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http://biology.num.edu.mn
http://mjbs.100zero.org/
Volume 10(1-2), 2012

Mongolian Journal of Biological Sciences

ISSN 1684-3908 (print edition)
MJBS
ISSN 2225-4994 (online edition)

Original Article

Bat Diversity at Ikh Nart Nature Reserve, Mongolia

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Abstract

Key words:
Bat diversity, *Eptesicus gobiensis*, Ikh Nart Nature Reserve, *Myotis aurascens*, *Vespertilio*

Article information:
Received: 31 July 2012
Accepted: 04 Dec. 2012
Published: 25 Dec. 2012

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Bats represent one of the least studied mammal groups in Mongolia, and little is known about the distribution and ecology of species in the country. We surveyed bats in Ikh Nart Nature Reserve, which lies at the intersection of two ecozones in Mongolia, to determine the species present and obtain preliminary data on habitat associations. We conducted mist net surveys at 9 sites, including 4 at natural springs, 2 at human-made wells, and 3 at sites without water, from June to August 2011. We captured 149 individuals representing 3 species, *Myotis aurascens, Eptesicus gobiensis,* and *Vespertilio* sp. One species, *E. gobiensis*, represents a new record for the reserve. We captured all three species at sites near natural springs, only one species, *M. aurascens,* at human-made well sites, and no bats at sites without water. We also collected basic morphometric measurements for *M. aurascens* and *E. gobiensis*. Analysis of morphometric measurements for *M. aurascens* indicated some sexual dimorphisms. Our results provide a baseline estimate of bats in Ikh Nart and suggest that bat diversity is greater than previously thought. Our results also validate the presence of *E. gobiensis* and suggest that the species we captured associate mainly with natural water sources.

Cite this paper as: Davie, H. S., Murdoch, J. D., Naran, N., Ariunbold, J., Batdorj, S. & Reading, R. P., 2012. Bat diversity at Ikh Nart Nature Reserve, Mongolia. *Mong. J. Biol. Sci.,* 10(1-2): 33-40.

Introduction

Very little is known about the distribution and ecology of Mongolia's fourteen extant bat species (Dolch *et al*., 2007; Nyambayar *et al*., 2010). Biologists have surveyed bats in some parts of the country, including sites in Arhangai, Bayanhongor, Bulgan, Darhan-Uul, Dundgovi, Khovd, Huvsgul, Umnugovi, Uvurhangai, Selenge, Tuv, and Zavkhan *aimags* (Dolch *et al*., 2007: Nyambayar *et al*., 2010). Results of these surveys form the basis for current species distribution estimates (Clark *et al*., 2006). Distribution maps have also been inferred from the distribution of potentially suitable habitats. However, details on the basic habitat associations of Mongolia's bats remain poorly studied, limiting inferences, effective management, and conservation planning.

Dornogobi Aimag (i.e., province) lies at the margin of two ecozones, steppe and semi-desert steppe (Mallon, 1985), making it an important area for assessing the ranges of species found in one or both ecozones. We surveyed bat species at a nature reserve in northern Dornogobi to estimate species presence and provide preliminary data on habitat associations. Past studies documented three bat species in the region, including *Myotis aurascens* (whiskered bat), *Verspertilio murinus* (particolored bat), and *Vespertilio superans* (Asian particolored bat) (Murdoch *et al*., 2006), and we expected to record these species during our surveys. We also expected to find all bats associated with water, based on observations elsewhere in Mongolia (Dolch *et al*., 2007; Batsaikhan *et al*., 2010; Nyambayar *et al*., 2010).

Materials and Methods

We surveyed bats in Ikh Nart Nature Reserve, Dornogobi Aimag, Mongolia (Reading *et al*., 2011). Ikh Nart (45°43'N, 108°39'E) is a 666 km^2 protected area established in 1996 to protect a population of argali sheep (*Ovis ammon*) and the unique landscape of the region (Myagmarsuren, 2000). Topography is variable, consisting of open, gently rolling plains, rugged areas of rocky outcrops, and steep-sided drainages (Reading *et al*., 2011). Grasses, forbs, and shrubs are the primary vegetation of the plains, while rocky areas and drainages often include trees (*Ulmus pumila* and *Salix* sp.) (Jackson *et al*. 2006). Climate is arid, with <200 mm of annual precipitation, and variable, with temperatures ranging from -40°C to +40°C. Water sources are rare and highly localized, occurring as natural springs in some drainages and as human-made wells near herder camps.

We conducted 30 bat surveys across 9 net sites from 05 June to 09 August 2011. Net sites included permanent natural springs (n = 4 sites and 16 surveys), human-made wells (n = 2 sites and 8 surveys), and areas without water (n = 3 sites and 6 surveys) (Fig. 1). The spring and well sites included six prominent water sources documented by on-going research projects (Reading *et al*., 2007). We randomly chose the sites without water. At each site, we erected a 2.5 x 11 m mist net with 20 x 20 mm mesh. Each survey involved opening the net from 20:00 to 23:00 (once until 0:00) to capture bats. We processed all bats on-site immediately after capture following guidelines of the American Society of Mammalogists (Sikes *et al*., 2011) and methods recommended by Kunz *et al*. (2009). We recorded the species and sex of all captured bats and measured morphological characteristics, including mass, head-body, forearm, tail, ear, tragus, 3rd finger, and 5th finger length. We identified species based on descriptions in Batsaikhan *et al*. (2010).

We examined habitat associations by testing for differences in capture rates (# captured/hr/survey) for each species between the three site types. We

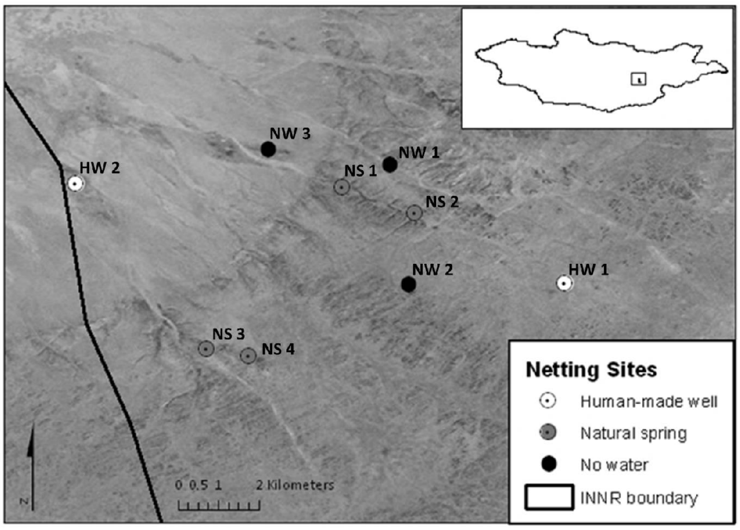

Figure 1. Bat mist netting sites in Ikh Nart Nature Reserve, Mongolia, from June to August 2011. We placed mist nets at 9 sites during 30 nights: 2 at human made wells (HW; white), 4 at natural springs (NS; gray), and 3 in areas without water (NW; black).

tested for differences using a repeated measures Analysis of Variance (ANOVA) and square-root transformed capture rates to meet assumptions of normality. We also examined sexual dimorphism in species with adequate sample size by testing for differences in morphological measurements. We tested for differences using nonparametric Kruskal-Wallis tests. We conducted all statistical tests using JMP software (JMP, Version 7. SAS Institute Inc., Cary, North Carolina, USA), and considered results significant when $p < 0.05$.

Results

We captured a total of 149 individual bats representing 3 species, including *Myotis aurascens* (whiskered bat; n = 136), *Eptesicus gobiensis* (Gobi big brown bat; n = 6), and an unidentified *Vespertilio* sp. (n = 7). We captured most bats in early June through early July (Fig. 2), with the highest capture rates between 16 and 30 June ($\bar{x}$ =5.50 ± 2.26 SE bats/hr, n = 6 surveys). Capture rates varied from 0 to 13 bats/hr (latter occurring one night in late June at a natural spring site). Capture rates dropped off to <1 bat/hr in late July ($\bar{x}$ = 0.52 ± 0.22 SE bats/hr, n = 9 surveys) and remained low through early August ($\bar{x}$ = 0.45 ± 0.30 SE bats/hr, n = 7 surveys) (Fig. 2). We recorded the highest nightly capture rates between 21:14 and 23:00 (Fig. 3), and caught no bats before 20:45 (sunset). Capture rates declined steadily from 22:30 to net closing (Fig. 3).

M. aurascens represented 91% of total captures and had a mean capture rate of 2.27 ± 0.60 SE bats/hr over all surveys (Table 1). We rarely captured the other two species (Table 1).

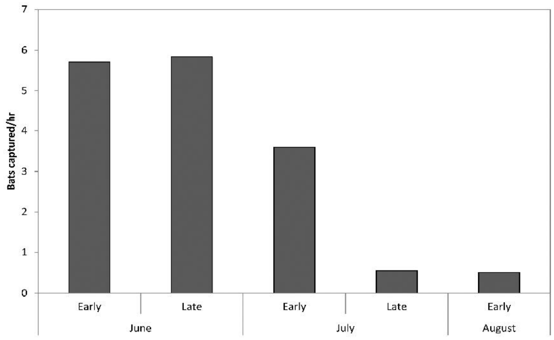

Figure 2. Total bats captured per hour of open net by month in Ikh Nart Nature Reserve, Mongolia, from June to August 2011. We captured bats using mist nets at 9 sites and pooled data from 30 nights.

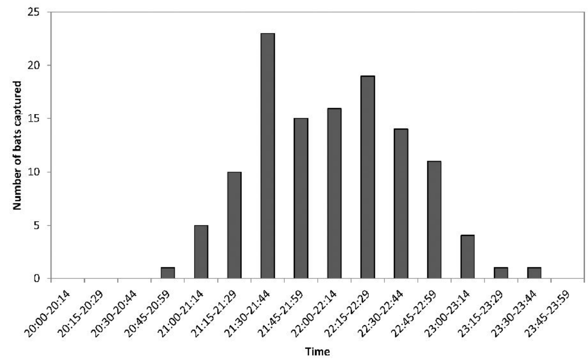

Figure 3. Bat captures by 15-minute intervals in Ikh Nart Nature Reserve, Mongolia, from June to August, 2011. We captured bats using mist nets at 9 sites between 20:00 and 23:00 (once until 0:00) and pooled data from 30 nights.

Table 1. Number of bats captured by species and site type in Ikh Nart Nature Reserve, Mongolia from June to August 2011. Effort refers to the total number of open mist net hours.

		Number of captures		
Site type	*Effort*	*Myotis aurascens*	*Eptesicus gobiensis*	*Vespertilio sp.*
Natural spring #1	9	51	2	7
Natural spring #2	8	35	1	0
Natural spring #3	8	13	0	0
Natural spring #4	7	31	3	0
Human-made well #1	8	4	0	0
Human-made well #2	8	2	0	0
No water site #1	3	0	0	0
No water site #2	3	0	0	0
No water site #3	4	0	0	0
TOTAL		136	6	7

Overall capture rate was 0.13 ± 0.06 SE bats/hr for *Eptesicus gobiensis* and 0.08 ± 0.08 SE bats/hr for *Vespertilio* sp. We captured most bats at natural springs, few at human-made wells, and none at sites without water (Table 1). We found a significantly higher capture rate at natural springs ($\bar{x}$ = 4.46 ± 1.05 SE bats/hr, n = 16 surveys) than at human-made wells ($\bar{x}$ = 0.36 ± 0.15 SE bats/hr, n = 8 surveys) (F= 4.38, df = 1, 4, p = 0.01). Because we caught no bats at sites without water, we did not include those sites in our analyses. *M. aurascens* occurred mainly at natural springs, but also at human-made wells (Table 1). We captured *E. gobiensis* at three separate natural spring sites, but not at any of the other site types (Table 1). We captured *Vespertilio* sp. on only one night at one natural spring site over the two-month netting period (Table 1).

Morphometric measurements for *M. aurascens* showed sexual dimorphism for some measurements (Table 2). We found significantly larger mass (Z = 2.68, p < 0.03), forearm length (Z = 2.65, p < 0.01), and 3rd finger length (Z = 2.41, p < 0.02) in females than in males. All other measurements showed no significant difference between sexes. We could not statistically compare *E. gobiensis* morphometrics due to small sample size, but present raw values (Table 2). We did not obtain measurements of *Vespertilio* sp. in the field.

Discussion and Conclusion

We initiated this project to investigate bat diversity and habitat associations in the Ikh Nart region of Dornogobi Aimag, Mongolia, an area where few surveys of bats have occurred. Our results indicate higher species diversity than reported by previous studies (Murdoch *et al*., 2006). We captured three species, all of which associated with natural water sources. One species (*E. gobiensis*) had not been previously documented in the reserve.

Table 2. Morphological measurements of bats captured in Ikh Nart Nature Reserve, Mongolia from June to August 2011. Mean (±SE) measurements presented for *M. aurascens*. Individual measurements presented for *E. gobiensis* due to small sample size. Mass is reported in grams; all other measurements reported in millimeters. Significant differences (p < 0.05) for *M. aurascens* are indicated in bold.

Species		*Mass*	*Forearm*	*Head-Body*	*Tail*	*Ear*	*Tragus*	*3rd finger*	*5th finger*
E. gobiensis	female	14, 9	39, 41	67, 59	42, 47	9, 10	5, 4	68	51
	n	2	2	2	2	2	2	1	1
	male	10, 10	42, 40	55, 53	43, 37	10, 8	4, 3	68, 66	51, 49
	n	2	2	2	2	2	2	2	2
	unknown	9, 9	40, 39	61, 53	35, 36	10, 9	*	*	*
	n	2	2	2	2	2	*	*	*
M. aurascens	female	**6.0 ± 0.1**	**34.9 ± 0.3**	47.3 ± 0.4	35.6 ± 0.5	10.8 ± 0.2	6.2 ± 0.1	**55.7 ± 0.4**	46.2 ± 0.5
	n	**48**	**48**	48	48	48	39	**32**	32
	male	**5.6 ± 0.1**	**34.1 ± 0.2**	47.6 ± 0.4	35.2 ± 0.5	10.8 ± 0.2	6.4 ± 0.1	**54.1 ± 0.4**	45.3 ± 0.3
	n	**54**	**54**	54	54	54	45	**30**	30

M. aurascens (previously *M. mystacinus*) inhabits a wide range that extends across Europe and Asia (Bates & Harrison, 1997; Benda *et al*., 2008). Common across Mongolia (Batsaikhan *et al*., 2010), we found *M. aurascens* throughout Ikh Nart, and other researchers recorded this species in most of Mongolia's twenty-one Aimags (Dolche *et al*., 2007; Batsaikhan *et al*., 2010). The population size of *M. aurascens* is believed to be large and stable in Mongolia, but we are unaware of any published estimates (Benda *et al*., 2008). Although previous studies have not documented sexual dimorphism in *M. aurascens* (Dolch *et al*., 2007; Batsaikhan *et al*., 2010), it does occur within the genus and we found females to be significantly larger than males in mass, forearm length, and length of 3rd finger. Previous studies with other species suggested that the larger size of females may represent an adaptation for the added weight and increased energy demands during pregnancy (Myers, 1978; Williams & Findley, 1979). Within Mongolia, *M. aurascens* associates with taiga, mixed forest, forest steppe, and semi-desert habitats, but in arid habitats the species is generally found near water sources (Batsaikhan *et al*., 2010).

The *Vespertilio* sp. we captured was probably either *V. murinus* or *V. superans*, both previously reported at Ikh Nart (Murdoch *et al*., 2006). However, due to limited personnel on the one night this species was captured (Table 1), we could not identify captured individuals to species level. Both *Vespertilio* species are Palearctic, wide-ranging, and migratory (Hutson *et al*., 2008). The range of *V. murinus* extends from Fennoscandia, Switzerland, south-east France, and northern Italy, through northern Iran, Afghanistan, Russia, and central Asia, to eastern China and Japan (Huston *et al*., 2008). Widespread throughout Mongolia, *V. murinus* occurs in low numbers within the country (Huston *et al*., 2008; Batsaikhan *et al*., 2010), and associates with taiga, forest steppe, and semi-desert habitats (Batsaikhan *et al*., 2010). *V. superans* (also *V. sinensis*) occupies a more easterly range, being found in Siberia, the Korean peninsula, central and eastern China, Taiwan, and Japan (Corbet & Hill, 1992; Stubbe *et al*., 2008b; Batsaikhan *et al*., 2010). *V. superans* is primarily found in riparian woodland and steppe habitat (Batsaikhan *et al*., 2010). The status of both *Vespertilio* sp. in the study area (e.g. transient, summer breeding, or occasional vagrant) remains unknown.

The presence of *E. gobiensis* represents a new record for the species in Ikh Nart Nature Reserve and Dornogobi Aimag (Murdoch *et al*., 2006). Our study area lies at the edge of its known range (Fig. 4; Stubbe *et al*., 2008a). The range of *E. gobiensis* is more limited than that of *M. aurascens* or the two *Vespertilio* sp., extending from the southern half of Mongolia into Kazakhstan, Pakistan, Nepal, India, and north-west China (Stubbe *et al*., 2008a). Consistent with our capture results, *E. gobiensis* is considered common, but not abundant. However, little information exists regarding its precise distribution in Mongolia and our results validate its presence in the region (Dolch *et al*., 2007; Stubbe *et al*., 2008a; Batsaikhan *et al*., 2010). We found morphological characteristics of *E. gobiensis* similar to earlier unpublished records within the reserve and other published accounts (Table 3), although average tragus and ear measurements were smaller than those recorded elsewhere in Mongolia (Table 3; Dolch *et al*., 2007). Our small sample size precluded analysis of sexual dimorphism, but earlier studies reported a significant difference in forearm length between the two sexes (Dolch *et al*., 2007). *E. gobiensis* associates with desert and semi-desert habitats elsewhere (Dolch *et al*., 2007; Batsaikhan *et al*., 2010) and is generally found near water sources (Batsaikhan *et al*., 2010).

Our nightly peak capture periods (21:30-22:30) roughly corresponded to the optimal capture window (21:00-22:00) reported by Nyambayar *et al*. (2010) suggesting that future surveys should concentrate netting efforts within this period if the goal is to maximize the number of bats captured.

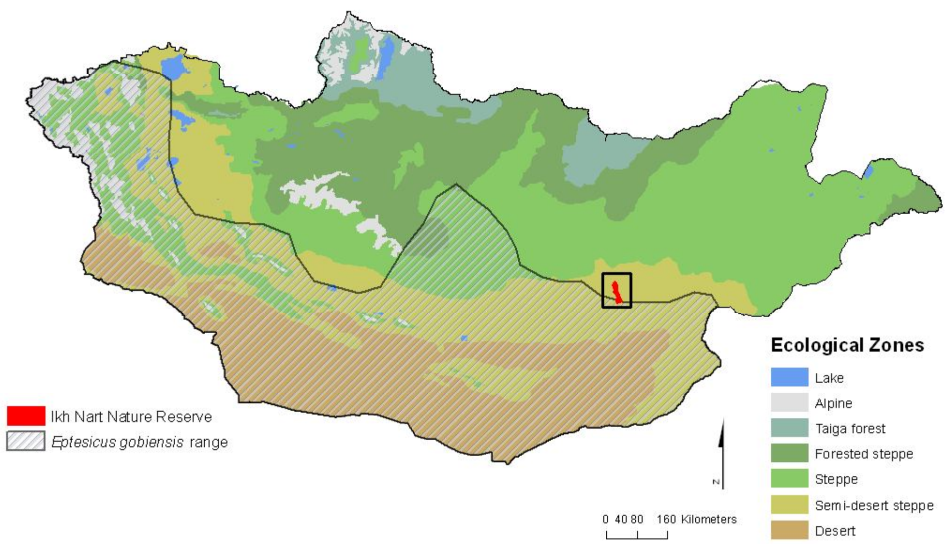

Figure 4. Distribution of Eptesicus gobiensis in Mongolia relative to ecological zones and Ikh Nart Nature Reserve, Dornogobi Aimag. Distribution adapted from Stubbe et al. (2008a).

Table 3. *Eptesicus gobiensis* morphological measurements reported from other studies in Mongolia (see references section for cited literature details). Mass reported in grams; all other measurements reported in millimeters.

References	*Sex*	*Value*	*Mass*	*Forearm*	*Head-Body*	*Tail*	*Ear*	*Tragus*
Ariunbold, unpublished data	*female*	Mean	*	39.9	57.9	42.35	11.8	4.4
		SE	*	0.2	0.4	0.4	0.3	0.1
		Range	*	39.1-40.7	56.5-59.0	40.5-43.7	10.6-12.6	4-4.7
		n	*	6	6	6	6	6
	male	Mean	*	39.7	58.1	41.1	10.9	4.4
		SE	*	0.8	0.1	1.6	1.4	0.1
		Range	*	38.8-40.5	58.0-58.1	39.4-42.7	9.5-12.3	4.3-4.4
		n	*	2	2	2	2	2
Dolche *et al*., 2007	*female*	Mean	11.4	41	59.7	45	14.8	6
		SE	0.4	0.3	0.3	0	0.8	0
		Range	9.9-14.5	39.5-42.8	59-60	45-45	14.0-15.6	6.0-6.0
		n	12	12	3	3	2	2
	male	Mean	11.2	39.8	60.7	43	14.3	6
		SE	0.5	0.2	1.4	2.1	0.3	0
		Range	9.0-15.0	38.5-41.6	58-63	40-48	14.0-15.0	6.0-6.0
		n	13	13	3	3	3	2
Batsaikhan *et al*., 2010		Range	9-15	38-43	58-63	40-48	14-16	5-7
Strelkov, 1986		Mean	*	39.6	55.2	43.4	*	*
		Range	*	37.5-41.0	49.0-62.5	38.5-51.0	*	*
		n	*	24	15	15	*	*
Bates and Harrison, 1997		Mean	*	41.3	*	*	14.5	*
		n	*	2	*	*	2	
		Range	*	41.0-41.5	*	*	14.0-15.0	*
Corbet and Hill, 1992		Range	*	38-43	*	*	*	*
Tate, 1947		Range	*	41.0-44.0	*	*	*	*

Bat activity is often highest shortly after sunset and again before sunrise (Kunz *et al*., 2009). During our study, sunset shifted from 21:15 in early June to 20:30 in early August. Although we caught the most bats from early June to mid-July, we are uncertain why we captured fewer bats later in the summer. We followed standard methods recommended by Kunz *et al*. (2009) to minimize any effects of handling on bat survival. Other studies noted a decrease in capture rates over consecutive nights of netting at the same site (Kunz & Brock, 1975) and learned “net shyness”, particularly in areas with lower bat density (Kunz *et al*., 2009). Although we did not net for consecutive nights at the same site, avoidance behavior may account for decreased capture rates later in the summer. Alternatively, high rainfall in early July may have increased the number of temporarily available water sources, leading to a decreased concentration of bats at permanent water sources. Razgour *et al*. (2011) reported a shift in the foraging patterns of desert bat communities following increases or decreases in temporary water source availability in the Central Negev Highlands, Israel. Further investigation of the roosting habits and foraging behavior of all three species would likely improve our understanding of temporal changes in abundance and distribution.

Our significantly higher bat capture rates at natural spring sites relative to human-made wells, along with the lack of captures at sites without water, suggest that natural water sources represent an important habitat requirement for bats in the region. Future conservation planning for bats in Mongolia should address this potential water dependence and consider bats when mitigating decreased water availability due to factors such as landscape development, increased livestock numbers, and climate change (Benda *et al*., 2008; Stubbe *et al*., 2008a; Stubbe *et al*., 2008b; Nyambayar *et al*., 2010). The low abundance, low reproductive rate, and slow growth rate of the bats we captured, especially *E. gobiensis* (Stubbe *et al*., 2008a), add to their potential vulnerability. Suggested areas for further study include a fine-scale assessment of factors affecting abundance, distribution, and habitat use. We also recommend surveys elsewhere in Dornogobi to provide a more comprehensive assessment of bat diversity in the region.

Acknowledgements

We thank the Denver Zoological Foundation, Earthwatch Institute, Mongolian Conservation Coalition, Mongolian Academy of Sciences – Institute of Biology, and University of Vermont for supporting the project. We also thank S. Dandarbaatar, T. Selenge, S. Buyandelger, and J. Pontius for their advice, support, and assistance with fieldwork, logistics, and analysis. We are grateful to C. William Kilpatrick and A. Strong of the University of Vermont for providing capture and handling advice and equipment.

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