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## *Myotis levis* (GEOFFROY SAINT-HILAIRE) INDEED OCCURS IN PARAGUAY

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**ABSTRACT:** Because of taxonomic difficulty with southern South American *Myotis*, the systematic status and distribution of *M. levis* remains unresolved. At the center of discussion is whether *M. levis* occurs in Paraguay. We report the occurrence of *M. levis* in Paraguay and substantiate our findings with comparative phenotypic and morphometric data for southern South American *Myotis*. This record closes a geographic gap for this species, whose distribution now includes parts of Argentina, Bolivia, Brazil, Paraguay, and Uruguay.

**RESUMEN:** *Myotis levis* (Geoffroy Saint-Hilaire) realmente ocurre en Paraguay. Debido a la complejidad de la taxonomía de las especies de *Myotis* del sur de Sudamérica, el estatus sistemático y distribución de *Myotis levis* permanece irresuelto. Parte crucial de la discusión es la ocurrencia o no de *M. levis* en Paraguay. En este trabajo se documenta por primera vez la presencia de *M. levis* para Paraguay. La asignación específica del mismo se apoya en la comparación de caracteres externos y morfometría craneal con ejemplares de otras regiones del sur de Sudamérica. Este registro llena un vacío en la distribución de la especie, para incluir parte de Argentina, Bolivia, Brasil, Paraguay y Uruguay.

**Key words.** Interior Atlantic Forest. *Myotis*. Paraguay. Range extension.

**Palabras clave.** Bosque Atlántico interior. Extensión de la distribución. *Myotis*. Paraguay.

The genus *Myotis* is the most diverse within Chiroptera, including 103 species (Simmons, 2005). In subtropical and temperate South America, *Myotis* currently is represented by 11 species (*aelleni*, *albescens*, *atacamensis*, *chiloensis*, *keaysi*, *levis*, *nigricans*, *oxyotus*, *riparius*, *ruber*, and *simus*). Nine of these taxa have been included in recent systematic assessments of the genus in South America (e.g. Anderson, 1997; Barquez et al., 1999; López-

González, 2005; Rocha, 2008), although their taxonomic and geographic limits are far from clear.

Five species of *Myotis* have been recorded for Paraguay (*albescens*, *nigricans*, *ruber*, *riparius*, and *simus*—López-González et al., 2001, 2005). A previous account (Baud and Menu, 1993) included also *M. levis*, based on one specimen recorded from the Department of Itapúa. Based on morphometric and exter-

nal characters, López-González et al. (2001) concluded that this specimen was in fact a large *M. albescens*. Because of occurrences in Bolivia, northern Argentina, as well as SE and S Brazil, they did not rule out the possibility of *M. levis* occurring in Paraguay. The objective of this note is to document for the first time the presence of *M. levis* in Paraguay and to comment on the status of populations currently included under this name.

We follow LaVal's (1973) definition of *M. levis*. It is not clear at this point whether *M. l. levis* and *M. l. dinellii* are distinct taxa (for example see discussions in Barquez et al., [1999] and López-González et al. [2001]), but LaVal defines the two forms unequivocally. This new distributional record corresponds clearly to *M. l. levis* and not to *M. l. dinellii*.

For comparison purposes, we examined selected specimens (**Appendix**). We quantified a set of cranial measurements (as in López-González et al., 2001) from the Paraguayan specimen as well as samples of *M. l. levis*, *M. l. dinellii*, and *M. albescens* from Paraguay and neighboring countries as follows: GLS, greatest length of the skull; CCL, condylocanine length; CBL, condylobasal length; MAB, mastoid breadth; ZYG, zygomatic breadth; BBC, breadth of braincase; INC, interorbital constriction; BAC, breadth across upper canines; BAM, breadth across upper molars; LNR, length of rostrum; MAX, length of maxillary toothrow; UML, length of upper molariform toothrow; MTR, length of mandibular toothrow, LML, length of lower molariform toothrow; forearm length (FAR) and length of the third metacarpal (MCIII). They are also reported in **Table 1**. Measurements were log-transformed and missing values estimated using the expectation-maximization algorithm of Little and Rubin (1987). We then used principal components analysis (PCA) on cranial measurements to summarize major trends in size and shape variation.

The specimen was taken adjacent to Estación Biológica Limoy, Department of Alto Parana, Paraguay (24° 46' 55.74"S -54° 30' 28.206" W), on 9 January 2008. The bat was collected

in a mist-net set over a small stream bordering the reserve. Habitat was a strip of subtropical broadleaf deciduous forest embedded in a much larger agricultural matrix of soybean. Along with the single individual of *M. levis*, we captured 14 *Artibeus lituratus*, four *Carollia perspicillata*, three *Sturnira lilium*, and three *Eptesicus furinalis*. The specimen was prepared as skin and skull, and it is deposited in the zoological collection of the Facultad de Ciencias Exactas y Naturales (FaCEN), Universidad Nacional del Asunción, San Lorenzo, Paraguay.

The Paraguayan specimen is large for the genus and has relatively short (4-5 mm on dorsum, between scapulae) and wooly hair. Dorsal coloration is dark brown, some hairs with peppered white tips. Individual dorsal hairs are bicolor, but not strongly so, with bases dark brown and tips lighter brown, in some cases white. Ventral pelage is lighter brown; individual ventral hairs also are dark brown at the base and either light brown or white at the tips. White-tipped ventral hairs become denser towards the posterior end. The plagiopatagium is inserted at the toes. A fringe of hairs is present on the edge of the uropatagium. On the ventral side of uropatagium, hairs emanate from white-colored pores. Ears reach the tip of the muzzle (15 mm). The skull is robust, with a long rostrum, sagittal crest not developed, wide braincase, and relatively narrow interorbital constriction. Forearm length is 37.2 mm. Measurements of the specimen and samples of *M. levis levis* and *M. levis dinellii* are included in **Table 1**.

This specimen was assigned to *Myotis l. levis* and not to *M. l. dinellii* because of its larger size (averaging smaller in most measurements in *M. l. dinellii*—**Table 1** and Barquez et al., 1999), individual dorsal hairs not being long and strongly bicolored, nor with yellow tips as in *dinellii* (LaVal, 1973). Because of its large size, *M. l. levis* can only be confused with *M. simus*, *M. ruber*, *M. oxyotus*, and *M. chiloensis*. However, it is easily distinguished by its external morphology; *M. simus* and *M. ruber* have relatively short, unicolored hair that

**Table 1**

Mean, minimum, maximum, and standard deviation (STD) of selected cranial and external measurements for *M. albescens*, *M. l. levis* and *M. levis dinellii*. N= sample size. The specimen from Paraguay is listed separately. Acronyms as in text.

	GLS	CCL	CBL	MAB	ZYG	BBC	INC	BAC	BAM	LNR	MAX	MTR	FAR	MC3
<i>M. levis levis</i> , (Brazil, Uruguay, Argentina)														
Mean	15.23	13.22	14.32	7.65	9.31	7.15	3.74	3.63	5.87	6.61	5.59	5.94	38.24	35.51
Min	14.89	12.42	13.41	7.02	8.9	6.83	3.50	3.36	5.6	5.78	5.41	5.73	35.81	33.12
Max	15.76	13.61	14.73	7.9	9.61	7.49	4.03	4.16	6.42	6.97	5.87	6.32	40.7	37.56
STD	0.24	0.27	0.30	0.18	0.20	0.17	0.13	0.15	0.16	0.19	0.11	0.14	1.01	0.95
N	34	35	35	35	31	37	35	35	35	35	35	35	36	32
<i>Myotis l. levis</i> (Limoy, Paraguay)														
	15.36	13.18	14.58	7.88	9.28	7.62	4.2	3.93	5.96	6.43	5.46	6.72	37.24	34.41
<i>M. l. dinellii</i> , Bolivia, NW Argentina														
Mean	14.36	12.38	13.45	7.16	8.66	6.85	3.57	3.39	5.45	6.36	5.33	5.67	34.92	32.99
Min	13.85	11.42	13.21	6.89	8.18	6.49	3.38	3.1	5.03	6.1	5.12	5.52	33	31.31
Max	14.6	12.79	13.78	7.65	9.11	7.18	3.75	3.67	5.8	6.71	5.53	5.87	36.7	35
STD	0.22	0.33	0.19	0.21	0.35	0.17	0.12	0.15	0.26	0.18	0.12	0.09	1.05	1.3
N	13	14	13	15	5	15	15	15	15	14	14	13	13	12
<i>Myotis albescens</i> (Paraguay, Argentina)														
Mean	13.98	11.98	13.02	7.32	8.45	7.08	4.02	3.52	5.34	5.84	4.88	5.15	33.87	31.96
Min	13.05	11.18	11.97	6.6	7.93	6.55	3.49	3.05	4.83	5.44	4.62	4.74	30.38	29.56
Max	14.63	12.49	13.59	7.7	8.91	7.53	4.27	3.81	5.66	6.19	5.26	5.43	36.77	34.75
STD	0.31	0.26	0.28	0.16	0.21	0.17	0.13	0.11	0.13	0.14	0.12	0.14	1.17	1.12
N	81	81	81	80	56	81	81	81	81	81	81	80	68	67

has bright orange to dull brown (*simus*) or cinnamon (*ruber*) coloration. Additionally, the insertion of the plagiopatagium is at the level of the ankle in *M. simus*, whereas it is at the toes in *M. l. levis*. Cranially, *M. simus* and *M. ruber* are easily separated by having a sagittal crest, *M. simus* additionally presents crowding of upper premolars (LaVal, 1973; López-González et al., 2001). From *M. chiloensis*, *M. l. levis* differs in having a fringe of hairs on the border of the uropatagium, in showing a more marked contrast between bases and tips of individual hairs, both dorsally and ventrally, having a more globose braincase, and lacking a sagittal crest (Barquez et al., 1999). *M. oxyotus* seems to be restricted to higher elevations than *M. l. levis* (LaVal, 1973; Anderson, 1997). Thus, its geographic distribution alone should be enough to separate *M. oxyotus* from *M. levis*. *M. oxyotus* also can be

distinguished externally by its silkier, longer, bicolored (black bases, brown tips, often bur-nished on tips) pelage, which extends over the dorsal portion of the uropatagium, usually past the knees (LaVal, 1973).

*M. albescens* and *M. l. levis* are often confused because in both species pelage can be dark brown peppered with silver white tips. Nonetheless, *M. albescens* is usually smaller (**Table 1**), and they can be readily distinguished by cranial shape. In *M. albescens* the rostrum is shorter, narrower, with a comparatively wider interorbital constriction, and a wider and globose braincase (López-González et al., 2001).

Morphometrically, *M. albescens*, *M. l. levis*, and *M. l. dinellii* are clearly distinct in PCA space (**Table 2, Fig. 1**). Variables related to the general size of the skull have similar loadings on PC1. Only INC has a low and nega-

**Table 2**

Loadings and percentage of variance explained by the first two PC's based on 14 cranial morphometric variables.

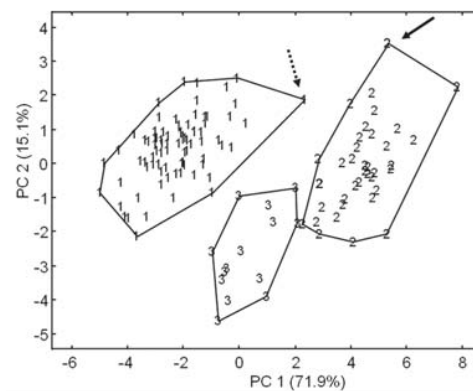
% variance explained	PC1	PC2
	71.9	15.1
GLS	0.3052	0.0148
CCL	0.3088	-0.0210
CBL	0.3094	-0.0009
MAB	0.2288	0.3828
ZYG	0.2838	0.1273
BBC	0.1041	0.5393
INC	-0.1561	0.5034
BAC	0.1650	0.4384
BAM	0.2848	0.0862
LNR	0.2925	-0.1769
MAX	0.3023	-0.1456
UML	0.2944	-0.1474
MTR	0.2986	-0.0878
LML	0.2942	-0.1039

tive loading on this axis. In contrast, PC2 is positively associated with variables related to the width of the braincase and interorbital constriction, and negatively correlated to variables related to the length of the rostrum. Thus *M. albescens* is a small bat with a wide braincase and INC, and a short rostrum; *M. l. dinellii* is intermediate in size, but has a narrower braincase and INC, and a comparatively longer rostrum. *M. l. levis* is the largest of the three, with a wide braincase but relatively narrow INC, and a shorter rostrum than *M. l. dinellii*, but slightly longer than *M. albescens*.

The taxonomic status of *M. levis* has been in flux since its original description. *M. levis* was first described in 1824 by I. Geoffroy Saint-Hilaire. Thomas (1902) described *M. dinellii* as a separate species. Miller and Allen (1928) subsequently relegated *M. dinellii* to a subspecies of *M. chiloensis*, and apparently ignored the name *levis*. Cabrera (1958) placed the epithet *dinellii* as subspecific under *M. chiloensis*, whereas he considered *levis* as a synonym of *M. ruber* (noting that this is not the same as *Vespertilio levis* I. Geoffroy Saint-Hilaire, 1824). Such confusion probably arose from a poor record of southern South Ameri-

can *Myotis*, and a wide degree of variability within and among populations.

LaVal (1973) revised the Neotropical species of *Myotis* and his classification has persisted mostly unchallenged to date. Based on external morphology and morphometric data, he defined *M. levis* as a separate species, and included *dinellii* as a subspecies of it. His definition clearly separates these populations from other small and medium size *Myotis*. However, within the species there is less definition. *M. l. levis* and *M. l. dinellii* differ "in no appreciable way except size and color" (LaVal, 1973; p. 39). Within *M. levis levis*, variation is large enough to consider the possibility of having actually two species. It is also possible that *levis* and *dinellii* represent different species (Barquez et al., 2006). Interestingly, only *M. l. levis* has been included in systematic treatments exploring phylogenetic relationships among taxa in the genus (Ruedi and Mayer, 2001; Bickham et al., 2004; Stadelmann et al., 2007); *M. l. dinellii* has never been included in such analyses and its implied placement sister to *M. l. levis* may be



**Fig. 1.** Distribution of South American *Myotis* in the two dimensional space defined by PCA of 14 cranial morphometric characters: Numbers refer to: *M. albescens* (1), *M. l. levis* (2), and *M. l. dinellii* (3). Hatched arrow points to specimen of *M. albescens* (MHNG 1747.54) from Itapua, reported in Baud and Menu (1989) as *Myotis levis*. Solid arrow points to *M. levis levis* from Estacion Biológica Limoy, Alto Paraná, Paraguay.

dubious. Although gaps in the distribution of this rare southern South American taxon are closing, uncertainty regarding its systematics prevails. Indeed, further systematic study will greatly enhance our understanding of the status of *Myotis* in South America in particular, and improve our understanding of evolutionary relationships of the New World clade in general.

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## APPENDIX

### Specimens examined

Museums from which specimens were examined with acronyms in parentheses are: The Museum, Texas Tech University (TTU, TK), Field Museum of Natural History (FMNH), Museum d'Histoire Naturelle, Geneve, Switzerland (MHNG), American Museum of Natural History (AMNH), and Museum of Vertebrate Zoology (MVZ).

*Myotis albescens* (81). —ARGENTINA: Entre Ríos, Depto. Gualeguachú, Islas del Ibicuí, Paranacito (TTU 32538, 32541-32543, 32546, 32550-52). PARAGUAY: Alto Paraguay, Estancia Doña Julia (TK 60986-95, 60997-98, 61000-01, 61054-55, 61062-64, 61066-69, 61135); Boquerón, Base Naval Pedro P. Peña, 22° 27.16'S, 62° 20.65'W, 240 m (TK 62827, 62842-43); Estancia La Victoria, 23° 39.04'S, 58° 34.79'W, 120 m (TK 60095-97, 60106, 60158, 60174); Estancia Loma Pora, 23° 27.87'S, 57° 36.29'W (TK 62170); Estancia Parra-Cue 21° 05.91'S, 57° 53.52' W (TK 60760-61, 60764-65, 60767-69); Estancia Samaklay, 23° 28.81'S, 59° 48.43'W (TK 62698-99, 62768, 62782, 62786, 62808); Fuerte Olimpo 21° 02.37'S, 57° 52.29'W, 95m (TK 60741, 60746-48, 60751-53); Misiones, Arroyo Atinguy, 27° 20.67'S, 56° 40.52'W, 77m (TK 60869, 60871); Ñeembucu, Estancia Yacare, 26° 37.97'S, 58° 07.55'W, 60 m (TK 61655, 61721, 61766); Presidente Hayes, 275 km NW Villa Hayes, by Rd. (MVZ 144576, 144580-82, 144584-87, 144636-39, 144641).

*Myotis levis levis* (35).—ARGENTINA: Buenos Aires, Maipú (TTU 32555); Entre Ríos, Estación Médanos (TTU 32535). BRAZIL: Rio Grande do Sul, Arroyo das Pedras, en la Barra con el Rio Camacua (AMNH 235863-77, 235880-81); São Paulo, Estação Biológica de Boracéia, 820 m (FMNH 141600, 145327-28). URUGUAY: Acosta y Lara, Rivera (FMNH 63829); Lavalleja, 9 km S Pirarajá, Cunetary (AMNH 205503-05, 205508-10, 205512-15); San José (FMNH 63827-28).

*Myotis levis dinellii* (15). —ARGENTINA: Chaco, General Vedia (TTU 32556); Córdoba, Dto. San Javier, Villa Dolores, (TTU 32524-25, 32528-29); Entre Ríos, Dpto. Gualeguachú, Islas del Ibicui, Paranacito (TTU 32537, 32544, 32547, 32549); Entre Ríos, Depto. Gualeguachú, Brazo Largo (TTU 32533-34); La Rioja, Depto. Castro Barros, Chuquis (TTU 32530); Salta, Capital, Buenavista (TTU 32531). BOLIVIA: Santa Cruz, Santa Cruz de la Sierra (AMNH 248202); Tarija, Narváez (MHNG 1748.89).