

## A REVIEW OF FRESHWATER ICHTHYOFAUNA RESEARCH PUBLISHED IN THE CROATIAN JOURNAL OF FISHERIES SINCE 1938

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### ABSTRACT

This paper represents a contribution to the knowledge of studies in ichthyology of Croatian open freshwaters published in the Croatian Journal of Fisheries from 1938 till 2014. Collected data provide information on the trends in Croatian ichthyology and give directions for further research. 80 papers all together were published. Overall analysis showed that majority of papers dealt with fish populations of open freshwaters, especially with analysis of fish condition and length-weight data, while papers related to the fish pathology were present in smaller numbers. Molecular analyses of fish population were not reported in this review. For the purpose of major contribution to the protection and quality management of Croatian ichthyofauna, further promotion and development of the Croatian Journal of Fisheries is required.

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## INTRODUCTION

Fish communities are excellent indicators of environmental stresses introduced by anthropogenic changes. Therefore, ichthyological studies provide valuable data relevant for the conservation of the environment, as wells as for sustainable fishing management.

In previous decades a lot of valuable scientific information was published in local journals, so they were less accessible and influential. The Croatian Journal of Fisheries began as such a journal in 1938 and since then it has been continually edited (Fig. 1).

However, over the years it has passed through a tremendous transformation. The first name of the Journal was Ribarstvo Jugoslavije (Fisheries of Yugoslavia), which was shortened into Ribarstvo (Fisheries) after the dissolve of Yugoslavia. Nowadays, the Journal has changed the name into the Croatian Journal of Fisheries (CJF) and it is published by the University of Zagreb, Faculty of Agriculture, Department of Fisheries, Beekeeping, Game Management and Special Zoology (Fig. 2).

During the time, not only the name has been changed but



Fig 1. Cover page of the first issue of the Journal published in 1938

also the approach of the Journal and the concept and content of the papers. In the beginning, the majority of papers were devoted to the growing freshwater aquaculture and popular scientific papers were mostly presented. However, over the years papers that cover open freshwater fish communities



**Fig 2.** Cover page of the recent journal issue with the photo of three-spined stickleback (*Gasterosteus aculeatus* L. 1758)

have been taking higher share and today only scientific papers are published (Habeković, 2000). Therefore, the objectives of this paper were: (1) to make historical analysis of papers published in the Croatian Journal of Fisheries, (2) to describe the development of the Croatian freshwater ichthyology and (3) to give directions for further ichthyological research in Croatia.

## MATERIALS AND METHODS

A short review of studies in ichthyology of Croatian open freshwaters is presented according to the papers published in the Croatian Journal of Fisheries from 1938 till 2014. It also covers papers that were published in the journals *Ekologija* (1973 - 1989) and *Ichthyologia* (1970 - 1990), which were partially included in ichthyological studies in Croatia. Additionally, collected papers were divided into six groups, according to the main topic.

**Table 1.** The list of papers published from 1938 - 2014 according to the journals and related scientific field

Journal	Croatian Journal of Fisheries	Ekologija	Ichthyologia	Total
Investigations of rivers	22	0	0	22
Investigations of lakes	7	0	0	7
Fish morphology	9	0	0	9
Fish condition and length-weight relationships	24	0	0	24
Fish health	3	2	0	5
Endangered fish species	13	0	0	13
<b>Total</b>	<b>78</b>	<b>2</b>	<b>0</b>	<b>80</b>

## RESULTS

All together, 71 papers divided into six groups according to the main topic (Tab. 1) were registered in the Croatian Journal of Fisheries. However, a few papers cover several topics so they were classified into several groups and therefore the total number of papers is 80. In *Ichthyologia* we have registered only two papers, while in *Ekologija* we have not found any paper related to this topic.

The majority of published papers were related to the studies of open freshwaters populations, especially in rivers, while papers related to the fish pathology were present in smaller numbers (Table 1). Also, this review showed that almost all regions of Croatia were covered by various ichthyological studies, except Istria, small freshwaters on the south of Croatia and on the islands (Fig. 3).



**Fig 3.** Light micrograph of diseased *Clarias batrachus* showing haemocyte infiltration (HI) and necrosis of muscle tissue (N), 1b. inflammation of epidermal tissue (I), rough epidermal layer (RE), extensive necrosis of muscle (EN) and fibrosis (F), 200X H&E staining

### Investigations of rivers

The River Sava is the longest Croatian river and it has been explored several times, mostly in order to investigate the influence of Slovenian-Croatian Krško nuclear power plant. In the last three decades several studies have showed that the Krško nuclear power plant did not significantly affect fish populations, because balanced age and sex structure was recorded (Habeković et al., 1990, 1997; Habeković and Popović, 1991). This part of the river is dominated by chub (*Squalius cephalus* L. 1758), bleak (*Alburnus alburnus* L. 1758) and roach (*Rutilus rutilus* L. 1758). Also, Habeković et al. (1990) registered stable population of brown trout (*Salmo trutta m. fario* L. 1758). During that period, Habeković and Popović (1991) registered the first appearance of invasive Asian stone moroko (*Pseudorasbora parva* Temminck & Schlegles 1846).

The downstream area of the River Sava and its wider catchment area were also investigated. This includes studies of the River Odra (Sabioncello et al., 1969), Bliznec Stream (Piria et al., 2009), area around Nova Gradiška (Delić, 1984), the River Ilova and its tributaries - Česma, Grđevica and Peratovica (Delić, 1989, 1993; Jelić et al., 2009, 2010). The dynamic of their ichthyocenoses was presented with the emphases on the relationship between autochthonous and allochthonous species, the influence of pollutions as well as the escapes from the big carp farm, Končanica. In this area two endemic species were recorded, Balkan loach (*Cobitis elongata* Heckle & Kner 1858) and striped ruffe (*Gymnocephalus schraetser* L. 1758) (Delić 1993). Flooded area of Lonjsko polje Nature Park is a valuable landscape, important for the spawning and growth of many species. Consequently, limnophilic species prevail, with Northern pike (*Esox lucius* L. 1758) as the main predator (Bakota et al., 2003). Also, it is important to mention the presence of pumpkinseed (*Lepomis gibbosus* L. 1758), an invasive freshwater fish from North America that negatively affects native fish populations (Bakota et al., 2003).

The second largest Croatian river is the Drava which is very suitable for the building of hydroelectric power plants due to considerable elevation differences. Therefore, Habeković et al. (1986) monitored changes within fish populations of the River Drava as the result of construction of dams and habitat fragmentation. They recorded, still active at the time, process of changes of rheophilic fish communities into limnophilic and neutrophilic. Furthermore, downstream at Donji Miholjac, Jelić et al. (2012) found nine allochthonous species and a cultured form of common carp (*Cyprinus carpio* L. 1758) that slowly prevails, compared to the wild form.

Although the River Danube, the second largest European river, passes 137 km along the Croatian-Serbian border, papers in CJF are more oriented to the Serbian part of the river. However, Ristić (1970) presented interesting investigation of fish migrations along this river. He marked a few fish species: common carp, freshwater bream (*Abramis brama* L. 1758), sterlet sturgeon (*Acipenser ruthenus* L. 1758), pike-perch (*Sander lucioperca* L. 1758) and Wels catfish (*Silurus glanis* L. 1758), released them and checked when they were caught again. The results showed that common carp and Wels catfish performed short migrations, contrary to sterlet sturgeon, freshwater bream and pike-perch. The important part of the Danube River flooded area is the Kopački rit National Park. Homen et al. (1991) found out that, besides native fish species, invasive Prussian carp (*Carassius gibelio* Bloch 1782) participated significantly in the catch.

The rivers that drain into the Adriatic Sea basin are well known for many endemic species. Habeković et al. (1992) mentioned two of them in the rivers of the Lika region, Croatian pijor (*Telestes croaticus* Steindachner 1866) and South Dalmatian minnow (*Delminichthys ghetaldii*

Steindachner 1882). These waters were dominated by brown trout but, aiming to increase fishing capacity, they were populated with common carp and some other cyprinid species. In order to eradicate them and reconstitute the previous state, Northern pike was introduced (Anonymous 1968). Paradoxically, Plančić et al. (1953) previously reported that the same species already existed in another river in this area, where it endangered native brown trout.

The estuary of the River Neretva was investigated by Sulić Šprem et al. (2012). As the result of the marine influence, most of the present fish species were marine. The same situation is at the estuary of the second largest Adriatic river, the Krka (Basioli, 1958). The author also differentiates two upstream parts, divided by waterfalls. After the spring, the river is fast running and cold, inhabited by the endemic Adriatic trout (*Salmothymus obtusirostris krkensis* Karaman 1926). The middle part of the river forms a lake inhabited by a typical lake form of brown trout. Here it is present at a lower altitude than usual (Taler, 1951b). It is important to mention the investigation of the distribution of bullhead (*Cottus gobio* L. 1758) in several Dalmatian rivers with new localities (Jelić, 2012).

### Investigations of lakes

In the review of the papers, the ones that speak about ichthyofauna of the lakes as a special ecosystem are separately studied.

Vransko Lake, Dalmatia Region, is the largest Croatian lake. Fijan (1949) described the attempts to enhance the fisheries in this lake after World War II by introducing common carp from the continental part of Croatia. Although initially it showed a very high growth rate, later Basioli (1960) recorded a negative rate. It is a result of overpopulation and the fact that some other species, like Wels catfish and pumpkinseed, were also introduced. Similarly, the stocking of rainbow trout (*Oncorhynchus mykiss* Walbaum 1792), introduced into the Plitvice Lakes in 1935, resulted in the change of fish and other aquatic communities and in reducing the number of native brown trout (Bogdanović, 1958).

The Cetina River has a huge hydro potential and several dams were built, forming artificial lakes. Investigations done by Habeković (1993, 1994a, 1994b) at Prančevići Reservoir showed a mixed cyprinid and salmonid fish community. Several allochthonous species were introduced but two endemic species were still dominant, Illyric dace (*Squalius illyricus* Heckel et Kner 1858) and ukliva dace (*Telestes ukliva* Heckel 1843). Two other endemic taxons were also present, Dalmatian spined loach (*Cobitis dalmatina* Karaman 1928) and Dalmatian barbellgudgeon (*Aulopyge huegellii* Heckel 1842).

In the alluvial valleys of northern Croatia, many gravel pits have been formed. The anthropogenic ichthyofauna of one of them, Vukovina, was investigated by Jakovlić and Treer (2001), showing the dominance of pumpkinseed.

## Fish morphology

Fish morphology refers to the various anatomical features amongst fish species. The review of importance of meristic and morphometric traits is done by Treer (1993). Morphometric traits are strongly influenced by present ecological conditions. This was documented by Treer et al. (1995) on the population of common carp from Vransko Lake. Additionally, comparative analysis of morphology of common carp from open waters and carp farms showed clear differences between them (Tomljanović et al., 2011). Similar observations were made for brown trout by Taler (1951b, 1959) at Lake Visovac and the Plitvice Lakes, and by Štefanac and Bunjevčić (1982) at the River Gacka.

Jakovlić and Treer (2001) compared the morphology traits of a few species with the ones described from the key of Yugoslavian freshwater fish species (Vuković and Ivanović, 1971). They found out that the number of scales above and below the lateral line differs from the data in the key for European perch (*Perca fluviatilis* L. 1758), chub and pumpkinseed. Similar differences were found for roach by Šprem et al. (2001) and for chub, Mediterranean barbel (*Barbus meridionalis* Risso 1827), barbel (*Barbus barbus* L. 1758), Schneider (*Alburnoides bipunctatus* Bloch 1782) and bleak by Domitrović et al. (2004). They concluded that these complex problems should be investigated further.

## Fish condition and length-weight relationships

The studies of variables such as condition factor and length-weight relationship are valuable and widely used tools, important in studying fish biology, conservation and sustainable management (Jakovlić and Treer, 2001; Bakota et al., 2003; Prpa et al., 2007).

These variables are influenced by various ecological and biological factors and they are often used to record a response of a specific organism toward a particular factor. This was used by several authors who documented the relationship between the growth rate and condition of chub with water pollution (Habeković et al. 1993), geographical location, water temperature and food availability (Treer et al. 1997; Piria et al. 2009). Chub was an excellent model organism as this is a eurytopic species that inhabits different water systems in Croatia, so these results are comparable. Similar analyses were performed by several authors.

Habeković (1994a, 1994b) recorded a good growth rate at Prančevići Reservoir on the Cetina River, while Jakovlić and Treer (2001) observed poor growth of fish in oligotrophic gravel pit. Delić (1985) analyzed the growth in length and weight of the fish community from the waters of Nova Gradiška, and Sabioncello et al. (1969) from the River Odra. At the Lonjsko polje Nature Park, Bakota et al. (2003) concluded that present ichthyofauna has exceptionally good growth and high condition factor, which confirms the importance of this ecosystem.

The growth and condition of different salmonid species in Croatia was thoroughly investigated (Sabioncello et al. 1970; Homen and Fašaić, 1981; Popović and Fašaić, 1982; Šprem et al., 2005; Treer et al., 2005). Northern pike was analyzed from the River Drava and Kruščica Reservoir (Popović, 1991; Treer et al., 1998), common carp from Vransko Lake (Sabioncello et al., 1964; Treer et al., 1995), rudd (*Scardinius erythrophthalmus* L. 1758) from Ključić Brdo Pond (Piria et al., 2011), Illyric dace from the Cetina River (Popović 1994), loaches (*Cobitis elongata* and *C. elongatoides* B. Cescu & R. Mayer 1969) from the Sava River (Ivelić et al., 2007) and European eel (*Anguilla anguilla* L. 1758) from six karst catchments of the Adriatic basin (Piria et al. 2014). Beside these analyses, Piria et al. (2007) made gut analysis of Balkan barb (*Barbus peloponnesius* Valenciennes 1842) from the River Sava. Younger specimens fed on plant and animal food, while bigger ones preferred animal component. At the estuary of the River Neretva, Bartulović et al. (2010) studied the growth of two mullet populations – golden grey mullet (*Liza aurata* Risso 1810) and flathead grey mullet (*Mugil cephalus* L. 1758).

## Fish health

Fish health status is a result of synergistic effect of various infections and anthropogenic pollutions and therefore it is a good indicator of problems in aquatic ecosystems.

Mass dying of European eel in Vransko Lake was reported by Plančić (1953). It was caused by bacteria *Vibrio anguillarum* and it was visible through red spots on the head and below anal and caudal fins. Čanković et al. (1972) recorded the presence of endohelminths in salmonids from the watercourses in the Neretva River basin.

Study of lipids in trouts at the Plitvice Lakes showed that rainbow trout has a higher lipid rate in contrast to domestic brown trout (Hrženjak and Ehrlich 1981). This study confirmed that rainbow trout is invasive species with aggressive feeding behavior and high adaptive capability to new environmental conditions.

Kurtović et al. (2007; 2009) investigated the health of chub in the Sava River. Bacteriological water analysis showed high number of bacteria in the water, which was positively correlated with the structural changes of internal organs. Also, correlation with the occurrence of ichthyophthiriasis and trichodiniasis was observed.

## Endangered fish species

Most of the endangered endemic fish species in Croatia belong to salmonids and cyprinids. They are endangered by meliorations and industrial pollution (Taler, 1951a), construction of dams, habitat fragmentation (Sabioncello 1962), overfishing and unprofessional stocking (Popović 1985) and poaching (Skalin 1990).

Several papers deal with different populations of Adriatic

trout in the rivers Krka, Jadro, Žrnovnica and Neretva in Dalmatia (Taler, 1950, 1951a, 1951c; Tomljanović et al., 2012). Successful use of Whitlock-Vibert boxes for hatching of brown trout was presented by Turković et al. (2006). Delić et al. (1997) pointed out that mudminnow (*Umbra krameri* Walbaum 1792) is the most endangered species in the Danube catchment area. It inhabits small ponds and old river bayous rich with vegetation which is rapidly decreasing. The other mentioned endangered species are grayling (*Thymallus thymallus* L. 1758) (Sabioncello 1962), several brown trout populations, marble trout (*Salmo marmoratus* Cuvier 1829, Croatian dace (*Telestes polylepis* Steindachner 1866), minnows from the genus *Phoxinellus*, huchen (*Hucho hucho* L. 1758), Neretva chub (*Squalius svallize* Heckel & Kner 1858), Tursky dace (*Telestes turskyi* Heckel 1843), Mostar minnow (*Phoxinellus pseudalepidotus* Bogutskaya & Zupančić 2003) (Taler, 1950, 1951a, 1951b, 1951c; Sabioncello, 1962; Skalin, 1990; Piria et al., 2012; Mihnjač et al., 2014a, 2014b).

## CONCLUSION

The Croatian Journal of Fisheries has significantly contributed to the development of ichthyology in Croatia. Collected information showed the current trend in studies but also pointed out their weaknesses. In the last decades, new research trends in ichthyology have emerged and many papers on Croatian ichthyofauna have been published in other international journals. Therefore, some studies, although existing, are missing in this Journal, as those on the fish molecular genetics. A more dedicated approach is needed in the future, especially in the case of protection and revitalization of endangered fish population. Therefore, it is necessary to improve the quality of the Journal, to work on its actualization and promotion, which would finally contribute to the further protection and quality management of Croatian ichthyofauna.

## Sažetak

## PREGLED ISTRAŽIVANJA SLATKOVODNE IHTIOFAUNE HRVATSKE OBJAVLJENIH U ČASOPISU RIBARSTVO OD 1938. GODINE

Rad predstavlja doprinos poznavanju istraživanja slatkovodne ihtiofaune otvorenih voda Hrvatske koja su objavljena u časopisu Ribarstvo od 1938. do 2014. godine. Prikupljeni podaci daju uvid u promjene razvoja hrvatske ihtiofaune, kao i smjernice budućih istraživanja. Ukupno je zabilježeno 80 radova. Najzastupljeniji su radovi koji obrađuju ihtiofaune otvorenih slatkih voda te zakonitosti njihova rasta i kondicije, dok se manji broj radova odnosi na istraživanja zdravstvenog stanja riba. Radovi u kojima su ihtiofaune obrađene na molekularnoj razini

u potpunosti izostaju. Zbog velikog doprinosa u pravilnom gospodarenju i zaštiti ribljih populacija, potrebna je daljnja promocija i aktualizacija časopisa Ribarstvo.

**Ključne riječi:** rijeke, jezera, kondicija, dužinsko-maseni odnos, morfologija, ugrožene vrste

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