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Status and distribution of spined loaches (Cobitidae) and stone loaches (Nemacheilidae) in Bosnia and Herzegovina

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Abstract. This paper presents a critical assessment of the current status and geographical distribution of loaches (Cobitidae, Nemacheilidae) in Bosnia and Herzegovina. This closes a gap in research knowledge with only general distribution data currently available. In the Danube catchment four cobitid (*Cobitis elongata*, *C. elongatoides*, *Misgurnus fossilis*, *Sabanejewia balcanica*) and one nemacheilid species (*Barbatula barbatula*) were recorded, while the Adriatic Sea catchment hosts three spined loaches: *C. narentana*, *C. illyrica*, and *C. herzegoviniensis* and nemachilid *B. barbatula*. *Cobitis elongatoides* was found to be the most common and distributed throughout the northern Bosnia and Herzegovina; i.e. in the rivers Sava, Drina, Bosna, Vrbas, Una (Danube catchment). *Sabanejewia balcanica* was recorded in the same area but less frequently. Recent bibliographic evidence forces us to exclude *C. taenia* from the current checklist. On the other hand, cobitid species from the Adriatic Sea catchment are endemic with a very small distribution. Also, the extinction risk status of each taxon is mentioned following IUCN categories. This study provides geographically constrained information on the recent status of loach populations in the freshwaters of Bosnia and Herzegovina. Further data on the status and geographical distribution would improve the conservation and management of these fishes.

Key words: loaches, Sava River catchment, Adriatic Sea catchment, species composition, distribution area

Introduction

Spined loaches of the family Cobitidae and stone loaches of the family Nemacheilidae are large groups of primarily freshwater fishes which are very common and widespread in waters of the Palearctic region (Nalbant et al. 2001). Their distribution and range encompasses Eurasia (including England and the Iberian Peninsula), the Japanese archipelago, Korean Peninsula and Amur River basin in the Far East, as well as northern Africa, making them one of the most widespread families of European freshwater fish (Bohlen & Ráb 2001, Kottelat & Freyhof 2007). Members of Cobitidae and Nemacheilidae are small sized bottom-dwellers characterized by low dispersal abilities, elongated body and short lifespan. Their preferred microhabitat characteristics are open, shallow areas with slow-flowing or stagnant water (Kottelat & Freyhof 2007). Due to the specific habitat requirement and the fact that they are not commercially important, data on their distribution and ecology are relatively poor and until recently, they have been overlooked in scientific study (Mustafić et al. 2003, Šanda et al. 2008a, b).

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In recent years, loaches have become the object of more focused investigations. Their peculiar ecology, unresolved taxonomy and unusual reproduction modes attracted the attention of ichthyologists. Recent phylogenetic studies have revealed significant phylogenetic relationships within the genus *Cobitis* and demonstrated an unexpectedly high diversity within this fish group in Europe (Perdices & Doadrio 2001, Janko et al. 2005a, b, Bohlen et al. 2006, Buj et al. 2008, 2014, 2015a, Perdices et al. 2008, 2016, Geiger et al. 2014). Genetic diversity and phylogenetic relationships have been studied on *Sabanejewia* (Perdices et al. 2003, Marešová et al. 2011) and *Barbatula* populations (Šedivá et al. 2008). However, although both loach families occur in many European waters, scientific knowledge on this species in Bosnia and Herzegovina is still sparse. Consequently, the taxonomic status and geographical distribution of Cobitidae and Nemacheilidae in Bosnia and Herzegovina is poorly understood and uncertain. The published literature only comprises a few contributions on their general distribution in the basin of the River Sava (Danube catchment) (Brusina 1892, Medić 1901, Zaplata & Taler 1932, Karaman 1963, Vuković 1963, 1977, Bogut et al. 2006, Sofradžija 2009) and a very general note from the River Neretva drainage system (Vuković 1963, 1977, Bogut et al. 2006, Sofradžija 2009) which belongs to the Adriatic Sea catchment. In addition to the sparse data on their distribution, there is a surprising deficiency in the knowledge on their biology and morphological characteristics in general. The available publications contain mainly general biological and ecological data (Vuković 1963, 1977, Vuković & Ivanović 1971, Bogut et al. 2006, Sofradžija 2009) and overall faunistic records (Kosorić 1978, Kosorić et al. 1983, Tutman et al. 2012a, Nedić et al. 2014). Several older papers concern systematic, genetic and chromosomal issues (Sofradžija & Berberović 1978, Sofradžija & Vuković 1979). There are also some data on age structure available from the Hutovo Blato wetland in the Neretva River catchment (Tutman et al. 2006, Dulčić et al. 2009). In fact, only Golub et al. (2016) coupled precise geographic location with morphometric measurements and meristic characteristics of the specimens caught.

Generally, according to the last book of the freshwater fishes of Bosnia and Herzegovina available (Sofradžija 2009) five cobitid species of three genera (*Cobitis*, *Misgurnus* and *Sabanejewa*) and one from Nemacheilidae (*Barbatula*) are cited as extant in domestic waters, but without detailed data of their distribution, ecology or biology. However, new results support differentiation of the Adriatic basin *Cobitis* and their independent evolution from the Central European group (Buj et al. 2008, 2014, 2015a, Perdices et al. 2008, 2016), revealing two new species (Freyhof & Stelbrink 2007, Buj et al. 2014).

Detailed data on the distribution of loach species have been reported in recent years from several surrounding countries (Mrakovčić et al. 2000, Povž & Šumer 2000, 2003, Bohlen et al. 2003, Erős et al. 2003, Marić & Pavlović 2005, Šanda et al. 2008c, Marić & Milošević 2010). However, no general summary paper is available from Bosnia and Herzegovina on the current status and geographical distribution of populations of the particular loach species. The fact is that knowledge of the distribution and present status of populations, including the precise taxonomic identity of species of these families is required for clarifying the taxonomic status and geographical distribution. These data provides basic information for conservation management and also contributes to more detailed knowledge of loach distribution at the continental scale. Such a compilation is needed, since the general distribution patterns of species can have deep impacts both on national as well as on European conservation.

Since there is little information available about the recent status and distribution, this paper reviews the existing data on taxonomy and distribution of spined loaches from the family Cobitidae and stone loaches from the family Nemacheilidae providing an important update of their present population status in Bosnia and Herzegovina. The aims of this paper are to update the existing information about the status and to investigate more fully the geographical distribution of loaches (Cobitidae, Nemacheilidae) in Bosnia and Herzegovina.

Material and Methods

Faunistic data on loach species' presence and distribution in Bosnia and Herzegovina waters were based on published literature in the form of research articles, monographs, books and technical reports. To promote the protection and conservation of these species, this paper attempts to give a comprehensive review of available published, analysed together with more recent data gathered by the authors from 2000 until present. Also, some conservation management recommendations are proposed in order to improve their natural status. Additional data, like information on the main threats are derived from different ichthyological monitoring surveys carried out in the last twenty years in Bosnia and Herzegovina by the Faculty of Science, University of Sarajevo.

Rivers in Bosnia and Herzegovina are divided into two separate drainage systems: the Danube (Black Sea) (38719 km^2 or 75.7 % of total Bosnia and Herzegovina surface area), and the Adriatic Sea catchment (12410 km^2 or 24.3 %), which are separated by the Dinaric mountain range (Fig. 1). Both catchments are characterised by a different ichthyofaunal composition: in general, the Danube basin accomodates species with wider distribution ranges, while the Adriatic Sea catchment area is characterized by a number of endemic forms (Vuković 1977, Kottelat & Freyhof 2007, Sofradžija 2009). The main part of the Danube catchment area is drained by the River Sava, which runs towards the northern border of Bosnia and Herzegovina and Croatia, and its major tributaries (the rivers Una, Sana, Vrbas, Ukrina,

Table 1. List of loach species and their distribution within the river basins of Bosnia and Herzegovina based on available literature data.

Family/Species	Rivers – locality	River basin	Catchment	Source
Cobitidae				
Cobitis elongata	Una	Una	Danube	Brusina 1892, Medić 1901, Sofradžija 2009, Drešković et al. 2011
	Sana			Drešković et al. 2011
	Sava	Sava		Bogut et al. 2006, Sofradžija 2009, Drešković et al. 2011, Nedić et al. 2014, Simonović et al. 2015
	Brka, Tinja			Drešković et al. 2011
	Modrac Reservoir, Gostilja			Adrović et al. 2012
	Vrbas	Vrbas		Sofradžija 2009, Drešković et al. 2011
	Bosna	Bosna		Sofradžija 2009, Drešković et al. 2011
	Spreča			Sofradžija 2009
	Fojnica			Pavličević et al. 2014
	Kozica – Lašva river tributary			Pavličević et al. 2014
	Misoča			Bogut et al. 2006, Škrijelj et al. 2016
	Drina	Drina		Hamzić et al. 2015
Cobitis elongatoides	rivers and tributaries of Black Sea basin	Sava	Danube	Bogut et al. 2006
	Modrac Reservoir, Brka, Gostilja, Tinja			Adrović et al. 2012
	Sava – lower part			Sofradžija 2009, Nedić et al. 2014
	Vrbas – middle courses	Vrbas		Sofradžija 2009, Hamzić et al. 2015
	Miljacka, Zujevina	Bosna		Zaplata & Taler 1932
	Bosna – middle courses			Sofradžija 2009, Hamzić et al. 2015
	Spreča			Memić & Adrović 2010
	Tinja			Škrijelj et al. 2016
	Drina – middle courses	Drina		Sofradžija 2009, Hamzić et al. 2015
	Una – middle courses	Una		Sofradžija 2009, Hamzić et al. 2015
Cobitis herzegoviniensis	Mostarsko Blato	Neretva	Adriatic	Šanda et al. 2008a, Glamuzina et al. 2013, Buj et al. 2014, 2015a, b
Cobitis illyrica	Lake Krenica	Neretva	Adriatic	Šanda et al. 2008a, b, Glamuzina et al. 2013, Buj et al. 2014, 2015a, b, Ćaleta et al. 2015
Cobitis narentana	lower River Neretva from Čapljina city	Neretva	Adriatic	Vuković 1963, 1977, Šanda et al. 2008a, b, Sofradžija 2009, Glamuzina et al. 2013, Buj et al. 2014, 2015a, b, Ćaleta et al. 2015
	Hutovo Blato wetland			Tutman et al. 2006, 2012a, Šanda et al. 2008a, b, Glamuzina et al. 2013, Buj et al. 2014, 2015a, b, Ćaleta et al. 2015
	rivers Bregava and Trebišnjica			Šanda et al. 2008a, b, Buj et al. 2014, 2015a ,b

Table 1. Continued.

Family/Species	Rivers – locality	River basin	Catchment	Source
Misgurnus fossilis	Sava	Sava	Danube	Brusina 1892, Sofradžija 2009, Hamzić et al. 2015
	waters of Black Sea basin			Vuković 1963, 1977, Bogut et al. 2006
	River Sava and lower reaches of their tributaries			Sofradžija 2009
	Una – near Dubica	Una		Brusina 1892
	Bosna	Bosna		Sofradžija 2009, Drešković et al. 2011, Hamzić et al. 2015
	Krivaja			Muhamedagić et al. 2013
	Drina	Drina		Sofradžija 2009
Sabanejewia balcanica	waters of Black Sea basin	Sava	Danube	Vuković 1963, 1977, Bogut et al. 2006
	Sava			Hamzić et al. 2015, Simonović et al. 2015
	Gostilja			Adrović et al. 2012
	River Vrbas and tributaries Suturlija and Široka	Vrbas		Karaman 1963, Vuković 1977, Sofradžija 2009, Marešová et al. 2011, Hamzić et al. 2015
	Bosna	Bosna		Sofradžija 2009, Drešković et al. 2011
	Krivaja			Muhamedagić et al. 2013
	Usora			Marešová et al. 2011
	Drina – middle reaches	Drina		Sofradžija 2009
	Una – Kostajnica Una – Bihać	Una		Drešković et al. 2011 Marešová et al. 2011
Nemacheilidae				
Barbatula barbatula	River Bosna	Bosna	Danube	Zaplata & Taler 1932, Sofradžija 2009
	rivers of Danubian catchment	Sava		Vuković 1963, 1977, Bogut et al. 2006
	lower Sava River			Nedić et al. 2014, Hamzić et al. 2015
	upper and middle reaches of Sana	Una		Sofradžija 2009
	upper and middle reaches of Ukrina	Ukrina		Sofradžija 2009
	upper and middle reaches of Vrbas	Vrbas		Sofradžija 2009
	upper and middle reaches of Drina	Drina		Sofradžija 2009
	upper Neretva River	Neretva	Adriatic	Vegara et al. 2009

Bosna, Brka, Tinja and River Drina) that drain deeply into central and northern Bosnia and Herzegovina. They receive several mountain tributaries each. The River Sava is the main waterway connecting Croatia, Bosnia and Herzegovina and Serbia. Together, these tributaries constitute a major drainage basin of the southeastern Europe, covering the total area of approximately 97713.20 km^2 representing one of the most significant sub-basins of the Danube River basin, with a share of 12 % (Jukić 2008).

In contrast, the Adriatic Sea catchment area of Bosnia and Herzegovina comprises of two sub-basins; the Neretva and Cetina rivers. The only river that flows into the Adriatic Sea is the River Neretva. The Neretva River basin, including the part of Trebišnjica River basin, has an area of 10100 km² or 81.4 % of the total Adriatic Sea catchment area of Bosnia and Herzegovina, while the Cetina river sub-basin extends over 2310 km² (18.6 % of the total Adriatic Sea catchment area of Bosnia and Herzegovina). In Herzegovina there is an extensive karst area (more than 4000 km^2) with important groundwater sources, that occur as small springs, streams, rivers and lakes.

Results

Diversity of loaches in Bosnia and Herzegovina

Review of the published literature reveals that data on loach species' composition and geographical

Fig. 1. Map of Bosnia and Herzegovina showing main catchments, Danube (or Black Sea) catchment (unshaded) and Adriatic Sea catchment (shaded).

distribution are very scarce, mostly based on species lists only lacking detailed descriptions of species and localities. According to the bibliographic data, a total of nine species of loach (eight Cobitidae and one Nemacheilidae) were reported from freshwaters within their geographical range (Vuković 1963, 1977, Bogut et al. 2006, Šanda et al. 2008a, b, Sofradžija 2009, Buj et al. 2014, 2015a, b, Golub et al. 2016). However, some of the data are in obvious conflict with the current taxonomy. Based on all available data it is clear that reports on the presence of *Cobitis taenia* Linnaeus, 1758 in Bosnia and Herzegovina are a result of taxonomic imprecision and it cannot be expected that this species inhabits waters of Bosnia and Herzegovina, because its distribution range is restricted to northern Europe (Nalbant et al. 2001). Bosnia and Herzegovina was thought to be a part of this species' range since *C. taenia* was considered to have extremely wide distribution through Palearctic region (Nalbant et al. 2001). However, already Bacescu (1962) reported *C. taenia* to be an assemblage of morphologically similar, but phylogeneticaly distinct species.

The ichtyofauna of Bosnia and Herzegovina comprises eight loach species, distributed in both catchments. In the northern part (Sava River basin), five species were recorded: Balkan spined loach *C. elongata* Heckel & Kner, 1858, Danube spined loach *C. elongatoides* Bacescu & Mayer, 1969, weather loach *Misgurnus fossilis* (Linnaeus, 1758), Balkan golden loach *Sabanejewia balcanica* (Karaman, 1922) and one member of nemacheilid family: stone loach *Barbatula barbatula* (Linnaeus, 1758). For the waters of the Adriatic Sea catchment three species of Cobitidae were reported; two recently described: Illyric spined loach, *C. illyrica* Freyhof & Stelbrink 2007; Herzegovinian spined loach, *C. herzegoviniensis* Buj & Šanda, 2014 and the Neretva spined loach, *C. narentana* Karaman 1928. From the Nemacheilidae family *B. barbatula* was recently reported in the upper part of the River Neretva (Vegara et al. 2009). Significantly more and newer data are available on the loaches in the Adriatic (Schneider et al. 2000a, b, Buj et al. 2008, 2014, 2015a, b) than for the Danube catchment. Reported species are not equally distributed across Bosnia and Herzegovina, but show a higher diversity in the north than in the south of the country. The only species shared among the both catchments is *B. barbatula* (Table 1).

Overview of the available literature

The earliest information comes from Brusina (1892) and Medić (1901), who indicated the presence of *B. barbatula* (as *Nemachilus barbatulus*) and *M. fossilis* in the River Sava, mentioning *C. taenia* and *B. barbatula* (as *Cobitis barbatula*), but only on the Croatian side. Later, Zaplata & Taler (1932) reported loach species in the River Bosna and its tributaries near Sarajevo recording the presence of *C. taenia* and *B. barbatula* (as *C. barbatula*). Karaman (1963) described a new subspecies *C. aurata bosniaca* from the River Vrbas which flows into the River Sava. In the first check-list, Vuković (1963) listed four species; *C. taenia*, *C. aurata*, *B. barbatula* (as *N. barbatulus*) and *M. fossilis* (as *M. fosillis*). *Cobitis taenia* was placed in the waters of both the Danube and Adriatic drainage systems with two subspecies; *C. taenia taenia* Linnaeus, 1758 in the Danube, and *C. taenia narentana* Karaman 1928 in the Adriatic basin. Vuković (1977) in a subsequent check-list just followed the previous one and mentioned *C. taenia* with the two same subspecies, *S. balcanica* (as *C. aurata*) with two subspecies; *C. aurata balcanica* Karaman, 1922 and *C. aurata bosniaca* Karaman 1963 (in the River Vrbas and their tributaries Suturlija and Široka), *B. barbatula* (as *N. barbatulus*) and *M. fossilis*, all in the waters of Danube catchment. Furthermore, Kosorić & Mikavica (1981) listed *C. taenia* in the River Krivaja (Danube basin), whilst Kosorić et al. (1983) for the River Bosna and Korjenić (2004) for the River Fojnica in middle Bosnia and Herzegovina. Sofradžija & Berberović (1978) investigated sexual dimorphism in *C. taenia*, while Sofradžija & Vuković (1979) presented the chromosomal set of *B. barbatula* (as *N. barbatulus*).

Cobitis narentana was the only *Cobitis* species that has been mentioned from the Neretva drainage (Karaman

1928, Taler 1953, Vuković 1977, Mrakovčić et al. 1995, 2000). Later phylogenetic research revealed their differentiation indicating independent evolution from the Central European group (Buj et al. 2008, 2014, 2015a, Perdices et al. 2008, 2016). In addition, two new species were described (Freyhof & Stelbrink 2007, Buj et al. 2014). Tutman et al. (2006) presented some biological parameters of *C. narentana* while Dulčić et al. (2009) reported a length-weight relationship of a *C. narentana* population from Hutovo Blato wetland (Neretva River basin). Furthermore, Tutman et al. (2012a) mentioned *C. narentana* in Hutovo Blato as a rare member of its ichthyofauna.

According to Bogut et al. (2006) the freshwaters of Bosnia and Herzegovina are inhabited by five loach species (*C. elongata*, *C. elongatoides*, *M. fossilis*, *S. balcanica* and *B. barbatula*), while Kottelat & Freyhof (2007) listed six, adding *C. narentana* to the list. A review of more recent studies shows that Sofradžija (2009), following the older systematics, indicated five species; *M. fossilis*, *B. barbatula* (as *N. barbatulus*), *C. elongatoides*, *C. elongata* for Danube and *C. narentana* for the Adriatic catchment and two subspecies (*C. aurata balcanica* Karaman, 1922 and *C. a. bosniaca* Karaman 1963), both in the waters of Danube basin. However, these data were presented without precise location of their distribution. Actually, Šanda et al. (2008a, b) were the first ones to analyze in detail the occurrence and the distribution of *Cobitis* species in the waters of Adriatic Sea catchment in Bosnia and Herzegovina. Further intensive research into the Cobitidae family in the last 15-20 years in the Neretva river catchment brought many crucial findings, which radically changed original insights on species structure (Schneider et al. 2000a, b, Buj et al. 2008, 2014, 2015a). Recently, data from different ichthyological monitoring surveys have provided more precise information on distribution ranges. Škrijelj et al. (2008a, b, 2016), and Pavličević et al. (2014) mentioned *C. elongata* for the upper streams of the River Fojnica and Misoča, tributaries of the River Bosna (Danube catchment), while *C. elongatoides* was recorded for the River Tinja, a tributary of the River Sava (Škrijelj et al. 2008b). However, it needs to be emphasized that with the exception of Golub et al. (2016), these investigations were not exclusively loach-oriented, nor supported by the analysis of specimens caught.

From the presented overview, it is evident that, although loaches have been known from Bosnia and Herzegovina for a long time, their species identity and geographical distribution is still incompletely resolved. Hovewer, as the taxonomy of fishes in Bosnia and Herzegovina has not been carefully studied yet, the distribution ranges of many taxa are not defined and evidence of the presence or absence of some of them needs to be clarified through further detailed study.

Status and distribution of loach species in Bosnia and Herzegovina

The distribution and the conservation status of each species were evaluated (Table 1) and are briefly discussed below.

Family Cobitidae

Cobitis elongata Heckel & Kner, 1858

Common name: Balkan spined loach; local name: veliki vijun, vijunica

Cobitis elongata is an autochthonous species occuring in many freshwaters throughout the Danube basin of South-Eastern Europe (including Slovenia, Croatia, Serbia, Montenegro, Macedonia, Bulgaria and Romania; Bănărescu 1964, 1990, Povž & Šumer 2003, Marić & Pavlović 2005, Mrakovčić et al. 2006, Kottelat & Freyhof 2007). However, data concerning both the status and the distribution of this species from Bosnia and Herzegovina are still scarce, mostly due its mistaken identification as *C. taenia* (Vuković 1963, 1977).

The first data about this species in Bosnia and Herzegovina came from Brusina (1892) and Medić (1901) who mention the River Una and their tributaries as the extent of the distribution area. Later, Kottelat & Freyhof (2007) and Sofradžija (2009), simply repeated the same data. Additional data may be found in Bănărescu & Nalbant (1957, 1998), Delić et al. (2003a), Buj et al. (2008), Mrakovčić et al. (2000, 2006, 2008), Dumbović et al. (2009) but only for the Croatian section of the River Sava and Una. Škrijelj et al. (2008a, 2016), and Pavličević et al. (2014) mention *C. elongata* for the upper streams of the River Misoča and Fojnica, tributaries of the River Bosna (Danube catchment, Fig. 2). This species occurs on moderate to fast-flowing stretches of shallow rivers and is more frequent in the upper parts of the rivers and streams. It also occurs on sandy banks and shores, sometimes on rocky substrates with submerged vegetation, however it is not known to enter small streams, large rivers or river stretches without currents (Mrakovčić et al. 2008). Recent phylogenetic investigations proved this species to be more closely related to the species from the Adriatic basin, than to the remaining species distributed in Central Europe (Perdices & Doadrio 2001, Perdices et al. 2008, Buj et al. 2008, 2014),

even though *C. elongata* does not posses Canestrini scale, unlike majority of the Adriatic species. Its phylogeography and evolutionary history still have to be uncovered. However, based on previous investigations it separated from the remaining species in Miocene (Buj et al. 2015a).

Habitat destruction, extraction of water for irrigation as well as industrial, agricultural and untreated sewage pollution are recognised as the main threats (Mrakovčić et al. 2008). It is categorized as Least Concern (LC) species in the IUCN Red List (Freyhof & Kottelat 2008a) and the Red List of fauna of the Federation of Bosnia and Herzegovina (Škrijelj et al. 2013).

Fig. 2. Distribution of *Cobitis elongata* in Bosnia and Herzegovina based on literature data. Danube (or Black Sea) catchment (unshaded), Adriatic Sea catchment (shaded).

Cobitis elongatoides Bacescu & Mayer, 1969

Common name: Danube spined loach; local name: vijun, badelj

Despite the wide distribution of this species (Kottelat & Freyhof 2007), limited historical data are available for Bosnia and Herzegovina. Like previous species, *C. elongatoides* was in the older literature most probably mentioned under the name of *C. taenia* (Vuković 1963, 1977, Vuković & Ivanović 1971, Sofradžija & Berberović 1978, Kosorić 1981, Kosorić et al. 1983, Korjenić 2004) for the River Sava and its tributaries. For the Croatian part of the River Sava it was mentioned in Mrakovčić et al. (2000) and Schneider et al. (2000a) under the name of *C. taenia danubialis*, while in Delić et al. (2003a) and Mrakovčić et al. (2008) it was identified as *C. elongatoides*. As *C. elongatoides* it was reported in Dumbović et al. (2009) for the Croatian section of the River Una.

There are some new data about ecological and biosystematic characteristics in Adrović et al. (2008). Memić & Adrović (2010) reported this species in the upper part of the River Spreča (Sava catchment), while Škrijelj et al. (2008b) mentioned it for the River Tinja, a tributary of the River Sava (Fig. 3). Golub et al. (2016) presented information about morphological, morphometric and meristic characteristics of this species from the River Suturlija, which colonises different habitat types, from minor stagnant waters to major rivers (Mrakovčić et al. 2008).

Phylogeography of this species has been investigated in Croatia and Central Europe, although Bosnian samples were not included. Already the first comprehensive phylogeographic investigation of the genus *Cobitis* in Europe (Perdices & Doadrio 2001) had included *C. elongatoides* inside the so called *Cobitis s. str.* lineage. Closer relatedness between *C. elongatoides* and some central and eastern European species (*C. taenia*, *Cobitis tanaitica* Bacescu & Mayer, 1969, *Cobitis stephanidisi* Economidis, 1992, etc.) was corraborated by investigation of Bohlen et al. (2006). Existence of both "pure" *C. elongatoides* populations, as well as populations comprising diploid *C. elongatoides* males and females, together with triploid hybridogenetic females has been determined in the Danube basin of Croatia (Buj et al. 2008). Thereafter, presence of hybrid individuals in Bosnia and Herzegovina is also likely. Moreover, Sofradžija & Berberović (1978) reported triploid females (with 75 chromosomes in somatic cells) from middle Danube system in Bosnia and Herzegovina.

The main threats are habitat alteration, untreated sewage, pollution, the extraction of gravel from the river, water flow and level regulations, and the introduction of non-native species. It is included as the LC species in the IUCN Red List (Freyhof

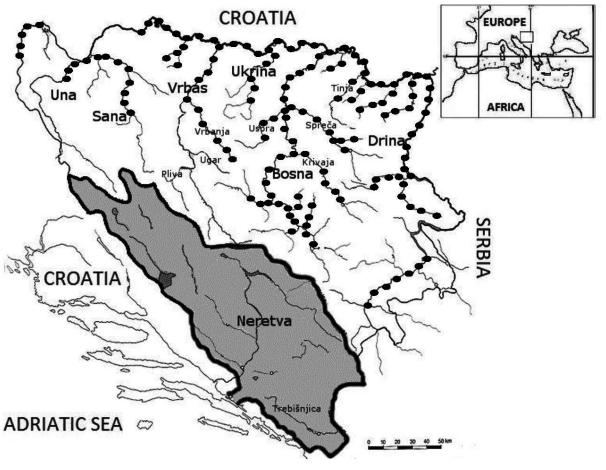

Fig. 3. Distribution of *Cobitis elongatoides* in Bosnia and Herzegovina based on literature data. Danube (or Black Sea) catchment (unshaded), Adriatic Sea catchment (shaded).

& Kottelat 2008b) and the Red List of fauna of the Federation of Bosnia and Herzegovina (Škrijelj et al. 2013), respectively.

Cobitis herzegoviniensis Buj & Šanda, 2014
Common name: Herzegovinian spined loach, local name: hercegovački vijun

The recently described species *C. herzegoviniensis* was first recorded by Šanda et al. (2008a) in the tributary of the River Neretva (Lištica) and surrounding karstic field (Mostarsko Blato) from where spined loaches have never previously been reported (Kosorić & Vuković 1966, Aganović 1969, Kosorić 1974, 1977, 1978, Kosorić et al. 1989). Šanda et al. (2008a, b) already stated that *Cobitis* diversity in the Neretva basin is probably underestimated and further detailed taxonomic research is needed to resolve this issue, suggesting the existence of possible new species. Furthermore, a recent taxonomic analysis has revealed that the population distributed in the Mostarsko Blato karstic field form a new species (Buj et al. 2014). This species lives only in the Mostarsko Blato karstic field (Buj et al. 2014) (Fig. 4). Phylogenetically, it represents a sister species to *C. illyrica*, and belongs to the so called Adriatic phylogenetic group (Buj et al. 2014).

Life history traits are not sufficiently known so an assessment of conservation status and extinction risk has not yet been conducted (Buj et al. 2015a). Nevertheless, low genetic diversity and effective population size of this species are alarming in conservational sense (Buj et al. 2015a).

Cobitis illyrica Freyhof & Stelbrink, 2007
Common name: Illyric spined loach, local name: ilirski vijun

This is another recently described species, with a fragmentary distribution. *Cobitis illyrica* is an endemic species of Croatia and Bosnia and Herzegovina. It was first recorded from Lake Prološko Blato, in Imotsko polje in neighbouring Croatia (Freyhof & Stelbrink 2007). Šanda et al. (2008b) noted the presence of a possibly undescribed species in Lake Krenica, Bekijsko polje. Buj et al. (2014) confirmed their findings, which is the first record of *C. illyrica* in Bosnia and Herzegovina. This species inhabits Lake Prološko Blato, Baćinska lakes and the River Matica in neighbouring Croatia, as well as Krenica in Bekijsko polje in Bosnia and Herzegovina (Fig. 4). Based on the results of Buj et al. (2015a), three populations of *C. illyrica* are genetically distinct and gene flow among them is very restricted. Out of all *C. illyrica* populations, the one from Lake Krenica contains the highest genetic diversity, but all three should be considered evolutionary significant units for this species (Buj et al. 2015a).

Assesment of the extinction risk for the Bosnia and Herzegovina has not yet been made (Škrijelj et al. 2013), but the global estimation for *C. illyrica* is Critically Endangered (CR), (Freyhof & Kottelat 2008c).

Fig. 4. Distribution of *Cobitis illyrica*, *C. narentana* and *C. herzegoviniensis* in Bosnia and Herzegovina based on literature data. Black rectangle indicate places were *C. illyrica* was recorded, black stars indicate *C. narentana* localities, while black dot shows record of *C. herzegoviniensis*. Danube (or Black Sea) catchment (unshaded), Adriatic Sea catchment (shaded).

Cobitis narentana Karaman 1928
Common name: Neretva spined loach; local name: neretvanski vijun

This is an endemic species distributed within the lower parts of the River Neretva, its tributaries and channels and Lake Modro Oko in Croatia (Schneider et al. 2000a, Zanella et al. 2003, Buj et al. 2014, 2015a), as well as in the River Trebišnjica and Hutovo Blato wetland in Bosnia and Hezegovina (Tutman et al. 2006, 2012a, Buj et al. 2014, 2015a, b). It was first described as a subspecies (*C. taenia narentana* Karaman 1928). Later data include only general notes from the Neretva River drainage system (Vuković 1963, 1977). The systematic status has been changed, since Schneider et al. (2000a) redescribed it as a separate species *C. narentana*. Sofradžija (2009) considered the lower Neretva River from town Čapljina as their distribution area in Bosnia and Herzegovina, while Tutman et al. (2006, 2012a), Šanda et al. (2008a, b), and Buj et al. (2015a, b) extended it to the Hutovo Blato wetland area, Šanda et al. (2008a, b) in the River Bregava and Šanda et al. (2008a, b) and Buj et al. (2015a, b) in

the River Trebišnjica, all in Bosnia and Herzegovina (Fig. 4). It prefers sandy or silty substrates or dense vegetation in slow-flowing water. Phylogenetically, *C. narentana* is a sister species to *C. dalmatina* (distributed in the River Cetina in Croatia), and also belongs to the Adriatic lineage (Perdices et al. 2008, Buj et al. 2014). Its genetic diversity is very high, due to long, unconstrained evolutionary history as well as distribution on several localities (Buj et al. 2015a). Contrary to situation with *C. illyrica*, populations of *C. narentana* are genetically similar (Buj et al. 2015a). This species is susceptible to anorganic pollution, watercourse regulation and sand and gravel extraction, as well as introduction of alien species such as pike-perch and rainbow trout (Tutman et al. 2006, 2012a, b). A proposed dam construction will decrease water flow, increase salinification and the threat of drought (Zanella et al. 2009). Based on the available data (IUCN 2016) it is categorized as a Vulnerable species (VU), which is also its status in the Red List of fauna of the Federation of Bosnia and Herzegovina (Škrijelj et al. 2013).

Misgurnus fossilis (Linnaeus, 1758)
Common name: weather loach; local name: čikov, piškor
This species is distributed throughout the whole of Europe from northern France to western Russia (including the Danube and Volga River basins) except for Scandinavia, the Mediterranean and the British Isles (Kottelat & Freyhof 2007). However, historical data on the distribution of this species in Bosnia and Herzegovina are very scarce (Vuković 1963, 1977, Bogut et al. 2006), so the actual distribution is not certain. According to the available data, *M. fossilis* occurs in the Sava River basin, namely the River Sava with its tributaries, river branches and oxbows in the lowland floodplain regions of northern Bosnia and Herzegovina (Fig. 5), where it prefers calm and stagnant waters (Sofradžija 2009). The factors threatening this species include loss of habitats due to change in hydrological regime, river regulation and pollution of backwaters, which are likely to have the most negative effect on this species in the region (Mrakovčić et al. 2000, 2008). It is categorised as the LC species in the IUCN Red List (Freyhof 2011a) and the Red List of fauna of the Federation of Bosnia and Herzegovina (Škrijelj et al. 2013), respectively.
Bohlen et al. (2007) investigated mitochondrial DNA phylogeography of *M. fossilis* in Europe and found very low mitochondrial divergence with just eight closely related haplotypes. The most southern haplotype, that is closest to the Bosnia and Herzegovina, was located in the Poganovo polje (Croatia, Park of Nature Lonjsko polje). This sample revealed specific population different from all other samples and localities. Authors also considered that southern-eastern part of the range was a refuge area for the species during the glaciation events in the Pleistocene. Another ecologically similar lowland species *Umbra krameri* Walbaum, 1792, was shown to be also genetically different in the Sava River basin (Marić et al. 2017). Phylogeography of this species has been investigated in Danube and Dniester drainages, and it has been found that population from Sava River basin belongs to specific phyletic lineage (haplogroup) and could be considered as potential Evolutionary Significant Units (ESU). Therefore, it is possible that southern part (Bosnia and Herzegovina) of the *M. fossilis* population in Sava River basin could be slightly genetically different from all other populations, and could represent an evolutionary significant unit. This need further investigation.

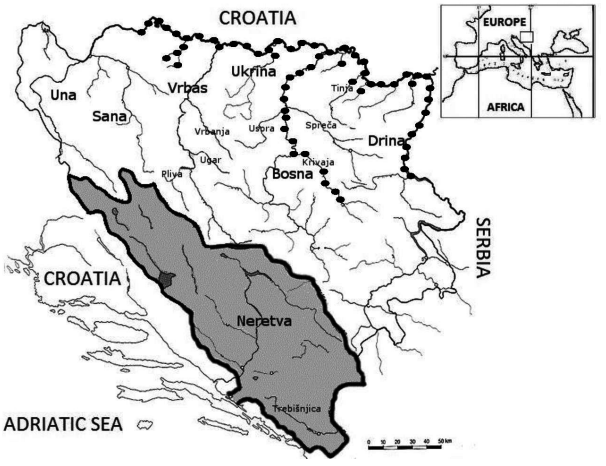

Fig. 5. Distribution of *Misgurnus fossilis* in Bosnia and Herzegovina based on literature data. Danube (or Black Sea) catchment (unshaded), Adriatic Sea catchment (shaded).

Sabanejewia balcanica (Karaman, 1922)
Common name: Balkan golden loach; local name: zlatni vijun
The Balkan golden loach is widely distributed in the Danube basin (Romania, Bulgaria, Croatia, Bosnia and Herzegovina, Serbia, Slovenia, Slovakia, Czech Republic, Ukraine, Russia) and it has been reported from the Aegean Sea catchment in Maritza and from Gallikos to Pinios drainages (Freyhof & Kottelat 2008d). In earlier studies, *S. balcanica* in Bosnia and Herzegovina was considered as a subspecies of *C. aurata*. Karaman (1963) conducted the first assessment of *S. balcanica* in Bosnia and Herzegovina

describing a new subspecies as *C. aurata bosniaca* in the River Vrbas and its tributaries Suturlija and Široka (Sava River catchment). Vuković (1963, 1977) and Sofradžija (2009) identified two subspecies; *C. aurata balcanica* Karaman, 1922 in waters of the Danube catchment and *C. aurata bosniaca* Karaman 1963 only in the River Vrbas and its tributaries Suturlija and Široka (Sava River catchment). Later authors (Mrakovčić et al. 2000, 2006, 2008, Bogut et al. 2006, Sofradžija 2009, Drešković et al. 2011) simply repeated previous reports without new data on the precise distribution.

However, it is now recognized that *S. aurata* is an Asian species and does not occur in European waters (Kottelat 1997). According to Kottelat & Freyhof (2007) single *Sabanejewia* species (*S. balcanica*) is present in Bosnia and Herzegovina waters. For the Croatian section of the River Una it was reported by Dumbović et al. (2009). Muhamedagić et al. (2013) reported *S. balcanica* in the upper parts of the River Krivaja in central Bosnia and Herzegovina. Recently, Golub et al. (2016) presented morphological, morphometric and meristic characteristics of this species from the River Suturlija. According to the available data, its known distribution was established in the middle and upper parts of several rivers and streams in eastern, northern and central Bosnia and Herzegovina, in the tributaries of the Sava River basin where it overlapped with the *C. elongatoides* distributed in lower tributaries (Drina, Bosna and Vrbas) (Fig. 6). It inhabits streams with a moderate current and sandy or gravely substrates. Samples from several rivers in Bosnia and Herzegovina (Una, Vrbas and Bosna) were included in the investigation of mitochondrial DNA phylogeography (Marešová et al. 2011). They turned out to belong to so called Danubian-Balkanian complex, which is genetically heterogenous (Perdices et al. 2003) and taxonomically still not resolved.

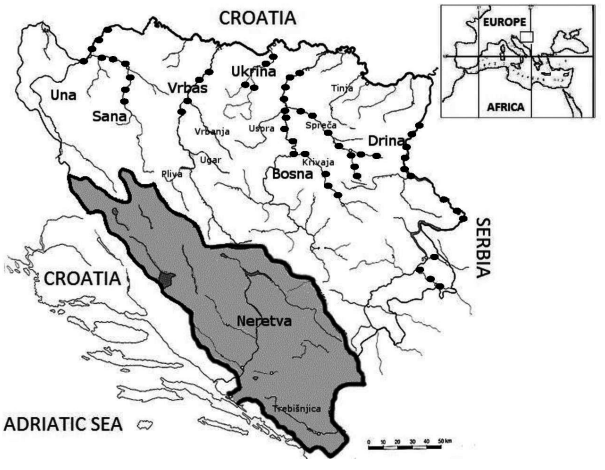

Fig. 6. Distribution of *Sabanejewia balcanica* in Bosnia and Herzegovina based on literature data. Danube (or Black Sea) catchment (unshaded), Adriatic Sea catchment (shaded).

Sabanejewia balcanica is categorized as LC in the IUCN Red List (Freyhof & Kottelat 2008b). Due to the lack of knowledge on its distribution range, frequency and deleterious factors, the species is categorized as Data Deficient (DD) in the Red List of fauna of the Federation of Bosnia and Herzegovina (Škrijelj et al. 2013).

Family Nemacheilidae

Barbatula barbatula (Linnaeus, 1758)

Common name: stone loach; local name: brkica, tivuška

The stone loach has a wide natural distribution in Eurasia, from the Pyrenees in the west to the Ural and Emba basins in the east, but it does not occur on the Italian and Iberian Peninsulas (Kottelat & Freyhof 2007). The species was first mentioned under the name *C. barbatula* by Zaplata & Taler (1932) in the main course of the River Bosna. Furthermore, Vuković (1963, 1977) and Sofradžija (2009) indicated the species as common, but not in greater numbers in the small rivers of the Sava River basin under the *Nemachilus barbatulus* and *Nemacheilus barbatulus*, respectively. Finally, under the name of *B. barbatula* Bogut et al. (2006) mentioned it for the waters of the Danube system without precise locations. There is a very interesting record of *B. barbatula* in the upper Neretva River, Adriatic catchment (Vegara et al. 2009) (Fig. 7). No other scientific publication has previously reported *B. barbatula* in the Neretva River catchment, nor in any other river of the Adriatic drainage system in Bosnia and Herzegovina (Vuković 1977, Sofradžija 2009). This paper describes the first record of *B. barbatula* in the River Neretva and consequently also the first record for the Adriatic drainage system in Bosnia and Herzegovina as a whole. The exact taxonomic status of this population cannot be resolved at the moment, since presence of *Barbatula zetensis* (Šorić, 2000) or *Barbatula sturanyi* (Steindachner, 1892), that inhabit the nearby Ohrid-Drin-Skadar basin cannot be ruled out. It is also not clear whether this population is an introduced one (source unknown) or if it is native, but overlooked in previous investigations. Genetic structure of *B. barbatula* is very complex. It comprises several highly distinct clades and its monophyly was not confirmed in previous investigations (Šedivá et al. 2008). Although samples from Bosnia and Herzegovina were not included in molecular genetic investigation

of this species (Šedivá et al. 2008), it is possible that different lineages, or even species, are present in different basins.

As no major threats are recognised, it is included as LC species in the IUCN Red List (Freyhof 2011b) and the Red List of fauna of the Federation of Bosnia and Herzegovina (Škrijelj et al. 2013), respectively.

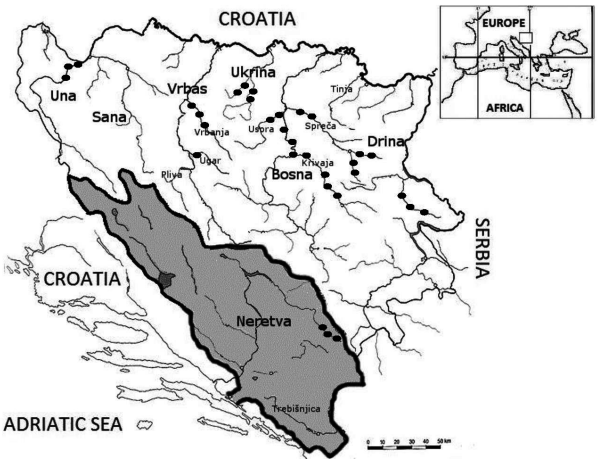

Fig. 7. Distribution of *Barbatula barbatula* in Bosnia and Herzegovina based on literature data. Danube (or Black Sea) catchment (unshaded), Adriatic Sea catchment (shaded).

Vulnerability

Loaches are considered threatened throughout Europe, owing to human induced alteration of freshwater ecosystems (Lelek 1987, Kotusz 1996). Even though taxonomic status and phylogenetic relationships of the Adriatic spined loaches have been investigated (Buj et al. 2014, 2015a), data on their, and other loach species vulnerability in Bosnia and Herzegovina are still lacking. The main threats affecting loach species in Europe are related to water pollution and habitat loss by inappropriate modifications of riverbeds (IUCN 2016). Their protracted residence in silt habitats and vegetation required by juveniles, makes them highly susceptible to habitat modification (IUCN 2016). Although there are no specialised investigations dedicated to this topic available for Bosnia and Herzegovina, it seems that the biggest threats are the regulation of the riverbeds, like in the River Trebišnjica (Buj et al. 2015a), and river remodeling and accumulation, thus reducing the flow of organic particles downstream. Loaches are known to be sensitive to pollution, as well as sediment and gravel extraction (Nedić et al. 2014). In Bosnia and Herzegovina none of them has any economic value and they are not subjected to economic exploitation. However, in some areas they can be used as live bait for salmon fishing.

Discussion

The region of the Balkans is often considered as an ichthyologic "hot spot", with a great number of species and a high portion of endemism for the loach species living in freshwaters in a relatively small area (Buj et al. 2015a). Bosnia and Herzegovina's zoogeographic location and climatic conditions provide a rich fish fauna in which several loach species have been identified in different types of water bodies with a soft substratum. Unfortunately, this rich ichthyofauna has been understudied and is not receiving adequate protection.

Level of investigation of loaches in Bosnia and Herzegovina

According to the available ichthyological literature, a total of nine species of loaches were reported to inhabit the freshwaters of Bosnia and Herzegovina. Although their presence has been reported for a long time (Brusina 1892, Medić 1901, Zaplata & Taler 1932), their species identity and geographical distribution is still poorly known. The incorrect identification, coupled with improvements in taxonomy, has resulted in confusing conclusions in several reports, making them unreliable. Considering data about biosystematic position of these species in the waters of Bosnia and Herzegovina, Golub et al. (2016) suggested that it could be at least partially due to an inconsistent approach to the identification of these species.

The list of eight species of Cobitidae and Nemacheilidae in Bosnia and Herzegovina established in this paper, exceeds the estimation of the most recent check-list of Sofradžija (2009). Such a pronounced difference in a number of listed species reflects shortcomings in the knowledge on the species composition and geographic distribution and confirms the need for more detailed analysis in this field. In the absence of precise scientific research, although rare, data from various ichthyological monitoring surveys present an important source of information. The obvious deficiency of data in published literature is probably associated with several problems: lack of adequately targeted loach-oriented research, as well as sampling techniques; small size and lack of commercial value of loaches, which is the reason that they can easily be overlooked (Mustafić et al. 2003, Šanda et al. 2008a, b), like other fishes with no economic value (Tutman et al. 2012b, 2013). Actually, the only targeted investigation into the morphological, morphometric and meristic characteristics of loach species were those presented by Golub et al. (2016).

Presence and distribution of loaches in Bosnia and Herzegovina

Scarce and sometimes unreliable data in the literature have led to problematic assesments of the presence of different loach species in the freshwaters of Bosnia and Herzegovina. Particulary problematic is the status of *C. taenia*. Despite its listing as a member of the Bosnia and Herzegovina ichthyofauna since Zaplata & Taler (1932) and Vuković (1977), it is now evident that its distribution range extends far beyond this area (Šlechtová et al. 2000, Bohlen et al. 2002) and it should not be considered as a part of the ichthyofauna of Bosnia and Herzegovina. However, it is not clear which species reports of *C. taenia* (Vuković 1963, 1977, Kosorić & Mikavica 1981 and others) should be assigned to.

Assesing distribution ranges from older reports is also problematic, since only general notes are sometimes given instead of the exact localities. Two catchments in Bosnia and Herzegovina accomodate different loach species. The Black Sea catchment is inhabited by five species with wider distribution ranges. The distribution area of *C. elongata* in Bosnia and Herzegovina includes the lower reaches of the rivers Una, Vrbas, Ukrina and Bosna, tributaries of the River Sava (Danube drainage), distribution range of *C. elongatoides* includes middle and lower reaches of tributaries of the River Sava (Una, Sana, Vrbas, Ukrina, Bosna and Drina), and River Sava itself. *Misgurnus fossilis* is distributed in the River Sava, *B. barbatula* in upper reaches of the rivers Sana, Vrbas, Bosna, Drina, while the area of distribution of *S. balcanica* includes the middle reaches of the same rivers in central Bosnia and Herzegovina.

On the other hand, the Adriatic catchment in Bosnia and Herzegovina is inhabited by three loach species, all of which are endemic: *C. narentana* is endemic to the Neretva River basin, *C. illyrica* is distributed fragmentarily in Croatia and Bosnia and Herzegovina and *C. herzegoviniensis* is found only in the Mostarsko Blato karstic field (Buj et al. 2014, 2015a). There is a single report of the occurence of *B. barbatula* in the upper River Neretva (Vegara et al. 2009), which would mean that *B. barbatula* is the only species found in both catchments. However, from the report it is not possible to make definitive conclusions about its status and distribution. Therefore, further detailed phylogenetic and taxonomic research is needed to resolve this issue.

The most common and widespread species of loaches in Bosnia and Herzegovina, as well as throughout central and northern Europe (Bohlen & Ráb 2001) is *C. elongatoides*. It was found on all major drainage systems inside the Danube catchment, in relatively numerous populations. The population data of this species in several rivers of the continental part of Croatia display the same pattern (Delić et al. 2003a, b, 2009). On the other hand, *B. barbatula* is the rarest with regards to its occurrence in both the Danube and Adriatic catchment.

The reported occurence and distribution of loach species in Bosnia and Herzegovina follows the pattern observed throughout Europe, with only rare syntopic occurrences of different species (Bohlen & Ráb 2001). It seems that smaller water systems usually contain only a single species, while in the larger ones sympatric species are often separated in different river sections. For example, in the river systems of the Vrbas and Bosna, *S. balcanica* inhabits the upper part of the basins, *C. elongatoides* is found in the middle, while *C. elongata* in the lower stretches (Sofradžija 2009). The same pattern is observed in the river systems of the Elbe and Odra (Boroń & Kotusz 1999, Ráb et al. 2000, Bohlen et al. 2002). The opposite pattern is observed in the Adriatic catchment, with only a single species of loach found in a particular locality or fish community (Šanda et al. 2008a, b, Buj et al. 2008, 2014, 2015a, b).

Extinction risk and conservation of loaches in Bosnia and Herzegovina

Unfortunately, regional assesment of the extinction risk of loaches in Bosnia and Herzegovina has not yet been conducted. Up to the present day, the Republic of Bosnia and Herzegovina has no Red Book of Freshwater Fishes nor a formal strategy for their conservation. There is only the Red List of fauna of the Federation of Bosnia and Herzegovina as part of the Republic of Bosnia and Herzegovina (Škrijelj et al. 2013). In this list six loach species were included; *C. narentana* as VU, *S. balcanica* as DD, and the *C. elongata*, *C. elongatoides*, *M. fossilis* and *B. barbatula* as LC species. Global assesment following IUCN criteria, however, has been conducted for the majority of loaches. Two endemic loach species present in Bosnia and Herzegovina are considered endangered according to the IUCN categories and significant anthropologic impact is posing a threat to their survival. On the other hand, both of them are endemic, distributed in a single river, river basin or only on several localities in a very small area (Buj et al. 2014, 2015a, b), implying the necessity of immediate effective protection. *C. narentana* is estimated as VU, and *C. illyrica* is considered CR. It is important to mention that the *C. illyrica* population

in Lake Krenica is genetically different from the Croatian populations (Buj et al. 2015a) and should be considered as a distinct conservation unit. For *C. herzegoviniensis* extinction risk estimation has not yet been conducted (IUCN 2016). The remaining species are included as the LC species in the IUCN Red List. Considering the extinction risk estimations of these species and the relatively poor understanding of their taxonomical position in Bosnia and Herzegovina, basic biological features, and balances in place with regard to habitat ecology, there is an imperative to employ ichthyological surveys of these species, as a basis for taking species protection security measures.

The need for detailed ichthyologic research in order to provide precise data about Bosnia and Herzegovina loach fish fauna is still required. A main limitation in active protection of a species is incomplete knowledge about its geographical distribution combined with uncertain taxonomic status. This highlights the importance of establishing conservation measures, considering the high faunistic and scientific value of this family.

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