

MATERIALS ON THE FAUNA AND DISPERSAL OF THE ICHTHYOFAUNA IN THE ESTUARIES OF RIVERS IN THE REPUBLIC OF ABKHAZIA

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Abstract: The results of complex hydroecological expeditions of the Department of Environmental Engineering and Water Management of Kazan (Volga region) Federal University and the Institute of Ecology of the Academy of Sciences of Abkhazia, during 2013-2016, are presented in the work. The objects of study were ichthyocenoses of 28 rivers of Abkhazia flowing into the Black Sea. 23 species of fish were found in the studied estuaries of rivers. *Alburnoides bipunctatus* and *Gambusia affinis* are the common species of ichthyocenoses. According to the salinity regime, freshwater species of ichthyofauna predominate in the estuaries of rivers. Linnophilous species predominate according to the disposition of river flow rates. According to the factor of disposition to different habitats, the bottom species of fish are the prevailing group. By the type of feeding, the most species are defined as benthophages. By the ratio of faunal groups, the most species belong to the Ponto-Caspian freshwater complex. The rivers Gudou, Pshap, Gumista, Bzyb, Mchishta, Maanikvara and the Akuna channel have the highest values of species richness and species diversity of ichthyocenoses. The most similar in species composition of ichthyocenoses are the Maanikvara, Kodori and Bzyb rivers. Multifactorial variance analysis of ecological conditions did not reveal any factor, statistically significant for the species composition, other population and cenotic parameters of the ichthyofauna.

Keywords: ichthyofauna, the Republic of Abkhazia, estuaries of rivers, faunistic groups of fish, variety of ichthyofauna.

1 Introduction

Recently, much attention has been paid to the problem of studying and preservation of biological diversity. It is generally accepted, that biological diversity is one of the component criteria for a sustainable ecosystem, and the loss of biological diversity can lead to irreversible effects for ecosystems (Devall, 2006).

The problem of conservation and study of biological diversity today is particularly acute. There are different ways to solve it. It is possible to address these issues, including in the urbanized areas, by developing a network of specially protected natural areas (Zamaletdinov et al, 2016).

Currently, due to various political events of recent decades, in some areas there is no up-to-date information on the status of individual ecosystem components. To date, the territory of the Republic of Abkhazia in this regard remains relatively unexplored.

In particular, the problem of dispersal and classification of the anamnies remains insufficiently studied. At present, there are only selected data on the classifications of the anamnies (Ermakov et al, 2016).

The ichthyofauna of the Republic of Abkhazia remains a comparatively little-studied component. To date, there has been almost no reliable information on the fish fauna in the estuaries of rivers. With the exception of quite obsolete data

(Chkhikvishvili, 1939; Svetovidov, 1964; Tsomoya, 1974). To date, there is no reliable information on the dispersal of ichthyofauna in the Republic of Abkhazia.

The estuaries of rivers in the Republic of Abkhazia, flowing into the Black Sea, are ecotonic zones. They are practically independent ecosystems.

The rivers of the Republic of Abkhazia are numerous, various in typology, hydrological and morphometric indicators. The flow and quality of river waters vary considerably in the seasonal (the period of high water and low streamflow periods) and long-term dynamics (Ekba et al, 2007). The state of the rivers in Abkhazia and their influence on the ecological state of the shallow coastal zone of the Black Sea have practically not been investigated until the present.

In the conditions of continuing intensive economic development of resources (including water objects), started in the postwar years, the rivers and lakes of Abkhazia undergo ecological changes, that threaten the stable existence and functioning of ichthyofauna communities. In this connection, the monitoring studies of the state of all elements in the ecosystems of water bodies emerge full blown. And especially this concerns the fish communities of the littoral zone, which are strongly affected by human.

The purpose of this work is to study the ichthyofauna of the water bodies of the Republic of Abkhazia. Ichthyocenoses of 28 rivers were the objects of the study.

2 Material And Methods

Material for this article was collected during complex expeditions of the Department of Environmental Engineering and Water Management of Kazan (Volga region) Federal University and the Institute of Ecology of the Academy of Sciences of Abkhazia in 2013-2016.

The material was collected in the following fresh water objects: the rivers Aapsta, Avzdra, Agudzera, Ambra, Atskvara, Basla, Bzyb, Galidzga, Gvandra, Gudoy, Gumista, Dgamsh, Dzhumkur, Kodori, Maanikvara, Mokva, Machara (в рус. варианте Мочара, но: Мачара), Mchishta, Mysra, Psou, Psyrtscha, Pshar, Sukhumka, Tamsh, Khashupse (в рус. варианте Хашипста, но: Хашупсе), Khipsta, Shitskvara, the Akuna channel. – примечания согласно названиям, взятым из географической карты).

Ichthyological material was collected by seining the fish from lakes, using active fishing gear: the minnow drag seine (6m long with 5mm bar), and fishing net (Sedenberg, 2002). The fishing net was stretched and plunged into water at the site of mass fish concentration, and the researches waded upstream over 10 meters. After that, the fishing net was quickly removed from the water. The collected material was then transferred to a special container and fixed in 4% formalin solution for further testing in laboratory conditions. For one ichthyological sample, from 5 to 10 efforts were selected, depending on the amount of fish caught.

Cameral processing of samples was carried out on a fixed ichthyological material. First of all, the species, the size and weight of each investigated fish were determined. On the basis of quantitative indicators of catches, the number of fish per one effort was calculated. The structure of ichthyocenoses was described by calculating the share of each species in the catches.

The estimation of α -diversity is based on consideration the species richness and uniformity of species abundances (Lebedeva et al, 2002). The most popular of these methods for estimating α -diversity are the Margalef and Shannon indices.

The estimation of β -diversity was carried out by comparing the species composition of different communities on the basis of the Jaccard index (Megarran, 1992).

We also carried out multifaceted variance analysis, which was widely used in modern environmental studies (Kaplunovsky, 2005; Thorson, 2015).

In the process of factor analysis, we assessed the impact of the following factors:

1. Current speed;
2. Average depth;
3. Oxygen content;
4. pH;
5. Mineralization;
6. Estimated pollution index;
7. Class of bonitet.

Statistical processing was carried out using MS Excel 2010 and Statsoft Statistica 10.0.

3 Results And Discussion

Ichthyofauna of the rivers, studied in the period from 2013 to 2016, is miscellaneous in species composition. In total, we found a reliable habitat of 23 fish species. The number of species varied from 1 (the Ambra River) to 13 (the Aapsta River) (Table 1). The largest number of species (14) belongs to *Cypriniformes*, 13 species of which are representatives of *Cyprinidae* and 1 belongs to *Cobitidae*. The order *Perciformes* is represented by 2 families: *Gobiidae* (3 species) and *Blenniidae* (1 species). The order *Mugilidae* is represented by 1 family, consisted of 2 species. The order *Gasterosteiformes* is represented by 2 species, including 2 families. Only 1 species was found in the order *Cyprinodontiformes*.

We analyzed 5 types of ichthyofauna ecological groups according to their disposition to environmental conditions. According to the disposition to the salinity regime, five ecological groups of ichthyofauna were identified in the estuaries of rivers. There are freshwater species - 57% (predominated), freshwater and brackish water species - 18%, marine, freshwater and brackish water - 17%, brackish and marine (by 4% in each group) in the rivers.

An approximately equal ratio of ecological groups is observed according to the disposition to the rate of water flow: rheophilic (48%) and limnophilic (52%) species.

According to the disposition to different habitats, the bottom group of fish was predominant (61%). Pelagic species were 39%. Three groups of ichthyofauna were distinguished according to the prevailing feeding type: benthophages (52%), planktophages (39%) and detritophages (9%).

At the estuaries of rivers in Abkhazia, we defined eight faunal complexes: Ponto-Caspian freshwater - 35%, Ponto-Caspian relic - 22%, Ponto-Caspian marine - 9%, Boreal-plain, South American, Boreal-Piedmont, Tertiary-Plain and Arctoboreal (в рус. варианте Арктобореальный, в англ. заменено на Арктобореальный) - the last five groups make up 4% of the total number of species.

The highest values of the ichthyocenoses species richness (according to Margalef index) were obtained for the rivers Gudou, Pshap, Gumista and for the Akuna channel. The rivers, which had the lowest values of species richness, were the following: Ambra, Machara, Gvandra and Shitskvara.

The highest values of the ichthyocenoses species diversity (according to Shannon index) were obtained for the rivers Pshap, Bzyb, Mchishta, Gudou, Maanikvara, Gumista. The rivers, which had the lowest values of species diversity, were the

following: Ambra, Mysra, Machara, and Tamsh (Nazarov, 2016).

An important aspect in the study of fauna is the assessment of the similarity of different communities of the identified species. Such a measure is the Jaccard index.

Table 1. Table of occurrence of fish species in the estuaries of rivers, according to data of 2013-2016.

Rivers	Aapsta	Avzdra	Agudzera	Ambra	Atskvara	Basla	Bzyb	Galidzga	Gvandra	Gudoy	Gumista	Dgamsh	Dzhumkur	Kelasuri	Kodori	Maanikvara	Mokva	Machara	Mchishta	Mysra	Psou	Psyrtsha	Pshap	Sukhumka	Tamsh	Khashupse	Khipsta	Shitskvara	Akuna channel
<i>Alburnoides bipunctatus</i>	+		+		+	+	+	+	+	+	+		+	+	+	+		+		+		+	+		+	+	+		+
<i>Neogobius melanostomus</i>						+		+				+									+	+		+					
<i>Neogobius fluviatilis pallasi</i>	+				+	+					+												+		+				
<i>Proterorhinus marmoratus</i>	+							+		+			+						+	+			+				+		
<i>Leucaspis delineatus delineatus natio caucasicus</i>	+					+	+		+					+	+	+					+						+		+
<i>Gambusia affinis</i>	+				+			+		+	+	+							+										+
<i>Squalius cephalus orientalis</i>									+			+					+												
<i>Squalius cephalus</i>		+		+			+			+					+	+				+		+							
<i>Phoxinus phoxinus</i>					+		+			+				+	+	+			+	+	+	+	+			+	+		+
<i>Rhodeus sericeus</i>	+	+						+					+								+		+						
<i>Carassius auratus</i>										+		+																	+
<i>Gasterosteus aculeatus</i>					+					+									+				+						+
<i>Mugil cephalus</i>	+				+								+						+				+		+		+		
<i>Parablemnus sanguinolentus</i>										+																			
<i>Gobio ciscaucasicus</i>							+				+			+	+	+													
<i>Gobio gobio lepidolaemus</i>																	+			+						+			
<i>Syngnathus nigrolineatus</i>																													+
<i>Liza aurata</i>	+					+		+						+								+		+					+
<i>Alburnus charusini charusini</i>	+	+	+				+			+				+		+							+	+	+		+	+	+
<i>Barbus tauricus escherichii</i>	+									+				+			+	+		+	+						+	+	
<i>Barbus barbus</i>	+									+																			
<i>Barbus ciscaucasicus</i>	+									+																			
<i>Cobitis taenia</i>	+		+							+									+				+	+					
Total number of species	13	3	3	1	6	5	6	6	2	7	10	4	6	7	5	6	3	2	6	6	5	5	8	4	4	3	7	2	9

Absolute similarity of the species composition was found on the Maanikvara and Bzyb rivers, where the Jaccard coefficient was $J = 1$. Also similar in the composition of ichthyofauna were the rivers: Kodori and Bzyb ($J = 0.83$), Kodori and Maanikvara ($J = 0.83$), Psyrtsha and Basla ($J = 0, 67$), Kelasuri and Bzyb ($J = 0.63$), Maanikvara and Kelasuri ($J = 0.63$), Hipsta and Kelasur ($J = 0, 56$), Jumkur and Galidzga, Hachslsta and Mysra, Khipsta and Pshap, where the Jaccard coefficient was 0.50 in the last three groups of rivers.

In the process of calculations of population and cenotic parameters of the ichthyofauna in the rivers of Abkhazia, the diversity of these values for each water body is evident. The

calculated values of the indicators of ecological and faunal groups, as well as the species diversity and species richness of the ichthyofauna, can be considered as high enough, especially that we study the mountain rivers. Such a distribution can be caused by the impact of many environmental factors of the environment (biotic and abiotic). Multifactorial variance analysis was carried out to determine the factor, which significantly influences the species composition and diversity of ichthyofauna, the ratio of ecological and faunal groups. According to the results of the study, not a single factor, significantly influencing the species composition, other population and cenotic parameters of the ichthyofauna, was found.

Table 2. The results of multifactorial variance analysis

	SS	Degr. of (Freedom)	MS	F	p
Intercept		0			
Drain	32,93099	3	10,97700	1,603626	0,406348
Deep	12,03063	3	4,01021	0,585850	0,680107
Oxygen	9,95453	3	3,31818	0,484751	0,726832
pH	37,57356	4	9,39339	1,372278	0,462791
Mineralization	30,23745	3	10,07915	1,472460	0,428902
Rank indicator	15,74847	4	3,93712	0,575173	0,713820
Class of bonitet	13,81238	4	3,45309	0,504462	0,747774
Error	13,69022	2	6,84511		

Hydrological, hydrochemical and hydrobiological indicators of rivers, as a whole, are close to the values of the ecological optimum and are favorable for the development and vital activity of ichthyocenosis (Table 2). The calculated value of the

determination coefficient is close to unity, which indicates the absence of other unaccounted factors, which significantly affect the species diversity (Table 3).

Table 3. The assessment of the degree of species diversity dependence on the mentioned factors

	Multiple (R)	Multiple (RI)	Adjusted (RI)	SS (Model)	df (Model)	MS (Model)	SS (Residual)	df (Residual)	MS (Residual)	F	P
Count of species	0,963729	0,928774	0,002830	178,5167	26	6,866026	13,69022	2	6,845108	1,003056	0,617327

It follows that among the examined biotic and abiotic factors of the environment, conditions, affecting the formation of species composition and ecological groups of ichthyofauna, were not found. It is possible, that the uneven and heterogeneous nature of the ichthyofauna groups' distribution and their abundance depends on other, more global environmental factors (for example, geographic isolation of the territory or different intensity of habitat development by different species at specific geological stages) or the combined effect of several factors. In addition, various interspecific and intraspecific features of fish behavior have not been taken into account, in the process of factor analysis according to one-dimensional criterion of significance. This, in turn, can have a significant effect on the dispersion of species, ecological and faunal groups and their abundance.

4 Deductions

23 species of fish were identified in the estuarine of rivers. The order of *Cypriniformes* is predominant. *Alburnoides bipunctatus* and *Gambusia affinis* are the common species of ichthyocenoses.

According to the salinity regime, freshwater species of ichthyofauna predominate in the estuaries of rivers. Limnophilous species predominate according to the disposition of river flow rates. According to the factor of disposition to different habitats, the bottom species of fish are the prevailing group. By the type of feeding, the most species are defined as benthophages. By the ratio of faunal groups, the most species belong to the Ponto-Caspian freshwater complex.

The rivers Gudou, Pshap, Gumista, Bzyb, Mchishta, Maanikvara and the Akuna channel have the highest values of species richness and species diversity of ichthyocenoses. The most similar in species composition of ichthyocenoses are the Maanikvara, Kodori and Bzyb rivers.

Multifactorial variance analysis of ecological conditions did not reveal any factor, statistically significant for the species composition, other population and cenotic parameters of the ichthyofauna. Hydrological, hydrochemical and hydrobiological indicators of rivers, as a whole, are close to the values of the ecological optimum and are favorable for the development and vital activity of ichthyocenosis

5 Conclusion

Monitoring investigation of ecosystems biotic components under current conditions is the key to sustainable development of territories. For a long time, in the territory of the Republic of Abkhazia, there have been no studies of the species composition and the features of fish ecology in the estuaries of rivers. The results, obtained by the team of authors, are preliminary results of the long-term study of this territory.

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