USE OF SOME STABLE ISOTOPES ($\delta^{13}C$ AND $\delta^{15}N$) IN ANALYSING THE FOOD WEB OF THE ROUND GOBY *APOLLONIA MELANOSTOMUS* (PALLAS, 1814) ON THE ROMANIAN COAST (BLACK SEA)

Daniela BANARU [1], *Mihaela CREȚEANU* [2] and *Mireile HARMELIN-VIVIEN* [1]

KEYWORDS: Black Sea, round goby, food web, stable isotopes, carbon sources.

ABSTRACT

The terrestrial inputs of the Danube River, added to the nutrients already present in the marine environment, influence considerably the productivity and functioning of the ecosystems from the north-western part of the Black Sea. Stable isotopes constitute a powerful tool for discriminating between marine and terrestrial carbon sources.

The feeding behaviour of the round goby *Apollonia melanostomus* (Pallas, 1814) was studied on the Romanian coast on 640 specimens from 21 stations in 2004 - 2005. The use of carbon and nitrogen stable isotopes provided a more detailed picture of *Apollonia melanostomus* food web structure and a good evidence of trophic transfers. The components of the round goby food web (macrophytes, polychaetes, bivalves, gastropods, amphipods, macrurids, brachyurans, sprat) showed a wide range of $\delta^{15}N$ (6.20‰ to 15.53‰) and $\delta^{13}C$ (- 29.79‰ to - 16.65‰) suggesting that *Apollonia melanostomus* consumed preys of different trophic levels and organic sources.

Stable isotope analyses S. I. A. provided an integrated picture of the resources used by the round goby for its growth. The average signature was - 18.20‰ in $\delta^{13}C$ and 14.34‰ in $\delta^{15}N$. A significant positive correlation was observed between spatial and temporal variations of the marine POM and the round goby signatures. Changes in the food behaviour of *Apollonia melanostomus* in correlation with spatial localisations and season were reflected by variations of stable isotope signatures.

REZUMAT: Utilizarea izotopilor stabili ($\delta^{13}C$ şi $\delta^{15}N$) în analiza rețelei trofice a strunghilului *Apollonia melanostomus* (Pallas, 1814) la litoralul românesc (Marea Neagră).

Aporturile terestre ale Dunării se adaugă nutrienților deja prezenți în mediul marin influențând productivitatea şi funcționarea ecosistemelor din NV Mării Negre. Izotopii stabili constituie o metodă importantă pentru diferențierea surselor terestre şi marine ale carbonului.

Comportamentul trofic al lui *Apollonia melanostomus* (Pallas, 1814) a fost studiat la 640 de indivizi din 21 de stații în 2004 - 2005 la litoralul românesc. Utilizarea izotopilor stabili ai carbonului şi azotului oferă imaginea structurii rețelei trofice a acestei specii şi evidențiază transferurile trofice. Elementele acestei rețele trofice (macrofite, polichete, bivalve, gasteropode, amfipode, macroure, brahiure, şprot) prezintă o gamă largă de variație a $\delta^{15}N$ (între 9.26‰ şi 14.61‰) şi $\delta^{13}C$ (între - 24.59‰ şi - 17.38‰), ceea ce sugerează că această specie consumă prăzi de diferite nivele trofice şi surse organice.

Analizele de izotopi stabili oferă o imagine integrată a resurselor utilizate de strunghil pentru creşterea sa. Semnătura medie a acestei specii este - 18.66‰ pentru $\delta^{13}C$ şi 14.40‰ pentru $\delta^{15}N$. O corelație pozitivă semnificativă a fost observată între variațiile spațiale şi temporale ale semnăturii MOP marină şi a strunghilului. Schimbări ale comportamentului alimentar ale acestuia în funcție de zonă şi sezon au fost reflectate prin variațiile semnăturilor în izotopi stabili.

RESUME: Utilisation d'isotopes stables ($\delta^{13}C$ et $\delta^{15}N$) dans l'analyse du reseau trophique du gobie à taches noires, *Apollonia melanostomus* (Pallas, 1814) sur la cote roumaine (Mer Noire).

Les apports terrestres du Danube, ajoutés aux nutriments déjà présents dans l'environnement marin influencent considérablement la productivité et le fonctionnement des ecosystems du nord-ouest de la Mer Noire. Les isotopes stables constituent un outil puissant pour discriminer les deux sources de carbones marine et terrestre.

Le comportement de nourrissage du Gobie à taches noires *Apollonia melanostomus* (Pallas, 1814) a été étudié sur la côte roumaine sur 640 specimens provenant de 21 stations en 2004 - 2005. L'utilisation des isotopes stables de carbone et d'azote permet de dresser un tableau plus détaillé de la structure du réseau trophique de *Apollonia melanostomus* et de mettre en évidence certains transferts. Les composants du réseau trophique du Gobie à taches noires (macrophytes, polychètes, bivalves, gastéropodes, amphipodes, macrouridés, crabes brachyoures, sprat) présentent une grande variation de $\delta^{15}N$ (6.20‰ à 15.53‰) et de $\delta^{13}C$ (- 29.79‰ à - 16.65‰) ce qui suggère que *Apollonia melanostomus* consomme des proies appartenant à différents niveaux trophiques et tributaires de différentes sources de matières organiques.

Les analyse S. I. A des isotopes stables fournissent une vision intégrée des resources utilisées par le gobie à taches noires pour sa croissance. La signature moyenne était de - 18.20‰ en $\delta^{13}C$ et 14.34‰ en $\delta^{15}N$. Une corrélation positive a été observée entre les variations spatiales et temporelles de la matière organique particulaire et la signature du Gobie à taches noires. Les modifications dans le comportement de nourrissage de *Apollonia melanostomus* en correlation avec la localisation spatiale et la saison sont reflétées par les variations des signatures en isotopes stables.

INTRODUCTION

The main objective of this study was to describe the structure of the trophic web of the *Apollonia melanostomus* (Pallas, 1814) on the Romanian Black Sea coast and to understand the respectives roles of the marine particulate organic matter (MPOM) and Danubian terrestrial particulate organic matter (TPOM) in his functioning of the coastal ecosystem.

Gobiids present economic interest for the demersal fisheries in the north-west part of the Black Sea. The Romanian annual average catch of the gobiids from 1970 to 2002 is 25.6 tonnes / year (Nicolaev et. al., 2004).

The round goby *Apollonia melanostomus*, a Ponto-Caspian species occurring in the Black, Caspian, Aral and Baltic seas presents a high ecological adaptability. Its introduction and rapid spread in several countries was reported by different authors as well as its adverse ecological impact in Canadian lakes (French and Jude, 2001; Jude et. al., 1992; 1995; Vangerplorg et. al., 2002). The round goby prefers rocky and debris-filled substrates where it can reach high abundances. *Apollonia melanostomus* is a bottom-feeding fish consuming bivalves, snails, crustaceans, polychaetes and small fish (Wandzel, 2003; Skora and Rzeznik, 2001; Ray and Corkum, 1997; Charlebois et al., 1996). In the Black Sea, 80% of the round goby diet were represented by molluscs (Nikolskii, 1954). On the Romanian Black Sea coast Porumb (1961) and Bănărescu (1964) studied the trophic behaviour of this species which mainly consumed molluscs, polychaetes, crustaceans.

The Danube River (6000 m^3s^{-1}) is the second largest river in Europe after the Volga River and represents 38% of the fresh water inputs into the Black Sea (Panin, 1997). It has a high impact on the sedimentation and on marine ecosystems in the north-western part of the Black Sea (Gomoiu, 1996). Preliminary stable isotopes analysis (Banaru et al., in press) showed a strong influence of the Danubian matter on marine ecosystems components (water, sediment and organisms) from the Romanian coast.

The transfer of the TPOM from the river into marine benthic food webs through deposit-feeding organisms has occasionally been considered (Salen-Picard and Arlhac, 2002). Whereas the role of detritus as a food source for benthic invertebrates has long been recognised (Kemp, 1986; Mann, 1988), the utilisation of terrestrial POM by benthic invertebrates in estuaries was established more recently using stable isotopes (Peterson et al., 1985; Riera et al., 1999; Bouillon et al., 2000). Stable isotopes have been used successfully to trace the transfer of organic matter of different origins through aquatic food webs (Fry and Sherr, 1984; Van der Zanden et. al., 1999; Kaehler et al., 2000; Pinnegar and Polunin, 2000). Provided that primary producers have distinct isotopic signatures, stable isotopes constitute a powerful tool for discriminating among carbon sources (Van der Zanden and Rasmussen, 2001). In general, multiple-isotope approaches are required to identify the contribution of the different sources of organic matter (Peterson et al., 1985). The use of carbon and nitrogen stable isotopes provides a picture of food web structures and a good evidence of trophic transfers within animal communities (Peterson and Howarth, 1987; Kwak and Zedler, 1997; Riera et. al., 1999; Kaehler et. al., 2000; Polunin et. al., 2001; Takai et. al., 2002). The nitrogen isotope signature is used to define the trophic levels of organisms; the $\delta^{15}N$ increasing from prey to predator vary from 2.5 to 4.5‰ (mean 3.4‰) (Minagawa and Wada, 1984; Post, 2002). As an increase in $\delta^{13}C$ of only 1 - 2‰ occurs between prey and consumer (De Niro and Epstein, 1978; Wada et. al., 1991), a consumer carbon isotope composition can give clues about the sources of its diet, particularly in systems with two distinct organic sources (Fry and Sherr, 1984). Terrestrial primary producers generally have lower $\delta^{13}C$ values than the marine ones (especially phytoplankton and microphytobenthos), allowing the origin of carbon in the POM pools of estuarine and coastal areas to be traced (Haines and Montague, 1979; Riera and Richard, 1996; Bouillon et. al., 2000).

Used for the first time in the aquatic ecology on the Romanian coasts, the proportion of stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) allowed the identification of the organic material sources (terrestrial and marine POM) and the analysis of the round goby food webs due to the predictable isotopic relation between consumer and its food.

MATERIALS AND METHODS

Study area and sampling

The study area is located in the north-western part of the Black Sea on the Romanian coast seawards of the Danube River (45º12' - 43º44'N, 29º40'- 28º35'E). From October 2004 to October 2005, river surface water, sea surface water, surface sediment, macrobenthic invertebrates and round gobies were collected seasonally (in autumn, winter, spring and summer seasons) at 21 sampling stations located in the North (Sulina, Sfântu - Gheorghe), Central (Midia, Constanța) and South (Costineşti, 23 August, Mangalia, 2 Mai, Vama - Veche) areas.

The TPOM brought by Danube and the marine phytoplankton were considered to be the two main sources of organic matter in the studied sites. In order to assess their temporal variability in isotopic signature, Danube and offshore surface seawater POMs were sampled in spring (April to May - when the Danube is flooding) and autumn (October - minimum river discharge period). POM samples were obtained by filtering 1 l of surface water, on pre-weighed Whatman GF/F glass micro fibre filters pre-combusted for 4 h at 500° C. Sediment and macrobenthic invertebrate samples were collected with a benthic dredge (50 x 30 cm) or benthic trawl. Drifted terrestrial plant detritus collected during sediment sampling were rinsed with distilled water and kept frozen for isotopic analysis. Invertebrates were sorted by taxon under a binocular microscope and stored separately. Small organisms were crushed and, when necessary, several individuals were pooled and homogenised together.

Round gobies were captured seasonally by trawling or with fishing nets. Their total length (L in cm) and weight (W in g) were recorded and their guts removed and preserved in 10% neutralised formaldehyde solution for stomach content analysis. Dorsal white muscle samples were taken for isotope analysis because this tissue tends to be less variable in terms of $\delta^{13}C$ and $\delta^{15}N$ (Pinnegar and Polunin, 1999). All samples for isotope analysis were kept frozen before being processed for analysis.

Stable isotope analysis

Water POM samples collected on GF/F filters were freeze-dried and cut into small pieces. Animal and sediment samples were freeze-dried and ground into a fine powder (< 6 µm) using a mortar and pestle. Samples from polychaetes and large molluscs' soft tissues and fish (white muscle) were analysed without any prior treatment. Samples of POM, sediment and small invertebrates with calcareous tests (juvenile bivalves, crustaceans, etc.) were divided into two subsamples. One subsample, for carbon isotope analysis, was acidified with 1% HCl solution to remove carbonates, rinsed with distilled water and oven-dried at 40°C for 24 h, as carbonates present a less negative $\delta^{13}C$ than organic carbon (De Niro and Epstein, 1978). The other subsample, for nitrogen isotope analysis, was not acidified, because acidification gives an enrichment of $\delta^{15}N$ (Pinnegar and Polunin, 1999). The $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios in the samples were determined using continuous flow isotope mass spectroscopy (Preston, 1992). Weighted samples of freeze-dried material (1 mg for fish and prey and 10 mg for filters and sediment) were used for CF-IRMS analysis using a Europa Scientific ANCA-NT 20 - 20 Stable Isotope Analyser with ANCA-NT Solid-Liquid Preparation Module (Europa Scientific Ltd., Crewe, UK). For samples containing around 10% N, the CF-IRMS was operated in the dual isotope mode, allowing $\delta^{15}N$ and $\delta^{13}C$ to be measured on the same sample. The analytical precision (SD, n = 5) was 0.2‰ for both N and C, estimated from standards analysed along with the samples. Working standards were 1 mg leucine prepared by freeze drying 50 µl of a 20 mg/ml stock solution into tin cups, and calibrated against 'Europa flour' and IAEA standards N1 and N2. The methods are fully described in Scrimgeour and Robinson (2003).

Isotope ratios were expressed as parts per thousand (‰) differences from a standard reference material:

$$\delta X (‰) = [(R\ sample / R\ standard) - 1] \times 1000$$

where X is ^{13}C or ^{15}N, R the corresponding ratio $^{13}C/^{12}C$ or $^{15}N/^{14}N$, and δ the measure of heavy to light isotope in the sample. The reference materials were the international standards Vienna Pee Dee Belemnite (vPDB) for carbon and atmospheric N_2 for nitrogen.

Round goby diet

The diet of the round goby was determined from the gut contents of 640 specimens. The individuals studied belonged to four age classes: 1 year (from 5.5 to 12.5 cm), 2 years (from 12.6 to 14.9 cm), 3 years (from 15 to 16.5 cm), 4 years (from 16.6 to 24.7 cm) according to Crețeanu and Banaru (in press). For each specimen, prey were sorted under a binocular microscope, identified to broad taxonomic categories and counted. The occurrence F (%) is the percentage of non-empty stomachs that contained a particular category of prey. Percentage number N (%) is the proportion of a given prey category related to the total number of prey consumed. The trophic level (TL) of the round goby was calculated according to its diet and stable isotopes signature from the following formula (Badalamenti et. al., 2002):

$$TL_i = (\delta^{15}N_i - \delta^{15}N_{ref}) / \Delta\delta^{15}N_c + 2,$$

where TL_i is the trophic level of the fish, $\delta^{15}N_{ref} = (\Sigma\ \delta^{15}N_{prey} \times N (\%)_{prey})/100$ and $\Delta\delta^{15}Nc$ = 3.4 ‰ is the mean of $\delta^{15}N$ increases from prey to predator. In this case, the most usual prey for the round goby are bivalves, which were assumed to be mostly feeding herbivorous and occupy trophic level 2.

RESULTS AND DISCUSSIONS

Isotopic signature of organic matter sources

The main "reservoirs" of organic matter accessible to coastal benthic invertebrates is the river plume water POM, situated in the North area and results from a mixing of Danube and seawater POM, the organic matter in surface sediments, derived mainly from the deposition of the Danube plume and the seawater POM in the Central and South areas. (Table 1, Figure 1). The stable isotopes signature of the Danube POM was given by terrestrial plants detritus, freshwater phytoplankton and bacteria. The marine POM signature is the mean of the small marine plankton (phyto- and bacterio-plankton) signatures. The Danube signature was lower in $\delta^{13}C$ and $\delta^{15}N$ than the marine signature ones. Marine MOP and sediment signatures increased from the North to the South according to the distance from the Danube mouths. Along the Romanian coasts (Central and South areas) $\delta^{13}C$ and $\delta^{15}N$ values of the MPOM were lower in spring than in autumn following the quantitative importance of the Danube terrestrial inputs. In spring, the values were $\delta^{13}C$ = - 23.98‰, $\delta^{15}N$ = 6.19‰ in the South area and $\delta^{13}C$ = - 26.75‰, $\delta^{15}N$ = 7.72‰ in the Central area. In autumn the values were $\delta^{13}C$ = - 21.05‰, $\delta^{15}N$ = 10.18‰ in South and $\delta^{13}C$ = - 25.57‰, $\delta^{15}N$ = 10.79‰ in the central area. The mean $\delta^{13}C$ of the marine sediment in front of the river mouths was lower in spring (- 26.51‰) than in autumn (- 23.70 ‰) following the Danube (spring - 28.14‰ to autumn - 26.54‰) supply influence. The mean $\delta^{15}N$ of the marine sediments raised from autumn (4.15‰) to spring (5.47‰), following the increase in river MOP signature (from 3.15‰ in autumn to 5.01‰ in spring) due to freshwater phyto- and bacterio-plankton development.

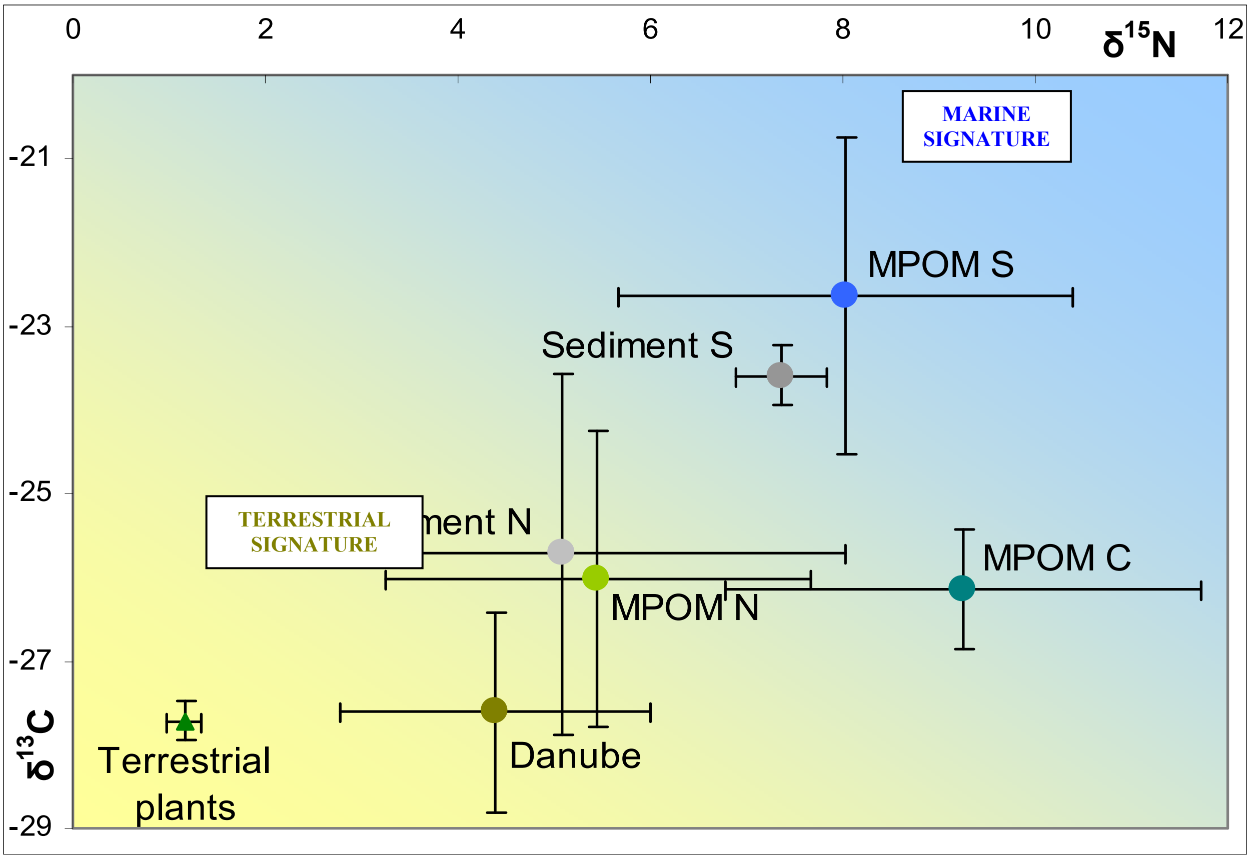

Figure 1. Representation of the marine and terrestrial stable isotope signatures mean values from the principal organic matter sources on the Romanian Black Sea coast. Danube = POM from the Danube River, MPOM = marine particulate organic matter,

N = North area, C = Central area, S = South area.

Isotopic signature of the macrobenthic potential preys of the round goby

The macrobenthic organisms consumed by the round goby fish species were grouped by broad categories. Their signatures varied according to area and seasons (Table 1).

The $\delta^{13}C$ and $\delta^{15}N$ values were function of their trophic level and ability to consume terrestrial POM. The polychaetes and the amphipods had the lower stable isotopes values and the macrurids, brachyurids and bivalves presented the higher ones. As for the sediment and marine POM, the macrobenthic organisms presented lower signatures in spring and in the North area following the Danube influence intensity.

Size and stable isotope analysis of the round goby

There was a significant difference in the mean length of the round gobies analysed between the three areas studied (ANOVA, $F = 21.8$, $p < 0.000$). The mean length was 11.3 cm in the North, 12.4 cm in the Central area and 14.7 cm in the South. There was also a significant correlation ($N = 85$, $R^2 = 0.805$, $p = 0.000$) between the round goby's total length L (cm) and its weight W (g). The growth rate of this species decreased with age (Table 2). The average growth rate was higher in the North area in spring. We can suppose that growth was influenced by the abundant food resources of this area due to Danube River inputs. The round goby spawned in spring and probably they need to feed more during this period of time.

The sex-ratio study of the populations showed the fact that the females dominated the first class 5.5 - 12.5 cm (0.5) and the males all the others studied classes 12.6 - 24.7 cm (3.3 - 6.1). The mean length of the males was higher than that of the females and males were more abundant than females (two times in spring to five times in winter).

The season was a significant factor of variation of the round goby stable isotopes signature (ANOVA $F = 5.03$, $p = 0.005$) whereas the area was not a significant factor of variation (ANOVA $F = 1.27$, $p = 0.313$). No correlation was observed between $\delta^{13}C$ and $\delta^{15}N$ values and the round goby total length ($N = 85$, $p = 0.610$ and $p = 0.968$ respectively) or weight W ($N = 85$, $p = 0.593$ for $\delta^{13}C$ and $p = 0.954$ for $\delta^{15}N$). This was due to the opportunistic feeding behaviour of *Apollonia melanostomus* which consumed preys of different trophic levels, using different carbon sources. Its stable isotope signatures were a mean of those of all its preys. The mean stable isotope signatures of the round goby on the Romanian Black Sea coasts was $\delta^{13}C$ = - 18. 20‰ and $\delta^{15}N$ =14. 34‰ (Table 3). These values were higher than the mean values of the gobiid stable isotopes signatures found in the literature for the Mediterranean Sea ($\delta^{13}C$ = - 19.07‰, $\delta^{15}N$ = 8.28‰) (Darnaude et al., 2004). This was due to important differences between the Black Sea and the Mediterranean Sea POM signatures (Banaru et al., in press).

Table 1. Seasonal and annual mean $\delta^{13}C$ and $\delta^{15}N$ (minimum - maximum) values of the most abundant potential prey organisms living on bottoms of the Romanian Black Sea coasts; n - number of species, N - North, C - Center, S - South areas.

Taxon		n	Min.	Max.	Autumn (mean) N	Autumn (mean) C	Autumn (mean) S	Spring (mean) N	Spring (mean) C	Spring (mean) S	Year Mean
Macrophytes	$\delta^{13}C$	5	-29.79	-16.65	-	-	-17.36	-24.44	-21.12	-21.33	-21.06
	$\delta^{15}N$		6.20	12.21	-	-	10.07	8.07	12.21	8.55	9.72
Polychaetes	$\delta^{13}C$	3	-27.21	-18.32	-	-18.32	-	-23.19	-19.99	-20.62	-20.53
	$\delta^{15}N$		6.54	15.53	-	15.20	-	11.58	12.23	11.67	12.67
Copepods	$\delta^{13}C$	-	-22.9	-	-	-	-	-	-	-22.90	-22.90
	$\delta^{15}N$		10.133	-	-	-	-	-	-	10.13	10.13
Amphipods	$\delta^{13}C$	1	-26.27	-23.74	-23.74	-	-	-26.27	-	-24.16	-24.73
	$\delta^{15}N$		9.01	11.40	9.48	-	-	11.40	-	9.01	9.96
Macrurids	$\delta^{13}C$	1	-24.35	-17.08	-20.08	-	-	-19.99	-17.83	-17.08	-18.75
	$\delta^{15}N$		7.31	15.48	14.09	-	-	14.24	14.56	15.10	14.50
Brachyurids	$\delta^{13}C$	3	-20.35	-18.01	-18.33	-	-	-20.18	-18.18	-22.90	-19.90
	$\delta^{15}N$		12.44	13.96	12.53	-	-	13.03	13.20	10.13	12.22
Bivalves	$\delta^{13}C$	7	-24.36	-17.79	-	-20.38	-19.95	-22.74	-19.32	-20.40	-20.56
	$\delta^{15}N$		7.32	11.24	-	10.59	9.89	9.08	9.94	9.50	9.80
Gastropods	$\delta^{13}C$	1	-17.74	-17.06	-	-17.68	-	-	-17.74	-17.06	-17.49
	$\delta^{15}N$		11.42	12.96	-	12.96	-	-	11.42	11.67	12.02

Table 2. Seasonal and annual mean of total length (L, cm), weight (W, g) and L/W ratio by size and age classes, for the round goby on Romanian coasts. n - number of specimens analysed, % n - percentage number of specimens in the different classes, N - North, C - Center, S - South areas.

	Spring												Summer							
Area (n)	North (n = 65)				Center (n = 20)				South (n = 54)				North (n = 22)				South (n = 286)			
Class	%n	L	W	L/W	%n	L	W	L/W	%n	L	W	L/W	%n	L	W	L/W	%n	L	W	L/W
1	95	9.2	15	0.6	25	10	17	0.6	46	11	19	0.6	100	8.2	8.9	0.9	5.2	12	36	0.3
2	4.6	14	37	0.4	65	14	41	0.3	24	13	36	0.4	-	-	-	-	34	14	49	0.3
3	-	-	-	-	10	15	60	0.3	22	16	66	0.2	-	-	-	-	40	15	67	0.2
4	-	-	-	-	-	-	-	-	7.4	18	84	0.2	-	-	-	-	22	18	87	0.2

	Autumn												Winter			
Area (n)	North (n = 8)				Center (n = 10)				South (n = 19)				South (n = 155)			
Class	%n	L	W	L/W	%n	L	W	L/W	%n	L	W	L/W	%n	L	W	L/W
1	25	8.5	15	0.6	80	9.4	16	0.6	5.3	12	29	0.4	1.9	12	23	0.5
2	38	14	36	0.4	20	14	46	0.3	47	15	51	0.3	18	14	42	0.3
3	25	16	58	0.3	-	-	-	-	37	16	61	0.3	34	16	58	0.3
4	13	18	83	0.2	-	-	-	-	11	18	102	0.2	47	17	88	0.2

Table 3. Seasonal mean $\delta^{13}C$ and $\delta^{15}N$ of the round goby located in the North, Central and South areas of the Romanian Black Sea coast. no - number of specimens analysed, N - North, C - Center, S - South areas.

Class		Spring						Autumn			
		no.	N	no.	C	no.	S	no.	N	no.	C
1	$\delta^{13}C$	9	-19.27	5	-18.26	22	-17.99	1	-18.74	8	-18.1
	$\delta^{15}N$	9	14.27	5	14.64	22	14.93	1	14.72	8	13.7
2	$\delta^{13}C$	1	-18.69	9	-18.3	11	-18.56	3	-19.46	2	-18.65
	$\delta^{15}N$	1	14.76	9	14.21	11	14.35	3	14.41	2	14.57
3	$\delta^{13}C$			2	-18.63	7	-18.55	2	-19.83		
	$\delta^{15}N$			2	13.38	7	14.35	2	13.63		
4	$\delta^{13}C$					2	-18.16	1	-18.56		
	$\delta^{15}N$					2	14.69	1	13.92		
Mean	$\delta^{13}C$	10	-18.98	16	-18.40	42	-18.32	7	-19.15	10	-18.38
	$\delta^{15}N$	10	14.52	16	14.08	42	14.58	7	14.17	10	14.14

Round goby's species gut content analysis

The analysis of preys in the non-empty round goby stomachs showed that bivalves exhibited the highest occurrence and percentage number in all seasons and areas, followed by polychaetes and amphipods (Table 4).

The others groups of prey, in decreasing order of importance were isopods, sprat fish, macrophytes, macrurids, brachurids, cirripeds, gastropods and small goby which presented local and seasonal occurrences. Polychaetes were frequently consumed in autumn in the North and Central areas especially by the first round goby class, but they were also eaten in the spring in the north and south areas. Amphipods presented a high occurrence in the gut contents of specimens from the Central area in spring and autumn, but they were also consumed in the others areas in spring. Isopods were most frequent in autumn in the Central area. In spring, sprat and macrophytes were frequent as preys in the South and macrurids in the Central area. Brachurids had an important percentage number in the South area in spring and summer, and the macrurids were numerically important in the North in autumn. As the bivalves dominated the round goby diet, their stable isotope signatures influenced largely those of the round goby signature. Bivalves are herbivorous suspension feeders and used mainly the marine POM. As a consequence the round goby rely principally on the marine source POM and presented high values of $\delta^{13}C$ and $\delta^{15}N$ (Figure 2).

On the opposite, polychaetes and amphipods used mainly the terrestrial sources, and the round goby which used these preys in the North and Central areas, presented its lowest values of isotopic signatures in these two areas (Table 3).

Table 4. Seasonal and regional occurrence (F%) and numerical percentage (N%) of the round goby preys. N - North, C - Center, S - South areas.

Gut content	Class	Spring						Summer				Autumn						Winter	
		N		C		S		N		S		N		C		S		S	
		F %	N %	F %	N %	F %	N %	F %	N %	F %	N %	F %	N %	F %	N %	F %	N %	F %	N %
Macrophytes	1	4.6	4.2			17	6.4							33	6.3				
	2					18	6.7												
	3					42	14												
	4					75	38												
Polychaetes	1	14	13			4.4	3.2					100	40	17	3.1				
	2	33	43	10	3	27	13							50	10			8.3	7.1
	3					17	8.1					50	100						
	4					25	25												
Amphipods	1	4.6	4.2			8.7	6.4			14	14			67	25				
	2	33	14	30	9.1									50	10				
	3			50	67	8.3	2.7												
	4					25	13												
Isopods	1					8.7	3.2							83	25				
	2									4.7	4.6			100	40				
	3					8.3	2.7			1.8	2.8								
	4																		
Macrurids	1			50	33														
	2			80	45							33	100						
	3																		
	4																		
Brachyurids	1									14	14								
	2					9.1	10			9.3	9.1					25	25		
	3									5.4	8.3					17	14		
	4					25	13			2.6	2.4							1.8	1.8
Bivalves	1	73	67	50	67	57	54	100	100	71	71	50	20	67	22	100	100		
	2	67	29	20	33	36	37			74	75			50	20	75	75	83	71
	3					58	41			45	69					100	86	86	86
	4									95	90	100	100			100	100	96	95
Gastropods	1																		
	2									2.3	2.3								
	3					17	8.1												
	4									5.1	4.9							1.8	3.5
Sprat	1					70	25												
	2			10	3	55	20												
	3					42	14			1.8	2.8								
	4					25	13												

Trophic level and food web of the round goby

The mean trophic level of *Apollonia melanostomus* was 3.04 (Table 5). There was no significant difference in the trophic level of the round goby with season or area ($p > 0.05$).

The use of both stable isotopes and gut content analyses allowed to reconstruct the food web of the round goby on the Romanian Black Sea coast (Figure 2).

Table 5. Seasonal and regional trophic level of the round goby on the Romanian Black Sea coast. N - North, C - Center, S - South areas.

Season	Spring			Autumn			Mean
Area	N	C	S	N	C	S	
NT	3.31	2.56	3.30	2.74	3.09	3.21	3.04

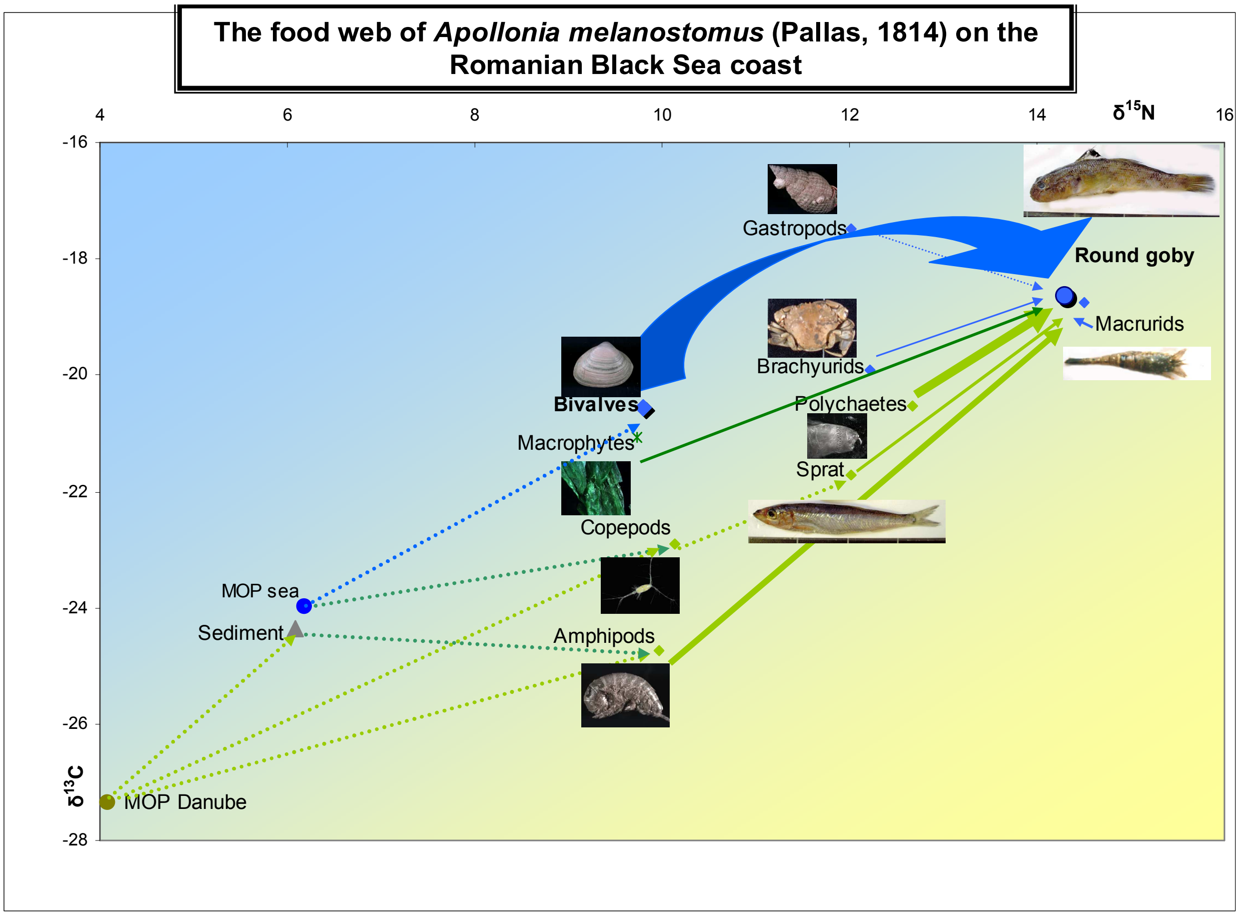

Figure 2. Reconstruction of the food web of *Apollonia melanostomus* species based on gut content and stable isotopes analyses.

CONCLUSIONS

Stable isotope analysis coupled with gut content description allows establishing food web interactions and energy flow. Preliminary results demonstrated a strong influence of the Danubian particulate organic matter on the various marine compartments (sea water POM, sediment and organisms) from the Romanian coast. The river influence decreased from the northern to the southern areas. In the spring the quantity of terrestrial POM carried by the river was more important and the Danube signature had a higher impact on all marine compartments than in autumn. It was also the case of the round goby which presented different isotopic signatures depending on its diet and location.

The round goby was an opportunistic feeder and consumed preys of different trophic levels relying on various carbon sources. In the North and Central areas the signature of the round goby was influenced by the terrestrial Danube inputs through its feeding on polychaetes and amphipods. However, the dominant preys in all seasons and areas were the bivalves that used mainly the marine sources of carbon. So, bivalves transferred to *Apollonia melanostomus* an essentially marine stable isotope signature.

The knowledge of the POM origin and its incorporation through the marine food and its potential impact on the coastal fisheries was as important and necessary step to a reasonable use of these resources in the Black Sea.

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AUTHORS:

[1] *Daniela BANARU*
banaru@com.univ-mrs.fr
[1] *Mirreille HARMELIN-VIVIEN*
harmelin@com.univ-mrs.fr
Centre d’Océanologie de Marseille,
UMR CNRS 6540,
Station Marine d’Endoume,
Marseille, France,
FR - 13007.

[2] *Mihaela CREȚEANU*
creteanu_mihaela@yahoo.com
National Agency for Fishing
and Aquaculture,
Revoluției St., no. 17 - 19,
Constanța, Constanța County, Romania,
RO - 900735.

SPACE-TIME VARIATIONS OF STABLE ISOTOPE ($\delta^{13}C$ AND $\delta^{15}N$) SIGNATURE OF DANUBE WATERS AND MARINE COMMUNITIES ON THE BLACK SEA ROMANIAN COASTS

Daniela BANARU [1], *Marian-Traian GOMOIU* [2] and *Mireile HARMELIN-VIVIEN* [1]

KEYWORDS: Danube, Black Sea, terrestrial organic matter, marine organisms.

ABSTRACT

Coastal marine zones located in front of large rivers are of major biological interest. The Danube is the second largest river in Europe and represents 58% of the freshwater inputs to the Black Sea. Its delta has a great impact on the sedimentation and marine ecosystems in the Black Sea.

The objective of the present study was to estimate the impact of the seasonal fluctuations of the particulate organic matter contribution of the Danube on the various marine trophic compartments (POM sea water, sediment, macro-invertebrates and fish) along the Romanian coasts. The ratios of the stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) allowed the identification of organic matter sources and the analysis of trophic webs.

The analysis of stable isotopes of the particulate organic matter (POM) of the Danube water as well as marine POM, marine sediments and marine organisms (macrophytes, polychaetes, bivalves, gastropods, amphipods, macrurids, brachyurids and fishes) has been carried out on 542 samples taken in 38 stations in October 2004 and April - May 2005. The POM of the Danube presented annual average values of $\delta^{13}C$ (- 27.34‰) and $\delta^{15}N$ (4.08‰), lower than those of the marine POM of the Black Sea ($\delta^{13}C$ = - 24.36‰ and $\delta^{15}N$ = 6.64‰). The sediment, presented annual average values lower in the North ($\delta^{13}C$ = - 24.29‰ and $\delta^{15}N$ = 6.26‰) than in the South ($\delta^{13}C$ = - 23.29‰, $\delta^{15}N$ = 10.11‰). Among invertebrates, stable isotopes values depended on their trophic level and aptitude to consume the terrestrial POM brought by the river. The lowest values were found in polychaetes, copepods and amphipods, and the highest ones in macrurids, brachyurids and gastropods. Among the fish species, the lowest values of $\delta^{13}C$ and $\delta^{15}N$ were observed in starry sturgeon (*Acipenser stellatus ponticus*) and sprat (*Sprattus sprattus*), while the highest value was found in beluga sturgeon (*Huso huso*). These differences were explained mainly by their differences in diet.

Preliminary results showed a strong influence of the Danube particulate organic matter on the marine compartments of the studied coasts. The river influence decreased from the North to the South and was higher in spring when the river was flooding.

REZUMAT: Variațiile spațio-temporale ale semnăturii izotopilor stabili ($\delta^{13}C$ şi $\delta^{15}N$) ale apelor Dunării şi comunităților marine ale litoralului românesc a Mării Negre.

Zonele marine costiere din fața marilor râuri sunt de interes biologic major. Dunărea este al doilea râu al Europei şi aduce 58% din cantitatea de apă dulce primită de Marea Neagră. Delta acesteia are un impact major asupra sedimentării şi a ecosistemelor marine din Marea Neagră.

Obiectivul studiului a fost estimarea impactului fluctuațiilor sezoniere a materiei organice particulate a Dunării asupra a variate compartimente trofice marine (POM apa mării, sediment, macronevertebrate şi peşti) de-a lungul coastei româneşti. Izotopii stabili de carbon ($^{13}C/^{12}C$) şi nitrogen ($^{15}N/^{14}N$) permit identificarea surselor de materie organică şi analiza rețelelor trofice.

Analiza izotopilor stabili ai materiei organice particulate (MOP) a apei Dunării, ca şi a apei marine, sedimentelor marine şi organismelor marine (macrofite, polichete, bivalve, gasteropode, amfipode, macruride, brachiuride şi peşti) a fost realizată pe baza a 542 probe luate în 38 de staţii în octombrie 2004 şi aprilie - mai 2005. Materia organică particulată a Dunării prezintă valori anuale medii de $\delta^{13}C$ (- 27.34‰) şi $\delta^{15}N$ (4.08‰), mai joase decât acelea a materiei organice particulate marine a Mării Negre ($\delta^{13}C$ = - 24.36‰ şi $\delta^{15}N$ = 6.64‰). Sedimentul prezintă valori medii anuale mai joase în nord ($\delta^{13}C$ = - 24.29‰ şi $\delta^{15}N$ = 6.26‰) decât în sud ($\delta^{13}C$ = - 23.29‰, $\delta^{15}N$ = 10.11‰). Printre nevertebrate valorile izotopilor stabili depind de nivelul lor trofic şi aptitudinea lor de a consuma materie organică particulată terestră adusă de râu. Cele mai jose valori au fost găsite în polichete, copepode, amfipode şi cele mai ridicate în macruride, brachiuride, gastropode. Printre speciile de peşti studiate, cele mai scăzute valori ale $\delta^{13}C$ şi $\delta^{15}N$ au fost observate la *Acipenser stellatus ponticus* şi *Sprattus sprattus*, în timp ce, cele mai ridicate au fost observate la *Huso huso*. Aceste diferenţe au fost explicate în principal prin diferenţele dietelor lor.

Rezultatele arată o influenţă ridicată a materiei organice particulate a Dunării asupra compartimentelor marine a zonei studiate. Influenţa râului scade de la nord la sud şi a fost mai mare primăvara la ape mari.

RÉSUMÉ: Variations spatio-temporelles de la signature des isotopes stables ($\delta^{13}C$ et $\delta^{15}N$) des eaux du danube et des communautés marines des cotes roumaines de la Mer Noire.

Les côtes marines situées au niveau des grands fleuves presentent un intérêt biologique majeur. Le Danube est le deuxième plus large fleuve en Europe et représente 58% des apports à la Mer Noire. Son delta a un grand impact sur la sédimentation et sur les écosystèmes marins de la Mer Noire.

L'objectif de cette etude est d'estimer l'impact des fluctuations saisonnières de la contribution du Danube en matière organique particulaire aux différents compartiments trophiques marins (MOP de l'eau de mer, sediment, macroinvertébrés et poissons) le long des côtes roumaines. La proportion des isotopes stables du carbone ($^{13}C/^{12}C$) et de l'azote ($^{15}N/^{14}N$) permet l'identification des sources de matière organique et l'analyse des réseaux trophiques.

L'analyse des isotopes stables de la matière organique particulaire (MOP) des eaux du Danube comme de la MOP marine, des sédiments marins et des organismes marins (macrophytes, polychètes, bivalves, gastéropodes, amphipodes, macrouridés, brachyoures et poissons) a été réalisée sur 542 échantillons prélevés dans 38 stations en Octobre 2004 et Avril - Mai 2005. La MOP du Danube présente des valeurs moyennes annuelles de $\delta^{13}C$ (- 27.34‰) et de $\delta^{15}N$ (4.08‰), moindres que celles de la MOP de la Mer Noire ($\delta^{13}C$ = - 24.36‰ et $\delta^{15}N$ = 6.64‰). Les sediments presentent des valeurs moyennes annuelles plus faibles dans le Nord ($\delta^{13}C$ = - 24.29‰ et $\delta^{15}N$ = 6.26‰) que dans le Sud ($\delta^{13}C$ = - 23.29‰, $\delta^{15}N$ = 10.11‰). Parmis les invertébrés, les valeurs des isotopes stables dependent de leur niveau trophique et de leur aptitude à consommer la MOP terrestre apportée par le fleuve. Les valeurs les plus faibles ont été trouvées pour les polychètes, les copépodes et les amphipodes, et les valeurs les plus élevées pour les macrouridés, les brachyoures et les gastéropodes. Parmis les poissons étudiés, les plus faibles valeurs de $\delta^{13}C$ et de $\delta^{15}N$ ont été observées chez le sevrouga (*Acipenser stellatus ponticus*) et le sprat (*Sprattus sprattus*), alors que les valeurs les plus élévées ont été observées chez le beluga (*Huso huso*). Ces différences sont expliquées principalement par leur difference de régime alimentaire.

Les résultats preliminaries montrent une influence le la matière organique particulaire du Danube sur les compartiments marins des côtes étudiées. L'influence du fleuve décroit du Nord au Sud et est plus importante au printemps lorsque le fleuve est en crue.

INTRODUCTION

Danube (6000 m^3s^{-1}) is the second largest river in Europe and represents 58% of the fresh water inputs into the Black Sea. Its delta, located between the north of Romania and the south of the Ukraine, has a great impact on the sedimentation and on marine ecosystems in the north-western part of the Black Sea (Gomoiu, 1996).

Stable isotopes were successfully used to trace the transfer of organic matter of different origins through aquatic food webs (Fry and Sherr, 1984; Peterson and Fry, 1987; Van der Zanden et al., 1999; Kaehler et al., 2000; Pinnegar and Polunin, 2000). Provided that primary producers have distinct isotopic signatures, stable isotopes constitute a powerful tool for discriminating among carbon sources (Van der Zanden and Rasmussen, 2001). In general, multiple-isotope approaches are required to identify the contribution of the different sources of organic matter (Peterson et al., 1985). The use of carbon and nitrogen stable isotopes provides a picture of food web structures and a good evidence of trophic transfers within animal communities (Peterson and Howarth, 1987; Dauby, 1995; Kwak and Zedler, 1997; Riera et al., 1999; Kaehler et al., 2000; Dufour and Gerdeaux, 2001; Polunin et al., 2001; Takai et al., 2002). The nitrogen isotope signature is used to define the trophic levels of organisms; the $\delta^{15}N$ increasing from prey to predator variates from 2.5 to 4.5‰ (mean 3.4‰) (Minagawa and Wada, 1984; Post, 2002). As an increase in $\delta^{13}C$ of only 1 - 2‰ occurs between prey and consumer (De Niro and Epstein, 1978; Wada et al., 1991), a consumer carbon isotope composition can give clues about the sources of its diet, particularly in systems with two distinct organic sources (Fry and Sherr, 1984). Terrestrial primary producers generally have lower $\delta^{13}C$ values than marine producers (especially phytoplankton and microphytobenthos), allowing the origin of carbon in the POM pools of estuarine and coastal environments to be traced (Haines and Montague, 1979; Riera and Richard, 1996; Bouillon et al., 2000).

Used for the first time in aquatic ecology on our coasts, the proportion of stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) allowed the identification of the organic material sources (terrestrial and marine) as well as the stable isotope signatures of some organisms and fishes.

The main objective of the study was to estimate the impact of the terrestrial particulate organic matter (TPOM) inputs of the Danube, and its seasonal fluctuations (flooding and minimum river discharge periods), on the various marine trophic compartments (POM of water, sediment, macro-invertebrates and fish) along the Romanian Black Sea coasts.

MATERIALS AND METHODS

The study area was located in the north-western part of the Black Sea on the Romanian coast seawards of the Danube River (45º12’ - 43º44’N, 29º40’ - 28º35’E). 542 samples of river and sea surface water, surface sediment, macrobenthic invertebrates and fishes were collected at 38 stations located to depths of 0 - 20 m and 20 - 30 m in the North (Sulina, Sfântu-Gheorghe), Central (Midia, Constanța) and South (Costinești, Mangalia, 2 Mai) areas.

The TPOM brought by the Danube River and the marine phytoplankton were considered to be the two main sources of particulate organic matter in the sites studied. In order to assess their temporal variability in isotopic signature, Danube River (from Sulina and Sfântu-Gheorghe channals) and offshore surface seawater POMs were sampled in spring (April to May 2005 - when the Danube is flooding) and autumn (October 2004 - minimum river discharge period). POM samples were obtained by filtering 1 l of surface water, on pre-weighed Whatman GF/F glass micro fibre filters pre-combusted for 4 h at 500° C (Aminot and Chaussepied, 1983). Sediment and macrobenthic invertebrate samples were collected with a benthic dredge (50 x 30 cm) or benthic trawl. Drifted terrestrial plant detritus collected during sediment sampling were rinsed with distilled water and kept frozen for isotopic analysis. Invertebrates were sorted by taxon under a binocular microscope and stored separately. Small organisms were crushed and, when necessary, several individuals were pooled and homogenised together.

Fishes were captured seasonally by trawling or with fishing nets. Their total length (L in cm) and weight (W in g) were recorded and their guts removed and preserved in 5% neutralised formaldehyde solution for stomach content analysis. Dorsal white muscle samples were taken for isotope analysis because this tissue tends to be less variable in terms of $\delta^{13}C$ and $\delta^{15}N$ (Pinnegar and Polunin, 1999). All samples were kept frozen before being processed for stable isotopes analysis.

Water POM samples on filters were freeze-dried and cut into small pieces. Animal and sediment samples were freeze-dried and ground into a fine powder (< 6 µm) using a mortar and pestle. Samples from polychaetes and large molluscs' soft tissues and fish (white muscle) were analysed without any prior treatment. Samples of POM, sediment and small invertebrates with calcareous tests (juvenile bivalves, crustaceans, etc.) were divided into two subsamples. One subsample, for carbon isotope analysis, was acidified with 1% HCl solution to remove carbonates, rinsed with distilled water and oven-dried at 40°C for 24 h, as carbonates present a less negative $\delta^{13}C$ than organic carbon (De Niro and Epstein, 1978). The other subsample, for nitrogen isotope analysis, was not acidified, because acidification gives an enrichment of $\delta^{15}N$ (Pinnegar and Polunin, 1999). The $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios in the samples were determined using continuous flow isotope mass spectroscopy (Preston, 1992). Weighted samples of freeze-dried material (1 mg for fish and prey and 10 mg for filters and sediment) were used for CF-IRMS analysis using a Europa Scientific ANCA-NT 20 - 20 Stable Isotope Analyser with ANCA-NT Solid-Liquid Preparation Module (Europa Scientific Ltd., Crewe, UK). For samples containing around 10% N, the CF-IRMS was operated in the dual isotope mode, allowing $\delta^{15}N$ and $\delta^{13}C$ to be measured on the same sample. The analytical precision (SD, n = 5) was 0.2‰ for both N and C, estimated from standards analysed along with the samples. Working standards were 1 mg leucine prepared by freeze drying 50 µl of a 20 mg/ml stock solution into tin cups, and calibrated against 'Europa flour' and IAEA standards N1 and N2. The methods are fully described in Scrimgeour and Robinson (2003).

Isotope ratios were expressed as parts per thousand (‰) differences from a standard reference material:

$$\delta X (‰) = [(R\ sample / Rstandard) - 1] \times 1000$$

where X is ^{13}C or ^{15}N, R the corresponding ratio $^{13}C/^{12}C$ or $^{15}N/^{14}N$, and δ the measure of heavy to light isotope in the sample. The reference materials were the international standards Vienna Pee Dee Belemnite (vPDB) for carbon and atmospheric N_2 for nitrogen.

The importance of the three analysed factors (season, area and depth) on the stable isotopes signature of the different compartments was estimated by independent variance analyses ANOVA with one or two factors. Because of missing data the ANOVA test with three factors was not possible.

RESULTS AND DISCUSSIONS

The main "reservoirs" of organic matter accessible to the coastal benthic invertebrates is the river plume water POM, situated in the North area and results from a mixing of Danube River and seawater POM, the organic matter in surface sediments, derived mainly from the deposition of the Danube River plume and the seawater POM in the Central and South areas.

The stable isotopes signature of the Danube POM was given by terrestrial plants detritus, freshwater phytoplankton and bacteria.

The marine POM signature is the mean of the small marine plankton (phyto- and bacterio-plankton) signatures.

The Danube POM signature ($\delta^{15}N$ = 4.08 ± 2.20‰, $\delta^{13}C$ = - 27.34 ± 1.46‰) had different values in d13C on the two analysed channals (F = 10.10, p = 0.000) and it changed according to the season (F = 5.05, p = 0.002).

The Sfântu-Gheorghe channel which had a more significant flow in spring presented a higher value in $\delta^{13}C$ and weaker signature in $\delta^{15}N$ than Sulina channel. In addition, on the two channals, the values in $\delta^{15}N$ increased in spring while those in $\delta^{13}C$ decreased (Table 1).

Table 1. Mean values and standard deviation (SD) of $\delta^{15}N$ (‰) and $\delta^{13}C$ (‰) of the Danube POM and mean flow of the two channals analysed: Sulina and Sfântu-Gheorghe in October, April and May 2004 - 2005. n = number of samples analysed.

Sulina	n	X/2004	IV/2005	V/2005	Mean ± SD
Flow (m^3s^{-1})		938	2000	2260	1733
$\delta^{13}C$ (‰)	9	-26.37 ± 0.36	-29.66 ± 0.42	-27.59 ± 0.09	-27.87 ± 1.46
$\delta^{15}N$ (‰)	9	2.23 ± 0.97	4.55 ± 0.31	7.17 ± 0.13	4.30 ± 2.20
Sfântu Gheorghe		X/2004	IV/2005	V/2005	Mean ± SD
Flow (m^3s^{-1})		1200	2700	2700	2200
$\delta^{13}C$ (‰)	9	-26.71± 0.23	-28.48 ± 0.12	-26.83 ± 0.08	-27.34 ± 0.87
$\delta^{15}N$ (‰)	9	4.07 ± 0.54	3.51± 0.73	4.83 ± 0.32	4.13 ± 0.75

Marine POM ($\delta^{15}N$ = 6.64±1.48‰, $\delta^{13}C$ = - 24.37 ± 1.15‰) presented higher values in $\delta^{13}C$ and $\delta^{15}N$ than the Danube ones.

The values of the isotopic signature of the marine POM increased from North towards South and from autumn to spring (Table 2). They increased from the coast to depth sea stations.

To explain the variations observed, the area (F = 6.72, p = 0.000) seemed to be a more significant factor than the season (F = 3.10, p = 0.059) or the depth (n.s).

Table 2. Mean values and standard deviations (SD) of $\delta^{15}N$ (‰) and $\delta^{13}C$ (‰) in the marine POM in different areas, depths and seasons on the Romanian coasts. n = number of samples analysed.

Area	Depth (m)	Month	n	$\delta^{15}N$ (‰) ± SD	n	$\delta^{13}C$ (‰) ± SD
North	0-20	X	3	2.37 ± 1.09	3	-24.33 ± 0.10
North	0-20	IV	5	4.36 ± 1.12	5	-26.69 ± 1.66
North	0-20	V	6	6.84 ± 0.99	6	-25.66 ± 1.09
North	20-30	IV	1	10.23 ± 0.00	1	-25.79 ± 0.00
North	20-30	V	3	6.02 ± 0.26	3	-23.52 ± 0.08
Mean - North area			18	5.96 ± 0.69	18	-25.20 ± 0.59
Centre	20-30	V	2	7.72 ± 0.35	2	-26.75 ± 0.33
South	0-20	X	3	9.29 ± 1.26	3	-21.67 ± 0.81
South	0-20	IV	2	7.17 ± 0.92	2	-24.80 ± 1.72
South	0-20	V	2	6.22 ± 0.45	2	-24.18 ± 1.49
South	20-30	X	3	11.07 ± 0.46	3	-20.43 ± 0.10
South	20-30	IV	2	5.05 ± 1.16	2	-22.93 ± 1.61
South	20-30	V	2	7.08 ± 0.93	2	-24.04 ± 0.00
Mean - South area			14	7.66 ± 0.79	16	-23.55 ± 0.87
Annual mean values			34	6.64 ± 1.48	34	-24.37 ± 1.15

The sediment ($\delta^{15}N$ = 6.77 ± 3.19‰, $\delta^{13}C$ = - 23.29 ± 2.75‰) presents higher signatures in $\delta^{15}N$ and $\delta^{13}C$ at spring than in autumn (F = 5.13, p = 0.002) and seawards compared to the coast stations (F = 11.60, p = 0.000) (Table 3).

Table 3. Mean values and standard deviation (SD) of $\delta^{15}N$ (‰) and $\delta^{13}C$ (‰) in the sediment from the North and South areas at different depths and periods. n = number of samples.

Area	Depth (m)	Month	n	$\delta^{15}N$ (‰) ± SD	n	$\delta^{13}C$ (‰) ± SD
North	0 - 20	IV	6	4.51 ± 1	6	-27.25 ± 0.187
North	20 - 30	IV	4	10.5 ± 0.93	4	-21.47 ± 0.422
North	20 - 30	V	4	9.93 ± 1.32	4	-20.02 ± 0.08
North	0 - 20	X	3	4.68 ± 0.3	3	-23.53 ± 1.147
North	20 - 30	X	3	3.63 ± 0.54	3	-23.88 ± 1.678
Mean North			20	6.65 ± 1.43	20	-23.23 ± 1.967
Mean South	20 - 30	V	3	7.36 ± 0.47	3	-23.59 ± 0.346
Annual mean			23	6.77 ± 1.19	23	-23.29 ± 1.759

The average stable isotopes signatures of the macro-invertebrates differed according to taxonomic groups' to which they belong (Table 4). Their signatures in $\delta^{13}C$ and $\delta^{15}N$ increased, generally, from autumn to spring. The $\delta^{13}C$ increased from North towards South, while the $\delta^{15}N$ decreased. The area influenced significantly the signature of macrophytes (F = 6.56, p = 0.011) and brachyurans (F = 48.54, p = 0.000), and the season influenced macrophytes (F = 10.35, p = 0.002), polychaetes (F = 12.65, p = 0.002) and brachyurans (F = 45.08, p = 0.000).

Table 4. Seasonal and annual variations of the mean values of $\delta^{15}N$ (‰) and $\delta^{13}C$ (‰) (minimum - maximum) for some groups of benthic organisms on the Romanian coasts of the Black sea. n = number of species analysed, N - North, C - Center, S - South.

Taxon		n	Min.	Max.	October (mean)			April- Mai (mean)			Annual
					N	C	S	N	C	S	mean
Macrophytes	$\delta^{13}C$	5	-29.79	-16.65	-	-	-17.36	-24.44	-21.12	-21.33	-21.06
	$\delta^{15}N$		6.20	12.21	-	-	10.07	8.07	12.21	8.55	9.72
Polychaetes	$\delta^{13}C$	3	-27.21	-18.32	-	-18.32	-	-23.19	-19.99	-20.62	-20.53
	$\delta^{15}N$		6.54	15.53	-	15.20	-	11.58	12.23	11.67	12.67
Copepods	$\delta^{13}C$	-	-22.9	-	-	-	-	-	-	-22.90	-22.90
	$\delta^{15}N$		10.133	-	-	-	-	-	-	10.13	10.13
Amphipods	$\delta^{13}C$	1	-26.27	-23.74	-23.74	-	-	-26.27	-	-24.16	-24.73
	$\delta^{15}N$		9.01	11.40	9.48	-	-	11.40	-	9.01	9.96
Macrurids	$\delta^{13}C$	1	-24.35	-17.08	-20.08	-	-	-19.99	-17.83	-17.08	-18.75
	$\delta^{15}N$		7.31	15.48	14.09	-	-	14.24	14.56	15.10	14.50
Brachyurans	$\delta^{13}C$	3	-20.35	-18.01	-18.33	-	-	-20.18	-18.18	-22.90	-19.90
	$\delta^{15}N$		12.44	13.96	12.53	-	-	13.03	13.20	10.13	12.22
Bivalves	$\delta^{13}C$	7	-24.36	-17.79	-	-20.38	-19.95	-22.74	-19.32	-20.40	-20.56
	$\delta^{15}N$		7.32	11.24	-	10.59	9.89	9.08	9.94	9.50	9.80
Gastropods	$\delta^{13}C$	1	-17.74	-17.06	-	-17.68	-	-	-17.74	-17.06	-17.49
	$\delta^{15}N$		11.42	12.96	-	12.96	-	-	11.42	11.67	12.02

The lowest values of $\delta^{15}N$ and $\delta^{13}C$ were found for polychaetes, copepods and amphipods, and the highest for macrurids, brachyurans and the gastropods (Figure 1).

The isotopic signatures of fishes varied according to the species (Table 4), seasons, areas. The pelagic species like sprat, anchovy and horse mackerel have the weakest signatures in $\delta^{15}N$. Contrary, large predators like beluga, starry sturgeon, turbot had highest signatures in $\delta^{15}N$ (Figure 1).

The fish feeding on preys which use terrestrial carbon sources had weak signature in $\delta^{13}C$ (sprat, sevruga). For some species, the seasonal variations dominated (round goby, sand sole, turbot), and for others the area variations were more significant (sprat, anchovy, mullet, whiting, flounder, sturgeon). As for the other compartments, the isotopic signatures of the majority of fish increased from the North towards the South and from the coast towards the seawards stations, following the reduction in the impact of the Danube, on the marine communities.

Table 5. Common and latin names, and mean values of the stable isotope signatures in $\delta^{15}N$ (‰) and $\delta^{13}C$ (‰) of fishes analysed on the Romanian coasts of the Black Sea. n = number of samples analysed.

Commun names	Species	n	$\delta^{15}N$ (‰)±SD	$\delta^{13}C$ (‰)±SD
European sprat	*Sprattus sprattus* (Linnaeus, 1758)	65	12.08±1.02	-21.72±1.06
European anchovy	*Engraulis encrasicolus* (Linnaeus, 1758)	16	11.74±1.40	-19.95±0.56
Horse mackerel	*Trachurus mediterraneus ponticus* (Aleev, 1956)	23	13.47±1.23	-19.78±1.20
Round goby	*Apollonia melanostomus* (Pallas, 1814)	41	14.35±0.57	-18.58±0.74
Red mullet	*Mullus barbatus ponticus* (Linnaeus, 1758)	85	15.05±0.64	-19.42±1.09
Whiting	*Merlangus merlangus euxinus* (Nordmann, 1840)	68	15.06±0.91	-18.96±0.54
Turbot	*Psetta maeotica* (Linnaeus, 1758)	27	16.15±0.87	-19.03±0.90
Sand sole	*Solea nasuta* (Risso, 1810)	4	14.35±0.71	-17.86±0.46
Flounder	*Pleuronectes flesus luscus* (Linnaeus, 1758)	17	14.11±0.68	-19.04±0.94
Starry sturgeon	*Acipenser stellatus ponticus* (Pallas, 1771)	7	16.36±0.97	-20.34±1.37
Beluga	*Huso huso* (Linnaeus, 1758)	2	16.87±0.65	-17.82±0.55

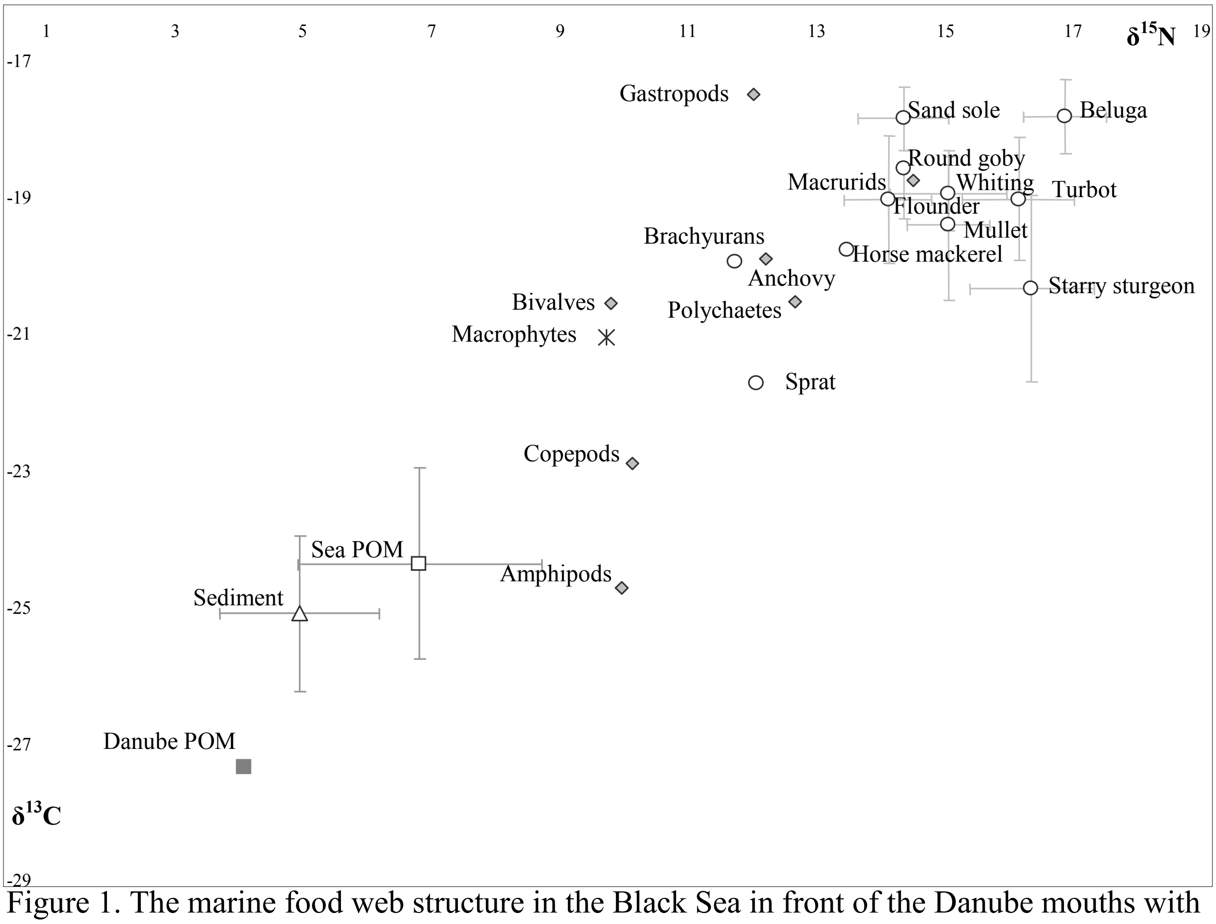

Figure 1. The marine food web structure in the Black Sea in front of the Danube mouths with annual mean values of the nitrogen and carbon stable isotopes signatures in the different compartments analysed (Danube POM, sea water POM, sediment, macro-invertebrates, fishes).

CONCLUSIONS

The preliminary results of this study showed a strong influence of Danube POM on all the marine compartments (water, sediment, organisms) on the Romanian coast.

The average signature of Danube is given by the terrestrial plants detritus (plants in C3 and C4) and the dulçaquicole phytoplankton. It varied with the season and the Danube level variations. In spring, $\delta^{15}N$ values increased and $\delta^{13}C$ ones decreased with the flowing of the river which brings more detritus plants and probably because of the phytoplankton's development.

The marine POM signature is given by the marine plankton (phyto- and bacterio plankton) and by the particles of terrestrial MOP brought by the river. The POM of Black Sea surface water has $\delta^{15}N$ and $\delta^{13}C$ values higher than the Danube POM.

The influence of the Danube decreased along the Romanian coast from North towards South in the direction of the general current of the water masses. This influence is more significant in spring, in period of the Danube flowing, that in autumn.

The values of $\delta^{15}N$ and $\delta^{13}C$ of the river seemed to influence more particularly those of amphipods, copepods and polychaetes, as well as sprat and starry sturgeon fish.

The isotopic signatures of the marine compartments (water POM, sediment, benthic organisms) analyzed in Black Sea presented higher values in $\delta^{15}N$ and $\delta^{13}C$ that those presented in the literature for the North-Western Mediterranean Sea seawards the Rhone River (Darnaude et al, 2004) suggesting different functioning of the marine systems submitted to the large rivers terrestrial inputs.

This study is a first approach in the comprehension of the Danube River inputs' impact on the marine communities as well as the trophic webs of fishes in the North-Western part of the Black Sea.

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AUTHORS:

[1] *Daniela BANARU*
banaru@com.univ-mrs.fr
[1] *Mirreille HARMELIN-VIVIEN*
harmelin@com.univ-mrs.fr
Centre d'Océanologie de Marseille,
UMR CNRS 6540,
Station Marine d'Endoume,
Marseille, France,
FR - 13007.

[2] *Marian-Traian GOMOIU*
mtg@cier.ro
National Institute for Research
and Development in Marine Geology
and Geoecology - GeoEcoMar,
Bucharest - Constanța, Romania.

STABLE ISOTOPE SIGNATURE ($\delta^{13}C$ AND $\delta^{15}N$) IN THE BLACK SEA DANUBIAN AREA - NEW APPROACH FOR UNDERSTANDING THE INFLUENCE OF TERRESTRIAL DISCHARGE UPON THE MARINE ECOSYSTEM

Daniela BANARU [1], *Mireile HARMELIN-VIVIEN* [1] and *Marian-Traian GOMOIU* [2]

KEYWORDS: Black Sea, stable isotopes, terrestrial organic matter, marine organisms.

ABSTRACT

Used for the first time in aquatic ecology on the Romanian coast, the proportion of stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) allowed the identification of the organic material sources (terrestrial and marine) as well as to analyse the food webs due to the predictable isotopic relation between consumers and their food. Preliminary analyses of stable isotopes of the particulate organic matter POM of the Danube water as well as marine POM, sediments and marine organisms were made on 186 samples collected at 10 stations in October 2004. The identification of the isotopic signatures of the main sources of organic material (terrestrial and marine) was achieved along with those of some present groups of marine organisms (macrophytes, bivalves, polychaetes, amphipods, macrurans, brachyurans, fish). The results obtained in the Black Sea were compared with those of the Mediterranean Sea seawards the Rhone River and showed that the isotopic signatures of the two river POM were close to eachother, whereas they largely differed in marine phytoplankton and macrophytes.

REZUMAT: Semnătura izotopilor stabili ($\delta^{13}C$ şi $\delta^{15}N$) în zona danubiană a Mării Negre - o abordare nouă în înțelegerea influenței descărcărilor terestre în ecosistemul marin.

Utilizată prima oară în ecologia acvatică a litoralului nostru, proporția izotopilor stabili de carbon ($^{13}C/^{12}C$) şi azot ($^{15}N/^{14}N$) a permis identificarea surselor de materie organică (terestră şi marină) ca şi analiza rețelelor trofice, datorită relației izotopice predictibile dintre consumatori şi hrană. Au fost realizat analize preliminarii ale izotopilor stabili a materiei organice particulate POM a apei Dunării, a apei marine, a sedimentelor şi a organismelor marine pe baza a 186 de probe colectate din 10 stații în Octombrie 2004. Identificarea semnăturilor izotopice ale principalelor surse de material organic (terestru şi marin) a fost realizată pe baza grupelor de organisme marine (macrofite, bivalve, polichete, amfipode, peşti). Rezultatele obținute în Marea Neagră au fost comparate cu cele obținute în Marea Mediterană în zona Rinului şi relevă faptul că semnăturile izotopice ale celor două râuri au fost apropiate, pe câtă vreme în ceea ce priveşte fitoplanctonul şi macrofitele au fost accentuat diferite.

RESUME: Signature des isotopes stables ($\delta^{13}C$ et $\delta^{15}N$) dans la région danubienne de la Mer Noire - Une nouvelle approche pour comprendre l'influence des apports terrestres dans les ecosysètmes marins.

Utilisé pour la première fois en écologie aquatique sur la côte roumaine, la proportion en isotopes stables du carbone ($^{13}C/^{12}C$) et de l'azote ($^{15}N/^{14}N$) permet l'identification des sources de matière organique (terrestre ou marine) aussi bien que l'étude de réseaux trophiques grâce à la relation prédite entre les consomateurs et leur nourriture. Des analyses preliminaries des isotopes stables de la matière organique particulaire (MOP) des eaux du Danube comme de la MOP marine, des sédiments et des organismes marins ont été réalisées sur 186 échantillons récoltés dans 10 stations en Octobre 2004. L'identification des signatures isotopiques des principales sources de matière organique (terrestre ou marine) a été obtenue, ainsi que celle des différents

groupes d'organismes marins (macrophytes, bivalves, polychètes, amphipodes, macrouridés, crabes brachyoures, poissons). Les résultats obtenus en Mer Noire sont comparés avec ceux de la Mer Méditerranée au large du Rhône. Ils montrent que les signatures isotopiques de la MOP des deux fleuves sont proches l'une de l'autre alors qu'elles diffèrent largement dans le phytoplancton et les macrophytes marins.

INTRODUCTION

The coastal environments located seaward large rivers mouths are productive ecosystems (Mann, 1982) with important economical value (Costanza et al., 1997). By theirs inputs in dissolved and particulate nutritive elements, the rivers contribute to the development of the plankton and benthic communities and have a major role in the the coastal marine ecosystems functioning.

Danube is the second European largest river and represents 58% of the fresh water inputs into the Black Sea (Panin, 1997). Its delta, has a great impact on the sedimentation and on the marine ecosystems in the Black Sea (Gomoiu, 1996).

On the Romanian coasts the nutriments brought by the Danube, as well as the extent of the continental shelf offer optimal trophic conditions for the development of the marine organisms (Chirea and Gomoiu, 1986).

Relations between terrestrial inputs, primary production and fisheries were shown in different seas (Cushing, 1995; Yanez et al., 1998; Harmelin-Vivien and Salen-Picard, 2002; Salen-Picard et al., 2002). In the North - Western Mediterranean Sea, the integration of the continental particulate organic matter POM of the Rhone in the trophic webs of the demersals fish, like the common plate *Solea solea*, was showed by the use of the stable isotopes of carbon and nitrogen (Darnaude, 2003; Darnaude et al., 2004).

Stable isotopes were successfully used to trace the transfer of organic matter of different origins through aquatic food webs (Fry and Sherr, 1984; Peterson and Fry, 1987; Van der Zanden et al., 1999; Kaehler et al., 2000; Pinnegar and Polunin, 2000). Provided that primary producers have distinct isotopic signatures, stable isotopes constitute a powerful tool for discriminating among carbon sources (Van der Zanden and Rasmussen, 2001). In general, multiple-isotope approaches are required to identify the contribution of the different sources of organic matter (Peterson et al., 1985). The use of carbon and nitrogen stable isotopes provides a picture of food web structures and a good evidence of trophic transfers within animal communities (Peterson and Howarth, 1987; Dauby, 1995; Kwak and Zedler, 1997; Riera et al., 1999; Kaehler et al., 2000; Dufour and Gerdeaux, 2001; Polunin et al., 2001; Takai et al., 2002). The nitrogen isotope signature is used to define the trophic levels of organisms; the $\delta^{15}N$ increasing from prey to predator variates from 2.5 to 4.5‰ (mean 3.4‰) (Minagawa and Wada, 1984; Post, 2002). As an increase in $\delta^{13}C$ of only 1 - 2‰ occurs between prey and consumer (De Niro and Epstein, 1978; Wada et al., 1991), a consumer carbon isotope composition can give clues about the sources of its diet, particularly in systems with two distinct organic sources (Fry and Sherr, 1984). Terrestrial primary producers generally have lower $\delta^{13}C$ values than marine producers (especially phytoplankton and microphytobenthos), allowing the origin of carbon in the POM pools of estuarine and coastal environments to be traced (Haines and Montague, 1979; Riera and Richard, 1996; Bouillon et al., 2000).

Used for the first time in aquatic ecology on the Romanian coasts, the proportion of the stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) allowed the identification of the organic material sources (terrestrial and marine POM) as well as the stable isotope signatures of some organisms and fish. The isotopic signatures in $\delta^{15}N$ and $\delta^{13}C$ of the marine compartments from the North-Western part of the Black Sea were compared to the similar ones in the North-Western Mediterranean Sea (Darnaude et al., 2004).

MATERIALS AND METHODS

The study area was located in the North-Western side of the Black Sea on the Romanian coast seawards the Danube River (45º12’ - 43º44’N, 29º40’ - 28º35’E). A number of 186 samples of river surface water (Sulina, Sfântu - Gheorghe and Agigea channals), sea surface water, surface sediment, macrobenthic invertebrates and fish were collected at 10 stations located to depths of 0 to 50 m in the North (Sulina, Sfântu-Gheorghe) and South (Constanța, Agigea, Mangalia, 2 Mai) areas (Figure 1). Sampling was carried out in October 2004 in the period of lowest water level of the Danube (Bondar, 1977).

The terrestrial POM brought by the Danube River and the marine phytoplankton were considered to be the two main sources of particulate organic matter POM in the studied sites. POM samples were obtained by filtering 1 l of surface water, on pre-weighed Whatman GF/F glass micro fibre filters pre-combusted for 4 h at 500 °C (Aminot and Chaussepied, 1983). Sediment and macrobenthic invertebrate samples were collected with a benthic dredge (50 x 30 cm) or benthic trawl. Drifted terrestrial plant detritus collected during sediment sampling were rinsed with distilled water and kept frozen for isotopic analysis. Invertebrates were sorted by taxon under a binocular microscope and stored separately. Small organisms were crushed and, when necessary, several individuals were pooled and homogenised together. Fish were captured seasonally by trawling or with fishing nets. Their total length (L in cm) and weight (W in g) were recorded and their guts removed and preserved in 5% neutralised formaldehyde solution for stomach content analysis. Dorsal white muscle samples were taken for isotope analysis because this tissue tends to be less variable in terms of $\delta^{13}C$ and $\delta^{15}N$ (Pinnegar and Polunin, 1999). All samples were kept frozen before being processed for stable isotopes analysis.

Water POM samples on filters were freeze-dried and cut into small pieces. Animal and sediment samples were freeze-dried and ground into a fine powder (< 6 µm) using a mortar and pestle. Samples from polychaetes and large molluscs’ soft tissues and fish (white muscle) were analysed without any prior treatment. Samples of POM, sediment and small invertebrates with calcareous tests (juvenile bivalves, crustaceans, etc.) were divided into two subsamples. One subsample, for carbon isotope analysis, was acidified with 1% HCl solution to remove carbonates, rinsed with distilled water and oven-dried at 40°C for 24 h, as carbonates present a less negative $\delta^{13}C$ than organic carbon (De Niro and Epstein, 1978). The other subsample, for nitrogen isotope analysis, was not acidified, because acidification increases the $\delta^{15}N$ values (Pinnegar and Polunin, 1999).

The $^{13}C/^{12}C$ and $^{15}N/^{14}N$ ratios in the samples were determined using continuous flow isotope mass spectroscopy. Weighted samples of freeze-dried material (1 mg for fish and prey and 10 mg for filters and sediment) were used for CF-IRMS analysis using a Europa Scientific ANCA-NT 20 - 20 Stable Isotope Analyser with ANCA-NT Solid-Liquid Preparation Module (Europa Scientific Ltd., Crewe, UK). For samples containing around 10% N, the CF-IRMS was operated in the dual isotope mode, allowing $\delta^{15}N$ and $\delta^{13}C$ to be measured on the same sample. The analytical precision (SD, n = 5) was 0.2‰ for both N and C, estimated from standards analysed along with the samples. Working standards were 1 mg leucine prepared by freeze drying 50 µl of a 20 mg/ml stock solution into tin cups, and calibrated against ‘Europa flour’ and IAEA standards N1 and N2. The methods are fully described in Scrimgeour and Robinson (2003).

Isotope ratios were expressed as differences of parts per thousand (‰) from a standard reference material:

$\delta X (‰) = [(R\ sample/R\ standard) - 1] \times 1000$

where X is ^{13}C or ^{15}N, R the corresponding ratio $^{13}C/^{12}C$ or $^{15}N/^{14}N$, and δ the measure of heavy to light isotope in the sample. The reference materials were the international standards Vienna Pee Dee Belemnite (vPDB) for carbon and atmospheric N_2 for nitrogen.

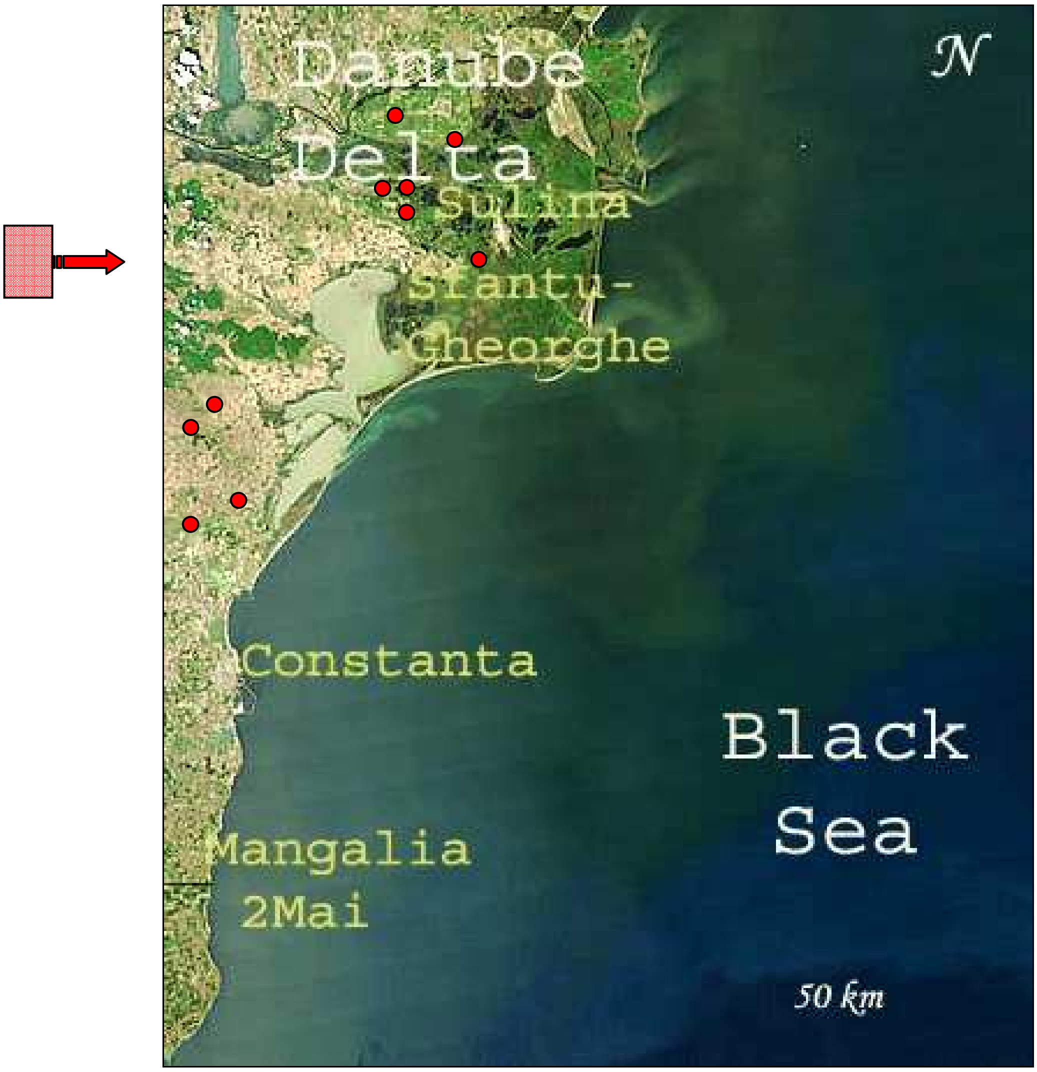

Figure. 1 - Sampling stations on the Romanian coasts in October 2004.

Table 1. The list of the compartments studied, the engines used for sampling, the material collected and the analyses carried on the samples taken from the Danube and the Romanian coasts; POM = particulate organic matter.

Compartments	Sampling material	Samples	Analysis
DANUBE (3 stations) Sulina, Sfântu - Gheorghe and Agigea			
Danube water	Filtration	Terrestrial POM	POM analysis Isotopes analyses C (decalcification) N (no treatment)
BLACK SEA (7 stations) Northern area, Southern area			
Marine water	Filtration	Marine POM	POM analysis Isotopes analyses C (decalcification) N (no treatment)
Superficial sediment	Dredge (50/30cm)	Sediment	Isotopes analysis C (decalcification) N (no treatment)
Endofaune	Dredge (50/30cm)	- Polychaetes, mollusks - Crustaceans	- Identification and sorting - Isotopes analysis C and N - IsotopesanalysisC(decalcification) N (no treatment)
Fish	Trawls, lines, bordigues	- Whitemuscle - Gut content	- Isotopes analysis (C et N) - Gut content analysis

RESULTS AND DISCUSSIONS

The 186 results of stable isotopes analysis in $\delta^{13}C$ and $\delta^{15}N$ carried out on samples taken from the 10 sampled stations evidenced the signatures of the different compartments: river water, marine water, sediment, endofauna and fish.

The main “reservoirs” of organic matter accessible to coastal benthic invertebrates is the river plume water POM (situated in the North area and results from a mixing of Danube and seawater POM), the organic matter in surface sediments (derived mainly from the deposition of the Danube plume) and the seawater POM in the Central and South areas.

The stable isotopes signature of the Danube POM was given by terrestrial plants detritus (plants in C3 and C4), freshwater phytoplankton and bacteria. The marine POM signature is the mean of the small marine plankton (phyto- and bacterio-plankton) signatures.

The mean signature of the Danube POM on Sulina and Sfântu-Gheorghe channals in October 2004 was of - 26.54 ‰ in $\delta^{13}C$ and of 3.71 ‰ in $\delta^{15}N$. It presented small different values on Sulina and Sfântu-Gheorghe channals (Table 2) and significant different ones on Agigea channal. River signature can vary according to the river flow and charge. The significant different signature on Agigea channal may be due to the fact that it’s a semi-closed chnal and the fresh water phytoplankton compartment was better represented than the terrestrial plants’ detritus one.

Table 2. Stable isotope signatures (13C/12C and 15N/14N) of the Danube POM and the marine POM on the Romanian coasts and the stable isotopes signatures of the sediment seawards the river mouths).

	Station	n	delta PDB ± SD (‰)	delta N ± SD (‰)
POM	Sulina Danube	6	- 26.37 ± 0.36	3.35 ± 0.01
	Sfântu - Gheorghe Danube	6	- 26.71 ± 0.23	4.07 ± 0.54
	Agigea	6	- 33.55 ± 1.19	6.76 ± 1.34
	Sfântu - Gheorghe 5m	6	- 26.22 ± 0.30	5.37 ± 1.09
	2Mai 1m	6	- 21.67 ± 0.81	9.29 ± 1.26
	Mangalia 35m	6	- 20.43 ± 0.10	11.07 ± 0.46
Sediment	Sulina 18m	6	- 23.88 ± 1.68	3.63 ± 0.54
	Sfântu - Gheorghe 35m	6	- 23.53 ± 1.15	4.68 ± 0.30

The seawater analysis from Sfântu-Gheorghe (5 m) showed their stable isotope signature similar to those of the river (Table 2). Marine POM in the South area presented higher values in $\delta^{13}C$ and $\delta^{15}N$ than the Danube ones (Table 2). The influence of the terrestrial POM in the sea decreased from North to South with the increasing distance from Danube mouths (Figure 1).

The particulate organic matter POM quantitative analysis showed highest values in the Danube water at Sulina (42.77 mg/l) and Sfântu Gheorghe (14.33 mg/l). In the sea these values reduced considerably seawards the Danube mouth at Sfântu Gheorghe (6.58 mg/l) because of strong sedimentation processes and decreased in the South at 2 Mai (6.17 mg/l) and Mangalia (4.9 mg/l) (Figure 1). The significant high values of the coastal POM at 2 Mai were most probably due to the coastal hydrodynamism, which caused the suspension of the particles.

The mean stable isotope signature of the sediment ($\delta^{13}C$ = - 23.71‰, $\delta^{15}N$ = 4.16‰) sampled off large Danube mouths was influenced by the signature of the terrestrial particles brought by the river and by the degraded dead marine organisms. This signature increased with the distance from the Danube mouths and with the reduction in the terrestrial influence.

Only a few species of benthic organisms were sampled and analysed. The database was supplemented in spring and autumn 2005 - 2006 with other species (not presented data). The endofaune stable isotopes signatures varied according to the species and the localization (Table 2). It seems that certain groups of organisms, such as amphipods and polychaetes use more terrestrial-origin matter than other groups, which can be characterised by highly marine signatures, such as bivalves, macrurans and brachyurans (Figure 2).

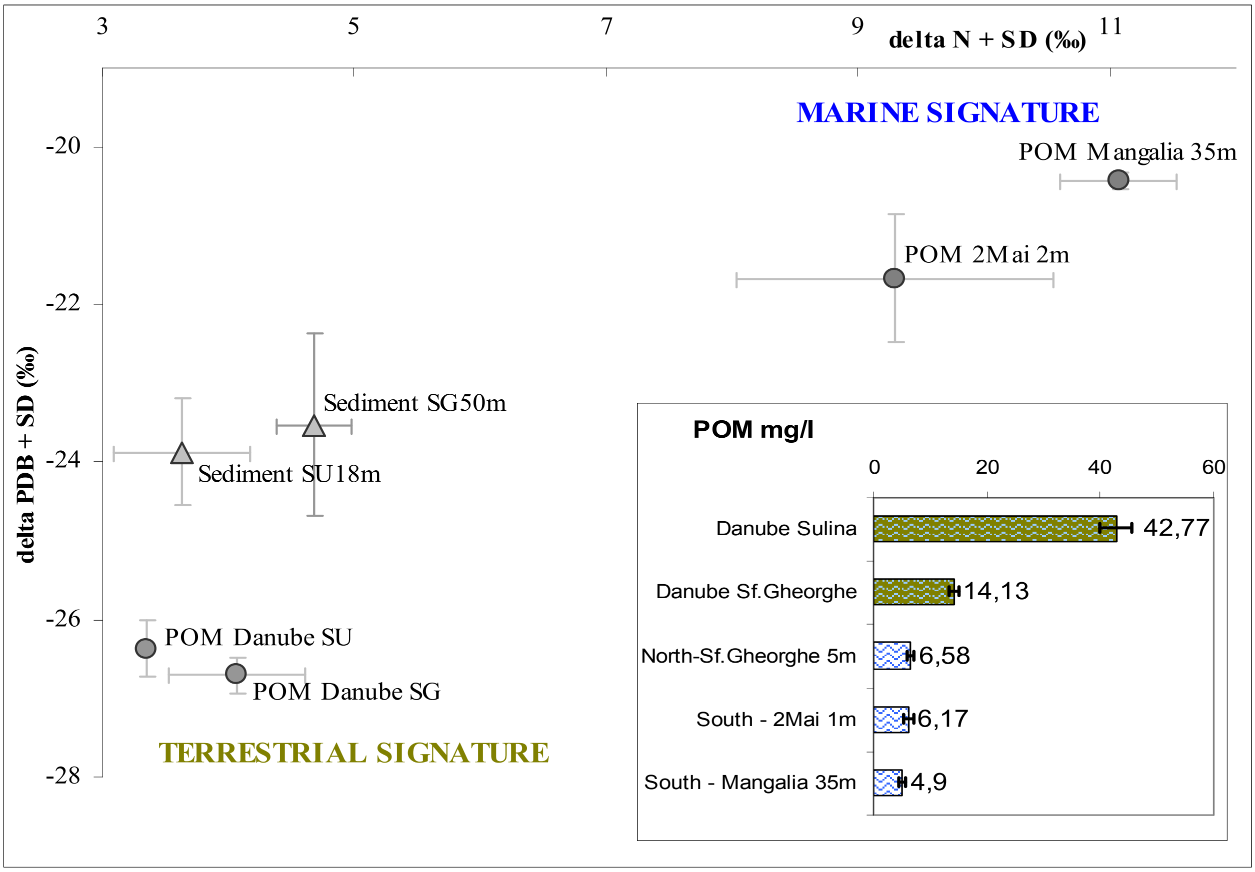

Figure 1. Particulate organic matter POM stable isotope signatures $\delta^{13}C$ and $\delta^{15}N$ in the Danube (SU = Sulina, SG = Sfântu-Gheorghe) and on the Southern Black Sea Romanian coast (MG = Mangalia, D = 2 Mai), sediment signatures and suspension organic matter charge of the water.

Table 2. Groups, species of benthic organisms, sampling stations and stable isotope signatures in $\delta^{15}N$ (‰) and $\delta^{13}C$ (‰).

Species / Station			Sfântu-Gheorghe		Constanța	Mangalia	2 Mai
			5m	50m	5m	35m	5m
Bivalves	*Mytilus* sp.	$\delta^{15}N$			10.59 + 0.30	9.89 + 0.49	
		$\delta^{13}C$			-20.38 + 0.30	-19.95 + 0.24	
	Cardium sp.	$\delta^{15}N$	8.98				
		$\delta^{13}C$	-21.03				
Gastropods	*Rapana* sp.	$\delta^{15}N$			12.96 + 0.05		
		$\delta^{13}C$			-17.68 + 0.24		
Macrurans	*Crangon* sp.	$\delta^{15}N$	13.27 + 0.31	14.91			
		$\delta^{13}C$	-20.60 + 0.45	-19.57			
Brachyurans	*Liocarcinus* sp.	$\delta^{15}N$		12.53			
		$\delta^{13}C$		-18.33			
Polychaetes	*Nereis* sp.	$\delta^{15}N$			15.20 + 0.49		
		$\delta^{13}C$			-18.32 + 0.50		
Amphipods	*Euxinia* sp.	$\delta^{15}N$	9.48 + 0.24				
		$\delta^{13}C$	-23.74 + 0.02				
Macrophytes	*Ulva* sp.	$\delta^{15}N$					11.36
		$\delta^{13}C$					-18.26
	Ceramium sp.	$\delta^{15}N$					11.05
		$\delta^{13}C$					-17.17
	Cystoseira sp.	$\delta^{15}N$					7.79
		$\delta^{13}C$					-16.65

Fish consumed preys of different trophic levels relying on various carbon sources. Some fish had rather terrestrial influences on their stable isotope signatures, like: carp, bluefish, Caspian shad, red mullet and starry sturgeon. Others had marine influence on theirs signatures: turbot, sand sole, flounder, tub gurnard, round goby, beluga, sprat, horse mackerel, mullet and whiting. (Table 4, Figure 2). The analysed fish presented variations of theirs signatures related to the individual size, to the depth of the sampling station, to the distance from the Danube, to the season and to the specific trophic behaviour (not presented data).

The carp is a freshwater fish, which was collected in the sea seawards Sfântu-Gheorghe. It presented a terrestrial stable isotope signature and it was analyzed for comparison with the marine fish's signatures.

The majority of the samples were taken in the North area of the Romanian coasts seawards the Danube mouths. The representation of a food web based on the two sources of terrestrial and marine particulate organic matter was represented in the figure 2. The lines corresponded to theoretic increasing signatures in a trophic web (see the introduction) and showed the limits of these signatures. All the various marine compartments (sea water POM, sediment and organisms) from the Romanian coast were strongly influenced by the terrestrial signature of the Danube POM.

The signatures in $\delta^{13}C$ of the analyzed fish compared to the bibliography data (fresh water fish $\delta^{13}C = - 19.7 \pm 4.5$ ‰ and fish marine $\delta^{13}C = - 12.5 \pm 1.4$ ‰) showed that the marine fish signatures on the Romanian coasts (average d13C = - 20.06 + 2.98 ‰) were close to those of the freshwater fish.

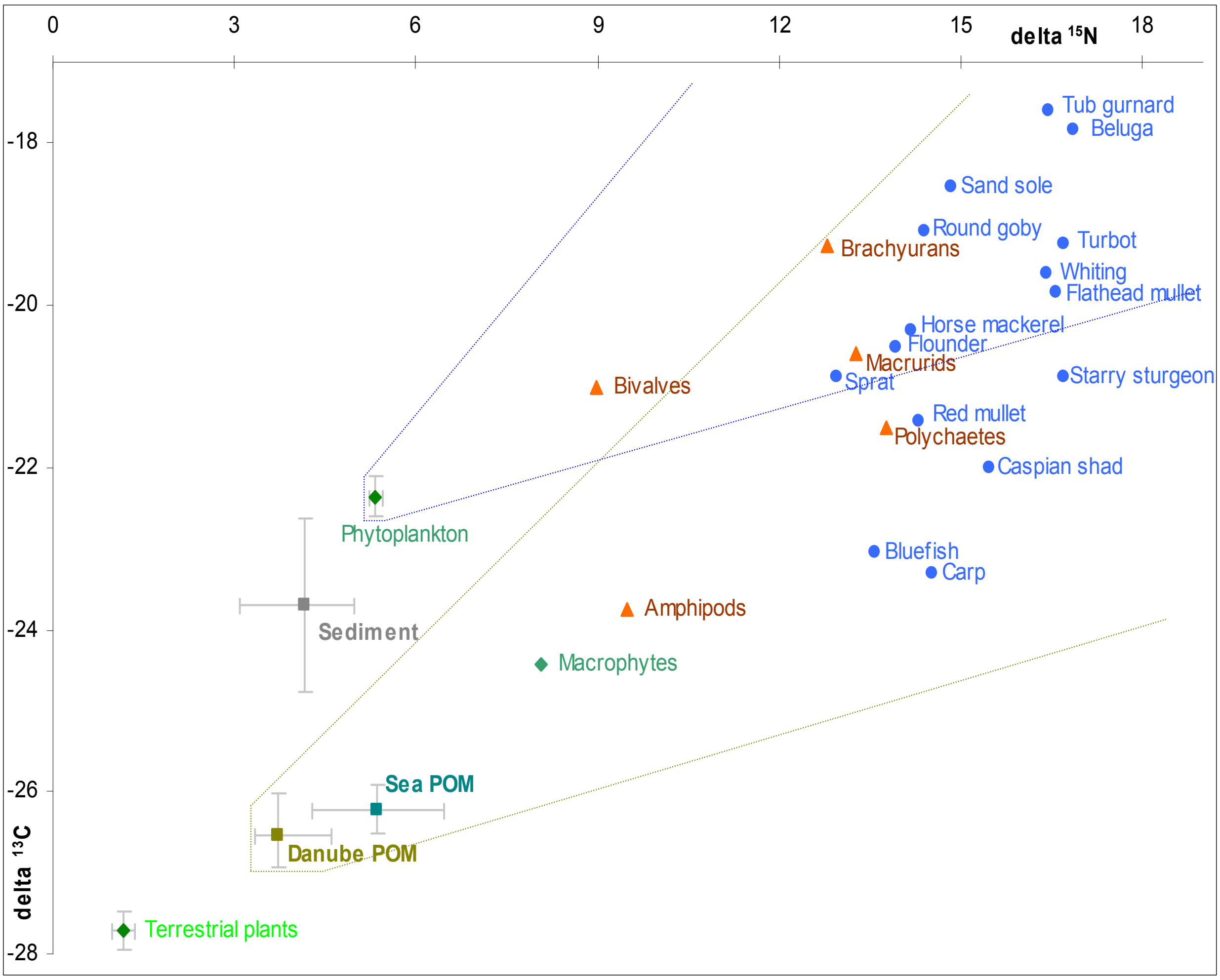

Figure 2. Representation of the stable isotope signatures of the food web components based on two main "reservoirs" of organic matter: the Danube plume water POM and seawater POM in the Northern area of the Romanian coasts in October 2004.

Table 4. Species and common nouns of the analyzed fish (www.fishbase.org), n = number of analyzed individuals and their stable isotope signatures in $\delta^{15}N$ and $\delta^{13}C$.

Species	n	$\delta^{15}N$ (‰)	$\delta^{13}C$ (‰)
Psetta maxima maeotica (Linnaeus, 1758) - turbot	6	16.70 + 0.55	-19.25 + 0.57
Solea nasuta (Risso, 1810) - sand sole	1	14.84	-18.53
Pleuronectes flesus luscus (Linnaeus, 1758) - flounder	1	13.92	-20.52
Trigla lucerna (Linnaeus, 1758) - tub gurnard	1	16.45	-17.59
Mullus surmuletus (Linnaeus, 1758) - red mullet	3	14.32 + 0.33	-21.42 + 1.45
Apollonia melanostomus (Pallas, 1811) - round goby	18	14.48 + 0.49	-18.80 + 0.60

Species	n	δ15N (‰)	δ13C (‰)
Liza aurata (Risso, 1810) - golden grey mullet	2	15.66 + 1.84	-18.41 + 0.07
Mugil cephalus (Linnaeus, 1758) - flathead mullet	2	16.57 + 0.01	-19.84 + 0.01
Merlangius merlangus euxinus (Nordmann, 1840) - whiting	6	16.40 + 0.61	-19.61 + 0.53
Acipenser stellatus (Pallas, 1771) - starry sturgeon	4	16.71 + 0.82	-20.88 + 1.86
Huso huso (Linnaeus, 1758) - beluga	2	16.87 + 0.65	-17.82 + 0.55
Pomatomus saltatrix (Linnaeus, 1766) - bluefish	2	13.57 + 0.70	-23.04 + 1.02
Trachurus mediterraneus ponticus (Aleev, 1956) - horse mackerel	11	14.19 + 0.84	-20.32 + 0.94
Sprattus sprattus (Linnaeus, 1758) - sprat	10	12.94 + 0.85	-20.89 + 0.01
Alosa caspia nordmani (Antipa, 1904) - caspian shad	6	15.48 + 1.91	-22.01 + 1.21
Vimba vimba carnata (Pallas, 1811) - carps	5	14.54 + 0.58	-23.32 + 1.40

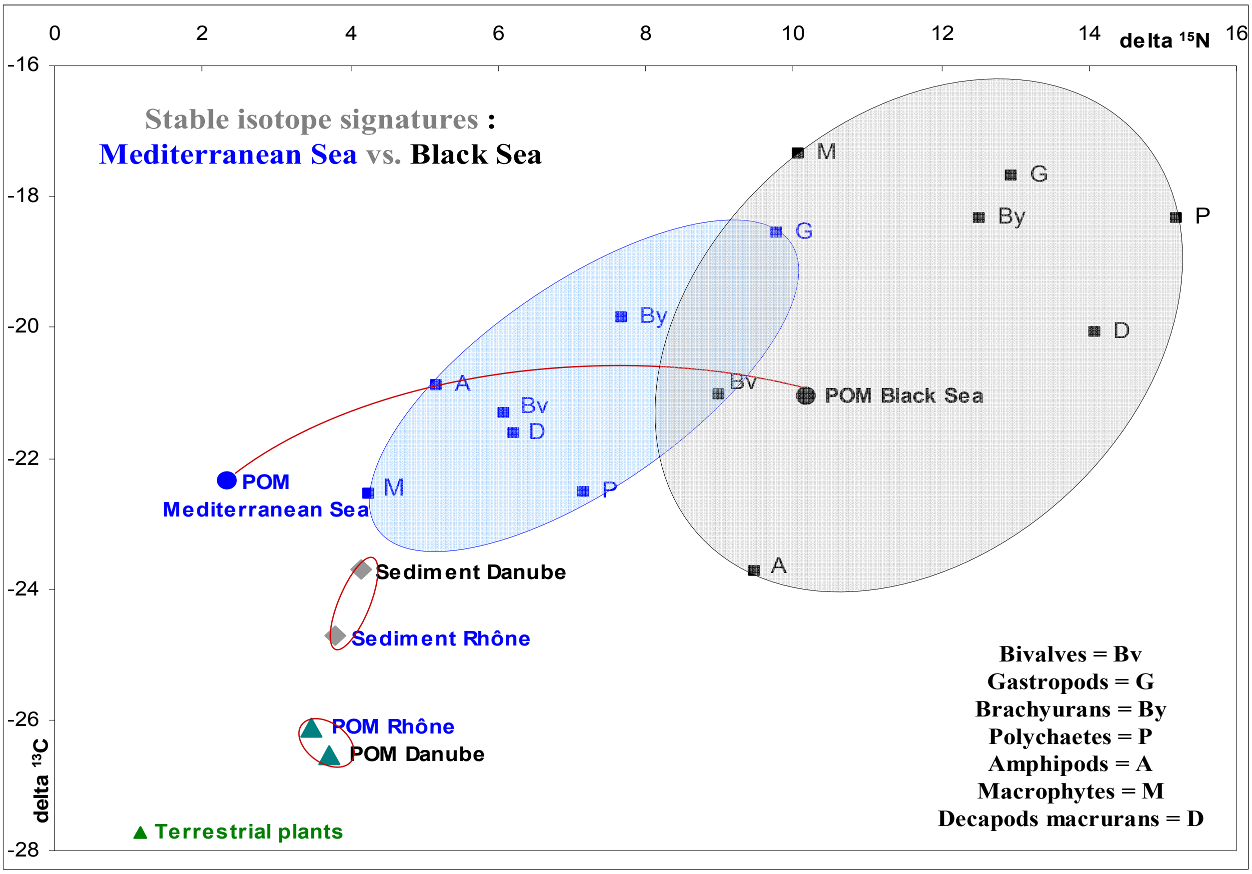

Figure 3. Representation of stable isotope signatures of the river and sea POM, the sediment and some groups of organisms on Romanian Black Sea coasts under Danube influence and in the North-Western part of the Mediterranean Sea seawards the Rhone.

The stable isotope values for the marine compartments in the North-Western Black Sea (under Danube influence) were compared to those of the North-Western Mediterranean Sea (under Rhone influence) (Darnaude et al., 2004) in order to observe possible differences or similarities between the two systems (Figure 3). The sources of these two rivers are situated in Central Europe and their flows are influenced by the global and regional weather evolution. The Danube flow and discharge are more important than the Rhone ones, and also its impact on the marine environment. The Danube and the Rhone waters, and their prodelta sediments have similar isotopic signatures. However, phytoplankton, marine macrophytes and invertebrates present higher isotopic values in the Black Sea (Figure 3).

CONCLUSIONS

The objective of the present study was to estimate the isotopic signatures of the Danube and marine water, the sediment and some benthic organisms and fish on the Romanian coasts.

Preliminary results demonstrated a strong influence of the Danubian particulate organic matter on the stable isotope signatures of the various marine compartments (sea water POM, sediment and organisms). The river influence decreased from the northern to the southern areas.

Among invertebrates, stable isotopes values depended on their trophic level and aptitude to consume the terrestrial POM brought by the river. The lowest values were found in polychaetes and amphipods, and the highest ones in macrurans, brachyurans and bivalves.

Among the fish species studied, the lowest values of $\delta^{13}C$ and $\delta^{15}N$ were observed in carp and bluefish, while the highest value was found in beluga and tub gurnard. These differences were explained mainly by their differences in diet and location.

The ratios of the stable isotopes of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) coupled with gut content description allowed the identification of organic matter sources and the analysis of food webs.

The knowledge of the POM origin and its incorporation through the marine food and its potential impact on the coastal fisheries is an important and necessary step to a reasonable use of these resources in the Black Sea.

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AUTHORS:

[1] *Daniela BANARU*
banaru@com.univ-mrs.fr
[1] *Vivien Mireille HARMELIN*
harmelin@com.univ-mrs.fr
Oceanologic Center of Marseille UMR CNRS 6540,
Station Marine d'Endoume, Marseille, France, FR - 13007.

[2] *Marian-Traian GOMOIU*
mtg@cier.ro
Ovidius University of Constanța,
Natural Sciences Department,
Mamaia Bd., no. 124,
Constanța, Constanța County, Romania, RO - 900527.

MORPHOLOGICAL VARIABILITY ASPECTS, OF *GOBIO KESSLERI KESSLERI* DYBOWSKI 1862

Doru BĂNĂDUC[1] and *Petru M. BĂNĂRESCU*[2]

KEYWORDS: Pisces, Cyprinidae, external and internal morphology, comparative taxonomy.

ABSTRACT

The analyzed data (1726 - 2004 period) regarding *Gobio kessleri kessleri* and a present contradiction regarding *Gobio* genus systematic classifications, based on different taxonomically tackles, induce the necessity of a new integrated taxonomic tackle, the results offering some working strategies and tools for this group systematic classification.

The results are based on the descriptive statistics of 11 external and internal morphological characters of 17 analyzed populations considered as representative for the Romanian territory, which represent a significant part of this subspecies areal.

Some of the main conclusions are: the present integrated taxonomic type of analyze is a valuable one as a working tool for the establishment of *Gobio* genus (species and subspecies) systematic; the high morphological variability reveal one of the reason for which *Gobio kessleri kessleri* has an initial systematic position in comparison with *Gobio kessleri banaticus* and *Gobio kessleri antipai* in the *Gobio* genus context.

REZUMAT: Aspecte de variabilitate morfologică la *Gobio k. kessleri* Dybowski 1862.

Analiza datelor (perioada 1726 - 2004) referitoare la *Gobio kessleri kessleri* şi o contradicţie prezentă între actualele clasificări sistematice ale genului *Gobio*, bazate pe instrumente taxonomice diferite, induce necesitatea unei abordări taxonomice integrate, rezultatele oferind unele strategii şi instrumente de lucru pentru realizarea clasificării sistematice a acestui grup.

Rezultatele se bazează pe statistica descriptivă a 11 caractere morfologice externe şi interne a 17 populaţii analizate, considerate ca fiind reprezentative pentru teritoriul româniei, care reprezintă o parte semnificativă a arealului acestei subspecii.

Câteva dintre concluziile principale sunt: acest tip de analiză taxonomică integrată este valabilă ca instrument de lucru în stabilirea sistematicii (speciilor şi subspeciilor) genului Gobio; variabilitatea morfologică ridicată relevă unul dintre motivele pentru care *Gobio kessleri kessleri* are o poziţie sistematică iniţială în comparaţie cu *Gobio kessleri banaticus* şi *Gobio kessleri antipai* în contextul genului *Gobio*.

RÉSUMÉ: Aspects sur la variabilité morphologique de *Gobio k. kessleri* Dybowski 1862.

L'analyse des données (période 1726 - 2004) concernant *Gobio k. kessleri* ainsi que la contradiction actuellement présente entre les classifications systématiques du genre *Gobio*, mises au point en utilisant des instruments taxonomiques variées, soulignent la nécessité d'une approche intégrée. Les résultats offrent des stratégies et instruments de travail pour la définition de la classification systématique de ce groupe.

Les résultats s'appuient sur la statistique descriptive de 11 caractères morphologiques externes et internes mesurés sur 17 populations considérées comme représentatives pour le territoire de la Roumanie, qui constitue une partie significative de l'aire de répartition de cette espèce.

INTRODUCTION

Based on the bibliographical data of 1726 - 2004 period, about the genus *Gobio* Cuvier 1817 taxonomy and systematics, on the Romanian territory, were emphasized some elements which still need extensive or/and intensive studies (Bănăduc 2003).

Such a case was tackled and analyzed in this study, due to some actual scientific controversy regarding *Gobio kessleri kessleri* subspecies systematic and phylogenetic tackle, or only through external morphological aspects or only through internal morphological aspects, in the broader context of *Gobio* genus and gobionins (Bănărescu 1992; Bănărescu and Nalbant, 1965; 1973; Naseka 1996).

Although the external morphological studies with applications in the subspecies, species and genus taxonomy and systematics are numerous and with defined phylogenetic conclusions, the initiative of Naseka (1996) concerning some studies based on anatomy elements raised possible new questions in this field of interest and induced the necessity of a new tackle which include external and internal morphological characters, as working tools for the group phylogeny establishment.

In this direction, as a first integrative contribution of the external morphological elements analyze (well studied till now at the national and international level) with the anatomic elements (not utilized by Romanian researchers till the present but utilized by some Russian researchers), in this work was done an integrated analyze of the intrasubspecific variability based on some external morphological characters and internal morphological characters too, and the analyze of some comparative taxonomic elements with applicability in *Gobio* genus systematic.

MATERIALS AND METHODS

The intrasubspecific variability of 7 external and 4 internal morphological characters was analyzed, for 17 *Gobio kessleri kessleri* (Bănărescu, 1964) populations (Figure 1).

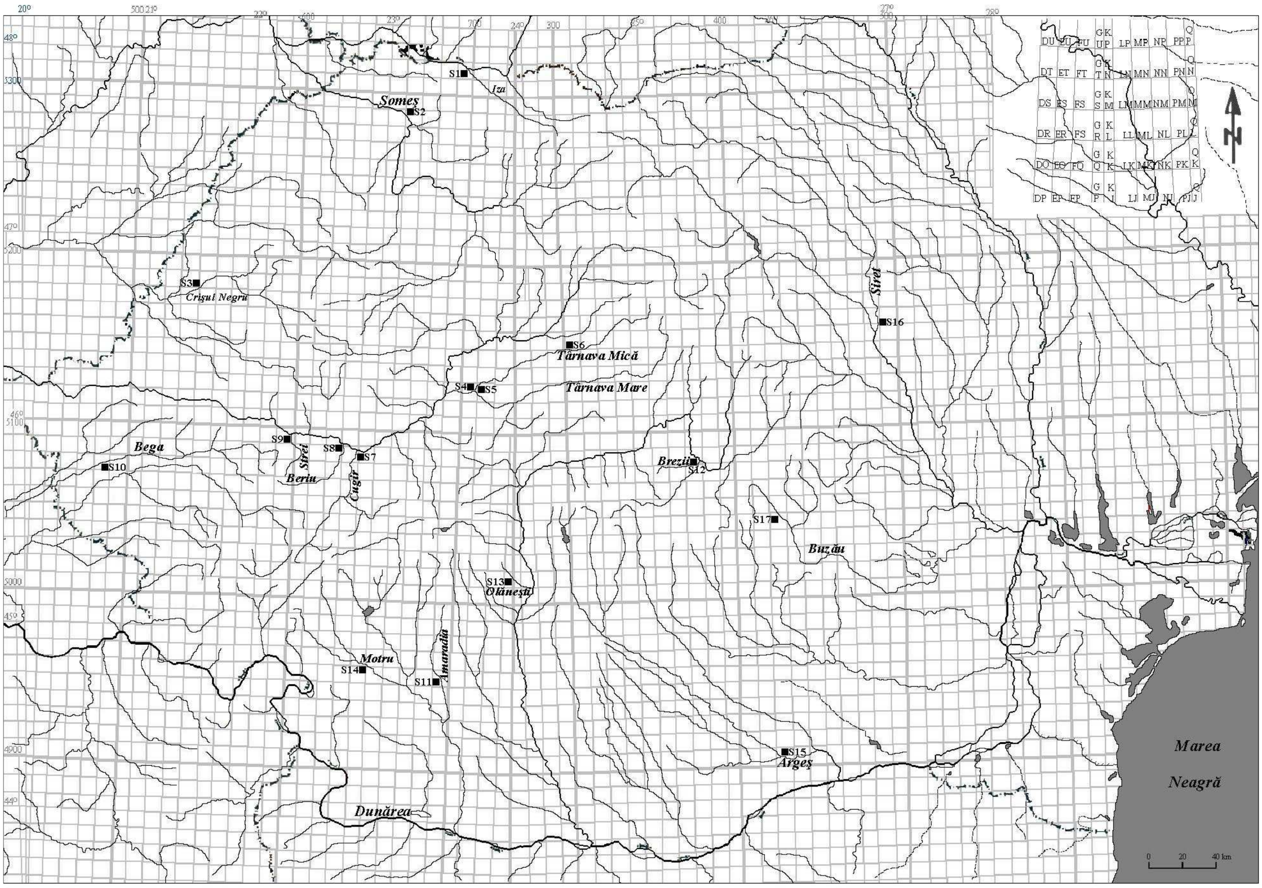
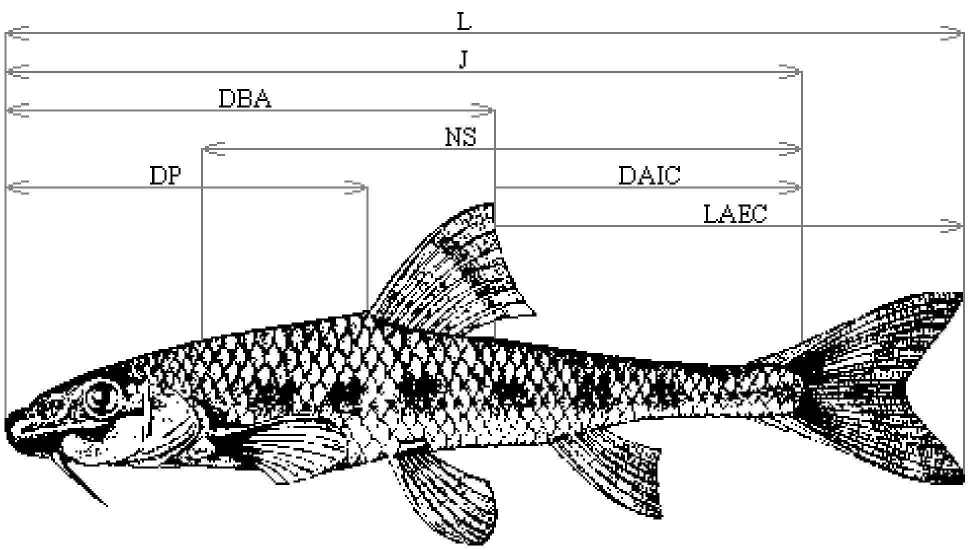


Figure 1. The sampling stations (■; S1 - S17) localization on the hydrographic net and U.T.M. net.

The 17 rivers samplings stations localizations are: Iza River/sampling station (S1) localized in Sighet locality (Maramureş County), Someş River/(S2) localized in Pomi locality (Satu Mare County), Crişul Negru River/(S3) localized in Tămaşda locality (Bihor County), Târnava River/(S4) localized at 500 m downstream the Târnava Mare and Târnava Mică rivers confluences (Alba County), Târnava Mare River/(S5) localized upstream of Blaj locality (Alba County), Târnava Mică River/(S6) localized in Coroisânmartin locality (Mureş County), Cugir River/(S7) localized upstream of its confluence with Mureş River (Alba County), Beriu River/(S8) localized at two km upstream of its confluence with Mureş River (Hunedoara County), Strei River/(S9) localized at 0.5 km Vest of the Simeria Veche locality (Hunedoara County), Bega River/(S10) in Timişoara locality (Timiş County), Amaradia River/(R11) localized in the proximity of Melineşti locality (Dolj County), Brezii River/(S12) localized in Voivodenii Mari locality (Braşov County), Olăneşti River/(S13) localized at one km upstream of Vlădeşti locality (Vâlcea County), Motru River/(S14) localized in the proximity of Gura Râului locality (Mehedinți County), Argeş River/(S15) localized in Copăceni locality (Giurgiu County), Siret River/(S16) localized in the proximity of Traian locality (Bacău County), Buzău River/(S17) localized in the proximity of Ungur locality (Buzău County).

The studied biological material was sampled with a hand net in 1999 - 2003 period, fixed in a 7% formaldehyde solution, than preserved in 70% alcohol and included in the „Lucian Blaga" University, Sciences Faculty, Ecology and Environmental Protection Department, Hydrobiology Laboratory collections and in the Sibiu Natural History Museum collections.

The considered external morphological characters in this study (Figure 2) are: the scales number along the fish body lateral line - NS; the total fish body length - L; the standard fish body length - J; the distance between the mouth orifice and the anal orifice - DBA; the distance between the tip of the fish mouth orifice and the front edge of the dorsal fin - DP; the length between the anal orifice and the caudal fin insertion - DAIC; the length between the anal orifice and the caudal fin extremity - LAEC.



NS - the scales number along the lateral line	DBA - the mouth to anal orifice length
L - the total fish body length	DAIC - the anal orifice to caudal fin insertion length
J - the standard fish body length	LAEC - the anal orifice to caudal fin extremity length
DP - the mouth to dorsal fin front edge length	

Figure 2. The analyzed external morphological characters (fish drawing - Bănărescu, 1964).

The considered internal morphological characters (Figure 3) are: the fish body total vertebrae number - T, the fish abdominal vertebrae number - A, the fish vertebrae number positioned in the front of the dorsal fin front insertion - AP and the fish caudal vertebrae number positioned between the fish anal orifice and caudal fin insertion - C.

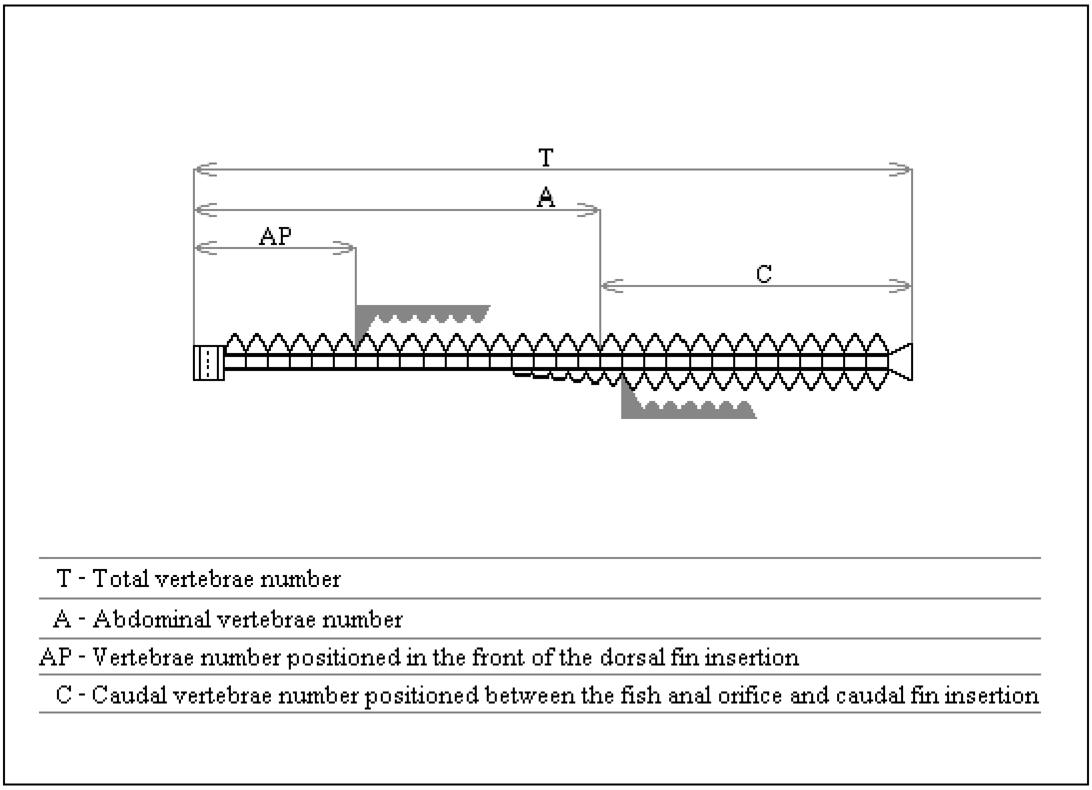


Figure 3. The analyzed internal morphological characters for the *Gobio kessleri kessleri* subspecies variability study.

All these four internal morphological characters, for the all sampled *Gobio kessleri kessleri* individuals, were analyzed with X rays.

For all these morphological characters variability analysis were considered only the adult individuals, respectively those with sexual mature gonads. A total number of 246 *Gobio kessleri kessleri* individuals, both males and females, were analyzed.

The general descriptive statistics is presented (Table 1), for each of the twelve considered variables of *Gobio kessleri kessleri* populations individuals.

To test which of the eleven variables are significantly correlating, from the statistical point of view, a correlation analysis for a 0.05 maximum probability level was applied.

Based on the regression multivariate analysis the existent deterministic relation between the considered metric variables and weight variable was aimed, in this way the regression linear equations were obtained.

The best mathematical model selection was realized based on three criteria: the highest deterministic coefficient (r^2); the lowest standard error (Es); the lowest probability level (q).

To emphasize these diverse morphological characters variability in 17 *Gobio kessleri kessleri* analyzed populations (of 17 sampling stations, of 17 rivers; S1 - S17) and between these populations, box plot graphics were utilized (Figures 4 - 12), which convey the median, the interquartile distances and the extreme values for each data row.

RESULTS AND DISCUSSIONS

A total of 246 individuals were analyzed, belonging to *Gobio kessleri kessleri* subspecies populations, of the 17 considered rivers. Table 1 contain the analyzed variables descriptive statistic.

Table 1. The 12 considered variables general descriptive statistic for the *Gobio kessleri kessleri* analyzed populations (MIN - minimum value of the data row, MAX - maximum value of the data row, MED - arithmetic mean, VAR - variance, ASD - standard deviation, ES - mean standard error, CA - asymmetry coefficient, CV - variation coefficient).

Para-meters	Variable											
	T	NS	L (cm)	J (cm)	A	BA (cm)	AP	DP (cm)	C	DAIC (cm)	LAEC (cm)	G (g)
MIN	35,000	36,000	5,100	3,100	23,000	2,000	11,000	1,800	12,000	1,900	2,700	1,000
MAX	40,000	43,000	11,100	9,400	26,000	5,600	14,000	4,200	16,000	4,700	6,800	15,000
MED	37,243	40,511	7,653	6,329	24,000	3,681	12,277	2,933	13,234	2,828	4,077	3,606
VAR	1,792	1,623	1,629	1,258	0,739	0,446	0,639	0,280	1,053	0,260	0,540	4,772
ASD	1,339	1,274	1,276	1,122	0,860	0,668	0,800	0,529	1,026	0,510	0,735	2,185
ES	0,195	0,134	0,135	0,118	0,125	0,070	0,117	0,056	0,150	0,054	0,077	0,230
CA	0,390	-0,598	0,389	0,177	0,622	0,247	0,241	0,363	0,618	0,658	0,665	2,381
CV	0,036	0,031	0,167	0,177	0,036	0,182	0,065	0,180	0,078	0,180	0,180	0,606

Applying the correlation analyzes for the eleven measured variables (excepting G variable - weight), can be record the positive significant correlations existence, for the considered probability level (maximum 5%), between the following variables (presented in the diminishing order of the correlation coefficient r): DBA and DP, LAEC and L, DBA and L, DP and L, DAIC and LAEC, DP and LAEC, DP and DAIC, DAIC and L, DBA and LAEC, DBA and DAIC, AP şi A, C and T, DP and J, DBA and J, J and L, LAEC and J, DAIC and J, A and T, AP and T.

No significant correlations between the variables which describe external characters and the variables which describe internal characters were found (concerning this aspect see below the correlation matrix and the probabilities matrix).

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Correlation matrix between the considered variables for *Gobio kessleri kessleri*

	T	NS	L	J	A
T	1.000				
NS	-0.222	1.000			
L	0.178	0.350	1.000		
J	0.275	0.304	0.802	1.000	
A	0.585	-0.159	0.063	0.153	1.000
DBA	0.292	0.242	0.945	0.802	0.134
AP	0.565	-0.067	0.131	0.142	0.877
DP	0.290	0.263	0.944	0.804	0.110
C	0.818	-0.223	0.125	0.235	0.098
DAIC	0.124	0.309	0.908	0.785	0.025
LAEC	0.125	0.350	0.949	0.800	0.002

	DBA	AP	DP	C	DAIC	LAEC
DBA	1.000					
AP	0.160	1.000				
DP	0.970	0.176	1.000			
C	0.242	-0.012	0.229	1.000		
DAIC	0.907	0.062	0.912	0.107	1.000	
LAEC	0.908	0.023	0.922	0.135	0.939	1.000

Probabilities matrix

	T	NS	L	J	A
T	0.000				
NS	0.133	0.000			
L	0.231	0.016	0.000		
J	0.061	0.037	0.000	0.000	
A	0.000	0.285	0.676	0.305	0.000
DBA	0.047	0.102	0.000	0.000	0.368
AP	0.000	0.656	0.380	0.340	0.000
DP	0.048	0.074	0.000	0.000	0.461
C	0.000	0.132	0.404	0.113	0.510
DAIC	0.408	0.035	0.000	0.000	0.870
LAEC	0.404	0.016	0.000	0.000	0.989

	DBA	AP	DP	C	DAIC	LAEC
DBA	0.000					
AP	0.282	0.000				
DP	0.000	0.238	0.000			
C	0.102	0.936	0.122	0.000		
DAIC	0.000	0.680	0.000	0.475	0.000	
LAEC	0.000	0.879	0.000	0.365	0.000	0.000

To describe the deterministic relation between the considered metric variables and the weight variable (G) the regression analysis was applied. The following equation is the regression equation obtained with the specification of the determination coefficient (r^2) and of the standard error (ES):

$$\ln G = 0{,}20659 * \ln(DP) * \ln(DBA) * \ln L * \ln J \text{ ; } r^2 = 0.976\text{; Es} \pm 0.19$$

The considered internal and external morphological characters variability is represented in box plot type graphs which emphasize the differences between the analyzed populations (Figures 4 - 12) of the following rivers: Iza (S1), Someş (S2), Crişul Negru (S3), Târnava (S4), Târnava Mare (S5), Târnava Mică (S6), Cugir (S7), Beriu (S8), Strei (S9), Bega (S10), Amaradia (S11), Râul Brezii (S12), Olăneşti (S13), Motru (S14), Argeş (S15), Siret (S16) şi Buzău (S17).

Figure 4. Box plot graphs for T variable in the case of 13 *Gobio kessleri kessleri* populations of the rivers: Iza (S1), Crişul Negru (S3), Târnava (S4), Târnava Mare (S5), Târnava Mică (S6), Cugir (S7), Beriu (S8), Strei (S9), Bega (S10), Olăneşti (S13), Argeş (S15), Siret (S16) şi Buzău (S17).

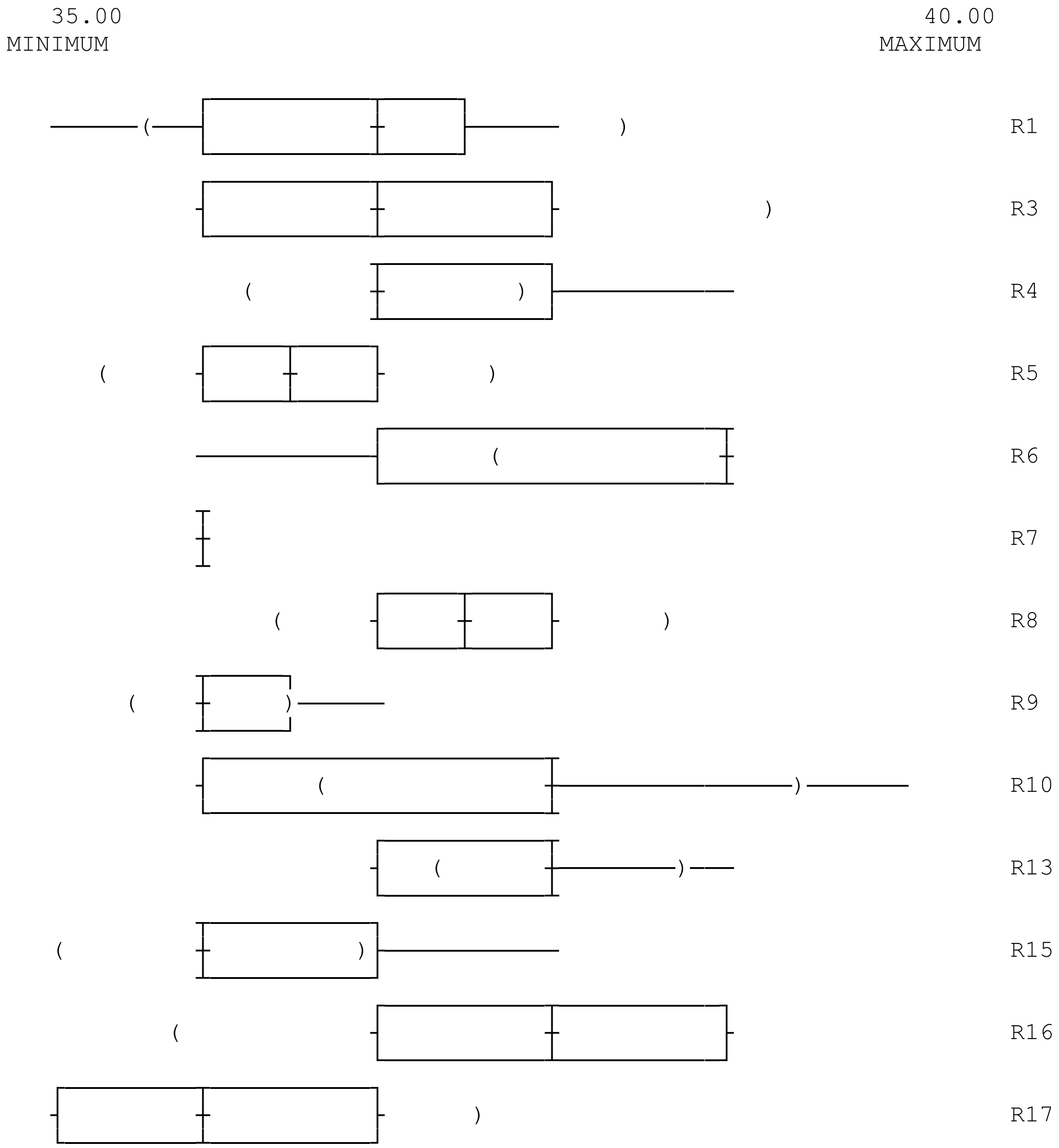


Figure 5. Box plot graphs for A variable in the case of 13 *Gobio kessleri kessleri* populations of the rivers: Iza (S1), Crişul Negru (S3), Târnava (S4), Târnava Mare (S5), Târnava Mică (S6), Cugir (S7), Beriu (S8), Strei (S9), Bega (S10), Olăneşti (S13), Argeş (S15), Siret (S16) şi Buzău (S17).

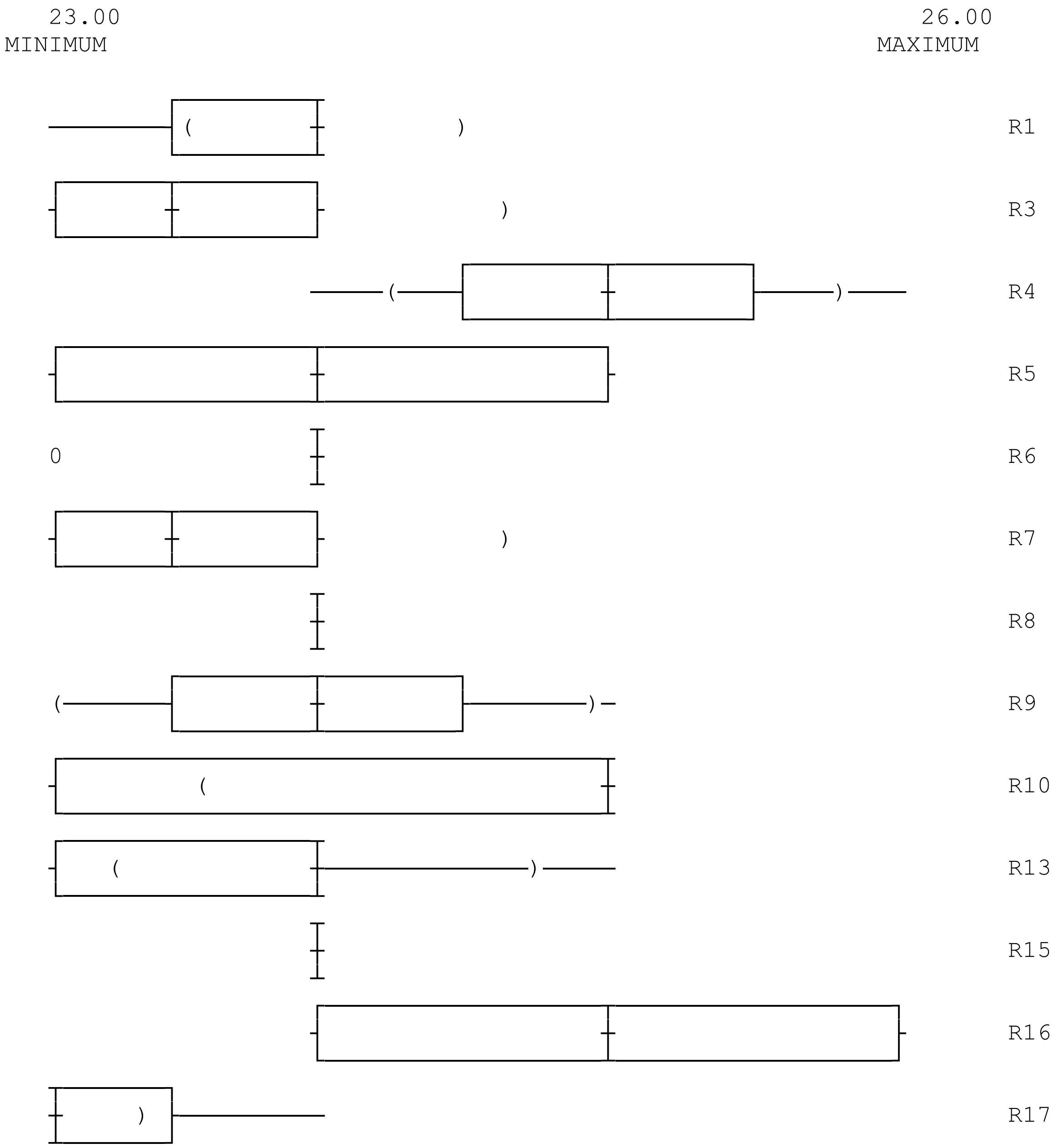


Figure 6. Box plot graphs for AP variable in the case of 13 *Gobio kessleri kessleri* populations of the rivers: Iza (S1), Crişul Negru (S3), Târnava (S4), Târnava Mare (S5), Târnava Mică (S6), Cugir (S7), Beriu (S8), Strei (S9), Bega (S10), Olăneşti (S13), Argeş (S15), Siret (S16) şi Buzău (S17).

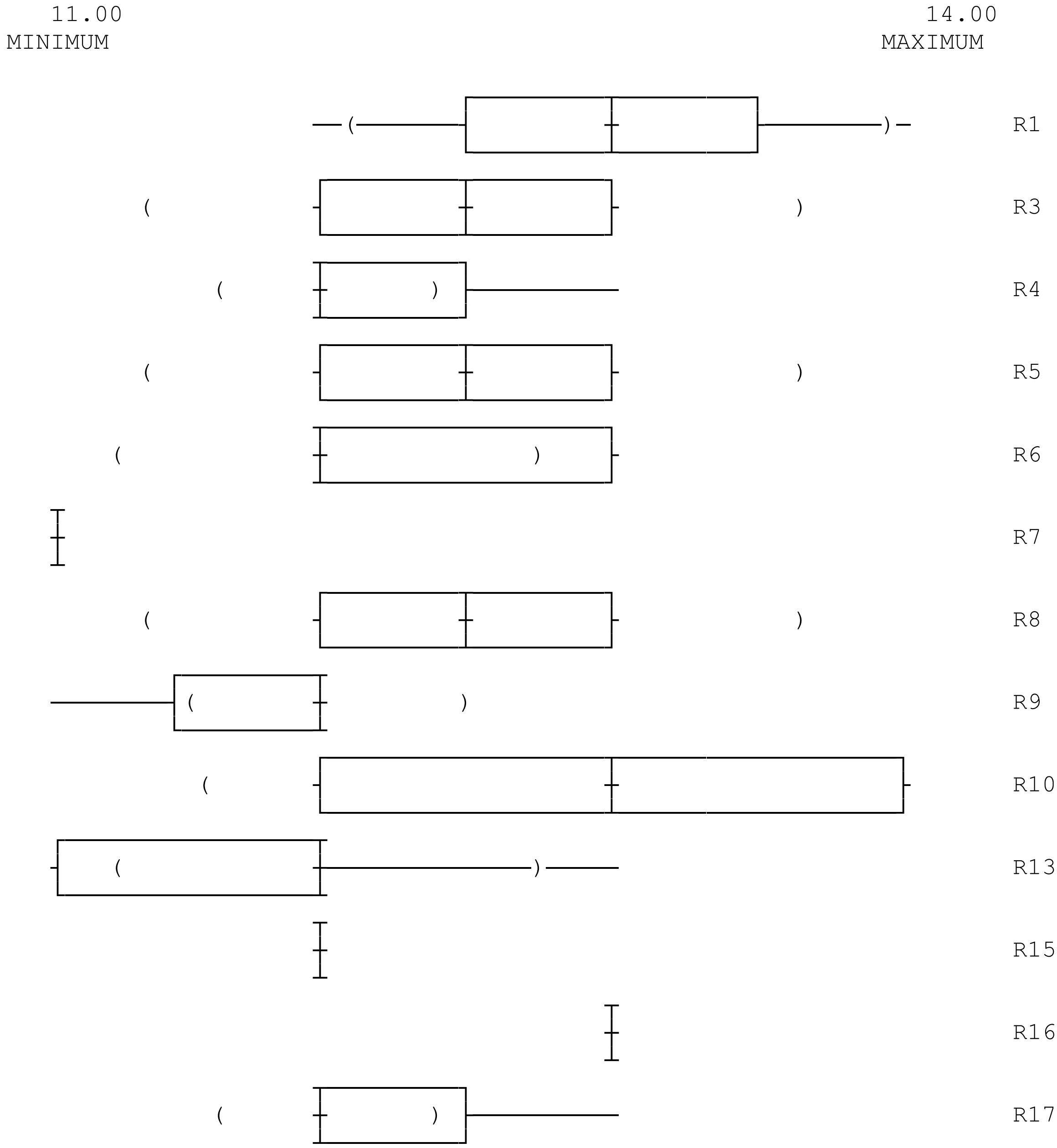


Figure 7. Box plot graphs for C variable in the case of 13 *Gobio kessleri kessleri* populations of the rivers: Iza (S1), Crişul Negru (S3), Târnava (S4), Târnava Mare (S5), Târnava Mică (S6), Cugir (S7), Beriu (S8), Strei (S9), Bega (S10), Olăneşti (S13), Argeş (S15), Siret (S16) şi Buzău (S17).

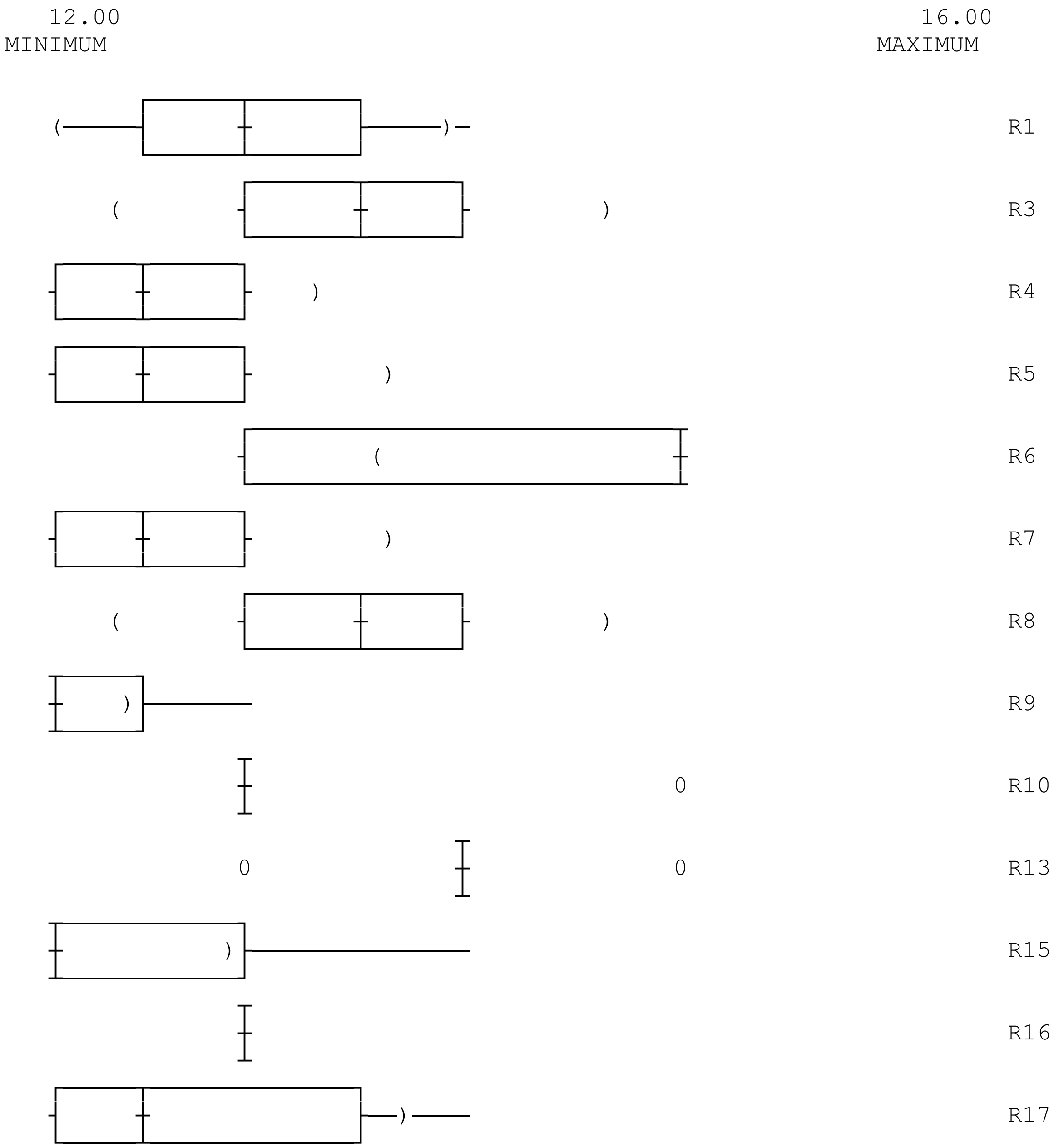


Figure 8. Box plot graphs for NS variable in the case of 17 *Gobio kessleri kessleri* populations of the sampling stations: (S1), (S2), (S3), (S4), (S5), (S6), (S7), (S8), (S9), (S10), (S11), (S12), (S13), (S14), (S15), (S16) şi (S17).

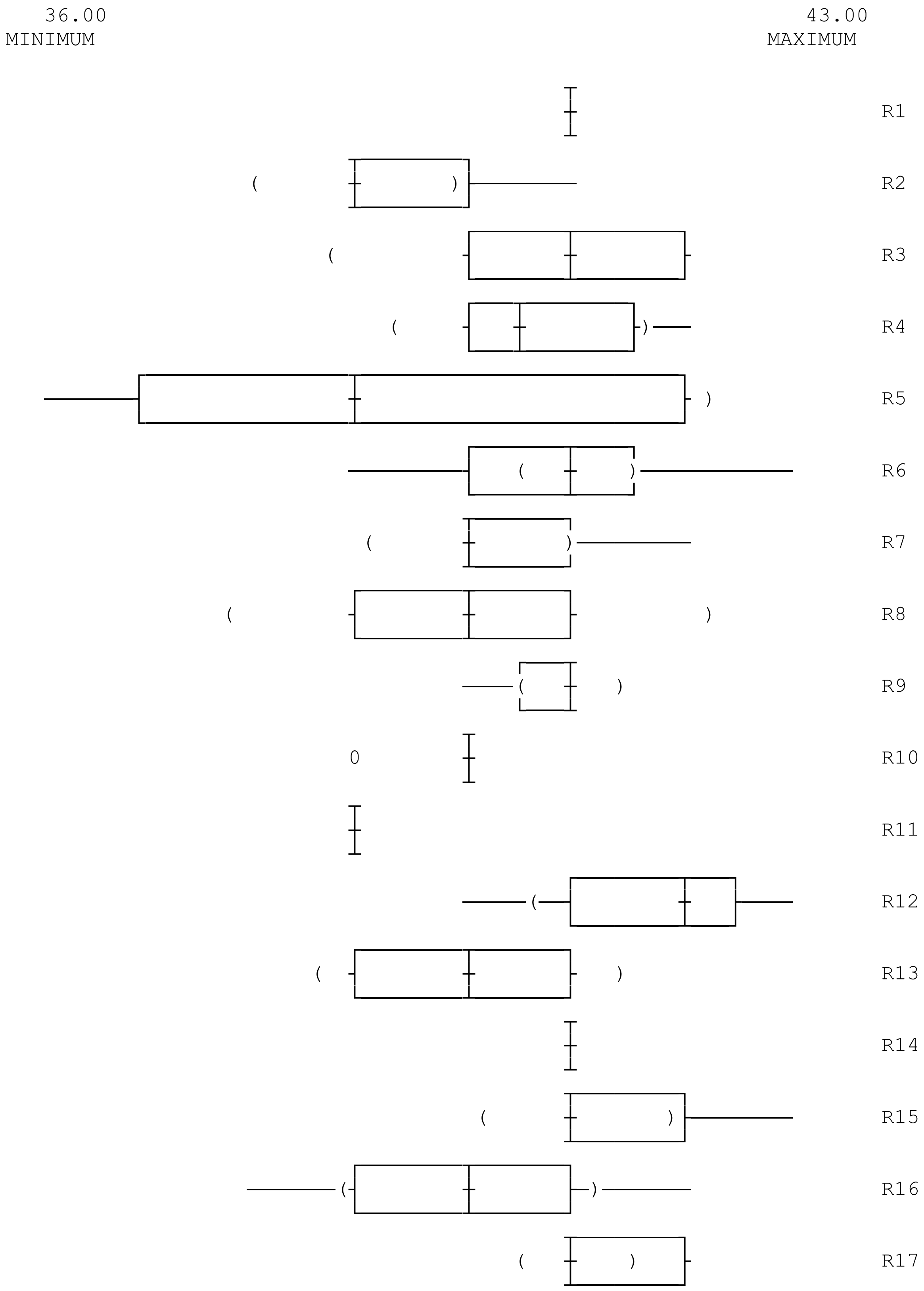


Figure 9. Box plot graphs for DBA variable in the case of 17 *Gobio kessleri kessleri* populations of the sampling stations: (S1), (S2), (S3), (S4), (S5), (S6), (S7), (S8), (S9), (S10), (S11), (S12), (S13), (S14), (S15), (S16) şi (S17).

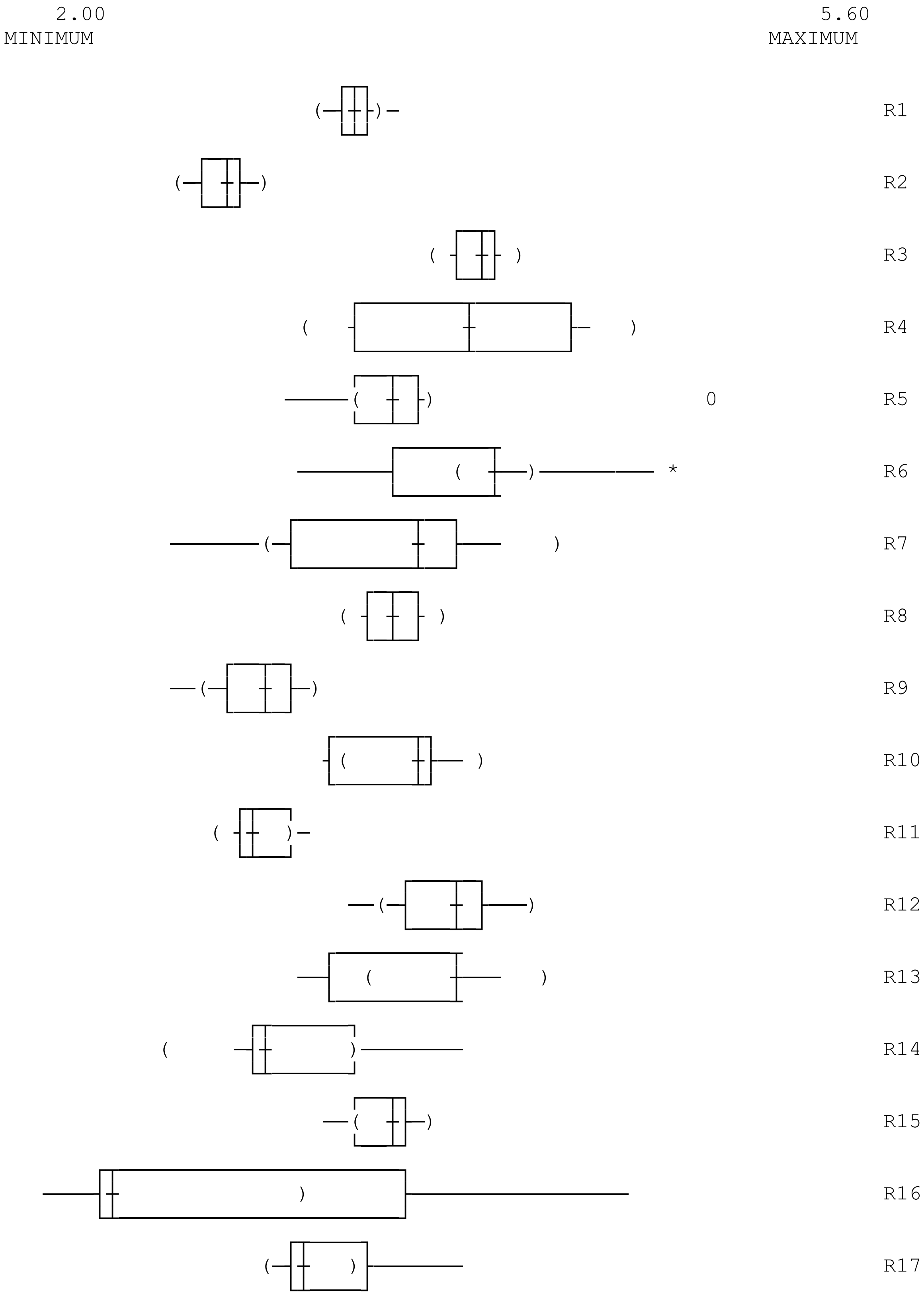


Figure 10. Box plot graphs for DP variable in the case of 17 *Gobio kessleri kessleri* populations of the sampling stations: (S1), (S2), (S3), (S4), (S5), (S6), (S7), (S8), (S9), (S10), (S11), (S12), (S13), (S14), (S15), (S16) şi (S17).

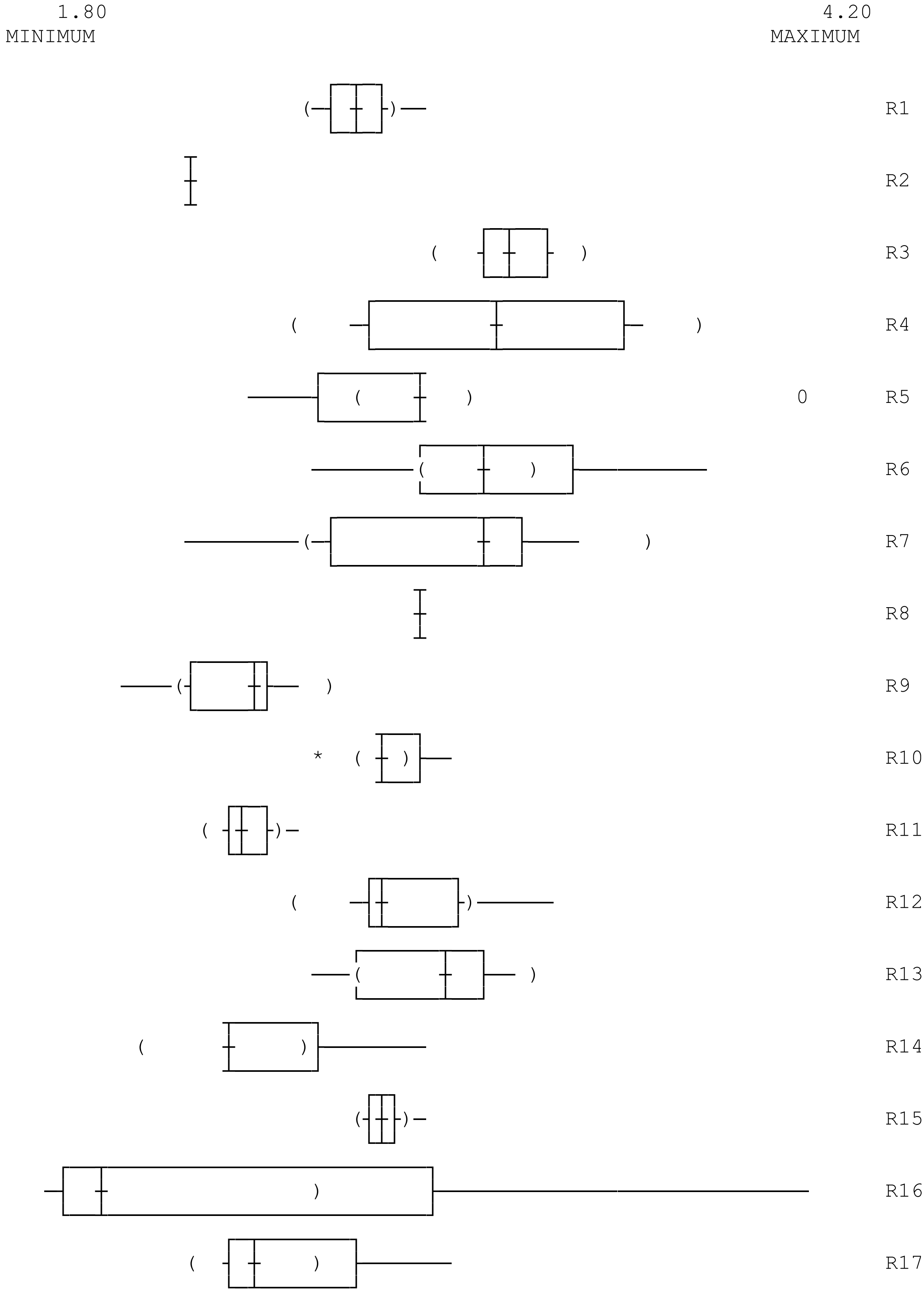


Figure 11. Box plot graphs for DAIC variable in the case of 17 *Gobio kessleri kessleri* populations of the sampling stations: (S1), (S2), (S3), (S4), (S5), (S6), (S7), (S8), (S9), (S10), (S11), (S12), (S13), (S14), (S15), (S16) şi (S17).

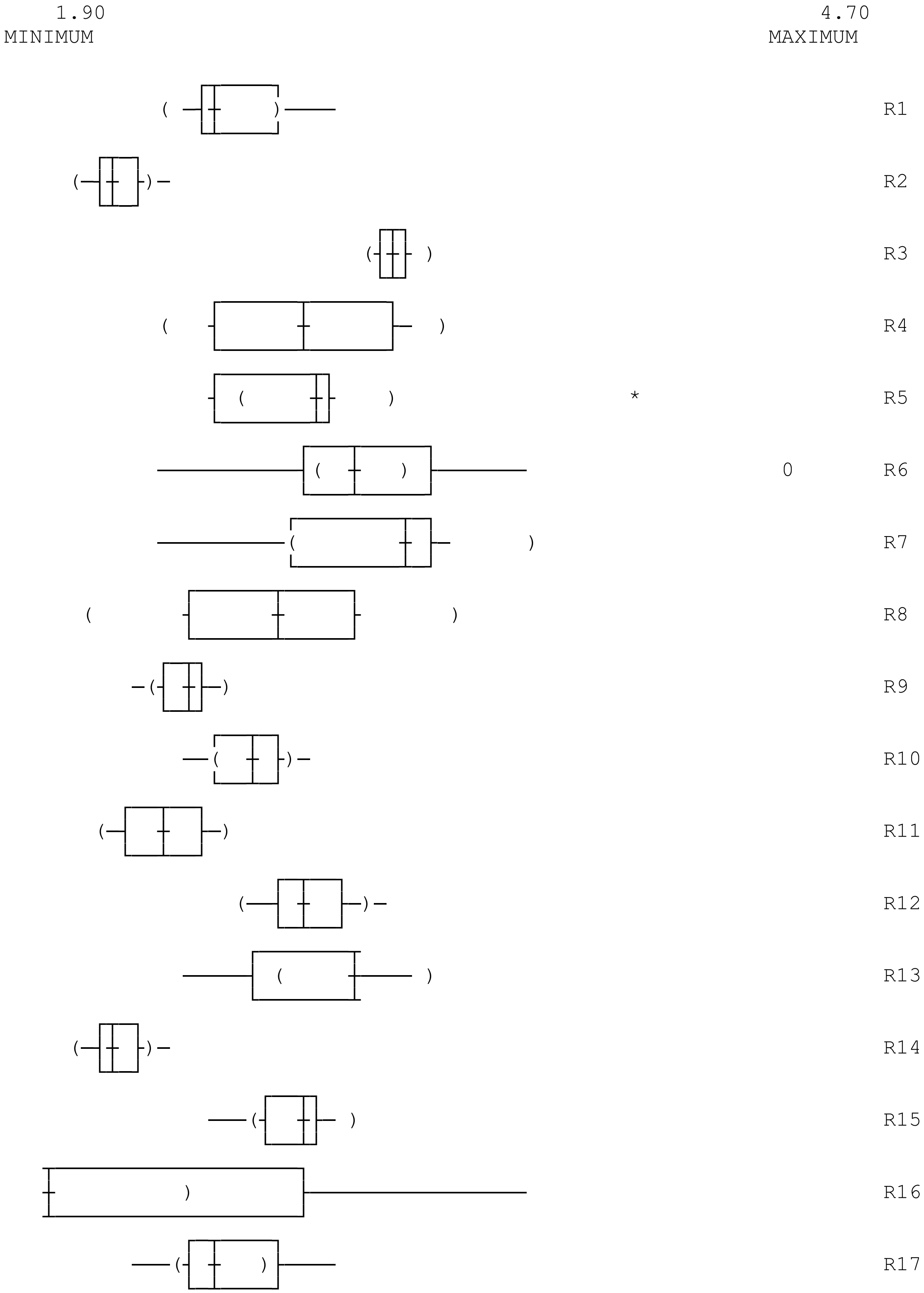
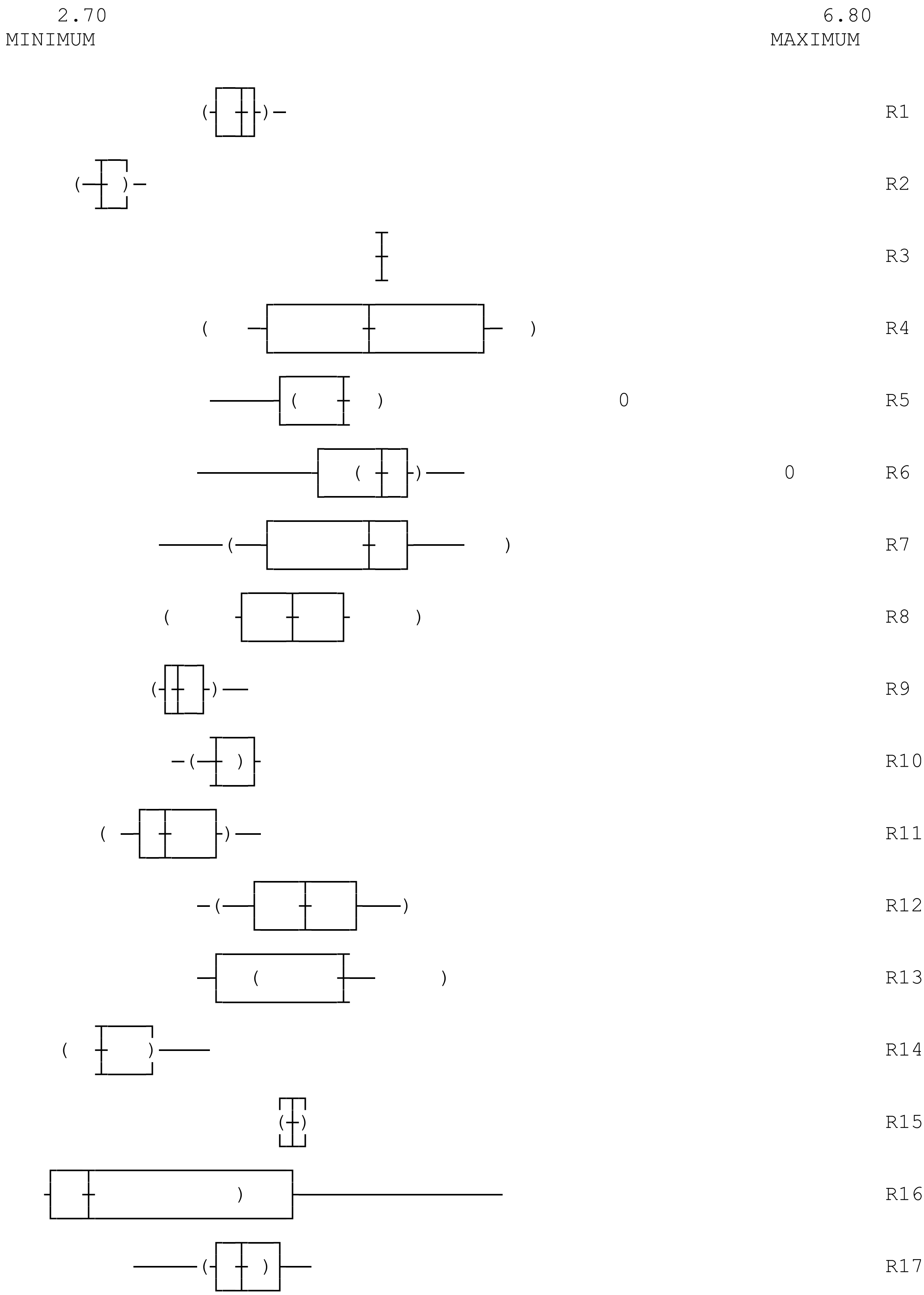


Figure 12. Box plot graphs for LAEC variable in the case of 17 *Gobio kessleri kessleri* populations of the sampling stations: (S1), (S2), (S3), (S4), (S5), (S6), (S7), (S8), (S9), (S10), (S11), (S12), (S13), (S14), (S15), (S16) şi (S17).



CONCLUSIONS

From the external and internal morphological characters variation analysis of the 17 *Gobio kessleri kessleri* populations, were emphasized some conclusions.

The present type of integrated taxonomic analyze is a valuable one as a working tool for the establishment of *Gobio* genus (species and subspecies) systematic.

For some of the considered populations the variation domain of the analyzed characters can be closed by (for example A for S6 and S8 populations - Târnava Mică and Beriu rivers; AP for S3, S5 and S8 - Crişul Negru, Târnava Mare and Beriu rivers; C for S4, S5 and S7 - Târnava, Târnava Mare and Cugir rivers; C for S3 and S8 - Crişul Negru and Beriu rivers; NS for S15 and S17 - Argeş and Buzău rivers; DBA for S5 and S8 - Târnava Mare and Beriu rivers; DAIC for S4 and S8 - Târnava and Beriu rivers; etc.) in consequence for these populations can be emphasize hypothesis on this base regarding to the possible existence of some zoogeographic and/or phylogenetic connexions.

Exist, however, cases of such variations in closed by domains (for example A for S6 and S15 sampling stations - populations of Târnava Mică and Argeş rivers; C for S10 and S16 - populations of Bega and Siret rivers; NS for S1 and S14 - populations of Iza and Motru rivers; DBA for S5 and S15 - populations of Târnava Mare and Argeş rivers) for which explanation, suplementary studies are needed which must include more diversified aspects of these populations evolution (the spatial and temporal phylogenetic route, the biotope and biocoenosis conditions influence, etc).

Among *Gobio kessleri kessleri* analyzed populations, the highest variability were recorded for the following variables: T and AP for Bega River (S15) population; A and NS for Târnava Mare River (S5) population; C for Târnava Mică River (S6) population; A, DBA, DP, DAIC and LAEC for Siret River (S16).

The *Gobio kessleri kessleri* population with the most numerous characters with highest variability (among the analyzed populations) is that one of Siret River.

On the whole, *Gobio kessleri kessleri* subspecies is characterized through a high morphological variability, fact which reveal one of the reason for its initial systematic position in comparison with *Gobio kessleri banaticus* and *Gobio kessleri antipai* subspecies, in the *Gobio kessleri* species context.

Further comparative studies are needed, regarding this integrated taxonomical method aplicability for the whole Gobio Genus systematic potential actualisation or confirmation.

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We thank to Mr. Dr. Ilie Telcean, for the ichthiological material sampled in Iza River.

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AUTHORS:

[1] *Doru BĂNĂDUC*
banaduc@yahoo.com
"Lucian Blaga" University,
Faculty of Sciences,
Department of Ecology and Environmental Protection,
Oituz St. no. 31,
Sibiu, Sibiu County, Romania,
RO - 4566378.

[2] *Petru Mihai BĂNĂRESCU*
pbana@ibiol.ro
Romanian Academy Institute of Biology,
Splaiul Independenței, no. 296,
Bucureşti, Romania,
RO - 79651.

DATA CONCERNING THE FISH COMMUNITIES OF THE JIJIA RIVER (ROMANIA)

Cătalin D. COSTINIUC [1], *Grigore DAVIDEANU* [2] and *Ana DAVIDEANU* [2]

KEYWORDS: Ihthyofauna, Jijia River.

ABSTRACT

The paper presents the results of an ecological study on the Jijia River fish community. Using an electrofisher they were captured, in 8 sample sites, a number of 2 067 fish specimens belonging to 13 species. They were calculated a series of ecological metrics and indexes in order to assess the fish community structure.

Based on this data we were able to conclude that fish community is still in good state, having a balanced ecological structure, even they are some negative human impacts on the aquatic habitats. In the area they are present a series of protected fish species as: *Cobitis taenia* and *Rhodeus amarus* that are protected at European or national level.

REZUMAT: Date privind comunitățile piscicole din râul Jijia (România).

Lucrarea prezintă rezultatele unui studiu ecologic al comunității piscicole din râul Jijia. Cu ajutorul unui electrofisher au fost capturati, în 8 stații, un număr de 2 067 pești aparținând la 13 specii. Au fost calculați indicatori ecologici pentru a evalua structura comunității piscicole.

Pe baza rezultatelor obținute se poate concluziona că asociația piscicolă este într-o stare bună, cu o structură ecologică echilibrată, chiar dacă se manifestă efecte negative ale impactului antropic asupra habitatelor acvatice. În zonă sunt prezente specii de pești protejate precum *Cobitis taenia* şi *Rhodeus amarus,* care sunt protejate la nivel european sau național.

RÉSUMÉ: Données sur les communautés piscicoles de la rivière Jijia (Roumanie).

Ce travail présente les résultats d'une étude écologique de la communauté piscicole de la rivière Jijia. Sur 8 stations échantillonnées par pêche électrique, 2067 poissons représentant 13 espèces ont été dénombrés. L'évaluation de la structure de la communauté piscicole a été réalisée à l'aide d'indicateurs écologiques.

D'après les résultats obtenus, nous pouvons conclure que le peuplement piscicole se trouve dans un trés bon état; il présente une structure écologique équilibrée, malgré les effets négatifs de l'impact anthropique sur les habitats aquatiques. Dans cette région, subistent encore des espèces protégées telles que *Cobitis taenia* et *Rhodeus amarus,* qui sont protégées au niveau européen ou national.

INTRODUCTION

Jijia is the main tributary (on the right side) of the Prut River. Jijia has a total length of 275 km and a basin surface of 5757 km^2. Its sources are at an altitude of 340 m. The river course has a low depth bed. Nearby the Dorohoi city it looks like a marshy plane with high grass (*Typha*), the remains of an old pond. In between Vlădeni and Larga Jijia the flood plane becomes marshy also being covered by high grass. Nowadays this area was regulated and transformed into large fishponds (1000 ha) and the river bad transformed into a channel. Most of Jijia's tributaries are on the right side: Sitna, Miletin, Jijioara, Bahlui; with scarce sources that cause their almost disappearing during droughts.

MATERIALS AND METHODS

The samples were collected by electro fishing during the 2005 summer period, using a FEG 5000 electro fisher (Cowx, 1990).

For each sample we fish on 150 m length covering all the habitat types in the area. In 8 sample sites we collected a total number of 2 067 specimens, belonging to 2 orders, 5 families and 13 species.

The identification was done based on the Bănărescu's 1964 and 2002 identification guidebooks.

After the specimens identification and measurements the fish were set free, less than 5% of them which were retained as voucher specimens for the Iaşi Natural History Museum.

We obtained a series of qualitative and quantitative data concerning the fish populations in the sample sites: the fish species list, the absolute numeric abundance for each species in each of the sites. All these data were computed using statistical methods (Angermeier, 1995; Barbault, 1994) in order to calculate a series of ecological metrics and indexes for characterize the fish communities in the studied area.

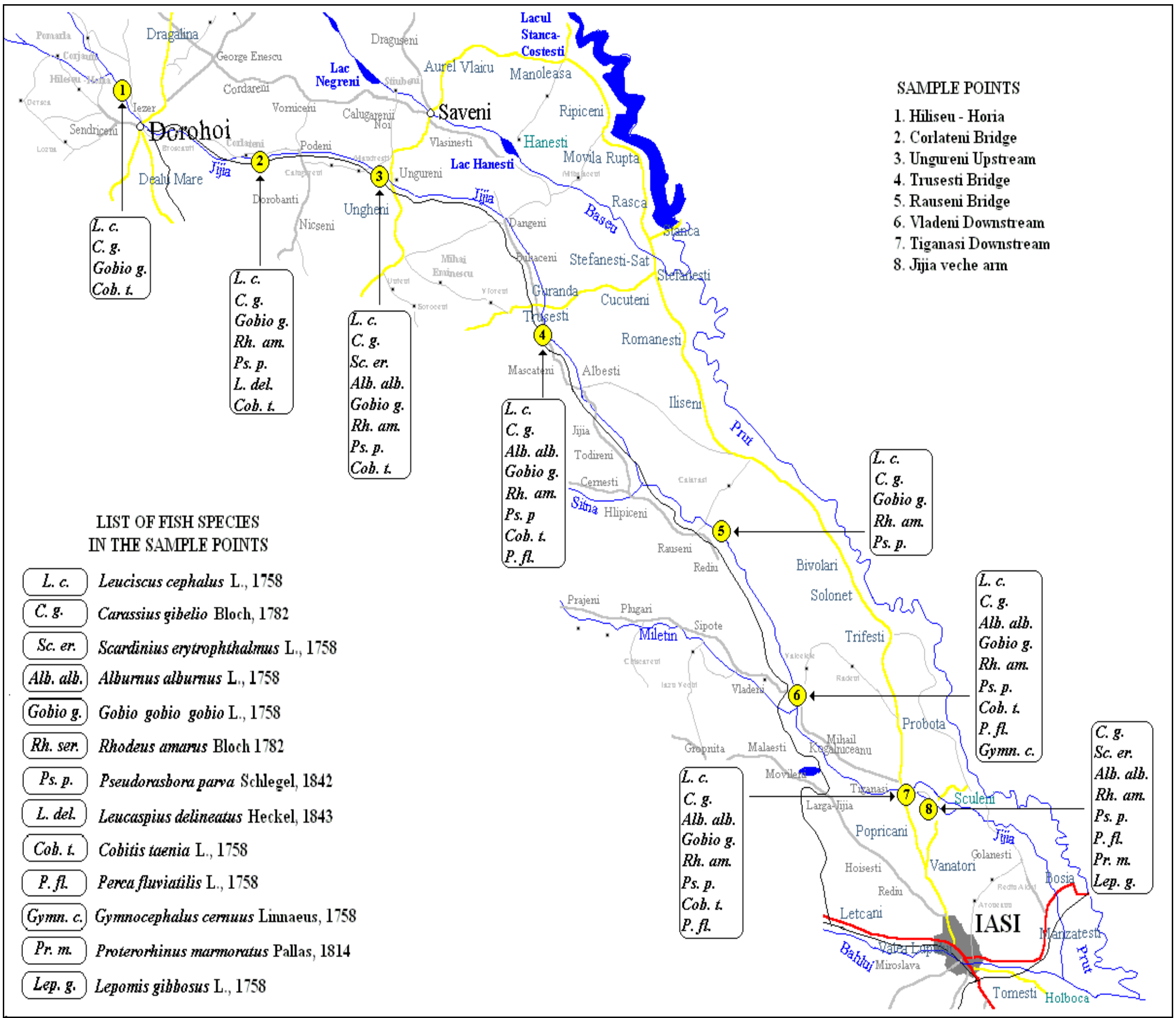

Figure 1. The map of the Jijia River, with the sample sites and lists of fish species captured for each site.

RESULTS AND DISCUSSIONS

Table 1 presents the species structure of the fish communities, as number and table 2 as weight for each of the captured species and in each sample site. From the total of 13 species 11 are indigenous and two are introduced, invasive species *Lepomis gibossus* and *Pseudorasbora parva*. The number of species varies in between 4 at Hilişeu (the sample site with highest altitude) to 9 at site downstream Vlădeni. The relatively high number of species here is probably due to the impact of fish farms upstream the site, which permanently repopulate the river thorough the escaping fish. The quantitative differences (both as number and weights) in between sites are important. They are due to ecological and habitat typology of each site and to the human impact. The numeric abundance of the fish for each site varies in between 120 at site 5 - Răuşeni and 437 at site 3 - Ungureni and the weight abundance varies in between 952 g at site 5 - Răuşeni and 4993 g at site 1 - Horia. For the entire river length (8 sampling sites) we collected 2 067 fish specimen, weighting 22 603 g.

Table 1. The numeric absolute abundance of fish species for each of the sampling sites, in August 2005.

	Sites / Taxa	Hilişeu - Horia 1	Corlăţeni Bridge 2	Upstrem Ungureni 3	Truşeşti Bridge 4	Răuseni Bridge 5	Downstream Vlădeni 6	Downstream Ţigănaşi 7	Old Jijia arm 8	Total ind/ site	Total sp/ site
		ind.	ind.	ind.	ind.	ind.	ind.	ind.	ind.	ind.	
	Ord. Cypriniformes Fam. Cyprinidae										
1.	*Leuciscus cephalus* L., 1758	57	27	18	18	12	24	18	-	174	7
2.	*Carassius gibelio* Bloch, 1782	312	102	45	234	18	33	78	12	834	8
3.	*Scardinius erythrophthalmus* L., 1758	-	-	15	-	-	-	-	6	21	1
4.	*Alburnus alburnus* L., 1758	-	-	6	93	-	6	9	27	141	5
5.	*Gobio gobio* gobio L. ,1758	27	33	69	24	15	113	15	-	296	7
6.	*Rhodeus amarus* Bloch, 1782	-	15	12	45	18	36	12	15	153	7
7.	*Pseudorasbora parva* Schlegel, 1842	-	63	42	15	57	15	27	42	261	7
8.	*Leucaspius delineatus* Heckel, 1843	-	46	-	-	-	-	-	-	46	1
	Fam Cobitidae										
9.	*Cobitis taenia* L.1758	9	6	6	3	-	9	6	-	48	6
	Ord. Perciformes Fam. Percidae										
10.	*Perca fluviatils* L.1758	-	-	-	5	-	9	6	33	53	4
11.	*Gymnocephalus cernuus* L, 1758	-	-	-	-	-	27	-	-	27	1
	Fam. Gobiidae										
12.	*Proterorhinus marmoratus* Pallas, 1814	-	-	-	-	-	-	-	6	6	1
	Fam Centrarchidae										
13.	*Lepomis gibbosus* L., 1758	-	-	-	-	-	-	-	7	7	1
	Total individuals /site	405	292	222	437	120	272	171	148	2067	
	Total species / site	4	7	8	8	5	9	8	8		

Table 2. The weight absolute abundance of fish species for each of the sampling sites, in August 2005.

	Sites Taxa	Hilişeu - Horia 1	Corlăţeni Bridge 2	Upstrem Ungureni 3	Truşeşti Bridge 4	Răuşeni Bridge 5	Downstream Vlădeni 6	Downstream Ţigănaşi 7	Old Jijia arm 8	Total g/ site	Total sp/ site
		g	g	g	g	g	g	g	g	g.	
	Ord. Cypriniformes Fam. Cyprinidae										
1.	*Leuciscus cephalus L.1758*	1459	523	410	228	132	461	267	-	3480	7
2.	*Carassius gibelio Bloch, 1782*	3287	2173	278	2106	288	556	663	246	9597	8
3.	*Scardinius erythrophthalmus L., 1758*	-	-	296	-	-	-	-	113	409	1
4.	*Alburnus alburnus L., 1758*	-	-	71	762	-	53	49	212	1147	5
5.	*Gobio gobio gobio L., 1758*	195	358	712	156	137	1456	134	-	3148	7
6.	*Rhodeus amarus Bloch, 1782*	-	108	83	236	116	231	78	74	926	7
7.	*Pseudorasbora parva Schlegel, 1842*	-	411	236	57	279	72	165	204	1424	7
8.	*Leucaspius delineatus Heckel, 1843*	-	296	-	-	-	-	-	-	296	1
	Fam Cobitidae										
9.	*Cobitis taenia L.1758*	52	42	95	23	-	68	40	-	320	6
	Ord. Perciformes Fam. Percidae										
10.	*Perca fluviatils L.1758*	-	-	-	115	-	234	215	865	1429	4
11.	*Gymnocephalus cernuus L, 1758*	-	-	-	-	-	367	-	-	367	1
	Fam. Gobiidae										
12.	*Proterorhinus marmoratus Pallas, 1814*	-	-	-	-	-	-	-	26	26	1
	Fam Centrarchidae										
13.	*Lepomis gibbosus L., 1758*		-	-	-	-	-	-	34	34	1
	Total biomass g / site	4993	3911	2181	3683	952	3498	1611	1774	22603	
	Total species / site	4	7	8	8	5	9	8	8	4	

From the table 1 and figures 2 and 3 we find that the most important species are *Carassius gibelio*, *Leuciscus cephalus* and *Gobio gobio gobio,* that represents more than half of the total capture, both as individual number and weight.

For the Jijia River the total capture is over than 120 specimens for each site /300 m^2. This capture consists mainly in small species as *Gobio gobio gobio* and *Pseudorasbora parva*, but includes also *Carassius gibelio.* This number decrease under 100 specimen/300 m^2, that is probably due to the hydro technical works that transformed the riverbed in a regularised channel. At the sampling moment these works was in train. The weight of fish capture was usually over 1000g/300 m, excepting Ţigănaşi, where it was lower.

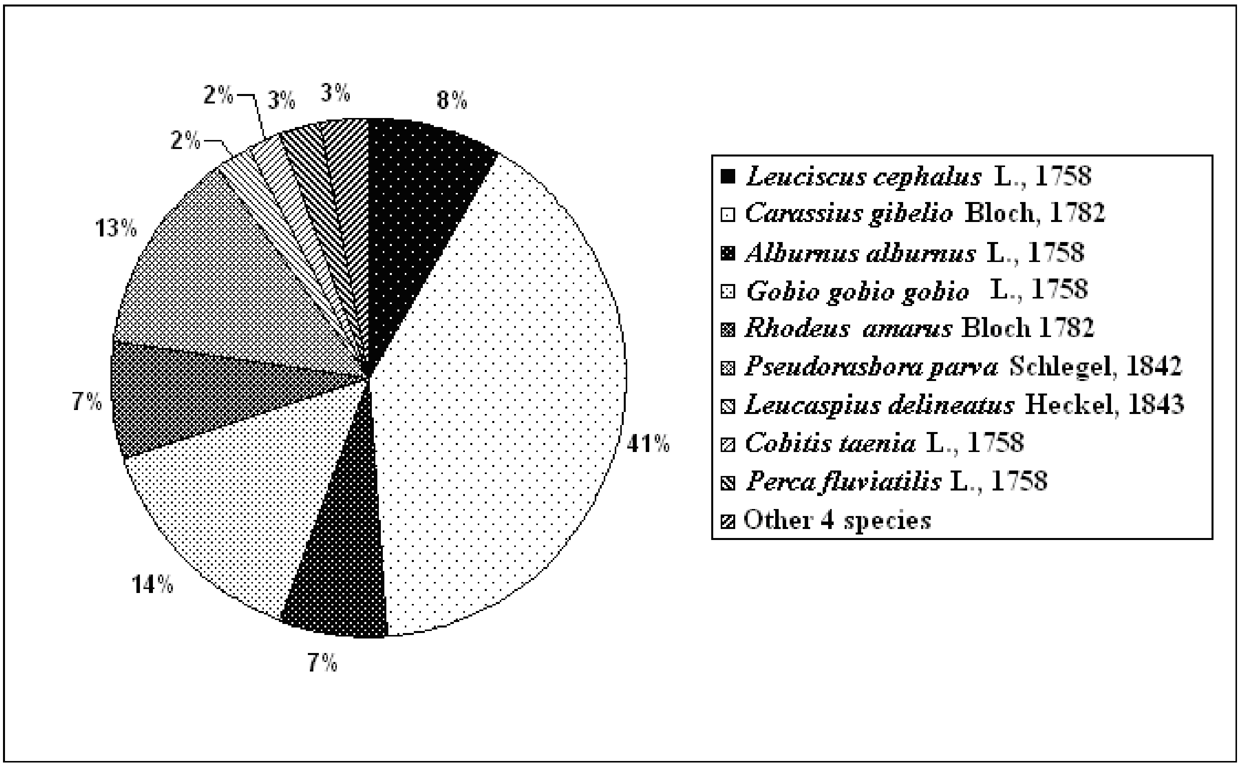

Figure 2. The pie chart indicating the relative numeric abundance of the species in the total fish capture for the Jijia River.

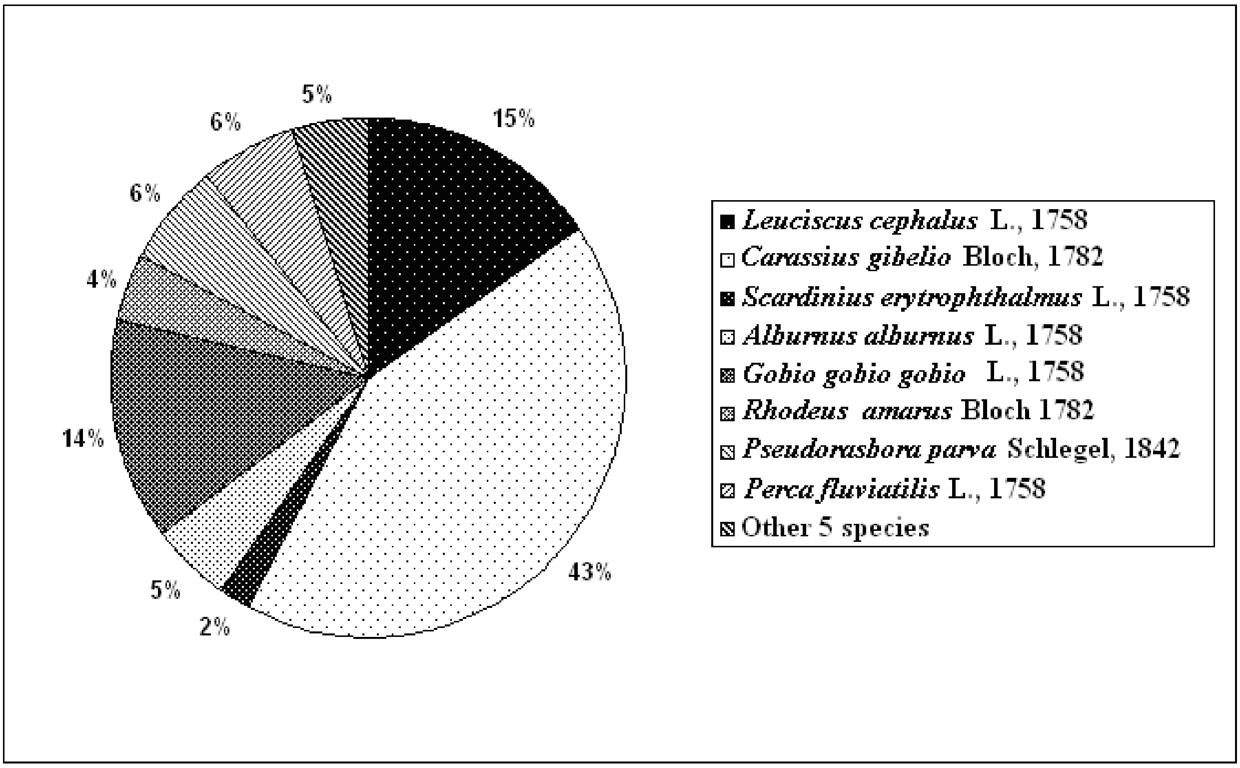

Figure 3. The pie chart indicating the relative weight abundance of the species in the total fish capture for the Jijia River.

Table 3 presents the values of the fish communities indexes. We calculated the constancy, the dominance of the species and ecological significance of different species.

The most important characteristic species is *Carassius gibelio* W = 40.35% followed by other characteristic species for this community dominance, and ecological significance index W. These indexes were used in order to identify the structures of *Gobio gobio gobio* and *Pseudorasbora parva*. Other, complementary, species are *Leuciscus cephalus* and *Rhodeus amarus*, with an ecological significance index < 10. All the other species are accidental or associate species.

Table 3. The values of the ecological indexes calculated ant the index of ecological significance calculated for the Jijia River.

No.	Species	Absolute abundance (A)	Ecological indexes					
			Constancy (C)		Dominance (D)		Ecological Signification (W)	
			%	Class	%	Class	%	Class
1	*Carassius gibelio*	834	100	C_4	40.35	D_5	40.35	W_5
2	*Gobio gobio gobio*	296	87.5	C_4	14.32	D_5	12.53	W_5
3	*Pseudorasbora parva*	261	87.5	C_4	12.63	D_5	11.05	W_5
4	*Leuciscus cephalus*	174	87.5	C_4	8.41	D_4	7.36	W_4
5	*Rhodeus amarus*	153	87.5	C_4	7.4	D_4	6.47	W_4
6	*Alburnus alburnus*	141	62.5	C_3	6.82	D_4	4.26	W_3
7	*Cobitis taenia*	48	75	C_3	2.32	D_3	1.74	W_3
8	*Perca fluviatilis*	53	50	C_2	2.56	D_3	1.28	W_3
9	*Leucaspius delineatus*	46	12.5	C_1	2.23	D_3	0.28	W_2
10	*Scardinius erythrophthalmus*	21	25	C_1	1.02	D_1	0.25	W_2
11	*Gymnocephalus cernuus*	27	12.5	C_1	1.31	D_2	0.16	W_2
12	*Lepomis gibbosus*	7	12.5	C_1	0.34	D_1	0.042	W_1
13	*Proterorhinus marmoratus*	6	12.5	C_1	0.29	D_1	0.036	W_1

Analyzing the index of species similarity graph, (Figure 4), we may notice that they are six sites of 8 that form a cluster with a specific similarity over 60%. That contains the sites with most characteristic habitat conditions for the area. The sites Hiliseu Horia is placed at the top basin having conditions different from the others especially because of the small water quantities during summer drought. The site Old Jijia arm is mostly a pond (oxbow) separated from the main river channel because of the hydro technical works.

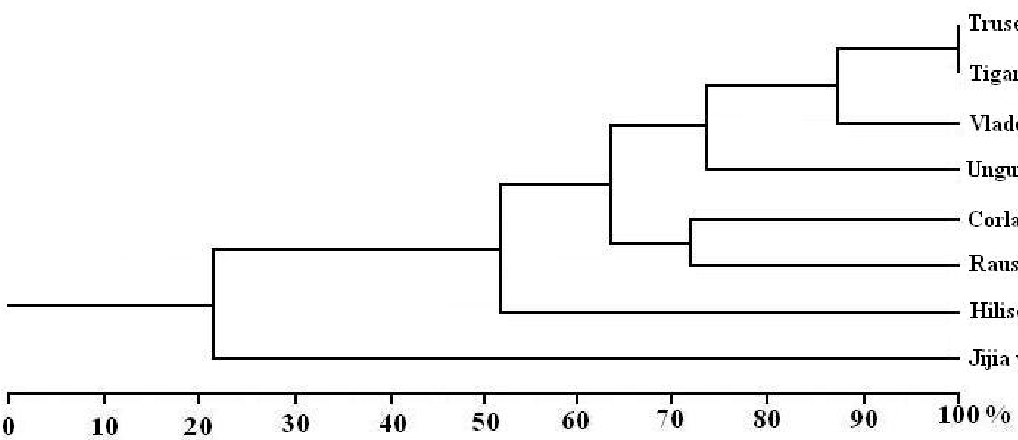

Figure 4. The graph of the species similarity.

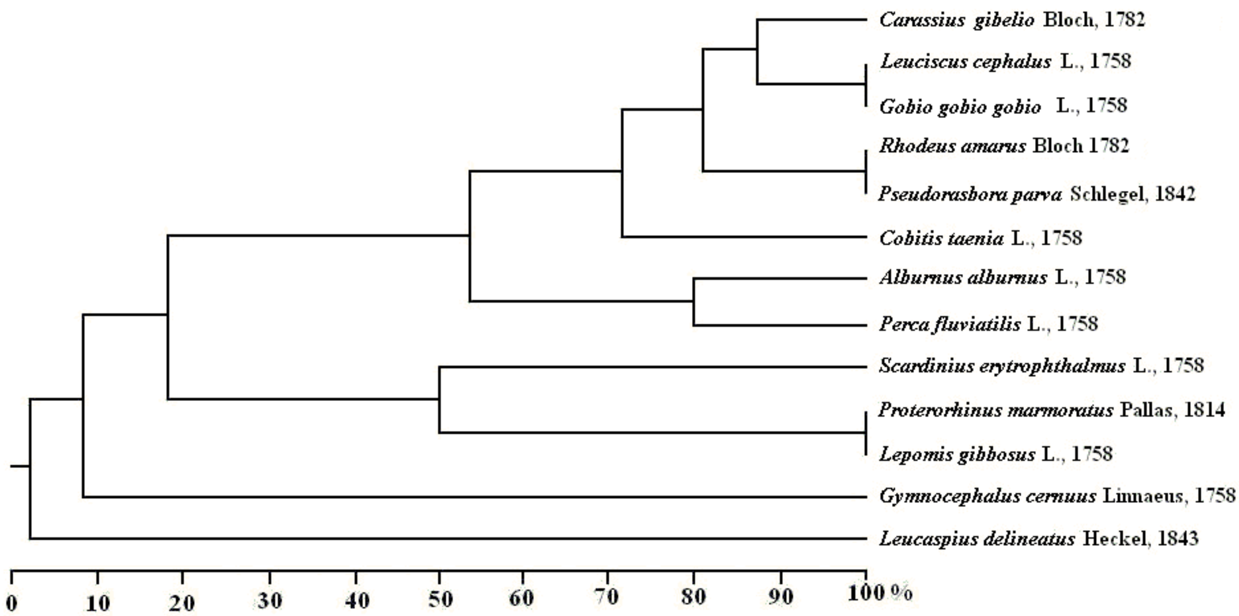

Figure 5. The graph of the cenotic affinity index.

The index of cenotic affinity (Figure 5) was calculated in order to appreciate the affinity in between species, which is due to the common preferences for certain habitat characteristics. On the graph, we find that they are 3 pairs of species having an 100% cenotic affinity. The species with an affinity index over 81% form a species group well adapted to ecological conditions in this river: *Carassius gibelio, Leuciscus cephalus, Gobio gobio gobio, Rhodeus amarus Pseudorasbora parva*, and *Cobitis taenia*. The species *Proterorhinus marmoratus* and *Lepomis gibosus*, with a cenotic affinity of 100% were collected in a single site, with peculiar conditions. The species *Gymnocephalus cernuus* and *Leucaspius delineatus* show a low affinity with the other species (only 1.9%).

Table 4. The values of the Shannon-Weaver diversity Index and Equitability Index, calculated for the Samples sites on in the Jijia River.

		Sample site							
No.		1	2	3	4	5	6	7	8
1	Number of individuals	405	292	222	437	120	272	171	148
2	Number of species	4	7	8	8	5	9	8	8
3	Shannon Weaver Index	0.742	1.688	1.772	1.389	1.412	1.801	1.676	1.842
4	Equitability Index	0.535	0.867	0.854	0.669	0.877	0.819	0.808	0.881

The Diversity Index Shannon and the Equitability Index, presented in the table 4 and figure 6, were calculated in order to find more about the stability and structure of the fish community. From these figures we may conclude that the fish community is relatively diverse and well balance for the entire river length. They are 9 or 8 fish species in 5 out of eight sample site and the values of the Equitability Index varies in between 0535 and 0881. The lowest diversity is at Hilişeu, site placed at the top basin where the water flow is very scarce.

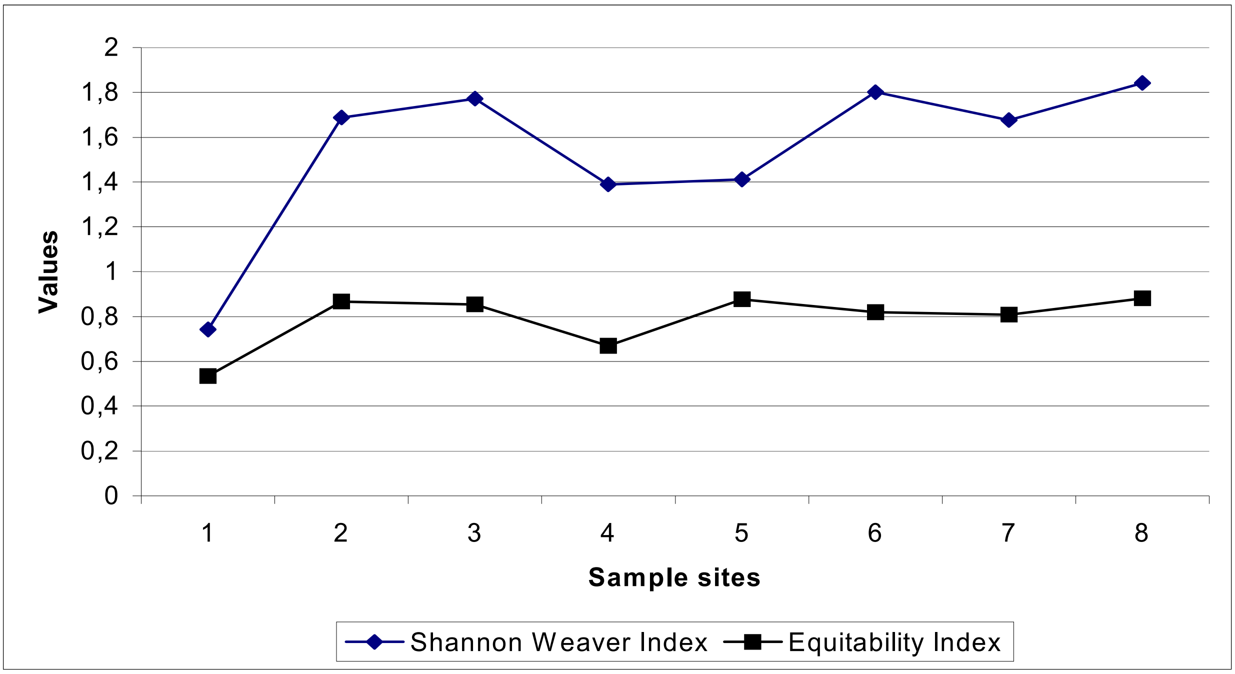

Figure 6. The graph of the Shannon Diversity Index and Index of equitability.

From these data we may also appreciate that the conditions along the riverbed are quite similar and this is true both because of the natural uniform habitat presence and because of the hydro technical works that transformed the river in a channel for most of its length (Davideanu, 1995, 2000).

CONCLUSIONS

The fish communities of the Jijia River consists in 13 species: 11 native and 2 introduced species - *Pseudorasbora parva* and *Lepomis gibossus*. The dominant species are: *Carassius gibelio, Gobio gobio gobio* and *Pseudorasbora parva. Lepomis gibossus* and *Proterorhinus marmoratus* are rare species. The fish communities composition is characteristic for the *Leuciscus* zone (European ecological delineation), small rivers in the hilly region, with river bed consists in sand, clay and moderate flow velocity.

The human impact is caused by the hydro technical amelioration works, drainage of the flooded plain at Vlădeni, dam construction and fish farm developed in the reservoirs. These works reduce the natural diversity of habitat, destroying the shelter and feeding areas of many fish species.

Both the number and weight abundance of the fish are varying in between 130 specimen/300 m^2 to 192 specimen/300 m^2 respectively 1000 g / 300 m^2 to 2337 g/300 m^2.

Considering the natural low number of species (because of the hydro morphology of the river we need to mention that they are present a series of species protected both at national and international level: *Cobitis taenia*, *Rhodeus amarus*, and one can find also *Aspius aspius* (captured in a separate sampling session) nearby the confluence with the Prut River; that are protected by the Habitat Directive of the EEC. *Leucaspius delineatus* and *Proterorhinus marmoratus* are protected by Bern Convention.

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AUTHORS:

[1] *Cătălin Dumitru COSTINIUC*
costiniuc_catalin@yahoo.com
"Alexandru Ioan Cuza" University,
Department of Biology,
Carol I St., no. 11,
Iaşi, Iaşi County, Romania,
RO - 700506.

[2] *Grigore DAVIDEANU*
[2] *Ana DAVIDEANU*
grigore@uaic.ro
"Alexandru Ioan Cuza" University,
Natural History Museum,
Independenței Bd., no. 16,
Iaşi, Iaşi County, Romania,
RO - 700100.

SOME DATA CONCERNING THE FISH COMMUNITIES OF THE BAHLUI RIVER (ROMANIA)

Cătălin D. COSTINIUC [1], *Grigore DAVIDEANU* [2] and *Ana DAVIDEANU* [2]

KEYWORDS: Ichthyofauna, fish ecology, Bahlui River.

ABSTRACT

The paper presents the results of an ecological study on the Bahlui River fish community. Using an electrofisher they were captured in 6 sample sites a number of 1703 fish specimens, belonging to 14 species. They were calculated a series of ecological metrics and indexes in order to assess the fish community structure. The data obtained confirmed that the fish community ecological structure is affected due to the hydrotechnical amelioration (regularisation) works, with negative impacts on the aquatic habitats. In the area they are present a series of rare and protected fish species as: *Cobitis taenia, Rhodeus amarus* and *Proterorhinus marmoratus,* that are protected at European or national level.

REZUMAT: Date referitoare la comunitățile piscicole ale râului Bahlui (România).

Lucrarea prezintă rezultatele unui studiu ecologic al comunității piscicole din râul Bahlui. Cu ajutorul aparatului electric de pescuit au fost capturați, în 6 stații, un număr de 1703 pești, aparținând la 14 specii. Au fost calculați o serie de indicii ecologici pentru a evalua structura comunității piscicole. Rezultatele obținute confirmă că structura comunității piscicole este afectată ca urmare a lucrărilor hidrotehnice cu impact negativ asupra habitatelor acvatice. În zonă sunt prezente încă specii de pești rare şi protejate: *Cobitis taenia*, *Rhodeus amarus* şi *Proterorhinus marmoratus,* care sunt protejate la nivel European sau național.

RÉSUMÉ: Données sur les communautés piscicoles de la rivière Bahlui (Roumanie).

Ce travail présente les résultats d'une étude écologique de la communauté piscicole de la rivière Bahlui. Sur 6 stations échantillonnées par pêche électrique, 1703 poissons représentant 14 espèces ont été dénombrés. L'évaluation de la structure de la communauté piscicole a été réalisée à l'aide d'indicateurs écologiques Les résultats obtenus confirment que la structure écologique du peuplement piscicole de cette région est affectée suite aux travaux hydrotechniques qui affectent (négativement) les habitats aquatiques.. Dans cette région, subistent encore des espèces protégées telles que *Cobitis taenia*, *Rhodeus amarus,* et *Proterorhinus marmoratus* qui sont protégées au niveau européen ou national.

INTRODUCTION

The study area comprises the Bahlui River basin 1960 km^2 (Figure 1). The river length is 119 km, the level difference is 280 m, and the average slope $2.5^{o}/_{oo}$. The river sources are in Dealul Mare Tudora, at 435 m. The lime stone boulders and pebbles river bed is mostly regular; the valley is deep and narrow with good woodland coverage the slope being between $105^{o}/_{oo}$ and $165^{o}/_{oo}$, with land slides stopped by trees plantations. The river maintains its natural aspect for 22 km then it reaches the Hârlău city. The next sector is a sandy plane that maintains water deposits even during the drought periods. The river bed depth decrease gradually and the river plane is exposed to often floods. At the confluence with Jijia the average flow is $4m^3/s$ and has large variation limits.

MATERIALS AND METHODS

The samples were collected by electro fishing during 2005 summer, using a FEG 5000 electro fisher. For each sample we fish on 150 m length covering all the habitat types in the area (Cowx, 1990). In 6 sample sites we collected a total number of 1703 specimens, belonging to 2 orders, 5 families and 14 species. The identification was done based on the Bănărescu's 2002 identification guidebook. After identification and measurements the specimens were set free, less than 5% of them were retained as voucher specimens for the Iaşi Natural History Museum. We obtained a series of qualitative and quantitative data concerning the fish populations in the sample sites: the fish species list, the absolute numeric abundance for each species in each of the sites. These data were computed using statistical methods in order to calculate a series of ecological metrics and indexes for characterize the fish communities in the area (Barbault, 1994).

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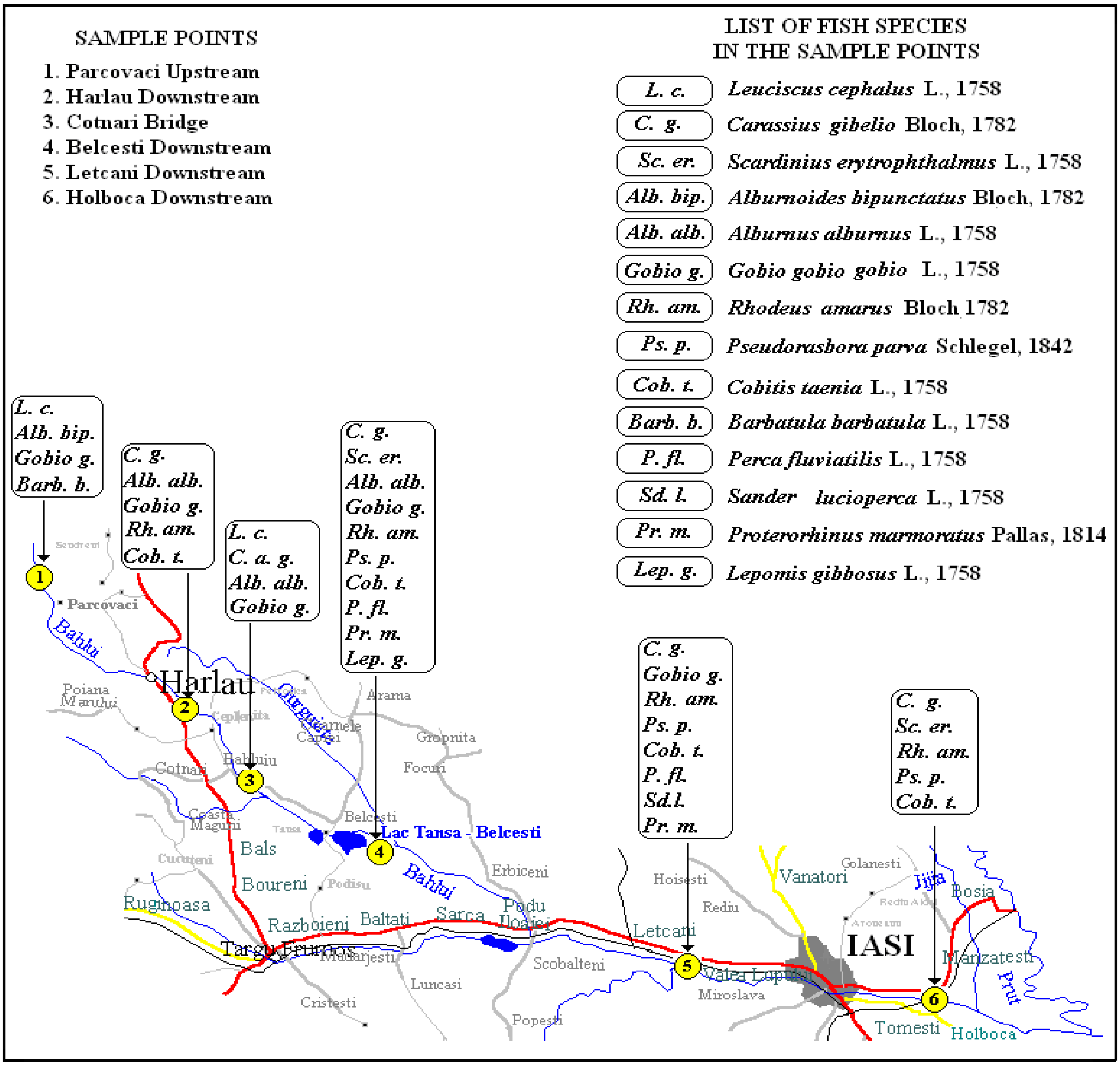

Figure 1. The map of the Bahlui River, with the sample sites and lists of fish species captured for each site.

RESULTS AND DISCUSSIONS

The figure 1 and table 1 present the species collected and their distribution. The species number increase, as expected, from the sources to the downstream river portion. The human impact of urban areas, Hârlău and Iaşi (caused by city waste waters) has a negative effect on the species number. The impact of the big reservoir at Belceşti has an opposite effect, increasing the species number on downstream proximity.

This data confirms that the species number increase is related to distance from sources and with the water flow of the river. In the upstream region, close to the river sources, we find species characteristic to the mountain region (*Barbatula barbatula, Alburnoides bipunctatus*) because of the habitat typology: boulder substrate, high flow velocity, clear and unpolluted water, wooded banks.

Table 1. The numeric absolute abundance of the fish species for each sampling sites.

	SPECIES	Pârcovaci 1	Hârlău 2	Cotnari 3	Belcesti 4	Leţcani 5	Holboca 6	Total Individuals / species	No. sites/ species
	Ord. Cypriniformes Fam. Cyprinidae								
1.	*Leuciscus cephalus* L. 1758	183	-	46	-	-	-	229	2
2.	*Carassius gibelio* Bloch, 1782	-	8	14	21	72	33	148	5
3.	*Scardinius erythrophthalmus* L., 1758	-	-	-	3	-	15	18	2
4	*Alburnoides bipunctatus* Bloch, 1782	9	-	-	-	-	-	9	1
5.	*Alburnus alburnus* L., 1758	-	10	24	15	-	-	49	3
6.	*Gobio gobio gobio* L. 1758	69	96	62	21	12	-	260	5
7.	*Rhodeus amarus* Bloch, 1782	-	4	-	63	512	15	594	4
8.	*Pseudorasbora parva* Schlegel, 1842	-	-	-	45	44	132	221	3
	Fam Cobitidae								
9.	*Cobitis taenia* L. 1758	-	8	-	15	40	24	87	4
10.	*Barbatula barbatula* L. 1758	30	-	-	-	-	-	30	1
	Ord. Perciformes Fam. Percidae								
11.	*Perca fluviatils* L. 1758	-	-	-	9	16	-	25	2
12.	*Sander lucioperca* L., 1758	-	-	-	-	8	-	8	1
	Fam. Gobiidae								
13.	*Proterorhinus marmoratus* Pallas, 1814	-	-	-	15	4	-	19	2
	Fam Centrarchidae								
14.	*Lepomis gibbosus* L., 1758	-	-	-	6	-	-	6	1
	Total individuals / site	291	126	146	213	708	219	1703	
	Total species /site	4	5	4	10	8	5		

Table 2. The absolute weigth abundance of species for each of the sampling sites.

	SPECIES	Pârcovaci 1	Hârlău 2	Cotnari 3	Belcesti 4	Lețcani 5	Holboca 6	Total Biomass grams/ site	No. sites/ species
	Ord. Cypriniformes Fam. Cyprinidae								
1.	*Leuciscus cephalus* L. 1758	3810	-	2966	-	-	-	6776	2
2.	*Carassius gibelio* Bloch, 1782	-	320	1690	759	1584	258	4611	5
3.	*Scardinius erythrophthalmus* L., 1758	-	-	-	135	-	440	575	2
4	*Alburnoides bipunctatus* Bloch, 1782	93	-	-	-	-	-	93	1
5.	*Alburnus alburnus* L., 1758	-	108	222	102	-	-	432	3
6.	*Gobio gobio gobio* L.1758	810	738	1168	337	288	-	3341	5
7.	*Rhodeus amarus* Bloch, 1782	-	18	-	384	1884	67	2353	4
8.	*Pseudorasbora parva* Schlegel, 1842	-	-	-	337	347	612	1296	3
	Fam Cobitidae								
9.	*Cobitis taenia* L. 1758	-	51	-	81	369	154	655	4
10.	*Barbatula barbatula* L. 1758	396	-	-	-	-	-	396	1
	Ord. Perciformes Fam. Percidae								
11.	*Perca fluviatils* L.1758	-	-	-	59	386	-	445	2
12.	*Sander lucioperca* L., 1758	-	-	-	-	114	-	114	1
	Fam. Gobiidae								
13.	*Proterorhinus marmoratus* Pallas, 1814	-	-	-	72	21	-	93	2
	Fam Centrarchidae								
14.	*Lepomis gibbosus* L., 1758	-	-	-	45	-	-	45	1
	Total biomass / site	5109	1235	6046	2311	4993	1531	21225	
	Total species /site	4	5	4	10	8	5		

On the middle portion of the river in between the Belceşti reservoir and Iaşi city there is a significant increase of the species number, probably due to the effect of the dam lake, which contributes for maintaining a constant flow and by permanently, repopulating the river with fish escaped from the farms (*Lepomis*, *Sander*, *Pseudorasbora*). Table 1. presents the quantities of the captured fish, calculated both as number and weight, for every fish species and sample site. The significant variations in between different sampling sites are due to the ecological condition and the human impact. The minimal number of collected fish is 126, respectively 1 235 g (at downstream Harlau) the maximal number being 708 (at downstream Lețcani) respectively maximal weight 6 046 g (at Cotnari bridge). The total weight of capture was of 21 225 g.

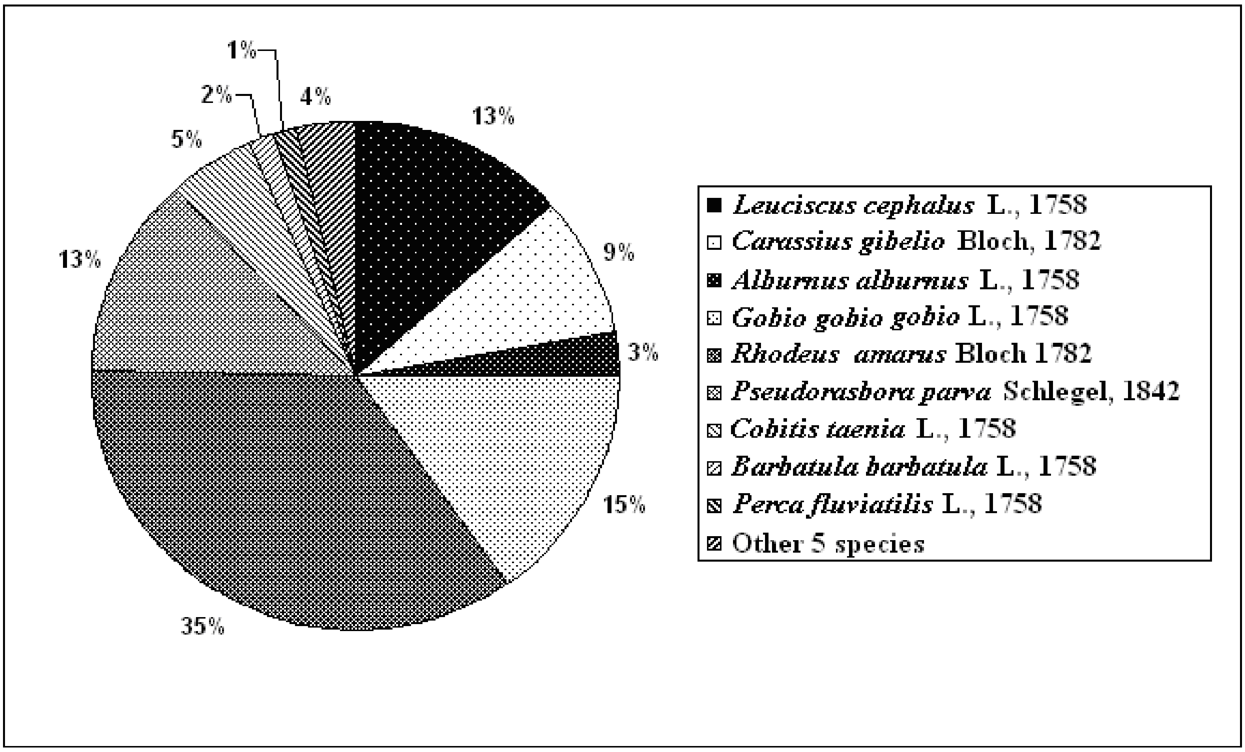

Figure 2. The pie chart indicating the relative numerical abundance of the species in the total fish capture for the Bahlui River.

For the Bahlui River the total capture is over 110 specimens /100 m, due to the small species *Rhodeus amarus* and *Pseudorasbora parva*. The weight of capture is also high, over 1200 g / 100 m with an exception for site downstream Hârlău city, which is damaged by the urban waste and sewage waters impact.

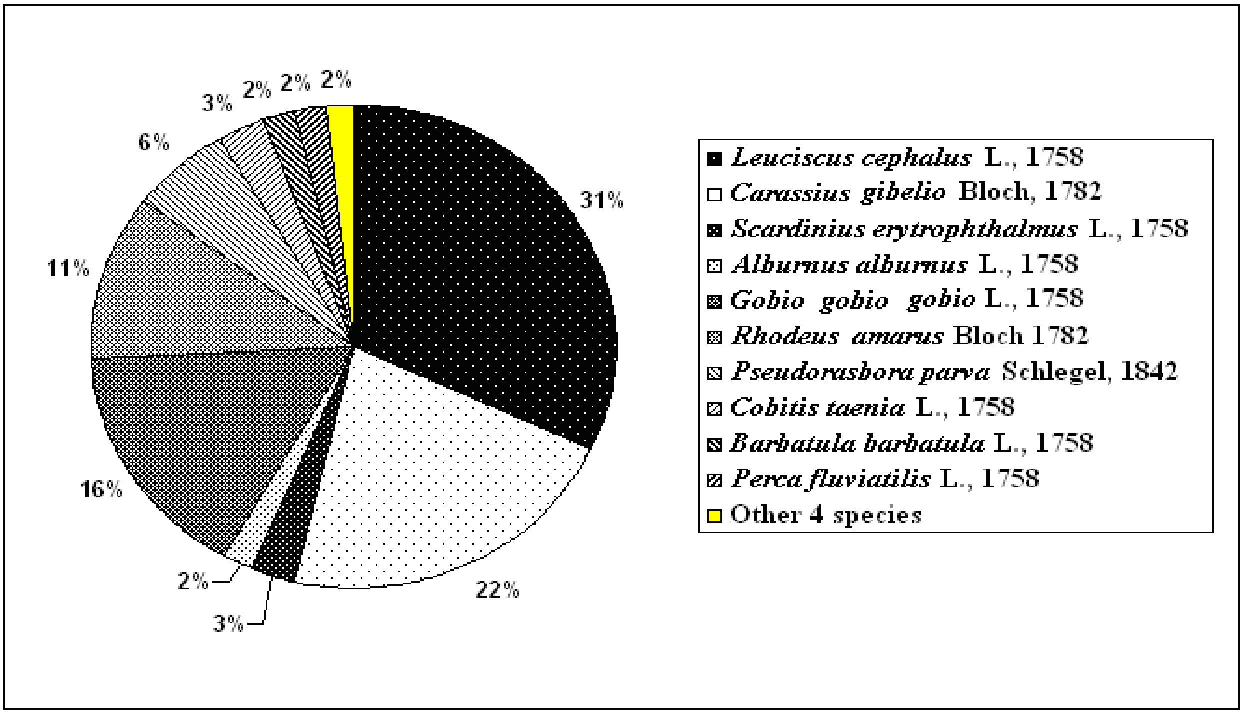

Figure 3. The pie chart indicating the relative weight abundance of the species in the total fish capture for the Bahlui River.

From the data in the table 1 and figure 2 we find that the most abundant species as individual numbers is *Rhodeus amarus*, representing 35% (594 individuals) of the total capture, fallowed by the *Gobio gobio gobio, Leuciscus cephalus* şi *Pseudorasbora parva* representing altogether 41% (710 individuals, uniformly distributed among the three species. From the weight point of view the species *Leuciscus cephalus* and *Carassius gibelio* have the biggest biomass (6 825 g), covering a percent of 53.75% from the total capture weight (Table 1 and Figure 3).

Analyzing the ecological indexes values (Table 2) we find that they are a number of four characteristic species for all sample sites: *Rhodeus amarus, Gobio gobio gobio, Carassius* gibelio and *Pseudorabora parva,* they also have the highest abundance and are a constant presence along the river. They are accompanied by some accessory species as: *Leuciscus cephalus, Cobitis taenia* and *Alburnus alburnus*, that are dominant both as number and weight, even that from the constancy index point of view they are accessory or accidental species. The species *Perca fluviatilis, Proterorhinus marmoratus, Scardinius erythrophthalmus, Barbatula barbatula, Alburnoides bipunctatus, Sander lucioperca* and *Lepomis gibbosus* should be considered accessory or accidental species, being present only in small numbers and few sample sites.

To improve the data on species hierarchy we calculated the same indexes using weight instead of specimen number.

From the figure 4 we may appreciate that they are a group of fish species that are well fitted to the habitat conditions and have a cenotic affinity over 54.1%: *Alburnus alburnus*, *Gobio gobio gobio, Carassius gibelio, Cobitis taenia, Rhodeus amarus.* They are characteristic for the Moldavian Plateau river habitats and are able to survive the natural oscillations of the environment factors in the area. The 100% affinity of the *Barbatula barbatula* and *Alburnoides bipunctatus*, is due to the fact that they were collected in a single sample site. They are characteristic for the forested habitats with high vegetal coverage and slope over 10‰. For this reason they are very rare in the Moldavian plateau basins. They could be found only in short portions of the top basins of Bahlui and Bârlad, in forested areas.

The other species are accessory species with a cenotic affinity under 29.1%, being clearly separated from the above mentioned two species. (Table 2)

Table 3. The values of the ecological indexes of the fish communities in the Bahlui River.

No.	SPECIES	Absolute Abundence (A)	Ecologic indexes					
			Constancy (C)		Dominance (D)		Ecological significance (W)	
			%	Class	%	Class	%	Class
1.	*Rhodeus amarus*	594	66.66	C_3	34.87	D_5	23.24	W_5
2.	*Gobio gobio gobio*	260	83.33	C_4	15.26	D_5	12.71	W_5
3.	*Carassius gibelio*	148	83.33	C_4	8.69	D_4	7.24	W_4
4.	*Pseudorasbora parva*	221	50.00	C_2	12.97	D_5	6.48	W_4
5.	*Leuciscus cephalus*	229	33.33	C_2	13.44	D_5	4.48	W_3
6.	*Cobitis taenia*	87	66.66	C_3	5.11	D_4	3.41	W_3
7.	*Alburnus alburnus*	49	50.00	C_2	2.88	D_3	1.44	W_3
8.	*Perca fluviatilis*	25	33.33	C_2	1.47	D_2	0.49	W_2
9.	*Proterorhinus marmoratus*	19	33.33	C_2	1.11	D_2	0.37	W_2
10.	*Scardinius erythrophthalmus*	18	33.33	C_2	1.05	D_1	0.35	W_2
11.	*Barbatula barbatula*	30	16.66	C_1	1.76	D_2	0.29	W_2
12.	*Alburnoides bipunctatus*	9	16.66	C_1	0.52	D_1	0.09	W_1
13.	*Sander lucioperca*	8	16.66	C_1	0.47	D_1	0.08	W_1
14.	*Lepomis gibbosus*	6	16.66	C_1	0.35	D_1	0.06	W_1

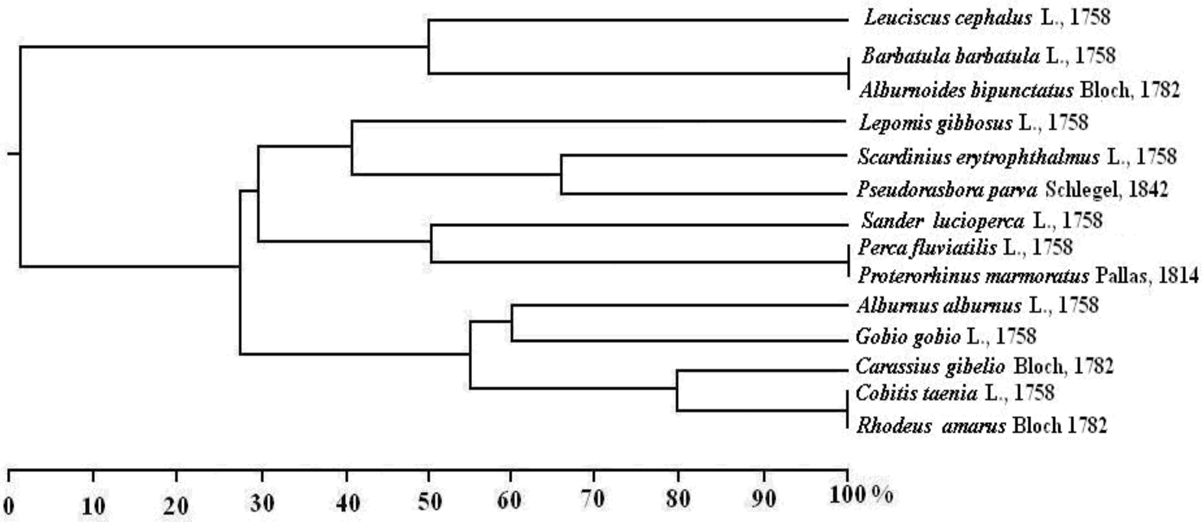

Figure 4. Graph of the cenotic affinity of the fish species in Bahlui River.

Analysing the of species similarities graph (Figure 5) we find that the site upstream Pârcovaci and Cotnari bridge have a special status having a small similarity with other sites. This character is due to the special habitat condition that makes possible the presence of the *Alburnoides bipunctatus* and *Barbatula barbatula* species. The high number of commons species among the other sites (related to rather similar habitat typology) determines a high similarity, over 62%. From the figure 5, graph of the species similarity we find the two groups of sites: one including site upstream Pârcovaci and Cotnari Bridge with clear water, hard bottom, high slope, and close to river sources (less 30 km). The others that grouped together have a slower flow velocity and sandy bottom.

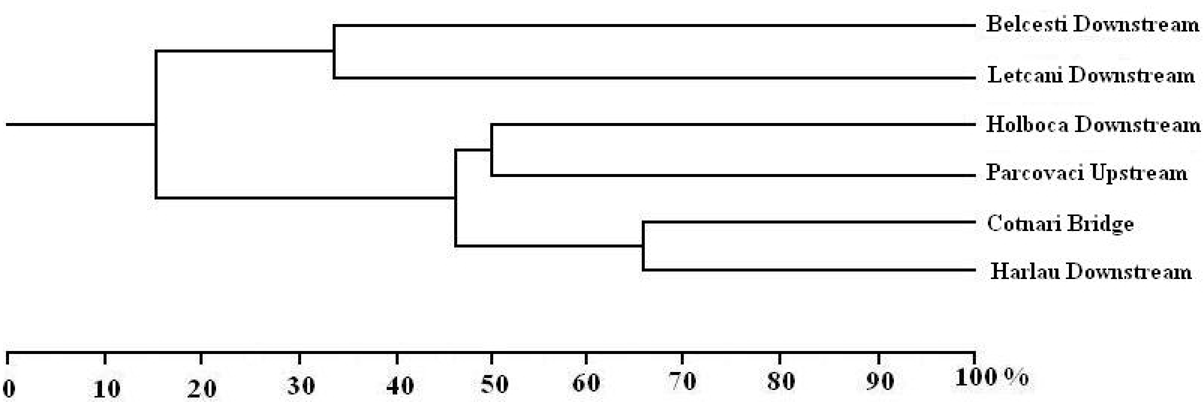

Figure 5. Graph of the species similarity for the sample sites on the Bahlui River.

Table 4. The values of the Shannon-Weaver Index and Equitability Index, calculated for the Samples sites in the Bahlui River.

		Sample site					
No.		1	2	3	4	5	6
1	Number of individuals	291	126	146	213	708	219
2	Number of species	4	5	4	10	8	5
3	Shannon Weaver Index	0.974	0.867	1.249	2.000	1.036	1.199
4	Equitability Index	0.702	0.539	0.901	0.868	0.498	0.745

Based on the diversity and equitability index (Table 4 and Figure 6) we find that the most of the sites have high values of the diversity and equitability indexes. This mean they have diverse and well balanced fish community the highest value was found at Cotnari Bridge - site 3, with an equitability index value of 0.901. At the site no 4, downstream the fish farm Belceşti, both the diversity and equitability indexes are high. This probably due to the fact that the number of species increases artificially because of the specimens escaped from the fish farm. These specimens have a random presence and they are not characteristic and adapted for the conditions in the river.

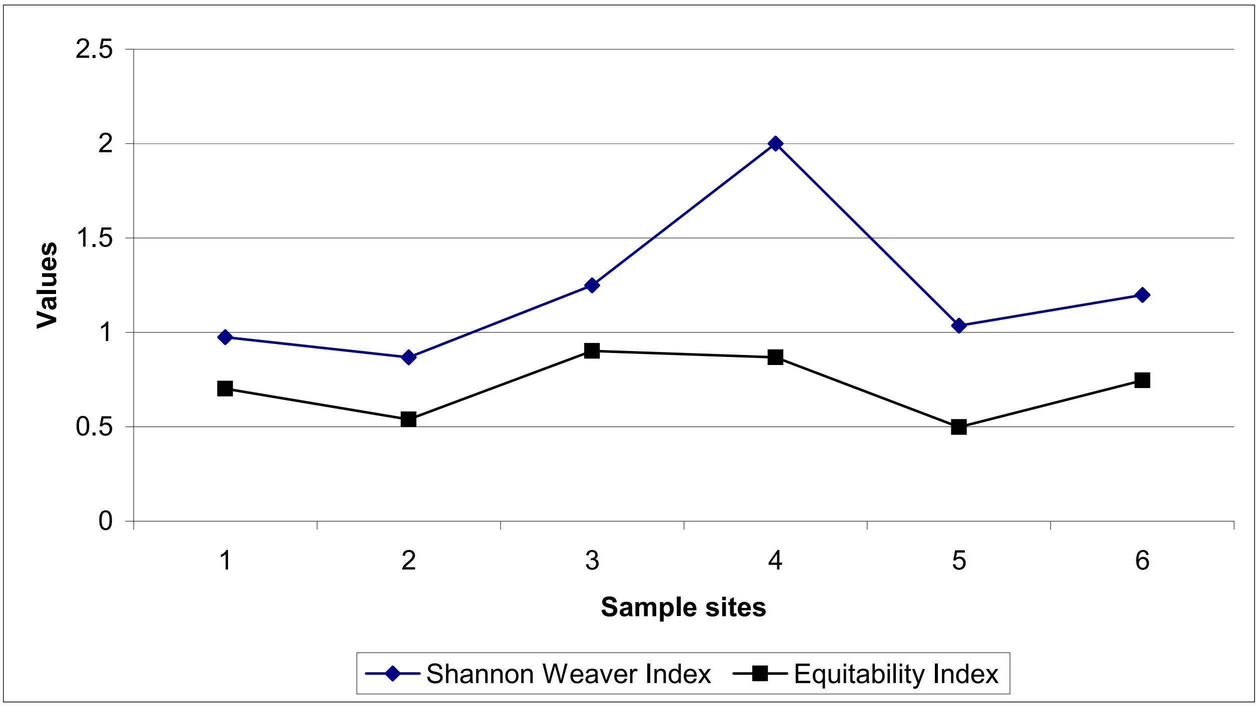

Figure 6. Graph of the Shannon-Weaver and Equitability Indexes.

CONCLUSIONS

The fish community of the Bahlui River are formed of 14 species from which two are introduced invasive species: *Pseudorasbora parva* and *Lepomis gibbosus*.

The absolute abundance, both as specimen number and weight is between 110 to 295 individuals for 100 m^2 and respectively from 1200 to 4650 g / 100 m^2**.** In the polluted site downstream Hârlău city they are only 82 specimen /100 m^2 and 850 g / 100 m^2.

The dominant species for most of the sites are *Rhodeus amarus* and *Gobio gobio gobio*, excepting a small portion close to sources where *Leuciscus cephalus* and *Gobio gobio gobio* are dominant. *Sander lucioperca* and *Lepomis gibbosus* can be considered as rare species for this river. They are accidental, probably escaped from reservoirs.

Analysing the cenotic affinity among species we find that there is significant difference in between the association characteristic for the upstream portion with *Alburnoides* and *Barbatula*, with clear fast water flow, hard bottom and the rest of the river with slow water and sandy/muddy bottom, with *Rhodeus* and *Carassius*.

Analysing the human impact we find perturbations due to the pollution caused by waist waters of cities downstream Hârlău and Iaşi, and also modifications due to the presence of reservoirs and fish farms. From these reservoirs, a number of specimens escape periodically modifying the species composition in the river.

From these results we may conclude that the presence of big reservoirs have a beneficial role for the fish fauna, ensuring a constant water flow thorough the year, reducing the stress of the drought periods (characteristic for this region), even they are associated with habitat diversity reduction.

From the collected species, *Rhodeus amarus* and *Alburnoides bipunctatus* are sensitive species, indicators of a good state of aquatic habitats.

Rhodeus amarus and *Cobitis taenia* are protected both at national and international level being included in the Annexes of the Habitat Directive of the EEC. *Proterorhinus marmoratus* is protected at international level by Bern Convention.

AKNOVLEDGEMENTS

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AUTHORS:

[1] *Cătălin Dumitru COSTINIUC*
costiniuc_catalin@yahoo.com
"Alexandru Ioan Cuza" University,
Department of Biology,
Carol I St., no. 11,
Iaşi, Iaşi County, Romania,
RO - 700506.

[2] *Grigore DAVIDEANU*
[2] *Ana DAVIDEANU*
grigore@uaic.ro
"Alexandru Ioan Cuza" University,
Natural History Museum,
Independenței Bd., no. 16,
Iaşi, Iaşi County, Romania,
RO - 700100.

DATA CONCERNING THE FISH COMMUNITIES OF THE UPPER PART OF BISTRIȚA RIVER AND TRIBUTARIES (ROMANIA)

Grigore DAVIDEANU [1], *Ionel MIRON* [2], *Iulia COMAN* [3] and *Ana DAVIDEANU* [1]

KEYWORDS: Ichthyofauna, fish ecology, Bistrița River.

ABSTRACT

This paper presents the results of an ecological study on the Bistrița River fish community.

Using an electrofisher they were captured in 12 sample sites a number of 1566 fish specimens, belonging to 12 species.

There were calculated a series of ecological metrics and indexes in order to assess the fish community structure.

Based on this data we were able to conclude that fish community is exposed to severe human impact that shifts its initial structure. In the area they are still present a series of rare and protected fish species as: *Thymallus thymallus, Barbus meridionalis, Chondrostoma nasus, Gobio uranoscopus, Sabanejewia aurata, Alburnoides bipunctatus* and *Cottus poecilopus* that are protected at European or national level.

REZUMAT: Date privind comunitățile piscicole din partea superioară a râului Bistrița şi afluenții săi (România).

Această lucrare prezintă rezultatele unui studiu ecologic al comunității piscicole din râul Bistrița.

Cu ajutorul aparatului de pescuit electric au fost capturati, în 12 stații, 1566 peşti aparținând la 12 specii.

Au fost calculați indicatori ecologici pentru a evalua structura comunității piscicole.

Pe baza rezultatelor se poate concluziona că asociația piscicolă din zonă este expusă unui impact antropic puternic care a modificat structura inițială a acesteia. În zonă sunt încă prezente specii de peşti rare şi protejate ca: *Thymallus thymallus, Barbus meridionalis, Chondrostoma nasus, Gobio uranoscopus, Sabanejewia aurata, Alburnoides bipunctatus* şi *Cottus poecilopus* care sunt protejate la nivel European sau național.

RÉSUMÉ: Données sur les communautés piscicoles de la rivière Bistrița (Roumanie)

Ce travail présente les résultats d'une étude écologique de la communauté piscicole de la rivière Bistrița.

Sur 12 stations échantillonnées par pêche électrique, 1566 poissons représentant 12 espèces ont été dénombrés.

L'évaluation de la structure de la communauté piscicole a été réalisée à l'aide d'indicateurs écologiques.

Les résultats obtenus permettent de conclure que le peuplement piscicole de cette région est exposé à un fort impact antropique qui a modifié sa structure initiale. Il subsiste encore dans cette région des espèces de poissons rares et protégées telles que *Thymallus thymallus, Barbus meridionalis, Chondrostoma nasus, Gobio uranoscopus, Sabanejewia aurata, Alburnoides bipunctatus* et *Cottus poecilopus* qui sont protégées au niveau européen ou national.

MATERIALS AND METHODS

The biological data were collected thorough electro fishing, during the 2005 summer. For the fishing we used a FEG 5000 electro fisher (Cowx, 1990).

They were designated twelve sample sites on the Bitrița River and tributaries upstream the Izvorul Muntelui lake, for each of them we sampled on 100 m length.

They were captured a total number of 1566 fish specimens, belonging to 12 species. After identification and measurements they were let free, less than 5% of them were retained as voucher specimens for the Natural History Museum, Iaşi.

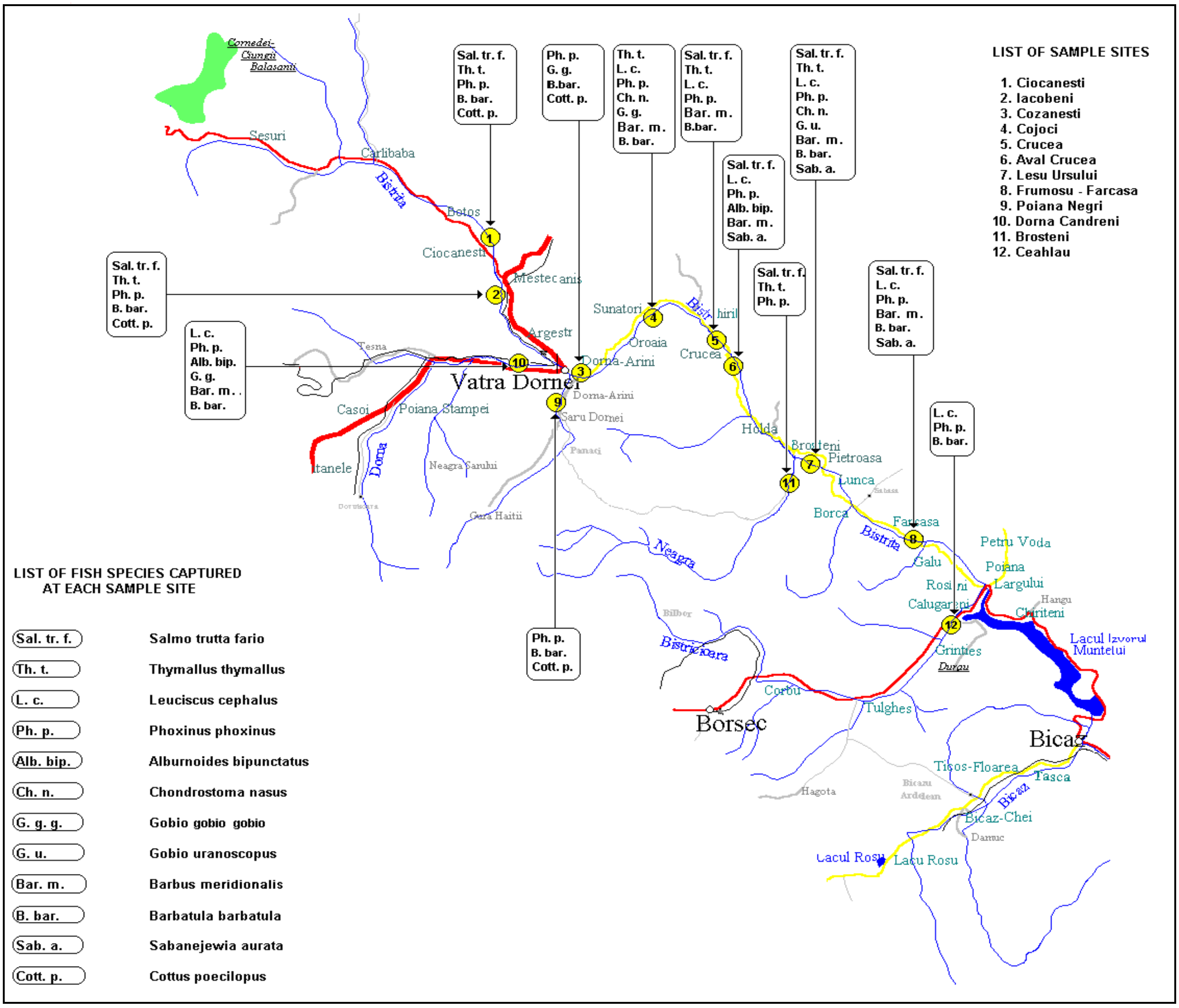

Figure 1. The map of the sampling area,
the sample sites and list of species captured for each site.

For the fish identification we used Bănărescu's 1964 and 2002, guide book.

We obtained a series of qualitative and quantitative data concerning the fish populations in the sample sites: the fish species list, the numeric abundance for each species in each of the sites. These data were computed using statistical methods (Angermeier, 1995; Barbault, 1994) in order to calculate a series of ecological metrics and indexes to characterize the fish communities in the area.

RESULTS AND DISCUSSIONS

They were captured in 12 sites (Figure 1) a total number of 1566 fish specimens, belonging to 3 orders, 4 families and 12 species (Table 1). Based on these values we appreciate the fish communities state in the upstream portion of the Bistrița.

The most abundant species is *Phoxinus phoxinus*, representing 72% (1 162 individuals) of the total capture, all of the other 11 species representing the rest of 28% of the capture (Table 1, Figure 2). The species *Thymallus thymallus*, once abundant, giving the name of this zone (fallowing the European ecological zones of rivers, Bănărescu 1964) represents nowadays (in our samples) only 1% of the capture as number - 8 individuals. In the same time, *Leuciscus cephalus*, a species characteristic for the hilly regions, represents nowadays 6%, of the capture - 86 individuals. The highest abundance was found in Vatra Dornei site 3, with 369 specimens, besides the low diversity (four species), followed by Cândreni (on Dorna tributary) and Cojoci sites. Opposing to this we have the sample site Broşteni with a capture of only 8 fish specimens

Table 1. The numeric absolute abundance of fish species for each of the sampling sites.

no.	Sites / Species	Bistrița Ciocănești	Bistrița Iacobeni	Bistrița Vatra Dornei	Bistrița Cojoci	Bistrita Crucea	Bistrița downstream Crucea	Bistrita Lesu Ursului	Bistrița between Frumosu and Fărcașa	Negrisoara Poiana Negrii	Dorna Candreni	Neagra Broșteni	Bistricioara Ceahlău	Total Sites / Species	Totalindividuals / species
	Salmoniformes														
	Salmonidae														
1.	*Salmo trutta fario* L. 1758	5	1			3	1	3	1			4		7	18
2.	*Thymallus thymallus* L. 1758	1	3		1	1		1				1		6	8
	Cypriniformes														
	Cyprinidae														
3.	*Leuciscus cephalus* L. 1758				17	14	5	3	24		21		2	7	86
4.	*Phoxinus phoxinus* L. 1758	30	40	360	201	108	23	45	19	76	199	3	58	12	1162
5.	*Alburnoides bipunctatus* Bl. 1782						2				63			2	65
6.	*Chondrostoma nasus* L. 1758				1			1						2	2
7.	*Gobio gobio gobio* L. 1758			4	1						23			3	28
8.	*Gobio uranoscopus Vl. 1925*							2						1	2
9.	*Barbus meridionalis* Risso 1827				5	7	13	20	11		1			6	57

	Cobitidae														
10.	*Barbatula barbatula* L. 1758	15	2	3	7	12		32	2	30	1		3	10	107
11.	*Sabanejewia aurata* K. 1922						2	1	1					3	4
	Scorpaeniformes														
	Cottidae														
12.	*Cottus poecilopus* H. 1836	10	4	2						11				4	27
	Total species/site	5	5	4	7	6	6	9	6	3	6	3	3		
	Total individuals/site	61	50	369	233	145	46	106	58	117	308	8	63		1566

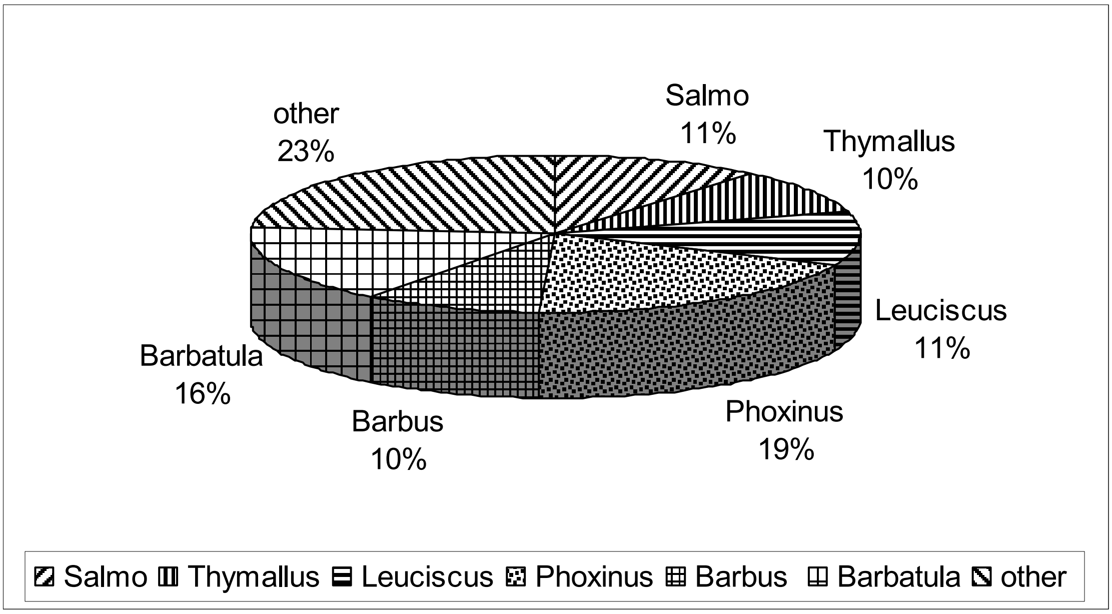

Figure 2. The pie chart indicating the relative numerical abundance of the species in the total fish capture for the Bistrița River.

Analyzing the species number captured on each site (Table1 and Figure 3) we find that at the Leşu Ursului sample site (9 species) and Cojoci sample site (7 species) there is a great diversity and the ecological state is relatively high. On sites placed on basin top, on small tributaries (as Bistricioara, Neagra and Negrişoara tributaries) where the diversity is naturally lower, we captured only 3 species. A low diversity (4 species) were found at Vatra Dornei also.

Most of the capture (95%) belongs to only one species *Phoxinus phoxinus*, this indicates without doubt the impact produced by the sewage water of the city. This way, the sample proves once more the ecological principle saying that in a degraded habitat the diversity lowers and the abundance of the remaining species (4) rise (369 individuals for *Phoxinus*).

For the other sites the species number varies in between 5 and 7.

Table 2. The values of the ecological indexes and ecological significance index calculated for the sample sites of the Bistrița River.

No	Species	Abun dance	Constancy		Dominance		Index of ecological significance	
			No. (%)	Class	No. (%)	Class	No. (%)	Class
1	*Phoxinus phoxinus* L. 1758	1162	100	C4 euconstant	74.2	D5 eudominant	74.2	W5 characteristic
2	*Barbatula barbatula* L. 1758	107	83.3	C4 euconstant	6.84	D4 dominant	5.69	W4 characteristic
3	*Leuciscus cephalus* L. 1758	86	58.3	C3 constant	5.49	D4 dominant	3.2	W3 accesory
4	*Alburnoides bipunctatus* Bl. 1782	65	16.6	C1 accidental	4.15	D3 subdominant	0.69	W2 accesory
5	*Barbus meridionalis* Risso 1827	57	50	C2 accesory	3.64	D3 subdominant	1.82	W3
6	*Gobio gobio gobio* L. 1758	28	25	C1 accidental	1.79	D2 recedent	0.44	W2 accesory
7	*Salmo trutta fario* L .1758	18	58.3	C3 constant	1.15	D2 recedent	0.67	W2 accesory
8	*Cottus poecilopus* H. 1836	17	33.3	C1 accesory	1.71	D1 recedent	0.32	W2 accesory
9	*Thymallus thymallus* L.1758	8	50	C2 accesory	0.51	D1 subrecedent	0.25	W2 accesory
10	*Sabanejewia aurata* K. 1922	4	25	C1 accesory	0.25	D1 subrecedent	0.06	W1 accidental
11	*Chondrostoma nasus* L. 1758	2	16.6	C1 accidental	0.12	D1 subrecedent	0.01	W1 accidental
12	*Gobio uranoscopus* Vl. 1925	1	8.3	C1 accidental	0.06	D1 subrecedent	0.01	W1 accidental

Analysing the values of the ecological indexes presented in the Table 2, we find that they are number of two characteristic species for all sample sites: *Phoxinus phoxinus* and *Barbatula barbatula*; they also have the highest abundance and are a constant presence along the river. They are accompanied by some accessory species as: *Leuciscus cephalus* and *Salmo trutta fario*, that are constant in the sample sites, even the trout is a recedent species, with a low abundance. The *Barbus meridionalis* species belongs also to the accessories species group. It is constantly present and well represented in the sites downstream Vatra Dornei, but lack on the tributaries. The species *Sabanejewia aurata, Gobio uranoscopus* and *Chondrostoma nasus* should be considered accidental being captured only one or two individuals each.

These data confirm the human impact effect on fish community structure. In the past, this river segment was evaluated as grayling zone *(Thymallus thymallus*), Bănărăscu 1964. Today, the grayling, because of the small number, even is still present in half of the sample sites, constitutes no more an important species.

In opposition with the *Thymallus* disappearance trend, the tolerant species *Leuciscus cephalus* advanced upstream and is present in all the sites downstream Vatra Dornei having a considerably bigger population than the grayling.

The omnipresence of the *Phoxinus phoxinus* (tolerant species) give us few information but decreasing of the presence of the *Alburnoides bipunctatus*, a species sensitive to human impact, indicates that the aquatic habitats are seriously damaged.

The increasing presence of the chub *Leuciscus cephalus*, an opportunistic and tolerant species, also indicates that the aquatic habitats suffer under human impact pressure as resulting from previous studies (Davideanu, 1994; Motaş 1944).

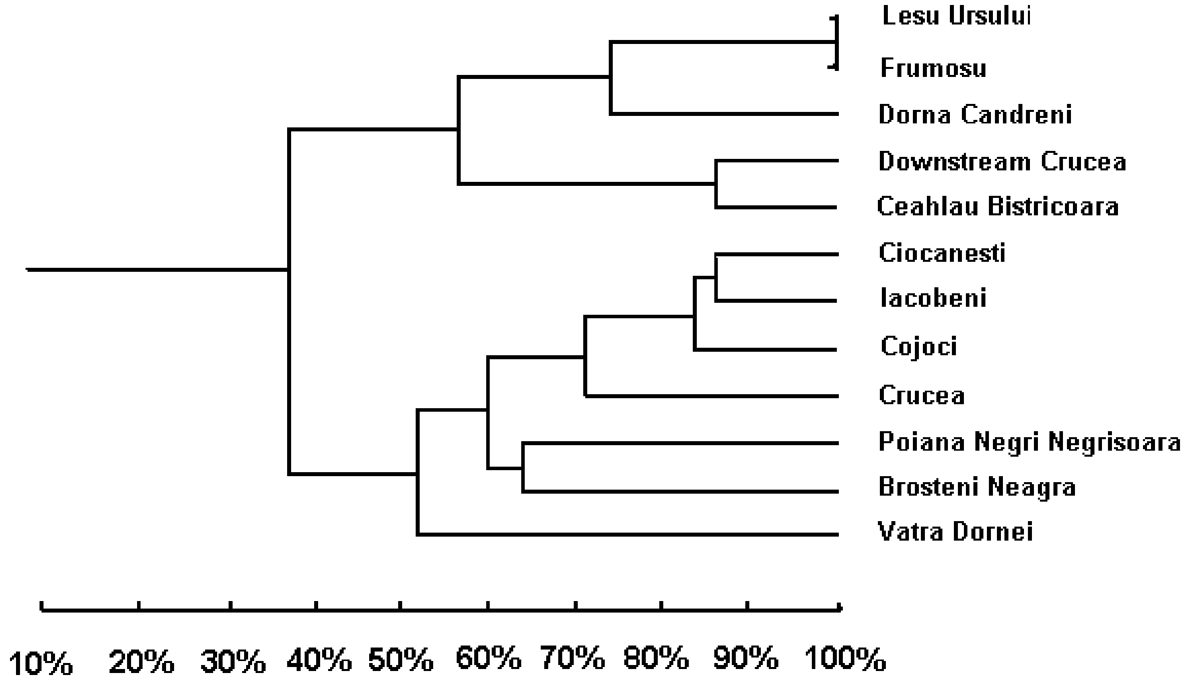

Figure 3. The cluster graph of species similarity among the sample sites on Bistrița River and tributaries.

Analysing the graph from figure 3 we find that the sites placed on the main river course (with a rapid flow) tends to group with a high species similarity (Ciocăneşti, Iacobeni, Cojoci, Crucea). The sites on the basin top with a scarce diversity form a second group with lower similarity. The site Vatra Dornei placed downstream a big urban area has a low similarity with the other because of the high human impact.

From table 3 and figure 4 we find that at the sites 1 - Ciocăneşti and 7 - Leşu Ursului the fish community has the highest diversity index and equitability, proving that the habitat are in good condition and there is well balanced fish association. The lowest values of these indexes (0.101) are at site 3 - Vatra Dornei. This can be explained because of the environment degradation induced by the sewage water impact. The small values found at sites 10 (0.569) and 12 (0.300) are due to the fact that the sites are placed on small tributaries with naturally lower diversity, because of smaller basin surface and reduced flow.

Table 3. The values of Shannon-Weaver Index and Equitability Index, calculated for the Samples sites on in the Bistrița River and tributaries.

			S	A	M	P	L	E		S	I	T	E
No.		1	2	3	4	5	6	7	8	9	10	11	12
1	Number of individuals	61	50	369	233	145	46	106	58	117	308	8	63
2	Number of species	5	5	4	7	6	6	9	6	3	6	3	3
3	Shannon-Weaver Index	1.262	0.756	0.140	0.576	0.912	1.30	1.440	1.302	0.851	1.020	0.974	0.330
4	Equitability Index	0.784	0.469	0.101	0.296	0.509	0.725	0.655	0.726	0.775	0.569	0.887	0.300

Figure 4. The graph presenting the variation of the Shannon-Weaver Index, Equitability Index among the sample sites on Bistrița River and tributaries.

CONCLUSIONS

The fish community and habitats of the upstream segment of the Bistrița River seems to be under a significant human impact pressure. The structure of the fish communities and the vertical distribution (zonation) suffered significant changes over last 30 years.

This is especially visible downstream Vatra Dornei (an urban agglomeration) and at the upstream part of the Izvorul Muntelui reservoir. The fish fauna here have been modified both due to the lake effect and newer hydro technical works upstream the area.In the Bistrița Basin they are still present, but declining, sensitive species protected both at national and international level.

The species: *Thymallus thymallus, Barbus meridionalis, Chondrostoma nasus, Gobio uranoscopus, Sabanejewia aurata, Alburnoides bipunctatus* and *Cottus poecilopus* are protected species, included in the III Annex of the Bern Convention.

The species: *Gobio uranoscopus, Barbus meridionalis, Sabanejewia aurata*, *Cottus poecilopus* and cyclostome *Eudontomyzon mariae* are included in the Habitat Directive Annexes as Species of Community interest and need the designation of Conservation areas.

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AUTHORS:

[1] *Grigore DAVIDEANU*
[1] *Ana DAVIDEANU*
grigore@uaic.ro
"Alexandru Ioan Cuza" University,
Natural History Museum,
Independenței Bd., no. 16,
Iaşi, Iaşi County, Romania,
RO - 700100.

[2] *Ionel MIRON*
mironi@uiac.ro
"Alexandru Ioan Cuza" University,
Department of Biology,
Carol I St., no. 11,
Iaşi, Iaşi County, Romania,
RO - 700506.

[3] *Iulia COMAN*
comani@rowater.ro
National Administratation Romanian Waters,
Prut River District,
Văscăuțeanu St., no. 10,
Iaşi, Iaşi County, Romania,
RO - 700462.

AN ALTERNATIVE METHODOLOGY IN FISH MORPHOMETRY

Istvan FALKA [1,] Ioan BUD [2] and Ionel-Claudiu GAVRILOAIE [3]

KEYWORDS: digital measuments, triple regresion, *Pseudorasbora parva*.

ABSTRACT

The aim of the our paper is to present an alternative to traditional morphological studies. Morphometry must keep up with the development of technology. There are new tools available, which may ease the job of those working in this field and to make the data more reliable.

In our paper we present a method based on digital image acquisition and image analysis, but we also deal with the statistical aspects. We try to exemplify this digital measurements on a smaller sample of topmouth gudgeon (*Pseudorasbora parva*).

For the statistical analysis of our data we use a less familiar statistic, the triple regression.

Finaly we try to highlight some of the pozitiv and negative aspects related to the presented methods.

REZUMAT: O abordare alternativă în morfometria peştilor.

Scopul vizat a lucrări noastre este prezentarea unei alternative la metodele de lucru din domeniul studiilor morfometrice tradiționale. Datorită progresului tehnologic, apare posibilitatea de a utiliza metode noi, care să faciliteze munca celor implicați în astfel de studii şi care să permită obținerea unor date mai exacte.

În lucrare prezentăm o metodă bazată pe fotografie şi pe procesare digitală a imaginilor, dar abordăm şi prelucrarea statistică a datelor obținute. Pentru exemplificare am aplicat metodele pe un eşantion mai mic de murgoi bâlțat (*Pseudorasbora parva*).

Analiza statistică a datelor obținute a fost realizată cu o metodă mai puțin cunoscută şi utilizată la noi, cu ajutorul regresiei triple.

În final am încercat să subliniem câteva aspecte pozitive şi negative în legătură cu metodologia prezentată.

ZUSAMMENFASSUNG: Eine alternative methodologie in fish morfometrie.

Das Ziel die unsere Arbeit ist eine alternative Metodologie bekant zu machen in das Bereich das tradizioneles morfologische Untersuchung. Mit die Entwicklung des Technologie est gibt eine Möglichkeit solche neue Methoden zu nuzten, welche das Arbeit für alles impliziertes in solche Unterschungen einfaher zu machen und welche ermöglicht mehr exacten Daten zu bekommen.

Wir presentiren eine Methode das auf digitalen Fotografischeblideumarbeitung sich verlassen. Wir presentieren auch eine statistische Methoden, geignete für das Bearbeitung des morphologische Daten. Für Exemplifizirung wir haben das Methode auf eine kleinere Probe aus *Pseudorasbora parva* durchgefürt.

Für die statistische Untersuchung unseres Daten wir haben eine wenig bekante Methode benutzt, die Dreifache Regression.

An die Ende unseres Artikel wir haben versuchen die Vorteile und die Nachteile dieses Methodologie zu hervorheben.

INTRODUCTION

Morphometry deals with the shape of organisms. Traditional morphometry means measurements of different exterior or interior characters, length, distances, angles or ratios between landmarks (Dryden and Mardia, 1999). Traditionally these measurements are undertaken with traditional measuring tools, most frequently with a caliper (Kovac, 1987)

Morphology is one of the most basic and ancient tool in study of biota. Shape and size are the most evident signs which help us recognize and identify different species. The shape study is of crucial importance in many research areas. The morphology of the organisms is the basis of any systematic study. The study of morphological diversity and phenotypic plasticity are of ecological and genetic interest (Rohlf, 1990), but body shape related date are also important in biogeography (Rosen, 1978; Wiley, 1981, 1988), ontogeny (Alberch and Alberch, 1981; Gould, 1966, 1977; Kluge, 1985), speciation, co-evolutionary interactions (Brooks, 1984; Brooks, 1998; Wiley, 1988; Cracraft, 1986; Mayden, 1988) and so on.

In spite of morphometry "ancient" nature, its must keep up with the development of technology. In the 1990's some already predicted fundamental changes in the tools and nature of morphological studies (Rohlf, 1990). These are the times predicted by them (especially in case of the Romanian ichthyology at least).

The progress we witnessed in image acquisition hardware and image analysis systems must not be overlooked. We consider these to be potentially new tools for morphometric studies, which we hope to ease our work and to make our data more accurate and reliable. We also tried to present a relatively new statistical method meant to deal with morphological data and to give new a perspective and reasoning of these endless rows of size and ratios data.

MATERIALS AND METHODS

In order to present and exemplify a method based on digital image acquisition and analysis, and also a statistical method for handling morphometric data, we worked with topmouth gudgeon (*Pseudorasbora parva*), a small cyprinid. This is an invasive fish species in Romanian freshwaters, introduced accidentally from Amur Basin in 1960's (Bănărescu 1964).

We considered this species first of all because its small size (70 - 89 mm SL, Bănărescu, 1964), which make morphological studies quite difficult.

45 individuals were caught with electrofishing (SAMUS device). All individuals were photographed using a digital camera (Konica-Minolta Z10), from a perpendicular point of view, illuminated with several spotlights to reduce shadows (Figure 1). Beside the photographed fish we placed a caliper, which serves as calibration tool for the image analyzing software.

The images were imported in a personal computer. Using a software (Impor) developed by University Comenius from Bratislava (Slovakia) we were able to measure several characters.

The software has a calibration option, which makes possible to transform pixels of the photograph in the real proportions of the photographed object (in our case the fish). This process is aided by the caliper photographed with the fish. In this case the software tells us how many pixels make up 1 mm. After the calibration process we can easily find out the distance between to landmarks chosen. The result of the measurements are saved by the software and than they may be exported in a statistical soft, to analyze the data.

The advantages of the calibration process consist in the fact that the image acquisition is not restricted by determined exposure distances and zoom. It only requires a trustable scale in the photograph.

We measured 19 morphometric characters presented in figure 2.

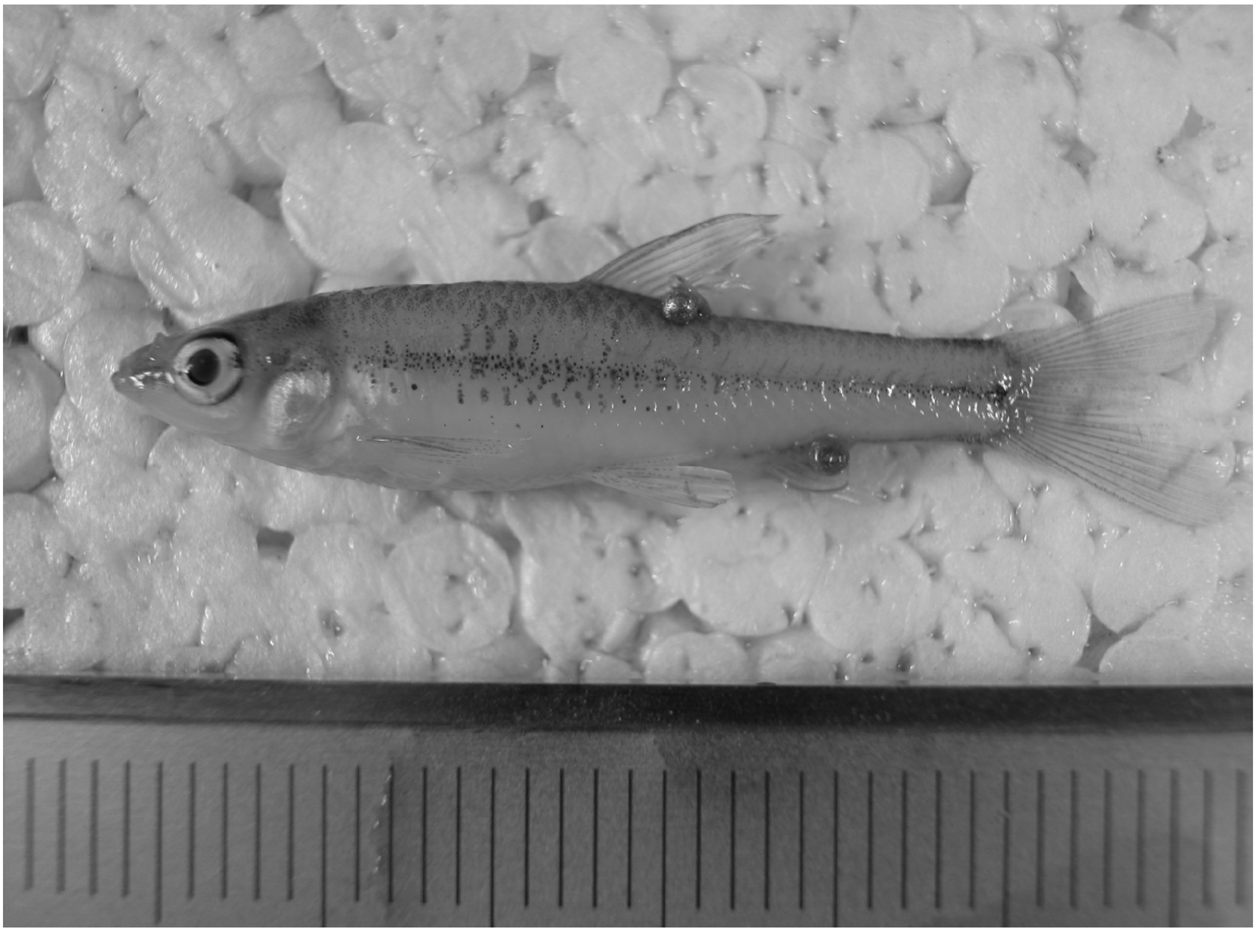

Figure 1. *Pseudorasbora parva* photographed for image analyzing with Impor.

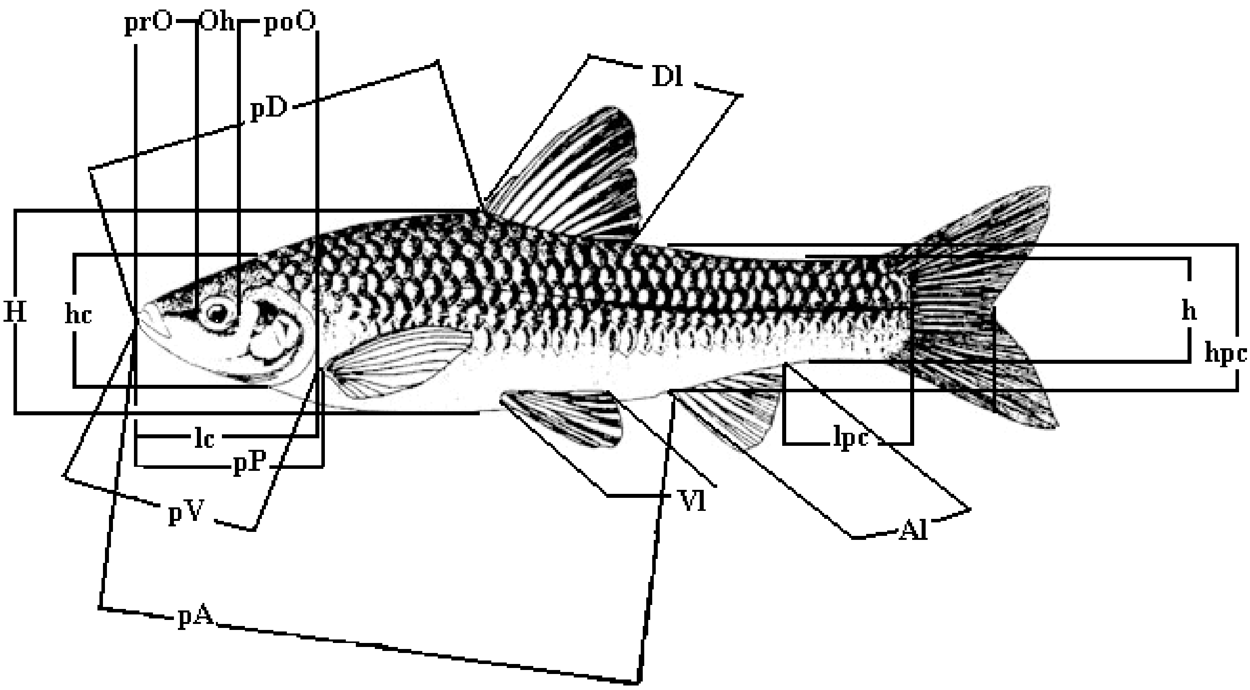

Figure 2. The measured characters.

The statistical analysis of the obtained data was carried out conform the triple regression methodology described by Tomecek (2005).

Our aim was not only to exemplify a new measurement method, but also a relatively new statistical approach, as far as concerns fish morphometry at present in Romania.

The central concept of the triple regression approach is that the ontological development of the individual may be not only a linear progress, but it may present split points along the development process, where the rate at which a given character is developing can slow down or speed up. If we consider the relationship of shape and function, these split points may indicate a change in life history of the biota; a change in habitat use, food etc. (Kovac, 1987, 1999, 2005). The most spectacular example in this matter can be considered sexual maturation, the inset of sexual dimorphism.

By applying upon our data the triple regression methodology we hoped to identify such split points in the life history of our specie.

RESULTS AND DISCUSSIONS

From the 19 characters measured we found 10 to have a development best described by the linear regression, 4 to fit quadratic regression and in case of 5 characters we found break-points at different standard length, though best fitted by split-linear regression (Table 1).

Table 1. Results of triple regression analysis on the examined 19 characters (n = 45).

	R2	R2	R2	F-test	P	F-test	P	F-test	P	best	break point	SE
	linear	quadratic	split linear	Q/L		S/Q		S/L		fit		
lc	0.9823	0.9872	0.988706	16.07813	< 0.01	5.46739	< 0.05	11.62784	< 0.01	S	31.9	2.57
hc	0.9763	0.9788	0.979563	4.95283	< 0.05	1.531088	NS	3.273273	NS	Q	-	-
H	0.9652	0.9707	0.975217	7.883959	< 0.01	7.47339	< 0.01	8.286245	< 0.01	S	54.7	2.27
pD	0.9931	0.9932	0.993389	0.617647	NS	1.173068	NS	0.89663	NS	L	-	-
pA	0.9967	0.9968	0.996836	1.3125	NS	0.461858	NS	0.87877	NS	L	-	-
pV	0.9934	0.9934	0.995473	0	NS	18.76998	< 0.01	9.384989	< 0.01	S	62.0	1.41

	R2	R2	R2	F-test	P	F-test	P	F-test	P	best	break point	SE
	linear	quadratic	split linear	Q/L		S/Q		S/L		fit		
prO	0.9226	0.9308	0.933833	4.976879	< 0.05	1.879536	NS	3.480319	NS	Q	-	-
h	0.9652	0.9662	0.967064	1.242604	NS	1.076065	NS	1.16046	NS	L	-	-
lpc	0.9426	0.9572	0.958978	14.3271	< 0.01	1.777257	NS	8.184749	< 0.01	Q	-	-
Dl	0.9681	0.9685	0.969219	0.533333	NS	0.958346	NS	0.745575	NS	L	-	-
Al	0.9722	0.9732	0.972414	1.567164	NS	-1.1685	NS	0.158874	NS	L	-	-
Pl	0.9695	0.9704	0.96956	1.277027	NS	-1.1315	NS	0.040361	NS	L	-	-
Vl	0.9636	0.9689	0.970681	7.157556	< 0.05	2.491092	NS	4.951378	< 0.05	Q	-	-
poO	0.9633	0.9639	0.964021	0.698061	NS	0.137514	NS	0.41062	NS	L	-	-
Oh	0.8638	0.8729	0.865909	3.007081	NS	-2.13758	NS	0.322429	NS	L	-	-
io	0.9753	0.9765	0.976974	2.144681	NS	0.844405	NS	1.49057	NS	L	-	-
LACO	0.945	9472	0.945433	-42.0002	NS	-7116298	NS	0.162767	NS	L	-	-
LAC	0.9898	0.991	0.991921	5.6	<0.05	4.671243	< 0.05	5.380371	< 0.05	S	57.7	2.38
hpc	0.9758	0.9804	0.98283	9.857143	< 0.01	5.803509	< 0.05	8.394003	< 0.01	S	50.9	3.56

All the 19 characters were examined in relation to standard length.

The characters with a development of linear nature are: pre-dorsal distance (pD), pre-anal distance (pA), minimal body depth (h), length of the dorsal fin (Dl), length of the anal fin (Al), length of the pectoral fin (Pl), post-orbital distance (poO), eye diameter (Oh), inter-orbital distance (io) and maximal body width (LACO). If we represent the linear development graphically we will get a strait line as shown in case of pre-anal distance (pA) in figure 3. This means in fact, as the fish grows in length so does the pre-anal distance as well. The pre-anal distance - standard length ratio will remain unchanged during the development and life of the fish.

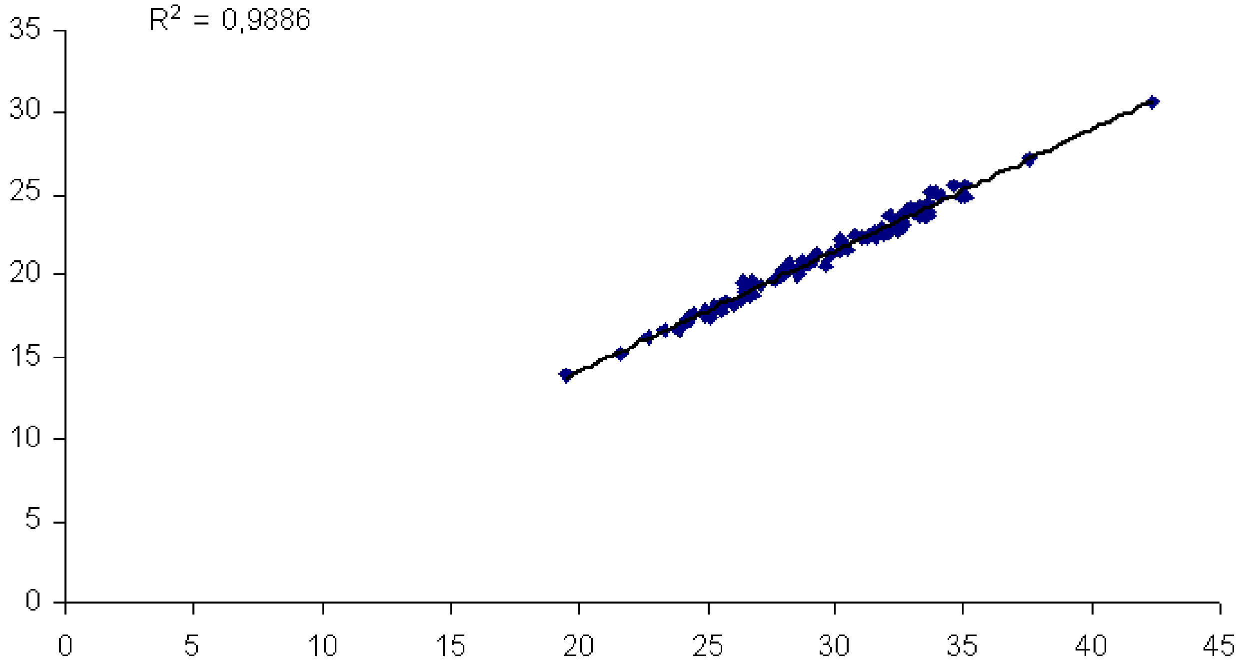

Figure 3. Linear regression in case of pre-anal distance.

The 4 characters fitted by the quadratic regression are: head depth (hc), pre-orbital distance (prO), length of caudal peduncle (lpc) and length of the ventral fin (Vl). We can see how does a quadratic development it presents in case of head depth, where this is of negative nature (Figure 4) - this character grows slower than standard length - or in case of length of caudal peduncle, where this is of positive nature (Figure 5) - this character grows faster than standard length.

The lines are curved, which means that the faster or slower growing trend will not last forever, or until our fish dies because it gets to old. Eventually the rate of development will set in a steady state; otherwise we would encounter fishes with diminishing heads as they get older and older or getting thinner and thinner.

In case of head length (lc), maximum body depth (H), pre-ventral distance (pV), maximal head width (LAC) and depth of caudal peduncle (hpc) we found the development to have break-points at different standard length. Actually this means that a character has a certain trend in development in relation with the changes of the standard length, than at certain point (certain standard length) the nature of its developments changes: it became slower or faster. If we presume form and function to go hand in hand, one determining the other, than the change in form may be considered as indicating a change in function. A change in form will indicate a change in function, thus a change in way of life, life history.

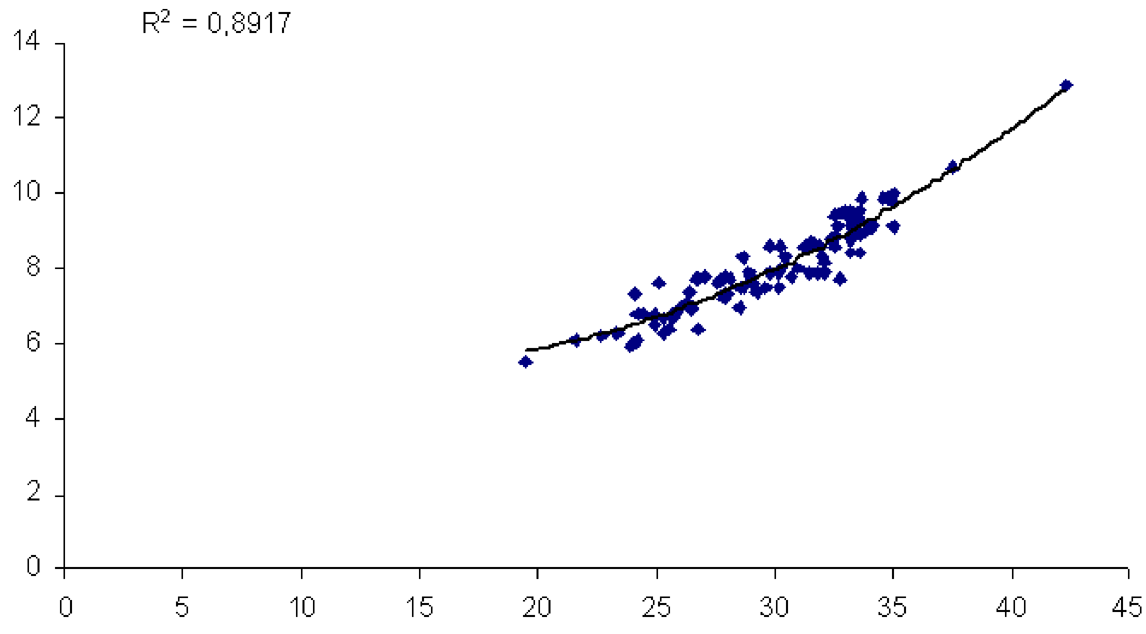

Figure 4. Quadratic regression in case of head depth.

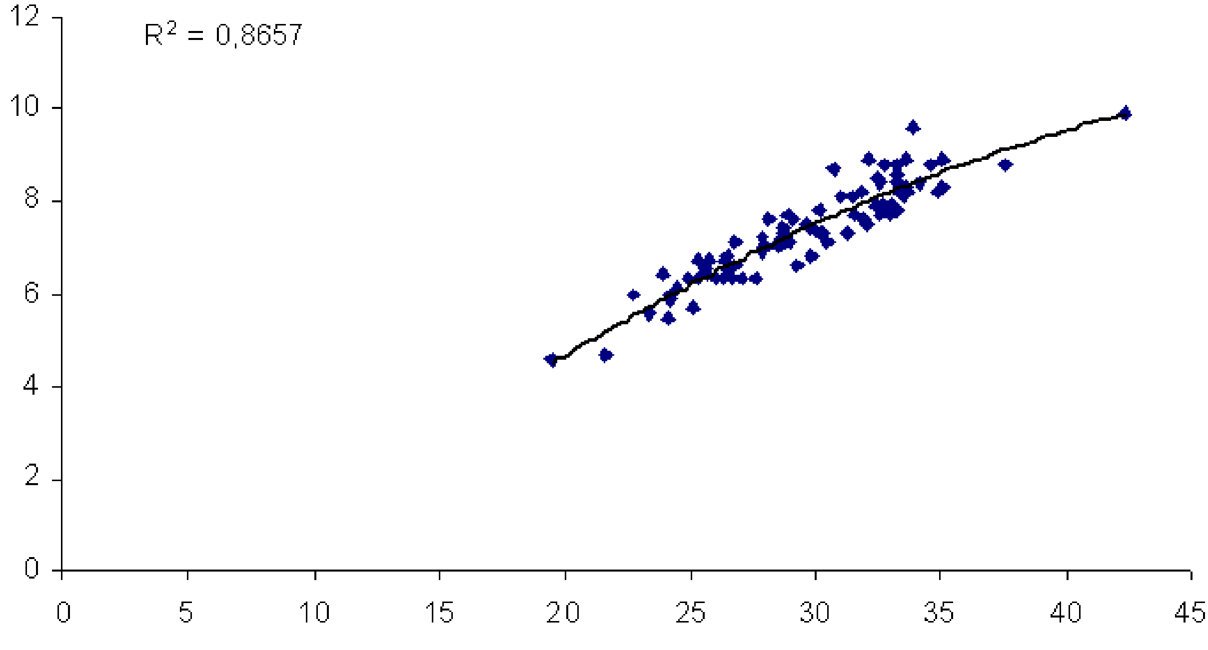

Figure 5. Quadratic regression in case of length of caudal peduncle.

In the case of our sample we found the break-points to be present in two groups. One period with such break-point occurs around a SL of 30 mm, while another period of changes seams to be at 50 - 60 mm SL.

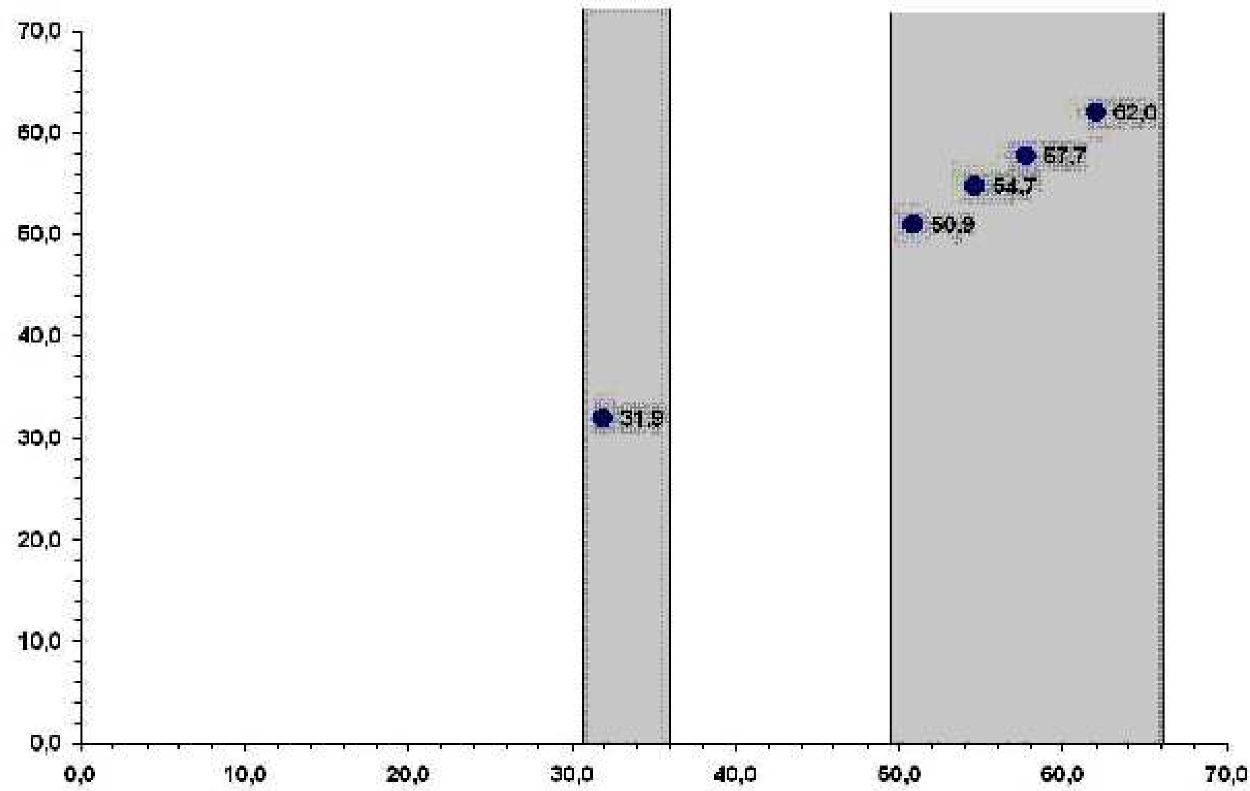

Figure 6. Distribution of break-points according to SL.

CONCLUSIONS

This paper aim is to present an alternative method in fish morphometry, for those which did not stop seeking methods to make they work easier, much more pleasant and the results more reliable.

We consider the digital image acquisition and analysis presented above to satisfy our expectations. It makes possible handling of extremly small individuals, which otherwise are almost imposible to be used in morphometric studies. It provides extremly accurate measuments.

The measurement of a large number of characters is imposible in field. Fishes must be conservated, mostly in formaldehyde. The method enable us to take a picture of the fish, release it and to work in the lab with the picture, without to have to endure the toxic effects of the formaldehyde.

There are some negative points regarding the method. There are measurements which can not be carried out on two dimensional pictures, (eg. body perimeter). When taking pictures of the fishes shadows may interfer. One should pay extra attention to the light and shadows. If there are characters more difficult to capture, they should be pointed out with accesories, like needles for example, to hold the fins apart from the body. If working with live animals one should pay attention not to hurt them. It is important to take the pictures perpendicular to the fish, otherwise our data will be altered.

Regarding triple regression our aim was, as in case of the morphometrical methodology as well, to present and exemplify a statisctical tool. Even if the number of individuals we worked with is small (only 45), we managed to find break-points in the development of 5 out of 19 characters.

We consider triple regression to be an usefull statistical tool especially in preliminary studies. It may be an usefull guide to identify interesting moments in the life of the individuals (life history of the specie), when may occur a change in habitat, food, reproduction, etc.

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AUTHORS:

[1] *István FALKA*
biologie@dam.rowater.ro
The National Administration
of Romanian Waters,
Str. Samuel Koteles, no. 33,
Târgu Mureş, Mureş County, Romania,
RO - 540057.

[2] *Ioan BUD*
ioanbud2000@yahoo.com
University of Agricultural Science
and Veterinary Medicine,
Pisciculture,
Mănăştur St., no. 3 - 5,
Cluj-Napoca, Cluj County, Romania,
RO - 400372.

[3.] *Ionel-Claudiu GAVRILOAIE*
ionelclaudiu@yahoo.com
University of Bucharest,
Faculty of Biology,
Splaiul Independenței, no. 91 - 95, sector 5,
Bucharest, Romania,
RO - 050095.

SEXUAL MATURATION OF THE INDUSTRIAL VALUABLE SPECIES OF FISH FEMALES UNDER MODIFIED CONDITIONS OF DUBĂSAR WATER ACCUMULATION RESERVOIR

Nina FULGA [1] and *Olga KISELIOVA* [1]

KEYWORDS: gonad maturity stage, spawning, water accumulation reservoir, *Lucioperca lucioperca*, *Abramis brama*, *Abramis sapa*, *Rutilus rutilus heckeli*, *Carassius auratus gibelio*.

ABSTRACT

There is given the morpho-functional characteristics of the females' gonads in *Lucioperca lucioperca*, *Abramis brama*, *Abramis sapa*, *Rutilus rutilus heckeli* and *Carassius auratus gibelio* during the sexual maturation under modified conditions of the Dubasar water accumulation reservoir.

There was revealed that sexual maturation in females of the investigated species occurs in the elder age and at the smaller body weight. There are elucidated disorders in the oocytes structure during the vitellogenesis and spawning shift to the later calendar terms.

REZUMAT: Maturizarea sexuală la femelele speciilor industriale de peşti în condiții modificate ale lacului de acumulare Dubăsari.

În lucrare este prezentată caracteristica morfo-funcțională a gonadelor la femele de *Lucioperca lucioperca*, *Abramis brama*, *Abramis sapa*, *Rutilus rutilus heckeli* şi *Carassius auratus gibelio* în proces de maturizare sexuală în condiții modificate ale lacului de acumulare Dubăsari.

A fost evidențiat faptul că maturizarea sexuală la femelele speciilor investigate de peşti are loc la vârsta mai mare şi la greutatea mai mică. Sunt elucidate dereglări în structura oocitelor pe parcursul perioadei de vitelogeneză şi deplasarea perioadei de depunerea icrelor pe o perioadă mai târzie.

RESUME: Maturation sexuelle des femelles chez des espèces de poissons d'intérêt économique dans les conditions changeantes du réservoir de Dubăsari.

Cette étude présente les caractéristiques morpho-fonctionelles des gonades chez les femelles de *Lucioperca lucioperca*, *Abramis brama*, *Abramis sapa*, *Rutilus rutilus heckeli* et *Carassius auratus gibelio* au cours de la maturation sexuelle d'individus soumis aux conditions environnementales changeantes du réservoir de Dubăsari.

Nous avons établi que la maturation sexuelle des femelles des espèces étudiées est atteinte pour des femelles plus âgées et présentant un poids du corps plus petit que ce qui est généralement observé par ailleurs On relève également des dérèglements dans la structure des oocytes pendant la période de vitelogenèse et un déplacement de la période de depôt des oeufs vers des périodes plus tardives.

INTRODUCTION

As it has been shown during numerous studies (Butskaya, Neiolova, 1960; Kazanskii, 1975; Koshelev, 1984) the modifications in the reproductive system development have a particular significance for reproduction and numeral fluctuations in fish under permanent modifying environmental conditions. The main direction of fish reproductive adaptation under changeable environmental, and first of all, hydrological conditions reveals in modification of gametogenesis character, age of sexual maturation, number of released portions of eggs, spawning time shift, etc., that vary at different fish species. We adduce data on the character of sexual cells development in valuable fish species during the process of their sexual maturation after Nistru control structure construction.

MATERIALS AND METHODS

As a gonads investigation material there have served immature females of *Lucioperca lucioperca*, *Abramis brama*, *Abramis sapa*, *Rutilus r. heckeli*, *Carassius auratus gibelio*, collected during 1995 - 2000. 275 have been investigated histologically, being previously fixed in the Buen solution with further treatment according to the generally recognized method. The gonads' maturity stages were determined by Meyen with specification by Sakun and Butskaia (1963), and the grade of oocytes development according to the Kazanskii (1949) classification. The oocytes diameters on the different development stages were determined with the aid of ocular micrometer.

RESULTS AND DISCUSSIONS

Lucioperca lucioperca. Actually 3 years old females (2+) with body length 28.5 - 30.0 cm and weight 198.0 - 292.0 g. have gonads on the I stage of maturity. The oocytes with diameter 134.0 - 149.0 mkm are on the early phase of the protoplasmic growth period. At the same time in the ovary could be found oogonia in process of division and oocytes on the phase of synaptene path. Previous research (Statova, 1962) has demonstrated that the I stage of maturity was characteristic for females with body weight 175.0 - 205.0 g. and 2 years (1+). It is evidence of the longer lasting of the I stage of gonads maturity in females under modified conditions of the Dubăsar water accumulation reservoir.

In majority of cases the transfer of gonads to the II stage starts in females in the age of 3 years old (2+) with the body weight 250.0 - 295.0 g. The ovary is mostly filled by the oocytes with diameter 134.0 - 164.0 mkm, finalizing their protoplasmic growth. The length of the II maturity stage at the major part of females gonads lasts up to 4 years old (3+), at some - up to 5 years old (4+), thus longer than one year.

According to the data of Statova (1962) the gonads transfer to the II stage of maturity occurs at 2 years old females (1+) and continues up to 3 (2+), in rare cases up to 4 years (3+), with body weight 350.0 - 475.0 g. and 540.0 - 670.0 g. correspondingly. The age of II stage of maturity reaching and its length determines the age of sexual maturity in females and represents the main reason of the weight heterogeneity in underyearlings.

In the second half of August the gonads of 4 years old (3+) females transfer to the III maturity stage, that lasts 2 - 2.5 months, i.e. till the October end. The oocytes dimensions reach in diameter 210.0 - 590. mkm. Previously during the transfer of gonads to the III stage of maturity the oocytes diameter constituted 234.0 - 583.0 mkm (Statova, 1962).

Actually, at females reaching maturity the first time the vitellogenesis process in oocytes starts earlier, than it has been revealed in previous investigations (Karlov, 1975). In this case the main role plays the temperature. As the result of decreased temperature in the water accumulation reservoir the gonads transfer to the III maturity stage starts from October and lasts for 5 months, in contrast to the earlier research, when the III maturity stage occurred in November and lasted for 4 months (Karlov, 1975).

At the age of 4 years old the gonads of immature females with the body weight of 575.0 - 710.0 g. transfer to the VI completed maturity stage and are characterized by the phase of oocytes filled up with vitelline, and their diameter reaches 736.0 - 790.0 mkm. According to the data of Statova (1962) the weight of 4 years old females varied 600.0 - 985.0 g., while the oocytes diameter at that gonads maturity stage was 825 - 850.0 mkm. The decrease in body weight at the females that reach sexual maturity for the first time causes the decrease of the oocytes dimensions, and consequently to the lower level of nutritive substances, necessary for embryos development, accumulation in them.

From the undertaken analysis of the sexual cells development in the immature females of pike perch during the period of 1993 - 2000 in comparison to 1956 - 1980, there has been revealed that actually the pike perch females become sexually mature being 4 and 5 years old, while during previous period they became sexually mature at 3 and 4 years old. The later sexual maturity in now-days females occurs due to the extension of the protoplasmic growth oocytes development, and as the result the completing of the II maturity stage in some females lasts till 4, but in others till 5 years old.

After spawning at females together with the processes of follicular membranes and unreleased oocytes resorption that lasts for month, the ovary contains the whole complex of oocytes at the II stage of maturity.

It is necessary to mention that last years research has demonstrated significant disorders in the oocytes development during winter-spring, when the water temperature in the Dubăsar water accumulation reservoir was higher during the winter and lower during the spring in comparison with the same periods before the Nistru control structure construction. Disorders in the sexual cells development in some females consist in own membrane swelling along the whole oocyte perimeter (Figure 1), while in others - in the damage of the cortical vacuoles integrity and fusion of their contents in a homogenous mass. Oocytes with such changes in the development are able to ovulate, while their fertilization rate decreases, that has negative influence on the reproductive ability of this species.

Abramis brama. Immature females with the weight of 300 - 330 g, being almost 4 years old (3+) have gonads on the I - II and II stages of maturity. The transition of oocytes from the stage of protoplasmic growth to the trophoplasmic growth occurs asynchronously. There could be met females with the gonads on the III stage of maturity, being as 4 years old (3+) as well 5 years old (4+) with the body weight 270.0 - 290.0 g and 600.0 - 824.0 g correspondingly. During the first years of Dubăsar water accumulation reservoir existence the immature females of bream had body weight 320.0 - 415.0 g. (Zelenin, 1960).

The dimensions of oocytes on the phase of vacuolization vary within 163.0 - 213.0 mkm. Asynchrony in their development is revealed also during period of vitelline granules accumulation in cytoplasm. The transfer to the vitellogenesis takes place in autumn and continues till the next year spring. During this period there occurs synchronization of the sexual cells development and the major mass of gonads is constituted from the one generation oocytes. As the result the sexual maturity of bream according to our data occurs at the age of 5 years with body weight 810.0 - 900.0 g. According to the data of Zelenin (1960), during previous years the majority of bream females from the Dubasar water accumulation reservoir reached sexual maturity being 4 years old with body weight 700.0 - 1000 g. According to the histological research the mass bream spawning starts on the second decade of May and lasts till the middle of June. After spawning season, in the second part of June the ovaries transfer to the II - III maturity stage. Together with the oocytes of the protoplasmic growth period there are present oocytes on the beginning of cytoplasm vacuolization stage. Simultaneously with the development of the new generation oocytes the follicular membranes and unreleased oocytes resorption takes place.

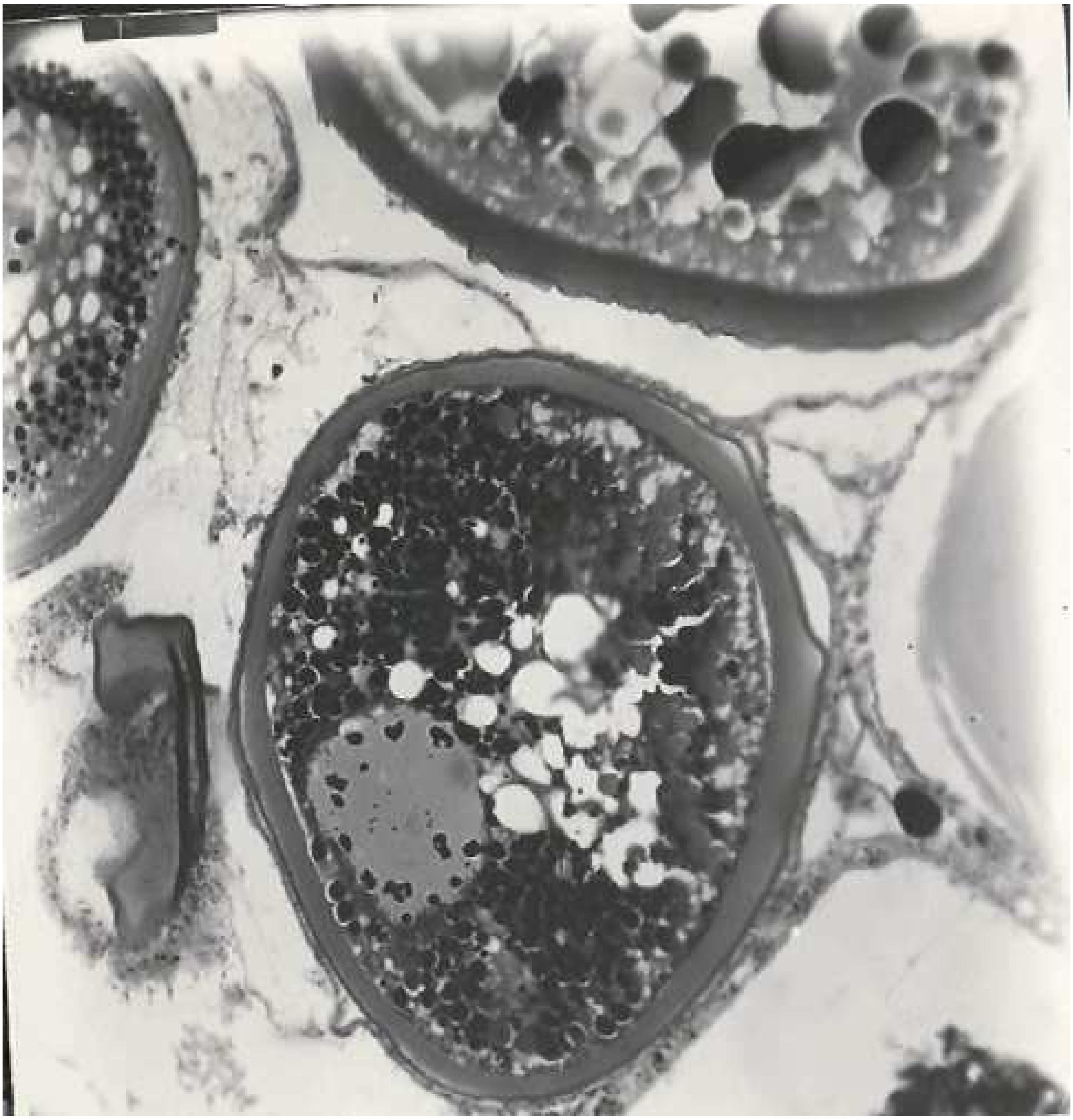

Figure 1. Degenerative changes in vitellogene oocytes in the females of *Lucioperca lucioperca*. Own membrane swelling along the whole oocyte perimeter.

Abramis sapa In immature females with body length 18.5 - 20.0 cm and body weight 80.0 - 128.0 g. the I stage of maturity lasts up to the beginning of the 3rd - 4th year of life. The gonads transfer to the II maturity stage occurs on 3rd - 4th year of life. The main part of ovary is constituted from the single-layered follicle oocytes with diameter 177.0 - 248.0 mkm. Fewer in number the synaptene path oocytes could be found. In order to make a comparison we would like to mention that before the Nistru electro-power station construction the I stage of gonads maturity occurred in females being 2 - 3 years old, but on the 3 - 4 years old their gonads transferred to the II maturity stage (Zelenin, Vladimirov, 1971).

At the beginning of 4th - 5th years of females' life, in June, oocytes start the vacuolization phase, but gonads transfer to the III maturity stage. As the result of asynchronous development of sexual cells, their dimensions on the initial phases of vacuolization (D_1 - D_2) vary within 280 - 312.0 mkm, while at those, which finalize the vacuolization (D_3) - 582.0 - 639.0 mkm.

During the autumn the gonads of 4 and 5 years old females (3+, 4+) transfer to the IV maturity stage, while the oocytes to the beginning of the vitelline accumulation (D_4) phase. This process lasts till the next year spring. During this period the oocytes on the initial phase of vacuolization reach in the growth the larger ones and their further development occurs synchronized. In October the immature females with body weight of 240.0 - 276.0 g. have gonads on the incomplete IV stage of maturity.

Thus, actually the *Abramis sapa* females reach sexual maturity being 4 - 5 years old, and their spawning period changed to later time (first half of May).

In previous years the *Abramis sapa* females from the Dubăsar water accumulation reservoir became sexually mature being 4 years old, while their spawning began in the first half of April (Zelenin, Vladimirov,1971).

After spawning the gonads transfer to the IV - II stage of maturity. In the ovary together with the protoplasmic growth oocytes and follicular membranes undergoing resorption, occur oocytes in the cytoplast vacuolization beginning phase.

Rutilus rutilus heckeli The gonads of the present one year old species females are constituted from oogonia and oocytes groups, on the different phases of the synaptene path. The juvinis form in the oocytes development that corresponds to the I maturity stage of gonads lasts 2 years. The oocytes transfer to the phase of single-layered follicle takes place gradually. In 3 years old (2+) females gonads are on the II maturity stage. The oocytes diameter varies within 191.0 - 227.0 mkm.

In the end of July of the 4^{th} year of life (3+) the females sexual cells enter the period of trophoplasmic growth, while the gonads transfer to the III stage of maturity. The oocytes development during the vacuolization period takes place asynchronously. In the ovary there are present simultaneously the oocytes of all vacuolization phases (D_1 - D_3). Sexual cells, which enter the vacuolization phase have a diameter of 220.0 - 225.0 mkm, but in the end of this process reaches 320.0 - 334.0 mkm. In autumn period (October) the oocytes enter the vitellogenesis phase. During this process in the gonads there are present as oocytes on the phase of initial vitelline accumulation, as well oocytes on the phase of intense vitellogenesis. And only to the spring of the next year sexual cells synchronize their development and single generation of oocytes is ready to be released.

During the prespawning period (April - May) the females' gonads are on the IV stage. In the phase of completed vitellogenesis (E), oocytes reach 880.0 - 960.0 mkm in diameter.

According to the undertaken histological research females become sexually mature for the first time at the age of 4 full years (4) with the body weight of 178.0 - 254.0 g, and their spawning occurs in the first decade of May.

During the first years after Dubăsar water accumulation reservoir construction the sexual maturity in *Rutilus rutilus heckeli* females occurred at the age of 2 years old, while the spawning began in the middle of April and lasted till the middle of May (Chepurnova, 1972).

In the first days of May gonads transfer to the V stage of maturity, and oocytes to the stage of maturation. The nucleus is situated near the animal pole, while nucleoli are concentrated in the center of nucleus. The oocytes dimensions reach in diameter 1093 - 1120 mkm.

Starting from the third decade of May in control samples could be found females after spawning with gonads on the VI - II stage of maturity, whose ovaries contain beside the protoplasmic growth oocytes and empty follicular membranes and unreleased oocytes on the stage of resorption. Actually in 30% of investigated females there are observed degenerative changes in oocytes of the intensive vitellogenesis, evidenced by own oocyte membrane swelling, damage of cortical vacuoles integrity and submergence of their contents in the vitelline mass. (Figure 2.).

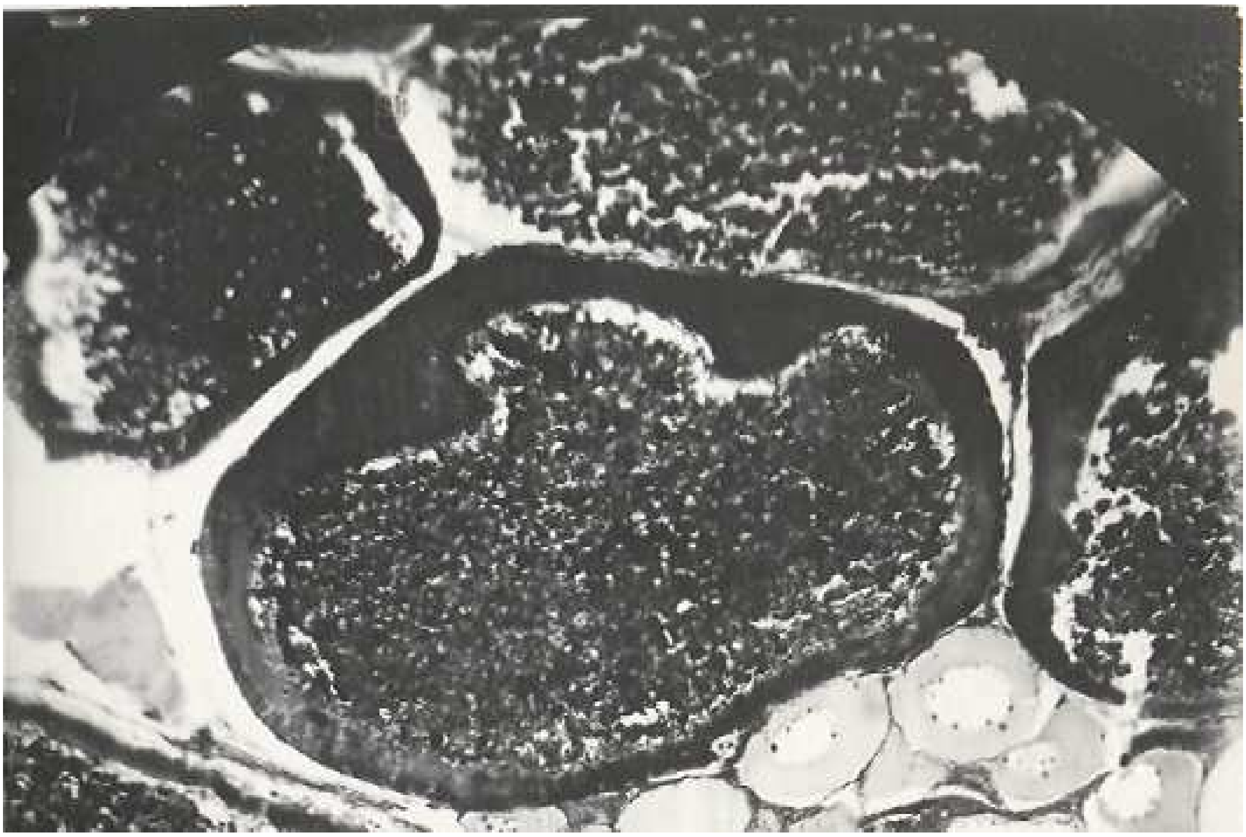

Figure 2. The ovary fragment in *Rutilus rutilus heckeli* with oocytes undergoing resorption process. Own oocyte membrane swelling, damage of cortical vacuoles integrity and submergence of their contents in the vitelline mass.

Carassius auratus gibelio The characteristic peculiarity of the oocytes' development in the continuous asynchrony in the protoplasmic growth phases. As the result it is impossible to determine the typical for other fish species II stage of maturity in gonads. In our research immature females with the gonads on the II - III stage of maturity were met at the end of June in the beginning of the third year of life. At the end of the month of September of the same year females being 3 years old (2+) with the body weight 100 - 180 g. have gonads on the III stage of maturity. The vacuolated oocytes at the trophoplasmic growth period beginning reach 350 - 459 mkm in diameter. According to the data of Statova (1966) during the first years of Dubasar water accumulation reservoir immature females being 3 years old (2+) had average body weight 390.0 g.

In the end of October gonads contain oocytes on all phases of vacuolization and on the beginning of the vitelline granules accumulation (D_1 - D_3, D_4). Such oocytes composition corresponds to the transition to the III - IV maturity stage of gonads. Together with the further decrease of water temperature in the water accumulation reservoir in the oocytes reduces and gradually ceases the nutritive substances accumulation.

For the first time females with gonads on the IV maturity stage are met in control samples being 2 - 3 years old, while according to the data of (1966) their average weight at the same age constituted 506.0 g. Our research has demonstrated that under modified conditions of the Dubăsar water accumulation reservoir the females that reach sexual maturity for the first time are as in previous years 2 - 3 years old, but their weight is lower.

In the second decade of May, after the release of the first portion of eggs, and simultaneously with the resorption of the vestigial elements, in the new generation of oocytes there takes place the intensive vitellogenesis process. Gonads transfer to the IV_2 maturity stage and the second portion of eggs gets ready to be released. In June, after second spawning season, females' gonads are on the IV_3 maturity stage. In spite of the short period of time oocytes reach the definitive dimensions and till the end of June the third generation of oocytes gets ready to release. But due to the lack of the temperature conditions the third portion of the eggs is not released. This fact is confirmed by the presence of vitellogenous oocytes in the stage of resorption in gonads in August (Figure 3).

Figure 3. Ovary *Carassius auratus gibelio* on the IV_3 stage of gonads maturity.
The total resorption of the third generation oocytes (August).

In the last years (Statova, 1966; Fulga, 1992) *Carassius a. g.* from the Dubăsar water accumulation reservoir released 3 eggs portions. As the result of midified environmental conditions after the Nistru dam construction in 60% of investigated carp females the vitellogenous oocytes were with degenerative modifications. At some there takes place the own membrane swelling along the whole diameter of oocyte, at others - damage of cortical vacuoles and fusion of their contents into the homogenous mass. Oocytes with such kind of disorders are able to ovulate, but at the same time reduces the rate of their fertilization or there occur some disorders in the process of embryo development, that negatively influence on the reproductive ability of this species in general.

CONCLUSIONS

After the Nistru hydro-electro power station construction at all females of the investigated fish species there took place the increase of the age of sexual maturity and spawning shift in females to the later terms, that leads to the reduce of vegetative period of the fish young.

Actually the sexual maturity in all investigated females occurs at the smaller body weight, that leads to the decrease of the oocytes dimensions and consequently to the lower level of nutritive substances accumulation in them, that is significant for the embryos development.

At some females of *Lucioperca lucioperca*, *Rutilus rutilus heckeli* during the prespawning period there were evidenced the degenerative modifications that decrease their fertilization ability, but in *Carassius carassius gibelio* in the lack of favorable conditions for spawning the release of the third generation of oocytes doesn't occur that negatively influences on the species reproduction in general.

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AUTHORS:

[1] *Nina FULGA*
okiseliova@yahoo.com
[1] *Olga KISELIOVA*
okiseliova@yahoo.com
Institute of Zoology,
Academy of Sciences of Moldova,
Academiei St., no. 1,
Chişinău, Chişinău County, Republic of Moldova,
MD - 2028.

ROMANIAN RESEARCHES ON THE SPECIES *LEPOMIS GIBBOSUS* (LINNAEUS, 1758) (PISCES, CENTRARCHIDAE)

Ionel C. GAVRILOAIE [1], *Lotus MEŞTER* [1] and *Istvan FALKA* [2]

KEYWORDS: pumpkinseed sunfish, biology researches, Romania.

ABSTRACT

Lepomis gibbosus belongs to the family Centrarchidae, native to North America.

The pumpkinseed sunfish was introduced to Europe firstly in France (1887) and Germany (1890) as an ornamental fish. In our country, it was recorded for the first time in 1929.

At present, the pumpkinseed sunfish is recorded in almost all the limnic ecosystems from our country and in lower basin of rivers, especially in former river channels.

Within the framework of this study, we analyzed, following the order of their publication, all the important materials we could find, published in Romania, regarding the species *Lepomis gibbosus*.

Various aspects of the species biology were studied along the time by many researches, but more data can be added on the knowledge of the biology of pumpkinseed sunfish in our country.

REZUMAT: Cercetări româneşti asupra speciei *Lepomis gibbosus* (Linnaeus, 1758) (Pisces, Centrarchidae)

Lepomis gibbosus aparține familiei Centrarchidae, nativă în America de Nord.

Bibanul soare a fost introdus in Europa mai întâi în Franța (1887) şi Germania (1890), ca peşte ornamental. În țara noastră a fost semnalat pentru prima dată în 1929.

În prezent, bibanul soare poate fi găsit în aproape toate ecosistemele limnice din România şi în cursul inferior al râurilor, mai ales pe brațele moarte.

În cadrul acestui studiu am analizat, în ordinea apariției lor, toate lucrările importante apărute la noi, în legătură cu specia *Lepomis gibbosus*. Aspecte variate ale biologiei acestei specii au fost studiate de-a lungul timpului de numeroşi cercetători, însă toate aceste cercetări pot fi aprofundate.

RESUME: Recherches roumaines sur l'espèce *Lepomis gibbosus* (Linnaeus, 1758) (Pisces, Centrarchidae)

Lepomis gibbosus fait partie de la famille des *Centrarchidae*, provenant d'Amerique du Nord.

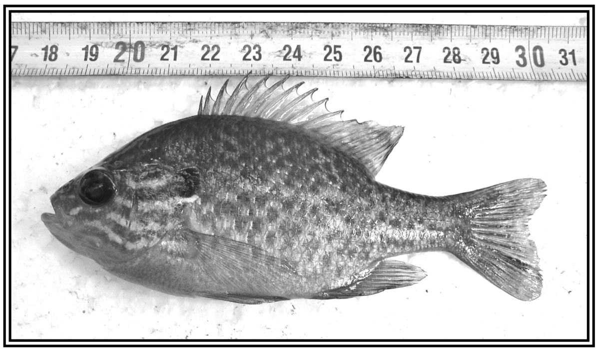
La carpe-soleil a été introduite en Europe, pour la première fois en France (1887), puis en Allemagne (1890), comme poisson ornemental. Dans notre pays, ellel a été signalée pour la première fois en 1929.

A présent, elle peut être trouvée dans presque tous les ecosystèmes limniques de Roumanie ainsi que dans le cours inférieur des rivières, surtout dans les bras morts.

Dans ce travail nous avons analysé, de manière chronologique, tous les travaux importants parus en Roumanie. Pendant de nombreuses, années différents aspects de la biologie de cette espèce ont été étudiés par différents auteurs, cependant ces recherches peuvent être approfondies.

INTRODUCTION

The species *Lepomis gibbosus* (see picture) belongs to the family Centrarchidae, native to North America, in the upper basin of the Atlantic Ocean from St. Laurent to South Carolina (Bănărescu, 1964).



The pumpkinseed sunfish was introduced to Europe firstly in France (in 1887) and Germany (1890) as an ornamental fish. From Germany, it spread through the Rhine, the Oder and the Danube toward the eastern Europe. In Bulgaria, it was recorded in 1921 in Svisciova pond which has a link with the Danube (Cărăuşu, 1952).

In our country, it was recorded for the first time by Buşniţă (1929). Since then, it spread in all the ponds of the flooding zone and the lower basin of the tributaries ot the Danube and even in some littoral lakes (Popovici, 1942). At present, the pumpkinseed sunfish is recorded in almost all the limnic ecosystems from our country (with the exception of the mountainous ones) and in lower basin of rivers, especially in former river channels. Fish-owners contributed to its spreading. Being a beautiful fish, it was often kept in captivity, then released in ponds, quite often in new places, thus extending its areal.

MATERIALS AND METHODS

In this study, we analyzed, following the order of their publication, all the materials we could find, published in our country, regarding the species *Lepomis gibbosus*. We could not investigate them all, but the most significant were included in our study. In order to gather all the papers discussed here, we needed three years of work in various libraries from Bucharest and from Bistriţa, Cluj-Napoca and the Station for Research and Development of Pisciculture Nucet-Dâmboviţa and, also, numerous second-hand bookshops. We think such paper is useful and greatly facilitates the investigations on certain species.

RESULTS AND DISCUSSIONS

The first record regarding the presence of our species belongs to T. Buşniţă in 1929: in August, two individuals of *Lepomis gibbosus* were caught in Sarieru Lake, near Giurgiu. The author erroneously identifies the species as *Micropterus salmoides* and presents the way it spread in Europe and some data on its biology. Then, he describes quite sketchily, from a morphological point of view, the individuals of pumpkinseed sunfish captured in Sarieru.

Subsequently, M. Dumitriu (1931) records the presence of the pumpkinseed sunfish at Greaca Lake and makes a detailed description of the species. He also points out that this species (the author uses the name *Pomotis vulgaris*) has not use in the pisciculture and is just an ornamental fish for the fish-owners.

In 1934, C. S. Antonescu mentions and describes summarily the pumpkinseed sunfish in his work "Fishes of inland waters from Romania". In the same year, professor Ion Borcea from Iaşi writes the first detailed work on *Eupomotis gibbosus.* The author describes the way the species was introduced in Europe from USA and describes it in detail, recording new areas occupied by the species in our country and data concerning the reproductive biology of the pumpkinseed sunfish (data quoted in the foreign literature) and, for the first time in our country, talks about restraining the spreading of the species in the Romanian waters as it consumes eggs and fry from valuable fishes.

In 1938, C. S. Antonescu records the presence of two new fish species, the pumpkinseed sunfish - *Eupomotis gibbosus* and the American Catfish - *Amiurus nebulosus* in our country. Concerning the pumpkinseed sunfish, the author establishes its systematic position describing its morphology and gives some data about its biology, mentioning that both male and female guard the eggs and the fry in turn. There is no mention in the literature, to such care for the eggs and fry and we did not notice it in our field or laboratory studies. Than, the author describes how the pumpkinseed sunfish was introduced in Europe and how it reached the Romanian waters and gives new localities from our country.

In 1942, Popovici records the presence of the pumpkinseed sunfish (the author uses the name *Eupomotis aureus*) in the littoral lake Tăbăcăria, nearby Constanța, and discusses the way it penetrated in this zone. Under certain circumstances, great amounts of freshwater fishes (*Cyprinus carpio, Blicca bjoerkna, Abramis brama, Perca fluviatilis* and other species) are taken by a marine current from the Danube Delta on a North-South direction and transported down the coast, sometimes reaching Mangalia. Tăbăcăria Lake is linked to the Black Sea by an 80 m channel and through this channel the pumpkinseed sunfish brought from the Danube by the marine current, entered the lake.

Also in 1942, the Academician Mihai Băcescu published a very important study on the pumpkinseed sunfish. The paper describes the species biology and morphology, then the origin and spreading of the species. The author discusses in detail about the appearance and the spreading of this fish in Romanian waters. He points out that the first Romanian naturalist who saw individuals of pumpkinseed sunfish (individuals brought from the Vlaşca zone) was Grigore Antipa in 1918, so 11 years earlier than the first recording of the species in our waters (the paper from 1929 of T. Buşniță). The main aim of the study made by Băcescu was to point out the way this species was regarded by the common people and so, he gave no less than 13 common names for this fish from different regions of the country.

In 1943, M. Băcescu resumes his 1942 study on the pumpkinseed sunfish and adds new observations concerning the way it spread in Romanian waters.

In 1946, G. D. Vasiliu gave some data taken from previous Romanian works on the pumpkinseed sunfish while P. Bănărescu, in a paper concerning the fishes from the area of Timişoara, records there the presence of our species. The author gives, for the first time in Romanian literature, data about the parasites of this species, mentioning a species of the genus *Lernaea*, taken by the pumpkinseed sunfish from the perch (*Perca fluviatilis*).

In 1947, M. Băcescu writes its well-known work *"Fishes, as they are seen by the Romanian peasant angler"* and makes some comments about the way the pumpkinseed sunfish entered and spread in the Romanian waters and about some common names from various zones of our country.

S. Cărăuşu, in 1952, in his *"Ichthyological treaty"* makes some references about the pumpkinseed sunfish but without adding any new data. Still, this is the first time when in the Romanian scientific literature is used the scientific name *Lepomis gibbosus* instead of *Eupomotis* (or *Pomotis*) *gibbosus.*

In 1955, Elena Roman adds important new data about the parasites of the fishes from Danube River. She discusses in detail, among others, about the parasites of the pumpkinseed sunfish from the Danube and shows that, although in North America it has 40 species of parasites, in the Danube River this number decreases to 13, two of these species coming from America (the species *Urocleidus dispar* and *Urocleidus similis*). These two new species were found only on the *Lepomis giboosus* and no other fish from the Danube River.

In 1956, T. Nalbant records the presence of *Lepomis gibbosus* in the lower part of Dâmbovița River, especially around Bucharest and 8 km up-stream of the city.

A series of works concerning the fishes from Romanian waters follows: C. S. Antonescu in 1957, G. D. Vasiliu in 1959, and, in 1963, T. Buşniţă and I. Alexandrescu, but they do not add anything new to the previous publications.

P. Bănărescu and collaborators (1960) add new contributions to the study of the feshwater ichthyofauna of our country and record the species *Lepomis gibbosus* in Crişul Repede River at Toboliu, in Berzasca River (a tributary of the Danube) and in Ialomiţa River.

P. Bănărescu (1964), in his exceptional work concerning the bony fishes from the Romanian fauna, describes in detail the species *Lepomis gibbosus*, giving many data concerning the morphology, ecology, economic importance and spreading of the species. He also comments on the parasites found on the pumpkinseed sunfishes from our waters.

A very important work is published in 1967 by P. Spătaru concerning the feeding of the pumpkinseed sunfish. The author analyses the feeding and trophic relations of the species *Lepomis gibbosus* in the ponds Crapina - Jijila (the flooding zone of the Danube) and draws the conclusion the pumpkinseed sunfish does not compete with more valuable fish species and it seems the species consumes its own fry. But, as the author specifies, the material investigated is insufficient: only 60 individuals, with sizes of 6.3 and 12.4 cm, collected during 6 months (February, March, April, June, July, September).

In the same year (1967), M. Papadopol and G. Ignat add some contributions to the knowledge ot the reproductive biology of the pumpkinseed sunfish in the Lower Danube, noting that both males and females became sexually mature en masse at a standard length of 55 - 60 mm and a weight of 6 - 8 g, reached in their third summer (II +), at an age of 2 years. Also, the females of the pumpkinseed sunfish have a high fertility, both absolute and relative, taking into account their size and age. The linear growth of the *Lepomis gibbosus* individuals is relatively slow, being more intense, just like at other fish species, in the year preceding the sexual maturity. The authors point out that the relatively fast spreading of the pumpkinseed sunfish in Romanian waters was enhanced by the high reproductive poential of the species (precocious sexual maturity of both sexes, high absolute and relative fecundity of the females and multiple spawnings).

In 1968, G. D. Vasiliu and G. Şova mention the species *Lepomis gibbosus* in their work "Fauna Vertebratica Romaniae" and V. Ionescu, in his work "The Vertebrates from Romania", shortly describes the species.

In 1969, P. Bănărescu makes an inventory of new and rare species from the fauna of Romania and mentions *Lepomis gibbosus* among the new species.

T. Nalbant (1976) adds some contributions to the knowledge of the ichthyofauna from the North-East of the Romanian Plain, between the Siret, the Danube and the Ialomiţa rivers and records the presence of *Lepomis gibbosus* in Balta Albă.

K. Battes and collaborators, in 1977, record the species in the basin of Bistriţa Moldovenească.

In 1979, E. Taisescu, in her Ph. D. thesis, studies the chromosomes at some fish species from our fauna. The author emphasized at *Lepomis gibbosus* an intrapsecific and interindividual chromosomial polymorphism by finding individuals with 2n = 48 chromosomes, all acrocentrical, but, also, individuals with 2n = 48 and 2n = 47 (46 acrocentrical and 1 submetacentrical chromosomes), but with the same number of arms, NF = 48.

In 1980, P. Bănărescu makes an analysis of the ichthyofauna from the Crişurilor basin within the general framework of the ichthyofauna of the Danube basin. The author mentions that in this area live 5 introduced fish species, among them the pumpkinseed sunfish.

V. Constantinescu, in 1981, analyses the relation of total length, body height and weight with the standard length of the pumpkinseed sunfish from Fundata Lake

(Ialomița). The author discusses the way this species penetrated in this lake and, also, notices an accentuated intrapopulational polymorphism at this species.

N. Bacalbaşa-Dobrovici, in 1984, in a work regarding the introduction of new fish species in the Romanian waters, mentions also the pumpkinseed sunfish.

In 1985, G. Manea, in an ample work about fishes and other hydrobionts acclimatized worldwide and in our country, also mentions the species *Lepomis gibbosus.*

V. Oțel and collaborators, in 1992 and 1993, investigate the freshwater ichthyofauna of the Danube Delta. The authors record and discuss about the abundance of the pumpkinseed sunfish in this zone, among other fish species.

N. Crăciun (1998), in his Ph. D. thesis, makes the first Romanian studies on the behaviour of the pumpkinseed sunfish. The author investigates, in the wild, and, especially, in captivity the following types of behaviour: schooling of the young, resting, defence, territoriality, aggression and reproduction.

D. Bănăduc (2000) discusses about the ichthyofauna of the Cibin River and records the presence, in comparison with the year 1964, of 4 new fish species, the pumpkinseed sunfish among them.

In 2002, the Romanian Academy Publishing House published a work (made by a group of authors) about the conservation of the biodiversity in Romania. N. Bacalbaşa-Dobrovici made a chapter about ichthyofauna and, among other issues, comments on the fish species deliberately or naturally introduced in the Romanian waters and mentions the species *Lepomis gibbosus*, stating that this species competes for the food and consumes the eggs and the fry of valuable fish species.

In 2003, K. Battes and collaborators record the presence of *Lepomis gibbosus* in the basin of the Bârlad River and I. C. Gavriloaie publishes a work about the fish species introduced (in a way or another) in the Romanian fauna and their importance and describes shortly the way the pumpkinseed sunfish reached our waters and some data about its biology. The author makes an important mention namely the contribution of the fish owners to the spreading of *Lepomis gibbosus* in the Romanian waters. Being a beautiful fish, it was often kept in captivity, then released in the wild, often in other places than the place of its capture thus enlarging its spreading.

At the beginning of April 2005, at Arcalia (Bistrița-Năsăud), the symposium "Neobiota in Romania and their implication upon ecosystems" took place. Within the scientific framework, works concerning, more or less, the species *Lepomis gibbosus* were presented. Thus, D. Bănăduc spoke about invasive alien fish species that penetrated in Romania, and, among them, the pumpkinseed sunfish, while I. Falka and I. C. Gavriloaie made a check-list of all alien fish species found in the Romanian fauna and, obviously, about the species *Lepomis gibbosus*.

At the end of 2005, I. C. Gavriloaie and Lotus Meşter published some preliminary data concerning the reproductive behaviour of the pumpkinseed sunfish.

CONCLUSIONS

The species *Lepomis gibbosus* was studied along the time by many researchers. Various aspects of the species biology were studied, more and more zones of the country where it entered (naturally or introduced by man) were recorded and some observations on the species behaviour were made. But these observations have to be developed. Concerning the feeding of this species, an ample study, extending for a whole year and on a great number of individuals, is also necessary. More data can be added on the spreading of the pumpkinseed sunfish in our country as there are very few data about the presence and the distribution of the species in Transylvania in the scientific literature.

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AUTHORS:

[1] *Ionel-Claudiu GAVRILOAIE*
ionelclaudiu@yahoo.com
[1] *Lotus MEŞTER*
University of Bucharest,
Faculty of Biology,
Animal Biology Department,
Splaiul Independenței, no. 91 - 95,
Bucharest, Sector 5, Romania,
RO - 050095.

[2] *Istvan FALKA*
falkai@yahoo.com
University of Agricultural Science
and Veterinary Medicine,
Faculty of Pisciculture,
Mănăştur St, no. 3 - 5,
Cluj-Napoca, Cluj County, Romania,
RO - 400372

A SAPROLEGNIASIS CASE IN TROUT (*SALMO TRUTTA*) IN AN AQUACULTURE SYSTEM

Daniel GHEOCA [1], *Voichița GHEOCA* [2] and *Ovidiu ONEȚIU* [3]

KEYWORDS: *Saprolegnia parasitica, Salmo trutta,* hatching farm, stress, defense systems, mucus.

ABSTRACT

The aims of this work is to present a case of saprolegniasis of *Salmo trutta* in a hatching farm in Transylvania.

The symptoms have started in March 2004, after the introduction of new reproductive individuals, in two of the 16 breeding tanks. This moment was also correlated with overpopulation and the increase of the temperature of the water, simultaneously with the decrease of oxygen content. About 9% of effective was affected in a first phase, thann the infection was extended to 11 tanks, affecting over 60% of the fish effective.

On infected fish, *Saprolegnia* took the form of profusely-branched, non-septate mycelia which form brownish cotton-wool-like tufts on the integument, dry depigmented skin and endophthalmia. Penetration of the fungus was in a first step, restricted to the integument and superficial musculature, in a second phase, penetration was much deeper, death fish exhibiting over 80% of body surface covered by the fungus, with profound lesions.

The treatment was carried out with malachite green 0.1%. The chemical treatment was completed through the dispersal of the individuals in some empty tanks, and the supplementation of oxygen pumps. The fish eggs and the alevins were destroyed.

REZUMAT: Un caz de saprolegnioză la păstrăv (*Salmo trutta*) într-un sistem de acvacultură.

Lucrarea de față prezintă un caz de saprolegnioză la *Salmo trutta* într-un sistem de creştere intensivă din Transilvania.

Simptomele au debutat în martie 2004, după introducerea de noi indivizi reproducători în două din cele 16 bazine. Momentul a fost corelat de asemenea cu creşterea temperaturii apei, simultan cu scăderea conținutului de oxigen. Aproximativ 9% din efectiv a fost afectat în prima fază, infecția extinzându-se ulterior la 11 bazine, reprezentând circa 60% din efectiv.

La peştii infectați, *Saprolegnia* determină apariția la suprafața tegumentului, a unei pelicule albicioase cu aspect pufos, alcătuite din micelii neseptate, piele uscată şi depigmentată şi exoftamie. În prima fază dezvoltarea miceliului a fost localizată la nivel tegumentar şi musculatura superficială, în faza a doua, extinzându-se în profunzime, peştii afectați având peste 80% din suprafață acoperită de micelii, şi manifestând leziuni profunde.

Tratamentul s-a realizat cu verde malachit 0,1%, fiind completat cu dispersia indivizilor neafectați în bazine nepopulate, suplimenatrea pompelor de oxigen, precum şi distrugerea ouălor şi alevinilor.

RESUME

L'article pressente une case de saprolegniose de *Salmo trutta* dans des conditions d'élevage intensif dans la Transylvanie.

Les symptômes ont débute en mars 2004 après l'introduction des nouveau individus dans deux des 16 bassins reproductives. Le moment a été en corrélation avec l'augmentation de la température et la surpopulation dans les bassins affectées. Environ 9% de l'effectif a été affecte au début de l'infection, après, l'infection s'est ex tendu a 11 bassins affectant plus que 60% de l'effectif piscicole. Sur les individus infectes *Saprolegnia* prend la forme des taches brunes avec aspect de coton, tégument sèche, dépigmente et endophtalmie. La pénétration des micetes est, dans une première phase restriction au tégument et la musculature superficielle, et dans une phase suivent plus de 80% de la surface est couverte par mycélium, avesc des lésions profondes.

Le traitement a été réalise avec vert malachite 0,1%, soutenue par la dispersion des individus dans des bassins vides, et le souplement des pompes d'oxygéné. Les oeufs et les alevins ont été détruits.

INTRODUCTION

Many fungi cause diseases that can infect and kill salmonid eggs, juveniles and adults. Most fungal infections are caused by water molds of the family Saprolegniaceae, so fungal diseases are commonly called saprolegniasis. Within the Saprolegniaceae family, *Saprolegnia* sp., is the genera that cause most disease in salmonid fish.

Fish mycosis is one of the more controversial and well known disease in ichtiopathology. The economic lost caused by this parasite is overpasst just by that caused by bacterias (Meyer, 1991). Not just the production is largely decreased, but fish quality is decreased to, so they are not able to respond to conservation tratements (de Kinkelin, 1985).

Saprolegniasis has a world-wide distribution and is found in a wide range of species as well as salmonids.

Saprolegnia fungi can cause primary infection. However they are most often secondary pathogens of fish already stressed by another disease, or fish with loss of scales due to mechanical damage allowing a site for the fungus to colonize. The fungus can spread rapidly between fish and the fungal spores can be spread by the water.

As a member of the class Oomycete, the genus *Saprolegnia* is considered an opportunist facultative parasite (Neish, 1977), which is saprotrophic and necrotrophic (Bruno and Wood, 1999).

Saprolegnia has a large impact on salmonids, especially those in aquaculture (Beakes et al., 1994; Hatai and Hoshiai, 1994). However, it can also infect a number of other teleosts as well (Bruno and Wood, 1999). Channel catfish (Howe et al., 1999), pike (Willoughby, 1985), bass (Noga, 1996), elver and suckers (Roberts, 1989), roach, orfe, carp, tench, lamprey, sturgeon, barramundi, tilapia and mullet (Bruno and Wood, 1999) have been infected with *Saprolegnia*. It has also been associated with tropical fish, including the kissing gourami, guppy, swordfish and platyfish (Roberts, 1989; Willoughby, 1994).

The most common and economically important fungal disease of cultured fish is winter saprolegniasis. The species of *Saprolegnia* responsible for this disease has not yet been identified. Other terms used to describe this disease are winter fungus, winter mortality and winter kill.

Clinical signs start with the developement of brown cotton wool like tufts on the surface of fish or on eggs. It grows by producing long filamentous strands called hyphae, hence the cotton wool effect. It starts off on the head and back of the fish as circular patches which get bigger and spread all over the fish. The rate of development depends on water temperature and the condition of the fish. Up to 40 or 50% of the body surface may be covered and the gills, nares and eyes may be infected. The tissue degeneration resulting from the invasion of the fungus disrupts the osmotic balance of the fish. Diseased fish become increasingly lethargic and lose equilibrium shortly before death. Mortalities can range from 10 to 50%.

As the fungus radiates away from the focus of the infection, the hyphae penetrate and destroy the layers of skin, and in some cases extend into the muscle. Very severe cases have been reported where the fungus blocked the pharynx of first feeding fry and grew out over the gill lamellae preventing feeding or normal respiratory functioning.

Saprolegnia species of fungi are common in fresh water and are also present in moist soil. They require oxygen and a nutrient source for growth, so egg incubators and fish tanks provide ideal conditions. The fungus produces long filamentous hyphae which can grow on and over fish, eggs and organic material such as feed. Once an infection is established on the surface of a fish, fungal enzymes damage adjacent tissue allowing the fungus to spread. Reproductive motile spores are released from the ends of the hyphae into the water and these quickly find other sites to colonise. The spores can be introduced into a system initially by the water, wind, on the feathers of birds and on faeces. The spores can quickly spread around a farm by water, on personnel and equipment and in feed.

Saprolegniasis is easy to control by malachite green applications also in combination with other fungicides. This colorant is prohibited in many countrys because of his teratogenic proprieties, but it remains the more effective for the treatement of this fungi. Treatments are carried out also with formalin, potassium permanganate, copper sulphate, methylen blue, sodium chloride.

MATERIALS AND METHODS

In March 2004 were colected samples of *Salmo trutta* death and moribund with tegumental lesions and body surface covered by brown cotton wool like tufts. More biologic material was colected during the folowing weeks, eggs, alevins and adults from the afected and non afected tanks.

Anatomopathological investigations were carried out, in a same time samples were analized by microscopy, directly and after MGG coloration.

Affected tisues were used for histologic analysis after HE and Pappenheim coloration.

After the diagnosis, the treatement was established and supervised until the disease disparition.

Causes were analysed and establised mesures for prevention of a new episode of desease.

RESULTS

This paper present a case of saprolegniasis of *Salmo trutta* in a hatching farm in Transylvania. The symptoms have started after the introduction of new reproductive individuals, in two of the 16 breeding basins. This moment was also correlated with overpopulation and the increase of the temperature of the water, simultaneously with the decrease of oxygen content. Sexual maturation in both sexes of salmonid fish can also be associated with a marked increase in susceptibility to *Saprolegnia.* About 9% of effective was affected in a first stage, than, the infection was extended to 11 of hatching tanks the lost could be estimate of over 60% of the population.

On infected fish, *Saprolegnia* took the form of profusely-branched, non-septate mycelia which form cotton-wool-like tufts on the integument. (Figure 1).

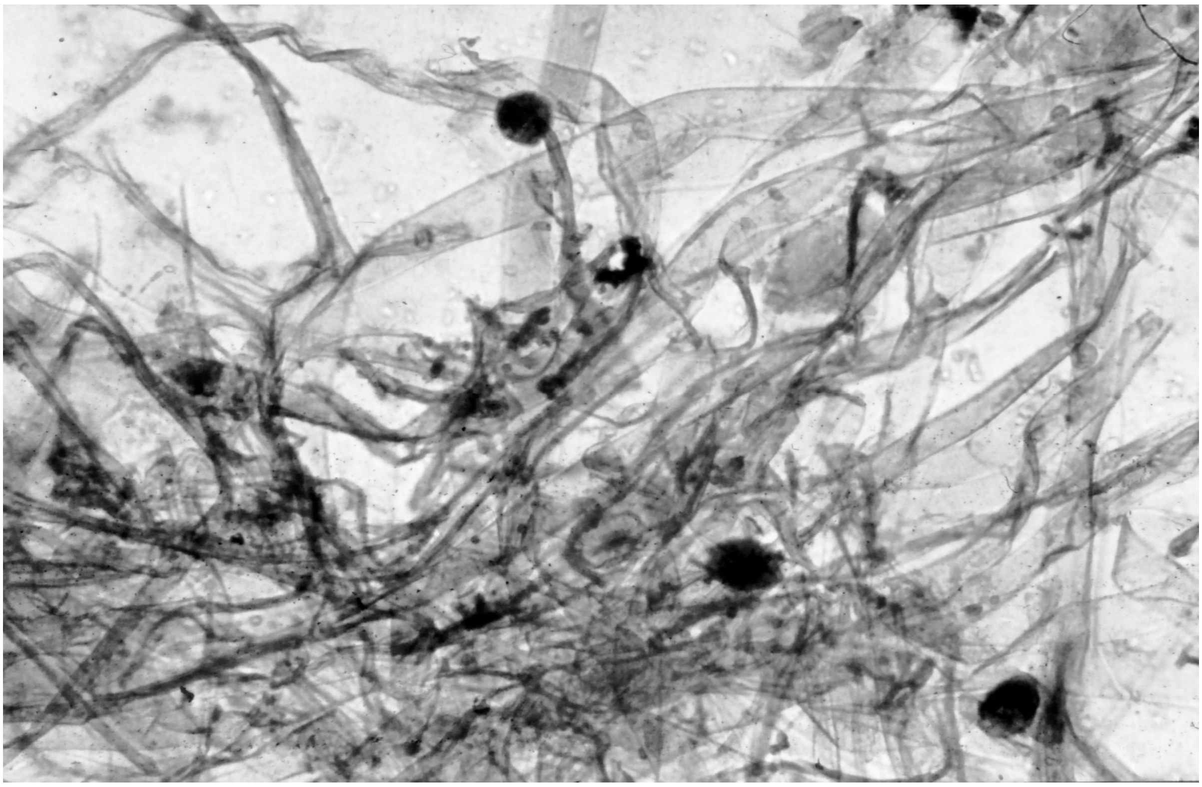

Figure 1. Saprolegnia hypfe - microscopic investigation MGG coloration.

The early lesions were grey-white and often appear as circular or crescent-shaped colonies growing by radial extension until adjacent lesions merge. In some cases, the infected fish were able to fight against *Saprolegnia*, by the physical removal of attached spores by the renewal of mucous, than by a cellular response of the mucous inhibiting mycelium growth. When the defense system collapsed, mycelia grow making localized and generalized lesions (Figure 2).

Figure 2. Saprolegnia on alevins.

The lesions are not randomly located but in severe cases, moribund fish may have as much as 80% of the body surface area covered by the fungus (Figure 3).

Penetration of the fungus was in a first step, restricted to the integument and superficial musculature. but after, penetration was much deeper.

Figure 3. *Saprolegnia* hypes on death fish.
The fungus was covered over 80% of body surface.

On alevins (Figure 2), and eggs, the fungus grow and cover the entire surface, in an advanced phase without the posibility of recovery. Histopathological changes beneath the superficial mycelial included dermal necrosis and oedema during the early stages with deeper myofibrillar necrosis and extensive haemorrhage in the more progressive lesions. The ultimate cause of death is the severe haemodilution caused by haemorrhage and by the destruction of the water-proofing properties of the fish's integument.

The treatment was carried out with malachite green 0.1%. The chemical treatment was completed by the dispersal of individuals in empty tanks, and the supplementation of oxygen pumps.

Fish have been starved before treatment. For the reduction of the metabolic rate of the fish and the organic loading of water from food and faeces. Initially only a few fish were treated. After observing these fish for good recovery over a few hours, the remaining fish were treated similarly.

The eggs and juveniles were destroyed.

DISCUSSIONS

Generally considered a secondary pathogen, *Saprolegnia* can also act as a primary pathogen (Neish and Hugues 1980; Whisler, 1996; Willoughby and Pickering, 1977; and others). *Saprolegnia* causes tissue destruction and loss of epithelial integrity (Bruno and Poppe, 1996; Neish, 1977), due to cellular necrosis or dermal and epidermal damage (Pickering and Willoughby, 1982; and others), including hyphae penetration of the basement membrane (Bruno and Wood, 1999; Neish, 1977). However, *Saprolegnia* does not appear to be tissue specific (Neish, 1977), Pickering (1994) suggests that *Saprolegnia* lesions are not randomly located. In our case we did not observe a tissue specificity of this fungus.

In incipient infection most susceptible seemed to be individuals with tegument lesions, or unbalanced mucus secretion.

Willoughby (1989) determined that fish have 3 types of defenses against *Saprolegnia*. First, the physical removal of attached spores by the renewal of mucous. Second, a morphogen in the mucous inhibited the growth of mycelium but not killing it. And third, a cellular response in the mucous is directed at growing mycelium. Therefore, the mucous acts as a primary physical barrier (Bruno and Wood, 1999; Pickering, 1994), by continuous replenishment of the mucous layer (Pickering and Willoughby, 1982), although not for complete, i.e., 100%, removal of fungal spores (Murphy, 1981). However, a fish having an intact epidermis is probably the best defense against saprolegniasis (Hatai and Hoshiai, 1994; Pickering, 1994).

Conditions that render fish susceptible to saprolegniasis seems to include the following: brood stock (Meyer, 1991), crowded hatchery conditions (Beakes et al., 1994; Whisler, 1996), epidermal integrity (Hatai and Hoshiai, 1994; Pickering, 1994), mature males (Bruno and Wood, 1999; Pickering, 1994), pathogens and parasites (Bruno and Wood, 1999; Meyer, 1991), handling (Bruno and Wood, 1999; Hatai and Hoshiai, 1994), water quality (Bruno and Wood, 1999; Pickering, 1994), water temperature changes, (Bruno and Wood, 1999; Howe et al., 1999), high corticosteroid level/androgen metabolism (Murphy, 1981), human error, (Meyer, 1991), mature males (Bruno and Woods, 1999; Pickering, 1994), sexual maturity (Pickering and Willoughby, 1982), pollution (Snieszko, 1974).

We have identified at least 4 conditions that may increase the susceptibility of saprolegniasis: crowding, mature males, epidermal integrity, water temperature changes. In these conditions Saprolegnia development was very rapid.

The effective treatment for this fungus included several antifungal chemicals. Malachite green was chosen for the treatment in our study, despite his teratogen properties because the severe infection claimed an appropriate treatment. Formalin treatments are an alternative to malachite green but are not as effective. Potassium permanganate is toxic in water of high pH because manganese dioxide may precipitate onto the gills. Potassium permanganate has an oxidizing effect which is potentially dangerous. Copper sulphate is for specialist use only as it is highly toxic and requires removal.

Recent research for controlling winter saprolegniasis include the use of fungicides such as hydrogen peroxide or bronopol.

Rach et al., (2004) found that hydrogen peroxide treatment reduced egg mortality and increased the percent hatch of channel catfish eggs regardless of whether eggs were incubated in the gelatinous matrix or without the matrix in comparison to the untreated control.

CONCLUSIONS

Because of the expense and undocumented efficacy of chemical treatment, control of winter saprolegniasis presently focuses on prevention and development of production strategies that limit the economic loss from the disease. Optimizing water quality and reducing stress, especially in the late summer and fall, can decrease the effect of this disease.

Diseases that occur in late summer or early fall may predispose fish to winter saprolegniasis, so it is important to diagnose and treat those conditions promptly.

Maintaining sufficient oxygen concentrations (4 to 5 ppm) may also be important in avoiding winter saprolegniasis. Unfortunately, optimal water quality is difficult to maintain in large, heavily stocked and fed ponds. One aspect of water quality that is relatively easy to manage is maintaining adequate chloride concentrations to prevent nitrite toxicity. Another factor that can influence the development of winter saprolegniasis is pond depth. In theory, deeper ponds have more capacity to resist changes in temperature. Therefore, maintaining ponds at their maximum depth can reduce temperature fluctuation and help fish acclimate to changes. One prevention strategy being investigated is using prophylactic chemical treatments to reduce the abundance of pathogenic spores.

Minimizing environmental stress, by maintaining the highest standards of fish husbandry, will do much to control saprolegniasis under aquaculture conditions.

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AUTHORS:

[1] *Daniel GHEOCA*
tomarctusgdc@yahoo.com
[2] *Voichița GHEOCA*
vgheoca@yahoo.com
"Lucian Blaga" University of Sibiu,
Faculty of Sciences,
Department of Ecology and Environment Protection,
Oituz St., no. 31,
Sibiu, Sibiu County, Romania,
RO - 550337.

[3] *Ovidiu ONEȚIU*
Rahovei St. no. 27, ap. 25,
Sibiu, Sibiu County, Romania
RO - 550345.

PHYLOGENETIC RELATIONSHIPS WITHIN *CARASSIUS* GENERA, BASED ON THE MITOCHONDRIAL CONTROL REGION (D-LOOP) SEQUENCES DIFFERENCES FOR INDIVIDUALS FROM MOVILENI AND IAŞI POPULATIONS

Lucian D. GORGAN [1]

KEYWORDS: *Carassius gibelio* Bloch., 1782, mtDNA, sequences.

ABSTRACT

From the mitochondrial control region, for species of *Carassius gibelio* Bloch., 1782 genera, its first hypervariable part was sequenced.

20 sequences obtained for individuals sampled from the two studied populations (Movileni and Iaşi), as well as sequences taken from the GenBank for species, subspecies and hybrids of *Carassius*'s genera were aligned. Based on the differences between sequences, the haplotypes were established, and based on the substitution rate as well as on some mathematical models, phylogenetic trees, presenting the analysed species' divergence ways and new possible directions of evolution were generated.

REZUMAT: Relații filogenetice în cadrul genului *Carassius*, bazate pe diferențe ale secvențelor regiunii de control mitocondrial (D-loop), la indivizi din populațiile Movileni şi Iaşi.

Pentru regiunea de control mitocondrial, în cazul speciilor genului *Carassius gibelio* Bloch. 1782, a fost secvențiată prima parte hipervariabilă a acesteia.

Au fost aliniate 20 de secvențe provenite de la indivizi ai celor două populații luate în studiu (Movileni şi Iaşi), precum şi secvențe preluate din banca de gene GenBank, provenite de la specii, subspecii şi hibrizi ale genului *Carassius*. Pe baza diferențelor între secvențe, au fost stabilite haplotipurile, iar pe baza ratei de substituție şi a unor modele matematice, au fost creați arborii filogenetici care prezintă căile de divergență ale speciilor analizate, precum şi inițierea de noi posibile căi de evoluție.

RESUME: Relations phylogénétiques chez le genre *Carassius*, basées sur des differences de sequences au niveau de la region de controle mitochondrial (D-LOOP) chez des individus des populations de Movileni et Iaşi.

A partir de la region de controle mitochondrial, chez le genre *Carassius gibelio* Bloch., 1782, une première partie hypervariable a été séquencée.

20 séquences obtenues pour des individus échantillonnés dans les deux populations étudiées, ainsi que les sequences obtenues à partir de GenBank pour des espèces, sous-espèces et des hybrides du genre *Carassius* ont été alignées. D'après les différences entre les sequences, des haplotypes ont été établis puis, d'après le taux de substitution ainsi que d'après des modèles mathématiques, des arbres phylogénétiques, présentant les divergences entre les espèces analysées et les potentialités d'évolution ont été construits.

INTRODUCTION

mtDNA replication is initiated on one single strand, inside the control region, (non codifying region). As this strand is replicated, the opposite strand of the original DNA duplex is displaced and forms a single-stranded loop (hence the name "D-loop" from Displacement loop). When replication advances to approximately 2/3 from the molecule's surface, replication at the loop's level is initiated, until a new double stranded circular genome will formed.

Evolutive changes from DNA macromolecules level are more complex compared to the ones from protein sequences, due to the existence of more DNA types, as codifying regions, noncodifying regions, exons, introns, terminal regions, repetitive regions and insertion sequences. Modifications induced by mutations at the DNA's level, vary depending on the occurrence area. Even if we take into account only one codifying region, the nucleoides substitution model in the first, second and third position of one codon is different. More, some regions are under the natural selection action, more than others, and this contribute to different DNA regions evolution model variations.

When two DNA sequences are derived from a common ancestral sequence, the descendant sequences gradually diverge by nucleotide substitution. A simple measure of the extent of sequence divergence is the proportion (p) of nucleotide sites at which the two sequences are different.

In case of amino acids substitution, the p distance gives an estimate of the number of nucleotide substitutions per site when the sequences are closely related. However, when p is large, it gives an underestimate of the number, because it does not take into account backward and parallel mutations.

To estimate the number of nucleotide substitution, it is necessary to use a mathematical model of nucleotide substitution. Towards this, a matrix of nucleotide substitution rate was created (Nei and Kumar, 2000).

In the evolutionary distances considered above, the rate of nucleotide substitution is assumed to be the same for all nucleotide sites. In reality, this assumption rarely holds, and the rate varies from site to site. In the case of protein-coding genes, this fact is obvious, because the first, second and third position of a codon have different substitution rates. The functional constraint of amino acids at the active centers of proteins also contributes to rate variation among nucleotide sites. Rate variation is also observed in codifying genes of RNA macromolecule, because mRNA have functional constraints and usually form a secondary structure consisting of loops and stems that have different substitution rates. Statistical analysis of substitution rate (r) at different nucleotide sites, suggested that the rate variation approximately follows the gamma distribution (Kocher and Wilson, 1991; Tamura and Nei, 1993; Wakeley, 1993, 1994).

There are some amino acids substitution numbers estimating methods between two sequences, depending on the used mathematic model. In practice, any model is a reality approximation and gives only amino acids substitution approximate values. Further more, the distances' estimated variances analytic formulas are also approximate.

When the phylogenetic tree's branches length must be estimated for more than one sequence, the LS (least-square) method is used, but the estimated distances' variances and covariances, for all different sequences pairs must be known.

In these cases, the bootstrap method can be used to calculate the measured distances' variances and covariances. This method does not demand a hypothesis regarding the distances distributions, excepting the fact that each amino acid site can evolve independently (Efron, 1982a, 1982b; Efron and Tibshirani, 1993).

DNA or protein sequences phylogenetic analyses, have become an important tool for the organisms evolutive historic study, from bacteria to humans.

Since the rate of sequence evolution varies extensively with gene or DNA segment (Wilson et. al., 1977; Dayhoff et. al., 1978), one can study the evolutionary relationships of virtually all levels of classification of organisms (kingdoms, phyla, families, genera, species and intraspecific populations) by using different genes or DNA segments. Phylogenetic analysis is also important for clarifying the evolutionary pattern of multigene families (Atchley et. al., 1994; Goodwin et. al., 1996; Nei et al., 1997) as well as for understanding the process of adaptative evolution at the molecular level (Chandrasekharan et. al., 1996; Zhang et. al., 1998).

Reconstruction of the phylogenetic trees by using statistical methods was initiated independently in numerical taxonomy for morphological characters and in population genetics for gene frequence data (Cavalli - Sforza and Edwards, 1964, 1967). Some of the statistical methods developed for these purposes are still used for phylogenetic analysis of molecular data, but in recent years many new methods have been developed.

For the methods based on distance or distance matrix, these are calculated for all taxa pairs, and the phylogenetic trees are generated according to the established relations between the values of these distances.

For this method, are considered 4 or more nucleotide or amino acids aligned sequences ($m \geq 4$), and the ancestral taxa's nucleotides (amino acids) are considered separately for each site and a special topology, supposing that the induced modifications appear at each one between four nucleotides (or 20 amino acids). The smaller number of nucleotide substitutions (or amino acids) is calculated which explain the entire evolutive process for a special topology. This approximation is done for all correct topologies and the one which involve the smaller substitution number is chosen for representing the correct tree. As long as is less involved in the evolutive creating process, we can obtain more exact conclusions.

If there are no backward and no parallel substitutions (there are no homology) at each nucleotide site and the examined nucleotides number *(n)* is very large, Maximum Parsimony methods (MP) are expected to produce the correct tree.

In practice, however, nucleotide sequences are often subject to backward and parallel substitutions and *n* is rather small. In this case MP methods tend to give incorrect topologies. Furthermore, Felsenstein (1978) has shown that when the rate of nucleotide substitution varies extensively with evolutionary lineage, MP methods may generate incorrect topologies even if an infinite number of nucleotides are examined. Under certain conditions, this can happened even when the rate of substitutions is constant for all lineages (Hendy and Penny, 1989). In this case, long branches (or short branches) of the true tree tend to join together or attract each other in the reconstructed tree. There for, this fenomena is often call long branch attraction (Hendy and Penny, 1989) or short branch attraction.

In parsimony analysis it is difficult to treat the phylogenetic inference in a statistical framework, because there is no natural way to compute the means and variances of the minimum numbers of substitutions, obtained by the parsimony criteria.

Nevertheless, MP methods have some advantages over other tree-building methods. First, they are relatively free from various assumptions that are required for nucleotide or amino acids substitution in distance or likelihood methods. Since any mathematical model currently used is a crude approximation to reality, model-free MP methods may give more reliable trees than other methods when the extent of sequence divergence is low. In fact, computer stimulation has show that when 1. the extant of sequence divergence is low ($d \leq 0.1$); 2. the rate of nucleotide substitution is constant and 3. the number of nucleotides examined is large, MP methods are often better than distance methods in obtaining the true topology (Sourdis and Nei, 1988; Nei, 1991). Furthermore parsimony analysis is very useful for some types of molecular data such as insertion sequences and insertions/deletions.

MATERIALS AND METHODS

From the mitochondrial control region, for species of *Carassius gibelio* Bloch., 1782 genera, its first hypervariable part was sequenced. 20 sequences obtained for individuals sampled from the two studied populations (Movileni and Iaşi), as well as sequences taken from the GenBank for species (*Carassius carassius* Ref. no. AY714387 and *Carassius cuvieri* Ref. no. AB045144), subspecies (*Carassius auratus langsdörfi* Ref. no. AB006953) and hybrids (*Carassius auratus* x *Cyprinus carpio* Ref. nr. AY694420 and *Carassius auratus x Cyprinus carpio* x *Carassius cuvieri* Ref. no. AY771781) of *Carassius* genera.

The sequences were aligned using the Clustal V method (Higgins and Sharp, 1989) and verified by Clustal W (Thompson et. al., 1994), obtaining in both cases the same result.

The phylogenetic trees were generated using MEGA 2 software.

RESULTS AND DISCUSSIONS

Between the two analyzed populations' sequences, one can notice the existence of two differences (or one difference which involves two sequences, compared to the other similar sequences of the same populations), which consist in the existence of one transition for each of the two sequences in the 133 position, were the thymine substitution with cytosine occurred (Figure 1).

										130										140	
121	A	C	T	A	A	G	G	T	T	T	T	A	C	T	T	C	A	A	A	C	A	Cag01I.seq
121	A	C	T	A	A	G	G	T	T	T	T	A	C	C	T	C	A	A	A	C	A	Cag02I.seq
121	A	C	T	A	A	G	G	T	T	T	T	A	C	T	C	A	A	A	C	A		Cag05I.seq

Figure 1. Diferences between the analyzed sequences, which conducted to the establishment of the two haplotypes (Cag = *Carassius gibelio* Bloch., 1782)

Towards generating the phylogenetic trees, methods based on distances and nucleotide substitution rate which also imply mutations like transitions and transversions were used. In this case, Minimum Evolution method (ME) using an Neighbour Joining algorithm (Figure 3) and Maximum Parsimony (Figure 4) were used.

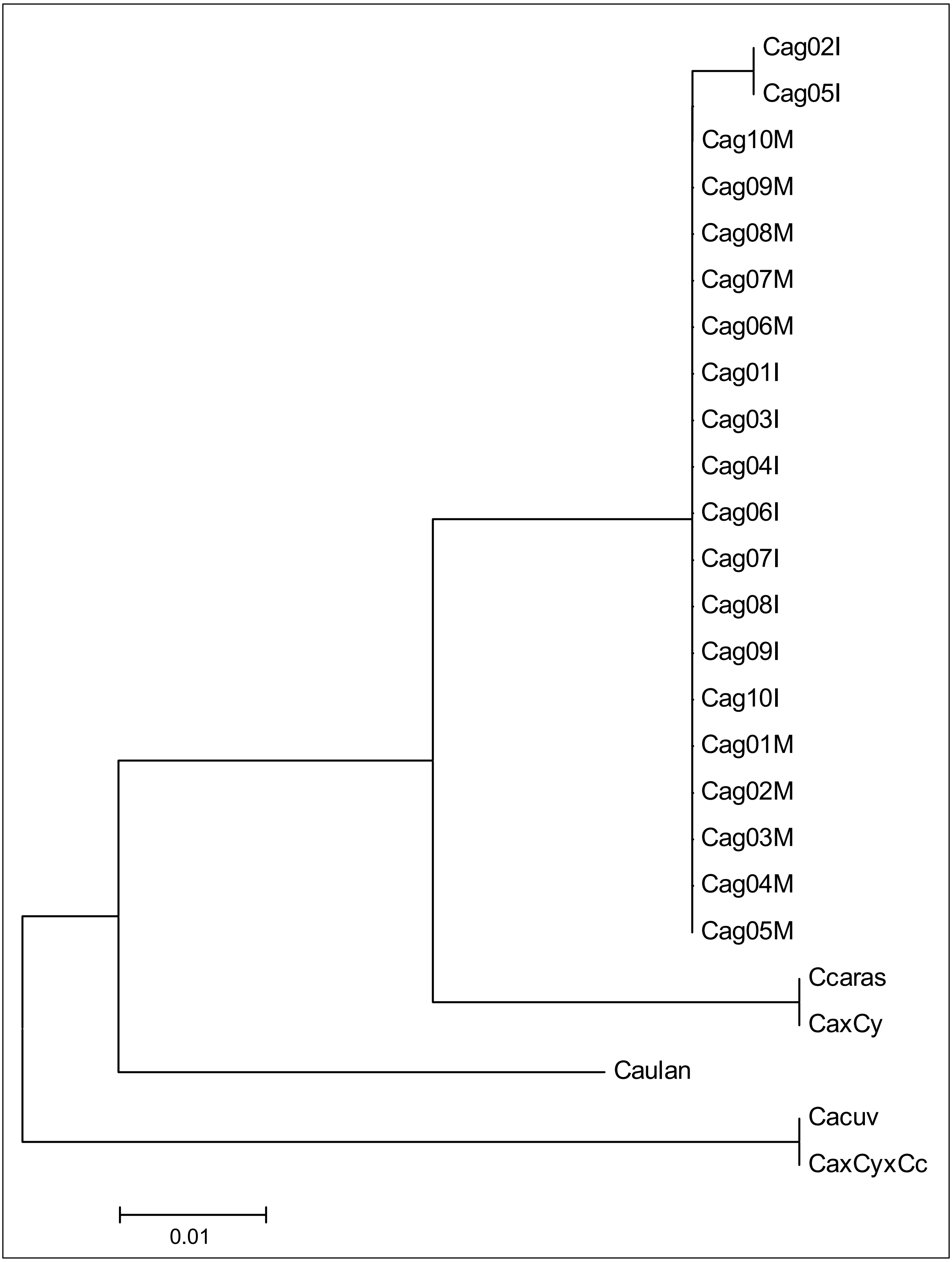

Figure 2. Phylogenetic relationships within *Carassius* genera, obtained with Minimum Evolution (ME) method, based on mitochondrial control region sequences (Cag = *Carassius gibelio* Bloch., 1782; Ccaras = *Carassius carasssius* Linnaeus, 1758; Cacuv = *Carassius cuvieri* Temminck and Schlegel 1846, Caulan = *Carassius auratus langsdörfii* Temminck and Schlegel, 1846)

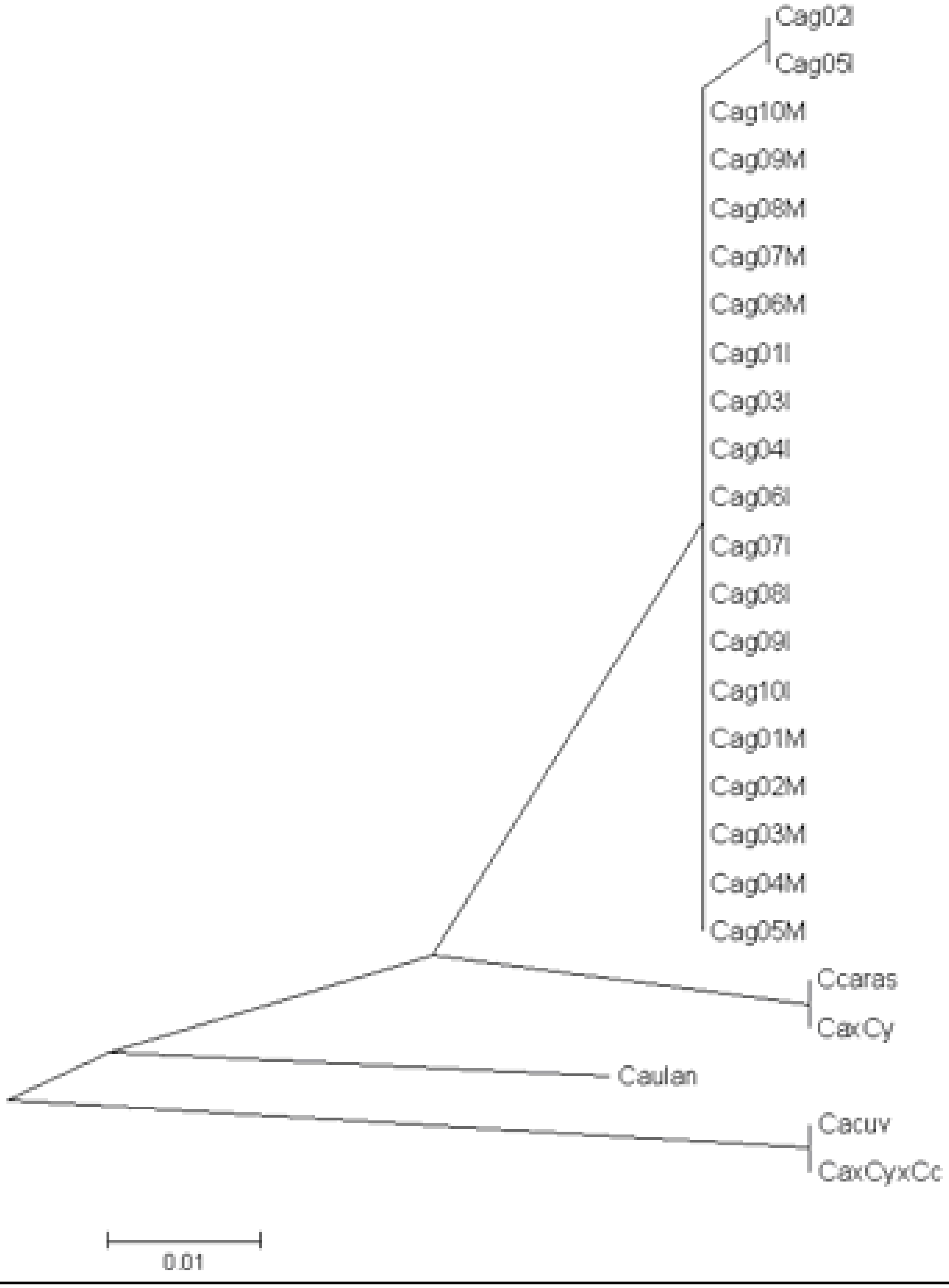

Figure 3. Phylogenetic relationships within *Carassius* genera, obtained with Neighbor Joining (NJ) method, based on mitochondrial control region sequences (Cag = *Carassius gibelio* Bloch., 1782; Ccaras = *Carassius carasssius* Linnaeus, 1758; Cacuv = *Carassius cuvieri* Temminck and Schlegel 1846, Caulan = *Carassius auratus langsdörfii* Temminck and Schlegel, 1846).

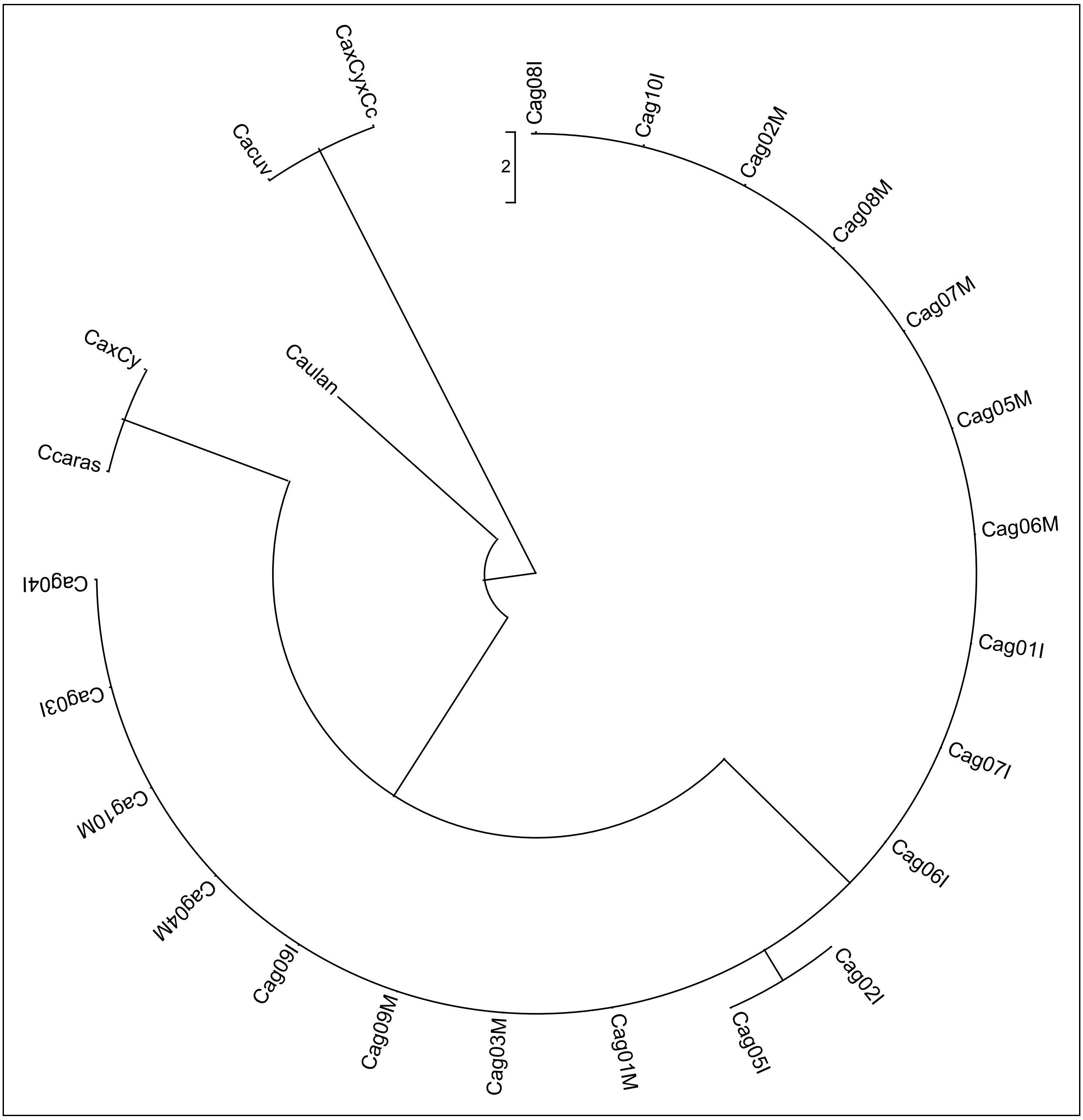

Figure 4. Phylogenetic relationships within *Carassius* genera, obtained with Maximum Parsimony (MP) method, based on mitochondrial control region sequences (Cag = *Carassius gibelio* Bloch., 1782; Ccaras = *Carassius carasssius* Linnaeus, 1758; Cacuv = *Carassius cuvieri* Temminck and Schlegel 1846, Caulan = *Carassius auratus langsdörfii* Temminck and Schlegel, 1846).

The trees generated using all three methods, have an identical topology, showing the taxa's clustering in similarity categories as well as each group's evolutive level. Therefore, we observe that *Carassius auratus langsdörfii* Temminck and Schlegel, 1846, species has the same origin as *Carassius cuvieri* Temminck and Schlegel, 1846, as well as the origin group for *Carassius carasssius* Linnaeus, 1758 and *Carassius gibelio* Bloch., 1782 species. We also noticed that the hybrids shared the same groups with the origin species.

CONCLUSIONS

From phylogenetic analysis results that the analyzed species evolutive groups are the same like the observed ones based on similarity degree.

On the last evolution level the haplotype established for the two sequences is placed, followed by the general haplotype characteristic for the two populations.

Carassius gibelio species is placed on a superior evolutive level compared to *Carassius carassius*, which is also proved in the present analysis.

Carassius cuvieri and *Carassius auratus langsdörfi* mitochondrial control region, has evolved monophyletic in both cases from a common phylogenetic node, but, the second species is placed, on an inferior evolutive level.

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AUTHOR:

[1] *Dragoş Lucian GORGAN*
lucian.gorgan@uaic.ro
"Alexandru Ioan Cuza" University,
Faculty of Biology,
Department of Molecular
and Experimental Biology,
Carol I St., no. 20 A,
Iaşi, Iaşi County, Romania,
RO - 700506.

THE SPREAD OF THE TUBENOSE GOBY (PROTERORHINUS MARMORATUS) AND MONKEY GOBY (NEOGOBIUS FLUVIATILIS) IN THE BASIN OF RIVER TISA AND CENTRAL EUROPE

Akos HARKA [1], *Zoltan SALLAI* [2], *Zsolt SZEPESI* [3] and *Sandor WILHELM* [4]

KEYWORDS: Gobiidae, Danube, Bodrog, Sajó, Körös/Criş, Maros/Mureş rivers.

ABSTRACT

Some ponto-caspic representatives of the Gobiidae family appear in more and more new waterbodies in Central-Europe that is maybe caused by the global warming and the low streaming of waters caused by river barrages.

In the Tisa River and tributaries the spreading of the above mentioned two species was occurred.

REZUMAT: Expansiunea zimbraşului (*Proterorhinus marmoratus*) şi a guvidului de baltă (*Neogobius fluviatilis*) în sistemul hidrografic al râului Tisa şi în Europa centrală.

Unii reprezentanți ai familiei Gobiidae apar în din ce în ce mai multe ape din Europa Centrală, probabil datorită încălzirii globale şi a încetinii vitezei de scurgere a râurilor în urma construirii barajelor.

În râul Tisa şi afluenții acestuia se răspândesc cele două specii menționate.

RÉSUMÉ: Expansion des espèces *Proterorhinus marmoratus* et *Neogobius fluviatilis* dans le système hydrographique de la river Tisa et en Europe centrale.

Il est probable que, suite au réchauffement climatique global et à la diminution du courant dans certaines rivières, conséquence de la construction de barrages, quelques espèces ponto-caspiques de Gobiidés apparaissent de plus en plus souvent dans les rivères de d'Europe centrale.

Dans le système hydrographique de la Tisa les deux espèces mentionnées ci-dessus sont largement répandues.

INTRODUCTION

There are several species of Ponto-Caspian origin in the ichtyofauna of the Central Europe which starting from the Black Sea region they used the water network of the river Danube getting so to the central part of the continent (Bănărescu, 1992). Some of them, starting in the post-glaciar period, have been living here for thousands of years being considerated autochtones, while the others, mainly certain gobiids have appeared recently (Anhelt, 1988; Harka, 1990; Anhelt et al., 1998; Guti, 2000). Two goby species have already adapted to the river Tisa, namely *Proterorhinus marmoratus* and *Neogobius fluviatilis*. Blanc and his companion (1971) and Terofal (1984) sign even the presence of the species *Neogobius kessleri*, but this one has not been found yet. The present study treats the spread of the first two species mentioned before.

MATERIALS AND METHODS

In the Hungary natural waters (Tisa, Dráva, Rába, Körös and Zala), as well as in the lakes of Balaton and Tisa-tó, in the past two decades there has been gathered data in connection with the spread of the two species (Harka 1988, 1992a, 1992b, 1993, 1996; Harka and Juhász, 1996; Sallai, 2002). In addition from 2002 we have performed researches focused on the tributaries of Tisa, as follows: Sebes-Körös, Berettyó, Sajó, Zagyva and other smaller tributaries in order to follow the expansion of the species mentioned.

The device of the instrument used most frequently was a trawl having size of 2 metres by 3 metres, the size of the stitches being 6 millimetres by 6 millimetres. During these researches we used mainly handnets making it possible to work even on areas covered by vegetation. In some cases we used electric fishing devices too.

In addition to our personal observations, we used the data of specialized literature too, as well as our colleagues' observations. In the research of tracing the species' expansion process we took into consideration the topographic place and the data of the observations, as well as the conditions of these researches. The reconstruction of the events was rendered more difficult by the fact that in very few places had been carried out researches of monitoring type. In these conditions the results of the former researches reflected the occasionality of them instead of the real process of the expansion.

RESULTS AND DISCUSSIONS

In what follows we are going to present the systemic conspectus of the main events resulting in the recent expansion of the two gobiid species of Ponto-Caspian origin being adapted to the Tisa River basin.

Tubenose Goby - *Proterorhinus marmoratus* (Pallas, 1814)

It was the first representative of gobiids in Cental Europe. This species of small size described in 1814 in the costal water of the Black Sea, in all probability was still present in the river Danube in the moment of description as in 1872 it was discovered even in Budapest at a distance of 2000 fluvial kilometres from the estuary (Kriesch, 1873). A short time later it was found at Bratislava (Koelbel, 1874), later on in Balaton, the biggest lake of Hungary (Vutskits, 1895), as well as in Neusidler See, a lake being situated on the Austrian-Hungarian border (Mika and Breuer, 1928).

On the territory of Slovakia, between 1947 and 1968, besides the branches and backwaters of the Danube it was revealed at the estuaries of the tributaries running from north (Morava, Váh, Nitra, Hron and Ipel), as well as in the channels connected with them (Oliva et al., 1968). These data still not modified esentially the areal limits determined in the 1870s. The spread of the species remained constant during a century, conform to the map outlined by Lelek (1987) (Figure 1).

The first signs of the expansion were registered in the 1970s, when the areal limits went up at about 200 fluvial kilometres from Wien up to Linz (Anhelt, 1988). Nevertheless we have to mention that Balon (1967) drew the expansion limits of the species at Linz two decades before.

During the following years the expansion of the species continued on Danube River and on its tributaries. In 1985 it got to Germany territory, where its first appearance was registered at Passau, a few years later it appeared 100 kilometres upstream at Regensburg (Reinartz et al., 2000).

The list of data in connection with *Proterorhinus marmoratus* was enriched in 1957, when a specimen was collected near Szeged, at a distance of 170 fluvial kilometres from the Danube (Berinkey, 1972). The presence of the species in the river Tisa was confirmed by Sterbetz (1963), who found several specimens in 1960 10 kilometres upstream from the previous collecting point.

From the 1980s there was shown a sudden advance of the species on the tributaries of Tisa in Hungary. First we observed it 200 kilometres upstream from the former collecting points, then we pointed out its spread in the Tisa-tó as well (Harka, 1988). A short time before we collected it from the river Körös, but we discovered it in the lower section of the river Dráva making the Hungarian-Croatian border (Harka, 1990, 1991, 1992a). A limited expansion was considered in the Western-Hungarian river called Marcal (Harka, 1991), as well as in the Hungarian-Slovakian border section of the river Ipoly (Ipel) (verbal information, K. Györe).

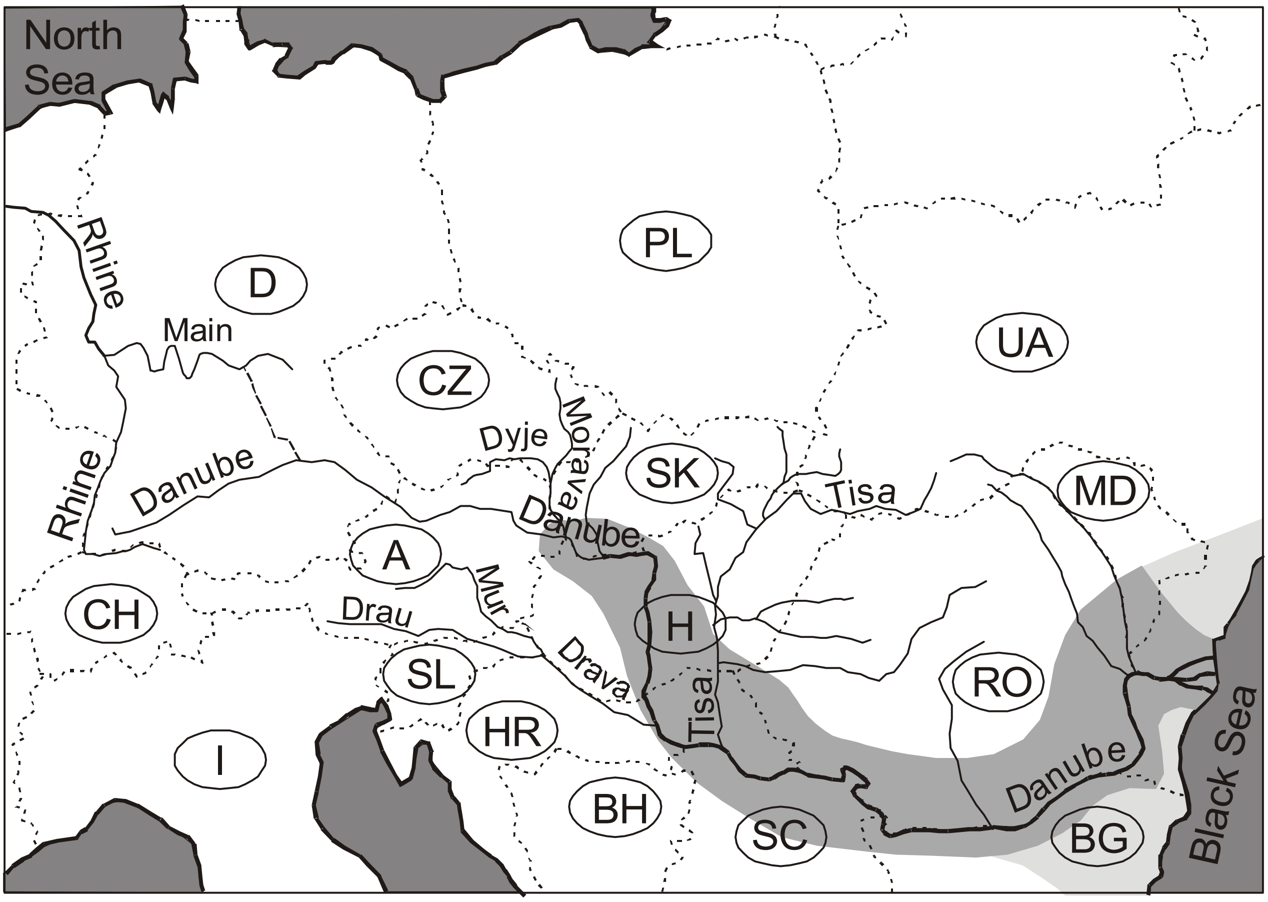

Figure 1. The former areal spread of the species *Proterorhinus marmoratus* (after Lelek, 1987).

The *Proterorhinus* appeared in the Check Republic in 1994. First it was found in the reservoir lake at Musov built on the river Dyje, a tributary of Morava (Lusk and Halačka, 1995), from where it spread up to the Austrian border during the following years. It spread in the tributaries of rivers Dyje and Morava as well (Lusk et al., 2000; Prásek and Jurajda, 2000).

The sudden advance of the species did not stop during the following years. In the case of river Dráva it was a slower process, but in river Mura (Mur) specimens were observed 200 kilometres upstream near Graz (Friedl and Sampl, 2000).

During the recent years in East-Hungary its advance was mainly observed in the Middle-Tisa region, nevertheless it has become a common species in the basin of river Zagyva, in the brooks running into the Tisza-tó, as well as it has appeared even in river Sajó (Harka and Szepesi, 2004a, 2004b). Its advance up the Tisa is also remarkable, it has already reached river Bodrog where it was first observed in 2003 (Harka and Sallai, 2004). It has got into the system of the Körös rivers, too, having been appeared in Kettõs-Körös and Sebes-Körös (Harka, 1996b). In 2003 we collected it from river Berettyó, in November 1st, 2005 it was also found in West-Roumania in the river Ier at Săcueni (Wilhelm, 2005). It was found in the collector channel of rivers Körös (verbal information I. Telcean). The main collecting points in the basin of river Tisa are presented on the figure 2.

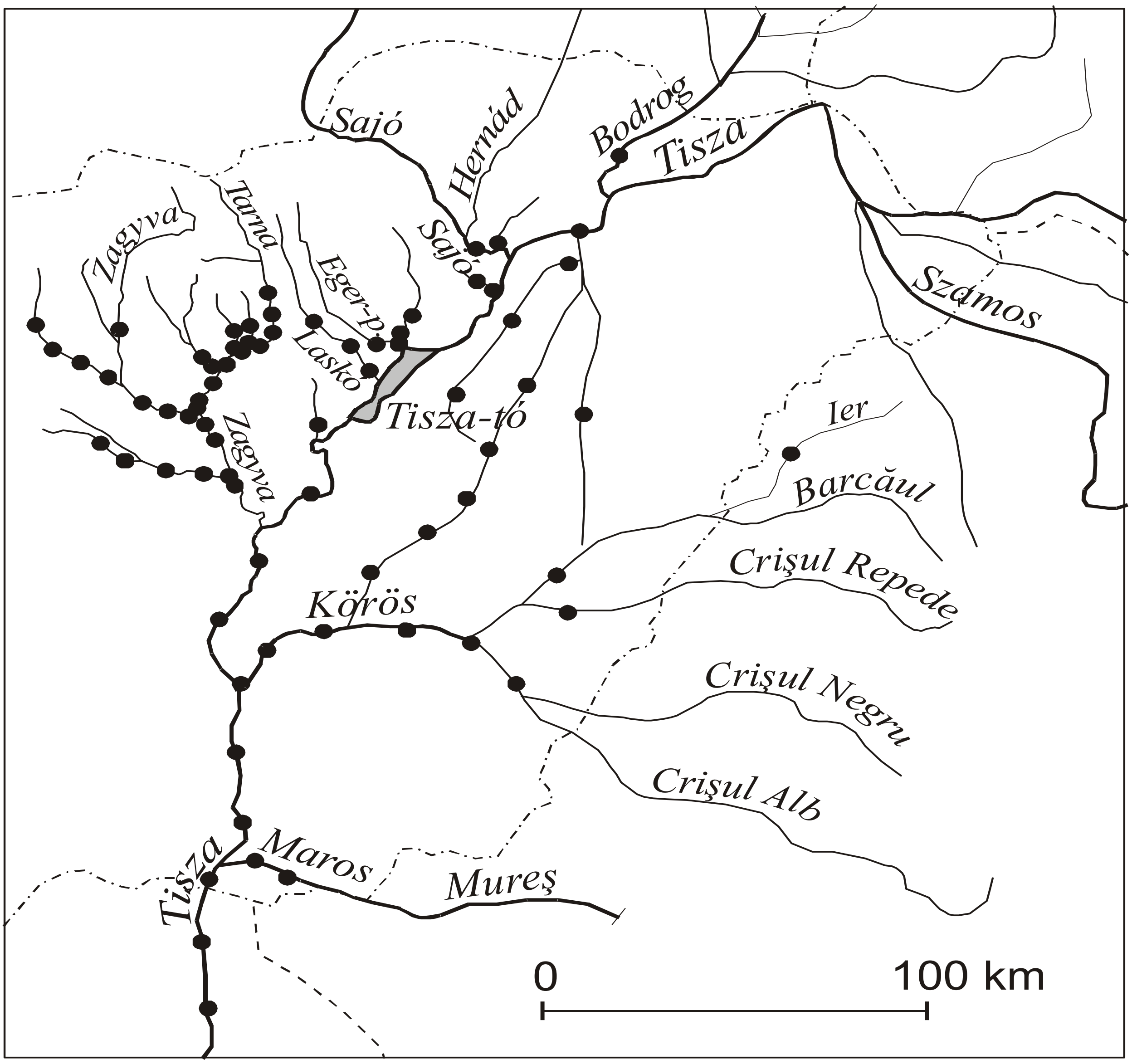

Figure 2. Collecting points in the basin of river Tisa.

In 1997 there happened an essential event of the species' advance in Germany. Probably through the Danube-Maine navigation channel inaugurated in 1992, the species got into the system of river Rhine (Reinartz et al., 2000) opening way towards the North Sea. In the recent years *Proterorhinus marmoratus* is no longer rare in the region of Middle-Main, and some specimens were found even in the Danube-Maine-Rhine Channel, as well as in the section of river Rhine being close to the Maine (personal information dr. Oliver Born).

As one can see it on the map of figure 3, the spread region sketched by Pinchuk et al. (2004) has been larged even in the basin of rivers Danube and Tisa. The collecting points being situated out of the limits drawn by Lelek (1987) make us clear that the species passed them a long time ago and that this process is lasting even these days.

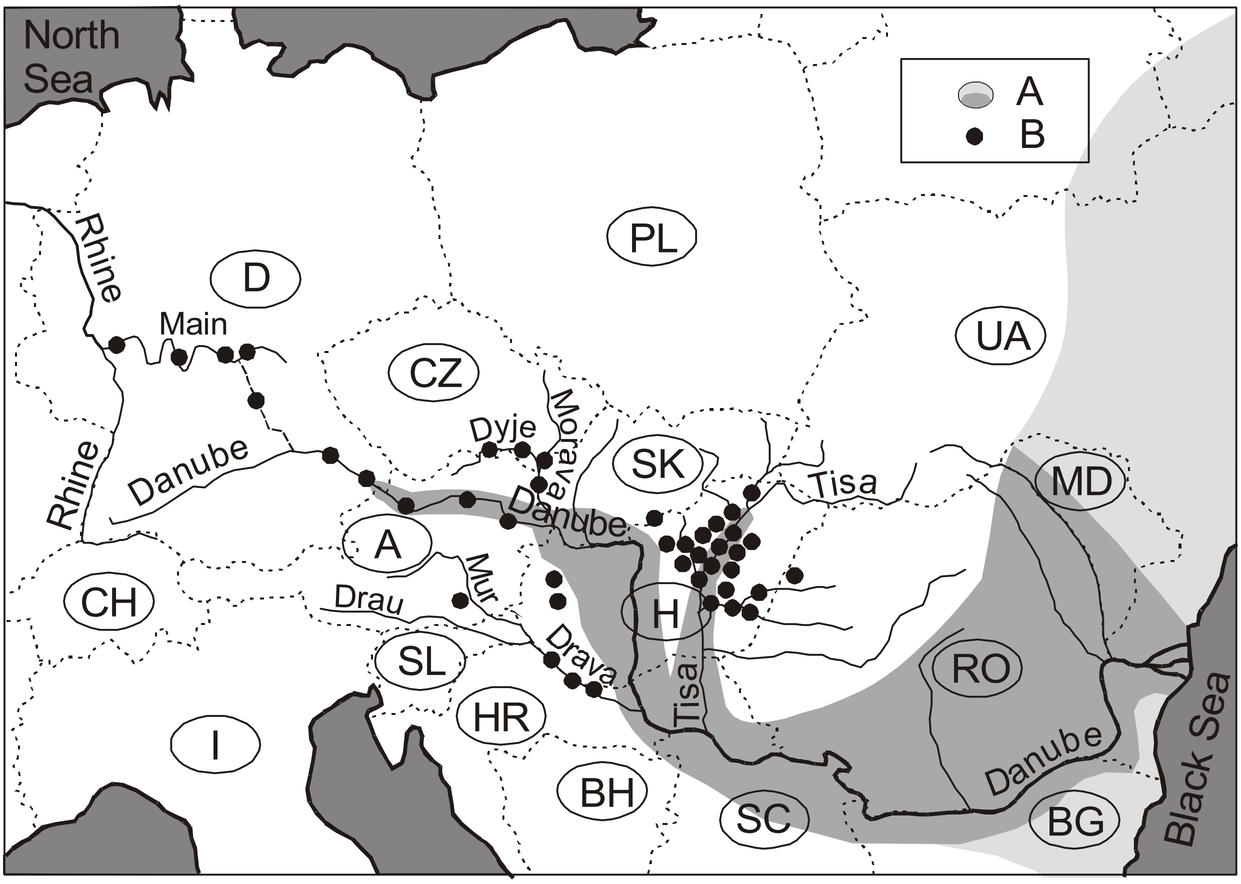

Figure 3. The area of the species *Proterorhinus marmoratus* after Pinchuk et al. (2004) (A), as well as the main new collecting points out of the zone given by Lelek (1987) (B).

Monkey Goby (*Neogobius fluviatilis*) (Pallas, 1814).

In the beginning the species belonged the same way to the lower section of the rivers running into the Black Sea. In the 1960s it was found only in Romania at Orşova (Bănărescu, 1964), in Slovakia below the estuary of the river Porečka (Ristić, 1977), that is why it was a real ichtiological sensation its appearance in Lake Balaton in Hungary (Biró, 1972). At first this point seemed to be an isolated one, but in 1984 it appeared in the South-Hungarian section of the Danube in accordance with its spreading way (Pintér, 1989) being reflected even on the map sketched by Biró (1972) taking over in unchanged form by Lelek (1987), as refers the spread of the species (Figure 4).

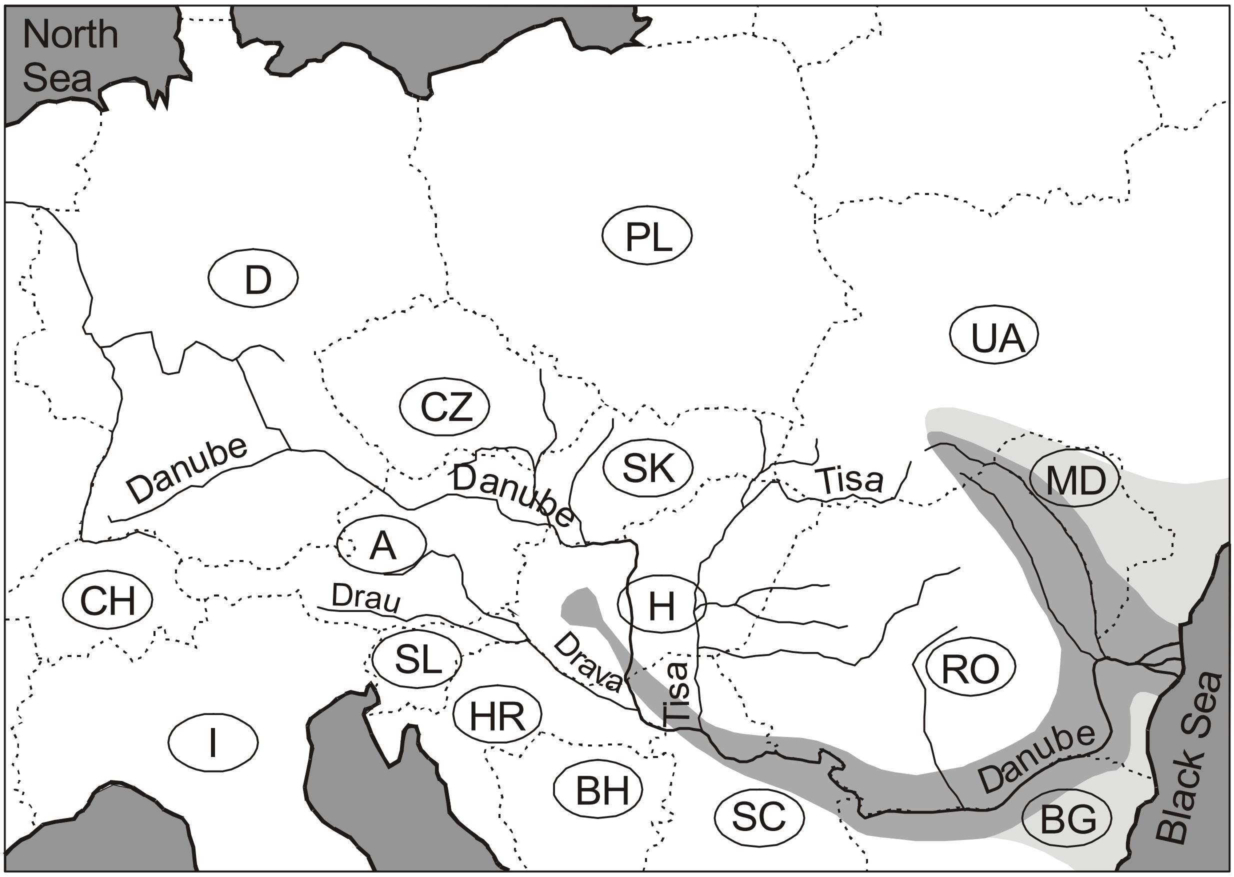

Figure 4. The original spread area of the species *Neogobius fluviatilis*, after Biró (1972).

During the following years the spread of the species clearly stopped, but in the Tisa-tó, an artificial lake realized in 1993 it was observed the multiplication of the species, similarly to the case in the Balaton Lake (Harka, 1993). At first this point seemed to be an isolated one, as well, but later ascertained that the species is present in the river section of the Tisa-tó, in Serbia and South-Hungary (Guelmino, 1994; Györe and others, 2001).

During the recent years the fluvial goby has been going up the Danube continually. In 2001 it was collected in the Hungarian-Slovakian section of the river (Stráňai and Andreji, 2001; Sallai, 2003; Holčik et al., 2003), as well as in 2003 it was found near the Austrian border, in the lower section of the river Rába (verbal information, G. Guti). Later, at the revise of the ichtiologic collection of Mátra Museum in Gyöngyös there was found a specimen collected in August 26th 1999 (legit Ambrus A., Juhász P. and Kovács T.), so the species had already been present in the zone.

In West-Hungary, in the region of the Lake Kis-Balaton, in the hydrographic system of the river Dráva (Sallai, 2002), as well as in river Kapos its spread was ascertained.

In the basin of river Tisa there were registered new collecting points in rivers Maros, Körös, Hortobágy-Berettyó and Zagyva, as well as in brooks Laskó and Eger running into the Tisa-tó (Sallai, 1995; Harka and Szepesi, 2004b; Harka and Sallai, 2004). The localization of the collecting points is given on figure 5.

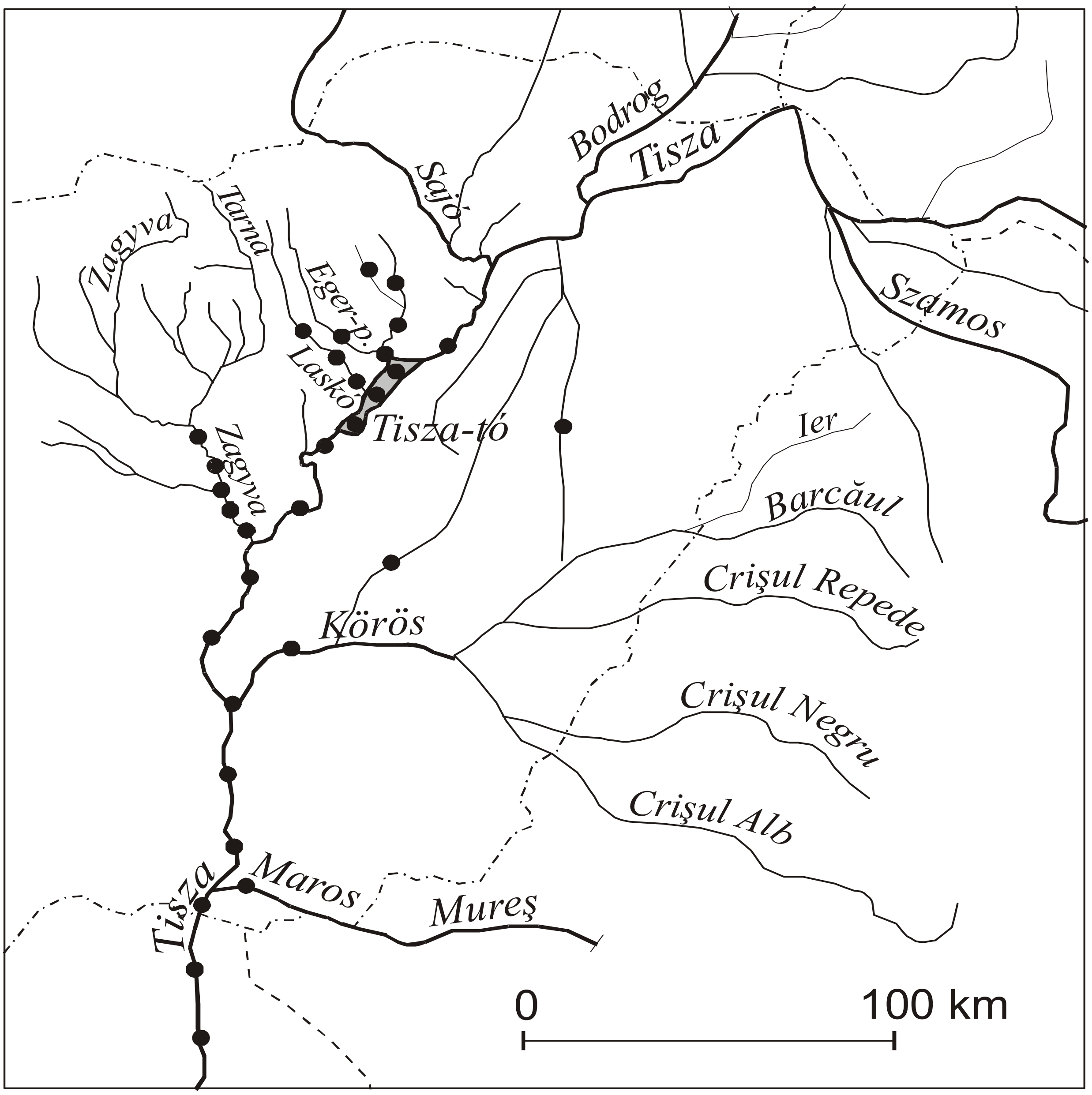

Figure 5. Collecting places of the species *Neogobius fluviatilis* in the basin of river Tisa.

The new spread map issued by Pinchuk et al. (2003) contains the majority of new collecting points of the last three decades, but it does not contain the ones on the Hungarian - Slovakian border, on the contrary it contains superior sections of rivers Dráva and Tisa where the species is still not present. The situation is the same in the case of rivers Criş/Körös and Mureş/Maros - on the Roumanian sections of these rivers still there are no signs of its appeareance (Figure 6).

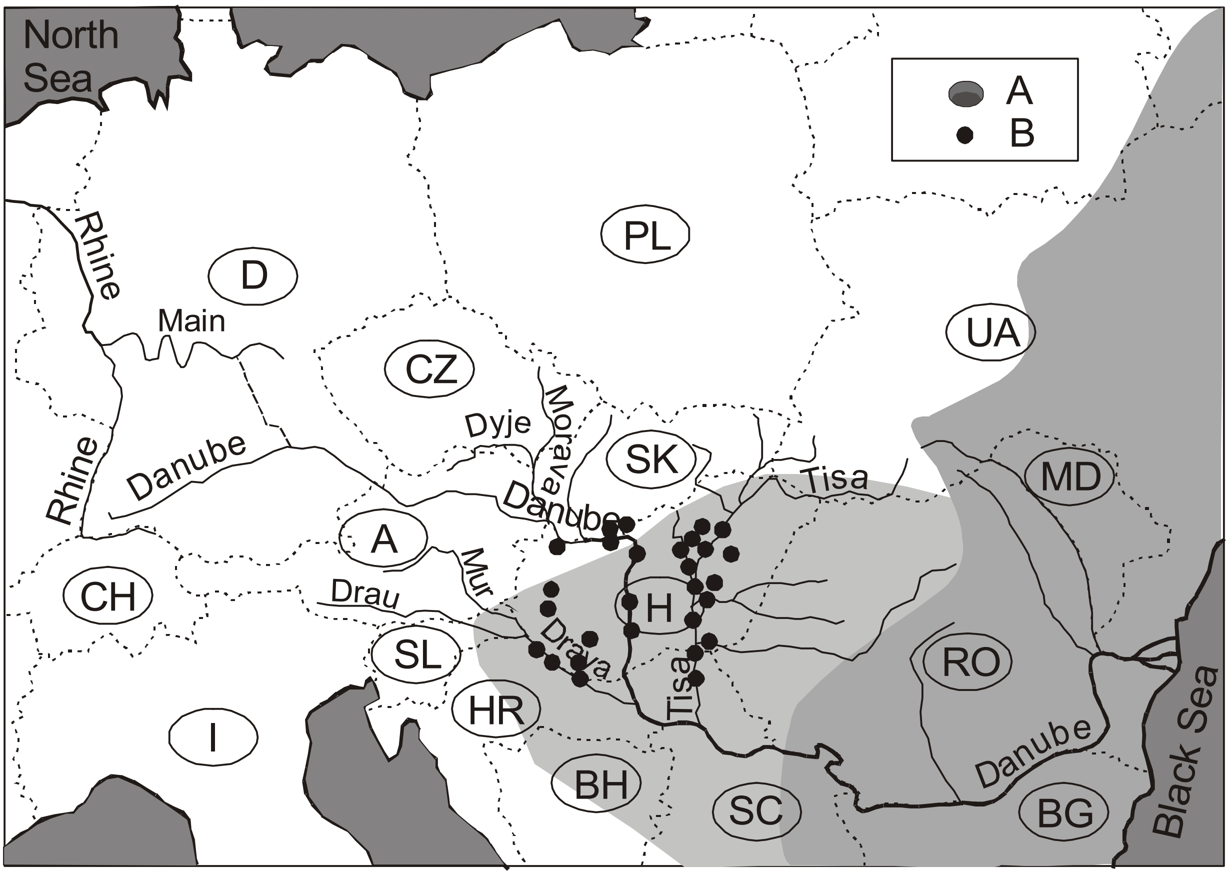

Figure 6. The original area of *Neogobius fluviatilis* (darker colour), and the enlargement of this after Pinchuk et al. (2003) (A), as well as the the new collecting places being situated out of the area indicated by Biró (1972) (B).

CONCLUSIONS

At present, the territory occupied by the fluvial goby in Central Europe, as well as in the basin of river Tisa is much smaller than the one occupied by tubenose goby that began its expansion 100 years earlier, but neither this process has been finished. We are looking forward to the appearance of fluvial goby in the waters of West-Roumania, hereby the territories signed on the map will be a real part of its area.

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AUTHORS:

[1] *Akos HARKA*
mhtt@freemail.hu
Magyar Haltani Társaság,
Táncsics St. no. 1,
Tiszafüred, Hungary,
H - 5350.

[2] *Zoltan SALLAI*
csuka@szarvasnet.hu
Nimfea Természetvédelmi Egyesület
Pf. 122,
Szarvas, Hungary,
H - 5541.

[3] *Zsolt SZEPESI*
szepesizs@freemail.hu
Omega/Audit Kft.,
Csiky Sandor U., no. 52,
Eger, Hungary,
H - 3300

[4] *Sandor WILHELM*
wilhelms@rdslink.ro
Liceul Teoretic „Petöfi Sándor”,
Piaţa. Libertăţii, no. 25,
Săcueni, Bihor County, Romania,
RO - 417435.

THE COMPARATIVE ANALYSIS OF INFECTION PARAMETERS OF THE ROUND GOBY *NEOGOBIUS MELANOSTOMUS* (PALLAS) (OSTEICHTHYES, GOBIIDAE) IN THE GULF OF GDAŃSK, BALTIC SEA, POLAND, AND THE NORTHWESTERN BLACK SEA, UKRAINE

Yuriy KVACH [1] and *Krzysztof E. SKÓRA* [2]

KEYWORDS: invasive species, parasitological indices, discriminant analysis, lagoons.

ABSTRACT

The aims of presented work were to compare the infestation with metazoan parasites of the invasive round goby, *Neogobius melanostomus*, in the Gulf of Gdańsk, Baltic Sea, to one in the native habitats of the Black Sea. Discriminant analysis was providing. In total of 12 metazoa parasite species found in the round goby in the Gulf of Gdańsk, but in the Northwestern Black Sea region there were 16 helminth species. Three parasite species were found both in the Northwestern Black Sea and the Gulf of Gdańsk: *Cryptocotyle concavum*, *Dichelyne minutus* and *Acanthocephalus lucii*. The parasitization of the round goby is similar in water areas with similar ecological conditions (opened water area or closed reservoirs) in native habitats and in a place of invasion.

REZUMAT: Analiza comparativă a parametrilor de infestare la *Neogobius melanostomus*(Pallas) (Osteichthyes, Gobiidae) în Golful Gdańsk, Marea Baltică, Polonia şi în nord-vestul Mării Negre, Ucraina.

Scopul prezentei lucrări este compararea infestării cu paraziţi a speciei invasive *Neogobius melanostomus*, în Golful Gdańsk, la Marea Baltică, şi în habitate native în Marea Neagră. A fost realizată analiza discriminantă. Un total de 12 specii de paraziţi au fost identificaţi pe această specie în Golful Gdańsk, iar în partea de nord west a Mării Negre au fost identificate 16 specii de paraziţi. Trei specii de paraziţi au fost identificate şi în nord-vestul Mării Negre şi în Golful Gdańsk: *Cryptocotyle concavum*, *Dichelyne minutus* şi *Acanthocephalus lucii*. Parazitarea lui *Neogobius melanostomus* este similară în zone cu condiţii ecologice similare (zone de apă deschise sau rezervoare închise) în habitate considerate ca native şi în zone de invazie.

ZUSSAMMENFASSUNG: Vergleichende Analyse der Infektionsparameter von *Neogobius melanostomus* (Pallas) (Osteichthyes: Gobiidae) im Golf von Gdańsk, Baltische See, Polen, und des nordwestlichen Schwarzen Meeres, Ukraine.

Eine Ziel dieser Forschung ist die Gegenüberstellung die Infiziertheit bei den Metazoaparasiten des invasiven *Neogobius melanostomus* Schwarzmundgrundel, in Danziger Bucht, Ostsee, mit der aus den natürlichen Habitaten in Schwarze Meer. Die Diskriminantanalyse ist verwendet. In der Danziger Bucht haben 12 Spezies von den Metazoaparasiten beim Schwarzm3undgrundel, und in nordwestlichen Teil Schwarze Meer - 16 Spezies der Helminthen entdeckt. Drei Spezies der Parasiten sind sowohl im nordwestlichen Teil Schwarzen Meeres, als auch in Danziger Bucht gefunden: *Cryptocotyle concavum*, *Dichelyne minutus* und *Acanthocephalus lucii*. Im Wasserflächen mit dem ähnlichen ökologischen Verhältnisse (die offenen oder geschlossenen Wasserflächen) ist die Infiziertheit des Schwarzmundgrundel von den Parasiten ähnlich an den natürlichen Habitaten und an den Stellen der Invasia.

INTRODUCTION

The round goby, *Neogobius melanostomus*, is a bottom dwelling Ponto-Caspian fish species that naturally habits the Black Sea basin (include Seas of Azov and Marmara) (Miller, 1986; Smirnov, 1986). Recently it occurred as invasive species in the Baltic Sea (Skóra and Stolarski, 1993; Winkler and Schröder, 2003), the Northern Sea (van Beek, 2006), Great Lakes (Jude et al., 1992; Charlebois et al., 1997), and upper and middle Danube (Simonović et al., 1998; Wiesner et al., 2000).

The distributions of the invasive gobies species present several problems. In addition to the obvious main problem of interference with the local native fauna, as parasite hosts, they can also take part in spreading diseases of economically valuable fishes and birds species. For example, in the Sea of Azov the round goby species is a host of nematodes *Tetrameres fissispina* and *Streptocara crassicauda* (Acuariidae) that lead to poultry epizootics (Kovalenko, 1960). Also the round goby species is intermediate host of the trematode *Pygydiopsis genata* (Heterophyidae) (Kvach, 2005), which can infect human (Youssef et al., 1987). In the Gulf of Gdańsk the invasive round goby takes a part of paratenic host of the nematode *Anguillicola crassus* (Dracunculidae) (Kvach, 2004; Kvach and Skóra, 2004; Rolbiecki and Kvach, 2005), which adults are invading the eels *Anguilla* spp. (Kuwahara et al., 1974; Moravec, 1994).

The first data about round goby parasites was published by Ciurea (1931) who notes metacercariae of *Cryptocotyle concavum* (Heterophyidae) in gobies from the Romanian Black Sea near-shores and central ponds of Bucharest. The most recent data are presented in the paper of Kvach (2005) where 16 helminth species are noted for the round goby. In the Baltic Sea the investigations of the invasive round goby parasites were provided by Kvach (2002, 2004), Kvach and Skóra (2004), Rokicki and Rolbiecki (2002), Rolbiecki and Kvach (2005).

The comparing of the existing data on this species parasitization, getting in places of invasion, to the same data from the natural habitats, could help to determine the ways of invasive species distribution. The aim of presented work was to compare the infestation with metazoan parasites of the invasive round goby in the Gulf of Gdańsk to one in the native habitats of the Black Sea.

MATERIALS AND METHODS

The fish individuals were sampled in the Gulf of Gdańsk of the Baltic Sea (during June 2001, April 2003, October - December 2003) and in the Northwestern part of the Black Sea (different seasons of 1996 - 2003) (Figure 1). The fish were caught using trawl, sweep, fyke nets, and angling. The standard length (SL, cm) of fish individuals was measured.

In total, 232 individuals of the round goby from the Baltic Sea and 774 individuals from the Black Sea were examined for parasites. All possible sites of parasites location were carefully examined. Metacercariae were isolated from cysts (if are) and stained with lactic or acetic carmine. Cestodes and adult trematodes were fixed in 70% ethanol and then stained with carmine. Later, the stained helminths were dehydrated in ethanol and mounted in Canada balsam. Acanthocephalans, nematodes and crustaceans were fixed in 70% ethanol and mounted in glycerol for identification.

The parasitological indices were calculated according to Bush et al. (1997):

- Prevalence (P) is the number of hosts infected with one or more individuals of a particular parasite species divided by the number of hosts examined for that parasite species (expressed as a percentage);

- Mean intensity (MI) is the average intensity (number of individuals of a particular parasite species in a single infected host) of a particular species of parasite among the infected numbers of a particular host species;
- Abundance (A) is the number of individuals of a particular parasite species in/on a single host regardless of whether or not the host is infected.

The significance of separate species in the parasite fauna was evaluated by the concept of Holms and Price (1986) according to abundance index: > 2 - core species, 0.6 - 2 - secondary species, 0.2 - 0.6 - satellite species, and < 0.2 - rare species.

Discriminant analysis was providing to compare the gobies parasitization in different water bodies. In analysis next types of water bodies were used: 1. Opened water areas (near-shores off Hel in the Baltic Sea; Gulf of Odessa in the Black Sea); 2. Lagoons (Puck Lagoon in the Baltic Sea; Budaki Lagoon in the Black Sea) and estuaries (Hryhorivsky and Khadzhibey Estuaries of the Black Sea). Also the summarized data from all sample sites in the Gulf of Gdańsk and same in the Northwestern Black Sea were used. Three indices (P, MI, A) of infection for particular parasite species were grouped according to the geographical region. The squared Mahalanobis distances were presented as a plot of discriminant function. The standard deviation (sd) is calculated for average parameters.

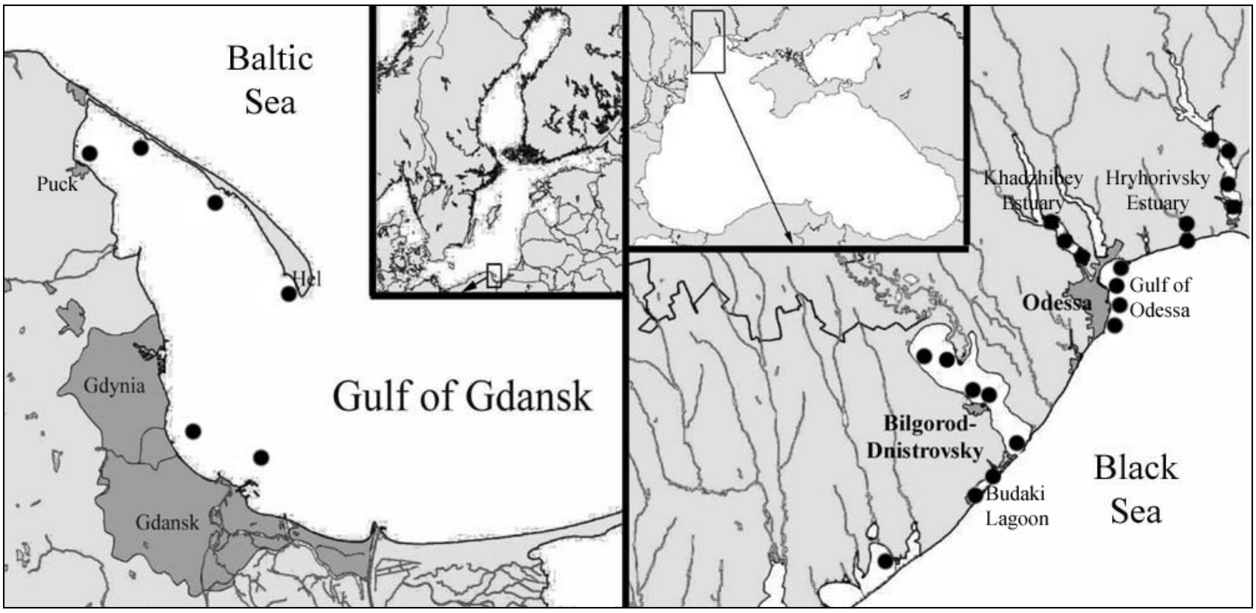

Figure 1. Schematic map of the investigation area (● - sampling sites).

RESULTS

In total of 12 metazoa parasite species, include one Cestoda species, four Trematoda, three Nematoda, two Acanthocephala, one Hirudinea, and one Crustacea species, were noted for the round goby in the Gulf of Gdańsk (Table 1). Monogenea were not occurred.

In the North-Western Black Sea region the round goby was infected with 16 helminth species (Table 1). Three parasite species were found both in the Northwestern Black Sea and the Gulf of Gdańsk: the trematode *Cryptocotyle concavum*, the nematode *Dichelyne minutus* (Cucullanidae), and the acanthocephalan *Acanthocephalus lucii* (Echinorhynchidae).

Table 1. Infection of the round goby fish species with the metazoa parasites in the Gulf of Gdańsk and in the Northwestern Black Sea; pl - plerocercoid, met - metacercaria, L3 - third stage larva.

Parasite species	Index	Gulf of Gdańsk				North-western Black Sea			
		Hel	Puck	Total*	Gulf of Odessa	Hryhorivsky Estuary	Khadzhibey Estuary	Budaki Lagoon	Total**
Number of studied fishes		108	74	232	330	68	198	44	775
Host standard length (M ± sd), cm		8.5 ± 2.8	14.0 ± 3.1	11.3 ± 4.3	9.7 ± 2.2	9.0 ± 1.7	6.8 ± 1.9	13.2 ± 17.4	9.6 ± 5.6
1	2	4	3	5	6	7	8	9	10
Cestoda									
Bothriocephalus sp. pl	P	0.9		0.4					
	MI	2.0		2.0					
	A	0.02		0.01					
Proteocephalus gobiorum pl	P								0.1
	MI								1.0
	A								0.001
Trematoda									
Acanthostomum imbutiformis met	P				0.3	25.0			2.3
	MI				7.0	10.6			10.4
	A				0.02	2.6			0.2
Asymphylodora pontica	P				7.6	16.2			4.6
	MI				19.8	18.4			19.3
	A				1.5	3.0			0.9
Bucephalus polymorphus met	P								1.7
	MI								8.2
	A								0.1
Cercaria gen. sp.	P		4.1	1.3					
	MI		41.0	41.0					
	A		1.7	0.5					
Cryptocotyle concavum met	P	6.5	45.9	17.7	25.2	88.2		56.8	28.5
	MI	8.6	74.0	62.8	89.3	184.5		156.8	141.4
	A	0.6	34.0	11.1	22.5	162.7		89.1	40.3

1	2	3	4	5	6	7	8	9	10
Cryptocotyle lingua met	P				23.3	85.3		59.1	26.2
	MI				54.7	564.2		167.4	224.9
	A				12.8	481.2		98.9	58.9
Diplostomum spathaceum met	P	18.5	36.5	26.3					
	MI	12.8	15.6	17.3					
	A	2.4	5.7	4.6					
Pygidiopsis genata met	P					26.5		9.1	4.0
	MI					178.8		2.3	105.0
	A					47.3		0.2	4.2
Tylodelphys clavata met	P		2.7	0.9					
	MI		1.0	1.0					
	A		0.03	0.01					
Nematoda									
Anguillicola crassus L3	P	13.9		6.5					
	MI	1.5		1.5					
	A	0.2		0.1					
Contracaecum microcephalum L3	P								0.1
	MI								1.0
	A								0.001
Contracaecum rudolphii L3	P						0.5		0.1
	MI						1.0		1.0
	A						0.01		0.001
Dichelyne minutus	P	0.9		0.4	19.4	58.8	26.3	34.1	25.5
	MI	1.0		1.0	6.7	11.6	10.2	3.8	9.1
	A	0.01		0.004	1.3	6.8	2.7	1.3	2.3
Eustrongylides excisus L3	P								0.9
	MI								1.0
	A								0.01
Hysterothylacium aduncum	P	2.8		1.3					
	MI	1.3		1.3					
	A	0.04		0.02					
Hysterothylacium aduncum L3	P	5.6	9.5	6.9					
	MI	1.3	1.1	1.2					
	A	0.1	0.1	0.1					
Raphidascaris sp. L3	P				0.3				0.3
	MI				1.0				1.0
	A				0.003				0.003
Streptocara crassicauda L3	P				0.3	1.5	0.6	4.6	0.8
	MI				4.0	1.0	1.0	25.5	9.7
	A				0.01	0.01	0.01	1.2	0.1
Acanthocephala									
Pomphorhynchus laevis	P	0.9		0.4					
	MI	1.0		1.0					
	A	0.01		0.004					

1	2	3	4	5	6	7	8	9	10
Acanthocephalus lucii	P	0.9		0.4			8.1		2.1
	MI	1.0		1.0			2.4		2.4
	A	0.01		0.004			0.2		0.05
Acanthocephaloides propinquus	P				3.3	19.1		50.0	6.3
	MI				1.2	1.5		8.1	5.1
	A				0.04	0.3		4.1	0.3
Telosentis exiguus	P				0.6	4.4	4.5		2.3
	MI				1.0	1.0	3.0		2.4
	A				0.01	0.04	0.1		0.1
Hirudinea									
Piscicola geometra	P	0.9		0.4					
	MI	1.0		1.0					
	A	0.01		0.004					
Crustacea									
Ergasilus sieboldi	P			2.2					
	MI			10.0					
	A			0.2					
Species number		9	5	11	9	9	6	7	16

* - includes the data from all sampling sites of the Gulf of Gdańsk (Figure 1);

** - includes the data from all sampling sites of the Northwestern Black Sea (Figure 1).

C. concavum was core species both in Baltic and Black Seas (Table 1). In the Baltic Sea the core species was also the trematode *Diplostomum spathaceum* (Diplostomatidae), but in the Black Sea it were *Cryptocotyle lingua* (Heterophyidae), *P. genata*, and *D. minutus*. The secondary species was *Asymphylodora pontica* (Monorchidae) (in the Black Sea only), but satellites were Cercaria gen. sp. and *Ergasilus sieboldi* (Ergasilidae) in the Baltic Sea, and *Acanthostomum imbutiformis* (Acanthostomatidae) in the Black Sea (Table 1).

The acanthocephalan *A. lucii* was rare both in Baltic and Black Seas. Also in the Baltic Sea the rare species were the cestode *Bothriocephalus* sp. (Bothriocephalidae), the trematode *Tylodelphys clavata* (Diplostomatidae), nematodes *A. crassus, D. minutus*, *Hysterothylacium aduncum* (Raphidascaridae), the acanthocephalan *Pomphorhynchus laevis* (Pomphorhynchidae), and the leach *Piscicola geometra* (Piscicolidae). In the Black Sea their were the cestode *Proteocephalus gobiorum* (Proteocephalidae), the trematode *Bucephalus polymorphus* (Bucephalidae), nematodes *Contracaecum microcephalus*, *Contracaecum rudolphii* (Anisakidae), *Eustrongylides excisus* (Dioctophymatidae), *Raphidascaris* sp. (Raphidascaridae), *S. crassicauda*, and the acanthocephalan *Telosentis exiguus* (Illiosentidae).

The Baltic goby infection with *A. lucii* is similar to one of the Black Sea goby, but same parameters for other two parasites (*C. concavum*, *D. minutus*) are distinguished (Figure 2a). The infection of the goby off Puck does not similar to other ones (Figure 2a). The goby infection off Hel is rather similar to one in the Gulf of Odessa and the Khadzhibey Estuary (Figure 2b). But the goby infection off Puck is similar to one in the Hryhorivsky Estuary and the Budaki Lagoon. The Baltic round goby infection is similar to ones in the Gulf of Odessa and the Khadzhibey Estuary but not to ones in the Hryhorivsky Estuary and the Budaki Lagoon (Figure 2c).

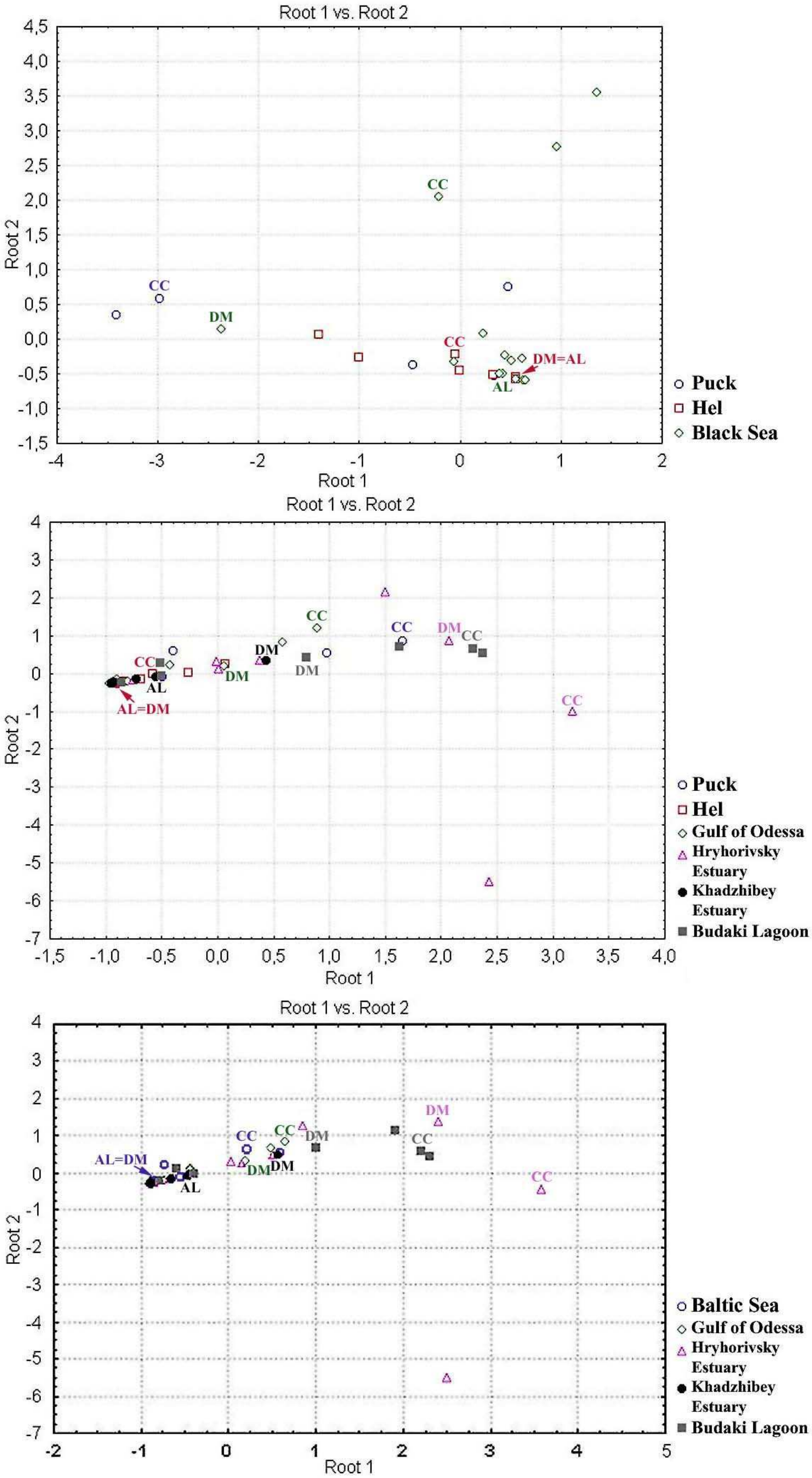

Figure 2. Plots of discriminant function of parasitological indices (P; MI; A) of helminths infest the round goby in the Baltic and Black Sea. A - comparing of two sites of the Baltic Sea to the Black Sea; B - comparing of two sites of the Baltic Sea to four sites of the Black Sea; C - comparing of the Baltic Sea to four sites of the Black Sea. CC - *Cryptocotyle concavum* met; DM - *Dichelyne minutus*; AL - *Acanthocephalus lucii*.

DISCUSSIONS

The sandy bottoms are typical for opened sea areas, such as Hel near-shores (Baltic Sea) and Gulf of Odessa (Black Sea), but not to the Puck Lagoon and Northwestern Black Sea lagoons and estuaries. It makes diference between goby parasitization with common parasites (*C. concavum*, *D. minutus*, *A. lucii*) off Hel and Odessa, and in Puck and Budaki Lagoons, and Hryhorivsky Estuary (Figure 2b).

Both in the Gulf of Gdańsk and in the Khadzhibey Estuary *A. lucii* occurred as parasite species of the round goby (Kvach, 2002; Kvach, 2004). The Khadzhibey Estuary of the Black Sea is similar to the Baltic Sea by its salinity. So, water salinity of the Gulf of Gdańsk is ~ 7‰, but in the Khadzhibey Estuary is 2 - 3‰ (up to 6‰). Also in the Khadzhibey Estuary the fish were sampled on sites with the sandy bottom. Therefore the round goby infection in this estuary is similar to ones in the Baltic Sea (Figure 2a, c).

The infection of the goby in the Puck Lagoon is more similar to one in the Hryhorivsky Estuary and Budaki Lagoon of the Black Sea (Figure 2b). These water areas are characterized by high abundance of the round goby infection with heterophyid (and diplostomatid in the Baltic Sea) trematodes. The muddy bottom of these water areas is best substrate for mud snails of *Hydrobia* genus that are first intermediate host for *Cryptocotyle* spp. (Zander et al., 2000). Therefore the infestation of the round goby in these water areas is higher than in Odessa and Hel near-shores.

CONCLUSIONS

The parasite fauna of the invasive round goby in the Gulf of Gdańsk is poorer than in the native habitats in the Northwestern Black Sea.

The parasitization of the round goby is similar in water areas with similar ecological conditions (opened water area or closed reservoirs) in native habitats and in a place of invasion.

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AUTHORS:

[1] *Yuriy KVACH*
quach@paco.net
National Academy
of Science of Ukraine,
Odessa Branch of the
Institute of Biology of the Southern Seas,
Pushkinska Vul., no. 37,
Odessa, Ukraine,
UA - 65011.

[2] *Krzysztof Edward SKÓRA*
oceks@univ.gda.pl
University of Gdańsk,
Institute of Oceanography,
Hel Marine Station,
Morska Ul., no. 2,
Hel, Poland,
PL - 84150.

SEX-DEPENDENT MORTALITY IN THE GUPPYFISH (*POECILIA RETICULATA* PETERS, 1859)

Valentin I. MAG [1], *Ioan BUD* [2] and *Ruxandra M. PETRESCU* [3]

KEYWORDS: low temperature-resistance gene, high temperature, sex-linkage, X chromosome, guppy, millionfish, sex-ratio.

ABSTRACT

The paper presents results regarding the difference of mortality values between the two sexes when guppy is exposed to overheating. The results indicate a possible X-linkage of high temperature-resistant gene, exactly as the low temperature-resistant gene.

This show an availability of hypothesis emitted by Karayücel et al., (2006) regarding the same identity of the two temperature-resistant genes: high temperature-resistant gene and low temperature-resistant gene respectively.

REZUMAT: Mortalitatea dependentă de sex la peştii guppy (*Poecilia reticulata* Peters, 1859).

Lucrarea prezintă rezultatele unor cercetări cu privire la valorile diferite ale mortalității între cele două sexe când peştii guppy sunt expuşi la supraîncălzire. Rezultatele arată un posibil linkaj al genei rezistenței la temperaturi ridicate cu cromosomul X, precum cel al genei rezistenței la temperaturi scăzute.

Acestea întăresc ipoteza emisă de Karayücel et al., (2006) cu privire la identitatea comună a celor două gene: gena rezistenței la temperaturi scăzute şi cea care conferă rezistență la temperaturi ridicate.

RESUME: Influence du sexe sur la mortalité des poissons guppy (*Poecilia reticulata* Peters, 1859).

Ce travail presente les résultats de quelques recherches sur la mortalité différentielle entre les deux sexes lorsque les poissons guppy sont exposés à une augmentation de température. Les résultats démonstrent un lien possible entre le gène de résistance à des témperatures hautes et le chromosome X, de la même manière que pour le gène de résistance aux témperatures basses.

Ceci confirme la supposition de Karayücel et al., (2006) sur l'identité commune des deux gènes de resistance à la température: le gène de résistance aux témperatures basses et le gène de résistance aux températures basses

INTRODUCTION

Poecilia reticulata, the popular and widespread guppyfish, has been brought for the first time in Europe in 1960 by Robert John Lechmere Guppy (Bud, 2002; Bud et al., 2005).

Origin and Distribution. The species originates from South America: Venezuela, Barbados, Trinidad, Northern Brazil and Guyanas. It was widely introduced and established elsewhere, mainly for mosquito control. Several countries report adverse ecological impact after introduction. Africa: feral populations reported from the coastal reaches of Natal rivers from Durban southwards, as well as in the Kuruman Eye and Otjikoto Lake in Namibia (www.fishbase.org). Europe: in countries having warm climate, or having thermal waters: Hungary, Romania (Băile Felix, Băile 1 Mai) (Mag et al., 2006).

Taxonomy of Guppyfish. Family: Poeciliidae (Poeciliids); subfamily: Poeciliinae; order: Cyprinodontiformes (rivulines, killifishes and livebearers); class: Actinopterygii (ray-finned fishes).

Morphology. dorsal spines (total): 0 - 0; dorsal soft rays (total): 7 - 8; anal spines: 0; anal soft rays: 8 - 10 (www.fishbase.org).

Biology and Environment. They occur in warm springs, their effluents, weedy ditches and channals. Found in various habitats, ranging from highly turbid water in ponds, channals and ditches at low elevations to pristine mountain streams at high elevations. Has a wide salinity range but requires fairly warm temperatures (23 - 24°C) and quiet vegetated water for survival. They feed on zooplankton, small insects, and detritus. Guppy is a benthopelagic, non-migratory, freshwater, brackish fish. pH range: 7 - 8; dH range: 9 - 19. Climate: tropical, 18 - 28 °C; 14 °N - 2 °N, 67 °W - 52 °W. High, minimum population doubling time less than 15 months (tm = 0.16 - 0.25; Fec = 20 - 100 (20 - 40 in the wild) with multiple spawning per year). Female reaches 5 cm SL. Males mature at 2 months and females at 3 months of age. Not in IUCN Red List (www.fishbase.org).

Sex Determination. In guppyfish, sex determination is one of drosophila type. The male possesses an X and a Y chromosome (Winge, 1922a,b) and produces, from this point of view, gametes of two kinds: X and Y. Female, two X chromosomes possesses, and produces X-type gametes only. Theoretically, if the male donates to its progeny the Y chromosome, a male is the result. Contrary, the future fry is a female. Practically, occasional XX males and XY females may occur because of autosomal polygenes, which can outbalance the effect of the epistatic sex determining genes. Winge named these XX males - false males. After he demonstrated the existence of these false males, he crossed them with normal females. As he expected, an all-female generation of progeny resulted. The obtained females have been backcrossed with the previous false males. After a few backcrossings of this type, the percentage of males increased, and the sex-ratio became approximately 1:1. According to this, the absence of Y chromosome in population do not affects its survival. He stated that masculinization of the females which have no Y chromosome can be explained by existence of autosomal masculinizing factors that outbalance the effect of the X chromosomes.

Genetics. *Poecilia reticulata* has a number of 46 chromosomes, 22 pairs of autosomes and two heterosomes. The X and Y chromosomes are both the same size in guppy. A survey of the literature on the inheritance of male traits shows that color patterns, caudal fin size and shape, courtship rates, and a composite measure of attractiveness are primarily sex-linked in the guppy (Lindholm and Breden, 2002). An exception is body size, which shows high heritability but has not been shown to be sex-linked (Reynolds and Gross, 1992; Yamanaka et al., 1995; Brooks and Endler, 2001). Both quantitative genetic and pedigree analyses indicate that most of the attractive male traits are not exclusively Y-linked (Kirpichnikov, 1981). Many of these traits recombine between the X and Y chromosomes, revealing the homology between guppy sex chromosomes. Suppression of recombination is probably not complete even in the nonhomologous region. A recent linkage map (Khoo et al., 1999a,b,c; Khoo et al., 2003), based on phenotypic traits suggested that the sex-determining region is flanked on both sides by recombining regions. Anyway, these seldom phenomena of recombination cannot explain the extraordinary variability of the Y-linked male guppy pattern and the rapid dynamic of evolution of these patterns depending on predator spectrum. It has recently been shown that there is some cytological and molecular differentiation between the X and Y chromosomes (Traut and Winking, 2001). Only one half of the Y chromosome pairs with homologous regions of the X in synaptonemal complexes. Furthermore, the orientation of the chromosomes allowed for recombination in only 2 of 49 synaptonemal complexes observed; this suggests that recombination is also greatly reduced even in the pairing, homologous region. Comparative genomic hybridization indicated that a large part of the non-pairing region of the Y chromosome comprises male specific repetitive DNA (Traut and Winking, 2001) and that there is structural variation among Y chromosomes in this region. This agrees with results from an in situ hybridization study showing that Y chromosomes, but not X chromosomes, of some domesticated guppies carry large numbers of simple repetitive sequences (Nanda et al., 1990). However, these male-specific repeats were not observed in recent descendants of wild guppies (Hornaday et al., 1994). Degeneration of the Y chromosome is supported by the observation that inheritance of Y chromosomes bearing alleles for attractive male traits leads to increased mortality (Brooks, 2000). The buildup of simple repetitive sequences and deleterious mutations on Y chromosomes that produce male guppies highly attractive to females would provide a mechanism for the result that more attractive males produce sons of lower viability.

The Y-linked traits express in males only (as long as female has no Y chromosome). A few much studied Y-linked traits are: *Maculatus*-red (Schmidt, 1920; Winge, 1922a,b, 1927, 1934; Winge and Ditlevsen, 1938, 1947; Haskins and Haskins, 1951; Haskins et al., 1970), *Oculatus* (Schmidt, 1920; Winge, 1927), *Armatus* (Blacher, 1927, 1928; Winge, 1927; Haskins et al., 1970), *Pauper* (Winge, 1927, 1934; Winge and Ditlevsen, 1938, 1947; Haskins et al., 1970), *Sanguineus* (Winge, 1927), *Iridescens* (Winge, 1922b; Blacher, 1928, Winge and Ditlevsen, 1947; Dzwillo, 1959), *Aureus* (Winge, 1927), *Variabilis* (Winge, 1927), *Ferrugineus* (Winge, 1927), *Bimaculatus* (Blacher, 1927, 1928), *Reticulatus* (Natali and Natali, 1931, in Kirpichnikov, 1981), *Trimaculatus* (Natali and Natali 1931, in Kirpichnikov, 1981), *Viridis* (Natali and Natali, 1931, in Kirpichnikov, 1981), *Bipunctatus* (Natali and Natali, 1931, in Kirpichnikov, 1981), *Doppelschwert* (Dzwillo, 1959), *Filigran* (Dzwillo, 1959). Beside these, there are a few quantitative traits which are encoded by poligenes. These Y-linked quantitative traits are: black area (Brooks and Endler, 2001), fuzzy black area (Brooks and Endler, 2001), iridescent area (Brooks and Endler, 2001), mean brightness (Brooks and Endler, 2001), brightness contrast (Brooks and Endler, 2001), mean chroma (Brooks and Endler, 2001), attractiveness (Brooks, 2000), tail area (Brooks and Endler, 2001), courtship (Farr, 1983).

The X chromosome is less well understood but is assumed to carry similar genes to the Y chromosome excepting those involved in sex determination of the males, since YY males which have no X chromosome, can be fully viable (Lindholm and Breden, 2002). Only one X-linked gene has been found in guppies which is unlikely to be sexually selected: a low temperature-resistance gene that is expressed in both males and females (Fujio et al., 1990). The X chromosome may have a region homologous to that of non-recombining region of the Y chromosome, but so far no genes have been shown to be exclusively linked to it. Two color pattern genes that are on the X chromosome but are not known to recombine to the Y chromosome are candidates for such a region *Lineatus* and *Nigrocaudatus* I. X-linked color patterns always have male-limited expression but can be developed in females with testosterone treatment (Jayasooriya et al., 2002; Lindholm and Breden, 2002; Mag-Mureşan et al., 2004), which allows confirmation of inheritance in females. Only patterns that have never been reported from wild populations show weak expression in females without testosterone treatment (*Nigrocaudatus* I and II, *Flavus*, *Pigmentiert caudalis*, black caudal peduncle, red tail, blue tail, green tail, variegated tail) and are most likely mutations restricted to domesticated populations. In general, male X-linked traits exclusively express in males, but a few of them can exppress in both male and female organism. Of course, their expresion is weak in females and their intensity cannot be compared with the fully expression of these traits in guppy males. This is the situation of some traits as: *Nigrocaudatus* I (Nybelin, 1947), *Nigrocaudatus* II (Dzwillo, 1959; Nayudu, 1979), *Flavus* (Winge and Ditlevsen, 1947; Nayudu, 1979), *Pigmentiert caudalis* (Dzwillo, 1959; Schröder, 1969a; Nayudu, 1979), red tail (Fernando and Phang, 1990; Khoo et al., 1999b,c), blue tail (Fernando and Phang, 1990; Phang and Fernando, 1991), green tail (Phang et al., 1989a; Phang and Fernando 1991), variegated tail (Khoo et al., 1999a,b), black caudal peduncle (Khoo et al., 1999b,c) and black tail (Mag and Bud, unpublished data).

Autosomes have many fewer genes for fin form and pigmentation. Expression of autosomal Z*ebrinus* (Winge, 1927) and *Bar* (Phang et al., 1999) genes is limited to males but the genes: blond (Goodricht et al., 1944), golden (Goodricht et al., 1944), blue (Dzwillo, 1959), *albino* (Haskins and Haskins, 1948), *kalymma* (Schröder, 1969b), suppressor (Schröder, 1969b) and elongated (Horn, 1972), are expressed in both males and females (Lindholm and Breden, 2002).

There is a huge polymorphism, a strong polychromism and an extraordinary variability between populations and as well between individuals of the same population, in the wild. In the case of standardized varieties (more than 40), the variability between the individuals of the same stock is much lower, and variability between different varieties is extraordinary. There are a few well known guppy varieties in Romania too. These are: Half-Black Red, Half-Black Black, Yellow Snakeskin, Red Snakeskin, Green Snakeskin, Blue Metallic, Micariff, and Red Blond. Snakeskin varieties are known also as King Cobra Guppy, or simply Cobra.

The guppyfish is a species of economical and commercial interest, having such an importance for the aquarium market, as also a model organism (physiology, endocrinology, carcinogenesis studies), in ecology (especially in behavioral ecology and sexual selection), ecotoxicology (as bioindicator), phylogeny (study of speciation phenomena, evolution of sex chromosomes in vertebrates, etc) and genetics research.

Low Temperature-Resistant Gene. In their paper „Detection of a low temperature-resistant gene in guppy (*Poecilia reticulata*), with reference to sex-linked inheritance”, Fujio et al., (1990) reported an X-linked gene, responsible of low temperature-resistance in guppy fish. In 2006, in the paper: „Effect of temperature on sex ratio in guppy *Poecilia reticulata* (Peters 1860)”, Karayücel et. al., 2006, emitted the hypothesis that the same gene is involved in high temperature resistance of guppy fish. In that moment the mentioned gene becomes a very important one for guppyculture fish and aquaculture, especially because of extrapolation possibility of these studies to many cases of economical and commercial important species.

In a CEEX research project programme (Mag et. al., 2006) intend to test a number of 150 - 175 RADP 10-mer primers from OPA, OPB, OPC, OPD, OPE, OPF and OPG series (Operon Tech. Alameda, CA., USA), and to identify markers associated to low temperature resistance. The next step of this research is obtaining a homozygote strain of guppy fish for that locus, and this will be possible because of gene's X-linkage. Crossing homo - or heterozygote low temperature-resistant females with hemizygote males for that locus eliminates the problem of dominance of the RAPD markers. Monitoring of low temperature-resistant gene is facilitated of the presence of an X-linked *Nigrocaudatus* gene that can be used as color marker gene (Mag and Bud, 2006). One hundred of homozygote individuals will be tested with previous identified genetic markers and then will be exposed to controlled increasing values of temperature. The tested stock will be compared with a control stock for obtaining conclusive results as regards involving of the same low temperature-resistant gene in high temperature-resistance too.

Purpose of The Research. The low temperature-resistant gene seems to be X-linked, dominant and it seems to be the one who confer to a guppyfish the resistance to water overheating too. That mean males which posses the gene are hemizygote and the chance of a male to inherit the gene is much lower than that of female which can be homozygote or heterozygote for that locus.

Let's consider the chance of male to inherit the resistant gene *R* (resistance); than chance of female to inherit the same gene is $2R-R^2$ (probability of inheritance from father + probability of inheritance from the mother - probability of an individual to inherit two X chromosomes bearing the gene for thermo-resistance). However, R^2 is not a significant value. The male cannot in generall inherit the X chromosome and consequently the temperature resistant gene from its father, but from its mother. Exposing three experimental lots to overheating, we studied the difference between mortality values in the two studied cases: males and females, if there is any. These obtained results permit the confirmation of linkage with X chromosome of high temperature-resistant gene in guppy fish if mortality of the two sexes is different affected of overheating and if the females are less serious affected of the high temperature. The X-linkage of the high temperature-resistant gene in the guppy fish may increase the credibility of identity between these two temperature resistant genes.

Research done by us wishes to be useful especially to ornamental fish breeders but, also, it is a step forward on studies on this field of biology and ecology.

MATERIALS AND METHODS

In our study we used three different lots of Green Filigran Guppy fish, all of them random taken from USAMV Cluj-Napoca Biobasis. Each lot was composed by equal numbers of males and females (20 males and 20 females).

These three lots of Green Filigran Guppy fish were gradually exposed to overheating. The temperature was increased with two degrees Celsius daily using an electric heater for each water tank. The experience began with 26ºC in water tank and continued for eight days. In the last day the temperature increased to 40 ºC. The value of mortality in each tank was taken in evidence and compared to control tank, where temperature was maintained to 26ºC.

RESULTS AND DISCUSSIONS

The mortality increased with increasing temperature and this fact was more evident in the case of males and less in the case of females. In the control lot no individual died in the eight days of experience (Table 1).

Table 1. Increasing mortality depending on temperature and fish gender.

Lot/ temperature/ day	26ºC 1 st day	28ºC 2 nd day	30ºC 3 rd day	32ºC 4 th day	34ºC 5 th day	36ºC 6 th day	38ºC 7 th day	40ºC 8 th day
1st lot	0	0	0	0	0	1 (♂1-♀0)	1 (♂1-♀0)	7 (♂4-♀3)
2nd lot	0	0	0	0	1 (♂1-♀0)	1 (♂1-♀0)	2 (♂2-♀0)	4 (♂3-♀1)
3rd lot	0	0	0	0	0	2 (♂2-♀0)	2 (♂1-♀1)	6 (♂4-♀2)
Control lot	0	0	0	0	0	0	0	0

In the first lot, nine individuals died from 40. There were six out of nine males and three of them were females. In other words, 66.67% from the lost individuals were males and 33.33 were females.

In the second lot, eight individuals died from 40. Seven out of eight were males and just an individual was female. That mean, 87.50% from the lost individuals were males and 30.00 were females.

Finally, in the 3rd lot, ten individuals died. There were seven out of ten males and three were females; in other words, 70.00% from the lost individuals were males and the rest of 30.00% were females. No individual died in the control lot, where the temperature remained at same value.

We can see, in the table 1 and table 2, the fact that values of the mortality are different in the case of two sexes, and males are stronger affected of overheating than females. The results are not much different of probabilistic estimated ones, taking in account the fact that male has a half of the female's chances to inherit the temperature resistant gene. Also, the results are almost identical in the three lots of guppy.

The results indicate a possible X-linkage of high temperature-resistant gene, exactly as the low temperature-resistant gene. This show an availability of hypothesis emitted by Karayücel et al. (2006) regarding the same identity of the two temperature-resistant genes: high temperature-resistant gene and low temperature-resistant gene. However, sure is the fact that guppy males are more vulnerable to overheating than females.

But which are ecological explanation of this phenomenon and its implication? Probably the phenomenon is related to sex-ratio regulation in *Poecilia reticulata.* We know from previous experiences (Mag and Bud, 2005) that guppy male, due to its sexual dimorphism is more exposed to predation and this predation is more intense in one season that in others. Perhaps guppy uses the temperature as a key regulator of its sex-ratio, producing more males when the temperature is higher and more females when the temperature is lower. This fact, probably, conducted to development of other regulation mechanisms that outbalance the effect of the previous one.

Anyway, sex-ratio regulation is not so simple, temperature is not the only key regulator. The complex interaction between guppy individuals have been shown to be implicated in this phenomenon too (Mag et al. 2005a,b,c), and probably pH is, as well, involved in sex-ratio in spite of chromosomal sex determination in guppy.

Implication of this gene in aquiculture can be of a significant economic advantage from three points of view. First, resistance to cold water reduces the costs of fish breeding. Second, resistance to overheating permits the culture of some species in warm climate. Third is that warm water is lethal to some pathogens that often appear in aquiculture.

Table 2. Mortality depending on temperature and fish gender.

Lot	Total individuals	Nr. ♂	Nr. ♀	Lost individuals	♂		♀	
					Nr.	%	Nr.	%
1 st Lot	40	20	20	9	6	66.67	3	33.33
2 nd Lot	40	20	20	8	7	87.50	1	12.50
3 rd Lot	40	20	20	10	7	70.00	3	30.00
Control Lot	40	20	20	0	0	-	0	-

CONCLUSIONS

Guppy males are stronger affected of overheating than females. Values of the mortality are different in the case of two sexes. The results are not much different of probabilistic estimated ones, taking in account the fact that male has a half of the female's chances to inherit the temperature resistant gene. The results indicate a possible X-linkage of high temperature-resistant gene, exactly as the low temperature-resistant gene. This agrees with hypothesis emitted by Karayücel et al. (2006) regarding the same identity of the two temperature-resistant gene: high temperature-resistant gene and low water-resistant gene respectively. However, sure is the fact that guppy males are more vulnerable to overheating then females.

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AUTHORS:

[1] *Valentin Ioan MAG*
zoobiomag2004@yahoo.com
[2] *Ioan BUD*
ioanbud2000@yahoo.com
[3] *Ruxandra Mălina PETRESCU*
pmalina2000@yahoo.com
University of Agricultural Sciences
and Veterinary Medicine,
Faculty of Animal Husbandry,
Department of Aquaculture,
Calea Mănăştur St., no. 3 - 5,
Cluj-Napoca, Cluj County, Romania,
RO - 400372.

EFFECT OF THE PH ON SEX-RATIO IN *POECILIA RETICULATA* (PETERS 1859)

Valentin I. MAG [1], *Ioan BUD* [2] and *Ruxandra M. PETRESCU* [3]

KEYWORDS: millionfish, guppyfish, male percentage, water quality, pH, aquaculture, sex-ratio manipulation.

ABSTRACT

The paper treats the influence of pH upon sex-ratio in guppies. The pH seems to be an another factor with influence upon sex-ratio but its use in guppyculture for manipulation of sex-ratio may lead to adverse effects as high mortality and low growth rate.

REZUMAT: Efectul pH-ului asupra raportului dintre sexe la specia *Poecilia reticulata* (Peters 1859).

Lucrarea de față tratează influența pH-ului asupra raportului dintre sexe la peştii guppy. pH-ul pare a fi un alt factor cu influență asupra sex-ratio, dar utilizarea lui în guppycultură în vederea manipulării raportului dintre sexe poate cauza efecte adverse precum mortalitate crescută şi rată de creştere redusă.

RESUMEN: El efecto del pH sobre el sex-ratio en los guppy *Poecila reticulata* (Peters, 1859).

El trabajo se dedica al estudio de la influencia del pH sobre el sex-ratio en los guppy. El pH parece ser otro elemento que tiene influencia sobre el sex-ratio, pero su utilización en guppycultura para la manipulación del sex-ratio trae efectos negativos, asi como una gran mortalidad y una lentitud en el crecimiento.

INTRODUCTION

Poecilia reticulata is considered to be the most popular ornamental fish. In 1992, it alone accounted for nearly 26% of the total number of freshwater ornamental fishes imported into the United States (Tamaru and Ako, 1998). The guppyfish is important for studies of genetics, behavioral ecology, ecotoxicology, evolutionary ecology and conservation, being an invasive species in many geographical areas, (Mag et al. 2005).

Guppy (or the millionfish) is native of Venezuela, Guyanas, northern Brazil, Trinidad and Barbados (Bud, 2002). This species presents a strong dimorphism between the two genders, due to the males' more colored bodies and larger fins. Because of this sexual dimorphism there is a price discrepancy between the two genders on the market. That's why the aquarists try to increase the percentage of males in guppyculture.

In one of the last research, our colective (Mag and Bud, 2006) intended to find the lowest concentration of 17-alpha-methyltestosterone which administered to gravid females in the period of gonadal differentiation (5 - 24 days prior to parturition) leads to permanent masculinization of 80% from the total number of viable progeny. We studied, also, the efect of prolonging treatment with approximately 10 days after parturition, feeding the newly born fry with the same doses of androgenes in order to increase the male percentage. The results of gravid guppy females treatment with 50 mg 17-alpha-methyltestosterone/kg food, 5 - 24 days prior to parturition indicated an incomplete sex reversal of the treated stocks.

The results, when 200 mg 17-alpha-methyltestosterone/kg food was administered 5 - 24 days prior to parturition, indicated the fact that this dose of 17-alpha-methyltestosterone and, as well, 150 mg 17-alpha-methyltestosterone/kg food can be used in production of all-male guppy stocks. The dose of 100 mg/kg food is the best when production of at least 80% males is intended. When the treatment was prolonged 10 days after the parturition, the percentage of males obtained for each dose of 17-alpha-methyltestosterone was higher. Treatment of both gravid guppy females and their newly born fry with the lowest dose (50 mg of 17-alpha-methyltestosterone/kg food), 5 - 24 days prior to parturition and aproximately 10 days after parturition respectively, was very efficient. Moreover, a higher intensity of fins and body colour was observed in treated fry which were feed with 17-alpha-methyltestosterone enhanced food. This higher intensity of the colour was observed in both male and female young individuals, and even in their mothers. The higher were the administered doses of 17-alpha-methyltestosterone, the more colorful were the treated guppies.

Beside artificial induced masculinization, there is an another way for obtaining of all male stocks: use of supermales. These are males that posess two Y chromosomes in their caryotypes. Generally, all the alevins resulted by mating of these males with normal females are males. Of course, these males are not very useful if they spontaneous appeared. They can be artificially induced by treatment with estrogens (Mag et al., 2006; Petrescu and Mag, 2006).

It has shown of Winge at the beginning of the century (1922) that major sex determining locus is located on sex chromosomes in the non-recombining region of the X and Y (Traut and Winking, 2001). However, a minor role in sex-determination seems to have the autosomal poligenes too (Mag-Mureşan and Bud, 2004).

Very recent studies concerning environmental factors that influence the sex-ratio in guppies indicate the fact that sex-ratio of the differentiated individuals affects more or less sex-ratio of the young generation. In that experiments were tested individuals in different stages of development: eggs, embryos, alevins, juveniles and adults. The results indicated that sex-ratio of the stock can be easier manipulated in the early onthogenetic stage of development than later when the gonads differentiate in ovaries and testicles respectively. As we expected, the sex of adults could not be modified in spite of stress exerted by conspecifics, which have the opposite sex, upon them. The same is the situation in juveniles, excepting the accidental sex-reversals that occurred in the experiment. But a strong influence of the above mentioned factor we found in the case of experimented eggs and embryos (Mag et al., 2005) because of postcopulatory selection of the male producing sperms (Y) in the female and gonadal differentiation before parturition in guppy (Mag-Mureşan and Bud, 2004). Unexpected was a modified sex-ratio compared to control lot (Mag et al., 2005) of the tested alevins, knowing that guppy alevins have already differentiated gonads. The results indicated an environmental mechanism of sex-ratio regulation in spite of its chromosomal and polygenic sex determination (Mag et al., 2005).

To test whether temperature plays an important role in sex-ratio regulation of the offspring we exposed their parents from above mentioned strains of guppy to two temperature ranges: 17 - 23ºC and 22 - 30ºC. Females bred at 22 - 30ºC produced with 8.41% (Non selected), 1.14% (Half-Black Red), 3.58% (Red Snakeskin), 9.15% (Yellow Snakeskin), respectively 8.80% (Red Blond) more males than those bred at 17 - 23ºC.

Breeding alevins at different values of temperature failed to indicate postpartum any influence of the temperature upon sex ratio in guppy. These results indicate a postcopulatory selection of sperm in females depending on temperature (Mag and Bud, 2005).

A long standing question between the aquarists remained, till now, without answer: is the pH a factor with influence upon sex-ratio? The second question is related to the previous and this one is more important than first one: can it be used in increasing percentage of males? In this paper we tried to answer to this two questions.

Păsărin and Stan (2004) indicated differences of 51.5% between sex-ratios of two lots of guppy alevins born by the same female (sixth and seventh birth), lots that were bred at different pH values (see Table 1).

Table 1. Differences of sex-ratios between the sixth and the seventh birth of the same guppy female, two lots that were bred at different pH values (Păsărin and Stan, 2004)

Birth	pH value of alevins breeding	Sex-ratio
Sixth birth	6.0 - 6.5	85.8% ♂ and 13.5% ♀
Seventh birth	7.5 - 8.3	34.3% ♂ and 65.6% ♀

MATERIALS AND METHODS

Obtaining of water with low pH, using acid natural soils, tree ritidom or radix, is since long time ago known, especially of characid, cyprinodontid and cychlid breeders. Generally, in their methods the aquarists use to boil these compounds in a precise quantity of water, resulting a concentrate solution, rich in tanins and many organic acids. This water is then added to the matured water from reproduction tank.

An another method is water filtering through solid mass of above mentioned compounds, and obtaining of the same acid water, but in a longer time period.If we intend to increase the water pH value, the filtration should be done through a calcarous material, that is rich in calcium and magnesium. Water durization will conduct to an increasing of the pH value over 7.

As pH effect upon sex-ratio is more likely to be stronger before copulation because of postcopulatory selection of sperm, we have bred the parents in water with different pH values. For slowly increasing pH value of water, or slowly decreasing of water pH value, we placed into water thanks boxes with 5g mosaic / 1 liter of water, or *Quercus robur ritidom* + *Alnus glutinosa radix* (in proportion of 4:1, dry) 2.5g / liter of water, respectively.

In this way, the tap water having pH 7.0 - 7.2 could be kept at values that varied between 6.0 and 7.0, using tree ritidom and radix. The pH value of water from experimental tanks was daily measured and adjusted using just tap water. Keeping water pH between 7.0 and 8.0 was possible, using calcarous material for durization and tap water for correction after daily analysis.

Parents, one male for each four females, were bred in above described conditions for two months before parturition. Resulted alevins were bred in their own parents water two weeks, and then in similar pH conditions (pH - 7).

Four guppy varieties were used in this experiment (Half-Black Red, Red Snakeskin, Yellow Snakeskin, Red Blond) and a non-selected population, all of them from USAMV Cluj-Napoca biobasis.

RESULTS AND DISCUSSIONS

We can observe in tables 2 and 3, the fact that breeding parents in water that had low values of pH (6.0 - 7.0) determined a higher percentage of males than high pH values (7.0 - 8.0).

Table 2. Results of breeding parents at pH of 6.0 - 7.0.

Variety	Total number of alevins born by ten young females	Percentage (number) of males	Percentage (number) of females
Non selected	348	49.43% (172)	50.57% (176)
Half-Black Red	299	51.51% (154)	48.49% (145)
Red Snakeskin	325	52.62% (171)	47.38% (154)
Yellow Snakeskin	340	51.76% (176)	48.24% (164)
Red Blond	345	52.17% (180)	47.83% (165)

Table 3. Results of breeding parents at pH of 7.0 - 8.0.

Variety	Total number of alevins born by ten young females	Percentage (number) of males	Percentage (number) of females
Non selected	491	43.79% (215)	56.21% (276)
Half-Black Red	318	38.99% (124)	61.01% (194)
Red Snakeskin	410	32.20% (132)	67.80% (278)
Yellow Snakeskin	450	41.56% (187)	58.44% (263)
Red Blond	397	45.34% (180)	54.66% (217)

However, there are differences between the numbers of viable alevins in the two cases too. As well, individuals bred in higher water pH were different from many points of view: health, vigour, growth rate, appearence, roundness. Considering guppy as a fish that originates from the hard and basic waters of South America, these last results need no other explanation.

Our results show beside genetic (epistatic and polygenic) components involved in sex differentiation of the guppy an environmental factor consisting in a complex interaction between individuals too. The mentioned factor may act upon the individual even after parturition, in the alevin stage. These results come to contradict the hypothesis that considers the sex differentiation of the bipotent gonad complete at the parturition in the guppy.

Investigations on temperature effect upon sex-ratio show a posible postcopulatory selection of sperm in females depending on this factor.

The pH seems to be an another factor with influence upon sex-ratio but its use for manipulation of sex-ratio may lead to adverse effects as high mortality and low growth rate. Postcopulatory selection of sperm in guppy seems to depends on pH too, but sex reversal before parturition or postpartum is not excluded as Păsărin and Stan (2004) found differences in sex-ratio between lots bred in different pH condition exclusively after parturition.

CONCLUSIONS

Our results show beside genetic (epistatic and polygenic) components involved in sex differentiation of the guppy an environmental factor consisting in a complex interaction between individuals too. The mentioned factor may act upon the individual even after parturition, in the alevin stage. These results come to contradict the hypothesis that considers the sex differentiation of the bipotent gonad complete at the parturition in the guppy.

Studies on temperature effect upon sex-ratio show a posible postcopulatory selection of sperm in females depending on this factor.

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AUTHORS:

[1] *Valentin Ioan MAG*
zoobiomag2004@yahoo.com
[2] *Ioan BUD*
ioanbud2000@yahoo.com
[3] *Ruxandra Mălina PETRESCU*
pmalina2000@yahoo.com
University of Agricultural Sciences
and Veterinary Medicine,
Faculty of Animal Husbandry,
Department of Aquaculture,
Calea Mănăştur St., no. 3 - 5,
Cluj-Napoca, Cluj County, Romania,
RO - 400372.

ELEMENTS ON THE ICHTHYOFAUNA DIVERSITY OF PRUT RIVER BASIN

Alexander J. MOSHU[1], *Grigore G. DAVIDEANU*[2] and *Aurel S. CEBANU*[1]

KEYWORDS: taxonomic composition, fishes, agnates, Prut River, Romania, Moldova, Ukraine.

ABSTRACT

This paper presents some data obtained both from literature and by sampling of the fish fauna in the Prut River.

There is presented a table with all the 104 fish species of the Prut River, 65 of them being collected by the authors in between 1995 and 2005, in the Prut River and its tributaries in the Republic of Moldova and Romania.

The sampling was done using different nets types and a FEG 500 electrofisher.

REZUMAT: Elemente privind diversitatea ihtiofaunei bazinului râului Prut.

Lucrarea prezintă informații privind fauna piscicolă a râului Prut.

Datele au fost obținute atât din literatură cât şi din colectările pe teren. Este prezentat un tabel cu 104 specii de peşti, dintre care 65 au fost capturate de autori în perioada 1995 - 2005, în râul Prut şi afluenții săi, în Republica Moldova şi România.

Colectările au fost făcute în râul Prut şi afluenții săi cu diverse tipuri de plase şi cu un aparat de electronarcoză model FEG 500.

RESUME: Eléments sur la diversité de l'ichthyofaune du bassin de la rivière Prut.

Ce travail présente des informations sur la faune piscicole du bassin de la rivière Prut.

Les données sont fournies par la littérature et par échantillonnage sur le terrain. Il est présenté une liste de 104 espèces de poissons dont 65 ont été capturées par les auteurs pendant la période 1995 - 2005 dans la rivière Prut et dans ses affluents de la République de Moldavie et de Roumanie.

Les collectes ont été réalisées à l'aide de divers types de filets et d'un appareillage de pêche électrique.

INTRODUCTION

The Prut River is the largest of the lower Danube left side tributaries. They are three sectors of this river. The upper portion - from sources to the Cernăuți city, the medial sector in between Cernăuți and Sculeni and the lower portion from Sculeni to the confluence with Danube. The river has a network of about 540 tributaries; the total length of the river itself is 953 km. The studies confirm the human impact on the river habitats and fish fauna over the last 50 years. They are numerous examples of the impact as: The hydraulic works, Stânca Costeşti dam, the flood protection dykes built almost on the entire river length, the modification of the tributary's hydrology due to the hydrotechnic works and sand an rock pits, water and soil pollution, eutrophication, fish poaching, over fishing, invasive species introduction (Usatai, 2000; 2003a,b; 2004a,b; Usatai et al., 1998; 2003; Usatai, 2004).

During the last decade the biodiversity studies increases all over Europe. This fact is due to the necessity of understanding the general effects of human impact and in order to find solution to restrain the biodiversity reduction. There is a need to find solutions in order to maintain the valuable fish species stocks, to preserve the rare and vulnerable species from disappearing. All this general observation are valid for the Prut River also, and because of its border status in between Romania, Republic of Moldova and Ukraine it is the least studied big river of Europe. We may also add that this border regime also ensured a better protection because of restraining the public access in the area for many years. The best-studied part of the river is the Stânca-Costeşti lake. Unlike the river itself the lake was subject for some research themes aiming to assess its economic potential for fishery (Dolghii, 1993; Dolghii and Samohvalov, 2000; Muscinschi, Bruma, Citoroaga and Popa, 1983; Popa, 2000; Usatai, 2000; Usatai et al., 2003; Usatyi, 2004). We only have some incomplete data on the tributaries in Ukraine and Romania and scarce information on the tributaries in Republic of Moldova (Antipa, 1909; 1916; Bănărescu, 1964; Fauna of Ukraine, 1980 - 1988; Movchan et al., 2003).

Based on the literature they are registered about 50 - 54 fish species in the Prut River, and for the tributaries, lakes and ponds in its basin they are other - 25 - 47 species (Antipa, 1909; 1916; Bănărescu, 1964; Blanc et al., 1971; Cozari, Usatai and Vladimirov, 2003; Dolghii, 1993; Dolghii and Samohvalov, 2000; Fauna of Ukraine, 1980 - 1988; Movchan et al., 2003; Muscinschi et al., 1983; Popa, 1976; 1977; 2000; Usatai, 2000; 2003a,b; 2004a,b; Usatyi, 2004; Usatai et al., 1998; 2003a,b). The differences in between the species number indicated by different authors are due to the different taxonomical status of the subspecies and/or the conception regarding the inclusion or not of the new introduced species. We need to mention that the status of some subspecies taxa is still unclear. Beside this, most of the information are scattered among different editions and languages and because of the rapid modification of the river morphology they become soon obsolete.

The aim of this paper is to put together all the data in the literature and the field data collected by the authors in order to have a better understanding of the actual state of the Prut River fish fauna, for the Republic of Moldova and Romania. Because the authors did not use similar tools and sampling methods, we did not intend to appreciate the abundance of the fish. They are some published data on fish abundance: (Cozari, Usatai and Vladimirov, 2003; Dolghii and Samohvalov, 2000; Popa, 1999; Usatai, 2000; 2003a,b; 2004a,b; Usatyi, 2004; Usatai et al., 2003a,b).

MATERIALS AND METHODS

The samples were collected during the 1985 - 2005 years in the Prut River bed both on the right bank (village Stânca, v. Darabani, v. Ungheni, v. Prisecani, v. Grozeşti) on the left bank (v. Criva, Lipcani City, v. Lopatnic, v. Branişte, v. Balatina, v. Cuhneşti, v. Pruteni, v. Sculeni, v. Medeleni, Ungheni City, Cantemir City, v. Goteşti, Cahul City, Crihana - Veche, v. Manta, v. Brânza, v. Slobozia Mare) and in the Stânca Costeşti reservoir v. Viişoara, v. Bădragii Vechi, v. Cuconeştii Vechi, v. Văratic, v. Duruitoarea, Costeşti City); lake tributaries - river Drăghişte (v. Bulboaca - v. Brânzeni. They was collected samples on the tributaries also river Drăghişte (v. Bulboaca - v. Brânzeni), river Racovăț (v. Buzdugeni - v. Brânzeni) Corpaci reservoir, Ciuhur River (v. Pociumbeni - v. Costeşti), Jijia River (v. Hilişei - v. Horia, v. Corlățeni, v. Ungureni, v. Truşeşti, v. Răuşeni, v. Vlădeni, v. Țigănaşi, old Jijia oxbow). In the Natural lakes Manta and Beleu; fishery farms - Ungheni and Cahul.

The sampling was done using gillnets (ø 14 x 14 mm - 100 x 100 mm), hoop-nets (ø 18 x 18 mm - 40 x 40 mm), townets (ø 6 x 6 mm - 20 x 20 mm, l 5 - 40 m) and electrofisher (FEG 500). This data were completed using information collected from the the State Fishery Inspection, professional and sport fisherman. The fish identification was done using the papers of (Antipa, 1916; Bănărescu, 1964; Berg, 1948 - 1949; Fauna of Ukraine. Fishes, 1980 - 1988; Holcik, 1989; Koblitskaya, 1981; Nikolsky, 1971; Popa, 1977; Pravdin, 1966; Reshetnikov, 2002 - 2003). For the fish taxonomy actualization we used the internet site: www.fishbase.org, 2006; (Bogutskaya, Naseka, 2004 and Kottelat, 1997, papers).

RESULTS AND DISCUSSIONS

Based on the literature and sampling results the list of agnates and fish species includes 104 taxa (91 species and 9 hybrids or subspecies, belonging to 66 genera, 24 families and 13 orders. (Table 1). The biggest taxa number belongs to the Cypriniformes (4 families, 33 genera and 57 species) and Perciformes (4 families, 9 genera and respectively 16 species), that also have the most important role for the fish communities structure in the Prut River basin. The family with biggest species number is Cyprinidae - 47 species/subspecies, fallowed by the. Percidae Families with 8 species, fam. Cobitidae and Gobiidae with 6, fam. Acipenseridae şi Salmonidae - with 5, Clupeidae şi Catostomidae - with 3 species. In between the genera the genus with the highest number of species is *Romanogobio*, that includes 5 species/subspecies, the genera *Acipenser*, *Gobio*, *Sabanejewia* and *Neogobius* includes 4, and the rest of them in between 1 and 3 taxa.

From the total number of fish species (95) was cited in the literature, for 15 species the data were obtained from local fisherman and 65 species were captured by the authors (39 of the taxa mentioned in the literature were not identified in our samples). New species for the Prut River basin are: *Carassius carassius humilis, Alburnoides bipunctatus rossicus, Leuciscus borysthenicus, Sabanejewia romanica, Gasterosteus aculeatus, Neogobius kessleri, Neogobius gymnotrachelus, Neogobius melanostomus* and *Percottus glenii*.

Generally speaking, the structure of the Prut River fish fauna is similar with that of the Danube River. The ecological and faunal analysis of the data proves that the actual structure have a mixed character both because of its origin and the peculiar ecological character of the river. Considering the origin and geographic range of the species we find representatives of different regions as: Boreal planes, Boreal hilly regions, tertiary planes, Ponto-Caspian- Aralo freshwaters, Ponto- Caspian-Aralo salt waters, Ponto- Caspian- Aralo brackish water, West-Asian, East-Asian, Nearctic, Arctic freshwaters etc. with diverse forms (Mediterranean immigrants, Ponto-Azov, Pontic, Danube River, European, Circumpolar European). The species complex with highest species number is the Boreal Planes complex (Bănărescu, 1964; Berg, 1948 - 1949; Dolghii, 1993; Holcik, 1989; Popa, 1976; 2000).

The endemic species of the Prut, Danube and Nistru basins are *Umbra krameri, Zingel zingel, Zingel streber, Romonogobio uranoscopus, Neogobio kessleri*) and exclusive of Danube Basin - *Hucho hucho, Gymnocephalus schraetser* and *Gobio gobio carpathicus*.

We found 3 tertiar relict species (*Cottus gobio, Cottus poecilopus* and *Cobitis aurata*), 15 pontic pliocenic relicts - 15 (*Acipenser ruthenus, Acipenser stellatus, Umbra krameri, Rutilus frisii, Pungitius platygaster, Rutilus rutilus heckeli, Vimba vimba carinata, Proterorhinus marmoratus, Syngnathus abaster, Neogobius gymnotrachelus, Neogobius kessleri, Neogobius fluviatilis, Neogobius melanostomus*), and 5 species of Central Europe origin. (*Eudontomyzon danfordi, Hucho hucho, Gobio gobio carpathicus, Zingel streber*, *Gymnocephalus schraetser*).

Many species of Prut River basin are under threat and enlisted as protected species. In the Red Book of the Ukraine (1994) they are included 17 species, 13 - in The Red Book of the Republic of Moldova (2001) 32 in the Red book of Romania (2004) and around 35 - in European Red List (1991) and Red List of International Union for Nature Conservation (1994).

From the total amount of Prut River species 15 are alohtonous (neoarctic species - *Polyodon spathula, Ictiobus cyprinellus, Ictiobus bubalus, Ictiobus niger, Lepomis gibbosus, Ictalurus punctatus, Ictalurus nebulosus*; East-asian - *Hypophthalmychthis molitrix, Aristichthys nobilis, Ctenopharingodon idella, Mylopharingodon piceus, Pseudorasbora parva, Cyprinus rubrofuscus, Carassius auratus gibelio, Percottus glenii*). We need to mention that the species - *Ictiobus cyprinellus, Ictiobus bubalus, Ictiobus niger, Mylopharingodon piceus* and *C. rubrofuscus* - introduced in the basin are allready disaperead. The worst consequences of invasive species were produced by the accidental introduction of *Percottus glenii, Lepomis gibbossus* and *Pseudorasbora parva*. The expansion of these species in the river basin, tributaries and ponds are still on its way.

The fish fauna composition and distribution in between different sections and basins of the Prut River differs because of their peculiar ecological and hydrological character. The authors found 65 fish species in Prut River. In the Prut River downstrem the village Viişoara most of the species belongs to Cyprinidae family (Table 1).

In the lake Stânca-Costeşti the fish fauna comprise 50 species. The downstream sector of the river (Ungheni city- confluence with Danube River) is the most species rich. The fish resources in this area includes both the migratory species and species in the adjacent lakes. The natural lakes (Manta and Beleu) have a smaller species number (46 species) than the Prut River, and includes mostly species characteristic to still waters. The yearly floods have a direct impact on their fish fauna structure. The differences in between the lakes, based on their fish species number are not significant.

For the Prut River tributaries the specific diversity is even lower (42 species). Most of the tributaries are regulated, polluted and have a rather similar and scarce fish fauna - 10 - 18 species (Racovăț - 18, Draghişte - 17, Ciuhur - 11, Jijia - 10).

The most of the tributaries contains mainly fish from the Cyprinidae family. The composition of the fish fauna of the Prut River tributaries depends mostly of their dimension, the water flow and peculiar data on the floods and droughts alternation and the presence of the fish ponds along them. The diversity of the habitat types and ecological condition are also important. It is worth to mention that close to confluence, both the qualitative and quantitative composition of the fish fauna of the tributaries, increases. The tributaries, especially in the deltaic areas, far away of the urban areas, have higher species diversity. Downstream the urban areas the fish fauna are scarcer. A common thing for all the tributaries is the almost total absence of the sensitive or economically valuable fish species. This is caused by their relatively small number in the Prut River itself and of the cease of the migration from Prut River to the tributaries.

In the fish farms using Prut River water besides the common farm species (*Cyprinus carpio*, *Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Ctenopharingodon idella*), we may find a high diversity (34 species) of wild species with or without economic value.

Our study proves that because of the human impact there is a general trend of replacement of the valuable fish species with species without economic value.

The diversity and peculiar character of the Prut River fish fauna are due to its position in between three big river basins Tisa, Danube and Nistru.

The presence of infraspecific forms increases the fish diversity in this basin.

The hydrologic alteration due to the Stânca-Costeşti dam and the closing of the oxbow lakes along the river by dykes, produced major changes of the aquatic habitats transforming the structure of the fish communities. The results of these changes are the almost complete disappearance of the rheophilic species and the endemic species.

An essential problem is, and remains, the depletion of the fish fauna and the reducing of the valuable species. The lowering of the diversity is also caused by the reducing of the natural oxbows lakes and the human impact, and partially because of the insufficient studies of the area.

Table 1. Taxonomic composition of ichthyofauna in the Prut River basin.

Nr.	TAXA	Literature data	Authors data				
			RB	R	L	T	F
1	2	3	4	5	6	7	8
Superclass Agnatha, Class Cephalaspidomorpha, Order Petromyzontiformes, Family Petromyzontidae							
1.	*Eudontomyzon mariae* (Berg, 1931)	+	-	I?	-	I?	-
2.	*Eudontomyzon danfordi* (Regan, 1911)	+	-	-	-	-	-
3.	*Lampetra planeri* (Bloch, 1784)	+?	-	-	-	-	-
Superclass Gnathostomata, Class Actinopterigii, Order Acipenseriformes, Family Acipenseridae							
4.	*Acipenser ruthenus* L., 1758	+	C	C	I?	-	-
5.	*Acipenser nudiventris* Lovetsky, 1828	+	I?	-	-	-	-
6.	*Acipenser gueldenstaedtii* Brandt et Ratzeburg, 1833 / *Acipenser gueldenstaedtii colchicus* Marti, 1940	+	I?	-	-	-	-
7.	*Acipenser stellatus* Pallas, 1771	+	C	-	-	-	-
8.	*Huso huso* (L., 1758) / *H.huso ponticus* Salnikov et Malyatskii, 1934	+	I?	-	-	-	-

1	2	3	4	5	6	7	8
Family Polyodontidae							
9.	* *Polyodon spathula* (Walbaum, 1792)	+	-	C	-	-	C
Order Anguilliformes, Family Anguillidae							
10.	*Anguilla anguilla* (L., 1758)	+	-	-	-	I?	-
Order Clupeiformes, Family Clupeidae							
11.	*Alosa tanaica* (Grimm, 1901)	+	C	-	C	-	-
12.	*Alosa immaculate* Bennett, 1835	+	I?	-	-	-	-
13.	*Clupeonella cultriventris* (Nordmann, 1840)	+	I?	-	I?	-	-
Family Engraulidae							
14.	*Engraulis encrasicolus ponticus* Aleksandrov, 1927	+	-	-	-	-	-
Order Cypriniformes, Family Cyprinidae							
15.	*Cyprinus carpio* L., 1758 typ. et varr.	+	C	C	C	C	C
16.	* *Cyprinus rubrofuscus* La Cépède, 1803	+	-	-	-	-	-
17.	*Carassius carassius* (L., 1758)	+	-	-	-	-	-
18.	*Carassius carassius humilis* Heckel, 1837	-	-	-	-	-	C
19.	* *Carassius gibelio* (Bloch, 1782)	+	C	C	C	C	C
20.	*Abramis brama* (L., 1758) / *A. brama danubii* Pavlov, 1956	+	C?	C?	C?	C?	-
21.	*Ballerus ballerus* (L., 1758)	+	C	I?	I?	-	-
22.	*Ballerus sapa* (Pallas, 1814)	+	C	C	C	-	-
23.	*Blicca bjoerkna* (L., 1758)	+	C	C	C	C	-
24.	*Alburnus alburnus* (L., 1758)	+	C	C	C	C	C
25.	*Alburnus mento* (Heckel, 1836)	+	I?	-	-	-	-
26.	*Alburnoides bipunctatus* (Bloch, 1782)	+	-	-	-	-	-
27.	*Alburnoides bipunctatus rossicus* (Berg, 1924)	-	C	-	-	-	-
28.	*Leucaspius delineatus* (Heckel, 1843)	+	C	C	C	C	C
29.	*Leuciscus leuciscus* (L., 1758)	+	C	C	-	C	-

1	2	3	4	5	6	7	8
30.	*Leuciscus idus* (L., 1758)	+	C	-	I?	-	-
31.	*Leuciscus souffia agassizi* Valenciennes, 1844	+?	-	-	-	-	-
32.	*Petroleuciscus borysthenicus* (Kessler, 1859)	-	I?	-	-	-	-
33.	*Rutilus rutilus* (L., 1758) / *Rutilus rutilus carpathorossicus* Vladykov, 1930	+	C?	C?	C?	C?	C?
34.	*Rutilus rutilus heckeli* (Nordmann, 1840)	+?	-	-	-	-	-
35.	*Rutilus frisii* (Nordmann, 1840)	+	C	-	C	-	-
36.	*Scardinius erythrophthalmus* (L., 1758)	+	C	C	C	C	C
37.	*Squalius cephalus* (L., 1758)	+	C	C	C	C	-
38.	*Aspius aspius* (L., 1758)	+	C	C	C	C	-
39.	*Chondrostoma nasus* (L., 1758)	+	C	C	-	-	-
40.	*Vimba vimba* (L., 1758) / *V.vimba carinata* (Pallas, 1811)	+	C?	C?	C?	I?	-
41.	* *Hypophthalmichthys molitrix* (Valenciennes, 1844)	+	C	C	C	C	C
42.	* *Aristichthys nobilis* (Richardson, 1845)	+	C	C	C	C	C
43.	*Phoxinus phoxinus* (L., 1758)	+	C	-	-	-	-
44.	*Rhodeus amarus* (Bloch, 1782)	+	C	C	C	C	C
45.	* *Rhodeus sericeus* (Pallas, 1776)	+	-	C?	C?	-	C?
46.	*Barbus barbus* (L., 1758) / *Barbus barbus borysthenicus* Dybowski, 1862	+	C?	C?	-	-	-
47.	*Barbus meridionalis* Risso, 1827 / *Barbus meridionalis petenyi* Heckel, 1847	+	C?	C?	-	-	-
48.	* *Ctenopharyngodon idella* (Valenciennes, 1844)	+	C	C	C	C	C
49.	* *Mylopharyngodon piceus* (Richardson, 1846)	+	-	-	-	-	C

1	2	3	4	5	6	7	8
50.	*Pelecus cultratus* (L., 1758)	+	C	-	C	-	-
51.	*Tinca tinca* (L., 1758)	+	-	I?	C	-	I?
52.	*Gobio gobio* (L., 1758) / *Gobio gobio obtusirostris* Valenciennes, 1842	+	C?	C?	C?	C?	C?
53.	*Gobio gobio carpathicus* Vladykov, 1925	+	-	-	-	-	-
54.	*Gobio gobio sarmaticus* Slastenenko, 1934	+	-	-	-	-	-
55.	*Gobio vladykovi* Fang, 1943	+	C?	-	-	-	-
56.	*Romanogobio kessleri* (Dybowsky, 1862)	+	C	-	-	C	-
57.	*Romanogobio kessleri antipai* Banarescu, 1953	+	-	-	-	-	-
58.	*Romanogobio albipinatus* (Lukasch, 1933)	+	-	-	-	-	-
59.	*Romanogobio belingi* (Slastenenko, 1934)	+	-	-	-	-	-
60.	E *Romanogobio uranoscopus* (Agassiz, 1828) / *R.uranoscopus frici* Vladykov, 1925	+	-	-	-	-	-
61.	* *Pseudorasbora parva* (Temminck et Schlegel, 1846)	+	C	C	C	C	C
	Family Cobitidae						
62.	*Cobitis taenia* L., 1758	+	C	C	C	C	C
63.	*Sabanejewia aurata* (De Filippi, 1863)	+	C	C	-	C	-
64.	*Sabanejewia aurata balcanica* (Karaman, 1922)	+	-	-	-	-	-
65.	*Sabanejewia aurata vallachica* (Nalbant, 1957)	+	C?	-	-	-	-
66.	*Sabanejewia romanica* Bacescu, 1943	-	C	-	-	-	-
67.	*Misgurnus fossilis* (L., 1758)	+	C	C	C	C	C
	Family Balitoridae						
68.	*Barbatula barbatula* (L., 1758)	+	C	-	-	C	-

1	2	3	4	5	6	7	8
Family Catostomidae							
69.	* *Ictiobus cyprinellus* (Valenciennes, 1844)	+	-	-	-	-	C
70.	* *Ictiobus bubalus* (Rafinesque, 1818)	+	-	-	-	-	C
71.	* *Ictiobus niger* (Rafinesque, 1820)	+	-	-	-	-	C
Order Siluriformes, Family Siluridae							
72.	*Silurus glanis* L., 1758	+	C	C	C	C	C
Family Ictaluridae							
73.	* *Ictalurus punctatus* (Rafinesque, 1818)	+	-	I?	-	-	C
74.	* *Ameiurus nebulosus* (Lesueur, 1819)	+?	-	-	-	-	-
Order Esociformes, Family Esocidae							
75.	*Esox lucius* L., 1758	+	C	C	C	C	C
Family Umbridae							
76.	[E] *Umbra krameri* Walbaum, 1792	+	-	-	I?	I?	-
Order Salmoniformes, Family Salmonidae							
77.	*Salmo trutta fario* L., 1758	+	-	-	-	-	-
78.	*Salmo trutta labrax* Pallas, 1811	+?	-	-	-	-	-
79.	*Oncorhynchus mykiss* (Walbaum, 1792) / *O.mykiss irideus* (Gibbons, 1855)	+	-	-	-	-	-
80.	*Salvelinus fontinalis* (Mitchill, 1814)	+?	-	-	-	-	-
81.	[E] *Hucho hucho* (L., 1758)	+	-	-	-	-	-
Family Thymallidae							
82.	*Thymallus thymallus* (L., 1758)	+?	-	-	-	-	-
Order Gadiformes, Family Lotidae							
83.	*Lota lota* (L., 1758)	+	-	I?	-	-	-
Order Gasterosteiformes, Family Gasterosteidae							
84.	*Gasterosteus aculeatus* L., 1758	-	C	C	C	C	-
85.	*Pungitius platygaster* (Kessler, 1859)	+	C	C	C	C	C

1	2	3	4	5	6	7	8
Order Syngnathifomes, Family Syngnathidae							
86.	*Syngnathus abaster* Risso, 1827	+	-	C	C	-	-
Order Scorpaeniformes, Family Cottidae							
87.	*Cottus gobio* L., 1758	+	C	-	-	I?	-
88.	*Cottus poecilopus* Heckel, 1837	+	-	-	-	-	-
Order Perciformes, Family Percidae							
89.	*Perca fluviatilis* L., 1758	+	C	C	C	C	C
90.	*Gymnocephalus cernuus* (L., 1758)	+	C	C	C	C	C
91.	*Gymnocephalus acerina* (Gueldenstaedt, 1774)	+	C	C	-	-	-
92.	[E] *Gymnocephalus schraetser* (L., 1758)	+	I?	-	I?	-	-
93.	*Sander lucioperca* (L., 1758)	+	C	C	C	C	C
94.	*Sander volgensis* (Gmelin, 1789)	+	I?	-	-	C	-
95.	[E] *Zingel zingel* (L., 1766)	+	C	I?	-	-	-
96.	[E] *Zingel streber* (Siebold, 1863)	+	I?	-	-	-	-
Family Centrarchidae							
97.	* *Lepomis gibbosus* (L., 1758)	+	C	C	C	C	C
Family Gobiidae							
98.	*Neogobius fluviatilis* (Pallas, 1814)	+	C	C	C	C	C
99.	*Neogobius gymnotrachelus* (Kessler, 1857)	-	C	C	C	C	-
100.	*Neogobius melanostomus* (Pallas, 1814)	-	C	C	C	C	-
101.	*Neogobius kessleri* (Guenther, 1861)	-	-	C	C	C	C
102.	*Proterorhinus marmoratus* (Pallas, 1814)	+	C	C	C	C	C
103.	*Benthophilus stellatus* (Sauvage, 1874)	+	I?	-	I?	-	-
Family Odontobutidae							
104.	* *Perccottus glenii* Dybowski, 1877	-	-	I?	-	C	C
	TOTAL:	95	65	50	46	42	34

Note: RB - river-bed; R - reservoir; L - lakes; T - tributaries; F - fisheries; [E] - endemic species; * - nonindigenous species; + - species cited in literature; +? - report of find is questionable; C - species captured/collected by authors; C? - species identification need to be check-up; I? - species information from fishermen and need confirmation.

CONCLUSIONS

The actual list of the agnates and fish in the Prut River basin includes 80 taxa (74 species and 6 subspecies) belonging to 55 genera and 18 families.

The fish fauna is represented mostly of the local rheophillic species with semi-migratory species in the downstream portion of the river (coming from the Danube River). The study of the literature and the data obtained by sampling proves that the fish fauna of the Prut River basin have yet a lot of unknown but interesting both scientific and practical interesting data to offer.

The Prut River fauna is a diverse complex including a lot of rare species that needs to be protected and conserved.

Nowadays the Prut River fish fauna, especially that of the lakes has a high diversity and acts like a reserve (gene bank) of the rare and valuable fish species.

The protection of the rare and vulnerable fish species of the Prut River basin can be efficient only by the common effort of the neighboring countries. In order to improve the conservation measures we need to include the aquatic habitats, to extend the protected areas, create new fishery protection areas ensuring the reproduction areas.

We need to put in practice the international agreements in between Ukraine R. Moldova and Romania in order to ensure the sustainable fishery and conservation of the international waters resources.

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AUTHORS:

[1] *Aurel Ştefan CEBANU*
[1] *Alexandru Jacob MOSHU*
sandu_moshu@rambler.ry
Academy of the Sciences of Moldova,
Institute of Zoology,
Ichthiology and Aquaculture Laboratory,
Academiei St., no. 1,
Chişinău, Chişinău County, Republic of Moldova,
MD - 2028.

[2] *Grigore DAVIDEANU*
grigore@uaic.ro
"Alexandru Ioan Cuza" University,
Natural History Museum,
Independenței Bd., no. 16,
Iaşi, Iaşi County, Romania,
RO - 700100.

ICHTHYOFAUNA OF RIVER DANUBE DELTA: GORGOVA - UZLINA AND ŞONTEA - FURTUNA LAKES COMPLEXES

Ion NĂVODARU and *Aurel NĂSTASE*

KEYWORDS: species richness, abundance, biomass, frequency, dominance, shallow lakes, fish diversity, gill netting, electric fishing.

ABSTRACT

In river Danube delta it were identified 30 fish species from what 27 in Gorgova - Uzlina and 24 in Şontea - Furtuna, roach - *Rutilis rutilus* (21% - eudominat) followed by bleak - *Alburnus alburnus* (14% - dominat) being the most abundant species while roach (92% - very frequent) and pike - *Esox lucius* (90% - very frequent) the most frequent species. The prey and native species dominated in biomass, rudd-*Scardinius erithrophthalmus*, from prey, pike from piscivores and Prussian carp-*Carassius gibelio*, from exotic species being dominants.

REZUMAT: Ihtiofauna Deltei fluviale: complexele lacustre Gorgova - Uzlina şi Şontea - Furtuna.

In total s-au identificat un număr de 30 specii de peşte din care 27 în Gorgova - Uzlina şi 24 în Şontea - Furtuna, babuşca - *Rutilus rutilus* (21% - eudominant) şi obletele - *Alburnus alburnus* (14% - dominant) fiind cele mai abundente specii, cele mai frecvente specii fiind babuşca (92% - foarte frecventă) şi ştiuca - *Esox lucius* (90% - foarte frecventă). Speciile paşnice şi cele native domină în biomasă, roşioara - *Scardinius erythrophthalmus* dintre cele paşnice, ştiuca dintre prădători şi carasul - *Carassius gibelio* dintre exotice fiind dominante.

RESUME: La faune de poisson de la delta fluviale du Danube: les complexes lacustres Gorgova - Uzlina et Şontea - Furtuna.

On avait identifié un nombre de 30 d'espèces de poisson dans la quelle 27 d'espèces en Gorgova - Uzlina et 24 d'espèces en Şontea - Furtuna, gardon - *Rutilus rutilus* (21% - eudominant) et l'oblette - *Alburnus alburnus* (14% - dominant) soyant les plus abondantes espèces, les plus fréquent espèces soyaient gardon (92% - très fréquent) et le brochet - *Esox lucius* (90% - très fréquent). Les espèces paisibles et les espèces natives prédominent en biomasse, dans la quelle les espèces dominantes sont: rotengle - *Scardinius erythrophthalmus* entre les espèces paisibles, le blochet entre les espèces pilleuses et le carassin - *Carassius gibelio* entre les espèces exotiques.

INTRODUCTION

The river (fluvial) delta is encompassed between maritime levee Letea and Caraorman at East, Chilia branch at North and Saint Gheorghe branch at South. After impoundment of Pardina and Sireasa, two complexes of lakes remain natural flooded in river delta: Şontea - Furtuna at North of Sulina branch and Gorgova - Uzlina at South of Sulina branch (Figure 1).

The Gorgova - Uzlina complex of lakes stretch out between Sulina branch at North, Caraorman levee at East and Saint Gheorghe arm at South on a total surface of 25.150 ha. The complex include a number of 26 lakes with total water surface of 5.845 ha, distributed surround of two centers: one is lake Gorgova (1322 ha) at North of channal Litcov and other lake Isac (1098 ha) at South of Litcov channal, with many other smaller lakes (100 - 150 ha) (Diaconu and Nichiforov, 1963).

The water inflows in complex through channals Litcov (25.3 m/s), Uzlina (15.4 m/s) and Perivolovca (10.22 m/s) and outflow through channals Litcov and Ceamurlia towards channal Crişan-Caraorman.

The ecosystems of complex are dominated by: flooding reed beds, 2) lakes with a large surface area and/or active change of waters, 3) lakes with reduced exchange of water and partially covered with floating vegetation, 4) floating reed beds (plaur) (Gâştescu et al., 1999).

The soil is dominated by histosoils and gley soils in zones covered by flooding reed beds and limnosoils in lakes (Munteanu and Curelariu, 1995).

The Şontea - Furtuna complex of lakes lay out between Sireasa polder at West, Stipoc levee at North, Sulina branch at South and Old Danube at East on a total surface of 24.636 ha. The complex include a water surface of 2.219 ha, from what the larger lakes are Furtuna (900 ha), Băclăneşti (300 ha) and Ligheanca (300 ha) (Diaconu and Nichiforv, 1963). The water inflow from Sulina branch through channals Arhipenco, Averian and Cranjala and outflow in Old Danube.

Ecosystems are dominated by: 1 flooding reed, 2 lakes with a large surface area and/or active change of waters, 3)lakes with reduced circulation of water partially covered by floating vegetation, 4 polders (Gâştescu et al., 1999). Soils are dominated by gley soils in zones with flooding reed beds and limnosoils in lakes (Munteanu and Curelariu, 1995).

In last 50 years morphological and water quality have changed conducted to a eutrophicated water affecting ecosystems and implicitly ichthyofauna. The scope of present paper is to inventory and analyse the fish fauna from river delta in new habitat condition.

MATERIAL AND METHODS

The fish from river delta were sampled in October 2004, with Nordic gillnets and electric fishing. Those two methods are complementary. The gillnetting was performed during the night in open water and electric fishing during the day time in lake shoreline area. In total was sampled 9 lakes, each with 3 stations using gillnets and 3 stations with electric fishing, amounting 54 stations, from what 36 station in Gorgova - Uzlina and 18 stations in Şontea - Furtuna complex of lakes (Figure**.** 1).

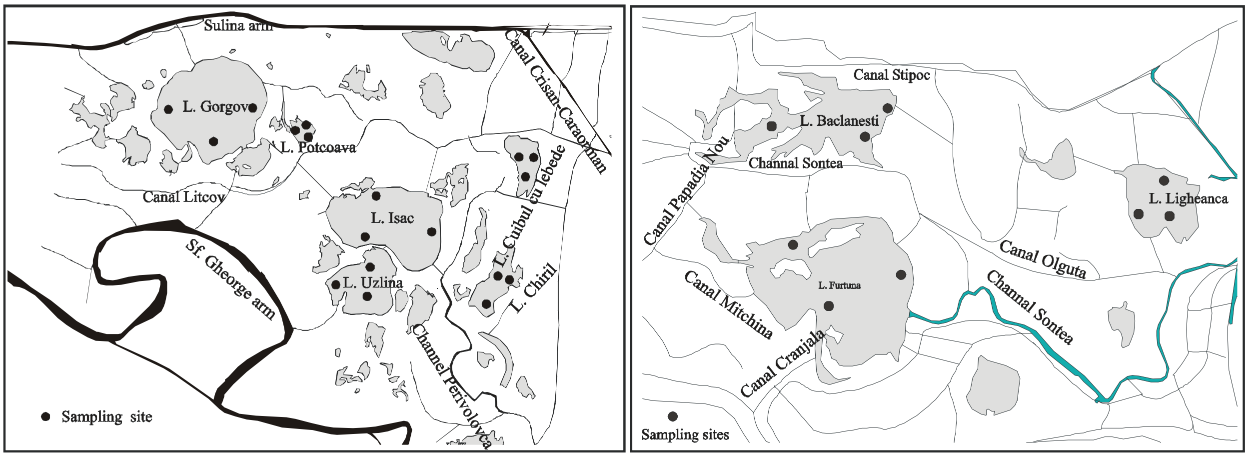

Figure 1. Distribution of sampling sites in Gorgova - Uzlina (left) and Şontea - Furtuna (right).

Each gillnets series units set per site was 150 m long and 1.8 high, formatted by 4 gillnets (20, 30, 40, 50 mm knot to knot mesh size), 30 m length each, followed by a Nordic gillnet with 12 panels (6, 6, 8, 10, 12, 16, 20, 24, 30, 35, 45, 55 mm mesh size, each of 2.5 m length with total length of 30 m) (Table 1).

Table 1. Fishing effort and catch of ichthyofauna sampling from river delta.

Lake complex /	Date	Site			Clasic gillnets	Nordic gillnets	Length	Electric	Catch	
lake		1	2	3	n sets x n gillnets	n sets x n gillnets	m	min	ind	kg
Gorgova - Uzlina										
Cuibul cu Lebede	29-IX	SW	E	NE	3 x 4 = 12	3 x 1 = 3	450	30	510	38
Isac	30-IX	NW	E	SW	3 x 4 = 12	3 x 1 = 3	450	30	1438	56
Uzlina	1-X	SW	SE	N	3 x 4 = 12	3 x 1 = 3	450	30	706	20
Chiril	2-X	NW	NE	SE	3 x 4 = 12	3 x 1 = 3	450	30	653	54
Gorgova	3-X	S	W	E	3 x 4 = 12	3 x 1 = 3	450	30	1467	64
Potcoava	4-X	S	N	W	3 x 4 = 12	3 x 1 = 3	450	30	996	44
Total complex					72 gillnets	18 gillnets	2700 m	180	5770	276
Şontea - Furtuna										
Ligheanca	5-X	N	W	S	3 x 4 = 12	3 x 1 = 3	450	30	493	25
Furtuna	6-X	N	E	W	3 x 4 = 12	3 x 1 = 3	450	30	539	18
Băclăneşti	27-X	NW	NE	SE	3 x 4 = 12	3 x 1 = 3	450	30	730	22
Total complex					36 gillnets	9 gillnets	1350 m	90	1762	65
TOTAL					108 gillnets	27 gillnets	4050 m	270	7532	341

Electric fishing was done by DEKA 7000 equipment in each site was sampled transects with variable length, standardized at 10 minutes fishing.

Were fished 7532 individuals, weighting 341 kg from what 5770 individuals weighting 276 kg in Gorgova - Uzlina complex and 1762 individuals and 65 kg in Şontea - Furtuna complex (Table 1). Each fish was measured (TL = Total length in cm and TW = Total weight in grams) and it was recorded gillnet and mesh size in what were caught.

Relative abundance and biomass were calculated as Catch Per Unit Effort (CPUE), and standardized at 100 m gillnetting night and 1 hour electric fishing.

The relative abundance or dominance (D) was calculated as proportion of species to the total catch according to Mühlenberg (1993): $D_i = n_i/N \cdot 100$ (%), where, D_i = dominance of species i, n_i = individuals of the species i, and N = total number of individuals.The frequency of occurrence (F) or constant (C) was calculated as proportion of samples containing a species, and used to characterize species distribution according to Schwerdtfeger (1975) quoted by Schindrilariu et al. (2002): $F_i = b_i/a \cdot 100$ (%), where, F_i = frequency of occurrence of specie i, b_i = the number of samples in which species i was observed, and a = total number of samples.

The ecological significance index (W) was calculated with formula: $W = D \cdot C/100$, where D = dominance and C = constant. The equitability (E) was calculated with Shannon-Wiener index (Odum 1975).

The dominance structure was interpreted by six dominance classes, frequency by five and ecological significance by 6 classes (Table 2).

The length - weight relationship was calculated with formula: $TW = a*TL^b$, were, W = weight of fish in grams, L = length of fish in cm, a = intercept, and b = slope of curve.

The taxonomic names of species were quoted after Bănărescu (1964), with actualization after Kottelat, (1997) and later checklist revision up to year 2006.

Table 2. Dominance, frequency and ecological significance classification.

Dominance /abundance (D)		Frequency (F)		Ecological significance (W)	
class	(%)	class	(%)	class	%
eudominat	>16 (2^4)	very rare	0 -10	accidental	<0.1
dominant	8 (2^3) - 16	rare	11 - 25	accid.-accessory	0.1-1
subdominant	4 (2^2) - <8	widespread	26 - 45	associated	1-5
recedent	2 (2^1) - <4	frequent	46 - 70	accompanying	5-10
subrecedent	1 (2^0) - <2	very abundant	71 - 100	characteristic	10-20
sporadic	<1			leading	>20

RSULTS AND DISCUSSIONS

Species richness

The 30 fish species were identified in river Danube delta in survey fishing from what 27 were caught in Gorgova - Uzlina and 24 in Şontea - Furtuna complex of lakes (Table 3).

In Gorgova - Uzlina complex were caught 24 fish species at electric fishing and 21 in gill nets fishing, while in Şontea - Furtuna complex were caught 19 species at electric fishing and 15 in gill nets fishing, 16 species of which are of commercial interest.

The majority are native fish species (25) but there are also 5 exotics species. The eurytope semi-migratory fish species (11 species) which make migration between Danube River and back waters from flooded zone are almost equal with limnophilic species (10 species). Fish communities include prey species (herbivores, omnivores and bentivores) beside piscivores species (*E. lucius*, *S. glanis*, *S. lucioperca*, *P. fluviatilis*).

The lakes include tolerant species of degraded habitats but also intolerant species duet o scattered of different degradation of habitats over complex of lakes. It is obvious the species richness is greater, the results being limited by survey fishing program and methods that was limited in space and time.

The species richness depends of Danube River ichthyofauna from/to where the fish can emigrate or immigrate due to water connectivity network or over bank flooding. The *C. gibelio*, *R. rutilus* and *A. brama* are important commercial species, while *U. krameri*, *P. borysthenicus* and *T. tinca* are valuable conservational and ecological interest species at the European level.

Table 3. Species richness of river Danube delta and ecological classification (guilds) (reophilly: eury = eurytopic; migr = migrator; limn = limnophilic; adult food: omni = omnivore; pisc = piscivores; bent = bentivores; herb = herbivores; tolerance of degradation: tole = tolerant; into = intolerant, intr = intermediary) (e = electric fishing; g = gill net fishing).

	Species	Occurrence							Classification guilds				
Nr.	complex	Gorgova-Uzlina			Şontea-Furtuna			total	Commercialsp	origin	reophilly	adult food	tolerance of degradation
	Fishing gear	e	g	e+g	e	g	e+g	e+g					
1	*Abramis bjoerkna*	1	1	1	1	1	1	1	1	n	eury	omni	tole
2	*Abramis brama*	1	1	1				1	1	n	eury	omni	tole
3	*Alburnus alburnus*	1	1	1	1	1	1	1	1	n	eury	omni	tole
4	*Alosa tanaica*		1	1				1	1	n	migr	omni	
5	*Aspius aspius*		1	1		1	1	1	1	n	eury	pisc	into
6	*Carassius carassius*	1	1	1				1	1	n	limn	omni	tole
7	*Carassius gibelio*	1	1	1	1	1	1	1	1	e	eury	omni	tole
8	*Clupeonella cultiventris*					1	1	1	1	n			
9	*Cobitis taenia*	1	1	1	1		1	1		n	eury	bent	into
10	*Cyprinus carpio*	1	1	1		1	1	1	1	e	eury	omni	tole
11	*Esox lucius*	1	1	1	1	1	1	1	1	n	eury	pisc	into
12	*Gymnocephalus cernuus*	1	1	1				1		n	eury	bent	tole
13	*Lepomis gibbosus*	1	1	1				1		e	limn		

	Species	Occurrence							Classification guilds				
Nr.	complex	Gorgova-Uzlina			Şontea-Furtuna			total	commercialsp.	origin	reophilly	adult food	tolerance of degradation
	Fishing gear	e	g	e+g	e	g	e+g	e+g					
14	*Leucaspius delineatus*	1		1	1		1	1		n	limn	omni	into
15	*Petroleuciscus borysthenicus*	1	1	1	1		1	1		n	limn	omni	
16	*Misgurnus fossilis*	1		1	1		1	1		n	limn	bent	tole
17	*Neogobius fluviatilis*				1		1	1		n		bent	
18	*Neogobius melanostomus*				1		1	1		n		omni	
19	*Perca fluviatilis*	1	1	1	1	1	1	1	1	n	eury	pisc	tole
20	*Proterorhinus marmoratus*	1		1	1		1	1		e	limn	omni	tole
21	*Pseudorasbora parva*	1	1	1	1	1	1	1		e			
22	*Pungitius platygaster*	1		1	1		1	1		n	limn	herb	into
23	*Rhodeus amarus*	1	1	1	1	1	1	1		n	eury	omni	tole
24	*Rutilus rutilus*	1	1	1	1	1	1	1	1	n	eury	pisc	into
25	*Sander lucioperca*		1	1		1	1	1	1	n	limn	omni	into
26	*Scardinius erythrophthalmus*	1	1	1	1	1	1	1	1	n	eury	pisc	into
27	*Silurus glanis*	1	1	1		1	1	1	1	n			
28	*Syngnathus abaster*	1		1				1		n	limn	omni	into
29	*Tinca tinca*	1	1	1	1	1	1	1	1	n	limn	omni	inter
30	*Umbra krameri*	1		1	1		1	1		n			
	Total	24	21	27	19	15	24	30	16				

The relative abundance or dominance (D)

The relative abundance or dominance (D), calculated for all sampling sites from river delta with both methods (gill netting and electric fishing) shows roach (eudominant), followed by bleak, bitterling, belica and perch (dominant) are the most abundant fish species (Table 4).

Table 4. The relative abundance or dominance of fish species from river Danube delta (all sites for both samples methods - gill netting and electric fishing - included).

Nr.	Species	Common name	(n_i)	D_i%	Class abundance
1	*Rutilus rutilus*	Roach	5855	21.01	eudominant
2	*Alburnus alburnus*	Bleak	4019	14.42	dominant
3	*Rhodeus amarus*	Bitterling	3933	14.11	dominant
4	*Leucaspius delineatus*	Belica	2574	9.24	dominant
5	*Perca fluviatilis*	Perch	2128	7.64	subdominant
6	*Carassius gibelio*	Prussian carp	2090	7.50	subdominant
7	*Scardinius erythrophthalmus*	Rudd	2024	7.26	subdominant
8	*Esox lucius*	Pike	1051	3.77	recedent
9	*Proterorhinus marmoratus*	Tubenose goby	1026	3.68	recedent
10	*Abramis bjoerkna*	White bream	685	2.46	recedent
11	*Misgurnus fossilis*	Weatherfish	564	2.02	recedent
12	*Tinca tinca*	Tench	485	1.74	subrecedent
13	*Carassius carassius*	Crucian carp	480	1.72	subrecedent
14	*Pseudorasbora parva*	Stone moroko	184	0.66	sporadic
15	*Petroleuciscus borysthenicus*	Nistru chub	151	0.54	sporadic
16	*Gymnocephalus cernuus*	Ruffe	116	0.42	sporadic
17	*Abramis brama*	Bream	101	0.36	sporadic
18	*Cobitis taenia*	Spined loach	69	0.25	sporadic
19	*Neogobius melanostomus*	Round goby	48	0.17	sporadic
20	*Lepomis gibbosus*	Pumpkinseed	42	0.15	sporadic
21	*Syngnathus abaster*	Black-striped pipefish	42	0.15	sporadic
22	*Umbra krameri*	Mudminnow	42	0.15	sporadic
23	*Silurus glanis*	Wels	41	0.15	sporadic
24	*Aspius aspius*	Asp	34	0.12	sporadic
25	*Pungitius platygaster*	Ninespine stickleback	24	0.09	sporadic
26	*Alosa tanaica*	Caspian shad	23	0.08	sporadic
27	*Sander lucioperca*	Pike perch	15	0.05	sporadic
28	*Cyprinus carpio*	Common carp	10	0.04	sporadic
29	*Neogobius fluviatilis*	Monkey goby	6	0.02	sporadic
30	*Clupeonella cultiventris*	Black Sea sprat	3	0.01	sporadic
	TOTAL (N)		27863	100	

Slight differences between lake complexes and sampling methods are noticed, but generally same species are ranking on the 10 dominance species. The abundance was greater in Gorgova - Uzlina (742 ind./h in electric fishing and 379 ind./100 m gill net in gillnet sampling) comparing with Şontea - Furtuna (633 ind./h and 222 ind./100 m gill net) (Table 5).

In Gorgova - Uzlina dominated roach, bleak, bitterling and perch with differences between sampling methods where roach and bitterling dominated in electric fishing while bleak and roach dominated in gillnetting. In Şontea - Furtuna dominated roach, bitterling, Prussian carp, belica and rudd. In electric fishing dominated roach and Prussian carp and in gillnetting bitterling and bleak.

Table 5. Relative fish abundance estimated in Catch Per Unit Effort (CPUE electric fishing = n/h, CPUE gillnetting = n/100 m gillnet).

	Lake Complex	Gorgova - Uzlina		Şontea - Furtuna	
Nr	Species	electric	gillnet	electric	gillnet
1	*Rutilus rutilus*	169	62	172	17
2	*Alburnus alburnus*	10	195	5	32
3	*Rhodeus amarus*	119	20.6	29	128.52
4	*Leucaspius delineatus*	91		103	
5	*Perca fluviatilis*	90	21	8	5
6	*Carassius gibelio*	53	3	119	1
7	*Scardinius erythrophthalmus*	34	37	55	30
8	*Esox lucius*	37	3	36	1
9	*Proterorhinus marmoratus*	49		15	
10	*Abramis bjoerkna*	13	24	1	1
11	*Misgurnus fossilis*	12		39	
12	*Tinca tinca*	14	2	22.0	1
13	*Carassius carassius*	26	1		
14	*Pseudorasbora parva*	1	1	15	3
15	*Petroleuciscus borysthenicus*	7	0.4	1	
16	*Gymnocephalus cernuus*	1	5		
17	*Abramis brama*	5	1		
18	*Cobitis taenia*	2	0.2	3	
19	*Neogobius melanostomus*			5	
20	*Lepomis gibbosus*	2	0.0		
21	*Syngnathus abaster*	2.3			
22	*Umbra krameri*	1		2	
23	*Silurus glanis*	2	0.2		0.06
24	*Aspius aspius*		1		1
25	*Pungitius platygaster*	1		1	

	Lake Complex	Gorgova - Uzlina		Şontea - Furtuna	
Nr	Species	electric	gillnet	electric	gillnet
26	*Alosa tanaica*		1		
27	*Sander lucioperca*		1		0.03
28	*Cyprinus carpio*	0.3	0.2		0.03
29	*Neogobius fluviatilis*			1	
30	*Clupeonella cultiventris*				0.4
	Total	742	379	633	222

Analyzing abundance per lakes inside Gorgova - Uzlina complex it is noticed that isolated lakes (Oosterberg et al., 2000), Cuibul cu lebede and Chiril have a smaller abundance in comparison with large central lakes (Isac, Gorgova) and lake with water short residence time (Uzlina) (Figure. 2).

In the complex Şontea - Furtuna, abundance increases from Ligheanca Lake to Furtuna Lake and Băclăneşti Lake in the gillnetting and reverse decrease in the electric fishing.

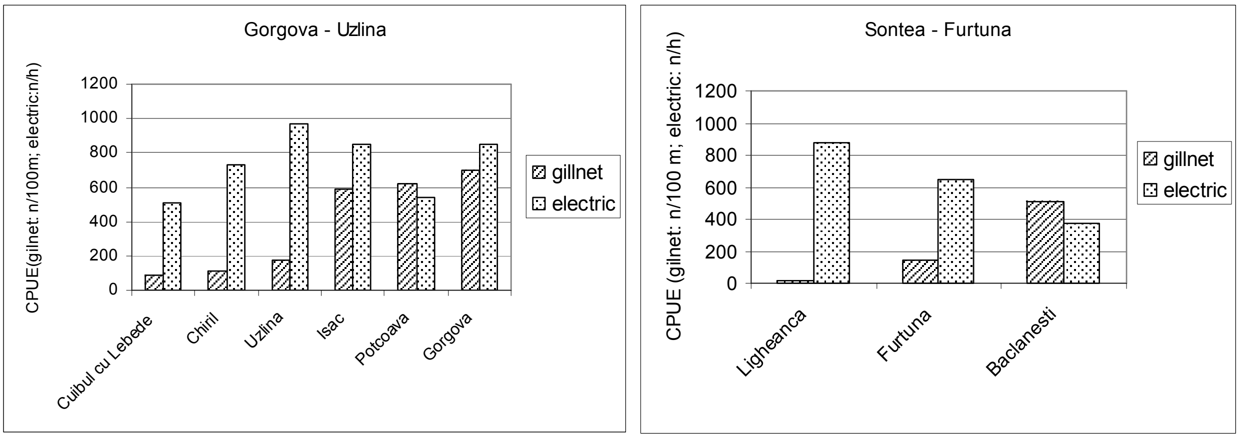

Figure 2. Fish abundance per complex lake, lakes and methods.

The frequency of occurrence (F) or constant (C). The "very frequent" species in almost all delta are roach (50 sites from 54), pike (49), perch (49), Prussian carp (47), rudd (40) (Table 6). Tench, bitterling and bleak are "frequent" species, many other are "widespread" while bream are "rare" and Common carp "very rare" species in delta.

Table 6. The relative frequency or constant of fish species from river Danube delta (all sites for both samples methods - gill netting and electric fishing - included).

Nr	Species	occurrence (b_i)	F_i%	Class of frequency
1	*Rutilus rutilus*	50	92.59	very frequent
2	*Esox lucius*	49	90.74	very frequent
3	*Perca fluviatilis*	49	90.74	very frequent
4	*Carassius gibelio*	47	87.04	very frequent
5	*Scardinius erythrophthalmus*	40	74.07	very frequent

Nr	Species	*occurrence (b_i)*	F_i%	Class of frequency
6	*Tinca tinca*	36	66.67	frequent
7	*Rhodeus amarus*	35	64.81	frequent
8	*Alburnus alburnus*	27	50.00	frequent
9	*Abramis bjoerkna*	21	38.89	widespread
10	*Proterorhinus marmoratus*	18	33.33	widespread
11	*Misgurnus fossilis*	16	29.63	widespread
12	*Carassius carassius*	15	27.78	widespread
13	*Leucaspius delineatus*	14	25.93	widespread
14	*Petroleuciscus borysthenicus*	12	22.22	rare
15	*Gymnocephalus cernuus*	11	20.37	rare
16	*Abramis brama*	10	18.52	rare
17	*Aspius aspius*	10	18.52	rare
18	*Pseudorasbora parva*	10	18.52	rare
19	*Silurus glanis*	9	16.67	rare
20	*Cobitis taenia*	8	14.81	rare
21	*Sander lucioperca*	6	11.11	rare
22	*Umbra krameri*	6	11.11	rare
23	*Cyprinus carpio*	5	9.26	very rare
24	*Lepomis gibbosus*	5	9.26	very rare
25	*Alosa tanaica*	4	7.41	very rare
26	*Pungitius platygaster*	3	5.56	very rare
27	*Syngnathus abaster*	3	5.56	very rare
28	*Clupeonella cultiventris*	1	1.85	very rare
29	*Neogobius fluviatilis*	1	1.85	very rare
30	*Neogobius melanostomus*	1	1.85	very rare
	Total sites (*a*)	54	100	

Relative biomass

The dominant species in biomass were rudd, pike, Prussian carp, roach and perch with slight differences between complexes and sampling methods.

In Gorgova - Uzlina at electric fishing dominated pike followed by Prussian carp and at gillnetting rudd followed by roach, while in Şontea - Furtuna dominated Prussian carp and pike at electric fishing and rudd followed by pike at gillnetting (Table 7). The biomass from electric fishing is almost equal in the two complexes, but is 2.6 fold greater in Gorgova - Uzlina comparing with Şontea - Furtuna in gillnetting.

Table 7. Relative biomass estimated in Catch Per Unit Effort (CPUE electric = g/h; CPUE gillnet = g/100 m gillnet).

	Lake complex	Gorgova - Uzlina		Şontea - Furtuna	
Nr	Species / sampling method	electric	gillnet	electric	gillnet
1	*Scardinius erythrophthalmus*	56	4120	19	1682
2	*Esox lucius*	960	1212	787	1201
3	*Carassius gibelio*	714	1106	1328	719
4	*Rutilus rutilus*	86	2596	41	252
5	*Perca fluviatilis*	304	1058	9	233
6	*Abramis bjoerkna*	16	1113	1	23
7	*Tinca tinca*	128	461	144	399
8	*Alburnus alburnus*	4	303	3	45
9	*Aspius aspius*		207		92
10	*Cyprinus carpio*	93	134		29
11	*Abramis brama*	23	168		
12	*Carassius carassius*	137	53		
13	*Misgurnus fossilis*	58		92	
14	*Silurus glanis*	9	60		34
15	*Sander lucioperca*		62		46
16	*Rhodeus amarus*	21	8	8	60
17	*Gymnocephalus cernuus*	1	20		
18	*Leucaspius delineatus*	8		7	

	Lake complex	Gorgova - Uzlina		Şontea - Furtuna	
19	*Petroleuciscus borysthenicus*	7	0.4	1	
20	*Proterorhinus marmoratus*	7		2	
21	*Lepomis gibbosus*	4	2		
22	*Pseudorasbora parva*	0.3	1	5	2
23	*Alosa tanaica*		4		
24	*Umbra krameri*	1		2	
25	*Cobitis taenia*	1		0.4	
26	*Neogobius melanostomus*			1	
27	*Pungitius platygaster*	0.1		0.2	
28	*Clupeonella cultiventris*				0.3
29	*Syngnathus abaster*	0.1			
30	*Neogobius fluviatilis*			0.1	
	Grand Total	2639	12688	2449	4817

Analysing biomass per lake inside Gorgova - Uzlina complex it notice that isolated lakes Cuibul cu lebede and Chiril have a smaller biomass comparing with large lakes (Isac and Gorgova) (Figure 3).

In Şontea - Furtuna, the biomass increase from Ligheanca to Furtuna and Băclăneşti in gillnetting and decrease reverse in electric fishing.

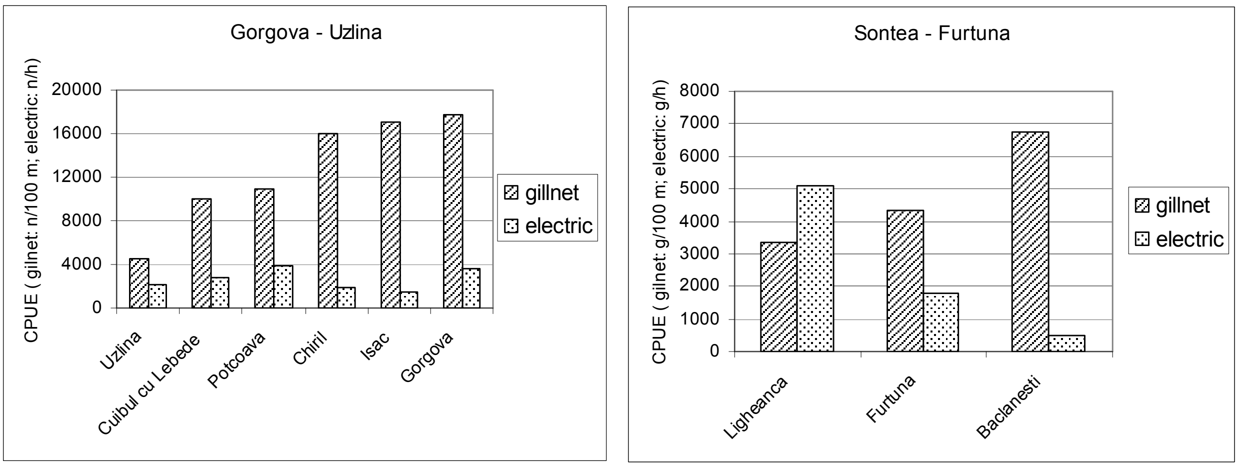

Figure 3. Relative biomass per complexes, lakes and sampling methods.

The prey species dominate in biomass in both sampling methods, gillnetting and electric fishing (Table 8). In gillnetting piscivores species are 20% in Gorgova - Uzlina and 33% in Şontea - Furtuna while in electric fishing they are more, 48%, respective 32%. This fact is due to electric fishing search bank habitas dominated by aquatic vegetation where two summer pike is located. The native species are dominant at gillnetting, representing 90% in Gorgova - Uzlina and 84% in Şontea - Furtuna, and smaller at electric fishing, representing 70% and respective 45%.

Table 8. The percentage of pray, piscivores, exotic, native species per complexes and lakes.

Lake complex	Gorgova - Uzlina							Şontea - Furtuna			
Lake	Chiril	C.c. lebede	Gorgova	Isac	Potcoava	Uzlina	Total	Băclăneşti	Furtuna	Ligheanca	Total
	Gillnet										
Predators/ prey	0.28	0.17	0.24	0.25	0.32	0.42	0.26	0.78	0.08	0.83	0.50
Prey (%)	77.87	85.44	80.93	80.24	75.79	70.32	79.35	56.08	92.46	54.62	66.68
Predators (%)	22.13	14.56	19.07	19.76	24.21	29.68	20.65	43.92	7.54	45.38	33.32
Exotic/ native	0.05	0.10	0.06	0.06	0.20	0.75	0.11	0.08	0.35	0.24	0.18
Native (%)	94.86	90.84	94.39	94.51	83.15	57.17	90.20	92.86	74.31	80.49	84.42
Exotic (%)	5.14	9.16	5.61	5.49	16.85	42.83	9.80	7.14	25.69	19.51	15.58
	Electric										
Predators/ prey	1.92	0.92	0.93	2.82	0.61	0.57	0.94	0.83	2.77	0.20	0.48
Prey (%)	34.24	52.06	51.84	26.20	62.05	63.54	51.57	54.62	26.51	83.18	67.51
Predators (%)	65.76	47.94	48.16	73.80	37.95	36.46	48.43	45.38	73.49	16.82	32.49
Exotic/ native	0.04	0.60	0.52	0.10	0.68	0.56	0.44	0.13	0.05	3.14	1.19
Native (%)	95.80	62.45	65.75	90.81	59.35	64.05	69.25	88.72	94.98	24.17	45.60
Exotic (%)	4.20	37.55	34.25	9.19	40.65	35.95	30.75	11.28	5.02	75.83	54.40

The Length - Weight relationship

The length - weight relationship are wide used in ichthyology as means of calculation of weight when only length are measured. Using "b" parameter of length - weight relationship it can made appreciation on growth character of fish (Battess et al. 2003). Analysing "b" parameter river delta fish we may conclude that bleak, asp, Prussian carp and pike perch have a *isometric* growth pattern when growth in length is proportionally with weight growth ($b \cong 3$), bream, pike, perch and rudd have a *allometric* growth pattern where growth of weight is faster than length growth ($b > 3$), while bitterling, wels and tench have a *allometric* growth where growth in weight is slower than length growth ($b < 3$) (Figure 4 and Table 9).

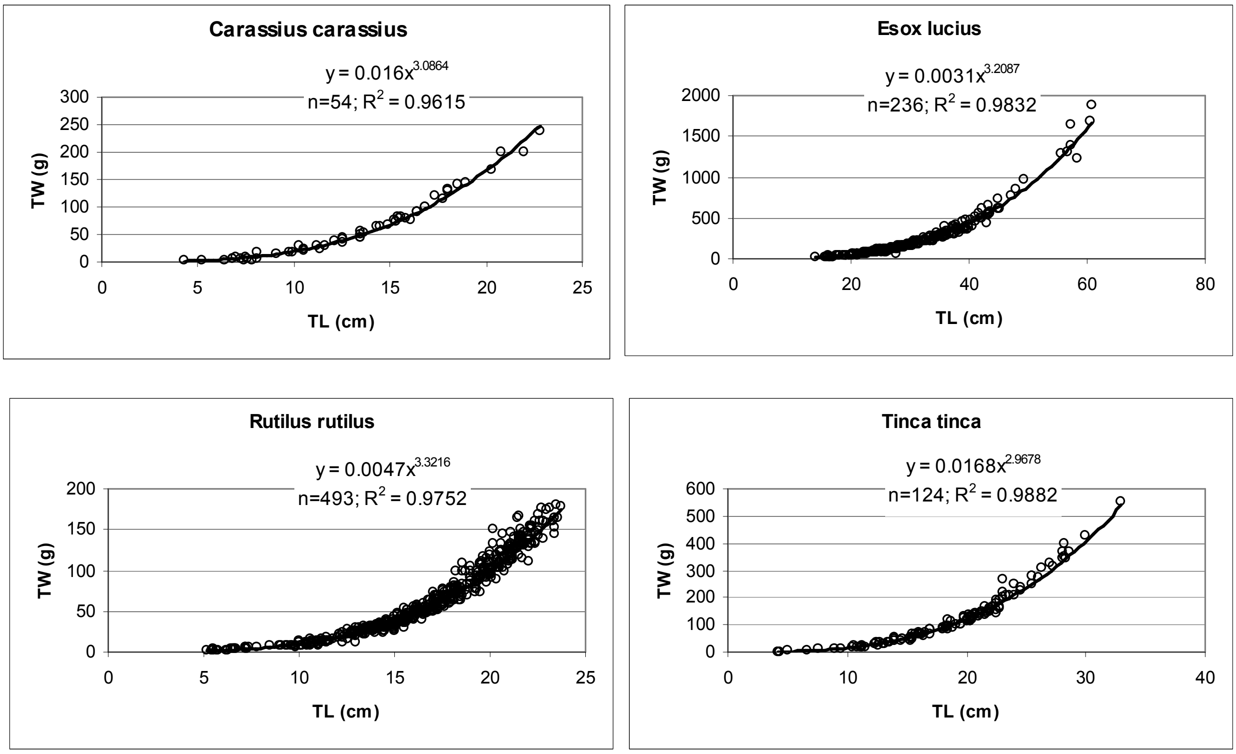

Figure 4. The length - weight relationship of 4 representative species from river Danube delta.

The length - weight relationships for small species as bleak, spined loach, bitterling, Nistru chub are less accurate due to weight measurement precision (1 g) and smaller number of individuals. Increasing in measurement precision and number of individuals it can increase accuracy of relationships reflected by a great R square.

Table 9. Parameter of length - weight relationship ($TW = a*TL^b$) for fish species from river Danube delta.

Species	n	a	b	R^2
Abramis bjoerkna	225	0.0072	3.1685	0.9616
Abramis brama	31	0.0021	3.5112	0.9857
Alburnus alburnus	86	0.0156	2.6626	0.8569
Alosa tanaica	5	0.0032	3.4169	0.9852
Aspius aspius	25	0.0253	2.6583	0.897
Carassius gibelio	389	0.0123	3.436	0.9606
Carassius carassius	54	0.016	3.096	0.9651
Cobitis taenia	5	0.0278	2.1828	0.9001

Species	n	a	b	R^2
Cyprinus carpio	25	0.0185	2.9816	0.9967
Esox lucius	236	0.0031	3.2087	0.9832
Gymnocepalus. cernuus	27	0.0079	3.1944	0.9633
Lepomis gibbosus	4	0.0007	4.3639	0.632
Petroleuciscus borysthenicus	26	0.0596	2.1567	0.6723
Perca fluviatilis	441	0.008	3.1806	0.9655
Misgurnus fossilis	94	0.0217	2.4579	0.906
Proterorhinus marmoratus	7	0.0227	2.6834	0.8054
Pseudorasbora parva	15	0.039	2.213	0.8374
Rhodeus amarus	15	0.021	2.7785	0.6962
Rutilus rutilus	493	0.0047	3.3216	0.9752
Sander lucioperca	10	0.0029	3.3362	0.9786
Scardinius erythrophthalmus	841	0.0066	3.225	0.9717
Silurus glanis	12	0.005	3.0501	0.99
Tinca tinca	124	0.0168	2.9678	0.9882
Umbra krameri	7	0.0971	2.0781	0.8892

Study of diversity

According with ecological significance index, there are not great differences between the two complexes (Table 10). Leading species are *R. rutilus, A. alburnus* and *R. amarus*, with differences for those two methods of sampling, characteristic and accompanying, complementary species are S. *erythrophthalmus, L. delineatus, C. gibelio, P. fluviatilis* and *A. bjoerkna,* while many species are accidental, like: *C. cultiventris, P. parva, P. platygaster, U. krameri, C. carassius* and *P. borystenicus,* but also some very important economical species (*S. glanis, C. carpio* and *S. lucioperca*) was not caught at all or insignificant quantity.

Table 10. Ecological significance index (W) of fish species from river delta.

Complex lakes/	Şontea - Furtuna		Gorgova - Uzlina	
Class of W: %	gillnet	electric	gillnet	electric
W1: < 0.1 (accidental)	*C. cultiventris* *S. glanis* *C. carpio* *S. lucioperca*	*P. platygaster* *N. fluviatilis*	*C. carassius* *P.parva* *P. borystenicus* *C. carpio* *S. glanis* *C. taenia* *L.gibbosus*	*S. glanis* *U. krameri* *G. cernuus* *P. parva* *P. platygaster* *C. carpio*
W2: 0.1 - 1 (accidental-accesori)	*P. parva* *C. gibelio* *T. tinca* *A. bjoerkna* *A. aspius* *E. lucius*	*A. alburnus* *N.melanostomus* *C. taenia.* *U. krameri* *A. bjoerkna* *P. borystenicus* *P.parva.*	*G. cernuus* *C. gibelio* *E. lucius* *T .tinca* *A. aspius* *A. tanaica* *A. brama* *S. lucioperca*	*A. alburnus* *P. borystenicus* *A. brama* *L. gibbosus* *S. abaster* *C. taenia*
W3: 1 - 5 (associated)	*P. fluviatilis*	*R. amarus* *T.tinca* *P. marmoratus* *P. fluviatilis*	*R. amarus*	*S.erythrophthalmus* *C. carassius* *T. tinca* *A. bjoerkna* *M. fossilis*
W4: 5 - 10 (accompanying)	*R. rutilus*	*S.erythrophthalmus* *M. fossilis* *E. lucius*	*S.erythrophthalmus* *A. bjoerkna* *P .fluviatilis*	*L. delineatus* *C. gibelio* *P. marmoratus* *E lucius*
W5: 10 - 20 (characteristic)	*A. alburnus* *S.erythrophthalmus*	*C. gibelio* *L. delineatus*	*R. rutilus*	*P. fluviatilis* *R. amarus*
W6: > 20 (leading)	*R. amarus*	*R. rutilus*	*A. alburnus*	*R. rutilus*

Analyzing the biodiversity and equitability indices values for each lakes, it is remarked that all lakes which are direct connected with the river through channals, have the smallest values of this indices (Uzlina, Isac from complex lakes Gorgova - Uzlina and Ligheanca from Şontea - Furtuna complex lakes), while small isolated lakes and remote from central lake of complex have increased values (Cuibul cu Lebede, Chiril from Gorgova - Uzlina complex lakes and Băclăneştii Mari from Şontea - Furtuna) (Figure 5).

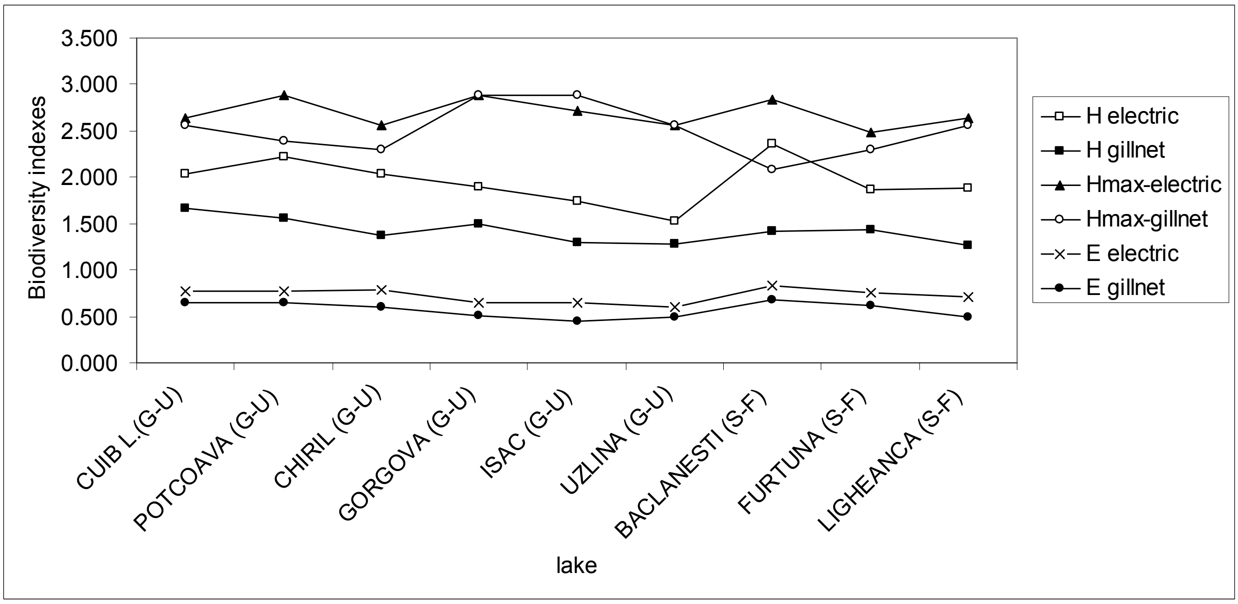

Figure 5. The biodiversity and equitability indices values for each lake.

The complexes lakes Gorgova - Uzlina and Şontea - Furtuna have a stable ecosystems regard of ichthyofauna, with increased values of equitability indices which long for 1 value. The diversity of fish community from Gorgova - Uzlina and Şontea - Furtuna complexes lakes in border zone has greater value than open water, because of equitable number of individuals from each species, reflecting a more stable ecosystem in shoreline.

CONCLUSIONS

The 30 fish species were identified in river Danube delta from what 27 were caught in Gorgova - Uzlina and 24 in Sontea - Furtuna complex of lakes.

The *C. gibelio*, *R. rutilus* and *A. brama* are important commercial species, while *U. krameri*, *P. borysthenicus* and *T. tinca* are valuable conservational and ecological interest species at European level.

The relative abundance or dominance, shows *R. rutilus* (eudominant), followed by *A. alburnus*, *R. amarus*, *L. delineatus* and *P. fluviatilis* (dominant) are the most abundant fish species.

"Very frequent" species distributed almost all Danube Delta are *R. rutilus*, *E. lucius*, *P. fluviatilis*, *S. erithrophthalmus C. gibelio*. *T. tinca*, *R. amarus*, *A. alburnus* are "frequent"species, while *A. brama* are "rare" and *C. carpio* "very rare" species.

The prey and native species dominated in biomass, *S. erithrophthalmus*, from prey, *E. lucius* from piscivores and *C. gibelio*, from exotic species being dominants.

The lakes with a large surface area and/or active change of waters have a greater abundance and biomass than lakes with reduced exchange of water and partially covered with floating vegetation.

The diversity of fish community from Gorgova - Uzlina and Şontea - Furtuna complexes lakes in border zone has greater value than open water, because of equitable number of individuals from each species, reflecting a more stable ecosystem in shoreline.

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AUTHORS:

Ion NĂVODARU
navodaru@indd.tim.ro
Aurel NĂSTASE
aureln@indd.tim.ro
Danube Delta National Institute
for Research and Development,
Babadag St., no.165,
Tulcea, Tulcea County, Romania,
RO - 820112.

THE GENUS *GOBIO* IN POLAND - HISTORICAL REVIEW AND PRESENT STATUS (TELEOSTEI, CYPRINIDAE)

Michał NOWAK [1], *Włodzimierz POPEK* [2] and *Piotr EPLER* [3]

KEYWORDS: gudgeons, *Gobio gobio*, *Gobio*, *Romanogobio*, systematics, morphometrics, Baltic Sea basin, Black Sea basin, Poland.

ABSTRACT

Systematics of the genus *Gobio* in Poland has never been thoroughly explained. From the time when *Gobio* and *Romanogobio* were distinguished all ichthyologists considered that only one species of the genus *Gobio* - common gudgeon *G. gobio* (L.) occurs in Poland. However, the most recent international studies have given new insights into this issue, enabling several distinct species, which had previously been associated with *G. gobio*, to be identified. This paper gathers data given by different authors and gives some general remarks on the *Gobio* in Poland.

REZUMAT: Genul *Gobio* în Polonia.

Sistematica genului *Gobio* în Polonia nu a fost niciodată amănunțit explicată. Din perioada în care *Gobio* şi *Romanogobio* au fost diferențiate toți ihtiologii au considerat că în Polonia există doar o specie a genului *Gobio* şi anume *G. gobio* (L.) - porcuşorul comun. Cu toate acestea, cele mai recente studii internaționale au oferit noi puncte de vedere asupra acestei probleme, susținând existența unor specii distincte, care inițial erau associate la identificare cu *G. gobio*. Această lucrare a adunat date aparținând la diverşi autori şi a oferit remarci generale asupra sistematicii genului *Gobio* în Polonia.

ZUSAMMENFASSUNG: Art *Gobio* in Polen.

Die Systematik von Gründlingen der Art *Gobio* in Polen wurde nie genau geklärt. Seitdem die *Gobio* und *Romanogobio* definitiv getrennt wurden, meinten alle Ichthiologen, dass in Polen nur eine Art von der Gattung *Gobio* vorkommt - der Gründling *G. gobio* (L.). Die internationalen Unter-Suchungen der letzten Jahre haben jedoch ein neues Licht auf dieses Problem geworfen, und man unterscheidet einige neue Gattungen, die man früher als eine betrachtet hat, *G. gobio*. Die Arbeit sammelt Angaben von verschiedenen Autoren und formuliert allgemeine Bemerkungen über die Systematik der Art *Gobio* in Polen.

INTRODUCTION

The genus *Gobio* Cuvier, 1816, belongs to the subfamily Gobioninae of the family Cyprinidae. Initially it included all of the Euro-Asian gudgeons. Petru M. Bănărescu (1961) divided it into three subgenera: *Gobio* sensu stricto, *Romanogobio* and *Rheogobio*. In 1996 Alexander M. Naseka reviewed it and divided into two different genera: *Gobio* Cuvier, 1816 and *Romanogobio* Bănărescu, 1961. Initially genus *Gobio* sensu stricto included the following species: *G. gobio*, *G. cynocephalus*, *G. uranoscopus*, *G. hettitorum*, *G. soldatovi* and *G. coriparoides* (Naseka, 1996; Bănărescu, 1999a).

During recent years the taxonomy of genera *Gobio* and *Romanogobio* has been changing dynamically. Changes in understanding what species are (Kullander, 1999) and implementation of uniform morphometrics methods (Naseka, Freyhof, 2004; Kottelat, Persat, 2005) developed many publications that contributed a new insight into systematics of gudgeons.

MATERIALS AND METHODS

Gudgeons in Poland had been mentioned in several tens of works before 1975, as they were listed by Rembiszewski and Rolik (1975). Most of them were simply ichthyofaunistic papers, where gudgeons were only pointed as a part of local ichthyofauna. More valuable for systematics were the morphometric works, however these were unfortunately not numerous.

In this study, nine works were used as the sources of morphometric data (Oliva, 1960; Balon, Holčik, 1964; Rembiszewski, 1964; Rolik, 1965b, 1967; Skóra, Włodek, 1966, 1971; Jarzynowa, Rechulicz, 1997; Nowak, Popek, Drag-Kozak, Epler, manuscript). All of them referred to the genus *Gobio* sensu stricto (Naseka, 1996; Bănărescu, 1999a). Publications on gudgeons from adjacent countries were used for comparison (Berg, 1949; Aleksandrova, Smirnov, 1969; Bănărescu et al., 1999; Ruchin, Naseka, 2003; Vasil'eva et al., 2004, 2005; Vasileva, Kuga, 2005; Kottelat, Persat, 2005). All of these data were applied in order to characterize gudgeons genus *Gobio* in Poland.

RESULTS AND DISCUSSION

First ichthyofaunistic papers, like Wałecki (1864), Nowicki (1882, 1889) and Staff (1950) showed that only two species of genus *Gobio* occured in Polish waters: common gudgeon *G. gobio* (Linnaeus, 1758) and danubian longbarbel gudgeon (stone gudgeon) *G. uranoscopus* (Agassiz, 1828). Halina Rolik (1959, 1965a, 1971) found that all populations from San River (The Vistula River drainage) described earlier as *G. uranoscopus,* belong in fact to a very similar species *G. kesslerii*[1] Dybowski, 1862 - sand gudgeon (Kessler's gudgeon). In 1965 the same author discovered one more species living in the Vistula River drainage. In San River she found and described white-fine gudgeon *G. albipinnatus* Lukasch, 1933 (Rolik, 1965c). After these discoveries Balon and Holčik (1964) found *G. kesslerii* in Czarna Orawa River (Danube River drainage) and others found *G. albipinnatus* in Oder River drainage (Błachuta et al., 1994) and Bug River (Vistula River drainage) (Danilkiewicz, 1999) (review in: Heese, 2004). So far there has been no evidence of *G. uranoscopus* occurrence in Polish waters. Some misunderstanding was caused by Gasowka (1962: 84), who used name *G. uranoscopus* as a synonym of *G. kesslerii*. The error made by Gasowska (1962) was then repeated by Białokoz (1986, 2000). Furthermore Heese (2004) used the name *G. uranoscopus* as a synonym of *G. albipinnatus*.

According to Naseka (1996), *G. kesslerii* and *G. albipinnatus* belong to *Romanogobio*. Their valid names are *Romanogobio kesslerii* (Dybowski, 1862) and *Romanogobio albipinnatus* (Lukasch, 1933). Naseka and Freyhof (2004) included *G. uranoscopus* to the same genus. Its valid name is *Romanogobio uranoscopus* (Agassiz, 1828).

The only species, the occurrence of which has never been doubtful in Poland, is *Gobio gobio* (Linnaeus, 1758). It is widely distributed in the whole country (Wałecki, 1864; Nowicki, 1882, 1889; Staff, 1950; Rolik, 1965b, 1967; Białokoz, 1986, 2000 and many others; see review in: Rembiszewski, Rolik, 1975). Usually three subspecies were distinguished into it: nominative form[2] *G. gobio gobio* (L.) in Vistula and Oder drainages (Rolik, 1965; Białokoz, 1986, 2000), Danubian gudgeon[3] *G. gobio obtusirostris* (Valenciennes, 1842) in mentioned herein Czarna Orawa River (Balon, 1964; Balon, Holčik, 1964) and Prut River, Danube drainage (Oliva, 1962)[4] and the Nistru gudgeon *G. gobio sarmaticus*

[1] According to the rules of International Code of Zoological Nomenclature the correct name should be *G. kesslerii* not *G. kessleri* (Kottelat, 1997; Bănărescu, 1999b)

[2] "Western gudgeon" according to Balon et al. (1987: 276)

[3] "Eastern gudgeon" according to Balon et al. (1987: 276)

[4] Rolik (1967) considered specimens from Prut River to be *G. gobio sarmaticus*

(Berg, 1949) in Strwiąż River, Nistru drainage (Rolik, 1967). However, most authors (e. g. Staff, 1950; Gasowska, 1962; Rembiszewski, 1964; Skóra, Włodek, 1966, 1971; Jarzynowa, Rechulicz, 1997) did not recognize subspecies but only *G. gobio*.

During last years several new species have been recognized and described through the Europe: *G. banacensis*, *G. kubanicus*, *G. lozanoi*, *G. delyamurei*, *G. alverinae*, *G. occitaniae* (Naseka et al. 2006), *G. bulgaricus*, *G. lepidolaemus*, *G. krymensis* (Vasileva et al., 2004, 2005; Vasileva, Kuga, 2005). Furthermore the neotype specimen of *G. gobio* has been designated from the stream Sieg at Eitorf, Rhine drainage (Kottelat, Persat, 2005). Presently some authors (Naseka, Freyhof, 2004; Freyhof, Naseka 2005; Vasileva et al., 2005; Freyhof, Huckstorf, 2006; Freyhof, pers. comm., 2007) consider *G. obtusirostris* and *G. sarmaticus* to be valid species. But it is still doubtful and other authors (Bănărescu et al., 1999; Kottelat, 1997) consider them to be junior synonyms of *G. gobio*.

Gudgeon's systematics is mostly based on the morphometric and meristic characters. Many misunderstandings have been developed as a result of using different methods by the scientists in different countries (Kottelat, Persat, 2005). In Eastern and Central Europe they traditionally used Pravdin's scheme (Pravdin, 1931; Berg, 1949; Gasowska, 1962) whereas ichthyologist in Western Europe (and United States) commonly applied Hubbs and Lagler (1958) scheme. The main difference between these two is "length of body" used for comprehension. In Pravdin's scheme it is the so-called "body-length" (abbreviation "l") measured from the tip of the snout to the end of the last scale on the caudal peduncle. In the Hubbs and Lagler method it is the standard length (abbreviation SL), measured from the tip of the snout to the end of the hypural complex. SL is somewhat shorter than "body-length" (Naseka et al., 1999: 41; Kottelat, Persat, 2005).

All the scientists who have ever examined gudgeons in Poland used Pravdin's (1931) scheme or its modification. The first who have applied Hubbs and Lagler (1958) method (taking into account Naseka and Freyhof (2004)) were Nowak et al. (2007 and unpublished manuscript).

Meristic characters did not vary much, as Rolik (1965b) and Bănărescu et al. (1999) noticed. In dorsal fin Polish common gudgeons had usually 3 unbranched and 7 ½ branched rays (Hubbs and Lagler (1958) = 7 in Pravdin's (1931) scheme). Berg (1949), Rolik (1965b) and Białokoz (1986, 2000) mentioned very rare cases of specimens with 8 ½ branched rays in dorsal fin. In anal fin they had 3 unbranched and 6 ½ branched rays. Berg (1949), Rolik (1965b, 1967), Rembiszewski (1964), Nowak et al. (unpubl.) found a few specimens with 2 unbranched and/or 5 ½ or 7 ½ branched rays. All 9 specimens from Jeziorka River and 43 from Czarna Struga River (Rembiszewski, 1964) had 2 unbranched rays in anal fin[5]. Total number of scales in lateral line varied from 37 to 44 (Rembiszewski, 1964; Rolik, 1965b, 1967; Białokoz, 1986, 2000; Nowak et al., unpubl.). Bănărescu et al. (1999), gathering data from many different authors, showed range 33 - 45, but the lowest values (33 - 41) became from populations inhabiting Lake Skadar and Ohrid draining area (Bănărescu et al. (1999) - *G. gobio ohridanus*), which are presently considered to be distinct species *G. ohridanus* Karaman, 1924 (confer: Kottelat, Persat, 2005). Vasileva et al. (2004) gave range from 38 to 45 in *G. gobio* sensu stricto from Yakot River, Volga drainage. Kottelat and Persat (2005) gave 42 - 44 in neotype and specimens from Rhine and Rhône areas. The dark blotches along the lateral line varied from 6 to 12 (Skóra, Włodek, 1966, 1971; Białokoz, 1986, 2000; Nowak et al., unpubl.). Meristic characters of several authors (Rembiszewski, 1964, Rolik, 1965b, 1967; Vasileva et al., 2004; Kottelat, Persat, 2005; Nowak et al., unpubl.) for gudgeons from different localities were compared in table 1.

[5] First unbranched ray in anal fin is very small and difficult to count and it could cause in some confuse in counting. On the other hand Kottelat and Persat (2005) also gave 2 unbranched rays in anal fin for all 19 specimens from Rhine and Rhône drainages

Table 1. Unbranched and branched rays in dorsal and anal fin, total number of scales in lateral line in gudgeons from different localities. Values in brackets appeared occasionally.

Author	Rays in dorsal fin		Rays in anal fin		Scales in lateral line
	unbranched	branched	unbranched	branched	
Rembiszewski, 1964	3	7 ½	2	6 ½	41 - 44
Rolik, 1965b	3	7(8) ½	2-3	5 - 6 ½	39 - 44
Rolik, 1967	3	(6)7 ½	2-3	(5)6(7) ½	39 - 43
Nowak et al., unpubl.	(2) 3	7 ½	(2) 3	(5)6 ½	37 - 42
Vasileva et al., 2004	2 - 3	(6)7 - 8 ½	2-3	(5)6 - 7 ½	38 - 45
Kottelat, Persat, 2005	3	7 ½	2	6 ½	42 - 44

In the tables 2 - 4 comparison of some morphometric characters given by different authors (Rembiszewski, 1964; Rolik, 1965b; Skóra, Włodek, 1966; Jarzynowa, Rechulicz, 1997; Nowak et al., unpubl.) was presented. Generally gudgeons in Vistula River drainage visually differed from these in the Oder River drainage in shorter head (22.4 - 28.3% of body length[6] vs. 26.1 - 31.2% in Oder drainage), a bit longer snout (the average of its length in percent of body length amounted from 9.91 to 12.14 % vs. 12.37 %) and deeper body (the average of its depth in percent of body length in Vistula drainage varied from 18.40 to 21.28 % vs. 17.93 % in Oder). Specimens in the Mamry Lake had lower caudal peduncle than the others (the average of its depth amounted 7.80 % of body length vs. 7.90 - 9.34% in all others). Gudgeons in Rudawa River had much shorter snout than the others (its length in percent of body length amounted 7.9 - 11.2% with average 10.04% vs. 10.14 - 13.8% in all others). Only specimens in Jeziorka River had shorter snout (average 9.91% of body length). But they had also shorter head. Snout length in percent of head length varied from 32.7 to 44.5%, with average 39.35% in Rudawa vs. 40.78% in Jeziorka (only average available). Average of horizontal eye diameter in percent of body length varied from 5.32 to 7.40% (21.70 - 26.91% of head length). The value 7.4% of body length (26.91% of head length) in specimens inhabiting Bukowa River was astonishingly high, much higher than in any population described by Bănărescu et al. (1999). They found maximum average 6.8% of SL (24.19% of head length) in specimens from Roading River (England).

Due to the earlier mentioned difference in methods of measurements only Nowak et al. (unpubl.) data for specimens in Rudawa and Silnica Rivers (Vistula drainage) were comparable with the diagnosis given by Kottelat and Persat (2005). Analyzed populations fit into the diagnosis: fish had thin lips, lower one without notch; slender caudal peduncle (its depth 8.67% of SL in Rudawa, 8.25% in Silnica and 8.7 - 10.8% in typical specimens; its length in percent of SL consecutively 21.28%, 21.77% and 18.8 - 24.0%; ratio length/depth 2.45, 2.64 and 2.0 - 2.7 times). According to Kullander (1999) suitability with diagnosis should define belonging (or not) to the species. But Kottelat and Persat (2005) diagnosis was situated in Western Europe *Gobio* species context, as it was pointed by authors themselves (Kottelat, Persat, 2005: 213).

[6] Nowak et al. (unpubl.) applied standard length (SL) rather than body length (l), as it was mentioned herein

Table 2. Head length (HL), snout length (r) and postorbital distance (po) in percent of body length (l) in gudgeons from different localities. Above the line - range of the values of the character, below - an average value of the character and its standard error. Markers: [1] values calculated from data given by authors; [2] in percent of standard length (SL).

Locality	HL/l	r/l	po/l	Author
Vistula River drainage				
Vistula	25.0 – 28.3 / 26.69 ± 0.19	11.2 – 13.1 / 12.14 ± 0.13	10.6 – 12.4 / 11.27 ± 0.11	Rolik, 1965b
Upper San	25.2 – 29.0 / 26.67 ± 0.08	10.7 – 13.8 / 12.07 ± 0.08	9.8 – 11.6 / 10.67 ± 0.05	``
Middle San	24.9 – 28.2 / 26.71 ± 0.19	9.8 – 11.6 / 10.67 ± 0.05	9.9 – 12.2 / 11.17 ± 0.14	``
Lower San	24.0 – 28.1 / 26.30 ± 0.18	10.1 – 12.4 / 11.72 ± 0.14	10.0 – 11.8 / 11.15 ± 0.10	``
Wieprz	24.6 – 28.2 / 26.08 ± 0.18	9.8 – 13.5 / 11.57 ± 0.16	10.1 – 12.4 / 11.20 ± 0.10	``
Okrzejka	25.0 – 26.8 / 25.87 ± 0.16	10.1 – 12.0 / 11.48 ± 0.14	9.5 – 11.3 / 10.50 ± 0.14	``
Jeziorka	23.8 – 25.4 / 24.3	– / 9.91[1]	– / 10.18[1]	Rembiszewski, 1964
Czarna Struga	22.4 – 27.0 / 24.5	– / 10.14[1]	– / 10.24[1]	``
Soła	24.6 – 26.8[1] / –	8.7 – 11.4[1] / –	10.1 – 12.2[1] / –	Skóra, Włodek, 1966
Bukowa	25.0 – 30.4 / 27.5	11.5 – 15.5 / 13.6	11.0 – 14.4 / 12.8	Jarzynowa, Rechulicz, 1997
Rudawa[2]	24.0 – 28.5 / 25.54 ± 0.11	7.9 – 11.2 / 10.04 ± 0.07	10.0 – 12.7 / 11.24 ± 0.07	Nowak et al., unpubl.
Silnica[2]	23.7 – 28.3 / 26.44 ± 0.13	10.0 – 12.2 / 11.10 ± 0.07	10.5 – 12.5 / 11.45 ± 0.07	``
Oder River drainage				
Kaczawa	26.1 – 31.2 / 28.13 ± 0.31	10.8 – 13.3 / 12.37 ± 0.21	10.9 – 12.8 / 11.83 ± 0.16	Rolik, 1965b
Baltic Sea basin				
Lake Mamry	23.4 – 25.4 / 24.52 ± 0.13	9.5 – 11.2 / 10.52 ± 0.09	8.8 – 10.6 / 9.52 ± 0.09	Rolik, 1965b

Kottelat and Persat (2005) stated that *G. gobio* sensu stricto occur, inter alia, in rivers draining to North and Baltic Seas, upper Nistru and Nipru drainages. Furthermore they consider (according to Freyhof, pers. comm., 2002) that populations in uppermost Danube drainage could be conspecific or could have introgression zone with *G. obtusirostris* (Freyhof and Huckstorf (2006) pointed the same). In that context all populations from Vistula, Oder and Nistru drainages should be classified as *G. gobio* sensu stricto whereas *Gobio* sp. from Czarna Orawa (Danube drainage) would have a still unexplained status. Furthermore Vasileva et al. (2004) concluded that *G. gobio* sensu stricto occurs in Baltic Sea basin (also in Great Britain, southern Sweden, North and White Sea basins).

Table 3. Horizontal eye diameter (o) in percent of body length (l), head length (HL) and interorbital width (io) in gudgeons from different localities. Above the line - range of the values of the character, below - an average value of the character and its standard error. Markers: [1] values calculated from data given by authors; [2] in percent of standard length (SL).

Locality	o/l	o/HL	o/io	Author
Vistula River drainage				
Vistula	4.9 – 6.8 6.00 ± 0.13	– 22.48[1]	66.3 – 95.0 75.48 ± 1.69	Rolik, 1965b
Upper San	5.6 – 7.3 6.21 ± 0.05	– 23.28[1]	69.3 – 93.0 80.22 ± 0.71	``
Middle San	5.8 – 7.1 6.55 ± 0.09	– 24.52[1]	75.7 – 93.0 82.63 ± 1.23	``
Lower San	5.2 – 7.2 6.11 ± 0.12	– 23.23[1]	70.5 – 92.5 83.00 ± 1.32	``
Wieprz	4.9 – 6.9 5.93 ± 0.08	– 22.74[1]	72.6 – 94.0 81.33 ± 1.00	``
Okrzejka	5.2 – 6.8 5.86 ± 0.11	– 22.65[1]	70.2 – 90.4 80.00 ± 1.38	``
Jeziorka	– 5.67[1]	17.0 – 29.3 23.4	–	Rembiszewski, 1964
Czarna Struga	– 5.32[1]	19.1 – 26.0 21.7	–	``
Soła	5.2 – 6.6[1] –	18.2 – 23.5[1] –	–	Skóra, Włodek, 1966
Bukowa	6.3 – 8.9 7.4	– 26.91[1]	–	Jarzynowa, Rechulicz, 1997
Rudawa[2]	4.6 – 7.2 5.97 ± 0.06	18.2 – 27.4 23.39 ± 0.22	60.2 – 97.5 76.40 ± 0.80	Nowak et al., unpubl.
Silnica[2]	4.7 – 6.9 5.91 ± 0.06	18.8 – 25.7 22.34 ± 0.20	62.2 – 95.83 81.02 ± 0.91	``
Oder River drainage				
Kaczawa	5.5 – 7.9 6.50 ± 0.15	– 23.11[1]	65.7 – 96.1 81.33 ± 2.26	Rolik, 1965b
Baltic Sea basin				
Lake Mamry	5.2 – 6.0 5.60 ± 0.05	– 22.84[1]	70.5 – 96.4 81.36 ± 1.32	Rolik, 1965b

Rolik (1965b) found that gudgeons from Vistula drainage resembled both *gobio* and *obtusirostris* subspecies. She tried to clasified them in order to "lotic" and "lentic" forms, according to Bănărescu (1954), and consider them to be "lotic" form of *G. gobio gobio*. Unlike the "lentic" form, this is characterised by shorter body depth, longer head, lower caudal peduncle, longer paired fins and deeper unpaired fins (Bănărescu, 1954; Bănărescu et al., 1999). However, Kottelat and Persat (2005) subjected this classification to thorough (and apparently sufficient) criticism as inconsistent and insufficiently defined.

Only one study on *G. gobio* cytogenetics (Kirtiklis et al., 2005) has been developed in Poland. Kirtiklis et al. (2005), using different staining methods, found that in Oder River *G. gobio* karyotype consisted 2n = 50 (22 meta-, 26 submeta-subtelo- and 2 acrocentric) chromosomes and NF = 98 chromosome arms. These results were similar with observations of other authors (Raicu et al., 1973; Vasileva et al., 2004, 2005).

Table 4. Body depth (H), caudal peduncle depth (h) and caudal peduncle length (pl) in percent of body length (l) in gudgeons from different localities. Above the line - range of the values of the character, below - an average value of the character and its standard error. Markers: [1] values calculated from data given by authors; [2] in percent of standard length (SL).

Locality	H/l	h/l	pl/l	Author
Vistula River drainage				
Vistula	18.5 – 21.5 / 19.62 ± 0.16	8.2 – 9.4 / 8.70 ± 0.09	20.9 – 24.3 / 22.62 ± 0.21	Rolik, 1965b
Upper San	17.3 – 21.1 / 19.13 ± 0.12	7.8 – 9.8 / 8.94 ± 0.06	20.4 – 25.6 / 23.17 ± 0.11	``
Middle San	18.0 – 21.1 / 19.45 ± 0.20	8.2 – 9.5 / 8.98 ± 0.09	22.1 – 25.0 / 23.60 ± 0.18	``
Lower San	17.5 – 20.2 / 18.65 ± 0.17	8.4 – 9.9 / 9.16 ± 0.09	22.0 – 25.1 / 23.45 ± 0.19	``
Wieprz	18.1 – 22.7 / 19.90 ± 0.22	8.6 – 10.3 / 9.34 ± 0.45	20.7 – 25.0 / 22.65 ± 0.20	``
Okrzejka	15.7 – 20.8 / 19.07 ± 0.04	8.2 – 9.4 / 8.70 ± 0.11	21.9 – 25.0 / 23.50 ± 0.28	``
Jeziorka	17.6 – 24.3 / 19.5	7.6 – 9.5 / 8.2	20.2 – 24.5 / 22.1	Rembiszewski, 1964
Czarna Struga	16.0 – 23.1 / 18.4	6.8 – 9.6 / 7.9	20.2 – 24.6 / 22.2	``
Soła	17.4 – 20.3[1] / –	7.2 – 8.1[1] / –	–	Skóra, Włodek, 1966
Bukowa	14.4 – 18.7 / 16.8	6.5 – 8.2 / 7.4	20.3 – 24.5 / 22.6	Jarzynowa, Rechulicz, 1997
Rudawa[2]	16.1 – 22.1 / 19.02 ± 0.16	6.9 – 15.2 / 8.67 ± 0.12	18.4 – 24.2 / 21.28 ± 0.16	Nowak et al., unpubl.
Silnica[2]	18.9 – 25.6 / 21.28 ± 0.17	6.9 – 9.5 / 8.25 ± 0.08	16.8 – 24.6 / 21.77 ± 0.20	``
Oder River drainage				
Kaczawa	16.3 – 20.7 / 17.93 ± 0.26	8.2 – 9.5 / 8.74 ± 0.11	20.7 – 24.5 / 22.90 ± 0.25	Rolik, 1965b
Baltic Sea basin				
Lake Mamry	16.1 – 20.9 / 19.57 ± 0.26	7.2 – 8.4 / 7.80 ± 0.07	21.1 – 24.6 / 22.91 ± 0.21	Rolik, 1965b

CONCLUSIONS

Systematics of the genus *Gobio* in Poland has never been clarified. Morphometric data given by different authors were usually incomplete and focused only on one small population. Only Rolik (1965b, 1967) has analyzed more populations in different localities, but "lentic" and "lotic" categories used by her seem completely useless in modern systematics context. Presently, when Naseka and Freyhof (2004) and Kottelat and Persat (2005) (also: Freyhof, Nasek 2005; Naseka et al., 2005, 2006) strongly unified methods of measurements, these data are incomparable due to the difference between Pravdin's (1931) scheme and Hubbs and Lagler (1958) method, as it was already mentioned here. Nowak et al. (2007 and unpubl.) examined gudgeons in two rivers in the left-bank Vistula drainage according to Naseka and Freyhof (2004) scheme in order to make such a comparison possible.

Generally taxonomical status of the so-called "common gudgeon" in Vistula and Oder drainages is still not clear. Traditionally it has been considered to be *Gobio gobio* (Linnaeus, 1758) but this view should be revised, especially when *G. gobio* sensu stricto had been redescribed (Kottelat, Persat, 2005). Although in Poland at least 3 subspecies were reported (*G. gobio gobio*, *G. gobio obtusirostris* and *G. gobio sarmaticus*), the species concept used by most of the authors (phylogenetic species concept, see: Kullander, 1999; Kottelat and Persat, 2005) did not recognize subspecies. Successive investigations are certainly needed. Until that time "common gudgeon" in Poland should be treated as *G. gobio* sensu lato, as Vasileva et al. (2004, 2005), Vasileva and Kuga (2005) and Naseka et al. (2005) did, in case of gudgeons in Crimea, and as Nowak et al. (2007) already suggested.

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AUTHORS:
[1] *Michał NOWAK*
mikhael.nowak@gmail.com
[2] *Włodzimierz POPEK*
rzpopek@cyf-kr.edu.pl
[3] *Piotr EPLER*
rzepler@cyf-kr.edu.pl
Agricultural University of Cracow,
Department of Ichtyobiology and Fisheries,
Prof. T. Spiczakowa ul., no. 6,
Kraków, Poland,
PL - 30 149.

PERCARINA DEMIDOFFI NORDMANN, 1840 (PISCES, PERCIDAE) STATUS AFTER TWO DECADES OF ITS RECORDING IN ROMANIA

Vasile OȚEL

KEYWORDS: brackish-water fish, frequency, abundance, population, new conditions.

ABSTRACT

Percarina demidofii a mainly brackish -water fish is a monotypic genus of *Percidae,* having a small size. Its known range is limans of the rivers from the northern slope of the Black Sea, east of the Danube: Nistru, Bug, Nipru, Don, Kuban and the slightly-brackish Sea of Azov. In Romania it was recorded for the first time in 1984 in a great number in lake Razim in almost pure freshwater, being probably a recent intruder.

In 1991 - 1992 its frequency in Razim - Sinoie was 100% and relative abundace 10.5% (numerical) and 1.64% (gravimetrical). Isolated specimens were recorded in the Black Sea (Gura Portiței and meleaua Sacalin) in the same period. A new fishing has been carried out in the lake Razim in 2005, when this species also has been recorded a frequency of 100% and relative abundance of 5.66% (numerical) and 0.32% (gravimetrical). Thus we can say that *Percarina* established a permanent population and successfully breeds in this new places and environmental conditions.

REZUMAT: Situația speciei *Percarina demidofii* Nordman, 1840 (*Pisces, Percidae*) după două decenii de la semnalarea sa în România.

Percarina demidofii, cunoscută mai ales ca specie eurihalină, aparține unui gen monotipic a fam. *Percidae*, fiind de talie mică. Arealul său de distribuție cunoscut se limitează la limanurile râurilor tributare coastei nordice a Mării Negre, la estul Dunării: Nistru, Bug, Nipru, Don, Cuban şi partea salmastricolă a Mării de Azov. Specia a fost descoperită pentru prima dată în România în anul 1884 în lacul Razim, într-o populație numeroasă, fiind probabil pătrunsă recent.

În 1991 - 1992 frecvența sa în Razim - Sinoie a fost de 100%, abundența relativă numerică de 10,5% iar cea gravimetrică de 1,64%. Tot în aceeaşi perioadă au fost înregistrate exemplare izolate la țărmul Mării Negre în zonele Gura Portiței şi meleaua Sacalin. In anul 2005, când s-a efectuat din nou pescuit în lacul Razim, frecvența a fost din nou 100%, iar abundența relativă numerică 5,66% şi cea gravimetrică 0,32%. Astfel, se poate afirma că specia şi-a stabilit în noile locuri şi condiții de mediu o populație permanentă care se reproduce cu succes.

RESUME: Statut de *Percarina demidoffi* Nordmann, 1840 (*Pisces, Percidae*) après deux décénnies de suivi en Roumanie.

Percarina demidoffi, un poisson principalement des eaux saumâtres, est un genre monospecifique de la famille des *Percidae* possédant une petite taille Sa répartition connue s'étend des rivières du nord de la Mer Noire, à l'est du Danube : au niveau des rivières Nistru, Bug, Nipru, Don, Kuban et la mer d'Azov, peu salée. En Roumanie, il a été apperçu pour la première fois en 1984 en grand nombre dans le lac Razim, dans une eau quasiment pure, probablement récemment introduit.

En 1991 - 1992, sa fréquence (occurrence) dans le système Razim - Sinoie était de 100% et son abondance relative de 10,5% (en nombre d'individus) et 1,64% (en biomasse). Des specimens isolés ont également été notés en Mer Noire (Gura Portiței et Meleaua Sacalin) pendant la même période. Une nouvelle pêche a été réalisée dans le lac Razim en 2005. Cette espèce a alors été trouvée avec une fréquence (occurrence) de 100% et une abondance relative de 5,66% (en nombre) et 0,32% (en biomasse). Nous pouvons donc dire que *Percarina* a établi une population permanente et se reproduit avec succès dans ces nouvelles stations et ces nouvelles conditions environnementales.

INTRODUCTION

Percarina demidoffi (Figure 1) is a species of small size (max. TL = 10.5 cm; usual TL = 6.5 - 7.5 cm). Its geographical distribution (Figure 2) is limans of the rivers from the northern slope of the Black Sea, east of the Danube: Nistru, Bug, Nipru, Don, Kuban and the slightly-brackish Sea of Azov (1, 4). Its absence from the lower Danube and from adjacent freshened waters of the Black Sea was pointed out first by Antipa (1909) and later confirmed by all authors (Figure 3) having dealt with the fish fauna of Romania (Bănărescu, 1964; Cărăuşu, 1952; Teodorescu et al., 1955-1956). The genus is to a certain measure intermediate between *Perca* and *Gymnocephalus*. Because of the absence of the predorsal bone, *Percarina* is considered not as intermediate between the two other genera, but as representing the apomorphic sister of the pair *Perca-Gymnocephalus* (Oțel and Bănărescu, 1986). Recent ichthyological investigations (Vasilieva, 2003) on the rivers Kuban, Don, Nipru and Nistru showing that *Percarina demidofii* has now become rare in the eastern area of the Black Sea (limans of Kuban, Don) and remained relatively common in the western (Nistru, Nipru). Concerning the biology, this species prefers open brackish-waters of lagoons. Sometimes it moves from one place to another in a great number. Its sexual maturity occurs at 1 - 2 years of age and spawning period is in June-August. Till 3000 sticky eggs are scattered by the female on the bottom of water, nonguarded by the males. The incubabation period lasts two days at the water temperature of 24 - 25°C. Its known longevity is 4 years. The main food consist in the small crustaceans and sometimes fry fishes. It has no directly economical value, but it is often eaten by the predatory fishes, mainly pike-perch. The only cariological analyses have been made till now on the population from Romania (lake Razim-Sinoie) (11). Kariotype: 2n-48, metacentrics - 14, submetacentrics - 14, ubtelocentric /acrocentrics-20. IUCN Red List mentions *Percarina* as Vulnerable. The species was recorded in Romania for the first time in 1984, in great quantities in the almost pure freshwater of lake Razim, south of the Danube Delta (8). The fishing was repeated in 1991 and 1992 in entire Razim-Sinoie area (9, 10), recording a frequency of 100% and relative abundace 10.5% (numerical) and 1.64% (gravimetrical). Isolated specimens were also recorded in the Black Sea (Gura Portiței and meleaua Sacalin) in the same period. Since 1992 till 2005 we no more obtained data about *Percarina* because of lack of an adequate fishing tackles (seine).

Figure 1. *Percarina demidofi*.

Figure 2. Actual range of *Percarina demidofii*.

MATERIALS AND METHODS

In July and September 2005 the author made a fishing in the lake Razim, using a seine having the following size: wings - 50 m length and 2.5 m depth, mesh size of the wings - 12 to10 mm diameter, mesh size of the codend - 7 mm diameter. The fishing has been carried out in 15 points of the lake, both in the middle area and near the bank. Two boats and six fishermen have been used. Sampled fishes were selected by species and average of frequency and abundance (both numerical and gravimetrical) has been recorded.

RESULTS AND DISCUSSIONS

Among 27 fish species sampled in July and September 2005 in the lake Razim, *Percarina demidoffi* has been recorded the following averages of relative abundance:

Numerical relative abundance			Gravimetrical relative abundance	
Years	2005	1991-1992	2005	1991-1992
%	5.66	10.5	0.32	1.64

It was found in all fishing points (100% of frequency). In comparison with data since 1991 - 1992. The population appear to be less, but we can say that now *Percarina demidoffi* is a common species in this lake where it formed an established population which successfully breeds. This aspect is emphasized by the fact that 76%

from sampled specimens in 2005 represented juveniles. We can not exactly mention the reason of its migration in our area from the East, but probably the pollution of rivers from Ukraine was the main cause. It is very possible that nowadays the population of *Percarina* from the lake Razim-Sinoie to be the most important reservoir of this species from its actual geographical range. From economically point of view, it has not a directly importance because of its small size. However it is known that this species often constitute the food of predatory fishes, mainly for the pike-perch which is very spread and important in this lake.

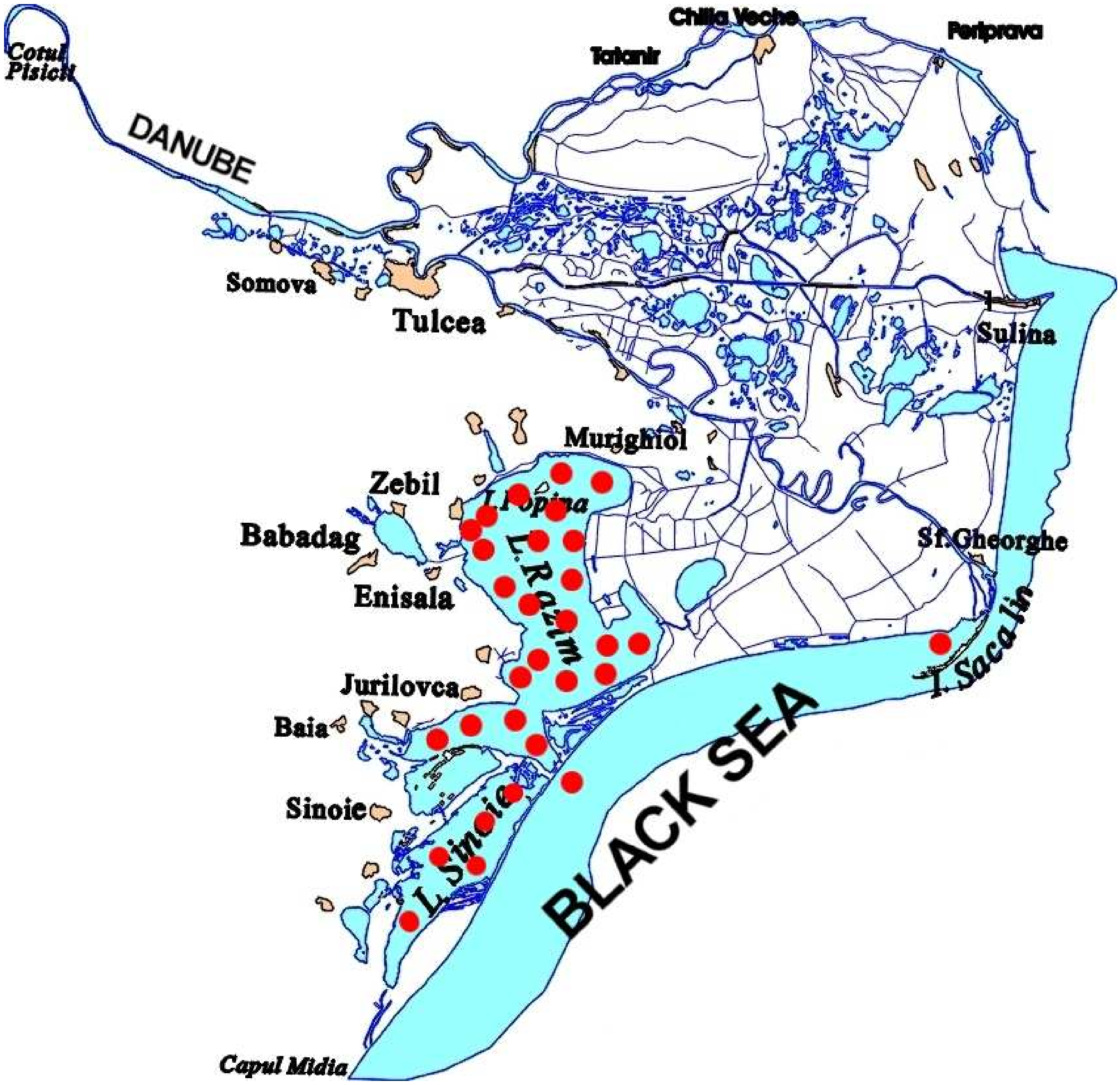

Figure 3. The points from the Romania where *Percarina demidoffi* species was recorded in 1984 - 2005.

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AUTHOR:

Vasile OȚEL
votel@indd.tim.ro
Danube Delta National Institute
for Research and Development,
Department of Biodiversity
Conservation and Natural Resources,
Babadag St., no. 165,
Tulcea, Tulcea County, Romania,
RO - 820112.

NON-NATIVE BIOLOGICAL INVADERS: ICTALURUS (AMEIURUS) NEBULOSUS (LESUEUR, 1819)

[1] *Ruxandra M. PETRESCU* and [2] *Valentin I. MAG*

KEYWORDS: brown bullhead, non-indigenous, invasive species, feeding behavior, adaptability.

ABSTRACT

The paper treats on detail aspects as international nomenclature concerning non-native species, hystorical of the brown bullhead in Romania, and brings new data on its feeding behavior.

Experiences we made show a high adaptability as regards trophic spectrum of brown bullhead and iterspecific competition for food.

REZUMAT: Invadatori biologici non-nativi: *Ictalurus (Ameiurus) nebulosus* (Lesueur, 1819).

Lucrarea de faţă tratează pe larg aspecte legate de nomenclatura internaţională privind speciile non-native, istoricul somnului pitic în România şi aduce contribuţii la cunoaşterea comportamentului de hrănire al acestuia.

Experimentele efectuate arată o adaptabilitate mare a somnului pitic în ceea ce priveşte regimul său de hrănire şi concurenţa pentru hrană cu alte specii de peşti.

RESUMEN: Invasores biologicos non-nativos: *Ictalurus (Ameiurus) nebulosus* (Lesueur, 1819).

El presente trabajo trata los aspectos concerniente a la nomenclatura internacional sobre las especies non-nativas, el histórico del *Ictalurus nebulosus* en Rumania y no en ultimo lugar tiene contribuciones al conocimiento de los hábitos de nutrición.

Los experimentos indican una grand adaptabilidad del siluro enano en lo que se refiere al régimen de nutrición y a la competencia en este sentido con otras especies de peces.

INTRODUCTION

Biological invasions by non-native species of animals, plants or microorganisms cause significant economic and ecological damage all over the world. A report from the Office of Technology Assessment estimates in 1993 the monetary costs associated with biological invasions in U. S. A. (Costello and McAusland, 2003). In the United States alone it is between 4.7 and 6.5 billion dollars a year. Subsequent research revises that estimate for the United States upward to over 100 billion dollars annualy (Pimentel et al., 2000). Non-native species enter a country either through intentional or unintentional introduction. Of unintentional introductions primary conduits include contaminated traded goods such as agricultural products and timber, contaminated packing materials, ballast water, and tourism. The proeminent role of intentional trade and transport of commodities in biological invasions has led to the common perception that freer trade will lead to an increase in the scale of biological invasions, and has even prompted the claim that broad tools such as bans or restrictions of imports may be necessary to protect biodiversity (Jenkins, 1996). However, the relationship between damage from invasive species and protectionism is not so simple (Costello and McAusland, 2003), and decisions in this field require advanced studies of impact.

Ictalurus nebulosus, or the brown bullhead, is an ictalurid fish originary from North America, where it has a wide distribution (Atlantic and Gulf Slope drainages from Nova Scotia and New Brunswick in Canada to Mobile Bay in Alabama in U. S. A., and St. Lawrence-Great Lakes, Hudson Bay and Mississippi River basins from Quebec west to Saskatchewan in Canada and South to Louisiana, U. S. A.). *Ictalurus nebulosus* was first introduced on the “Old Continent”, in Berlin (1880), as a fish of exhibitions; few years later it was also introduced in other European countries as aquarium fish, Germany, France and Belgium, (Gavriloaie and Falka, 2005). According to Vasiliu (1959), *Ictalurus nebulosus* was introduced in Romania in 1908, in St. Ana Lake. As result of natural dispersion and translocations, the species colonized most water bodies from the western regions of Romania. In a natural way, *Ictalurus nebulosus* reached, in 1934, the Tisa River and its following affluents: Someş, Crişuri, Mureş, Bega, then Timiş, Beregsău and Sat-Chinez pools, rivulet Peţea (nearby Oradea), Ineu, lower Danube at Brăila. Nowadays, the brown bullhead it is considered, by many, one of the most invasive fish species in Romania (Gavriloaie and Falka, 2005; Mag et al., 2006).

But what is an invasive species, and what is a non-native species? An important difficulty of governmental and non-governmental organizations, in the struggle to prevent the introduction and mitigate the establishment and impact of non-native species, is the definition of what mean native and what mean non-native, which ones of the non-natives are desirable for social and economic reasons, and how to classify non-native species that are endangered in their native ranges.

In the assessment of nativeness, it is essential to understand biological invasion as a process of overcoming and removal barriers (Richardson et al., 2000; Copp et al., 2005). The geographic barrier is the first one, and overcoming of geographic barrier is often due to introduction of the species. Introduction - means “mechanical transfer by man of a species to locations not normally achievable by that species”. A non-native fish species can be characterized either as intentional/accidental introduced or as an independent invader. The causes for such dispersal can be natural or indirect human action, which result in new conditions (temperature regime, access routes) that permit the species to disperse into the new area. After subsequent barriers have been removed, dispersal may be enhanced by mechanisms and circumstances, such as changes in physical habitat, hydrological regime, water chemistry, hydrosystem connectivity, or ecosystem and genetic impacts. To avoid ambiguity, the U. S. National Aquatic Invasive Species Act of 2003, which re-authorized and amended the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, specified that a non-indigenous species refers to "any species in an ecosystem that enters that ecosystem from outside the historic range of the species", whereas an invasive species is defined as a "non-indigenous species, the introduction of which into an ecosystem may cause harm to the economy, environment, human health, recreation, or public welfare, i. e. there is a significant risk attached to its introduction". The United Nations Convention on Biological Diversity (Canada) define the term of invasive alien as "any species, subspecies or lower taxon introduced outside its normal past or present distribution"; whereas an alien invasive species is defined "an alien species, the establishment and spread of which threaten ecosystems, habitats or species with economic or environmental harm". The definition has been adopted by the Canadian government (Canadian Biodiversity Strategy, 1995). In some respects, the Canadian and American legal definitions of alien species seem to be quite similar to the biological definitions of exotic or alien species. However, both American and Canadian definitions emphasize economic, human health and social consequences of exotic species rather than the ecological or environmental implications (Copp et al., 2005). The legal definitions do not describe the acceptable level of harm or threat an exotic species must demonstrate before it is regarded as invasive and control action is needed.

Some definitions of an invasive species (UNEP 1994, Canadian Biodiversity Strategy 1995) are more restrictive, encompassing only negative impacts (including economic) on recipient ecosystems: alien invasive species - "an alien that becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity" (Clout and Lowe, 1996; SSC Invasive Species Specialist Group, 2000). The criteria used to categorize a species as invasive aliens are usually derived from subjective assessments of negative consequences. These criteria are relative and anthropocentric, particularly as regards introductions to semi-natural and artificial ecosystems (Copp et al., 2005).

In Europe, some consensus seems to have been reached in certain quarters, such as support in Manchester and Bullock (2000) of the recommended UKINC (1979), IUCN (1987), ICES (2004) and MARLIN (2005) glossaries. Richardson et al. (2000) also provided a useful glossary of definitions for plants, which has been adapted to freshwater fishes by Copp et al. (2005, see below).

Acclimatized - "Species (or taxon) that are able to complete part or most of their life cycle in the wild in an alien environment or climate, but are unable to reproduce and sustain a population without the support of humans" (Copp et al., 2005). However, the European Commission LIFE programme specifies the support of humans as "for food and shelter" (Scalera and Zaghi, 2004), which could be interpreted under aquaculture conditions.

Captive conditions - "controlled and isolated circumstances such as research facilities, private indoor aquaria, private garden ponds outside a river flood plain, enclosed hatcheries and fish farms, zoological gardens/parks" (Bogutskaya and Naseka, 2002).

Casual - "a taxon (species, sub-species, race or variety) that is introduced, unable to sustain its presence, despite the ability to reproduce in the novel environment (Richardson et al., 2000), without human intervention (i. e. through stocking)" (Copp et al., 2005).

Colonization - "an integral part of the naturalization process whereby the organisms of a founding population reproduce and the species increases in number to form a colony that is self-perpetuating" (Richardson et al., 2000).

Established - refers to species that are able to maintain self-sustaining populations in garden ponds but not yet recorded outside such isolated conditions (Audit of Nonnative Species in England, English Nature, York, Ref. VT 0313).

Establishment (“naturalized”) - “process undergone by a non-native taxon (species, subspecies, race, variety), following introduction to create a self-sustaining wild population in the, beginning with successful reproduction (establishment is the first phase of naturalization)” (Copp et al., 2005).

Feral - an organism or its descendants, that is domesticated, or has undergone domestication, been kept in captivity that has escaped into the wild. A feral population is not necessarily self-sustaining (Manchester and Bullock, 2000).

Foreign (“transferred”, see also “introduction”) - “a taxon (species, sub-species, race or variety) that has been moved across a national border to a country outside its native range. This only applies to an organism translocated between political states (countries)” (Copp et al., 2005).

Indigenous (“native”) - “refers to a taxon (species, subspecies, race or variety) that occurs naturally in a geographical area, with dispersal occurring independent of human intervention, whether direct or indirect, intentional or unintentional” (Copp et al., 2005). To this definition may be added that of Manchester and Bullock (2000) and of ICES (2004), specifically that “a species or race thought to have occurred in a geographical area before the Neolithic can be considered to be native” (Manchester and Bullock, 2000).

Introduced species - “non-native”, “non-indigenous”, “exotic”.

Introduction - is a deliberate or unintentional transfer and/or release, by direct or indirect human agency, of an organism into the wild, or into locations not completely isolated from the surrounding environment, by humans in geographical areas where the taxon (species, subspecies, race or variety) is not native (adapted from Copp et al., 2005). This applies to translocations within and between political states. Richardson et al. (2000, the ICES 2003 Code of Practice) give a complementary definition to that above mentioned, and he referred to as a “new introduction”: “the human-mediated movement of a species outside its present distribution”. Considering this definition, a species has overcome, through human agency, a major geographical barrier. This “biogeographical” approach to introduction contrasts the “bio-political” approach of the FAO, which considers an introduced species to be one “that has been moved across a national border to a country outside of its natural range” (Welcomme, 1988; FAO, 1998).

Invasive organisms - “native or alien species that spread, with or without the aid of humans, in natural or seminatural habitats, producing a significant change in composition, structure, or ecosystem processes, or cause severe economic losses to human activities” (Copp et al., 2005), adapted from: Allard and Alouf, 1999; Scalera and Zaghi, 2004). Richardson et al., (2000) categorized such plants as “weeds”. No equivalent term to “weeds” exists for fish and “pest” does not seem appropriate (Copp et al., 2005).

Invasion - dispersal of a species into a locality that is not native to that species, and inclusion of the species into a community of species new for it; all cases of penetration of living organisms into ecosystems situated beyond the limits of their initial range; all cases of distribution of organisms brought about by human activity and natural shifts of species beyond the limits of their natural distribution (adapted from Copp et al., 2005).

Native range - refers to natural limits of the species’ geographical distribution (adapted from ICES 2004). However, range is dynamic, possessing “the same historical notion as species” (Sinskaya, 1948), which may adapt morphologically, physiologically, or in terms of behaviour in response to environmental conditions” (Copp et al., 2005).

Naturalized - “a non-native species, sub-species, race or variety that, following introduction, has established self-sustaining populations in the wild and has been present of sufficient duration to have incorporated itself within the resident community of organisms” (Copp et al., 2005, adapted from:

Allard and Alouf, 1999; Manchester and Bullock, 2000; Richardson et al., 2000). Definition of Scalera and Zaghi (European Commission LIFE 2004) restricts itself to “introduced or feral species” but accentuate that self-sustaining of the population is independent of humans.

Non-native - “non-indigenous”, “alien” or “exotic” (see also “foreign”) - “refers to a species, sub-species, race or variety (including gametes, propagules or part of an organism that might survive and subsequently reproduce) (Scalera and Zaghi, 2004) that does not occur naturally in a geographical area, i.e. it did not previously occur there or its dispersal into the area was mediated or facilitated directly or indirectly by humans, whether deliberately or unintentionally (Manchester and Bullock, 2000)” (Copp et al., 2005). Allard and Alouf (1999) give a definition that complete the previous one, and which is rather concise, and more specifically with that accepted by the European Commission LIFE programme (Scalera and Zaghi, 2004) and by ICES (2004). It assumes that species that have colonized since the Neolithic, 6000 B (i. e. about 4000 BC), are non-indigenous. This deviates from the threshold date (5000 BC or 3000 BC) given for marine species (MarLIN 2005), and the distinction between native and non-native may not be straightforward, relying upon estimates of the length of time a species has been resident (Manchester and Bullock, 2000).

Re-introduction - is used in conservation to refer to the release of a species into a part of its former native range in which the species became extinct in historical times (adapted from IUCN, 1987; MarLIN, 2005; Copp et al., 2005).

Transferred species (“foreign”) - “a transferred species is one that has been moved across a national border to a country within its natural range (FAO, 1998).

Translocation (see also “foreign”) - is the introduction of a species, from one part of a political entity in which it is native to another part of the same country in which it is not native (adapted from Copp et al., 2005). Fuller et al.m (1999) refers to such species as “transplanted”.

Vagrant - this refers to a taxon (species, sub-species, race or variety) that, by natural means, moves from one geographical region to another outside its usual range, or away from usual migratory routes, and that do not establish a self-sustaining population in the visited region (adapted from MarLIN, 2005).

The wild - This is defined as any conditions in which organisms can disperse to other sites or can breed with individuals from other populations (UK Nature Conservancy Council 1990).

As we stated above, *Ictalurus nebulosus* is an invasive species, and its invasiveness is due to its high capacity of propagation, wide trophic spectrum, lack of natural enemies and care of offsprings. Let’s begin with a hystorical of the species in Romania, compiled in principal by two young but good scientists of the moment in domain of invasive species research - Gavrloaie and Falka (2005).

This species has been reported for the first time in Romania by Antonescu (1934) in his work „Peştii apelor interioare din România” (Inlandwater fishes of Romania). The same autor refers in 1938 to two new species of fish in the Romanian fauna: *Eupomotis gibbosus* and *Amiurus nebulosus*. The paper was publish in „Grigore Antipa, Hommage à son oeuvre” and it is focused on the biology and morphology of these two new fish species, but also deals with the introduction of brown bullhead in Europe and the Romanian occurence of this fish, which is present only in some of the large rivers of Transylvania.

Ziemiankowski (1944), in „Fauna peştilor din Bucovina” (Fishes of Bucovina) describes the ecology and morphology of *Ameiurus nebulosus* and treat the introduction of this species in Europe. He also mentions that the species had recently appeared in Romania, it is present only in the Mureş River, and in Bucovina it was introduced accidentally in the fish-farms (Iujineți and Stăuceni), simultaneous with crucian carp brought from Yugoslavia.

Băcescu (1947), in „Peştii, aşa cum îi vede pescarul ţăran român" (Fishes, as seen by the Romanian fisherman), beside the occurence of the species in Romania, also presents the common names of this fish from different regions of the country.

Cărăuşu, in 1952, in „Tratat de ichtiologie" (Treaty of Ichthyology) summarizes the data till that year, on brown bullhead, in the Romanian literature.

Four years later, Ghelase (1956) describes the morphology and ecology of the brown bullhead, and adds new information on the occurence of the species in Romania. He also reffers to the angling of this species and he emphasizes that it should not be introduced in fisheries.

In 1957, Antonescu mentions the brown bullhead in his work „Peştii din apele R. P. R." (Fishes of R. P. R.).

Vasiliu, in 1959, shortly treats morphology of brown bullhead and its distribution in Romania, sustaining that the species was introduced in Romania for the first time, in 1908, into the St. Ana Lake.

In the same year, Rădulescu and Suceveanu published a paper on diet and parasites of *Ictalurus nebulosus.* The authors analyzed 34 fishes from Cefa fish-farm (Bihor County) and from Timiş River. They found a diet of the brown bullhead consisting in principal in invertebrates. In the case of three individuals there were fish remains in the gastro-intestinum. One had inside remains of a frog. Diatomea and filamentous alges seem to be the most abundent in the food of vegetal origin. Rădulescu and Suceveanu identified a parasite, a specific one of to brown bullhead, which is native to North America: *Ancyrocephalus pricei*. The other parasites were common to native freshwater fishes of Romania.

In 1961, Bera reported the first time the brown bullhead from the southern Romania, in a pond, west from Câmpulung - Muscel. In this paper we can also find some observations regarding the behaviour of *Ictalurus nebulosus* in captivity.

Two years later, (1963) Buşniţă and Alexandrescu introduce the species in „Atlasul peştilor din apele R. P. R." (Atlas with Fishes of R. P. R.).

In 1964, the greatest biologist on ichtiology, Bănărescu describes in detail the brown bullhead in his monumental work „Fauna R. P. R. - Pisces-Osteichtyes" (Fauna of R. P. R. - Pisces-Osteichtyes) and treats problem as: morphology, ecology, economic value and species' distribution.

In 1968, Ionescu speaks in „Vertebratele din România" (Vertebrates of Romania) about brown bullhead. In the same year, Oros and Stăncioiu made rsearch on metabolism of *Ichtalurus nebulosus* in the cold sezon. They found the metabolism of brown bullhead significantly slower than of the indigenous species of freshwater fish.

Between 1970 and 2000, the only Romanian scientist interested in brown bullhead was A. Wilhelm. He published several important articles on the species in this period. In 1973, Wilhelm studied the growth of the brown bullhead in the Criş and Beretău basins, in 1975 he published biometric data on this species from the same waterbodies. In 1979, the same author published papers regarding the reproduction of the species in the Criş and Barcău basins. He consider the species to be less prolific but highly viable, due to lack of natural enemies and care of offsprings. In 1980 in his doctoral thesis Wilhelm presents data on diet and growth dynamic of the brown bullhead in the natural waterbodies and the fish-farm of Bihor County. He also offers some data on the behavior of *Ictalurus nebulosus.* In 1981 the author published new data on the growth of this species from the Criş and Barcău basins, in 1983 on the diet of the same fish from Bihor County. He found the brown bullhead to have a wide trophic spectrum, a fact which allows it to use a wide range of nutrients. An another conclusion of Wilhelm is that there is a low level of intraspecific competition between the different classes of age.

In 2004, a collective from University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, coordonated by Ioan Bud, began a three years research project financed by CNCSIS (Cod 832), entitled

„Cercetări privind impactul unor specii invazive de peşti asupra productivității, producției şi echilibrului faunei acvatice" (Research concerning the impact of some invasive fish species upon productivity, production and aquatic fauna equilibrium). These research had as a consequence publishing of a number of papers, the most important of them being that of Falka and Bud, 2006, presented in the section Fisheries of the International Croatian Symposium on Agriculture (Opatija, 2006), entitled „Contributions to the morphology and phenotypic variability of *Ictalurus nebulosus* and its possible impacts on native fish species". The aim of their research was to analyze the morphometric characteristics and phenotypic variability of the brown bullhead. Because of its persistence and invasive success, they proposed to study the phenotypic variability of the species, as a possible indicator of its adaptability. They collected a number of 123 individuals from three fisheries situated in the western region of Romania. The fishes were captured using an electrofishing. Each individual was photographed, and then 30 external somatic measurements was carried out with a special software. Based on these data they tried to accomplish a detailed morphometric characterization of the species. For the interpopulational comparison they used the GraphPad Instat statistical software, namely ANOVA (Analisys of Variance) and Kruskal-Wallis Test (Nonparametric ANOVA, Table1).

Table 1. The morphometric characterization of the brown bullhead (Falka and Bud, 2006).

Nr.	Characters	X+/-sx (in % of the standard lenghth)			Limits (mm)			CV
1	Standard length	88.30	mm		16.1	-	212.75	5.46
2	Head length	30.57	+/-	1.67	7.1	-	68.61	12.92
3	Preorbital distance	10.18	+/-	1.31	1.7	-	24.16	25.18
4	Eye diameter	3.95	+/-	0.99	0.9	-	6.66	6.59
5	Postorbital distance	17.50	+/-	1.15	3	-	41.12	13.34
6	Head depth	20.73	+/-	2.77	3.9	-	51.63	4.61
7	Predorsal distance	39.56	+/-	1.82	6.4	-	84.87	3.55
8	Preventral distance	50.50	+/-	1.79	7.5	-	112.34	3.72
9	Preanal distance	62.13	+/-	2.31	9.4	-	134.8	12.06
10	P-V distance	25.16	+/-	3.03	6.9	-	53.2	16.99
11	V-A distance	12.72	+/-	2.16	2	-	26.33	12.84
12	Body depth	24.27	+/-	3.12	4	-	56.8	5.20
13	Da-A distance	33.17	+/-	1.72	5	-	69.03	9.25

Nr.	Characters	X+/-sx (in % of the standard lenghth)			Limits (mm)			CV
14	Dp-A distance	25.68	+/-	2.37	3.5	-	56.01	4.16
15	Postdorsal distance	55.22	+/-	2.29	8.6	-	111.79	4.56
16	Postanal distance	39.79	+/-	1.81	6.8	-	84.11	6.37
17	C peduncle length (dorsal)	51.85	+/-	3.30	7.8	-	111.6	26.61
18	C peduncle length (ventral)	11.05	+/-	2.94	1.4	-	28.74	11.14
19	C peduncle depth	13.72	+/-	1.53	2	-	32.59	15.87
20	D base fin length	10.15	+/-	1.61	1.9	-	20.26	5.97
21	A base fin length	23.60	+/-	1.41	3.9	-	50.07	16.61
22	P fin length	15.82	+/-	2.63	10.4	-	34.7	8.74
23	V fin length	14.77	+/-	1.29	3.2	-	31.17	31.97
24	C upper lobe length	10.08	+/-	3.22	1.7	-	21.3	12.52
25	C fork length	17.48	+/-	2.19	3	-	32.1	26.63
26	C lower lobe length	12.17	+/-	3.24	2	-	24.9	13.69
27	D fin depth	21.02	+/-	2.88	4	-	42.26	12.06
28	V fin length	14.77	+/-	1.29	3.2	-	31.17	31.97
29	C upper lobe length	10.08	+/-	3.22	1.7	-	21.3	12.52
30	C fork length	17.48	+/-	2.19	3	-	32.1	26.63
31	C lower lobe length	12.17	+/-	3.24	2	-	24.9	13.69
32	D fin depth	21.02	+/-	2.88	4	-	42.26	12.06

Nr.	Characters	X+/-sx (in % of the standard lenghth)			Limits (mm)			CV
33	A fin depth	17.17	+/-	2.07	2.6	-	46.46	2.27
34	Adipose fin - nose	83.60	+/-	1.90	13.2	-	179.31	7.20
35	Adipose fin - D	37.21	+/-	2.68	5.1	-	77.01	11.66
36	Adipose fin - A	12.48	+/-	1.46	1.7	-	27.38	5.46

In case of 21 characters out of the 31 studied traits they found statistically significant differences among the three populations and positive correlations between the distances amid the fisheries and the number of significantly different features. In case of the two most distant populations (from Arad and Maramureş counties) there were differences in 16 features, while amid the nearest ones (Maramureş and Sălaj counties) they found differences in 14 features. In one case they found negative correlation, which may indicate a human mediated dispersal of the species (between Arad and Sălaj counties, differences in 17 features). They concluded, that the brown bullhead exhibits an increased morphometric variability and phenotypic plasticity. This is an important aspect, because plasticity means adaptability and this may be a key factor responsible for the invasive success of the species (Falka and Bud, 2006).

The aim of our paper is to treat the problem of *Ictalurus nebulosus* as a non-native invasive species, and to bring new information about this invader of our country making some experiments on its feeding behavior.

MATERIALS AND METHODS

So as to study the feeding behavior we made two experiments, one of them in the aquaria regarding the interspecific competition, especially competition for food and the prey-predator relation, and the other in the fish ponds, where the competition for vegetal fodder with other species was analyzed.

The first experiment was made in a Fish-farm from Ariniş (northwestern România, Maramureş County), in the period of vegetal fodder administering in the ponds to common carp (*Cyprinus carpio*), gibel carp (*Carrasius auratus gibellio*), and other species of cyprinids.

Feeding of the fish in the ponds was made many times in the same place, with vegetal fodder (consisting in principal in many types of cereals). The fodder did not contain any component of animal origin.

In the subsequent period (10 - 40 minutes after feeding), the catches from the place of feeding were dissected, and the gastro-intestinal components were analyzed by estimation in percentages of vegetal fodder from the total food ingested.

For fish feeding, angling and dissection was used: a boat, two sets of equipment for anglers and one for dissection. The total number of captures was 21, eight of them were brown bullhead, seven of them were common carp, and six were gibel carp.

The second experiment was made in three complete equipped aquaria, where three of the most euribiont (warm water) species of poeciliids were bred together with brown bullhead captured from Ariniş. These three species are *Poecilia reticulata*, *P. sphenops*, and *Xiphophorus helleri*. We have chosen individuals from length point of view as it follows in the table 2.

Table 2. Length of the individuals that were chosen for experiment.

Species (latin name)	Species (vernacular name)	Number of individuals used	Body length
Ictalurus nebulosus	Brown bullhead	15	Approximately 2.0 cm
Poecilia reticulata	Guppy (millionfish)	15	Approximately 2.5 cm female; approximately 2.0 males.
Poecilia sphenops	Black molly	15	Approximately 2.5 cm
Xiphophorus helleri	Swordtail (xipho)	15	Approximately 2.5 cm

Into aquaria of 200 liters we bred, 15 individuals from each species from the mentioned ones, for each aquarium.

The fish were feed three times a day with many types of natural and artificial fodder, from vegetal and animal sources both.

We bred the brown bullhead together with these species which normally do not occupy the same water bodies as *Ictalurus nebulosus*, and this is an interaction that illustrates the behavior of brown bullhead when it meets for the first time new species of fish in new geographical area.

RESULTS AND DISCUSSIONS

Results of dissection revealed high quantities of vegetal fodder (cereals) in their gastro-intestinum which varied function of species (Table 3) and, probably, function of duration between feeding and catching moment.

Table 3. Vegetal fodder percentage from the total gastro-intestinal content.

Species	Number of fish examined	Percentage of vegetal fodder from total (approximately estimated)	Other components
Ictalurus nebulosus	8	70%	30%
Cyprinus carpio	7	50%	50%
Carassius auratus gibellio	6	70%	30%

Regarding the percentage of vegetal fodder, the brown bullhead ingested approximately the same quantity of vegetal fodder as gibel carp, and more then the common carp, in spite of fact that it is a catfish. All the brown bullheads had a highly turgescent abdomen, even those captured immediately after the fodder has been given. The rapidity of ingestion is so high that there are often air bullets in their abdomen after their feeding. They seem to accept with pleasure many types of food, even the vegetal one. Probably, its adaptability regarding feeding behavior, beside its wide trophic spectrum, permits to brown bullhead to compete for nutrients with other fish species, be they omnivorous or predator species. Ironic is the fact that gibel carp, beside its nature of omnivorous fish, it is an authentic euribiont. In spite of these, there was no difference between its gastro-intestinal percentage of vegetal fodder and that of brown bullhead, which is a predator (or primarily predator, at least).

Regarding the second experiment, made in order to observe the behavior of brown bullhead in contact with new species, it took place for 3 months in USAMV biobasis. The results were used to complete the table 4.

Table 4. Evolution of relation brown bullhead-poeciliids as a simulation of relation brown bullhead-new fish species.

Chronology	Observation
After a week	The fish length is higher then a week ago. All the fishes are normally feeding. The brown bullhead takes the food from the water surface, and do not wait it to drop on the bottom.
After ten days	Some guppy males loose their anal and dorsal fins. The brown bullhead bites when the fish agglomerates at the water surface for feeding.
After two weeks	All guppy males loose their anal and dorsal fin. The brown bullhead surpasses in length the poeciliids. Poeciliids do not agglomerate at the water surface, when they are feeding.
After three weeks	The male swordtails loose their sword. Three males of guppy disappear (they have been eaten). Differences between individuals appear even between different brown bullhead individuals. Some of them doubled their length. The intraspecific aggressiveness lacks between the brown bullhead individuals.
After a month	All guppy males disappear, and a swordtail male, too. The poeciliids become thinner than first. The brown bullhead attains a higher length than the poeciliids.
After 43 days	All the poeciliid males disappear, and a few females too, from each poeciliid species (guppy first).
After two months	There is no poeciliid female with gestation spot, they become thinner than never. Females' bodies reach to look like a reversed litter "U".
After three months	All the poeciliid females die. Females die because of concurrency for food, and brown bullhead's aggressiveness. They are often eaten few hours later.

CONCLUSIONS

The brown bullhead rapidly ingests high quantity of vegetal fodder in the Fisheries, in spite of fact that it is a catfish, being a serious concurrent for food with omnivorous cyprinids. The rapidity of ingestion is so high that there are often air bullets in their abdomen after their feeding. They seem to accept with pleasure many types of food, even the vegetal one. Probably, its adaptability regarding feeding behavior, beside its wide trophic spectrum, permits to brown bullhead to compete for nutrients with other fish species, be they omnivorous or predator species.

Ictalurus nebulosus has an aggressive behavior when other species of fish are feeding beside them. It bites when the fish agglomerates at the water surface for feeding, even when the other fish is not smaller. The brown bullhead takes the food sometimes from the water surface, and do not wait it to drop on the bottom. When the other fish are smaller then brown bullhead, they become a pray for him. The intraspecific aggressiveness lacks between the brown bullhead individuals, even when there are significant differences between their lengths.

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AUTHORS:

[1] *Ruxandra Mălina PETRESCU*
pmalina2000@yahoo.com
[2] *Valentin Ioan MAG*
zoobiomag2004@yahoo.com
University of Agricultural Sciences
and Veterinary Medicine,
Faculty of Animal Husbandry,
Department of Aquaculture,
Calea Mănăştur St., no. 3 - 5.,
Cluj-Napoca, Cluj County, Romania,
RO - 400372.

DYNAMICS OF THE CATCHES OF PELAGIC FISH FROM THE BLACK SEA ROMANIAN WATERS, IN 2000-2004 PERIOD

Elena RADU[1], *Gheorghe RADU*[2], *Eugen ANTON*[3] and *Ion STAICU*[4]

KEYWORDS: Black Sea, pelagic species, catch, sprat, anchovy, horse mackerel, bluefish, grey mullet, shads, sand smelt.

ABSTRACT

Beginning of the ninth decade of the 19th century represents a border stone for the Romanian fisheries. The malfunctions produced by the transition toward the market economy, the socio-political and economical structural modifications which took place determined some lack of balance and implicitly a dramatic decrease of fish production. The reasons which led to this decline are multiple and complex, being linked by the overexploitation of fishing basins and natural waters from last 15 - 20 years, the aggressive pollution of waters, the modifications occurred in the fish populations, the legal void existing more then 12 years in this transition period which determined disorders in exploitation. Living marine resources must to be efficiently managed if the desire is the protection of their economic viability.

This paper presents the evolution of catches of main pelagic fish species from the Romanian marine waters during 2000 - 2004.

REZUMAT: Dinamica capturilor de peşti pelagici din zona marină românească în perioada 2000 - 2004.

Începutul deceniului al nouălea al secolului trecut reprezintă o piatră de hotar pentru pescuitul din România. Disfuncționalitățile datorate tranziției către economia de piață, modificările structurale politico-sociale şi economice care au avut loc, au determinat unele dezechilibre şi implicit o scădere îngrijorătoare a producției de peşte. Cauzele care au condus la acest regres sunt multiple şi complexe fiind legate de o supraexploatare a bazinelor piscicole si a apelor naturale în ultimii 15 - 20 ani, de poluarea agresivă a apelor, de schimbările petrecute în cadrul populațiilor piscicole, de vidul legislativ care a existat peste 12 ani în această perioadă de tranziție şi care a determinat nereguli în exploatare.

Lucrarea prezintă evoluția capturilor principalelor specii de peşti pelagici din apele marine româneşti în perioada 2000-2004.

RESUME: Dynamique des captures de poissons pelagiques de la zone marine roumaine pendant la periode 2000 - 2004.

Le début de la neuvième décennie du siècle dernier constitue marque un tournant pour les activités de pêche en Roumanie. Les transformations provoquées par la transition vers l´économie de marché, par les changements politiques, sociaux et économiques qui y ont lieu, ont provoqué certains déséquilibres et, implicitement, conduit à une diminution alarmante de la production de poissons. Les raisons de cette régression sont multiples et complexes car elles sont liées à une surexploitation des bassins piscicoles et des eaux naturelles pendant les 15 - 20 dernières années, à la pollution agressive des eaux, aux modifications de la structure des populations piscicoles, ainsi qu´à un vide législatif de plus de 12 années sur cette période de transition, ce qui a facilité les irrégularités d´exploitation.

Le travail ci-dessous présente l´évolution des captures des principales espèces de poissons pélagiques des eaux marines roumaines pendant la période 2000 - 2004.

INTRODUCTION

The significant role played by the marine and continental fishing as well as the aquaculture is appreciated both due to their contribution at the alimentary supplying and the economic and social welfare of population. In the same manner, there is appreciated the economic and social role of subsistence, artisanal, commercial and other fishing types, and consequently there are carried out efforts for creating an environment capable to permit to fishing to bring it optimal contribution to the socio-economic prosperity. Sustainable development and environmental protection can be compatible if an adequate reform of the economic theory and practice is achieved at worldwide level.

The Black Sea ecosystem seems being stable by the second half of the XX Century. The first sign of its significant disturbance was the modification of the specific composition of commercial catches during period 1970 - 1980.

In order to guarantee the conservation and sustainable management of marine fishing resources, there are necessary measures for stopping or eliminating the over-capacity of fishing, controlling as the level of fishing effort to be compatible with their sustainable exploitation. The quantification of effectives represents the main objective for elaboration the strategy for fisheries, for obtaining the sustainable productions (Radu G., 2001).

MATERIALS AND METHODS

For assessment the results of fisheries is necessary a continually input of information, because the fishery, its parameters and management objectives know a dynamics in time, both due to variability of natural environment and also long-term modifications, which have anthropogenic origin, such as pollution and climatic change.

With a view to elaborate the norms for sustainable management of marine bio-resources, the biodiversity conservation, maintenance and amelioration the environment quality, the knowledge of functional structure of the ecologic systems is essential. It is obviously that the measures for protection and conservation of living resources from the Black Sea do not be formulated without a systematic surveillance of the environment, as well as a monitoring on the stocks, reproduction capacity and biomass of fishing resources.

Evolution of main pelagic fish species from the Romanian waters was obtained through the centralization and systematization of data regarding the catch and effort from the commercial fisheries. The data analyzing was achieved on 2000 - 2004 period.

RESULTS AND DISCUSSIONS

Worldwide, the dynamics of catch obtained during the last decades mirrored the discrepancy between the size of fishing effort and productive capacity of exploited stocks. This disproportion is noted also on the Black Sea level, between fishing capacity of the six coastal states. Thus, in 1985, out of 2.448 units of 1 - 24.9 TRB, about 99% were possessed by Turkey (2415 vessels) (FAO, 1998).

On the basin of the Black Sea, the pelagic species are prevailing in fishing, among them the dominant species being the anchovy in the last 11 years (FAO, 2001).

As for the qualitative and quantitative structure of the pelagic species catches, at the Romanian littoral it oscillated temporally depending on the stocks status, effort and fishing gears, during the last years the Romanian fishing became a sector conditioned by the market (IRCM/INCDM, 1980 - 2004).

Among the pelagic species, the small-sized species are prevailing in Romanian marine fishing, with a percentage ranging from 84 to 92 (Figure 1) (Pârcălabu, 1977; Porumb, 1996; Radu et al., 1996 – 1997; Radu et al., 2003; Staicu et al., 2000).

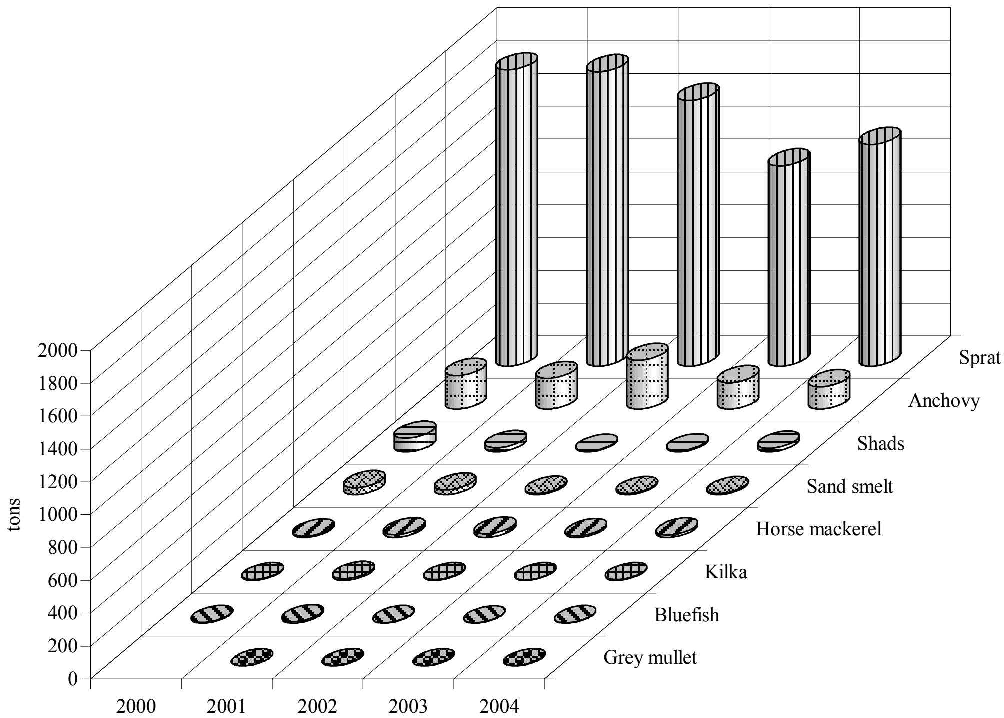

Figure 1. The total catch and main pelagic species from the Romanian littoral, in 2000 - 2004.

Sprattus sprattus, L. 1758. During last years, the dominant species was the sprat. After a significant increase of the catches in 1986 - 1989, they get more and more reduced, in the last five years the catches being placed from 1.200 to 1.800 tons (Figure 2) (Cauţiş and Verioti, 1976; Nicolaev et al*.,* 1994; Porumb, 1977; 1998; Radu 1999; Radu et al*.,* 2002; IRCM/INCDM, 1980 - 2004).

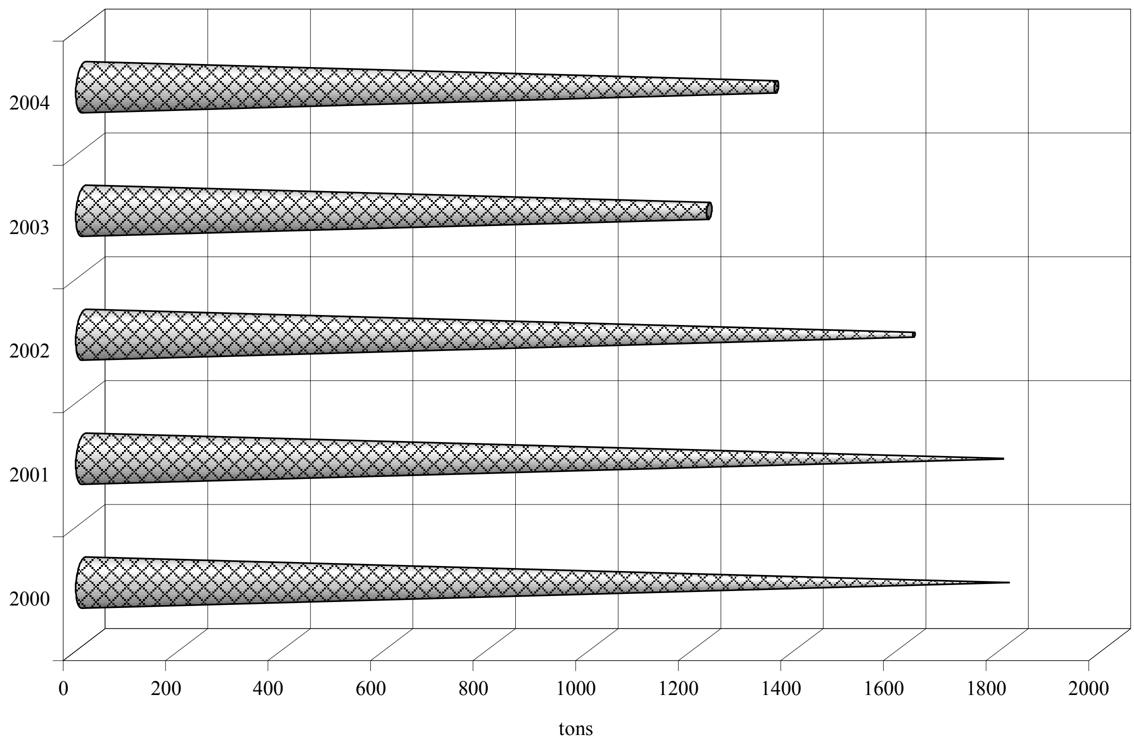

Figure 2. The catch of sprat obtained at the Romanian littoral between 2000 and 2004.

Sprat remains the main species in the Romanian fisheries, its contribution in the total catch obtained during last five years being 73 - 76% (Figure 3) (Radu et al*.,* 2002; Radu et al., 2003; Staicu et al*.,* 2000). In 2000 - 2004, more then 90% from the catch sprat was obtained with trawlers, the quantities oscillating among 1.124 and 1.750 tons, while the quantities obtained in stationary fishing were among 53 and 174 tons (Figure 4) (Staicu et al*.,* 2000; Staicu et al*.,* 2004; IRCM/INCDM 1980 - 2004).

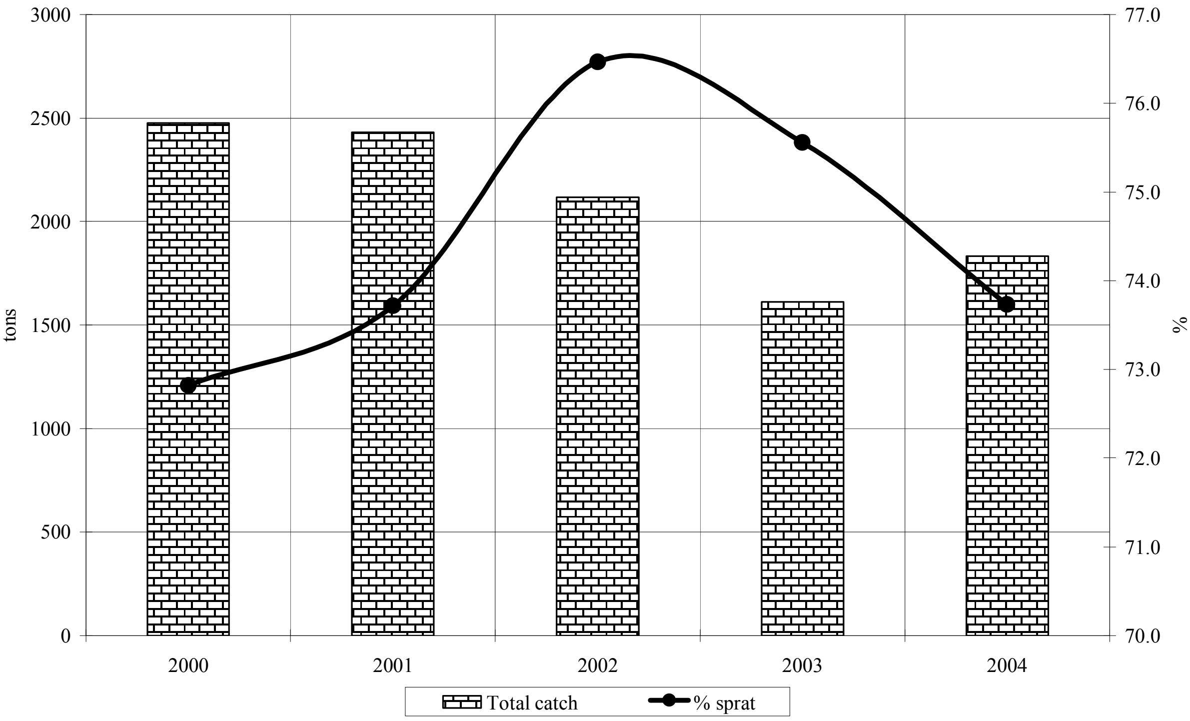

Figure 3. The total catch (t) achieved at the Romanian littoral and quota of participation (%).

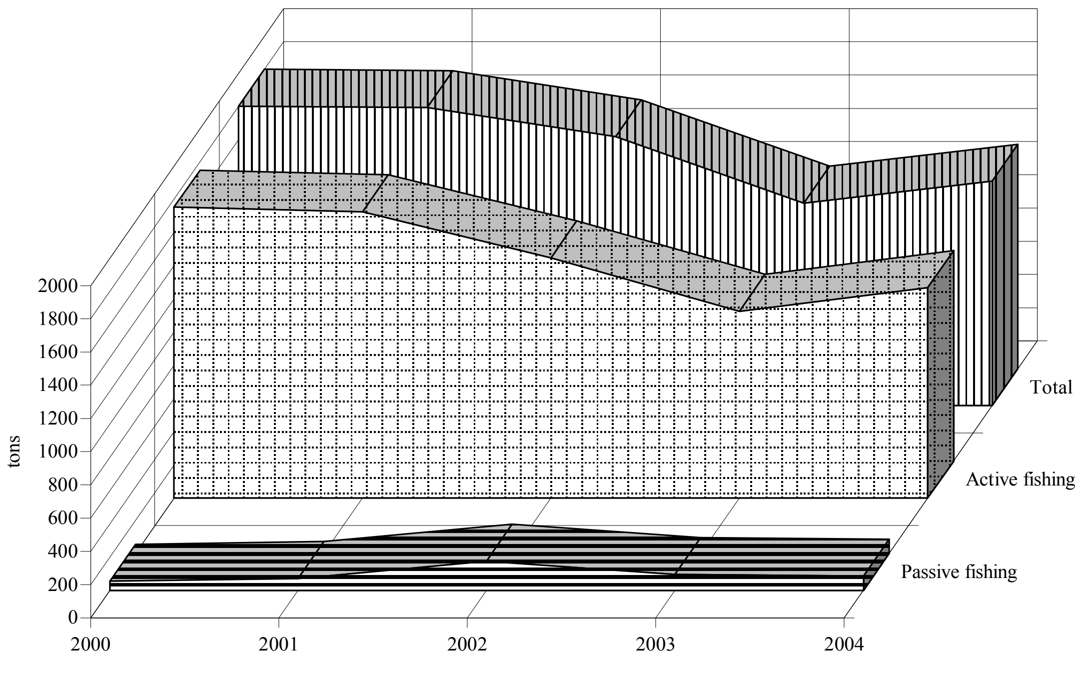

Figure 4. The sprat catch in actively and passively fishing at the Romanian littoral in 2000 - 2004.

Engraulis encrasicolus (L. 1758). The second important species in marine Romanian fishery is anchovy (Figure 1). In the course of time, the mean production of anchovy oscillated among 5 and 643 tons. Thus, between 1950 and 1959, the anchovy catch was situated among 110 and 1.184 tons, with a multi-yearly mean of 688 tons; between 1960 and 1969, the variation amplitude was higher, 323 - 3.115 tons; in the following period, the anchovy catch oscillated between 592 and 3.230 tons, with a multi-yearly mean of 1.852 tons. The highest anchovy catch was obtained between 1980 and 1989, the multi-yearly mean being 3.716 tons, after this period the anchovy catch begun to be continually depleted (Radu et al., 2002).

During the last five years, the anchovy catch was situated between 135 and 296 tons (Figure 1), the contribution of species at the total catch being 7 - 13% (Figure 5). These results were obtained only with the stationary gears. The catch on effort unit in the stationary fishing presents an increasing tendency, attaining 6.4 tons/trap net (Staicu et al., 2000).

In the period 2000 - 2004, the participation quota of the anchovy achieved in the Romanian fisheries with stationary gears was 28 (2004) and 48% (2002) (Staicu et al., 2000, Staicu et al., 2004).

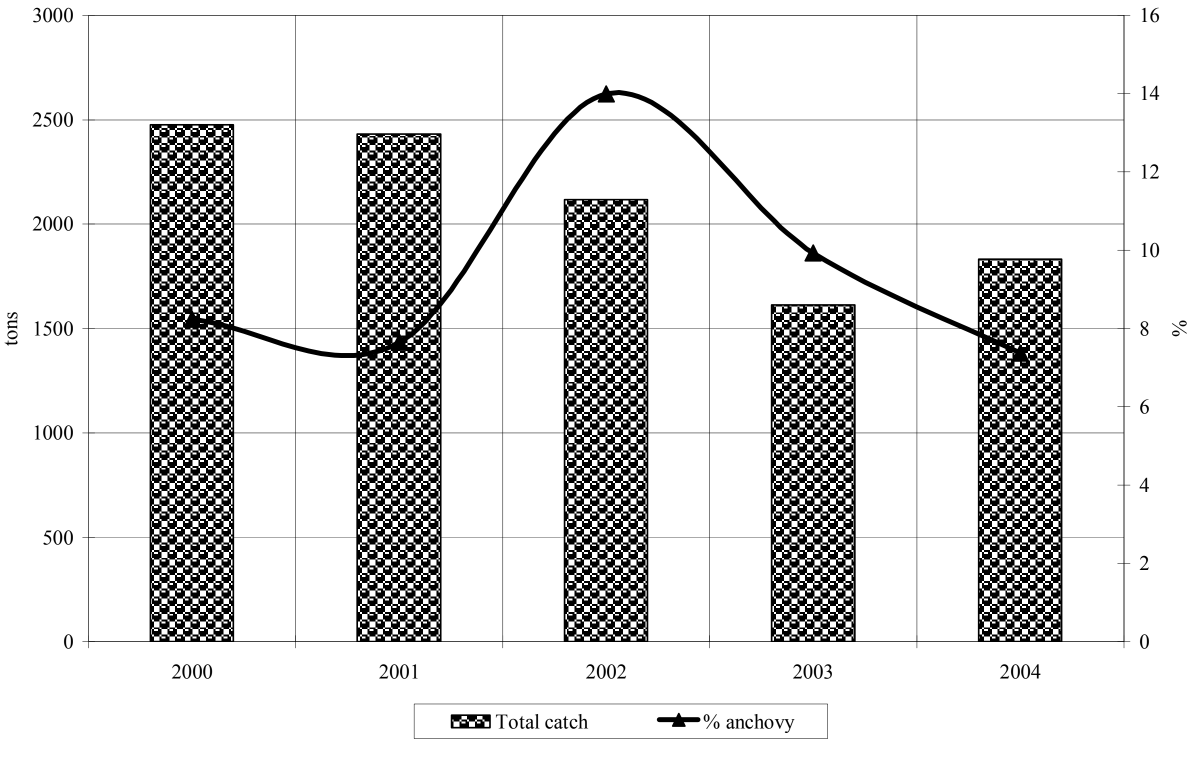

Figure 5 - Th total catch (tons) of anchovy and its participation quota (%) achieved in the Romanian fisheries.

Trachurus mediterraneus ponticus, Aleev, 1956. At the Romanian littoral, the values of horse mackerel catches had dramatically diminished, from quantities of more then 1.000 tons in ’70 - ’80 years up to 1 - 3 tons in 1997 - 1999; in the last five years, the catches begun to increase (up to 21 tons) (Figure 6) (Nicolaev et al., 1994, Pârcălabu, 1977; Radu, 1999; Radu et al., 2002).

The horse mackerel catches were obtained also with trawlers and at the stationary fishing (Figure 7) (Staicu et al., 2000; Staicu et al., 2004).

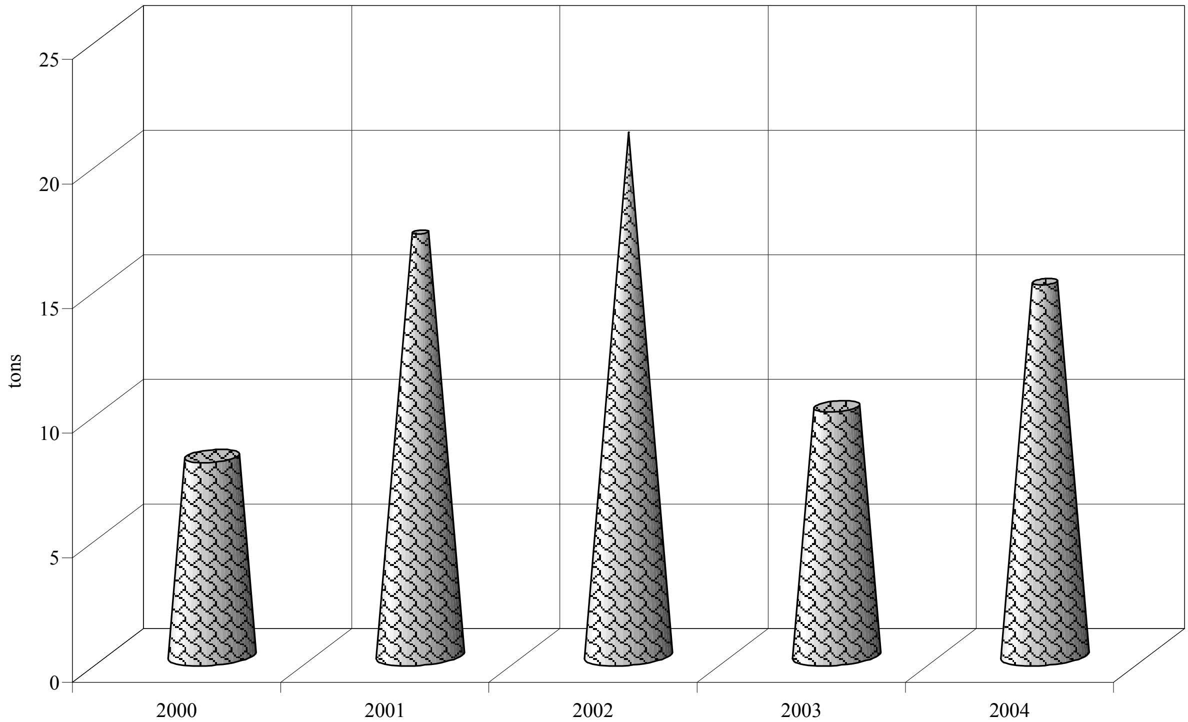

Figure 6. The catch of horse mackerel (tons) achieved at the Romanian littoral between 2000 and 2004.

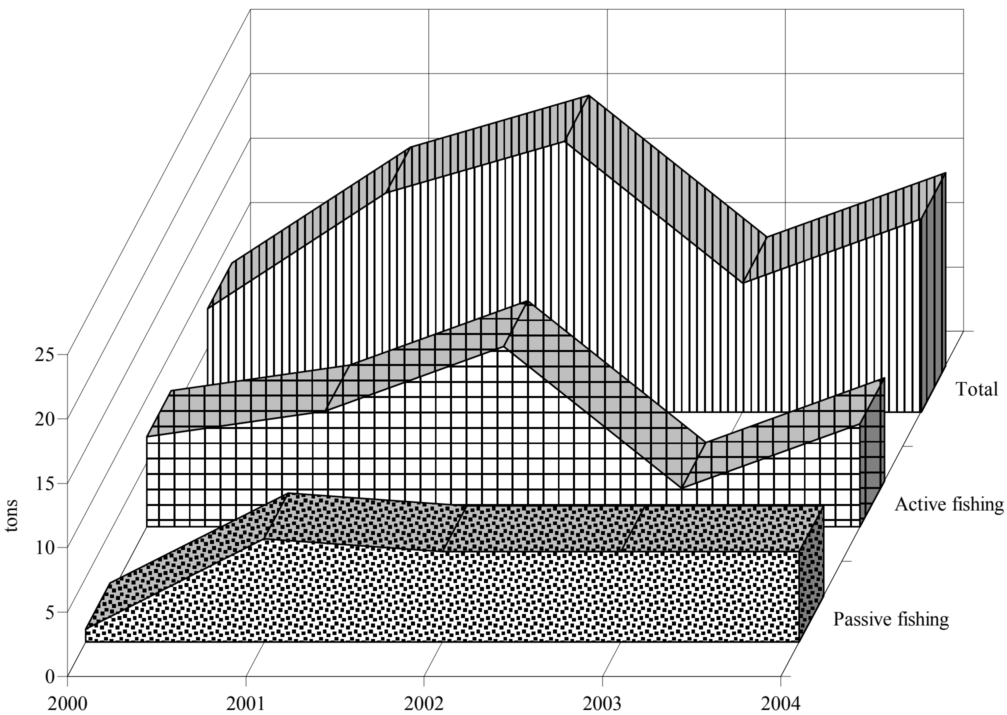

Figure 7. The horse mackerel catch achieved in actively and passively fisheries at the Romanian littoral between 2000 and 2004.

The stocks of horse mackerel from the Black Sea are heavily affected by the over-fishing carried out by the coastal countries, pollution more and more intense and the environmental changes; a continually decreasing is noted after ’85 - ’86 years, when the highest catches of horse mackerel were registered.

The fishing of ***Pomatomus saltatrix***, L. 1766 (bluefish), known veritable collapse, any catch of this species is not recorded in 1984 - 1993 period. The situation was determined both as a consequence of a continually degradation of environmental conditions in the north-western part of the Black Sea, and also to the un-favourable conditions for its reproduction and feeding. Beginning in 1994, the distribution of bluefish is linked by the improvement of environmental conditions and tendency of population rehabilitation (Figures 1 and 8) (Porumb, 1998; Radu, et al., 1996 - 1997; Radu et al., 1998; Radu, 1999; Radu, et al., 2002; Radu et al., 2003, IRCM/INCDM 1980 - 2004).

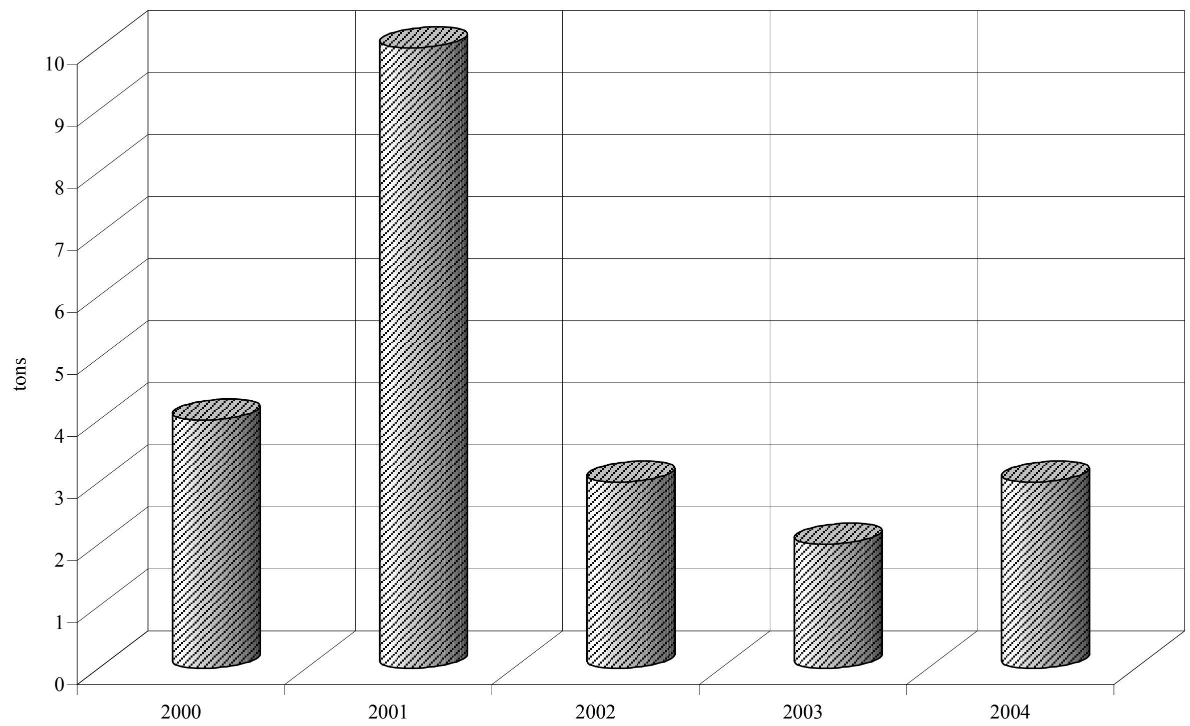

Figure 8. The catch of bluefish achieved at the Romanian littoral, between 2000 and 2004.

The **Mugillidae Family** (grey mullet) has suffered due to the worsening of the environmental conditions, the fishing of grey mullet knowing a dramatic depletion after 1989 (Figures 1 and 9) (Radu et al., 2002; Radu et al., 2003; Staicu et al., 2000; IRCM/INCDM 1980 - 2004). Taking into consideration the re-occurrence in the industrial catches, as well as the signalization of the artisan fishermen, the species pertaining to this family seem to restore their stocks little by little (Radu, 2001).

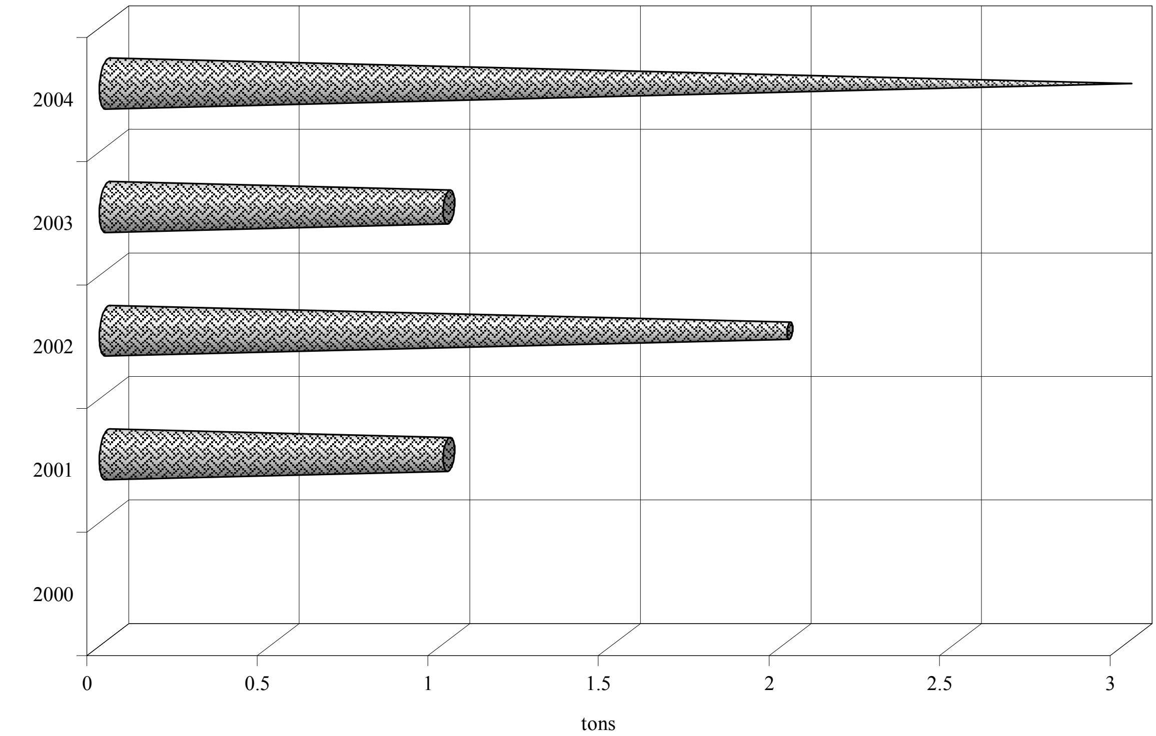

Figure 9. The catch of grey mullet achieved at the Romanian littoral between 2000 and 2004.

Although the catches of the ***Alosa*** species diminished from 1000 tons, obtained in 1986 and 1987, at 45 tons obtained in 1997, or 25 tons in 2001, they participated in the total catch with percentages oscillating among 0.2 (2002) and 43 (1975). During the last five years, the mean production ranged from 4 to 81 tons (Figure 10) (Porumb, 1998; Radu, 1999; Radu, et al., 2003; Staicu et al.; 2004, IRCM/INCDM 1980 - 2004).

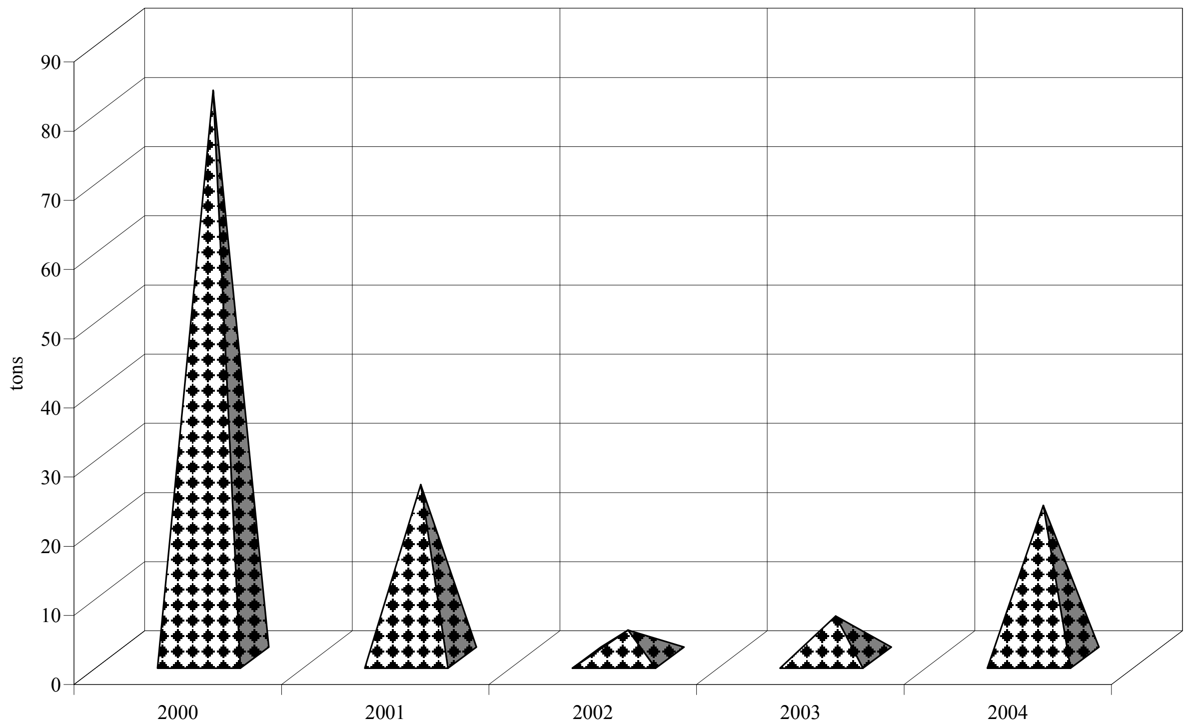

Figure 10. The catch of *Alosa* spp. obtained at the Romanian littoral between 2000 and 2004.

In the 1971 - 1989 period, the catch of ***Atherina (Hepsetia) boyeri***, Risso, 1810, registered values comprised among 2 and 254 tons, then the values became lower and lower, and in the last five years they ranged from 6 to 42 tons (Figure 11). Being the main component of the catches achieved at trap nets, the species has a good status of its stocks, demonstrated by the increase of the share of long-sized individuals. The catch on unit effort increased up to 1 ton/trap net (Staicu et al*.,* 2004). At the whole Black Sea basin, Ukraine obtained the 63 - 99% from the total catch of sand smelt, Russia fished 5 - 99 tons, and Romania 3 - 73 tons (FAO, 2001; FAO, 1999).

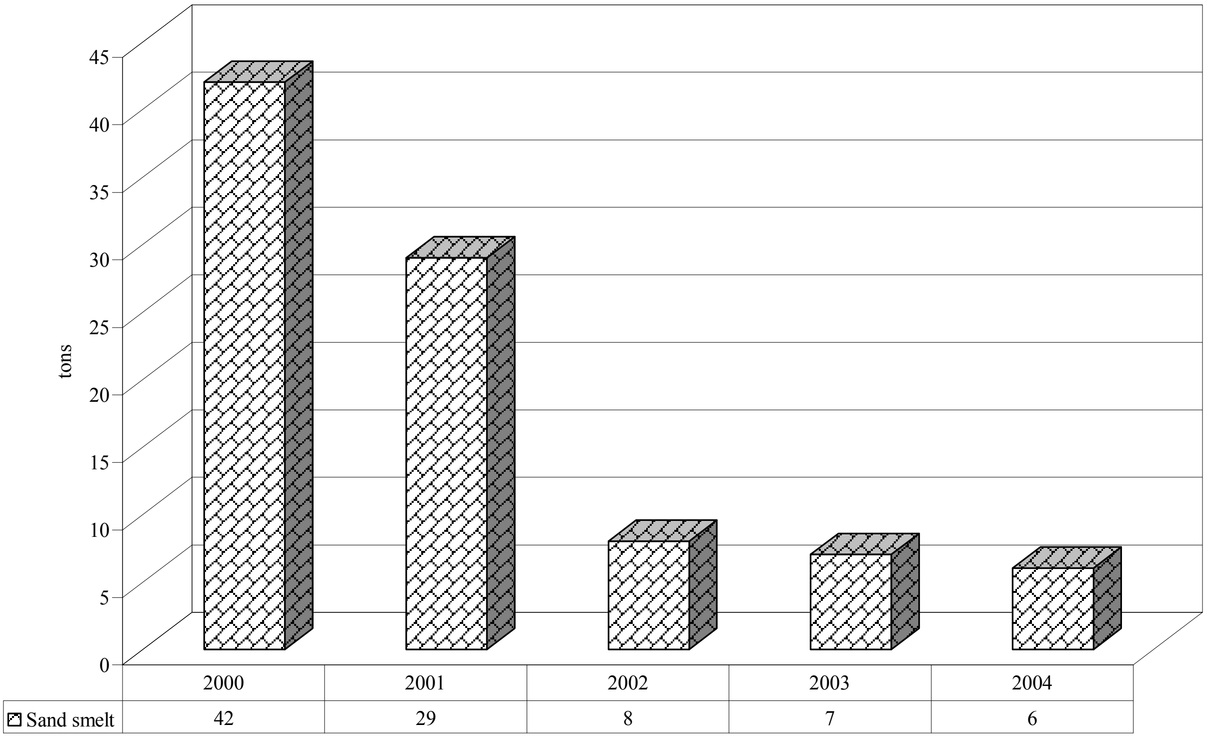

Figure 11. Mean production (tons) of sand smelt achieved at the Romanian littoral between 2000 and 2004.

The actual situation of the majority interested species from the Romanian littoral have the stocks diminished, they requesting protection measures for their restoration.

Taking into consideration the integrity of marine ecosystem and its resources, the transboundary character of resources, being caught in common by the coastal countries, it is necessary the cooperation among countries, able to make easier the rehabilitation and protection of marine ecosystem and sustainable development of its resources, and consequently further exploitation compatible with their restoration.

CONCLUSIONS

A briefly analyzing of catches evolution of main pelagic fish species from the Romanian waters between 2000 and 2004 evinced some main aspects.

At the Black Sea level, the pelagic species are prevailing in fishing, and the small-sized ones at the Romanian littoral.

At the Romanian littoral the sprat is dominant species for 20 years; although during last years its mean productions decreased, the contribution in total catch was more then 73%.

Between 2000 and 2004, more then 90% from total catch of sprat was obtained in the trawlers activity, the caught quantities ranged among 1.124 and 1.750 tons, while the quantities obtained in stationary fisheries were only 53 - 174 tons.

The second species economically important in Romanian fisheries is anchovy, with a contribution of 0.1 - 63%. In time, the mean production of anchovy oscillated from 5 to 643 tons, the biggest catches being obtained between 1980 and 1989. During last five years, its catches were settled among 135 and 296 tons, being obtained only with stationary gears.

The horse mackerel catches diminished dramatically, from 1.000 tons in ’70 - ’80 years, to 1 - 3 tons in 1997 - 1999, registering a slightly restoration in 2000. The catches were obtained both with trawlers and stationary gears.

In a long-term view, the contribution of horse mackerel at total catch obtained at the Romanian littoral was 0.03 - 37%, and the multi-yearly mean catch registered a largely oscillations, from 1.190 tons in 1980 - 1989 period to 14 tons in the last five years.

The fishing of bluefish known a veritable collapse, in the 1984 - 1994 period no catch was reported; a slightly rehabilitation of its stock was noted after 1997.

The Mugillidae Family suffered due to the worsening of environmental conditions, the fishing of grey mullet knowing a failure after 1989. Like bluefish, it seems to register a restoration of populations.

Although decreasing, the *Alosa* spp. have participated in the total catch achieved at the Romanian littoral with a percentage between 0.2 and 43; during last five years, the mean production was 4 - 81 tons.

The sand smelt catch framed among 6 and 42 tons, and the kilka among 3 and 81 tons.

The small-sized species which constituted the main object of fishing at the Romanian littoral during last 20 - 25 years known important fluctuations of their catches, with obviously tendency of regress or spectacular reducing. There may be concluded that the status of commercially interested stocks is instable enough. However, a tendency of rehabilitation for anchovy and a moderately disposition of rehabilitation for bluefish, grey mullet and horse mackerel is exhibited.

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AUTHORS:

[1] *Elena RADU*
elena_radu2005@yahoo.fr
[2] *Gheorghe RADU*
gpr@alpha.rmri.ro
[3] *Eugen ANTON*
eanton@alpha.rmri.ro
[4] *Ion STAICU*
eradu@alpha.rmri.ro
National Institute for
Marine Research and Development
"Grigore Antipa" Constanța,
Mamaia Bd., no. 300,
Constanța 3, Constanța County, Romania,
RO - 900581.

STATE OF THE MARINE FISHERY RESOURCES AT THE ROMANIAN LITTORAL REFLECTED BY THE FISHERY INDICATORS

Gheorghe RADU [1], *Simion NICOLAEV* [2], *Elena RADU* [3] and *Eugen ANTON* [4]

KEYWORDS: Black Sea, indicators, catch, fishing effort, stock, CPUE.

ABSTRACT

The paper presents data regarding the evolution of main indicators for the fishing resources in the last years. Are analysed the following indicators:

- pressure indicators (marine water temperature, fishing effort, total catch level;

- impact indicators (percentage of species whose stock are out of safety limits, percentage of complementary species, changes in length classes, age, length, CPUE);

- status indicators (stocks biomass, spawning intensity, population structure).

REZUMAT: Starea resurselor marine pescăreşti de la litoralul românesc reflectată de indicatori pescareşti.

Lucrarea prezintă date privind evoluția principalilor indicatori ai stării resurselor pescăreşti. Sunt analizați următorii indicatori:

- indicatorii de presiune (temperatura apei marine, efort de pescuit, captura totală);

- indicatorii de impact (procentul speciilor al căror stocuri sunt în afara limitelor de siguranță, procentul speciilor complementare, schimbări în structura pe clase de lungime, vârstă, CPUE);

- indicatorii de stare (biomasa stocurilor, intensitatea reproducerii, structura populațiilor).

RESUME: Etat des ressources halieutiques marines du littoral roumain reflété par des indicateurs de pêche.

Ce travail présente des données sur l’évolution des principaux indicateurs de l’état des ressources halieutiques. Ainsi sont présentés ici des analyses sur:

- les indicateurs de pression (température de l’eau marine, effort de pêche, capture totale);

- les indicateurs d’impact (taux des espèces présentant des stocks supérieurs à la limite de sûreté; taux des espèces complémentaires; modifications dans la structure en classes de longueur et d’âge; cpue);

- les indicateurs d’état (biomasse des stocks, intensité de la reproduction, structure des populations).

INTRODUCTION

Managing fisheries for sustainable development is a multi-dimensional and multi-level activity, which must deal with a wider range of considerations than survival of the fish stocks and the fisheries alone. It requires information, and hence indicators, on dimensions well beyond fish stocks and fishing activity. Changes to fisheries activity should be assessed with reference to the driving forces of economic and ecological change that bear on both the demand for and the supply of fish. These external forces will include competing claims on use and management of marine ecosystems.

Indicators are not an end in themselves. They are a tool to help make clear assessments of and comparisons between fisheries, through time. They describe in simple terms the extent to which the objectives set for sustainable development are being achieved.

There are several objectives to consider under the heading of fisheries sustainable development:

- Sustaining fisheries harvesting and processing activities based on specified and identifiable marine ecosystems;
- Ensuring the long-term viability of the resource which supports these activities;
- Catering for the well-being of a fishery workforce within a wider community and broader economic context;
- Maintaining the health and integrity of marine ecosystems for the benefit of other uses and users including biodiversity, scientific interest, intrinsic value, trophic structure and other economic uses such as tourism and recreation.

Indicators are now needed that can be used to determine how well these objectives are being pursued and whether the broader goals of sustainable development are being achieved.

Indicators used previously in fisheries management have tended to be biological and to focus on target species. A wider range of indicators will need to be used in assessing progress towards sustainable development, including indicators that reflect the broader ecological, social, economic and institutional objectives.

An indicator is a quantitative or qualitative value, a variable, pointer, or index related to a criterion. Its fluctuations reveal the variations of the criteria. A reference point indicates a particular state of a fisheries indicator corresponding to a situation considered as desirable (target reference point, TRP), or undesirable and requiring immediate action (limit and threshold reference points, LRP and ThRP). Reference points relate directly to human objectives (TRPs) or system constraints (LRPs). The position and trend of the indicator in relation to the target or limit reference points or values indicate and qualify the present state and dynamics of the system. They provide the elements needed to assess the situation and a bridge between objectives and actions.

The role of the scientist in this system is to suggest indicators, monitor the state of the resource and environment using standard or agreed indicators measured in a standard way, and to determine the annual value of the indicators, and the probability that indicator values have reached pre/established LRP's built into the management system.

MATERIALS AND METHODS

In the case of the Black Sea, the starting point represent the objectives provided by Black Sea Strategic Action Plan and those selected in special seminar organised in Sile (Turkey) in 2003 by Black Sea Commission (BSC) and General Fisheries Council for the Mediterranean (GFCM).

Selection procedures of specific indicators for marine living resources took place in the frame of The Advisory Group on Environmental Aspect of Management of Fisheries and Other Marine Living Resources (AG FOMLR) taking into consideration the following elements:

- keeping the parameters used traditionally in the Black Sea area for assuring the historical data sets;

- introduction of new modern approaches for fisheries indicators recommended by specialised European institutions and EU strategies;

- assessment of fishery resources will be initial focused only on six species considered key species for the Black Sea: sprat, anchovy, horse mackerel, turbot, whiting and spiny dogfish.

The AG FOMLR considers process of elaboration of the fisheries indicators only at beginning and we need to validate him at concrete activities.

For these reasons AG FOMLR decide to test initial designed indicators in annual national and regional reporting to the Commission.

The list of indicators contain about 20 basic proposals structured on four groups: pressure, impact, state and response.

The basic sources of analysis were:

- EU Common Fisheries Policy (CFP)
- Green Paper on Future of the CFP
- Towards a Strategy to Protection and Conservation of the Marine Environment (EC)
- Proposed EEA Core Set of Fisheries and Aquaculture Indicators (EEA/EC)
- Biodiversity Action Plan for Fisheries (EC)
- Review and Gap Analysis of Environmental Indicators for Fisheries and Aquaculture (2003, IEEP)
- Tools for Measuring (integrating) Fisheries Policy aiming at a Sustainable Ecosystem (2002, EEA-EEC)
- Monitoring Changes in the Black Sea Ecosystem and Fisheries using indicators in support of management decision-making (Caddy and Mahon 1995).

Specific needs for Black Sea indicators

❖ Each indicators addresses specific fisheries/aquaculture issues or ecosystem related issues/objectives.

❖ For indicator assessment available support data are needed.

❖ The support data are produced trough existing or under building informational system (e.g. fisheries statistics, fish stock assessment, multi-disciplinary research, ecosystem monitoring etc.)

❖ For reporting reason, the definition of indicators must be simple and their calculation should be easy.

❖ Where it is appropriate, a combination of standard indicators in order to create new complex indicators should be possible.

Fisheries sustainability indicators should be:

❖ Observable by stakeholders, either directly or by transparent process;

❖ Understandable;

❖ Acceptable by fishers and the public at large;

❖ Efficient and within economic resources for research on a sustained basis;

❖ Related to management and have associated reference values (limits, targets, precautionary etc) and responding management measures.

Conforming OECD critera for indicators for environmental performance reviews (OECD 1993) an environmental indicator should:

* provide a representative picture of environmental conditions, pressures on the environment or society's responses;

* be simple, easy to interpret and able to show trends over time;

* be responsive to changes in the environment and related human activities;

* provide a basis for international comparisons;

* be either national in scope or applicable to regional environmental issues of national significance;

* have a threshold or reference value against which to compare it so that users are able to assess the significance of the values associated with it.

* be theoretically well founded in technical and scientific terms;

* be based on international standards and international consensus about its validity;

* readily available or made available at a reasonable cost/benefit ratio;

* adequately documented and of known quality;

* updated at regular intervals in accordance with reliable procedures.

Indicators selected by AG FOMLR are:

Presssure

- environmental constrain factor
- occurrence of algal blooms
- extension of hypoxia areas
- rate of biomass jelly fish
- rate of fishing effort
- rate of catches and discard level

Impact

- rate of species whose stocks are out of safety limits (species whose biomass / or catches are under decline in last 20 years)
- rate of changes in mean CPUE
- rate of changes in size structure of catches
- rate of by-catch (especially impact of fishing methods targeting small size fishes)
- rate of registered stranding dolphins
- changing rate of spatial extension of critical habitats
- rate of increasing sensitivity of habitats (by quality, biodiversity, etc.)
- biodiversity near mariculture farms compared with away from farms
- number of exotic species naturalized or which become commercially resources

State

- rate of biomass of living resources stocks whose exploitation is under regulation
- evolution of growth parameters
- evolution of spawning intensity and stock recruitment
- evolution of population structure

Response

- integration of environmental changes in the fisheries management (fisheries management based on ecosystem approach)
- integration of fisheries management system policies and practices in ICZMI procedures
- number of stocks regulated through fishing quota (TAC)
- enforcement system for control of fishing effort, TACs, and restriction

For comparisons there was used the 1975 - 1989 period.

RESULTS AND DISCUSSIONS

1. Pressure indicators

1. 1 Environmental factors

The spatial-temporal fluctuations of the whole complex of ecological factors induce numerical sometimes-structural oscillations inside the fish populations. Among great of deal of environmental stimuli affecting the fish, the water temperature is the most importance, being the environmental factor easiest identified, and thus the majority of researchers tried to make correlations the fish behaviour and abundance with water temperature and its oscillations.

In the general context of natural variability of Romanian waters, the main abiotic environmental factors of marine waters presented large amplitude of values in 2005, most of them in the limits of natural feature. The main characteristic of the year is represented by the Danube's extremely high flows, the monthly means exceeding the multi-yearly ones. The highest differences were registered in April and May 2005, when the flows were higher then 35 km^3, as high as the quotas of the floods recorded in 1970.

The water temperatures registered mean monthly values higher then multi-yearly ones of the 1959 - 2004 period; over the whole period of observations, the highest differences in plus were attained in January, July and August (Cociaşu et al., Reports NIMRD).

It is significant the fact that, the sector of Danube mouths, the most important area of fishing for sprat, especially in the summer months, diminished its importance in the last years.

Like in 2004, in 2005, the water temperature favoured the occurrence of fishing shoals of red mullet in the activity zone of pound nets, its share in catches attaining up to 8.4%.

Also, the bloom events registered in the shallow waters on 12/13 September 2005, produced by blue-green algae *Microcistis orae*, followed by the organic decomposition of its overwhelming populations, determined the reduction of oxygen content of water, from 7 to 1.6 cm^3/l, meaning a hypoxia phenomenon, which provoked the mass mortality of the benthic fish species in the Mamaia Bay sector, the estimated quantity being 2 - 3 tons.

Regarding the development of gelatinous organisms having a significant impact on the fishing resources, *Mnemiopsis leidyi* and *Aurelia aurita.* Comparatively with the period of maximum development, when *M. leidyi* had reached 3.2 $tons/Nm^2$ in spring 1994, and 10.0 $tons/Nm^2$ in summer 1993 at the Romanian littoral (Radu et al., 1996), the influence of this ctenophore on the fishing resources became almost negligible in 2004 and 2005.

Beginning 1995, especially in spring season, the spreading area and density on unit of surface of the jelly-fish increased up to 40.4 $tons/Nm^2$ (1998), comparatively with 1.79 $tons/Nm^2$ (1994) (Radu et al., 1996/1997; Reports NIMRD, 1993 - 1999). During the analyzed period, due to the huge agglomerations of jelly-fish, influenced by the favourable conditions, the fishing activity was very difficult.

1. 2 Fishing effort

Since 1980, a new commercial fishing fleet has been organized in Romania and it included small-size coastal trawlers type B410(132GRT/570HP), type Baltica (98GRT/300HP) and TCMN (95GRT-365HP). During 1980 - 1989, this fleet had 20 trawlers, after 1999, 7 - 14, presently 8 - 9. The number of fisherman decreased from 180 - 200 up to 70 - 90 in the commercial fleet (Figure 1) (Radu et al., 1996/1997).

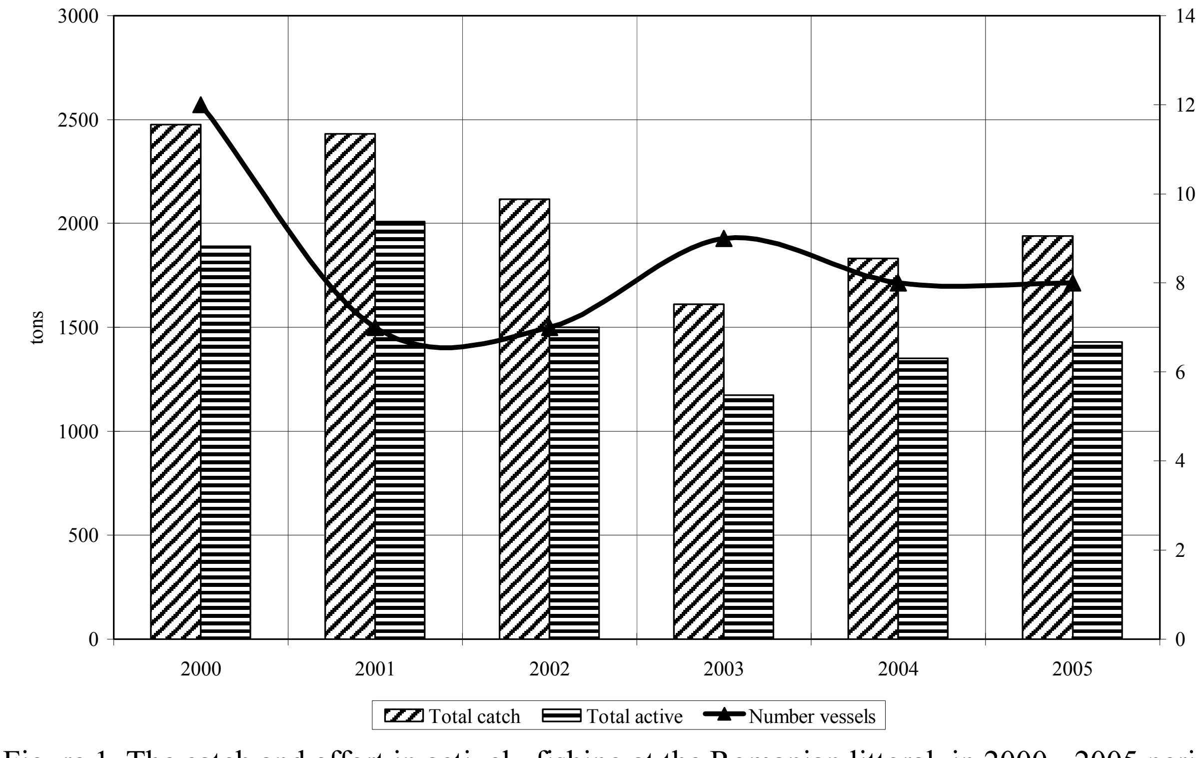


Figure 1. The catch and effort in actively fishing at the Romanian littoral, in 2000 - 2005 periods.

If in 1960 - 1989 the stationary fishing was carried out by 3 state companies, in 18 fishing locations along the Romanian littoral between Sulina and Mangalia, with about 70 - 150 pound nets yearly, and catches (3120 - 7900 t) manly consisting of pelagic species, while the bottom species were to be found only as by-catches, since 1990, similarly to the situation in the coastal fishing fleet, the stationary fishing at the Romanian littoral has declined.

During the last 10 years, the fishing effort decreased continually, up to 30 - 41 pound nets on the whole littoral. A number of 150 - 200 fishermen acted in the last years, comparatively with 400 - 500 from '80 decade (Figure 2) (Radu et al., 1996/1997).

In 2005, the fishing effort maintained close to the level of 2003 and 2004, in the fishing with fixed gears being in activity 1.840 sturgeon gill nets, 7.000 turbot gill nets, 300 grey mullet gill nets, 30 pound nets, 16 beach seines, 3.100 long lines and 230 shad gill nets. In actively fishing, eigt coastal trawlers were operational. Although the values of effort official reported during last two years, a tendency of reduction in the number of pound nets in the area of "Danube Delta" Biosphere Reserve (DDBR), and the increasing of effort based on the introduction in fishing of a number higher and higher of turbot gill nets, long lines and other nets (Staicu et al., 2004).

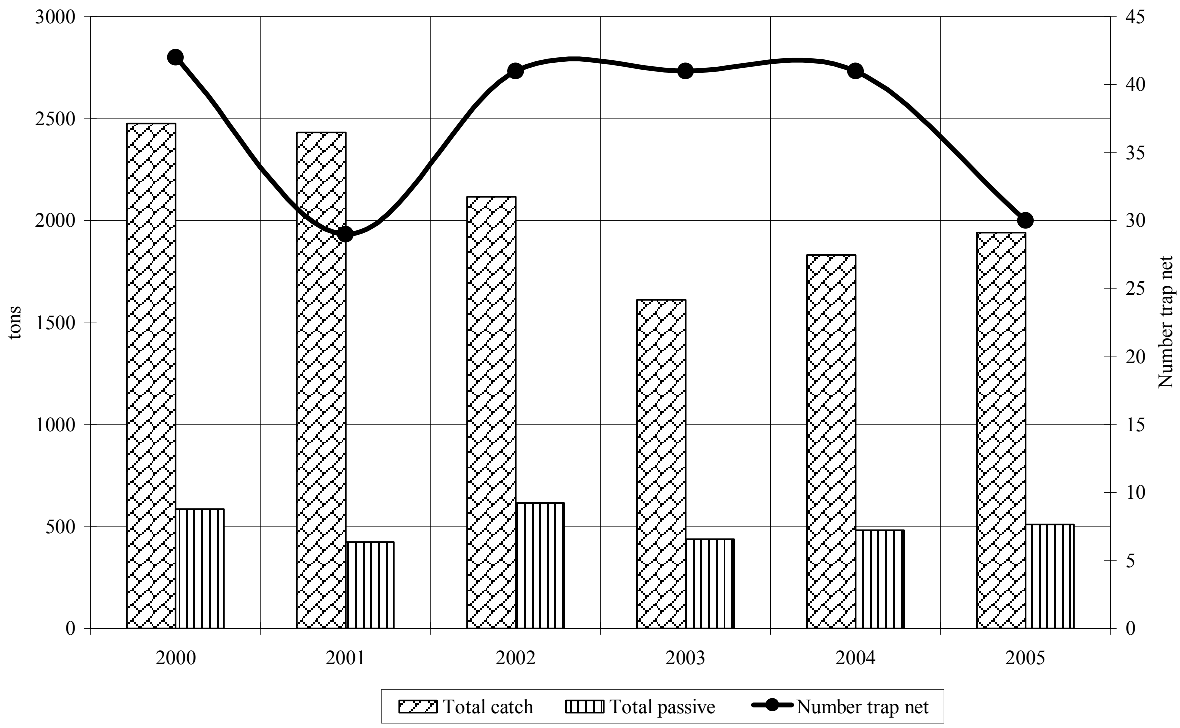


Figure 2. The catch and effort in passively fishing in the Romanian marine zone, between 2000 and 2005.

1. 3. Level of catches and landings

At the Black Sea level, especially at the Romanian littoral, the catch level has continually increased beginning in '70 up to late '80. Thus, between 1970 and 1979, total catches achieved at the Romanian littoral were settled among 5.500 and 7.900 tons, with a multi-yearly mean of more then 6.600 tons. Between 1980 and 1989, the catches had a tendency of increasing; the multi-yearly mean got two fold comparatively with the previous period. Beginning 1990, the catches level was continually decreasing, the multi-yearly mean of last 16 years represented only 1/3 from that of the 1980 - 1989 period. The reasons of this situation are multiple, referring both to the pollution and also to the incompatibility between the stock status and level of fishing effort (Radu et al., 1996/1997; Staicu et al., 2004).

During 2000 - 2005 period, the level of total catch situated among 1.612 tons (2003) and 2.476 (2000), more then 70% being obtained with trawlers (Figure 3) (Radu et al., 2005).

The sprat was dominant species, with catches comprised among 1.200 and 1.800 tons/year. The second important species, both quantitatively and economically, was the anchovy (Figure 4). Between 2000 and 2005, the quota of participation of anchovy in the catch achieved with stationary gears was 28 - 48%.

Beginning ’90 years, the Romanian marine fishing of some economically valuable species, such as, mackerel and grey mullet registered a significant decrease.

Over the last six years, the contribution of pelagic species in total catch obtained at the Romanian sector of Black Sea ranged from 84 (2004) to 92% (2002) (Figure 5), the sprat was prevailing, covering more then 83% of total catch. Among demersal species, waiting contributed with the highest percentages, from 35 (2005) to 88 (2001) (Radu et al., 1996/1997,2003; Radu et al.,2003; Staicu et al., 2004).

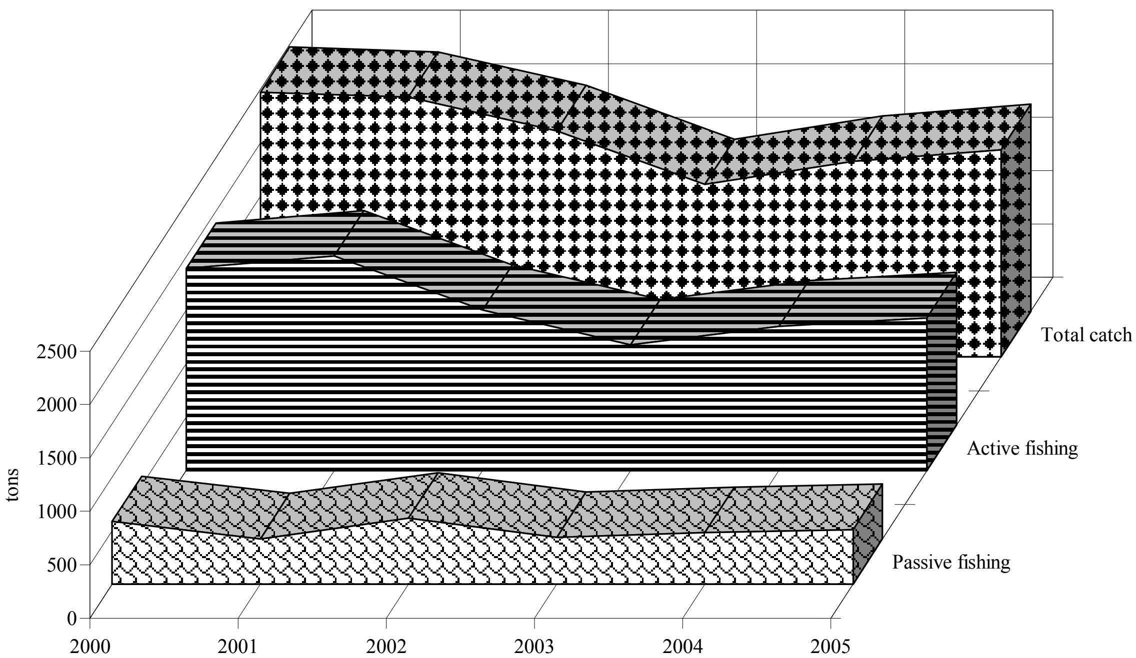


Figure 3. The catch achieved at actively and stationary fisheries from Romanian sector of the Black Sea, in 2000 - 2005 period.

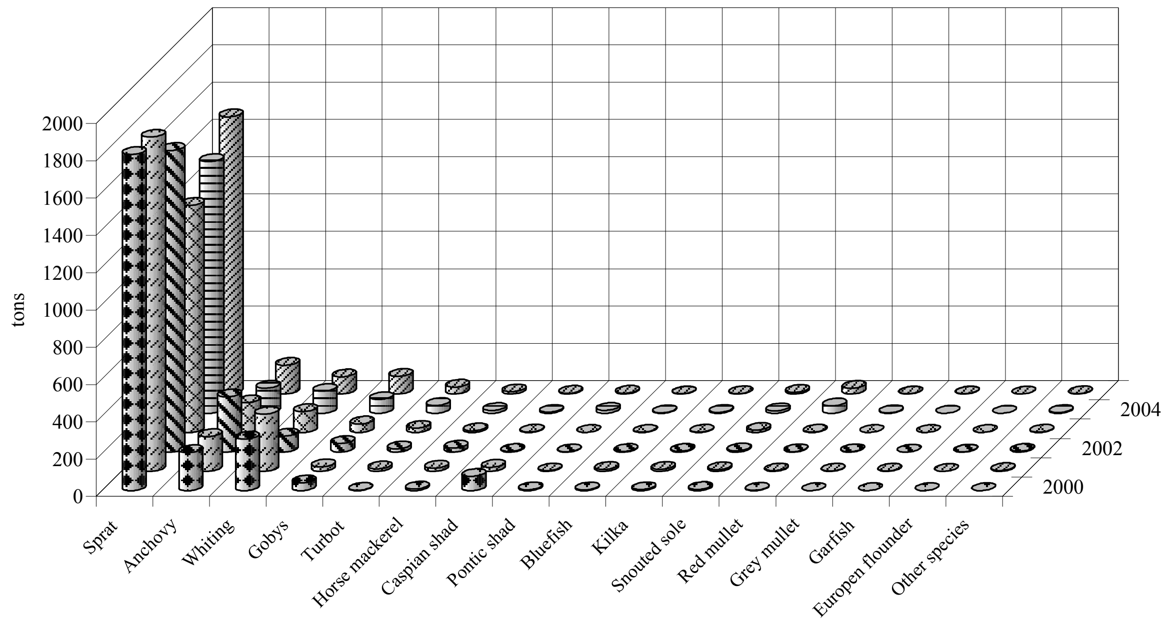


Figure 4. The main species caught at the Romanian littoral during last six years.

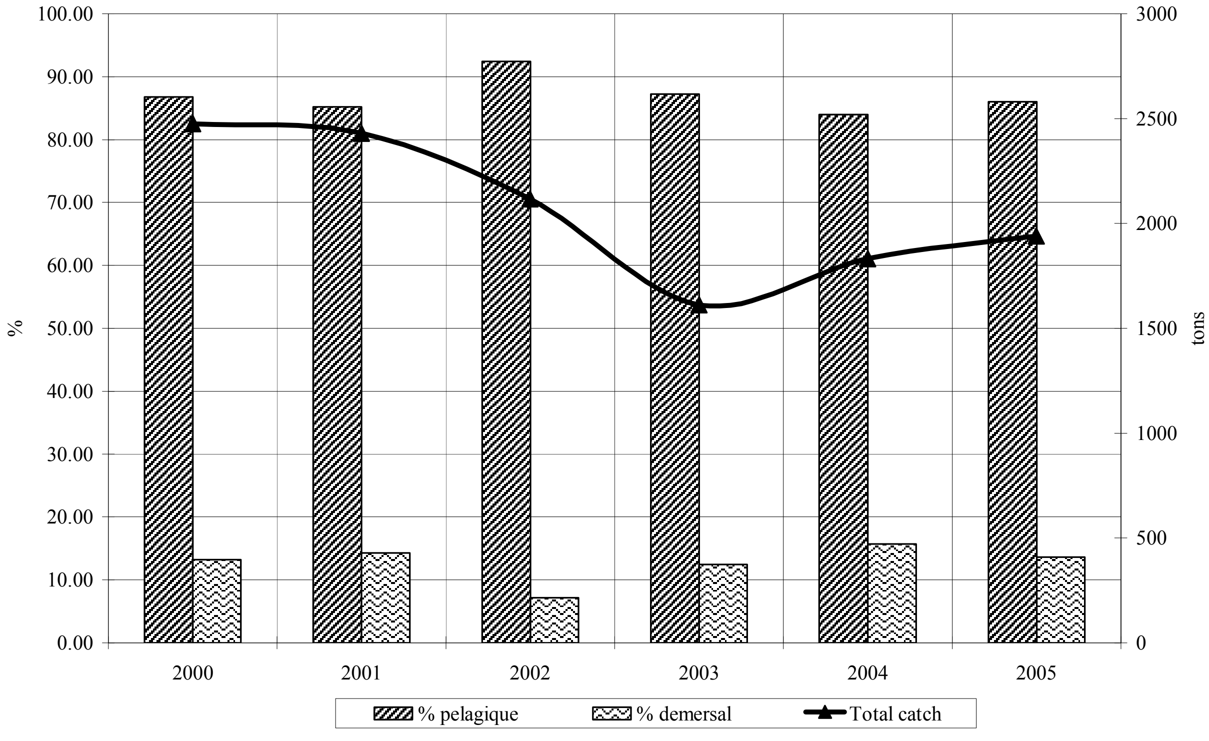


Figure 5. The total catch and percentage of pelagic and demersal species at the Romanian littoral, in 2000 - 2005 periods.

2. Impact indicators

2. 1 Rate of species whose stocks are out of safety limits

The percentage of species whose stocks are out of limits of security was 92, similarly in previous years, the sprat and waiting being the single species having the evolution almost normal. There must be mentioned that the exceeding of the security limits are not only due to the exploitation in the marine Romanian sector, the majority of species being transzonal, imposing a common management (Radu et al., 2005; Staicu et al., 2004).

2. 2 Rate of changes in mean CPUE

In 2005, the catch per unit effort registered at the fishing with fixed gears maintained at closed values to 2003 and 2004, being 12.4 tons/pound net, and 0.16 tons/pound net/day respectively. In the fishing with actively gears, CPUE was 170 tons/vessel, 1.8 tons/day respectively, and 0.68 tons/hour of hauling. In the reference period, the mean catch per fishing vessel was around 500 tons/year, and the mean catch was around 60 tons/year (Radu et al., 1996/1997; Staicu et al., 2004).

2. 3 Rate of changes in size structure of catches

The sprat (*Sprattus sprattus*) has lengths comprised among 40 and 130 mm over the whole reference period, the highest frequency pertaining to the individuals of 70 - 100 mm lengths (Figure 6).

The age corresponding to these lengths was 0+ - 4; 4+, the ages 2:2+ - 3; 3+ having a significant participation. By 1982, the age classes 4; 4+ years had a share of 34% from the catch of this species, then the percentage continually decreased up to 1995 when this age was not signalled, meaning the increase of the pressure through fishing exerted on the populations. While the share of this age decreased, the prevalence of 0+ especially 1; 1+ ages became increased (Radu et al., 1999).

During last years, the 2;2+ and 3;3+ ages have been prevailing, meaning that the pressure through fishing on this species decreased in the commercial catches from Romanian littoral (Figure 7) (Radu, 2000; Staicu et al.,2004).

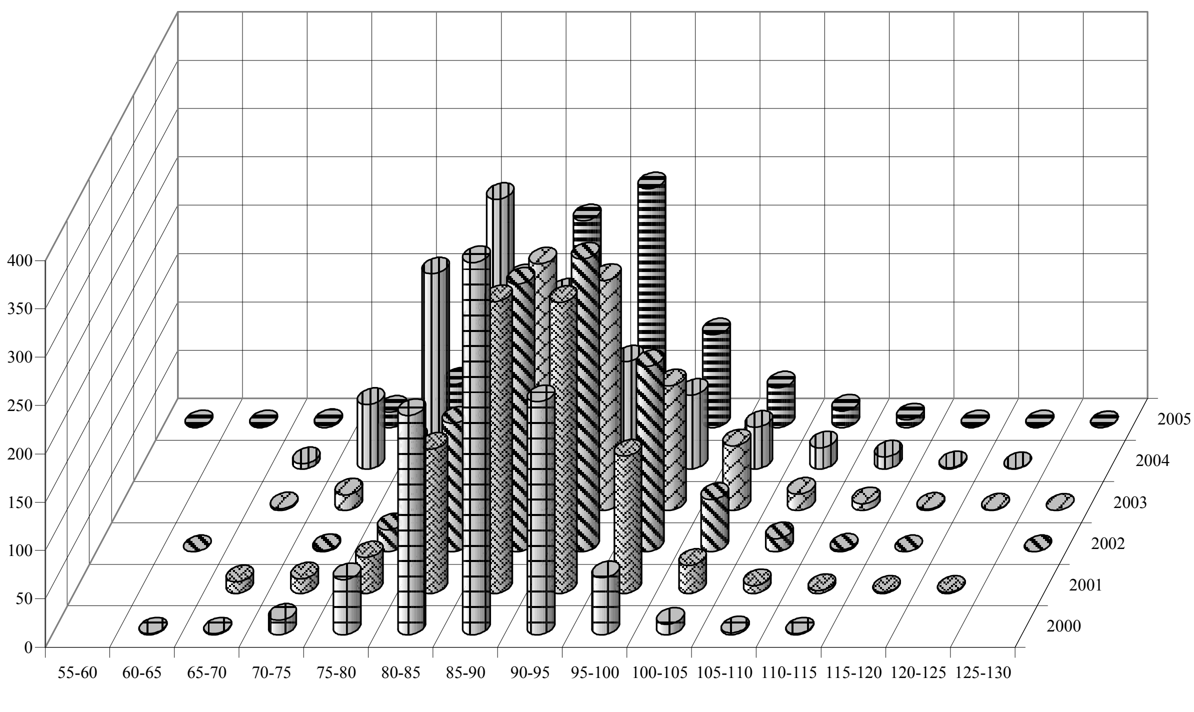


Figure 6. The structure on length classes of sprat achieved in the Romanian fisheries.

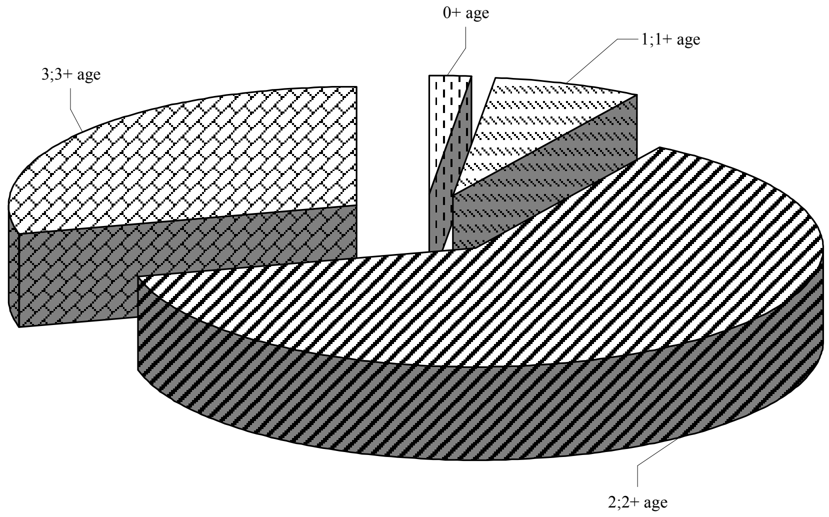


Figure 7. The structure on age classes of sprat.

The catches of *Merlangus merlangus euxinus* (whiting) had also the age 6 years in the age-class composition at the beginning of period; little by little, the ages spectrum reduced up to 4;4+ between 1985 and 1988, 3;3+ between 1990 and 1992, 2;2+ between 1933 and 1996, reaching 0+ and maximum 3;3+ years during last years; the 1+ and 2;2+ groups prevailed (Radu 2001; Staicu et al., 2004).

Like for the sprat, the phenomenon means that the pressure through fishing on the species populations increased once with the decrease of importance of anchovy and mackerel. As soon as the stocks of the last two species, especially of anchovy, begun to rehabilitate, the pressure on waiting decreased, leading to a slightly restoration of its stock.

Engraulis encrasicolus (anchovy) was present in catches with individuals of 45 - 160 mm length; the dominance was due to the 75 - 115 mm length-classes (Figure 8).

By 1986, the composition on age-class shows the presence of individuals with ages comprised from 0+ to 4; 4+ years, the classes 2; 2+ and 3; 3+ years prevailing. Then , 10 years period, between 1987 and 1997, from the anchovy's catches the 3;3+ and 4;4+ ages disappeared, only 0+, 1;1+ and 2;2+ years remaining, the groups 1 and 2 prevailing. During this period, the anchovy stock suffered very much due to the over-exploitation and negative impact exerted by the ctenophore *Mnemiopsis leidyi.*

After 1997, the anchovy population begun to recover, fact signalled by the increasing of ichtioplankton presence and re-occurrence of 3; 3+ age-class in catches (Radu 2001).

During last years, the lengths of anchovy individuals ranged from 45 to 160 mm, the mean length being 110.09 mm and the mean weight 8.15 g, having 0+-3;3+ years (Figure 9) (Staicu et al., 2004).

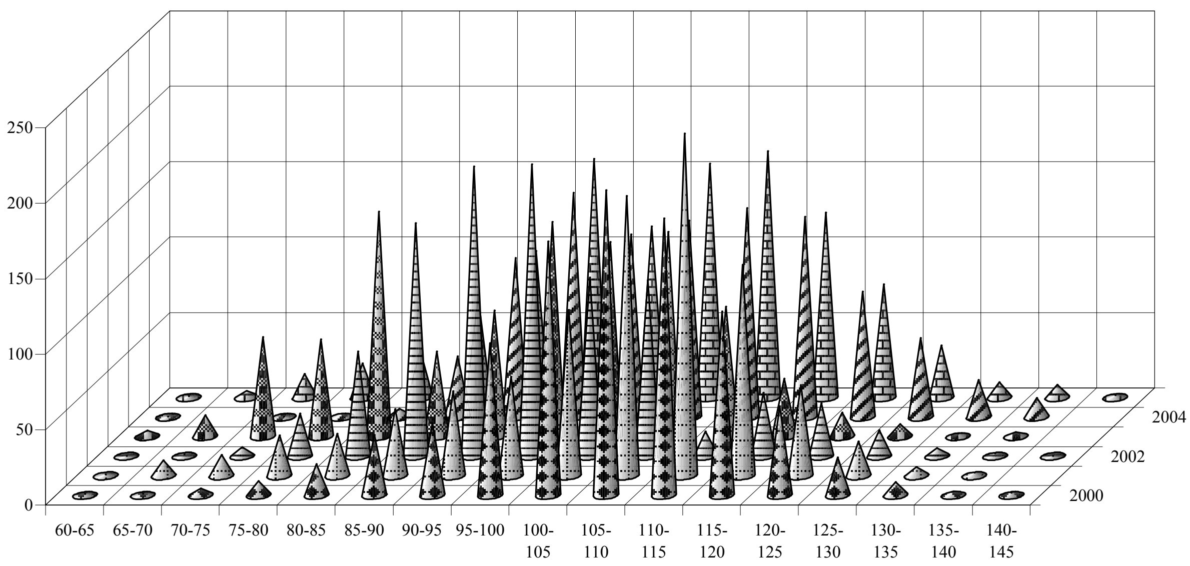


Figure 8. The structure on length-classes of anchovy.

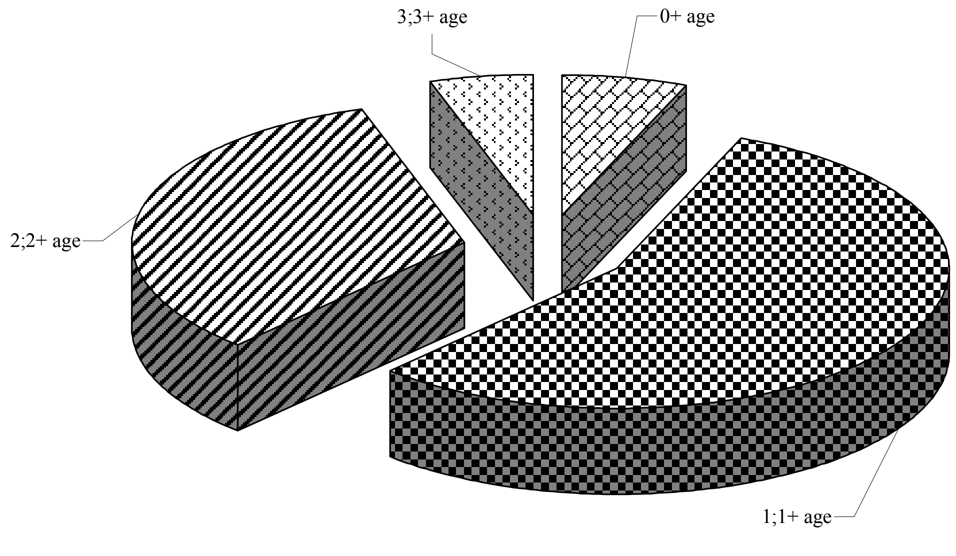


Figure 9. Th structure on age-classes on anchovy

Trachurus mediterraneus ponticus (horse mackerel) is one of the species whose population has suffered very much during last 15 years. By 1984, its catches were composed from age-classes up to 6 years, the ages between 2 and 4 years were prevailed. In the 1985 - 1988 period, the maximum age dropped at 5 years, the ages of 2 and 3 years were dominant; following 1989 up to 1993, the maximum age was reduced to 4 years, the 1;1+ class being dominant (Radu 2001).

During last years, the analyzed samples contained juveniles of mackerel but also mature individuals.

The length spectrum oscillated from 95 to 140 mm, and the age was 2; 2+ years (Figure 10 and Figure 11) (Staicu et al., 2004).

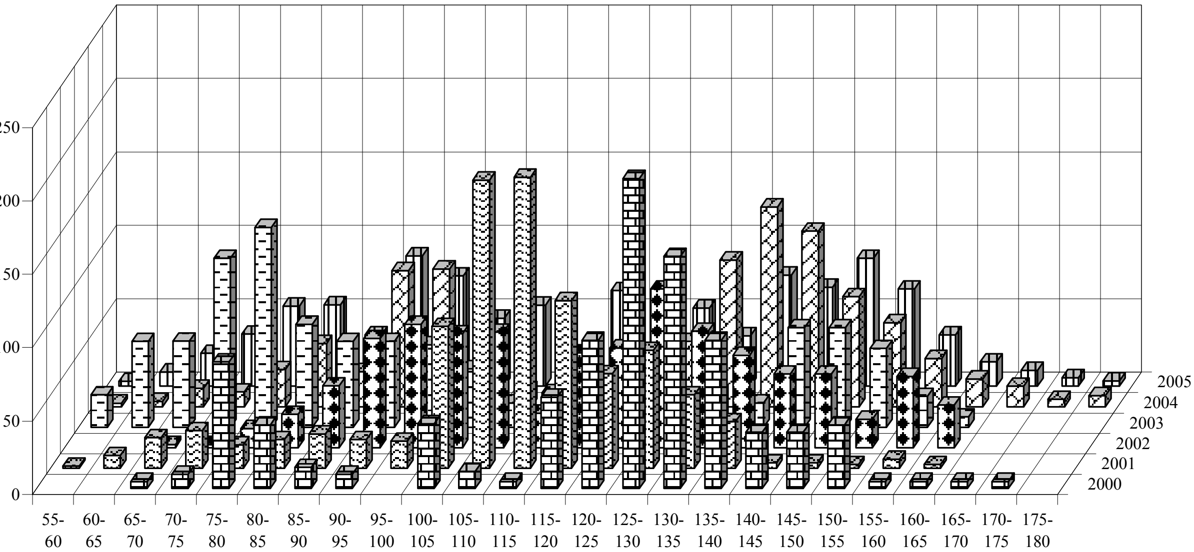


Figure 10. The structure on length-classes at mackerel.

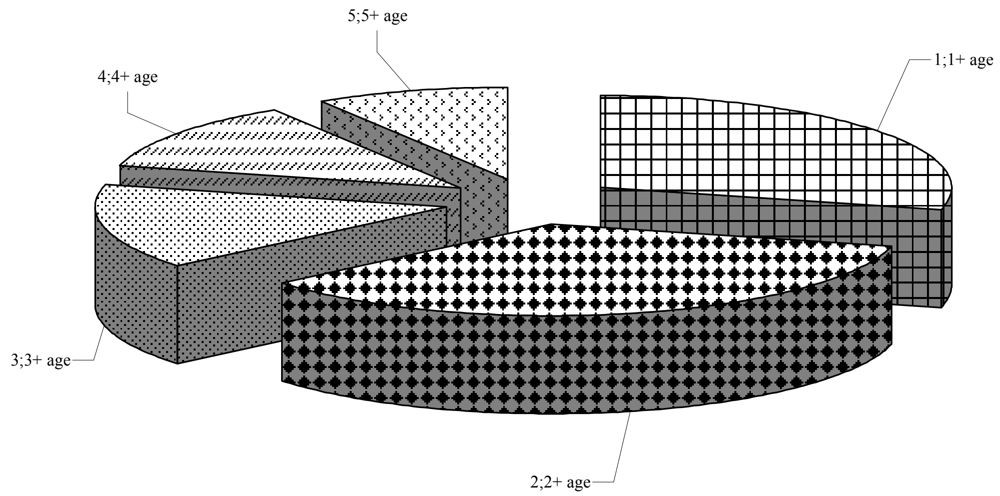


Figure 11. The structure on age-classes at mackerel.

2. 4 Rate of by-catch

The percentage of complementary species was 24, similarly as in the last years.

2. 5 Rate of registered stranding dolphins

Number of stranded dolphins varied among 8 (2004) and 119 (2003).

In the course of a year, the most critical period is May - July, and the most affected is P*hocoena phocoena* (above 70% from the stranded carcasses) (Figure 12) (Radu G, 2005).

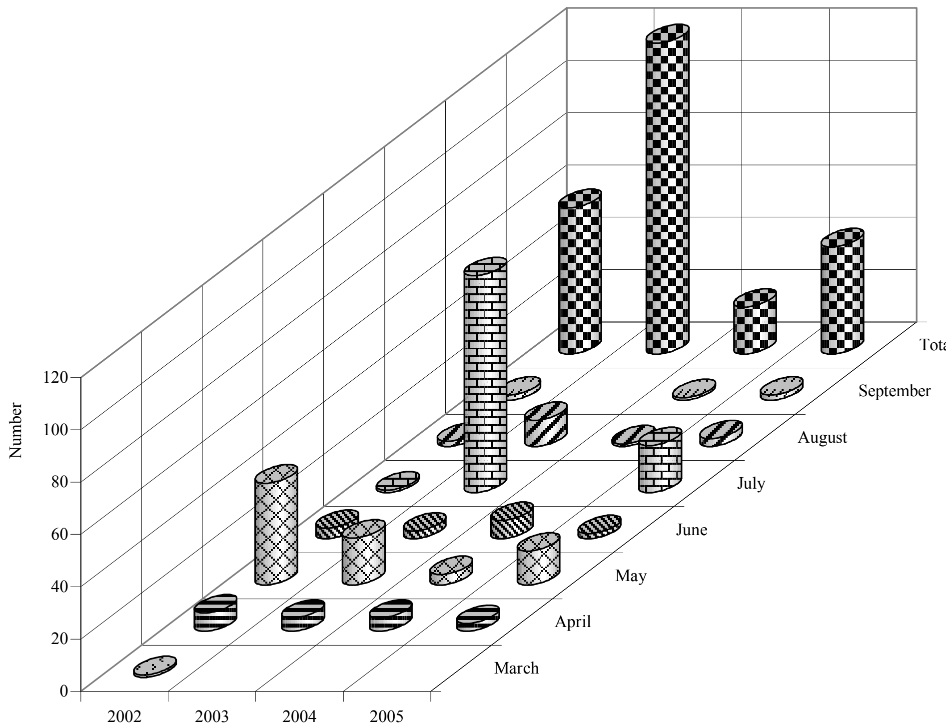


Figure 12. The state of dolphin stranding at the Romanian littoral.

3. State Indicators

3. 1 Rate of biomass of living resources stocks whose exploitation is under regulation.

The holistic method of swept area was used in order to assess the fishing agglomerations (one part from the stock) of the sprat, turbot, whiting and spiny dog fish. The method can be applied on limited zones (the littoral of a country), without taking into account the spreading area of the whole stock. The biomass of spawners of anchovy and mackerel was assessed through the Parker's method (Radu 2005; Radu et al., 2003).

The biomass values of the analysed species presented seasonal oscillations, their fishing agglomerations being influenced by the fluctuation of the environmental factors:

- sprat has presented a natural fluctuation and an abundance almost good, the agglomeration biomass being of 65.000 tons, bigger than in 2003 and 2004 respectively (Figure 13);
- the turbot, the most important economically species, achieved fishing agglomerations whose biomass oscillated among 247 and 1.066 tons, the highest values being obtained in November, when the distribution area was largest also (Figure 14);
- the dogfish constituted agglomerations whose biomasses oscillated among 751 and 1.650 tons in April (Figure 14);
- the whiting achieved agglomerations whose biomasses oscillated among 565 and 1.618 tons, the highest values being obtained in May and November (Figure 14).

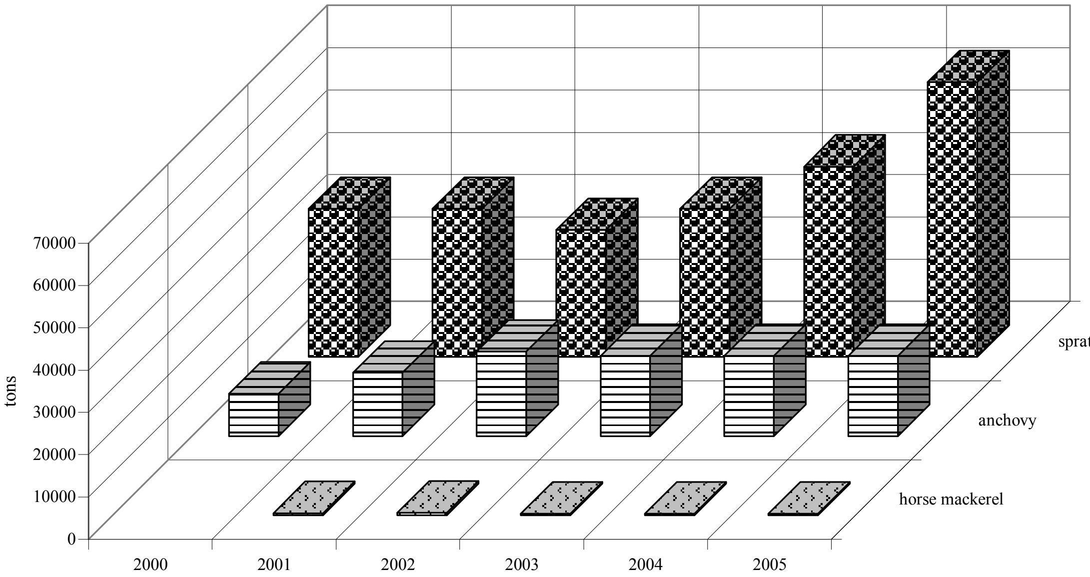


Figure 13. The biomass of sprat agglomerations
and anchovy and mackerel spawners.

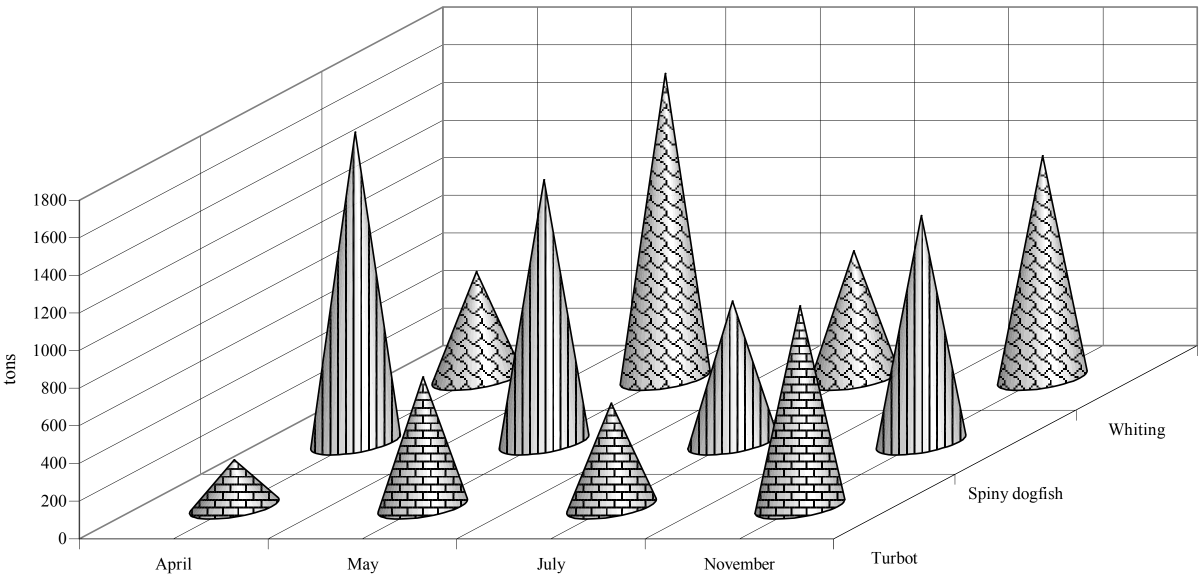


Figure 14. The biomass of main demersal species
in Romanian marine zone, in 2003.

3.2 Evolution of spawning intensity and stock recruitment

During April - May (1995 - 2005), the assessed relative abundance for sprat eggs was ranged from 0.289•10^9 individuals (May 1998) and 28.046•10^9 individuals (May 2003). The dynamics of mean number reveals variation amplitude from 0.5 ind. /m^2 and 7.8 ind. /m^2 (Figure 15) (Radu et al., 2002, 2003).

As for larvae, for the period 1995 - 2005, the dynamics of mean densities and effective for larvae are characterized by fluctuations from one year to other, and one place to other, the variation amplitude of mean densities oscillation from 0.32 (September 1996) to 49 ind. /m^2 (April 1997), while the relative abundance was settled among 71.365 10^6 individuals (May 1999) and 11418.69 10^6 individuals (April 1997) (Figure 16) (Radu et al., 2002, 2003).

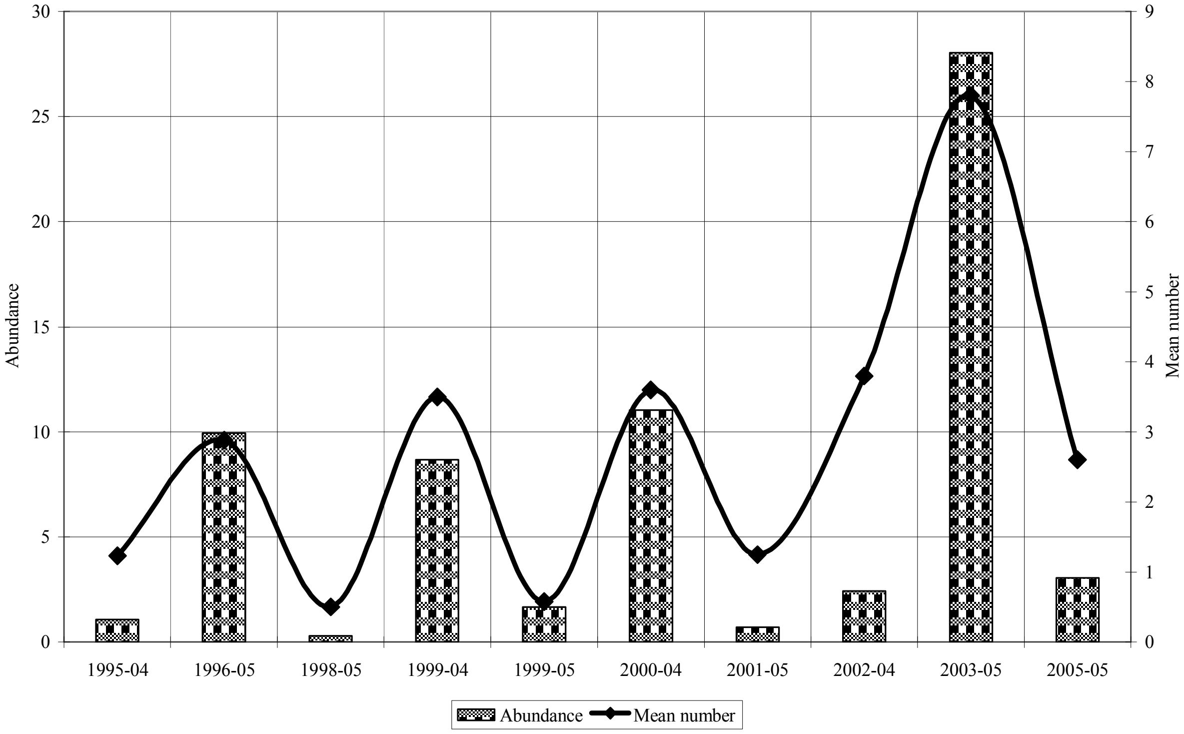


Figure 15. Th abundance of the sprat eggs.

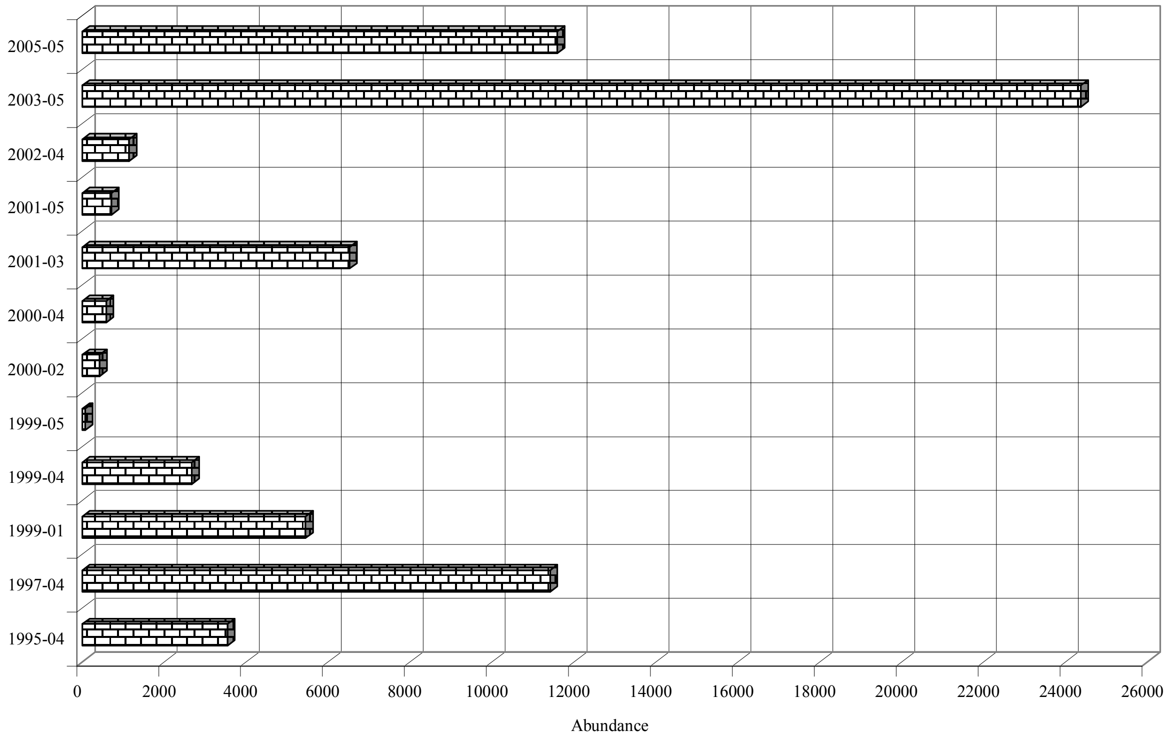


Figure 16. The abundance of the sprat larvae.

The dynamics of total eggs of anchovy in the 1995 - 2004 period reveals a large amplitude $0.481 \cdot 10^9 \div 4737 \cdot 10^9$ individuals, as well as important fluctuations from one year to other and from one season to other (Figure 17) Also, the highest values of relative abundance are registered in June and July ($740.14 \cdot 10^9 \div 4737 \cdot 10^9$ individuals), meaning that the reproductive processes of anchovy are controlled, first, by the temperature variations, the changes of these conditions being able to outrun or delaying, among some limits, the active period of reproduction. Equally, this situation can be explained also through the general tendency of amelioration in the physical-chemical quality of Romanian coastal waters (Radu E et al., 2002, 2003).

Evolution of mean densities and assessed effective for anchovy larvae is characterized through fluctuations among years and spaces, the variations field of mean densities being 0.21 ind. /m^2 (September 1995) and 58.8 ind. /m^2 (June 1997), while the relative abundance was settled among $483.086 \cdot 10^6$ individuals (August 1997) and $61969.06 \cdot 10^6$ individuals (August 2001) (Figure 18) (Radu et al., 2002, 2003).

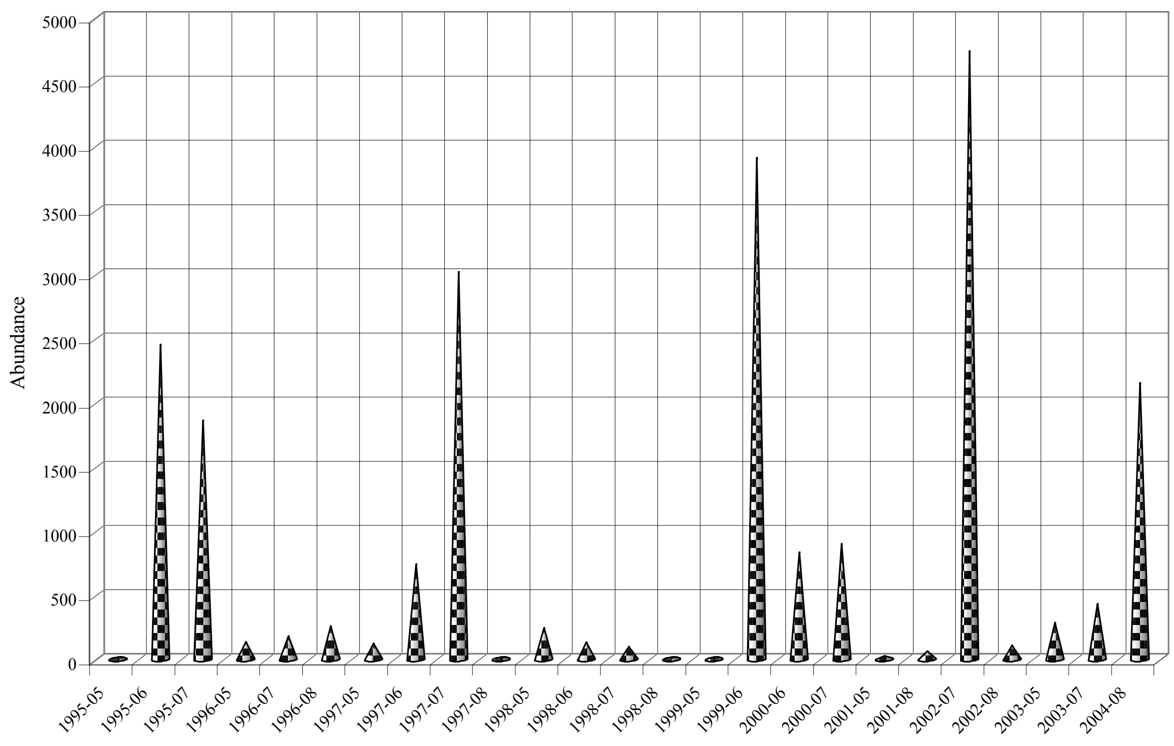


Figure 17. The abundance of the anchovy eggs.

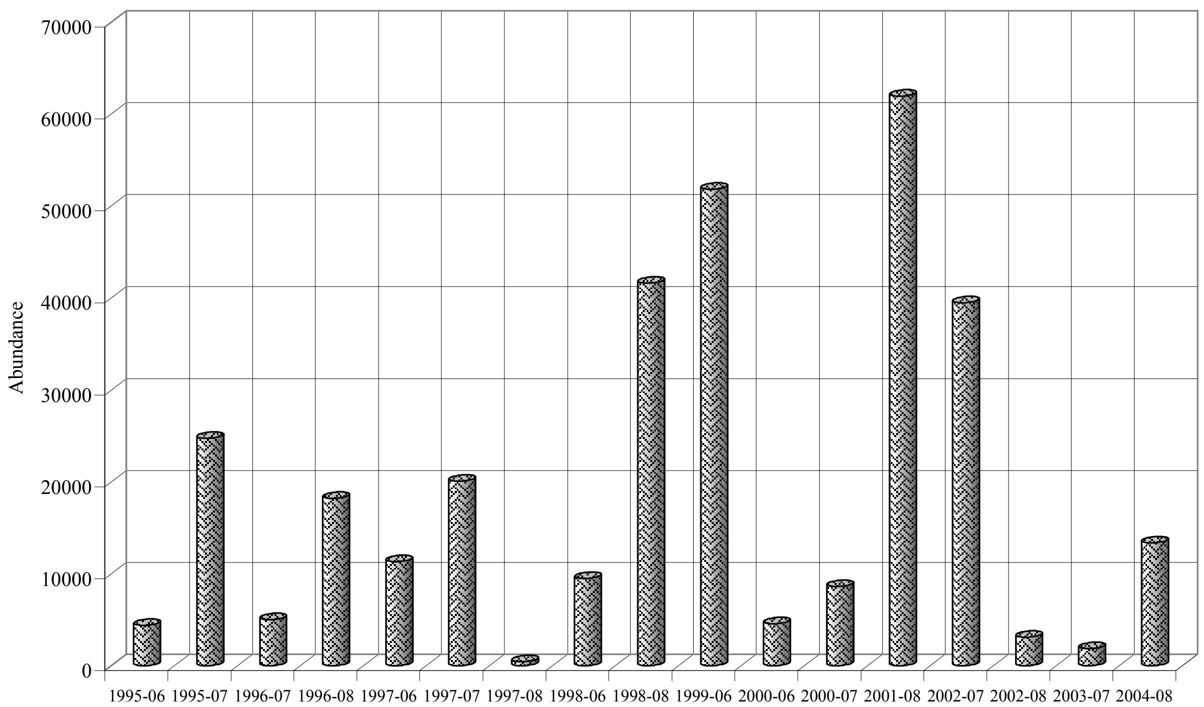
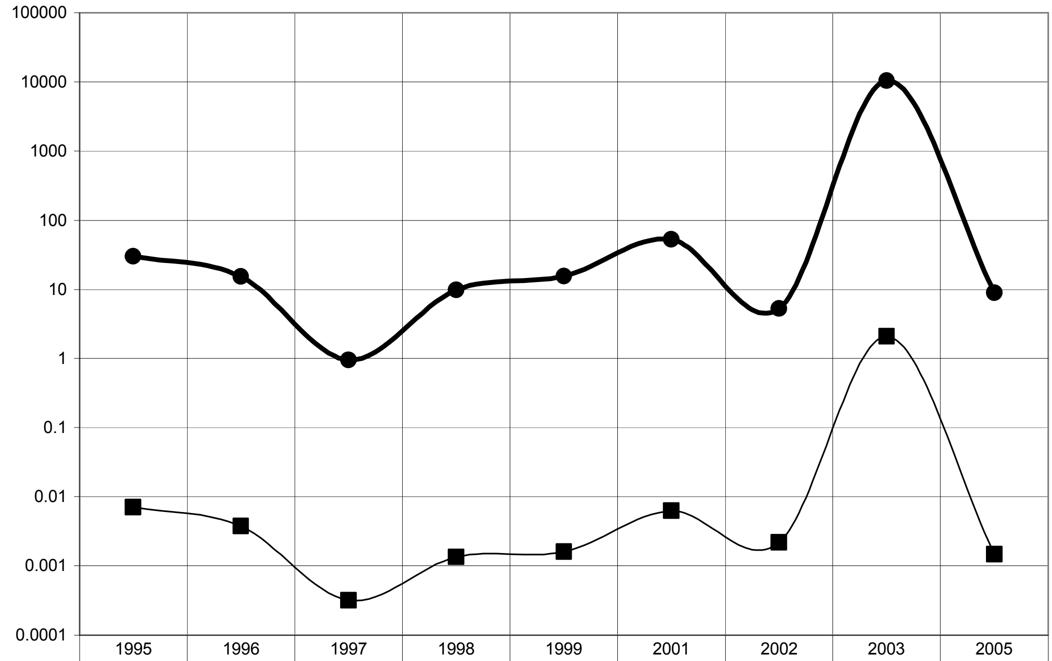


Figure 18. The abundance of the anchovy larvae.



	1995	1996	1997	1998	1999	2001	2002	2003	2005
Abundance	29.9135	15.3737	0.95033	9.7973	15.411	52.6669	5.3099	10440.65	8.9037
Mean number (ex/mp)	0.0071	0.0037269	0.00032	0.001349	0.0016	0.0063	0.00218591	2.073	0.001475

Figure 19. The abundance of the sprat juveniles.

The dynamics of anchovy juveniles for August - September (1995 - 2004) period reveals a maximum of abundance registered in 2001 (173.59 10^6 ind.), and a minimum in September 1995 (0.7018 10^6 ind.), a good condition of the effective being registered also in 1996 and 1997(Figure 20).

During the reference period, the oscillations of mean number of anchovy juveniles per surface unit is overlap on the fluctuation of relative abundance, ranging from 0.0004768 ind. /m^2 (September 1995) and 0.0257 ind. /m^2 (September 2001) (Radu et al., 2002, 2003).

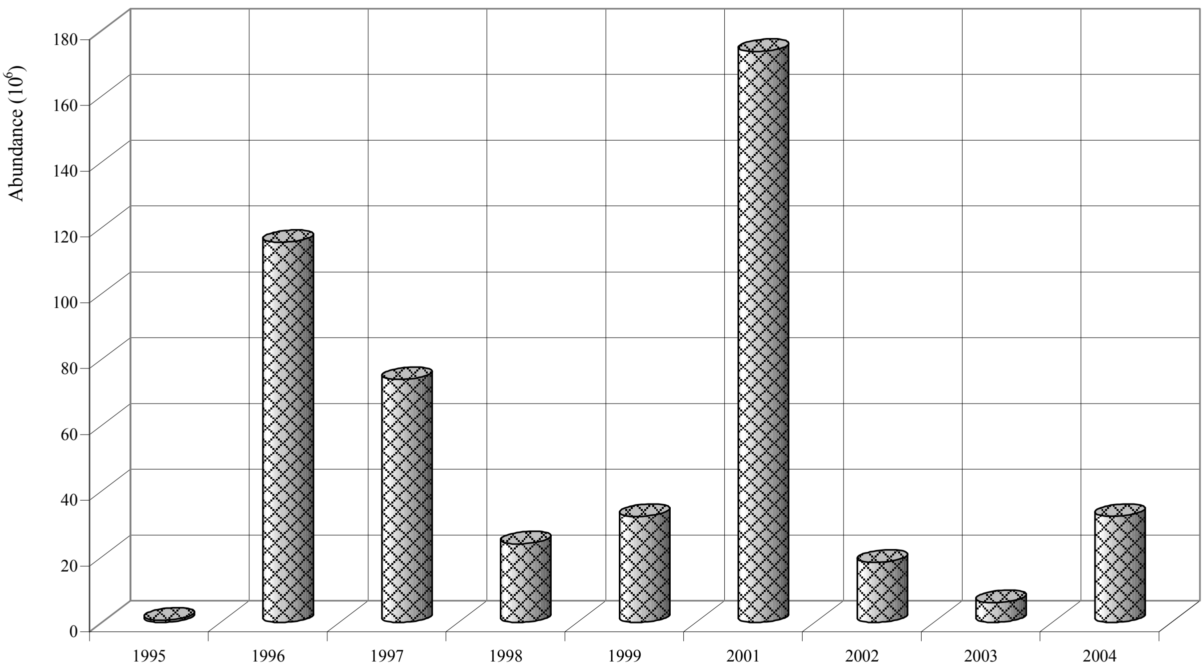


Figure 20. he abundance of the anchovy juveniles.

4. Response indicators

The Low 192/2001 regarding the fishing fund, fishing and aquaculture was adopted for pursuing a balanced and responsible exploitation of aquatic living resources from natural basins, favouring the sustainable development and adoption of measures necessary for protection, conservation and restoration of these resources and aquatic ecosystems. This low represents the general frame of regulation, then, the secondary legislation for fishery sector is based on this low.

In the chapter "Right for fishing, licenses and authorization of fishing" is specified "for to restore and conserve the aquatic living resources, the central public authority responsible for fishing and aquaculture establish regulation measures of the fishing effort and/or establish the allocated quotas". In the chapter "Structural policy and administration of production capacities", this low provides, among others, that "the policy for organization of fishing sector is achieved through: measures for adaptation of fleet capacity, measures for adaptation of fishing effort at the situation of living aquatic resources from the fishing zones, taking into consideration the assumed international obligations".

Romanian legislations viewing to the living aquatic resources is ongoing for finalizing and improving, after that it will be applied with consistency, and, depending on the signals obtained from the fishery indicators and sustainable development, the decision-makers will take the requested measures.

CONCLUSIONS

Under the circumstances presented above, we can say that in the situation of Romania, the active fishing is mainly affected by the following:

a) The reduction of the fishing effort as a consequence of the economical changes occasioned by the transformation of the state capital into private capital;

b) The limitation of market demands for some periods of the year, mainly amplified by the fact that more than 80% of the production is delivered as salted fish;

c) The jellyfish and ctenophore agglomerations, making difficult the trawl fishery on all hauling level in some years and periods.

The passive fishery uses pound nets and has suffered the strongest impact due to the change of the ecological conditions near the coast zone. Moreover, there are observations attesting the fish migration routes changed during the last 6 - 7 years. The fish has the tendency to remain in the offing, at a certain distance from the coast zone with the isobaths of 5 - 13 m where the pound nets are located.

So, the main problems that face the Romanian fishery are:

- Strong reduction of catches in the passive fishery owing to the decrease of the anchovy and horse mackerel stocks and to the intensity of fish migration from shallow waters, where the environmental conditions have been continuously deteriorating. The incomes of the fishery companies as well as their staff are drastically reduced.

- The change of catch structure where the less valuable species are predominant limits the production and its diversification.

- So far have been no suitable legal and institutional framework, and this fact has favoured the proliferation of the illegal and uncontrolled fishery in the Romanian exclusive economic zone of the Black Sea. The over-fishing is mainly directed to the valuable species (e. g. Black Sea turbot).

- The free market and imported products have caused the limitation of the traditionally prepared products and the reduction of their price until the limit of the profitableness.

- The transboundary migrations and distribution of the commercial fish species and the lack of on integrated management for whole Black Sea basin cause difficulties in the fishery activity of each riparian country for a short term and can cause collapses for a medium and long term.

In order to control the illegal fishing is necessary to consolidate the control of Border Police and new Fishing Inspection to be effective.

Protection of living resources from Black Sea is realized on the basis of an adequate legal and institutional framework both at national and regional level.

The transboundary character of the living resources from the Black Sea imposes the necessity for coordinated efforts at regional level for their exploiting and protection.

Major lacks in the management practices are:

- coordination at regional level regarding the assessment of fish stocks and the environmental factors influencing them;
- elaboration and implementation of regulations in compliance with UE norms regarding the permits for fishing, vessel licenses, establishing the fishing quotas and other conditions for fishing (zone, periods, type of gears);
- achievement of efficient systems for fishing inspection and control,
- lack of agreements for preventing the illegal fishing;
- lack of annual assessment of the fish stocks at regional level.

For sustainable development of the Black Sea fisheries, the regional standardization of the methods and means of sampling, processing, analyzing and interpreting of the data as well as the assessment of the fish stocks, in compliance with the international regulations is needed. Also, there is necessary to know the status and evolution of the demersal and transboundary anadromous fish species

AKNOWLEDGEMENTS

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AUTHORS:

[1] *Gheorghe RADU*
gpr@alpha.rmri.ro
[2] *Simion NICOLAEV*
nicolaev@alpha.rmri.ro
[3] *Elena RADU*
gpr@alpha.rmri.ro
[4] *Eugen ANTON*
eanton@alpha.rmri.ro
National Institute for
Marine Research and Development
“Grigore Antipa” Constanța,
Mamaia Bd., no. 300,
Constanța 3, Constanța County, Romania,
RO - 900581.

STATUS OF POPULATIONS OF MAIN ECONOMICALLY IMPORTANT FISH SPECIES FROM THE ROMANIAN MARINE SECTOR

Ionel STAICU [1], *Elena RADU* [2], *Gheorghe RADU* [3], *Vasile MAXIMOV* [4] and *Eugen ANTON* [5]

KEYWORDS: Black Sea, catch, CPUE, stock, sprat, anchovy.

ABSTRACT

In the paper, the data regarding the results of research carried out between 1990 and 2005 in the Romanian sector of the Black Sea are written down. The data on catch, fishing effort, CPUE, qualitative and quantitative composition of the catches obtained in stationary and actively fisheries are presented.

The main biologic characteristics of the analyzed species, insisting on structure of length, mass and age classes, are described.

Also, references on the actual tendencies in the stocks evolutions for main exploitable species of economic interest are made..

REZUMAT: Starea populațiilor de peşti de importanță economică principală din sectorul marin românesc.

În lucrare sunt consemnate datele privind rezultatele cercetărilor efectuate în perioada 1990 - 2005, în sectorul românesc al Mării Negre. Se prezintă date referitoare la capturi, efortul de pescuit, CPUE-ul, componența calitativă şi cantitativă a capturilor realizate în pescuitul staționar şi activ.

Sunt prezentate şi principalele caracteristici biologice ale speciilor analizate cu referiri asupra structurii pe clase de lungimi, masă şi vârstă.

De asemenea, se fac referiri asupra tendințelor actuale în evoluția stocurilor exploatabile pentru principalele specii de peşti de interes economic.

RESUME: Etat des populations des poissons de grande importance économique dans la zone marine roumaine

Dans ce travail, on présente des données concernant les recherches effectuées dans le secteur roumain de la mer Noire durant la période 1990 - 2005: captures, effort de pêche, cpue, composition qualitative et quantitative des captures réalisées par la pêche à poste (stationnaire) et par la pêche active.

On étudie également les principales caractéristiques biologiques des espèces analysées, à savoir la structure en classes de longueur, poids et âge.

Les tendances actuelles d'évolution des stocks exploitables des principales espèces de poissons à valeur marchande sont également présentées.

INTRODUCTION

The investigations regarding the status of main fish species of commercial interest from the Romanian littoral had in view: the catches evolution, fishing effort, catch per unit effort (CPUE), structure of populations, biological parameters of main exploitable species, biomass of fishing agglomerations.

The research on status of populations of main species had a continuity character (Porumb, 1994 - 1995, 1998; Nicolaev et al., 1992, 1994, 1994 - 1995, 2004; Radu et al., 1996 - 1997, 1998; Butoi et al., 1993; Staicu et al., 2000, 2004).

MATERIALS AND METHODS

Methodology and techniques used for collecting, checking, processing and data analyzing, as well as for assessment of fish stocks are generally those accepted in the whole Black Sea basin and in compliance with the international one.

The qualitative and quantitative composition of fish catches was obtained from the fishing statistic achieved through the centralization, on time periods, of data obtained from the commercial societies in the field, and through interviews with the fishermen.

The fishing effort (number of vessels, number of traps net, days of activity) was obtained also from the commercial societies. The data are necessary for exploitable biomasses assessment and admissible catches.

The study of the fish populations was performed through biometric measurements as well as determinations of age at the main caught species, in the 1990 - 2005.

Out of 150.000 biometric measurements 52.2% pertained to *Sprattus sprattus* (sprat), 17.0% *Engraulis encrasicolus* (anchovy), 14.7% - *Merlangius merlangus euxinus* (whiting), 2.8% - *Trachurus mediterraneus ponticus* (horse mackerel), 2.3% *Clupeonella cultriventris* (kilka), 1.0% - *Alosa caspia nordmani* (shad), 5.4% *Atherina boyeri* (sand smelt), 1.4% - *Neogobius melanostomus* (round goby), 1.0% - *Pomatomus saltatrix* (bluefish), 0.2% - *Mugil cephalus* (grey mullet) and 2.0 *Mullus barbatus* (red mullet).

Assessment of fishing agglomerations biomass was made using the swept area method.

RESULTS AND DISCUSSIONS

Catch, fishing effort and CPUE

Presently, the industrial fishing at the Romanian littoral comprises two main categories:

- fishing with fixed gears, practiced on the whole Romanian littoral, in the fishery units settled between Sulina and 2 Mai - Vama Veche, with fixed gears (traps net, gill nets, longline, trammel nets and beache seine), on depths comprised from 3 to 11 m, and between 60 and 80 m with the gill nets for turbot and longline;
- fishing with active gears, with coastal trawlers type B - 410, Baltica and TCMN, working in offshore waters, on 20 m depth, with industrial trawl.

During fishing season (March - October) from the 1990 - 2005 period, the level of catch was reduced enough, ranged from 1.200 to 2.500 tons, excepting 1990, 1992, 1993 and 1998 when there were obtained 4.000 - 6.000 tons (Figure 1).

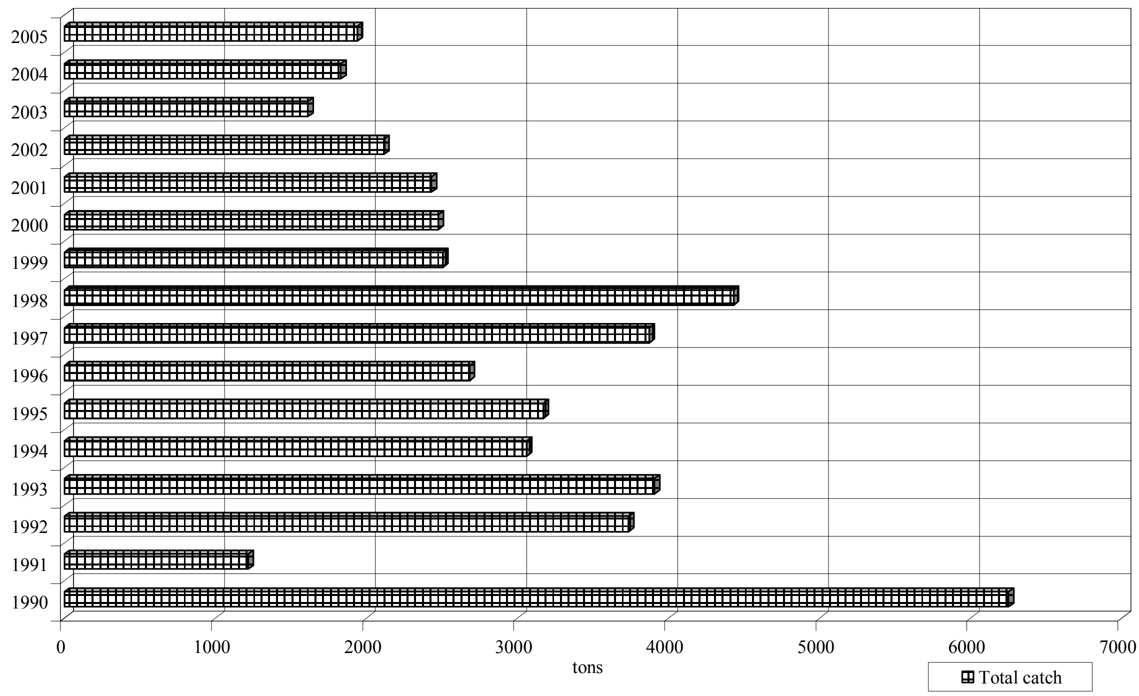

Figure 1. The total catch (tons) achieved in the Romanian marine sector in 1990 - 2005.

Generally, at the Romanian littoral, the fishing with fixed gears is characterized by the concentration of activity in the first 3 - 4 months of the season (Apri - July), when, the main fishing species came near the coasts in searching food and for spawning.

The levels of catches and fishing productivity differed from one year to other one, depending on the fishing effort (number of traps net and effective days of fishing), evolution of hydro-climatic conditions, stocks status and anthropogenic factors) (Figures 2 and 3).

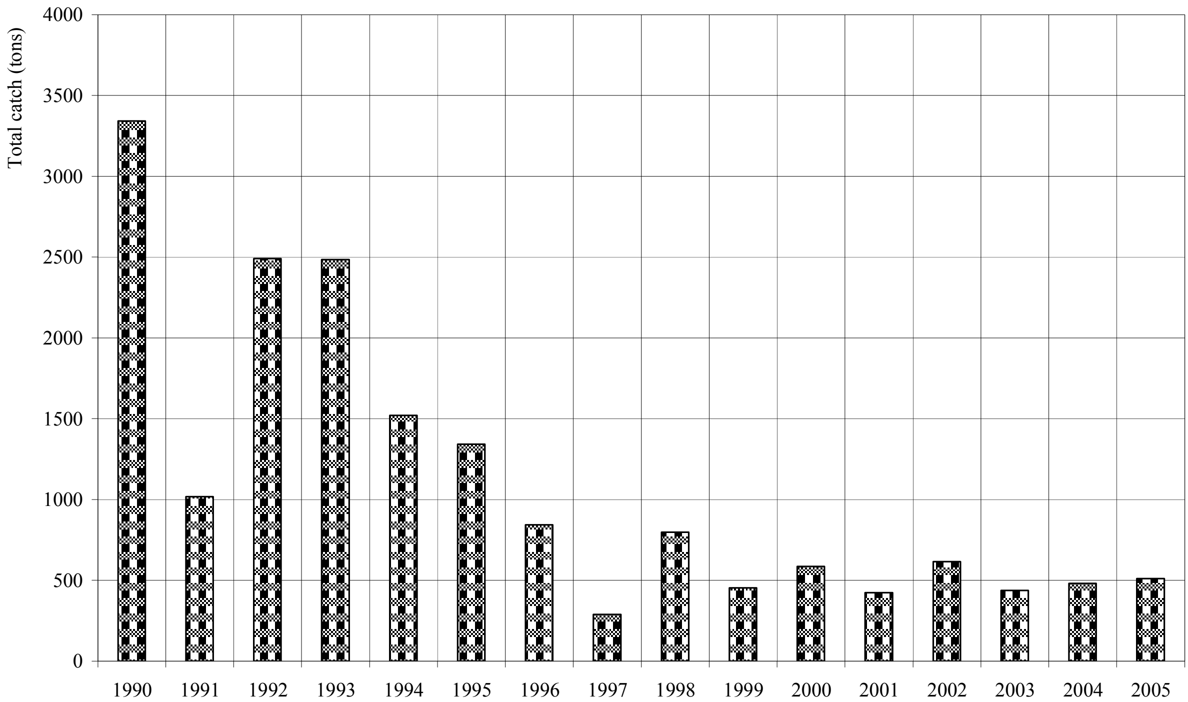

Figure 2. The total catch (tons) achieved with fixed gears, during 1990 - 2005.

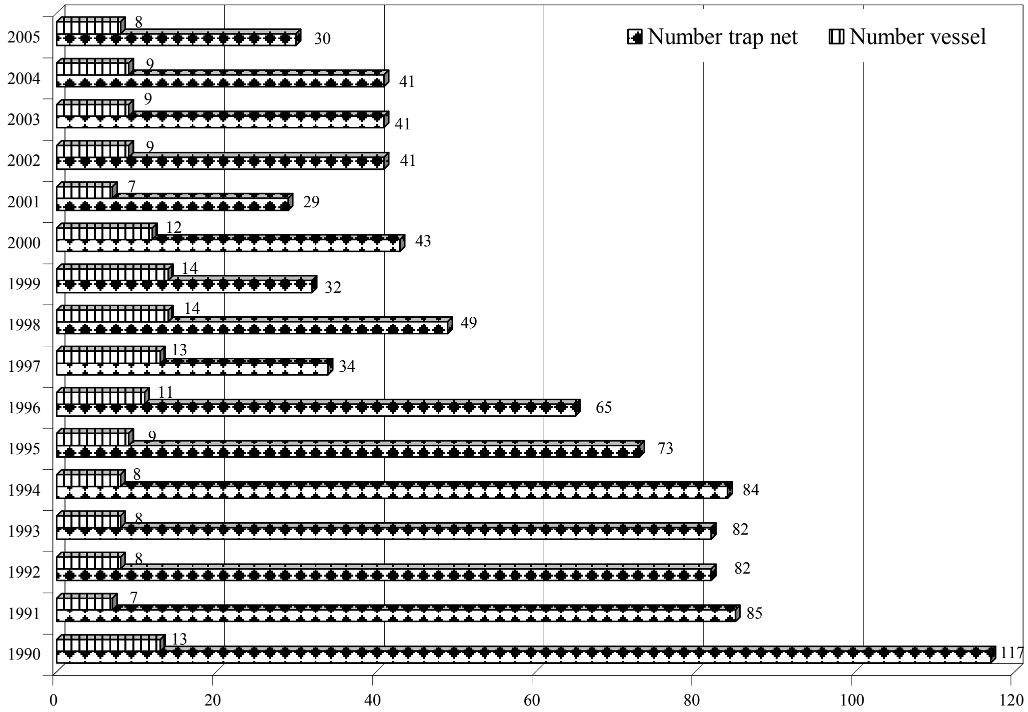

Figure 3. The fishing effort achieved in the fishing with fixed and active gears, 1990 - 2005.

At the fishing with fixed gears, the catches registered values of 2.500-3.000 tons in 1990, 1992 and 1993, and smaller then 1.000 tons in the rest of years (Figure 2).

In 1990 - 2005, during the eight months of activity (March - October), the Romanian coastal trawlers obtained different catches, determined both by fishing effort (number of vessels, effective days of fishing, number of hauling and hours of hauling) as well as on the evolution of hydro-meteorological conditions, status of fishing species (sprat and whiting) and market offer (Figures 3 and 4). Only in 1997 and 1998 the catches were of 3.500 tons, in the rest of years only 2.000 tons (Figure 4).

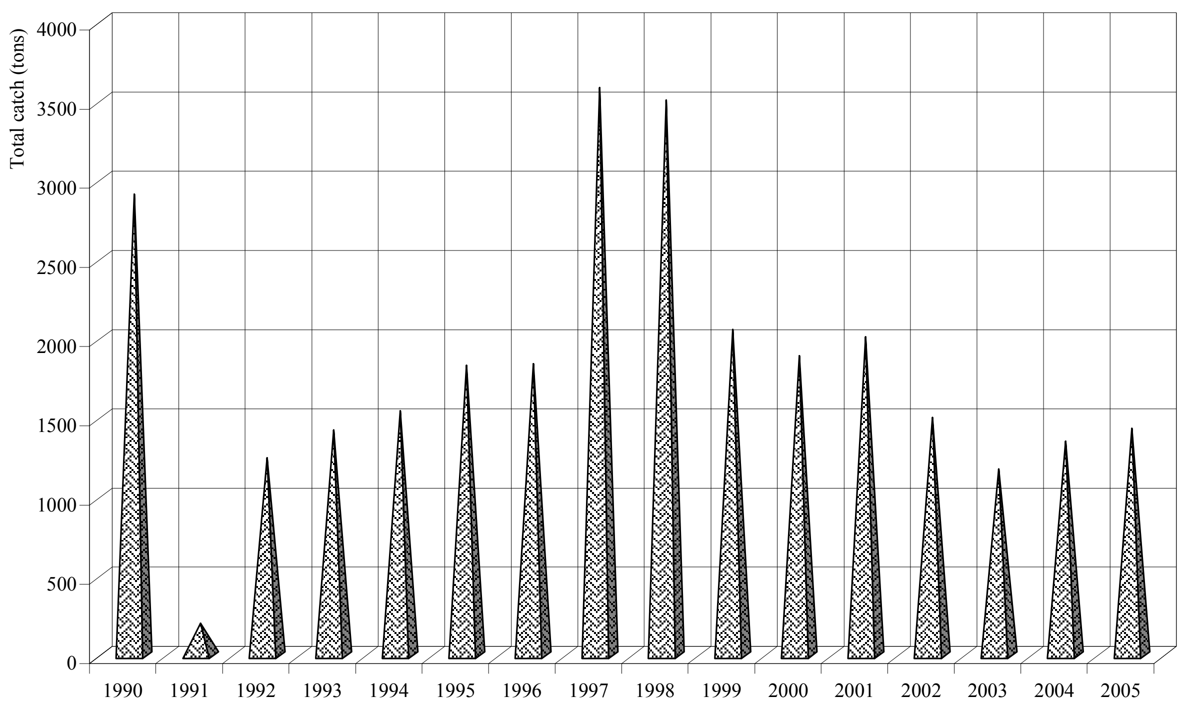

Figure 4. The total catch (tons) achieved in the fishing with actively gears, during 1990 - 2005.

During this period, the fishing with actively gears had the same characteristics. Thus, during the first three months (March - May), the fishing of coastal vessels was concentrated in the southern sector (Mangalia - Vama Veche), where a specialized fishing of sprat (found in the spawning period) was developed on 30 - 70 m depths. Once with the passing toward the warm season and displacement of the sprat shoals toward North in searching food, the area of vessels activity was gradually extended also toward North, up to South of Sf.Gheorghe, where the fishing was developed on 20 - 70 m depths, depending on the available agglomerations with trawlers.

Composition in species of catches

The main characteristic of fish catches obtained at the Romanian littoral was the presence of a high number of species (more then 20), the small-sized species being the basic ones. The valuable species were also present but in reduced quantities (turbot, sturgeons, pontic shad, mackerel, grey mullet, bluefish); atlantic mackerel and atlantic bonito almost disappeared (Figure 5).

Over the whole fishing period with fixed gears (April - September), almost 20 species were present, the main caught species being: anchovy (34.2 - 44.0%), whiting (9.2 - 25.1%), sprat (9.0 - 16.6%), caspian shad (5.2 - 13.2%), sand smelt (6.8 - 7.3%) and gobies (5.8 - 7.0%) (Figure 6).

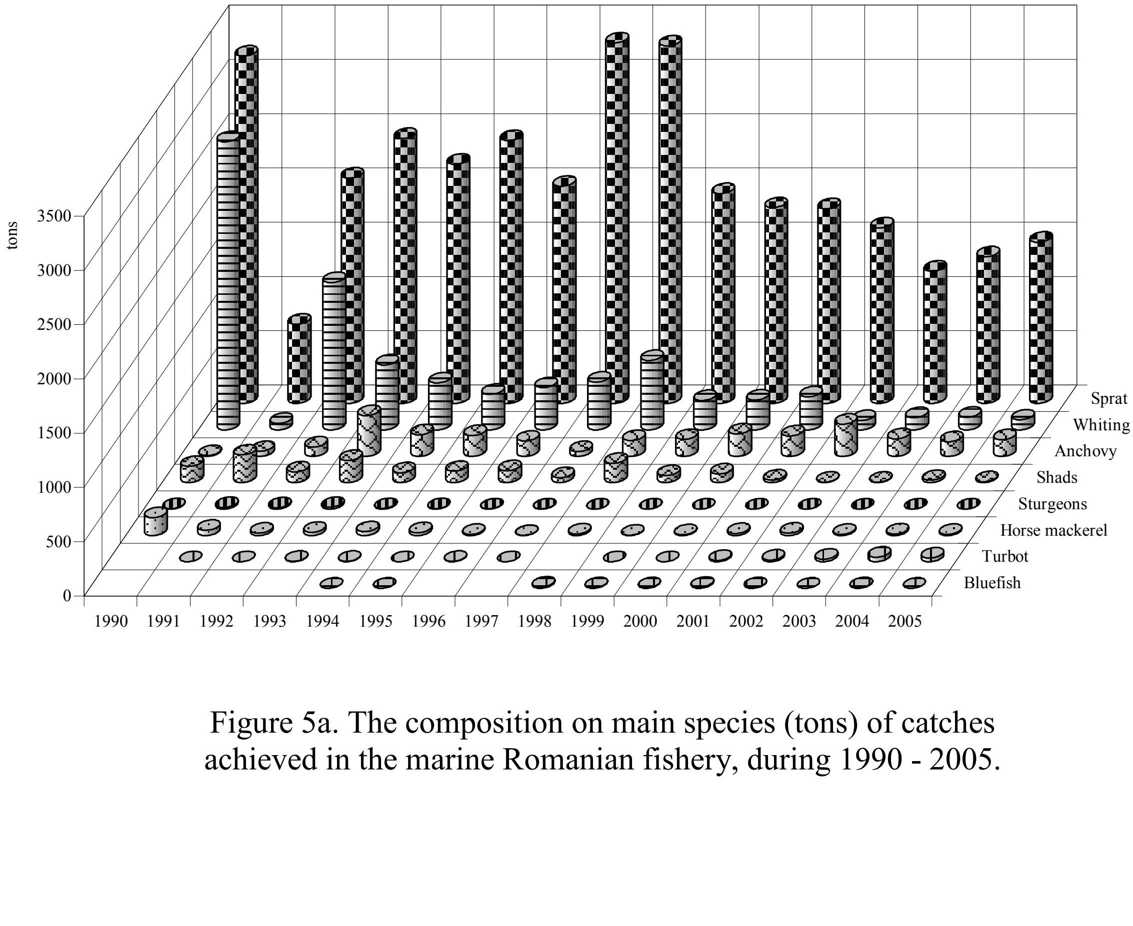

Figure 5a. The composition on main species (tons) of catches achieved in the marine Romanian fishery, during 1990 - 2005.

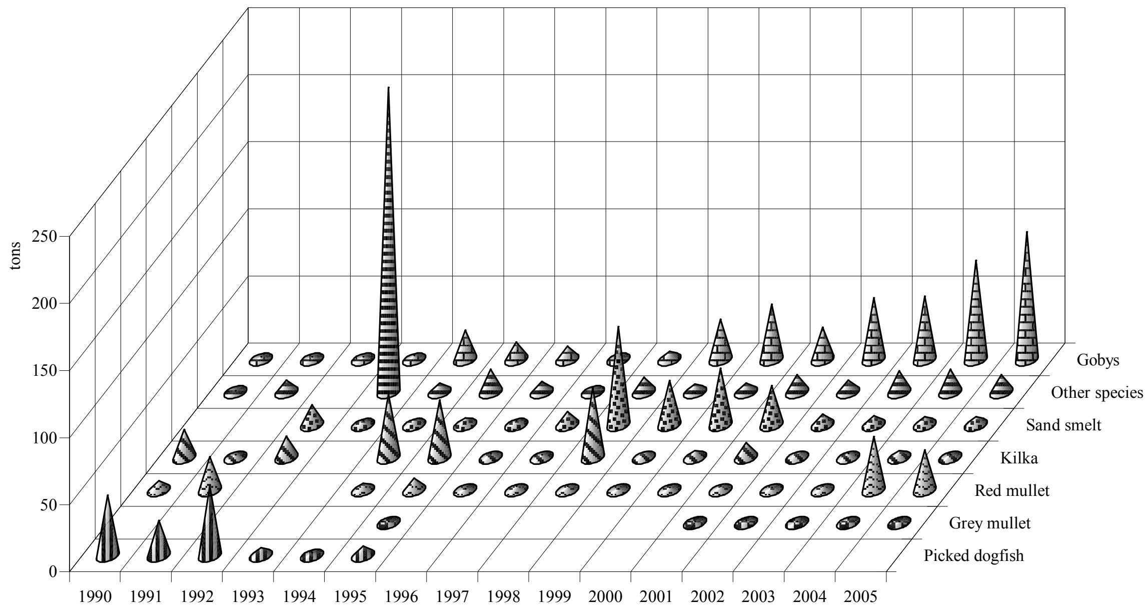

Figure 5b. The composition on main species (tons) of catches achieved in the marine Romanian fishery, during 1990 - 2005.

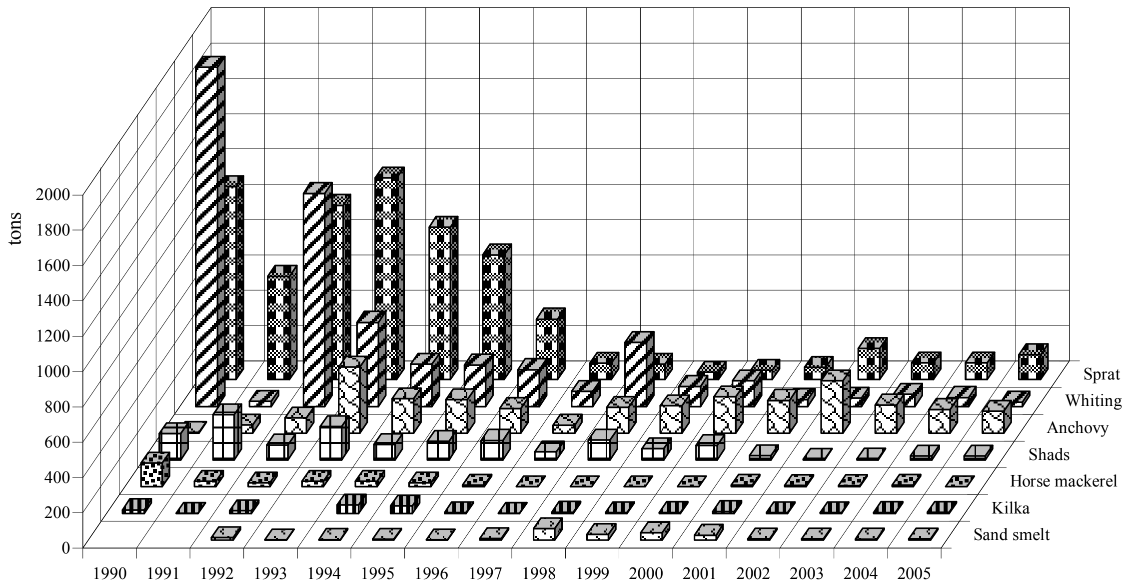

Figure 6a. The composition on main species (tons) of catches achieved on fixed gears, the marine Romanian fishery, during 1990 - 2005.

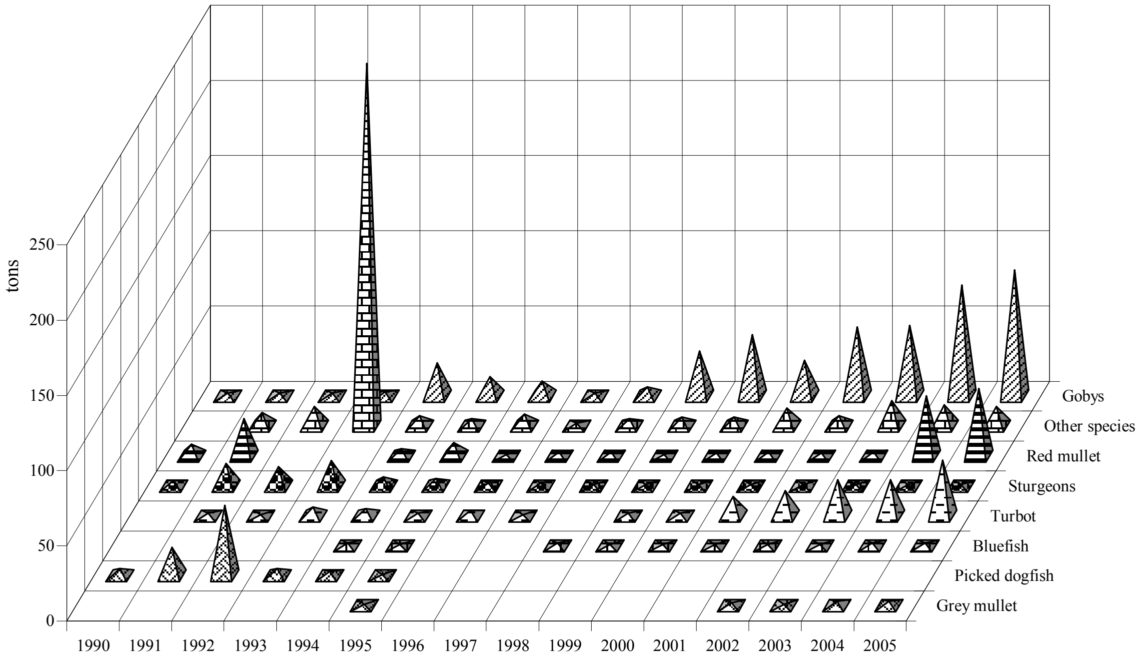

Figure 6b. The composition on main species (tons) of catches achieved on fixed gears, the marine Romanian fishery, during 1990 - 2005.

The basic species in the fishing performed with actively gears was the sprat, representing 85.7 - 92.7% from the annual total catch; the whiting (6.9 - 7.8%), and incidentally mackerel and bluefish, have been occurred toward the end of fishing season (September - October) (Figure 7).

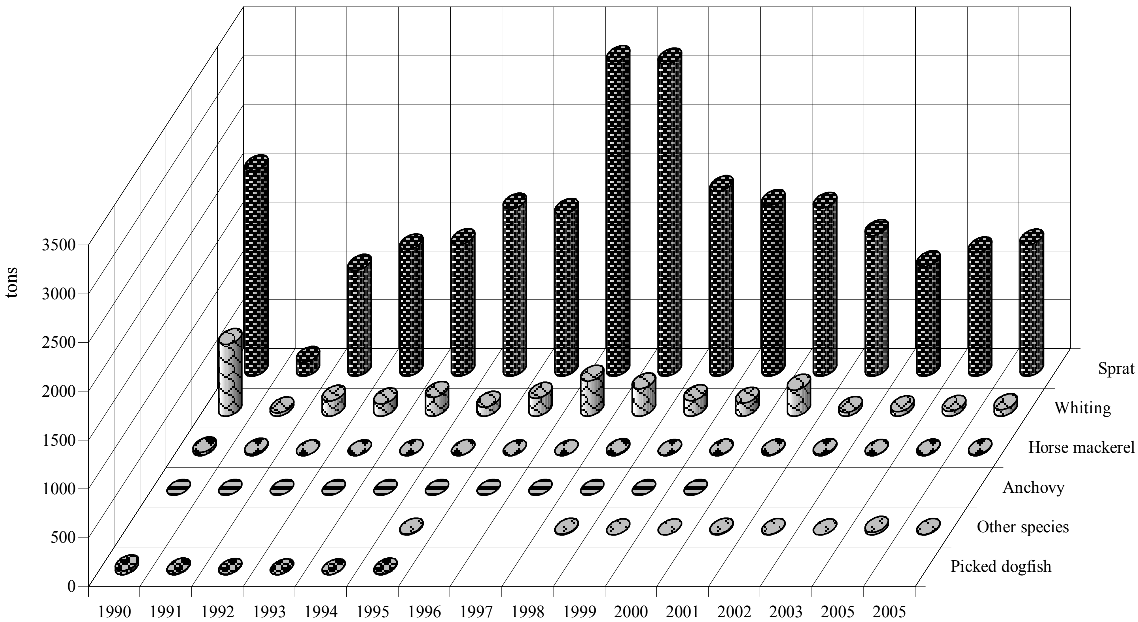

Figure 7. The composition on main species (tons) of catches achieved with actively gears, at the marine Romanian fishery, during 1990 - 2005.

Biological parameters of main commercially exploited fish.

Analyzing the main biological parameters of the fish occurred in catches, a slightly increasing tendency of share of higher length classes was noted (Table 1).

Table 1. The main biological parameters of the fish species caught between 1990 and 2005.

Species	Amplitude length (mm)	Prevailing classes (mm)	Mean length (mm)	Mean weight (g)	Prevailing age (years)
Sprattus sprattus	55-125	70-100	86.83	3.84-3.95	2;2+/3;3+
Engraulis encrasicolus	60-160	95-130	110.09	8.15	
Merlangius merlangus euxinus	55-200	65-155	113.01	14.91	1;1+/2;2+
Trachurus mediterraneus ponticus	55-175	95-140	111.30	8.55-19.92	1;1+/2;2+
Neogobius melanostomus	90-170	110-140	113.40	24.04-32.93	-
Clupeonella cultriventris	45-85	50-65	63.70	1.85-2.5	-
Atherina boyeri	50-135	80-95	78.07	3.43-4.57	-
Alosa caspia nordmanni	130-270	210-260	227.50	90.52	3;3+
Mugil cephalus	80-220	145-170	146.51	33.26	-
Mullus barbatus	60-125	75-105	87.67	7.91	-
Pomatomus saltatrix	125-200	150-170	116.1	45.63	-

Actual stocks status of main commercial interested fish species

Tables 2 and 3 give the assessed values of stocks and TAC (total admissible catch) for main fishing species.

Table 2. The values of stocks (tons) of main fish species from the Romanian marine sector.

Species	Stocks							
	1998	1999	2000	2001	2002	2003	2004	2005
Sprat	40.000	45.000	35.000	35.000	30.000	45.000	45.000	45.000
Whiting	15.000	15.000	10.000	11.000	10.000	8.000	8.000	8.000
Anchovy	11.000	20.000	10.000	15.000	20.000	19.000	19.000	19.000
Horse mackerel	-	-	-	500	600	400	400	400
Caspian shad	400	380	450	350	300	100	100	100
Sand smelt	-	-	-	450	400	-	-	-
Gobies	-	-	-	800	950	600	600	600
Turbot	-	-	-	800	1.000	1.066	1.066	1.066
Picked dogfish	-	-	-	950	1.100	1.650	1.650	1.650

Table 3. TAC (total admissible catch) values for main fish species from the Romanian marine sector.

Species	TAC (tons)					
	2000	2001	2002	2003	2004	2005
Sprat	10.000	10.000	10.000	10.000	10.000	10.000
Whiting	1.000	1.000	1.000	1.000	1.000	1.000
Anchovy	2.000	2.000	2.000	2.000	2.000	2.000
Horse mackerel	100	100	100	100	100	100
Caspian shad	50	50	50	50	50	50
Sand smelt	100	100	100	100	100	100
Gobies	100	100	100	100	100	100
Turbot	100	100	100	50	50	50
Picked dogfish	100	100	100	50	50	50

During the last years, biomass of stocks shows that the sprat (*Sprattus sprattus*) and whiting (*Merlangus merlangus euxinus*) presented fluctuations natural almost normal, and a relatively good effective, namely 45.000 and 8.000 tons respectively.

The anchovy (*Engraulis encrasicolus*) exhibited a tendency of rehabilitation of its stocks; for mackerel (*Trachurus mediterraneus ponticus*), bluefish (*Pomatomus saltatrix*) and grey mullet (*Mugil cephalus*) this rehabilitation presents a slighter rhythm.

Psetta maeotica (turbot) - its stock was affected both by un-controlled fishing and also by hypoxia, which accompanied the algal blooms. Its eggs and larvae were found especially in April and May, with a slow tendency of rehabilitation up to 1996. In the next years, the abundance values would decrease again, occurring very rarely in samples.

Mullus barbatus ponticus (red mullet) - exhibited oscillating catches, but after 1991 its contribution in total catch was significantly reduced; in the last two years, *Mullus* formed fishing shoals in the areas of activity of traps net. As the evolution of structure on length classes demonstrates, the population of *Mullus* is getting restored.

Squalus acanthias (picked dogfish) shows an obviously tendency of decrease of its stocks; this situation being mirrored in the values of its catch. Like for turbot, a special program of stock assessment is necessary.

Gobiidae Family (gobies) has the stocks in a relative good status, despite the mortalities produced in the years running with overwhelming algal blooms. Populations of Gobies are found in a relatively stable balance, with fluctuations produced only by the environmental conditions.

Acipenseridae Family (sturgeons) has the stocks heavy affected by the over-fishing and hydro-technical works carried out during its reproduction habitats. From the field observations, especially from the sample hauling performed during the research, the presence of only juveniles pertaining to starry sturgeon and beluga was noted; the rest of Acipenseridae have completely absented. For knowledge of real status of sturgeons, a complex program of assessment is requested, comprising both the marine and also the fluvial part. As a precautionary approaching in management of this family, the fishing of them, especially during the spawning season, must be banned.

Comparing the TACs values and obtained catches, the conclusion is that the annual quantity caught in the Romanian marine sector did not exceed the biological limits for the main species.

CONCLUSIONS

From the huge volume of data obtained in the Romanian marine sector between 1990 and 2005 on the main economically important fish species, the following aspects can be evinced:

- the agglomerations of main fishing species from the whole Romanian littoral, both at traps net, on 3 -11 m depths, and also in the area of trawlers activity, on 20 - 68 m depths, had a non-uniform distribution; some changes of fish species behavior was noted, a stressed dynamism of the fishing agglomerations which tend to move away by the shores;
- in the fishery with fixed gears, the traditional species (anchovy, whiting, caspian shad, sprat, sand smelt, gobies) have been prevailed, besides them a great number of other species occurred, but the sprat had the dominant species (more then 90%), in the fishing with actively gears, followed by whiting and other species (anchovy, mackerel and bluefish);
- in the catches obtained at traps net, the anchovy keeps having an increased weight, but the valuable species (sturgeons, turbot, dog fish, garfish, mackerel, grey mullet and bluefish maintained a dropped level;
- all the analyzed species presented a slight tendency of increasing of higher length classes shares in the catches, which mean a mitigation of pressure exerted by the fishing activity;
- the status of stocks for main commercially interested fish species from the Romanian marine sector was different enough, with an obviously tendency of restoration for anchovy stocks, a slightly restoration for bluefish, grey mullet and mackerel; the sprat and whiting were the only ones species presenting a natural almost normal fluctuation, and a good effective;
- the stocks decrease of some valuable species, such as anchovy and mackerel, during the last decade, led to the increasing in pressure through fishing on the sprat and whiting. However, the stocks size of these populations did not diminish, their chance being the fact that these species did not make dense agglomerations, and did not constitute the target of some fishing gears with great output, such as the purse seines.

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AUTHORS:

[1] *Ionel STAICU*
eradu@alpha.rmri.ro
[2] *Elena RADU*
elena_radu2005@yahoo.fr
[3] *Gheorghe RADU*
gpr@alpha.rmri.ro
[4] *Vasile MAXIMOV*
maxi@alpha.rmri.ro
[5] *Eugen ANTON*
eanton@alpha.rmri.ro
National Institute for
Marine Research and Development
"Grigore Antipa" Constanța,
Mamaia Bd., no. 300,
Constanța 3, Constanța County, Romania,
RO - 900581.

PRELIMINARY STUDY CONCERNING THE ROLE OF THE BENTHIC POLYCHAETES IN THE FEEDING OF SOME FISH SPECIES FROM THE ROMANIAN COAST OF THE BLACK SEA

Victor SURUGIU

KEYWORDS: gastrointestinal content, trophic spectrum, nutrition coefficient, Polychaeta.

ABSTRACT

The purpose of this paper is to investigate the importance of the polychaetes in the nutrition of fishes from Romanian Black Sea coast. The analysis of the gastrointestinal content of 18 species of fish showed that polychaetes, in different stages of digestion, were present in the food of 14 species. The most frequent polychaete species found in the stomach of fish were *Neanthes succinea* and *Platynereis dumerilii*, which are the most common species at the Romanian seacoast.

Polychaetes play an important role in the feeding of benthophagic fishes such as the Pontic horse mackerel, the whiting, the mushroom goby, the snouted sole, the common stingray, the European flounder and the spiny dogfish.

Polychaetes are also intensely consumed during the swarming of the epitokous forms of these worms, which rises into the water column, by some planktophagic fish species, such as the anchovy and the Boyer's sand smelt.

REZUMAT: Studiu preliminar privind rolul polichetelor bentonice în nutriția unor specii de pești de la litoralul românesc al Mării Negre.

Scopul acestei lucrări constă în stabilirea importanței polichetelor în hrănirea peştilor de la litoralul românesc al Mării Negre. În urma analizei conținutului stomacal la 18 specii de peşti colectate în zona Agigea, s-a constatat că 14 dintre acestea prezentau polichete în diferite stadii de digestie. În mod obişnuit, proporția cea mai însemnată în dieta peştilor o au speciile de masă de polichete, ca *Neanthes succinea* şi *Platynereis dumerilii*.

Polichetele joacă un rol considerabil în alimentația speciilor bentofage de peşti cum ar fi stavridul, bacaliarul, guvidul de mare, limba de mare, pisica de mare, cambula şi câinele de mare.

De asemenea, polichetele bentonice sunt intens consumate în timpul roirii formelor epitoce de polichete, care urcă pentru reproducere în masa apei, de către unii peşti planctonofagi, ca de exemplu hamsia şi aterina.

RESUME: Etude préliminaire concernant le rôle des Annélides Polychètes dans la nutrition des quelques espèces de poissons de la côte roumaine de la mer Noire.

Le but du présent travail est d'établir l'importance des Annélides Polychètes dans la nourriture des poissons du littoral roumain de la mer Noire. L'analyse du contenu stomacal de 18 espèces de poissons à révélé la présence de Polychètes chez 14 espèces. Les Polychètes les plus fréquents dans l'estomac des poissons étaient *Neanthes succinea* et *Platynereis dumerilii*, les espèces les plus communes du littoral roumain de la mer Noire.

Les Annélides Polychètes jouent un rôle considérable dans la nourriture de poissons benthiques, comme le chinchard, le merlan commun, les gobies, la petite sole, le flet, la pasténague commune et l'aiguillat commun.

De plus, les Annélides Polychètes sont intensivement consommés par quelques poissons planctonophages, comme l'anchois et l'athérine. pendant l'essaimage des formes épitoques des Polychètes, qui montent dans la masse d'eau lors de la reproduction.

INTRODUCTION

Polychaeta is one of the major groups of benthic invertebrates which play an important role in the energy flow at the level of the sea floor (Fauchald, 1977; Hutchings, 1998). The researches undertaken in the Black Sea area show, that with regard to the species number, the polychaetes occupy the second place after that one of the crustaceans (Marinov, 1977). The extremely wide ecological adaptations of the polychaetes group contributed to the fact that the sea worms inhabit all the benthic habitats. The population densities reached by the polychaetes (30.2% of the total abundance of the macrozoobenthos) make them as an important component of all benthic communities, in some cases these having the leading role (e. g. in the biocoenosis of silts with *Terebellides*, in biocoenosis of silts with *Melinna*, in the pre-deltaic enclaves with *Nephtys* etc.). With the respect to the participation of polychaetes to the total biomasses of the macrozoobenthos, this is of 18.6%, placing them on the second place after the molluscs (Băcescu et al., 1971).

All the facts mentioned above indicate the fact that the polychaetes represent one of the main trophic resources of the fish fauna, thus having an indirect importance for the human's economy. Polychaetes are characterised by a relatively high caloric content, being integrally ingested and digested (undigested remains of their bodies are only the cuticle, seta, jaws and paragnaths). The scientific studies shows that energetic value of the polychaetes represent in average 21.1 $J \cdot mg^{-1}$ ash free dry substance (Kisseleva, 2004). According to another study made by Stepaniuk (1967), *Hediste diversicolor* from the north-western part of the Black Sea contains 84.3% water and 11.7% ash. Of the dry substance proteins represent 40.3%, fats 14.8% and carbohydrates 33.4%. This group species has also a high content of free amino acids - 976.5% mg of the wet weight. Also, the proportion of indispensable amino acids represents 49.9% of the total amino acids, which confirms again the high nutritional value of the polychaetes. Of smaller nutritional value are the tubicolous species of polychaetes (ampharetids, pectinriids, sabellids, serpulids or spirorbids) and those species whose digestive tract is full of swallowed sand or silt (capitellids and opheliids).

The pelagic larvae of the polychaetes belonging to the nereidids and spionids, alongside with the pelagic crustaceans, enters in the composition of food of the most common planktophagic fish species such as the anchovy *Engraulis encrasicolus ponticus* and the sprat *Sprattus sprattus phalericus* (Vinogradov, 1948; Băcescu et al., 1965b; Marinov, 1977; Kisseleva, 2004).

A much higher participation in the nutrition of fish had the adult polychaetes individuals. The researches employed to this respect shows the fact that these individuals are consumed by almost all benthophagic fishes (Vinogradov, 1949; Kaneva-Abadzhieva and Marinov, 1960, 1961, 1963; Karapetikova, 1962; Peshev, 1964). An important place in the food of adult sturgeons from the north-western part of the Black Sea is occupied by the polychaetes *Nephtys hombergii*, *Melinna palmata* and *Spio decoratus* (Vinogradov, 1948; Losovskaya, 1956; Dragoli, 1960, 1962; Băcescu et al., 1965b).

These establishments determined some of the researchers to attempt measures of acclimatization of polychaetes in some water bodies in order to enrich their nutritional base. Thus, in the 1939 - 1940 period the polychaete *Hediste diversicolor* from the Azov Sea, misidentified as *Neanthes succinea* (Hartman, 1960; Khlebovich, 1963), was introduced into the Caspian Sea area in order to augment the regional food resources for the sturgeons from this sea. The species naturalized itself and beginning from 1945 the populations of this polychaete in the northern part of the Caspian Sea area increased considerably, being in the present an important component of the food of Caspian sturgeons (Birstein, 1952, 1956; Sokolova, 1952). In 1960 the Russian scientists succeeded the acclimatization of this species into the Lake Aral area (Kortunova, 1968, cited by Manoleli, 1988) and in 1962 the Caspian ampharetids *Hypania invalida* and *Hypaniola kowalewskii* were transferred into the Lake Balkhash, were they also survived (Vorobiova, 1967, cited also by Manoleli, 1988).

In the Romanian scientific literature there are no special studies regarding the use of some polychaetes as food for fish. Some data regarding the participation of polychaetes individuals in nutrition of some fish species from the Romanian coast of the Black Sea can be found in the papers of Băcescu and Dumitrescu (1958), Porumb (1961, 1965, 1968), Bănărescu (1964) and also Băcescu et al. (1957, 1965a, 1965b, 1967).

The purpose of this study is: (1) to identify the fish species that nourish on polychaetes, (2) to establish the qualitative composition of the food of fishes which consumes polychaetes and (3) to establish the importance of polychaetes in the feeding of analysed fish species.

MATERIALS AND METHODS

The material for the present study was collected in June - July 2000 period with the passive fishing gear ("talian") placed in the Agigea locality area. Some additional biologic material was obtained with the fishing line.

The fish individuals collected were sorted by species, measured and weighted in order to establish theire size classes. After that each fish specimen was dissected and the gastrointestinal tract was extracted and fixed in 4% formalin solution. In the laboratory the digestive tracts were dissected, in their turn, and the alimentary bolus was weighted with an analytical scale with the sensitivity of 0.0001 grams. The alimentary bolus was transferred to Petri dishes, sorted and identified under the stereomicroscope. The number of identifiable polychaete individuals from each species per each fish stomach was counted. The number of empty fish stomachs was also noted. The identified organisms or fragments of organisms from each fish gastrointestinal tract were weighted separately and preserved in 70% alcohol.

For statistical interpretation of data the frequency index (F %) was calculated. This represents the ratio between the number of stomach in which the polychaete species were present and the total number of stomach analysed.

The nutritional preferences of each fish species was marked out by the calculation of the proportion of weight of each group ingested (p_i) to the total weight of the gastrointestinal content.

The degree of filling of gastrointestinal tracts was estimated by the calculation of the partial nutrition coefficient (C_H) according to the following formula:

$$C_H = \frac{G_S}{G_P} \cdot 10000$$

were: C_H - nutrition coefficient; G_S - the weight of the polychaetes from the gastrointestinal content; G_P - the weight of the fish.

For each fish species was calculated the range of the partial nutrition coefficient and its mean.

RESULTS AND DISCUSSIONS

In total were analysed the gastrointestinal contents of 428 specimens belonging to 18 fish species (Table 1). Polychaetes, in different stages of digestion, were identified in stomachs of 14 species of fish. However, the number of polychaete species that participates in the diet of fish proved to be very small. The most abundant and most frequent polychaetes found in the stomach of fish were *Neanthes succinea* and *Platynereis dumerilii*, which are the commonest species recorded at the Romanian coast of the Black Sea (Surugiu, 2002). Because the action of gastric enzymes continues even after the death of fishes (Reys, 1960) and because of the impossibility to analyse immediately the gastrointestinal content of the fish collected, the small-bodied polychaetes were absent in our study. We suppose that small polychaete species are digested within 4 - 5 hours, which was the time elapsed between the catching and the preservation of the stomachs. However, the literature data indicates that small polychaete species have an important contribution in the feeding of fish (Marinov, 1977).

Despite the fact that the Pontic anchovy (*Engraulis encrasicolus ponticus*) is known to nourish exclusively on plankton and especially on zooplankton (Bănărescu, 1964), this study proved that this species also feeds on polychaetes (Table 1). The frequency of polychaetes found in the stomach of anchovy was of 81%. At this fish species the polychaetes made up 52% of the total ingested food (Figure 1). Pontic anchovy also presented the highest values of the partial nutrition coefficient, which in some cases reached 569.83. This is due to the fact that at this species was observed the highest number of individuals of polychaetes per stomach. Thus, in the stomach of one specimen of anchovy of 12 cm length and 20 g weight were counted no less than 51 individuals of *Neanthes succinea*. The high proportion of this worm in the food of anchovy could be explained by the swarming of the heteronereid forms that rises for reproduction into water column in May-June and August-September (Kisseleva, 2004), i.e. the same period in which the fishes for the present study were collected. Similar observations were made by Stark (1959) for the populations of *Neanthes succinea* from Azov Sea. According to this author, in the years with weak development of zooplankton, this polychaete represents up to 50 - 60% of the diet of the anchovy.

Table 1. List of the fish species analysed: N - number of individuals, L - length (cm), m - weight (g), F - frequency coefficient (%), $C_{H\ max}$ - maximum value of the partial nutrition coefficient, $C_{H\ mean}$ - average value of the partial nutrition coefficient, + - polychaetes present, but not counted due to advanced degree of digestion.

Fish species	N	L (cm)	m (g)	F (%)	$C_{H\ max}$	$C_{H\ mean}$
Engraulis encrasicolus ponticus Aleksandrov, 1927	157	10.0-14.5	8-40	81	569.83	162.04
Trachurus mediterraneus ponticus Aleev, 1956	51	9.8-18.0	15-75	88	406.89	112.72
Atherina boyeri pontica Eichwald, 1831	50	7.9-10.4	5-16	28	322.25	75.98
Neogobius cephalarges (Pallas, 1811)	48	12.6-18.6	30-70	29	0.84	0.81
Sprattus sprattus phalericus (Risso, 1826)	43	6.7-8.6	4-5	-	-	-
Mullus barbatus ponticus Essipov, 1927	22	10.2-17	10-80	-	-	-

Fish species	N	L (cm)	m (g)	F (%)	$C_{H\ max}$	$C_{H\ mean}$
Neogobius melanostomus (Pallas, 1811)	15	12.2-16.4	30-80	-	-	-
Solea lascaris (Risso, 1810)	12	14.0-20.0	30-80	33	2.23	0.50
Merlangus merlangus euxinus (Nordmann, 1840)	12	13.0-15.5	20-50	33	+	+
Squalus acanthias L., 1758	6	32.0-39.5	110-280	16.7	0.03	0.19
Scorpaena porcus L., 1758	2	17-17.5	115-130	50	+	+
Gaidropsarus mediterraneus (L., 1758)	2	20-27	100-205	50	+	+
Sardina pilchardus (Walbaum, 1792)	2	12.3-13.3	19-20	50	+	+
Psetta maxima maeotica (Pallas, 1811)	2	40.0-52.0	1000-2000	50	+	+
Alosa caspia nordmanni Antipa, 1906	1	19.5	50	-	-	-
Dasyatis pastinaca (L., 1758)	1	47	580	+	2.59	2.59
Alosa pontica pontica (Eichwald, 1838)	1	19.6	55	+	+	+
Platichthys flesus luscus (Pallas, 1811)	1	21.9	100	+	+	+

The most diversified food was recorded at Pontic horse mackerel (*Trachurus mediterraneus ponticus*), in the stomach of which were identified 3 species of polychaetes (*Neanthes succinea*, *Platynereis dumerilii* and *Nephtys hombergii*).

At this species was found the highest frequency of stomachs in which polychaetes were found (88%).

The mean of the partial nutrition coefficient at this species was of 112.72 and the maximum value of 406.89.

The elevated nutrition coefficient as well as very high frequency indicates that these play a very important role in the nutrition of this fish species.

The majority of stomachs of specimens of horse mackerel were practically cram-full with polychaetes, in a single stomach being counted up to 43 individuals of *Neanthes succinea*. Pora et al. (1956) found that the diet of horse mackerel was composed mostly of other fish (60 - 91%) and crustaceans (7 - 33%), the polychaetes and planktonic algae playing a secondary role. In our study, however, the polychaetes ranked first, representing 66% of the stomach content volume (Figure 2).

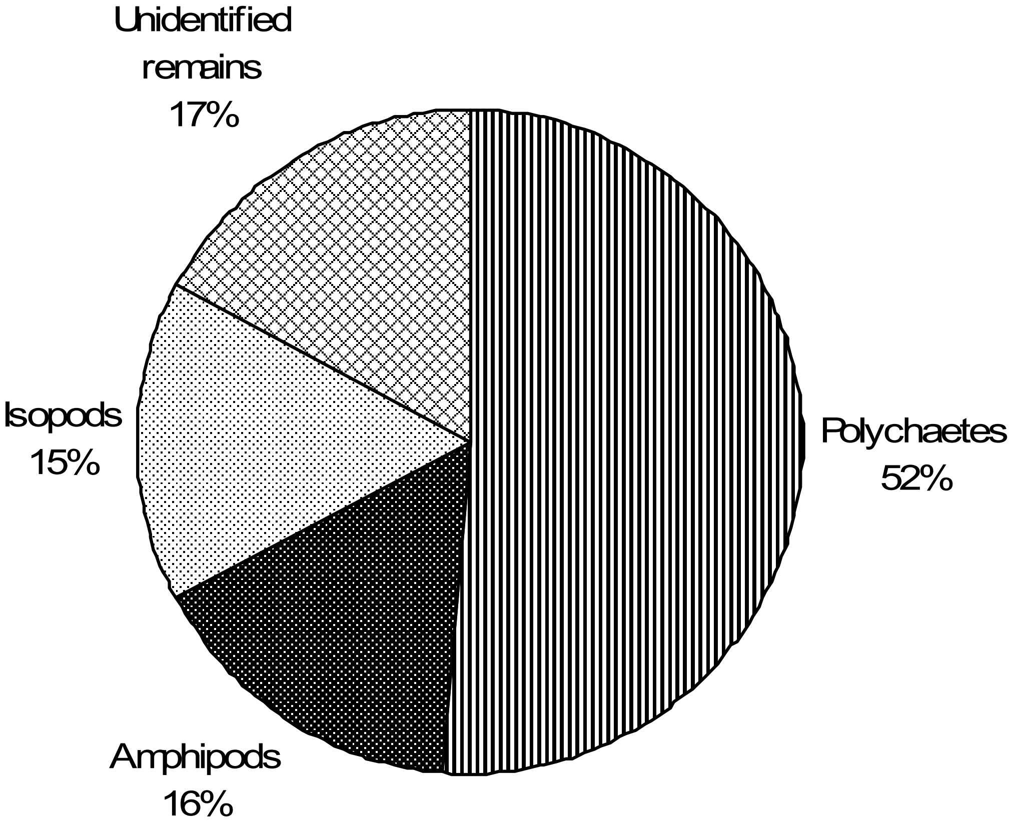

Figure 2. The trophic spectrum of the Pontic horse mackerel
(*Trachurus mediterraneus ponticus*).

At the Boyer's sand smelt (*Atherina boyeri pontica*, syn. *Atherina mochon pontica*) polychaetes made up 68% of the stomach content (Figure 3). However, the frequency of polychaetes in the food of this fish is only of 28% (Table 1). In the food of silversides predominated *Neanthes succinea*, reached a mean partial nutrition coefficient of 75.98.

Despite the fact that the literature sources indicates that in the Black Sea the red mullet (*Mullus barbatus ponticus*) has the most diversified specific composition of consumed polychaetes, Vinogradov (1948) reporting 15 species and Kaneva-Abadzhieva and Marinov (1960, 1961) 13 species, no polychaete species were found in the stomach of this species in the present study. However, Băcescu et al. (1965b) shows that at the mouths of Danube the red mullet feeds especially on *Spio decoratus*, which represents from 1.3 to 11.5% of the total ingested food.

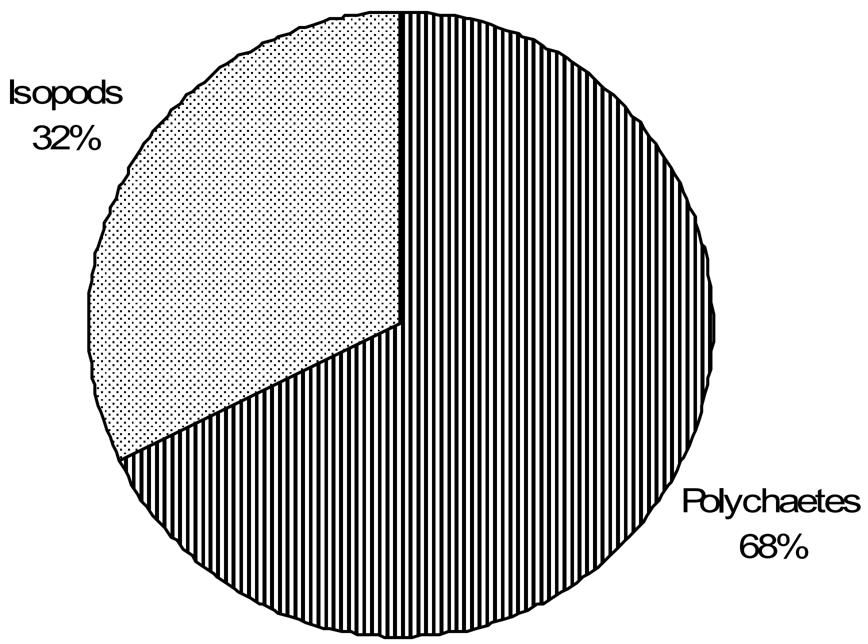

Figure 3. The trophic spectrum of the silverside (*Atherina mochon pontica*).

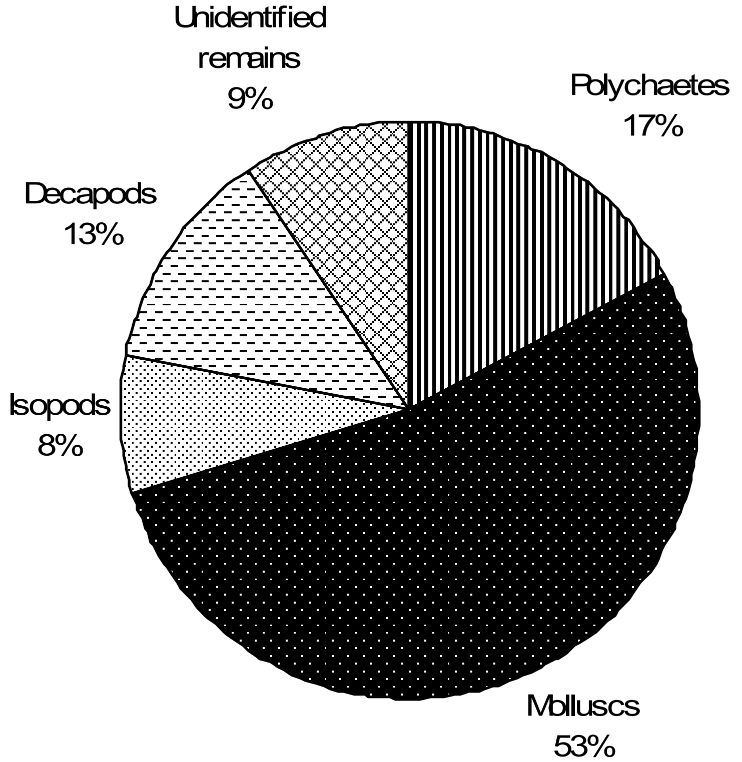

Figure 4. The trophic spectrum of the mushroom goby (*Neogobius cephalarges*).

In the food of the snouted sole (*Solea nasuta*) the participation of polychaetes was insignificant, the maximal value of the nutrition coefficient being of 2.23 (Table 1). The polychaetes, represented only by *Neanthes succinea*, were found in 33% of the cases at this fish. Băcescu et al. (1967) indicates that at Mamaia the sole feeds on *Spio decoratus*, which represents 30 - 50% of the stomach content volume. At southern coast of Crimea Vinogradov (1948) have identified in the stomach of the snouted sole 5 polychaete species (*Sthenelais boa*, *Nereis zonata*, *Glycera tridactyla*, *Lysidice ninetta* and *Heteromastus filiformis*).

At spiny dogfish (*Squalus acanthias*) only 16.7% of the analysed stomachs contained polychaetes, the nutrition coefficient being of only 0.19 (Table 1).

The stomach of the single individual of the common stingray (*Dasyatis pastinaca*), of 47 cm length and 580 g weight, contained 13 individuals of *Neanthes succinea*, with the nutrition coefficient of 2.59 (Table 1).

Polychaetes are also consumed to a certain extent by whiting (*Merlangus merlangus euxinus*), one third of the analysed stomach containing undigested remains of polychaetes (jaws and aciculae).

Polychaetes are also consumed by the European flounder (*Platichthys flesus luscus*). In the stomach of the single individual of flounder captured, of 22 cm length and 100 g weight were found only aciculae. According to Băcescu et al (1965a) in the food adults of flounder were frequently found *Arenicola marina*, *Nereis* spp., spionids and chaeta of various polychaetes. Flounder from the Razim Lagoon feed intensely on populations of *Hediste diversicolor* (Băcescu et al., 1971). At the Bulgarian coasts the flounder feeds especially on *Scolelepis squamata*, *Capitella giardi* and *Arenicola marina* (Kaneva - Abadzhieva and Marinov, 1960, 1961).

In the stomachs of two specimens of the Black Sea turbot (*Psetta maxima maeotica*), one of 40 cm length and 1 kg weight and the other of 52 cm length and 2 kg weight, the remains of seta and aciculae were found only in the former, confirming the data of Karapetikova (1962) and Bănărescu (1964) which stated that polychaetes are consumed especially by the juveniles of turbot, while in adults polychaetes constitute a complementary food. Similarly, Băcescu et al. (1967) showed that the participation of polychaetes in the composition of the food of Black Sea turbot is quite reduced, being of only 2.7 - 3.7% of the volume of the stomach content. According to this author, in the food of adults of turbot predominated isolated individuals of *Nephtys cirrosa* and *Arenicola marina*, while the juveniles contained numerous *Spio decoratus* specimens.

In that concern the nutritional spectrum of some representatives of the family Gobiidae, Porumb (1961) indicated that polychaetes have an important contribution in the feeding of the mushroom goby (*Neogobius melanostomus*) and the knout goby (*Mesogobius batrachocephalus*) only in spring, to a lesser extent in autumn and at all in the summer. This is why in our study was observed a much reduced participation comparatively to the data published by Porumb (1961) and Kaneva-Abadzhieva and Marinov (1963). In the stomach of the mushroom goby (*Neogobius cephalarges*) polychaetes were found in 28% of the cases (Table 1). They represented 17% of the total volume of the ingested food (Figure 4). The average nutrition coefficient of this species was of 0.81. Porumb (1961) reports for this species in the same area a partial nutrition coefficient of 2.77 - 17.23. In the food of the round goby (*Neogobius melanostomus*) polychaetes were completely absent.

Polychaetes were also found to a bigger or smaller extent in the stomach content of the small scaled scorpion fish (*Scorpaena porcus*), shore rockling (*Gaidropsarus mediterraneus*), Danube shad (*Alosa pontica pontica*) and European pilchard (*Sardina pilchardus*).

The importance of the polychaetes in the diet of some fish in the front of the Romanian seacoast is underlined by the fact that these represent a precious object for the amateur fishermen. Thus, *Hediste diversicolor* from the Tomis harbour and from the adjacent Modern beach and *Neanthes succinea* from the Gulf of Mangalia, known among fishermen as “sea worms”, are used as bait for fishing of the common grey mullet (*Mugil cephalus* L., 1758), golden grey mullet (*Liza aurata* Risso, 1810) and various gobies.

CONCLUSIONS

Polychaetes play a very important role in the food web and especially in the nutrition of fish species from the Romanian coast of the Black Sea.

Polychaetes, in different stages of digestion, were identified in the gastrointestinal content of 14 fish species, of the total 18 species analysed.

The most considerable proportion in the diet of fish had the most abundant and most frequent polychaete species encountered at the Romanian Black Sea coast, such as *Neanthes succinea* and *Platynereis dumerilii*.

Small polychaete species are very quickly and completely digested (within approximately 4 - 5 hours).

Among the benthophagic fishes which intensely consumes polychaetes at the Romanian littoral of the Black Sea the Pontic horse mackerel ranked first. In the food of this species polychaetes represented 66% of the total ingested food. At the mushroom goby polychaetes made up 17% of the diet. Polychaetes are preferred also by the whiting, the snouted sole, the common stingray, The European flounder and the spiny dogfish.

Polychaetes play an important role also in the food of some planktophagic fish species, such as the anchovy (52% of the ingested food) and the Boyer's sand smelt (68% of the stomach volume). These fishes feed intensely with polychaetes during the epitoky of nereidid species, which rises for reproduction into the water column.

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AUTHOR:

Victor SURUGIU
vsurugiu@uaic.ro
"Alexandru Ioan Cuza" University,
Faculty of Biology,
Department of Zoology and Ecology,
Carol I Bd., no. 20A,
Iaşi, Iaşi County, Romania,
RO - 4566378.

DATA CONCERNING THE FISH COMMUNITIES OF THE MOLDOVA RIVER (ROMANIA)

Bogdan VORNICU[1], *Grigore DAVIDEANU*[2] and *Ana DAVIDEANU*[2]

KEYWORDS: Ichthyofauna, fish ecology, Moldova River.

ABSTRACT

The paper presents the results of an ecological study on the Moldova River fish community. Using an electrofisher they were captured in 18 sample sites a number of 1951 fish specimens belonging to 17 species.

They were calculated a series of ecological metrics and indexes in order to assess the fish community structure. Based on this data we were able to conclude that fish community is still in good state, having a balanced ecological structure even they are some negative human impacts on the aquatic habitats. In the area they are present a series of protected fish species as: *Chondrostoma nasus, Alburnoides bipunctatus, Alburnus alburnus, Rhodeus amarus*, *Gobio uranoscopus*, *Barbus meridionalis, Cobitis taenia, Barbatula barbatula, Sabanejewia aurata* that are protected at European or national level.

REZUMAT: Date privind comunităţile piscicole ale râului Moldova (România).

Lucrarea prezintă rezultatele unui studiu ecologic al comunităţii piscicole din râul Moldova. Cu ajutorul unui electrofisher au fost capturaţi, în 18 staţii, un număr de 1951 peşti aparţinând la 17 specii.

Au fost calculaţi o serie de indici ecologici pentru a evalua structura comunităţii piscicole. Pe baza rezultatelor obţinute se poate concluziona că asociaţia piscicolă este într-o stare bună cu o structură ecologică echilibrată, chiar dacă se manifestă unele efecte negative ale impactului antropic asupra habitatelor acvatice. În zonă sunt prezente încă specii de peşti rare şi protejate: *Chondrostoma nasus, Alburnoides bipunctatus, Alburnus alburnus, Rhodeus amarus*, *Gobio uranoscopus*, *Barbus meridionalis, Cobitis taenia, Barbatula barbatula, Sabanejewia aurata* care sunt protejate la nivel European sau naţional.

RESUME: Données sur les communautés piscicoles de la riviere Moldova (Roumanie).

Ce travail presénte les résultats d'une étude écologique de la communauté piscicole de la rivière Moldova. Sur 18 stations échantillonnées par pêche électrique, 1951 poissons représentant 17 espèces ont été dénombrés.

L'évaluation de la structure de la communauté piscicole a été réalisée à l'aide d'indicateurs écologiques. Les résultats obtenus indiquent que le peuplement piscicole de cette région est en bon etat malgré l'impact negatif antropique sur le habitats aquatiques. Il y a encore dans cette région des espèces de poissons rares et protégées telles que *Chondrostoma nasus, Alburnoides bipunctatus, Alburnus alburnus, Rhodeus amarus*, *Gobio uranoscopus*, *Barbus meridionalis, Cobitis taenia, Barbatula barbatula, Sabanejewia aurata* qui sont protégées au niveau européen ou national.

INTRODUCTION

The study concerns a 170 km river section comprising the main course and the most important tributaries (Putna, Suha, Moldovița, Humor, Râşca, Ozana) of the Moldova River. Most of the sample sites have a similar look, the riverbed is 20 - 35 m wide, bottom is constituted of gravel, in some cases the flow is divided in 3 or more arms. The Pojorâta sites and the tributaries are narrow and due to accentuated slope the riverbed consists mainly of boulders.

The banks are natural in most of the cases, excepting the sites Roman and Gura Humorului where they was regularized and have flood protection dykes.

The riverbed is stable and constituted of boulders in between 25 - 250 mm and gravel 2.5 - 25 mm. In the upstream part they are also big rocks, downstream we may find sand, mud and clay.

The slope is in between $20^{o}/_{oo}$ at Putna and $5.8^{o}/_{oo}$ at Tupilați. The highest site is Putna site (781 m) and the lowest is Roman at 187m.

The vegetation is rather scarce, grasslands and bushes; we only find forested banks at Pojorâta. The whole river length was scattered with woody debris. This was due mainly to the recent flows in the area. We need to mention that woody debris have an important ecological role ensuring a high habitat diversity and shelter both for fish and invertebrates.

In the upstream portion most lands are forested and are used as pastures, in the downstream portion they are urban areas.

Downstream the village Vama are many gravel pits that have a serious impact on the fish communities due of the modification of the riverbed and flow velocity.

Table 1. The numeric absolute abundance of fish species for each of the sampling sites on the Moldova River in August 2005.

No.	Sites / Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
		Moldova/Pojorâta	Moldova/Molid	Moldova/Frasin	Moldova/Păltinoasa	Moldova/Cornu Luncii	Moldova/Vadu Moldovei	Moldova/Drăgușeni	Moldova/Miroslăvești	Moldova/Tupilați	Moldovaa/Gherăești	Moldova/Roman	Putna/Valea Putnei	Moldovița/Vama	Suha/Dorotea	Humor/M-rea Humor	Suha Mică/Mălini	Râșca/Praxia	Ozana/Timișești	Total Indiv/ speciees	Total sites/ species
	Ord. Salmoniformes Fam. Salmonidae																				
1	*Salmo trutta fario* L. 1758	1	2	-	2	-	-	1	-	-	-	-	11	-	3	2	1	1	-	24	9
	Ord. Cypriniformes Fam. Cyprinidae																				
2	*Leuciscus cephalus* L. 1758	-	89	4	2	9	15	85	31	7	46	41	-	43	5	-	13	13	2	405	15
3	*Phoxinus phoxinus* L. 1758	35	85	62	33	41	16	93	-	1	1	-	-	140	78	30	70	25	38	748	15
4	*Alburnus alburnus* L. 1758	-	-	2	-	1	-	5	3	1	10	26	-	-	-	-	-	2	1	51	9
5	*Alburnoides bipunctatus* Bl. 1782	-	-	25	8	3	-	1	-	4	2	-	-	20	12	-	-	-	2	77	9
6	*Chondrostoma nasus* L. 1758	-	-	-	1	20	8	31	14	28	23	15	-	-	-	-	-	-	-	140	8
7	*Rhodeus amarus* Bl. 1782	-	-	-	-	-	-	1	7	-	-	-	-	-	-	-	-	-	1	9	3
8	*Gobio gobio gobio* L. 1758	-	24	1	1	5	3	11	-	-	12	4	-	-	1	-	4	-	3	69	11
9	*Gobio uranoscopus* Ll. 1925	-	-	-	-	-	-	2	-	2	-	-	-	1	-	-	-	-	-	4	3

No.	Sites / Species	1 Moldova/Pojorâta	2 Moldova/Molid	3 Moldova/Frasin	4 Moldova/Păltinoasa	5 Moldova/Cornu Luncii	6 Moldova/Vadu Moldovei	7 Moldova/Drăgușeni	8 Moldova/Miroslăvești	9 Moldova/Tupilați	10 Moldovaa/Gherăești	11 Moldova/Roman	12 Putna/Valea Putnei	13 Moldovița/Vama	14 Suha/Dorotea	15 Humor/M-rea Humor	16 Suha Mică/Mălini	17 Râșca/Praxia	18 Ozana/Timișești	Total Indiv/ speciees	Total sites/ species
10	*Pseudorasbora parva* Sch. 1842	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2	2
11	*Barbus barbus* L. 1758	-	-	-	-	-	-	2	1	2	25	9	-	-	-	-	-	2	1	42	7
12	*Barbus meridionalis* Risso 1827	-	4	21	5	9	18	18	-	-	3	5	-	63	3	22	11	13	1	196	14
13	*Carassius gibelio* Bl. 1783	-	-	-	-	-	-	6	4	-	-	-	-	-	-	-	-	-	-	10	2
	Fam. Cobitidae																				
14	*Barbatula barbatula* L. 1758	-	6	18	15	8	-	7	-	-	-	2	-	4	6	14	13	2	10	105	13
15	*Sabanejewia aurata* K. 1922		6	15	4	9		2			2			14	3		1			56	9
16	*Cobitis taenia* L. 1758	-					1	1	-	-		3	-			-		-	-	5	3
	Ord. Scorpaeniformes Fam. Cottidae																				
17	*Cottus poecilopus* H. 1836	1	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	8	2
	Total species/site	2	7	8	9	9	6	15	7	7	10	8	2	7	8	4	7	7	9		
	Total individuals / site	37	216	148	71	105	61	266	61	45	125	105	18	284	111	68	113	58	59	1951	

The chemical analysis reveals a relatively constant pH 8.5 - 9, asociated with a 4 gH hardness on Putna, 5gH on Ozana and Moldovița, 8 - 9 gH on the Moldova. The exception was Humor site with 11 gH. The hardness is correlated with the geological substrate and the acid soils in the upstream portion.

We want to mention the absence of the NH_3 for all sites that indicates the lack of important polution sources (animal and urban waste). The nitrates are present at 2 - 5 mg/l, they are used for photosinthesis by aquatic plants. The phosphorous reach the normal concentration, under 0.1 mg/l.

MATERIALS AND METHODS

For sampling we use the electrofisher FEG 500. The samples were collected in 18 sample sites, 6 of them being placed on the tributaries (Cowx, 1990). The total capture consists in 1951 fish specimens identified as belonging to 3 orders, 4 families and 17 species. The identification was done based on the Bănărescu's 2002 identification guidebook. After identification and measurements the fish were set free, less than 5% of them were retained as voucher specimens for the Iaşi Natural History Museum. Based on these data we calculated a series of ecological indexes in order to appreciate the ecological state of the fish community (Angermeier 1995; Barbault, 1994).

Table 2. The absolute weigth abundance of species for each of the sampling sites on the Moldova River in August 2005.

No	Sites / Species	1 Moldova/Pojorâta	2 Moldova/Molid	3 Moldova/Frasin	4 Moldova/Păltinoasa	5 Moldova/Cornu Luncii	6 Moldova/Vadu Moldovei	7 Moldova/Drăguşeni	8 Moldova/Miroslăveşti	9 Moldova/Tupilaţi	10 Moldovaa/Gherăeşti	11 Moldova/Roman	12 Putna/Putna	13 Moldoviţa/Vama	14 Suha/Dorotea	15 Humor/M-rea Humorului	16 Suha Mică/Mălini	17 Râşca/Praxia	18 Ozana/Timişeşti	Total sites/ species	Total biomass /specie
	Ord. Salmoniformes Fam. Salmonidae																				
1	*Salmo trutta fario* L. 1758	200	40	-	140	-	-	60	-	-	-	-	244	-	103	450	620	120	-	9	1977
	Ord. Cypriniformes Fam. Cyprinidae																				
2	*Leuciscus cephalus* L. 1758	-	2895	299	85	455	224	412	386	152	584	635	-	490	254	-	725	288	33	15	7917
3	*Phoxinus phoxinus* L. 1758	295	140	73	57	45	44	97	-	3	3	-	-	390	136	72	80	37	35	15	1507
4	Alburnus alburnus L. 1758	-	-	23	-	22	-	19	16	10	29	176	-	-	-	-	-	22	10	9	327
5	*Alburnoides bipunctatus* Bl. 1782	-	-	29	88	7	-	6	-	22	7	-	-	42	88	-	-	-	8	9	297
6	*Chondrostoma nasus* L. 1758	-	-	-	60	441	95	102	95	521	354	402	-	-	-	-	-	-	-	8	2070
7	*Rhodeus amarus* Bl. 1782	-	-	-	-	-	-	2	46	-	-	-	-	-	-	-	-	-	2	3	50
8	*Gobio gobio gobio* L. 1758	-	180	17	11	70	10	46	-	-	31	36	-	-	10	-	36	-	7	11	454
9	*Gobio uranoscopus* Ll. 1925	-	-	-	-	-	-	7	-	9	-	-	-	3	-	-	-	-	-	3	19
10	*Pseudorasbora parva* Sch. 1842	-	-	-	-	-	-	-	2	-	3	-	-	-	-	-	-	-	-	2	5
11	*Barbus barbus* L. 1758	-	-	-	-	-	-	18	3	120	68	103	-	-	-	-	-	101	15	7	428
12	*Barbus meridionalis* Risso 1827	-	49	157	33	132	210	105	-	-	31	55	-	679	129	221	96	303	2	14	2202
13	*Carassius gibelio* Bl. 1783	-	-	-	-	-	-	148	70	-	-	-	-	-	-	-	-	-	-	2	218
	Fam. Cobitidae																				
14	*Barbatula barbatula* L. 1758	-	23	36	34	20	-	13	-	-	-	7	-	17	24	40	74	11	28	13	327
15	*Sabanejevia aurata* K. 1922	-	20	44	12	34	-	6	-	-	9	-	-	32	6	-	2	-	-	9	165
16	*Cobitis taenia* L. 1758	-	-	-	-	-	3	3	-	-	-	10	-	-	-	-	-	-	-	3	16
	Ord. Scorpaeniformes Fam. Cottidae																				
17	*Cottus poecilopus* H. 1836	5	-	-	-	-	-	-	-	-	-	-	127	-	-	-	-	-	-	2	132
	Total species/site	2	7	8	9	9	6	15	7	7	10	8	2	7	8	4	7	7	9		
	Total biomass/site	371	500	1650	3347	750	678	783	520	1226	1633	586	882	1044	140	618	840	1119	1424		18111

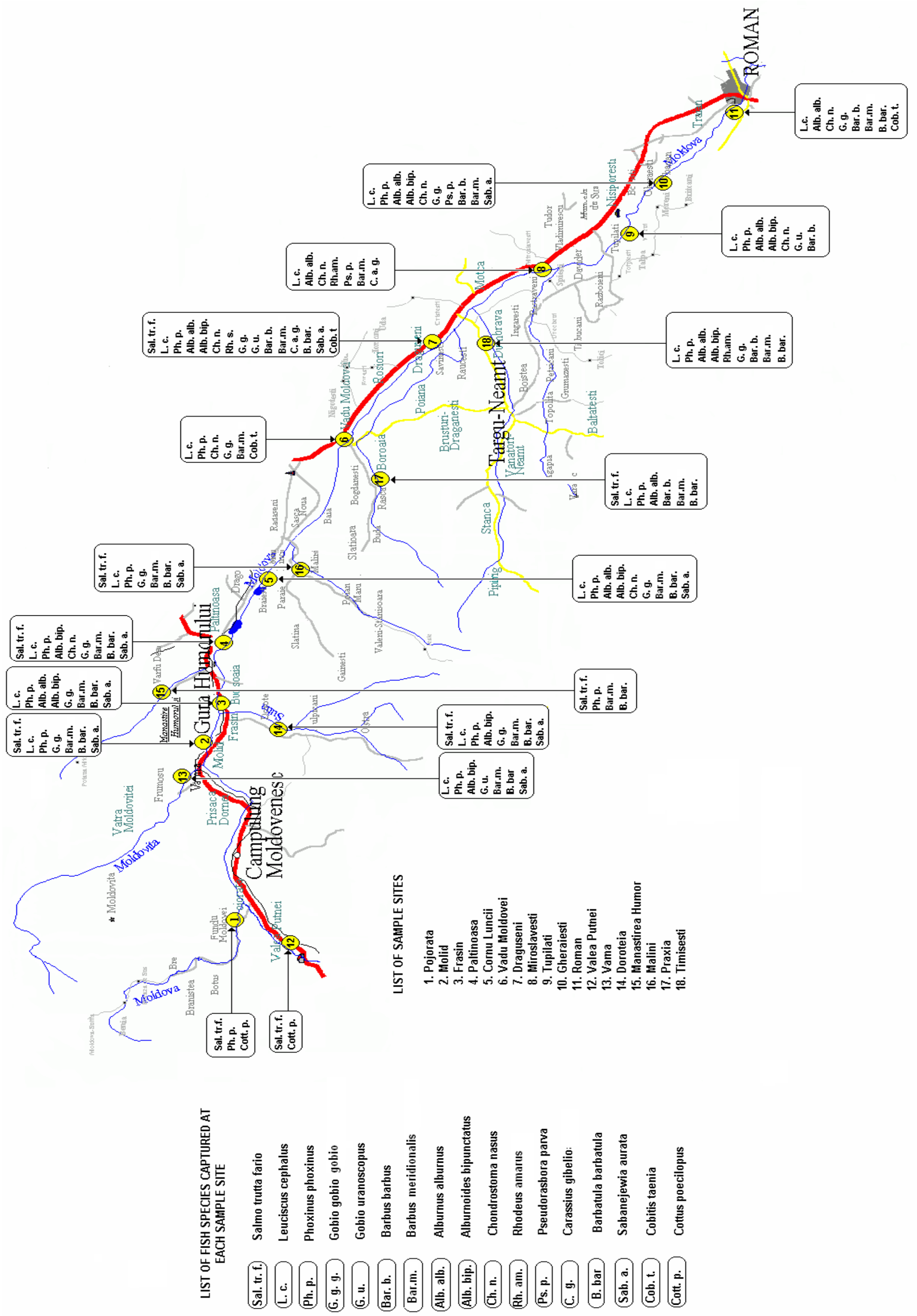

Figure 1. Map of the Moldova River,
with sample sites and species lists for each sampling site.

RESULTS AND DISCUSSIONS

Analyzing the data in the table 1 we may appreciate: for the whole 18 sample sites the capture was 1951 fish specimens belonging to 3 orders, 4 families and 17 species.

Analyzing the data from the tables 1 and 2 we find that the Drăguşeni - site 7, on Moldova River have the higher species number - 15. Opposing to that are the sites 12 - Putna and site 1 - Pojorâta, on the basin top with only 2 species, at the Gura Humorului site we captured 4 species. For the rest of the sample sites the diversity is in between 7 and 10 species.

The sites with highest abundance were Vama, on Moldoviţa tributary - 284 specimens, Moldova at Draguşani - 266 specimens, Molid, on Moldova River - 216 specimens.

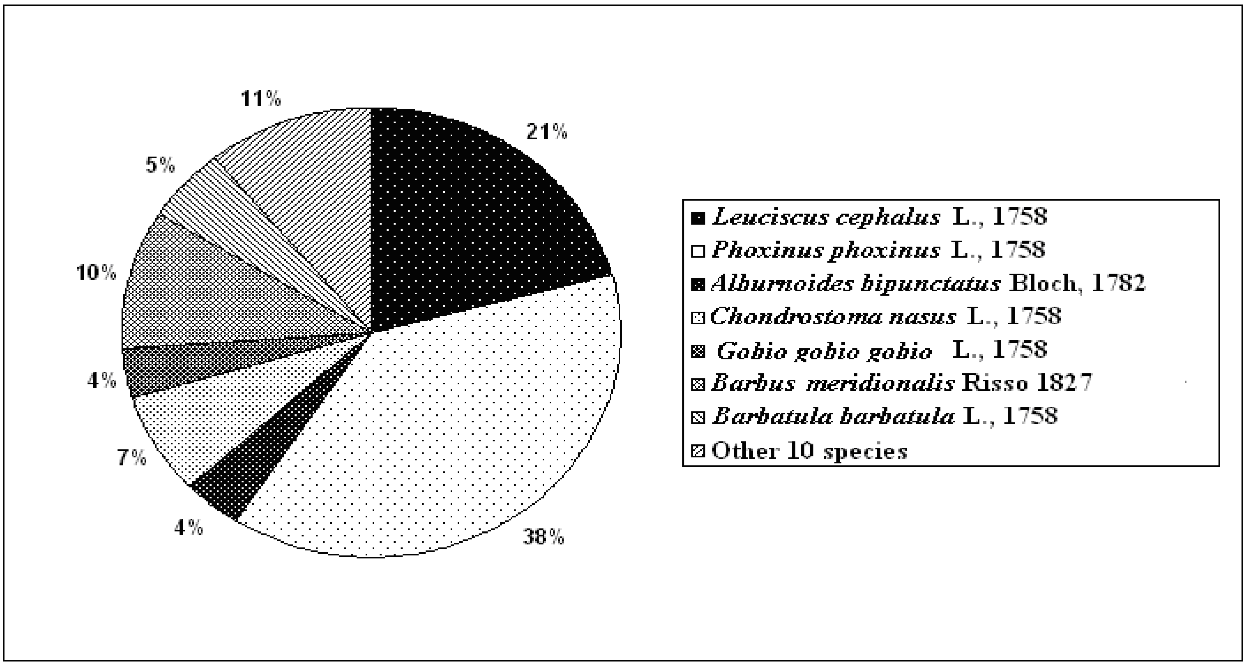

Figure 2. The pie chart indicating the relative numerical abundance of the species in the total fish capture for the Moldova River.

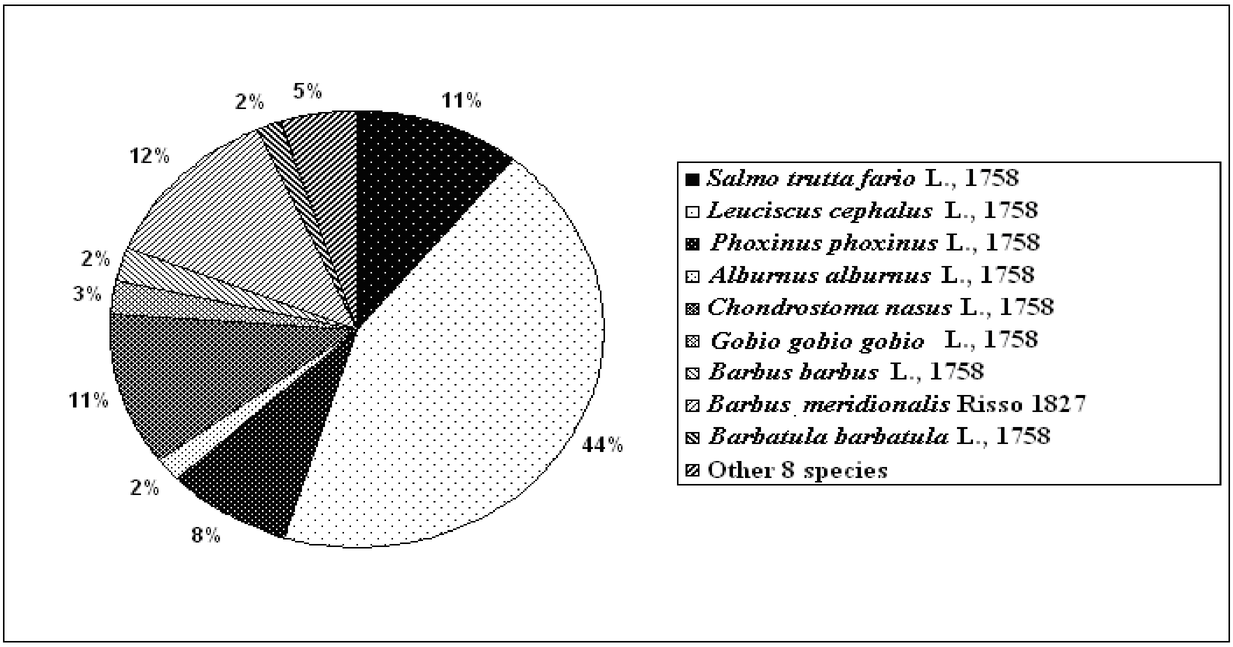

Figure 3. The pie chart indicating the relative weight abundance of the species in the total fish capture for the Moldova River.

The lowest abundance was registered at Putna, on Putna tributary, with only 18 specimens, belonging to *Salmo trutta fario* and *Cottus poecilopus*. The most abundant species is *Phoxinus phoxinus* with a total of 784 specimens - 38% of the total capture. Next to it is *Leuciscus cephalus* 405 specimens - 21% of the total capture. The rest of the 40% of the capture is distributed among 15 other species with abundances in between 2 and 196 specimens (Table 1, Figure 2).

Considering the biomass of the species for each sample site (Table 2, Figure 3) we may appreciate more accurate the role that the species play for a certain community.

Leuciscus cephalus species represents the biggest quantity among total capture 7917 g.

Table 3. The values of the ecological indexes and ecological significance index calculated for the sample sites of the Moldova River.

no	Species	Abundance	Constancy C		Dominance D		Index of ecological significance W	
			%	class	%	class	%	class
1	*Phoxinus phoxinus*	748	83.3	C4 euconstant	38.33	D5 Eudominant	31.94	W5 characteristic
2	*Leuciscus cephalus*	405	83.3	C4 euconstant	20.75	D5 eudominant	17.29	W5 characteristic
3	*Barbus meridionalis*	196	77.7	C4 euconstant	10.04	D5 eudominant	7.80	W4 characteristic
4	*Chondrostoma nasus*	140	44.4	C2 accesory	7.17	D4 dominant	3.18	W3 accesory
5	*Barbatula barbatula*	105	66.6	C3 constant	5.38	D4 dominant	3.58	W3 accesory
6	*Alburnoides bipunctatus*	77	50.0	C2 accesory	3.94	D3 subdominant	1.97	W3 accesory
7	*Gobio gobio gobio*	69	61.1	C3 constant	3.53	D3 subdominant	2.15	W3 accesory
8	*Sabanejevia aurata*	56	52.9	C3 constant	2.87	D3 subdominant	1.51	W3 accesory
9	*Alburnus alburnus*	51	50.0	C2 accesory	2.61	D3 subdominant	1.30	W3 accesory
10	*Barbus barbus*	42	38.8	C2 accesory	2.15	D3 subdominant	0.83	W2 accesory
11	*Salmo trutta fario*	24	50.0	C2 accesory	1.23	D2 recedent	0.61	W2 accesorie
12	*Carassius gibelio*	10	11.1	C1 accidental	0.51	D1 subrecedent	0.05	W1 accidental
13	*Rhodeus amarus*	9	16.6	C1 accidental	0.46	D1 subrecedent	0.07	W1 accidental
14	*Cottus poecilopus*	8	11.1	C1 accidental	0.41	D1 subrecedent	0.04	W1 accidental
15	*Cobitis taenia*	5	11.1	C1 accidental	0.25	D1 subrecedent	0.02	W1 accidental
16	*Gobio uranoscopus*	4	11.1	C1 accidental	0.20	D1 subrecedent	0.02	W1 accidental
17	*Pseudorasbora parva*	2	11.1	C1 accidental	0.10	D1 subrecedent	0.01	W1 accidental

Second to this they are *Barbus meridionalis* with 2202 g and *Chondrostoma nasus* 2070 g. We need to consider these species as the most important for the community structure. *Phoxinus phoxinus* that seems to be also very important because of his big number, play a smaller role, since its total biomass is only of 327 g. Comparing the sample's biomass for each site we find that the biggest capture was at Paltinoasa - site 4 (3347 g), followed by Frasin - site 3 (1650 g), Gherăieşti - site 10 (1633 g) and Timişeşti - site 18 (1424 g); all these sites have also a many species, in between 10 and 8, proving that the fish community on these sites are well structured and productive.

Analyzing the data in the table 3 we find a well-balanced distribution of the species that are characteristic to this river. This distribution offers a rather objective reflection of fish fauna. This is due to the rigorous fallow of the sampling protocol, respecting the CPUE and relatively good choice of the sampling sites placement.

Due to the human impact nowadays the Moldova River have rather similar (uniform) habitat condition and the fish fauna tends to become more similar with those of the hilly regions than mountains river. Only at the sample sites Putna, Pojorâta and Humor the river have a mountain area aspect and this is reflected in the fish community structure.

We find a group of three species *Phoxinus phoxinus, Leuciscus cephalus, Barbus meridionalis* that are euconstant species present in more than 77% percent of the sites. These species have also the highest abundance, domination and ecological significance values. They are forming a characteristic species group for this river and habitat types. This group is fallowed by the accessories species *Condrostoma nasus, Barbatula barbatula, Gobio gobio, gobio, Sabanejevia aurata, Alburnoides bipunctatus,* and *Alburnus alburnus* that have high values for the dominance index and are more or less constant in samples.It is important to mention that most of the sites have a high diversity and equitability index confirming the good state of the habitats. The highest diversity index was calculated for the site 13 - Drăguşeni, that actually have the highest species number, 15 species.

Table 4. Values of the Shannon Weaver Index and Equitability Index for the Moldova River.

No.	site	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Number of individuals	37	216	148	71	105	61	266	61	45	125	105	18	285	111	68	113	58	59
2	Number of species	2	7	8	9	9	6	15	7	7	10	8	2	7	8	4	7	7	9
3	Shannon Weaver Index	0.126	1.292	1.619	1.600	1.801	1.538	2.436	1.391	1.245	1.727	1.647	0.668	1.382	1.120	1.155	1.222	1.451	1.241
4	Equitability Index	0.181	0.663	0.778	0.728	0.819	0.858	0.899	0.715	0.640	0.750	0.792	0.963	0.710	0.538	0.833	0.627	0.746	0.564

We find that in the upstream portion, dominated by grayling *Thymallus thymallus* in the past, we find nowadays a quite dense population of chub, *Leuciscus cephalus* characteristic to the hilly region. This species is an omnivorous species with high ecological plasticity. The relatively small number of the *Alburnoides bipunctatus* (sensitive species) indicates also a degradation of the environmental factors.

For the downstream portion, the presence of the *Pseudorasbora parva* in only two sites may be considered a good news because this is an invasive species competing the sensitive species for food and shelter resources. A number of 8 species can be consider as accessories or accidental, *Salmo trutta fario* only appears in a significant number at Putna and 1 - 2 specimens in the downstream portion toward Păltinoasa.

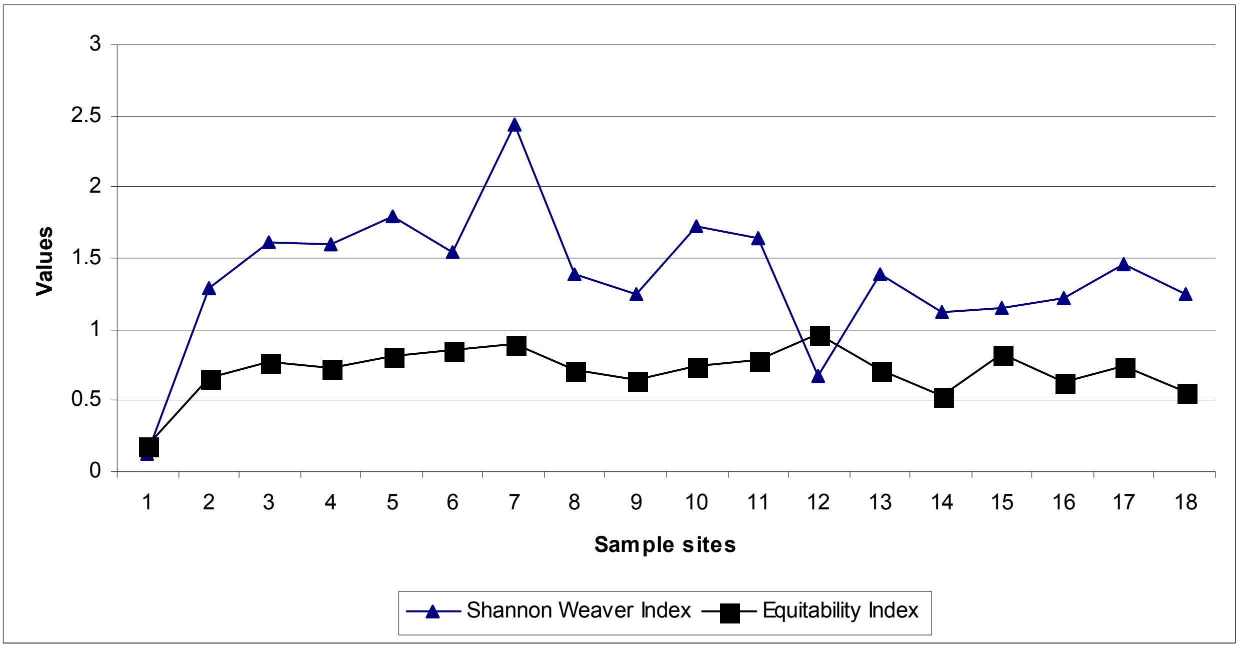

Figure 4. The graph of the Shannon Weaver Index of diversity and the Equitability index for the sample sites on the Moldova River.

Other species as: *Carassius gibelio*, *Pseudorasbora parva* that are tolerant species and rather stagnophilous show a degradation of the environmental factors in the downstream portion. Their presence also may be linked to accidental events as evading from fish farms due to the floods. Species as *Cottus poecilopus, Gobio uranoscopus* and *Rhodeus amarus* are rare species ecologically linked to certain limitative factors. *Cotus poecilopus* is an intense rheophilic species, *Rhodeus amarus* depends on mussels (that at their turn are sensitive to pollution) and *Gobio uranoscopus* depends on flow velocity and substrate granulation.

Analyzing the index of specific similarity in between sample sites (Figure 5) we find that most of the sampling sites forms a cluster having the similarity index over 50%. This is due to a rather similar typology (habitat conditions) of the sample sites.

The sample sites with a species composition rather different than the above mentioned (placed at the bottom of the sites list on the graph) have a lower value of the similarity index and differentiate themselves from the other either because they are in a top basin site or because the site was impacted by human activities.

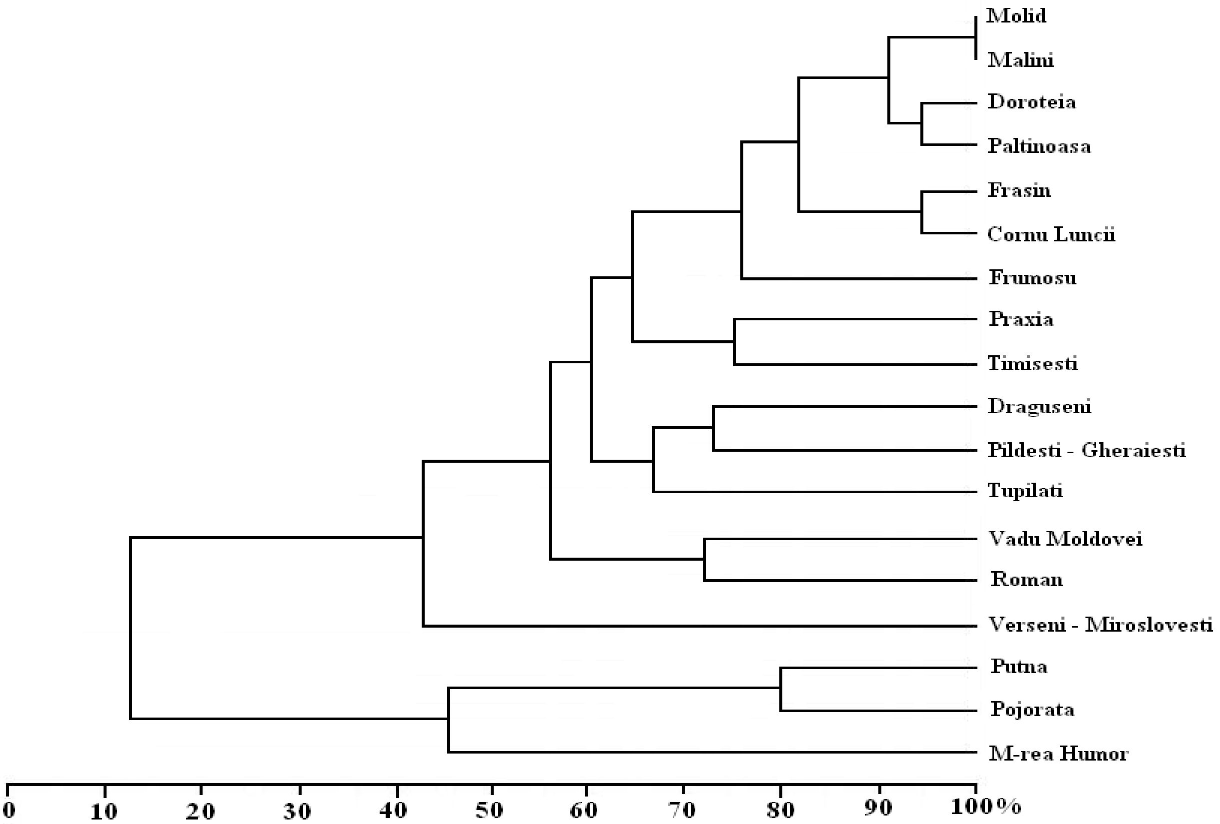

Figure 5. The graph of the species similarity index in between the sample sites on the Moldova River.

CONCLUSIONS

Comparing the results of fishing from the year 2005 with those of the year 1995 (Davideanu, 2003) we find that for both sampling campaigns the total species number is the same. In 1995 we find *Salvelinus fontinalis* in a portion upstream Colacu and *Gymnocephalus cernuus* in the downstream portion at Tupilați. In 2005 we add three more species: *Gobio uranoscopus, Cobitis taenia, Carassius auratus gibelio* raising the total species number identified in the river at 20. We should consider the Moldova River as a river with a rather good ecological state even they are some signs of fact that the habitat tends to become more uniforme. As a conclusion is worth to mention that in Moldova River basin we find rare fish species protected both at national and international level. The species: *Chondrostoma nasus, Barbus meridionalis Barbatula barbatula, Sabanejewia aurata, Alburnoides bipunctatus,* and *Alburnus alburnus* are protected by Bern Convention, Annex III. The species: *Cobitis taenia*, *Gobio uranoscopus*, *Sabanejewia aurata*, *Barbus meridionalis, Rhodeus amarus* are included in the annex II of the Habitat Directive of EEC.

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AUTHORS:

[1] *Bogdan VORNICU*
vorniku@yahoo.com
"Alexandru Ioan Cuza" University,
Department of Biology,
Carol I St., no. 11,
Iaşi, Iaşi County, Romania,
RO - 700506.

[2] *Grigore DAVIDEANU*
[2] *Ana DAVIDEANU*
grigore@uaic.ro
"Alexandru Ioan Cuza" University
Natural History Museum,
Independenței Bd., no. 16,
Iaşi, Iaşi County, Romania,
RO - 700100.