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RECENT DATA ON THE DISTRIBUTION OF FRESHWATER ICHTHYOFAUNA IN ALBANIA

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ABSTRACT

In this article, we provide an updated list of freshwater fishes in Albania for each sub-basin. The distribution data and taxa-lists presented are based on a literature review up to October 2022 and intensive fieldwork conducted in the last 15 years. Distributional records of 101 fish species (deriving from 25 families) in 11 different sub-basins are reported. There are new records that include native, alien and translocated fish species. The distinctiveness of Albanian freshwater fishes is highlighted while defining a specific ichthyological region for the whole Balkan region. The freshwater fish fauna of Albania represents a special value of the national heritage, especially due to its diversity and a high degree of endemicity. This is mainly due to the complex geological and climatic conditions, and the location between the Adriatic and Ionian Seas on the west and the continental areas of the Balkans on the other side, which have allowed different colonization from outside the area and long periods of speciation. Eleven hydrographic basin units are analyzed for species composition, evolutionary patterns, and ecological features. This review brings the number of Albanian freshwater fish taxa to 101, with 20 species added from the previous 1995 inventory and several species deleted due to taxonomic changes.

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INTRODUCTION

Knowledge of species diversity is a central component of biodiversity conservation (Wei et al., 2014), while accurately described, measured, and assessed species diversity is a long-standing concern in ecology and conservation biology (Chen et al., 2021; Higgins et al., 2021). In addition, the classification of fish assemblages is also critical for biodiversity conservation as single fish communities may warrant specific conservation measures (Angermeier and Winston, 2003). Fish assemblage classification also depends on accurate knowledge of fish taxonomy, which has been an active area of research in recent years, especially in globally important biodiversity areas such as the Balkans (Kottelat and Freyhof, 2007). Despite these efforts, knowledge of fish diversity in the Balkans and Albania, in particular, remains limited, while their habitats and ecosystems are subject to a variety of anthropogenic pressures.

The large lakes and rivers of the Balkans have been classified as one of the most threatened freshwater ecosystems in the Mediterranean (Markovic et al., 2017), while freshwater species appear to be the most threatened (Freyhof, 2012; Freyhof et al., 2020). Fifty-three freshwater fish species (out of 194 at the European level) are listed among the most endangered in Europe, making the Balkan the most important hotspot for threatened fish species (Freyhof, 2012; Koutsikos et al., 2012). In recent years, the resilience of freshwater ecosystems to climate change has been shown to be severely affected by anthropogenic disruption of hydrological habitat connectivity by dams. Considering that freshwaters of the Balkans are home to a highly diverse and endemic fish fauna, the magnitude of the threat to important natural resources is significant. Beside the fact that fishes are the animal group most affected by human activities worldwide (Dudgeon et al., 2006; Collen et al., 2014), the conservation of their diversity has not received the same attention as that of other vertebrates (Su et al., 2021). The particularities and characteristics of Albanian freshwater fishes were recognized by Bianco (1990) who defined specific ichthyological regions within the Mediterranean. The freshwater fish fauna of Albania represents a specific value of national heritage, particularly due to its diversity and a high degree of endemicity. This is mainly due to its complex geological and climatic conditions and location between the Adriatic and Ionian Seas on the west and continental areas of the Balkan on the other side, which have allowed different colonization from outside the area and long periods of speciation.

The inland ecosystems of Albania are either crucial part of the protected area system or stands at their buffer areas. This is required to integrate ecological sustainability into a protected area context of the national ecological network and ecosystem services (i.e. regulating, supporting and cultural services) and is even more crucial within current developments. This is also due to the catchment continuum; communities are longitudinally linked but often owned by different legislative entities as well as countries (der Sleen and Albert, 2021). While there is a lack of planning and sector integration, the pressures on fisheries sustainability are in essence linked to factors including inappropriate land use, water pollution, habitat modifications and the introduction of non-native species, as well as overuse of fish stocks.

MATERIAL AND METHODS

Study area

This article provides occurrence data based on the watershed as a geographic unit for an inventory of species distributions. Watersheds are defined here as distinct river basins or isolated sub-basins, usually defined naturally by watershed boundaries. In Albania, there are several large, temporally independent rivers and lake systems (Figure 1).

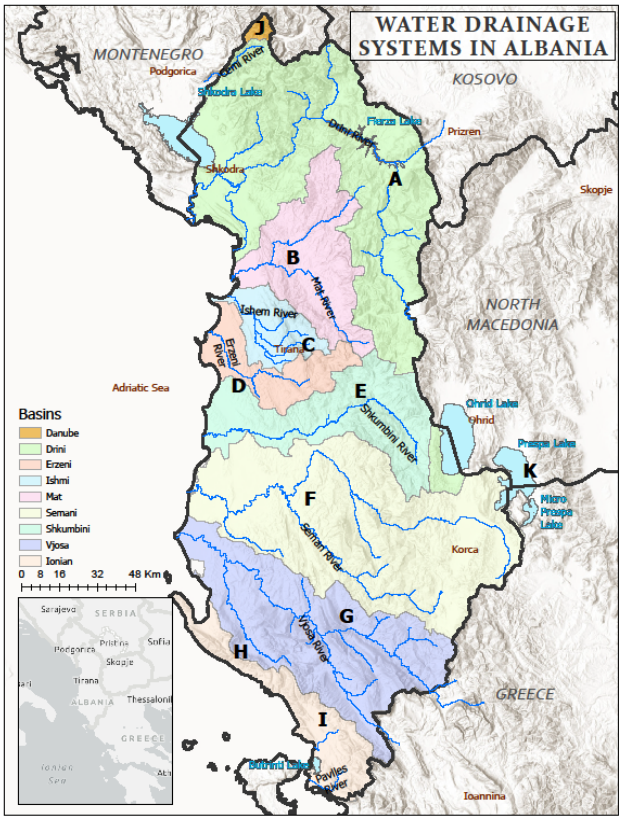

Fig 1. Water drainage systems in Albania

From north to south, they are arranged as follows: Drini (Ohrid-Drin-Skadar system including the Buna River) (A), Mat (B), Ishëm (C), Erzen (D), Shkumbin (E), Seman (consisting of two major tributaries - Devoll and Osum) (F), Vjosë (Aoos in Greece) river systems (G), several short rivers flowing from the Cikes Mountains to the southernmost part of the Adriatic Sea and to the

northernmost part of the Ionian Sea (H), the area around the Butrint Lagoon (rivers Bistrica and Pavllo) (I) and Lake Prespa (K). Most of the above-mentioned lakes and rivers (A-G) belong to the catchment area of the Adriatic Sea and the southernmost area (I) to the slope of the Ionian Sea. Area H is located on the border between the Adriatic and Ionian Seas. While there is no surface runoff of water from the Prespa Lakes, there are underground connections to Lake Ohrid. Only a very small area in the northernmost part of Albania, in the Albanian Alps, is part of the Danube River basin (J). The area covered by this study corresponds to the entire Albanian watershed. The data were compiled for the period 2015-2022. Since the first list compiled by Poljakov et al. (1958), and later by Rakaj (1995), about 110 sites have been re-sampled, and new data on occurrence at the watershed level have been collected mainly by the authors of the present paper. Most of the authors involved systematic, site-specific sampling using electrofishing, seine nets, fishing gear in lotic freshwater ecosystems, etc. A literature review of the collected data from all available recent ichthyological publications and technical reports was included here. In addition to purely freshwater species, data on euryhaline species inhabiting brackish and transitional waters (*Aphanius fasciatus, Alosa fallax, Platichthys flesus, Dicentrarchus labrax, Sparus aurata*, gobiids, and mugilids) and migratory fish species (*Anguilla anguilla, Petromyzon marinus*, and sturgeons) are presented.

Data analysis

PAST 3 Software was used to analyse the data obtained. A clustering method was applied to check if the fish communities of the samples were homogeneous. Bray-Curtis similarity analysis with group average linkage (UPGMA tree) was used to cluster different sampling sites according to their fish community and create a similarity tree plot. Multi-dimensional scaling (MDS) was performed to determine the relative placement of the samples in a two-axis ordination plot according to their fish fauna.

RESULTS AND DISCUSSIONS

Recent knowledge of the diversity and distribution of freshwater fishes in the Mediterranean has considerably increased. The actual number of fish species in inland waters is not easy to determine since various marine species are often found in the lower and middle sections of watercourses, especially in transitional waters, while new alien species continue to establish themselves in natural ecosystems. In addition, taxonomic changes are occurring at a rapid pace, with new species being described, numerous former synonyms being reintroduced, and former "subspecies" being elevated to species status. Under these circumstances and with these dynamics, there are constant changes in the country list of freshwater fish species. This is also true for the knowledge of Albanian freshwater fishes. The main sources of information in the past were the books of Poljakov et al. (1958) in which 36 freshwater species were listed, and Rakaj (1995) in which 77 species were mentioned. The difference between the data in these two publications is probably due in part to the inclusion of newly introduced species (Dhora, 2015), but more importantly to changes in the taxonomic status of many species. In addition, data on the freshwater fishes of Albania have changed in the 21st century. A number of new species have been described from this area (Bianco and Kottelat, 2005; Economidis, 2005; Kovačić and Šanda, 2007; Miller and Šanda, 2008; Bogutskaya et al., 2010; Zupančič et al., 2010), with most species from transboundary waters. The updated checklists of Dhora (2015) included a total of 120 species, of which almost 25 were classified as doubtful. Detailed field studies in specific catchments provided additional valuable information on the freshwater ichthyofauna of Albania (Shumka et al., 2018a; Shumka et al., 2020a). In addition, numerous studies focusing on specific groups (Böhlen et al., 2006; Mendel et al., 2008; Šanda et al., 2008; Buj et al., 2010; Marková et al., 2010; Palandačić et al., 2015; Stierandová et al., 2016; Schönhuth et al., 2018; Meulenbroek et al., 2020; Viñuela Rodríguez et al., 2020) helped to determine the systematic position of a number of populations of Albanian freshwater fishes. Based on a literature review, we counted 101 freshwater fish species belonging to 25 families (Table 1). Of these, 77 species are considered native freshwater fishes, 16 amphidromous species that regularly occur in freshwaters and 24 introduced species. In terms of species richness, the highest number of species was found in the Drini basin (including lakes Ohrid and Skadar/Skadar) (Table 1), followed by the Vjosa basin, while the lowest number of species is found in the Danube basin, which is represented in Albania to a very low extent, even more so at high altitudes. From biogeographic point of view, most of the Albanian region formed specific districts (delimited by the Drini basin on the north and Vjosa in the south), referred to by various authors as the Albanian, south Adriatic or southeastern Adriatic (Economidis and Daoulas, 2003; Snoj et al., 2009; Geiger et al., 2014; Meulenbroek et al., 2018; Shumka et al., 2018a; Shumka et al., 2020b).

A clustering method was used to test whether the fish communities were homogeneous: Jaccard similarity matrix with group average linkage (UPGMA tree) was used to cluster different basin samples according to their fish community and create a similarity tree (Figure 2).

Multi-dimensional scaling (MDS) ordination was used, prior to determining the relative placement of the basins in a two-axis ordination plot, according to their fish fauna (Figure 2).

Table 1. Fish species present in different water basins of Albania (N-native, A-alien)

No	Species	English name	Categories	Drini Basin	Vermoshi	Prespa	Mati	Ishmi	Erzeni	Shkumbini	Semani	Vjosa	Ionian Streams	Pavllo
1	*Acipenser naccarii* (Bonaparte, 1836)	Adriatic sturgeon	N	+								+		
2	*Acipenser sturio* (Linnaeus, 1758)	Atlantic sturgeon	N	+								+		
3	*Alburnoides devolli* (Bogutskaya, Zupančič & Naseka, 2010)	Devolli spirlin	N								+			
4	*Alburnoides fangfangae* (Bogutskaya, Zupančič & Naseka, 2010)	Osumi spirlin	N								+			
5	*Alburnoides ohridanus* (Karaman, 1928)	Ohrid spirlin	N	+			+	+	+					
6	*Alburnoides prespensis* (Karaman, 1928)	Prespa spirlin	N			+				+	+	+	+	
7	*Alburnus belvica* (Karaman, 1924)	Prespa bleak	N			+								
8	*Alburnus scoranza* (Bonaparte, 1845)	Skadar bleak	N	+			+					+		
9	*Alosafallax* (La Cepède, 1803)	Twait shad	N	+								+		
10	*Alosa* sp. Skadar	Skadarshad	N	+										
11	*Ameiurus nebulosus* (Lesueur, 1819)	Brown bullhead	A	+										
12	*Anguilla anguilla* (Linnaeus, 1758)	European eel	N	+		+	+	+	+	+	+	+	+	+
13	*Atherinaboyeri* (Risso, 1810)	Sand smelt	N	+			+				+	+	+	+
14	*Abramisbrama* (Linnaeus, 1758)	Freshwater bream	A							+	+			
15	*Aphaniusfasciatus* (Valenciennes, 1821)	Mediterranean tooth-carp	N	+			+				+	+		+
16	*Barbatula sturanyi* (Steindachner, 1892)	Brook loach	N	+										
17	*Barbatula zetensis* (Soric, 2001)	Zeta stone loach	N	+										
18	*Barbus balcanicus* (Kotlík, Tsigenopoulos, Ráb&Berrebi, 2002)	Balkan barbel	N	+	+									
19	*Barbus peloponnesius* (Valenciennes, 1842)	Peloponnese barbel	N										+	
20	*Barbus prespensis* (Karaman, 1924)	Prespa barbel	N			+				+	+	+	+	
21	*Barbus rebeli* (Köller, 1926)	Balkan barbel	N				+	+	+					

Continued. Table 1.

No	Species	English name	Categories	Drini Basin	Vermoshi	Prespa	Mati	Ishmi	Erzeni	Shkumbini	Semani	Vjosa	Ionian Streams	Pavllo
22	*Barbus* sp. Drini	Drini barbel	N	+										
23	*Carassius auratus* (Linnaeus, 1758)	Goldfish	A	+						+	+			
24	*Carassius carassius* (Linnaeus, 1758)	Crucian carp	A	+						+	+			
25	*Carassius gibelio* (Bloch, 1782)	Prussian carp	A	+		+		+	+	+	+	+		
26	*Carassius langsdorfi* (Temminck& Schlegel,1846)	Gin-buna carp	A	+							+			
27	*Caspiomyzon graecus* (Renaud & Economidis, 2010)	Epirus brook lamprey	N											+
28	*Chelonaurata* (Risso, 1810)	Golden grey mullet	N	+								+		
29	*Chelonramada* (Risso, 1827)	Thinlip grey mullet	N	+								+		+
30	*Chelonsaliens* (Risso, 1810)	Sharp nose grey mullet	N	+								+		
31	*Oedalechiluslabeo* (Cuvier, 1829)	Boxlip grey mullet	N	+								+		
32	*Chondrostoma scodrense* (Elvira, 1987)	Skadar nase	N	+										
33	*Chondrostoma ohridanum* (Karaman, 1924)	Ohrid nase	N	+								+		
34	*Chondrostoma prespense* (Karaman, 1924)	Prespa nase	N			+								
35	*Cobitis meridionalis* (Karaman, 1924)	Prespa spined loach	N			+								
36	*Cobitis ohridana* (Karaman, 1928)	Ohrid spined loach	N	+			+	+	+	+	+	+		
37	*Cottus gobio* (Linnaeus, 1758)	European bullhead	N		+									
38	*Citharus linguatula* (Linnaeus, 1758)	Atlantic spotted flounder	N	+										
39	*Ctenopharyngodon idella* (Valenciennes, 1844)	Grass carp	A	+		+				+	+			
40	*Cyprinus carpio* (Linnaeus, 1758)	Carp	N	+		+	+	+	+	+	+	+		+
41	*Dicentrarchus labrax* (Linnaeus, 1758)	Sea bass	N	+								+		
42	*Economidichthy spygmaeus* (Holly, 1929)	Western Greece goby	N			+								

Continued. Table 1.

No	Species	English name	Categories	Drini Basin	Vermoshi	Prespa	Mati	Ishmi	Erzeni	Shkumbini	Semani	Vjosa	Ionian Streams	Pavllo
43	*Eudontomyzon stankokaramani* (Karaman, 1974)	Drini brook lamprey	N	+										
44	*Gambusiaholbrooki* (Girard, 1859)	Mosquitofish	A	+		+	+	+	+	+	+	+		
45	*Gasterosteus aculeatus* (Linnaeus, 1758)	Western three-spined stickleback	N	+									+	
46	*Gobio ohridanus* (Karaman, 1924)	Ohrid gudgeon	N	+										
47	*Gobio skadarensis* (Karaman, 1936)	Skadar gudgeon	N	+			+	+	+	+	+	+		
48	*Hypophthalmichthys molitrix* (Valenciennes, 1844)	Silver carp	A	+		+					+			
49	*Hypophthalmichthys nobilis* (Richardson, 1845)	Bighead carp	A	+							+			
50	*Huso huso* (Linnaeus, 1758)	Beluga	A	+										
51	*Knipowitschia goerneri* (Ahnelt, 1991)	Corfu dwarf goby	N											+
52	*Knipowitschia montenegrina* (Kovačić&Šanda, 2007)	Montegerinian goby	N	+										
53	*Lampetra soljani* (Tutman, Freyhof, Dulčić, Glamuzina& Geiger, 2017)	Soljani lamprey	N	+										
54	*Lepomis gibbosus* (Linnaeus, 1758)	Pumpkinseed	A	+		+	+	+	+	+	+	+		
55	*Luciobarbus albanicus* (Steindachner, 1870)	Strossidi	N									+		
56	*Megalobrama terminalis* (Richardson, 1846)	Black Amur bream	A	+							+			
57	*Mugil cephalus* (Linnaeus, 1758)	Striped mullet	N	+								+	+	+
58	*Mylopharyngodon piceus* (Richardson, 1846)	Black carp	A	+										
59	*Oreochromis niloticus* (Linnaeus, 1758)	Nile tilapia	A					+						
60	*Oncorhynchus mykiss* (Walbaum, 1792)	Rainbow trout	A	+			+		+	+		+		
61	*Oxynoemacheilus pindus* (Economidis, 2005)	Pindus stone loach	N						+	+	+	+		
62	*Pachychilon pictum* (Heckel &Kner, 1858)	Ohrid roach	N	+			+	+	+	+	+	+		+
63	*Parabramis pekinensis* (Basilewsky, 1855)	White amur bream	A			+					+			

Continued. Table 1.

No	Species	English name	Categories	Drini Basin	Vermoshi	Prespa	Mati	Ishmi	Erzeni	Shkumbini	Semani	Vjosa	Ionian Streams	Pavllo
64	*Pelasgus minutus* (Karaman, 1924)	Ohrid minnow	N	+										
65	*Pelasgus prespensis* (Karaman, 1924)	Prespa minnow	N			+					+			
66	*Pelasgus thesproticus* (Stephanidis, 1939)	Epiros minnow	N									+		+
67	*Perca fluviatilis* (Linnaeus, 1758)	European perch	A	+										
68	*Petromyzon marinus* (Linnaeus, 1758)	Atlantic sea lamprey	N	+								+		
69	*Phoxinus karsticus* (Bianco & De Bonis 2015)	Karst minnow	N	+										
70	*Phoxinus* sp. Drini	Drini minnow	N	+										
71	*Platichthys flessus* (Linnaeus, 1758)	European flounder	N	+								+		
72	*Pomatoschistus montenegrensis* (Miller&Šanda, 2008)	Skadargoby	N	+										
73	*Pseudorasbora parva* (Temminck&Schlegel, 1846)	Top-mouth gudgeon	A	+		+	+	+	+	+	+	+		
74	*Rhodeus amarus* (Bloch, 1782)	Bitterling	A	+		+					+			
75	*Rutilus albus* (Marić, 2010)	White Skadar roach	N	+										
76	*Rutilus ohridanus* (Karaman, 1924)	Ohridroach	N	+										
77	*Rutilus prespensis* (Karaman, 1924)	Prespa roach	N	+		+								
78	*Sabanejewia balcanica* (Karaman, 1922)	Balkan golden loach	N	+	+									
79	*Salariopsis fluviatilis* (Asso, 1801)	Freshwater blenny	N	+			+					+	+	+
80	*Salmo aphelios* (Kottelat, 1997)		N	+										
81	*Salmo balcanicus* (Karaman, 1927)		N	+										
82	*Salmo farioides* (Karaman, 1938)	Adriatic brown trout	N	+			+			+		+		
83	*Salmo labrax* (Pallas, 1814)	Danuabia brown trout	N		+									
84	*Salmo letnica* (Karaman, 1924)	Ohrid trout	N	+		+								

Continued. Table 1.

No	Species	English name	Categories	Drini Basin	Vermoshi	Prespa	Mati	Ishmi	Erzeni	Shkumbini	Semani	Vjosa	Ionian Streams	Pavllo
85	*Salmo lumi* (Poljakov, Filipi&Basho, 1958)		N	+										
86	*Salmo marmoratus* (Cuvier, 1829)	Marble trout	N	+										
87	*Salmo obtusirostris* (Heckel, 1852)	Softmouth trout	N	+										
88	*Salmo ohridanus* (Steindachner, 1892)	Belvica	N	+										
89	*Salmo peristericus* (Karaman, 1938)	Prespa trout	N			+								
90	*Sander lucioperca* (Linnaeus,1758)	Pike-perch	A	+										
91	*Scardinius knezevici* (Bianco&Kottelat, 2005)	Skadar rudd	N	+										
92	*Silurus glanis* (Linnaeus, 1758)	Wels catfish	A			+								
93	*Squalius pamvoticus* (Stephanidis, 1939)	Pamvotis chub	N											+
94	*Squalius platyceps* (Zupančič, Marić, Naseka & Bogutskaya, 2010)	Skadar chub	N	+			+	+	+	+	+	+		
95	*Squalius prespensis* (Fowler, 1977)	Prespa chub	N			+								
96	*Syngnathusabaster* (Risso, 1827)	Black-striped pipefish	N	+									+	+
97	*Telestes pleurobipunctatus* (Stephanidis, 1939)	Greek riffle dace	N										+	+
98	*Telestes montenigrinus* (Vuković, 1963)	Montenegro riffle dace	N	+										
99	*Thymallus thymallus* (Linnaeus,1758)	European grayling	A	+										
100	*Tinca tinca* (Linnaeus, 1758)	Tench	A	+		+					+			
101	*Valencia letourneuxi* (Sauvage, 1880)	Corfu toothcarp	N											+
				73	4	22	17	13	14	20	29	33	10	15

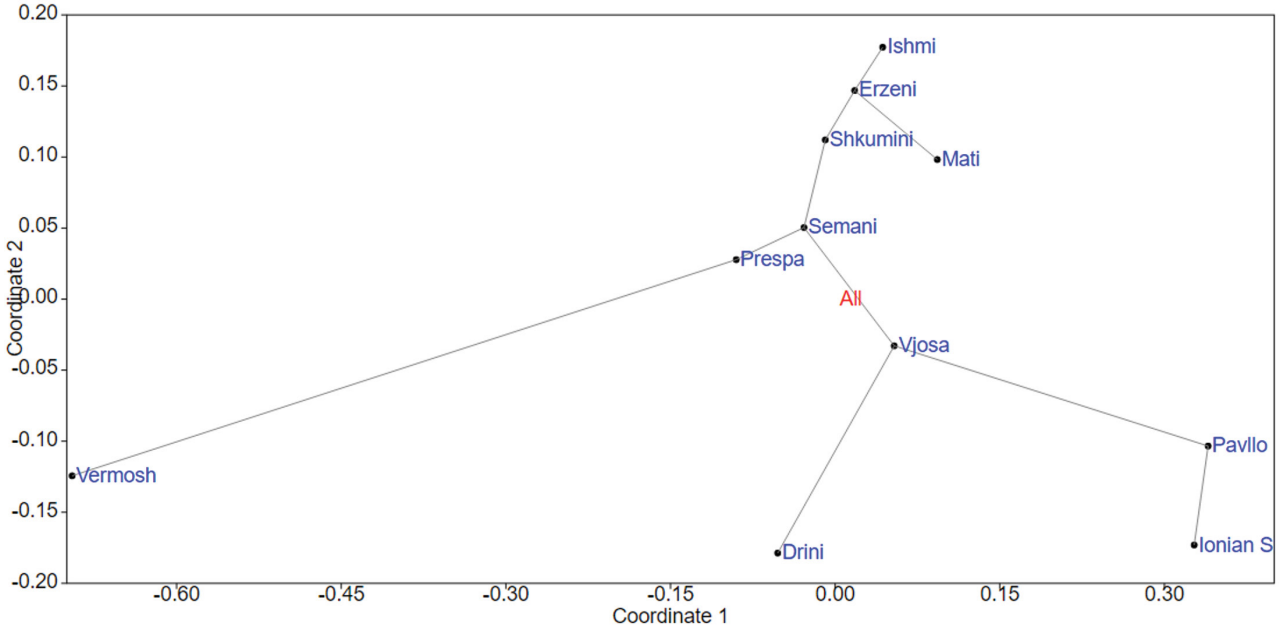

Fig 2. Relative placement of 11 Albanian basins according to their fish population using multi-dimensional scaling (MDS)

CONCLUSION

The following general findings were generated from the present study: (1) there are 101 species of freshwater fish in eleven water basins of Albania, these include 77 native freshwater fish and 24 alien species.

This study provides recent data of species and distribution records following different water basins in Albania, incorporating aspects of a taxonomic review for selected taxa. The distribution data are presented here at a geographic scale, including transboundary water ecosystems. Further on, this may help in the determination of species conservation and assessment of non-indigenous species invasions and associated impacts on native species.

The sub-basins of the national hydrographic network represent an appropriate approach for the evaluation and monitoring of freshwater fish species since water drainage boundaries are important parameters that determine the biogeography of freshwater species.

NEDAVNI PODACI O DISTRIBUCIJI SLATKOVODNE IHTIOFAUNE U ALBANIJI

SAŽETAK

U ovom članku izložen je ažurirani popis slatkovodnih riba u Albaniji za svaki podsliv. Prikazani podaci o rasprostranjenosti i popisi taksona temelje se na pregledu literature do listopada 2022. i intenzivnom terenskom radu u posljednjih 15 godina. Prikazani su podaci o distribuciji 101 vrste riba (koje potječu iz 25 porodica) iz 11 različitih podslivova. Postoje novi zapisi koji uključuju domaće, strane i translocirane vrste riba. Osobitost albanskih slatkovodnih riba je istaknuta pri definiranju specifične ihtiološke regije za cijelu balkansku regiju. Fauna slatkovodnih riba Albanije predstavlja posebnu vrijednost nacionalne baštine, posebice zbog svoje raznolikosti i visokog stupnja endemičnosti. To je uglavnom zbog složenih geoloških i klimatskih uvjeta i položaja između Jadranskog i Jonskog mora na zapadu i kontinentalnih područja Balkana s druge strane, što je omogućilo različite kolonizacije izvan područja i duga razdoblja specijacije. Jedanaest hidrografskih bazenskih jedinica analizirano je u pogledu sastava vrsta, evolucijskih obrazaca i ekoloških značajki. Ovim pregledom broj albanskih slatkovodnih riba iznosi 101, s 20 vrsta dodanih iz prethodnog popisa iz 1995. godine i nekoliko vrsta izbrisanih zbog taksonomskih promjena.

Ključne riječi: slatkovodna ihtiofauna, zajednica riba, distribucija, podslivovi, Albanija

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