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SETTING UP A SYSTEM FOR ECOLOGICAL STATUS ASSESSMENT BASED ON FISH FAUNA – THE PČINJA RIVER – CASE STUDY

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Last decades many investigations were focused on the design of the efficient system of water monitoring capable to evaluate the degree of human influence. The monitoring system is an important part of the management system and the main objective of status assessment is to provide data for design of effective measures for prevention of further deterioration and status improvement. Despite the European trend to promote biological investigations as an important part of the assessment system (Water Framework Directive, WFD – EC 2000), biological methods have been unjustifiably neglected in the water quality monitoring systems in many countries, including Republic of Macedonia. The aim of the current study was to set up and the evaluation of the water quality of the Pčinja River based on the structure of the fish community. The results of the study presents solid basis for testing the efficiency of the EFI index in R. Macedonia.

Key words: fish; water status assessment; EFI-index; Pčinja River, Republic of Macedonia

ПРОЦЕНА НА ЕКОЛОШКИОТ СТАТУС ВРЗ ОСНОВА НА РИБНАТА ФАУНА – СТУДИЈА ЗА РЕКАТА ПЧИЊА

Последните децении бројни истражувања се насочени кон дизајнирање на ефикасен систем за мониторирање на водите. Овој систем е неопходен за успешно менаџирање, бидејќи дава податоци врз основа на кои се донесуваат мерки за заштита од идно влошување, како и за подобрување на состојбата со квалитетот на водата. И покрај европскиот тренд на примена на биолошките индикатори во мониторирањето на квалитетот на водата (Water Framework Directive, WFD – EC 2000), тие се неоправдано изоставувани во голем број земји, вклучувајќи ја и Република Македонија. Целта на оваа студија е да се изврши процена на еколошкиот статус на реката Пчиња врз основа на структурата на рибната фауна. Добиените резултати послужија како основа за тестирање на ефикасноста од примена на EFI-индексот на територија на Р. Македонија.

Клучни зборови: риби; оцена на состојбата na вода; EFI-индекс; река Пчиња, Република Македонија

INTRODUCTION

In the last decades, the scientific, but also the management structures, have demonstrated particular interest in river ecosystem monitoring, with the ultimate goal of establishing the effective ecological status assessment procedure and pursuing manners, methods of control, and proposed solutions for water protection. Since 2000, when the Water Framework Directive (WFD – EC 2000) has become in force, biological assessment of water quality becomes essential for successful imple-

mentation of the monitoring system. The use of biological quality elements (BQE) in monitoring studies has certain advantages compared to traditional methods, where physical and chemical parameters are most commonly used as water quality indicators. Organisms continuously live in aquatic environment and they react to changes, hence, they reflect conditions over the time.

Improvement of the water status represents an imperative of all European countries, and this objective can be realized only with a well defined management strategy. The WFD (EC 2000) represents the basis for water management in the European Union (EU). The general aim of directive is to provide the frame for achieving good water status for all water bodies within the territory of the EU by the year of 2015 (Pont et al., 2006). WFD (EC 2000) underlined the significance of biological parameters in evaluation of the aquatic ecosystem status and fish fauna was pointed up as obligatory element for status assessment.

Despite the European trend of fast development of biological assessment methodology for waters, biological methods, including metrics based on analyses of fish community are neglected in R. of Macedonia. As a candidate country for the European Union, R. of Macedonia is obligated to harmonize the national legislation with the European Directive WFD (EC 2000), which includes the harmonization of the national monitoring system. Natural perturbations and recent increased anthropogenic influences (such as water abstraction, canalization, damming, introductions of exotic species, and agricultural, industrial, and municipal waste inputs) on freshwater resources have become more intense over the past 40 years, resulting in elimination and degradation of surface water resources and aquatic habitats in R. of Macedonia. These alterations have resulted in fragmented, polluted freshwater fish habitats and communities that have led to extirpation of some native species (Kostov et al., 2010). According to the last assessment from the Ministry of Environment and Physical Planning (Assessment and Evaluation of Biodiversity on National Level, 2010) fish in R. of Macedonia are the most endangered group of organisms.

One approach used to evaluate the effect of environmental modification on fish assemblages is to compare the current fish assemblage data with the historical data (Paul & Meyer, 2001). But, unfortunately in many rivers in R. of Macedonia, including the Pčinja River, there are no historical fish data available and the fish-habitat relationships are poorly known.

On the other hand, in R. of Macedonia there is still lack of data about the fish community structure of many rivers.

The Pčinja River is a good model system for the testing of the assessment methodology, since the different segment types are available and the different level of pressures are in force along the watercourse. The purpose of this study was to reveal species composition and community structure of ichthyofauna from the Pčinja River, as well as assessment of the ecological status of the river based on the fish fauna. As the European Water Framework Directive (EC, 2000) proposes the use of abundance of data, as well as the presence–absence of fish species, the results of this study could be a solid basis for future bioassessment programs.

STUDY AREA

The Pčinja River is the left tributary of the Vardar River and belongs to the Aegean Sea drainage basin. It originates from several streams on the western slopes of the Dukat Mountain which meet at the village of Radovnica and flows into the Vardar River, on the gorge of the Taor section of the Vardar course, halfway between the cities of Skopje and Veles. The river length is 135 km, 100 km of which are in the Republic of Macedonia. In its course on the territory of the Republic of Macedonia, the Pčinja River is a recipient of waters from 8 tributaries, more significant of which are the Kumanovska River with 44 km and the Kriva River with 85 km length.

MATERIAL AND METHODS

During the summer of 2009, a qualitative and quantitative analysis of fish fauna from the Pčinja River was done. The Macedonian and Serbian river sector was analyzed. Investigation was performed at eight sampling stretches, seven on the river itself and one on the Kumanovska River (Fig. 1, Table 1).

Sampling stretches were selected based on the position of settlements and main tributaries, in order to be able to evaluate the anthropogenic influence.

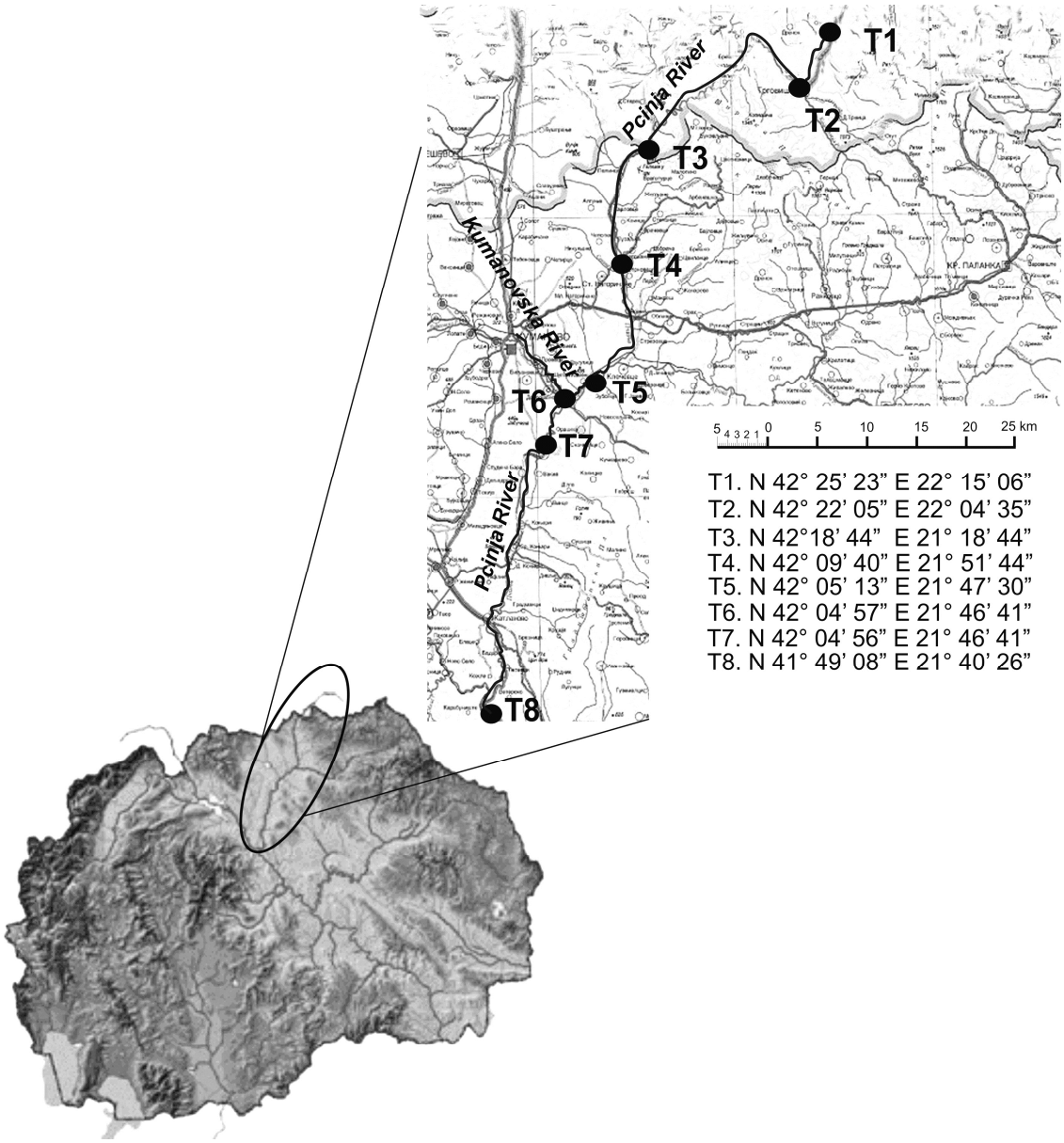

Figure 1. Map of the investigated area

The fishes were caught by electro fishing (Samus 725G) according the FAME (2002, 2004) methodology and relevant standards (EN 14011-CEN 2003).

All specimens were identified to the species level. The total number of individuals per species was recorded on the field protocol data sheet. After processing and measurement of basic characteristics the fish were photographed and returned into the water at the same place where they were caught. Fish determination was made with standard keys (Vuković, 1971; Georgiev, 1998; Kottelat, 1997; Kottelat & Freyhof, 2007), while the taxonomic classification of fish species was based on Kottelat & Freyhof (2007). Classification of the ecological status using the European Fish Index (EFI) was done (FAME 2002, 2004).

RESULTS

During our investigation, the presence of 16 fish species belonging to five families were recorded. Among them, 13 are autochthonous (native), while three are alien (non-native) species (Table 1).

Cyprinidae were found to be the dominant family in the qualitative (11 species) and quantita-

tive (94.89 % of the relative contribution in total caught) composition, which points out that the Pčinja River is a typical cyprinid river. *Nemacheilidae* has been presented with two and *Salmonidae*, *Cobitidae* and *Centrarhidae* with one fish species each (Table 1).

Table 1

Qualitative and quantitative composition of the ichthyofauna along the Pčinja River and from the mouth of Kumanovska River

Fish species	T1	T2	T3	T4	T5	T6	T7	T8	Total No. of specimens
Alburnoides bipunctatus		78	235	52	14			16	395
Alburnus macedonicus						+	13	7	20
Barbatula barbatula					2				2
Barbus balcanicus		217	261	219	119	+	6	1	823
Chondrostoma vardarense			8	12	157	+	13	14	204
Gobio bulgaricus		1	2	17	4	+	4	4	32
Oxynoemacheilus bureschi		6	12	51	11				80
Pachychilon macedonicum					9	+	16	8	33
Pseudorasbora parva							11	7	18
Rhodeus meridionalis			5	4	6	+	42	25	82
Sabanejewia balcanica		1	4	8					13
Salmo macedonicus	2								2
Squalius vardarensis		6	18	50	14	+		55	143
Vimba melanops			3	43	5	+	1	12	64
Carassius gibelio								4	4
Lepomis gibbosus								1	1
Number of species	1	6	9	9	10	8	8	12	1916

The most frequent species (85.7 %) were found to be Balkan barbel (*B. balcanicus*) and the gudgeon (*G. bulgaricus*), followed by the riffle minnow or Vardarka (*A. bipunctatus*), Vardar nase (*C. vardarense*), bitterling (*R. meridionalis*), the Vardar chub (*S. vardarensis*) and the malamida (*V. melanops*), with frequency of 71.4 %. Balkan barbel formed the bulk of ichthyofauna (43 %); together with riffle minnow (Vardar nase and Vardar chub) they accounted for 81.7 % of the total caught (Fig. 2).

According to our results four different sectors of the Pčinja River separated by the Correspondence Analysis are characterized by a distinct fish community, which indicated difference in the overall environmental conditions along the river course (Fig. 3).

Salmo macedonicus was registered in the first sampling site T1. This part of the river showed lower similarity in relation to other sectors (Fig. 3)

Species richness (6–10 taxa) was considerable at the sampling sites T2-T5, mainly due to the appearance of *A. bipunctatus, B. balcanicus, G. bulgaricu, C. vardarense, R. meridionalis*, *S. vardarensis* and *V. melanops*.

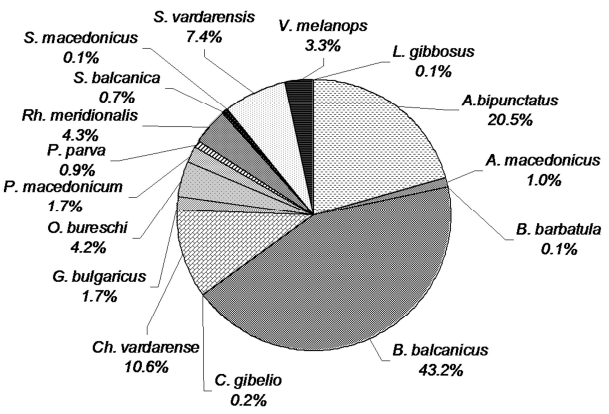

Figure 2. Relative contribution (%) of the fish fauna in the Pčinja River

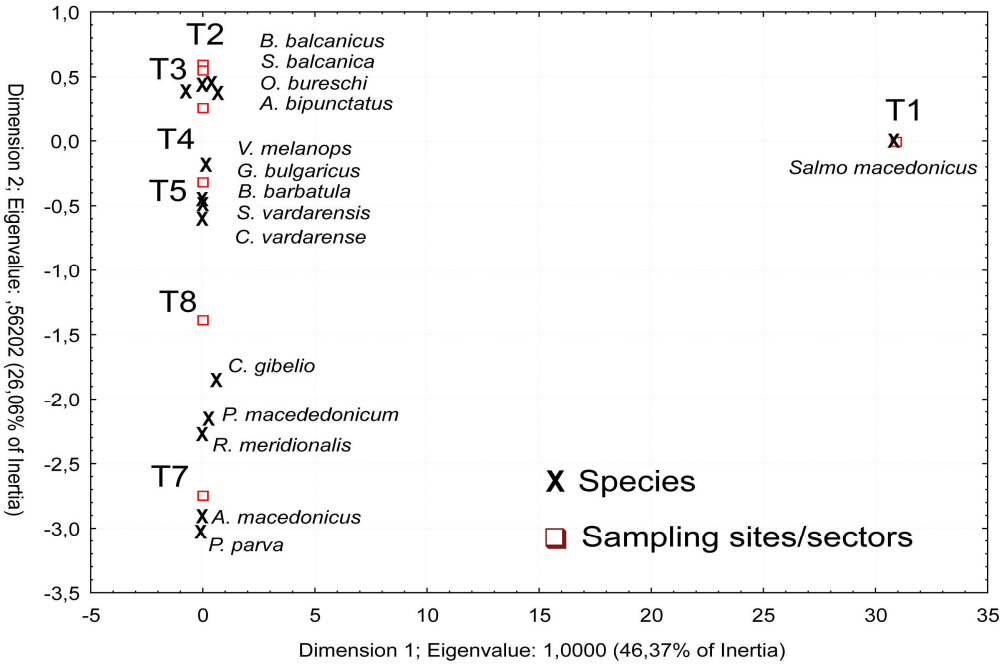

Figure 3. Correspondence Analysis performed on the data from the Pčinja River; data on the relative abundance of the taxa on sampling sites

The degradation of the Kumanovska River (T6) influenced the fish community. At this sampling point (T6) fish specimens were caught only within the zone of the confluence of the Kumanovska River and the Pčinja River, while along the fishing transect (500 m) along the Kumanovska River, no specimens were caught.

Comparing to the fish fauna at the sampling point T5, at the sampling point T7 a moderate change of the structure of the fish community was detected. Namely, at this part of the river ecosystem fish community density decreased, mostly due to the density decrease of the species that were found to be dominant in the river basin – *B. balcanicus* and *S. vardarense*. Further disappearance of *A. bipunctatus*, *S. vardarensis* and *O. bureschi* and appearance of non-native and tolerant species *P. parva* occurred (Fig. 3).

T8 – mouth of the Pčinja River into the Vardar River was the richest sampling point with 12 fish species recorded (Table 1). At this locality appearance of the most frequent species *A. bipunctatus S. vardarensis* was registered. Probably the environmental conditions improved and allowed the latter species again to inhabit the lower part of the river. Concerning to *C. gibelio* and *L. gibbosus*, probably this species migrated from the Vardar River. The same situation was registered in the mouth of the Bregalnica River (Kostov et al., 2010).

In Table 2 the biological assessment of the status of the Pčinja River based on EFI index is presented. The composition and structure of fish communities, as well as EFI values, indicated healthy, natural or near natural water ecosystem or good ecological status along the river course from the source region to the sampling point T5. The sampling point T7 is characterized by deterioration of water quality in comparison to the upstream sites – moderate ecological status at the T7. The last sampling point (T8) shows good toward moderate status.

Table 2

Categorization of water quality based on the EFI index

Sampling points	T1	T2	T3	T4	T5	T6	T7	T8
EFI values	0.61	0.52	0.58	0.60	0.61	/	0.34	0.42
Categorization	good	good	good	good	good	/	moderate	moderate

Having in mind that fish community structure at the mouth of the Kumanovska River (T6) does not significantly differ in comparison to the fauna

recorded at the sampling site T7, as well as, that the catch was successful only within a limited area, the EFI index was not included in the assessment study, taking into the consideration that the calculated values could lead to the wrong judgement.

DISCUSSION

Research of fish community structure is carried out by many authors in Europe and the Balkan Peninsula (Oberdorff & Hughes, 1992; Oberdorff & Porcher, 1994; Verbruggen et al., 1996; Urbanic & Podgornik, 2008; Benejam et al., 2010; Grapci-Kotori et al., 2010; Kostov et al., 2010; Simonović et al., 2010). Initially investigated river ecosystems are located in different climate parts, different length of the river basin, water velocity, hydrometrical conditions, physical and chemical parameters of water, type of habitat, vegetation, etc., which require a different composition and differences in structural and functional features in fish communities. On the other hand, there are similarities in the distribution of fish fauna across most river ecosystems. Namely, in the upper streams dominated mainly salmonid fish, while cyprinid fish characterize middle and lower flows of rivers. The same situation has been noticed along the watercourse of the Pčinja River.

A total of 16 fish species belonging to five families were recorded, with domination of *Cyprinidae* in the investigated river basin. However, the structure of fish fauna on some parts of riverbed indicated environmental stress caused by the impact of some human activities.

Namely, the deterioration of the river status in lower stretches was illustrated by the absence of the fish specimens along the considerable part of the fishing transect (500 m) in the Kumanovska River. At this sampling point (T6) fish specimen were caught only within the zone of the confluence of the Kumanovska River and the Pčinja River. In comparison to upstream sites, fish community density decreased at the site 7, mostly due to the abundance decrease of the species that were found to be generally dominant in the river basin – *B. balcanicus* and *S. vardarense* that could be connected with environmental stress. Further disappearance of *A. bipunctatus*, *S. vardarensis* and *O. bureschi* and appearance of non-native and tolerant species *P. parva*, also indicate the influence of pollution.

The change of the river type was illustrated by the considerable change in the fish community structure, which has been shown with the results of the Correspondence Analysis (Fig. 3). Thus, *Salmo macedonicus* was registered only in the first sampling site T1 similarly as in the upper part of many other mountain rivers (Kostov et al., 2010). Further, considerable species richness (6–10 taxa) in comparison to other sites and community structure typical (Karaman, 1924; Apostolski et al. 1956; Grupče and Dimovski, 1973; Kostov et al., 2010) for the middle part of many Macedonian rivers (*A. bipunctatus, B. balcanicus, G. bulgaricus, C. vardarense, R. meridionalis*, *S. vardarensis* and *V. melanops*) was recorded at the sampling sites T2-T5. At T8 the direct influence of the Vardar River could be illustrated by the presence of *C. gibelio* and *L. gibbosus*. The migration of the same taxa from the Vardar River into the tributary was recorded in the case of the Bregalnica River, as well (Kostov et al., 2010).

Composition and structure of fish community, as well as values of the selected fish based metric (EFI) indicated healthy, natural or near natural water ecosystem or good ecological status along the river course from the source region to the sampling point T5.

The Kumanovska River causes deterioration of the water quality downstream the confluence. Therefore, the sampling point T7 is characterized with deterioration of water quality in comparison to upstream sites. EFI indicated a moderate ecological status at the T7. The last sampling point (T8) shows a good towards moderate status. Such a degree of category recorded in a confluence area of a river (water quality is naturally diminished) shows that the Pčinja River has high capacity of self-purification. After passing through the Gorge Taor, the sector characterized by low anthropogenic influence, slight improvement of the water quality in the lower stretch of the Pčinja River (T8) occurred, which is mostly illustrated by the structure of fish community (the species richest sampling point and reappearance of *A. bipunctatus S. vardarensis*).

The results of this study show, that the Kumanovska River has strong negative influence on the Pčinja River ecosystem. Therefore, an adequate monitoring and management strategy should be implemented in the Pčinja River watershed.

According to our results, fish based assessment system EFI (Schmutz et al., 2007, FAME

2002, 2004) was found to be applicable for the status evaluation in Macedonia in certain river types. According to Pont et al. (2007) the discriminative capacity of EFI between disturbed and natural sites was found to be satisfactory. Anyhow, further testing of the EFI (Pont et al. 2007) and EFI+ (Gutierrez et al., 2009) system is needed to define a trusty fish based type specific assessment system for Macedonia. The need for the type specific reference condition for parameters selected in EFI and EFI+ should be defined for water types in Macedonia. Further, the other approaches, such as FIS index (Kovač, 2008) should be tested for specific circumstances in the Macedonian river types.

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