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First record of *Histiotus laephotis* (Thomas, 1916) from Chile and new distributional information for *Histiotus montanus* (Phillipi and Landbeck, 1861) (Chiroptera, Vespertilionidae)

Abstract: We report new distributional records for *Histiotus montanus* and first records of *Histiotus laephotis* for Chile. Morphological measurements and analyses of echolocation calls confirm the differences between the species. *Histiotus montanus* has a smaller forearm (49.7±0.8 vs. 51.7±0.4 mm) and darker and shorter ears than *H. laephotis*; the latter has a yellowish fur in contrast to other *Histiotus* species. Acoustic analyses showed significant differences between the species: *H. laephotis* have shorter pulses (1.3±0.4 vs. 3.6±2.6 ms), with lower start and peak frequencies (start frequency 38.2±2.6 vs. 46.4±4.6 kHz; peak frequency 30.4±3.7 vs. 32.1±2.2 kHz) than *H. montanus*. These findings place the Tarapacá region of northern Chile as the most diverse in terms of bat species in the country. Furthermore, these results increase the total number of bat species known to occur in the country to 13.

Keywords: bat fauna; distribution; echolocation; morphology; Tarapacá.

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Introduction

To date, only 12 species of bats have been reported for the Chilean territory (Muñoz and Yañez 2009, Diaz et al. 2011, Ossa and Diaz 2014), most of which are insectivorous (Mann 1978) and apparently restricted to the northern regions of the country where favorable climatic conditions are available throughout the year (Di Castri and Hajek 1976). Northern Chile comprises some of the driest landscapes in the world, where vegetation is practically absent in some areas (Luebert and Pliscoff 2006), but there are also valleys where agriculture and livestock are developed.

Several field studies of bats were conducted in the Tarapacá region during the last century, resulting in the currently known species list: *Myotis atacamensis* (Lataste, 1982) and *Desmodus rotundus* (E. Geoffroy, 1810) by Osgood (1943); *Tadarida brasiliensis* (I. Geoffroy, 1824) by Mann (1945); and *Amorphochilus schnablii* (Peters, 1877), *Mormopterus kalinowskii* (Thomas, 1893), and *Histiotus macrotus* (Poeppig, 1835) by Mann (1950).

According to Simmons (2005), the genus *Histiotus* (Gervais, 1856) comprises seven species, all endemic of the Neotropics. *Histiotus montanus* (Phillipi and Landbeck, 1861) is distributed along the western Latin America, from Venezuela to Patagonia and the eastern coast from Porto Alegre, Brazil to the south (Redford and Eisenberg 1992, Gardner 2007), and in Chile its distribution was reported from Calama (22°28′S) to the north of Tierra del Fuego (Galaz and Yáñez 2006, Muñoz and Yañez 2009). Currently, *H. montanus* is categorized as of least concern because of its wide distributional range (González and Barquez 2008). *Histiotus laephotis* (Thomas, 1916) was reported only for Bolivia, Paraguay, northern Argentina, southern Peru, and southern Brazil (Acosta and Venegas 2006, Miranda et al. 2007, Barquez and Díaz 2008) (Figure 1), and considered as near threatened because of habitat loss, especially in the forested areas in the highlands of Bolivia and Argentina (Barquez and Díaz 2008).

This study extends the distribution of *Histiotus montanus* to the Tarapacá region and reports the first record of *H. laephotis* for Chile, increasing the total number of species of bats known to occur in the country to 13.

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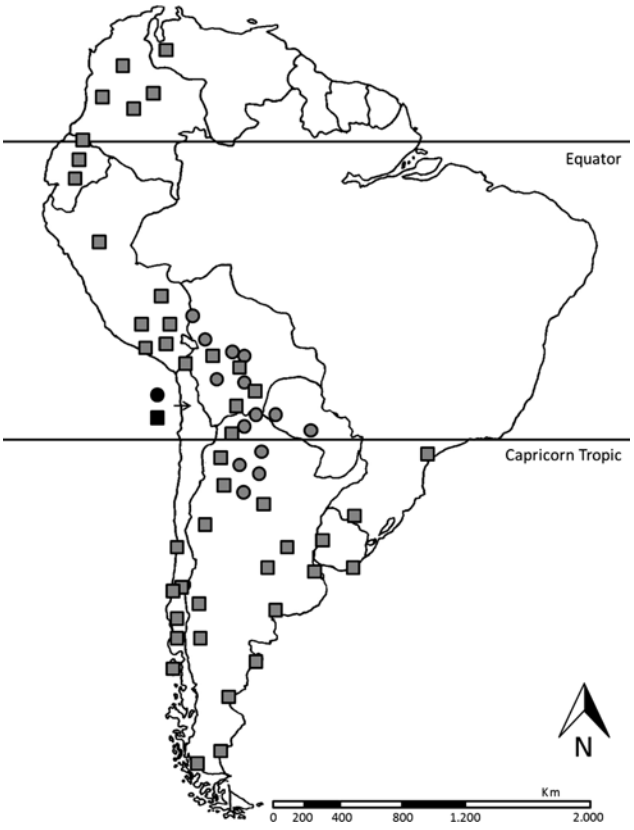

Figure 1 Distribution map of extant localities for *Histiotus montanus* (gray squares) and *H. laephotis* (gray circles). New locality records for each species are shown in black (squares and circles, respectively). Adapted from Gardner (2007), Miranda et al. (2007), and Barquez and Díaz (2009).

Materials and methods

The study was conducted in Pampa del Tamarugal Natural Reserve (20°26′S 69°41′W), Tarapacá Region, an area where the forests of native species of *Prosopis* were almost eliminated by the saltpeter extraction during the last century (Núñez et al. 2010). The study area now consists of a surface of 100,650 ha of artificially regenerated forests divided into three plots. Bat sampling was done in the southern and bigger plot of the reserve, where the nurseries are established. Bats were sampled with mist-nets (Ecotone, Gdynia, Poland) in winter (from June 29 to July 2, 2013) and spring (from September 28 to October 03, 2013).

We used four 12 m mist-nets each night around the *Prosopis* sp. nurseries, totaling a sampling effort of 60 linear meters per day. Mist-nets were opened 30 min after sunset and kept open for 3 h during the period of highest activity of bats (Ossa 2010). The mist-netting procedure was complemented with the use of a Pettersson D240X ultrasound detector (Pettersson Elektronik AB, Uppsala, Sweden) connected to a Zoom H2n digital recorder (Zoom Corporation, Tokyo, Japan) to obtain the vocalizations of the species.

All captured specimens were placed in cloth bags until they were weighed using a 100 g Pesola (Pesola AG, Baar, Switzerland) and their forearm, 5th finger, and total (body and tail) lengths measured with a caliper to the nearest 0.1 cm following Mitchell-Jones and McLeish (2004). Each specimen was identified using the field identification keys of bats from Argentina (Barquez and Díaz 2009), Bolivia (Aguirre et al. 2009), and the southern cone of South America (Diaz et al. 2011). Once identified, they were marked with Larvispray (Pfizer Inc., New York, USA) to account for recaptures during the campaign, and released in the same area where they were captured when no bat activity was heard through the bat detector. At the moment of release, the vocalizations of each individual were recorded for acoustic analysis.

To obtain the vocalizations, we followed the method of Ossa et al. (2010a,b). A Pettersson D240X bat detector was utilized with the 10X expanded mode, connected to a Zoom H2n digital recorder, which allows WAV audio files to be stored. A person released the bat while another, located 10 m away, recorded the ultrasound emissions. All calls were analyzed using a 44.1 kHz sampling frequency, FFT 256 length, Hanning type window, and 75% of overlapping (Avisoft SASLab Pro 5.2.07 Software, Glienicke, Germany). Only files with a good signal-to-noise ratio were used for characterizing echolocation calls. For each obtained pulse, we manually measured the start, end, and peak frequencies and the duration and pulse intervals because those parameters can explain for acoustic differences between species in Chile (Ossa 2010, Rodríguez-San Pedro and Simonetti 2013). We performed a multivariate analysis of variance (MANOVA) to check for differences between the two species, and univariate F-tests for each variable to know which explain better the differences between the species. All tests were carried out using the software R (R Development Core Team 2013).

Results

During the winter, we captured a total of eight individuals: one *Myotis atacamensis*, four *Histiotus macrotus*, one *H. montanus*, and two *H. laephotis*. During the spring, we caught 16 individuals, seven of which were recaptures: nine *H. montanus*, six *H. macrotus*, and one *M. atacamensis*. *Histiotus laephotis* was clearly identified by its general

Table 1 Morphometric measurements of male (M) and female (F) individuals of *Histiotus montanus* and *H. laephotis* captured at Pampa del Tamarugal National Reserve, Tarapacá region, Chile.

Species	Sex (N)	Weight	Forearm	5th Finger	Total length
H. montanus	M (3)	10–13	49.5–50.6	60–61.4	104–109.1
	F (7)	9–12	48.7–51.1	50.1–63.3	91.4–110.1
H. laephotis	M (1)	11	52.0	65.7	96.0
	F (1)	11	51.4	62.6	94.4

Values are presented in ranges. Weight was measured in grams, and the other measurements in millimeters.

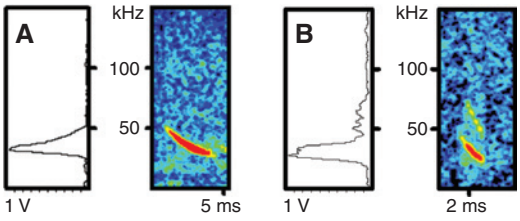

Figure 2 Spectrograms (B/W) and sonograms (color) of A) *Histiotus montanus* and B) *H. laephotis* individuals captured at the Pampa del Tamarugal National Reserve, Tarapacá region, Chile. The spectrogram shows the energy displayed in each pulse and the sonogram shows the shape of echolocation calls. The *x* axis shows frequencies in kHz and the *y* axis shows time in milliseconds.

yellowish fur, including the venter, and by the conspicuous connecting band between the ears (Barquez and Díaz 2009, Díaz et al. 2011). Morphometric measurements of the captured specimens of *H. montanus* and *H. laephotis* showed that both have a similar weight and total length, but *H. laephotis* has a longer forearm and 5th finger than *H. montanus* (Table 1).

With regard to the ultrasound recordings taken from released individuals, we obtained audio files from nine individuals of *Histiotus montanus* and one *H. laephotis*. The characteristics of their ultrasound pulses are described in Table 2 and sonograms in Figure 2. We observed that *H. montanus* and *H. laephotis* have a component of quasi-constant frequency. MANOVA showed that there are differences between the echolocation calls from both species (λ-*Pillai*=0.36; F=11.97; p<0.001). Differences were significant for all measured parameters, except for end frequency (Table 2).

Discussion

We report the first record of *Histiotus montanus* and *H. laephotis* in the Tarapacá region, Northern Chile, include new data about the echolocation calls of *H. montanus*, and describe for the first time the echolocation calls of *H. laephotis*.

The differences between *Histiotus laephotis* and *H. montanus* are clear, as well as those between them and *H. macrotus*, the better known species in northern Chile (Mann 1978, Galaz and Yáñez 2006). *Histiotus macrotus* is characterized by black and large ears (>30 mm) and the belly fur with dark brown bases and whitish tips (Díaz et al. 2011). *Histiotus laephotis* is clearly a different species having a typical yellowish belly and pale and very large ears with a conspicuous connecting band between them (Barquez and Díaz 2009) (Figure 3).

Both species showed some differences in echolocation calls. The values obtained for *Histiotus montanus* coincided with those reported in previous studies (Ossa et al. 2010a, Rodríguez-San Pedro and Simonetti 2013), showing higher start and peak frequencies than *H. laephotis*, with the latter using shorter duration pulses. These differences need to be confirmed on a larger and extended sample.

Although *Histiotus montanus* is considered to have a very wide distribution in South America, which ranges from Venezuela to Tierra del Fuego, the species was not previously known to occur in areas between Calama (22°28′S) and Putre (18°11′S) at the western side of the

Table 2 Echolocation calls of *Histiotus montanus* and *H. laephotis* captured at Pampa del Tamarugal National Reserve, Tarapacá region, Chile.

Species	*H. montanus*	*H. laephotis*	df	F-value	p-Value
No. of pulses	95	13			
Start frequency (kHz)	46.4±4.6	38.2±2.6	106	39.538	<0.001
End frequency (kHz)	25.5±2.2	26.3±1.8	106	1.8711	0.174
Peak frequency (kHz)	32.1±2.2	30.4±3.7	106	5.7161	0.012
Duration (ms)	3.6±2.6	1.3±0.4	106	9.8044	0.002
Interval (ms)	144.5±74.7	94.0±55.9	106	7.0153	0.009

For each species we measured frequency at the start, at the end, and at the maximum energy (peak) in kilohertz (kHz), the duration of pulses and interval between two consecutive pulses in milliseconds (ms), and tested the differences between species using univariate F-tests.

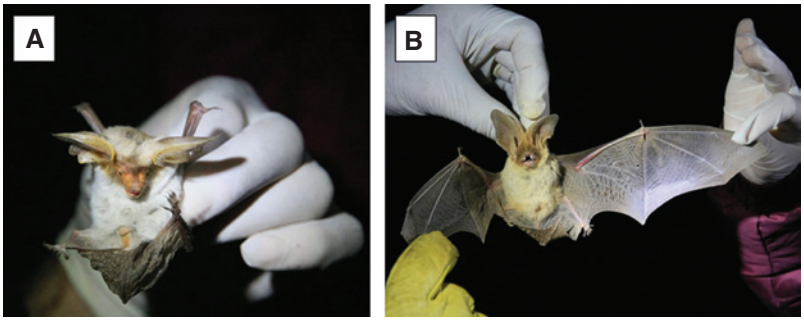

Figure 3 Morphological differences between *Histiotus montanus* (A) and *H. laephotis* (B). Note the white belly in (A) compared with the yellowish fur and pale and very large ears in (B).

Andes (Gardner 2007, Muñoz and Yañez 2009). This study suggests a probable connection between the species' northern and southern populations.

Histiotus laephotis is not a well-known species with respect to its distribution, but its presence in northern Chile is probably due to the area's relative closeness to the type locality in Caiza, Bolivia (about 400 km in straight line to the east) – an area with geological, climatic, and vegetation continuity with Pampa del Tamarugal – that may allow migratory displacements of this species in search of insect preys during winter.

As a consequence of this new record, the Tarapacá region can now be considered as the richest region in Chile in terms of bat biodiversity, with a total of eight species. Therefore, the role of Pampa del Tamarugal National Reserve is not only a climate modulator because of the presence of dense *Prosopis* plantations inside a matrix of absolute desert (Di Castri and Hajek 1976), but also a hotspot for biodiversity.

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