Local bats diversity exceeded the regional bats diversity in Xinjiang, China

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Abstract

Echolocation acoustic signature identification is an ideal non-invasive field survey method for chiropteran diversity. Located in the far easternmost region of the Xinjiang Uyghur Autonomous Region where covers one sixth of China's land territory, Komul city includes a variety of landscapes, including typical mountains, plateaus, plains, and the Gobi Desert, which is home to a number of terrestrial animals. By gathering bat echo sound waves between July and September 2022 and during April 2023, we investigated bat species diversity in Komul, Xinjiang, China. As a result, we identified a total of 24 species of bats belonging to two families and ten genera, of which *Myotis* is the dominant genus with seven species, followed by *Pipistrellus* with four species, and both *Eptesicus* and *Nyctalus* come after with three species. 16 of these species are novel to Xinjiang. The altitudinal distribution of these species is 500m to 2200m above sea level, and their horizontal distribution includes most of the surveyed region, e.g., Barkol Kazakh Autonomous County, Arturk County, and Ivirghul District. From a conservation perspective, three species (*Miniopterus schreibersii*、*Myotis capaccinii* and *Nyctalus lasiopterus*) and two species (*Barbastella barbatellus* and *Myotis dasycneme*) are listed as "vulnerable" and "near threatened" in the IUCN Red List of Threatened Species, respectively. Rest of which are of least concern. Our findings provide a valuable reference for future ecological, genetic, and conservational studies of bats in China, especially in Xinjiang.

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Abstract: Echolocation acoustic signature identification is an ideal non-invasive field survey method for chiropteran diversity. Located in the far easternmost region of the Xinjiang Uyghur Autonomous Region where covers one sixth of China's land territory, Komul city includes a variety of landscapes, including typical mountains, plateaus, plains, and the Gobi Desert, which is home to a number of terrestrial animals. By gathering bat echo sound waves between July and September 2022 and during April 2023, we investigated bat species diversity in Komul, Xinjiang, China. As a result, we identified a total of 24 species of bats belonging to two families and ten genera, of which *Myotis* is the dominant genus with seven species, followed by *Pipistrellus* with four species, and both *Eptesicus* and *Nyctalus* come after with three species. 16 of these species are

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Key words: Chiroptera; Acoustic parameters; Species identification; Regional distribution; Xinjiang of China

1 INTRODUCTION

Chiroptera (bats) are one of the most successfully evolved taxa in all of mammalian evolution. With over 1400 species, they are the second largest order of mammals after rodents, and are found throughout the world, with the exception of the poles (Solari & Baker, 2007; Wilson & Mittermeier, 2019). They carry many naturally occurring epidemic diseases as well as a variety of newly emerging infectious pathogens. More than 200 different virus species have been found in bats to date (Moratelli & Calisher, 2015; Wu et al., 2016). Chiroptera is one of the most sophisticated eating mammal orders, mostly feeding on insects, while certain species have been known to consume fruits, pollen, or nectar. A few species suck animal blood (Calisher et al., 2006). Bats promote the succession of tropical forests and hasten the recovery of degraded regions, such as abandoned pastures (Galindo-González et al., 2000; Muscarella & Fleming, 2007), by acting as mobility agents for the seeds and pollen of hundreds of species (Wang & Smith, 2002; Kunz et al., 2011). From the standpoint of more immediate human welfare, bats play a crucial role in agriculture by functioning as biological agents for the suppression of important agricultural pests, minimizing plant damage, and increasing crop yields (Maine & Boyles, 2015; Taylor et al., 2017; Aguiar et al., 2021). Shortly, bats provide vital ecosystem services in the form of insect pest consumption, plant pollination, and seed dispersal, making them essential to the health of global ecosystems.

Bats have been on Earth for more than 50 million years (Teeling et al., 2005). Based on their morphology, genomes, and other characteristics, bats are further divided into two suborders: Yang bat suborder (Yangochiroptera) and Yin bat suborder (Yinpterochiroptera). The Yin bat suborder primarily uses vision to navigate, whilst the Yang bat suborder has significantly impaired vision and a sophisticated auditory system to adapt to the requirement to gather information about the surrounding environment by echolocation, hence the name echolocation bats (Bruns & Schmieszek, 1980; Griffin, 1974; Ulanovsky & Moss, 2008; Sulser et al., 2022). There are many different types of echolocation bats, which can be broadly divided into three groups based on the frequency composition patterns and characteristics of the echolocation acoustic signals they emit (Bruns & Schmieszek, 1980; Neuweiler, 2003; Jones & Teeling, 2006; Altringham, 1996; Smotherman et al., 2016): frequency modulated (FM) bats, whose vocal signals are downward sweeping FMs; constant frequency-frequency modulation (CF-FM) bats, whose vocal signals start with a very short FM component followed by a longer CF component; click bats, which have the ability to use echolocation and normally create a broadband (up to 80 kHz) sound signal for a brief period of time (40–50 μs) (Brewton et al., 2018). The CF component of the CF-FM bat echolocation signal primarily analyzes velocity-related data, whereas the FM component primarily analyzes distance and target detail data (Schnitzler & Denzinger, 2011; Kober & Schnitzler, 1990).

To identify bats, researchers often combine morphological characteristics with molecular techniques (Abduriyim et al., 2022), but sample collection is frequently challenging and capturing bats in the field can be harmful to them. Species identification and species diversity monitoring based on echolocation sound waves using acoustic sampling and machine learning are excellent techniques for bat conservation since the echolocation sound waves of bats are species-specific (Mac Aodha et al., 2018). Thus, it is possible to identify the species of bats in a given location by capturing their acoustic waves with an expert ultrasound recorder, evaluating them using acoustic spectroscopy, and doing so without disturbing the bats. The echolocation sound spectra of various bat species differ significantly according to species, and more than 80% of bat species can be correctly identified using echolocation sound waves (Papadatou et al., 2008; Russo & Jones, 2006; Sun et al., 2006).

With more than 140 recognized species, China has one of the highest bat species diversity rates in the world (Jiang et al., 2020). Although there are many different species of bats in the wild, more than half of them are currently experiencing rapid population declines (Frick et al., 2019), with bat numbers in China decreasing by 50% in just 20 years (Zhao, 2020). Bats are primarily threatened by habitat loss and degradation (Clarke et al., 2005; Andrews, 2018), pesticide usage (Liu et al., 2018; Heiker et al., 2018; Hu et al., 2016), anomalous global temperature change (Welbergen et al., 2008; Jones et al., 2009), and the effects of urbanized light and noise (Stone et al., 2015; Song et al., 2019; Jiang et al., 2019). Bat surveys and taxonomic studies have become more important as a result of the focus on ecological protection and enhancement of the ecological environment, as well as global climate change, more frequent human activities, and the introduction of significant human-animal epidemics. Understanding the background resources of bats will allow us to not only finish revising the previous classification system and possibly find new distributions, new record species, or new species, but also to provide crucial taxonomic support for future ecological conservation and restoration, the development and utilization of biological resources, and the prevention and control of significant epidemics.

13 species of bats have been recorded in Xinjiang Uyghur Autonomous Region (Xinjiang), belonging to 1 family and 8 genera (Huang et al., 2007; Jiang, 2015; Zhang, 2021), the largest region/province in China. The 13 bat species are derived from these three references (Huang et al., 2007; Jiang, 2015; Zhang, 2021), but they vary in age, by author, and with different results. Bat diversity in Xinjiang needs to be studied urgently. However, most of them lack of evidence of distribution (Abduriyim et al., 2022) and more locations unstudied. In addition, little is known about their chances of surviving and the dangers they are exposed to (Feijó et al., 2019). In order to provide a foundation for the conservation and management of bats in Xinjiang, particularly in Komul city, we employed the Song Meter SM4 bio-acoustic recorder to study the species and distribution of bats in Komul, Xinjiang.

2 MATERIALS AND METHODS

2.1 Study area profile

Located in the eastern part of Xinjiang, Komul is traversed by the eastern Tianshan Mountains and at the 91°06'—96deg23'E,40deg52'—45deg05'N (Fig. 1). It covers 142,100 square kilometers in total. With 100–250 mm of rainfall in the north, 30–50 mm in the south, and 500–600 mm in the Tianshan Mountains, Komul has a representative continental arid climate. However, because of the effect of the Tianshan Mountains, the climate varies significantly from north to south. There are numerous wild creatures, like the *Capra sibirica* , *Gazella subgutturosa* ,*Panthera uncia* , and *Ursus arctos* (Wang et al., 2023; Abduriyim, Nabi, Halik, 2018; Abduriyim, Zibibulla, Eli, et al., 2018), as well as birds like *Milvus migrans* , *Podoces hendersoni* , and *Aquila chrysaetos* , that call Komul home, but there are no reports of bats.

2.2 Echolocation recording

The survey was conducted in July-September 2022 and April 2023 in Komul, including Ivirghul District (YZQ), Barkol Kazakh Autonomous County (BLK) and Arturk County (YW). The bat surveys were conducted in two broad ways, active recording and passive recording. Active recording — a method of recording echolocation calls whereby the researcher actively orients the bat detector to follow bats as long as possible in real time; this method generally results in higher quality pulses and longer call sequences than passive recording. Passive recording – bat echolocation sampling from a spatially fixed recorder, in contrast to active recording. Our survey was conducted using both methods simultaneously. Firstly, we conducted treks in different habitats (urban, farmland, lakes, etc.), and when bats were encountered, echolocations were recorded using a Song Meter SM4 bioacoustic recorder (supporting sampling rates of 8000 ˜ 96000 Hz). The microphone was tied to a stick about 5 m away and headphones could be connected to monitor the real-time audio while recording, getting as close as possible to the bat to record its sound waves. The next step is to place the Song Meter SM4 bioacoustic recorder in the area where the bats are likely to be found according to their habits, set its GPS and the time to start and end recording (based on sunrise and sunset times), and place the microphone as high as possible to ensure the quality of the recorded sound waves.

2.3 Data analysis

Kaleidoscope Pro can be used to analyze recordings of bat calls for the purpose of automatic species identification. Verified recordings of bat calls are used as the foundation for Classifier Libraries in Kaleidoscope Pro. Classifier Libraries contain multiple individual Species Classifiers. Species identification works by comparing recordings of bat calls to a known Species Classifier. To ensure greater accuracy, adjust the Classifier Threshold Menu to +1 (Conservative) and select the Classifier Library "Bats of Europe 5.4.0". Use the default parameters for the remaining settings. We will be using Maximum-Likelihood Estimate (MLE), a statistical method that estimates the parameters of a model. In our case, MLE will help us determine the presence or probable absence of species at a specific location and time by using a classification matrix. Local bat presence was determined by MLE and P-values (Britzke et al., 2002).

3 Results

In total, we collected 78.859 GB of data, consisting of 15,893 recording files. The software analysis identified a total of 3853 recordings as a species. out of which 2780 were unidentified and 9260 were noise. Our results revealed the presence of 24 bat species belonging to ten genera and two families (Table 1). These genera included *Barbastella* (1 species), *Eptesicus* (3), *Hypsugo* (1), *Miniopterus*(1), *Myotis* (7), *Nyctalus* (3), *Pipistrellus* (4),*Plecotus* (2), *Tadarida* (1) and *Vespertilio* (1).

Table 1 also presents the acoustic parameters of 24 bat species, indicating that the maximum frequency (Fmax) is 96.695 +- 6.619 kHz and the minimum frequency (Fmin) is 14.103 +- 0.412 kHz. The duration of sound waves ranges from the longest at 13.106 +- 3.261 ms to the shortest at only 2.462 +- 0.258 ms. With the exception of *Miniopterus schreibersii* and *P. nathusii* , the Qual values are less than 10%, indicating that the collected bat sound waves are of high quality and can be used for further analysis.

Table 1 Acoustic parameters of bats identified in Komul city, Xinjiang Uyghur Autonomous Region, China

Species	Fc (kHz)	Sc (Octaves per Second)	Dur (ms)	Fmax (kHz)	Fmin (kHz)	Fme
Vespertilionidae						
Barbastella barbastellus	39.197±4.070	64.579±33.0249	2.877±0.397	44.441±5.281	37.292±3.285	40.59
Eptesicus isabellinus	24.467±0.793	21.597±13.145	5.691±3.351	27.536±1.147	23.379±1.458	25.04
E. nilssonii	29.748±0.809	17.959±2.532	12.405±0.582	39.180±4.177	29.165±0.580	31.77
E. serotinus	26.538±0.474	54.345±8.732	5.907±0.341	56.360±2.758	26.287±0.304	33.38
Hypsugo savii	31.332±1.231	38.946±27.734	9.471±3.857	40.350±5.595	30.862±0.982	33.00
Miniopterus schreibersii	51.534±1.050	27.016±19.235	3.890±0.495	66.186±.9104	51.371±0.103	54.39
Myotis alcathoe	49.142±2.928	244.437±30.441	2.462±0.258	76.815±6.467	44.148±1.184	57.23
M. brandtii	48.472±5.286	248.370±53.723	3.530±0.269	96.695±6.619	40.470±2.799	60.85
M. capaccinii	48.051±1.763	163.847 ±39.106	3.235±0.626	69.751±8.056	42.205±1.857	53.43
M. dasycneme	34.970±2.237	54.454±29.886	7.544±2.667	58.588±14.387	32.669±1.714	40.22
M. daubentonii	44.313±5.643	157.741 ±57.243	3.586±0.382	74.732±6.135	37.726±1.786	51.11
M. emarginatus	46.977±1.067	209.364 ±30.639	3.225±0.359	81.060±4.544	42.411±1.806	57.34
M. mystacinus	45.943±2.172	294.690 ±33.806	2.537±0.425	77.055±7.324	40.297±1.324	54.33
Nyctalus lasiopterus	17.766±1.121	8.873±5.565	13.185±6.898	21.515±4.199	17.669±1.063	18.77
N. leisleri	23.394±0.761	10.513±6.125	8.549±2.486	25.004±1.458	23.099±0.893	23.86
N. noctula	18.833±0.544	9.377±4.450	13.106±3.261	20.873±1.390	18.419±0.625	19.35
Pipistrellus kuhlii	36.982±1.039	12.876±13.240	8.260±2.247	40.446±4.434	36.465±0.820	38.08
P. nathusii	38.027±0.940	21.234±10.273	6.864±0.616	43.397±2.761	37.531±0.505	39.41
P. pipistrellus	45.602±0.900	17.830±13.844	5.749±1.225	52.585±5.911	45.286±1.306	46.88
P. pygmaeus	54.252±0.843	13.196±6.441	4.924±0.800	64.742±5.523	54.105±0.841	55.84
Plecotus auritus	18.711±2.949	99.802±16.058	6.103±1.110	36.706±7.218	17.917±3.109	23.43

Species	Fc (kHz)	Sc (Octaves per Second)	Dur (ms)	Fmax (kHz)	Fmin (kHz)	Fme
P. austriacus	23.957±2.082	130.498 ±76.078	3.357±0.588	38.487±3.759	21.766±1.485	26.96
Vespertilio murinus	25.523±0.353	25.164±6.551	8.106±0.567	39.822±2.676	25.401±0.340	28.46
Molossidae						
Tadarida teniotis	14.205±0.372	15.604±16.074	4.135±1.595	15.135±1.106	14.103±0.412	14.38

Note Fc: Average characteristic frequency (kHz) - the body of the call is the portion of the call consisting of the flattest slope where the characteristic frequency is typically the frequency at the latest part of the call body; Sc: Average characteristic slope (Octaves per Second), This is the slope of the body of the call, Positive values correspond to decreasing frequency while negative values correspond to increasing frequency; Dur: Duration of the call; Fmax: Maximum frequency detected in the call (kHz); Fmin: Minimum frequency detected in the call (kHz); Fk: Frequency at the beginning of the call body(kHz); Qual: Average call quality (%), A measure of the smoothness of the call where smaller values indicate a smoother call.

The distribution of bats varied among the regions studied. BLK had the lowest number of species with only 18, while YZQ and YW had the highest number with 24 species each (Table 2). In terms of horizontal distribution, BLK had the highest latitude, followed by YW, and YZQ had the lowest latitude. Regarding vertical distribution, the average elevation of BLK and YW was similar, while YZQ had a lower average elevation. The altitude distribution of various bat species varied. With the exception of *M. capaccinii* and *M. dasycneme* , the other five species of *Myotis* had an altitude range exceeding 1000 m, indicating a broad altitude distribution. Among the species studied,*Barbastella barbastellus* , *Hypsugo savii* , and *Vespertilio murinus* had the largest altitude distribution range. With the exception of *P. pipistrellus* and *P. pygmaeus* , the other two bat species were widely dispersed; *Eptesicus* and*Nyctalus* bats had a limited altitude distribution. *Tadarida teniotis* and *Miniopterus schreibersii* have comparable elevation distributions but not much of a range; Within the genus *Plecotus* ,*Plecotus* bats have a very different distribution of altitude. While *P. auritus* has a smaller altitude distribution, *P. austriacus* has an altitude range of more than 1000 m.

Table 2 Horizontal and vertical distribution of bats in Komul city, Xinjiang Uyghur Autonomous Region, China

Species	Distributions	Distributions	Distributions	Elevation	IUCN
	IZQ	BLK	YW		
Barbastella barbastellus	*		*	727-2153	NT
Eptesicus isabellinus	*	*	*	532-1586	LC
E. nilssonii	*	*	*	879-1338	LC
E. serotinus	*	*	*	532-1338	LC
Hypsugo savii	*	*	*	532-2153	LC
Miniopterus schreibersii	*		*	532-1586	VU
Myotis alcathoe	*	*	*	532-2153	DD
M. brandtii	*	*	*	532-2153	LC
M. capaccinii	*	*	*	532-1338	VU
M. dasycneme	*	*	*	1345-2153	NT
M. daubentonii	*	*	*	532-2153	LC
M. emarginatus	*		*	564-2153	LC
M. mystacinus	*	*	*	532-2153	LC
Nyctalus lasiopterus	*		*	532-1338	VU
N. leisleri	*	*	*	532-1338	LC
N. noctula	*	*	*	532-1345	LC
Pipistrellus kuhlii	*	*	*	532-2153	LC
P. nathusii	*	*	*	532-2153	LC
P. pipistrellus	*	*	*	532-1338	LC

Species	Distributions	Distributions	Distributions	Elevation	IUCN
P. pygmaeus	*		*	681-1651	LC
Plecotus auritus	*	*	*	532-1338	LC
P. austriacus	*	*	*	692-2153	LC
Tadarida teniotis	*		*	707-1338	LC
Vespertilio murinus	*	*	*	532-2153	LC

Notes: * Indicate existence

The number of recordings identifying the same bat species ranged from one to 1338 out of the 3853 total recordings. The presence of bats in the area was investigated using the Maximum-Likelihood Estimate and P-value, and the findings revealed that all bat populations, with the exception of *B. barbastellus* , *M. dasycneme* , *M. emarginatus* , and *M. mystacinus* , were less than 0.1 (Table 3).

Remarkably, the echolocation call structure and frequency of each bat species found in Komul may be used to distinguish one species from another, which is useful for acoustic identification and monitoring.

Table 3 The number of bats identified and the P-Value test

Species	Correct identification of quantity	Correct identification of quantity	Presence P-value
Barbastella barbastellus	*Barbastella barbastellus*	1	1.0000000
Eptesicus isabellinus	*Eptesicus isabellinus*	7	0.0065978
E. nilssonii	*E. nilssonii*	26	0.0000000
E. serotinus	*E. serotinus*	16	0.0000000
Hypsugo savii	*Hypsugo savii*	148	0.0000000
Miniopterus schreibersii	*Miniopterus schreibersii*	4	0.0713141
Myotis alcathoe	*Myotis alcathoe*	36	0.0000000
M. brandtii	*M. brandtii*	43	0.0000142
M. capaccinii	*M. capaccinii*	159	0.0000000
M. dasycneme	*M. dasycneme*	12	1.0000000
M. daubentonii	*M. daubentonii*	762	0.0000000
M. emarginatus	*M. emarginatus*	5	1.0000000
M. mystacinus	*M. mystacinus*	3	1.0000000
Nyctalus lasiopterus	*Nyctalus lasiopterus*	15	0.0000001
N. leisleri	*N. leisleri*	25	0.0000043
N. noctula	*N. noctula*	84	0.0000000
Pipistrellus kuhlii	*Pipistrellus kuhlii*	1037	0.0000000
P. nathusii	*P. nathusii*	1338	0.0000000
P. pipistrellus	*P. pipistrellus*	86	0.0000000
P. pygmaeus	*P. pygmaeus*	17	0.0000000
Plecotus auritus	*Plecotus auritus*	5	0.0814827
P. austriacus	*P. austriacus*	5	0.0011133
Tadarida teniotis	*Tadarida teniotis*	15	0.0000000
Vespertilio murinus	*Vespertilio murinus*	4	0.7985771

4 Discussion

Our survey's findings indicate that Komul has a wide variety of bat species, with a potential distribution of 24 bat species. The Classifier Libraries in Kaleidoscope Pro are built on verified recordings of bat calls. Multiple distinct Species Classifiers can be found in Classifier Libraries: Bat call recordings are compared to a database of known species classifiers to determine the species. There haven't been any prior bat surveys in Komul, and there is a dearth of acoustic data on bats in Xinjiang, China as well. Because the European bat database in Kaleidoscope Pro contains the vast majority of the known bats in Xinjiang, it was used for machine species identification of bats (Huang et al., 2007; Jiang, 2015; Zhang, 2021).

24 species of bats have been identified (Table 1), including 8 species recorded in Xinjiang, except *B. leucomelas*、 *E. gobiensis*、 *M. blythii*、 *M. nipalensis* and *M. petax* (Huang et al., 2007; Jiang, 2015; Zhang, 2021). The European bat database lacks acoustic data for these five species, so they have not been identified, but they may exist in Komul. Although *M. brandtii* and *P. auritus* are not distributed in Xinjiang, they are distributed in Gansu and Inner Mongolia (Jiang, 2015), and Komul borders Gansu and Inner Mongolia, and bats have strong flight ability, so their distribution is also very possible. 2780 unidentified recordings also indicate that above five species are likely distributed in Komul. Our results implied that the bat species diversity in Xinjiang possibly underestimated (Jiang, 2015) and it needs further investigation.

The Cicadellidae, Carabidae, Pyralidae, and Pieridae are some examples of the insects that the Vespertilionidae family of bats primarily consumes (Liang & Yang, 1985). A variety of crops, including grapes, Hami melons, jujube, and other crops, are grown in Komul, a famous hometown of melons and fruits in China. It is also a sizable area for raising other livestock, such as camels, sheep, and cattle. It has a large grazing area and is watered by the snow-melting-water from the Tianshan Mountains. Additionally, this leads to an abundance and diversity of mosquito species. The 24 bat species that were surveyed (Table 2) therefore fit the local natural context.

The area of Komul with the least number of bats is BLK (Table 2). The species variety of bats in local environments was mostly influenced by habitat types, according to previous studies, which revealed that the species richness pattern of bats declined with increasing latitude (Willig & Selcer, 1989). Since altitude gradients represent significant environmental changes over comparatively small geographic distances, they are especially helpful for examining patterns of biodiversity and their potential structural mechanisms (Korner, 2007). The species diversity of bats decreases with increasing height, Low altitudes are generally distributed in a rich manner (Cisneros et al., 2014; Martins et al., 2015). The distribution of bats is significantly impacted negatively by the low temperature environment in the high altitude area and the relatively isolated habitat type it has produced. The high altitude region also has a dearth of caves and other habitats, which further limits the ability of bats to survive there. But even though it's higher than YZQ, the variety of bats in YW is comparable (Table 2). It might be as a result of the river's lack of ice and the abundance of water resources in YW. The abundance of species is firstly influenced by water resources, and until elevation, the abundance of species does not further diminish. Second, YW has a good local habitat and is surrounded by mountains, both of which are key factors in determining the species richness of an area.

Among all the identified echolocation acoustic files, *Pipistrellus kuhlii* and *P. nathusii* had the most, with 1037 and 1338 respectively. *Barbastella barbastellus* has only one bat (Table 3), which indicates that the number of bats in Komul city varies greatly, which can also be seen from its protection level (Table 2). The value of P-value can judge its existence in Komul City (Britzke et al., 2002).

However, there are several issues with the bat detector. The identification accuracy of bat sound waves collected with bat detectors depends on a number of factors. For instance: Background noise and clutter can obfuscate the contour of a bat call that has been recorded. The simultaneous calling of several bats of the same species or similar species can lead to incorrect identification. The degree of identification accuracy can be significantly influenced by the distance between the bat and the microphone: This is so because call shape is what allows for identification. Depending on the distance or other amplitude changes, the call shape that is recorded may differ from the call that the bat actually makes; This may occur if the bat call's various frequency components are produced at various amplitudes. False positive and false negative identifications are to be anticipated. Bats use echolocation to navigate and hunt, thus they can adjust their sounds in the moment to suit their needs (such as catching insects or avoiding collisions) (Schnitzler et al., 2003; Lin et al., 2014). Additionally, different bat species have extremely diverse call repertoires (Mac Aodha et al., 2018), and it can be challenging to distinguish some of a species' calls from those of other bat species.

The P-Value of the 24 bat species varies greatly, with some being 0 and some reaching 1 (Table 3). These differences indicate the possibility of these bats existing in Komul City. All analysis tools must use a maximum-likelihood estimator approach rather than relying solely on a single sequence to identify the species present at the site because species identifications are never 100% accurate. P-values from the post-hoc maximum-likelihood estimator will be utilized to choose the acceptance levels for the identification decision (Britzke et al., 2002). The P-value is not perfect, despite being arguably the strongest statistical instrument we have at our disposal. A large P-value does not imply absence. Simply put, it indicates that there is insufficient statistical proof of presence. Furthermore, a low P-value does not prove the presence of something; it merely indicates that the data cannot support the null hypothesis of absence. A low P-value could indicate that a different hypothesis is more likely. Perhaps that is presence. However, it's also possible that the classification error matrix didn't fit the data well.

Despite being a thorough examination of Komul's bat population, this study had a number of limitations that should be considered when analyzing the findings. First of all, our survey did not do secondary confirmation using morphological and genetic methods. Instead, we employed biological recorders to capture the echo sound waves of bats and software to identify bat species. Second, only the echo acoustic waves produced when bats were moving were collected for this investigation since the acoustic properties of bats vary depending on the state of locomotion (Schnitzler et al., 2003; Lin et al., 2014). Although bat acoustics vary depending on the species, it is possible that some bat species are not widespread. We can further identify the species of bats by monitoring them in various locomotor phases, capturing their echo acoustic waves, assessing their physical traits, and using fog net capture to recreate bat circumstances in the wild through an indoor environment.

REFERENCES

Abduriyim, S.; Kasimu, T.; Lan, J.; Pu, Z.; Bai, J.; Wang, Y. (2022). Morphological and molecular confirmation of the common pipistrelle bat, Pipistrellus pipistrellus Schreber, 1774 (Vespertilionidae: Chiroptera), in Xinjiang, China. Mammalia, 86(3), 298-302.

Abduriyim, S.; Nabi, A.; Halik, M. (2018). Low genetic diversity in the goitered gazelle *Gazella subgutturosa* (Guldenstadt, 1780) (Artiodactyla: Bovidae) in North-western China as revealed by the mitochondrial cytochrome b gene. Acta zoologica bulgarica, 70(2), 211-218.

Abduriyim, S.; Zibibulla, G.; Eli, S.; Ismayil, Z.; Halik, M. (2018). Phylogeny and genetic structure of the goitered gazelle (Artiodactyla, Bovidae) in north-western China indicated by the hypervariable mitochondrial control region. Systematics and Biodiversity, 16, 527-537.

Aguiar, L.M.S.; Bueno-Rocha, I.D.; Oliveira, G.; Pires, E.S.; Vasconcelos, S.; Nunes, G. L.; Frizzas, M.R.; Togni, P.H.B. (2021). Going out for dinner – the consumption of agriculture pests by bats in urban areas. PLoS One, 16, e0258066.

Altringham, J.D. (1996). Bats: Biology and Behavior. Oxford: Oxford University Press, 2-30.

Andrews, H. (2018). Bat Roosts in Trees: A Guide to Identification and Assessment for Tree-Care and Ecology Professionals. Exeter: Pelagic Publishing.

Brewton, D.; Gutierrez, V.; Razak, K.A. (2018). Accurate sound localization behavior in a gleaning bat, *Antrozous pallidus* . Sci Rep, 8(1), 13457.

Britzke, E.R.; Murray, L.; Heywood, J.S.; Robbins. L.W. (2002). Acoustic identification. Identification of Echolocation Calls, 221-225.

Bruns, V.; Schmieszek, E. (1980). Cochlear innervation in the greater Horseshoe bat: demonstration of anacoustic fovea. Hear Res, 3(1), 27-43.

Calisher, C.H.; Childs, J.E.; Field, H.E.; Kathryn, V.H.; Schountz, T. (2006). Bats: Important reservoir hosts of emerging viruses. Clin Microbiol Rev, 19(3), 531-545.

Cisneros, L.M.; Burgio, K.R.; Dreiss, L.M.; Klingbeil, B.T.; Patterson, B.D.; Presley, S.J.; Willing, M.R. (2014). Multiple dimensions of bat biodiversity along an extensive tropical elevational gradient. Journal of Animal Ecology, 83: 1124-1136.

Clarke, F.M.; Pio, D.V.; Race, P.A. (2005). A comparison of logging systems and bat diversity in the neotropics. Conservation Biology, 19; 1194-1204.

Feijó, A.; Wang, Y.Q.; Sun, J.; Li, F.H.; Wen, Z.X.; Ge, D.Y.; Xia, L.; Yang, Q.S. (2019). Research trends on bats in China: a twenty-first century review. *Mammalian Biology* , 98, 163-172.

Frick, W.F.; Kingston, T.; Flanders, J. (2019). A review of the major threats and challenges to global bat conservation. Annals of the New York Academy of Sciences.

Galindo-González, J.; Guevara, S.; Sosa, V. J. (2000). Bat- and bird-generated seed rains at isolated trees in pastures in a tropical rainforest. Conserv. Biol, 14, 1693–1703.

Griffin, D.R. (1974). Listening in the Dark. NewYork: Dover Publications, 5-11.

Heiker, L.M.; Adams, R.A.; Ramos, C.V. (2018). Mercury bioaccumulation in two species of insectivorous bats from urban China: Influence of species, age, and land use type. Archives of Environmental Contamination and Toxicology, 75, 585-593.

Hu, Y.; Cheng, H.; Tao, S. (2016). The challenges and solutions for cadmium-contaminated rice in China: a critical review. Environment International, 92-93:515-532.

Huang, W.; Xia, L.; Feng, Z.J.; Yang, Q.S. (2007). Distribution pattern and zoogeographical discussion of mammals in Xinjiang. Acta Theriologica Sinica, 4, 325-337.

Jiang, T.L.; Guo, X.; Lin, A.; Wu, H.; Sun, C.; Feng, J.; Kanwal, J.S. (2019). Bats increase vocal amplitude and decrease vocal complexity to mitigate noise interference during social communication. Animal Cognition, 22(2):199-212.

Jiang, T.L.; Zhao, H.B.; He, B.; Zhang, L.B.; Luo, J.H.; Liu, Y.; Sun, K.P.; Yu, W.H.; Wu, Y.; Feng, J. (2020). Research progress of bat biology and conservation strategies in China. Acta Theriologica Sinica, 40(6), 539-559.

Jiang, Z.G. (2015). Diversity and geographical distribution of mammals in China. Beijing: science press.

Jones, G.; Jacobs, D.S.; Kunz, T.H.; Willig, M.R.; Racey, P.A. (2009). Carpe noctem: the importance of bats as bioindicators. Endangered Species Research, 8, 93-115.

Jones, G.; Teeling, E.C. (2006). The evolution of echolocation in bats. Trends EcolEvol, 21(3), 149-156.

Kober, R.; Schnitzler, H.U. (1990). Information in sonar echoes of fluttering insects available for echolocating bats. J Acoust, 82, 882-896.

Korner, C. (2007). The use of 'altitude' in ecological research. Trends in Ecology and Evolution, 22, 569–574.

Kunz, T.H.; de Torrez, E.B., Bauer, D., Lobova, T.; Fleming, T. H. (2011). Ecosystem services provided by bats. Ann. N. Y. Acad. Sci, 1223, 1–38.

Liang, R.J.; Yang, Z. (1985). The diet of bats. Bulletin of Biology, 6, 11-12.

Lin, H.J.; Wang, L.; Feng, J. (2014). Plasticity and ecological adaptability of bat echolocation calls. Acta Theriologica Sinica, 34(03), 307-312.

Liu, S.; Yu, W.; Li, F.; Zhao, J.; Yin, R.; Zhou, Z. (2018). Fertilizer application in rural cropland drives cadmium enrichment in bats dwelling in an urban area. Environmental Pollution, 242, 970-975.

Mac Aodha, O.; Gibb, R.; Barlow, K.E.; Browning, E.; Firman, M.; Freeman, R.; Harder, B.; Kinsey, L.; Mead, G.R.; Newson, S.E.; Pandourski, I.; Parsons, S.; Russ, J.; Szodoray-Paradi, A.; Szodoray-Paradi, F.;

Tiloca, E.; Girolami, M.; Brostow, G.; Jones, K.E. (2018). Bat detective—Deep learning tools for bat acoustic signal detection. PLoS Comput Biol, 14(3), e1005995.

Maine, J.J.; Boyles, J.G. (2015). Bats initiate vital agroecological interactions in corn. Proc. Natl. Acad. Sci. U.S.A, 112, 12438–12443.

Martins, M.A.; Carvalho, W.D.; Dias, D.; Franca, D.; Oliverira, M.B.; Peracchi, A.L. (2015). Bat species richness (Mammalia, Chiroptera) along an elevational gradient in the Atlantic Forest of Southeastern Brazil. Acta Chiropterologica, 17, 401-409.

Moratelli, R.; Calisher, C.H. (2015). Bats and zoonotic viruses: Can we confidently link bats with emerging deadly viruses?. Mem Inst Oswaldo Cruz, 110(1), 1-22.

Muscarella, R.; Fleming, T.H. (2007). The role of frugivorous bats in tropical forestsuccession. Biol. Rev, 82, 573–590.

Neuweiler, G. (2003). Evolutionary aspects of bat echolocation. J Comp PhysiolA, 189(4), 245-256.

Papadatou, E.; Butlin, R.K.; Altringham, J.D. (2008). Identification of bat species in Greece from their echolocation calls. Acta Chiropterologica, 10(6), 127-143.

Russo, D.; Jones, G. (2006). Identification of twenty-two bat species (Mammalia: Chiroptera) from Italy by analysis of time-expanded recordings of echolocation calls. Journal of Zoology, 258 (1), 91-103.

Schnitzler, H.U.; Denzinger, A. (2011). Auditory fovea and Doppler shift compensation: adaptations for flutter detection in echolocating bats using CF-FM signals. J Comp Physiol A Neuroethol Sens Neural Behav Physiol, 197(5), 541-559.

Schnitzler, H.U.; Moss, C.F.; Denzinger, A. (2003). From spatial orientation to food acquisition in echolocating bats[J]. Trends in Ecology & Evolution, 18(8), 386-394.

Smotherman, M.; Knornschild, M.; Smarsh, G. (2016). The origins and diversity of bat songs. J Comp PhysiolANeuroethol Sens Neural BehavPhysiol, 202(8), 535-554.

Solari, S.; Baker, R.J. (2007). Mammal Species of the World, A Taxonomic and Geographic Reference by D. E. Wilson; D. M. Reeder. Journal of Mammalogy, 3(88), 824-830.

Song, S.J.; Lin, A.Q.; Jiang, T.L.; Zhao, X.; Metzner, W.; Feng, J. (2019). Bats adjust temporal parameters of echolocation pulses but not those of communication calls in response to traffic noise. Integrative Zoo-logy, 14, 576-588.

Stone, E.L.; Harris, S.; Jones, G. (2015). Impacts of artificial lighting on bats: a review of challenges and solutions. Mammalian Biology, 80(3), 213-219.

Sulser, R.B.; Patterson, B.D.; Urban, D.J.; Neander, A.I.; Luo, Z.X. (2022). Evolution of inner ear neuroanatomy of bats and implications for echolocation. Nature, 602(7897), 449-454.

Sun, K.P.; Feng, J.; Jin, L.R.; Liu, Y.; Jiang, Y.L. (2006). Identification of bat species inhabiting the same area by analyzing the echolocation call. Journal of Northeast Normal University: Natural Sciences Edition, 38 (3), 109-114.

Taylor, P.J.; Grass, I.; Alberts, A. J.; Joubert, E.; Tscharntke, T. (2017). Economic value of bat predation services – a review and new estimates from macadamia orchards. Ecosyst. Serv, 30, 372–381.

Teeling, E.C.; Springer, M.S.; Madsen, O.; Bates, P.; O'brien, S.J.; Murphy, W.J. (2005). A molecular phylogeny for bats illuminates biogeography and the fossil record. Science, 307, 580–584.

Ulanovsky, N.; Moss, C.F. (2008). What the bat's voice tells the bat's brain.Proc Natl Acad Sci USA, 105(25), 8491-8498.

Wang, B.C.; Smith, T.B. (2002). Closing the seed dispersal loop. Trends Ecol. Evol, 17, 379–386.

Wang, R.R.; Dong, P.P.; Hirata, D.; Abduriyim, S. (2023). Mitochondrial DNA analyses revealed distinct lineages in an alpine mammal, Siberian ibex (*Capra sibirica*) in Xinjiang, China. Authorea. March 29.

Welbergen, J.A.; Klose, S.M.; Markus, N.; Eby, P. (2008). Climate change and the effects of temperature extremes on Australian flying-foxes. Proceedings of the Royal Society: Biological Sciences, 275, 419-425.

Willig, M.; Selcer, K. (1989). Bat Species Density Gradients in the New World: A Statistical Assessment. Journal of Biogeography, 16(2), 189-195.

Wilson, D.E.; Mittermeier, R.A. (2019). Handbook of the Mammals of the World. Vol. 9. Bat. Barcelona: Lynx Edicions.

Wu, Z.Q.; Yang, L.; Ren, X.W.; He, G.M.; Zhang, J.P.; Yang, J.; Qian, Z.H.; Dong, J.; Sun, Y.F.; Zhu, Y.F.; Du, J.; Yang, F.; Zhang, S.Y.; Jin, Q. (2016). Deciphering the bat virome catalog to better understand the ecological diversity of bat viruses and the bat origin of emerging infectious diseases. ISME J, 10(3), 609-620.

Zhang, Y.Z. (2021). Distribution Patterns of Chiroptera Species Diversity in China. WuHan university.

Zhao, H.B. (2020). COVID-19 drives new threat to bats in China. Science, 367(6485), 1436.

Figure captions

Fig.1. The map of the study area showing the surveyed points.

Conflicts of Interest

The authors declare no conflict of interest.

Author contributions

S.A. conceived and designed the study; P.D., W.G., R.W., and S.A. did the fieldwork and data collection; P.D. and W.G. conducted data analysis; P.D. and S.A. discussed, wrote, and edited the manuscript, W.G. and R.W. took part in drafting. All authors approved the final version of this manuscript.

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Data Accessibility Statement

The raw data analysed in this paper have been deposited into the Dryad data repository (DOI https://doi.org/10.5061/dryad.vhhmgqp02).

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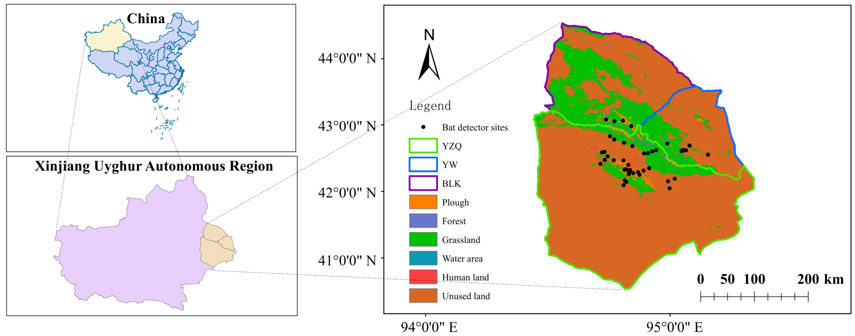
China
Xinjiang Uyghur Autonomous Region
N
Legend
Bat detector sites
YZQ
YW
BLK
Plough
Forest
Grassland
Water area
Human land
Unused land
44°0'0" N
43°0'0" N
42°0'0" N
41°0'0" N
94°0'0" E
95°0'0" E
0 50 100 200 km

Fig. 1