

Mammal species richness and new records in protected natural areas of the northern part of the metropolitan area of the Valley of México

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Sierra de Guadalupe is the only mountain range in the northern part of the Valley of Mexico metropolitan area. The accelerated urban expansion over the past decades has turned Sierra de Guadalupe into an isolated natural area immersed within the urban matrix. This study aimed to gather a documented inventory of the mammals of Sierra de Guadalupe as such information is useful to improve the management, restoration, and conservation of this important natural area of the basin of Mexico. Mammal collection records were extensively surveyed in the literature, collection databases, web pages, and scientific collections; field surveys were also conducted. A taxonomic list of the mammal species and their conservation status in the four Protected Natural Areas of Sierra de Guadalupe was compiled. A species-accumulation curve was constructed using the Chao 1 model and a map showing the distribution of collection records was produced. This work reveals that the mammals of Sierra de Guadalupe include 29 species, 23 genera, 15 families, and six orders. Six species are endemic to Mexico; two of them, *Choeronycteris mexicana* and *Cratogeomys fumosus*, are listed as threatened and one, *Leptonycteris yerbabuena*, as under special protection. Collection records were gathered from 62 different localities. The largest number of species records and collections were made between 2009 and 2020. The species-accumulation curve projects a total of 36 mammal species. This is the first documented inventory ever compiled of the wild mammals of Sierra de Guadalupe. The species richness observed in this area is remarkable, considering its extension and environmental stressors; in addition, it harbors species endemic to Mexico, some of which are threatened. This is the first time that the species *Sorex saussurei*, *Choeronycteris mexicana*, *Leptonycteris yerbabuena*, *Cratogeomys merriami*, *Neotomodon alstoni*, and *Peromyscus melanophrys* have been recorded in this area. The species-accumulation curve indicates that our inventory provides a good representation of the local species assemblage. This information can support the formulation of action plans for the conservation and restoration of the biological diversity of these important Protected Natural Areas and the last significant natural area remaining in the northern part of the Valley of Mexico Metropolitan Area.

La Sierra de Guadalupe es la única cadena montañosa en la parte norte de la Zona Metropolitana del Valle de México. Debido a la expansión acelerada de las áreas urbanas, en las últimas 40 décadas, la Sierra de Guadalupe se ha convertido en un espacio natural aislado e inmerso en esta matriz urbana. El objetivo de este trabajo fue realizar un inventario documentado de los mamíferos de la Sierra de Guadalupe y que la información generada contribuya al manejo, recuperación y conservación de este importante pulmón ubicado en la Cuenca de México. Se hizo la búsqueda de registros en la literatura, bases de datos, portales electrónicos, colecciones biológicas y se realizaron colectas de campo. Se elaboró un listado taxonómico de las cuatro áreas naturales protegidas de la Sierra de Guadalupe, incluyendo su estado de conservación. Se obtuvo la curva de acumulación de especies utilizando el modelo de Chao 1 y se generó un mapa de distribución de localidades. La composición taxonómica para la Sierra de Guadalupe fue de 29 especies, seis órdenes, 15 familias y 23 géneros. Seis especies son endémicas de México, dos en categoría de Amenazadas *Choeronycteris mexicana* y *Cratogeomys fumosus* y una en Protección especial *Leptonycteris yerbabuena*. Las colectas corresponden a 62 localidades. La mayor riqueza y abundancia se observó entre los años 2009 a 2020. La curva de acumulación de especies predijo un total de 36 especies. Este es el primer inventario documentado de la fauna de mamíferos silvestres para la Sierra de Guadalupe, la cual presenta una riqueza notable considerando su extensión y su problemática. Alberga especies endémicas de México y en estado de conservación. Se registran por primera vez en el área a las especies *Sorex saussurei*, *Choeronycteris mexicana*, *Leptonycteris yerbabuena*, *Cratogeomys merriami*, *Neotomodon alstoni* y *Peromyscus melanophrys*. La curva de acumulación de especies indica que se tiene una buena representación de las especies. La información que se aporta es valiosa para establecer acciones de conservación y recuperación de la diversidad biológica de estas importantes ANP y último reducto de área natural ubicado al norte del Área Metropolitana de la Ciudad de México.

Keywords: Basin of Mexico; biodiversity; conservation; endemic; inventory; Protected Natural Areas, Trans-Mexican Volcanic Belt.

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Introduction

The Sierra de Guadalupe mountain range is an isolated natural area in the northern part of the Valley of Mexico Metropolitan Area, bordering the southern end of the extensive arid zones of northern Mexico. Sierra de Guadalupe is the largest remnant of natural vegetation north of Mexico City (CDMX); it harbors a high species richness and supplies environmental services to the inhabitants of this vast urban area. It comprises one federal and three state-level Protected Natural Areas (PNA): Parque Nacional El Tepeyac (PNT), Parque Estatal Sierra de Guadalupe (PESG), Zona Sujeta a Conservación Ecológica Sierra de Guadalupe (ZSCESG), and Zona de Conservación Ecológica La Armella (ZCELA). The PESG is entirely located in the Estado de México (EDOMEX) jurisdiction, whereas the other three are in CDMX. Except for the Parque Nacional El Tepeyac, the other PNA are managed according to an official management program ([Periódico oficial 1999](#); [GOCDMX 2016a, b](#)). The term Sierra de Guadalupe is used herein to refer to the four PNA, as they are contiguous to each other and share similar morphological, geological, and ecological characteristics.

Very few scientific studies on the Sierra de Guadalupe have been published, mainly focused on invertebrates ([Velázquez 2014](#); [Stanford-Camargo et al. 2016](#); [Medina-Reyes et al. 2019](#)), flora ([Márquez et al.](#) undated), soil ([Vela-Correa and Flores-Román 2004](#)), geomorphology ([Lugo-Hubp and Salinas-Montes 1996](#); [Martínez-Yáñez et al. 2009](#)), land-use planning ([Villavicencio 2007](#)), hydrology ([Vázquez 2016](#)), and conservation status ([Cedillo et al. 2007, 2008](#); [Paniagua 2016](#)). Information on vertebrates is almost nil, with only two publications on avifauna ([Contreras 1999](#); [Salazar et al. 2018](#)) and three on herpetofauna ([Méndez de la Cruz et al. 1992](#); [Martínez 2017](#); [Arias 2018](#)). No scientific publications focused on the mammals of the area are currently available; there is only one study that includes some collection records ([Hortelano-Moncada et al. 2016](#)) and several general technical reports ([GEM.SE.CGCE 2002](#); [GODF 2006](#); [Cedillo et al. 2008](#); [PAOT 2009](#); [CEPANAF 2015](#); [GOCD 2016a, b](#)).

The knowledge and conservation of the biodiversity of Sierra de Guadalupe face several challenges that should be addressed. Its location within one of the most populous cities of the world puts an enormous pressure on its natural resources, soil, water, flora and fauna. The main threats to Sierra de Guadalupe include irregular settlements, wildfires, changes of land use for agricultural and livestock ranching activities, feral fauna, solid waste dumping in the surroundings or within the area that facilitates the proliferation of harmful fauna, and pollution of soil, groundwater, and air ([Periódico oficial 1999](#); [Paniagua 2016](#)). This mountain range lies in between areas dedicated to urban, industrial, or mineral exploitation uses, as well as deforested areas; thus, it functions as a natural barrier against pollution and environmental degradation, in addition to supplying environmental services. Its morphological, geological, and eco-

logical features make it one of the most important biotic reserves in the basin of Mexico ([Cedillo et al. 2007, 2008](#)).

This study aimed to compile a properly documented inventory of the diversity of wild mammals of the four Protected Natural Areas in Sierra de Guadalupe. This information would contribute to the better management, restoration, and conservation of this important natural area of the northern part of the Valley of Mexico metropolitan area.

Materials and Methods

Study Area. Sierra de Guadalupe is located at $-19^{\circ} 37' 00''$, $-19^{\circ} 29' 09''$ N and $99^{\circ} 11' 20''$, $99^{\circ} 03' 00''$ W and comprises a total area of 8,649 ha (Figure 1). Some 82 % of this mountain range is located in the State of Mexico and the remaining 18 % in the Gustavo A. Madero municipality, in the northern part of Mexico City ([PAOT 2009](#)). It is part of the Trans-Mexican Volcanic Belt physiographic province, corresponding to the Alto Río Pánuco hydrological region in the drainage basin of the Moctezuma river.

Sierra de Guadalupe includes some of the highest peaks in the basin of Mexico: Picacho Moctezuma, with an elevation of 3,055 m; Cerro del Sombrero y Pico Tres Padres, 3,010 m; Cerro del Chiquihuite, 2,730 m; Zacatenco, 2,500 m; El Guerrero, 2,440 m; Los Gachupines, 2,330 m, and El Tepeyac, 2,270 m ([SPC 2014](#)). The native vegetation cover includes xeric shrubland and oak forest, but the latter can now be found only in hard-to-access areas or as scattered patches. Induced or cultivated vegetation includes pastures, thorny shrubland, and tree plantations of eucalyptus, casuarina, acacia and, less frequently, Peruvian pepper, cypress, pine, ash, oak, and several types of fruit trees such as Mexican hawthorn, peach, quince, guava, pear, and black cherry ([Rzedowski 1979, 1986](#); [Periódico oficial 1999](#); [GOCDMX 2016a](#)). A network of seasonal streams and intermittent creeks crisscrosses the area, carrying little surface water but supplying a high infiltration into the water table ([GODF 2006](#); [Cedillo et al. 2008](#); [GOCDMX 2016a](#)).

The Parque Estatal Sierra de Guadalupe (PESG) was decreed in 1976 and currently comprises 6,322 ha; it includes parts of the municipalities of Coacalco de Berriozábal, Ecatepec de Morelos, Tlalnepantla de Baz, and Tultitlán, in the Estado de México ([Periódico oficial 1976](#); [CEPANAF 2015](#)). The other three Protected Natural Areas are located in the Gustavo A. Madero municipality in Mexico City. The Zona Sujeta a Conservación Ecológica Sierra de Guadalupe (ZSCESG) was decreed in 1990 ([DOF 1990a, b](#)) with 633.68 ha ([GOCDMX 2016a](#)). The zona de Conservación Ecológica La Armella (ZCELA) was decreed in 2006 with a total area of 93.38 ha ([GODF 2006](#)). The federal Protected Natural Area, Parque Nacional El Tepeyac (PNT) was decreed in 1937 with an area of approximately 1,500 ha; it comprises El Tepeyac, Gachupines, Guerrero, and Zacatenco mountains (Figure 1b; [DOF 1937](#); [PAOT 2009](#)).

Gathering of Collection Records. The relevant literature was thoroughly reviewed to gather all mammal collection records made in Sierra de Guadalupe: [Villa-Ramírez 1953](#),

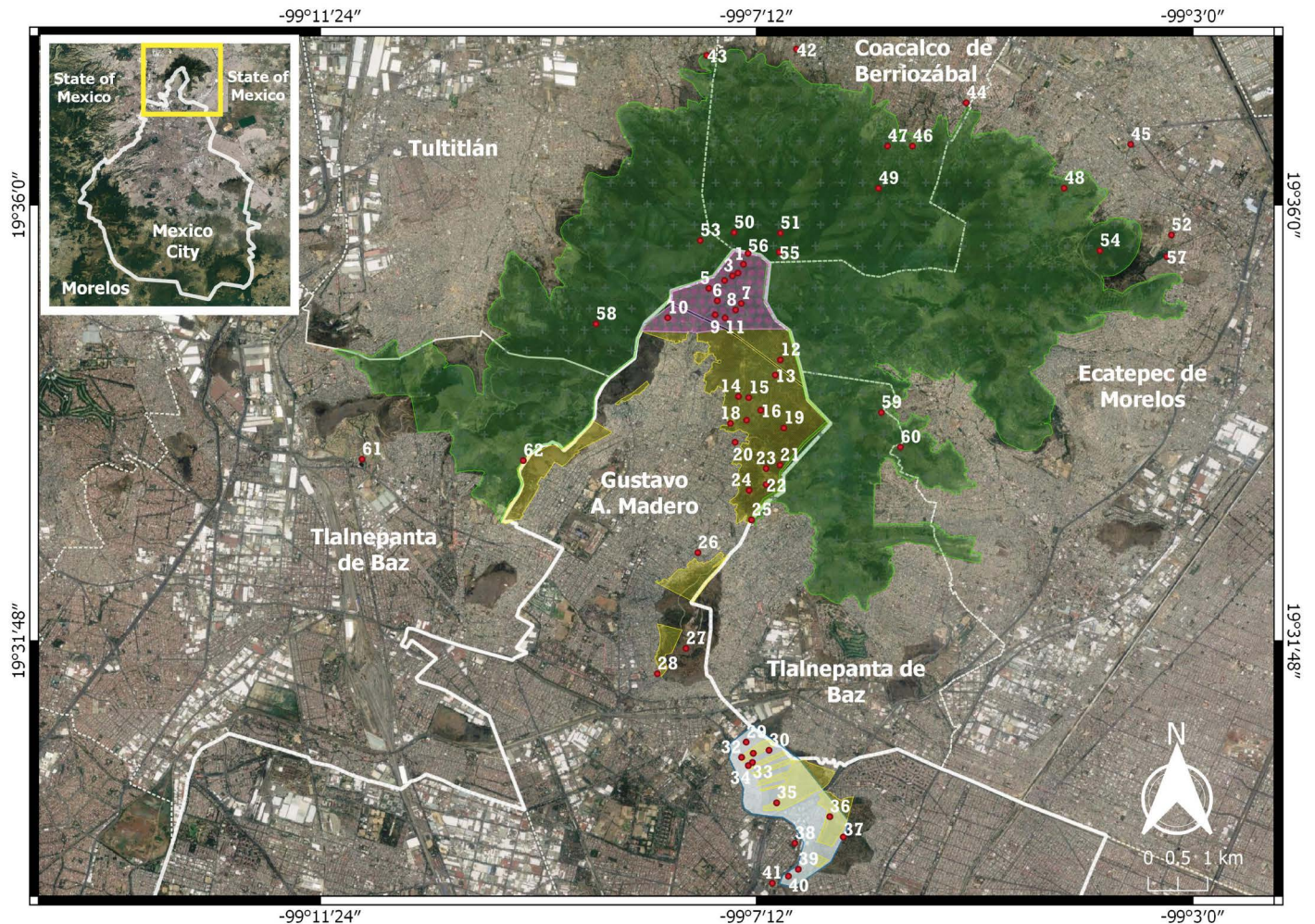


Figure 1. Location of the four Sierra de Guadalupe protected natural areas: Parque Estatal Sierra de Guadalupe (PESG, green polygon), Zona de Conservación Ecológica Sierra de Guadalupe (ZCELA, purple polygon), Zona Sujeta a Conservación Ecológica Sierra de Guadalupe (ZSCESG; yellow polygon), and Parque Nacional El Tepeyac (PNT; blue polygon). PESG is located in the Coacalco de Berriozábal, Ecatepec de Morelos, Tlalnepantla de Baz, and Tultitlán municipalities in the State of Mexico; the three other protected natural areas are located in the Gustavo A. Madero municipality, Mexico City. Numbered red dots = Collection localities.

Hall 1982, Chávez and Ceballos 1998, Villa-Ramírez and Cervantes 2003, Chávez et al. 2009, Hortelano-Moncada and Cervantes 2011, Guevara et al. 2016, Hortelano-Moncada et al. 2016, Ramírez-Pulido et al. 2017. Databases and image collections available in the following web pages were also reviewed: Sistema Nacional de Información sobre la Biodiversidad de México (SNIB 2019; <https://www.snib.mx/ejemplares/mamiferos.201904.csv.zip>), Global Biodiversity Information Facility (GBIF 2019; <https://doi.org/10.15468/dl.7fc2rw>; <https://doi.org/10.15468/dl.k4k7dr>), iNaturalist (<https://www.naturalista.mx/>), and IREKANI (<https://unibio.unam.mx/irekani/>).

The databases of four institutional scientific collections were also reviewed, and some of their specimens were examined to retrieve supplementary data: Instituto de Biología, Universidad Nacional Autónoma de México (CNMA), Escuela Nacional de Ciencias Biológicas (ENCB), Universidad Autónoma Metropolitana Iztapalapa (UAMI), and Museo de Zoología “Alfonso L. Herrera”, Facultad de Ciencias, Universidad Nacional Autónoma de México (FCMM). The database of the Biodiversity Institute and Natural History Museum (KU) was also reviewed. The names

and acronyms of these collections are as listed in the directory of mammal collections of the Western Hemisphere (Dunnun et al. 2018).

In addition, six field trips were carried out in the Zona Sujeta a Conservación Ecológica Sierra de Guadalupe and Zona de Conservación Ecológica La Armella as part of a wildlife monitoring program: 12-13 March, 20-21 and 27-28 May, 12-14 June, and 2-3 September 2019, and 23 September, 2020. Only one-night monitoring was carried out in five of the six field surveys due to security concerns and logistic restrictions; a two-night monitoring was conducted only during the June 2019 survey.

The field surveys allowed capturing specimens, recovering material, and containing specimens in the field. A total of 30 collapsible Sherman traps measuring 8×9×23-cm were used to capture small terrestrial mammals; with a separation of approximately 5 m between adjacent traps. These were baited with a mixture of oatmeal and vanilla and set in operation from 17:00 h until the morning of the following day. Bats were captured with three 6×2 m mist nets set within the vegetation, on roads, water bodies, and potential shelters, where they were left open for four hours

starting at dusk and then checked every 30 minutes. Morphometric measurements, weight, sex, and reproductive status of each specimen were recorded; some specimens were prepared by taxidermy for further study following the guidelines issued by [Sikes \(2016\)](#).

Medium-sized mammals were captured with four Tomahawk traps; the traps were placed near trails, water sources, and latrines, baited with sardine and fruit (orange, tangerine, and apple), and left in operation for 12 consecutive hours. The specimens captured were photographed, their ectoparasites sampled, and then released at the same capture site.

Two motion-activated camera traps were used for recording medium- and large-sized mammals; simple photo-trapping stations baited with sardine were placed at strategic sites such as near burrows, water sources, roads, and trails that showed footprints or excreta. These camera traps were set at 17:00 h, left in operation overnight, and deactivated on the following morning, for an approximate sampling intensity of 13 h per night per camera. The name and geographic coordinates of the location of each photograph were recorded, along with the name of the person who set the camera-trap, date and time of the event, and surrounding vegetation type. In addition, excreta and pellets were collected, where available, and their contents (hair, bone material) were examined to add to the mammal record.

The specimens and derived materials were identified ([Álvarez-Castañeda et al. 2015](#)) and then deposited into the CNMA collection; the photographic material was uploaded onto the CNMA image collection (Irekani repository: (https://unibio.unam.mx/irekani/handle/123456789/186/browse?proyecto=Irekani&type=title&submit_browse=Title&collec=only)).

The specimens and derived material for this study were collected under collection permit 09/k5-144/06/19 issued by the Subsecretaría de Gestión para la Protección Ambiental, Dirección General de Vida Silvestre, Secretaría de Medio Ambiente y Recursos Naturales, México.

Taxonomic List, Geographic Distribution, and Analysis. The biological, taxonomic, and geographic data recorded for each specimen were systematized in an *ad hoc* database. A taxonomic list of the mammal species recorded in Sierra de Guadalupe was prepared following [Ramírez-Pulido et al. \(2014\)](#); the nomenclature was updated, as needed, based on more recent studies ([Burgin et al. 2018](#); [Greenbaum et al. 2019](#)).

All the collection localities were georeferenced on Google Earth and the species collection records were mapped using the Geographic Information System QGIS v 3.14. A species-accumulation curve was constructed to evaluate the completeness of our sampling. The data were first subjected to a smoothing process using the program Estimates S v 9.1.0 ([Colwell 2013](#)). The species-accumulation curve was then constructed in the program Excel using the Chao 1 model; this method is recommended for studying

individual abundances in a single sample ([Escalante 2003](#)). Species-accumulation models use site and species richness data to analyze the accumulation of species as the number of sampling sites increases and thus estimate the number of unrecorded species in the area ([Oksanen 2020](#)). Pivot tables and dynamic graphs were used for a historical analysis and visualization of how the records evolved over time.

Results

A total of 178 collection records were compiled; of these, 149 correspond to specimens deposited in five scientific collections: 65 in CNMA, 78 in ENCB, one in UAMI, one in FCMM, and four in KU. The other 29 records were found in virtual galleries: 11 in IREKANI and 18 in iNaturalist. These records were made in 62 different localities, 41 in CDMX and 21 in EDOMEX; 21 records were made in the PESG, 11 in ZCELA, 21 in the ZSCESG, and nine in the PNT (Figure 1, Appendix 1).

Taxonomic List, Geographic Distribution, and Conservation Status. The taxonomic list of the mammals of Sierra de Guadalupe compiled in this work includes 29 different species in 23 genera, 14 families, and 6 orders (Table 1). Six of these species are new records for Sierra de Guadalupe: *Saussure's shrew*, *Sorex saussurei*; Mexican long-tongued bat, *Choeronycteris Mexicana*; lesser long-nosed bat, *Leptonycteris yerbabuena*; Merriam's pocket gopher, *Cratogeomys merriami*, Mexican volcano mouse, *Neotomodon alstoni*; and plateau mouse, *Peromyscus melanophrys*.

The species distribution across the PNA was as follows: 20 species in PESG, eight in ZCELA, 17 in ZSCESG, and seven in PNT. Thirteen species were recorded in more than one PA: *Baiomys taylori*, *Bassariscus astutus*, *Didelphis virginiana*, *Nyctinomops macrotis*, *Otospermophilus variegatus*, *Peromyscus difficilis*, *P. gratus*, *P. labecula*, *Sciurus aureogaster*, *Sigmodon toltecus*, *Spilogale angustifrons*, *Syvilagus floridanus*, and *Urocyon cinereoargenteus*. Sixteen species were found in only one PA: *Canis latrans*, *C. fumosus*, *Heteromys irroratus*, *Microtus mexicanus*, *Mustela frenata*, *Myotis velifer*, *Reithrodontomys fulvescens*, *S. saussurei*, *Tadarida brasiliensis* were recorded only in the PESG; *Aeorestes cinereus*, *C. mexicana*, *L. yerbabuena*, and *P. melanophrys* were recorded only in ZSCESG; *C. merriami* and *N. alstoni* in ZCELA; and *M. occultus* in PNT (Figure 2).

Overall for the Sierra de Guadalupe, rodents are the group best represented with 14 species (48.3 %), followed by bats with seven species (24.1 %), carnivores with five species (17.2 %), and marsupials, shrews, and rabbits represented by a single species each (*D. virginiana*, *S. saussurei*, and *S. floridanus*, respectively), which together account for 10.4 % of all the mammal species recorded in Sierra de Guadalupe.

The Rodentia species belong to four different families: Cricetidae (nine species), Sciuridae (two), Geomyidae (two), and Heteromyidae (one) and ten genera. The species most frequently recorded was *P. gratus* with 33 specimens,



Figure 2. Some mammals inhabiting Sierra de Guadalupe. a) Gray fox, *Urocyon cinereoargenteus*, b) Mexican gray squirrel, *Sciurus aureogaster*, c) eastern cottontail, *Sylvilagus floridanus*, d) lesser long-nosed bat, *Leptonycteris yerbabuena*, e) Mexican long-tongued bat, *Choeronycteris mexicana*, f) Merriam's piñon mouse, *Peromyscus gratus*, g) Virginia opossum, *Didelphis virginiana*. (Photos: Rafael Alvarado (a), Diego Alvarado (b, c, d); Asela Barragán (e); Jesús Fernández (f, g).

followed by the Zacatecan deer mouse, *P. difficilis*, with 27 specimens, and the fulvous harvest mouse, *R. fulvescens*, with 11. The Chiroptera species belong to three different families: Vespertilionidae (three species), Molossidae (two), and Phyllostomidae (two), and seven genera; the species most frequently recorded was *M. velifer*, with seven specimens.

Three species are listed in the Official Mexican Standard NOM-059 (SEMARNAT 2019): *C. mexicana* and *C. fumosus* are threatened species, and *L. yerbabuena* is under special protection. The International Union for the Conservation of Nature (IUCN 2019) lists *C. mexicana* as near-threatened (NT), *L. yerbabuena* as vulnerable (VU), and the other species as of least concern. None of these species has been listed by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Six species inhabiting the Sierra de Guadalupe are endemic to Mexico (Table 1).

Specimens Collected, Species, and Collection Periods. The collection records compiled were used to analyze how the number of specimens collected and species recorded evolved over time. Three time periods were defined for this analysis: a historical period (1937 to 1980), an intermediate period (1981 to 2008) when little collection activity took place, and the recent period (2009 to 2020) when renewed collection activity and new findings are observed.

A total of 100 specimens, representing 14 different species, were collected during the historical period. One new species was recorded in each of the years 1947 (seven specimens collected), 1949 (eight specimens), 1952 (four),

and 1967 (25); two additional species were recorded in 1937 (seven specimens) and 1948 (two specimens); and three new species in each of 1964 (16 specimens) and 1980 (three). Although 1965 and 1967 were the years when most collections were made, no new species were recorded in the area. Only two specimens were collected during the second 27-year period (1981–2008), in 1988 and 1997, with no new species recorded in the area.

The collection of mammal specimens in Sierra de Guadalupe resumed in the recent period (2009–2020). Two species, the hoary bat, *A. cinereus*, and the Mexican volcano mouse, *N. alstoni*, were first recorded in the area in 2009. One new species was recorded in each of the years 2012, 2013, 2015, 2017, and 2018; these included the Virginia opossum, *D. virginiana*; the ringtail, *B. astutus*; the Saussure's shrew, *S. saussurei*; the gray fox, *U. cinereoargenteus*; and the Mexican gray squirrel, *S. aureogaster*. The smoky pocket gopher, *C. fumosus*, and the coyote, *C. latrans*, were first recorded in 2014. The largest number (36) of specimens was collected in 2019, finding two previously unrecorded species: the Mexican long-tongued bat, *C. mexicana*, and the plateau mouse *P. melanophrys*. An additional species, the lesser long-nosed bat, *L. yerbabuena*, was first recorded in 2020. A total of 76 specimens were collected and 14 previously unrecorded species were found during this period (Figure 3).

A total of 24 data points was used to construct the species-accumulation curve. This analysis included only those

Table 1. Mammal species recorded in the four Sierra de Guadalupe protected natural areas. En = species endemic to Mexico. NOM = listed in the official Mexican standard NOM-059-SEMARNAT-2019 (A = Threatened, Pr = under special protection). IUCN = International Union for Conservation of Nature (VU = Vulnerable, NT = Near Threatened, LC = Least Concern). TR = type of record (C = collected specimen, F = photograph, E = excreta, H = footprint). ANP = Protected Natural Areas (PESG = Parque Estatal Sierra de Guadalupe; ZCELA = Zona de Conservación Ecológica La Armella; ZSCESG = Zona Sujeta a Conservación Ecológica Sierra de Guadalupe; PNT = Parque Nacional El Tepeyac).

Especie	En	NOM	IUCN	TR	ANP
Orden Didelphimorphia					
Familia Didelphidae					
<i>Didelphis virginiana</i>			LC		
<i>Didelphis virginiana californica</i>				C,F	PESG, ZCELA, ZSCESG
Orden Eulipotyphla					
Familia Soricidae					
<i>Sorex saussurei</i>			LC	C	PESG
Orden Chiroptera					
Familia Phyllostomidae					
<i>Choeronycteris mexicana</i>	A		NT	C	ZSCESG
<i>Leptonycteris yerbabuenae</i>	Pr		VU	C	ZSCESG
Familia Molossidae					
<i>Tadarida brasiliensis</i>			LC		
<i>Tadarida brasiliensis mexicana</i>				C	PESG
<i>Nyctinomops macrotis</i>			LC	C	PESG, ZSCESG, PNT
Familia Vespertilionidae					
<i>Aeorestes cinereus</i>			LC		ZSCESG
<i>Myotis occultus</i>			LC	C	PNT
<i>Myotis velifer</i>			LC		
<i>Myotis velifer velifer</i>				C	PESG
Orden Lagomorpha					
Familia Leporidae					
<i>Sylvilagus floridanus</i>			LC		
<i>Sylvilagus floridanus orizabae</i>				C,H	PESG, ZCELA, ZSCESG
Orden Rodentia					
Familia Sciuridae					
<i>Otospermophilus variegatus</i>			LC		
<i>Otospermophilus variegatus variegatus</i>				C,F	PESG, ZCELA, ZSCESG
<i>Sciurus aureogaster</i>			LC		
<i>Sciurus aureogaster aureogaster</i>				F	PESG, ZSCESG
Familia Geomyidae					
<i>Cratogeomys fumosus</i>	En	A	LC		
<i>Cratogeomys fumosus tylorhinus</i>				C	PESG
<i>Cratogeomys merriami</i>	En		LC	C	ZCELA
Familia Heteromyidae					
<i>Heteromys irroratus</i>			LC		

Especie	En	NOM	IUCN	TR	ANP
<i>Heteromys irroratus alleni</i>				C	PESG
Familia Cricetidae					
<i>Microtus mexicanus</i>			LC		
<i>Microtus mexicanus mexicanus</i>				C	PESG
<i>Baiomys taylori</i>			LC		
<i>Baiomys taylori analogus</i>				C	PESG, ZSCESG, PNT
<i>Neotomodon alstoni</i>	En		LC	C	
<i>Neotomodon alstoni alstoni</i>					ZCELA
<i>Peromyscus difficilis</i>	En		LC		
<i>Peromyscus difficilis felipensis</i>			LC	C	PESG, ZCELA, ZSCESG, PNT
<i>Peromyscus gratus</i>			LC		
<i>Peromyscus gratus gratus</i>				C	PESG, ZCELA, ZSCESG, PNT
<i>Peromyscus labecula</i>			LC		
<i>Peromyscus labecula fulvus</i>				C	ZSCESG
<i>Peromyscus labecula labecula</i>				C	PNT
<i>Peromyscus melanophrys</i>	En		LC		
<i>Peromyscus melanophrys melanophrys</i>				C	ZSCESG
<i>Reithrodontomys fulvescens</i>	En		LC		
<i>Reithrodontomys fulvescens toltecus</i>				LC	C
<i>Sigmodon toltecus</i>			LC		PESG, ZSCESG, PNT
Orden Carnivora					
Familia Canidae					
<i>Canis latrans</i>			LC		
<i>Canis latrans cagottis</i>				C	PESG
<i>Urocyon cinereoargenteus</i>			LC		
<i>Urocyon cinereoargenteus nigrirostris</i>				F	PESG, ZCELA
Familia Mephitidae					
<i>Spilogale angustifrons</i>			LC		
<i>Spilogale angustifrons angustifrons</i>				C,F	ZSCESG, PNT
Familia Mustelidae					
<i>Mustela frenata</i>			LC		
<i>Mustela frenata frenata</i>				C	PESG
Familia Procyonidae					
<i>Bassariscus astutus</i>			LC		
<i>Bassariscus astutus astutus</i>				C,F,E	PESG, ZSCESG

years for which the number of specimens collected could be accurately determined (namely, years 1936, 1937, 1947, 1948, 1949, 1950, 1952, 1956, 1964, 1965, 1967, 1969, 1980, 1988, 1997, 2009, 2012, 2013, 2014, 2015, 2017, 2018, 2019, and 2020). The results of the Chao 1 model projected a total of 36 (35.95) mammal species in Sierra de Guadalupe, with a completeness index (probability of finding new species) of 0.81; this means that, given the relationship between

the number of sites sampled and the number of species recorded, seven additional species may be expected.

Discussion

Our inventory of the wild mammals of Sierra de Guadalupe includes a total of 29 different species. Prior to this study, the presence of only four species had been properly documented: *N. macrotis*, *S. toltecus*, *M. occultus* ([Hortelano-](#)

Moncada et al. 2016), and *P. gratus* (IREKANI-CFB-2366). No peer-reviewed scientific publications on the wild mammals of Sierra de Guadalupe could be found; various technical reports and the management plans of the PNA of the area mention some species. Nineteen species were reported by GEM.SE.CGCE (2002), six species by GODF (2006), seven by Cedillo et al. (2008), six by PAOT (2009), six by CEPANAF (2015), twenty nine by GOCDMX (2016a), and twenty seven by GOCDMX (2016a b). In most of those cases, the source of such information and the existence of specimens supporting such claims are unknown.

The cumulative list of mammals reported by those sources includes 29 different species. The presence of 21 of those species was corroborated by our study; the remaining eight species, which are not included in our inventory, are the Mexican ground squirrel, *Ictidomys mexicanus*; the nine-banded armadillo, *Dasybus novemcinctus*; Mexican long-tailed shrew, *S. oreopolus*; nimble-footed mouse, *P. levipes*; Western harvest mouse, *R. megalotis*; bobcat, *Lynx rufus*; American hog-nosed skunk, *Conepatus leuconotus*; and hooded skunk, *Mephitis macroura*. In contrast, we documented the presence of eight species that had not been

previously reported for the area. Six of these species are new records for Sierra de Guadalupe: the Saussure's shrew, *S. saussurei*; Mexican long-tongued bat, *C. mexicana*; lesser long-nosed bat, *L. yerbabuena*; Merriam's pocket gopher, *C. merriami*; Mexican volcano mouse, *N. alstoni*; and plateau mouse, *P. melanophrys*. The other two species are the recently recorded *N. macrotis* and *S. toltecus* (Hortelano-Moncada et al. 2016).

The criteria adopted for including species in our inventory were that their presence in the area is properly documented through a formal record with correct taxonomic identification, and that the collection site is located within the boundaries of Sierra de Guadalupe. Thus, three species the Mexican ground squirrel, *I. mexicanus* (CNMA-7908); Mexican least shrew, *Cryptotis soricinus* (CNMA-1963); and silky pocket mouse, *Perognathus flavus* (ENCB 2268-2269) were not included in our inventory because they have been recorded near Sierra de Guadalupe but not within its boundaries. If the latter two species ever occurred in Sierra de Guadalupe, they are unlikely to be found now as records of them from other areas of CDMX are old and scarce (Hortelano-Moncada and Cervantes 2016). The Mexican

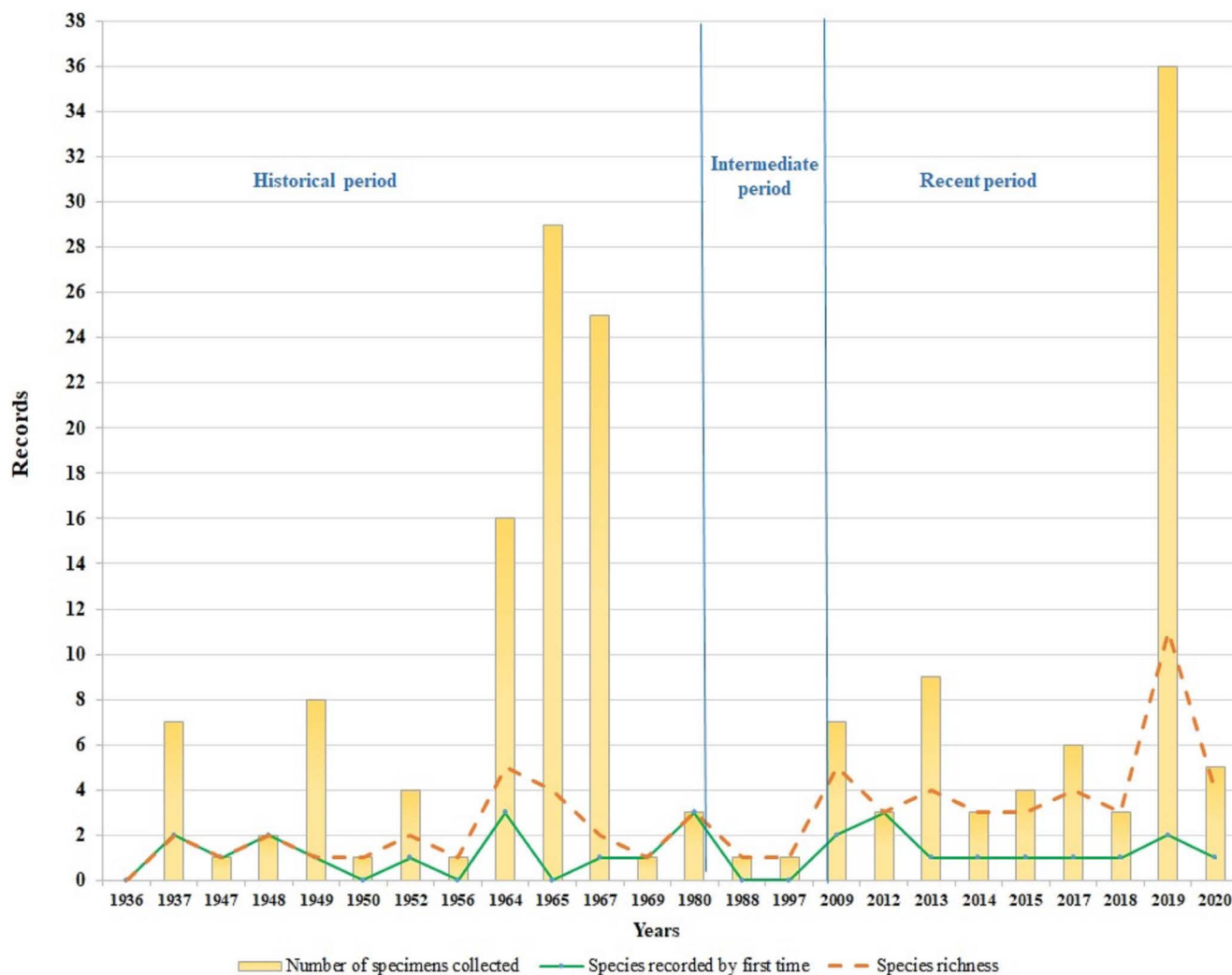


Figure 3. Number of specimens collected per year (yellow bars) and per period, number of species recorded per year (solid green line), and total species richness (dashed orange line) in Sierra de Guadalupe.

ground squirrel has been recently recorded in other parts of CDMX in habitats with shrubby herbaceous vegetation and can also occupy suburban green spaces. Thus, natural conditions suitable for its occurrence do exist in Sierra de Guadalupe ([Linzey et al. 2016](#)).

There are informal reports of the presence of the bobcat, *L. rufus*, in Sierra de Guadalupe and, in fact, we obtained a photographic record of what seems to be *L. rufus* excreta within the boundaries of Sierra de Guadalupe; however, since this could not be ascertained, we did not include this species in our inventory; this aspect deserves further surveys in the best preserved areas of Sierra de Guadalupe. In contrast, the lesser long-nosed bat, *L. yerbabuena*, had not been initially included in our inventory as only one recent photographic record (iNaturalist_15353123) from within the area was found, but its poor resolution did not warrant its taxonomic determination. However, we were able to properly document the presence of this species in 2020 (specimen CNMA-49828).

Our data search found three records of the wrinkle-faced bat, *Centurio senex*, from areas near Sierra de Guadalupe. The first is a 2014 photographic record (iNaturalist-581022) from the Gustavo A. Madero municipality; the record entry states that the specimen had been collected and deposited in a scientific collection, but this could not be confirmed. A second specimen (ENCB_4322) was collected in 2002 in the same municipality, and the third was mentioned by [Ramírez \(2012\)](#) as recorded in the Tlalnepantla municipality, State of Mexico, without reporting the collection locality. In the absence of further supporting evidence and based on the conclusions reached by [Sánchez et al. \(1989\)](#) and [Uhart and López-Vidal \(2008\)](#), who regard those records as the product of incidental dispersal, we believe that the distribution range of this species does not include the Sierra de Guadalupe, CDMX, or EDOMEX. Although [Ceballos et al. \(2006\)](#) include Mexico City and the State of Mexico within the potential distribution of this species, the nearest properly documented record comes from the Sierra de Huautla Biosphere Reserve, State of Morelos, where the dominant vegetation is deciduous tropical forest ([Orozco-Lugo et al. 2014](#)).

The most species-rich PNA within Sierra de Guadalupe is the Parque Estatal Sierra de Guadalupe (PESG) with 20 species, followed by the Zona Sujeta a Conservación Ecológica Sierra de Guadalupe (ZSCESG) with 17, the Zona de Conservación Ecológica La Armella (ZCELA) with eight, and the Parque Nacional El Tepeyac (PNT) with only seven species. These results seem consistent given that the PESG covers 82 % of the area of this mountain range, it is better preserved than the other PNA, its vegetation cover is mainly oak forest and xeric shrubland, and it includes the highest elevations of Sierra de Guadalupe ([Cedillo et al. 2007](#); [CEP-ANAF 2015](#)).

The historical analysis of the number of collections made and species recorded shows that 14 species (48.3 % of the total number of known species) were first documented in Sierra de Guadalupe between 2009 and 2020. This figure

contrasts with the 43-year historical period (1937–1980) when only 15 species were recorded. Only two specimens were collected, and no new species were recorded during the 27-year period between 1981 and 2008). This might be related, on the one hand, to the restrictions on the collection of wild specimens imposed with the decree of these areas as Protected Natural Areas. The portion of the Sierra de Guadalupe mountain range located in the State of Mexico was officially decreed as the Sierra de Guadalupe State Park in 1976. The portion located in CDMX was decreed as the Sierra de Guadalupe Ecological Conservation Area by the federal government in 1990 aimed at containing urban expansion; the gradual invasion of irregular settlements was causing serious damage to this area of great ecological value and adversely affecting the wildlife. Moreover, in an attempt to protect the Sierra de Guadalupe, a perimeter fence was built in the mid-1990s in the area corresponding to CDMX; this led to social conflicts that increased insecurity in the area and perhaps also contributed to the lack of field studies therein.

The study reported herein, which started in 2019, has recorded the largest number of specimens and species collected, with 36 specimens and 11 species, respectively. This highlights the importance of carrying out systematic and scheduled samplings using various data collection methods, including direct and indirect evidence (excreta, pellets, and photographic material) in addition to collecting specimens. On the other hand, the support of and collaboration with staff of the Dirección General de Sistemas de Áreas Naturales Protegidas y Áreas de Valor Ambiental Sierra de Guadalupe DGSANPAVA) office at the Secretaría del Medio Ambiente (SEDEMA) of the Mexico City government was extremely valuable. They provided biological material that they had collected while implementing the management programs; this material was properly documented and deposited in the Colección Nacional de Mamíferos of Instituto de Biología of Universidad Nacional Autónoma de México. Another valuable source of historical information was the specimens deposited in various scientific collections; this highlights the importance of such collections for a range of studies, including biological inventories, as they keep the specimens and their supplementary information available now and in the future ([Hortelano-Moncada and Cervantes 2011](#); [León-Tapia et al. 2020](#)).

The species-accumulation curve showed that the data gathered provide a reasonably good representation of the mammal species inhabiting Sierra de Guadalupe. The possibility of finding additional species such as bats, particularly in the PA located in EDOMEX, cannot be ruled out. At the same time, some of the species listed in our inventory might no longer be found in Sierra de Guadalupe due to the reduction and alterations of the original habitat in this area ([Cedillo et al. 2007, 2008](#); [Villavicencio 2007](#)). This might be the case of *H.s. irroratus* (last recorded in 1964 and 1967), *M. mexicanus* (1949), *P. maniculatus* (1948, 1956), and *R. fulvescens* (1956, 1964). Additional collection efforts may

be required to confirm the continued presence of other species such as *N. macrotis* (last recorded in 1980, 1988, and 1997), *M. occultus* (1969), *M. velifer* (1937, 1950, 1956), and *C. merriami* (1980).

The number of wild mammal species reported herein for Sierra de Guadalupe accounts for 35.8 % of all the species recorded for CDMX (Hortelano-Moncada et al. 2016) and 23.2 % of the species for EDOMEX (Chávez et al. 2009). A total of 21 species (considering the three PNA) were recorded in the CDMX portion of Sierra de Guadalupe, while 20 species were recorded in the area located in EDOMEX, representing 72.4 and 68.9 %, respectively, of the total diversity of mammals of Sierra de Guadalupe. Our field work was mainly carried out in the PNA of CDMX due to security concerns and logistic considerations. However, if additional collection efforts are carried out, the number of species in the PESG (EDOMEX) would be expected to increase, as this PNA is almost three times the size of the PNA located in CDMX and has a larger well-preserved area (GEM.SE.CGCE 2002).

Eleven species (38 %) are shared by CDMX and EDOMEX; these include highly vagile species such as *B. astutus*, *D. virginiana*, *N. macrotis*, *O. variegatus*, *S. aureogaster*, *S. floridanus*, and *U. cinereoargenteus*, as well as other less vagile but widespread species such as *B. taylori*, *P. difficilis*, *P. gratus*, and *S. toltecus*. Nine species (31 %) are unique to either CDMX or EDOMEX; these are rare species that use sites of Sierra de Guadalupe as a refuge, habitat, or perch during their migration, and others that are difficult to capture. The species recorded in Mexico City but not in EDOMEX are *A. cinereus*, *C. mexicana*, *C. merriami*, *L. yerbabuena*, *M. occultus*, *N. alstoni*, *P. labecula*, *P. melanophrys*, and *S. angustifrons*. The species unique to the State of Mexico are *C. latrans*, *C. fumosus*, *H. irroratus*, *M. mexicanus*, *M. frenata*, *M. velifer*, *R. fulvescens*, *S. saussurei*, and *T. brasiliensis*.

Of the 118 Protected Natural Areas in EDOMEX and the 24 in CDMX, studies with documented records of mammals have been conducted only in 11: five protected natural areas of EDOMEX (Monroy-Vilchis and Velázquez 2002; Monroy-Vilchis et al. 2011; Sánchez-Jasso et al. 2013; Aranda et al. 2014; Espinosa-Graciano and García-Collazo 2017) and six in CDMX (Villa-Ramírez 1953; Aranda et al. 1980; Mandujano and Hernández 1990; Castro-Campillo et al. 1992; Ramírez-Pulido et al. 2004; Bárcenas and Medellín 2007; Navarro-Frías et al. 2007; Castro-Campillo et al. 2008; Hortelano-Moncada et al. 2016). These are disturbing figures as, even including the four PNA studied in the present work, it means that documented records of mammals only exist for 12.7 % of the PNA of both states.

Considering its extent, the species richness of Sierra de Guadalupe is remarkable; for instance, only 11 species have been reported for the similarly sized (9768.2 ha) Sierra de Tepozotlán State Park (Espinosa-Graciano and García-Collazo 2017). Sierra de Guadalupe is also species-richer than the Desierto de los Leones National Park where 22 species have been recorded (Aranda et al. 1980; Mandujano

and Hernández 1990; Ramírez-Pulido et al. 2004; Castro-Campillo et al. 2008), although this protected natural area is about half the size of Sierra de Guadalupe. Thus, the Desierto de los Leones is proportionately more diverse per unit area, but Sierra de Guadalupe is richer in terms of the total number of species. Moreover, Desierto de los Leones is better preserved than Sierra de Guadalupe and has drawn greater scientific interest. Separately, there are fewer mammal species in Sierra de Guadalupe than in the urban reserve Reserva Ecológica del Pedregal de San Ángel, where 33 mammal species have been recorded in only 237.3 ha. We attribute this difference to the great scientific interest that Pedregal de San Ángel has drawn for many years, which has led to a large number of collection records and species findings (Hortelano-Moncada et al. 2009).

The conservation of Sierra de Guadalupe is fundamental as it harbors three Mexican mammal species (*C. mexicana*, *L. yerbabuena*, and *C. fumosus*) that are listed under some level of threat by the Official Mexican Standard (NOM-059-SEMARNAT-2019), and the first two are also listed by IUCN (2020). Sierra de Guadalupe harbors six rodent species (*C. fumosus*, *C. merriami*, *N. alstoni*, *P. difficilis*, *P. melanophrys*, and *R. fulvescens*) that are endemic to Mexico. Although all the species living in this mountain range have been also recorded in other parts of CDMX and EDOMEX, they have probably become isolated in these PNA that are surrounded by urban areas.

Sierra de Guadalupe is the last significant natural area remaining in the northern part of Mexico City. This is the first documented inventory of the wild mammals occurring in that area and one of the few detailed inventories addressing the protected natural areas of CDMX and EDOMEX. Anthropogenic alterations and impacts including formal and irregular human settlements, introduced fauna and flora, illegal trade of native fauna, logging and timber extraction, pollution, agricultural activities, induced pastures for sheep and cattle ranching, and wildfires altogether pose enormous pressures on the area and jeopardize its preservation (Cedillo et al. 2007; Villavicencio 2007; SPC 2014).

Our study highlights the importance of nature reserves for wildlife conservation in urbanized landscapes. Knowledge of the native mammal fauna helps the local population to better appreciate the natural environment and perceive its benefits; it can also inform the formulation and implementation of governmental actions for the preservation and restoration of the natural resources of this area, which has endured high disturbance rates driven by increasing population density (SPC 2014). It is also expected to help improve the coordination between the two states that have jurisdiction over the Sierra de Guadalupe in the implementation of management plans.

A total of 29 wild mammal species was found in the Sierra de Guadalupe PA; this is a significant number compared to other smaller PNA. Three of those species have been listed under some level of threat by the Mexican government and two of those are also listed in an international

standard; six other species are endemic to Mexico. These facts are important, particularly considering that this area is located in one of the most populated areas of the world, under enormous pressures caused by urban expansion, pollution, wildfires, introduction of exotic fauna, and vandalism, among others.

Our study contributes to better appreciate the importance of the wild fauna thriving in the last significant natural area remaining in the northern part of Mexico City, where resources are limited and the demands of a growing population make conservation actions difficult to implement and maintain. The updated taxonomic list of mammals sets the grounds to initiate actions for the conservation and restoration of biodiversity in this area.

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Appendix 1

Specimens examined (n) of the species that are distributed in the Sierra de Guadalupe. Catalog number and biological collections or web pages where the specimens are deposited (CNMA = Colección Nacional de Mamíferos del Instituto de Biología de la Universidad Nacional Autónoma de México; ENCB = Colección de Mamíferos de la Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional; UAMI = Colección Mastozoológica de la Universidad Autónoma Metropolitana, Unidad Iztapalapa; FCMM = Colección de Mamíferos del Museo de Zoología "Alfonso L. Herrera, Facultad de Ciencias, Universidad Nacional Autónoma de México; KU = Biodiversity Institute and Natural History Museum; IR = IREKANI e iN = iNaturalist). Collection location: number, geographical description, coordinates (location in Figure 1). ZCELA = Zona de Conservación Ecológica "La Armella"; ZSCESG = Zona Sujeta a Conservación Ecológica "Sierra de Guadalupe"

Didelphis virginiana (n = 14). **Mexico City:** Locality 1: ZCELA, 1.76 km NNE Malacates, 2,471 m (19° 35' 25.70", -99° 07' 19.66"; 49450 CNMA); Locality 5: Paraje La Cruz, 1.13 km NNE Malacates, 2,590 m (19°35'11.78", -99°07'39.59"; 49448 CNMA); Locality 8: ZCELA, 1.03 km NE Malacates, 2,585 m (19°34'59.27", -99°07'24.17"; 9508175 iN); Locality 12: ZSCESG, 1.51 km E Malacates, 2,414 m (19°34'30.42", -99°06'58.34"; 7635574 iN); Locality 14: Caballerizas, 0.58 km ENE La Forestal 1, 2,359 (19°34'09.28", -99°07'22.55"; 12659 IR); Locality 15: Barranca La Mora, 0.77 km ENE La Forestal, 2,431 m (19°34'08.57", -99°07'16.62"; 49447, 49449 CNMA); Locality 18: La Mora 0.49 km ESE La Forestal 1, 2,380 m (19°33'53.70", -99°07'27.18"; 48826 CNMA); Locality 21: Torre de Joya, 0.88 km ENE La Casilda, 2,508 m (19°33'29.58", -99°06'58.57"; 12656 IR); Locality 23: Torre de Joya, 0.64 km ENE La Casilda, 2,563 m (19°33'27.62", -99°07'06.60"; 49822-49825 CNMA). **State of Mexico:** Locality 52: 0.15 km NW Amp. Izcalli, Ecatepec de Morelos, 2,294 m (19°35'42.61", -99°03'12.43"; 38032568 iN).

Sorex saussurei. (n = 2). **State of Mexico:** Locality 51: 3.25 km SEE Amp. San Mateo, Tultitlán, 2,375 m (19°35'43.73", -99°06'58.31"; 49452 CNMA); Locality 55, 3.90 km ESE Solidaridad 3ra Secc., Tultitlán, 2,285 m (19°35'32.70", -99°06'58.95"; 49451 CNMA).

Choeronycteris mexicana. (n = 1). **Mexico City:** Locality 33: Cerro Zacatenco, 0.55 Km NNW San Pedro Zacatenco, 2,259 m (19°30'37.73", 99°07'14.47"; 49827 CNMA).

Leptonycteris yerbabuena. (n = 1). **Mexico City:** Locality 33: Cerro Zacatenco, 0.55 Km NNW San Pedro Zacatenco, 2,259 m (19°30'37.73", 99°07'14.47"; 49828 CNMA).

Tadarida brasiliensis. (n = 3). **State of Mexico:** Locality 47: 0.67 km SW Bosques de Coacalco, Coacalco de Berriozábal, 2,384 m (19°36'33.99", -99°05'56.40"; 5177-5178 ENCB); Locality 49: 1.40 km SSW Bosques de Coacalco, Coacalco de Berriozábal, 2,472 m (19°36'09.59", -99°06'01.67"; 49453 CNMA).

Nyctinomops macrotis. (n = 4). **Mexico City:** Locality 26: 0.38 km S Cerro del Chiquihuite, 2,274 m (19°32'39.00", -99°07'46.00"; 3160 UAMI); Locality 31: Cerro Zacatenco 0.50 km

E Zacatenco Lindavista, 2,248 m (19°30'42.99", -99°07'14.00"; 30502 ENCB); Locality 41: Cerro Los Gachupines, 0.83 km SSW Santa Isabel Tola, 2,240 m (19°29'28.00", -99°07'03.00"; 6684 FCMM). **State of Mexico:** Locality 42: 1.05 km WSW San Francisco Coacalco, Coacalco de Berriozábal, 2,253 m (19°37'56.74", -99°06'49.07"; 37309396 iN).

Aeorestes cinereus. (n = 1). **Mexico City:** Locality 32: ZSCESG, 0.75 km SSE La Casilda, 2,445 m (19°32'57.95", -99° 07'15.44"; 49454 CNMA).

Myotis occultus. (n = 1). **Mexico City:** Locality 39: Cerro de la Villa, 0.49 km S Santa Isabel Tola, 2,255 m (19°29'36.00", -99°06'48.00"; 4238 ENCB).

Myotis velifer. (n = 7). **State of Mexico:** Locality 45: 0.72 km E Vista Hermosa, Ecatepec de Morelos, 2,392 m (19°36'35.00", -99°03'36.00"; 5167 CNMA); Locality 47: 0.67 km SO Bosques de Coacalco, Coacalco de Berriozábal, 2,384 m (19°36'33.99", -99°05'56.40"; 5170-5175 ENCB).

Sylvilagus floridanus. (n = 8). **Mexico City:** Locality 9: ZCELA, 0.75 km NE Malacates, 2,533 m (19°34'56.64", -99°07'36.12"; 7620962, 7689594 iN); Locality 10: ZCELA, 0.69 km NW Malacates, 2,463 m (19°34'54.77", -99°08'03.40"; 49829 CNMA); Locality 16: ZSCESG, 0.94 km E La Forestal 1, 2,460 m (19°34'01.30", -99°07'09.69"; 7689602 iN); Locality 19: ZSCESG, 1.24 km ENE Arboledas de Cuauhtepic, 2,465 m (19°33'51.03", -99°06'56.34"; 12696 IR); Locality 5: ZCELA, 1.22 km NNE Malacates, 2,599 m (19°35'13.85", -99°07'36.45"; 12696 IR). **State of Mexico:** Locality 45: 0.72 km E Vista Hermosa, Ecatepec de Morelos, 2,392 m (19°36'35.00", -99°03'36.00"; 1055 CNMA); Locality 52: 0.15 km NW Amp. Izcalli, Ecatepec de Morelos, 2,294 m (19°35'42.61", -99°03'12.43"; 48488674 iN); Locality 54: 1.30 km W Amp. Izcalli, Ecatepec de Morelos, 2,376 m (19°35'33.55", -99°03'53.79"; 10492020 iN).

Otospermophilus variegatus. (n = 4). **Mexico City:** Locality 6: ZCELA, 0.98 km NNE Malacates, 2,511 m (19°35'04.62", -99°07'34.80"; 7635584 iN); Locality 27: Cerro Chiquihuite, 0.48 km E La Pastora, 2,473 m (19°31'43.68", -99°07'52.91"; 49456 CNMA). **State of Mexico:** Locality 52: 0.15 km NW Amp. Izcalli, Ecatepec de Morelos, 2,294 m (19°35'42.61", -99°03'12.43"; 48488763 iN); Locality 57: 0.31 km SSW Amp. Izcalli, Ecatepec de Morelos, 2,284 m (19°35'30.17", -99°03'15.25"; 23814129 iN).

Sciurus aureogaster. (n = 3). **Mexico City:** Locality 23: Torre de Joya, 0.64 km ENE La Casilda, 2,563 m (19°33'27.62", -99°07'06.60"; 12691 IR). **State of Mexico:** Locality 52: 0.15 km NW Amp. Izcalli, Ecatepec de Morelos, 2,294 m (19°35'42.61", -99°03'12.43"; 12692 IR, 19493033 iN).

Cratogeomys fumosus. (n = 1). **State of Mexico:** Locality 43: 0.39 km ESE Santa María Cuauhtepic, Tultitlán, 2,333 m (19°37'26.49", -99°07'41.40"; 49457 CNMA).

Cratogeomys merriami. (n = 1). **Mexico City:** Locality 4: ZCELA, 1.36 km NNE Malacates, 2,600 m (19°35'16.30", -99°07'30.57"; 27176 CNMA).

Heteromys irroratus. (n = 4). **State of Mexico:** Locality 61: 0.75 km W Amp. Independencia, Tlalnepantla de Baz, 2,257 m (19°33'33.01", -99°10'59.99"; 1164 ENCB); Locality 46: 0.47

km S Bosques de Coacalco, Coacalco de Berriozábal, 2,392 m (19°36'33.99", -99°05'42.00"; 3387-3389 ENCB).

Microtus mexicanus. ($n = 8$). **State of Mexico:** Locality 60: 0.42 km NNE Loma Linda, Tlalnepantla de Baz, 2,361 m (19°33'40.01", -99°05'48.99"; 850-857 CNMA).

Baiomys taylori. ($n = 4$). **Mexico City:** Locality 30: Cerro Zacatenco 0.78 km ENE Zacatenco Lindavista, 2,262 m (19°30'44.76", -99°07'04.90"; 49830 CNMA); Locality 35: Cerro Zacatenco, 0.34 Km SE San Pedro Zacatenco, 2,252 m (19°30'15.71", -99°07'00.62"; 49831 CNMA). **State of Mexico:** Locality 61: 0.75 km W Amp. Independencia, Tlalnepantla de Baz, 2,257 m (19°33'33.01", -99°10'59.99"; 1179, 1255 ENCB).

Neotomodon alstoni. ($n = 2$). **Mexico City:** Locality 11: ZCELA, 0.81 km NE Malacates, 2,443 m (19°34'54.70", -99°07'30.30"; 49661, 49662 CNMA).

Peromyscus difficilis. ($n = 27$). **Mexico City:** Locality 2: ZCELA, 1.58 km NNE Malacates, 2,660 m (19°35'20.63", -99°07'22.85"; 49833, 49834 CNMA); Locality 4: ZCELA, 1.36 km NNE Malacates, 2,600 m (19°35'16.30", -99°07'30.57"; 49835 CNMA); Locality 22: Torre de Joya, 0.59 km E La Casilda, 2,561 m (19°33'18.36", -99°07'06.60"; 49832 CNMA); Locality 29: Cerro Zacatenco 0.39 km ENE Zacatenco Lindavista, 2,445 m (19°30'49.50", -99°07'18.08"; 49837 CNMA); Locality 37: Cerro Vicente Guerrero 0.81 km E Santa Isabel Tola, 2,262 m (19°29'54.64", -99°06'21.97"; 49458 CNMA). **State of Mexico:** Locality 46: 0.47 km S Bosques de Coacalco, Coacalco de Berriozábal, 2,392 m (19°36'33.99", -99°05'42.00"; 3390-3411 ENCB); Locality 53: 2.64 km ESE Solidaridad 3ra Secc., Tultitlán, 2,805 m (19°35'39.42", -99°07'44.62"; 49836 CNMA).

Peromyscus gratus. ($n = 34$). **Mexico City:** Locality 7: ZCELA, 1.20 km NE Malacates, 2,610 m (19°35'03.06", -99°07'20.92"; 2366 IR-CFB); Locality 23: Torre de Joya, 0.64 km ENE La Casilda, 2,563 m (19°33'27.62", -99°07'06.60"; 49838 CNMA); Locality 24: ZSCESG, 0.33 km ESE La Casilda, 2,445 m (19°33'14.99", -99°07'16.40"; 49839 CNMA); Locality 37: Cerro Vicente Guerrero 0.81 km E Santa Isabel Tola, 2,262 m (19°29'54.64", -99°06'21.97"; 49459 CNMA); Locality 38: Cerro Vicente Guerrero 0.1 km E Santa Isabel Tola, 2,245 m (19°29'51.00", -99°06'50.00"; 686 CNMA). **State of Mexico:** Locality 44: 0.89 km ENE Bosques de Coacalco, Coacalco de Berriozábal, 2,358 m (19°36'59.00", -99°05'11.00"; 1216-1222, 2014, ENCB); Locality 53: 2.64 km ESE Solidaridad 3ra Secc., Tultitlán, 2,805 m (19°35'39.42", -99°07'44.62"; 49840 CNMA); Locality 61: 0.75 km W Amp. Independencia, Tlalnepantla de Baz, 2,257 m (19°33'33.01", -99°10'59.99"; 1168-1177, 1245-1254, 2013 ENCB).

Peromyscus labecula fulvus. ($n = 2$). **Mexico City:** Locality 28: Cerro del Chiquihuite, 0.12 km NW Cuauhtémoc, 2,327 m (19°31'28.99", -99°08'09.37"; 49332-49333 KU).

Peromyscus labecula labecula. ($n = 1$). **Mexico City:** Locality 38: Cerro Vicente Guerrero 0.1 km E Santa Isabel Tola, 2,245 m (19°29'51.00", -99°06'50.00"; 629 CNMA).

Peromyscus melanophrys. ($n = 8$). **Mexico City:** Locality 14: Caballerizas, 0.58 km ENE La Forestal 1, 2,359 m (19°34'09.28", -99°07'22.55"; 49841-49848 CNMA).

Reithrodontomys fulvescens. ($n = 12$). **Mexico City:** Locality 28: Cerro del Chiquihuite, 0.12 km NW Cuauhtémoc, 2,327 m (19°31'28.99", -99°08'09.37"; 49050-49051 KU). **State of Mexico:** Locality 44: 0.89 km ENE Bosques de Coacalco, Coacalco de Berriozábal, 2,358 m (19°36'59.00", -99°05'11.00"; 1165-1167 ENCB); Locality 61: 0.75 km W Amp. Independencia, Tlalnepantla de Baz, 2,257 m (19°33'33.01", -99°10'59.99"; 1209-1215 ENCB).

Sigmodon toltecus. ($n = 5$). **Mexico City:** Locality 13: Barranca La Mora, 1.34 km ENE La Forestal 1, 2,373 m (19°34'21.64", -99°07'01.30"; 49460 CNMA); Locality 34: Cerro Zacatenco, 0.45 Km NNW San Pedro Zacatenco, 2,292 m (19°30'35.93", -99°07'16.88"; 49461 CNMA); Locality 41: Cerro Los Gachupines, 0.83km SSW Santa Isabel Tola, 2,240 m (19°29'28.00", -99°07'03.00"; 3425-3426 CNMA). **State of Mexico:** Locality 61: 0.75 km W Amp. Independencia, Tlalnepantla de Baz, 2,257 m (19°33'33.01", -99°10'59.99"; 1178 ENCB).

Canis latrans. ($n = 1$). **State of Mexico:** Locality 58: 2.46 km E Buenavista 2da Secc., Tultitlán, 2,373 m (19°34'51.21", -99°08'44.82"; 49462 CNMA).

Urocyon cinereoargenteus. ($n = 4$). **Mexico City:** Locality 3: ZCELA, 1.49 km NNE Malacates, 2,621 m (19°35'19.00", -99°07'26.00"; 12662 IR). **State of Mexico:** Locality 43: 0.39 km ESE Santa María Cuauhtémoc, Tultitlán, 2,333 m (19°37'26.49", -99°07'41.40"; 12693 IR); Locality 50: 3.46 km ESE Amp. San Mateo, Tultitlán, 2,321 m (19°35'44.05", -99°07'14.06"; 12694 IR); Locality 56: 3.45 km ESE Solidaridad 3ra Secc., Tultitlán, 2,270 m (19°35'32.00", -99°07'17.00"; 12659 IR).

Spilogale angustifrons. ($n = 4$). **Mexico City:** Locality 25: ZSCESG, 0.75 km SSE La Casilda, 2,445 m (19°32'57.95", -99°07'15.44"; 49464-49465 CNMA); Locality 36: Cerro Vicente Guerrero 0.72 km NE Santa Isabel Tola, 2,241 m (19°30'06.39", -99°06'29.77"; 7714755 iN); Locality 40: Cerro Los Gachupines, 0.62 km S Santa Isabel Tola, 2,264 m (19°29'32.00"-99°06'53.70"; 49463 CNMA).

Mustela frenata. ($n = 1$). **State of Mexico:** Locality 45: 0.72 km E Vista Hermosa, Ecatepec de Morelos, 2,392 m (19°36'35.00", -99°03'36.00"; 21581 CNMA).

Bassariscus astutus. ($n = 7$). **Mexico City:** Locality 17: ZSCESG, 0.84 km NE Arboledas de Cuauhtémoc, 2,349 m (19°33'55.77", -99°07'17.81"; 7635408 iN); Locality 20: 0.40 km NE Arboledas de Cuauhtémoc, 2,377 m (19°33'42.80", -99°07'24.47"; 49849 CNMA); Locality 27: Cerro Chiquihuite, 0.48 km E La Pastora, 2,473 m (19°31'43.68", -99°07'52.91"; 49466 CNMA). **State of Mexico:** Locality 48: 0.83 km SSW Vista Hermosa, Ecatepec de Morelos, 2,371 m (19°36'09.66", -99°04'14.42"; 49874606 iN); Locality 55: 0.15 km NW Amp. Izcalli, Ecatepec de Morelos, 2,294 m (19°35'42.61", -99°03'12.43"; 24285898 iN); Locality 53: 2.64 km ESE Solidaridad 3ra Secc., Tultitlán, 2,805 m (19°35'39.42", -99°07'44.62"; 12654 IR); Locality 62: 1.11 km ENE Cuauhtémoc, Tlalnepantla de Baz, 2,404 m (19°33'32.25", -99°09'26.85"; 7635448 iN).

