

## ASSESSING TEMPORAL VARIATION IN FISH COMMUNITIES IN THE LESPEZI SECTOR OF THE SIRET RIVER (2021–2025)

### EVALUAREA VARIAȚIEI TEMPORALE A COMUNITĂȚILOR PISCICOLE ÎN SECTORUL LESPEZI AL RÂULUI SIRET (2021–2025)

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#### **Abstract.**

*This study evaluates changes in fish biodiversity in the Lespezi sector of the Siret River by comparing data collected in 2023 and 2025. Abundance data, derived from scientific fishing surveys, were used to calculate multiple biodiversity indices, including Margalef's richness, Shannon–Wiener diversity, Simpson's dominance, and McIntosh's evenness, providing a comprehensive assessment of community structure. Although the results are subject to some limitations, as the captures reflect only those individuals caught during scientific fishing, the analysis highlights temporal variations in species richness and abundance over the two-year period, reflecting potential influences of environmental factors, anthropogenic pressures, and habitat changes. These findings offer insights into the ecological status of the Siret River fish communities and support sustainable management and conservation strategies for freshwater ecosystems.*

**Key words:** Fish biodiversity, Ecological assessment, Population structure, Temporal comparison.

#### **Rezumat.**

*Acest studiu evaluează modificările biodiversității piscicole în sectorul Lespezi al râului Siret prin compararea datelor colectate în 2023 și 2025. Datele privind abundența, obținute prin capturi științifice de pești, au fost utilizate pentru calcularea mai multor indici de biodiversitate, inclusiv numărul de specii Margalef, diversitatea Shannon–Wiener, dominanța*

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*Simpson și uniformitatea McIntosh, oferind o evaluare cuprinzătoare a structurii comunității. Deși rezultatele sunt supuse unor limitări, întrucât capturile reflectă doar indivizii prinși în cadrul pescuitului științific, analiza evidențiază variații temporale ale numărului și abundenței speciilor pe parcursul celor doi ani, sugerând influențe potențiale ale factorilor de mediu, presiunilor antropice și modificărilor habitatului. Aceste constatări oferă perspective asupra stării ecologice a comunităților piscicole din râul Siret și susțin strategiile de management durabil și conservare a ecosistemelor de apă dulce.*

**Cuvinte cheie:** Biodiversitate piscicolă, Evaluare ecologică, Structura populațiilor, Comparare temporală.

## INTRODUCTION

Covering a distance of 559 km from its entry into the country to its confluence, the Siret River is one of the most important tributaries [Romanescu, 2009] of the Danube River, with one of the largest drainage basins in Romania, approximately 28,000 km<sup>2</sup>. The Siret River is not navigable. Due to multiple floods, intensified by climate change, such as those in 1991, 2004, 2005, 2008 [Obreja, 2013; Romanescu and Stoleriu, 2013], dams and reservoirs have been constructed along the river. Dams alter the balance of aquatic ecosystems by modifying the flow regime and reducing sediment transport, which directly affects available habitats and biological diversity [Petts and Gurnell, 2005; Salit *et al.*, 2015].

While in previous years the river experienced ice cover during winter, this process was no longer observed in the last few years [www.inhga.ro], suggesting a significant change in the hydrological and thermal regime of the water, with direct consequences for aquatic biodiversity, particularly the structure of the fish community.

Beyond fish communities, the river hosts a complex aquatic biodiversity, represented by phytoplankton and zooplankton, whose trophic structures and seasonal dynamics form the basis of the food web and directly influence ecosystem productivity [Tenciu *et al.*, 2004]. Hydrological alterations and pollution impact not only fish but also planktonic communities, which respond rapidly to changes in water quality and can serve as sensitive ecological indicators of ecosystem health.

The river's ichthyofauna consists of 52 fish species [Battes *et al.*, 2005], but its structure has been modified by anthropogenic factors such as pollution [Faciuc *et al.*, 2014; Chidiac *et al.*, 2023] and hydrotechnical regulations [Battes *et al.*, 2005; Danalache *et al.*, 2020; WWF-Ukraine, 2023].

However, studies conducted on the Siret River are relatively few, and those specifically focusing on its ichthyofauna are almost nonexistent, highlighting a significant gap in the scientific literature and justifying the need for further research in this direction.

## MATERIAL AND METHOD

**Study area.** Data on the fish community of the Siret River were collected over two years, 2023 and 2025, at the same monitoring station and during the same period: the Lespezi hydrometric station (Figure 1) – Siret km 387, during May–June, using electrofishing. Fish species were identified to the species level, and the number of individuals was recorded for each species. For each year, the total and relative abundance of each species was calculated. In addition, specimens were measured with an ichyometer (with a precision of  $\pm 0.01$  cm) and weighed with the help of a field scale ( $\pm 0.01$ g).

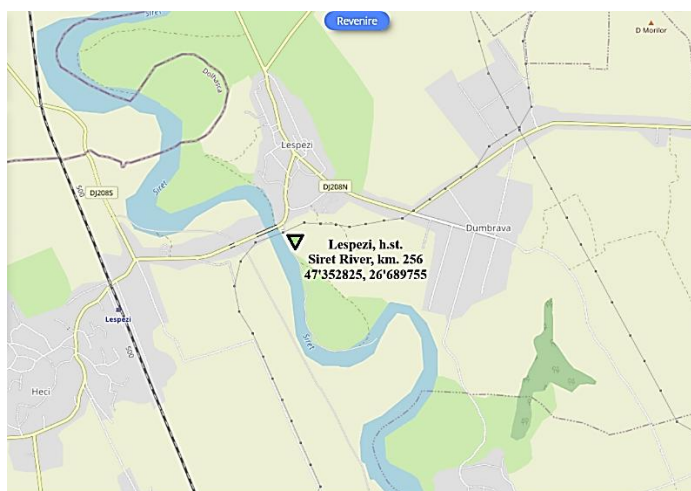


Fig. 1. Study area – Location of the Lespezi hydrometric station (Siret River).

**Comparative analysis of biodiversity indices: 2023 vs. 2025.** Based on the raw data, biodiversity indices were calculated to assess the richness, diversity, and evenness of the fish community:

- **Margalef (R):** a species richness index that considers the total number of species and the total number of individuals. It is calculated as:  $R = (S - 1) / \ln(N)$ , where  $S$  = number of species,  $N$  = total number of individuals [Kitikidou *et al.*, 2024].
- **Simpson (D):** a dominance/diversity index reflecting the probability that two randomly selected individuals belong to the same species:  $D = \sum p_i^2$ , where  $p_i$  = proportion of individuals of species  $i$ . Values close to 0 indicate high diversity, while values close to 1 indicate strong dominance by a single species [Simpson, 1949]. Diversity is higher if species are evenly distributed [Gregorius and Gillet, 2008].
- **Shannon-Wiener (H')**: a diversity index that combines species richness and evenness of individual distribution:  $H' = -\sum p_i \cdot \ln(p_i)$ , where  $p_i$  is the proportion of individuals of species  $i$ . Higher values indicate greater diversity [Kutsch *et al.*, 2001].
- **Berger-Parker (d):** a dominance index based on the most abundant species:  $d = N_{\max} / N$ , where  $N_{\max}$  = number of individuals of the most abundant species,

$N$  = total number of individuals. Higher values indicate stronger dominance [Kitikidou *et al.*, 2024].

- **Shannon's Equitability (E):** measures how evenly individuals are distributed among species:  $E = H'/\ln(S)$ , where  $H'$  = Shannon-Wiener index and  $S$  = number of species. Values range from 0 to 1, with 1 indicating a perfectly even distribution [Shannon and Weaver, 1963].
- **McIntosh (U):** an index combining species richness and individual distribution, calculated as:  $U = (N - \sqrt{\sum n_i^2}) / (N - \sqrt{N})$ , where  $n_i$  = number of individuals of species  $i$ ,  $N$  = total number of individuals. Values close to 1 indicate a balanced community, while low values indicate dominance [McIntosh, 1967].

To test whether the community structure underwent significant changes between 2023 and 2025, a Chi-square test for species distribution independence was applied ( $df = 13$ ,  $\alpha = 0.05$ ). The calculated  $\chi^2$  values were compared with the critical value  $\chi_{crit}^2 = 9.49$ . Since the Chi-square test is non-parametric, it does not require data normality.

The similarity between the fish communities in 2023 and 2025 was evaluated using the Jaccard index, which is based on species presence/absence. Values were transformed into a binary format, with 1 for present species and 0 for absent species, to calculate the proportion of species shared between the two communities. The index ranges from 0 (no species in common) to 1 (all species in common), providing an estimate of the degree of overlap in species composition between the two years. Additionally, similarity indices, such as Jaccard, were calculated to quantify changes in the composition and structure of the fish community.

For the evaluation of hydrological parameters of the Siret River, daily data corresponding to the study area were obtained from the National Institute of Hydrology and Water Management (INHGA). Based on these data, descriptive statistical indicators were calculated, including minimum and maximum values, mean, median, range (difference between maximum and minimum values), and standard deviation, for both water level and discharge, to characterize the monthly variability of the water level.

**Hydrology–biodiversity correlation.** To evaluate the relationship between hydrological variability and fish community structure, the monthly/yearly water level range and standard deviation were calculated. These variables were then correlated with biodiversity indices (Shannon–Wiener, Simpson, and Berger–Parker) using Spearman's correlation, due to the low number of observations and the lack of normality. This combined approach allows for the identification of both linear trends and monotonic relationships between hydrological variability and fish community structure.

**Statistical analysis.** Statistical analyses, data processing, and graphical representations (bar and boxplots) were performed using R software (version 4.5.1).

## RESULTS AND DISCUSSIONS

Out of the 52 species reported in the literature [Battes *et al.*, 2005], 11 species were identified in our catches in 2023, while in 2025 only 7 species were recorded. This reduction in diversity suggests a possible degradation of ecological conditions in the Siret River, driven by both anthropogenic pressures and recent hydrological variations. The decrease in species number may reflect not only a decline in habitat quality and its fragmentation but also increased pressure on trophic resources, leading to a restructuring of the fish communities. Thus, the results indicate a trend

toward simplification of the ichthyofauna structure and highlight the need for continuous monitoring to capture its dynamics in relation to environmental factors and human pressures.

Analysis of relative abundance highlights the distribution of individuals among species and emphasizes the dominant species. In 2023, *Carassius gibelio* [Bloch, 1782] represented approximately 30% of the community, followed by *Cyprinus carpio* [Linnaeus, 1758] and *Abramis brama* [Linnaeus, 1758] - 13% each), while the remaining species had lower abundances, indicating a moderately balanced community. In 2025, *Abramis brama* became the dominant species with 41%, and *Vimba vimba* [Linnaeus, 1758] contributed 26%, while the remaining species had much lower abundances, below 12% each, emphasizing the imbalance and loss of diversity. Figures 2 and 3 clearly illustrate these changes in community structure and allow visualization of the relative proportions of species between the two years.

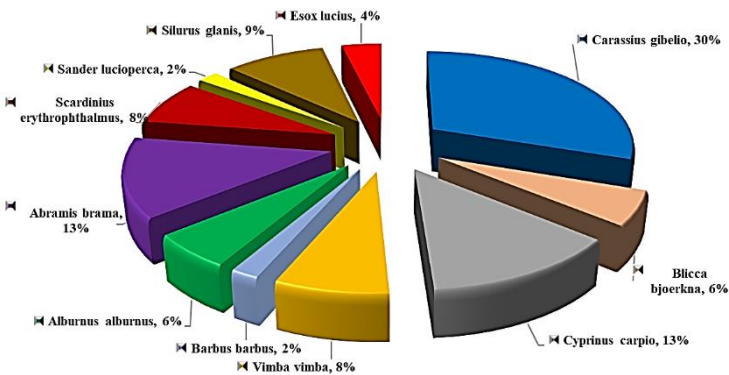


Fig. 2. Relative abundance of fish populations in the Siret River in 2023

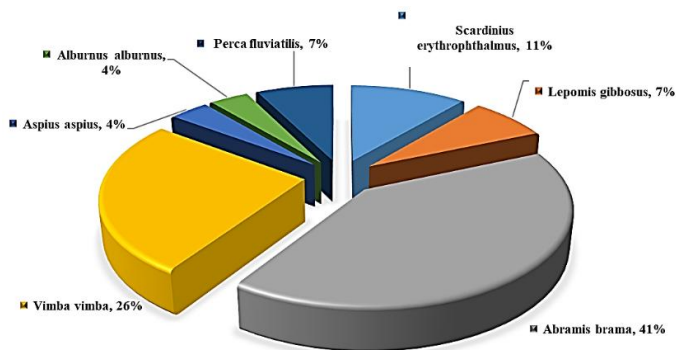
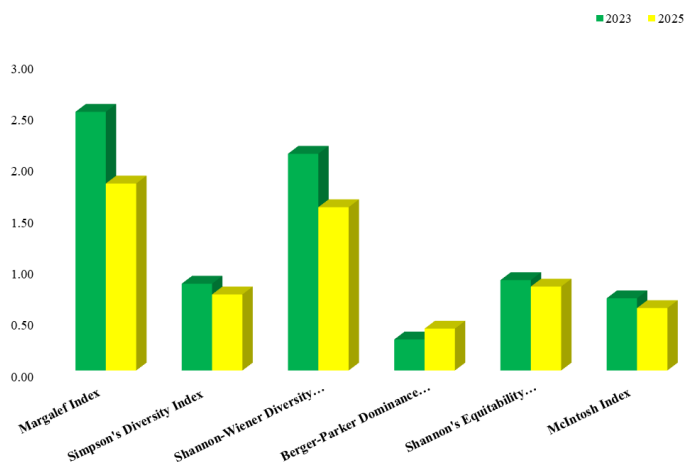


Fig. 3. Relative abundance of fish populations in the Siret River in 2025

### Comparative analysis of biodiversity indices: 2023 vs. 2025

Comparing the fish communities of the Siret River in 2023 and 2025 highlights significant changes in both species' composition and the numerical structure of populations (Figure 4).



**Fig. 4.** Biodiversity variation in the fish communities of the Siret River (2023 and 2025)

- **Margalef index (R)**, which reflects species richness by relating the total number of species to the logarithm of the total number of individuals, decreased from 2.52 in 2023 to 1.82 in 2025. This decline indicates a loss of rarer species and a general reduction in taxonomic diversity.
- **Shannon–Wiener index (H')**, which combines both richness and evenness of individual distribution among species, decreased from 2.11 to 1.59. This suggests that the community became less diverse, with a higher concentration of individuals in the dominant species.
- **McIntosh index (U)**, which assesses community evenness by comparing each species' abundance with a perfectly uniform distribution, decreased from 0.70 to 0.61. A lower value indicates weaker evenness and a numerical structure where individuals are not evenly distributed among species.
- **Berger–Parker index**, which quantifies the dominance of the most abundant species, increased from 0.30 to 0.41, showing that a single species (*Abramis brama*) became more dominant in 2025, while the remaining species were less represented.

- **Shannon's Equitability (E)**, which reflects the evenness of individual distribution, decreased from 0.88 to 0.82. This confirms that the proportions of individuals among species became more uneven, emphasizing the dominance of the main species.

Overall, these values indicate that between 2023 and 2025, the fish community of the Siret River became poorer in species and more unbalanced, with a clearly dominant species and the loss of some rarer species, which may reflect changes in ecological conditions, anthropogenic pressures, or shifts in available resources.

With only 29% similarity between the analyzed years, based on species presence, the Jaccard index indicates that the fish communities differ markedly in species composition. This conclusion was confirmed by statistical analysis using the Chi-square test, which highlighted a significant difference between the community structure in 2023 and 2025 ( $\chi^2 = 38.46$ ,  $df = 13$ ,  $p = 0.00024$ ). The critical  $\chi^2$  value for  $\alpha = 0.05$  and  $df = 13$  is 22.36, emphasizing that the observed differences are not random but statistically significant.

This change reflects a substantial decrease in species diversity and richness, with an increase in the dominance of certain species and the appearance of invasive species. The fish community changed significantly between 2023 and 2025: species such as *Carassius gibelio*, *Cyprinus carpio*, *Silurus glanis* [Linnaeus, 1758], *Esox lucius* [Linnaeus, 1758], *Barbus barbus* [Linnaeus, 1758], and *Sander lucioperca* [Linnaeus, 1758] disappeared from the catches, being replaced by *Aspius aspius* [Linnaeus, 1758], *Perca fluviatilis* [Linnaeus, 1758], and the invasive species *Lepomis gibbosus* [Linnaeus, 1758]. Dominance shifted from *Carassius gibelio* to *Abramis brama*, while species diversity and richness decreased, and the distribution of individuals among species became more uneven.

The transition in dominance from *Carassius gibelio* to *Abramis brama* suggests an improvement in environmental conditions and a return of community structures toward a balance closer to the natural state. This change is justified by the fact that the common bream (*Abramis brama*), a native benthivorous species, requires more stable habitats and higher benthic productivity [Persson and Brönmark, 2002], unlike the Prussian carp (*Carassius gibelio*), an invasive species tolerant of degraded habitats [Razlutskiy *et al.*, 2021].

Moreover, the presence of the pumpkinseed (*Lepomis gibbosus*), an invasive species, in 2025 (7% of the total) indicates the expansion of a non-native species within the fish community of the Siret River and may have a significant ecological impact: competition for food and habitat with native species, alteration of trophic relationships, and reduction of native species abundance [Meinam *et al.*, 2023]. Although its current abundance is low, its appearance may serve as an early indicator of ecological imbalance and the risk of altering the structure of the fish community. The presence of this species in the aquatic ecosystem was first reported in 2005 [Battes *et al.*, 2005], with the Siret River basin identified as one of the

hotspots for non-native species, according to Drăgan et al. [2024], while two other invasive species were reported in 2016 by Ureche and Ureche [2019].

### Analysis of hydrological parameters at the Lespezi station during April–June (2023 vs. 2025)

Comparing water level and discharge data for April–June in 2023 and 2025 reveals notable differences in the hydrological regime of the Siret River – Lespezi h.st (Table 1).

Table 1

Descriptive statistical summary (Lespezi, Apr–Jun)

Year	Month	Parameter	No. of days	Min (cm)	Max (cm)	Mean (cm)	Observations
2023	April	Level	30	22	200	86.2	Marked increase in water level with high amplitude; typical spring regime influenced by snowmelt.
		Discharge		21.6	234	77.51	High discharges, with peaks exceeding 200 m <sup>3</sup> /s, reflecting snowmelt and rainfall contribution.
	May	Level	31	-1	69	30.2	Lower water levels compared to April, indicating stabilization and a near-drought regime.
		Discharge		10.8	52.3	27.07	Moderate to low discharges, without flood events; decreasing trend compared to the previous month.
	June	Level	30	-7	95	22.7	Moderate oscillations with a few short-lived peaks; predominantly low values.
		Discharge		8.33	73.5	23.79	Low discharges, close to minimum values, suggesting an early-summer drought regime.
2025	April	Level	30	-10	100	41.83	Increased instability with high amplitude; oscillating levels reflecting the transition between low water and moderate floods.
		Discharge		8.2	78	35.71	Variable discharges, no extremes, but higher compared to the same month in 2023.
	May	Level	31	-6	232	60.77	Presence of significant flood episodes (up to +232 cm), alternating with low-water periods.
		Discharge		9.52	299	64.7	Very high discharge peaks, indicating extreme hydrological events.
	June	Level	30	-12	218	29.97	Wide oscillations; elevated levels dropped rapidly, returning to low stages.
		Discharge		7.68	271	33.64	High flows at the beginning of the month followed by a quick decrease; pronounced variability.

In 2023, water levels remained within a relatively stable range, with monthly averages between 22.7 cm (June) and 86.2 cm (April), while associated discharges varied between 23.8 m<sup>3</sup>/s and 77.5 m<sup>3</sup>/s. Both levels and discharges exhibited low variability, with minima close to zero and maxima of 200 cm (level) and 234 m<sup>3</sup>/s (discharge), and compact distributions with medians close to the monthly averages. These characteristics suggest a predictable hydrological regime without extreme fluctuations during the analyzed period, well below the flood defense level at the Lespezi station (450 cm).

In contrast, 2025 was marked by pronounced hydrological instability, reflected in both water level and discharge. Monthly average levels were higher in May (60.8 cm) but much lower in June (29.9 cm) compared to 2023. Discharges experienced major fluctuations, with monthly averages higher than in 2023, especially in May (64.7 m<sup>3</sup>/s), and much more pronounced maxima, with levels reaching 232 cm and discharges approaching 300 m<sup>3</sup>/s. Although these maxima remain below the flood defense threshold (450 cm), they represent more than half of this critical level, indicating a significant increase in flood risk. Minima were similar between years (approx. -10 cm for level and 8 m<sup>3</sup>/s for discharge), indicating the persistence of low-water periods, but the contrast between these minima and maxima was much steeper in 2025.

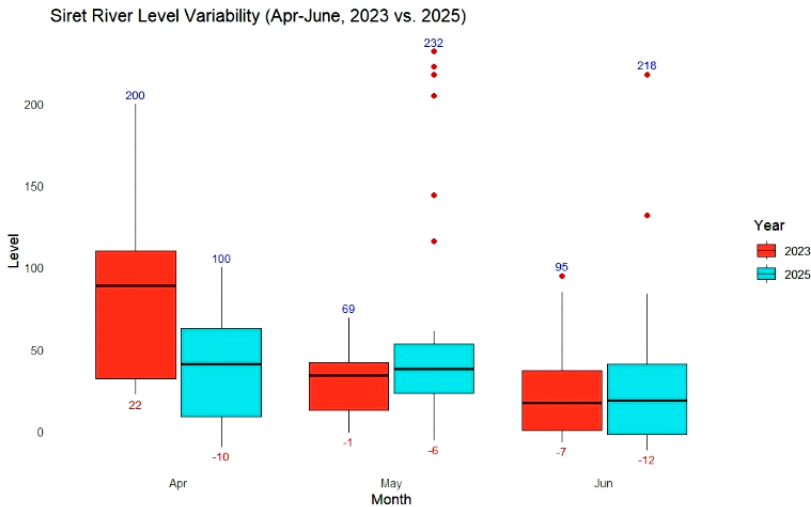
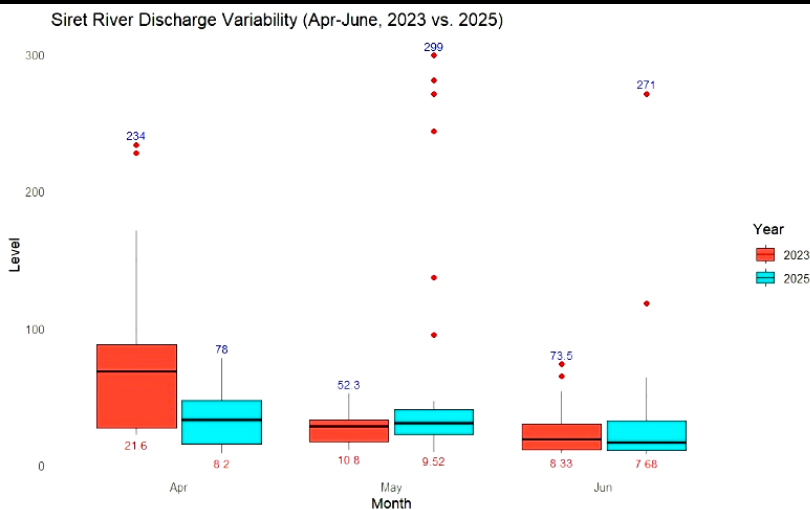


Fig. 5. River level variation during the analyzed period (2023 vs 2025)



**Fig.6.** River discharge variation during the analyzed period (2023 vs 2025)

Boxplots clearly show that while the interquartile ranges in 2023 were compact and distributions uniform (Figures 5 and 6), in 2025 they were stretched and included multiple extreme values, particularly in May and June. This highlights a predisposition toward flood episodes and rapid oscillations between low and high-water levels and discharges.

In conclusion, 2023 reflects a stable and predictable hydrological regime, well within safe limits, while 2025 is characterized by pronounced variability and hydrological extremes, approaching critical levels (450 cm flood defense) with potential consequences for aquatic ecosystems and fish communities dependent on water stability.

### **Impact of Hydrological Variability on Fish Biodiversity in the Siret River (2023–2025)**

The analysis of correlations between water level and discharge amplitudes and biodiversity indices (Shannon-Wiener, Simpson, and Berger-Parker) reveals important ecological trends, even though the results are not statistically significant ( $p > 0.12$ ), likely due to the small number of observations (six months).

Spearman and Pearson correlations indicate that the amplitude of both water level and discharge negatively affects community diversity and numerical balance: Shannon and Simpson indices show negative values (-0.67 to -0.70), suggesting that periods with large fluctuations in water level and discharge are associated with reduced diversity and a more uneven distribution of individuals among species. The Berger-Parker index, with positive values (0.67–0.70), indicates that high hydrological fluctuations favor the dominant species, increasing its dominance and reducing the participation of other species.

Periods with high hydrological variability (increased amplitudes, peak water levels, and discharge) create unstable conditions for sensitive species, favoring tolerant or dominant species. In the Siret River, this effect is reflected in the decline of Shannon and Simpson indices and the increased dominance of *Abramis brama* in 2025 compared to 2023, when the community was more balanced and diverse. This indicates a simplification of community structure and a loss of rarer species, correlated with instability in the hydrological regime. The appearance of invasive species, such as *Lepomis gibbosus* and *Perca fluviatilis*, seems facilitated by these fluctuations, further increasing pressure on native communities.

Even though the p-values do not indicate statistical significance, the trends suggest that hydrological stability is crucial for maintaining fish biodiversity. Managing water resources, preventing extreme fluctuations, and continuous monitoring can help conserve an ecological balance closer to natural conditions. Maintaining water levels below the Lespezi flood protection level (450 cm) remains critical to prevent flood events that impact both diversity and community structure.

The correlation analyses for water level and discharge, together with observations from fish catches, indicate that changes in the Siret River's hydrological regime between 2023 and 2025 led to reduced diversity, numerical imbalance, and increased dominance of a single species. Although the statistical effects are not significant with the available data, the clear trend suggests an ecological link between water instability and fish community structure, highlighting the need for continuous monitoring and ecosystem protection measures.

## CONCLUSIONS

Based on the analyses conducted, it can be concluded that during the period April–June 2025, the fish communities in the Siret River exhibited a significant reduction in biodiversity compared to 2023, with the number of species decreasing from eleven to seven. This decline in diversity was reflected in lower values of the Shannon-Wiener, Margalef, and McIntosh indices, accompanied by an increase in the Berger-Parker index, indicating a pronounced dominance of a single species.

The community structure changed, with *Carassius gibelio* being replaced by *Abramis brama* as the dominant species, while valuable species such as *Cyprinus carpio* and *Silurus glanis* disappeared, and were even replaced by invasive species, such as *Lepomis gibbosus*.

These changes coincide with a much more pronounced hydrological instability in 2025, characterized by alternating extreme floods (with water levels reaching +232 cm and maximum discharges of 299 m<sup>3</sup>/s) and periods of very low water, whereas 2023 exhibited a more uniform regime.

Statistical correlations showed that increased water level amplitude is associated with a decrease in fish diversity, suggesting that extreme fluctuations favor the dominance of a few species and reduce community evenness.

Overall, these results highlight the effects of anthropogenic pressures and climate change on the ichthyofauna of the Siret River, confirming the trend toward simplification of the fish community and emphasizing the importance of implementing long-term monitoring and conservation programs.

Continuous monitoring of fish communities is essential, through systematic surveillance of species abundance and distribution at different hydrometric stations throughout the year, in order to capture seasonal variations and the effects of extreme hydrological events. It is recommended to implement measures for the protection of native species and control of invasive species, particularly *Lepomis gibbosus* and other non-native species that may alter the fish community structure and trophic resources. Additionally, conserving and restoring habitats favorable to valuable native species, such as *Cyprinus carpio* and *Silurus glanis*, is crucial.

Reducing anthropogenic pressures is a major objective, through policies aimed at limiting pollution and industrial and agricultural discharges in the Siret basin. At the same time, promoting sustainable water management practices is necessary to minimize the impact of flood and drought periods on fish habitats.

## ACKNOWLEDGMENTS

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