STRUCTURE AND ECOLOGICAL ASSESSMENT OF FISH COMMUNITIES FROM PREDELTAIC DANUBE SECTOR, BETWEEN SIRET RIVER AND PRUT RIVER MOUTH

Petronela Georgiana Calin Sandu[1*], L. Oprea[1], Daniela Gheorghe[1], N. Patriche[2]

[1]*"Dunarea de Jos" University of Galati, Romania*
[2]*Institute of Research and Development for Aquatic Ecology, Fishery and Aquacuture, Galaţi, Romania*

Abstract

The paper is presenting some aspects regarding the structure of fish communities from 22 Km of predeltaic sector of Danube River, between the mouth of Siret River (km 155) and Prut River (Mm 72.5). The aim of the study is to assess the ecological status of the area, using the main ecological indices as abundance, dominance, constancy and ecological significance. From April to December 2011, in four fishing areas (km 150-151, Mm 77-78, Mm 76-77, Mm 74-74.5), 4805 fish of twenty three species, from six famillies, were collected. The best represented family is Cyprinidae with 14 breeds. The numerical abundance ranged between 2 fish/breed (zingel, common nase) and 2035 fish/breed (pontic shad). The pontic shad (42.35%), common bream (11.63%) and common carp (10.9%) are eudominant breeds, having the biggest potential in fish productivity. Pike–perch (75%), common bream (75%), common barbel (75%), vimbe (75%), white-eye bream (75%), asp (66.66%), prussian carp (66.66%), white bream (58.33%), common carp (58.33%), silver carp (58.33%) and sterlet (58.33%) are constant species with high adaptability. In term of ecological significance, Danube shad (14.11%), common bream (8.72%), common carp (6.36%) and common barbel (5.32%) are characteristic species.

Key words: Danube, fish communities, abundance, dominance, constancy, ecological significance

INTRODUCTION

The fishery is a system conposed of three components which interact with each other: *the habitat* (the abiotic and biotic living environment where organisms live), *the biota* (represented by the living organisms in an ecosystem, including the fish, the plankton, the insects, the plants etc.) and *the people* (users of the water and fishing resources) [11]. A good management of the three interactive components of the fishery should always lead to a durable exploitation, in terms of biodiversity conservation and protection. In the last decades, however, unfortunately, the over-exploitation of the fish communities at the same time as the continuous degradation of the habitats led to the decline and even to the extinction of some fish species [2]. Therefore, in order to take some efficient conservation measures, a good knowledge of the species ecobiology and of their interaction with their living environment is necessary [9].

In this work there are presented some aspects regarding the structure and the ecological assessment of the fish communities from the predeltaic Danube. The aim of the researches is to highlight the structural changes from the level of the ichthyofauna, by using some analytical and synthetic ecological indices.

MATERIAL AND METHOD

Fishing area

The study area is represented by a region in the predeltaic Danube, located between the Siret River Mouth (km 155) and the Prut River Mouth (Mm 72.5). This region has approximately 22 km, representing the length of the Danube sector in Galati county. Monthly, systematic measurements have been made in 4 fishing areas: Galati area (km 150-151), Condrea area (Mm 77-78), Mureşanu area (Mm 76-77) and Plopi area (Mm 74-74.5) (fig.1).

*Corresponding author: georgiana_nutu@yahoo.com;
The manuscript was received: 17.02.2013
Accepted for publication: 11.05.2013

Fig. 1 Map of fishing area (satellite image)

Fishing effort, fishing gears and methods

The structure of a fishing unit (FU) is the following: the fishing boat, the gear and 2 fishermen. On the average, in an area more FU operate, making 2-3 operations / fishing day [6]. The fishing has been made through active methods, on areas, with filtering gear: gill net and trammel net type. The constructive characteristics of these varied, depending on the targeted species to be caught: gill nets (Lp 100-150 m; Hp 2.5-3.5; a 30-60 mm), trammel nets (Lp 150-200 m; Hp 2.5- 4.0; a 40-80 mm). The used method for obtaining the capture data is the simple randomised samples. The caught specimens have been identified and divided on species; biometric and gravimetric measurements have been made. The identification of the fish species was made by analysing the specialised literature [1] [7] [8] [13] [14].

Fishermen teams, from "Dunărea de Jos" University of Galați, Department of Aquaculture, Environmental Science and Cadastre and from the Institute of Research and Development for Aquatic Ecology, Fishery and Aquacuture Galați, have been making scientific fishing, according to the conditions of the authorization issued by National Agency for Fishing and Aquaculture.

The calculation of the ecological indices and statistical approaches

The structural changes at the level of ichtiocenoses are characterized by using some analytical ecological indices (abundance, dominance, constancy) and synthetic ones (the index of ecological significance), but also diversity and equitability indices.

The statistical methods of the data has been made with the computer (MSOffice Excell) and with the software BioDiversity Pro.

Formulas

The Bray-Curtis (B) disimilarity index, takes values between 0-1 [5].

$$B = \frac{\sum \mid Xij - Xik \mid}{\sum (Xij + Xij)}$$

where: Xij, Xik – the number of individuals from a species in each sample;
Shannon-Wiener (H') index

$$H' = -\sum_{i=1}^{S} pi \ln pi$$

pi – the abundance ratio of breed i; ln – common logarithm.
Simpson (D) index, is among the first diversity indices (*Simpson* 1949), [10].

$$D = 1 - \sum_{i=1}^{S} pi^2$$

The Simpson (1-D) diversity index, is used for the correct estimation of a finit population:

$$1-D=1-\sum\frac{n_i(n_i-1)}{N(N-1)}$$

n_i – the number of individuals from breed i;
N_i – the total number of individuals from the analysed sample.

The equitability refers to the example of individuals distribution between species [3]. The Shannon equitability index has been calculated (relative diversity $\mathbf{H_R}$) but also the Simpson E_{1-D} equitability index.

$$H_R=\frac{H_S}{H_{Smxa}}=\frac{H}{\log S}$$

$$E_{1-D}=\frac{1-D}{(1-D)_{\max}}$$

RESULTS AND DISCUSSIONS

Between April - December 2011, there were caught 4805 fish, with a total biomass of 6027.35 kg, of 23 species, from 6 families, respectively 6 orders. The autochthon and allochthonous ichthyofauna in the predeltaic Danube is divided in two groups, depending on salinity tolerance: euryhaline and stenohaline species (table 1). The best represented family is *Cyprinidae*, of the *Cypriniformes* order, with 14 species (fig. 2).

In table 2 there are presented the main analytic and synthetic ecological indices. The numerical abundancy of the species is given in fig. 3. It ranged between 2 fish/breed (zingel, common nase – rare species) and 2035 fish/breed (pontic shad – abundant breed). The total values of the biomass ranged between 0.4-2093.9 kg/breed.

Concerning the dominance (D), the breeds are grouped on 5 classes, depending on the percentage. The pontic shad, common bream and common carp are eudominant breeds (over 10% from the fish production), which influence decisively the fishing productivity. The common barbel is the dominant breed (5.1-10%). The Prussian carp, grasscarp, european catfish, whitefish, sterlet and asp are subdominant breeds (2.1-5%). The zander is a recedent breed (1.2-2%), and the other twelve identified breeds are under-recedent, with percentage under 1.1%.

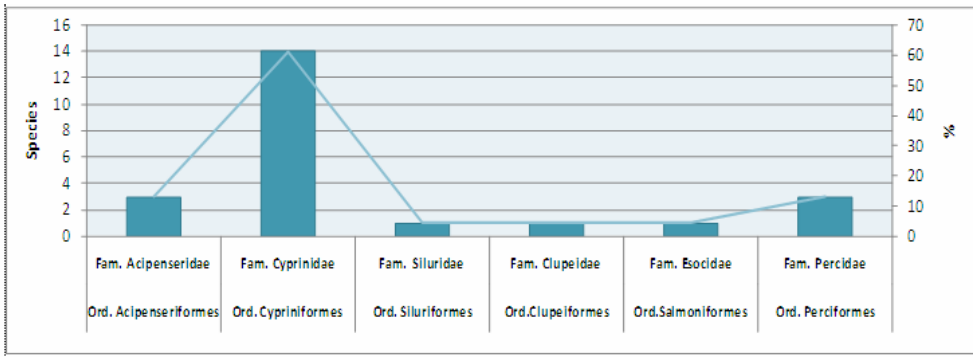

Fig. 2 The qualitative structure of Danube ichthyofauna

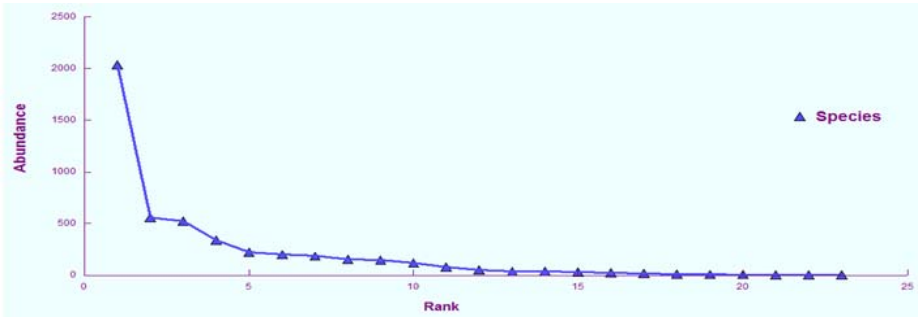

Fig. 3 The abundance of the fish

Table 1 The ecological plasticity of fish

No. crt.	Specie	Name popular	Eurihaline	Stenohaline
1	*Aspius aspius (Linnaeus, 1758)*	Asp	x	
2	*Blicca björkna (Linnaeus, 1758)*	White bream		x
3	*Carassius gibelio (Bloch, 1782)*	Prussian carp	x	
4	*Abramis sapa (Pallas, 1814)*	White-eye bream		x
5	*Ctenopharyngodon idella (Valenciennes,1844)*	Grass carp		x
6	*Cyprinus carpio (Linnaeus,1758)*	Carp	x	
7	*Vimba vimba (Linnaeus,1758)*	Vimba		x
8	*Barbus barbus (Linnaeus,1758)*	Barbel		x
9	*Hypophthalmichthys nobilis (Richardson, 1845)*	Bighead carp		x
10	*Abramis brama(Linnaeus,1758)*	Common bream		x
11	*Pelecus cultratus (Linnaeus,1758)*	Ziege	x	
12	*Hypophthalmichthys molitrix*	Silver carp		x
13	*Chondrostoma nassus (Linnaeus,1758)*	Common nase		x
14	*Leuciscus idus (Linnaeus,1758)*	Ide		x
15	*Acipenser ruthenus (Linnaeus,1758)*	Sterlet		x
16	*Huso huso (Linnaeus,1758)*	Beluga sturgeon	x	
17	*Acipenser stellatus (Pallas,1771)*	Stellate sturgeon	x	
18	*Alosa immaculata (Bennett, 1835)*	Pontic shad	x	
19	*Zinger streber (Linnaeus, 1758)*	Danube streber		x
20	*Zingel zingel (Linnaeus, 1758)*	Zingel		x
21	*Sander lucioperca (Linnaeus, 1758)*	Pike-perch	x	
22	*Silurus glanis (Linnaeus, 1758)*	Wels catfish	x	
23	*Esox lucius (Linnaeus,1758)*	Northern pike		x

Dependent on the value of the constant (C), which represents the continuity in the biotope, the breeds are divided in the following categories: *constant*, present in 50.1-75% of the months (white-eye bream, vimba, common barbel, common bream, pike-perch, asp, prussian carp, white bream, common carp, silver carp, sterlet, wels). The *accessory* breeds (25.1-50%) are bighead carp, ziege, ide and pontic shad. There are seven *accidental* breeds (1-25%), less common during the year: stellate sturgeon, zingel, northern pike, grass carp, common nase, Danube streber and beluga sturgeon.

The values of the ecological significance index (W) shows us that pontic shad (W5), common bream (W4), carp (W4) and barbel (W4) are *characteristic* breeds (over 5.1%). There are thirteen *accessory* breeds (0.1-5%): grass carp, prussian carp, vimba, wels, sterlet, asp and pike-perch (W3) and zingel, silver carp, bighead carp, white bream, ziege and stellate sturgeon (W2). In category W1 there are six *accidental* breeds, with an index lower than 0.1% (grass carp, common nase, ide, beluga, streber and nortern-pike).

Concerning the frequency in the catch (the numerical abundancy), from the analysis of the Bray-Curtis similarity dendrogram of the fish species, it can be seen that two breeds (Danube streber and common nase) have a maximum coefficient of 100%, because they occured in the catches only twice (fig. 4). From this point of view, there is a great resemblance between the stellate sturgeon and the bighead carp (98.70%), which occured in catches 38 times and respectively 39 times. Other groups of high similarity: between sterlet and vimba (97.70%), also between the common bream and the common carp (96.76%). A relative heterogeneity between the captured breeds can be observed. The pontic shad (43.09%) is isolated from the other breeds, because it registers the highest percent in the catches, during the spring season, when it migrates for reproduction.

Table 2 Indices of ecological communities of the fish from Danube River, between the mouth of Siret River (km 155) and Prut River (Mm 72.5)

No. crt.	Specie	Abundance (A)		Ecological indices					
				Dominance (D)		Constancy (C)		Ecological significance (W)	
		Number	Biomass	%	Class	%	Class	%	Class
1.	*Aspius aspius (Linnaeus, 1758)*	120	142,7	2,49	**D3**	66,66	**C3**	1,66	**W3**
2.	*Blicca björkna (Linnaeus, 1758)*	51	17,05	1,06	**D1**	58,33	**C3**	0,62	**W2**
3.	*Carassius gibelio (Bloch, 1782)*	221	75,1	4,6	**D3**	66,66	**C3**	3,06	**W3**
4.	*Abramis sapa (Pallas, 1814)*	199	54,4	4,14	**D3**	75	**C3**	3,1	**W3**
5.	*Ctenopharyngodon idella (Valenciennes,1844)*	8	40	0,16	**D1**	8,33	**C1**	0,014	**W1**
6.	*Cyprinus carpio (Linnaeus,1758)*	524	2093,9	10,9	**D5**	58,33	**C3**	6,36	**W4**
7.	*Vimba vimba (Linnaeus,1758)*	156	71,8	3,25	**D3**	75	**C3**	2,43	**W3**
8.	*Barbus barbus (Linnaeus,1758)*	341	584,5	7,09	**D4**	75	**C3**	5,32	**W4**
9.	*Hypophthalmichthys nobilis (Richardson, 1845)*	38	137,9	0,79	**D1**	41,66	**C2**	0,33	**W2**
10.	*Abramis brama(Linnaeus,1758)*	559	215,1	11,63	**D5**	75	**C3**	8,72	**W4**
11.	*Pelecus cultratus (Linnaeus,1758)*	24	5,2	0,5	**D1**	33,33	**C2**	0,16	**W2**
12.	*Hypophthalmichthys molitrix*	32	25	0,66	**D1**	58,33	**C3**	0,38	**W2**
13.	*Chondrostoma nassus (Linnaeus,1758)*	2	0,4	0,04	**D1**	8,33	**C1**	0,0034	**W1**
14.	*Leuciscus idus (Linnaeus,1758)*	6	2,3	0,12	**D1**	33,33	**C2**	0,041	**W1**
15.	*Acipenser ruthenus (Linnaeus,1758)*	149	144,6	3,1	**D3**	58,33	**C3**	1,8	**W3**
16.	*Huso huso (Linnaeus,1758)*	17	0,6	0,35	**D1**	8,33	**C1**	0,029	**W1**
17.	*Acipenser stellatus (Pallas,1771)*	39	178,4	0,81	**D1**	16,66	**C1**	0,13	**W2**
18.	*Alosa immaculata (Bennett, 1835)*	2035	536,6	42,35	**D5**	33,33	**C2**	14,11	**W5**
19.	*Zinger streber (Linnaeus, 1758)*	2	0,5	0,04	**D1**	8,33	**C1**	0,0034	**W1**
20.	*Zingel zingel (Linnaeus, 1758)*	3	0,8	0,062	**D1**	16,66	**C1**	0,0104	**W2**
21.	*Sander lucioperca (Linnaeus, 1758)*	81	185,5	1,68	**D2**	75	**C3**	1,26	**W3**
22.	*Silurus glanis (Linnaeus, 1758)*	186	1502	3,87	**D3**	58,33	**C3**	2,26	**W3**
23.	*Esox lucius (Linnaeus,1758)*	12	13	0,25	**D1**	16,66	**C1**	0,041	**W1**

D1 - subrecedent breeds (< 1.1%); **D2** - recedent breeds (1.2-2%); **D3** - subdominant breeds (2.1-5%); **D4** - dominant breeds (5.1-10%); **D5** - eudominant breeds (>10%);
C1 - accidental breeds (1-25%); **C2** - accessory breeds (25.1-50%); **C3** - constant breeds (50.1-75%); **C4** - euconstant breeds (75.1-100%);
W1 - subrecedent breeds (accidental) (< 0.1%); **W2** - recedent breeds (0.1-1%); **W3** - subdominant breeds (accessory) (1.1-5%); **W4** - dominant breeds (5.1-10%);
W5 - eudominant breeds (characteristic) (>10%);

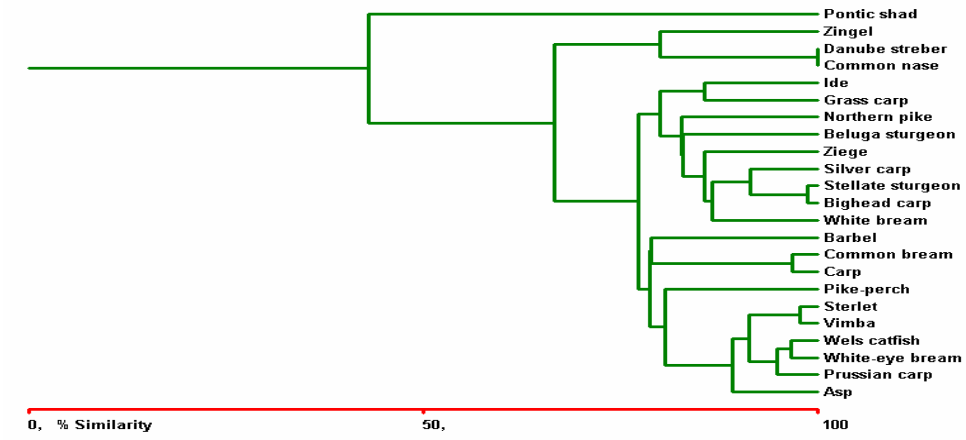

Fig. 4 Dendrogram of similarity Bray-Curtis, according with catch frequency

In fig. 5 are presented the Shannon-Wiener indices values (H'), the equitability (H_R), the Simpson diversity index (1-D) and equitability (E_{1-D}).

The Shannon-Wiener index has the value (H') of 2.07, and the teoretical maximum (H'_{max}) of 3.135. The specialised literature mentions that for (H') values between 0 (when there is only one breed in the sample) and 5 (when there are more breeds) [4][12].

The equitability (H_R) is 0.66 representing 66% from the real maximum diversity.

The Simpson diversity index (1-D), has value between 0-1 [5]. By calculating, a good value has been obtained (0.78), the maximum theoretical value is 0.957. The equitability (E_{1-D}) is 0,817; this represents 82% from the real maximum diversity.

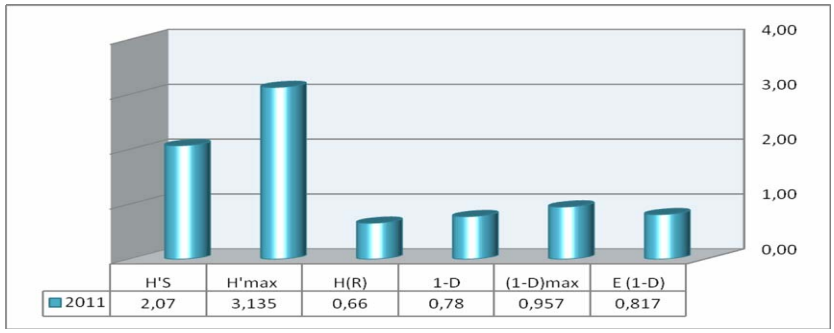

Fig. 5 Variation of diversity and equitability indices, in 2011

CONCLUSIONS

In terms of taxonomic point of vue, the overall number of fish species caught in 2011 year, from Danube area, between Siret and Prut River Mouth, was 23, belonging 6 families and 6 orders. From *Cypriniformes* order, *Cyprinidae*, the dominant family, was represented by 14 species *(Cyprinus carpio, Carassius gibelio, Barbus barbus, Abramis brama, Abramis sapa, Blicca bjoerkna, Leuciscus idus, Vimba vimba, Aspius aspius, Pelecus cultratus, Chondrostoma nasus, Ctenopharingodon idella, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis).* Other orders and families had the following structure: *Clupeiformes* order, *Clupeidae* family, with one species *(Alosa immaculata), Acipenseriformes* order, *Acipenseridae* family

with 3 species *(Huso huso, Acipenser stellatus, Acipenser ruthenus), Perciformes* order, *Percidae* family with 3 species *(Sander lucioperca, Zingel zingel, Zingel streber), Siluriformes* order, *Siluridae family,* with one species *(Silurus glanis)* and *Salmoniformes* order, *Esocidae f*amily with one species *(Esox lucius).* The most abundant species was the pontic shad, followed by common bream, common carp and barbel.

Analitical ecological indices (absolute abundance, constancy, dominance) and synthetic (ecological significance) were calculated, in order to establish the structure and composition of fish communities in the sampling sites. The values of diversity indices showed that the degree of the structural stability of the ichthyocoenoses is relatively good; an important number of species live and growth normally. It's being observed that the best adapted species to living in this sector of the Danube and which bring an important contribution to the productivity area are cyprinids, like common bream, common carp, barbel, prussian carp.

The structure of the fish communities is various, well balanced. It can be seen that the impact of the anthropic activities is quite significant.

ACKNOWLEDGEMENTS

Researches was conducted in the framework of the project POSDRU "Quality and continuity of training in the doctoral studies – no. 76822 - TOP ACADEMIC", funded by the European Union and Romanian Government. The authors thank to the management staff of the project for their support.

REFERENCES

[1] Bănărescu, P., 2002: Class Osteichthyes, Diversity in Living World, Vol II, Inland Waters, Ed. Bucura Mond, p. 692.
[2] Bram G. W. Aarts, Piet H. Nienhuis, 2003: Fish zonations and guilds as the basis for assessment of ecological integrity of large rivers, Aquatic Biodiversity, Developments in Hydrobiology, Volume 171, p. 157-178.
[3] Gheorghe, D.C., 2010: Research on the foundation of sustainable exploitation of fishery resources in the Danube and Danube Meadow, PhD Thesis, „Dunărea de Jos" University of Galati, p.52-55.
[4] Gheorghe, D.C., Cristea V., Ciolac A., 2010: Ecological aspects of the ichthyofauna from Fundu Mare Island and Cravia Arms, Scientific Papers-Animal Series, Vol 54, p. 348.
[5] Gomoiu, M.T., Skolka, M., 2001: ECOLOGY Methodologies for environmental studies, Ovidius University Press, Constanta, p. 63-130.
[6] Năvodaru, I., 2008: The estimation of the fish and fisheries stocks, Ed. Dobrogea, Constanta, p.163-168.
[7] Greenhalgh M., 2000: Freshwhater Fish, Hardcover, Octopus Publishing Group, ISBN 1-84000-144-5;
[8] Otel V., 2007: Atlas of fish from the Danube Delta Biosphere Reserve, Publishing Delta Center for Information Technology, p.14-18.
[9] Pătroescu, M., Rozylowicz, L., Iojă, C., 2002: Conservation of biological diversity, Ed. Tehnica, Bucharest, p.57-59.
[10] Simpson, E. H., 1949: Measurement of diversity, Nature 163, p. 688.
[11] Terrance J.Q., R.B. Deriso, 1999: Quantitative Fish Dynamics, Oxford Univ. Press, SUA;
[12] Washington, H. G., 1984: Diversity, biotic and similarity indices: a review with special relevance to aquatic ecosystems, Water Res., 18:653-694.
[13] www.calacademy.org
[14] www.fishbase.org