

# Bat species richness in the region of the Central Valleys of Oaxaca, Mexico

M. García–Luis, M. Briones–Salas, M. C. Lavariega

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## Abstract

*Bat species richness in the region of the Central Valleys of Oaxaca, Mexico*  
We present a revised checklist of bat species occurring in the semi–urbanized region of the Central Valleys of Oaxaca, Mexico. The checklist is based on surveys using mist nets, recordings of echolocation calls, data from literature, and museum databases. Results show that the Central Valleys of Oaxaca have a species richness of 33 bat species belonging to 22 genera and five families. Species like the Mustached bat *Pteronotus parnellii*, the Western Red bat *Lasiurus blossevillii* and the Free–tailed bat *Promops centralis* were recorded after 32, 30 and 19 years respectively according to the records of the literature. We also recorded four species classified in some risk category according to either the Mexican government’s red list (NOM–059) or the IUCN red list. The recordings of the echolocation calls are the first from the region of Central Valleys of Oaxaca. Bat diversity in the Central Valleys of Oaxaca was underestimated and emphasizes the need for further research.

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Key words: Urban biodiversity, Acoustic monitoring, Anabat SD 1, *Promops centralis*, *Pteronotus parnellii*, *Lasiurus blossevillii*

## Resumen

*Riqueza específica de murciélagos en la región de los Valles Centrales de Oaxaca, Méjico*  
Presentamos una lista revisada de las especies de murciélagos que se encuentran en la región semiurbanizada de los Valles Centrales de Oaxaca, México. La lista de especies se basa en muestreos realizados con redes de niebla, grabación de llamadas de ecolocalización y revisión de literatura y bases de datos de colecciones científicas. La riqueza acumulada de especies de murciélagos en los Valles Centrales de Oaxaca es de 33 especies, distribuidas en 22 géneros y cinco familias. El murciélago bigotudo de Parnell *Pteronotus parnellii*, el murciélago de cola peluda de Blossville *Lasiurus blossevillii* y el murciélago mastín mayor *Promops centralis* fueron registrados después de 32, 30 y 19 años, respectivamente, de acuerdo con los registros de la literatura. También registramos cuatro especies clasificadas en alguna categoría de riesgo por el gobierno mexicano o por la lista roja de la UICN. Las

grabaciones acústicas de llamadas de ecolocalización son las primeras realizadas en la región de los Valles Centrales de Oaxaca. La diversidad de murciélagos en los Valles Centrales de Oaxaca ha sido subestimada por lo que se requiere estudios que complementen el conocimiento actual de este grupo.

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Palabras clave: Biodiversidad urbana, Monitoreo acústico, Anabat SD 1, *Promops centralis*, *Pteronotus parnellii*, *Lasiurus blossevillii*

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## Resum

*Riquesa específica de ratpenats a la regió de Valles Centrales, Oaxaca, Mèxic*  
Presentem una llista revisada de les espècies de ratpenats que es troben a la regió semiurbanitzada de Valles Centrales, Oaxaca, Mèxic. La llista d'espècies es basa en mostrejos practicats amb xarxes de boira, enregistrament de crides d'ecolocalització i revisió de literatura i bases de dades de col·leccions científiques. La riquesa acumulada d'espècies de ratpenats a Valles Centrales d'Oaxaca és de 33 espècies, distribuïdes en 22 gèneres i cinc famílies. El ratpenat de bigotis de Parnell *Pteronotus parnellii*, el ratpenat de cua peluda de Blossville *Lasiurus blossevillii* i el ratpenat cuallarg de Thomas *Promops centralis* van ser registrats després de 32, 30 i 19 anys, respectivament, d'acord amb els registres de la literatura. També vam registrar quatre espècies classificades en alguna categoria de risc pel govern mexicà o per la llista roja de la UICN. Els enregistraments acústics de crides d'ecolocalització són els primers portats a terme a la regió de Valles Centrales d'Oaxaca. La diversitat de ratpenats a Valles Centrales d'Oaxaca ha estat subestimada per la qual cosa requereix estudis que complementin el coneixement actual d'aquest grup.

Dades publicades a GBIF ([doi: 10.15470/qp5ccr](https://doi.org/10.15470/qp5ccr))

Paraules clau: Biodiversitat urbana, Monitoratge acústic, Anabat SD 1, *Promops centralis*, *Pteronotus parnellii*, *Lasiurus blossevillii*

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## Introduction

Bats are the world's second largest group of mammals (Wilson and Reeder, 2005). Their high ecological diversity, their high abundance, and the multiple approaches that can be used for their monitoring make bats an ideal group and an indicator of a habitat's quality and biodiversity (Fenton et al., 1992; Medellín et al., 2000; Gehrt and Chelsvig, 2004; Stahlschmidt and Brül, 2012). In all regions, knowledge of bat presence is necessary to promote their management and conservation.

In Mexico, the largest bat species richness occurs in the State of Oaxaca, where 96 species are known (Briones–Salas et al., 2015). In the State of Oaxaca, most studies on bat diversity come from regions with low urbanization such as the Isthmus of Tehuantepec (López et al.,

2009; Lira-Torres et al., 2011; Kraker-Castañeda et al., 2013; Briones-Salas et al., 2013), northwestern valleys (Rojas-Martínez and Valiente-Banuet, 1996; Briones-Salas, 2000), northern mountains (Calderón-Patrón et al., 2013), central western mountains (Lavariega et al., 2012), and the Pacific coast plains (Buenrostro-Silva et al., 2012; García-Grajales et al., 2013). In our search we found only one study –unpublished– about vertebrates in the region. The study was conducted in the natural protected Benito Juárez National Park, to the north of the Central Valleys of Oaxaca, and only 19 bat species were listed (Bonilla et al., 1988); studies of bat diversity in this region are thus virtually nonexistent.

To promote the management and conservation of bats in the region of the Central Valleys of Oaxaca it is first essential to know which bat species are found therein. This region has been occupied by humans for at least 7,000 years and its landscape has been widely modified for agriculture and urban development (Ordóñez, 2004; Coronel, 2006), both major causes of declines in populations of species (Wilson, 1988). Within the State of Oaxaca, the Central Valleys of Oaxaca is the region with the largest concentration of human populations (> 1,033,884 people; GEO, 2015). The aim of this work was to determine bat species richness in this region through mist netting and echolocation calls recorded during surveys. In addition, literature and museum databases were reviewed.

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## Material and methods

### Study site

The region of the Central Valleys is located in the State of Oaxaca, Mexico (95° 54' to 97°14' W and 16° 28' to 17° 38' N) and has an area of 7,974 km<sup>2</sup> and includes the political districts of ETLA, Centro, Zaachila, Ocotlán, Zimatlán, Tlacolula and Ejutla. The region includes the physiographic subprovince of the Central Valleys and parts of the physiographic subprovinces of the Sierra Madre of Oaxaca, Fosa of Tehuacan, Central Mountains and Valleys, Western Mountains and Southern Mountains and Valleys (fig. 1; Ortiz-Pérez et al., 2004). The climate is semi-warm, sub-humid temperate [(A)C(wo)] and warm semi-arid [BS1(h')w] (INEGI, 2000). The area has been transformed to agriculture and pastureland, but hilly areas still have dry forest and pine-oak forest (INEGI, 2013).

### Data analyses

To estimate bat species richness, two methods were used at each location: mist netting and echolocation recordings. Mist nets were located in places with high bat activity such as flight paths and edges, and within vegetation fragments, near streams and refuges; the nets were open from 18:00 to 02:00 h. The total sampling effort was 3,072 m<sup>2</sup>n/h (8 sites, 2 nights/site). Bats captured were identified to species level based on Álvarez et al. (1994) and Medellín et al. (1997). Voucher specimens were deposited in the mammalian collection of the Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional Unidad Oaxaca of the Instituto Politécnico Nacional (OAX.MA.026.0497; CIIDIR-Oaxaca, IPN). Bat echolocation calls were recorded using an Anabat SD 1 detector (Titley Scientific, Australia). Echolocation calls were recorded using minor modifications from the O'Farrell and Miller (1999) and O'Farrell et al. (1999) methods; these modifications consist of setting the Anabat SD 1 detector at an angle of 45° at ground level, and rotating it clock-wise every 10'. The Anabat SD 1 was programmed with a sensitivity level of five (intermediate) and a frequency division of eight. A total of 55 h of vocalizations were recorded in 8 localities, 1 night/site. Echolocation call recordings were analyzed using AnalookW version 3.8s (Corben, 2003) and species were determined based on the characteristics of the search-phase, following O'Farrell and Miller (1997, 1999) and O'Farrell et al. (1999, 2000), William et al. (2001), Gannon et al. (2004), Jung et al. (2007), Orozco-Lugo et al. (2013) and the Corben (2014) reference library.

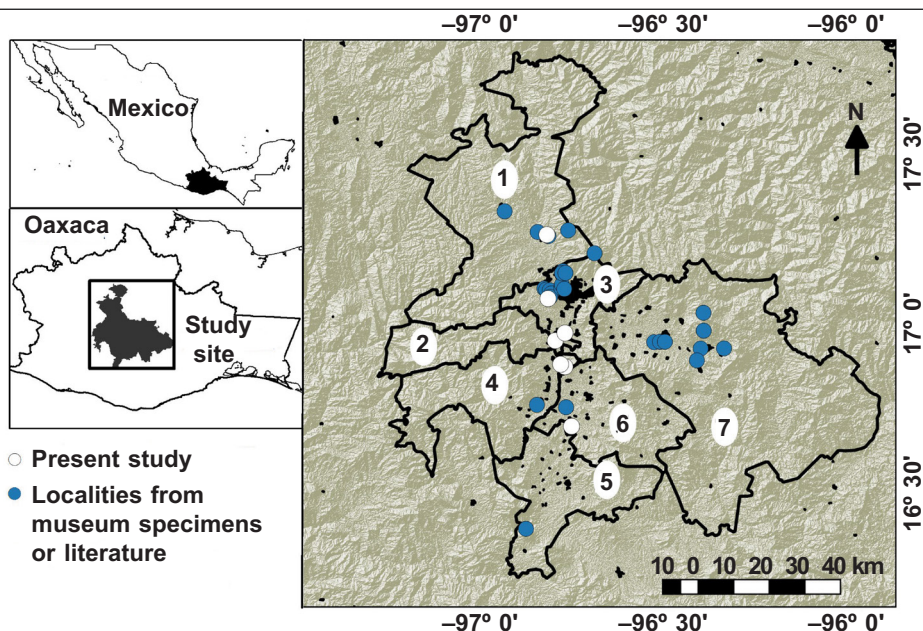


Fig. 1. Location of the Central Valleys of Oaxaca, Mexico. Blue and white dots show the localities with historical and recent bat records. Districts: 1, Etlá; 2, Zaachila; 3, Centre; 4, Zimatlán; 5, Ejutla; 6, Ocotlán; 7, Tlacolula.

*Fig. 1. Localización de los Valles Centrales de Oaxaca, México. Los puntos azules y blancos muestran las localidades con registros históricos y recientes de murciélagos. (Para las abreviaturas de los distritos, véase arriba).*

Species accumulation curves were created using Species Accumulation Functions software (CIMAT, 2003). Previously, the samples were randomized 1,000 times with EstimateS software (Colwell, 2009) to prevent order effect and to smooth the curve (Moreno and Halffter, 2000).

Finally, we consulted the CIIDIR–Oaxaca mammal collection database, which contains records of four national museums and 23 international museums (Briones–Salas et al., 2015) to obtain records of bat species for the region of the Central Valleys of Oaxaca. Guilds of bats were obtained from Ceballos and Oliva (2005) and scientific names for bat species were searched on the list of threatened species of the Norma Oficial Mexicana 059 (NOM–059–ECOL–2010; SEMARNAT, 2010) and the red list of the International Union for Conservancy of Nature (IUCN, 2016). Taxonomic arrangement is based on Ramírez–Pulido et al. (2014).

## Results

### Accumulated bat species richness

We found that the total accumulated bat species richness for the region of the Central Valleys of Oaxaca was 33 bat species belonging to 18 genera and five families (mist nets, acoustic survey, museums and literature): Emballonuridae (2 species), Mormoopidae (three species), Phyllostomidae (14 species), Molossidae (3 species), and Vespertilionidae (11 species) (table 1, [GBIF dataset: doi:10.15470/qp5ccr](https://doi.org/10.15470/qp5ccr)). During fieldwork we recorded



Table 1. List of bat species from the Central Valleys of Oaxaca, Mexico. This list is based on the taxonomic arrangement of Ramírez-Pulido et al. (2014). Guild: I, insectivore; S, sanguivore; N, nectarivorous; F, frugivorous. Survey data: AD, acoustic detection; NOM-059, Norma Oficial Mexicana 059. IUCN: <sup>TH</sup>Threatened; <sup>VU</sup>Vulnerable; <sup>EN</sup>Endangered; <sup>NT</sup>Near threatened. Acronyms: AMNH, American Museum of Natural History, New York; CNMA, Colección Nacional de Mamíferos, Instituto de Biología, UNAM; OAXMA, Colección Mastozoológica, CIIDIR-IPN Unidad Oaxaca; KU, University of Kansas, Museum of Natural History; LACM, Natural History Museum of Los Angeles County; ENCB, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, CAS, California Academy of Sciences; UMMZ, University of Michigan, Museum of Zoology; USNM, United States National Museum of Natural History; MVZ, University of California, Berkeley, Museum of Vertebrate Zoology; LSUMZ, Louisiana State University, Museum of Natural Science; MCZ, Harvard University, Museum of Comparative Zoology. (In acoustic records, each record is a file).

Tabla 1. Lista de especies de murciélagos de los Valles Centrales de Oaxaca, México. Esta lista está basada en la distribución taxonómica de Ramírez-Pulido et al. (2014). Grupo: I, insectívoro; S, hematófago; N, nectarívoro; F, frugívoro. Datos del estudio: AD, detección acústica; NOM-059, Norma Oficial Mexicana 059. IUCN: <sup>TH</sup>Amenazado; <sup>VU</sup>Vulnerable; <sup>EN</sup>En peligro; <sup>NT</sup>No amenazado. (Para los acrónimos, véase arriba; en los registros acústicos, cada registro es un archivo).

Taxa	Common name	Guild	Type of record (n°)	Source
Family Emballonuridae				
<i>Balantiopteryx plicata</i> Peters, 1867	Sac-winged bat	I	Museum (2)	MCZ
<i>Saccopteryx bilineata</i> (Temminck, 1838)	Greater white-lined bat	I	Literature	Briones-Salas and Sánchez-Cordero (2004)
Family Molossidae				
<i>Nyctinomops macrotis</i> (Gray, 1839)	Big free-tailed bat	I	Museum	OAXMA
<i>Promops centralis</i> Thomas, 1915	Free-tailed bat	I	Museum (10), Acoustic (10)	AMNH, OAXMA, LACM, present study
<i>Tadarida brasiliensis</i> I. Geoffroy Saint-Hilaire, 1824	Mexican free-tailed bat	I	Literature, Museum (7) Net mist (69) Acoustic (2,444)	Hall (1981), Goodwin (1969), AMNH, LACM, ENBV, present study
Family Mormoopidae				
<i>Mormoops megalophylla</i> (Peters 1864)	Leaf-chinned bat	I	Literature, Acoustic (10)	Briones-Salas and Sánchez-Cordero (2004), present study
<i>Pteronotus davyi</i> Gray, 1838	Naked-backed bat	I	Literature, Acoustic (2)	Briones-Salas and Sánchez-Cordero (2004), present study
<i>Pteronotus parnellii</i> Gray, 1843	Mustached bat	I	Acoustic (20)	Present study
Family Phyllostomidae				
<i>Desmodus rotundus</i> (É. Geoffroy St.-Hilaire, 1810)	Common vampire bat	S	Literature, Museum (77), Mist net (3)	Goodwin (1969), AMNH, CNMA, LACM, MVZ, present study
<i>Anoura geoffroyi</i> Gray, 1838		N	Mist net (1), Museum (2)	LSUMZ, AMNH, present study
<i>Choeroniscus godmani</i> (Thomas, 1903) <sup>TH, NT</sup>	Godman's long-tongued bat	N	Literature, Museum (95), Mist net (1)	Briones-Salas and Sánchez-Cordero (2004), AMNH, CNMA, KU, LACM, USNM, LSUMZ, present study
<i>Choeronycteris mexicana</i> Tschudi, 1844 <sup>TH, NT</sup>	Mexican long-tongued bat	N	Literature, Museum (95), Mist net (1)	Goodwin (1969), AMNH, CNMA, KU, LACM, USNM, LSUMZ, present study
<i>Glossophaga leachii</i> (Gray, 1844)		N	Literature	Briones-Salas and Sánchez-Cordero (2004)
<i>Glossophaga soricina</i> (Pallas, 1766)		N	Museum (21), Mist net (4)	CNMA, KU, LACM, present study
<i>Leptonycteris nivalis</i> (de Saussure, 1860) <sup>TH, EN</sup>	Mexican long-nosed bat	N	Museum (2)	AMNH
<i>Leptonycteris yerbabuenae</i> Martínez and Villa, 1940 <sup>VU</sup>	Lesser long-nosed bat	N	Literature, Museum (7), Mist net (2)	Goodwin (1969), UMMZ, LACM, KU, present study
<i>Micronycteris microtis</i> Miller, 1898	Common big-eared bat	I	Museum (3)	OAXMA
<i>Artibeus jamaicensis</i> Leach, 1821	Jamaican fruit bat	F	Literature, Mist net (41),	Hall (1981), Goodwin (1969), present study
<i>Artibeus lituratus</i> Olfers, 1818	Big fruit-eating bat	F	Museum (3), Mist net (2)	CNMA, OAXMA, ENCB, present study
<i>Dermanura azteca</i> (Andersen 1906)	Aztec fruit-eating bat	F	Literature	Lavariega et al. (2012), Briones-Salas and Sánchez-Cordero (2004)
<i>Sturnira hondurensis</i> Goodwin, 1940	Highland yellow shouldered bat	F	Museum (2), Mist net (20)	CNMA, AMNH, present study
<i>Sturnira parvidens</i> Goldman, 1917	Yellow shouldered bat	F	Museum (4), Mist net (64)	CNMA, present study
Family Vespertilionidae				
<i>Myotis californicus</i> (Audubon and Bachman, 1842)	Forest dwelling California bat	I	Literature, Museum (7), Mist net (3), Acoustic (684)	Hall (1981), Goodwin (1969), AMNH, KU, LACM, CAS, present study
<i>Myotis fortidens</i> Miller and G. M. Allen, 1928	Cinnamon myotis	I	Museum (4)	AMNH
<i>Myotis keaysi</i> J. A. Allen, 1914	Black myotis	I	Mist net (1)	Present study
<i>Myotis thysanodes</i> Miller, 1897	Fringed myotis	I	Mist net (1), Acoustic (1,483)	Present study
<i>Myotis velifer</i> J. A. Allen, 1890	Cave myotis	I	Mist net (1)	Present study
<i>Eptesicus fuscus</i> (Palisot de Beauvois, 1796)	Big brown bat	I	Literature, Museum (30), Mist net (30), Acoustic (2,691)	Goodwin (1969), AMNH, CNMA, OAXMA, ENCB, present study
<i>Lasiurus blossevillii</i> (Lesson and Garnot, 1826)	Western red bat	I	Museum (2)	ENCB, OAXMA
<i>Lasiurus cinereus</i> (Palisot de Beauvois, 1796)	Hoary bat	I	Literature, Museum (18), Mist net (1), Acoustic (1,357)	Goodwin (1969), AMNH, ENCB, present study
<i>Lasiurus intermedius</i> H. Allen, 1862	Northern yellow bat	I	Museum (1)	ENCB
<i>Rhogeessa gracilis</i> (Miller, 1897)	Yellow bat	I	Literature, Museum (1)	Hall (1981), Goodwin (1969), AMNH
<i>Corynorhinus townsendii</i> (Cooper, 1837)	Townsend's big-eared bat	I	Literature, Museum (4)	Hall (1981), Goodwin (1969), USNM

Table 2. Measurements (in millimeters) of bats collected in mist nets in the Central Valleys of Oaxaca, Mexico: N, number of individuals; ToL, total length; TaL, tail length; HF, hind foot; EL, ear length; FL, forearm length; W, weight (in gr).

Tabla 2. Medidas (en milímetros) de los murciélagos recolectados mediante redes de niebla en los Valles Centrales de Oaxaca, México: N, número de individuos; ToL, longitud total; TaL, longitud de la cola; HF, longitud de la pata trasera; EL, longitud de la oreja; FL, longitud del antebrazo; W, peso (en gr).

Specie	N	ToL	TaL	HF	EL	FL	W
<i>Promops centralis</i>	3	132–137	50–53	12–13	14–20	51–57	29–37
<i>Tadarida brasiliensis</i>	69	79–102	17–42	5–11	9–20	40–48	7–34
<i>Desmodus rotundus</i>	3	70–74	0	14–17	16–19	58–65	26–37
<i>Anoura geoffroyi</i>	1	56	0	11	11	41	15
<i>Choeronycteris mexicana</i>	1	82	8	11	14	46	35
<i>Glossophaga soricina</i>	4	55–66	5–6	7–10	7–13	34–37	10–29
<i>Leptonycteris yerbabuenae</i>	2	74–75	0	14	11–12	55	50–75
<i>Artibeus jamaicensis</i>	41	76–98	0	11–22	59–69	43–78	0
<i>Artibeus lituratus</i>	2	84–92	0	15–16	17–20	71	71–72
<i>Sturnira hondurensis</i>	20	55–70	0	8–15	9–15	40–47	13–51
<i>Sturnira parvidens</i>	64	50–70	0	9–15	8–17	39–44	13–49
<i>Myotis californicus</i>	3	78–88	36–42	6–7	12–15	30–37	5–7
<i>Myotis keaysi</i>	1	68	37	9	13	33	6
<i>Myotis thysanodes</i>	1	80	38	8	12	29	5
<i>Myotis velifer</i>	1	91	41	8	16	42	8
<i>Eptesicus fuscus</i>	30	82–121	32–50	8–11	9–15	41–53	8–28
<i>Lasiurus cinereus</i>	1	127	60	10	17	52	20

20 species of bats. Of these, 16 species were captured in mist nets (80%; tables 1 and 2), four species were detected using Anabat SD 1, and five were recorded with both methods (table 1, fig. 2). Noteworthy records for the region of the Central Valleys are: mustached bat *Pteronotus parnellii* (first record of the region, only recorded with acoustic sampling), Western red bat *Lasiurus blossevillii*, and free-tailed bat *Promops centralis*. The last two had been recorded from occasional samplings in 1986 and 1992, respectively. However, we captured one individual and recorded echolocation calls for both.

Throughout our search in the museums' databases, we obtained 251 records belonging to 23 species. The best represented species were the Mexican long-tongued bat *Choeronycteris mexicana* with 72 specimens and the common vampire bat *Desmodus rotundus* with 52. The least represented species are *Pteronotus parnellii*, *Lasiurus blossevillii*, Northern yellow bat *L. intermedius*, yellow bat *Rhogeessa gracilis* and Townsend's big-eared bat *Corynorhinus townsendii* with one specimen respectively (table 1).

#### Guilds and conservation

The guild with most species was insectivorous (20 species; 60.60%), followed by nectarivorous (seven species; 21.21%), and frugivorous (five species; 15.15%); only one sanguivorous species was recorded (3.03%; table 1). Three species were in some threatened category. Mexican long-nosed bat *L. nivalis*, Godman's long-tongued bat *Choeronycteris*

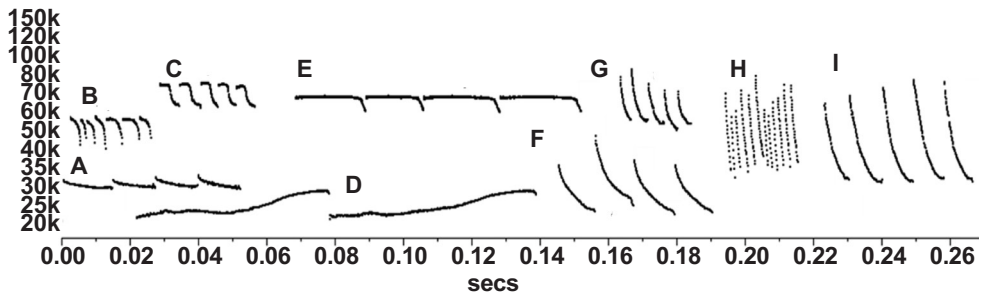


Fig. 2. Echolocation calls of insect eating bats recorded with Anabat SD 1 from the Central Valleys of Oaxaca, Mexico: A, *Tadarida brasiliensis*; B, *Mormoops megalophylla*; C, *Pteronotus davyi*; D, *Promops centralis*; E, *Pteronotus parnellii*; F, *Lasiurus cinereus*; G, *Myotis californicus*; H, *M. thysanodes*; I, *Eptesicus fuscus*.

Fig. 2. Llamadas de ecolocalización de murciélagos insectívoros registradas con Anabat SD 1 en los Valles Centrales de Oaxaca, México. (Para las abreviaturas de las especies, véase arriba).

*godmani* and *Choeronycteris mexicana* are classified as threatened species by the Mexican Government (SEMARNAT, 2010), whereas IUCN classifies *L. yerbabuena* as vulnerable species, *L. nivalis* as endangered species, *Choeronycteris godmani* and *Choeronycteris mexicana* as near threatened species (IUCN, 2016).

#### Species accumulation model (mist nets)

The species accumulation model which best fitted the obtained data was the logarithmic model ( $\rho = 0.9993$ ; parameters  $a = 3.63$  and  $b = 0.152$ ), followed by the Clench model ( $0.9990$ ;  $a = 2.49$  and  $b = 0.097$ ), and the exponential model ( $0.997$ ;  $a = 1.89$  and  $b = 0.10$ ). Asymptotes for these models were 19.47, 24.25, and 17.09 species, respectively. The exponential model showed that 95% of the estimated species were recorded and it suggested an additional sampling effort of 28 days to complete 100% of the estimated actual species in the area. The Clench model suggested 194 days of additional sampling (fig. 3).

## Discussion

We recorded a total of 33 bat species inhabiting the Central Valleys of Oaxaca, corresponding to 34.38 % of all bat species in Oaxaca (96 species). Mist-netting work produced captures of seven species of insectivorous bats (21.21%). Such species are frequently absent in the inventories because of their high flight during foraging (Bonaccorso, 1979; Jung and Kalko, 2011) but low flight near their refuges. Mist-netting is the best method to capture bats from the family Phyllostomidae (nectarivorous, frugivorous, and sanguinivorous), due to their low flight and foraging in and between vegetation patches (Villa and Cervantes, 2003). On the other hand, the acoustic detectors are very useful devices to record insectivorous bat species, and can be a complementary method for bats monitoring (Pech-Canché et al., 2011). Thanks to acoustic detector Anabat SD 1, we recorded nine species, three only with this method (*Pteronotus parnellii*, *P. davyi* and *Mormoops megalophylla*). These recordings represented the first effort in the regions to register species using detectors.

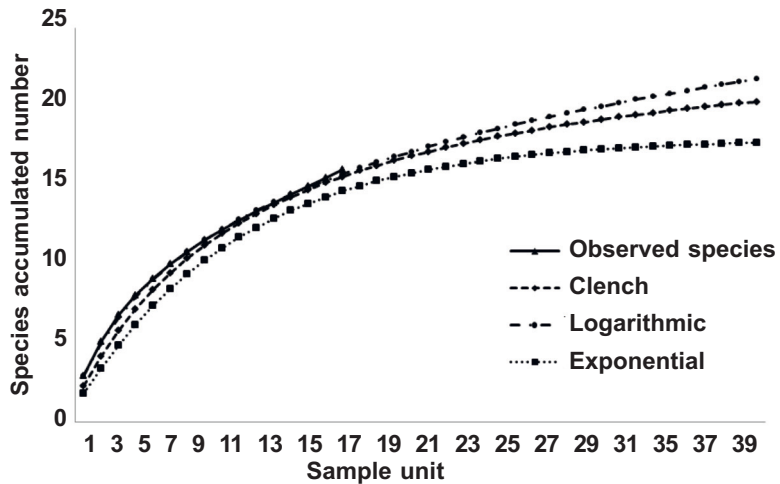


Fig. 3. Species accumulation curve for bats captured with mist nets in the Central Valleys of Oaxaca, Mexico.

Fig. 3. Curvas de acumulación de especies de murciélagos capturados mediante redes de niebla en los Valles Centrales de Oaxaca, México.

Studies on bats in Neotropical cities are few and are survey–method biased. Using mist netting, 13 to 28 species have been recorded in this region (Sánchez et al., 1989; Silva et al., 2005; García–Grajales et al., 2013). On the other hand, six to 20 species have been recorded with acoustic methods in cities (Siles et al., 2005; Ávila–Flores and Fenton, 2005; Jung and Kalko, 2010, 2011). This survey method bias precludes the possibility of comparisons but shows the need for a major survey effort using complementary methods to evaluate the bat diversity in urban landscapes.

The variety of guilds and the high number of bat species recorded in Central Valleys of Oaxaca, a third of the total number in the state (Briones–Salas et al., 2015), may be due to the variety of habitats of the region (e.g. gardens, parks, riparian vegetation, agave crops) that provide adequate resources for the bats. Due to their conservation status, it is especially favorable for *Leptonycteris nivalis*, *Choeroniscus godmani* and *Choeronycteris mexicana* species.

Presence of insectivorous bats such as *Tadarida brasiliensis* and species of the genus *Lasiurus*, *Myotis*, and *Eptesicus* is relevant because their diet can include insect pests, an ecosystem service with economic benefits (Tuttle and Moreno, 2005). *Artibeus* and *Sturnira* genus accounted for half of the captures (52%). The importance of these two species lies in their contribution to the forest regeneration process through their role as seed dispersers. Moreover, *Choeronycteris mexicana*, *Anoura geoffroyi* and *Leptonycteris yerbabuena* play a critical role as pollinators for plants like cacti and agave (Tuttle and Moreno, 2005). Only one sanguinivorous species was recorded, *Desmodus rotundus*, but it did not appear to be a problem for the cattle in the visited localities (pers. observ.).

This work contributes with the first bat list for the Central Valleys of Oaxaca. The variety of habitats in these regions promotes the presence of a high ratio of species, one third of the total in all of Oaxaca. Nevertheless, further work, focusing on acoustic monitoring, is needed in this region to record possible additional species, to enlarge the state library calls (Briones–Salas, unpublished data), and to understand the factors that have allowed bats to remain in the Central Valleys despite the disturbance.



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