

## SPECIES DIVERSITY OF THE ICHTHYOFAUNA OF THE STRYAMA RIVER

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In the present study, the species diversity of the fish fauna of the Stryama River, a left tributary of the Maritsa River, was examined. Three biotopes were visited along the Stryama River, located in the vicinity of the villages of Pesnopoy, Razhevo Konare and Stryama. A total of 9 fish species were caught – pumpkinseed, *Lepomis gibbosus* (Linnaeus, 1758) (Centrarchidae); Bulgarian spined loach, *Cobitis strumicae* Karaman, 1955 (Cobitidae); bleak, *Alburnus alburnus* (Linnaeus, 1758); round-scaled barbell, *Barbus cyclolepis* Heckel, 1837; *Chondrostoma vardarensense* Karaman, 1928; European bitterling, *Rhodeus amarus* (Bloch, 1782); Orpheus dace, *Squalius orpheus* Kottelat & Economidis, 2006; Macedonian vimba, *Vimba melanops* (Heckel, 1837) (Cyprinidae), European perch, *Perca fluviatilis* Linnaeus, 1758 (Percidae). The conservation status of the caught fish species was examined. For the study, the Margalef total species diversity index (Dmg), Brillouin diversity index (H<sub>B</sub>), Pielou evenness index (E), Simpson dominance index (C), and Fulton condition factor (K) were calculated.

**Key words:** ecological biodiversity indices, freshwater fish species, Fulton condition factor, Stryama River.

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# ВИДОВО РАЗНООБРАЗИЕ НА ИХТИОФАУНАТА НА РЕКА СТЯМА

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Целта на настоящото изследване е да се предоставят нови данни за видовото разнообразие и числеността на рибната фауна на р. Стряма (ляв приток на р. Марица), както и за някои индекси, отнасящи се до видовото разнообразие и състоянието на рибните комплекси. Статията разширява знанието за ихтиофауната и за състоянието на реката. Посетени са три биотопа по течението на р. Стряма, намиращи се в околностите на селата Песнопой, Ръжево Конаре и Стряма. Уловени са общо 256 екземпляра от 9 вида риби – слънчева риба, *Lepomis gibbosus* (Linnaeus, 1758) (семейство Centrarchidae); струмски щипок, *Cobitis strumicae* Karaman, 1955 (семейство Cobitidae); уклея, *Alburnus alburnus* (Linnaeus, 1758); маришка мряна, *Barbus cyclolepis* Heckel, 1837; вардарски скобар, *Chondrostoma vardarensis* Karaman, 1928; европейска горчивка, *Rhodeus amarus* (Bloch, 1782); егейски речен кефал, *Squalius orpheus* Kottelat & Economidis, 2006; маришки морунаш, *Vimba melanops* (Heckel, 1837) (семейство Cyprinidae) и речен костур, *Perca fluviatilis* Linnaeus, 1758 (семейство Percidae). С най-голям брой екземпляри са представени три вида риби от сем. Cyprinidae (*B. cyclolepis*; *Alb. alburnus*; *Sq. orpheus*). Разгледан е природозащитният статус на уловените видове риби. Пет вида риби (*C. strumicae*; *B. cyclolepis*; *Ch. vardarensis*; *Sq. orpheus*; *V. melanops*) са ендемити за Европа; един вид (*C. strumicae*) е ендемит за Балканския полуостров; един вид (*B. cyclolepis*) – за басейна на р. Марица и три вида (*Ch. vardarensis*; *Sq. orpheus*; *V. melanops*) – за егейския водосборен басейн. За целта на изследването са изчислени и дискутирани индексът на видово богатство по общо видово разнообразие на Margalef (Dmg), индексът на разнообразие на Brillouin (HВ), индексът за изравненост на Pielou (E), индексът на доминиране на Simpson (C) и фактор за състоянието на Фултън (K). Установените при това изследване индекс на общото видово разнообразие (индекс на Margalef) и индекс на разнообразие на Brillouin са ниски. Индексът на изравненост на Pielou показва умерено състояние на изследваната ценоза. Състоянието на изследваните видове риби е изследвано чрез използването на фактора за състоянието на Фултън.

**Ключови думи:** екологични индекси за биологично разнообразие, река Стряма, сладководни видове риби, фактор за състоянието на Фултън.

## INTRODUCTION

The Stryama River springs from the Zlatishko-Tetevenska mountain (2,158 meters above sea level), passes through the Karlovka valley, forms a gorge between Sashtinska Sredna gora and Sarnena Sredna gora, then enters the Upper Thracian Lowland and flows into the Maritsa River (149 meters above sea level) (Kiradzhiev, 2013). The river flows for 110.1 km, which ranks it among the large tributaries of the Maritsa River (Kirin et al. 2019). The catchment area of

the Stryama River covers an area of 1,789 km<sup>2</sup> (Kolev, 2013b; Kolev, Raikova, 2015). The Stryama River falls into Ecoregion 7 Eastern Balkans, as part of the Maritsa River basin. According to the typology of rivers in Bulgaria, the Stryama River belongs to type R3 Mountain rivers (Stryama River from its sources to Rozino), R5 Semi-mountain type rivers (Stryama River from Rozino to the confluence of the Pikla River and tributaries) and R13 Small and medium level Aegean rivers (Stryama River from the confluence of the Pikla River to its mouth) (Pehlivanov et al., 2012; Belkinova et al., 2013; East Aegean River Basin Directorate, 2018). The entire course of the Stryama River falls within the BG0000429 “Stryama River” protected area under the Habitats Directive, as part of the European Ecological Network Natura 2000. The subject of conservation in the protected area is 6 natural habitats, 7 species of invertebrates, 4 species of fish, 7 species of amphibians and reptiles, as well as 17 species of mammals, including bats (Information system for protected areas from the Ecological Network Natura 2000, 2022). Various studies have been conducted on freshwater fish from the Stryama River. Trout density and biomass from four tributaries of the Maritsa River, including the Stryama River, were studied by Kolev (2010). The ichthyofauna of the Stryama River was studied by Kolev (2013a; 2020). The difference in the height of the anal fin in male and female specimens of round-scaled barbell, *Barbus cyclolepis* Heckel, 1837 from two tributaries of the Maritsa River (Stryama River and Chepinska River) was studied by Kolev (2013b). The growth rate and the condition factor of *B. cyclolepis* and Orpheus dace, *Squalius orpheus* Kottelat & Economidis, 2006 from the Stryama River were studied by Raikova, Kolev (2015) and Kolev, Raikova (2015) respectively. Other studies of round-scaled barbell (Kolev, 2021a) and Orpheus dace (Kolev, 2021b) from the Stryama River refer to different reproductive parameters. Few studies exist concerning the parasite fauna of *Sq. orpheus* from the Stryama River (Kirin et al., 2005; Kirin et al., 2019).

The purpose of the present study is to provide new data on the species diversity and abundance of the ichthyofauna of the Stryama River, as well as on some basic indices relating to species diversity and the state of the fish complexes. The poor study of the river ecosystem and anthropogenic impacts provoked the research. The condition of the fish species and the part of the ecosystem studied were assessed.

## RESEARCH AREA

Three biotopes along the Stryama River were visited in 2023 – the Pesnopoy biotope, the Razhevo Konare biotope, and the Stryama biotope, from which the fish, the research subject, were collected. The village of Pesnopoy is located in the gorge of the Stryama River between Sashtinska Sredna gora and Sarnena Sredna gora, Plovdiv District, Kaloyanovo Municipality. The Stryama River flows on

the outskirts of the village, where the first investigated section of the river is located. The village of Razhevo Konare is located in the Pazardzhik-Plovdiv field, Plovdiv District, Kaloyanovo Municipality. The Stryama River flows past the village, where the second investigated section of the river is located. The village of Stryama is located in the Pazardzhik-Plovdiv field, Plovdiv District, Rakovski Municipality. To the west of the village flows the Stryama River, where the third investigated section of the river is located (Kiradzhiev, 2013) (Figure 1-2; Table 1).



Fig. 1. Views from the studied biotopes of the Stryama River (biotopes Pesnopoy, Razhevo Konare, and Stryama from left to right; author’s photos)

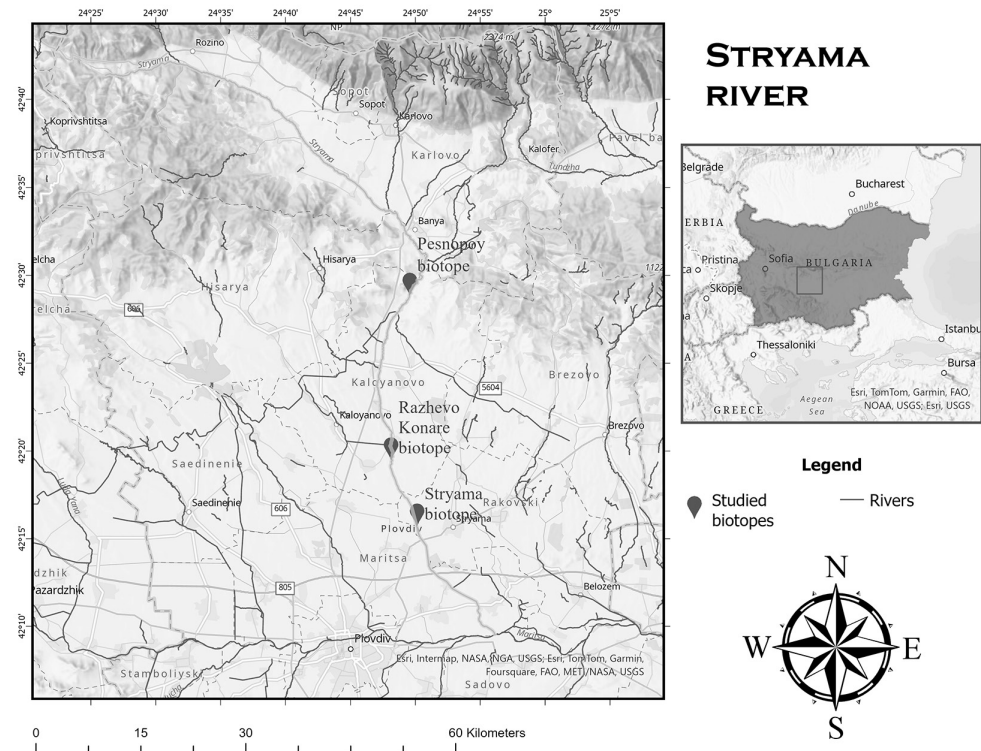


Fig. 2. Location of the studied biotopes of the Stryama River (ESRI, 2024)

Table 1

*Description of the studied biotopes of the Stryama River*

<b>Biotope number</b>	<b>Name of the biotope</b>	<b>Description of the biotope</b>
1	Pesnopoy	The biotope covers a section of the Stryama River, located east of the village of Pesnopoy, next to the Darobas winery bridge
2	Razhevo Konare	The biotope covers a section of the Stryama River, located south of the village of Razhevo Konare and near the concrete center
3	Stryama	The biotope covers a section of the Stryama River, located west of the village of Stryama and southeast of the village of Dink

## RESEARCH METHODOLOGY

The fish were caught with a SAMUS-725MP electrofishing device according to BDS EN 14011:2004. Fish species were determined according to Karapetkova, Zhivkov (2006), and Froese, Pauly (2024). A total of 254 fish specimens belonging to 9 species and 4 families (Centrarchidae; Cobitidae; Cyprinidae; Percidae) were collected. A diary of the study was kept, in which the biotope, the type of fish, and basic metric data of each fish specimen (total length of body (TL) in centimeters; maximum body height (MH) in centimeters; weight (BW) in grams) were recorded. The conservation status of caught fish species was examined (Council Directive 92/43/EEC, 1992; Biodiversity Law, 2002; Golemanski, 2011; Freyhof, Brooks, 2011; IUCN, 2024). The number of individual species, the Margalef total species diversity index (Dmg) (Belkinova et al., 2013), the Brillouin diversity index (HB), the Pielou evenness index (E), the Simpson dominance index (C) (Magurran, 1988) and Fulton's condition factor (K) (Jin et al., 2015; Radkhah, Eagderi, 2015; Kolev, 2023) were calculated and discussed. Statistical data analysis was performed using MS Excel (Microsoft, 2010).

The Margalef total species diversity index (Dmg) is calculated using the formula:

$$d = \frac{(S - 1)}{\log_2 N}$$

where: S – the number of species in the sample; N – total number of organisms in the sample.

The Brillouin diversity index (HB) is calculated by the formula:

$$HB = \frac{\ln N! - \sum \ln ni!}{N}$$

where: ni = number of individuals of each species (i = 1, 2, ..., S); N =  $\sum ni$  = total number of individuals; S = total number of species.

The Pielou evenness index (E) is calculated using the formula:

$$E = \frac{H}{\log_2 N}$$

where: H – index of individual species diversity (Shannon index); N – number of specimens.

The Simpson dominance index (C) is calculated using the formula:

$$C = \sum \left( \frac{n_i}{N} \right)^2$$

where:  $n_i$  – number of specimens of each  $i$  species; N – number of specimens of all species (total number).

The Fulton's condition factor (K) is calculated by the formula:

$$K = 100 \times \frac{W}{L^3}$$

where: W – the whole body weight (g); L – the total length (cm).

## RESULTS AND DISCUSSIONS

In the present study, it was established that the species diversity of the fish fauna of the Stryama River (Pesnopoy, Razhevo Konare, and Stryama biotopes) includes 9 fish species (pumpkinseed, *Lepomis gibbosus* (Linnaeus, 1758); Bulgarian spined loach, *Cobitis strumicae* Karaman, 1955; bleak, *Alburnus alburnus* (Linnaeus, 1758 *Barbus cyclolepis* Heckel, 1837; *Chondrostoma vardarensis* Karaman, 1928; European bitterling, *Rhodeus amarus* Linnaeus, 1782; Orpheus dace, *Squalius orpheus* Kottelat & Economidis, 2006; Macedonian vimba, *Vimba melanops* (Heckel, 1837); European perch, *Perca fluviatilis* Linnaeus, 1758), belonging to 4 families (Centrarchidae; Cobitidae; Cyprinidae; Percidae). A total of 256 fish specimens were registered. Three types of fish are represented with the largest number of specimens – *B. cyclolepis* (168 specimens), *Alb. alburnus* (42 specimens) and *Sq. orpheus* (21 specimens) from the family Cyprinidae (Figure 4).

Seven of the fish species studied in this study are included in the IUCN Red List with the category "LC" (=Least Concern, IUCN), one species with the category "NT" (=Near Threatened, IUCN) and one species with the category "DD" (=Data Deficient, IUCN). One species is protected by the Red Book of the Republic of Bulgaria (RBBG). Three species are protected by the Biodiversity Law (BDL) and two species by the Habitats Directive. Five species are endemic to Europe. One species is endemic to the Balkan Peninsula, one species to the Maritsa River basin, and three species to the Aegean watershed. An alien species

(*L. gibbosus*) was found in this study. The remaining eight species are native (Tables 2).

Table 2

*Conservation status of caught fish species*

Fish species	International legislation		National legislation		Endemics	
	IUCN Red List Europe <sup>1,5</sup>	Habitats Directive (92/43/EEC) <sup>2</sup>	BDL <sup>3</sup>	RBBG <sup>4</sup>	Endemic to Europe <sup>5</sup>	Endemic <sup>6,7</sup>
<i>Lepomis gibbosus</i> (Linnaeus, 1758) (Centrarchidae)	Least Concern	-	-	-	-	-
<i>Cobitis strumicae</i> Karaman, 1955 (Cobitidae)	Least Concern	-	II	-	+	endemic to the Balkan Peninsula
<i>Alburnus alburnus</i> (Linnaeus, 1758) (Cyprinidae)	Least Concern	-	-	-	-	-
<i>Barbus cyclolepis</i> Heckel, 1837 (Cyprinidae)	Least Concern	V	II, IV	-	+	endemic to Maritza River basin
<i>Chondrostoma vardarensense</i> Karaman, 1928 (Cyprinidae)	Near Threatened	-	-	-	+	endemic to Aegean watershed
<i>Rhodeus amarus</i> (Bloch, 1782) (Cyprinidae)	Least Concern	II	II	-	-	-
<i>Squalius orpheus</i> Kottelat & Economidis, 2006 (Cyprinidae)	Least Concern	-	-	-	+	endemic to Aegean watershed
<i>Vimba melanops</i> (Heckel, 1837) (Cyprinidae)	Data Deficient	-	-	Vulnerable	+	endemic to Aegean watershed
<i>Perca fluviatilis</i> Linnaeus, 1758 (Percidae)	Least Concern	-	-	-	-	-

<sup>1</sup> – IUCN (2024)

<sup>2</sup> – Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and wild flora and fauna (Habitats Directive)

<sup>3</sup> – Biodiversity Law (BDL) (2002)

<sup>4</sup> – Golemanski (2011). Red Book of the Republic of Bulgaria (RBBG)

<sup>5</sup> – Freyhof, Brooks (2011)

<sup>6</sup> – Kolev (2013a)

<sup>7</sup> – Kolev (2013b)

The metric data of each fish specimen by biotope are presented in Figure 3.

The number of established species by biotope is presented (Figure 4).

Kolev (2013a) reported 14 species of fish (*Gobio bulgaricus* Drensky, 1926; *B. cyclolepis*; *Alb. alburnus*; *Ch. vardarensis*; Eurasian minnow, *Phoxinus phoxinus* (Linnaeus, 1758); roach, *Rutilus rutilus* (Linnaeus, 1758); *Sq. orpheus*; *V. melanops*; *C. strumicae*; Balcan spined loach, *Sabanejewia balcanica* (Karaman, 1922); Rainbow trout, *Oncorhynchus mykiss* (Walbaum, 1792); *Salmo* sp.; *L. gibbosus*; *P. fluviatilis*) from 5 families for the ichthyofauna of the Stryama River. The author reports that species of the Cyprinidae family predominate in the ichthyofauna of the river and that two species of fish (*B. cyclolepis* and *Sq. orpheus*) are dominant. This is also confirmed in the present study. Kolev (2020) studied alien fish species in the Stryama River and reported

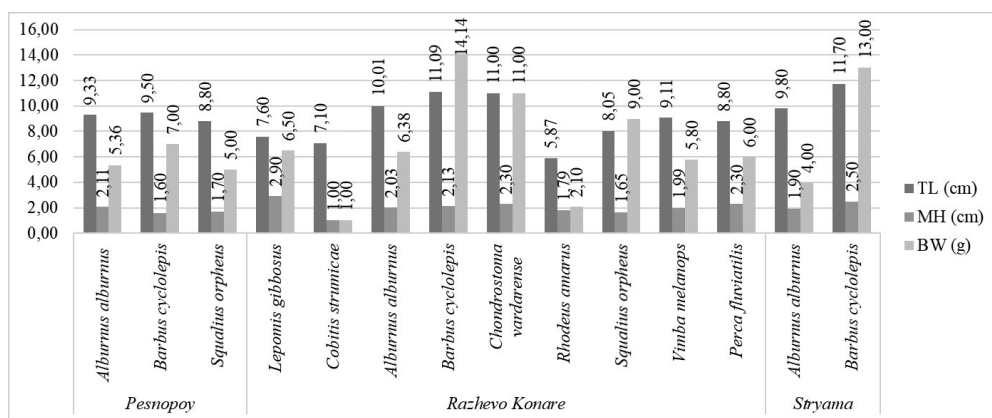


Fig. 3. Metric data (TL, MH in cm; BW in g) of fish from the studied biotopes from the Stryama River

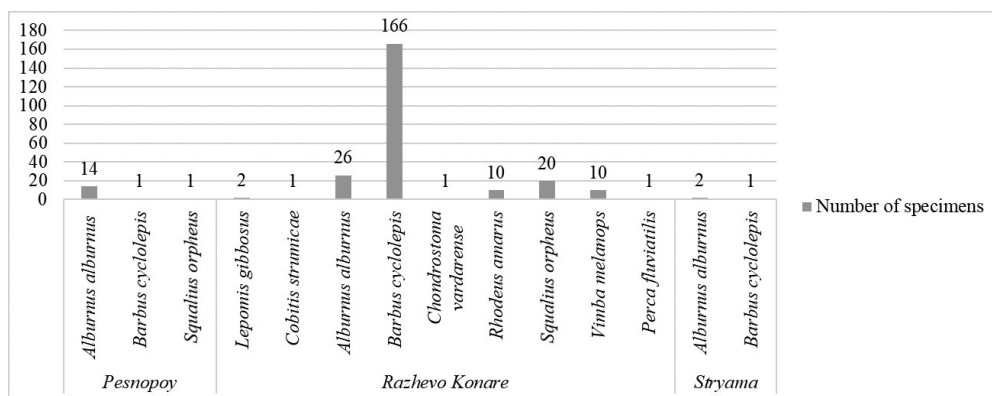


Fig. 4. Number of established freshwater fish species from the Stryama River by studied biotopes

three alien species (Prussian carp, *Carassius gibelio* (Bloch, 1782); *Onc. mykiss*; *L. gibbosus*) and 11 native (*Sq. orpheus*; *B. cyclolepis*; *Salmo* sp.; *R. rutilus*; *Ch. vardarensis*; *G. bulgaricus*; Northern pike, *Esox lucius* Linnaeus, 1758; *P. fluviatilis*; *Alb. alburnus*; *V. melanops*; *Ph. phoxinus*) for the river ichthyofauna. In the present study, the number of native species found was also higher than that of alien species.

Table 3 shows the values of the Fulton coefficient.

Fulton's condition factor is used to evaluate the condition of the fish based on its length and weight and the interaction of abiotic and biotic environmental factors. A factor of  $K > 1$  indicates favorable environmental conditions, and  $K < 1$  indicates less favorable environmental conditions (Radkhah, Eagderi, 2015).

Basic indicators of the ichthyocomplexes are discussed (Table 4).

Table 3

*Fulton's condition factor (K)*

№	Fish species	Fulton's condition factor (K)
1.	<i>Alburnus alburnus</i>	0.6
2.	<i>Barbus cyclolepis</i>	1.0
3.	<i>Chondrostoma vardarensis</i>	0.8
4.	<i>Cobitis strumicae</i>	0.3
5.	<i>Lepomis gibbosus</i>	1.5
6.	<i>Perca fluviatilis</i>	0.9
7.	<i>Rhodeus amarus</i>	1.0
8.	<i>Squalius orpheus</i>	1.7
9.	<i>Vimba melanops</i>	0.8

Table 4

*Basic indicators of the studied ichthyocomplexes*

Indicators	Total	Mean ± SD
Number of species (S)	9	4.67 ± 3.79
Number of specimens (N)	256	85.34 ± 131.51
Margalef total species diversity index (Dmg)	1.44	1.03 ± 0.38
Brillouin diversity index (HB)	1.08	0.57 ± 0.38
Pielou evenness index (E)	0.52	0.61 ± 0.27
Simpson dominance index (C)	0.47	0.61 ± 0.14

The index of total species diversity (Margalef index) refers to the total number of species, not to the abundance of each one of them. The index found in this study is low ( $Dmg = 1.44$ ). The Brillouin diversity index refers not only to the total number of species but also to their abundance and is also low ( $HB = 1.08$ ). The evenness index ( $E$ ) shows the evenness in the distribution of the total numbers between the individual species. The obtained value ( $E = 0.52$ ) testifies to a moderate state of the studied biocenosis. The dominance index ( $C$ ) shows the possibility that some more durable species increase their numbers at the expense of others. The obtained value ( $C = 0.47$ ) also testifies to a moderate state of the fish communities and the conditions in the studied ecosystem.

## CONCLUSION

When studying the Stryama River ichthyofauna, nine freshwater fish species were found, represented by 256 specimens. Dominant species are *B. cyclolepis*, *A. alburnus*, and *Sq. cephalus*. Eight established species are native, and one is alien (*L. gibbosus*). All described species are included in the IUCN list and are under different forms of protection according to international and national legislative documents. Endemics have been established for Europe, the Balkan Peninsula, the Aegean watershed, and the Maritsa River basin. A value of  $K > 1$  was found for two fish species (*L. gibbosus*, *Sq. orpheus*), indicating perfect condition. The obtained results for the diversity indices, evenness, and dominance indicate a moderate state of the fish communities and the conditions in the studied freshwater ecosystem.

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