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FISH SPECIES DISTRIBUTION AND DIVERSITY INDICES FROM IARA RIVER – TRANSYLVANIA, ROMANIA

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Abstract

In the present study we analyzed fish species composition and diversity indices of Iara River (Cluj County). A total number of 189 specimens belonging to 9 species and 4 families were caught, using single pass electrofishing techniques. A total number of 11 sampling sectors were established. Our results were compared to previous studies and show changes in species distribution and diversity indices, due to environmental changes caused by climate changes and anthropic activities. We noticed the absence of the Grayling (Thymallus thymallus) and Stone loach (Barbatula barbatula) mentioned in previous studies, and the first record of Prussian carp (Carassius gibelio) in Iara River catchment. Also, the Caps dam (Iara – Fântânele deviation) blocks the upstream migration of Common bullhead (Cottus gobio). The calculated diversity indices (Shannon H', Simpson 1-D, Margalef Md, Berger-Parker d and Evenness J') show a low species diversity. This is the result of intense anthropic activities such as deforestation, dam construction and habitat fragmentation, even though the upper sector of Iara River is integrated in Natura 2000 protection areas.

Key Words: *electrofishing, habitat fragmentation, ichthyofauna, Natura 2000, Salmonidae.*

INTRODUCTION

In Romania there are two categories of Nature 2000 sites: 435 SCI sites (Sites of Communitary Importance) and 171 SPA sites (Sites of Avifaunistic Special Protection).
The superior sector of Iara River is integrated in ROSCI0263 Iara Valley. Iara River is a left side tributary of Arieș River, located in Cluj County and has a total length of 54 km.
The river crosses eight villages: Caps, Valea Ierii, Frăsinet, Moara de Pădure, Băișoara, Iara, Surduc, and Buru, where it flows in Arieș River. On Iara River, there is one fragmentation point, the Caps dam (Iara-Fântânele deviation). The dam blocks downstream-upstream migration of fish because there is no fish pass construction (Bâdiliţă et al., 2013; Danalache et al., 2017).
Habitat fragmentation causes genetic isolation and inbreeding (Curtean-Bănăduc et al., 2019).
Fish communities from mountain water bodies are heavily influenced by several anthropic factors such as climate change, deforestation, agriculture, overfishing, poaching pollution, micro-hydropower plants and dam constructions (Holcík, 2003; Almodóvar et al., 2004; Hu et al., 2019).
Integrative monitoring programmes are required to prevent species and habitat losses (Colette et al., 2018).
Measuring biological diversity (Mohebban et al., 2019) is indeed challenging (Magurran, 2004) especially in areas where anthropic disturbances are frequent.
Distribution and diversity of fish are altered when constant changes to environment occur.
In order to evaluate the dynamics in fish community, a regular ichthyological survey is required in order to have a global view regarding fish species distribution (Oţel, 2007; Kottelat and Freyhof, 2007).

MATERIALS AND METHODS

Sampling method

Fish specimens were captured using single-pass electrofishing techniques. Samus 725 MP electrofisher apparatus was used, powered by a 22 Ah rechargeable battery. The frequency of the electrofisher was set to 45Hz. In general single pass electrofishing techniques are efficient when it comes to species composition (Benejam et al., 2012). Water temperature, conductivity and pH were determined in each sector using Hanna HI-9828 multi-parameter apparatus.

Geographical data

GPS coordinates were collected using a Garmin eTrex 20x device, and mapping (station length, station altitude) of the river catchment were generating using GIS software (Nemec and Raudsepp-Hearne, 2013; Nicula et al., 2017). Also river structure parameters (mean sector depth, mean sector width) were determined using a 20 m tape measure. At the starting point and at the end point of each sampling sector, GPS coordinates, water depth and river width were measured. The collected fish specimens were identified, measured and photographed.

Data analysis

The data was processed using MS Excel and GraphPad Prism. Diversity indices were calculated based on field counts and determinations: Species Richness (R), Relative Abundance (%Abd), Shannon's Index (H'), Simpson's Index (D), Evenness (J'), Margalef Index (M_d), and Berger-Parker Index.

Diversity analysis

Species Richness

Species Richness (R) refers to the number of species present in an ecosystem, area or region.

Relative Abundance:

$$pi = Ni \,/\, N$$

Where *pi* is the proportion of individuals of *i-th* species, *Ni* is the number of individuals of that species and *N* is the total number of individuals of all species and *S* is the total number of species (or Richness).

$$N = \sum_{i=1}^{S} Ni$$

Shannon's Index H':

$$H' = -\sum pi \ln (pi)$$

Where *pi* is is the proportion of individuals of *i-th* species (Shannon and Wiener, 1949).

Simpson's Index 1-D:

$$1 - D = 1 - \frac{\Sigma_{ni}(ni-1)}{N(N-1)}$$

Where n is the total number of specimens of a particular species and N is the total number of specimens of all species (Simpson, 1949).

Evenness J':

$$\mathrm{J}' = \frac{\mathrm{H}'}{\mathrm{H}'_{\max}}$$

Where H' is Shannon's Index and H'_{max} is the maximum possible value of Shannon's Index H' in the context of equality of species (Pielou, 1966).

Margalef Index Md:

$$M_d = \frac{S-1}{\ln N}$$

Where S is total number of species and N is the total number of individuals from all species (Margalef, 1958).

Berger Parker Index d:

$$d = \frac{N_{max}}{N}$$

Where N_{max} is the number of individuals of the most abundant species and N is the total number of individuals from all species (Berger and Parker, 1970).

RESULTS AND DISCUSSIONS

Geographical data

Our research was conducted on the main course of Iara River, located in the Apuseni Mountains (Western Carpathians) (Figure 1). The geographic location of Iara River hydrographic microbazine related to the main course is found between the coordinates 46° 29 '00' 'N 23° 14' 00 " E (Muntele Mare Peak) and 46° 30 '30' 'N 23° 35' 38 " E (at the confluence with Aries River). The topoclimate is of sub-mountain type, with foehnal processes that decrease in intensity from West to East. The average annual temperature is around 8°C and the quantitative values of annual average rainfall do not exceed 750 mm / year (Pop, 2001). According to our GIS calculations, the studied location covers an area of 165.7 km^2 with a perimeter of 125.168 km.

The altimetric upstream – downstream ecart is 1468 m, with the maximum altitude of 1826 m in the Muntele Mare Peak and the minimum altitude of 381.5 m at the confluence of the main course of Iara River with Arieș River, near Buru village. The average slope is 30 ‰ and the sinuosity coefficient is 2.06 (The atlas of the Romanian water cadastre, 1992).

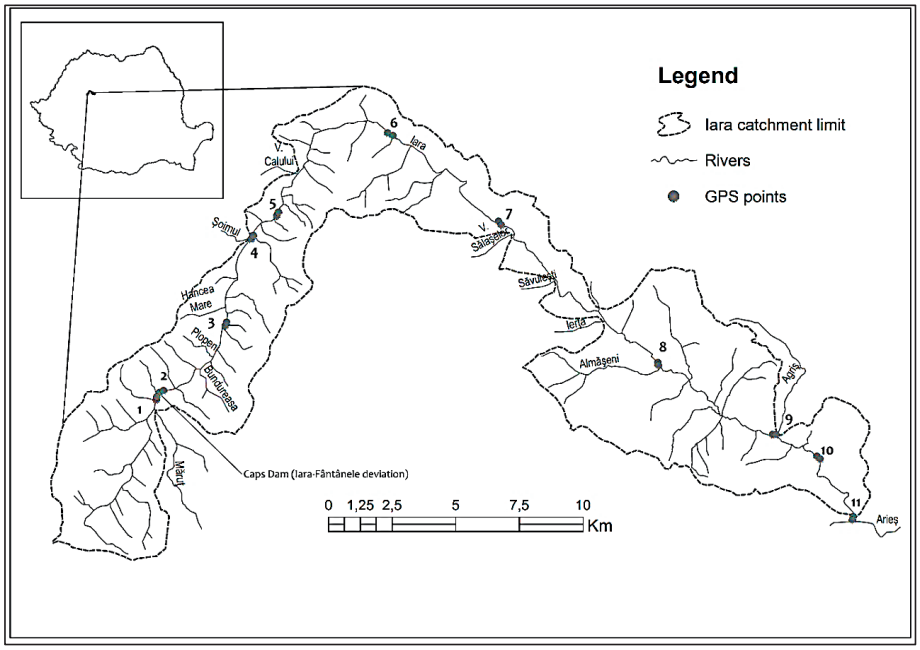

Figure 1. Iara River Catchement (Source: the authors)

Table 1. GPS coordinates of the sampling stations from Iara River

Sector	Upstream limit	Downstream limit	Mean altitude of sector (m)
1	N46° 32.768' E23° 14.206'	N46° 32.831' E23° 14.220'	1100
2	N46° 32.924' E23° 14.298'	N46° 32.966' E23° 14.429'	1093.5
3	N46° 34.374' E23° 16.276'	N46° 34.447' E23° 16.320'	940
4	N46° 36.225' E23° 17.021'	N46° 36.306' E23° 17.082'	847
5	N46° 36.733' E23° 17.790'	N46° 36.812' E23° 17.838'	843
6	N46° 38.541' E23° 21.152'	N46° 38.486' E23° 21.316'	708
7	N46° 36.714' E23° 24.613'	N46° 36.639' E23° 24.695'	599.5
8	N46° 33.779' E23° 29.600'	N46° 33.724' E23° 29.613'	475.5
9	N46° 32.296' E23° 33.162	N46° 32.294' E23° 33.268'	430.5
10	N46° 31.849' E23° 34.544'	N46° 31.792' E23° 34.642'	423
11	N46° 30.582' E23° 35.680'	N46° 30.512' E23° 35.658'	381.5

The length of Iara River is 53.304 km and runs through eight localities (Caps, Valea Ierii, Frăsinet, Moara de Pădure, Băișoara, Iara, Surduc and Buru). In the lower sector, the river forms the Surduc-Buru Defile (Pop, 2001), carved in hard formations mainly composed of crystalline shales.

The altitude and GPS coordinates of the sampling sectors are showed in Table 1. The lowest altitude (381.5 m) was recorded in sector 11. The highest sampling sector was situated at 1100 m. The mean length of the sampling sectors was 172.47 m (min=129.7m; max=266.7 m). The width of Iara River ranged from 2.5 m in sector 1 to 6.6 m in sector 11 (mean water width=4.75 m). Water depth ranged from 0.29 m in sector 2 to 0.45 m in sector 11 (Figure 2).

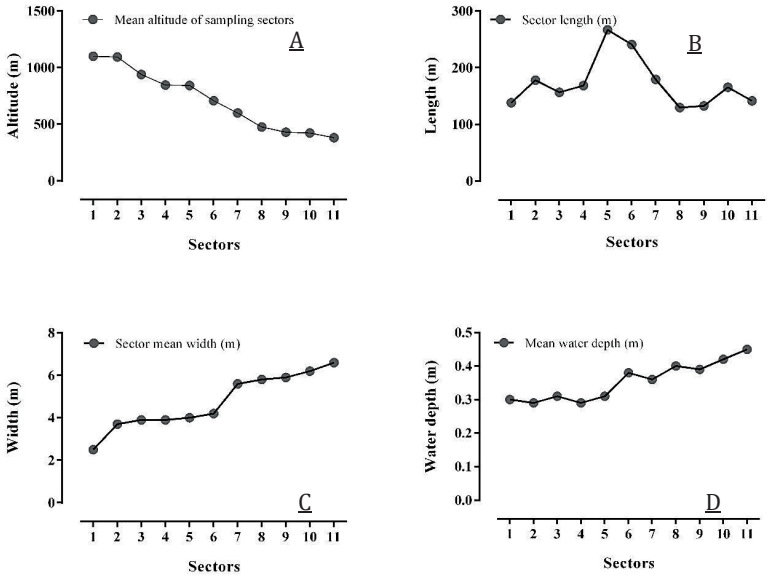

Figure 2. Water depth: A-altitude of studied sectors; B-length of sectors; C- width of sectors; D- mean water depth

Species composition structure and species abundance

Electrofishing and data analysis were performed from June 15th to June 27th 2019 on 11 sampling sectors. A total number of 189 fish specimens belonging 9 species (*Salmo trutta, Barbus petenyi, Squalius cephalus, Alburnoides bipunctatus, Phoxinus phoxinus, Carassius gibelio, Gobio obtusirostris, Cottus gobio* and *Eudontomyzon danfordi*), 4 families and 7 subfamilies, were caught (Table 2).

The most abundant species was *Salmo trutta* (77 specimens), representing 40.7407% from all the fishes caught, followed by *Barbus petenyi* (59 specimens), representing 31.2169%. Abundance percentages with lower values were registered for *Alburinoides bipunctatus* (15 specimens-7.9365%), *Cottus gobio* (14 specimens-7.4074%) and *Gobio obtusirostris* (12 specimens-6.3492%). The lowest abundance percentages were registered for *Squalius cephalus* (7 specimens-3.70375), *Carassius gibelio* (3 specimens-1.5873%), *Phoxinus phoxinus* and *Eudontomyzon danfordi* (1 specimen-0.5291%, for each species) (Table 3).

The presence of Brown trout *Salmo trutta* was signaled in the upper sectors of Iara River (Sectors 1 to 7). The distribution of *Salmo trutta* based on altitude ranged from 599.5 m to 1100 m.

The presence of European bullhead *Cottus gobio* was signaled in the upper sectors of the river (Sectors 3, 4, 5 and 7) and ranged from 599.5 m to 940 m. *Cottus gobio* was not signaled upstream the Caps Dam, in sectors 1 and 2 (Iara-Fântânele deviation).

The distribution of *Phoxinus phoxinus* in Iara River based on field data shows that it has a point presence (1 specimen in sector 4 at 847 m).

The Carpathian brook lamprey *Eudontomyzon danfordi* was present only in sector 6 at 708 m (1 specimen).

The Romanian barbel *Barbus petenyi* was present in the lower section of Iara River (sectors 8 to 10) at altitudes ranging from 423 m to 475 m. *Gobio obtusirostris,* was captured in two sectors from the lower section of the river (sectors 9 and 11) at altitudes ranging from 381.5 m to 430.5 m.

The Schnieder *Alburnoides bipunctatus* was present only in sector 11, very close to the confluence of Iara River with Arieș River (381.5 m).

The presence of Prussian carp *Carassius gibelio* is less common in this type of water. Three specimens were caught in sector 11 at 381.5 m altitude. The European chub *Squalius cephalus* was present only in sector 11, at the confluence with Arieș River (Table 4).

Table 2. Taxonomic table of fish species found in Iara River

Order	Family	Subfamily	Species
Salmoniformes	Salmonidae	Salmoninae	*Salmo trutta*
Cypriniformes	Cyprinidae	Barbinae	*Barbus petenyi*
		Leuciscinae	*Squalius cephalus*
			Alburnoides bipunctatus
			Phoxinus phoxinus
		Cyprininae	*Carassius gibelio*
		Gobioninae	*Gobio obtusirostris*
Scorpaeniformes	Cottidae	Cottidae	*Cottus gobio*
Petromyzontiformes	Petromyzontidae	Lampetrinae	*Eudontomyzon danfordi*

Table 3. Relative abundance percent of fish species found in Iara River

Species	n	Relative Abundance (%)	IUCN Status
Salmo trutta	77	40.7407	LC
Barbus petenyi	59	31.2169	LC
Alburnoides bipunctatus	15	7.9365	LC
Cottus gobio	14	7.4074	LC
Gobio obtusirostris	12	6.3492	LC
Squalius cephalus	7	3.7037	LC
Carassius gibelio	3	1.5873	LC
Phoxinus phoxinus	1	0.5291	LC
Eudontomyzon danfordi	1	0.5291	LC

LC – Least Concern

Table 4. Fish species distribution in the sampled sectors from Iara River

	Upstream→Downstream sectors											
	1	2	3	4	5	6	7	8	9	10	11	Total
Salmo trutta	19	13	22	6	9	4	4					77
Cottus gobio			4	5	4		1					14
Phoxinus phoxinus				1								1
Eudontomyzon danfordi						1						1
Barbus petenyi								4	37	18		59
Romanogobio vladykovi									6		6	12
Alburnoides bipunctatus											15	15
Carassius gibelio											3	3
Squalius cephalus											7	7
Total Number of Individuals/sector	19	13	26	12	13	5	5	4	43	18	31	189
Total Number of species/sector	1	1	2	3	2	2	2	1	3	2	4	9

Diversity Indices

The calculated value for Shannon Index (H') was 1.5414 and it shows low diversity. The same situation is encountered in the case of Simpson (1-D) index, 0.7229, Margalef Index (Md), 1.5262 and Berger-Parker Index (d), 1.5262. The calculated value of Evenness (J') is 0.7016 (Table 5).

This reflects the fact that Iara River fish community has dominant species (*Salmo trutta* in the superior section of the river and *Barbus peteniy* in the lower section of the river).

Table 5. Diversity indices of Iara River

Index	Value
Shannon (H')	1.5414
Simpson (1-D)	0.7229
Margalef (Md)	1.5262
Berger-Parker (d)	0.4074
Evenness (J')	0.7016

Fish communities distribution are affected by latitude and altitude (Parra et al., 2009) but also by climate change (Junker et al., 2014) and human activities (Ruppert et al., 2017; Nicolae et al., 2017).

The imprinted effects of deforestation, agriculture and urbanization are noticed in fish communities and may have destructive consequences (Petrișor, 2016).
The degradation of riparian vegetation caused by deforestation and ancillary activities (sawmills, wood processing and loading, log yards, storage of sawdust) (Adhikari and Ozarska, 2018) have negative impact on fish species diversity.
Fish species identification and historical evaluation of fish stocks represent scientific approaches for the evaluation of aquatic ecosystems (Clausen and York, 2007).
LeRoy Poff et al. (2001), stated that fish respond in three ways to climate change and land use changes: they may adapt to new conditions, change their distribution pattern in available coridors and extinct if environmental parameters and conditions change under tolerance levels of species. As Iara River fish community passes through severe landscape pressure caused by anthropic activities (Mulk et al., 2016) and climate change (Wabnitz et al., 2018), we noticed two out of three responses to environmental changes. First, fish adapted to the new conditions (*Salmo trutta, Cottus gobio*) even though their number is low.
It was found the same response in the case of *Carassius gibelio*, which has found a new coridor from Arieș River to Iara River. The second response was the absence of *Thymallus thymallus*, first signaled by Petru Bănărescu (1964).
A similar study to ours was conducted by Imecs and Nagy (2012) did not confirm the presence of *Thymallus thymallus.* Also in the same study the presence of *Barbabtula barbatula* was mentioned. In our study this species was not present. The small number of fish caught (189 specimens) is a consequence of water quality degradation over time due to logging activities, overfishing, poaching, household pollution and climate change.

CONCLUSIONS

The distribution of fish species in Iara River is influenced by anthropic activities. The most abundant area was at the confluence of Iara River and Arieș River (4 species). The presence of *Carassius gibelio* in sub-mountain fast flowing water is very unusual, but it is explained by the short distance to Arieș River. In four out of eleven sectors we found only one fish species (Sector 1-*Salmo trutta*; Sector 2-*Salmo trutta*, Sector 8-*Barbus petenyi*, Sector 10-*Barbus petenyi*). Fish species composition changes based on altitude. Fish species specific to mountain area are found from sector 1 to sector 7 (altitude ranging from 1100 m to 599.5 m). In the next sectors (8 to 11, altitude ranging from 475.5 m to 381.5) are found fish species corresponding to sub-mountainous area belong to Cyprinidae family.

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