



## Underground Habitats as a Unit for Bat Conservation in Southwestern Kyrgyzstan

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**Abstract:** The study was conducted in Southwestern Kyrgyzstan, which is a transboundary territory. The presence of limestone rocks from the Carboniferous and Devonian age determines the availability of many underground sites. These characteristics make the area an important place for cave-dwelling bat species. Assessment of bat abundance, species richness, and conservation priority of each cave was estimated using the Bat Cave Vulnerability Index (BCVI) for the first time outside the tropics. The method revealed that two underground sites are the most threatened and in need of protection. These caves are easily accessible and under constant anthropogenic pressure. Significant maternity colonies of *Rhinolophus ferrumequinum*, *Rh. lepidus*, *Myotis blythii* and *M. emarginatus* were confirmed in five caves. The most abundant summer colonies were found for *M. blythii* in two of these caves. We report for first time a maternity colony of *Rh. lepidus* in Kyrgyzstan due to its long-term erroneous identification as *Rh. hipposideros*. The results show that the IUCN conservation status of *Rh. hipposideros* must be reviewed and changed to “Near Threatened” or “Vulnerable” for the Central Asia region. The study will be used as a baseline for future conservation research on cave-dwelling bats and underground habitats in the region.

**Key words:** Central Asia, Chiroptera, caves, protection

### Introduction

Underground habitats, or caves *sensu lato*, represent natural openings mainly in limestone rocks and, rarely, in lava tubes. They are considered as azonal habitats unevenly distributed around the Earth, providing uniform environment characterised by total darkness (except in the entrance zone), relatively constant temperature, and humidity across all latitudes (FUREY & RACEY 2016, MOLDOVAN et al. 2018). They are suitable roosts for many bat species, protecting them against inclement weather and reducing the loss of body water (KUNZ 1982, GUNN 2003, AVILA-FLORES & MEDELLIN 2004). Caves are

used by bats as maternity colonies in the summer, hibernacula in the winter and swarming sites in the autumn and the spring (DIETZ et al. 2009, NAGY & POSTAWA 2010, DUNDAROVA 2018).

Considering that bats are extremely sensitive to habitat loss, pollution, disturbance, quarrying, mining and vandalism (BAKER et al. 1998, HUTSON & MICKLEBURGH 2001), regular monitoring of their colonies in underground sites is a widely used method for assessment of their species richness, age structure, seasonal changes, population trends and anthropogenic threats (PETROV 2008, KUNZ et al. 2009, BATTERSBY 2010). The main international agreements that are of particular relevance for the

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bat conservation include the Ramsar Convention, World Heritage Convention, CITES, Bonn Convention, Bern Convention, EEC Habitats and Species Directive and EUROBATS. However, national legal protection given to bats is varying across countries and, in some countries, bats receive no protection at all. According to HUTSON & MICKLEBURGH (2001), in Central Asia and the former Soviet republics, little information on the status and distribution of bat species is available. Studies of the bat fauna included the Soviet and the post-Soviet periods of the XX<sup>th</sup> century. Most of them presented sporadic data and were focused on Uzbekistan, Kazakhstan, Tajikistan and Turkmenistan (BOBRINSKOJ 1925, KUZYAKIN 1950, BOGDANOV 1953, BOBRINSKOJ et al. 1964, STRELKOV 1978, 1980, 1983, STRELKOV & SHAJMARDANOV 1983, KHABILOV 1980, 1992).

The first thematic study aimed to assess bat diversity in Kyrgyzstan reported 16 species (RYBIN et al. 1987). BENDA et al. (2011) provided a review of bats from Transcaucasia and West Turkestan and clarified some of the questionable taxa previously discussed by RYBIN et al. (1987) in Kyrgyzstan. Finally, KHABILOV et al. (2018) discussed the distribution of Blyth's horseshoe bat (*Rh. lepidus*) in Central Asia and its sympatry with the Lesser horseshoe bat (*Rh. hipposideros*).

Due to the absence of detailed research in Kyrgyzstan focused on the cave-dwelling bat specific sites, recent mining and quarry activities have been started without preceding impact-assessment. Since the importance of bat colonies in caves is largely unknown, need for detailed impact assessments in big infrastructure and exploitation planning can only be raised by providing basic data for the existence of the affected species groups. Furthermore, Kyrgyzstan has become a popular tourist destination during the last few years and most of the tour operators conduct illegal excursions to caves adjacent to villages. The influence of such anthropogenic factors has a negative impact on the species composition and abundance of bats.

The present article provides the results of a pilot study for the region of Central Asia and aims to: (1) assess the main threats for bat summer colonies in Southwestern Kyrgyzstan, (2) examine the underground habitats as possible units for bat conservation and (3) initiate a regular monitoring of cave-dwelling bat colonies in Southwestern Kyrgyzstan. The results are relevant to ecological and environmental issues linked to habitat loss, climate change and bat conservation decision-making.

## Materials and Methods

### Study region

The investigation was conducted in Southwestern Kyrgyzstan, located within the Tien Shan and Alai-Pamirs Mountain Systems in Central Asia. The total area is 46,195 km<sup>2</sup> and includes two provinces: Batken and Osh (Fig. 1a). This part has a transboundary character situated between Uzbekistan and Tajikistan. The territory can be divided into two main zones: arid with agricultural areas in the valleys, and mountainous, covered by sparse meadows or not covered by vegetation.

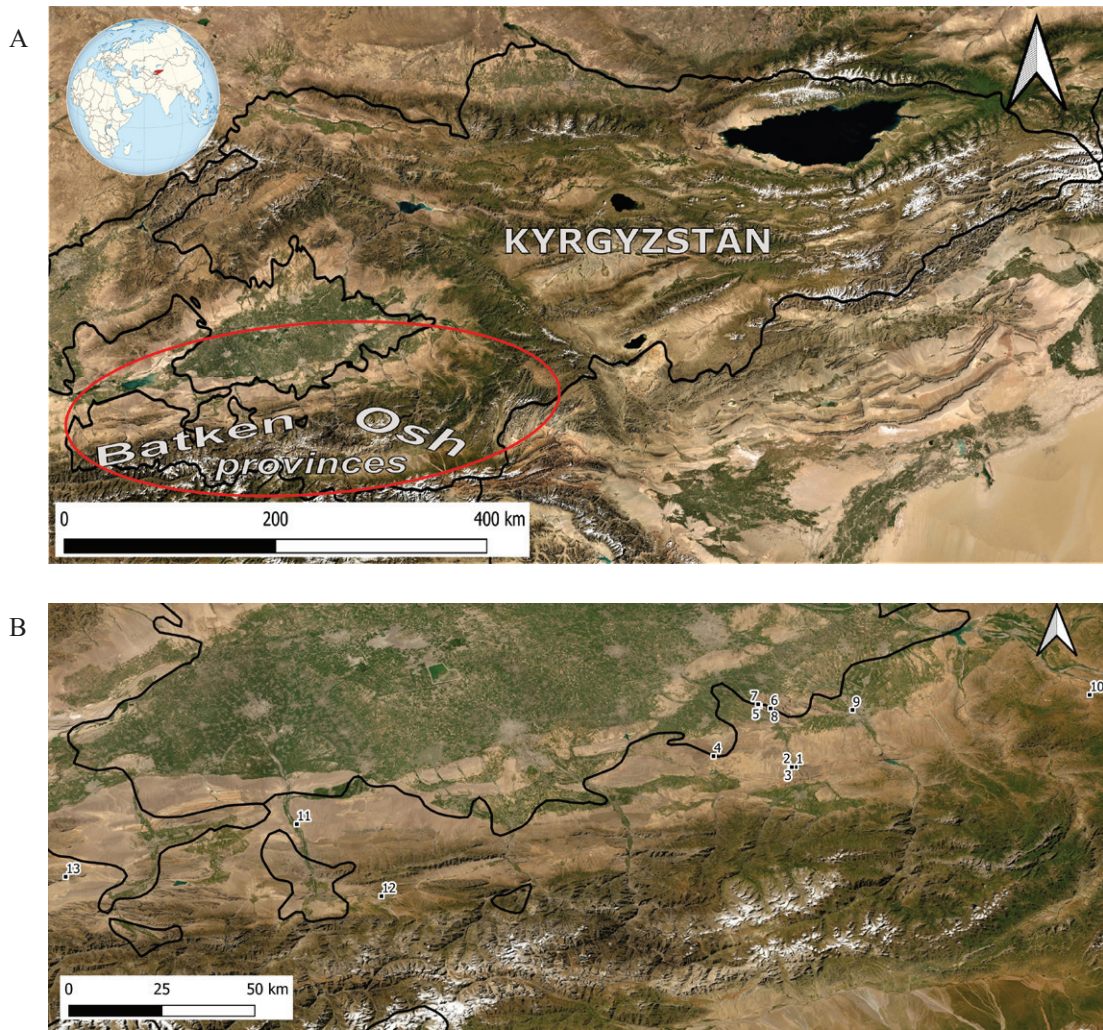
### Cave survey

Fieldwork was conducted during two periods: June – September 2018 and February 2019 – April 2019 (Table 1). Information about the caves and their accessibility was gathered from DUDASHVILI (2012) and OGUDIN (2013); according to these publications, more than 60 underground habitats in Carboniferous and Devonian limestones were present in the study region. The final decision for the valuable underground sites was taken using RYBIN et al. (1987), BENDA et al. (2011) and preliminary explorations in 2017 (Fig. 1b). Data were collected from each site, which was visited at least twice (once in the bats' active summer period and once in their hibernation period, see Appendix A, Table 1). The location and elevation of each cave was determined using a GPS unit. We also described the number of entrances, cave length and the presence of water.

### Bat surveys

Bat species were identified based on their morphological characteristics. Specimens were captured using mist-nets of different lengths. Every bat was placed in a separate cloth bag. Determination of the gender, age and reproductive status was provided for every individual. Calipers were used to take measurements of the length of the forearm (FA) and, for some species, additional measurements such as fifth finger (D5), third finger (D3), and the upper tooth-row length (CM3) (KUNZ et al. 2009) were also taken. All captured bats were released as soon as possible after being measured.

Population sizes were estimated for each species. In small clusters of bats, e.g., c. 30 individuals, they were counted directly in the cave. For larger colonies, a photographic method of counting inside the site was used (EUROBATS 2008). No voucher specimens were collected during this study. Capture and handling with the bats were carried out under the research permits No. 000025ZhO/2018 and



**Fig. 1.** Map of Kyrgyzstan. **A.** location of Osh and Batken Provinces in the southwestern part of the country. **B.** Studied underground sites: 1. Mine of Fersman; 2. Baritovaya; 3. Azhidar-Unkur; 4. Uлуу-Too; 5. Duvahan/Jarganat-Unkur; 6. Chil-Ustun; 7. Sasyk-Unkur; 8. Ashkana; 9. Sulaiman-Too; 10. Kara-Unkur. 11. Aktur-Pak; 12. Sulunkur, 13. Kan-i-Gut.

**Table 1.** Physical characteristics, location and visit time of 13 underground sites in Southwestern Kyrgyzstan; Summer (June – early August); Autumn (end of August – September); Winter (February – March); Spring (April), where “+” means visited and “-“ not visited.

Cave	Coordinates		Altitude (m)	Cave length (m)	No. of entrances	Water	2018		2019	
	N	E					Summer	Autumn	Winter	Spring
Mine of Fersman	40.3534	72.6095	1106	990	2	present	+	+	+	+
Baritovaya	40.3538	72.5938	1217	110	2	absent	+	+	+	+
Azhidar-Unkur	40.3533	72.5976	1226	120	1	absent	+	+	+	+
Uлуу-Too	40.3868	72.3549	1475		1	absent	-	+	+	-
Duvankhan -Unkur/ Jarganat-Unkur	40.5433	72.4975	937	110	1	absent	+	-	+	+
Chil-Ustun	40.5341	72.5319	1250	380	1	present	+	-	+	-
Ashkana niche	40.5349	72.5315	1220	30	1	absent	-	+	+	-
Sasyk-Unkur	40.5479	72.4931	659	115	1	absent	+	-	+	-
Sulaiman-Too	40.5299	72.7859	1123	10	passable	absent	+	+	-	-
Kara-Unkur	40.5769	73.5213	1812	100	1	present	-	+	-	-
Kan-i-Gut	40.0133	70.3462	1588	> 2000	2	absent	+	-	-	-
Aktur-Pak	40.1764	71.0625	880	50	1	absent	+	-	-	-
Sulunkur	39.9533	71.3254	1865	30	1	absent	-	-	-	+



Fig. 2. Maternity colony of *Rhinolophus lepidus* in the Mine of Fersman.

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#### Assessment of conservation priorities for the caves

The conservation priority of each cave was estimated using the Bat Cave Vulnerability Index (BCVI) based on the bat species diversity and the presence of human-induced threats (TANALGO et al. 2018). The index has been tailored to evaluate rapidly cave biotic potential and vulnerability based on bat species diversity and the presence of human-induced threats using two components. The first one is Biotic Potential Index (BP), which contains species richness, abundance, relative abundance, endemism and conservation status (IUCN 2018) and rarity index. The BP index values varies between 1 and 4, where level 1 is the highest and 4 the lowest.

The second component is the Biotic Vulnerability Index (BV), which gives information on cave accessibility, morphology, visitation and land use in adjacent areas. The BV index values are A, B, C, and D, where A represents the highest vulnerability to disturbance and D means no disturbance.

Underground roosts in the study area were classified using the combined values of BP and BV. Caves classified under 1A, 1B and 2A values have the highest conservation priority. Caves under 1C

and 3D have moderate conservation priority, and those under category 4 have low conservation priority (for description, see TANALGO et al. 2018).

## Results

Overall, 13 underground sites (natural and artificial), 10 in Osh Province and 3 in Batken Province, were studied (Fig. 1). The average elevation was 1260 m a.s.l. The minimum altitude was 659 m a.s.l. (Sasyk-Unkur cave) in Osh and the maximum was 1865 m a.s.l. (Sulunkur cave) in Batken Province. The length of the caves varied from 10 m in the Sulaiman-Too cave to more than 2000 m in Kan-i-Gut cave, with average cave length of 472 m. Most of the caves were with one entrance. Water was present only in three of them (Mine of Fersman, Chil-Ustun and Kara-Unkur), see Table 1. Technical equipment was required for the vertical passage of Fersman mine and for rock climbing to the entrance of Chil-Ustun cave.

During the cave survey, 11 bat species of three families were registered. These were: the family Rhinolophidae: *Rhinolophus ferrumequinum*, *Rh. hipposideros* and *Rh. lepidus*); the family Vespertilionidae: *Myotis blythii*, *M. emarginatus*, *Eptesicus ognevi*, *Hypsugo savii*, *Pipistrellus pipistrellus*, *Barbastella caspica* and *Plecotus strelkovi*) and the family Molossidae (*Tadarida teniotis*). Significant

**Table 2.** Bat conservation status and population trends in the studied caves, where \* indicates significant abundance, \*\* significant species richness (diversity), and \* the highest abundance and species diversity. NE – not evaluated.

Species	IUCN status	Population trends	Cave sites												
			Fersman**	Baritovaya*	Azhidar*	Uluu	Duvahan*	Chil*	Sasyk**	Ashcan**	Sulaiman	Kara	Aktur	Sulunkur	Kan-i-Gut
<i>Rh. ferrumequinum</i>	LC	Decreasing	158	595		6		10	111	1				1	
<i>Rh. hipposideros</i>	LC	Decreasing				3				1					
<i>Rh. lepidus</i>	LC	Unknown	1809					580		1			1		
<i>M. blythii</i>	LC	Decreasing	71	877	6600	105	10409		2			1			
<i>M. emarginatus</i>	LC	Stable		36		1			1		1				
<i>E. ognevi</i>	NE	Unknown							1						
<i>H. savii</i>	LC	Stable	2						1	1					
<i>P. pipistrellus</i>	LC	Stable								11	10				
<i>B. caspica</i>	NE	Unknown	5	1									2		4
<i>P. strelkovi</i>	NE	Unknown	3												
<i>T. teniotis</i>	LC	Unknown							3	2					
Abundance (A)			2048	1509	6600	115	10409	590	119	17	11	1	3	1	4
Species richness (S)			6	4	1	4	1	2	6	6	2	1	2	1	1

bat abundance was found in four caves, significant species richness in three caves, and both parameters only in one cave (Table 2). The prevalent species were *M. blythii* ( $n > 10000$ ), *Rh. lepidus* ( $n > 1700$ ) and *Rh. ferrumequinum* ( $n > 500$ ), followed by *M. emarginatus* ( $n > 20$ ) and *P. pipistrellus* ( $n > 10$ ). Less frequent species were *Rh. hipposideros*, *E. ognevi*, *H. savii*, *B. caspica*, *P. strelkovi* and *T. teniotis* (Appendix A, Table 1).

Most of the recorded bat species have been categorized applying IUCN criteria (IUCN 2021) as Least Concern (LC), for *Rh. ferrumequinum*, *Rh. hipposideros* and *M. blythii* with Decreasing population trends. Not-evaluated species and species with unknown population trends are *E. ognevi*, *B. caspica* and *P. strelkovi*. *Rh. lepidus* is classified as Least Concern with unknown population trends (Table 2).

### Evaluation of cave vulnerability and conservation priority

Assessment using the BCVI showed different vulnerability and conservation priority levels for each cave (Table 3). The BP index scored Mine of Fersman and Baritovaya cave as the most vulnerable (BP= 1), since the first one comprises the highest abundance and species richness, and they both comprise cave-dwelling bat species with decreasing and unknown population trends. Other caves were less

vulnerable (BP = 3 and 4), because of the relatively low species richness, mostly present by one common species and the absence of endemic species. Surprisingly, Azhidar-Unkur and Ashkana caves were evaluated with BP index 4, probably due to the high abundance of one common species in the first one and high species richness but less frequent species in the second one.

The BV index identified six caves as vulnerable (BV = A) due to their easy accessibility and signs of local exploitation and illegal tourism. Six caves had BV index status B, indicating their accessibility for local people. There was one cave – Ashkana with BV index status of C, which indicates its location in less accessible area and with fewer signs of exploitation.

Both BP and BV indices revealed the Mine of Fersman and Baritovaya caves as high priority underground sites for conservation (BCVI = 1A). Two caves were assessed as medium priority for conservation and nine caves were assessed as low priority for conservation. Azhidar-Unkur and Ashkana caves were assessed as low priority caves (BCVI = 4B and 4C) because they are less accessible for the local people and not popular for tourism. Duvankhan/Jarganat-Unkur were categorized with a high level of vulnerability (BV=A) but at the same time with low species richness (BP =4) due to the large population of one species.

**Table 3.** Assessing cave disturbance in Southwestern Kyrgyzstan using BCVI. This index is a combination between Biotic Potential Index (BP) and Biotic Vulnerability Index (BV) derived from assessing status of cave-dwelling bats and caves. Based on TANALGO et al. (2018).

BCVI		Priority	Description	Underground sites
BP index	BV index			
1	A	High	Largest population abundance and species richness, easy accessibility and highly prone to disturbance	Mine of Fersman, Baritovaya,
3	A	Medium	Relatively large population abundance of common species, low species richness, easy accessibility and highly prone to disturbance	Sasyk-Unkur
3	B	Medium	Relatively large population abundance of common species, low species richness, lesser accessibility, but prone to disturbance	Chil-Ustun
4	A	Low	Large population abundance, one species, easy accessibility and highly prone to disturbance	Duvankhan/Jarganat-Unkur, Sulaiman-Too, Aktur-Pak
4	B	Low	Relatively large population abundance, one species, lesser accessibility, and prone to disturbance	Azhidar-Unkur, Uluu-Too, Kan-i-Gut, Sulunkur, Kara-Unkur
4	C	Low	Small population abundance, relatively high species richness, lesser accessibility, and less prone to disturbance	Ashkana

## Discussion

### Bat abundance and diversity

The most abundant cave-dwelling species were *Rhinolophus ferrumequinum*, *Rh. lepidus*, *Myotis blythii* and *M. emarginatus* in the Mine of Fersman, Baritovaya, Azhidar-Unkur, Duvankhan/Jarganat-Unkur, and Chil-Ustun caves. Comparing our results with the available literature (BOGDANOV 1953, RYBIN et al. 1987, KHABILOV 1992, BENDA 2011, TADZHIBAeva 2018), these sites included one of the biggest maternity aggregations of *Rh. lepidus* and *M. blythii* in Central Asia (Table 2). Due to the fact that for a long time *Rh. lepidus* was mis-identified as *Rh. hipposideros* (BENDA et al. 2016), we confirm nursery colonies of *Rh. lepidus* (Fig. 2) for the first time in Kyrgyzstan (in the Mine of Fersman and Chil-Ustun Cave). During the field study, we found only four individuals of *Rh. hipposideros*, one in a mist-net in front of Ashkana Cave in the summer and three hibernated individuals in Uluu-Too Cave (Appendix A, Table 1). This observation and the wrongly assigned colonies of *Rh. lepidus* in previous studies confirm that *Rh. hipposideros* is a rare element in the Central Asian fauna.

According to BOBRINSKOJ (1925), KUZYAKIN (1950), BOGDANOV (1953), BOBRINSKOJ et al. (1964), YANUSHEVICH (1972), STRELKOV (1978, 1980, 1983, 1987), STRELKOV & SHAJMARDANOV (1983), KHABILOV (1980, 1992), RYBIN et al. (1987) and BENDA et al. (2011), *Rhinolophus bocharicus* is a typical representative of the Central Asian cave-

dwelling bat fauna. The species was reported in the Mine of Fersman, Duvankhan/Jarganat-Unkur and Kan-i-Gut caves (RYBIN et al. 1987, BENDA et al. 2011, TADZHIBAeva 2018) in Kyrgyzstan. However, *Rh. ferrumequinum* and *Rh. bocharicus* are sibling species and the photographic method is not a useful tool for assessment in mix bat aggregations. Based on the morphometric characteristics, we failed to find *Rh. bocharicus* and all specimens were assigned to *Rh. ferrumequinum*.

We observed mixed maternity colony of *Rh. ferrumequinum*, *M. blythii* and *M. emarginatus* in Baritovaya Cave, where up to 30 individuals of *M. emarginatus* were directly counted. The biggest nursery sites belonging to *M. blythii* and exceeding 6000 and 10000 individuals were in Azhidar-Unkur and Duvankhan/Jarganat-Unkur (Appendix A, Fig. A1). However, neither *M. blythii* nor *M. emarginatus* were detected during the winter period. Small colonies of *M. blythii* were found in the beginning of the spring (April) in both caves.

*Pipistrellus pipistrellus s. l.* is one of the most common species in the Palearctic region (WILSON & MITTERMEIER 2019). Therefore, it was not surprising to find summer colonies in Ashkana and Sulaiman-Too Caves.

In addition, we captured a single representative of each of *Eptesicus ognevi*, *Hypsugo savii*, *Barbastella caspica*, *Plecotus strelkovi* and *Tadarida teniotis* in front of the Mine of Fersman, Baritovaya, Sasyk-Unkur, Ashkana, Aktur-Pak and Kan-i-Gut caves in the summer, and only *B. caspica* and *P.*

*strelkovi* in the Mine of Fersman and Baritovaya cave in the winter. These results corresponded well with the published data (BENDA et al. 2011) characterising these species as rarely-recorded species (except *T. teniotis*, a common bat in Southern Kyrgyzstan (RYBIN 1987, BENDA 2011), and *B. caspica*, a frequently reported species from Northern Tajikistan (TADZHIBAEVA 2018).

### Underground habitats as a unit for bat conservation

Generally, underground habitats in Southwestern Kyrgyzstan are drier due to the lower humidity resulting from the semi-arid climate zone (Beck et al 2018), compared with those in the Palearctic region (ZUKAL et al. 2017, BARLAS & YAMAÇ 2019). Water bodies were rarely present within the studied caves (Table 1), except in the Mine of Fersman, Chil-Ustun and Kara-Unkur caves in the Osh Province. Kara-Unkur cave is located in Jalpak – Tash, which is a hilly gypsum karstic terrain with thick loess cover. Bat guano and an individual of *M. blythii* were found inside during our visit in the late autumn. This cave is a potential significant roost for the bats inhabiting Jalpak – Tash, regarding the large area of the plateau and the absence of other suitable shelters. We also found both extremes for water bodies within the underground sites (appendix A, Fig. A2), sinter lakes in a typical limestone cave (Chil-Ustun) and hydrothermal karst with thermal water in the Mine of Fersman (DUDASHVILI 2012). Both caves are significant for the horseshoe bat species. The altitude of this study does not exceed 2000 m with maximum bat diversity around 1000 m. The highest cave, which we surveyed, was Sulunkur in the Batken Province. However, the weather was cold and snowy in the early spring and only one bat from the species *Rh. ferrumequinum* was observed. Both underground sites Kara-Unkur and Sulunkur were visited only once. The same applies to Aktur-Pak and Kan-i-Gut because of technical reasons.

Standardized assessment using BCVI revealed two underground sites (Mine of Fersman and Baritovaya cave) that were the most threatened and in need of protection. They are home to relatively diverse and abundant cave-dwelling bats and present important maternity sites for four bat species (*Rh. ferrumequinum*, *Rh. lepidus*, *M. blythii* and *M. emarginatus*) in Central Asia. These caves are in easily accessible locations and subjected to illegal tourism pressure. Unregulated tourism causes a variety of negative impacts, especially to the cave-dwelling bats, which might result in roost abandonment and/or decline in the population (FUREY et al 2016). Four additional caves (Sasyk-Unkur, Duvankhan/

Jarganat-Unkur, Sulaiman-Too, Aktur-Pak) are vulnerable, as these sites are prone to disturbance, in some of them signs of recent mining and vandalism were found. Two caves (Azhidar-Unkur and Ashkana) seemed to be naturally protected from the anthropogenetic pressure due to their inaccessibility regarding illegal tourism.

A pressing concern from the present study is that most of the species are classified as Least Concern (IUCN 2021). Contrary to this statement, our study displayed the rarity of *Rh. hipposideros* in the region. The species is also presented in the Red Data Book of Kyrgyzstan (DAVLETKELDIEV et al. 2007) and we suggest it to be categorised as Near Threatened or Vulnerable for the Central Asia area. In addition, three species (*E. ognevi*, *B. caspica* and *P. strelkovi*) are still not evaluated by IUCN due to the absence of sufficient and comparable information.

## Conclusion

We believe that the present study is a key step for the development of conservation strategies for protection of the most important and vulnerable to anthropogenic pressure underground sites in Southwestern Kyrgyzstan. Since more than 60 caves have been reported within the territory, this study provides baseline information for future long-term monitoring programmes of the bat colonies inhabiting these caves. Previous studies have been focused on bat taxonomy and diversity (RYBIN et al. 1987, BENDA et al. 2011), without information of the cave-dwelling species abundance and the conservation status of the maternity colonies. Our research confirms that underground sites in Southwestern Kyrgyzstan are important roosts for the cave-dwelling bats, playing an irreplaceable role as nursery sites and are inhabited by a rich bat fauna, regarding the bat diversity in the arid and semi-arid climate zone.

The majority of the bat species in Kyrgyzstan are of low conservation priority (least concern) because of their wide distribution in the Palearctic region. However, some species are locally rare or declining as is the case with *Rh. hipposideros*. Therefore, capacity-building programmes for bat researchers must be included in the national priorities and monitoring programs are to be established. In this way, scientists will be able to trace the change in populations and to take conservation actions if certain species are declining.

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**Contributions of authors:** HD conceived the project and designed the study. HD, KA, PM, GM, AN, and BS organised fieldwork and performed the field studies. HD analysed the data and wrote the article with input from all authors.

### Supplementary materials:

**Appendix** ([http://www.acta-zoologica-bulgaria.eu/2021/002569\\_appendix](http://www.acta-zoologica-bulgaria.eu/2021/002569_appendix)): Table A1. List of caves and bat species studied in 2018–2019; Fig. A1. Maternity colony of *Myotis blythii* including 10,390 individuals in Duvankhan/Jarganat-Unkur; Fig. A2. Water bodies within the underground sites. (a) Mine of Fersman and (b) Chil-Ustun cave.

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