. There is also a reduction in water levels, often below biological minimum. It is important to emphasize that all these negative factors do not affect only aquatic organisms, but also reflect on the survival of other organisms, which are in various ways dependent on water, and also affects human life.

Based on the researched literature and available data on the river Bregava, it can be noticed that the river Bregava is of great importance both locally and globally. Although the Bregava is the major tributary of the Neretva, it has been very sparsely explored. However, research conducted on this river indicates the presence of plant and animal communities, many of which require direct protection actions as they are threatened with extinction. For this reason, it is necessary to pay more attention to the river Bregava, but also to the surrounding habitats, because only the adequate protection of entire ecosystem would preserve the diversity of species that inhabit them.

Short vegetation inventory indicates the presence of aquatic macrophytes, of which the most numerous are representatives of the Poaceae family. There is a large number of endemics. Due to the specific geographical position, the influence of the Adriatic Sea, altitude, pronounced terrain features, the endemic flora of this area is very pronounced. In addition to plant species, the area around the river Bregava is rich in wildlife. Butterflies and the European freshwater crayfish are present, which is also an indicator of water quality. Some of the butterfly species are on the Red List and endangered. Fish, amphibians, reptiles, birds and mammals are also present. Four species of fish are present and belong to the Salmonidae family. A characteristic group of mammals are bats, which are present with three species in caves in the area around Bregava. Other mammals have been less studied, but according to available information, the wider area is inhabited by 31 species.

The river Bregava and the wider area around it has a great wealth of plant and animal species, which in recent years have been under constant negative influences of anthropogenic factors. This is especially pronounced in recent times, due to the operation of hydropower plant, inadequate waste disposal, hunting and poaching, water pollution and, excavation. More intensive research is needed on the living communities in this area, as well as elucidating the most efficient methodology of their protection.

TREBIZAT RIVER

1. Introduction

Trebižat River is located in the south-western region of Bosnia and Herzegovina. It is a part of the Neretva Rivers basin and a major tributary of the Neretva river. The river rises from the large karstic wellspring within cave in Peć Mlini village. Numerous scientists who researched the Trebižat River area at various locations did not provide a sufficient amount of accurate data. Exceptions are works on the vegetation of the Trebižat river valley by Lasić and Jasprica (2016). It is safe to say that the flora and vegetation of hygrophilous and aquatic ecosystems along the Trebižat river are very well researched and known.

This river is essential for the life of people in this area since it passes through a karst region, forming fertile plateaus and fields. Permanent human settlements have developed around it, and in addition to drinking water, the river provides freshness during the summer heat, irrigation to the arable land and watering the livestock. The river Trebižat is a typical karst watercourse. It is characterised by a poorly developed surface hydrographic network and dominant underground runoffs. There are multiple springs in the riverbed itself, which are not visible. This fact is very important for maintaining the water temperature at an acceptable level necessary for the survival of many species.

2. Ecological characteristics of the Adriatic province

The Adriatic province covers a very narrow belt between the sea coast up to about 400 m above sea level in the south, i.e. up to about 300 m above sea level in the north-exposed parts of the terrain (Kušan, 1961). The Adriatic province belongs to the area of the lower Herzegovina, i.e. the unique area of the Neretva River valley from Mostar's Bijelo polje with the Dubravska and Brotnjanska valleys and Popovo polje. The Adriatic province is an area with typical karst features, given that the petrographic structure of the rock substrate is dominated by cretaceous limestones with a high percentage of $CaCO_3$ (which in some places is over 90%) (Lakušić, 1981). The basic climatic characteristics of the Adriatic province are defined by belonging to the following climatic types: Csa (Mediterranean climate with hot summers) in the transition zone and Csb (Mediterranean climate with warm summers). The area of the Adriatic province is characterised by a typical Adriatic climate. The duration of sunshine is the highest in Bosnia and Herzegovina and amounts to 2,250 hours. Average annual temperatures vary from 14^{o}C to 16^{o}C. The pluviometric regime is typically Mediterranean, considering that the dry period is present during the warmer period of the year and lasts up to eight months.

3. Ecological characteristics of Trebizat River

Trebižat is 51 km long and is the second largest sinking stream in Bosnia and Herzegovina, whose waters drains into the underground and reappears several times at various locations. Denivelation from the source in Peć Mlini (approx. 127-130 m above sea level) to the estuary in Neretva (approx. 8 m above sea level) is about 120 m. It is the largest right tributary of the Neretva, with a total of 51 km in length. Near the village of Studenci, Trebižat forms the travertine waterfall Kravica. It is a continuation of several sinkholes that start near Posušje at the elevation of Tribistovo (903 m).

However, as part of a very specific and complex system of drainage of karst in western Herzegovina, the same water flows in different sections under different names. The section

from the source to the mouth of the Klokun spring is known as the Tihaljina river, from the Klokun estuary to the Vrioštica estuary it is called Mlade, and finally, from Humac to the Neretva estuary, is called Trebižat.

Going upstream from the source of the Tihaljina, the waters of Trebižat have five different names: Matica - Vrlika - Tihaljina - Mlade - Trebižat. Orographically, the total area of the basin is about 1200 km^2, including about 90 km^2 of the Imotski-Bekijsko field. In the broader area there are several specific arable karst fields: Ljubuško polje, Veljačko polje, Vitinsko polje, Rastok and Beriš, which are irrigated from the system Tihaljina - Mlade - Trebižat. There is also a large number of springs with lush flora and fauna (spring Tihaljina, Modro oko, Klokun, Vrioštica), and beautiful waterfalls Koćuša and Kravica.

The area of the Trebižat River basin is an area under the changing influence of the Mediterranean, with the characteristics of mild and rather short, rainy winters, and dry and hot summers. There are the effects of the eu-mediterranean and the sub-Mediterranean zone. This area is located in a zone of altered continental climate, with abundant rainfall and hot summers. The relatively dry season lasts from June to September. The rest of the year is rainy, with the highest rainfall from October to January.

Construction of numerous hydro-accumulation plants is planned in the Tihaljina-Mlade-Trebižat (TMT) region. The Peć Mlini hydroelectric power plant was the first plant built. The Peć Mlini Hydroelectric Power Plant regulates the flow of water with metal shutters, which has led to the creation of an artificial accumulation of the Nuga Compensation Basin with a total volume of 51,800,000 m^3. The lake is still under construction. Water scarcity is the biggest problem, especially due to the formation of new abysses (Study of the overview of the state and valorization of soft-mouthed trout in the Adriatic basin region, 2019).

4. Travertine formations on the river Trebižat

The occurrence of tufa or travertine formation is related to karst rivers, which results in the formation of characteristic geomorphological forms, especially waterfalls. Tufa is calcium carbonate precipitated from water under certain conditions (water temperatures, calcium carbonate saturation) (Ford and Pedley, 1996). The development of travertine conditioned the formation of numerous travertine barriers and waterfalls on the river Trebižat. Water purity is also an important factor. The property of sedimentary limestone rocks is that they dissolve relatively easily in water and thus create caves, furrowed slabs, ravines, canyons, etc. The dissolution of limestone rocks produces one of the most important substances needed to form travertine waterfalls, soluble calcium bicarbonate (Srdoč et al. 1985). Ventilation of water containing calcium carbonate releases CO_2, thus precipitating calcium carbonate. Tufa-forming formations occur in parts of watercourses that have a relatively low water temperature and a fairly high alkalinity and relatively slow flow.

These two factors have an antagonistic effect on the process of travertine formation. High alkalinity (significantly above the deposition limit) affects travertine deposition, and lower temperature, which is almost regularly below the deposition temperature limit, prevents stronger travertine deposition. The relatively low flow rate of water reduces its dispersal, which leads to a slower deposition of tufa. In locations where the fall is more pronounced and where the water has a faster flow, there is a stronger ventilation and deposition of travertine.

The formation of travertine deposits also requires the presence of certain organisms, especially hygrophytic and hydrophytic mosses and, to some extent, algae. First, lower cascades are formed, and communities develop on their surfaces that significantly encourage the growth of travertine formations due to strong water aeration, such as *Cinclidotus-Platypnidium-Rivulogamarus*, the community of mosses and green algae. Some animals participate in the formation of travertine deposits as well (Matoničkin & Pavletić 1972). This community also creates special travertine shapes known as travertine cones. Between the communities of mosses and algae, several species of woodpeckers, shellfish, waterflowers, barnacles, tularas and adult helmsmen settle.

Plant species characteristic for the Kravice - Trebižat waterfalls are: *Polypogon viridis* (below waterfalls), *Adiantum capillus veneris* and *Cratorneruon commutatum, Plathypnidum sp., Cindlidotus sp*. and green algae (*Vaucheria sp.*) (found in drip caves).

Critical parameters for existence of travertine formations are: water temperature higher than 14˚C (which is the deposition temperature limit), water velocity in the range of 0.5 - 3.5 m/s (the optimal velocity is 1-2 m/s, where the largest number of travertine organisms is retained), water pH levels above 8, reduced concentration of dissolved organic matter and ensured sufficient constant flow of clean water (Spatial Identification Spatial Identification Project, Dinarica Association / WWF ADRIA).

4.1. Anthropogenic impact in the Trebižat river basin

In the Trebižat basin, anthropogenic impact is very pronounced. It is present and visible in the form of numerous artificial hydrotechnical facilities. There are numerous water intakes for various purposes, especially for agriculture. With a sub-Mediterranean climate and arable land (in karst fields), water is needed for irrigation, especially during the warm season. That is why the network of surface artificial irrigation canals is very developed. Near the source Grabovo vrelo, there is a water intake for a fish farm, as well as for the needs of agriculture, with a pronounced influence on the flow of watercourses.

In the upstream part of the basin, there are reservoirs Ričica (1987), Tribistovo (1990), Rastovača. The Pećnik underground tunnel was built in 1950, with a closing tower for the needs of defending the Imotski field from floods, i.e. for the evacuation of large waters from the occasional lake Nuga during the rainy season. Since 2004, the hydroelectric power plant Peć Mlini has been in operation, located downstream from the source of Tihljina 12 (Project; Living Neretva, Assessment of environmentally acceptable flow for the rivers Trebižat and Vrbanja).

4.2. Protected areas of the river Trebižat

According to the Law on Environmental Protection of BiH, protected environmental objects of the river Trebižat are: travertine forms around the Kravica waterfall, which is one of the natural monuments; geomorphological monuments: Tihaljina spring in Peć Mlini, Vrioštica spring in Vitina; waterfalls: Koćuša, Kravice and Bučine. Other main ecological values of the Tihaljina-Mlade-Trebižat area are: limestone deposits on the river Tihaljina in Peć Mlini and the spring Modro Oko - left tributary of the river Mlada, coastal communities that form tufa/ travertine on the river Trebižat, vegetation in waterfalls that form tufa, forms of tufa with phytonutrient species, macrophytes.

4.3. Hydropower In the Trebižat River basin

At the moment, the use of water through hydropower in the Trebižat river basin is realized through HPP Peć Mlini, the construction of which began in 2001. Its operating started in 2004. HPP Peć Mlini is a derivation-type hydroelectric power plant that uses the waters of the Vrljika River and the waters of Grudski Vril, which are brought to the Nuga Reservoir by an 11 km long canal. The operable volume of the reservoir is 850,000 m^3, which is enough for daily inflow equalisation. The hydroelectric power plant is located near the Petnik hill, about 7 km southwest of Grude, and about 3 km from the border with Croatia. Considering the technical solution, some facilities of the hydroelectric power plant are several kilometers apart. Thus, the compensation basin was built north of the Petnik hill, in the area of Nuga in the southern part of the Imotski-Bekija field, and the power plant south of the Petnik hill near the region of Peć Mlini. Due to the height difference of about 110 m, the energy use of Vrljika waters was carried out by renovating the existing tunnel and building a pressure pipeline to the engine room. Near the region of Peć Mlini, cut into the surrounding hills, there is a narrow valley of the karst river Tihaljina.

Tihaljina springs from several springs, and for the most part is a continuation of the Vrljika River, which sinks into the abysses along the southern edge of the Imotski field. The water to the Tihaljina spring partly flows from other abysses in the wider area. HPP Peć Mlini uses the waters of the Vrljika River in the fall from the Imotski-Bekija field to the area of the Tihaljina spring. Due to the insufficient capacity of the abyss at the location of Nuga, the river Vrljika often flooded the area of the Imotski-Bekija field for a long time. In order to avoid great floods, a tunnel from Nuga was constructed in 1951 through the Petnik hill towards the Tihaljina spring. (Water Management Plan for the Adriatic Sea Basin in the Federation of BiH in front of the Adriatic Sea Basin Agency in Mostar).

5. Elements of the flora

The lower belt of the sub-Mediterranean zone is characterised by the forest association *Carpinetum orientalis adriaticum (Carpinion orientalis aliansa*, order *Quercetalia pubescentis*, class *Querco - Fagetea*). In most of the Sub-Mediterranean coast in the eastern Adriatic, the community *Carpnetum - orientalis adriaticum* has developed in the form of larger or smaller shrubs. In the highlands, in the belt of the Mediterranean mountains, in the direction of the hinterland, there are habitats of the forest community *Carpinetum orientalis adriaticum*. Due to degradation, these sub-Mediterranean forests have transformed into specific, permanently anthropogenic forms - dry grasslands and rocky pastures of the order *Scorzonero–Chrysopogonetalia*.

Several vegetation belts are formed. The following associations develop in deeper water: *Ceratophylletum demersi* (Hild 1956), *Potamogetonetum pectinati* (Carstensten, 1955) and *Myriophyllo-Nypharetum* (W. Koch, 1926.). Occasionally flooded coastal region develops semi-aquatic vegetation consisting of the association *Sparganietum erecti* (Roll, 1938), *Scirpetum lacustris* (Schmale, 1939) and *Phragmitetum australis* (Soó, 1927) which are in contact with meadow, forest and ruderal vegetation (Štambuk Giljanović, 1998). Endangered species are *Adiantum capillus - veneris, Aristolochia rotunda, Campanula portenschlagiana, Hippuris vulgaris, Nupharlutea, Nyphaea alba,* and *Periploca graeca* (Bajić, 1997).

6. Ichthyofauna of the river Trebižat

During our research, six species of fish were recorded in the river Trebižat: S*almo trutta m. fario, Salmothymus obtusirostris oxyrhynchus, Leuciscus svallize, Chondrostoma kneri, Anguilla anguilla and Esox lucius.*

Fish are very sensitive to changes in flow rate, river barriers, habitat degradation, water warming, and intensive water use (Descy and Empain, 1984). The structure of the fish community in the ecosystem is determined by water flow, oxygen content, temperature, transparency and pollution. Changes in these factors will alter fish populations and may also reduce species diversity. Harmful and negligent human impact, however, endangers many species.

The community of fish in the flood zone of the river Trebižat is today severely endangered.Causes of endangerment are eutrophication, land reclamation, overfishing, introduction of non-native fish and construction of dams on rivers, destruction of karst water habitats, reduction of water quality (pollution). If a long-term change in one or more factors occurs in the aquatic ecosystem, rare and vulnerable species will be at particular risk.

Lagoons, marshes and backwaters connected to the main river play a very important role as permanent and occasional habitats of individual fish communities, especially those characterised by transverse migrations. Species that migrate from the river to floodplains and cannot survive without floodplains, depressions and unconnected canals, often get separated from the main river. The regulation of watercourses prevents them from entering the flood zone where they feed and reproduce. Due to such interventions, their population is drastically reduced, and some species are on the verge of extinction.

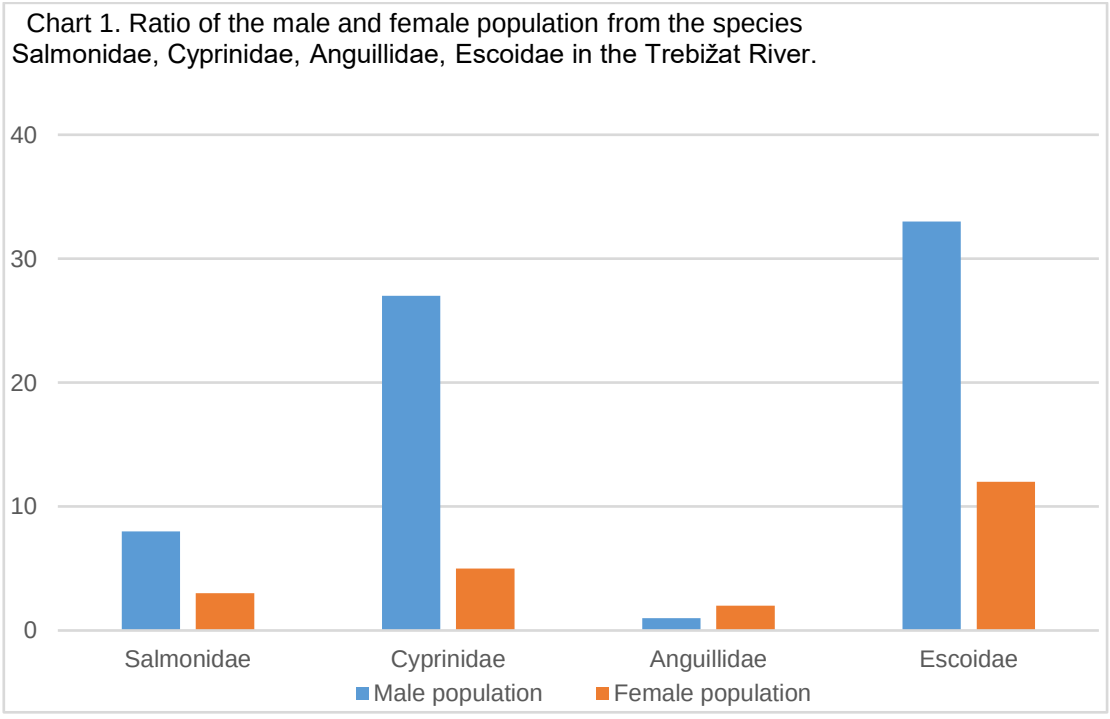
Endemic species are unique to a certain water body, place or region. Endemics of Bosnian ichthyofauna are largely associated with distinctive karst habitats. Endemic fish species that inhabit the waters of the Adriatic basin are invaluable and make up a significant part of European biodiversity. They are particularly sensitive and usually have little ability to adapt to changes in external factors. Insufficient research of our endemic species and insufficient awareness of the general public does not contribute to their protection in nature.

The whole fish community of this area is endangered due to various human activities and their actions often have a synergistic effect. Fish are very sensitive to changes in flow rate, river blockage, habitat degradation, warming, and intensive water use. Although there have been many negative anthropogenic impacts in recent years on the Trebižat River, especially from hydropower and irrigation exploitation, unchecked urbanization and tourism, the analyses of aquatic organisms and river ecology still show a high diversity, despite high level of endangerment.

Table 1. Results of the study of the current state of the ichthyopopulation of the Trebižat River

Family	Species	Population of the study percentage		Male population percentage		Female population percentage	
Salmonidae	Trout *(Salmo truta m. fario)* Linnaeus, 1758.	5	5,5%	4	5,80%	1	4,54%
Salmonidae	Neretva's soft-mouthed trout *(Salmothymus obtusirostris oxyrhynchus)* Steindachner, 1882.	6	6,60%	4	5,80%	2	9,09%
Cyprinidae	Neretva chub (*Leuciscus svallize*) Heckel et Kner, 1858.	17	18,68%	14	20,29%	3	13,63%
Cyprinidae	Neretvan Nase (*Chondrostoma knerii*) Heckel, 1834.	15	16,48%	13	18,48%	2	9,09%
Anguillidae	European eel (*Anguilla anguilla*) Linneaus, 1758.	3	3,29%	1	1,45%	2	9,09%
Escoidae	Pike (*Esox lucius*) Linneaus, 1758.	45	49,45%	33	47,82%	12	54,54%
Total population		**91**	**100%**	**69**	**75,82%**	**22**	**24,18%**

Chart 1. Ratio of the male and female population from the species Salmonidae, Cyprinidae, Anguillidae, Escoidae in the Trebižat River.



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