

MODIFICATIONS IN THE QUANTITATIVE STRUCTURE OF BARCĂU RIVER'S FISH FAUNA UNDER ANTHROPOGENIC PRESSURE

Doru Ioan ARDELEAN

"Vasile Goldiș" Western University Arad

ABSTRACT. As a consequence of carrying on this study, the following conclusions have been possible on the Barcau ichthyofauna: a) 34 species of fish were identified, most of them in the inferior course; b) 8-12 species are found in the area Suplac – Marghita, where the trophic impact is the most severe, and no species on a distance of approximately 2 kilometers are found immediately downstream from the refinery from Suplac; c) the number of fish individuals captured varies from one collecting point to another (48-78 individuals), being bigger at the exits from the country; d) most of the fish populations (80%) are small, in danger of extinction; e) the total fish biomass on Barcău is modest, 17,6 kg/100 m²; f) only 1/3 of the fish total are mature, which does not ensure a good reproduction; g) the number of species with economic value is small (2-4 species) and because of this Barcău is not interesting as far as fishing is concerned; h) the diversity coefficient is generally small in most sections, proving that the aquatic systems from Barcău are unbalanced.

Keywords: water quality, pollution with petroleum, fish fauna, qualitative structure of the fish fauna

INTRODUCTION

Barcău is a medium sized river that belongs to the system of the Criș Rivers. It springs from Plopișului Mountains and it falls into Crișul Repede in Hungary. Its main hydrographical characteristics are: length – 208.5 kilometers, debit – 8mc/s, the surface of the river catchment – 6095 square km, the slope difference decreases from 15-20 m/km to 20 cm/km. The debit increases over 30 times during the abundant rains or, on the contrary, decreases 10-15 time during the drought. It crosses Plopiș's mountain area, Suplac's, Nușfalău's and Șimleu's depressions, the gorge from Marca, and in the inferior course the east of the Pannonian Plain. It disposes of a big number of tributaries, especially on the left side, of which the most important one is the Bistra brook. As hydrological and of medium leak account, it belongs to the western peri Carpathian type that has the fingerprint of some accentuated ocean influences. The highest monthly debits are registered in the period February-March, and the lowest ones at the end of summer and the beginning of autumn. The water temperature varies from +1 degrees Celsius in February to +22 degrees Celsius in July. The water temperature can reach +33-34 degrees Celsius in July in the inferior course. A strong deposition of the innings brought from upstream takes place on Barcău's course, especially in plain, so that, each year, the river carries off approximately 127.000 tons of materials in suspension. In the superior course, Barcău has a natural, unaffected water with a mineralization degree of 300-350 mg/l, offering good living conditions. The water is polluted downstream (Fig. 1).

Barcău river hydrographical characterization was realized by Marosi and Szilard (1968), Ujvari (1972), Harka and collaborators (1998), Șumălan (2010), and the aspects regarding the anthropic pressure on it by Sarkany-Kiss and collaborators (1999), Andrikovics and collaborators (2001), Wilhelm (2002), Istvan (2010) and Andrișca (2011).

The main sources of pollution of Barcău river are: a) the untreated commune waters from the localities that it crosses, especially from the Nușfalău Depression; b) the polluted waters discharged in the area Suplac – Marghita from the oil's extraction and processing; c) the commune ammonia waters discharged by Marghita that cause the water's eutrophication; d) the careers of extraction of sand, ballast, calcite and coal from the mountain area; e) Barcău is channeled and dammed downstream from Sălard, receiving waste waters and agricultural fertilizers stepped out from the slopes from localities; f) more recently, the accumulation of water from Marca-Suplac from behind a dam that crosses the river.

Still, undoubtedly, the most severe pollution of Barcău's water is caused by the oil drills from the area Marghita and the Refinery of petroleum products from Suplac. Leaks of oil from the old broken pipes that pollute Barcău's water occurred even in the last years. For example, on 18.07.2011, the level of the oxygen dissolved in water was 9 times lower than the admitted limit, and the retrievable and petroleum substances surpassed the maximum admitted limit 10 times (fig. 2-5).

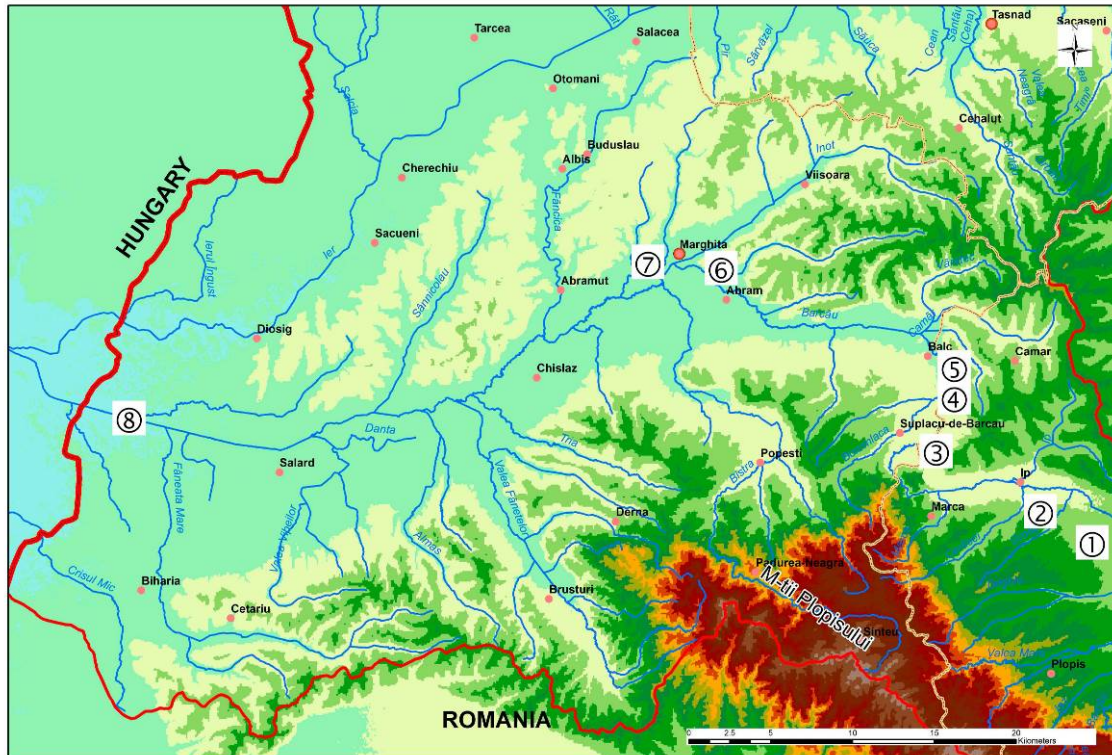


Fig. 1 The map of Barcău's river hydrographic system and the collecting points of the fish samples (1-8)



Fig. 2 Barcău river source, at Tusa (original photo)



Fig. 3 The Barcău river, inferior course, at the railway bridge from Diosig (original photo)



Fig. 4 Stone pit in Barcău river Valley at Marca



Fig. 5 Barcău river – Concrete river bed at Suplac

MATERIALS AND METHODS

They regard the taking of ichthyologic samples, the identification of the fish species and the effectuation of the measurements of the captured individuals.

Materials. The most important were:

- GPS for the establishment of the coordinates of the place;
- thermometers and pHs for the determination of the water's temperature and chemical reaction;
- equipments and fishing devices (angles and portable device of electric sleep);
- recipients for the keeping of the fish captures;
- fish species guide book;
- linear and balance for the measurement of the captured fish samples.

The research methods: Are based on 2 methodological documents regarding:

- the monitoring of the fish fauna from the aquatic basins (*Pricope and collaborators, 2004*),
- the standard operational procedure for the collecting of the fish fauna (*EuropeAid/114902/D/SV/RO*).

The following was established on their basis:

1. *the collecting way:* with the angle and the device of electric sleep;
2. *the collecting place:* from one bank of the river to the other, crossing the water course;
3. *the number of collecting stations of the fish samples,* established depending on the variation coefficient (CV = 0,5) is of 8:
 - (1) upstream Subcetate
 - (2) Nuşfalău
 - (3) upstream Suplacu de Barcău
 - (4) downstream Suplacu de Barcău
 - (5) Cohani
 - (6) upstream Marghita
 - (7) downstream Marghita
 - (8) Roşiori
4. *the surface of the water plant:*
 - superior course – 100 square metres
 - middle and inferior course – 150 square metres
5. *the ingathering period:* at the end of the growing period (August – September 2010)
6. *the completion of a file* regarding the gathered samples
7. *the identification of the species of fish* with the help of the species guide
8. *the fishes' measurement* (length – mm; weight / g)
9. *the releasing of the captures into the water,* with the exception of the individuals that require laboratory analyses

10. *the rapport of the results* as representative coefficients

- a. *the composition in species* (the list of the captured species)
- b. *the abundance of each species* (nr.ind./100 m² or gr/m²)
- c. *the structure of the fish communities* through usual ecological indicators
 - *the absolute abundance (A)* – the number rapport between the species that exist in the sample (the percent rapport between nr. ind. of a taxonomic group to a total nr. of individuals from a sample, appreciations: very abundant; abundant; relatively rare);
 - *the biomass abundance (AB)* – the biomass percent of a species reported to the biomass of the other species;
 - *the frequency (F)* – the number of samples in which the species (P) is found reported to the total number of samples (Pt):

$$F = \frac{P}{Pt} \cdot 100$$

- *the constancy (C)* – the frequency degree of the species;
- *the dominance (D)* – the relation in which the species is found to the total number of species from the ichtiocenosis

$$D = \frac{nA}{N} \cdot 100$$

where: nA = the total number of individuals from the species A; N = the total number of captured individuals from the ichtiocenosis (in %)

- *the coefficient of ecological significance (W),* in %:

$$W = \frac{C \cdot D}{10.000} \cdot 100$$

where C = the constancy; D = the dominance;

- *the diversity coefficient* (the Shannon-Weaver coefficient)

$$H' = \sum_{i=1}^S P_i \cdot \ln P_i$$

where: S – the number of species; P_i – the proportion of representation of each species.

(It is the coefficient of the ecosystem's equilibrium state; the higher it is the least affected by the anthropogenic impact the system is).

RESULTS AND DISCUSSIONS

The results are presented in tables 1-7. They comprise data regarding the quantitative structure coefficients of Barcău's fish fauna at 100 m² sparkle on sampling points in the summer of 2012.

(1) Upstream Subcetate (table 1)Table 1. Data regarding the quantitative structure of Barcău's fish fauna upstream Subcetate (the collecting surface 100 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
Salmo trutta fario	34	1534,0	59	26	1534	2	70,83	88,17	12,50	12,50	7,70	0,90		+
Leuciscus cephalus	2	126,4	63,2	2	126,4	-	4,17	7,26	8,75	8,75	0,40	0,01		+
Gobio gobio	10	67,0	6,7	10	67	3	20,83	4,18	62,50	62,50	2,20	1,30		-
Phoxinus phoxinus	2	12,4	6,2	2	12,4	1	4,17	0,71	25,00	25,00	0,40	0,10		-
Total section	48	1739,8	-	48	1739,8	6	-	-	-	-	-	-	371,61 373,86	2

Note:

- * - the first value is Hn calculated after the number of individuals, and the second value is Hm calculated after the biomass
- SN – number stock (number exemplaries/100m²)
- SG – gravimetrical stock (g/100m²)
- the constancy: F > 50 = constant species; F – 25-30 = accessory species; F < 25 = accidental species
- dominance: D > 10% = eudominant species; D – 2-5% = subdominant species; D – 2-11% = recedent species; D < 1% = subrecedent species
- coefficient of ecological significance: W > 20 = leading species; W – 10-20 = characteristic species (dominant-indicating); W – 5-10 = complementary species (companion dominant); W – 1-5 = associated species (subdominant); W – 0,1-1 = accidental species
- the diversity coefficient (the Shannon-Weaver coefficient) H = the coefficient of the ecosystem's equilibrium state (the higher it is the more affected by the anthropogenic impact the ecosystem is).

Table 2. Data regarding the quantitative structure of Barcău's fish fauna at Nuşfalău (the collecting surface 100 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
Leuciscus cephalus	40	1540	38,5	40	1540	11	51,95	69,72	62,50	62,50	9,00	5,60		+
Phoxinus phoxinus	4	24,4	6,1	4	24,4	1	5,19	1,10	25,00	25,00	0,90	0,20		-
Alburnoides bipunctatus	3	17,7	5,9	3	17,7	1	3,90	0,80	50,00	50,00	0,60	0,30		-
Abramis brama	2	206,8	103,4	2	206,8	1	2,60	9,36	50,00	50,00	0,40	0,20		+
Chondrostoma nasus	1	46,3	46,3	1	46,3	-	1,30	2,10	25,00	25,00	0,20	0,01		+
Rhodeus sericeus	2	8,8	4,4	2	8,8	-	2,60	0,40	50,00	50,00	0,40	0,20		-
Gobio kessleri	2	14,4	7,2	2	14,4	1	2,60	0,65	12,50	12,50	0,40	0,01		-
Gobio albipinnatus	3	16,2	5,4	3	16,2	1	3,90	0,73	87,50	87,50	0,60	0,50		-
Cobitis elongatoides	1	7,3	7,3	1	7,3	1	1,90	0,33	37,50	37,50	0,20	0,01		+
Gobio gobio	3	18,3	6,1	3	18,3	-	3,90	0,83	87,50	87,50	0,60	0,50		-
Sabanejewia aurata	8	47,6	11,9	4	47,6	2	10,30	21,55	25,00	25,00	1,80	0,40		-
Barbus barbus	2	22,2	11,1	2	22,2	-	2,60	1,00	25,00	25,00	0,40	0,10		-
Barbatula barbatula	5	11,8	5,9	5	11,8	2	6,49	0,53	12,50	12,50	1,10	0,10		-
Carassius auratus	2	226,4	113,2	2	226,4	1	2,60	10,25	50,00	50,00	0,40	0,20		+
Total section	77	2208,6	-	77	2208,6	22	-	100,0	100,0	-	-	-	279,54 406,67	5

Note: the same explanations as at table 1

The following characteristics of Barcău's fish fauna quantitative structure upstream Subcetate in 2012 result from the situation presented in table 1: 1) it has a small number of species, only 4, but representative to the trout's area, specific to a superior course of river; 2) the indigenous trout (*Salmo trutta fario*) is abundant in the area, both numerical and as biomass; 3) the chub (*Leuciscus cephalus*) has the highest frequency in the area, a fish less choosy to the environment conditions; 4) the fish biomass from the area is smaller, only 1,7 kg/100 mp because most of the species are immature (the individuals of trout only have 5-6 centimeters in length); 5) the trout has theoretically economical value in the area but not presently because the captures taken from the river are immature; as a result, presently, very few individuals from the area's fauna can be used to advantage economically; 6) the main ecological coefficients of the fish fauna of this section are: a) the abundance and the stock (both at number and at biomass) are high only for trout; b) only the chub (*Leuciscus cephalus*) has a big frequency on the river; c) the gudgeon (*Gobio gobio*), considered an associated species (subdominant), has a bigger coefficient of ecological significance; d) the diversity coefficient is big (Hn – 371,61, Hn – 373,86), confirming that the water is not affected by the anthropogenic impact, and the aquatic ecosystem is in state of equilibrium.

(2) Nușfalău (table 2)

We formulated the following aspects regarding the quantitative structure of Barcău's fish fauna on the superior course, section Nușfalău in the summer of 2012, from the situation presented in table 2: 1) the number of species increases compared to the previous section, reaching 14, which represents a situation corresponding to a section of river from burdock and chub's area; 2) only the chub (*Leuciscus cephalus*) is abundant in this river section, with 40 captured individuals, whereas the other species are represented

by small populations (only 1-3 individuals were captured), in danger of extinction from the river in an immediately following period if measures of improvement of the water quality won't be taken; 3) still, the fact that 28,57% from the captured individuals are mature shows corresponding situation concerning the reproduction on total section; but, still with the chub's exception, the other species are represented by 0-2 mature individuals, raising problems regarding the reproduction of the respective species; 4) the total fish biomass is small also in this section (2,2 kg/100 mp), representing a reduced fish production (only the clean contributes more substantially, with almost 70% of the total fish biomass identified in this section), because almost all the captured species are of small dimensions (under 8 g); 5) also, still only the chub in this section is a valuable species under economic aspect, but also at this species the number of mature individuals is small, one collecting, in most cases, individuals still in growth; 6) the ecological coefficients of the fish fauna of this sections are the following: a) the abundance and the stock fish are big only at chub (51,95% respectively 69,72%); b) only the chub and the bleak (*Alburnoides bipunctatus*) have a high frequency in this section, on the river; c) only the chub has a more important dominant, being an eudominant species, whereas all the other species are only accidental; d) the diversity coefficient decreases at the number of individuals (Hn – 279,54) and it maintains itself big at biomass (Hn – 406,67), revealing certain unbalances regarding the functioning of the aquatic biocenosis from Barcău at Nușfalău. This situation is the consequence of the over-exploitation of the fish resources from the area and of the reduced water debit from the droughty summer of 2012 when the discharges of commune waters increased the concentration of chemical pollutants.

(3) Upstream Suplacu de Barcău (table number 3)

Table 3. Data regarding the quantitative structure of Barcău's fish fauna in the section upstream Suplacu de Barcău (the collecting surface is of 100 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
Leuciscus cephalus	14	456,4	32,6	14	456,4	6	24,56	9,52	62,50	62,50	3,10	1,90		+
Abramis brama	2	11,6	5,8	2	11,6	1	3,51	0,24	50,00	50,00	0,40			-
Alburnoides bipunctatus	6	32,4	5,4	6	32,4	3	10,53	0,68	50,00	50,00	1,30	0,60		-
Gobio gobio	1	5,9	5,9	1	5,9	-	1,75	0,12	87,50	87,50	0,20	0,10		-
Gobio albiginnatus	13	71,5	5,5	3	71,5	1	22,81	1,49	37,50	37,50	2,90	1,00		-
Gobio kessleri	2	11,2	5,6	2	11,2	-	3,50	0,23	75,00	75,00	0,40	0,30		+
Barbus barbus	10	4100,0	410,0	10	4100,0	3	17,54	85,57	12,50	12,50	2,20	0,20		+
Sabanejewia aurata	9	102,6	11,4	9	102,6	3	15,79	2,14	25,00	25,00	2,00	0,50		+
Total section	57	4791,6	-	57	4791,6	17	100,00	100,00	-	-	-	-	273,12 403,68	4

Note: the same explanations as at table 1.

The following characteristics of the quantitative structure of Barcău's fish fauna, upstream from the Suplac Accumulation result from the analysis of the results presented in table number 3: 1) the number of fish species is 8; they are specific to the burdock and to the chub's area; 2) the fish fauna of this section is dominant quantitatively (14 individuals) by the chub (*Leuciscus cephalus*) that disposes here of a vigorous, big population; the common nase (*Chondrostoma nasus*) which with the small number of individuals and with the lack of mature individuals for reproduction is obviously an endangered species, is at the opposite pole; 3) only the chub (*Leuciscus cephalus*) and the barbel (*Barbus barbus*) that are fished preferably have economic value in this section; 4) Barcău's fish biomass in this section is relatively modest (4,8 kg/100 mp) at which only 3 species bring their more significant contribution (97,23%): the barbell (*Barbus barbus*), the chub (*Leuciscus cephalus*) and Golden spined loach (*Sabanejewia aurata*); the other species are "bleaches", meaning species of fish that are not searched by fishers, having small dimensions at maturity; 5) the values of Barcău's quantitative ecological coefficients, upstream from Suplacu de Barcău are: a) only the chub (*Leuciscus cephalus*) – 24,56% and the gudgeon (*Gobio albipinnatus*) – 22,81% have a more significant numeric abundance; the other species have a more modest abundance,

between 17,54 and 1,75%; b) only the barbell (*Barbus barbus*) has a significant weight as biomass abundance and gravimetric stock – 94,97%; c) only the species of gudgeon (g. *Gobio*) have big frequency; d) the chub (*Leuciscus cephalus*) and the bleak (*Alburnoides bipunctatus*) are constant species, and the white fin gudgeon (*Gobio albipinnatus*) is an accessory species; the other species captured in this section are accidental; e) only the chub (*Leuciscus cephalus*) is an associated subdominant species as coefficient of ecological significance; the dominant species are missing from this sector of Barcău; f) the Shannon-Weaver coefficient decreases slightly compared to the sampling point from upstream (Hn – 273,12; Hm – 403,68), confirming the fact that the aquatic ecosystem from this section had to suffer because of the exercitation of a more violent aquatic pressure, consisting in the petroleum leaks from the oil exploitations from this area.

(4) **Downstream Suplacu de Barcău.** The discharges of petroleum products from the Refinery Suplacu de Barcău and the leaks of oil from the pipes in exploitation from this section make that the aquatic fauna from downstream, including the fish disappear totally from the area, on a length of approximately 2 kilometers.

(5) **Cohani** (table number 4).

Table 4. Data regarding the quantitative structure of Barcău's fish fauna at Cohani (the prelevation surface 100 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
<i>Rutilus rutilus</i>	2	16,2	16,2	0,7	10,8	1	3,85	2,32	25,00	25,00	0,40	0,10		-
<i>Leuciscus cephalus</i>	12	52,8	26,4	8,0	35,2	-	23,08	7,57	62,50	62,50	2,70	1,60		+
<i>Leucaspis delineatus</i>	3	111,3	37,1	2,0	74,2	1	5,77	15,95	12,50	12,50	0,60	0,01		+
<i>Alburnoides bipunctatus</i>	8	44,8	5,6	5,3	29,9	3	15,38	6,43	50,00	50,00	1,80	0,90		-
<i>Cyprinus carpio</i>	1	281	281	0,3	187,3	-	1,92	40,30	50,00	50,00	0,20	0,10		+
<i>Gobio gobio</i>	9	61,2	6,8	6	40,8	3	17,31	3,78	62,50	62,50	2,04	1,10		-
<i>Gobio albipinnatus</i>	11	60,5	5,5	7,3	40,3	4	21,15	8,68	37,50	37,50	2,50	0,90		-
<i>Gobio kessleri</i>	5	34,5	6,9	3,3	23,0	1	9,61	4,95	75,00	75,00	1,00	0,70		-
<i>Carassius auratus</i>	1	35,1	35,1	0,3	23,4	-	1,92	5,03	37,50	37,50	0,20	0,01		+
Total section	52	697,0	-	34,7	464,9	13	100,00	100,00	-	-	-	-	270,70 201,62	4

Note: the same explanations as at table 1

The most important quantitative aspects of Barcău's fish fauna at Cohani are: 1) Barcău's fish fauna recovered in the sense that 9 species from the most resistant appeared after the anthropogenic impact from Suplac; 2) also, the number of fish individuals taken is relatively small (52 individuals) which corresponds to

some reduced frequencies and abundances of fish that survive in this water; 3) the number of mature individuals is small (25,00%) and 3 species do not have mature individuals at all, being endangered species in this river section; 4) only 4 species – the chub (*Leuciscus cephalus*), the belica (*Leucaspis*

delineatus), the carp (*Cyprinus carpio*) and the goldfish (*Carassius auratus*) have economic value, but they are represented by singular and immature individuals; 5) as a result, the fish biomass from this point is very small (0,7 kg/100 m²; 6) the ecological coefficients of the river present themselves in this way: a) the chub (*Leuciscus cephalus*), the gudgeons (*Gobio gobio* and *G. albipinnatus*) and the bleak (*Alburnoides bipunctatus*) have medium abundance; the other species have an insignificant biomass; c) the situation is similar also at frequency, being big only at chub (*Leuciscus cephalus*), gudgeon (*Gobio gobio*) and especially at the Kessler's gudgeon (*Gobio kessleri*);

the frequency is medium and small at the other species; d) the species from point c) are also constant species; the other species are accessory or accidental; e) as far as the coefficient of ecological significance is concerned, almost all the species are accidental species are very few are associated, subdominant, like the bleak (*Alburnoides bipunctatus*); f) the diversity coefficient decreases compared to the upstream situation (Hn – 207,70; Hm – 201,62), revealing an obvious degradation of the aquatic ecosystem in cause due to the discharge of petroleum products in the river.

(6) Upstream Marghita (table 5)

Table 5. Data about the quantitative structure of Barcău's fish fauna, upstream Marghita (the collecting surface is of 150 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
<i>Leuciscus cephalus</i>	31	936,0	30,2	20,7	624,0	6	55,36	77,46	62,50	62,50	7,0	4,30		+
<i>Rutilus rutilus</i>	2	32,2	16,1	1,3	21,57	-	3,57	2,67	50,00	50,00	0,40	0,20		-
<i>Alburnus alburnus</i>	3	15,3	5,1	2,0	10,2	1	5,26	1,27	12,50	12,50	0,60	0,01		-
<i>Abramis brama</i>	1	58	5,8	0,6	3,9	-	1,78	0,48	50,00	50,00	0,20	0,10		-
<i>Gobio gobio</i>	2	13,2	6,6	1,3	8,8	2	3,57	1,09	62,50	62,50	0,90	0,60		-
<i>Pseudorasbora parva</i>	6	31,2	5,2	4,0	20,8	2	10,71	2,58	37,50	37,50	1,30	0,40		-
<i>Rhodeus sericeus</i>	6	27,0	4,5	4,0	18,0	2	10,71	2,23	50,00	50,00	1,30	0,60		-
<i>Gobio albipinnatus</i>	2	10,6	5,3	1,3	7,1	-	3,57	0,88	75,00	75,00	0,40	0,30		-
<i>Gobio kessleri</i>	2	11,0	5,5	1,3	7,3	1	3,57	0,91	75,00	75,00	0,40	0,30		
<i>Cyprinus carpio</i>	1	18,6	186,00	1,6	124,00	-	1,78	15,39	50,00	50,00	0,20	0,1		+
Total section	56	1268,3	-	37,3	845,5	14	100,00	100,00	-	-	-	-	301,95 386,18	2

Note: the same explanations as at table 1

According to the data from table 5, the quantitative structure of Barcău's fish fauna, upstream Marghita presents itself in this way: 1) the number of species is small (10 species); 2) only the chub (*Leuciscus cephalus*) has a vigorous population (31 individuals were captured); 3) besides the carp (*Cyprinus carpio*), only the chub (*Leuciscus cephalus*) has economic importance in this section, these being also the fished species; the individuals from the other captured species are of small dimensions (bleaches), being released by fishermen in the river's water; 4) the fish biomass is very small (1,3 kg/100 m²) because of the small number of individuals, all of them immature; also because of this the reproduction capacity of the species from the area is very reduced; 5) the ecological coefficients of the fish fauna from this section present themselves as follows: a) there is only 1 abundant

species (the chub - *Leuciscus cephalus*), both numerically and as biomass and it has, at the same time, the highest frequency (together with the species of gudgeon – g. *Gobio*), being an eudominant species and characteristic to this section; c) most of the species identified in the area have the frequency under 50%, being constant species or even species with inferior status; d) the diversity coefficient (of over 300) is in a contradiction with the results of the water's laboratory chemical analyses which show a high load with benzene. The explanation for the scarce quantitative structure in this section is given by the cruel living conditions offered by Barcău because of the accumulation of petroleum products from the drills and the refinery from upstream.

(7) Downstream Marghita (table 6)

Table 6. Data about the quantitative structure of Barcău's fish fauna, downstream Marghita (the collecting surface is of 150 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
<i>Esox lucius</i>	1	215,0	215,0	0,7	143,3	-	1,39	10,46	25,00	25,00	0,20	0,01		+
<i>Rutilus rutilus</i>	2	35,2	17,6	1,3	23,5	1	2,78	1,71	25,00	25,00	0,40	0,10		-
<i>Leuciscus cephalus</i>	8	389,6	48,7	5,3	259,7	3	11,11	18,95	62,50	62,50	1,80	1,10		+
<i>Abramis brama</i>	2	11,8	5,9	1,3	7,9	-	2,78	0,57	50,00	50,00	0,40	0,20		-
<i>Alburnoides bipunctatus</i>	28	159,6	5,7	18,7	106,4	11	38,89	7,73	50,00	50,00	6,30	3,10		-
<i>Chondrostoma nasus</i>	1	409,0	409	0,7	272,7	-	1,39	19,89	25,00	25,00	0,20	0,01		+
<i>Rhodeus sericeus</i>	5	26,5	5,3	3,3	17,7	-	6,94	1,29	50,00	50,00	1,10	0,50		-
<i>Gobio gobio</i>	5	33,5	6,7	3,3	17,7	3	6,94	1,63	62,50	62,50	1,30	0,80		-
<i>Carassius auratus</i>	3	262,8	87,6	2,0	175,2	1	4,17	12,78	37,50	37,50	0,60	0,20		+
<i>Pseudorasbora parva</i>	1	5,2	5,2	0,7	3,5	1	1,39	0,25	37,50	37,50	0,20	0,01		-
<i>Gobio albipinnatus</i>	4	20,8	5,2	2,7	13,9	-	5,55	1,01	75,00	75,00	0,90	0,60		-
<i>Cobitis elangatooides</i>	1	5,5	5,5	0,7	3,6	-	1,39	0,27	37,50	37,50	0,20	0,01		-
<i>Gobio kessleri</i>	3	16,2	5,4	2,0	10,8	1	4,17	0,79	75,00	75,00	0,60	0,40		
<i>Perca fluviatilis</i>	1	84,5	84,5	0,7	56,3	-	1,39	4,11	25,00	25,00	0,20	0,01		+
<i>Cyprinus carpio</i>	2	16,6	8,3	1,3	11,1	-	2,78	0,81	50,00	50,00	0,40	0,20		-
<i>Cobitis taenia</i>	1	5,1	5,1	0,7	3,4	-	1,39	0,25	25,00	25,00	0,20	0,01		-
<i>Silurus glanis</i>	1	194,0	194,0	0,7	129,3	-	1,39	9,43	25,00	25,00	0,20	0,01		+
<i>Gymnocephalus cernuus</i>	2	10,8	5,4	1,3	7,2	-	2,78	0,82	25,00	25,00	0,40	0,10		-
<i>Zingel zingel</i>	1	5,1	5,1	0,7	3,4	-	1,39	0,25	12,50	12,50	0,20	0,01		-
Total section	72	2056,2	-	48	1370,8	21	100,00	100,00	-	-	-	-	231,84 208,94	6

Note: the same explanations as at table 1

The structure of Barcău's fish fauna improved but very little in the section downstream Marghita because the waste, the domestic, the industrial waters discharged by Marghita's sewerage add to at the pollution from downstream: 1) the improvement concerns, though, the increase of the number of species at 19; 2) only the bleak (*Alburnoides bipunctatus*), the gudgeon (*Gobio gobio*) and European Bitterling (*Rhodeus sericeus*) have sure, vigorous populations; 3) the fact that 8 species identified in this section are represented only by isolated individuals which means that they do not reproduce themselves in the river is concerning; 4) the situation is similar also as far as the mature individuals is concerned, 12 species do not have mature individuals in the area, a fact that affects the fish production and the reproduction; only the bleak (*Alburnoides bipunctatus*), the gudgeon (*Gobio gobio*) and the chub (*Leuciscus cephalus*) have more mature individuals which ensure the perpetuation of the species, and the last has a significant contribution at the realization of the fish biomass; 5) the 6 species with

economic value offer modest fish resources because of the afore mentioned causes (the gravimetric stock of the identified fish is of only 2,0 kg/100 m²); 6) the same modest situation is noticed also as far as the ecological coefficients of the fish fauna of this section are concerned: a) only the bleak - 38,89% (*Alburnoides bipunctatus*) and the chub (*Leuciscus cephalus*) register significant numeric abundancies; b) the common nase (*Chondrostoma nasus*), the chub (*Leuciscus cephalus*), the wels catfish (*Silurus glanis*), the silver crucian (*Carassius auratus*) and the northern pike (*Esox lucius*) have significant values of abundance as far as the biomass is concerned; c) the frequent species from the area are: the chub (*Leuciscus cephalus*) and the gudgeons (*Gobio albipinnatus*, *G. gobio* and *G. kessleri*); the other species are recedent or even subrecedent; e) the bleak (*Alburnoides bipunctatus*) has the best position also as ecological significance, being complementary (companion) species; most of the species captured here are, though, accidental species; f) the diversity coefficient maintains itself reduced,

between 208 and 232, the expression of the alteration of the aquatic ecosystem (Hn – 231,84; Hm – 208,94).

(8) *Roșiori* (table 7)

Table 7. Data about the quantitative structure of Barcău fish fauna at *Roșiori* (the collecting surface is of 150 m²)

Species	Nr. ex.	Total weight (g)	Medium weight (g)	SN (nr. ex/100 m ²)	SG (g/100 m ²)	Ex. mature	An %	Abm %	F %	C %	D %	W %	H	Val. ec.
<i>Esox lucius</i>	2	992,0	496,0	1,3	661,3	1	2,56	20,37	25,00	25,00	0,40	0,10		+
<i>Rutilus rutilus</i>	5	89,5	17,9	3,3	59,7	2	6,41	1,84	25,00	25,00	1,10	0,20		-
<i>Leucaspis delineatus</i>	19	1354,7	71,3	12,7	903,1	6	24,36	27,82	12,50	12,50	4,30	0,50		+
<i>Scardinius erythrophthalmus</i>	2	52,8	26,4	1,3	35,2	1	2,56	1,08	12,50	12,50	0,40	0,01		+
<i>Alburnoides bipunctatus</i>	12	70,8	5,9	8	47,2	7	15,38	1,45	50,00	50,00	2,70	1,30		-
<i>Blicea bjoerkna</i>	2	11,4	5,7	1,3	7,6	-	2,56	0,23	12,50	12,50	0,40	0,01		-
<i>Rhodeus sericeus</i>	6	27,0	4,5	4	18,0	3	7,60	0,55	12,50	12,50	1,30	0,10		-
<i>Gobio gobio</i>	6	40,2	6,7	4	26,8	2	7,60	0,82	62,50	62,50	1,30	1,80		-
<i>Gobio albipinnatus</i>	5	28,0	5,6	3,3	18,7	1	6,41	0,57	37,50	37,50	1,10	0,40		-
<i>Gobio kessleri</i>	4	21,2	5,3	2,6	14,1	1	5,13	0,43	75,00	75,00	0,90	0,60		-
<i>Carassius auratus</i>	2	184,0	92,3	1,3	122,7	1	2,56	3,78	37,50	37,50	0,40	0,10		+
<i>Pseudorasbora parva</i>	1	5,3	5,3	0,7	3,5	1	1,50	0,11	37,50	37,50	0,20	0,01		-
<i>Cyprinus carpio</i>	1	221,0	221,0	0,7	147,3	-	1,28	4,54	50,00	50,00	0,20	0,10		+
<i>Misgurnus fossilis</i>	2	226,0	113,0	1,3	150,7	1	2,56	4,64	12,50	12,50	0,40	0,01		+
<i>Cobitis taenia</i>	1	5,2	5,2	0,7	3,5	-	1,28	0,11	25,00	25,00	0,20	0,01		-
<i>Cobitis elangatoides</i>	1	5,6	5,6	0,7	3,6	1	1,28	0,12	37,50	37,50	0,20	0,01		-
<i>Silurus glanis</i>	1	314,0	314,0	0,7	209,3	-	1,28	6,45	25,00	25,00	0,20	0,01		+
<i>Ictalurus nebulosus</i>	1	264,0	264,0	0,7	176,0	1	1,28	5,42	12,50	12,50	0,20	0,01		+
<i>Gymnocephalus cernuus</i>	1	5,5	5,5	0,7	3,7	1	1,28	0,11	25,00	25,00	0,20	0,01		-
<i>Perca fluviatilis</i>	2	183,2	91,6	1,3	122,1	1	2,56	4,87	25,00	25,00	0,40	0,10		+
<i>Stizostedion lucioperca</i>	1	762,0	762,0	0,7	508,0	1	1,28	15,65	12,50	12,50	0,20	0,01		+
<i>Gymnocephalus baloni</i>	1	5,4	5,4	0,7	3,6		1,28	0,11	12,50	12,50	0,20	0,01		-
Total section	78	4868,8	-	52	3245,9	32	100,00	100,00	-	-	-	-	196,38 249,17	9

Note: the same explanations as at table 1

The quantitative structure of Barcău's fish fauna improved in the summer of 2012 at the country exit, as table 7 shows: 1) the number of species increased significantly, at 22, most of the species typical to the inferior course, the carp zone, being present; 2) more species – the roach (*Rutilus rutilus*), European Bitterling (*Rhodeus sericeus*), the gudgeon (*Gobio gobio*), the white fin gudgeon (*Gobio albipinnatus*) and especially the belica (*Leucaspis delineatus*) and the bleak (*Alburnoides bipunctatus*) – have certain

populations; 15 species have, though, small populations (only 1-2 individuals per species were captured); 3) but most species have medium weight and gravimetric stock under those of the species from a natural, unaltered lake; 4) only the 9 species of high body and especially the bleak (*Alburnoides bipunctatus*), that also has big effectives, have economic importance and are fished; 5) an obvious increase of the fish biomass compared to the other sampling points (approximately 5 kg/100 m²) is

noticed, due to the species with economic value, but the value of the biomass is way under the potential of a river of the same size unaffected by pollution; 6) the ecological coefficients present themselves in this way: a) only the belica (*Leucaspilus delineates*) has a bigger abundance, of medium value; the other species are not abundant; b) the highest frequency in this section of Barcău have, in decreasing order: the Kessler's gudgeon (*Gobio kessleri*) – 75%, followed by the bleak (*Alburnoides bipunctatus*) and carp (*Cyprinus carpio*), as well as by the gudgeon (*Gobio gobio*) have, in decreasing order, the highest frequency from this

section of Barcău; c) no species is dominant, only the belica (*Leucaspilus delineates*) is subdominant; most of the species are recedent and subrecedent; d) the identified species are neither valuable as ecological significance, only the belica (*Leucaspilus delineates*) is complementary species; the other species are accidental; e) the diversity coefficient is small in this case also, under 250, being the expression of the degradation of the aquatic system, affected both by the upstream pollution which still persists, and by the agricultural fertilizers discharged in the river from the agricultural terrains.

CONCLUSIONS

Table 8. The quantitative structure of Barcău fish fauna of its entire course in the summer of 2012

Nr. crt.	The collecting point	Nr. species	Nr. ex.	Total weight (g)	Ex. mature		Species with economic value	
					Nr.	%	Nr.	%
1	Subcetate	4	48	1739,8	6	12,50	2	50,00
2	Nuşfalău	14	77	2208,6	22	28,57	4	28,57
3	Downstream Suplacu de Barcău	8	57	4791,6	17	29,82	4	50,00
4	Upstream Suplacu de Barcău	-	-	-	-	-	-	-
5	Cohani	9	52	697,0	13	25,00	4	44,44
6	Downstream Marghita	10	56	1268,3	14	25,00	2	20,00
7	Upstream Marghita	19	72	2056,2	21	29,17	6	31,58
8	Roşiori	22	78	4868,8	32	41,02	9	40,91
	Total	34	440	17630,3	125	28,41	31	91,18

Table 9. The diversity coefficient on all Barcău's river investigated sections

Nr. crt.	The collecting point	Diversity coefficient	
		Hn	Hm
1	Subcetate	371,61	373,86
2	Nuşfalău	279,54	406,67
3	Upstream Suplacu de Barcău	273,12	403,68
4	Reffinery Suplacu de Barcău	-	-
5	Cohani	270,70	201,62
6	Upstream Marghita	301,95	386,18
7	Downstream Marghita	231,84	208,94
8	Roşiori	196,38	249,17

Table 8 (of synthesis) and 9, as well as the graphs presented in figures 6 and 7 were made in view of formulating the conclusions.

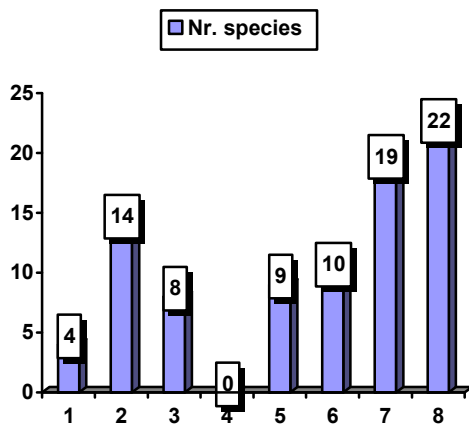
The present research allowed the detachment of the following conclusions regarding the quantitative structure of Barcău's fish fauna in the summer of 2012: a) 34 species were identified on Barcău, most of them met in the inferior course; the number of the species

increases downstream on sampling points (from 4 to 22); the aquatic fauna is practically inexistent in the Suplac area, severely polluted, on a distance of 1-2 kilometers; b) the number of individuals of captured fish varies from one collecting point to another (48-78 individuals), being more reduced in the section Suplac-Marghita; c) the total fish biomass from the river is modest, being estimated at 17,6 kg/100 m² because of

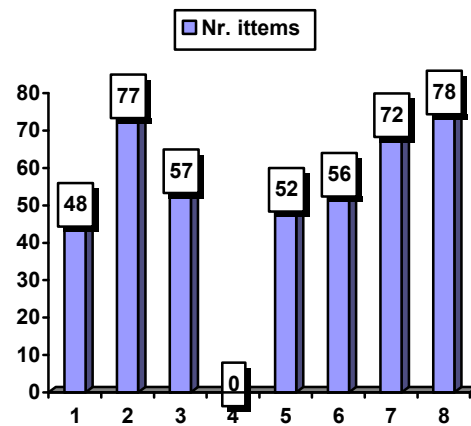
the anthropogenic impact, especially the petroleum one; d) the mature individuals represent 1/3 of the total populations of fish, the reproduction of more species present on Barcău being assured; e) the number of species with economic value varies from one river section to another, between 0 (upstream and downstream Suplac) and 9 (at Roșiori), having a tendency of increase towards the inferior course where the fish biomass is superior to all river sections. The graph from figure 6 obviously suggests the effect that the discharge of the petroleum products (benzene and

phenols) has in Barcău's water. At the same time, the evolution of the diversity indicator on Barcău results from table 9 and figure 7, noticing a chemical block on the river, after the Refinery from Suplac, tantamount to the presence of a physical dam on the river.

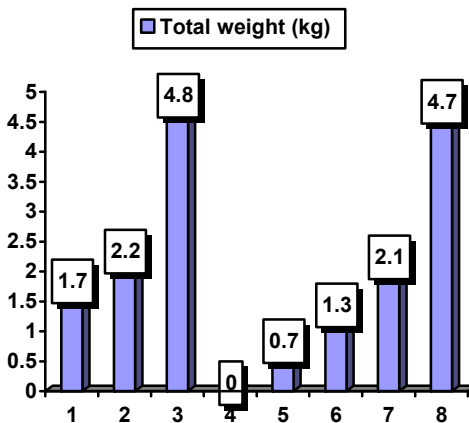
Table 10 and the graphs from figure number 8 that present a comparison between Barcău River and Tur river, previously researched by me, were made so that the conclusions regarding the evolution of the diversity indicator be more relevant.



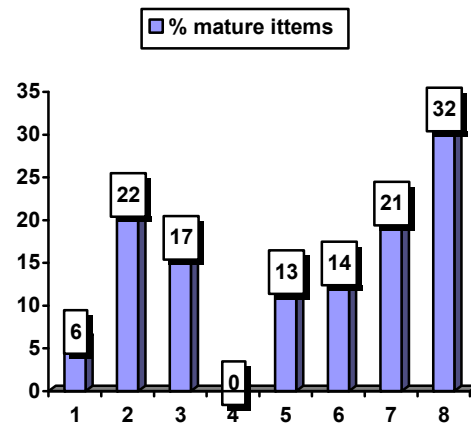
(a)



(b)



(c)



(d)

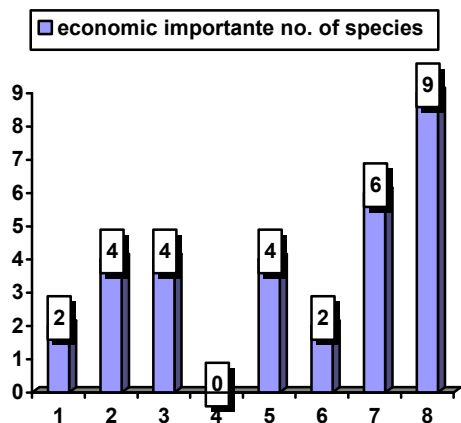


Fig. 6. The graphs of the quantitative structure of Barcău fish fauna in the summer of 2012

(e)

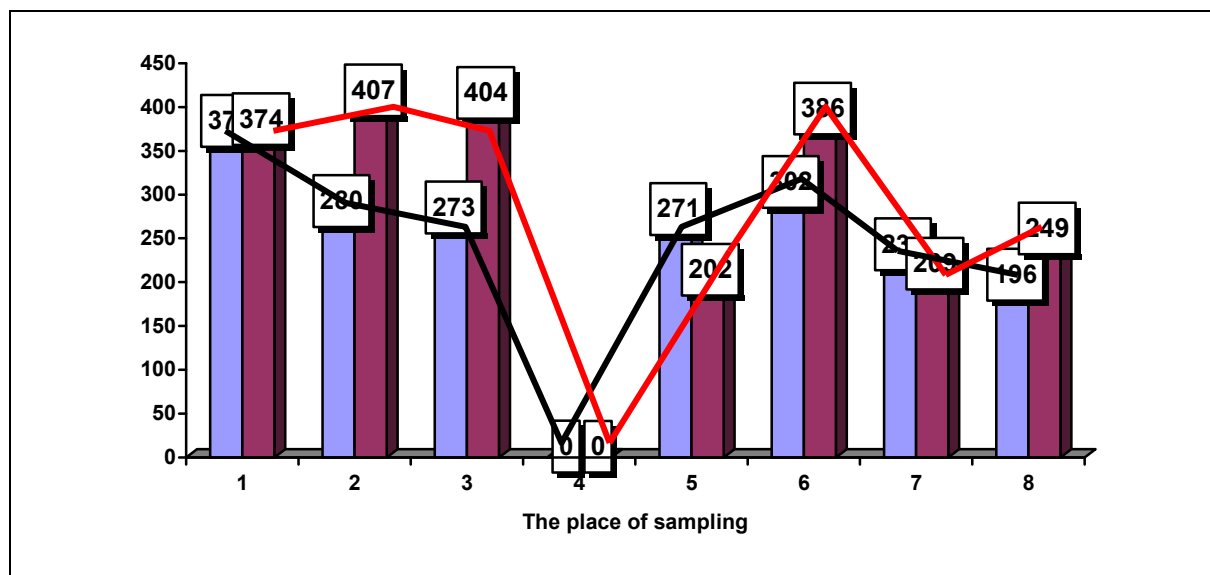


Fig. 7. The evolution of the diversity indicator on the entire Barcău course (- = Hn; - = Hm)

Table 10. Table regarding the comparison of the data about the diversity indicator on Tur and Barcău

Sections	Diversity indicator			
	Tur		Barcău	
	Hn	Hm	Hn	Hm
1	398	387	372	374
2	281	376	280	407
3	247	258	273	404
4	211	199	-	-
5	-	-	271	202
6	232	264	302	386
7	147	222	232	209
8	-	-	196	249

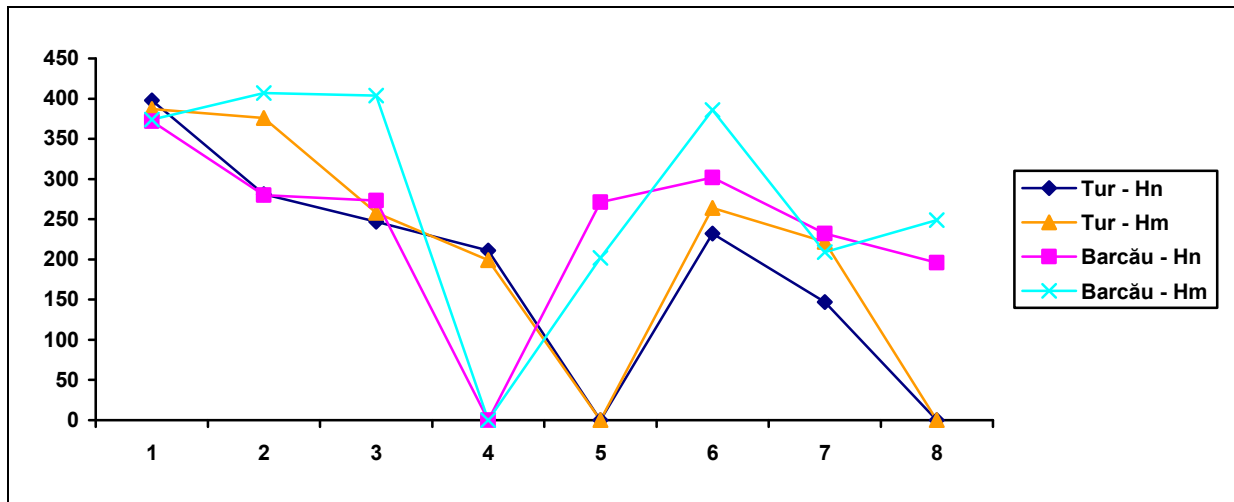


Fig. 8. The graph regarding the evolution of the diversity indicator on Tur and Barcău

Consequently, I formulated the following conclusions regarding the evolution of the diversity indicator: a) the superior course has natural, unaffected water and a fauna specific to it on both rivers; b) the diversity indicator has the same tendency of evolution on both rivers; c) the ecosystems from the middle and inferior courses are affected by pollution, but the pollution forms and their intensity take different forms (heavy metals on Tur; petroleum on Barcău); d) a dam that blocks the fish circulation and affects the fish fauna appears downstream on each river, in the immediate vicinity (the physical dam from Călinești Oaş on Tur; the chemical dam produced by petroleum products on Barcău at Suplac – Marghita); e) there is a correlation, but not strict, between the diversity coefficient on basis of number of individuals (Hn) and that on basis of biomass (Hm).

Proposals: The measures that regard the improvement of Barcău's water quality and its fish fauna structure.

The improvement of the water quality is possible by taking some hydrological and ecological management measures as: a) the maintenance of an acceptable minimum level of water on the river in the drought periods (water reservoirs to overtake the floods); b) the improvement of the river's water quality by placing water plants and by improving the functioning of the existing ones, the fixing of the pipes that take the oil to the drills, the prevention of the uncontrolled evacuation of waste water and animal husbandry fertilizers and dejections from the Suplac refinery; c) the recuperation of the bordering meadows and swamps for the assuring of the nourishment resources and the shelter and reproduction places.

The improvement of the qualitative and quantitative structure of Barcău's fish fauna regard measures of fish management as: a) the protection of the endemic, more sensible, species; b) the diminution of the populations of invasive allochthonous species; c) repopulations with alevins of some species with high economic value

(carp, crucian, waller, zander, honey locust, clean and so on and so forth); d) the reduction of the over-exploitation by giving a smaller number of fishing authorizations; f) the interdiction of poaching; g) the extension of the prohibition periods.

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