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Pregled statusa zaštite, rasprostranjenosti i ekologije vrste *Plecotus kolombatovici* Đulić, 1980 s dodatnim novim informacijama o njenoj eholokaciji, skloništima i hranjenju s otoka Lokruma, Hrvatska

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Abstract

Plecotus kolombatovici Đulić, 1980 was given full species status in 2008. However, it was still being combined with a sister species *P. gaisleri* until 2020, which caused confusion in determining its true distribution and status. Studies of the roosting and foraging of this species are very limited, and little has been reported on its

echolocation calls. In this paper, we review the history of the identification of this species, its current distributional data, and former studies of its roosting and foraging ecology. In addition, we present new data on roosting, foraging and echolocation of this species from the Croatian island of Lokrum, and discuss the status and conservation needs of *P. kolombatovici* more widely.

Key words: Chiroptera, *Plecotus kolombatovici*, ecology, echolocation, Lokrum island

Sažetak

Vrsta *Plecotus kolombatovici* Đulić, 1980 dobila je puni status 2008. godine. Međutim, sve do 2020. još uvijek se povezivala sa sestrinskom vrstom *P. gaisleri*, što je uzrokovalo pometnju u raspoznavanju njene prave distribucije i statusa. Istraživanja o skloništima i traženju hrane ove vrste vrlo su ograničena, a malo je i podataka o njezinom ultrazvučnom glasanju. U ovom radu dajemo pregled povijesti identifikacije ove vrste, njezinih trenutnih podataka o rasprostranjenosti i prijašnjih istraživanja o njenoj ekologiji skloništa i traženja hrane. Također, predstavljamo nove podatke o skloništima, traženju hrane i eholokaciji ove vrste s hrvatskog otoka Lokruma te raspravljamo o statusu i potrebama očuvanja vrste *P. kolombatovici*.

Ključne riječi: Chiroptera, *Plecotus kolombatovici*, ekologija, eholokacija, otok Lokrum

Introduction

The taxonomy and systematics of the genus *Plecotus* have seen major changes over the past 40 years, with new genetic techniques alongside traditional morphological studies identifying new species and redrawing the long-eared bat map of Europe. Amongst these 'new' species is *Plecotus kolombatovici*, the smallest of the European *Plecotus* species with a very restricted distribution along the coastal areas and islands of the eastern Mediterranean.

The systematics of *P. kolombatovici* reflects a 40-year history of changing status and assignment. During bat surveys in the late 1970s, Beatrica Đulić and Nikola Tvrtković from the University of Zagreb, recorded particularly small specimens of *Plecotus* bats on the Croatian islands. Đulić (1980) proposed that these were a sub-species of *P. austriacus* and named them after a 19th century Croatian zoologist, Juraj Kolombatović; the type locality was the island of Korčula.

This initial assignment as a sub-species for *P. austriacus* was based on morphological analysis, but the development of new genetic tools in the 1990s and 2000s opened new avenues for species' assessment. It led to it initially being reassigned as a sub-species of the Canary long-eared bat *P. teneriffae,* along with a second, closely related *Plecotus* species from Libya and Morocco, Gaisler's bat, *P. t. gaisleri* (Benda et al. 2004). Further genetic reviews followed, eventually reverting to the earlier proposal by Kiefer et al. (2002) that *P. kolombatovici* should be raised to a full species. This was accepted in 2008 (Hutson et al. 2008) with the species firmly within the '*austriacus*' clade.

The situation, however, wasn't completely resolved. The sister sub-species *P. t. gaisleri* was subsumed into *P. kolombatovici* (Juste et al. 2004, Spitzenberger et al. 2006), leading to a single species with a distribution split between two discrete and geographically distant populations in the eastern Mediterranean and north-west Africa. This situation made assessing its true conservation status difficult and resulted in a Red Listing assessment of 'Least Concern' based mainly on its wide distribution and because it was showing "no sign of declining at a fast rate in North Africa" (Hutson et al. 2008), where we now know it does not occur. This was finally settled in 2020 following the acceptance of the assessment of Mayer et al. (2007) when Gaisler's bat itself was recognised as a full species (Razgour 2020).

Still relatively little is known of the ecology of *P. kolombatovici* (Razgour 2023) and much of the distributional data comes from non-systematic surveys and the grey literature. The need to address these evidence gaps for this species has been recognised by the Agreement on the Conservation of Populations of European Bats (UNEP/EUROBATS, Meeting of Parties Resolution 9.3 available at www.eurobats.org). In this paper we seek to review the current knowledge of *P. kolombatovici* regarding 1) its distribution and 2) its roosting ecology, and then 3) to present new data on its ecology from our studies of this species on one Croatian island, Lokrum.

1 | A review of the distribution of *P. kolombatovici*

1.1 | Materials and methods

Distribution records for the species were gathered using literature searches carried out in Google Scholar, databases of scientific literature held at the University of Sussex, and general internet searches of grey literature. The key search words and

phrases were – Country, *Plecotus kolombatovici*, Kolombatovici's long-eared bat and Mediterranean long-eared bat for all countries within the known range of the species according to the IUCN global distribution map (Benda & Piraccini 2023). In addition, direct approaches were made to key individuals working on bats in the countries covered by the species range. Lists of latitude and longitude were compiled for all records from the coordinates cited within papers, country databases or derived from the descriptions of geographical locations (accuracy to 10 km²) in papers or grey literature.

1.2 | **Results**

The data search resulted in 24 published papers with references to the species and geographical locations and 6 grey literature sources (websites describing capture of the species); databases were used from two countries and we found 114 locations where *P. kolombatovici* were recorded, excluding duplicates where repeated surveys had been undertaken at the same location. Overall, the distribution of *P. kolombatovici* stretches from Croatia south-east to Türkiye (Figure 1).

Data on the species on the Croatian mainland are sparse, with records from Rovinj and Boljun in Istria. In Zadar County the species has been recorded at Paklenica National Park, the coastal area between Rtina and Ljubač, and at Vransko Lake Nature Park. It has been netted in Čikola Canyon in Krka National Park. In Biokovo Nature Park, it has been recorded roosting in buildings at Bast, in the village of Gornja Podgora, and north of Brela, where it has been netted whilst foraging. It has also been recorded at two sites in the far west of the Pelješac peninsula. In contrast to the mainland, the Croatian islands are well covered, with records from the islands of Sv. Andrija, Brač, Dugi, Hvar, Korčula, Kornati National Park, Lastovo, Lokrum, Lopud, Mljet, Mrčara, Sušac and Vis (Tvrtković et al. 2005, Willemsen & Resoort 2012, Authors' data).

Records from Montenegro are limited, with two males recorded in July 2020 near Nudo in the far west of the country and a parous female found in hibernation at Vojvode Dakovića Cave at Grahovo village in 2024 (Šestović et al. 2023). There are also scarce records from Bosnia and Herzegovina, the most recent being from Stolac and Dračevo (Presetnik 2017, Presetnik et al. 2022), the first new records since Červený & Kryštufek (1988) at Bjelušica cave. Đulić (1980) herself recorded the first occurrence of the species in Bosnia and Herzegovina at Lištica.

A very thorough review of the records and distribution of the species in Albania has recently been provided by Benda et al. (2019), who report the species from 15

localities in the country. Most of these records conform to the types of landscapes they occupy in Croatia – islands and more coastal areas. These include the island of Sazan, which has three records at separate locations. Along the western side of Albania, within 30 km of the coast, it has been recorded in military tunnels at Lezhë and Halil, a building in Tirana, a gallery at Nojë, a bunker at Fier, a cave at Velçë and a fortress at Vlorë. The remaining locations are further from the coastal strip, with records in the far east in caves at Pishkash and Shpella e Trenit – at over 100 km from the coast, the furthest from the coast in the Balkan peninsula. The other records are from the south of Albania, a bunker at Goranxi, a bat netted in a canyon in Lengaria and a military tunnel at Leskovik.

P. kolombatovici is well documented in Greece with the country's database holding over 60 records recently compiled for publication (Georgiakakis et al. 2023). Close to the border with Albania in northern Greece, the species was netted at three locations around Papingo in Ioannina, two over rivers and one at a cave (Hanák et al. 2001). Papadatou and von Helversen trapped the species at a cave near Holy Kipinas Monastery some 50 km to the south-east of Papingo (Panagiotis Georgiakakis pers. comm.). Hanák et al. (2001) caught the species at two locations near Kompotades and one at Delphi. It has also been repeatedly trapped some 4 km to the north-east of Delphi at Korykeio cave. The species is widespread on the Peloponnese, which has the largest known breeding colony of *P. kolombatovici* numbering some 120 individuals in a tunnel in the Vouraikos Gorge. A great deal of inventory work was undertaken by Otto von Helversen in Greece, particularly on the Peloponnese, during the 1990s and early 2000s; he recorded the species in the upper reaches of the Erymanthos River, at Alfios bridge south of Megalopolis, in a bunker at Derveni, and at Dirrachi and Voutianoi. On the coast he recorded the species in the west at Kastro Kyllinis, near Proastio and at Agios Dimitrious in the south. In addition, more recent records include from Panagopoula and a bat caught over Mavriani Stream, Vlisidia. As with Croatia, island populations feature heavily in the distribution of the species in Greece. There are 19 records from Crete alone, distributed across the island. It has been recorded from Corfu and Zakynthos in the Ionian Sea as well as Andros, Chios, Kalymnos, Lemnos, Lesvos, Limnos, Naxos, Rhodes, Samos, Symi and Thassos in the Aegean. (Benda & Uhrin 2017, Hanák et al. 2001, Georgiakakis et al. 2023)

There are seven records for Cyprus (Benda et al. 2007, Benda et al. 2018). Three are from the north of the island, two at caves in Agırdağ and Alevkaya, and one detector record from Pınarbaşı. The records from the south include three in the Troodos mountains at mines at Hadjipavlou and Kakopetria, and a netting record on the Krios river. The fourth is from the Mines of Magnesia on the Akamas peninsula.

Records of *P. kolombatovici* for Türkiye are sparse and all are from inland areas. With so many records from the Greek islands in the eastern Aegean, we assume the

absence of reports from the western seaboard of Türkiye is due to under surveying rather than a true absence. Three females were recorded from a cave near Üçbölük village, Ermenek, Karaman Province (Karataş 2019). Karataş & Sözen (2006) report the species being netted at Gürpınar Pınar and Soğanlı in Kayseri Province, and at a college campus in the city of Niğde. The species is also known from Beyşehir and Zencirli in Konya Province, and from 5 km east of Lale in Karaman Province (Emrah Çoraman pers. comm.). The records from Kayseri Province are the farthest inland of any reported for this species at over 200 km.

Ancillotto et al. (2019) reported the species had been found for the first time in Italy, following molecular analysis of tissue taken from a grounded bat found near the port of Follonica, in Tuscany. At 360 km from the nearest known population of the species in Croatia and the opposite side of Italy, this would be a considerable extension of their known range. The authors argue that this cryptic species may have been missed during faunal studies; an alternative explanation could simply be this particular bat was accidentally translocated on one of the numerous small yachts that journey around the eastern Mediterranean. This record is such an outlier that, whilst noting it, we have omitted it from the records' map in Figure 1, until there is more certainty around the veracity of an isolated population in north-western Italy.

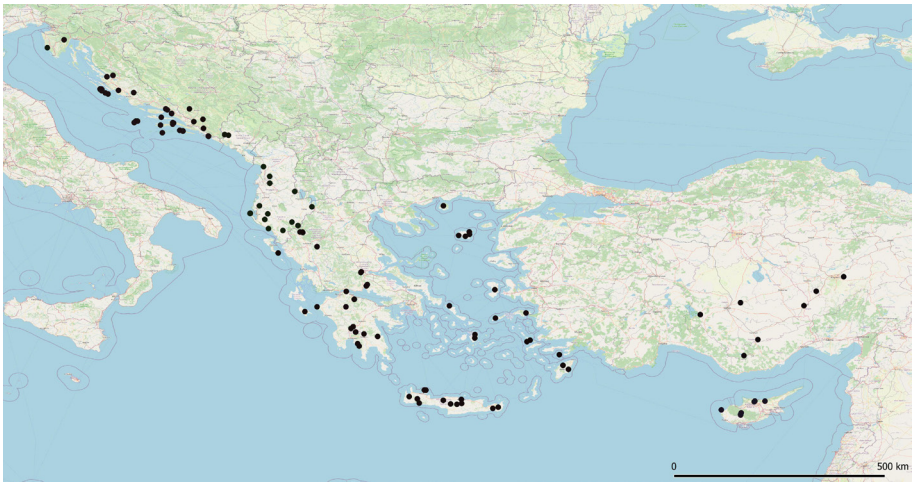

Figure 1. Map of distribution records of *Plecotus kolombatovici* (© OpenStreetMap).
Slika 1. Karta nalaza rasprostranjenosti *Plecotus kolombatovici* (© OpenStreetMap).

2 | A literature review of the roosting sites used by *P. kolombatovici*

2.1 | Materials and methods

In the literature review for distribution data, any reference to roosting behaviour, types of site or colony numbers were recorded; these included the roosts identified during our studies on Lokrum Island. We categorised the records associated with roosts into nine Roost Types: Buildings (type or function unspecified in the paper), Bunkers/Tunnels (military or civil structures consisting of tunnels and chambers buried below ground), Caves, Mines, Churches (simple ecclesiastical buildings), Monasteries (extensive and complex ecclesiastical buildings), Fortifications (large above ground military structures), Stone Walls (city, town walls or other structures made of large blocks) and Trees. The compiled records from the literature and from Lokrum Island, were categorised in the appropriate 'Roost Type'.

2.2 | Results

The records of *P. kolombatovici* collected for the distribution review included 81 locations where the species was found roosting, where they were netted inside or at the entrance to structures, or where radio-tagged bats were located day roosting (the remaining records were of bats caught in the field (n=57).

P. kolombatovici were mainly encountered in sub-terranean roosts (60/81); caves, mines, bunkers, and a disused railway tunnel (Figure 2). The above-ground roosts were typically in historical buildings, which were often large stone-built structures. We recorded two instances of the species roosting in city walls, one in the wall of a stone bridge and two radio-tagged bats day roosted in trees.

Of the 81 records of roosts used by *P. kolombatovici*, 69 contained references to the number of bats observed or caught. The majority (n=54) were observations of just one or two animals; only five sites were identified with a colony of more than 10 individuals. By far the largest of these was Vouraikos Gorge railway tunnel (Greece) with 120 bats; Boljun Church and the Monastery on Lokrum (Croatia) contained colonies of approximately 50 bats, the cave at Nojë (Albania) had 21 and a bunker on Mljet (Croatia) had 15.

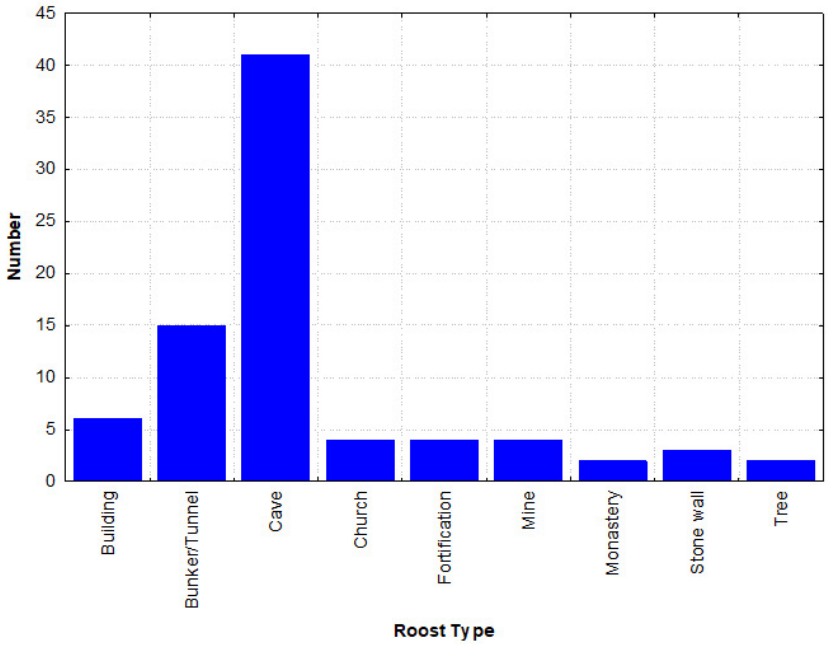

Figure 2. The roost types used by *P. kolombatovici*.

Slika 2. Tipovi skloništa koje koristi *P. kolombatovici*.

(Building – zgrada, Bunker/Tunnel – bunker/tunel, Cave – špilja, Church – crkva, Fortification – utvrda, Mine – rudnik, Monastery – samostan, Stone wall – kameni zid, Tree – stablo)

3 | Roosting, foraging behaviour and echolocation of *P. kolombatovici* on Lokrum Island

3.1 | Study site

Lokrum is a small island (70 ha), being 1600 m in length and between 300–600 m wide, and is located some 600 m off the coast of Dubrovnik (42.628556° N, 18.119155° E) (Figure 3). The island has several historical buildings (Figure 3), the main one being a Benedictine Monastery dating back to 11th century, with a later 19th century addition in the form of a four-storey Tower; both the Monastery and Tower are largely derelict. Associated with the Monastery are some renovated two-storey stone outbuildings now used as offices, and the 15th/16th century Church of the Annunciation of the Blessed Virgin Mary. The Fort Royal, a 19th century fortification,

is located at highest point on the island at 96 m a.s.l.. In addition, there is a 19th century Forest Rangers House by the docks and the modern replacements of twin timber-built barracks that are now used as a restaurant and offices. An unfinished 16th century quarantine area, the Lazaret, is located on the north-east of the island. Consisting largely of stone walls with alcoves and enclosures, the Lazaret now encloses an olive grove.

The underlying geology of Lokrum is limestone and dolomite, resulting in the island's fertile soils. Around the coast and splash zone, erosion has created several large caves and numerous cracks and crevices in the island's cliffs. Away from the Monastery and Tower, and their associated formal gardens and Botanical Garden, the island is densely wooded, predominantly with Aleppo pine (*Pinus halepensis*) and Holm oak (*Quercus ilex*). There are three water bodies on the island, all of which are man-made. Centrally located, the largest reservoir is the Velika vodosprema. To the north are two smaller pools, the reservoir Mala vodosprema and a pond in the Lazaret. (www.lokrum.hr)

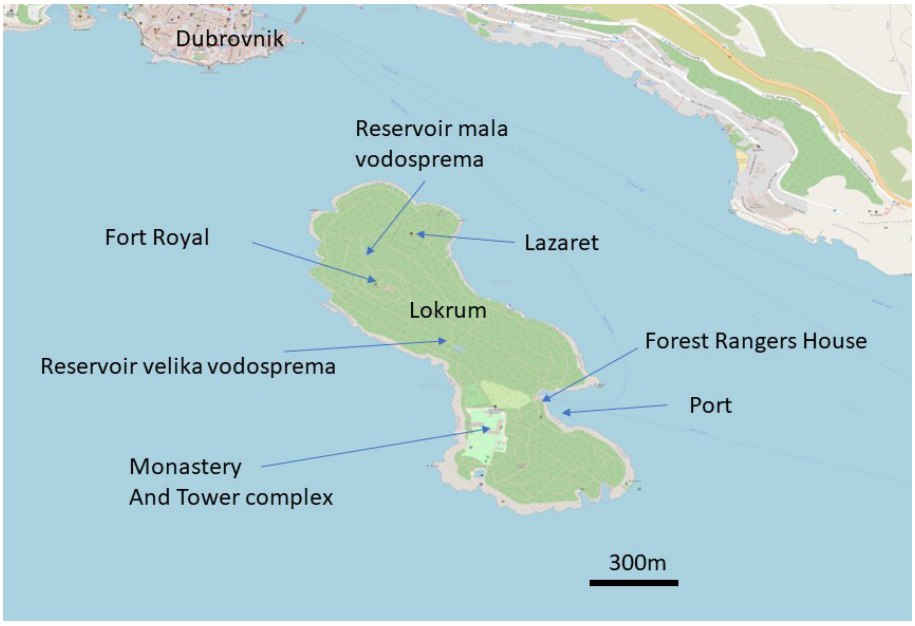

Figure 3. A Map of Lokrum © OpenStreetMap.

Slika 3. Karta Lokruma © OpenStreetMap.

(Fort Royal – Utvrda Royal, Monastery and Tower complex – Kompleks samostana i tornja, Forest Rangers House – Lugareva kuća, Port – Uvala Portoč)

3.2 | **Main roost sites – The Benedictine Monastery and Maximilian Tower**

The original Monastery built in 1023 was occupied and developed by the monks until they were excluded from the island in 1800. Following the purchase of the island by the Habsburg Archduchess Charlotte as a gift for her husband, the Archduke Maximilian built a four-storey tower, named Maximilian Tower, to the north end of the original Monastery (Figure 4). Although there have been attempts to shore up the buildings, they have deteriorated over the years and been subject to both earthquakes and bombardment during the siege of Dubrovnik in 1991/92.

The main roof of the top floor of the Tower (Figure 5) has been lost and so the fourth floor now mainly consists of an open platform, although a small area of roof above the spiral staircase serving the building on the south-west of the Tower survives. The remaining three floors and a series of cellars are in poor condition and the floors along the inside of the Tower's north wall have collapsed (Figure 4).

The Monastery itself is a large L-shaped building, and for general orientation can be divided into East and South wings (see Figure 4). The East wing (Figure 6) is a large two-storey structure, the ground floor of which consists of a series of rooms with windows facing east that are served internally by a corridor. The western side of this wing forms the east section of the covered cloister and is open to the garden. Upstairs, the central roof of this part of the Monastery has disappeared (Figure 7); to either side of a now open gallery are two long unpartitioned rooms, which originally would have been sectioned off as monks' cells. The roofs of both these rooms are largely intact.

The Southern wing of the Monastery has an extensive cellar, now used for storage and tourist displays and a large ground floor room used as an exhibition space. At the western end of this wing and above the exhibition space, is a complex of rooms over three storeys, that previously formed the Abbot's quarters. The lower sections of the Abbot's rooms are used by one of the restaurant outlets on the island. Significant sections of the roof of this southern wing are missing and the building is open to the elements.

The existence of a range of bat species using the Monastery is known to date to the 1970s; it was one of the study sites used to gather biometric data for the identification of *P. kolombatovici* as a separate species (Đulić 1980). The island was subsequently visited by Associate Professor Nikola Tvrtković, and his students, but little bat survey work had been undertaken on the island in recent years until 2016, when the Croatian Biospeleological Society were commissioned to carry out a survey (Žvorc & Hamidović 2017). This highlighted the important *P. kolombatovici* population and the extent of the other bat species using the island's buildings and habitat. It formed the basis for

an opinion that the buildings would require a full survey, review and compensation and mitigation plan prior to the renovation of the Monastery and Tower.

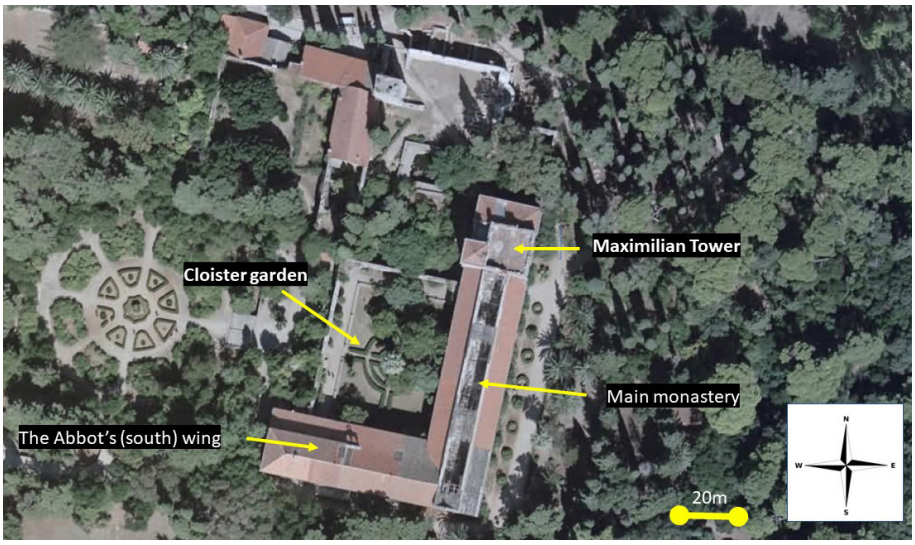

Figure 4. Aerial photograph of the main sections of the Monastery and Tower.

Slika 4. Fotografija iz zraka glavnih dijelova samostana i tornja.

(Maximillian Tower – Maksimilianov toranj, Main monastery – Glavni dio samostana, Abbot's (south) wing – Opatovo (južno) krilo, Cloister garden – Samostanski vrt)

Figure 5. The Maximilian Tower.

Slika 5. Maksimilianov toranj.

(photo/foto: Henry Schofield)

Figure 6. The east elevation of the main Monastery.
Slika 6. Istočna strana samostana.
(photo/foto: Henry Schofield)

Figure 7. The roof missing from the central gallery of the Monastery and the damaged roof of the Abbot's (South) Wing.
Slika 7. Krov koji nedostaje na središnjoj galeriji samostana i oštećeni krov opatovog (južnog) krila.
(photo/foto: Henry Schofield)

3.3 | **Roosting ecology of *P. kolombatovici* on the island of Lokrum**

3.3.1 | **Materials and methods**

To identify the range of roosts used by *P. kolombatovici* on Lokrum at an island-wide scale, radiotelemetry was used. During June 2017 and 2019, 17 adult *P. kolombatovici* (Table 1) were caught in mist-nets either at the reservoir Mala vodosprema (42.631453° N, 18.115831° E) or inside the Monastery (42.624339° N, 18.121089° E). After taking biometric measurements and assessing the reproductive state of the animals, the selected bats had their fur trimmed between the scapulae and a 0.3 g PicoPip or 0.38 g Pip4 radio-transmitter (Lotek UK LTD, Wareham, Dorset, UK) was glued to the dorsum using Torbot adhesive (Torbot Group Inc., Rhode Island, USA). Following their release, the bats were tracked back to their day roosts after dawn using Biotrack Sika radio-receivers and 3-element Yagi antennae (Lotek UK LTD, Wareham, Dorset, UK). The tracking was repeated until the tags were shed or their batteries depleted. This work was undertaken under Licence numbers: Class: UP/I-612-07/17-48/58, Reg.Number: 517-07-1-1-1-17-4 (2017 – 2019), Class: UP/I-612-07/19-48/127, Reg.Number: 517-05-1-1-19-6 (2019 –2021), Class: UP/I-612-07/21-48/152, Reg.Number: 517-10-1-1-21-4 (2021 – 2023).

At a more local scale, visual surveys and infra-red video photography were used to identify roosts and assess their level and period of occupancy in the Monastery and Tower. Each room in the Monastery and Tower (other than those in unsafe areas) was inspected during the day on four occasions in 2020, three times in both 2021 and 2022, as part of monitoring by the Croatian Biospeleological Society. During our fieldwork on the island in 2023, we carefully surveyed all the rooms using the same protocol on two occasions during a two-week visit. In addition, dusk visual surveys of the buildings were conducted on five nights during the June field visit in 2023.

A Sannce CCTV system (Sannce, South Brunswick, New Jersey, USA) with four cameras (with built in infra-red LED illuminators) linked to a central recording HDD system by 100 m long cables, was used for general recordings. The quality of recording from the Sannce was adequate to assess bat activity over large parts of the buildings, and by putting the cameras on 3 – 4 m long extension poles, inaccessible or unsafe areas of the buildings could be surveyed.

High quality video images of any roosts identified were captured using Canon XA11, and two XA30s (Canon Europa, Amsterdam, Netherlands). Scenes were illuminated using generic infrared flood lamps typically fitted with 96 850 nm LED emitters, and NightFox infrared torches used as spotlights (Nightfox, Bristol, UK).

As well as count and occupancy data, the micro-climates of some of the roosts were

assessed using external probes from Tiny Tag Temperature loggers (Gemini Data Loggers, Chichester, UK).

3.3.2 | **Results**

3.3.2.1 | **Roosts identified during the radio-telemetry study**

All of the 17 radio-tagged bats were females; of these, nine were lactating, two post lactating and six were nulliparous (Table 1). In addition to the already confirmed roosts in the Monastery and the Tower, new roosts were identified in cracks in masonry in the walls of the Fort Royal, in natural cracks of sea caves around the coast (Figure 8) and in trees (Figure 9). All of the roosts (used by both groups and individual bats) we identified in the Monastery and Tower opened to the inside of the building, not directly outside. This is a similar situation in the Fort Royal and the sea caves around the island. Overall, the bats that were not day roosting in the main island buildings, proved difficult to locate. During the 2017 tracking session, we lost all radio contact with six of the seven bats during the day. We had similar problems in 2019, especially with individuals tagged away from the main Monastery complex.

Figure 8. Coastal cave used as a day roost by *P. kolombatovici*.
(The arrow indicates the main crevices inside the cave used by bat Pk 1.)

Slika 8. Obalna špilja koju tijekom dana koristi *P. kolombatovici*.
(Strelica pokazuje glavne pukotine unutar špilje koju je koristila jedinka Pk 1.)

(photo/foto: Henry Schofield)

Figure 9. a) Old conifer tree used as a day roost by a tagged *P. kolombatovici* adjacent to the Monastery. b) old woodpecker's hole in the general location of the tagged bat.

Slika 9. a) Stari bor kojeg tijekom dana koristi označen *P. kolombatovici* u blizini samostana. b) stara duplja djetlića na širem području gdje je zabilježen označeni šišmiš.

(photo/foto: Chris Damant)

In both 2017 and 2019, we chartered a small boat and sailed around the island after dawn scanning the bat radio-tag frequency bands with our radio-receivers. This allowed us to locate the missing animals and identified that they were either in sea caves or cracks and crevices in coastal rock formations, although one of these 'lost' bats was discovered roosting in the old city walls of Dubrovnik when we picked up her signal when sailing halfway between Lokrum and the old city. In all but the situation with the bat roosting in Dubrovnik, the radio signal from the tags was being broadcast into areas we could not access on foot from the island (mostly straight out to sea). Unfortunately, we were unable to charter boats on a daily basis, and so any patterns of roost occupancy could not be determined.

Although the two netting sites, at reservoir Mala vodosprema and the Monastery, were only 900 m apart, there was complete separation in the areas of the island the bats used to roost. None of the Mala vodosprema bats roosted in the Monastery or Tower, either in 2017 or 2019. The bats from this capture site were found in sea caves or coastal rock cracks and crevices, and in gaps in the stonework in the Fort Royal, all the roosts identified on the island were about 200 m from the capture site. The exception was one of the bats caught at Mala vodosprema, which flew the 600 m across the sea to Dubrovnik and day roosted in the old city walls. Of the remaining two bats, one roosted in a tree and the other in dense woodland, where the roost

could not be properly identified. All but one of the bats caught in the Monastery returned to day roost in the buildings, although four also used alternative day roosting sites. These alternative roosts included the cliffs on the south of the island and a large conifer tree adjacent to the Monastery (10 m from the south wing of the Monastery) (Figure 9). The exception amongst the Monastery bats was an individual that roosted in dense woodland in the southern part of the island. The dense nature of the vegetation on the island and the potential danger of unexploded ordnance from the bombardment of the island in 1991 and 1992, prevented us leaving the island's woodland paths and approaching the roosting areas of the tree dwelling bats, so the precise type of roost is unknown.

Table 1. Summary of location of captures and day roosts used by radio-tagged bats.
Tablica 1. Sažetak lokacija hvatanja i dnevnih skloništa koje su koristili šišmiši označeni radijskim odašiljačima.

Bat ID Ident. br. šišmiša	**Sex** Spol	**Date** Datum	**Place of Capture** Mjesto hvatanja	**Day Roosts** Dnevna skloništa
Pk 1	Adult female (Lactating)	19.6.2017	Mala vodosprema	Sea Cave (42.63317° N 18.11455° E)
Pk 2	Adult female (Lactating)	19.6.2017	Mala vodosprema	Sea Cave (42.631170° N 18.113834° E)
Pk 3	Adult female (Lactating)	19.6.2017	Mala vodosprema	Roof crevice lower-level Fort Royal and adjacent building (approx.42.629964° N 18.116742° E)
Pk 4	Adult female (Lactating)	19.6.2017	Mala vodosprema	Sea Cave (42.63322° N 18.11474° E)
Pk 5	Adult female (Lactating)	19.6.2017	Mala vodosprema	Probably in a rock crevice (approx. 42.62890° N 18.11530° E)
Pk 6	Adult female (Lactating)	19.6.2017	Mala vodosprema	Dense woodland (approx. 42.63314° N 18.11448° E)
Pk 7	Adult female (Lactating)	21.6.2017	Monastery	Ceiling in first floor of Monastery
Pk 8	Adult female (Lactating)	20.6.2019	Monastery	Monastery
Pk 9	Adult female (Nulliparous)	20.6.2019	Monastery	Monastery
Pk 10	Adult female (Nulliparous)	20.6.2019	Monastery	Monastery and rock crevice south along the south coast cliffs (42.62178° N 18.12056° E)
Pk 11	Adult female (Nulliparous)	20.6.2019	Monastery	Roost not identified in dense woodland

Bat ID Ident. br. šišmiša	**Sex** Spol	**Date** Datum	**Place of Capture** Mjesto hvatanja	**Day Roosts** Dnevna skloništa
Pk 12	Adult female (Nulliparous)	20.6.2019	Monastery	Monastery and rock crevices south coast cliffs (42.62178° N 18.12056° E)
Pk 13	Adult female (Post lactating)	21.6.2019	Mala vodosprema	Not identified
Pk 14	Adult female (Post lactating)	21.6.2019	Mala vodosprema	City walls Dubrovnik (approx. 42.63923° N 18.11199° E)
Pk 15	Adult female (Nulliparous)	21.6.2019	Mala vodosprema	Not identified
Pk 16	Adult female (Nulliparous)	21.6.2019	Mala vodosprema	Tree west of Fort Royal (approx. 42.63018° N 18.11559° E)
Pk 17	Adult female (Lactating)	21.6.2019	Monastery	Tower and Tree adjacent to the Monastery (approx. 42.624° N 18.120° E)

Table 2. Number of *Plecotus kolombatovici* observed during daytime visual surveys of the accessible areas of the Benedictine Monastery and Maximilian Tower.

Tablica 2. Uočena brojnost *Plecotus kolombatovici* tijekom dnevnih vizualnih pregleda pristupačnih mjesta unutar benediktinskog samostana i Maksimilijanove rezidencije.

Date Datum	**Number of *P. kolombatovici*** Brojnost *P. kolombatovici*	**Notes** Bilješke
8.2.2020	0	/
19.6.2020	0	/
24.8.2020	0	/
10.1.2020	3	One individual was recorded in the cellar of the southern wing of the monastery (Exhibition area) while two individuals were recorded in the cellar of the Tower active, but hanging from the ceiling.
14.6.2021	0	/
26.7.2021	0	/
23.8.2021	3	One individual was recorded roosting in the open, while two individuals were recorded in crevices in the monk's rooms area on the first floor of the eastern wing of the Monastery.
3.8.2022	1	Freely hanging from the ceiling of the first floor of the southern wing of the Monastery.
19.9.2022	17	Cluster of bats in the open on a ground floor ceiling of the Monastery's east wing
7.12.2022	1	Inside a crevice in the cellar of the southern wing of the Monastery (Exhibition area)

Date Datum	**Number of *P. kolombatovici*** Brojnost *P. kolombatovici*	**Notes** Bilješke
1.4.2023	3	In a cluster in ground floor room of the Monastery's east wing
15.6.2023	1	Roosting in ground floor room of the Tower
28.6.2023	3	Observed at entrance to a maternity roost on ground floor of the Monastery's east wing (see below)

Despite acoustic monitoring of the Monastery and Tower using bat detectors over 2019 and 2020 clearly showing the site having a resident population of *P. kolombatovici* all year around, the daytime visual surveys of the buildings generally proved to be unfruitful (Table 2). Over a three-year period of systematic surveys (2020–2023) we typically recorded between 0–3 bats; the exception was the recording of a cluster of 17 bats in a ground floor room in September 2022, which was after the breeding season had finished.

In contrast with daytime surveys, visual surveys at dusk were productive, with significant numbers of animals roosting at dusk prior to leaving to forage (Table 3, Figure 10). The location of the dusk roosting bats was not consistent, and indicated a movement of bats around the buildings, with a switch in focal areas for this behaviour over a two-week period.

The results of the infra-red video filming of the Monastery and Tower showed there was no single area of the buildings used consistently as a focal roosting point for the colony. Instead, the colony was spread out with a mixture of individual bats roosting in cracks and crevices in the buildings' stonework and a core group of between 10 – 23 animals roosting together in cavities in the walls of the Monastery. Over a two-week period, we identified three of these core group maternity roosts (Roosts One, Two and Three, Figures 11 a – c), which the group would occupy for up to seven days before abandoning the site and moving to another roost. We were able to film the presence of pups inside one of these roosts. They were also centres of social activity in the period around dusk, when conspecifics not roosting in the cavity would repeatedly fly up to the entrance and hover in front of it.

The locations of the dusk roosting sites and the locations of the core maternity roosts appear to be linked. We observed changes in the number of bats dusk roosting in proximity to core maternity roosts over the two-week period of our fieldwork in June 2023. *P. kolombatovici* were observed using dusk roosting sites within 10 m of the core maternity roost. Every time the colony moved day roost, the dusk roosting site also changed.

Table 3. Number of *P. kolombatovici* observed during dusk visual surveys of the accessible areas of the Benedictine Monastery and Maximilian Tower.

Tablica 3. Uočena brojnost *P. kolombatovici* tijekom vizualnih pregleda pristupačnih mjesta benediktinskog samostana i Maksimilijanove rezidencije u sumrak.

Date Datum	**Number of *P. kolombatovici*** Brojnost *P. kolombatovici*	**Notes** Bilješke
15.6.2023	10	Dusk roosting in first floor room on east side of Monastery close to Maternity Roost One
19.6.2023	3	Dusk roosting in first floor room on east side of Monastery close to Maternity Roost Two
21.6.2023	9	Eight in second floor of south wing, one in room on first floor room east side of Monastery
22.6.2023	15	Six in first floor room and eight in second floor room of south wing. One in room on first floor room east side of Monastery
23.6.2023	13	Two in first floor and ten in second floor rooms of south wing of Monastery. One at the top of the stairs in the Tower.

Figure 10. Dusk roosting group of *P. kolombatovici* in the Monastery.

Slika 10. Odmor grupe *P. kolombatovici* u sumrak u samostanu.

(photo/foto: Daniel Hargreaves)

Figure 11. Photographs of the locations of the three cavity maternity roosts and a close-up view of Roost Three. a) Roost One (in the ground floor corridor of the east wing), b) Roost Two (in the first floor on the east side of the east wing of the monastery), c) Roost Three (in a ground floor room in the east wing of the monastery).

Slika 11. Fotografije lokacija triju šupljina s porodiljnim kolonijama i pogled izbliza na skloništе tri. a) skloništе jedan (u hodniku prizemlja istočnog krila), b) skloništе dva (na prvom katu na istočnoj strain istočnog krila samostana), c) skloništе tri (unutar sobe u prizemlju istočnog krila samostana).

(photo/foto: Henry Schofield)

We identified seven 'individual' roosts being used by *P. kolombatovici* in the Monastery complex; however, the number of very similar potential roosting sites in the derelict buildings, and the limited time we had available to survey the sites almost certainly makes this a gross under-estimate. These roosts varied from cracks in terracotta ceiling bricks to hollows in redundant chimneys (Figure 12a – c). Visual inspection of these roosts showed it was not possible to see the individual bats roosting in cracks and crevices; these animals were hidden deeper inside the walls or ceilings.

Figure 12. Examples of individual roosts used by *P. kolombatovici* in the Monastery.
Slika 12. Primjeri pojedinačnih skloništa koje koristi *P. kolombatovici* u samostanu.
(photo/foto: Henry Schofield)

3.3.2.2 | **Temperature microclimate in *P. kolombatovici* roosts**

Logging the temperature hourly, the ceiling crevice used as an individual roost had a mean temperature of 26.8°C (n=384, SD=2.02) in the last two weeks of June 2021. The temperature in two of the cavities used as maternity roosts in June 2023 was logged once the colony had abandoned that roost. In Roost One on the ground floor (Figure 11a) the mean temperature was 26.5°C (n=43, SD=0.19); in Roost Two on the first floor (Figure 11b), the mean temperature was 27.5°C (n=25, SD=0.51).

3.4 | **Foraging behaviour and habitat selection on Lokrum Island**

3.4.1 | **Materials and methods**

3.4.1.1 | **Radio-telemetry**

The same bats tagged during the roosting study were tracked overnight using Biotrack Sika Radio Receivers and directional three element Yagi antennae (Lotek UK LTD, Wareham, Dorset, UK.). Observer location data were determined using Garmin GPS units. Foraging data were collected by observers recording their own location and taking a bearing on the direction of strongest signal from the tagged animal. The foraging locations were generally the result of *close approach* where the observer attempted to get as close to the tagged animals as possible, although on a small number of occasions, the bat's position was triangulated by two observers working together. Where possible and when observers were in detection range of the bat, fixes were taken every five minutes. Tracking fixes were recorded in notebooks or to Dictaphone and later transcribed into Excel spreadsheets.

The raw tracking data were visualised in a Geographical Information System (QGIS 3.32, QGIS Association. http://www.qgis.org) and tools within the software were used to calculate the location of the bat from close approach and triangulation data. Radio-telemetry data is subject to some error and in order not to overstate the precision of these 'fixes', a buffer of 200 m around the point was used for further analysis. The error buffer on an island as small as Lokrum means that fixes determined close to the coast sometimes result in areas of the sea being included in the animals' ranges; although this may be an artefact of the analysis process, it could also indicate animals foraging over the sea around the coast.

Spatial analysis of the foraging fixes was made in a software package, Ranges 7 (Anatrack Ltd., Dorset, UK); two types of range analysis were conducted. First, the Minimum Convex Polygon (MCP) was determined; this describes the overall foraging range for an individual animal and is constructed by enclosing the outer-most foraging fixes recorded. Second, a Kernel analysis was used; this creates a contour map based on the density of foraging fixes and allows for the identification of the 50% core foraging area of each animal.

The habitat preferences of *P. kolombatovici* on Lokrum Island were determined using Compositional Analysis (Aebischer et al. 1993). This commonly used technique for analysing radio-telemetry data and determining habitat preferences, encompasses all MANOVA/MANCOVA-type linear models to test the nonstandard multivariate data associated with proportional use of available habitat. The habitats can then be ranked according to relative use, and significance between-rank differences

identified. The analysis produces a complex matrix, which can then be visualised as a simplified matrix where statistical significance of one habitat type over another is signified using + symbols with three of these indicating a significance of $P < 0.05$. This analysis was undertaken using an Excel Macro built by Peter Smith (Smith 2004). The *Available* habitat was taken as the habitat within the combined MCP for all the bats successfully radio-tracked during the study. The habitat type was taken from Hudina et al. (2016), who produced a 1:50000 scale habitat map and assessment of the island. The habitats in this report employed the National Habitat Classification System for Croatia; for the analysis we used all the major habitat types but combined the rocky shoreline with the coastal water in the total MCP, and we also combined Olive Groves and wild Olive woodland habitats. *Used* habitat was taken as the habitat within the 50% kernel estimates for each individual bat successfully radio tracked.

3.4.1.2 | **Light tagging**

18 *P. kolombatovici* were fitted with chemiluminescent light tags during June 2023. 14 animals were caught adjacent to reservoir Velika vodosprema (42.627693°N, 18.119432°E), the rest inside the Monastery. The tags were glued to the fur on the dorsum of the bat. Observers stationed around the two release sites made field observations of the flight and foraging behaviour of the light-tagged bats.

3.4.2 | **Results**

3.4.2.1 | **Analysis of radio-telemetry data/observations**

Foraging data were successfully collected from 13 of the 17 animals fitted with radio-tags (Table 4, Figure 13). In 2017, the bats were tracked for seven nights with between 30 and 56 fixes being recorded during the concurrent tracking period. In 2019, the tracking period was extended to 10 nights and between 36 and 68 fixes were recorded per bat. The mean foraging range (MCP) was 48.15 ha (SD 13.69), the mean core foraging area was 5.37 ha (SD 3.08) and the mean distance from roost to centroid of the foraging area was 125 m (SD 79.67).

The Compositional Analysis ranked habitat sequence (most to least used) as → Dense, evergreen forest with holly and myrtle scrub → Historical buildings and associated gardens → Artificial water bodies → Amenity parkland → Amenity grassland → Mixed forest of holm oak and ash → Aleppo pine forest with Phoenician juniper understorey → Mixed forest of Aleppo pine and holm oak → Pistachio and Phoenician juniper scrub → Shore and immediate coast → Olive groves, and olive and euphorbia scrub (Table 5).

Table 4. Foraging range data from the radio-tracked bats.
Tablica 4. Podaci o područjima traženja hrane za šišmiše označene radio-odašiljačima.

Bat ID Ident. Br. Šišmiša	**MCP area (ha)** Područje Minimalnog konveksnog poligona (ha)	**50% Kernel (ha)** 50% Kernel (ha)	**Main roost site** Glavno skloništе	**Distance from main roost to kernel centroid (m)** Udaljenost od glavnog skloništa do središnje točke kernela (m)
Pk 2	57.42	8.04	Sea Cave	128
Pk 3	20.66	1.26	Fort Royal	67
Pk 5	63.24	4.95	Rock crevice	154
Pk 6	60.91	13.02	In dense woodland	337
Pk 7	57.54	4.87	Monastery	94
Pk 8	27.58	1.70	Monastery	55
Pk 9	51.47	3.44	Monastery	106
Pk 10	66.57	5.95	Monastery	120
Pk 11	44.87	4.16	Unidentified	-
Pk 12	36.90	3.16	Monastery	91
Pk 13	48.35	4.89	Unidentified	-
Pk 15	46.22	7.63	Unidentified	-
Pk16	44.24	6.71	Tree west of Fort Royal	101

3.4.2.2 | **Flight and foraging observations of light-tagged bats.**

The light-tagged bats released by the reservoir largely disappeared from sight shortly after their release, although two individuals were observed foraging high in the canopy of mature trees close to the water body and further animals were seen roosting in trees and attempting to groom off the tags in the Botanical Garden adjacent to the monastery. The light-tagging at the Monastery was more productive. Here we observed bats emerging from open windows on the ground floor of the building and foraging along the ornamental box (*Buxus sempervirens*) hedges along the east wall of the Monastery and in the box maze in the cloister garden. The bats were observed flying at heights less than 1 m above the ground and making repeated circuits of the box plants, gleaning moths from the vegetation.

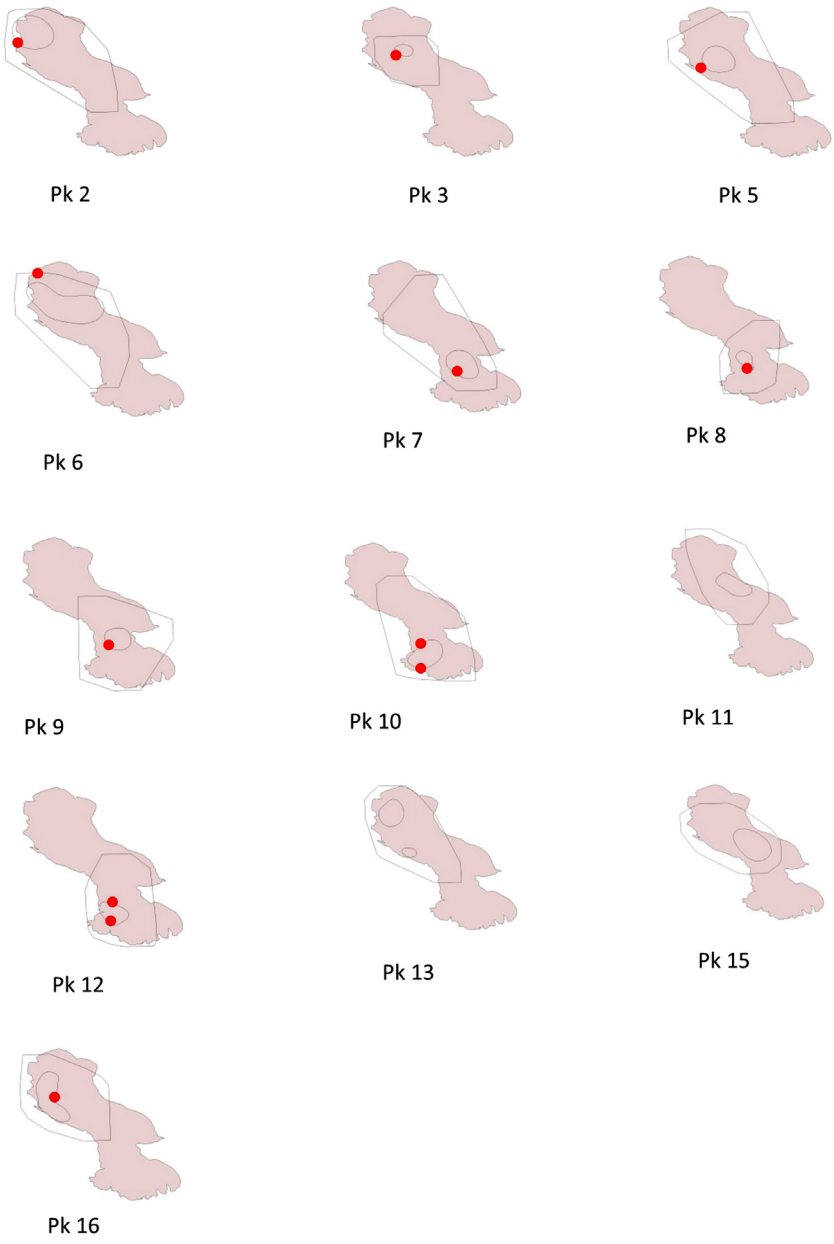

Figure 13. Minimum Convex Polygon, 50% Kernel Cores and day roost locations (red dots) where identified, of radio-tracked bats.

Slika 13. Područja minimalnog konveksnog poligona, 50% jezgri Kernela i dnevnih skloništa (crvene točke) su utvrđene, za šišmiše označene radio-odašiljačima.

Table 5. Results of the Compositional Analysis Matrix of Foraging Habitat Preferences of *P. kolombatovici* on Lokrum Island.

(+++ indicates habitat ranks significantly over another P < 0.05), + and ++ indicate habitat ranks over another but fails to reach significance at P < 0.05, the minus (-) rankings are a mirror of the positive (+) rankings)

Tablica 5. Rezultati analize matrice sastava izbora staništa za hranjenje *P. kolombatovici* na otoku Lokrumu.

(+++ označava da je stanište značajno rangirano u odnosu na drugo P < 0,05), + i ++ označavaju rangiranje staništa iznad drugog, ali ne dosežu značajnost na P < 0,05, minus (-) rangiranja su zrcalna pozitivnim (+) rangiranjima)

Habitat type Stanišni tip	Amenity parkland	Amenity grassland	Building and gardens	Aleppo pine and holm oak forest	Holm oak and ash	Water	Dense evergreen forest	Olive groves and scrub	Shore and coast	Aleppo pine and juniper	Pistachio and juniper	**Rank** Rang
Amenity parkland		+	-	+	+	-	-	+++	+	+	+++	**7**
Amenity grassland	-		-	+	+++	-	-	+++	+++	+	+++	**6**
Building and gardens	+	+		+	+++	+	-	+++	+++	+++	+++	**9**
Aleppo pine and holm oak forest	-	-	-		-	---	---	+	+	-	+	**3**
Holm oak and ash	-	---	---	+		---	---	+++	+++	+++	+++	**5**
Water	+	+	-	+++	+++		-	+++	+++	+++	+++	**8**
Dense evergreen forest	+	+	+	+++	+++	+		+++	+++	+++	+++	**10**
Olive groves and scrub	---	---	---	-	---	---	---		-	-	---	**0**
Shore and coast	-	---	---	-	-	---	---	+		-	-	**1**
Aleppo pine and juniper	-	-	---	+	-	---	---	+	+		+	**4**
Pistachio and juniper	---	---	---	-	-	---	---	+++	+	-		**2**

3.5 | **Echolocation and social calls of *P. kolombatovici***

3.5.1 | **Materials and methods**

Targeted sound recording of *P. kolombatovici* was carried out on Lokrum over eight nights in June 2023 as part of a wider European-scale project focused on improving the capacity of an acoustic monitoring tool, the BTO Acoustic Pipeline https://www.bto.org/pipeline, to support projects in southern and eastern Europe. The Acoustic Pipeline is the result of a decade of work, building machine-learning algorithms to automatically identify bats and other species groups from sound recordings.

For this, it is important to build a large reference library of recordings where it can be certain that the recordings are of the target species, and that the library is as representative as possible of the range of calls that can be produced by the species. Lokrum is an ideal study site to work on *P. kolombatovici* because the population is well studied, and we know after several years of fieldwork, that no other species of *Plecotus* have been recorded on the island.

Every night, 11 full spectrum bat detectors (4 x Wildlife Acoustics SM4Bat-FS, 6 x Song Meter Mini Bats and a Pettersson M500-384 USB Ultrasound Microphone) were deployed at different locations to record with a sample rate of 384 kHz and to use a high pass filter of 8 kHz which defined the lower threshold of the frequencies of interest for the triggering mechanism. Recording was set to continue until no trigger was detected for a 2 second period up to a maximum of 5 seconds. Detectors were deployed before sunset and set to switch on and record 30 minutes before sunset until 30 minutes after sunrise the following day. Each bat detector or microphone, if on a lead, was mounted on a tripod at a height of at least 1.5 m (Figure 14) off the ground and positioned away from any flat surface or vegetation which would influence the quality of the recordings.

This resulted in an acoustic dataset that was equivalent to 88 complete nights of bat recording. After each night, the .wav files from the previous night were reviewed, by looking at spectrograms of bat calls in the software SonoBat. Based on an assessment of the range of calls recorded, the locations for deployment for the following night were decided on, to ensure that the dataset included a good number of examples across call types. In closed environments for example, such as in woodland or in the Monastery buildings, many bat species, including *P. kolombatovici* produce very short calls which cover a broad band of frequencies (Rnjak & Hamidović 2021). When the same bat flies into a more open environment, the band of frequencies (in kHz) covered by the calls is reduced, whilst calls become longer in duration (in ms). In addition to echolocation calls, as far as possible we also wanted to try and record the range of social calls that *P. kolombatovici* can produce. In this paper, we

Figure 14. Photographs showing the use of tripods to position the bat detector or microphone to obtain good recordings.

Slika 14. Fotografije koje pokazuju upotrebu stativa za postavljanje ultrazvučnih detektora ili mikrofona kako bi se zabilježile kvalitetne snimke.

(photo/foto: Stuart Newson)

categorise bat social calls according to Pfalzer & Kusch (2003), who classified social calls into four distinct groups (Types A, B, C and D) according to the call structure characteristics produced across a range of species. Most relevant here are Type C social calls, which are relatively simple in their structure, whilst Type D calls are more complex and song-like, often consisting of numerous and differing component types. From 95,487 triggered bat wav files, we manually extracted 2,554 sequences of *P. kolombatovici* calls, including echolocation and social calls to work with.

Our first task when working on any new species is to produce a visualisation of the range of calls recorded, which can be used to make direct comparisons with potential confusion species for informing our understanding of species identification. The range of variation in bat echolocation calls for most bat species is influenced by the environment that the bat is flying in, with longer duration calls being produced in more open environments (Russ 2021); therefore, our starting point was to work through the 2,554 wav files, extracting good quality examples of calls across the range of call durations from very short to very long duration calls and noting their call duration (ms). We then selected a sample of 15 – 20 examples of the same call duration (or narrow range of durations) and appended these together using the SonoBat utility Reference Compiler to produce a new compiled wav file/s containing examples of similar duration calls. In doing this, it was possible to summarise the range of variation in calls that were observed across the 2,554 wav files into 79

compiled recordings of *P. kolombatovici*. We then repeated this process for the three other *Plecotus* species that occur in Croatia, and for the closely related *P. gaisleri*. The main geographic areas from which recordings for each species were collected for use in this paper are as follows: *P. kolombatovici* (Lokrum), *P. auritus* (United Kingdom and north-west Europe – 1,025 wav files), *P. austriacus* (Channel Islands and France – 1,429 wav files), *P. macrobullaris* (Italy and Switzerland – 121 wav files), and *P. gaisleri* (Gozo - Malta archipelago – 1,429 wav files). This resulted in the production of a total of 190 compiled wav files that together help provide a summary of the range of variation in calls of each *Plecotus* species across the range of observed call durations.

In this paper, we only present a few examples of these as figures to illustrate some important points, but by taking this approach, it is possible to i) visualise the typical range of variation for a given call duration for a given species, and to ii) visualise how the calls of one species compare with comparable calls of another. Note that the recording length is not standardised across Figures. Using this visual approach to European bat sound identification, we have found it much easier to identify, and to highlight to others where there are important differences between species. For example, given an unknown *Plecotus* species recording with call durations of 4 ms, it is possible to visualise what a representative sample of known calls of *P. kolombatovici* with that call duration look like in comparison, and so to consider whether the unknown calls are likely to have been produced by this, or another *Plecotus* species.

3.5.2 | **Results**

P. kolombatovici echolocation calls are frequency-modulated signals that normally consist of two harmonics, although if the sequence of calls is weak, the second harmonic can be lost (Rnjak & Hamidović 2021). As with all European *Plecotus*, they also produce lower frequency longer duration calls (Type C social calls) which are interesting among bat species, in that they may fulfil an echolocation and a social function.

In Table 6 we provide a comparison of some simple call measurements of *P. kolombatovici* in relation to comparable measurements for three other *Plecotus* species that occur in Croatia. We also include measurements for the closely related *P. gaisleri*. Please note the small sample size of short calls of *P. gaisleri* and *P. macrobullaris* of < 3 ms in duration, and long calls of 9 ms or more, where any comparisons should be treated with caution.

Whilst it is beyond this paper to provide a detailed comparison and discussion on the sound identification of European *Plecotus*, we pick out a few visual comparisons

Table 6. Mean and standard deviation (in brackets) of call measurements of *Plecotus kolombatovici* (highlighted in grey) in relation to comparable measurements for the three other *Plecotus* species that are present in Croatia, and for the closely related *P. gaisleri*, broken down into classes of signal duration. N – Number of calls included.

Tablica 6. Prosječne vrijednosti i standardna devijacija (u zagradama) mjerenja glasanja vrste *Plecotus kolombatovici* (istaknute sivom bojom) u odnosu na usporediva mjerenja za tri druge vrste roda *Plecotus* koje su prisutne u Hrvatskoj, te za blisko povezanu vrstu *P. gaisleri*, razvrstane prema trajanju signala. N - broj analiziranih zova.

Species Vrsta	**Class of call duration** Razred duljine poziva	**N of calls** Br. poziva	**Mean duration (SD) (ms)** Prosječna duljina (SD) (ms)	**Start frequency of first harmonic (kHz)** Početna frekvencija prve harmonične (kHz)	**End frequency of first harmonic (kHz)** Krajna frekvencija prve harmonične (kHz)	**Bandwidth of first harmonic (kHz)** Razpon frekvencija prve harmonične (kHz)	**Peak frequency (kHz)** Maksimalna frekvencija (kHz)
P. kolombatovici	< 3 ms	147	2.22 (0.44)	49.78 (2.35)	25.33 (1.35)	24.45 (2.75)	35.64 (3.70)
P. gaisleri	-//-	2	2.10 (0.71)	49.96 (0)	25.41 (0.61)	24.55 (0.61)	36.17 (2.44)
P. auritus	-//-	55	2.51 (0.28)	55.64 (3.39)	24.95 (1.41)	30.69 (3.28)	37.37 (4.06)
P. macrobullaris	-//-	9	2.63 (0.26)	49.00 (2.64)	22.39 (0.97)	26.61 (2.13)	34.64 (3.49)
P. austriacus	-//-	70	2.34 (0.49)	45.95 (4.17)	22.49 (1.81)	23.45 (3.29)	33.56 (3.75)
P. kolombatovici	3 to 4.99 ms	185	4.06 (0.59)	49.59 (3.57)	22.84 (1.75)	26.76 (3.62)	33.08 (3.07)
P. gaisleri	-//-	67	4.27 (0.48)	46.63 (2.57)	20.55 (1.36)	26.07 (2.53)	30.04 (3.15)
P. auritus	-//-	190	4.12 (0.55)	51.89 (4.58)	20.71 (2.82)	31.18 (4.13)	31.95 (3.71)
P. macrobullaris	-//-	60	4.20 (0.58)	46.76 (2.57)	19.19 (1.64)	27.56 (3.03)	31.14 (3.77)
P. austriacus	-//-	141	3.99 (0.56)	42.97 (4.42)	19.03 (1.85)	23.94 (4.01)	29.36 (4.52)
P. kolombatovici	5 to 6.99 ms	155	6.00 (0.56)	48.94 (4.91)	20.25 (1.98)	28.68 (4.83)	31.81 (3.31)
P. gaisleri	-//-	146	6.02 (0.58)	46.93 (3.15)	18.83 (1.68)	28.11 (3.08)	29.24 (3.26)
P. auritus	-//-	177	5.95 (0.58)	48.69 (6.03)	15.61 (3.44)	33.08 (4.91)	27.91 (5.35)
P. macrobullaris	-//-	80	5.94 (0.59)	46.40 (3.50)	17.26 (1.64)	29.15 (3.89)	29.18 (3.51)
P. austriacus	-//-	99	5.94 (0.62)	42.71 (4.83)	16.80 (2.18)	25.91 (4.75)	27.79 (3.67)
P. kolombatovici	7 to 8.99 ms	83	7.95 (0.59)	50.68 (4.35)	20.01 (3.06)	30.68 (5.09)	32.42 (3.41)
P. gaisleri	-//-	108	7.83 (0.48)	47.17 (3.57)	18.71 (1.88)	28.46 (3.50)	28.91 (2.95)
P. auritus	-//-	124	7.75 (0.47)	45.39 (5.92)	11.55 (2.95)	33.84 (5.30)	25.39 (5.62)
P. macrobullaris	-//-	44	7.95 (0.58)	45.38 (3.25)	16.27 (2.25)	29.11 (3.49)	27.64 (3.88)
P. austriacus	-//-	76	7.93 (0.47)	43.27 (6.29)	15.98 (3.09)	27.29 (6.93)	27.72 (4.10)
P. kolombatovici	≥ 9 ms	237	12.68 (2.61)	48.82 (4.73)	17.06 (3.08)	31.76 (5.40)	31.60 (4.34)
P. gaisleri	-//-	27	10.98 (1.90)	45.08 (6.44)	16.46 (3.64)	28.62 (4.25)	26.96 (3.51)
P. auritus	-//-	38	10.62 (1.81)	48.12 (6.58)	9.70 (2.19)	38.42 (7.17)	24.30 (6.73)
P. macrobullaris	-//-	5	9.43 (0.59)	48.58 (2.33)	16.54 (1.42)	32.04 (3.13)	26.01 (3.30)
P. austriacus	-//-	73	11.19 (1.78)	41.73 (7.38)	15.45 (2.88)	26.29 (8.41)	25.60 (3.54)

of known calls of *P. kolombatovici* of specific call durations, against comparable calls of *P. auritus* and *P. austriacus* to illustrate some of the main differences between *P. kolombatovici* and these species.

We feel that we need more reference material for *P. macrobullaris* before making a similar visual comparison for the third *Plecotus* species present in Croatia, but Table 6 suggests that the calls of *P. macrobullaris* are most similar to *P. austriacus* (and *P. gaisleri* – not present in Croatia), but intermediate between *P. austriacus* and *P. kolombatovici*.

Comparing *P. kolombatovici* and *P. auritus*, the echolocation calls of *P. auritus* for a given call duration are more broadband than the calls of *P. kolombatovici* across call durations (see Figure 15 – 17 and Table 6). Given this, in most situations, and given good recordings, it should be possible to distinguish *P. kolombatovici* and *P. auritus* acoustically. We also have not found examples of D Type social calls of *P. auritus* that are similar to common D Type social calls of *P. kolombatovici* recorded on Lokrum (Figure 21). Not illustrated here, but the difference between the echolocation calls of *P. auritus* and *P. austriacus* are even more extreme, where again in most situations it should be possible to distinguish these two species acoustically.

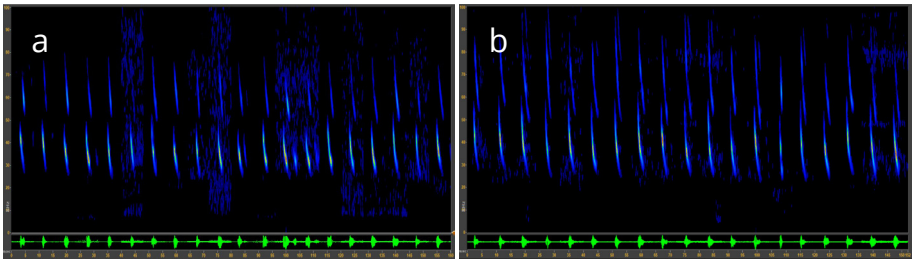

Figure 15. Echolocation calls duration 1.2 – 1.6 ms: a) *P. kolombatovici*, b) *P. auritus*.
Slika 15. Eholokacijsko glasanje duljine 1,2 – 1,6 ms: *P. kolombatovici*, b) *P. auritus*.

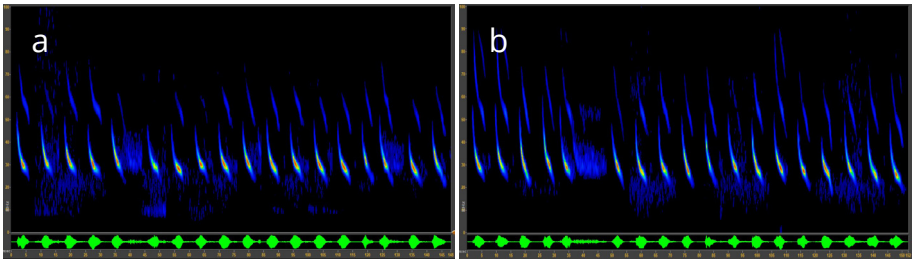

Figure 16. Echolocation calls duration 3.9 – 4.0 ms: a) *P. kolombatovici*, b) *P. auritus*.
Slika 16. Eholokacijsko glasanje duljine 3,9 – 4,0 ms: a) *P. kolombatovici*, b) *P. auritus*.

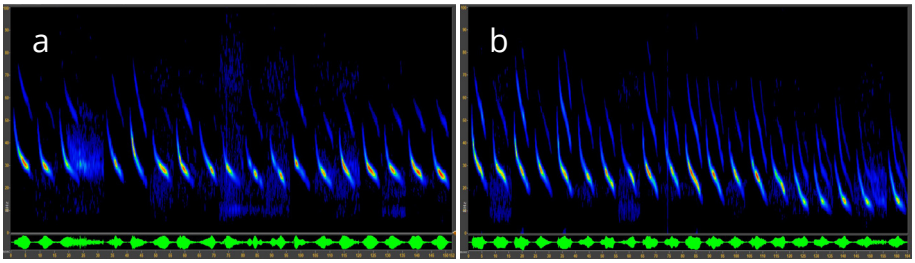

Figure 17. Echolocation calls duration 5.6 – 5.8 ms: a) *P. kolombatovici*, b) *P. auritus*.
Slika 17. Eholokacijsko glasanje duljine 5,6 – 5,8 ms: a) *P. kolombatovici*, b) *P. auritus*.

For *P. kolombatovici* and *P. austriacus*, the short duration calls of these species are very similar (see Figure 18 and Table 6), but as the call duration increases, there is a tendency for *P. kolombatovici* calls to be more broadband than those of *P. austriacus*, and to have higher start and end frequencies on average (as illustrated in Figure 19 and Table 6). These small differences seem to persist as the call durations get longer (see Figure 20 and Table 6), but there is some overlap. As a more general point, *P. kolombatovici* tends to have the highest end frequency for a given call duration of all *Plecotus* species here.

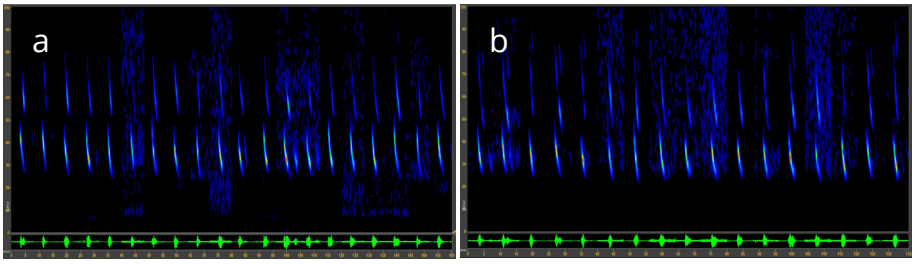

Figure 18. Echolocation calls duration 1.2 – 1.6 ms: a) *P. kolombatovici*, b) *P. austriacus*.
Slika 18. Eholokacijsko glasanje duljine 1,2 – 1,6 ms: a) *P. kolombatovici*, b) *P. austriacus*.

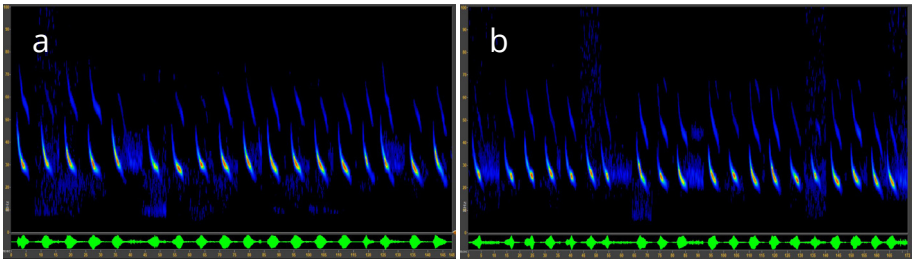

Figure 19. Echolocation calls duration 3.9 – 4.0 ms: a) *P. kolombatovici*, b) *P. austriacus*.
Slika 19. Eholokacijsko glasanje duljine 3,9 – 4,0 ms: a) *P. kolombatovici*, b) *P. austriacus*.

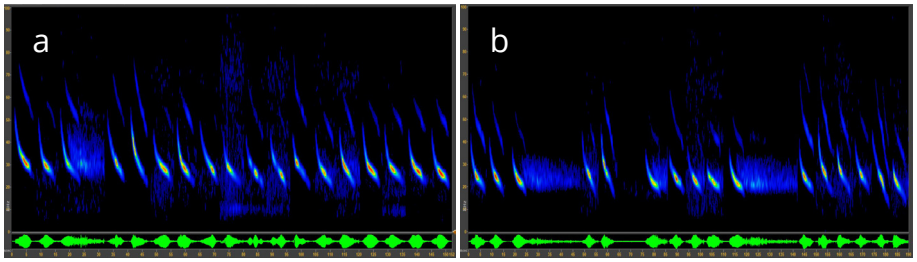

Figure 20. Echolocation calls duration 5.6 – 5.8 ms: a) *P. kolombatovici*, b) *P. austriacus*.
Slika 20. Eholokacijsko glasanje duljine 5,6 – 5,8 ms: a) *P. kolombatovici*, b) *P. austriacus.*

For *P. kolombatovici*, it has been reported by Dietz et al. (2009) that the two harmonics do not usually overlap (end frequency of the second harmonic ends above the start frequency of the first harmonic). Rnjak & Hamidović (2021) corrected this to state that the harmonics overlap most of the time. We revisit this in Table 7, by looking at the proportion of *P. kolombatovici* calls where there is an overlap in the two harmonics for different classes of signal duration.

Table 7. Proportion of calls of *Plecotus kolombatovici* (highlighted in grey) where there is an overlap in the two harmonics, in relation to the three other *Plecotus species* that are present in Croatia, and for the closely related *P. gaisleri*, broken down into classes of signal duration. The total sample size of calls considered is shown in brackets.

Tablica 7. Udio signala vrste *Plecotus kolombatovici* (označeno sivom bojom) gdje postoji preklapanje u dva harmonika, u odnosu na tri druge vrste roda *Plecotus* koje su prisutne u Hrvatskoj, te za srodnu vrstu *P. gaisleri*, razvrstani prema trajanju signala. Veličina uzorka svih promatranih signala prikazana je u zagradama.

Species Vrsta	**Class of call duration (no. of all analysed calls)** Razred duljine signala (broj svih analiziranih signala)				
	< 3 ms	**3 – 4.99 ms**	**5 – 6.99 ms**	**7 – 8.99 ms**	**≥ 9 ms**
	Overlap	**Overlap**	**Overlap**	**Overlap**	**Overlap**
P. kolombatovici	52% (166)	96% (146)	99% (172)	100% (117)	99% (537)
P. gaisleri	93% (14)	95% (105)	100% (79)	100% (29)	100% (16)
P. auritus	98% (126)	100% (194)	100% (189)	100% (132)	100% (27)
P. macrobullaris	67% (9)	100% (118)	99% (96)	-	-
P. austriacus	87% (121)	85% (151)	94% (95)	72% (93)	38% (34)

It is important to interpret the results for short duration calls (< 3 ms) of *P. gaisleri* and *P. macrobullaris* with caution because of the small sample of calls that were available, but Table 7 highlights some important differences between *Plecotus* species.

Firstly, given short duration calls of *P. kolombatovici* (< 3 ms), there is no overlap in the harmonics about 50% of the time. The difference between *P. kolombatovici*, and for example *P. auritus* where there was overlap in 98% of comparable short duration calls, is illustrated visually in Figure 15. However, for longer duration calls of *P. kolombatovici* of 3 ms or more, and as with most other *Plecotus* species, it becomes difficult to find examples where the harmonics do not overlap. This is seen in Figures 18 and 19.

It is also worth noting, that in contrast to other *Plecotus* species (accepting a sample size caveat for *P. gaisleri* and *P. macrobullaris*), it is not difficult to find longer duration (> 3 ms) examples of *P. austriacus*, where there is no overlap in harmonics.

If we consider the social calls (C and D Type social calls) of *P. kolombatovici* and *P. austriacus*, both species produce a broad range of social calls illustrated below (Figures 21 and 22). In *P. austriacus*, this species can also produce some long duration calls which could be confused with *Nyctalus* species (Piers Sangan pers. comm.). So far, we have not recorded similar long duration calls to these in *P. kolombatovici*.

For *P. kolombatovici*, the most common social calls produced in the Monastery building are shown in Figure 21a, and in Figure 22, we show longer examples up to 12.8 ms. We were initially considering whether these social calls with a hooked start were species specific, but we have since found similar examples for *P. austriacus* and for *P. gaisleri* (Figure 23).

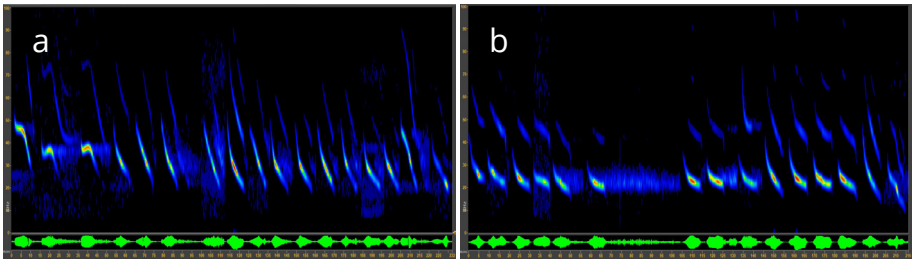

Figure 21. Social calls duration 8.4 – 8.7 ms: a) *P. kolombatovici*, b) *P. austriacus*.
Slika 21. Socialno glasanje duljine 8,4 – 8,7 ms: a) *P. kolombatovici*, b) *P. austriacus.*

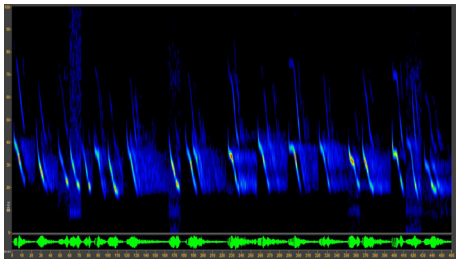

Figure 22. Social calls duration 11.1 – 12.8 ms of *P. kolombatovici.*

Slika 22. Socialno glasanje duljine 11,1 – 12,8 ms *P. kolombatovici.*

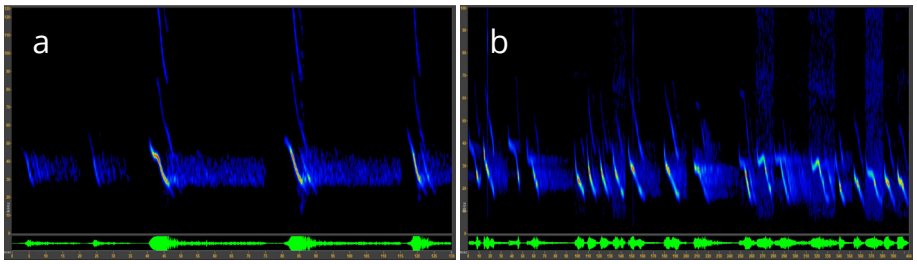

Figure 23. Social calls: a) *P. austriacus*, b) *P. gaisleri*.

Slika 23. Socijalno glasnje: a) *P. austriacus*, b) *P. gaisleri.*

Summary discussion

Although *P. kolombatovici* was recognised as a full species in 2008, its separation from *P. gaisleri* in 2020 is still relatively recent. This division has certainly helped clarify the distribution of the species but the genetic story of *P. kolombatovici* may not end there. Çoraman et al. (2013) found that on the analysis of mitochondrial DNA, there were two distinct clades of this species – one in the Balkans and another in southern Anatolia. Further research is needed to assess whether these clades constitute anything more than intra-specific variation within a single population. Interestingly, the habitat preferences presented here, in Pavlinić (2008) and by Đaković (2017), indicate a species with a preference for woodland foraging habitat, and this appears to be the norm across its distribution, with the exception of the records from central Türkiye where it is occurring in steppe habitat. This behavioural outlier reinforces the need to clarify the status of the Anatolian clade.

The geographically restricted and mainly island and coastal distribution of *P. kolombatovici* is unusual amongst bat species. It appears that unlike *P. austriacus* and *P. auritus* which have expanded out from their respective glaciation refugia, *P. kolombatovici* remained within its eastern Mediterranean peninsula refugia after the last Pleistocene glaciation (Spitzenberger et al. 2006). Having survived in its range

since the last glaciation, climate change scenarios may yet cause this species problems. As the climate envelope of species moves north, *P. kolombatovici* has nowhere to go (von Brackel 2022); there are no more-northerly coastal areas or islands for the species to occupy beyond the northern Adriatic.

Although we have shown that *P. kolombatovici* does occasionally roost in trees, most roosts found on Lokrum were in stone buildings or rock crevices in caves; none of the roosts in buildings were in or against timber. This roost type preference is supported by the wider records and is perhaps not surprising, as *P. kolombatovici* is part of the *austriacus* lineage, which originally evolved as a cave species (Horáček et al. 2004). Bats roosting in buildings and caves are often faithful to their roosting sites (Kunz 1982); however, we observed a significant amount of roost switching within the Monastery on Lokrum, with a core colony moving roost cavity every four to seven days. When this happens in tree bats, it is usually attributed to a build-up of faeces or parasites in roosts (Lewis 1995), but neither was evident in the cavities we inspected following their abandonment by the colony. In fact, one of difficulties in identifying occupied cavities during building surveys was the general absence of accumulations of droppings on the floor beneath entrances or stuck to the walls below entrances.

The internal temperatures of both the roosting cavities and crevices used by *P. kolombatovici* in this study were similar to those selected by *P. austriacus* (Scheunert et al. 2009). This temperature preference is cooler than that reported in some other European bat species (Kayikcioglu & Zahn 2004, Lourenço & Palmeirim 2004), which has implications for the provision of new roosting sites during building restoration or development mitigation projects.

We found daytime walk-over surveys of buildings for this species in the spring and summer were generally unproductive and gave little indication of the presence of this species or, when they were seen, the extent of the colony, despite knowing the building was extensively used by the species. The only time we saw a significant cluster (10+) of *P. kolombatovici* hanging out in the open was following the breeding season in the autumn. This behaviour was also recorded by Sachanowicz & Ciechanowski (2018). Another interesting feature of the roosting behaviour of this species was its dusk roosting within the building following emergence from its day roosts. The emergence period from the cavities within the Monastery typically lasted 15 – 30 minutes and the first bats out of the cavities were frequently earlier than we observed *P. kolombatovici* exiting the building or foraging in the vegetation close to the Monastery. This period before emergence was accompanied by a large amount of social activity. It appears that the colony members emerging earlier in the building were waiting until light levels outside dropped before they left the building to forage. As a piece of behaviour, the presence of dusk roosting *P. kolombatovici* may prove

a good indicator of the proximity of a breeding cluster of this species, hidden in a cavity.

Studies of the habitat preferences of *P. kolombatovici* are limited. At a wide landscape scale, Đaković (2017) studied the distribution and ecological features associated with the four *Plecotus* species found in Croatia using ecological models. She found *P. kolombatovici* preferred mixed forest habitats in areas with high summer temperatures. She also reports, *P. kolombatovici* had the narrowest ecological niche within the Croatian *Plecotus* bats. Pavlinić (2008) conducted the first radio-telemetry study on this species, during a comparative study with *P. macrobullaris* in Istria, Croatia. He radio-tracked 10 *P. kolombatovici* and analysed data from 9 of these animals. He found that upon emergence from their roost in a church, the bats flew to a large horse chestnut tree (*Aesculus hippocastanum*) close to the roost entrance and spent time there before moving away to forage. This behaviour bears similarities to the bats at Lokrum dusk roosting and waiting for light levels to drop before they finally leave to forage. Once they left the confines of the horse chestnut tree, the bats flew in a straight line directly to their foraging areas. The average foraging distance from the roost was 894 m, with the furthest distance travelled 4210 m. Pavlinić divided the landscape available to the bats into a hectare grid and assigned proportions of available habitat to each of these hectares. The dominant habitat types in the hectares used as foraging areas were deciduous woodland followed by meadow/pasture. He also found that *P. kolombatovici* was more likely to use forest vegetation associated with water courses.

The information presented here of our work on Lokrum island is the only other radio-tracking study of the species to date. The two study areas are strongly contrasting, with the Pavlinić study being conducted at the far north of its distribution range and some 12 km inland on the Istrian peninsula, compared with Lokrum island which is more centrally located in terms of the latitudinal range of this species and has a population on a small island. Consequently, any direct comparisons between the two are not possible. The small size of Lokrum island reduces foraging distances and foraging ranges, although bats roosting at the north of the island were not recorded foraging in the far south, despite only being 1.5 km away. One of our study animals was found to be roosting in the city walls of Dubrovnik 940 m from where it was captured on the island, a distance more closely aligned with the data collected by Pavlinić. Frustratingly, we were not able to collect foraging data using our radio-receivers for this animal, as there was strong interference from radio masts in the area of Lokrum it was using to forage.

We also used different methods of habitat preference analysis to Pavlinić (2008), who assessed the proportion of habitat by hectares in the area used by the foraging bats. Pavlinić reports the species' preference for deciduous woodland followed

by meadow/pasture; he also reported the woodland was more likely to be used if associated with a water course. Đaković (2017), who used a maximum entropy (MaxEnt model) to predict suitable habitat in Croatia for *P. kolombatovici,* found that in addition to the presence of mixed forest, distance to water channels was a key feature for this species, although this was not the case in her Ecological Niche Factor Analysis model (ENFA) model. Compositional analysis of the habitat preferences of *P. kolombatovici* on Lokrum island also indicated that woodland habitat was the highest ranked preference; however, in this area of the Mediterranean, deciduous trees were very limited and most tree species growing on the island were evergreen. Water bodies were also preferentially selected for; these accounted for only 0.07% of available habitat cover, but were the third ranked habitat type. The combination of short foraging distances from roosts and the 200 m buffer of foraging fixes used in the kernel analysis probably resulted in the inclusion of the Historical Buildings and associated gardens habitat type as the second ranked habitat type. The Amenity Parkland surrounding the Monastery consists of an Arboretum and closed canopy planted woodland. The more scrub habitats on the island were not selected for, nor were olive groves and wild olive trees. This contrasts with Davy et al. (2007), who only caught *P. kolombatovici* in olive groves on Zakynthos and Đaković (2017), who found olive groves contributed to the ENFA model she developed, although they were not significant in her MaxEnt models.

During our radio-telemetry study, we recorded bats repeatedly returning to preferred areas of habitat, but the impression we gained was that the bats were not stopping and gleaning at individual trees but instead were continually moving around the habitat and foraging using an aerial hawking technique; this was true of all the radio-tagged individuals. However, the light-tagging exercise, especially around the Monastery, indicated that *P. kolombatovici* were also gleaning prey during a hatch of moths from Box hedges (*Buxus sempervirens*), so it appears to have a flexible hunting strategy depending on prevailing circumstances.

P. kolombatovici produces echolocation calls that are typical for the genus *Plecotus*, with frequency modulated signals that commonly comprise two harmonics. We have not yet worked on *P. teneriffe* or *P. sardus* to see how these species compare, but of other European *Plecotus*, its echolocation calls are most similar to *P. austriacus* and *P. gaisleri*. In comparison with these, there is perhaps a tendency for the calls of *P. kolombatovici* to have a higher start and end frequency. More generally, *P. kolombatovici* almost always has a higher end frequency for a given call duration than other *Plecotus* species. Within a roost setting, *P. kolombatovici* commonly produces distinctive hooked social calls, but we have found very similar social calls in both *P. austriacus* and *P. gaisleri*. On Lokrum there is no species to confuse with *P. kolombatovici*, but more widely in Croatia, there are three other resident *Plecotus* species, including *P. austriacus, P. auritus* and *P. macrobullaris*. As discussed, there

are some challenges for distinguishing *P. kolombatovici* from *P. austriacus*, but for a given call duration, the calls of *P. kolombatovici* tend to have a higher start frequency than *P. austriacus* and are more broadband than the calls of *P. austriacus*. It should be possible to distinguish *P. auritus* from both *P. kolombatovici* and *P. austriacus* in most situations. Given short duration calls (< 3 ms), it is also useful to consider that there is often no overlap (about 50% of calls) in the two harmonics of calls of *P. kolombatovici*. This contrasts with some other *Plecotus* species like *P. auritus*, where it is unusual to find short duration calls where the two harmonics do not overlap (2% of calls).

Of all *Plecotus* species present in Croatia, we currently have the least experience with the sound identification of *P. macrobullaris*. From the call reference material that we have, it appears that for a given call duration, the other call measurements of this species are intermediate between *P. kolombatovici* and *P. austriacus.* In agreement with Dietrich et al. (2016), the calls of *P. macrobullaris* also appear to be more similar to *P. austriacus* than to *P. auritus*. However, it is difficult to draw too much from this at this stage, until we are able to carry out a similar targeted study to collect and review a much more extensive reference library of *P. macrobullaris* sound recordings than we have had access to date, to understand the range of variation of calls that can be produced by this species.

In summary, given an unknown *Plecotus* recording, an important first consideration is the quality of the recording. Firstly, to look at the ends of the calls, and to determine whether there is important attenuation of the weaker ends of the calls – in other words, whether you are missing the ends of the calls. Where there is attenuation of the calls, the apparent ends of the calls may appear to be higher in frequency than is really the case, and the start of the calls lower in frequency than is really the case. If there is important attenuation of the calls, it is often necessary to stop at this point and to not go further with an identification. If the quality of the recordings and calls is good, it is helpful next to consider what you would expect calls of possible *Plecotus* species, (given the observed call duration/s) to look like in comparison to these. In doing this, it is important to consider the body of evidence in support of one species over another, and if after this, it is thought that the calls could have been produced by more than one possible *Plecotus* species, that a cautious approach to species identification is taken.

The ecology of *P. kolombatovici* is starting to clarify. It evolved as a cave roosting species and the indications are that it uses cracks, crevices and cavities in the walls and ceiling of caves as its main roosts. As with other bats, *P. kolombatovici* has adopted human structures that mimic the conditions in its original cave roosts, so it is found in mines, tunnels, and underground structures like military bunkers. Large buildings like churches and monasteries have sufficiently cavernous areas for these bats to

roost in internal cavities in these buildings.

Both Pavlinić (2008) and Whitaker & Karataş (2009) have, shown that in common with other *Plecotus* spp., Lepidoptera imagines are the predominant insect group in their diet; in Pavlinić's study accounting for over 75% of their prey. The second most important group were Hemiptera (Heteroptera), which made up about 13% of their diet in Istria. Diptera, Hymenoptera, Coleoptera, Neuroptera and Lepidoptera larvae accounted for the rest. Whitaker & Karataş (2009), reported that 100% of the diet of *P. kolombatovici* in Türkiye were Lepidoptera.

It appears to be a predominantly forest foraging species, adopting different types of woodland depending on their geographical location. The steppe habitat of their central Anatolian range appears to be an outlier, but interestingly another 'forest' species, *Barbastella barbastellus* is also found in this area (Karataş et al. 2020). The presence of water bodies as a preferred habitat is probably not surprising in the more arid parts of its distribution range, but worryingly open water is a dwindling resource on many of the Mediterranean islands where the species is currently found. During survey work by the authors on a variety of Mediterranean islands we have seen water bodies drying up and in some cases being covered over to prevent mosquitos breeding or where they had previously been traditional agricultural watering holes, allowed to become derelict. All of this is limiting the water supply for this species and others, a matter that is crying out for a good conservation project to address this issue.

Following the separation of this species from *P. gaisleri*, it has recently been re-classified following a European IUCN Red List Assessment as 'Vulnerable' (Russo & Cistone 2023). We feel this is a realistic assessment of the current status of the species, which should spur others on to address the conservation of the species in the limited number of countries in which it is resident.

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Details on first observations of *Plecotus kolombatovici* in Montenegro

Detalji prvih zapažanja *Plecotus kolombatovici* u Crnoj Gori

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Abstract

We report on three records of *Plecotus kolombatovici* in SW Montenegro. The first, an adult male was found in crack in an old stone bridge, while the second, also an adult male was mist netted nearby on the same day. The third record was of a parous female found hibernating in a cave. These records are proof that *P. kolombatovici* is a resident species in Montenegro, and 32nd bat species recorded in the country.

Key words: distribution, bats, *Plecotus kolombatovici*, Montenegro

Sažetak

Izvještavamo o tri nalaza vrste *Plecotus kolombatovici* na jugozapadu Crne Gore. Prvi nalaz je jedan odrasli mužjak pronađen u pukotini ispod starog kamenog mosta, dok je drugi, također odrasli mužjak, istog dana uhvaćen u blizini mrežama. Treći nalaz je pronađena ženka koja se već kotila u stadiju hibernacije unutar pećine. Ovi nalazi dokaz su da je *P. kolombatovici* rezidentna vrsta u Crnoj Gori i 32. vrsta slijepih miševa zabilježena u zemlji.

Ključne riječi: rasprostranjenost, slijepi miševi, *Plecotus kolombatovici*, Crna Gora

Plecotus kolombatovici Đulić, 1980, is one of the four *Plecotus* species resident on the Balkan peninsula (Russo 2023). It has been recorded in coastal areas, but also deeper inland in countries neighbouring Montenegro, namely Croatia (e.g. Tvrtković et al. 2005), Bosnia and Herzegovina (Presetnik 2017, Presetnik et al. 2022) and Albania (e.g. Benda et al. 2019). Therefore, it was assumed it also inhabits Montenegro, for example on IUCN maps by Benda & Piraccini (2023). Šestović et at. (2021) reported its presence in an area of Mountain Orjen in the SW Montenegro, though not exact site was given. Therefore, here we present the details of these first records and the observations on the specimens collected during field work in 2020 and early 2024.

During the day on 25 July 2020, we inspected the old stone bridge over the Zaslapnica river (also known as Nudolska rijeka) (Figure 2) near the hamlet of Kamiševo of the village Nudo (42.66918° N, 18.57841° E, 435 m a.s.l.). In a crack between stones, we noticed a bat, which we extracted, measured, and identified to species, before returning it to the roost. The same day in the evening, we set up 6 m mist net (Ecotone Series 700 Mist Net 16 mm mesh). The net was placed diagonally above the puddle of dried up Zaslapnica river under the big bridge (42.66936° N, 18.57766° E, 435 m a.s.l.), 50 m downstream from the first site. Nets were standing from the sunset till the midnight. Captured bats were quickly disentangled from the net and placed in a cotton bag awaiting morphological measurement and identification. On 9 February 2024, we conducted a winter bat census of Pećina Vojvode Dakovića cave at Grahovo village (42.6558° N, 18.6758° E, 710 m a.s.l.). This is a long horizontal cave with several large halls connected by narrower passages.

During all surveys *P. kolombatovici* were distinguished from other *Plecotus* species according to Dietz & Kiefer (2018) based on the shorter length of forearm, tibia, tragus, thumb and its claw and short length of III. and V. finger, but also based on the penis shape and lower lip. Sex, age and reproductive status were determined before the bats were released.

The crack at the height of 2.6 m, with the opening of 9 cm in diameter and 15 cm in depth in the old stone bridge in the Nudo village was a roost of single adult male of *P. kolombatovici* (Figure 1, Table 1). During more extensive bat survey at the nearby Zaslapnica river we mist netted another adult male of *P. kolombatovici* (Table 1). In Pećina Vojvode Dakovića cave we found a parous female hibernating app. 50 m inside the cave, partly inside a shallow celling fissure at the end of the first narrow passage. Fissure was located at a height of app. 1.4 m and temperature adjacent to the bat was 7.6°C.

All record sites are located in the karst landscape of Montenegro, on the thickest layer of carbonate rocks, where strong karst erosion is caused by a large amount of precipitation. This causes very small amount of fertile land, mainly at the bottom

of karst fields. In vicinity are arable land, pastures, small villages, hills, mountains overgrown with thickets and scrub-woods of oriental hornbeam (*Carpinus orientalis*) and manna ash (*Fraxinus ornus*) (Saveljić 2021). Although all record sites of *P. kolombatovici* are situated in SW part of Montenegro (Figure 1), in fact less than 10 km apart, this is possibly just coincidence and with further research this bat species may be found along all Montenegrin coastal areas. Nevertheless, summer and winter records confirm *P. kolombatovici* is a resident species in the country. Thus, it is a 32nd bat species confirmed for Montenegro (Presetnik et al. 2014, Rachwald et al. 2019, Mulaomerović & Husanović 2020, Šestović et al. 2021).

Table 1. Measurements of Kolombatovic's long-eared bat *Plecotus kolombatovici* from Montenegro. (/ – measurements were lost)

Tabela 1. Mjere primorskih ušatih slijepih miševa (*Plecotus kolombatovici*) iz Crne Gore. (/ – podaci su se izgubili)

Site Lokacija		**Old bridge Nudo village** Stari most selo Nudo	**Big bridge Nudo village** Veliki most selo Nudo	**Pećina Vojvode Dakovića Cave** Pećina Vojvode Daković
sex pol		M	M	F
reproductive assessment reprodukcijo stanje		adult / odrasli	adult / odrasli	ad, parous / odrasla, već se kotila
length [mm] dužina [mm]	**forearm** podlaktica	36.4	/	36.7
	tibia potkoljenica	16.1	/	17.2
	foot stopalo	7.0	/	6.0
	thumb palac	4.5	/	5.9
	thumb claw kandža na palcu	1.9	/	2.0
	III. finger III. prst	57.0	/	60.5
	V. finger V. prst	44.4	/	49.0
	tragus length dužina ušne resice	13.1	/	13.6
	tragus width širina ušne resice	4.0	/	5.1

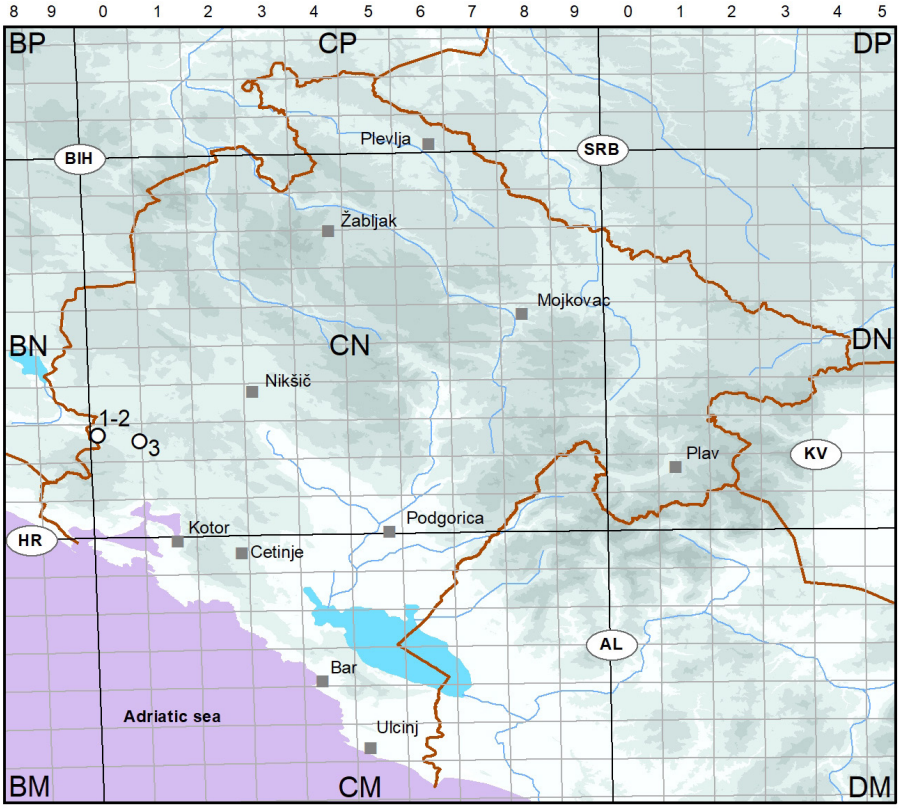

Figure 1. Record sites of *Plecotus kolombatovici* in Montenegro.
(1, 2 – Old stone bridge & Big bridge over Zaslapnica river, 3 – Pećina Vojvode Dakovića Cave)

Slika 1. Lokaliteti nalaza *Plecotus kolombatovici* u Crnoj Gori.
(1, 2 – Stari most i veliki most nad rijekom Zaslapnicom, 3 – Pećina Vojvode Dakovića)

Figure 2. The old bridge over dried up Zaslapnica river is the first record site of *Plecotus kolombatovici* in Montenegro (red arrow shows the roost site).

Slika 2. Stari most iznad presušene rijeke Zaslapnice je prvo nalazište primorskih ušatih slijepih miševa (*Plecotus kolombatovici*) u Crni Gori (crvena strelica pokazuje na sklonište).

(photo/foto: Marina Radonjić & Belma Šestović).

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Eptesicus serotinus, 9. 9. 2023, Učka Nature Park (Croatia)

Eptesicus serotinus, 9. 9. 2023., Park prirode Učka (Hrvatska)

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Učka Nature Park is located in southeastern part of Istrian peninsula and consists of Učka massif and southeastern slopes of Ćićarija massif. This area is characterised by a system of thrust fault structures in the north, i.e. Ćićarija area which is characterised by light slopes, and in the east, i.e. Učka area whose southern and eastern slopes are significantly steeper (Mejrušić 2020). So far, more than 500 caves and pits have been explored, some more than 150 m deep (Kukuljan & Grozić 2021, JU PP Učka et al. 2023). As a part of the project “Podzemlje Učke i Ćićarije 2023”, organised by Section for biospeleology of Biology Students Association – BIUS, a survey was conducted during the period from 4th to 10th of September 2023. Inside Vela peć cave (45.33312° N, 14.15815° E; Brest pod Učkom) bat skeletal remains were found, including a whole skull. Based on species determination using available literature (Đulić & Tvrtković 1979) the remains belong to the serotine bat (*Eptesicus serotinus*). Basic morfological

Park prirode Učka nalazi se na sjeveroistočnom dijelu Istarskog poluotoka, a čine ga područje planinskog masiva Učke te jugoistočni obronci Ćićarije. To područje karakteriziraju sustavi navlačnih rasjednih struktura na sjeveru, tj. na prostoru Ćićarije, za koju su karakteristični obronci blagog nagiba, i istoku, tj. na prostoru Učke, čije su južne i zapadne padine znatno strmije (Mejrušić, 2020). Područje Učke i Ćićarije obiluje speleološkim objektima. Do sada je istraženo preko 500 špilja i jama, neke i dubina većih od 150 m (Kukuljan & Grozić 2021, JU PP Učka et al. 2023). U sklopu projekta “Podzemlje Učke i Ćićarije 2023”, u organizaciji Sekcije za biospeleologiju Udruge studenata biologije – BIUS provedeno je istraživanje u razdoblju od 4. do 10. rujna 2023. godine. Unutar špilje Vela peć (45,33312° N, 14,15815° E; Brest pod Učkom) pronađeni su dijelovi kostura šišmiša, zajedno s cjelovitom lubanjom. Prema determinaciji vrste na temelju dostupne literature (Đulić ¸& Tvrtković 1979), pripadaju vrsti kasni noćnjak (*Eptesicus serotinus*). Osnovne morfološke mjere na

measurements of the serotine bat cranium which were used for determination confirmation are shown in Table 1. Also, during the cave inspection two horseshoe bats were observed (*Rhinolophus* spp.). In the cave itself small amount of waste was observed, suggesting occasional visits to the cave and therefore potential disturbance of present bats.

temelju kojih je potvrđena determinacija prikazane su u Tablici 1. Također, pregledom špilje utvrđena je prisutnost dvije jedinke potkovnjaka (*Rhinolophus* spp.). U samoj špilji zabilježena je i manja količina otpada što daje naznaku povremenih posjeta špilji , a samim time i potencijalnog uznemiravanja prisutnih šišmiša.

Tablica 1. Osnovne morfološke mjere i karakteristike lubanje vrste E. serotinus na temelju kojih je potvrđena determinacija.

Table 1. Basic morfological measurements and characteristics of the serotine bat cranium which were used for determination confirmation.

Morphological measures and characteristics Morfološke mjere i karakteristike
Cranial breadth in the auditory region is lower than cranial breadth in the zygomatic arch. Širina lubanje u slušnoj regiji je manja od širine u području zigomatičnog luka.
In every side of upper maxilla there is one premolar, and in every side of lower maxilla there are two premolars. U svakoj strani gornje čeljusti nalazi se po 1 pretkutnjak, a u donjoj čeljusti po 2 pretkutnjaka.
Dent in the palatine bone is small, narrow and shallow, and it reaches the line which connects canines' front edges. Udubljenje na nepčanoj kosti je malo, usko i plitko te dopire do crte koja spaja prednje rubove očnjaka.
Rear incisors in the upper maxilla are longer than one half of the larger front incisor. Stražnji sjekutići u gornjoj čeljusti veći su od polovice prednjeg velikog sjekutića.
Upper third molar is narrowed through the anterior posterior line. Gornji treći kutnjak sužen je u anteriorno-posteriornom pravcu.
Third commissure of third molar's chewing surface is two times smaller than its first commissure. Treća komisura žvačne površine trećeg gornjeg kutnjaka dva je puta manja od prve komisure.
Condilobasal length is 19.0 mm which matches the range from 18.9 to 21.2 mm for *Eptesicus serotinus*. Kondilobazalna dužina iznosi 19,0 mm što odgovara rasponu 18,9 do 21,2 mm vrste *Eptesicus serotinus*.

Figure 1. Entrance of Vela peć cave.
Slika 1. Ulaz u špilju Vela peć.
(photo/foto: Dora Kermek)

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Chiroptera, 31. 4. – 5. 5. 2023, 23. – 29. 9. 2023, Hrvatsko zagorje (Croatia)

Chiroptera, 31. 4. – 5. 5. 2023., 23. – 29. 9. 2023., Hrvatsko zagorje (Hrvatska)

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Biology Students Association – BIUS organized the research and education project “Zagorje zelene 2023” from 31st of April to 5th of May 2023 and from 23rd to 29th of September 2023. Bat presence was surveyed in potential overground and underground bat roosts in Krapina-Zagorje County and Varaždin County, with the focus mainly on caves of Strahinjčica, Ivanščica and Ravna gora. Hrvatsko zagorje is located in an isolated karst area in carbonate rocks characterised by smaller number of caves, often small in size (Ozimec & Šincek 2011). All bat individuals were determined using determination keys Dietz & von Helversen (2004) and Tvrtković (2017) during visual observation. All species and locations at which they were observed are listed in the text below:

Rhinolophus ferrumequinum

Dopolanščica, cave (46.275019° N, 16.059639° E; 24. 9. 2023) – 1 individual

Cincilator, cave (46.167609° N, 16.04507° E; 25. 9. 2023) – 2 individuals

Udruga studenata biologije – BIUS organizirala je istraživačko-edukacijski projekt “Zagorje zelene 2023” u razdobljima 31. 4. – 5. 5. 2023. i 23. 9. – 29. 9. 2023. Prisustvo šišmiša istraživano je u potencijalnim nadzemnim i podzemnim skloništima na području Krapinsko-zagorske i Varaždinske županije, s naglaskom na speleološke objekte Strahinjčice, Ivanščice i Ravne gore. Hrvatsko zagorje nalazi se na području izoliranog krša u karbonatnim stijenama kojeg karakterizira manji broj speleoloških objekata, često manjih dimenzija (Ozimec i Šincek, 2011). Svi su objekti pregledani u cijeloj duljini, pri čemu su sve uočene jedinke determinirane uz pomoć determinacijskih priručnika Dietz i von Helversen (2004) i Tvrtković (2017) na temelju vizualnog opažanja. U daljnjem tekstu donosimo popis svih vrsta i lokaliteta na kojima su pronađene:

Rhinolophus ferrumequinum

Dopolanščica, špilja (46.275019 N, 16.059639° E; 24. 9. 2023.) – 1 jedinka

Cincilator, špilja (46.167609° N, 16.04507° E; 25. 9. 2023.) – 2 jedinke

Rhinolophus hipposideros

Volarščica, cave (46.184293° N, 15.893218 E, 30. 4. 2023.) – 1 individual

Rana peć, cave (46.20164° N, 15.88483° E; 3. 5. 2023.) – 1 individual

Rana peć, cave (46.20164° N, 15.88483° E; 23. 9. 2023) – 3 individuals

Dopolanščica, cave (46.275019° N, 16.059639° E; 24. 9. September 2023) – 1 individual

Zdenec pri Ciglaru, cave (46.283905° N, 16.061034° E; 24. 9. 2023) – 3 individuals

Vilina jama, cave (46.18808° N, 15.864862° E; 27. 9. 2023) – 1 individual

Barbastella barbastellus

Škedenj, cave (46.270809° N, 16.023761° E; 25. 9. 2023) – 1 individual

Rhinolophus hipposideros

Volarščica, špilja (46,184293° N, 15,893218 E, 30. 4. 2023.) – 1 jedinka

Rana peć, špilja (46,20164° N, 15,88483° E; 3. 5. 2023.) – 1 jedinka

Rana peć, špilja (46,20164° N, 15,88483° E; 23. 9. 2023.) – 3 jedinke

Dopolanščica, špilja (46,275019° N, 16,059639° E; 24. 9. 2023.) – 1 jedinka

Zdenec pri Ciglaru, špilja (46,283905° N, 16,061034° E; 24. 9. 2023.) – 3 jedinke

Vilina jama, špilja (46,18808° N, 15,864862° E; 27. 9. 2023.) – 1 jedinka

Barbastella barbastellus

Škedenj, špilja (46,270809° N, 16,023761° E; 25. 9. 2023.) – 1 jedinka

Figure 2. Western barbastelle (*Barbastella barbastellus*), Škedenj cave (25th of September 2023).

Slika 2. Širokouhi mračnjak (*Barbastella barbastellus*), špilja Škedenj (25. 9. 2023.).

(photo/foto: Karla Tolić)

Miniopterus schreibersii

Old thermae building, Sutinske Toplice, no. cad. par. 2228
(46.11593 N, 16.00782° E; 25. 9. 2023) – 2 individuals

Miniopterus schreibersii

Ruševna zgrada toplica, Sutniske Toplice, br. kat. čest. 2228
(46,11593° N, 16,00782° E; 25. 9. 2023.) – 2 jedinke

Figure 1. Schreibers' Bent-winged bat (*Miniopterus schreibersii*), Sutinske Toplice (25th of September 2023)
Slika 1. Dugokrili pršnjak (*Miniopterus schreibersii*), Sutinske Toplice (25. 9. 2023.)
(photo/foto: Jure Banić)

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Nyctalus noctula, 24. 7. 2022, Gradiška (Bosna and Herzegovina)

Nyctalus noctula, 24. 7. 2022., Gradiška (Bosna i Hercegovina)

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Whenever we had the opportunity to travel and spend the night somewhere or at least return home after dark, we tried to record bat echolocation calls to fill as many gaps as possible in known distribution of bat species in Bosnia and Herzegovina. The opportunity presented itself when we decided to spend the weekend in northern Bosnia while surveying stork nests. On 24 July 2022 we found ourselves in the town Gradiška. Motel "Italy" (45.129074° N, 17.272922° E, 90 m a.s.l.) is located in a series of private houses with business premises. On one side there is a regional road, and on the other are gardens and arable land – a typical suburban area. We recorded echolocation calls with the D500X detector (Pettersson Elektronik AB), and the recordings were analysed using BatSound 4.1.4 software (Pettersson Elektronik AB) using available literature (Russo & Jones 2002, Barataud 2015). It's not exactly that the acoustic survey was successful. Still, *Nyctalus noctula* was detected on a larger number of recordings. Only

Kad god smo imali priliku otputovati i prenoćiti negdje ili bar se vraćati kući po mraku, nastojali smo snimati eholokacijske signale šišmiša da bi što više popunili praznine u poznavanju distribucije vrsta u Bosni i Hercegovini. Prilika se pružila kad smo odlučili vikend provesti u sjevernoj Bosni u obilasku gnijezda roda. 24. 7. 2022. našli smo se u Gradišci. Motel „Italy" (45,129074° N, 17,272922° E, 90 m n.v.) nalazi se u nizu privatnih kuća sa poslovnim prostorima. S jedne strane je regionalna cesta, a s druge strane su bašte i obradive površine – tipično suburbano područje. Tamo smo snimali detektorom D500X (Pettersson Elektronik AB), a obrada snimaka vršena je pomoću programa BatSound 4.1.4 (Pettersson Elektronik AB) na temelju dostupne literature (Russo & Jones 2002, Barataud 2015). Nije baš da je snimanje bilo uspješno. Ipak, na većem broju snimaka je registrovan noćni šišmiš (*Nyctalus noctula*). Pored njega zabilježena je još samo zvučna grupa *Pipistrellus kuhlii/nathusii*. Ipak, ovo je prvi podatak o šišmišima Gradiške (nekada Bosanske Gradiške) i

Pipistrellus kuhlii/nathusii phonic group was recorded alongside. Nevertheless, this is the first information about the bats of Gradiška (formerly Bosanska Gradiška) and the northernmost finding of a *N. noctula* in our country.

najsjeverniji nalaz noćnog šišmiša u našoj zemlji.

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Chiroptera, 16. 9. 2023, Ribnik Municipality (Bosnia and Herzegovina)

Chiroptera, 16. 9. 2023., opština Ribnik (Bosna i Hercegovina)

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The urban part of municipality of Ribnik stretches mainly in the north-south direction and is situated in the alluvial plain of the Sana River in its upper course. The landscape of Ribnik consists of private houses, farm buildings next to them and several smaller wood processing plants surrounded by arable agricultural land, orchards and gardens.

Working on the research on bats of the settlement of Pecka and the source area of the Sana River, we passed through this small municipality and made an auto transect on 16 September 2023. We recorded echolocation calls with ultrasonic detector Batlogger C (Elekon, Switzerland) and analysed them using BatSound 4.1.4 software (Pettersson Elektronik AB, Sweden) and literature (Russo & Jones 2002, Middleton et al. 2014, Barataud 2015).

Recorded species were: *Nyctalus noctula*, *Pipistrellus pipistrellus*, *P. pygmaeus*, *P. kuhlii*, *Hypsugo savii*, *Miniopterus*

Urbani dio opštine Ribnik proteže se uglavnom pravcem sjever-jug i situiran je u aluvijalnoj ravnici rijeke Sane u njenom gornjem toku. Pejsaž Ribnika čine privatne kuće, gospodarski objekti uz njih te nekoliko manjih pogona za obradu drveta okruženo obradivim poljoprivrednim površinama, voćnjacima i vrtovima.

Radeći na istraživanju šišmiša naselja Pecke i izvorišnog dijela rijeke Sane, prošli smo i kroz ovu malu opštinu i načinili auto transekt 16. 9. 2023. godine. Snimali smo eholokacijske signale ultrazvučnim detektorom Batlogger C (Elekon, Švajacarska), a njihova obrada vršena je uz pomoć programa BatSound 4.1.4 (Pettersson Elektronik AB, Švedska) i literature (Russo & Jones 2002, Middleton et al. 2014, Barataud 2015).

Zabilježene su vrste: *Nyctalus noctula*, *Pipistrellus pipistrellus*, *P. pygmaeus*, *P. kuhlii*, *Hypsugo savii*, *Miniopterus schreibersii* (za tačna nalazišta vidi Tabelu 1). Zvučna grupa *Pipistrellus kuhlii/*

schreibersii (for exact sites see Table 1). The phonic group *P. kuhlii/nathusii* was registered through the entire transect. These are the first data on bats for the municipality of Ribnik.

nathusii registrovana je na cijelom transektu. Ovo su prvi podaci o šišmišima opštine Ribnik.

Table 1. Sites of recorded bat echolocation calls in Ribnik Municipality, 16. 9. 2023.
Tabela 1. Nalazišta eholokacijskih zapažanja šišmiša u opštini Ribnik, 16. 9. 2023.

Species Vrsta	**lat. (° N)** širina (° N)	**long. (° E)** dužina (° E)	**m a.s.l.** m n.v.
Nyctalus noctula	44.475894	16.820944	275
Pipistrellus pipistrellus	44.416358	16.813367	340
	44.426228	16.830794	300
	44.421428	16.832817	295
Pipistrellus pygmaeus	44.422594	16.821947	310
	44.423536	16.830664	300
Pipistrellus kuhlii	44.417547	16.815125	325
	44.429442	16.829022	290
	44.428594	16.828969	290
	44.473903	16.823042	275
Hypsugo savii	44.417375	16.814064	330
	44.429442	16.829022	290
Miniopterus schreibersii	44.438319	16.829817	305

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Chiroptera, 7. 11. 2023, Lupac hill and Vjetrenice village, Vitez (Bosnia and Herzgovina)

Chiroptera, 7. 11. 2023., brdo Lupac i selo Vjetrenice, Vitez (Bosna i Hercegovina)

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An interesting trip with archaeologists from Vienna, Travnik and Zenica took us on 7 November 2023 to the surroundings of Gornji Vakuf and Vitez. Near the town Gornji Vakuf, there are several caves right above the Krupljanka spring, which will be excavated in the spring of the following year. There, 20 years ago, we saw a large number of horseshoe bats (*Rhinolophus ferrumequinum*) (Zagmajster et al. 2008), so this will be an opportunity for more detailed chiropterological survey of the caves.

This time we had to be satisfied with recording echolocation signals in the vicinity of Vitez, in the SE part of the municipality, from the Lupac hill to the first houses of the village of Vjetrenica, where it started to rain. Due to previous bad experiences with the microphone sensitivity for the Batlogger M (Elekon, Switzerland), we recorded very briefly, from 18:00 to 18:10. Ecolocation analysis was performed using BatSound 4.1.4 software (Pettersson Elektronik AB,

Zanimljiv izlet sa arheolozima iz Beča, Travnika i Zenice odveo nas je 7. 11. 2023. u okolicu Gornjeg Vakufa i Viteza. Kod Gornjeg Vakufa ima nekoliko pećina iznad vrela Krupljanke u kojima će se vršiti iskopavanja u proljeće iduće godine. Tamo smo prije 20 godina vidjeli veći broj velikih potkovastih šišmiša (*Rhinolophus ferrumequinum*) (Zagmajster et al. 2008) pa će to biti prilika da se pećine detaljnije hiropterološki istraže.

Ovaj put smo se mogli zadovoljiti samo snimanjem eholokacijskih signala u okolici Viteza, u SE dijelu općine, od brda Lupac do prvih kuća sela Vjetrenice gdje je počela da pada kiša. Zbog dosadašnjih loših iskustava sa osjetljivošću mikrofona za Batlogger M (Elekon, Švajcarska), snimali smo vrlo kratko, od 18:00 do 18:10. Analiza signala izvršena je uz pomoć programa BatSound 4.1.4 (Pettersson Elektronik AB, Švedska) i literature (Russo & Jones 2002, Barataud 2015).

Na Brdu Lupac (44,18803° N, 17,83852° E,

Sweden) and literature (Russo & Jones 2002, Barataud 2015).

On Lupac Hill (44.18803° N, 17.83852° E, 780 m a.s.l.), which is covered by an oak forest, we recorded the signals of *Hypsugo savii* and *Barbastella barbastellus*. On the outskirts of the village of Vjetrenica, in the hamlet of Zvizda (44.18312° N, 17.83727° E, 780 m a.s.l.) we recorded only the phonic group *Pipistrellus kuhlii/nathusii*.

From the Vitez area, we only have data from the SW part of the municipality (the Kruščica river and the cave of the same name), where *Rhinolophus hipposideros, Myotis myotis, Hypsugo savii* and the phonic group *Pipistrellus kuhlii/nathusii* were observed (Zagmajster et al. 2008, Pašić 2018).

780 m n. v.), kojeg pokriva hrastova šuma, snimili smo signale vrsta *Hypsugo savii* i *Barbastella barbastellus*. Na periferiji sela Vjetrenice, u zaseoku Zvizda (44,18312° N, 17,83727° E, 780 m n. v.) snimili smo samo zvučnu grupu *Pipistrellus kuhlii/nathusii*.

Sa područja općine Vitez imamo samo podatke iz SW dijela općine (rijeka Kruščica i istoimena pećina) gdje su opažene vrste *Rhinolophus hipposideros, Myotis myotis, Hypsugo savii* i zvučna grupa *Pipistrellus kuhlii/nathusii* (Zagmajster et al. 2008, Pašić 2018).

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Chiroptera, 20. 7. 2023, Koprivna, Slovenia

Chiroptera, 20. 7. 2023, Koprivna, Slovenija

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On 20 July 2023, during this year's Biology Students' Research Camp (Črna na Koroškem 2023), members of the bat research group revisited the highest known maternity roost of *Rhinolophus hipposideros* in Slovenia for the first time since 2016 (Presetnik 2017). The maternity colony is located in the attic of St. Jacob's Church in Koprivna (46.4544° N, 14.7471° E, 1,060 m a.s.l.). We found 20 *R. hipposideros* of undetermined age, 20 adults, 14 females with juveniles and one juvenile *R. hipposideros*, hanging on its own, which is almost twice as much as in the last survey in 2016. Additionally, in the bell fry, we found three individuals of *Plecotus* above the bells. We caught two adult males (Figure 1) and determined them according to Spitzenberger et al. (2002) and Dietz & Kiefer (2016). Key differences were observed in the shape of the lower lip, shape of the penis and in the density of hairs covering the toes. A difference in the colour of the fur which corresponded with the difference in species was also observed. Therefore, we determined one as *P. auritus* and the other as *P. macrobullaris*. By the best of

Na letošnji izvedbi Raziskovalnega tabora študentov biologije (Črna na Koroškem 2023) smo, 20. 7. 2023 člani skupine za preučevanje netopirjev, prvič po letu 2016, ponovno pregledali najvišje ležeče znano kotišče malega podkovnjaka (*Rhinolophus hipposideros*) v Sloveniji (Presetnik 2017). Porodniška kolonija je na podstrehi cerkve sv. Jakoba v kraju Koprivna (46,4544° N, 14,7471° E, 1.060 m n.m.). Našteli smo 20 malih podkovnjakov neznane starosti, 20 odraslih živali, 14 samic z mladiči in enega samostojno visečega mladiča malega podkovnjaka, kar je skoraj dvakrat več, kot ob predhodnem pregledu leta 2016. Poleg tega smo v zvoniku, nad zvonovi, videli tri uhate netopirje (*Plecotus*). Ujeli smo dva odrasla samca (slika 1) in jima določili vrsto, po znakih opisanih v Spitzenberger in sod. (2002) ter Dietz & Kiefer (2016), od katerih, so bili za razlikovanje bistveni predvsem oblika spodnje ustnice in penisa ter mesto in gostota sršečih dlakah na prstih zadnjih nog, značilna pa je bila tudi obarvanost kožuha. Izkazalo se je, da je bil eden rjavi uhati netopir (*P. auritus*) drugi pa usnjebradi uhati netopir (*P. macrobullaris*). Po našem vedenju je to prva najdba

our knowledge, this is the first case of both species in one summer roost at the same time in Slovenia.

omenjenih vrst uhatih netopirjev v istem poletnem zatočišču v Sloveniji.

Figure 1. *Plecotus macrobullaris* (left) and *Plecotus auritus* (right) in the church of St. James in Koprivna, on the 20 July 2023.

Slika 1. Usnjebradi uhati netopir (*Plecotus macrobullaris*) (levo) in rjavi uhati netopir (*Plecotus auritus*) (desno) v cerkvi sv. Jakoba v kraju Koprivna, 20. 7. 2023.

(photo/foto: Teodora Tanjević)

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Barbastella barbastellus, 21. 7. 2023, Ciganska jama Cave, Slovenia

Barbastella barbastellus, 21. 7. 2023, Ciganska jama, Slovenija

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On 21 July 2023, during the Biology Students' Research Camp – Črna na Koroškem 2023, members of the bat research group visited the Ciganska jama Cave (Slovene cave cadastre no. 3081, 46.47045° N, 14.79869° E, 753 m a.s.l.) in the Topla valley. It is a wide and high cliff overhang that following geological fault continues into a cave. The cave is a fissure a few metres wide, rising towards the end of the cave, with a ceiling about 10 m high. The cave polygon is 27 m long, and the height difference is 12 m (IZRK 2022). At the time of our visit, water was dripping from the ceiling almost everywhere, since days before there was a heavy rain in the wider area. We were surprised to find a subadult male of *Barbastella barbastellus*, partly hidden in a fissure on the wall of the cave, about 8 m high and just as far from the entrance. This is an unusual find, as no summer roosts of this species are known in caves in Slovenia (CKFF 2023).

Med Raziskovalnim taborom študentov biologije – Črna na Koroškem 2023 smo člani skupine za preučevanje netopirjev, 21. 7. 2023, obiskali Cigansko jamo (katastrska številka 3081, 46,47045° N, 14,7986° E, 753 m n.m.) v dolini Topla. Gre za širok in visok spodmol, ki se po prelomu nadaljuje v jamo. Le-ta je nekaj metrov široka poka, ki se dviguje proti koncu jame, s stropom visokim približno 10 m. Jamski poligon je dolg 27 m, višinska razlika pa je 12 m (IZRK 2022). V času našega obiska je skoraj povsod iz stropa precej kapljalo, saj je v predhodnih dneh na širšem območju močno deževalo. Presenečeni, smo v jami, delno skritega v razpoki na steni, približno 8 m visoko in prav toliko od vhoda, našli mladega samca širokouhega netopirja (*Barbastella barbastellus*). Najdba je neobičajna, saj v Sloveniji v jamah ne poznamo poletnih zatočišč te vrste (CKFF 2023).

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