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URBAN ICHTHYOFAUNA: BECAȘ RIVER CASE STUDY, CLUJ-NAPOCA (TRANSYLVANIA)

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Abstract

The monitoring of ichthyofauna from rivers and rivulets crossing urban areas is important in the context of preserving ecosystems under continuous anthropic pressures. In addition, new invasive species may be observed. This study aims to present current data on the ichthyofauna of Becaș River, which has its entire course in Cluj-Napoca, Romania. For this purpose, alpha diversity, LWRs, Fulton condition factor (K) and relative condition factor (Kn) were determined. In total, 1216 specimens were analyzed, classified into 13 species, from 8 families. The species with the highest abundance was Pseudorasbora parva (46.46%), and the species with the lowest abundance were Cyprinus carpio and Perca fluviatilis (0.16%). Regarding LWRs, the lowest value of the b coefficient was obtained for Rutilus rutilus (2.7651) and the highest value for Phoxinus phoxinus (4.0868). The highest value of K was obtained for C. carpio (1.815) and the lowest value for Cobitis elongatoides (0.5942). The Kn was between 0.5436 (Gobio carpathicus) and 1.0330 (C. elongatoides).

Key words*: anthropization, aquatic ecosystem, Cyprinidae, invasive species.*

INTRODUCTION

Fish populations in natural waters are in a continuous dynamic in terms of species structure. The factors leading to these changes are numerous (Bănăduc et al., 2023). The most important are represented by anthropogenic influences that include changes in water courses (Hellström et al., 2019; Holban et al., 2020; Dănălache et al., 2020), expansion of urban habitats (Burger et al., 2022), hydrotechnical facilities (Piria et al., 2019), irrational exploitation of fish populations, poaching (Gotkiewicz, 2018), predatory species (Oehm et al., 2022) and pollution resulting from industrial, agricultural activities and the discharge of rainwater, wastewater and household water (Casatti et al., 2006; Jacobson, 2011). Agricultural activities that include the use of fertilizers, especially inorganic compounds such as nitrogen and phosphorus, have a primary effect on the development of phytoplankton communities (Kremser & Schung, 2002), which represent the primary food for the juveniles of various fish species. In principle, this is a favorable consequence, but various chemical products such as insecticides, pesticides, or herbicides (Gibbons et al., 2015; Houssou et al., 2018; Yang et al., 2021) can have long-term implications that will lead to degenerative aspects of fish populations, especially with regard to the reproductive and perpetuating functions of species, thus influencing aquatic biodiversity (Higgins et al., 2019; Jwaideh et al., 2022) and fish health. Domestic and industrial waters discharged into watercourses in urbanized areas can have a similar effect (McCallum et al., 2017).

Other factors responsible for the dispersion of fish species are geo-morphological and climatic factors (Georgiev & Nazarova, 2015; Bănăduc et al., 2022), their parameters changing continuously. Sometimes, even without the influence of the previously listed factors, structural changes occur generated by the ecological relationships between different species (Zeng et al., 2022), the accidental appearance of new fish species (Brysiewicz et al., 2022; Larentis et al., 2022), the overlapping of trophic niches (Leunda, 2010; Alonso et al.,

2019) or the uncontrolled numerical increase of specimens, which will lead to a drastic reduction of food resources. Last but not least, economic and commercial activities also contribute to changes in species structures (Cocan et al., 2014; Cocan et al., 2016).

Currently, there is an increasingly accentuated trend of migration of human populations from rural to urban environments. The reasons are complex, but generally relate to the availability of better living conditions, wage gaps between rural and urban environments (Stanef, 2014), easier access to jobs, education, and health services. These migrations lead to the spatial development of large cities, sometimes in homogeneously (Földes, 2019), including the expansion of areas intended for housing. Thus, the peripheral areas of cities that in the past were either agricultural areas or unexploited areas, become new neighborhoods that exert intense anthropogenic pressures on natural environments.

The expansion of urban areas can have catastrophic effects on fish populations in the rivers that cross these areas (Panja et al., 2020). However, there are situations in which fish species adapt to new conditions (Czeglédi et al., 2020), both in terms of the physicochemical parameters of the water and in terms of food resources (Peressin et al., 2018). Sometimes, the process of adaptation to new conditions can take several years (Sun et al., 2022). Moreover, previous studies and researchers' observations have demonstrated many times that river sectors in urbanized areas are more abundant with fish compared to isolated areas (Qiao et al., 2022). This is the result of easier access to food resources (Tófoli et al., 2013), generally represented by food waste dumped uncontrolled into watercourses by humans. Fish adapt to new food resources (Ganassin et al., 2019) and multiply numerically.

Fish populations in the urban areas of Romania have been scarcely studied both in terms of fish diversity and abundance. Thus, the purpose of this study is to determine the species structure and biodiversity indices of fish in the Becaș River, a tributary of the Someș-Tisa hydrographic catchment. This river crosses the city of Cluj-Napoca from South to North and it is subject to different anthropic pressures on its route from the sources to the outlet, from areas with real estate potential, to commercial and industrial areas, crossing, among others, the entire area belonging to the international airport.

MATERIALS AND METHODS

Fish sampling was conducted using a SAMUS 725 MP electrofishing apparatus, powered by a 12V (24A) rechargeable battery. Each fish was weighed (BW = fish wet body weight) and measured (TL = total length of fish) and data was used for length-weight relationships (LWRs), Fulton's condition factor (*K*), and relative condition factor (*K*n) (Reid et al., 2009; Imecs & Nagy, 2016; Cocan et al., 2020; Lațiu et al., 2023). Based on the number of encountered species and their frequencies, alpha diversity indices were determined.

Relative abundance (%), Simpson's index (1-D), Shannon's index (H'), Evenness (J'), Margalef index (Md) and Berger-Parker index (d) were determined to provide general information on species structure and to be used for future conservation plans for aquatic habitats (Cheng et al., 2019). Alpha diversity indices were determined using Past 4.03 software (Hammer & Harper, 2001; Hammer & Harper, 2006).

LWRs were calculated using the formula $BW = aTL^b$, where *a* and *b* are the coefficients of the regression between BW and TL (Le Cren, 1951). Coefficients a and b were obtained by the least-square linear regression from the log-transformed values of TL and BW, using the formula $BW = \log a + b \log TL$ (Morey et al., 2003). To determine the type of growth for the sampled specimens, *b* values were analyzed as follows: positive allometric growth, if $b>3$; negative allometric growth, if $b<3$; and isometric growth, if $b=3$ (Froese, 2006). Confidence intervals (CI) at 95% were used to establish if the b values obtained from the linear regressions were significantly different from the isometric value ($b = 3$). The t-test was used to determine if the obtained *b* value was significantly different from the isometric value and establish the growth type (Ricker, 1975; Zar, 1984).

Fulton's condition factor (*K*) was obtained using the formula $K = 100 * BW/TL^3$, where *K* is the value of the index, BW is the fish's wet body weight and TL is the total length of the fish (Fulton, 1904; Ricker, 1975; Nash et al., 2006). The relative condition factor (*K*n) of each individual was determined by the following equation: $Kn = W_o/W_e$, where W_o is the observed/determined wet weight of the fish and W_e is the expected weight, determined from the LWRs (Narejo et al., 2002). The fish condition can be evaluated as follows: $Kn \geq 1$, when fish growth condition is good, and $Kn<1$, when the fish growth condition is poor (Le Cren, 1951; Cone, 1989).

RESULTS AND DISCUSSIONS

Becaș River is a right-hand tributary of Someșul Mic River, being located in the eastern part of Cluj-Napoca City, flowing from South to North. This small river has a total length of 9 km and overpasses major infrastructures of the city such as industrial, commercial and transportation areas (Figure 1).

A total number of 1216 specimens from 13 species, belonging to 8 families (Centrarchidae, Cobitidae, Acheilognathidae, Cyprinidae, Gobionidae, Leuciscidae, Nemacheilidae, Percidae) were captured from 15th to 17th of June, 2022. The most abundant species was *Pseudorasbora parva* (Temminck and Schlegel, 1846), representing 46.46% of the total catch. Another highly abundant species was *Rutilus rutilus* (Linnaeus, 1758) representing 38.82%. *Barbatula barbatula* (Linnaeus, 1758) specimens represented 2.47% of the analyzed specimens. A similar percentage (2.38%) was observed in the case of *Squalius cephalus* (Linnaeus, 1758). *Phoxinus phoxinus* (Linnaeus, 1758) and *Cobitis elongatoides* (Băcescu & Mayer, 1969) had similar abundances, 0.99% and 0.90% respectively.

Figure 1. Riverine landscape across the studied area: A - Confluence of Becaș River and Someșul Mic River; B - Concrete banks from the Airport Area; C - Landscape from the Industrial Area of the River; D - Landscape from the Commercial Area of the River

The specimens of *Barbus carpathicus* (Kotlík et al., 2002) represented 0.82% of the total catch. The specimens of *Lepomis gibbosus* (Linnaeus, 1758) represented 0.41% of the catch. *Rhodeus amarus* (Bloch, 1782) represented 0.25% of the analyzed fishes. *Perca fluviatilis* Linnaeus, 1758 and *Cyprinus carpio* Linnaeus, 1758 had identical abundance (0.19%) (Figure 2).

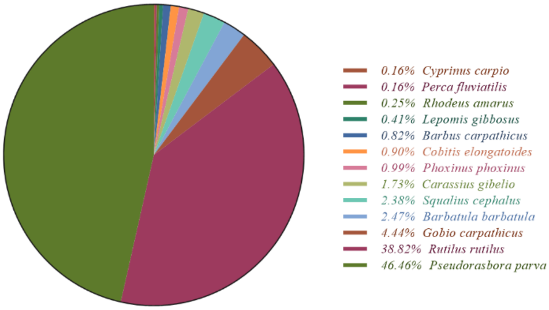

Figure 2. Relative abundance for fish species observed in Becaș River

Simpson's index 1-D showed a moderate degree of diversity (1-D = 0.6297). Shannon's index H', takes into consideration both species richness and evenness, showing low-moderate diversity (H' = 1.2818). In this case, the determined Evenness (J' = 0.5061) articulates the fact that Becaș river has a moderate evenness between the species. Regarding the Margalef index (Md), a moderate degree of diversity was observed, similar to Simpson's index. The Berger-Parker index (d), expressing, in general, the proportional importance of the most abundant species, showed that *P. parva* dominates the fish community (d = 0.4646) (Table 1.).

Table 1. Alpha Diversity Indices for the fish species observed in Becaș River

Species richness (number of species)	13
Number of individuals	1216
Simpson 1-D	0.6297
Shannon H'	1.2980
Evenness J'	0.5061
Margalef Md	1.6890
Berger-Parker d	0.4646

From the total of 13 species observed in Becaș river, 8 species showed positive allometric growth (*L. gibbosus*, *C. elongatoides*, *R. amarus*, *B. carpathicus*, *C. gibelio*, *G. carpathicus*, *P. parva*, *P. phoxinus*), 2 species showed isometric growth (*S. cephalus* and *B. barbatula*), 1 species showed negative allometric growth (*R. rutilus*) and for 2 species (*C. carpio* and *P. fluviatilis*) the LWRs were not determined due to the small number of specimens (Table 2).

Parameter/exponent *b* ranged from 2.7651 (*R. rutilus*) to 4.0868 (*P. phoxinus*). The unusual value observed in the case of *P. phoxinus* may be caused by the length class of the analyzed specimens and the small number of analyzed individuals. The coefficient of determination r^2 ranged from 0.8181 (*C. elongatoides*) to 0.9998 (*L. gibbosus*).

Fulton's condition factor *K* showed ununiform variations across the individuals and also across the species. In the case of *L. gibbosus*, the mean value of *K* was 1.680±0.0805 and a coefficient of variation (CV%) of 4.796%; for *C. elongatoides* *K*=0.5942±0.2024 and CV% = 34.06; for *R. amarus* mean *K* = 1.343±0.2463 and the CV%=18.34; for *B. carpathicus* mean *K* = 0.8538 ± 0.0967 and CV% = 11.33; for *C. carpio* mean *K* = 1.815±0.0368 and CV% = 2.030; for *C. gibelio* mean *K* = 1.651±0.1331 and CV% = 8.063; for *G. carpathicus* mean *K* = 0.8784 ± 0.1296 and CV% = 14.75; for *P. parva* mean *K* = 0.8076±0.1808 and CV% = 22.39; for *P. phoxinus* mean *K* = 0.7718 ± 0.2162 and CV%=28.01; for *S. cephalus* mean *K* = 0.9121 ± 0.0745 and CV% = 8.170; for *R. rutilus* mean *K* = 1.090 ± 0.2334 and CV% = 21.42; for *B. barbatula* mean *K* = 0.8265±0.0827 and CV% = 10.01; and for *P. fluviatilis* mean *K* = 1.305±0.0876 and CV% = 6.712 (Figure 3).

The mean relative condition factor *K*n ranged from 0.5436 ± 0.0778 in the case of *G. carpathicus* to 1.0330 ± 0.2991 in the case of *C. elongatoides* (Figure 4).

Table 2. The determined LWRs for fish species observed in Becaș River

Family	Species	n	Total length (mm)		Body weight (g)		Parameters of LWRs					Growth type
			TL min.-max.	TL mean ± SD	BW min.-max	BW mean ± SD	*a*	*b*	*a* CI95%	*b* CI95%	r^2	
Centrarchidae	*Lepomis gibbosus*	5	3.7-9.8	7.28 ±3.012	0.8-16.9	9.26 ±7.637	0.01421	3.0876	0.0119-0.0169	2.9981-3.1771	0.9998	b≠3 (ALO+)
Cobitidae	*Cobitis elongatoides*	11	6.5-9.8	8.055 ±1.16	1.4-9.8	3.445 ±2.436	0.00143	3.6667	0.00009-0.02181	2.35882-4.97466	0.8171	b≠3 (ALO+)
Acheilognathidae	*Rhodeus amarus*	3	3.8-6.1	5.2 ±1.229	0.6-3.6	2.233 ±1.518	0.00430	3.6931	0.00004-0.46904	0.08338-6.5524	0.9963	b≠3 (ALO+)
Cyprinidae	*Barbus carpathicus*	10	4.5-15.4	8.87 ±4.759	0.7-37.1	11.89 ±14.55	0.00606	3.1644	0.00490-0.00750	3.06363-3.26513	0.9985	b≠3 (ALO+)
	Cyprinus carpio	2	n too small									
	Carassius gibelio	21	3.8-14.6	8.814 ±3.785	0.8-50.3	17.7 ±16.88	0.01334	3.1012	0.01167-0.01526	3.03805-3.16437	0.9982	b≠3 (ALO+)
Gobionidae	*Gobio carpathicus*	54	3.2-12.8	7.056 ±2.726	0.3-19.6	4.761 ±5.241	0.00650	3.1534	0.00529-0.00799	3.04615-3.26072	0.9853	b≠3 (ALO+)
	Pseudorasbora parva	565	2.3-8.4	4.212 ±0.8682	0.1-6.6	0.7207 ±0.6288	0.00452	3.3920	0.0040-0.0052	3.2991-3.4849	0.9014	b≠3 (ALO+)
Leuciscidae	*Phoxinus phoxinus*	12	3.1-6.1	4.675 ±1.017	0.1-2.2	0.975 ±0.6717	0.00141	4.0868	0.0005-0.0044	3.3514-4.8222	0.9388	b≠3 (ALO+)
	Squalius cephalus	29	4.8-22.5	11.86 ±4.238	1-112	21.33 ±21.47	0.00789	3.0593	0.00659-0.00945	2.9851-3.1334	0.9962	b=3 (ISO)
	Rutilus rutilus	472	3.4-11.9	5.352 ±1.386	0.3-17.8	1.99 ±2.105	0.01570	2.7651	0.01376-0.01791	2.6859-2.8443	0.9093	b≠3 (ALO-)
Nemacheilidae	*Barbatula barbatula*	30	4.1-11.2	7.613 ±2.031	0.6-12.3	4.447 ±2.941	0.00675	3.0991	0.00519-0.00787	2.96856-3.22969	0.9883	b=3 (ISO)
Percidae	*Perca fluviatilis*	2	n too small									

Legend: n - number of individuals; TL - total length (mm); BW - wet body weight (g); SD - standard deviation; *a* and *b* - are the coefficients of the regression; CI 95% - confidence intervals; R^2 - coefficient of regression; ISO - isometric growth; ALLO+ - positive allometric growth; ALLO– - negative allometric growth.

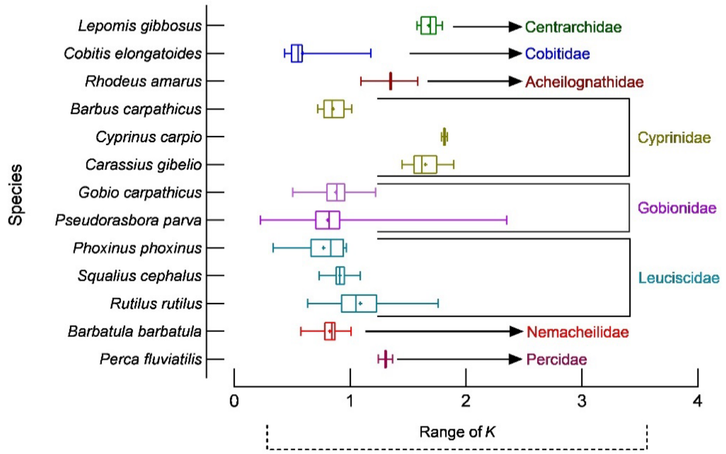

Figure 3. The determined Fulton Condition Factor (*K*) for the fish species found in Becaș River

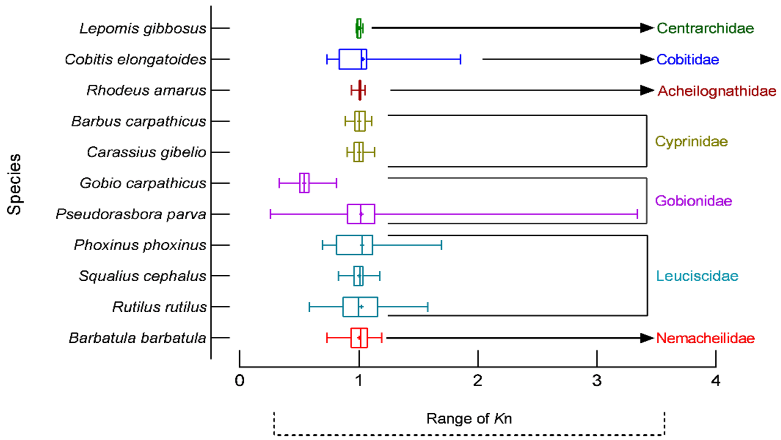

Figure 4. The determined Relative Condition Factor (Kn) for the fish species found in Becaș River

When analyzing the entire sampled population, it can be observed that only one species (*G. carpathicus*) presented the *K*n mean value smaller than 1, suggesting that its growth condition was poor. Two species (*L. gibbosus* and *R. amarus*) had *K*n equal to 1, suggesting that they were in normal growth conditions. The remaining species (*C. elongatoides, Barbus carpathicus, Carassius gibelio, P. parva, P. phoxinus, S. cephalus, R. rutilus* and *B. barbatula*) except *C. carpio* and *P. fluviatilis* (due to the small number of specimens) showed a mean *K*n value larger than 1, suggesting that the species were in good growth condition.

The determined LWRs were compared to the available data from FishBase (Froese & Pauly, 2000). Species such as *L. gibbosus, B. carpathicus, G. carpathicus, S. cephalus,* and *B. barbatula* had similar *b* exponent values compared to those provided by FishBase. Other species such as *C. elongatoides, R. amarus, C. gibelio, P. parva, and P. phoxinus* had larger *b* exponent values compared to those from Fishbase. Only one species (*R. rutilus*) had a smaller *b* exponent value. *C. carpio* and *P. fluviatilis* were not compared to the above-mentioned source, because of the small number of specimens. In terms of occurrence, 8 species (*C. elongatoides, R. amarus, C. gibelio,* *P. phoxinus, S. cephalus, R. rutilus, B. barbatula* and *P. fluviatilis*) are mentioned as native by FishBase. Three species (*L. gibbosus, C. carpio* and *P. parva*) are mentioned as introduced by the same data source. Two species (*B. carpathicus* and *G. carpathicus*) were not mentioned to be present in Romanian freshwater ecosystems by FishBase, but they were mentioned by other sources to be present in Romanian freshwater ecosystems (Kotlík et al., 2002; Konopiński et al., 2013; Năstase & Oțel, 2015; Ardelean et al., 2016). Iftimie & Iftimie (2021) mentioned two of the species observed in the present study as introduced/alien (*L. gibbosus* and *P. parva*), with unclear status under Romanian law, both potential threats to native fish species. According to the IUCN Red List, 11 of the observed species from the present study were under the "LC - Least Concern" category. *C. gibelio* is not mentioned and *C. carpio* is considered "VU - Vulnerable" (IUCN Red List, accessed November 15, 2022).

CONCLUSIONS

This is the first study on the ichthyofauna of the Becaș River, Cluj County, Romania. Although it is a small body of water, about 9 km long, it is home to 13 species of fish, of which 10 species are native and 3 are introduced. The length-weight relationship, the Fulton condition factor (*K*) and the relative condition factor (*K*n) show that the maintenance status of the fish population is generally good for most species. The continuous monitoring of the ichthyofauna of the Becaș River is necessary, because the composition of the species and their abundance can provide important information regarding the anthropogenic impact.

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