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Study of bats in the upper Neretva River valley (Bosnia and Herzegovina)

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Abstract. The upper Neretva River valley with river and tributaries, preserved forests, natural caves and buildings represents a very interesting area for bats. During two field expeditions in summer 2022, we collected data on bats using a variety of methods: inspecting the potential roosts, mist netting, and recording bat echolocation calls. We used manual and automatic ultrasound detectors most frequently at sites along and near the Neretva River. The morphological identification of some species was confirmed using DNA analyses. We detected at least 13 bat species in the study area extending from Krupac to Konjic. With one addition, known from the literature, 14 different bat species have been found in the upper Neretva River valley, presenting nearly a half of all bat species recorded in Bosnia and Herzegovina. We confirmed the presence of three species of the highest conservation concern in Europe, listed in the Annex II of the Habitats directive: lesser horseshoe bat (*Rhinolophus hipposideros*), greater horseshoe bat (*Rhinolophus ferrumequinum*), and greater mouse-eared bat (*Myotis myotis*). Our finding of the alcathoe bat (*Myotis alcathoe*) presents new confirmation of this species in Bosnia and Herzegovina. Also, observation of the parti-coloured bat (*Vespertilio murinus*) is one of the few records of the species in this country. The upper Neretva River valley can be considered as an area of high conservation importance for bats. Additional fieldwork, including during other seasons, would likely reveal more bat species and their sites in the area of the upper Neretva River valley.

Key words: Bosnia and Herzegovina, Neretva River, bats, echolocation, mist netting, roosts, *Rhinolophus ferrumequinum*, *Rhinolophus hipposideros, Myotis myotis, Myotis alcathoe*

Izvleček. Raziskava netopirjev v dolini zgornje reke Neretve (Bosna in Hercegovina) – Dolina zgornje reke Neretve je z reko in pritoki, ohranjenimi gozdovi, naravnimi jamami in zgradbami zelo zanimivo območje za netopirje. Na dveh terenskih odpravah poleti 2022 smo popisovali netopirje z različnimi metodami: pregledi potencialnih zatočišč, lovom z mrežami in snemanjem eholokacijskih klicev. Na več mestih ob reki Neretvi in v njeni bližini smo uporabili ročne in avtomatske ultrazvočne detektorje. Morfološko določitev nekaterih vrst smo potrdili z analizami DNK. Skupno smo v naši raziskavi na preučevanem območju od Krupca do Konjica zabeležili vsaj 13 vrst netopirjev. Ob upoštevanju še ene, iz literature znane vrste, je bilo na območju zgornje Neretve skupno zabeleženih 14 različnih vrst netopirjev, kar predstavlja skoraj polovico vseh zabeleženih v Bosni in Hercegovini. Potrdili smo prisotnost treh vrst, ki so v Evropi deležne največje varstvene pozornosti in so navedene v Prilogi II Direktive o habitatih: mali podkovnjak (*Rhinolophus hipposideros*), veliki podkovnjak (*Rhinolophus ferrumequinum*) in navadni netopir (*Myotis myotis*). Najdba nimfnega netopirja (*Myotis alcathoe*) je nova potrditev vrste v Bosni in Hercegovini. Tudi najdba dvobarvnega netopirja (*Vespertilio murinus*) je eno redkih opažanj te vrste v državi. Dolino zgornjega toka reke Neretve lahko štejemo za območje, ki je zelo pomembno za varstvo netopirjev. Dodatno terensko delo, ki bi vključevalo tudi druge letne čase, bi razkrilo še več vrst in njihovih nahajališč na tem območju.

Ključne besede: Bosna in Hercegovina, reka Neretva, netopirji, eholokacija, lov z mrežami, zatočišča, *Rhinolophus ferrumequinum, Rhinolophus hipposideros, Myotis myotis, Myotis alcathoe*

Apstrakt. Studija šišmiša u dolini gornje rijeke Neretve (Bosna i Hercegovina) – Dolina gornje rijeke Neretve sa rijekom i pritokama, očuvanim šumama, prirodnim pećinama i građevinama predstavlja vrlo interesantno područje za šišmiše. U dvije terenske ekspedicije početkom i krajem ljeta 2022. godine prikupljali smo podatke o šišmišima različitim metodama: pregledom potencijalnih skloništa, mreženjem i snimanjem eholokacije šišmiša. Koristili smo ručne i automatske ultrazvučne detektore na više lokacija uz i u blizini rijeke Neretve. Morfološka identifikacija nekih vrsta potvrđena je analizom DNK. Na području istraživanja, koje se proteže od Krupca do Konjica, otkrili smo najmanje 13 vrsta šišmiša. Uz još jednu, poznatu iz literature, u dolini rijeke Neretve pronađeno je ukupno 14 različitih vrsta šišmiša, što predstavlja skoro polovinu svih vrsta zabilježenih u Bosni i Hercegovini. Potvrdili smo prisustvo tri vrste koje su od najveće važnosti za očuvanje u Evropi, navedene u Aneksu II Direktive o staništima: mali potkovasti šišmiš (*Rhinolophus hipposideros*), veliki potkovasti šišmiš (*Rhinolophus ferrumequinum*) i veliki mišouhi šišmiš (*Myotis myotis*). Naš nalaz patuljastog brkatog šišmiša (*Myotis alcathoe*) predstavlja novu potvrdu prisutnosti vrste u Bosni i Hercegovini. Također, posmatranje dvobojnog šišmiša (*Vespertilio murinus*) je jedan od rijetkih zapisa ove vrste u zemlji. Gornja dolina rijeke Neretve može se smatrati područjem od velikog značaja za očuvanje šišmiša. Dodatni terenski rad, uključujući druga godišnja doba, otkrio bi više vrsta šišmiša i njihovih lokacija u tom području.

Ključne riječi: Bosna i Hercegovina, rijeka Neretva, šišmiši, eholokacija, mreže, skloništa, *Rhinolophus ferrumequinum, Rhinolophus hipposideros, Myotis myotis, Myotis alcathoe*

Introduction

In the past two decades, knowledge on bats in Bosnia and Herzegovina (BIH) has increased. Many of the studies refer to inventories of bats at hibernation sites, mostly from caves (e.g. Presetnik et al. 2016; Mulaomerović et al. 2021), but also inventories using other methods, like mist netting and ultrasound detectors (e.g. Babić et al. 2018). To date, 31 bat species were recorded in BIH (Zagmajster et al. 2010; Babić et al. 2018), yet data on the distribution and ecology of some species remain scarce.

While a study of bat fauna was conducted in the lower Neretva River valley (Mulaomerović et al. 2015), the upper Neretva River valley in Eastern Bosnia and Herzegovina was amongst the regions with virtually no records of bats. The region is covered with well preserved pristine forests (that extend around the Neretva River's main stream and its tributaries), caves in karstic hills above the valley, pastures, and a few human settlements and buildings. All these characteristics present a high potential for a rich bat community. Yet, there were only three records for three species of bats from or in close vicinity of the upper Neretva River valley area prior to our study. In a small cave close to the village of Pridvorica u Borču (Borač under Dumoš planina), nine individuals of *Rhinolophus hipposideros* were observed on 29.9.2019 (J. Mulaomerović, pers. comm.). Mirić & Paunović (1997) reported on finding *Nyctalus leisleri* on 15.3.1968 at Boračko jezero NW from Glavatičevo, within 3 km distance from the Neretva River. The same locality and date is given for the record of *Pipistrellus pipistrellus*, which is deposited in the Natural History Museum in Belgrade (Serbia) (Zagmajster et al. 2010).

To fill this knowledge gap, a study of bats was conducted over a few days in June/July and August 2022, the first period being during the »Neretva Science Week 2022«. This event was organised to improve the knowledge on biodiversity of the area, which is threatened by a series of hydropower plants that are planned to be built on the upper Neretva River and its tributaries. Bats were studied by combining different methods: visual checking of the potential roosts in

caves and buildings, recording the echolocation calls, and mist netting. Here, we present the results which revealed a rich bat community despite short time of research.

Materials and methods

Study area

We conducted the study in the upper Neretva River valley, extending from Krupac to Konjic (Fig. 1). The surrounding hills above the river and its tributaries are overgrown by forests, with few villages and individual buildings (many abandoned) present. The bedrock in the valley is formed of Cretaceous flysch at the foothills and Cretaceous carbonate, dolomite, and marl higher up on the slopes. Few caves are known from karstic hills surrounding the river valley.

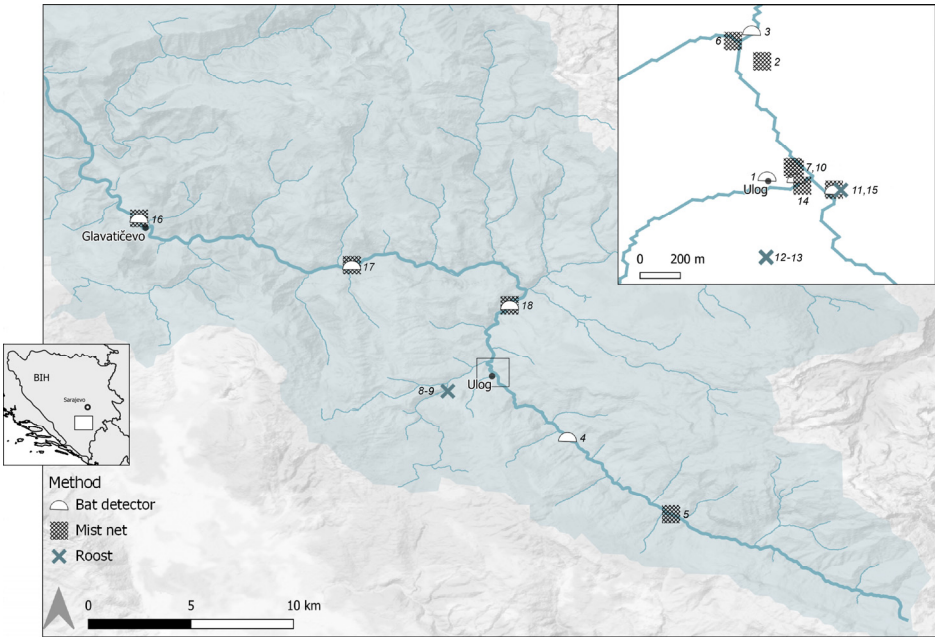

Figure 1. Map of the the upper Neretva River valley, with marked localities where we searched for bats in June/July and August 2022. Different symbols mark different study methods (explained in the legend, with details in the text). Numbers refer to localities, listed in Tab. 2. The embedded map on the left shows the position of the study area within Bosnia and Herzegovina, while the map on the top right presents a close up to Ulog area (marked with black frame on the main map).

Slika 1. Zemljevid doline zgornje Neretve z označenimi kraji, kjer smo netopirje iskali junija/julija in avgusta 2022. Z različnimi simboli so označene različne metode preučevanja (pojasnjene v legendi, podrobnosti pa v besedilu). Številke se nanašajo na lokalitete, ki so navedene v Tab. 2. Vstavljena karta na levi prikazuje položaj območja raziskave znotraj Bosne in Hercegovine, medtem ko karta desno zgoraj prikazuje približano območje okoli Uloga (označeno s črnim okvirjem na večji karti).

Slika 1. Karta doline gornje Neretve, sa označenim lokalitetima na kojima smo tražili šišmiše u junu/julu i augustu 2022. Različiti simboli označavaju različite metode istraživanja (objašnjeno u legendi, s detaljima u tekstu). Brojevi se odnose na lokalitete, navedene u Tab. 2. Ugrađena mapa pokazuje položaj istraživanog područja unutar Bosne i Hercegovine, a mapa u gornjem desnem kutu područje Uloga približano (markirano s crnim okvirom).

Checking the potential roosts

During the day, we checked two caves, »Velika Đeverđela« (the whole cave) and »Mala Đeverđela« (only the entrance part), and a few abandoned buildings in the village Ulog. We also checked one small abandoned concrete building in Ulog during the night (Tab. 2). We looked for bats by using strong headlamps or handheld lights.

Mist netting and handling of individuals

On nine nights we set polyester mist nets (mesh size 1.5 cm, and up to 3 m height) at places where we anticipated the bats' flight paths: at the bank or over the surface of the Neretva River, on the forest edge, and amongst buildings of the village Ulog (Fig. 1; Tab. 2). We set the mist nets at the time of sunset (around 20:30), and took them down at least three hours later (around midnight). Night bat inventories were carried out when there was no rain and air temperatures exceeded 10°C.

We checked the mist nets every few minutes to remove bats immediately after capture and placed them in a cloth bag. We measured the bats (weight, forearm length, other species-specific characters), determined their age class according to the presence of cartilage in the epiphysal part of the metacarpal bones (Dietz & von Helversen 2004) and determined their reproductive status (Dietz & von Helversen 2004; Dietz et al. 2009; Dietz & Kiefer 2016). In some species, we took a small patch of wing membrane tissue with a puncher (1.5 mm diameter) and stored it in 96% ethanol for subsequent molecular analyses (Wilmer & Barratt 1996). Before release, we marked each bat by cutting a tuft of hair (scapular or abdominal region) or by colouring the ear with a marker to recognise it in the case of recapture within the same night.

Molecular analyses

To confirm morphological identification in some cryptic species, we sequenced the the cytochrome C oxidase subunit I (COI) gene. We extracted the DNA from the punched wing tissue, using MagMAX DNA Multi-Sample Kit (Thermo Fisher Scientific), and amplified a standard barcoding marker, COI, using the Folmers primer pair, LCO1490 and HCO2198 (Folmer et al. 1994). After purification we sent the PCR products for sequencing to Macrogen Europe laboratory (Amsterdam, Netherlands). We handled and assembled the sequences in Geneious Prime and compared them to the available sequences of bat species in the public database GenBank, using the Basic Local Alignment Search Tool (BLAST, NCBI) as a computational method. We submitted the COI sequences from this study to GenBank and we provide them in Tab. 3.

Ultrasound detectors and sound analysis

We conducted bat surveys using ultrasound detectors on the nights without rain and with temperatures over 10°C, using two approaches: by recording bat calls manually using a hand ultrasound detector and by installing automatic ultrasound detectors (Tab. 2).

We used hand D240x ultrasound detectors (Pettersson Elektronik AB) at or in the vicinity of the mist netting sites (Tab. 2). While in heterodyne mode, we scanned the frequencies (from 20 to 110 kHz; mostly around 40 kHz) to detect bat calls. Once detected, we recorded them in 10 x time expansion mode and stored them on an external digital recorder Roland RH-09.

We set the automatic ultrasound detector (Song Meter SM4BAT FS, Wildlife Acoustics) at different sites along the Neretva River, and once in the village of Ulog (Tab. 2). The microphone was set at least 1.5 m above the ground, directed towards the river surface and its bank vegetation. The ultrasound detector recorded bats through the whole night, starting half an hour before sunset, and finishing at sunrise. The device recorded the full spectrum of sound for eight seconds with two seconds breaks, with no limits put on the sensitivity triggering the recording. We transferred all recordings to a PC and ran them through the Kaleidoscope software (Kaleidoscope Lite, Wildlife Acoustics) to produce the first separation of files with call sequences from the files with recorded noise. Due to the high number of automatic recordings, we checked only a subset of recordings per night to identify bat taxa.

We analysed the files with call sequences using the sound analysis program Batsound 4.0 (Pettersson Elektronik AB). We identified species or species groups based on characteristics of the echolocation calls, measured from spectrogram and power spectrum (FFT, 2048 samples, Hanning window), and using different references on bat calls (e.g. Russ 1999; Russo & Jones 2002; Barataud 2014; Middleton et al. 2014; Dietz & Kiefer 2016). We checked the shape of the calls, start and end frequency, frequency of maximum energy, and call duration for determinations (Russ 1999; Russo & Jones 2002). In some cases, recognition to species level was not possible due to similar calls between species and variation within species. In these cases, calls were attributed to species groups or genera.

Results and discussion

General overview

During the summer of 2022, we recorded at least 13 different bat species within 17 different bat taxa (Tabs. 1, 2). Groups of two or more species are given for some cases, where they could not be further identified with the methods used – but are nevertheless still informative about the presence of the bats. We confirmed the presence of two species of Rhinolophidae and at least 11 species of Vespertilionidae (Tabs. 1, 2), belonging to one and six genera, respectively.

Our results represent a considerable increase in the knowledge on bats in the area, as previously only single records of three species existed. Of those, we reconfirmed the presence of two (*R. hipposideros*, *P. pipistrellus*), while the third, *N. leisleri* (Mirć & Paunović 1997), could not be confirmed unambiguously based on echolocation calls we checked.

Table 1. Overview of bat taxa (species or species groups) recorded during summer 2022 in the upper Neretva River valley in BIH, together with abbreviations of species names and number of localities where they were observed. The list of localities is in Tab. 2.

Tabela 1. Pregled taksonov netopirjev (vrst ali skupin vrst), zabeleženih poleti 2022 v dolini zgornje Neretve v BIH, skupaj s kraticami imen vrst in številom lokalitet, kjer so bili opaženi. Seznam lokalitet je v Tab. 2.

Tabela 1. Pregled vrsta šišmiša (vrsta ili grupa vrsta) zabilježenih u ljetu 2022. godine u dolini gornje Neretve u BiH, zajedno sa skraćenicama naziva vrsta i brojem lokaliteta, na kojima su uočeni. Spisak lokaliteta nalazi se u Tab. 2.

No.	Family ***Species/species group***	Abb.	No. of localities
	Rhinolophidae		
1	*Rhinolophus hipposideros* (Bechstein, 1800)	*Rhip*	5
2	*Rhinolophus ferrumequinum* (Schreber, 1774)	*Rfer*	2
	Vespertilionidae		
3	*Myotis myotis* (Borkhausen, 1797)	*Mmyo*	1
4	*Myotis nattereri* (Kuhl, 1817)	*Mnat*	1
5	*Myotis mystacinus* (Kuhl, 1817)	*Mmys*	2
6	*Myotis alcathoe* O. von Helversen & K.-G. Heller, 2001	*Malc*	1
7	*Myotis* sp.	*Myosp*	6
8	*Pipistrellus pipistrellus* (Schreber, 1774)	*Ppip*	4
9	*Pipistrellus pygmaeus* (Leach, 1825)	*Ppyg*	2
10	*Pipistrellus nathusii* (Keyserling & Blasius, 1839)	*Pnat*	1
11	*Pipistrellus kuhlii/nathusii*	*Pkuh/nat*	5
12	*Hypsugo savii* (Bonaparte, 1837)	*Hsav*	7
13	*Nyctalus noctula* (Schreber, 1774)	*Nnoc*	1
14	*Nyctalus noctula/lasiopterus*	*Nnoc/las*	2
15	*Vespertilio murinus* Linnaeus, 1758	*Vmur*	1
16	*Vespertilio/Nyctalus/Eptesicus*	*V/M/E*	6
17	*Plecotus* sp.	*Plesp*	1

Most of the findings refer to observations with ultrasound detectors at the Neretva River bank which recorded the bats on their flight paths; either when they were flying by, or were present near the point of observation whilst hunting at the bank's vegetation or above the river surface. In some cases, the bats were observed near the street lights in villages or near the houses, where many species hunt for insects attracted to light. This approach gathered a lot of information on bat presence, but in many cases exact determination to species level was not possible due to ther similarity of the echolocation calls (Barataud 2014; Middleton et al. 2014). We identified at least five different bat species with this approach (Tab. 2).

Five out of nine mist netting evenings/nights were successful in catching at least one individual bat (Tab. 2). Even though this approach is time consuming, and limited to one site per night, it allows for the most exact species identifications, as individuals are held in the hand and directly observed and allow for samples for DNA analyses to be taken. We confirmed the presence of ten different bat species using this method (Tab. 2).

Table 2. List of localities with bat taxa (species or species group) recorded in summer 2022 in upper Neretva River valley in BIH (number of individuals given in brackets in the column Taxa). Geographical coordinates are in decimal degrees (WGS84). Abbreviations: Method: OB – observation, RC – roost check, MN – mist netting, AUD – automatic ultrasound detector, HUD – hand ultrasound detector; Leg/Det. – legator/determinator: AV – Anton Vorauer, BR – Behare Rexhepi, EP – Ester Premate, SA - Stefan Andjus, ŠB – Špela Borko, VM – Vojo Milanović, MZ – Maja Zagmajster. Taxa abbreviations are in the Tab. 1.

Tabela 2. Seznam lokalitet s taksoni netopirjev (vrstami ali skupinami vrst), zabeleženimi poleti 2022 v dolini zgornje Neretve v BIH (število osebkov je podano v oklepaju v stolpcu Taxa). Geografske koordinate so v decimalnih stopinjah (WGS84). Okrajšave: Metoda: OB – opazovanje, RC – preverjanje kotišč, MN – lovljenje z mrežo, AUD – avtomatski ultrazvočni detektor, HUD – ročni ultrazvočni detektor; Leg/Det – legator/določevalec: AV – Anton Vorauer, BR – Behare Rexhepi, EP – Ester Premate, SA – Stefan Andjus, ŠB – Špela Borko, VM – Vojo Milanović, MZ – Maja Zagmajster. Okrajšave taksonov so v Tab. 1.

Tabela 2. Spisak lokaliteta vrtsa šišmiša (vrste ili grupe vrsta) evidentiranih tokom ljeta 2022. godine u dolini gornje Neretve u BiH (broj jedinki je u zagradama u koloni Taxa). Geografske koordinate su u decimalnim stepenima (WGS84). Skraćenice: Metoda: OB – posmatranje, RC – provjera skloništa, MN – mreženje, AUD – automatski ultrazvučni detektor, HUD – ručni ultrazvučni detektor; Leg/Det. – legator/određivač: AV – Anton Vorauer, BR – Behare Rexhepi, EP – Ester Premate, SA - Stefan Andjus, ŠB – Špela Borko, VM – Vojo Milanović, MZ – Maja Zagmajster. Skraćenice taksona nalaze se u Tab. 1.

No	Locality	Coordinates	Date	Method	Leg./ Det.	Taxa	Comments
1	Ulog, near Mosque/Church	43.41590, 18.31067	27.6. 2022	OB	AV/ AV	*Plesp* (1 flying)	Observed in flight
2	Ulog, downstream Camp	43.42299, 18.31037	27.6. 2022	MN	AV/ AV	*Nnoc* (1), *Vmur* (1)	Mist nets set at the river bank
3	At the right bank of the Neretva, downstream from Swimming Beach, Ulog	43.42485, 18.30973	28./29.6. 2022	AUD	MZ/ MZ	*Rfer*, *Myosp*, *Ppip*, *Ppyg*, *Pkuh/nat*, *Hsav*, *Nnoc/las*, *V/N/E*	Microphone set toward the river
4	At the right bank of the Neretva, upstream of the Cerova location	43.37879, 18.35610	29./30.6. 2022	AUD	MZ/ MZ	*Myosp*, *Pkuh/nat*, *Hsav*, *Nnoc/las*, *V/N/E*	Microphone set toward the river
5	Near the bridge over Neretva, 600 m downstream of the Krupac confluence, Southeast from the farm	43.33218, 18.41821	29.6. 2022	MN	MZ, VM, (EP, SB, BR, SA)/ MZ, VM	*Mmyo* (2), *Mnat* (1), *Mmys* (2), *Malc* (4), *Pnat* (1), *Ppyg* (1)	Five mist nets set up, one (15 m) over the river, one near the forest edge (7 m), three over small dry channel (7 m, 6 m, 10 m)
6	Ulog »beach«	43.42420, 18.30857	29.6. 2022	MN	AV/ AV	*Rfer* (1)	
7	Ulog, between two houses, south from the bar-house, near the Cinema	43.41648, 18.31223	30.6. 2022	MN	AV, VM/ AV, VM	*Ppip* (1)	Two mist nets set up
8	Velika Đeverđela cave, Ulog	43.40587, 18.28429	30.6. 2022	BR	MZ/ MZ	*Rhip* (1 humerus)	In the chamber just after the vertical drop

No	Locality	Coordinates	Date	Method	Leg./ Det.	Taxa	Comments
9	Mala Đeverđela cave, Ulog	43.40660, 18.28416	30.6. 2022	RC	MZ/ MZ	*Rhip* (1 flying)	In the entrance chamber, before the vertical drop
10	At the street light in Ulog, near the first road curve South from the Neretva	43.41578, 18.31244	30.6./1.7. 2022	AUD	MZ/ MZ	*Pkuh/nat*, *Hsav*, *V/N/E*	
11	At the right bank of Neretva River, Northeast from the bar house in Ulog	43.41509, 18.31475	1.7. 2022	MN	MZ, VM/-	/	Two mist nets: 6 m at the gravel road; 15 m above the river
				HUD	MZ/ MZ	*Myosp*, *Ppip*, *Hsav*, *Nnoc/las*, *V/N/E*	D240x Pettersoon, at the river bank, recordings
12	Ulog, above the Mosque/Church old house 1	43.41095, 18.31061	1.7.2022	RC	AV/ AV	*Rhip* (6)	Pregnant females – visual observation
13	Ulog, above the Mosque/Church old house 2	43.41091, 18.31061	1.7.2022	RC	AV/ AV	*Rhip* (8)	Pregnant females – visual observation
14	Ulog, meadow east of the Camp	43.41533, 18.31282	1.7.2022	MN	AV/-	/	
15	Abandoned small building, north from Neretva, Southeast from Ulog	43.41507, 18.31518	1.7.2022	RC	MZ/ MZ	*Rhip* (1)	Active, left the room when we checked on it (at about midnight)
16	At the right bank of Neretva River, below the Grand River Adventure Ranch, Glavatičevo	43.51044, 18.09880	2.7.2022	MN	VM/-	/	
				HUD	VM, MZ/ MZ	*Myosp*, *Pkuh/nat*, *Hsav*, *V/N/E*	
17	At the bank of Neretva River at the Brijestov bridge	43.482282, 18.226530	4.8.2022	MN	VM/-	–	Three mist nets: 9 m, 3 m, 6 m above the river
				AUD	VM/ MZ	*Myosp*, *Hsav*, *V/N/E*	
18	At the bank of Neretva River near Nedavic	43.45797, 18.32121	5.8.2022	MN	VM/ VM	*Mmys* (3)	Two mist nets: 9 m and 6 m above the river
				AUD	VM/ MZ	*Hsav*, *Pkuh/nat*, *Myosp*, *V/N/E*	

There were few observations of bats in roosts, in one case this was only based on finding bony remnants which confirmed the species' presence in the cave (Tab. 2). We recorded roosts of only one species, *R. hipposideros*, in a few buildings and caves, as this is the species that can be more easily observed due to hanging in exposed places (Dietz et al. 2009). In the short time for this research, only a few potential roosts could be checked, even though there were many more potentially suitable in the wider Neretva River valley (not only in buildings, but also in caves, rocky walls, and tree trunks).

The species richest site during our survey was at the Neretva River near the Krupac confluence, where six different bat species were caught in mist nets (Tab. 2). Mist nets were set at the edge of the forest next to the Neretva, as well as over a small side river channel next to the main river bed. This confirms that forests around the river support a very diverse bat community, including species that are typical forest species (*M. mystacinus*, *M. alcathoe*) or species hunting near riparian vegetation (*Pipistrellus* spp.). Even though other mist netting events revealed fewer bat species, one to two, they still revealed the presence of rarely encountered species. These were mist nettings at the Neretva River, both in the wider surroundings of Ulog (Tab. 2).

Measurements of bat individuals are within the typical ranges of all the species (Tab. 3). Most of the females had signs of lactation, indicating that they were rearing a juvenile. This further supports their presence in the valley and the importance of the area for reproduction of at least four bat species (Tab. 3). The tissues taken from some bats enabled exact identification to species level (see comments in the next section).

Table 3. Measurements of the bats mist netted in summer 2022 in the upper Neretva River valley in BIH. For species abbreviations see Tab. 1, for localities and dates see Tab. 2. Abbreviations: FA - forearm length, W - weight, Repr.- reproduction state, M - male, F - female, Ad - adult, Sad - subadult, D1 - length of the first finger, D5 - length of the fifth finger, P3.2 - length of the second phalang of the third finger, P3.3 - length of the third phalang of the third finger, CM^3 - length of the upper tooth row from canine to 3rd molar, P - premolar, in upper (superscripted number) or lower (subscripted number) tooth row.

Tabela 3. Meritve netopirjev, ujetih v mreže poleti 2022 v zgornjem toku reke Neretve v BIH. Za kratice vrst glej Tab. 1, za nahajališča in datume glej Tab. 2. 2. Okrajšave: FA - dolžina podlakti, W - teža, Repr.- reprodukcijsko stanje, M - samec, F - samica, Ad - odrasel, Sad - subadult, D1 - dolžina prvega prsta, D5 - dolžina petega prsta, P3.2 - dolžina druge prstnice tretjega prsta, P3.3 - dolžina tretje prstnice tretjega prsta, CM^3 - dolžina zgornje vrste zob od kanina do tretjega molarja, P - premolar, v zgornji (nadnapisana številka) ali spodnji (podnapisana številka) vrsti zob.

Tabela 3. Mjerenja šišmiša koji su uhvaćeni u mreže tokom ljeta 2022. godine u dolini gornje Neretve u BiH. Za skraćenice vrsta vidi Tab. 1, za lokalitete i datume vidi Tab. 2. Skraćenice: FA - dužina podlaktice, W - težina, Repr.- stanje reprodukcije, M - mužijak, Ž - ženka, Ad - odrasla jedinka, Sad - pododrasla jedinka, D1 - dužina prvog prsta, D5 - dužina petog prsta , P3.2 - dužina druge falange trećeg prsta, P3.3 - dužina treće falange trećeg prsta, CM^3 - dužina gornjeg zubnog reda od očnjaka do 3. kutnjaka, P - premolar, u gornjem (nadpisani broj) ili donjem (potpisani broj) zubnom redu.

Loc	Time	Species	Sex	Age	FA [mm]	W [g]	Repr.	Remarks, other measurements
2	/	*Vmur*	M	Ad	42.4	15	Inactive	D5: 48.5 mm, D1: 6,1 mm
2	/	*Nnoc*	M	Ad	54.4	30	Inactive	
5	21:40	*Mmyo*	M	Ad	59.8	29.5	Active	Enlarged testices, CM^3: 10.5 mm, strong smell, black tip on tragus
5	21:41	*Mmyo*	M	Ad	60.9	28.0	Active	Enlarged testices, CM^3: 10.2 mm, strong smell, black tip on tragus
5	21:15	*Mnat*	M	Ad	38.1	7.0	Inactive	Black epididymis; GenBank Acc.No. OR487194

Loc	Time	Species	Sex	Age	FA [mm]	W [g]	Repr.	Remarks, other measurements
5	22:00	*Mmys*	F	Ad	34.4	7.0	Lactating	D1: 6.0 mm, Tibia: 17.8 mm, dark ear, face brownish-pale
5	22:26	*Mmys*	F	Sad	34.8	6.1	Nuliparous	D1: 6.0 mm, Tibia: 17.6 mm, Foot: 5.6 mm, dark ear, greyish, young
5	21:15	*Malc*	M	Ad	33.1	4.5	Active	Enlarged testices, D1: 5.3 mm, Tibia: 15.6 mm, Foot: 4.4 mm, Upper teeth row: no cing obvious (Dietz et al. 2009). Species first identified as Mmys, but allocated to *Malc* according to DNA; GenBank Acc.No. OR487193
5	21:43	*Malc*	F	Ad	32.8	5.5	Lactating	D1: 4.3 mm, Tibia: 14.5 mm, Foot: 4.3 mm, bright face; GenBank Acc. No. OR487195
5	22:00	*Malc*	F	Ad	32.3	5.0	Lactating	D1: 4.1 mm, Tibia: 14.9 mm, Foot: 4.4 mm, light face, bright ears; GenBank Acc.No. OR487196
5	22:00	*Malc*	M	Ad	31.6	4.0	Inactive	D1: 4.9 mm, Tibia: 14.5 mm, Foot: 5.3 mm, light face, black epididymis; GenBank Acc.No. OR487197
5	22:30	*Pnat*	M	Ad	34.3	8.5	Active	Enlarged testices, epidydimis slightly black, D5: 43.8 mm, upper teeth like *Pnat* (Dietz & von Helversen 2004); Ring: BIHA0140
5	21:15	*Ppyg*	F	Ad	30.5	5.0	Lactating	D5: 37.5 mm, P3.2: 7.7 mm, P3.3: 6.7 mm, internal edge of the ear: 7.6 mm, orange glands (buccal and around vagina)
6	/	*Rfer*	M	Ad	54.7	24	Inactive	
7	23:00	*Ppip*	F	Ad	30.0	6.0	Lactating	Wing membrane as in Dietz et al. (2004) for *Ppip*, echolocation upon release – around 45 kHz
18	21:10	*Mmys*	F	Sad	36.0	6.0	Nuliparous	No protocone, $P^3 < 2/3\ P^2$; $P_3 < P_2$; dark ears, face; greyish fur, cartilage in joints; Ring: BIHA0114; GenBank Acc.No. OR487200
18	/	*Mmys*	F	Ad	34.9	5.0	Lactated	No protocone, $P^3 \sim 2/3\ P^2$; $P_3 < P_2$; dark ears, face; brownish fur; Ring: BIHA0115; GenBank Acc.No. OR487201
18	21:20	*Mmys*	M	Sad	35.9	5.5		No protocone, $P^3 < 2/3\ P^2$; $P_3 < P_2$; dark ears, face; greyish fur, cartilage in joints; Ring: BIHA0116; DNA did not amplify

Comments to bat species

Rhinolophidae, *Rhinolophus* spp.

We recorded two species of the genus during our study, the smallest (*R. hipposideros*) and the largest (*R. ferrumequinum*) of this family in Europe (Dietz et al. 2009). Both are known to use caves and parts of buildings as shelters. In our study we only found roosts of *R. hipposideros* by recording individuals or small groups of individuals in some abandoned buildings and a cave (Tab. 2). The groups of individuals in some of the buildings in Ulog (Tab. 2) indicate that these were females forming nursery colonies. Individuals had fat bellies and looked to be close to gestation period (Fig. 2).

We caught only one male of *R. ferrumequinum* in the mist net set near the Neretva River near Ulog (Tab. 2), but did not find any roosts of the species. Its presence in the region was further supported with the species echolocation calls detected at one site near the Neretva River near Krupac (Tab. 2). The species is known to feed in riparian habitats (Dietz et al. 2019), and considering the preserved habitats it could be expected to be more common in the Neretva River valley. There was an old record of the species from the town of Nevesinje (Felten et al. 1977), but our observations confirm its current presence in the upper Neretva River valley.

Figure 2. A group of Lesser horseshoe bats (*Rhinolophus hipposideros*) observed in an abandoned building in Ulog. Due to fat bellies of the individuals, and typical behaviour in forming summer groups, this is very likely a group of females forming a nursery colony (Photo: A. Vorauer).

Slika 2. Skupina malih podkovnjakov (*Rhinolophus hipposideros*) opazovana v zapuščeni stavbi v Ulogu. Zaradi debelih trebuhov osebkov in značilnega vedenja pri oblikovanju poletnih skupin je zelo verjetno, da gre za skupino samic v porodniški koloniji (Foto: A. Vorauer).

Slika 2. Grupa malih potkovastih šišmiša (*Rhinolophus hipposideros*) uočena u napuštenoj zgradi u Ulogu. Zbog debelih trbuha jedinki i tipičnog ponašanja pri formiranju ljetnih grupa, vrlo je vjerovatno da je riječ o grupi ženki koja formira prodničnu koloniju (Foto: A. Vorauer).

Vespertilionidae, *Myotis* spp.

The biggest species of this genus, *Myotis myotis*, uses caves and abandoned buildings as roosts, and feeds mostly in the forest openings or along forest roads (Dietz et al. 2019). We caught one male (Fig. 3) at the Neretva River near Krupac, flying out of the forest at the river bank.

Figure 3. The greater mouse-eared bat (*Myotis myotis*) caught in the mist net close to the Krupac confluence with Neretva (photo: Ester Premate).
Slika 3. Navadni netopir (*Myotis myotis*), ujet v mrežo v bližini sotočja Krupca z Neretvo (foto: Ester Premate).
Slika 3. Veliki mišouhi šišmiš (*Myotis myotis*) uhvaćen u mrežu u blizini ušća Krupca u Neretvu (foto: Ester Premate).

Myotis nattereri is a medium sized species of the genus, being a typical forest species, dwelling in crevices in tree trunks, and feeding among the forest vegetation (Dietz et al. 2019). We caught one male at the Neretva River near Krupac, flying out of the forest at the river bank (Tab. 2). Due to a suitable habitat for roosting and feeding, it can be predicted that this species is resident here and common in the upper Neretva River area.

There were two sites at which individuals of the smallest species of the genus were mist netted, belonging to the *Myotis mystacinus* species complex (*M. mystacinus, brandtii, alcathoe, davidii*, Dietz & Kiefer 2016). It is a group of morphologically similar species, where discrimination is not always unambiguous. All species of the complex are forest species, roosting in tree hollows, and feeding in the forest (Dietz et al. 2019). *M. alcathoe*'s description has been supported by using molecular differences (von Helversen et al. 2001; Dietz et al. 2009). In order to reliably identify species, we used DNA barcoding to help identify the species of this complex.

One of the animals first morphologically identified as *M. mystacinus* in the field was genetically identified as *M. alcathoe*, proving the difficulty in morphological discriminations of the species (Tab. 3). Also on the European level, distribution of this species is full of knowledge gaps, mainly due to under-sampling of the habitats of this bat species and misidentifications during fieldwork (Jan et al. 2010; Bashta et al. 2011). For example, the presence of *M. alcathoe* in Portugal was also confirmed using DNA barcoding, after an individual, morphologically determined as *M. mystacinus*, was analysed molecularly (Rebelo et al. 2020).

Myotis alcathoe was confirmed only at Neretva near Krupac site, flying in the net set at the forest edge near Neretva. The first record of the species in the country comes from Sarajevo area, and was based on morphological characters only (Babić et al. 2018). Later, the species was confirmed for eastern Bosnia and Herzegovina also with molecular analyses (Verhees et al. 2021). As *Myotis alcathoe* is a species bound to riparian and forest habitats, more findings of the species in the upper Neretva River could be expected. Proper management of the forest is crucial for preservation of the species (von Helversen et al. 2001; Coronado et al. 2017).

The other bat species of the complex are here referred to as *Myotis mystacinus* (Tabs. 1,2). However, in a recent study, it has been suggested that *Myotis davidii* populations may have historically replaced the *M. mystacinus* s.str. in the Balkans, where even hybridising zones between the species may exist (Çoraman et al. 2020). Discrimination between two species is difficult both morphologically or based on mitochondrial DNA (Benda et al. 2016; Dietz & Kiefer 2016; Çoraman et al. 2020). We report *M. mystacinus* s.l. here, but its exact species status, not only in the upper Neretva River valley but probably in the whole Bosnia and Herzegovina, remains to be resolved.

The species of the genus *Myotis* sp. have characteristic frequency modulated shape echolocation calls, which are very similar to one another and species can only rarely be identified to species/species group level. The calls recorded near the Neretva River surface most likely belong to the species group *M. daubentonii/capaccinii;* species that typically hunt over water surfaces (Dietz et al. 2009). Due to this, their calls show typical interruptions due to the reflection from the water surface (Russ 1999) (Tab. 2). Further analyses of bat calls, as well as additional field work, including mist netting, may reveal further bat species of this genus in the area.

Vespertilionidae, *Pipistrellus* spp. & *Hypsugo savii*

Pipistrellus pipistrellus and *P. pygmaeus* are morphologically very similar, and were only recognised as separate species three decades ago (Jones & van Parijs 1993; Barlow & Jones 1997). The two species can be distinguished based on echolocation calls (Russo & Jones 2000; Barataud 2014). In our study, we detected *P. pygmaeus* more often, whilst both species were caught in the mist nets. *Pipistrellus pygmaues* is a species that is more bound to riparian habitats, and indeed it was recorded at sites near the Neretva River (Tab. 1, 2).

It was less than ten years ago that the species *P. nathusii* was confirmed to occur in BIH (Karapandža et al. 2014), with a few records in subsequent years (Husanović & Presetnik 2021). Our finding of the species at the Krupac site near the Neretva River is therefore one of the rare findings in the country. Part of the reason that the species distribution is poorly known could be the fact that its echolocation calls overlap with the echolocation calls of the species *P. kuhlii,* to

such an extent that discrimination is not possible (Kalko 1995; Russo & Jones 1999; Barataud 2014; Dietz & Kiefer 2016). As the two species cannot be reliably discriminated based on echolocation calls, such observations are allocated to a species group *P. kuhlii/nathusii*, which was recorded in almost all sites where ultrasound detector observations were made (Tabs. 1, 2). Social calls of the species are species-specific, and they were used to confirm the presence of *P. nathusii* during autumn in Mostar (Husanović & Presetnik 2021).

Hypsugo savii was confirmed at all sites where bats were recorded with ultrasound detectors, showing the species is generally widespread in the region. The species typically roosts in rocky walls, but also in building walls, which are both present in the Neretva River valley.

Vespertilionidae, other bat taxa recorded

Species of the group *Vespertilio murinus*, *Nyctalus* spp., *Eptesicus* spp. (»V/N/E« in Tabs. 1, 2) use echolocation with a lot of overlap, therefore we conservatively used this call determination category for such cases. Even though this category includes the genus *Eptesicus*, we cannot confirm its presence based on our results, whilst we did detect species of the other two genera in our study (Tabs. 1, 2).

In some cases we were able to identify species of the group *Nyctalus noctula/Nyctalus lasiopterus*, due to two characteristic types of echolocation calls, and low call frequency (Russo & Jones 2002; Barataud 2014). We decided to remain conservative in separating the two species, due to large frequency overlap, and kept the group category. However, some studies have shown that discrimination between the two species is possible in some cases (Estók & Siemers 2009). Considering that we mist netted the male of *N. noctula*, it is most probable that most of the echolocation calls belong to this species.

Based on the amount of recording analyses for this study, we could not yet unambiguously confirm the presence of *N. leisleri*. The species is expected in the area as it is bound to large forested areas. The only reliable confirmation of species presence so far is the report from near Boračko jezero, close to Glavatičevo (Mirić & Paunović 1997).

Reliable discrimination of *V. murinus* is possible only based on male display song calls (Zagmajster 2003), but they were not recorded during our study, as they are typically emitted during the mating season in autumn. The confirmation of the species presence in the Neretva river valley was therefore possible due to a successful mist netting event close to the Ulog region. The species typically feeds in riparian zones, finding many suitable habitats within the Neretva River valley (Dietz et al. 2009).

The observation of the *Plecotus* bat is so far based on the visual observation of the flying individual made by AV. It is highly likely that the species of this genus are present in the area, yet the only data existing to date are from about 14 km from Ulog, close to the region of Zalomka – where echolocation calls of *Plecotus auritus* were recorded (Mulaomerović 2022).

Conservation notes

We detected at least 13 bat species in the study area extending from Krupac to Konjic. With one additional species, known from the literature, 14 different bat species have been found in the upper Neretva river valley, presenting nearly a half of all bat species recorded in Bosnia and Herzegovina. The rich bat community in the Neretva River valley, despite the short time of research, proved that this area is potentially very rich in bat species and of high importance for conservation. All bat species are protected under the Bern convention, which is the basis for the designation of Emerald protection sites - since 2023, the upper Neretva River valley has been amongst such proposed sites (EEA 2023). Bats as migratory species are protected under the Bonn Convention (OJ L 1982), and a special agreement of this convention dedicated specifically to bat protection (Eurobats 1991), which was also officially signed by Bosnia and Herzegovina in 2021.

In European Union (EU) member states, one of the most powerful international documents for the protection of bats is the EU Habitats Directive (OJ EC 1992). As accession to the EU is also a path being taken by Bosnia and Herzegovina, under this directive, one of the obligations shall be the list of proposed Sites of Community Importance. In this EU document, all bats are protected (Annex IV), but there are some species of even higher conservation concern, which need designation of areas for protection (Annex II). In our study, we recorded three bat species with the highest conservation concern in the Neretva River valley: *R. ferrumequinum*, *R. hipposideros* and *M. myotis*. According to the EU Habitats Directive, these species need the designation of special areas for their conservation. The upper Neretva River valley could be such an area for bats and should be included in such an European conservation network.

Planned constructions in the Neretva River valley, including a set of hydropower plants and their corresponding reservoirs, accompanied by forest cuts due to the building processes, threaten to significantly change the pristine nature of the area. This will consequently change the habitats for bats, which have been shown to suffer from hydropower constructions and related changes of natural habitats (Zortéa et al. 2021). Considering the rich bat community in the area, hydropower plants on the Neretva River present a significant threat to bats in the area. It is also highly important to conduct further studies of bats in the area, including other seasons, to get a more complete overview of the bat diversity in the area.

Povzetek

V BIH je bilo doslej zabeleženih 31 vrst netopirjev (Zagmajster et al. 2010; Babić et al. 2018), vendar je podatkov o razširjenosti in ekologiji nekaterih vrst malo. Za tri vrste netopirjev so bili z območja zgornje doline reke Neretve ali iz njene neposredne bližine zabeleženi le trije zapisi: *Rhinolophus hipposideros* je bil opažen 29.9.2019 (J. Mulaomerović, pers. comm.). Mirić & Paunović (1997) poročata o najdbi *Nyctalus leisleri* 15.3.1968 pri Boračko jezero SZ od Glavatičeva, v oddaljenosti 3 km od reke Neretve. Isto nahajališče in datum sta navedena tudi pri zapisu o *Pipistrellus pipistrellus*, ki je shranjen v Prirodoslovnem muzeju v Beogradu (Srbija) (Zagmajster et al. 2010). Da bi zapolnili to vrzel v znanju, smo v juniju/juliju in avgustu 2022 opravili raziskavo netopirjev, pri čemer je bilo prvo obdobje v času »Neretvanskega tedna znanosti 2022«.

Raziskavo smo opravili v zgornjem delu doline reke Neretve, ki se razteza od Krupca do Konjica (Sl. 1). Čez dan smo pregledali dve jami, »Velika Đeverđela« (celotno jamo) in »Mala Đeverđela« (samo vhodni del), ter nekaj zapuščenih stavb v vasi Ulog. Devet noči smo postavili poliestrske mreže za meglo na mestih, kjer smo predvidevali preletne poti netopirjev (Sl. 1; Tab. 2). Za potrditev terenskih določitev pri nekaterih kriptičnih vrstah smo iz tkiva, odvzetega nekaterim netopirjem, sekvencirali gen COI. Preiskave netopirjev z ultrazvočnimi detektorji smo izvajali v nočeh brez dežja in ob temperaturah nad 10 °C, in sicer z ročnimi in avtomatskimi ultrazvočnimi detektorji (Tab. 2).

Med 17 različnimi taksoni netopirjev smo zabeležili vsaj 13 različnih vrst netopirjev (Tab. 1, 2). Skupine dveh ali več vrst so navedene v nekaterih primerih, ko jih z uporabljeno metodo ni bilo mogoče natančneje določiti - vendar so še vedno informativne glede prisotnosti netopirjev. Potrdili smo prisotnost dveh vrst iz družine Rhinolophidae (*Rhinolophus hipposideros*, *Rhinolophus ferrumequinum*) in vsaj 11 vrst iz družine Vespertilionidae znotraj 15 različnih taksonov (*Myotis myotis*, *Myotis nattereri*, *Myotis mystacinus* s.l., *Myotis alcathoe*, *Myotis sp.*, *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Pipistrellus nathusii*, *Pipistrellus kuhlii/nathusii*, *Hypsugo savii*, *Nyctalus noctule*, *Nyctalus noctula/lasiopterus*, *Vespertilio murinus*, *Vespertilio/Nyctalus/Eptesicus* spp., *Plecotus* sp.) Zabeležili smo tudi nekaj redko opaženih vrst v BIH (*Myotis alcathoe*, *Vespertilio murinus*).

Večina ugotovitev se nanaša na opazovanja z ultrazvočnimi detektorji. V petih od devet noči, ko smo lovili z mrežami, smo uspešno ujeli vsaj enega netopirja (Tab. 2). S to metodo smo potrdili prisotnost desetih različnih vrst netopirjev (Tab. 2). Le pri eni vrsti, *R. hipposideros*, smo zabeležili zatočišča v nekaj stavbah in jamah, od katerih so nekatere najverjetneje kotišča. Vrstno najbogatejša lokacija je bila na reki Neretvi pri sotočju s Krupcem, kjer smo v mreže ujeli šest različnih vrst netopirjev.

Bogata združba netopirjev, ki smo jo odkrili v dolini reke Neretve kljub kratkemu času raziskave, je pokazala, da je to območje potencialno zelo bogato z netopirji in zelo pomembno za njihovo ohranjanje. Vse vrste netopirjev so zavarovane. V skladu z EU Habitatno direktivo (OJ ES 1992) je treba za nekatere vrste netopirjev predlagati potencialno območje, pomembno za Skupnost (Priloga II). V naši raziskavi smo v dolini reke Neretve zabeležili tri take vrste netopirjev, ki so najpomembnejše za varstvo: *R. ferrumequinum, R. hipposideros* in *M. myotis*.

Načrtovane gradnje v dolini reke Neretve, vključno z nizom hidroelektrarn in pripadajočih zadrževalnikov, ki jih spremlja krčenje gozdov, predstavljajo nevarnost, da se bistveno spremeni neokrnjena narava območja. To bo posledično spremenilo habitate za netopirje, na katere ima gradnja hidroelektrarn dokazano negativen vpliv (Zortéa et al. 2021). Glede na bogato vrstno pestrost lahko dolino zgornjega toka reke Neretve štejemo za območje velikega varstvenega pomena za netopirje.

Sažetak

U BiH je do sada zabilježena 31 vrsta šišmiša (Zagmajster et al. 2010; Babić et al. 2018), ali podataka o rasprostranjenosti i ekologiji nekih vrsta je malo. Za tri vrste šišmiša iz ili u neposrednoj blizini gornje doline rijeke Neretve zabilježena su samo tri zapisa: *Rhinolophus hipposideros* uočeni su 29.9.2019 (J. Mulaomerović, pers. comm.). Mirić & Paunović (1997) izvještavaju o pronalasku *Nyctalus leisleri* 15.3.1968 na Boračkom jezeru SZ od Glavatičeva, na udaljenosti od 3 km od rijeke Neretve. Isti lokalitet i datum dat je i za zapis *Pipistrellus pipistrellus,* koji se nalazi u Prirodnjačkom muzeju u Beogradu (Srbija) (Zagmajster et al. 2010). Kako bi se popunila ova praznina u znanju, nekoliko dana u junu/julu i augustu 2022. godine provedeno je istraživanje šišmiša, a prvi period je bio tokom »Neretvanske sedmice nauke 2022.«.

Istraživanje smo proveli u dolini gornje Neretve, koja se proteže od Krupca do Konjica (Sl. 1). Tokom dana smo proverili dve pećine, »Velika Đeverđela« (cela pećina) i »Mala Đeverđela« (samo ulazni deo), i nekoliko napuštenih objekata u selu Ulog. Devet noći smo postavljali poliesterske mreže na mjestima gdje smo predviđali puteve leta šišmiševa (Sl. 1; Tab. 2). Da bismo potvrdili terenska određivanja kod nekih kriptičnih vrsta, sekvencirali smo COI gen iz tkiva uzetog od nekih vrsta. Istraživanja vršili smo ručnim ili automatskim detektorima u noćima bez kiše i pri temperaturama preko 10°C (Tab. 2).

Zabilježili smo najmanje 13 različitih vrsta šišmiša unutar 17 različitih taksona šišmiša (Tab. 1, 2). Za neke slučajeve date su grupe od dvije ili više vrsta, gdje se nisu mogle dalje identificirati s korištenom metodom - ali su i dalje informativne o prisutnosti šišmiša. Potvrđeno je prisustvo dvije vrste Rhinolophidae (*Rhinolophus hipposideros, Rhinolophus ferrumequinum*) i najmanje 11 vrsta iz porodice Vespertilionidae u okviru 15 različitih taksona (*Myotis myotis*, *Myotis nattereri*, *Myotis mystacinus*, *Myotis alcathoe*, *Myotis* sp., *Pipistrellus pipistrellus*, *Pipistrellus pygmaeus, Pipistrellus nathusii, Pipistrellus kuhlii/nathusii, Hypsugo savii*, *Nyctalus noctula*, *Nyctalus noctula/lasiopterus*, *Vespertilio murinus*, *Vespertilio/Nyctalus/Eptesicus*. Zabilježili smo i neke rijetko opažene vrste u BiH (*Myotis alcathoe, Vespertilio murinus).*

Većina nalaza odnosi se na opažanja ultrazvučnim detektorima. Pet od devet pokušaja lova s mrežom bilo je uspješno u hvatanju najmanje jedne jedinke šišmiša (Tab. 2). Ovom metodom smo potvrdili prisustvo deset različitih vrsta (Tab. 2). Zabilježili smo skloništa samo jedne vrste, *R. hipposideros*, u nekoliko zgrada i pećina, od kojih su neke najvjerovatnije porodiljske kolonije. Vrstama najbogatije nalazište tokom našeg istraživanja zabilježeno je na rijeci Neretvi kod ušća Krupca, gdje je u mrežama uhvaćeno šest različitih vrsta šišmiša.

Bogata zajednica šišmiša otkrivena u dolini rijeke Neretve i pored kratkog vremena istraživanja, dokazala je, da je ovo područje potencijalno vrlo bogato vrstama šišmiša i od velikog značaja za njihovo očuvanje. Sve vrste šišmiša su zaštićene različitim konvencijama. Prema Direktivi EU o staništima (OJ EC 1992), neke vrste šišmiša trebaju odrediti područja za zaštitu (Aneks II). U našem istraživanju zabilježili smo tri vrste šišmiša od najvećeg značaja za očuvanje u dolini rijeke Neretve: *R. ferrumequinum, R. hipposideros* i *M. myotis*.

Planirana gradnja u dolini rijeke Neretve, uključujući niz hidroelektrana, njihovih odgovarajućih akumulacija, praćena sječom šuma, predstavlja prijetnju netaknuti prirodi područja. To će posljedično promijeniti staništa šišmiša, za koje se pokazao negativni utjecaj hidroenergetskih konstrukcija i sličnih promjena prirodnih staništa (Zortéa et al. 2021). S obzirom na bogatstvo vrsta, dolina gornje Neretve može se smatrati područjem od velikog značaja za očuvanje šišmiša.

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