Comparative assessment of fish diversity indices in protected Vlasina Reservoir and unprotected Gruža Reservoir

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Abstract: The species diversity indices, namely the Shannon Index (H), Reciprocal Simpson's Index (1/D), Fisher's Alpha Diversity Index (A), and Pielou's Evenness Index (J), were calculated for both the protected Vlasina Reservoir and the unprotected Gruža Reservoir. A total of 15 fish species were identified in the Vlasina Reservoir during the investigation period from 2003 to 2022, while the Gruža Reservoir revealed 10 fish species within the period from 2013 to 2021. The obtained values of the H, 1/D, and A indices, were not considerably high, sometimes even lower than expected, showing a slight increase in recent years for both reservoirs. In Vlasina Reservoir, the J Index was in a range from 0.2488 to 0.3348, while in Gruža Reservoir it varied from 0.1834 to 0.3832, indicating the low homogeneity in terms of well-balanced fish assemblage structure. Moreover, an increasing trend in recent years has been observed, which favors the dominance of some fish species against the balanced fish structure. Our results provide valuable information about fish diversity and evenness in the investigated areas under high anthropogenic threats, considering the importance of both reservoirs in Serbia.

Keywords: fish diversity indices, fish assemblage structure, Serbia

1. Introduction

The Vlasina Reservoir is ranked among the largest and highest artificial lakes in Serbia, with a system of four hydroelectric power, while Gruža Reservoir is the most important artificial lake in Central Serbia, mainly used for the water supply of Kragujevac. Both reservoirs have been faced with strong anthropogenic threats, even though Vlasina has been protected in Serbia [1]. Some of the main anthropogenic pressures are the development of unplanned urbanization which leads to the spreading of agricultural lands and waste depots, agricultural discharge, as well as sewage discharge. Additionally, the considerable water level regulation, boosting tourism and recreational fishing, construction of roads, etc. significantly impact both reservoirs [2]. From the aspect of the fish species diversity in fish assemblage structure, the most severe anthropogenic impact has been the inadequate fish introduction in both reservoirs [1,3].

This study aimed to assess the fish diversity and evenness indices in some protected and unprotected areas under severe anthropogenic threats, without the intention to compare these two reservoirs due to their different origin, and hydrological, geological, and morphological characteristics.

2. Material and methods

2.1 Sampling collection

The fish specimens were collected during the five-field sampling from the Vlasina Lake Reservoir spanning the period 2003–2022, and from the Gruža Reservoir covering the period 2013–2021, following the standard procedure (Figure 1). The ichthyological research on both reservoirs was conducted to develop fisheries management plans for the protection and sustainable use of fish stocks.

2.2 Fish Diversity Indices

The basic diversity indices of the fish community were determined: species richness (S), Shannon Diversity Index (H), and Alpha Diversity Index (A) or Fisher's Alpha diversity index (A) [2]. The Simpson's Index (D) was used to measure the probability that two randomly chosen specimens from a sample will belong to different fish species. Due to the potential errors during the reverse interpretation of the obtained results, Simpson's Index was expressed as Reciprocal Simpson's Index (1/D) because its value increased with greater diversity [2]. Additionally, the link between the number of species and their abundances is determined with Fisher's Alpha diversity index (A) [2,4]. Pielou's evenness (J) was used to compare the actual diversity value (H index) to the maximum possible diversity value (ln S). It is constrained between 0 and 1 and the more variation in abundances between different fish species within the community, the lower J [4]. All fish diversity indices were calculated using BioDiversityPro version 2 software.

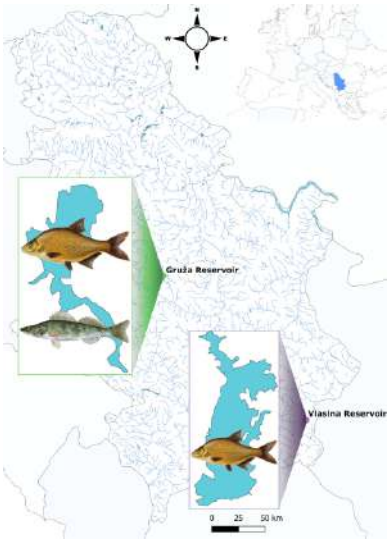

Figure 1. The map of the investigated reservoirs with highlighted dominant fish species**.**

3. Results and discussion

The obtained results of fish diversity and evenness indices in investigated reservoirs were summarized and presented in Table 1.

Table 1. Diversity indices were calculated based on sampled fish species at individual localities of the Vlasina Reservoir and the Gruža Reservoir.

Localities	Species richness S	Shannon Index H	Reciprocal Simpson's Index 1/D	Alpha Index A	Evenness Index J
Vlasina Reservoir 2022	7	0.6515	3.5906	1.4702	0.3348
Vlasina Reservoir 2019	7	0.6038	3.4340	1.1239	0.3102
Vlasina Reservoir 2016	8	0.5426	2.4950	1.3415	0.2609
Vlasina Reservoir 2014	6	0.5892	3.0845	0.9113	0.3288
Vlasina Reservoir 2003	8	0.5175	2.0889	1.5118	0.2488
Gruža Reservoir 2021	5	0.6047	3.6683	1.1550	0.3757
Gruža Reservoir 2020	7	0.7457	4.7258	1.4576	0.3832
Gruža Reservoir 2019	5	0.4914	2.3963	0.7882	0.3053
Gruža Reservoir 2017	9	0.4107	1.8608	1.2559	0.1869
Gruža Reservoir 2013	5	0.2953	1.5186	0.6616	0.1834

A total of 15 fish species were identified during the investigation period in the Vlasina Reservoir, while the Gruža Reservoir had 10 fish species identified. The species richness diversity for both reservoirs is presented in Table 1. According to the available literature on the Vlasina Reservoir, a total of 16 fish species have been previously documented [1,3]. Comparing with these data, our results indicate the changes in the composition and structure of the fish community since we did not register the *Salmo trutta* L. and *Barbus peloponessius* (Valenciennes, 1842) but there were abundant *Abramis brama* L. as well as *Carassius gibelio* (Bloch, 1782), while the *Alburnus albidus* (Costa, 1838; Vulnerable according to IUCN) and *Rutilus pigus* (Lacepède, 1803) have not been registered since 2003. According to Simić et al. [1], *A. brama* was introduced to the Vlasina Reservoir between 1998 and 2010. Personal observation suggests that *Esox lucius* L. and *Silurus glanis* L. have been present in recent years, likely due to frequent catches by fishermen. On the other side, in the Gruža Reservoir *A. brama* stood out as the dominant fish species, along with *Sander lucioperca* L. and *Rutilus rutilus* L. It has been observed the stagnation of previously dominant fish *C. gibelio* in the last year.

The Shannon Index (H) values in the Vlasina Reservoir have varied from 0.5175 to 0.6515, while in the Gruža Reservoir were in the range of 0.2953 to 0.7457 (Table 1). Although we obtained the moderate and lower values of the H index, interestingly an increasing trend in recent years in both reservoirs has been observed. Generally, the values of Shannon Index, Reciprocal Simpson's Index, as well as Fisher's Alpha Index were not considerably high and sometimes were even lower than expected, which could be a consequence of the strong anthropogenic pressure [2]. Both reservoirs faced

inadequate anthropogenic introduction of attractive fish species for recreational fisheries improvement, which led to the disappearance of native species and changes in fish species' relative abundances [1,3]. Consequently, of the native species' reduction in abundance, the tendency toward non-native fish species dominance has been observed. Moreover, in both reservoirs, we registered the occurrence of invasive fish species (*Lepomis gibbosus* L. and *Ameiurus nebulosus* Lesueur, 1819) [5]. In the Vlasina Reservoir, the Pielou's Evenness Index ranged from 0.2488 to 0.3348, whereas in the Gruža Reservoir, it varied between 0.1834 and 0.3832. Evenness indices show how homogeneous the fish community is, it can be even seen as an ecosystem, considering different fish species' abundances [4]. To be more precise, the evenness index represents the distribution of specimens among different fish species. Our results, obtained for both reservoirs, indicated a low level of homogeneity in terms of a well-balanced fish assemblage structure. Moreover, an increasing trend in recent years has been observed, favoring the dominance of certain fish species over a balanced fish structure.

4. Conclusions

Our results provide valuable information about fish diversity and evenness in the investigated areas under high anthropogenic threats, considering the importance of both reservoirs in Serbia.

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