Sveučilište u Zagrebu
Agronomski fakultet

University of Zagreb
Faculty of Agriculture

Characterization of freshwater fish assemblages from small streams in the Sava river basin

MASTER'S THESIS

Petra Štefanac Šporčić

Zagreb, September 2020.

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Diplomski studij:

Graduate study programme:

Environment, agriculture and resource management (INTER-EnAgro)

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Mentor: prof. Marina Piria

Zagreb, September 2020.

STUDENT'S STATEMENT

ON ACADEMIC RECTITUDE

I, **Petra Štefanac Šporčić**, JMBAG 0066199223, born on 4th of July 1990 in Zagreb, declare that I have independently written the thesis under the title of

Characterization of freshwater fish assemblages from small streams in the Sava river basin

With my signature, I guarantee:

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REPORT

ON EVALUATION AND MASTER'S THESIS DEFENSE

Master's thesis written by **Petra Štefanac Šporčić**, JMBAG 0066199223, under the title of

Characterization of freshwater fish assemblages from small streams in the Sava river basin

Is defended and evaluated with the grade______________________, on
____.

Committee for thesis evaluation and defense:

1. Mentor prof. Marina Piria
2. Committee member assist. prof. Daniel Matulić
3. Committee member assoc. prof. Tea Tomljanović

Acknowledgement

I would first like to thank my mentor prof. Marina Piria for her guidance and help in the process of writing this thesis. I would like to thank her for answering all my questions and providing me with a topic that enriched my knowledge and taught me how to conduct a research.

I would also like to thank the committee members: assoc. prof. Tomljanović and assist. prof. Daniel Matulić for their validation.

Most important, I would like to thank my parents and grandmother, for providing me with endless encouragement through my education, never asking anything in return.

In the end, I would like to thank my fiancé Lovro for always being there and never doubting my dreams.

This Thesis is dedicated to my late grandfather.

Thank you.

Petra

TABLE OF CONENTS

SUMMARY

Of the master's thesis – student **Petra Štefanac Šporčić,** entitled

Characterization of freshwater fish assemblages from small streams in the Sava river basin

The Sava river has always been a source of good quality food for local inhabitants, but the number of fish deteriorated in the second half of the 20th century. Reasons for such losses were changes of flow characteristics of watercourses such as streams and channels which consequently lead to the altered hydrological regime, ground water levels, temperature, quantity of dissolved oxygen, concentration of nutrients in the water, and flow rate. These changes most often result in the loss of species, with the common introduction of new resistant species. The purpose of this research was to determine the composition of ichthyocenosis of small streams and canals located in eastern Croatia, to determine the dominance of species and diversity of communities between different watercourses. Additionally, ecological stress of fish communities was investigated. Species richness, Margalef's index, Simpson's index and Shannon Weawer index were used to investigate fish diversity and ABC index to determine ecological stress. Dominant native species in investigated streams were chub (*Squalius cephalus*) and gudgeon (*Gobio gobio*) while the most dominant alien species were Prussian carp (*Carassius gibelio*) and pumpkinseed (*Lepomis gibbosus*). Dominant native species in investigated channels were bleak (*Alburnus alburnus*) and European perch (*Perca fluviatilis*) while the most dominant alien species were Prussian carp (*Carassius gibelio*) and pumpkinseed (*Lepomis gibbosus*). The highest number of specimens was caught in the Reka stream while the highest number of species richness was found for the Gradnica stream. Margalef index was the highest for the Utinja stream, Simpson index for the Reka stream and Shannon Weawer index for the confluence of Okičnica and Gonjava. According to ABC index, all sampled waterbodies and all identified fish communities were under moderate or heavy stress. This led to conclusion that fish communities in most of streams were under anthropogenic influence. Very low number of predatory fish species (only chub is present in a higher percentage) were found and mostly small short-lived species dominated. Lower number of species has been recorded in the canals, in comparation with streams, and number of specimens of alien species predominate in sample. It is necessary to reduce pollution and human impact on small streams to eliminate stress for aquatic organisms in general, which is only model how to successfully recover native fish communities.

Keywords: Sava tributaries, ichthyocenosis, streams, channels, diversity index, stress

1. INTRODUCTION

The Adriatic Sea basin in Croatia is characterized by short and isolated karst river catchments while the Black Sea Basin represents the Danube River with vast areas of inland water network dominated by two large rivers, Sava and Drava (Piria et al., 2018). The importance of the Sava river through history lies in its commercial and recreational fishing as a basic source of good quality food for local inhabitants, but the number of catch rapidly declined in the second half of the 20th century and available resources remarkably deteriorated (Habeković et al., 1990).

In the time space of the last 100 years there were various changes in the riverbed of the Sava river, primarily for the purpose the mining industry in Slovenia in the 1920s, which emitted carbon dust into the Sava River. At the same time, the construction of embankments to mitigate flooding started in the middle section. Furthermore, in the 1980s, the Krško nuclear power plant (NPP), and in the 2010s, the Krško hydropower plant (HPP) were built in Slovenia (Piria et al., 2019). Five major threat categories to freshwater biodiversity have been identified: flow modification; destruction or degradation of habitats; overexploitation; water pollution; invasion by exotic species (Dudgeon et al., 2006). The construction of nuclear (NPP) and hydropower plants (HPP) and their hydrological effects can significantly affect aquatic habitats, organisms and river ecosystem processes (Teixeira et al., 2012; Tonolla et al., 2017). These specific activities cause harm to the composition of fish communities downstream from the major sources of disturbances. The disturbances resulted in the habitat loss of fish species in the main stream and also the changes in the flow of small streams of Sava tributaries has been observed (Piria et al., 2019). Consequently, these disturbances possibly alter the habitat quality of fish in channels. Changes of flow characteristics of watercourses such as streams and channels causes changes in the physicochemical properties of the water, as seen in the altered hydrological regime, ground water levels, temperature, quantity of dissolved oxygen, concentration of nutrients in the water, and flow rate. These changes most often result in the loss of species, with the common introduction of new resistant species (Ćaleta et al., 2015).

The introduction of alien species together with anthropogenic habitat loss and degradation, hydrological alteration and pollution often act synergistically towards the reduction or extinction of native freshwater fish species. Invasive species are often superior competitors in relation to the evolutionary isolated native species populations, and they have broader environmental tolerances, being thus able to thrive in degraded habitats (Piria et al., 2018). Alien species of freshwater fish can enter new areas by intentional or unintentional introduction. Many freshwater fish were introduced for ornamental purposes and were deliberately released or escaped into the wild to establish populations. This was the pathway for pumpkinseed *(Lepomis gibosus*) introduction. Also, for fishing purposes, species such as topmouth gudgeon (*Pseudorasbora parva*) were translocated from the Danube to the Adriatic basin. Freshwater fish species can also be transported on hulls and ballast waters and independently through water corridors (Boršić et al., 2018). Pumpkinseed and topmouth gudgeon are on the list amongst the most invasive species alien species in Europe due their wide distribution and serious threat to native species (Piria et al., 2017).

Replacement of common species by formerly rare, absent or alien species could be related to urbanization and impoundment. Urban zones and sections downstream of impoundments are suitable for species tolerant to controlled flows, siltation, channelization, homogenous spawning substrates, and elevated temperatures. Also, barrier-free headwater and agriculture zones with abundant riparian vegetation supporting community's intolerant of controlled flows, dependent on lower summer water temperatures (Fitzgerald et al., 1997).

Greater understanding of the causative forces shaping fish communities can be used to facilitate integration of greater biological realism into any future conservation or restoration programs in anthropogenically-modified streams (Fitzgerald et al., 1997).

Therefore, it is important to describe the assemblages of ichthyocenosis from smaller streams and channels in Croatia in order to determine fish community structure and intensity of ecological stress on those communities.

1.1. Hypothesis and aims

The hypothesis of this research is that there is a difference between the composition of ichthyofauna in streams and canals, which occurs because of habitat change. Also, it is assumed that there is no difference of ichthyocenosis between the first 100m and other 100m of sampling on streams.

The specific objectives of this study were to:

(1) determine the composition and structure of ichthyocenosis of small streams and canals, located in eastern Croatia;

(2) determine the diversity of communities between different watercourses;

(3) determine the dominant species in streams and in channels; and

(4) determine intensity of ecological stress of ichthyocenosis.

2. MATERIALS AND METHODS

2.1. Study area

For the purpose of this thesis 15 streams and 6 channels in the vicinity of Karlovac and Jastrebarsko have been sampled. All of them are connected to the Sava River and belong to the Sava River Basin. Examined waterbodies were all marked by appropriate code for easier distinction. Their names, codes, time of sampling, and average depth of the waterbodies are shown in the table below (Table 2.1.1.)

Table 2.1.1. Sampling sites, codes,date of sampling, and average depth of the waterbodies

Waterbody	Code	Sampling date	Average depth of waterbody	GPS position	
Streams				x	y
Gradnica	GRD1	19.06.2019	40cm	437091,934300	5034816,873000
Utinja	UTI2	19.06.2019	1m	438199,612400	5034930,598000
Utinja Bukovica	UTB3	21.06.2019	1m	439358,519500	5028545,526000
Trebinja	TRB4	21.06.2019	0,3 m	434118,796700	5032322,350000
Kupčina Krašić	KKR5	26.06.2019	70 cm	424009,408218	5057753,805161
Malunjčica	MAL6	26.06.2019	0,5 m	432177,905118	5057892,612397
Confluence Malunje and Volavčice	UMV7	26.06.2014	70 cm	431658,413142	5056417,535201
Lomnica	LOM8	04.07.2019	60 cm	460634,388600	5063280,904000
Lipnica	LIP9	04.07.2019	30 cm	454605,075000	5054793,095000
Rečica	REČ10	02.07.2019	30 cm-1 m	434237,256000	5038960,243000

Brebernica	BRB11	27.06.2019	30 cm	443392,927848	5059134,566001
Reka	REK12	26.06.2019	30 cm		
Confluence Okičnica and Gonjava	UOK13	03.07.2019	30 cm	438997,235175	5056317,483591
Okičnica	OKK14	03.07.2019	1,5 m	439124,938832	5053705,411430
Skakavac	SKK15	02.07.2019	30 cm	437165,070000	5035845,000000
Channels					
Pisarovina output channel	PIS1	28.06.2019	1m	449943,047290	5046455,956401
Connecting channel Draganić	SKD2	02.07.2019	50 cm	433244,019000	5045800,225000
Bukovac	BUK3	02.07.2019	50 cm	432802,290000	5045576,947000
Tešnjić	TEŠ4	02.07.2019	1 m	440134,962000	5044788,308000
Crna mlaka input channel	CMU5	03.07.2019	1,5-2 m	440331,072442	5053253,868082
Ličnik	LIČ6	03.07.2019	1m	440062,663724	5049949,681048

Most of streams have not been under visible antropogenic threat except Lomnica, Lipnica and Okičnica (Fig. 2.1.1.-2.1.15). Chanels are formed artificially mainly for purpose of pond water supply (Fig. 2.1.16.-2.1.20.)

Figure 2.1.1. Gradnica stream

Figure 2.1.2. Utinja stream

Figure 2.1.3. Utinja Bukovica stream

Figure 2.1.4. Trebinja stream

Figure 2.1.5. Kupčina Krašić stream

Figure 2.1.6 .Malunjčica stream

Figure 2.1.7. Confluence Malunje and Volavčice

Figure 2.1.8. Lomnica stream

Figure 2.1.9. Lipnica stream

Figure 2.1.10. Rečica stream

Figure 2.1.11. Brebernica stream

Figure 2.1.12. Reka stream

Figure 2.1.13. Confluence Okičnice and Gonjave

Figure 2.1.14. Channelized Okičnica

Figure 2.1.15. Skakavac stream

Figure 2.1.16. Pisarovina channel

Figure 2.1.17. Channel Draganić

Figure 2.1.18. Bukovac channel

Figure 2.1.19. Tešnjić channel

Figure 2.1.20. Crna mlaka input channel

Figure 2.1.21. Ličnik channel

2.2. Sample collection

Sampling was carried out during the day in a period when the watercourse level was lower than the annual average. Electrofishing method was used to collect fish samples in the field. Electrofishing cannot be carried out during rainy weather, which is why the weather forecast plays a key role in determining the field dynamics of the research.

During field sampling fish species, two different sampling methods for streams and for channels were used.

During sampling in streams, the method of electrofishing by walking in the middle of the watercourse was used since all watercourses were very shallow (Table 2.1.1).

Two transects of 100m (2x 100 m) were sampled in streams with a distance of at least 500 m between each section.

The canals were also sampled by electrofishing walking along the shore or in the middle, depending on their depth and accessibility.

In contrast to the stream, the length of the sampling transect was 300 m during only one sampling per location.

Each locality was photo-documented. Scientific and english names of fish species were taken from Fishbase (Froese and Pauly., 2020). At each waterbody basic physico-chemical parameters were measured with portable multiparameter instrument: O_2 %, O_2 mg×L^{-1}, water temperature (ºC), pH and conductivity (COND).

2.3. Statistical analysis

All specimens in the sample were counted and a standard length (SL) of each specimen were measured. ANOVA was applied to test statistical differences between two ichthyocenosis sampled in each transect of investigated streams. Sampling has been done in the middle and lower part of chosen streams.

Species Richness, Simpson's, Margalef's and the Shanon Weaver index were used to determine the diversity of communities in streams and channels. ABC diagrams were used to determine fish community stress at each watercourse.

Species richness (N) associated with any given number of transects (sampling effort: two, three, up to ten) is represented as a mean value that was calculated using, in a random sequence, the entire set of the ten transects.

Margalef's indeks (d) represents a simple equation that reduces the bias in species richness caused by sample size (i.e., small samples are less likely to contain rare species than large ones) and is calculated as:

$$d = (S-1)/\ln(N)$$

where S is the total number of species observed and ln (N) is the natural log of the total number of individuals captured.

Simpson's indeks (SI) answer the question what is the probability that two individuals in a sample will be from the same species. Iti s calculated by following exuation:

$$SI = 1 - S n_i(n_i-1)/N(N-1)$$

where n_i is the number of individuals of species i and N is the total number of individuals.

Shannon-Weaver indeks (SWI) is developed by Shannon and Weaver (1949) with information theory, asks how additional information (i.e., larger sample size), contributes to our diversity estimate. This index assumes that all species are represented in a sample and are sampled randomly. Iti s calculated as:

$$SWI = -S p_i \ln(p_i)$$

where p_i is the proportion of a sample consisting of individuals from species i.

ABC (Abundance biomass comparison) diagram and ABC indeks

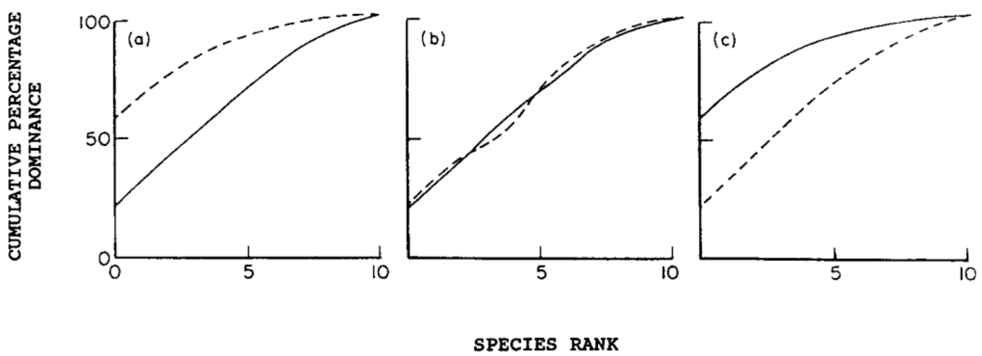
Shows if a certain fish community is in a state of stress. Total biomass of each fish species was calculated based on average Croatian length weight relationship according to Treer et al. (2008).

To compare data sets from different study sites, ABC's are converted into an index. We use the ABC index proposed by Meire and Dereu (1990). This index is calculated as the average of the difference between cumulative biomass and abundance.

The ABC indeks is calculated by subtracting the percentage from the biomass percentage for every two species, which belong to the same number on the ordinate. The values obtained are summed and then divided by the total number of species. This is expressed by the following formula:

$$ABC = (\sum Bi - Ai) \times N-1$$

Bi is the percentage dominance of species i and Ai the percentage dominance of species i. N is the total number of species. The number of times the cumulative percentage dominance for biomass is higher than the cumulative percentage dominance for abundance can be totaled and expressed as the percentage of the total number of species minus one (Coeck et al., 1993). If the ichthyocenosis is not in a state of stress, the result obtained will be a positive number because the biomass curve goes above the abundance curve. Of course, a negative result will show that the ichthyocenosis is in a state of stress, while values around zero will indicate a state of moderate stress (Figure 2.3.1.).



1. Hypothetical K-dominance curves for species abundance (——) and biomass (— — —), showing unstressed (A), moderately stressed (B) and heavily stressed (C) conditions (after Warwick, 1986)

Figure 2.3.1. ABC diagram explanation (Coeck et al., 1993)

3. RESULTS

3.1. Water quality of investigated streams and channels

Water quality parameters of investigated streams and channels varied greatly. The average measured temperature in 15 investigated streams was 21.72 ºC with the highest measured in stream Reka (26.6 ºC) and lowest measured in stream Kupčina Krašić (17.7 ºC). Water dissolved oxygen resulted the highest in stream Kupčina Krašić (10.23 mg×L^{-1}) and the lowest in stream Skakavac (2.05 mg×L^{-1}). The highest oxygen saturation measured was at Confluence of Malunja and Volavčica (115.3%) and the lowest measured in Skakavac (24%). The average measured pH in streams was 7.07, highest measured at Confluence Malunje and Volavčice (8.39) and lowest in stream Gradnica (6.97). Water Conductivity in Lipnica had the highest value (808) and Gradnica the lowest (69.9).

In comparison to streams, the average measured temperature in 6 investigated channels was 3.83 degrees higher (25.5 ºC). Water dissolved oxygen varied more than in streams with the highest value in channel Draganić (16.11) and lowest in channel Ličnik (2.7). The highest oxygen saturation in channel Tešnjić (112.4%) and lowest in channel Crna mlaka (29.7%). The average measured pH in channels was 7.53, highest measured in channel Draganić (8.49) and lowest in channel Pisarovina (6.94), (Table 3.1.1).

Table 3.1.1. Water quality parameters of (Oxygen = O_2 %, O_2 mg×L^{-1}; temp = water temperature (ºC), pH and COND=conductivity)

Waterbody	O_2		temp	pH	COND
	%	mg×L^{-1}	ºC		
Streams					
Gradnica	86.21	7.64	19.5	6.97	69.9
Utinja	89.1	8.27	18.3	7.42	146.4
Utinja Bukovica	86.3	8	18.4	7.53	169.7
Trebinja	97.1	8.45	21.6	7.23	89.5
Kupčina Krašić	108.3	10.23	17.7	8.22	583
Malunjčica	85.6	7.46	22.3	8.09	582

Confluence Malunje and Volavčice	115.3	9.43	23	8.39	586
Lomnica	74.3	6.09	23.8	7.42	442
Lipnica	44.9	4.05	20.2	7.64	808
Rečica	43.6	3.87	20.8	7.31	443
Brebernica	101.5	8.5	23.8	7.46	230
Reka	113	9.02	26.6		586
Conluence Okičnice and Gonjave	60.3	5.13	20.9	7.88	548
Okičnica	62.6	5.4	25.1	7.57	511
Skakavac	24	2.05	20.3	7.05	159
Channels					
Pisarovina output channel	50.5	4.18	24.6	6.94	138.8
Connecting channel Draganić	74.9	16.11	26.8	8.49	537
Bukovac	71.5	5.35	25.8	7.68	459
Tešnjić	112.4	9.32	28.6	7.55	443
Crna mlaka input channel	29.7	2.47	24.8	7.33	410
Ličnik	31	2.7	22.7	7.23	249

3.2. Fish assemblages of investigated streams

30 species were recorded during the research of 15 streams. The most frequent species in every investigated stream were chub (*Squalius cephalus*) and gudgeon (*Gobio gobio*). Species that occurred the least were Wels catfish (*Silurus glanis*), common dace (*Leuciscus leuciscus*), black bullhead *(Ameiurus melas),* common nase *(Chondrostoma nasus),* freshwater bream *(Abramis brama)* and tench *(Tinca tinca)*. Gudgeon was present with 99.2% in REK13 which is the highest specimen percentage amongst all streams, schneider (*Alburnoides bipunctatus*) following with 65% in KKR5, 62.9% in UMV7 and 51.1% in GRD1. As follows, chub was present with 46.4% in UTI2, 34.3% in UTB3, 34.8% in TRB4 and 30.1% in BRB11. Wels catfish had the smallest percentage in OKK14 with 0.8%, following with common dace in UTI2 with 1.8% and black bullhead with 1.6% in OKK14. The highest number of specimens was caught in REK12 (236) while the lowest number of specimens was in UTI2 (56) (Table 3.2.1., Appendix 1)

Table 3.2.1. Composition, number, percentage of species caught at each stream and percentage of alien fish species in sample with ANOVA test of differences between first and second sampling trial at the same stream (*alien fish species)

Species	GRD1		UTI2		UTB3		TRB4		KKR5	
	n	%	n	%	n	%	n	%	n	%
Schneider (*Alburnoides bipunctatus*)	68	51.1	15	26.8	7	10.5			145	65
Chub (*Squalius cephalus*)	6	4.5	26	46.4	23	34.3	54	34.8	19	8.5
Bleak (*Alburnus alburnus*)	28								3	1.4
European bitterling (*Rhodeus amarus*)		21.1								
Gudgeon (*Gobio gobio*)	8	6	1	1.8	18	26.9	63	40.6	1	0.4
Spined loach (*Cobitis elongatoides*)			2	3.6						
Common carp (*Cyprinus carpio*)										
Prussian carp (*Carassius gibelio*) *										
Common gudgeon (*Gobio obtusirostris*)	4	3	2	1.8						
Freshwater bream (*Abramis brama*)										
Mediterranean barbel (*Barbus meridionalis*)			2	3.6					32	14.4
Common nase (*Chondrostoma nasus*)			1	1.8						
Stone loach *(Barbatula barbatula*)	4	3			2	3	15	9.7		
Topmouth gudgeon (*Pseudorasbora parva*) *			1	1.8	5	7.5				
Eurasian minnow (*Phoxinus phoxinus*)	4	3					20	13	7	3.1
Common dace (*Leuciscus leuciscus*)			1	1.8						
Kessler's gudgeon (*Romanogobio kessleri*)										
Wels catfish (*Silurus glanis*)										
Brown bullhead (*Ameiurus nebulosus*) *					6	79				
European perch *(Perca fluviatilis*)	5	3.8								
Pumpkinseed (*Lepomis gibbosus*) *	4	3								
Rudd (Scardinius erythrophtalmus)									5	2.2
Northern pike (*Esox lucius*)	1	0.1								
Roach (*Rutilus rutilus*)										
Bullhead (*Cottus gobio*)			4	7.1	6	9			5	2.2
Balkan spined loach (*Sabanejewia balcanica*)	1	0.7	2	3.6			1	0.6	6	2.7
Balkan loach (*Cobitis elongata*)										
Tench (*Tinca tinca*)										
European brook lamprey (*Lampetra planeri*)							2	1.3		
Black bullhead (*Ameiurus melas*) *										
Percentage of alien specimens (%)	4	3	1	1.8	11	86.5	0	0	0	0
p values of ANOVA results	p< 0.01		p< 0.01		n.s.		p<0.01		p<0.01	
SUM	**133**	**100**	**56**	**100**	**67**	**100**	**155**	**100**	**223**	**100**

Table 3.2.1. Continued

Species	MAL6		UMV7		LOM8		LIP9		REČ10	
	n	%	n	%	n	%	n	%	n	%
Schneider (*Alburnoides bipunctatus*)	13	14.6	61	62.9	66	46.8				
Chub (*Squalius cephalus*)	26	29.2	8	8.3	15	10.6	25	19.1	18	18.9
Bleak (*Alburnus alburnus*)					3	2.1			1	1.1
European bitterling (*Rhodeus amarus*)	6	6.7			5	3.5	49	37.4	26	27.4
Gudgeon (*Gobio gobio*)	7	7.9	4	4.1	9	6.4	45	34.4	6	6.3
Spined loach (*Cobitis elongatioides*)	10	11.2			6	4.3			8	8.4
Common carp (*Cyprinus carpio*)										
Prussian carp (*Carassius gibelio*) *	7	7.9							12	12.6
Common gudgeon (*Gobio obtusirostris*)										
Freshwater bream (*Abramis brama*)										
Mediterranean barbel (*Barbus meridionalis*)	4	4.5	18	18.6	14	9.9				
Common nase (*Chondrostoma nasus*)										
Stone loach (*Barbatula barbatula*)	6	6.7	6	6.2			7	5.3		
Topmouth gudgeon (*Pseudorasbora parva*) *									1	1
Eurasian minnow (*Phoxinus phoxinus*)	7	7.9					4	3		
Common dace (*Leuciscus leuciscus*)										
Kessler's gudgeon (*Romanogobio kessleri*)					8	5.7				
Wels catfish (*Silurus glanis*)							1	0.8		
Brown bullhead (*Ameiurus nebulosus*) *										
European perch (*Perca fluviatilis*)	3	3.4			1	0.7			1	1
Pumpkinseed (*Lepomis gibbosus*) *									13	13.7
Rudd (*Scardinius erythrophtalmus)*										
Northern pike (*Esox lucius*)									2	2.1
Roach (*Rutilus rutilus*)					1	0.7			5	5.3
Bullhead (*Cottus gobio*)										
Balcan spined loach (*Sabanejewia balcanica*)					13	9.2				
Balkan loach (*Cobitis elongata*)									2	2.1
Tench (*Tinca tinca*)										
European brook lamprey (*Lampetra planeri*)										
Black bullhead (*Ameiurus melas*) *										
Percentage of alien specimens (%)	7	7.9	0	0	0	0	0	0	26	27.3
p values of ANOVA results	p< 0.01		p< 0.01		n.s.		p< 0.01		n.s.	
SUM	**89**	**100**	**97**	**100**	**141**	**100**	**131**	**100**	**95**	**100**

Table 3.1.1. Continued

Species	BRB11		REK12		UOK13		OKK14		SKK15	
	n	%	n	%	n	%	n	%	n	%
Schneider (*Alburnoides bipunctatus*)					55	29.9				
Chub (*Squalius cephalus*)	46	30.1	2	0.8	14	7.6			11	7.7
Bleak (*Alburnus alburnus*)					17	9.2	39	20.9	1	0.7
European bitterling (*Rhodeus amarus*)	46	30.1			44	23.9	8	4.3		
Gudgeon (*Gobio gobio*)	44	28.8	234	99.2	3	1.6			38	26.6
Spined loach (*Cobitis elongatioides*)							5	2.7		
Common carp (*Cyprinus carpio*)							2	1.1		
Prussian carp (*Carassius gibelio*) *					4	2.2	67	35.8		
Common gudgeon (*Gobio obtusirostris*)										
Freshwater bream (*Abramis brama*)							2	1.1		
Mediterranean barbel (*Barbus meridionalis*)	10	6.5								
Common nase (*Chondrostoma nasus*)										
Stone loach (Barbatula *barbatula*)	3	2							7	4.9
Topmouth gudgeon (*Pseudorasbora parva*) *	3	2			1	0.5	25			
Eurasian minnow (*Phoxinus phoxinus*)	1	0.7							86	60.1
Common dace (*Leuciscus leuciscus*)										
Kessler's gudgeon (*Romanogobio kessleri*)										
Wels catfish (*Silurus glanis*)										
Brown bullhead (*Ameiurus nebulosus*) *					12	6.5				
European perch (*Perca fluviatilis*)					10	5.4	12			
Pumpkinseed (*Lepomis gibbosus*) *					3	1.6	22			
Roach (*Rutilus rutilus*)					2	1.1				
Bullhead (*Cottus gobio*)										
Balcan spined loach (*Sabanejewia balcanica*)					16	9				
Balkan loach (*Cobitis elongata*)					3	1.6	1	0.5		
Tench (*Tinca tinca*)							1	0.5		
European brook lamprey *(Lampetra planeri*)										
Black bullhead (*Ameiurus melas*) *							3	1.6		
Number and percentage of alien specimens (%)	3	2	0	0	20	10.3	114	37.4	0	0
p values of ANOVA results	p< 0.01		p< 0.01		p< 0.01		n.s.		p< 0.01	
SUM	**153**	**100**	**236**	**100**	**184**	**100**	**187**	**100**	**143**	**100**

5 Alien fish species were documented during the investigation in 15 streams: Prussian carp (*Carassius gibelio*), topmouth gudgeon (*Pseudorasbora parva*), brown bullhead (*Ameiurus nebulosus*), pumpkinseed (*Lepomis gibbosus*) and black bullhead (*Ameiurus melas*). Streams GRD1, UTI2, UTB3, UMV7, REČ10, BRB11, UOK13 and OKK14 contained 174 specimens of listed alien fish species. 4 out of 5 species were found in OKK14 following with 4 out of 5 species in UOK13. OKK14 had the highest number of specimens (117) while UTI2 had the smallest amount (1). The most common specimen was Prussian carp (*Carassius gibelio*) with 90 specimens documented, following pumpkinseed (*Lepomis gibbosus*) with 41 specimens, topmouth gudgeon (*Pseudorasbora parva*) with 25 specimens, brown bullhead (*Ameiurus nebulosus*) with 18 specimens and black bullhead (*Ameiurus melas*) with 3 specimens. 82 specimens of alien fish species were documented in the first 100m of streams and 150 specimens were documented in the second 100m of streams. In GRD1, UTI2, MAL6, LIP9 and UOK13 we had occurrences of alien species in the first 100m but not in the second 100m while in UTB3 alien species appeared only in the second 100m (Table 3.2.1.)

Calculated p values of ANOVA results have shown significant differences ($p<0.01$) between ichtyocenosis in the first and second 100 meters of 11 investigated streams. 4 streams (UTB3, LOM8, REČ10 and UKK14) resulted with non-significant (n.s.) differences between the first and second 100 meters measured (Table 3.2.1.)

3.3. Fish assemblages of investigated channels

15 species were recorded during the research on 6 channels which is 15 less than those caught in streams. The most numerous species in each investigated channel were bleak (*Alburnus alburnus*) and European perch (*Perca fluviatilis*). Species that occurred in the low density were spined loach (*Cobitis elongatioides*), rudd (*Scardinius erythrophtalmus),* common dace *(Leuciscus leuciscus),* Balkan loach *(Cobitis elongata)* and barbel *(Barbus barbus).* Bleak was present with 70% in SKD2, 46.7% in LIČ6 followed by 45.4% in TEŠ4. As follows, Prussian carp (*Carassius gibelio*) was present in PIS1 with 61.4% and two other most frequent species in CMU5 were topmouth gudgeon (*Pseudorasbora parva)* 24.6 % and pumpkinseed *(Lepomis gibbosus)* 22.5%. Common dace had the smallest percentage amongst all species with 0.7% in CMU5. The biggest number of specimens was caught in CMU5 (138) while the smallest number of specimens was in SKD2 (30) (Table 3.3.1.).

Table 3.3.1. Composition, number (n) and percentage of species caught at each channel (*alien fish species)

Species	PIS1		SKD2		BUK3		TEŠ4		CMU5		LIČ6	
	n	**%**	**n**	**%**	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**
Chub (*Squalius cephalus*)	3	6.8	2	6.7			15	15.1				
Bleak (*Alburnus alburnus*)	1	2.3	21	70	14	21.2	45	45.4	7	5.1	28	46.7
European bitterling (*Rhodeus amarus*)							21	21.2	5	3.6	1	1.7
Spined loach (*Cobitis elongatioides*)	3	6.8										
Common carp (*Cyprinus carpio*)							3	3	3	2.2		
Prussian carp (*Carassius gibelio*) *	27	61.4			16	24.2	6	6.1	10	7.2	17	28.3
Rudd (*Scardinius erythrophtalmus*)									2	1.4		
Topmouth gudgeon (*Pseudorasbora parva*) *	2	4.5			3	4.5			34	24.6	4	6.7
Common dace (*Leuciscus leuciscus*)									1	0.7		
European perch (*Perca fluviatilis*)	1	2.3	5	16.7	8	12.1	3	3	29	21	2	3,3
Pumpkinseed (*Lepomis gibbosus*) *	5	11.4			14	21.2	6	6.1	31	22.5	3	5
Roach (*Rutilus rutilus*)	1	2.3	1	3.3	12	16.6			16	11.6	5	8.3
Balkan loach (*Cobitis elongata*)	1	2.3										
Barbel (*Barbus barbus*)			1	3.3								
Percentage of alien specimens (%)	34	77.3	0	0	33	49.9	12	12.2	75	53.3	24	43.3
SUM	**44**	**100**	**30**	**100**	**66**	**100**	**99**	**100**	**138**	**100**	**60**	**100**

3 Alien fish species were documented during the investigation in 6 channels: Prussian carp (*Carassius gibelio*), topmouth gudgeon (*Pseudorasbora parva*) and pumpkinseed (*Lepomis gibbosus*). Channel PIS1, BUK3, TEŠ4, CMU5 and LIČ6 contained 178 specimens of listed alien fish species. 3 alien species were found in PIS1 following with BUK3, TEŠ4, CMU5 and LIČ6. CMU5 had the highest amount of specimen (75) while TEŠ4 had the smallest amount (12). The most common specimen was Prussian carp (*Carassius gibelio*) with 76 specimens documented, following pumpkinseed (*Lepomis gibbosus*) with 59 specimens and topmouth gudgeon (*Pseudorasbora parva*) with 43 specimens (Table 3.3.1.).

3.4. Fish diversity of streams and channels

Species richness was the highest in streams GRD1 (9,10), LOM8 (9,10), UOK13 (11,6) and the lowest in REK12 (2,1). The significant difference in species richness between first 100m and second 100m was calculated in UTI2 and UOK13 ($p<0.01$). Margalef index showed its highest value in the first 100 m of UTI2 (2.7) and overall highest in first and second 100m of GRAD1 (1.9, 2.1). The lowest Margalef index was calculated for the first and second 100m of REK12 (0.2,0).

Simpson index showed variations between the values 0 and 1. The highest index value was present in REK12 (1,1) for the first and second 100m of the stream and the overall lowest for both sections of the stream was SKK15 (0.3,0).

The Shannon Weawer index varied between 0 and 2.1. The highest index value was present in UOK13 (2.1, 1.3) and in UTI2 (2,0.8) for the first and second 100m and the lowest for the first and second 100m of the stream was REK12 (0,0). (Table 3.3.3.)

Species richness was the highest in channels CMU 5 (10) and PIS1 (9) and the lowest in SKD2 (5) and BUK3 (6). The most significant difference in species richness was calculated between CMU5 (10) and SKD2 (5).

Margalef index showed its highest value in PIS1(2.1) and SKD2 (1.8). The lowest Margalef index was calculated for BUK3 (1.2) and TEŠ4 (1.3).

Simpson index showed variations between the values 0.2 and 0.4. The highest index value was present in SKD2 (0.4) and the lowest for BUK3 (0.2).

The Shannon Weawer index varied between 1 and 1.7. The highest index value was calculated for BUK3 (1.7) and the lowest for SKD2 (1) (Table 3.4.)

Table 3.3. Species richness, Margalef index, Simpson index and and Shannon Weawer index of ichtyofauna caught in streams (1= first 100 m; 2= second 100

INDEX	GRD1		UTI2		UTB3		TRB4		KKR5		MAL6		UMV7		LOM8		LIP9		REČ10		BRB11		REK12		UOK13		OKK14		SKK15	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Species richness	9	10	10	4	3	4	6	4	7	8	3	8	5	7	9	10	5	5	9	6	5	7	2	1	11	6	7	10	5	3
Margalef index	1.9	2.1	2.7	0.9	0.7	0.8	1.1	0.8	1.6	1.3	0.7	1.6	1	1.6	1.7	2.1	1	0.9	2.1	1.3	0.9	1.4	0.2	0	2.3	1.1	1.4	1.9	1	0.5
Simpson index	0.3	0.4	0.2	0.5	0.4	0.3	0.3	0.4	0.2	0.5	0.4	0.2	0.3	0.5	0.3	0.2	0.4	0.3	0.2	0.2	0.3	0.3	1	1	0.2	0.3	0.2	0.5	0.3	0
Shannon Weawer	1.6	1.1	2	0.8	1	1.2	1.3	0.9	1.7	1.1	1	1.8	1.2	0.9	1.7	1.7	1.2	1.3	1.9	1.5	1.3	1.5	0	0	2.1	1.3	1.6	1.2	1.3	0.6

Table 3.4. Species richness, Margalef index, Simpson index and Shannon Weawer index of ichtyofauna caught in channels

INDEX	PIS1	SKD2	BUK3	TEŠ4	CMU5	LIČ6
Species richness	9	5	6	7	10	7
Margalef index	2.1	1.8	1.2	1.3	1.7	1.5
Simpson index	0.4	0.5	0.2	0.3	0.3	0.3
Shannon Weawer	1.4	1	1.7	1.5	1.6	1.4

3.5. Stress characterization of ichthyofauna in investigated waterbodies

Values of ABC index for all investigated waterbodies have shown that 21 sampled waterbodies and fish comunities are under moderate or heavy stress. 2 waterbodies are in heavy stress (GRD and SKD2) while 19 in moderate stress (UTI2, UTB3, TRB4, KKR5, MAL6, UMV7, LOM8, LIP9, REČ10, BRB11, REK12, UOK13, OKK14, SKK15, PIS1, BUK3, TEŠ4, CMU5 and LIČ6) (Table 3.5.1.).

Table 3.5.1. Values of ABC index for all investigated waterbodies M= moderate stress; H= heavy stress

Waterbody	ABC index	Stress character
Streams		
Gradnica	-0.18182	H
Utinja	0.0	M
Utinja Bukovica	0.0	M
Trebinja	0.01667	M
Kupčina Krašić	0.00909	M
Malunjčica	0.0	M
Confluence Malunje and Volavčice	0.004	M
Lomnica	0.027272	M
Lipnica	0.03333	M
Rečica	0.04	M
Brebernica	0.0	M
Reka	0.05	M; low number of data

Cofluence Okičnice and Gonjave	-0.04535	M
Okičnica	-0.0908	M
Skakavac	0.0	M
Channels		
Pisarovina output channel	0.02727	M
Connecting channel Draganić	-0.12	H
Bukovac	0.0	M
Tešnjić	-0.0143	M
Crna mlaka input channel	-0.01	M
Lično	-0.0125	M

ABC diagrams confirmed level of stress shown by ABC indeks (Figures 3.5.1.1. - 3.5.1.6.).

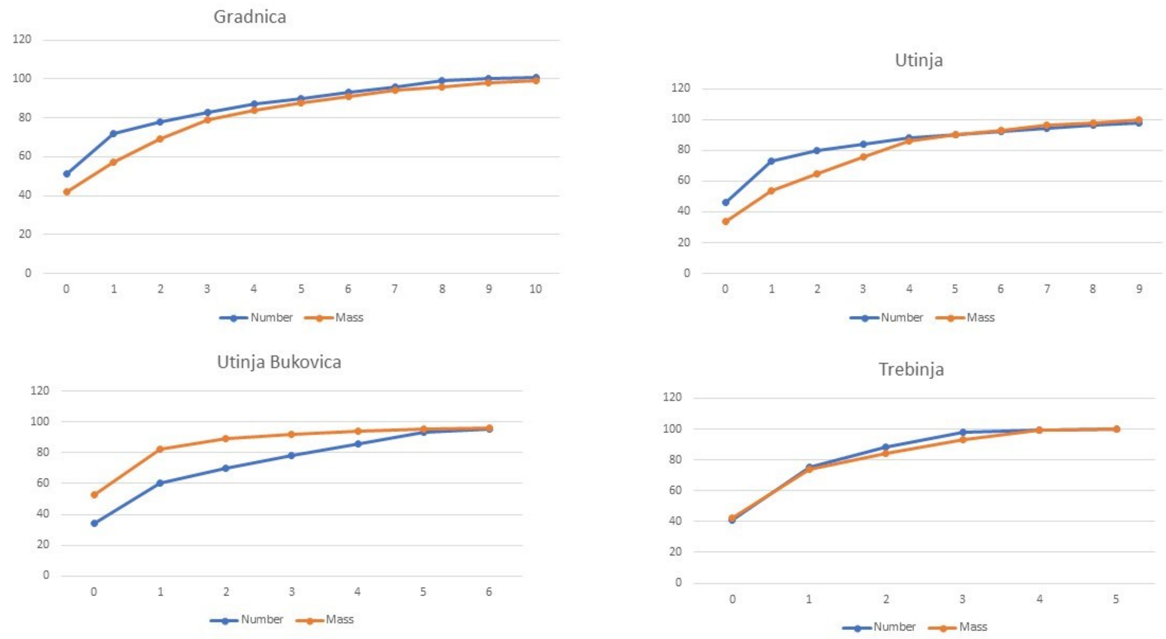


Figure 3.5.1.1. ABC diagram of Gradnica, Utinja, Utinja Bukovica and Trebinja Stream

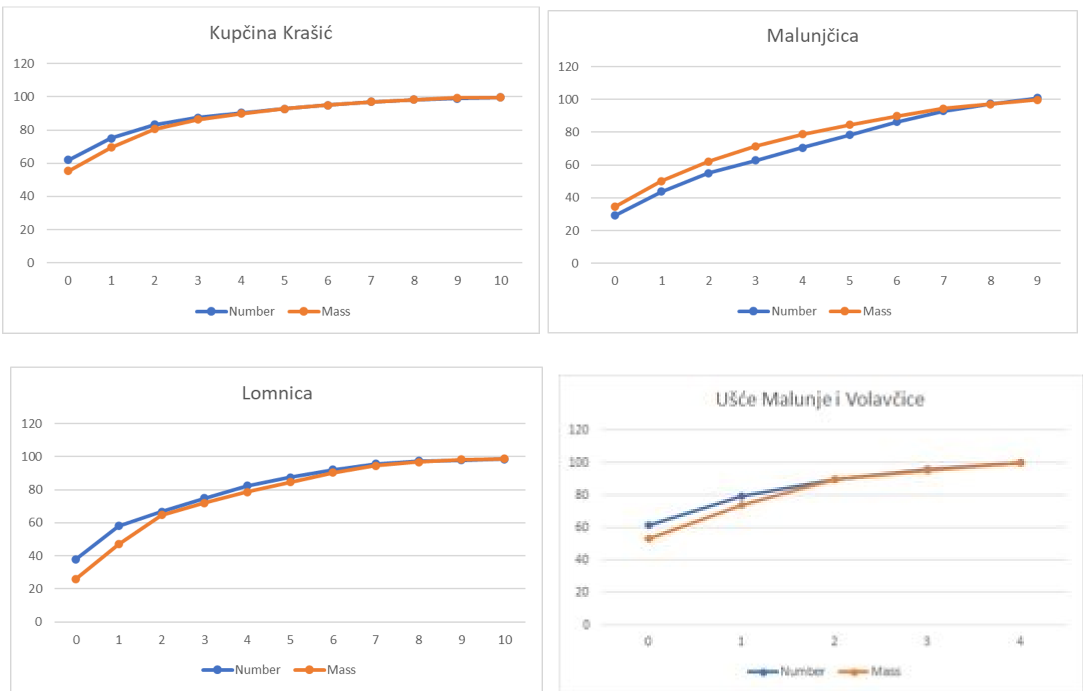


Figure 3.5.1.2. ABC diagram of Kupčina Krašić, Malunjčica, Confluence Malunje and Volavčive and Lomnica Stream

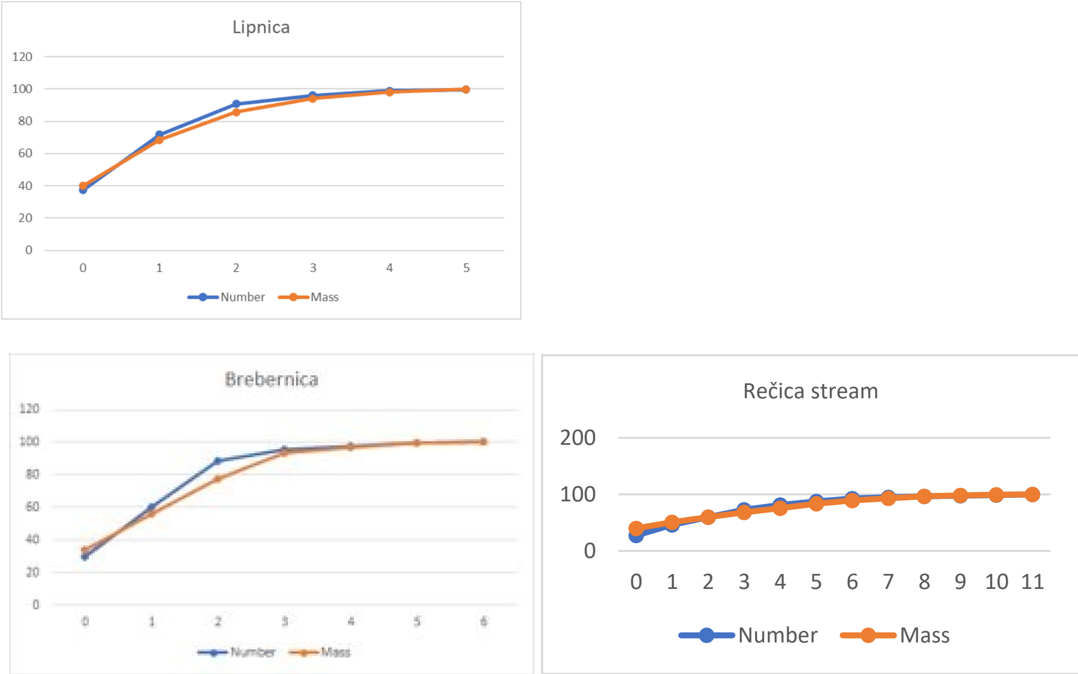


Figure 3.5.1.3. ABC diagram of Lipnica, Rečica and Brebernica stream

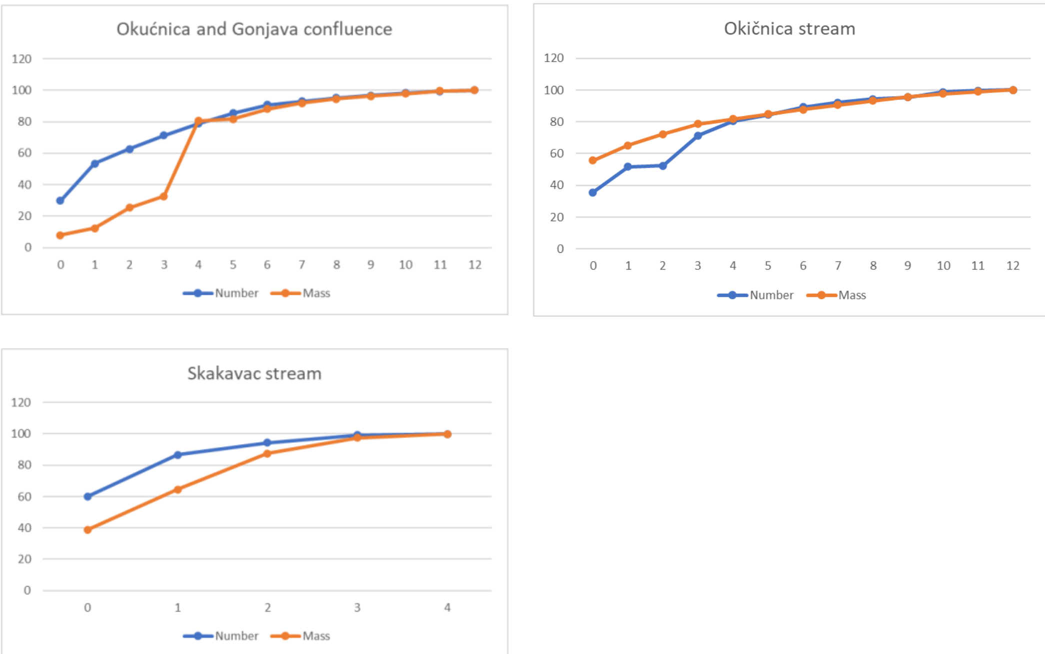


Figure 3.5.1.4. ABC diagram of Confluence Okičnice i Gonjave, channelized Okićnica and Skakavac stream

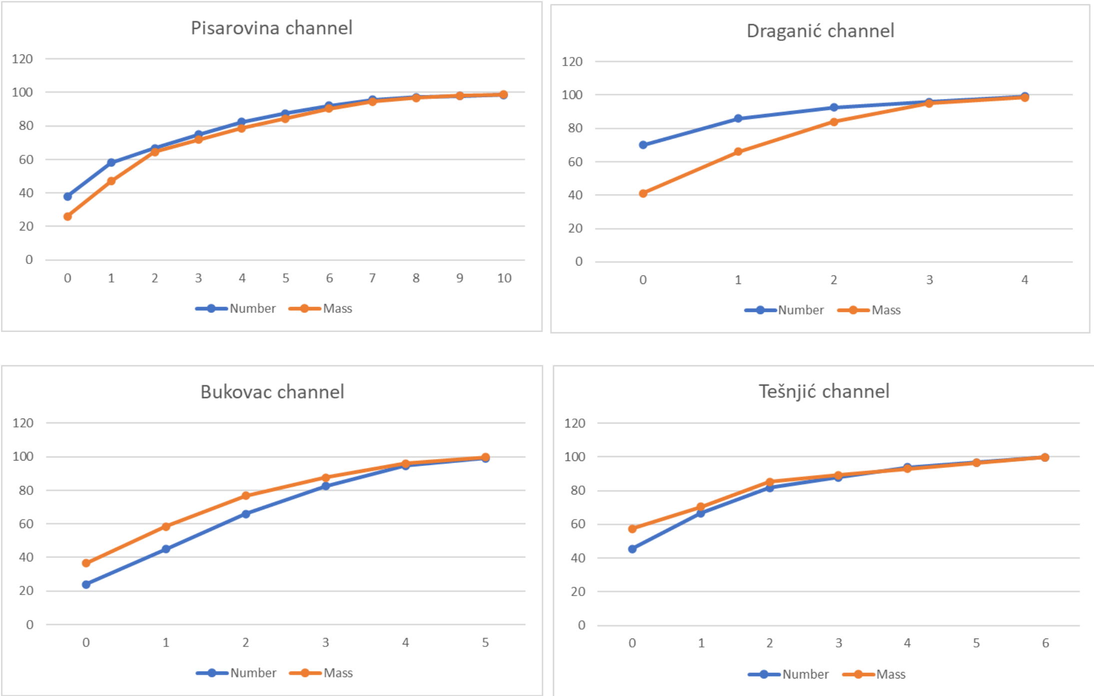


Figure 3.5.1.5. ABC diagram of Pisarovina, Draganić, Bukovac and Tešnjić channel

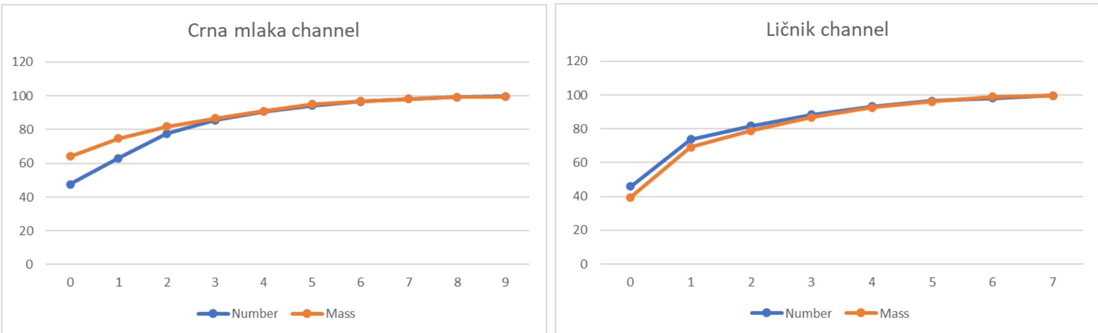


Figure 3.5.1.6. ABC diagram of Crna mlaka input channel and Ličnik channel

4. DISCUSSION

During the research of small streams and channels located in eastern Croatia in 2019, 30 species of fish were documented in streams and 15 species were documented in channels. A total of 2209 specimens were caught by electrofishing, 1051 in the first 100 meters and 1158 in the second 100 meters of streams while 458 specimens were caught in one transect of investigated channels. In this research the most abundant species in investigated stream was gudgeon with 481 specimens. This result coincides with research conducted in 2005 in the Sava river tributaries (Mustafić et al, 2005). Species with the lowest number of specimens was Wels catfish with only 1 specimen found. The highest number of specimens was caught in REK12 (236) while the lowest number of specimens was in UTI2 (56). Although they did not differ greatly in sample location characteristics, the difference in the sampling waterbody depth and measured water quality parameters could have had an impact because conductivity influences the power, and hence field density, that an electrofisher creates at a given voltage, which could influence efficiency. Conductivity increases as the content of ionized salts increases, and is also temperature dependent, increasing by approximately 2% for each centigrade degree increase in water temperature (Port et al, 2006).

Water quality of investigated streams and channels indicates a correlation between water quality parameters and diversity, or stress measured with the ABC index. Channels LIČ6 and CMU5 measured a high level of stress but simultaneously suffered from depletion of oxygen. Their oxygen concentration measured under 5mg/L which was adequate for alien species which are tolerant to a low oxygen concentration level and strive in such conditions. Examples found in such condition in CMU 5 AND LIČ6 were topmouth gudgeon and Prussian carp. SKD2 had shown a connection between very high stress, high pH and low species richness which is comparable to GRD1 with very high stress, a moderately lower pH value and lowest conductivity measured, but at the same time the highest species richness value has been detected. SKD2 had the lowest number of specimens caught without alien species detected. In REČ10 an oxygen concentration value was below 5, a high species richness and a high number of alien species were identified and in moderate stress conditions were recorded. However, even low oxygen concentration in SKK15 were found, alien species has not been detected but low to moderate species richness has been found. All these examples had proven that some species are more tolerant to low values of oxygen demand and lower water quality conditions. This is particularly dedicated to alien species such as topmouth gudgeon and Prussian carp (see REČ10) which are well known to as tolerant to low quality habitats (Gozlan et al., 2010).

The most abundant species documented in each investigated channel was bleak (116). According to Almeida et al. (2014) this species mainly inhabiting lentic like environments and prefers slower waters or channels of medium-large rivers, which corresponding to investigated channels of this research. The species that occurred in the low density was spined loach (3 specimens). The highest number of specimens was caught in CMU5 (138) and the smallest in SKD2 (30) which may be the result of anthropogenic activities on the embankment of SKD2.

5 alien fish species were documented during the investigation in 15 streams and 3 alien fish species were documented during the investigation in 6 channels. The most common species in streams was Prussian carp with 90 specimens documented, while the most common specimen in channels was also Prussian carp with 76 specimens documented. Such alien species composition matches the official monitoring data from the Final Report for the Ministry of Agriculture of the Republic of Croatia by the Faculty of Agriculture, University of Zagreb (2010-2017) (Treer et al., 2017). 82 specimens of alien fish species were documented in the first 100m of streams and 150 specimens were documented in the second 100m of streams.

Species richness was the highest in streams GRD1 and LOM8 and the lowest in REK12. The significant difference in species richness between first 100 meters and second 100 meters was calculated in UTI2 and UOK13 ($p<0.01$) as mentioned most likely the result of a difference in depth of sampling and water quality parameters. Margalef index showed its highest value in the first 100 meters of UTI2 and overall highest in first and second 100 meters of GRD1. The lowest Margalef index was calculated for the first and second 100 meters of REK12.

Simpson index showed variations between the values 0 and 1. As relative abundance or evenness of each species increases; the Simpson index rises with value. The highest index value was present in REK12 for the first and second 100 meters of the stream where 2 species with high abundancy were documented, therefore we had the result of low species richness and Margalef index with a high value of Simpson index. The overall lowest value for both sections of the stream was SKK15 with calculated low value for richness and Margalef index following low Simpson index.

The Shannon Weawer index varied between 0 and 2.1. The Shannon Weawer index lower values indicated more diversity while higher values indicate less diversity .The highest index value was calculated for UOK13. The lowest result that was calculated for the first and second 100 meters of the stream was REK12 already discussed as lowest in species richness.

Species richness was the highest in channels CMU 5 and PIS1 and the lowest in SKD2. The most significant difference in species richness was calculated between CMU5 and SKD2. Margalef index showed its highest value in PIS1 and SKD2 while the lowest Margalef index was calculated for BUK3.

Simpson index showed variations between the values 0.2 and 0.4. The highest index value was present in SKD2 due to the result of low species richness. The lowest was calculated for BUK3 with a low species richness value.

The Shannon Weawer index varied between 1 and 1.7. The highest index value was present in BUK3 with the lowest Simpson index and the lowest for SKD2 with the highest Simpson index.

Calculated p values of ANOVA results have shown significant differences ($p<0.01$) between ichthyocenosis in the first and second 100 meters of 11 investigated streams. 4 streams (UTB3, LOM8, REČ10 and UKK14) resulted with non-significant (n.s.) differences between the first and second 100 meters measured. Obtained results lead to the rejection of the hypothesis of this research. We reject the hypothesis that there is no difference in ichthyocenosis between the first 100 meters and other 100 meters of sampling on streams. The majority of investigated streams (11) have shown significant differences ($p<0.01$).

In river ecosystems two major human induced stressors may be distinguished, namely pollution and river regulation (Coeck, 1983). Analyzing fish communities in the Sava river streams and channels we found that the ABC method seems to detect anthropogenic disturbances which could possibly be pollution or as documented in most of investigated waterbodies-river regulation. It has to be taken in account that the ABC method reacts as a sensitive toll to different kinds of stress and in our investigated waterbodies stress could have been environmental but also pollution caused stress. When it comes to the determination of ABC index for all investigated waterbodies, results have shown that all sampled waterbodies and fish comunities are under moderate or heavy stress.

2 waterbodies are in heavy stress (GRD1 and SKD2) with the ABC index being a negative number and the biomass curve surpassing the fish abundance curve. 19 waterbodies are in moderate stress with the number curve rising and overlapping with the biomass curve, cutting it in one or more places (UTI2, UTB3, TRB4, KKR5, MAL6, UMV7, LOM8, LIP9, REČ10, BRB11, REK12, UOK13, OKK14, SKK15, PIS1, BUK3, TEŠ4, CMU5 and LIČ6). In our research, stressed waterbodies probably are a result of concrete embankments, neighboring agricultural activity, waste from household and pollution from traffic. The results show that the method is a sensitive indicator for the disturbance of fish communities.

5. CONCLUSION

Based on this research it was determined that the most abundant species in investigated streams was gudgeon with 481 specimens while the species with the lowest number of specimens was Wels catfish with 1 specimen. The most abundant species documented in each investigated channel was bleak with 116 specimens. Species that occurred in the low density was spined loach with only 3 specimens found.

Species richness, Margalef's index, Simpson's index and Shannon Weawer index show variations in richness and frequencies in investigated waterbodies. Several streams and channels showed high index values while majority of investigated streams had an average outcome with a few exemptions of low values.

In determination of ABC index for all investigated waterbodies, we concluded that all sampled waterbodies and fish communities are under moderate or heavy stress.

Obtained results lead to the acceptance of hypothesis which is related that different fish assemblages will be found in streams and channels. Result shows that lower number of species and higher number of specimens of alien origin inhabiting channels in comparation with streams. However, significant difference ($p<0.01$) between ichtyocenosis in the first and second 100 meters of 11 investigated streams were found, which led to conclusion that the sampling distance in the middle part of streams are important for inventory research, and led to rejection of this part of hypothesis.

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Appendix 1. Composition and number of ichthyocenoses caught at first (1) and second (2) 100 m at each stream (*alien fish species)

Species	GRD1		UTI2		UTB3		TRB4		KKR5	
	1	2	1	2	1	2	1	2	1	2
Schneider (*Alburnoides bipunctatus*)	33	35	9	6	7	0	0	0	16	129
Chub (*Squalius cephalus*)	3	3	6	20	0	23	27	27	5	15
Bleak (*Alburnus alburnus*)	0	28	0	0	0	0	0	0	0	3
European bitterling (*Rhodeus amarus*)	0	0	0	0	0	0	0	0	0	0
Gudgeon (*Gobio gobio*)	8	0	0	1	0	18	55	8	0	1
Stone loach (*Cobitis elongatoides*)	0	0	2	0	0	0	0	0	0	0
Common carp (*Cyprinus carpio*)	0	0	0	0	0	0	0	0	0	0
Prussian carp (*Carassius gibelio*) *	0	0	0	0	0	0	0	0	0	0
Common gudgeon (*Gobio obtusirostris*)	0	4	1	0	0	0	0	0	0	0
Freshwater bream (*Abramis brama*)	0	0	0	0	0	0	0	0	0	0
Mediterranean barbel (*Barbus meridionalis*)	0	0	2	0	0	0	0	0	0	32
Common nase (*Chondrostoma nasus*)	0	0	1	0	0	0	0	0	0	0
Stone loach *(Barbatula barbatula*)	4	0	0	0	2	0	10	5	10	0
Stone moroko (*Pseudorasbora parva*) *	0	0	1	0	0	5	0	0	0	0
Eurasian minnow (*Phoxinus phoxinus*)	4	0	0	0	0	0	18	2	2	5
Common dace (*Leuciscus leuciscus*)	0	0	1	0	0	0	0	0	0	0
Kessler's gudgeon (*Romanogobio kessleri*)	0	0	0	0	0	0	0	0	0	0
Wels catfish (*Silurus glanis*)	0	0	0	0	0	0	0	0	0	0
Brown bullhead (*Ameiurus nebulosus*) *	0	0	0	0	0	6	0	0	0	0
European perch *(Perca fluviatilis*)	4	1	0	0	0	0	0	0	0	0
Pumpkinseed (*Lepomis gibbosus*) *	4	0	0	0	0	0	0	0	0	0
Rudd (Scardinius erythrophtalmus)	0	0	0	0	0	0	0	0	0	2
Northern pike (*Esox lucius*)	1	0	0	0	0	0	0	0	0	0
Roach (*Rutilus rutilus*)	0	0	0	0	0	0	0	0	0	0
Bullhead (*Cottus gobio*)	0	0	3	1	6	0	0	0	1	4
Balcan spined loach (*Sabanejewia balcanica*)	1	0	2	0	0	0	1	0	6	0
Balkan loach (*Cobitis elongata*)	0	0	0	0	0	0	0	0	0	0
Tench (*Tinca tinca*)	0	0	0	0	0	0	0	0	0	0
European brook lamprey (*Lampetra planeri*)	0	0	0	0	0	0	0	0	0	0
Black bullhead (*Ameiurus melas*) *	0	0	0	0	0	0	0	0	0	0
SUM	**63**	**71**	**28**	**22**	**15**	**52**	**111**	**42**	**40**	**191**

Appendix 1. Continued

Species	MAL6		UMV7		LOM8		LIP9		REČ10	
	1	2	1	2	1	2	1	2	1	2
Schneider (*Alburnoides bipunctatus*)	0	13	29	32	51	15	0	0	0	0
Chub (*Squalius cephalus*)	0	26	3	7	11	4	7	18	9	9
Bleak (*Alburnus alburnus*)	0	0	0	0	0	31	0	0	0	0
European bitterling (*Rhodeus amarus*)	0	6	0	0	5	31	32	17	14	12
Gudgeon (*Gobio gobio*)	0	7	2	2	6	3	11	34	6	0
Stone loach (*Cobitis elongatoides*)	9	1	0	0	3	3	0	0	8	0
Common carp (*Cyprinus carpio*)	0	0	0	0	0	0	0	0	0	0
Prussian carp (*Carassius gibelio*) *	7	0	0	0	0	0	0	0	0	12
Common gudgeon (*Gobio obtusirostris*)	0	0	0	0	0	0	0	0	0	0
Freshwater bream (*Abramis brama*)	0	0	0	0	0	0	0	0	0	0
Mediterranean barbel (*Barbus meridionalis*)	0	4	16	2	11	3	0	0	0	0
Common nase (*Chondrostoma nasus*)	0	0	0	0	0	0	0	0	0	0
Stone loach *(Barbatula barbatula*)	0	6	4	2	0	0	5	2	0	0
Stone moroko (*Pseudorasbora parva*) *	0	0	0	0	0	0	0	0	0	1
Eurasian minnow (*Phoxinus phoxinus*)	0	7	0	0	0	0	0	4	0	0
Common dace (*Leuciscus leuciscus*)	0	0	0	0	0	0	0	0	0	0
Kessler's gudgeon (*Romanogobio kessleri*)	0	0	0	0	6	2	0	0	0	0
Wels catfish (*Silurus glanis*)	0	0	0	0	0	0	0	0	0	0
Brown bullhead (*Ameiurus nebulosus*) *	0	0	0	0	0	0	1	0	0	0
European perch *(Perca fluviatilis*)	3	0	0	0	0	1	0	0	1	0
Pumpkinseed (*Lepomis gibbosus*) *	0	0	0	0	0	0	0	0	1	12
Rudd (Scardinius erythrophtalmus)	0	0	0	0	0	0	0	0	0	0
Northern pike (*Esox lucius*)	0	0	0	0	0	0	0	0	2	0
Roach (*Rutilus rutilus*)	0	0	0	0	0	0	0	0	0	0
Bullhead (*Cottus gobio*)	0	0	0	0	0	0	0	0	0	0
Balcan spined loach (*Sabanejewia balcanica*)	0	0	0	0	8	18	0	0	0	0
Balkan loach (*Cobitis elongata*)	0	0	0	0	0	0	0	0	0	2
Tench (*Tinca tinca*)	0	0	0	0	0	0	0	0	0	0
European brook lamprey (*Lampetra planeri*)	0	0	0	0	0	0	0	0	0	0
Black bullhead (*Ameiurus melas*) *	0	0	0	0	0	0	0	0	0	0
SUM	**19**	**70**	**54**	**45**	**101**	**111**	**56**	**75**	**40**	**48**

Appendix 1. Continued

Species	BRB11		REK12		UOK13		OKK14		SKK15	
	1	2	1	2	1	2	1	2	1	2
Schneider (*Alburnoides bipunctatus*)	0	0	0	0	25	30	0	0	0	0
Chub (*Squalius cephalus*)	32	14	2	0	11	3	0	0	11	0
Bleak (*Alburnus alburnus*)	0	0	0	0	12	5	22	17	1	0
European bitterling (*Rhodeus amarus*)	15	31	0	0	0	44	5	3	0	0
Gudgeon (*Gobio gobio*)	28	16	204	33	3	1	0	0	19	19
Stone loach (*Cobitis elongatoides*)	0	0	0	0	0	0	0	5	0	0
Common carp (*Cyprinus carpio*)	0	0	0	0	0	0	0	2	0	0
Prussian carp (*Carassius gibelio*) *	0	0	0	0	0	0	1	86	0	0
Common gudgeon (*Gobio obtusirostris*)	0	0	0	0	0	0	0	0	0	0
Freshwater bream (*Abramis brama*)	0	0	0	0	0	0	0	2	0	0
Mediterranean barbel (*Barbus meridionalis*)	4	6	0	0	0	0	0	0	0	0
Common nase (*Chondrostoma nasus*)	0	0	0	0	0	0	0	0	0	0
Stone loach *(Barbatula barbatula*)	0	3	0	0	0	0	0	0	5	2
Stone moroko (*Pseudorasbora parva*) *	1	2	0	0	1	0	25	21	0	0
Eurasian minnow (*Phoxinus phoxinus*)	0	1	0	0	0	0	0	0	22	64
Common dace (*Leuciscus leuciscus*)	0	0	0	0	0	0	0	0	0	0
Kessler's gudgeon (*Romanogobio kessleri*)	0	0	0	0	0	0	0	0	0	0
Wels catfish (*Silurus glanis*)	0	0	0	0	0	0	0	0	0	0
Brown bullhead (*Ameiurus nebulosus*) *	0	0	0	0	12	0	0	0	0	0
European perch *(Perca fluviatilis*)	0	0	0	0	9	1	8	4	0	0
Pumpkinseed (*Lepomis gibbosus*) *	0	0	0	0	3	0	20	2	0	0
Rudd (Scardinius erythrophtalmus)	0	0	0	0	0	0	0	0	0	0
Northern pike (*Esox lucius*)	0	0	0	0	0	0	0	0	0	0
Roach (*Rutilus rutilus*)	0	0	0	0	2	0	0	10	0	0
Bullhead (*Cottus gobio*)	0	0	0	0	0	0	0	0	0	0
Balcan spined loach (*Sabanejewia balcanica*)	0	0	0	0	0	16	0	0	0	0
Balkan loach (*Cobitis elongata*)	0	0	0	0	3	0	1	6	0	0
Tench (*Tinca tinca*)	0	0	0	0	0	0	0	1	0	0
European brook lamprey (*Lampetra planeri*)	0	0	0	0	0	0	0	0	0	0
Black bullhead (*Ameiurus melas*) *	0	0	0	0	0	0	0	3	0	0
SUM	**80**	**73**	**206**	**33**	**81**	**100**	**82**	**162**	**58**	**85**