Check List 8(6): 1122–1133, 2012

ISSN 1809-127X (available at *www.checklist.org.br*)

Check List
Journal of species lists and distribution

Lists of Species

A checklist of the mammals (Mammalia) of Chihuahua, Mexico

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Abstract: An updated list of the mammals of Chihuahua state, Mexico was assembled from the literature and from museum specimens. We documented 133 species (15 endemic to Mexico and 11 new for Chihuahua), representing 25 families, 75 genera, and 27.4% of the Mexican terrestrial mammalian fauna. Four species are probably extirpated from the state. Four major ecoregions have been defined for Chihuahua: Arid, Valleys, Sierra, and Quebradas. Species richness was the highest in Valleys, and consisted mostly of species with Nearctic affinities. In contrast, Quebradas were the least species-rich, but included mostly Neotropical species that occur only in this ecoregion of Chihuahua. Despite the fact that Chihuahua harbors considerable biodiversity and unique Mexican biomes, conservation efforts are insufficient. The current rate of anthropogenic modification in the state requires a comprehensive strategy if Chihuahua's biodiversity is to be preserved.

Introduction

Mexico harbors one of the most diverse mammalian faunas in the world, and is host to the second largest number of endemic species worldwide (Ceballos *et al*. 2005a). As with the rest of the world, the Mammalia of Mexico is one of the best known faunal groups. Few new species have been described from the country recently, and most of those are cryptic taxa discovered through molecular techniques (*e.g.* Bradley *et al.* 2004). Nonetheless, some areas are better known than others. Chihuahua is the largest state in Mexico (247,460 km^2, INEGI 2005), is landlocked and traversed by the Sierra Madre Occidental (SMO) from northwest to southeast. It is located in the northwestern portion of the country, bordering the United States (New Mexico and Texas) to the north, Coahuila to the east, Sinaloa and Sonora to the west, and Durango to the south (Figure 1). Additionally, the Neotropical biogeographic region reaches its northern limit in Chihuahua (Morrone 2005). The presence of mountains produces a complex landscape that ranges from 400 m above sea level on the western slope of the SMO to over 3200 m at the highest elevations. The western slope of SMO is covered by tropical deciduous forests that spread into the mountains through a complex system of canyons. As elevation increases, these forests are replaced by pine and pine-oak associations. The eastern slope descends gradually to a plain historically covered by grasslands, which becomes part of the Chihuahuan desert in the eastern most portion of the state (Comisión para la Cooperación Ambiental [CCA] 1997).

Most of the current territory of Chihuahua was not explored by naturalists until the first half of the 19th century. Prior to 1853 very few records of its mammalian fauna are available, and usually they are part of historical writings of travelers/explorers (*e.g.* Torquemada 1615; de la Mota y Escobar 1621; Ruxton 1847) rather than biological accounts. The earliest biological survey in Chihuahua was carried out by the parties in charge of delimiting the US-Mexico Border (Baird 1859; Mearns 1907), who made the first significant collections in the area, but only along the border itself. The history of mammalogy in Chihuahua until 1970 is summarized in Sydney Anderson's "Mammals of Chihuahua - Taxonomy and Distribution" (Anderson 1972), the only treatise available on the mammals of the state. Anderson (1972) documented the presence of 122 species and suggested that other 17 are likely to occur in the state. Subsequently, papers on ecology and conservation (Ceballos *et al*. 1993; List and McDonald 1998; Ceballos *et al.* 1999; Pacheco *et al*. 2002; Ceballos *et al*. 2005b; Medellín *et al*. 2005; Rodríguez-Martínez *et al*. 2008), distribution (Gallo 1989; Galindo-Leal 1993; González-Romero and Lafón-Terrazas 1993; Gallo 1997; List *et al*. 1999; Hernández-Huerta *et al*. 2002; Gómez-Ruiz *et al*. 2006; Pelz-Serrano *et al*. 2006), species lists for specific areas (Webb and Baker 1984; Pacheco *et al*. 2000) or specific groups (López-González and García-Mendoza 2006), new records (Easterla 1972; García-Mendoza and López-González 2005), archaeozoology

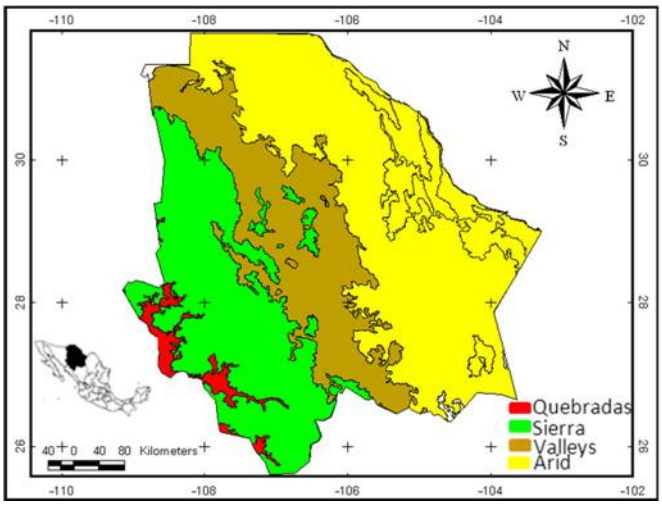

Figure 1. Geographic location of Chihuahua, Mexico, and ecologial regions (after González-Elizondo et al. 2007, and CCA 1997). See text for detailed descriptions of ecoregions.

and ethnobiology (Foster 1992; Polaco and Guzmán 1997; Sánchez-Villanueva and Corona-M. 2000; Merrill and López-González 2007), and ectoparasites (Villegas-Guzmán *et al*. 2003) have been published for Chihuahuan mammals. Chihuahua also has been part of region-wide taxonomic studies (*e.g.* Schmidly 1972; Riddle *et al*. 2000a, b; Edwards *et al*. 2001; Tejedor 2005; Carraway 2007). Nonetheless, no comprehensive summary of the mammals for the state has been published since Anderson (1972); thus the objective of this work is to present an updated checklist of the mammals of Chihuahua, with comments on their general distribution.

Materials and Methods

The updated list was built starting with those of Anderson (1972) and Ramírez-Pulido *et al*. (2000). We also conducted a search in the major internet journal databases for all literature published through November 2011, using "mammals" and "Chihuahua" as keywords. Additionally, previously unpublished records were taken from specimens deposited at the Mammal Collection, CIIDIR-IPN Unidad Durango (CRD); Colección Nacional de Mamíferos, Universidad Nacional Autónoma de México (CNMA); Colección de Mamíferos, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, México (ENCB); the Museum of Michigan State University Mammal Collection (MSU), Natural Science Research Laboratory, The Museum, Texas Tech University (TTU); and the Mammal Collection, Department of Ecology and Evolutionary Biology, University of Kansas (KU). Thus, all records included in this account are based either on specimens examined by us or by published records based on museum specimens. Nomenclature was standardized following Ceballos *et al.* (2005a), except for the order Soricomorpha, for which we follow Carraway (2007), the genera *Natalus,* for which we follow Tejedor (2005, 2006), and *Spermophilus*, for which we follow Helgen *et al.* (2009). Zoogeographic affinities follow Álvarez and Lachica (1974). Conservation status category and endemisms are indicated when appropriate following Ceballos *et al.* (2005a), and current Mexican legislation (SEMARNAT 2010). We did not include introduced or domesticated species.

We assigned each species to one or more ecological regions based on the distributional records obtained. The Commission for Environmental Cooperation (CCA 1997) divided the Chihuahuan landscape into four major ecoregions that coincide with those defined by González-Elizondo *et al*. (2007) for Durango State, Chihuahua's southern neighbor. These ecological regions encompass the major biomes of the state (Figure 1); from east to west they are:

1) Arid and semiarid region. Lowland plains and mountain ranges from Puerto Palomas at the border with the US, southeastward to the Bolsón de Mapimí at the border with Durango. This area is part of the Chihuahuan desert and covers the western portion of the Mexican Plateau. Elevation ranges from 1100 to 1800 m above sea level. Climate varies from dry, to very dry and warm (BWh, BSh, BWh'; García 1988). Vegetation includes a variety of thorn scrubs, as well as halophylic associations in the northern areas (CCA 1997).

2**) Valleys region.** A wide strip of land extending from northwest to southeast between the Chihuahuan desert and the SMO. It includes mostly grasslands, as well as mesas and a few small mountain ranges. Elevation ranges from 1300 to 2200 m at the SMO foothills. Climate is warm and dry, with extreme temperatures throughout the day (BS_1K; García 1988) in most of the area. Although originally it was covered with grasslands and mesquite grassland, currently most of this area has been modified for agriculture and cattle ranching (CCA 1997).

3) Sierra Region. This region includes the highest elevations in the SMO, from 2200 m above sea level on the eastern slope, and 2000 m on the western slope, to 3280 m at the summit of Cerro Mohinora, the highest elevation. Climate is temperate, dry on the eastern slope (C(w)), and more mesic and cooler (C(E)(w)) in the higher ranges (García 1988; CCA 1997). Vegetation includes pine, pine and oak, and open oak forests, as well as secondary chaparral produced by deforestation. This region also includes the isolated sierras east of Madera, including Sierra La Montosa and Sierra del Nido.

4) Quebradas Region. Lowlands on the western slopes of the Sierra Madre Occidental. Elevation ranges from 2000 to 250 m above sea level. The region is rugged, with steep slopes and deep canyons. The climate is warm, with a long dry season and medium to high precipitation (600-900 mm annually) in the rainy season (climate BS1 to AC(w), respectively; García 1988). Accordingly, the local vegetation consists of a mixture of arid and tropical associations, such as dry, deciduous, or semidecidous tropical forests, and thorn scrubs mixed with secondary vegetation resulting from agricultural and cattle ranching activities (CCA 1997).

We made checklists for all mammals documented from Chihuahua for each ecoregion. Regional faunas were compared via Cluster analysis (UPGMA) of a resemblance matrix based on presence-absence data. Analysis was performed using the SAHN module of NTSYSpc Ver. 2.02 (Applied Biostatistics Inc. 1998). The Jaccard index (Brower and Zar 1977) was used to measure community similarity.

Results and discussion

Species richness

Seven orders, 25 families, 75 genera, and 133 species of mammals have been recorded from Chihuahua (Table 1), representing 27.4% of the terrestrial mammalian fauna of Mexico (Ceballos *et al*. 2005a). We added 11 species to the list published by Anderson (1972). Most species (84.2%) have nearctic affinities (Álvarez and Lachica 1974 and Figure 2). Species richness by order is similar to that of all Mexico for Chiroptera, Lagomorpha, and Rodentia. No primates, perissodactyls, or cingulates have been registered, but Artiodactyla and Carnivora are over-represented compared to the country as a whole (Figure 3). These orders have holarctic affinities, thus explaining their abundance in a subtropical area. In contrast, Chihuahuan bats are a mixture of nearctic elements from the highlands and Mexican plateau, and of tropical species from the Pacific coastal plain that penetrate the Sierra Madre Occidental through the canyons on its western slope (Figure 2). Bats account for most of the neotropical

component of the Chihuahuan fauna. Didelphimorphia and Soricomorpha are underrepresented (Figure 3); the former because most species are tropical and only *Didelphis virginiana* Kerr, 1792 reaches the northernmost portion of the country. Soricomorpha appears to be restricted by habitat availability, as most species of shrews prefer areas with humid, deep soils or ample cover (Carraway 2007).

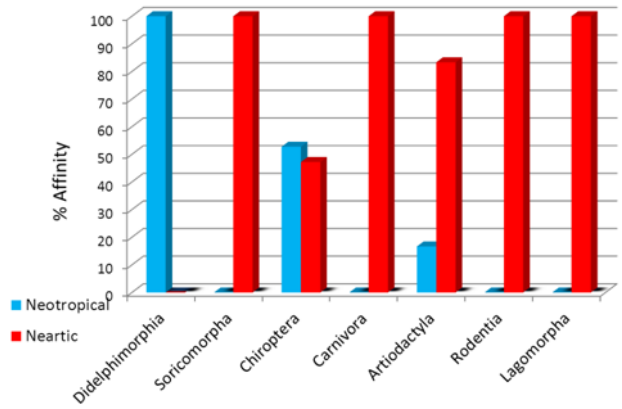

Figure 2. Percentage of neotropical and nearctic species per order in Chihuahuan Mammals. Affinities after Alvarez and Lachica (1974).

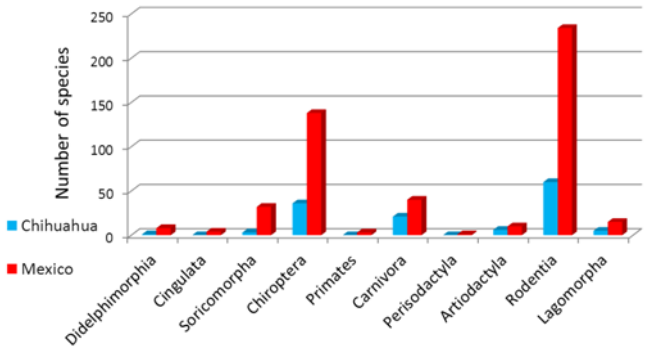

Figure 3. Mammalian species richness by order for Mexico (red bars) and Chihuahua (blue bars). Data for Mexico from Ceballos *et al.* (2005a).

Conservation status

Of the 133 species recorded, 15 are endemic to Mexico; most endemics are rodents (13 species), and two are bats (Table 1). Twenty-two are species of concern according to Mexican laws (SEMARNAT 2010): four are of special concern for being endemic or migratory, eight are considered threatened, and eight endangered. The Mexican wolf (*Canis lupus baileyi* Nelson and Goldman, 1929) is considered extinct by SEMARNAT (2010), but Ceballos *et al*. (2005a) considered wolves as extirpated rather than extinct because of successful reintroduction efforts in Arizona, USA (Hedrick and Fredrickson 2008). The most recent record of wolves in Chihuahua is a specimen deposited at CNMA (IB24553), collected in 1980 near Buenaventura (see also McBride 1980). This suggests that the Mexican wolf remains extirpated from Chihuahua.

The Grizzly bear (*Ursus arctos horribilis* Ord, 1815) is also considered as extinct in Mexico by Mexican laws (SEMARNAT 2010). As with the Mexican wolf, because wild populations of *U. arctos* still occur in the United States (Wilson and Ruff 1999), it is more appropriate to consider grizzly bears as extirpated from Mexico rather than extinct (Ceballos and Navarro 1991). According to Allen (1942), grizzly bears (under the name *Ursus nelsoni* Merriam, 1914*)* were distributed across the SMO from northwestern Chihuahua and northeastern Sonora to southern Durango. Subsequently, Hall (1981; 1984) and Moctezuma Orozco (2005) proposed the same distribution in their accounts on grizzly bears. Isolated records for *U. arctos* are available for Chihuahua, the southernmost known to us being from Sierra del Nido, in the north-central portion of the state (Leopold 1959). Biologists surveyed Sierra del Nido in 1979 looking for evidence of grizzly bears, and based on their findings, they concluded that its presence was likely in that year (Treviño and Jonkel 1986). We found no additional records for *U. arctos* in Chihuahua, which lead us to agree with previous authors that grizzlies are currently extirpated from the state.

Microtus pennsylvanicus (Ord, 1815), a rodent listed as endangered, is represented in Mexico by a relict population from a single locality near Galeana, Chihuahua. Specimens were collected in 1964 and were described as the subspecies *M. pennsylvanicus chihuahuensis* Bradley and Cockrum, 1968. As far as we know, no new collections have been made in the area. Ceballos *et al*. (2005a:54) reported that in 1988 "we still found it", but presented no specimens or any other evidence of the presence of these mice. They further reported that specimens had not been seen since 1988, even though they searched for them. Nonetheless, it is not clear how systematic or comprehensive the efforts were to find them. In addition, these authors reported that *M. pennsylvanicus chihuahuensis* became extinct due to the disappearance in 2004 of the spring that supported the meadow where these animals lived (Ceballos *et al*. 2005a). Although their conclusions are reasonable, from this information only it is difficult to ascertain the current status of the population. Considering that periodic droughts are common in the area, a long-term study is necessary to ascertain the true status of the Mexican population of *M. pennsylvanicus*.

The beaver (*Castor canadensis* Kuhl, 1820) is listed as endangered. We could find no recent records of beavers from Chihuahua beyond those of Anderson (1972) for the Bravo and Conchos river basins, all based on data prior to 1960. However, Gallo-Reynoso *et al*. (2002) found beavers in Sonora, at Rio Bavispe on the Sierra San Luis, less than 20 km from the Sonora-Chihuahua border. Pelz-Serrano *et al*. (2005) reported additional records from Sierra San Luis. Because these mountains are shared by Chihuahua and Sonora, it is likely that beavers still occur in western Chihuahua.

The only Chihuahuan record for the muskrat *Ondatra zibethicus* (Linnaeus, 1766) was reported in Anderson (1972) from a specimen collected around 1959 near Ojinaga. Further reports (Hall 1981; López-Wilchis and López-Jardines 1999) refer to the same specimen. Nothing else seems to be known about muskrats in Chihuahua, even though wildlife monitoring and research has been conducted actively in the northern portion of the state in the last 25 years (List and McDonald 1998; Pacheco *et al.* 2000; List *et al.* 2010). *O. zibethicus* is probably extirpated from the state.

The porcupine *Erethizon dorsatum* (Linnaeus, 1758) is considered endangered for Mexico. Nonetheless, porcupines have been observed at the Janos Area recently

(List *et al*. 1999). This region was declared a biosphere reserve in 2009; if protection is effective, and habitat remains available, *E. dorsatum* may thrive again in the northern portion of the state.

At the end of the 19th century the bighorn sheep (*Ovis canadensis* Shaw, 1804) were common in the desert mountain ranges of Chihuahua (Anderson 1972); however, uncontrolled grazing and overhunting decimated populations in the early 20th century. Sporadic reports of individuals drifting from the US to Mexico are available (Heffelfinger and Márquez-Muñoz 2005; Pelz-Serrano *et al*. 2006), but no stable Mexican population has been reported since the middle of the 20th century (Baker 1956; Anderson 1972; Heffelfinger and Márquez-Muñoz 2005). We consider this species extirpated from Chihuahua.

Distribution by ecological regions

Species richness (129, not including the four extirpated species: *Ovis canadensis, Ondatra zibethicus, Canis lupus,* and *Ursus arctos*) was the highest in the Valleys (72), followed by Aridlands (62), Sierra (59) and Quebradas (47). The cluster analysis (Figure 4) grouped Valleys and Aridlands, which share 67.5% of the species, most of them of nearctic affinities (mostly vespertilionid bats, carnivores, and to a lesser degree murid rodents). This group is joined to the Sierra region, with which it shares 29.2% of the species, mostly vespertilionids and some carnivores (Figure 4, Table 1). The Quebradas region is the most distinct: it shares only 16% of the species with the rest of the ecoregions, and 25 species occur exclusively here. Most of these species are bats of neotropical affinity that reach their distributional termini in the coastal plain of Southern Sonora and SW Chihuahua.

The Sierra and Quebradas are contiguous areas that share mostly widely distributed species (16). Nineteen species (2 shrews, 14 rodents, 2 bats and one carnivore), were recorded only in the highlands of the SMO. The bat *Dermanura azteca* (Andersen, 1906) is a tropical species that was captured in the Urique River Canyon (López-González and García-Mendoza 2006). It likely represents a vagrant from the lowlands, but it is possible that seasonal, elevational migrations may occur between the tropical and temperate areas of the Sierra Madre Occidental. This subject remains to be investigated.

The Sierra and Valleys regions have 34 species in common, primarily widely-distributed carnivores, rodents, and bats. The Valleys region includes mostly species of nearctic affinity. For being a transitional area between the Aridlands to the east and the Sierra to the west, it is mostly a mixture of elements from the desert and the Sierra. Even though it has the highest species richness (72), only six are exclusive to the Valleys region: *Cynomys ludovicianus* (Ord, 1815); *Baiomys taylori* (Thomas, 1887); *Bison bison* (Linnaeus, 1758); *Peromyscus leucopus* (Rafinesque, 1818); *Microtus pennsylvanicus* (Ord, 1815); and *Mustela nigripes* (Audubon and Bachman, 1852), all of which are endemics of the grasslands and prairies of North America.

The Arid zone (Chihuahuan Desert) shares 54 species with the Valleys and has species richness comparable to that of the Sierra (62 for Arid zone, 59 for the Sierra). Only six species occurred exclusively there: *Ammospermophilus interpres* Merriam, 1890; *Geomys arenarius* Merriam, 1895; *Cratogeomys castanops* (Baird, 1852); *Dipodomys nelsoni* Merriam, 1907; *Neotoma goldmani* Merriam, 1903; and *N. micropus* (Baird, 1855). Most genera are widely distributed across North American Aridlands (*e.g. Dipodomys, Geomys*), or are generalist, widely-distributed species like coyotes (*Canis latrans* Say, 1823), skunks (*Mephitis, Conepatus*), jackrabbits (*Lepus*) or deer mice (*Peromyscus*). Endemic species are more frequent in the Sierra region (8). *Callospermophilus madrensis* (Merriam, 1901); *T. durangae* (J.A. Allen, 1903); *Peromyscus polius* Osgood, 1904; *Reithrodontomys zacatecae* Merriam, 1901; and *Nelsonia neotomodon* Merriam, 1897 are endemic to the SMO, whereas *Corynorhinus mexicanus* G.M. Allen, 1916; *P. difficilis* (J.A. Allen, 1891) and *Sigmodon leucotis* Bailey, 1902 are endemic to Mexico. An additional endemic could be *P. melanotis* J.A. Allen and Chapman, 1897; which inhabits the Mexican Highlands. There is an isolated population in Arizona that has been assigned to *P. melanotis* by some authors (*e.g.* Ceballos and Oliva 2005; Musser and Carleton 2005) and to *P. maniculatus* (Wagner, 1845) by others (Hoffmeister 1986; Wilson and Ruff 1999; Ramírez-Pulido *et al*. 2005). There is no consensus about the identity of these populations, and therefore to the endemic status of *P. melanotis.*

The Quebradas harbor five species endemic to Mexico: *Artibeus hirsutus* Andersen, 1906; *Sciurus colliaei* Richardson, 1839; *Chaetodipus artus* Osgood, 1900; *C. goldmani* (Osgood, 1900); and *Peromyscus spicilegus* J.A. Allen, 1897*.* No endemics have been reported from the Valleys and only two from the Arid zone (*Neotoma goldmani* Merriam, 1903 and *Dipodomys nelsoni* Merriam, 1907)*.* This is expected because the Arid and Valley areas are part of larger ecoregions that encompass central Mexico and the western portion of the United States (CCA 1997), with many species broadly-distributed throughout the area in both countries. As to the Sierra endemics, it has been proposed that the highlands of the Sierra Madre Occidental harbor relict populations from the last glaciation (Escalante *et al*. 2004). Additionally, the Sierra is a system of sky islands, in which speciation by isolation probably occurred throughout the Holocene and is still occurring. Less is known about the processes that resulted in the high number of endemics on the Mexican Pacific Plateau, but a few reach the northern limits of the Neotropics in southwestern Chihuahua (Escalante *et al*. 2004; Morrone 2005).

Additional Records

Additional species have been reported as present in Chihuahua, but we found no evidence of their presence. *Herpailurus yagouaroundi* (Lacépède, 1809) is reported in Table 21.1 of Ceballos *et al*. (2005a), but no further comment, evidence, or reference was given for the basis of this record. The elk (*Cervus merriami* Nelson, 1902) is listed for Chihuahua by Pacheco *et al*. (2000) and Ceballos *et al.* (2005a), but neither paper provided evidence for the presence of elk in Chihuahua, other than a record by Mearns (1907). However, this record only refers to "San José Mountains, Sonora, Mexico" (Mearns 1907:220). Furthermore, a thorough revision of the literature (including Mearns 1907) as well as physical evidence, including fossil and subfossil material, led Carrera and

Ballard (2003) to conclude that during historical times (1800s) there probably was a relict population of elk in Arizona and New Mexico, but that no evidence exists for the presence of elk in Mexico.

The flying squirrel *Glaucomys volans madrensis* Goldman, 1936 is included in the Chihuahuan fauna based on two specimens collected in the late 19th century and labeled "Sierra Madre, Chihuahua" (Goodwin 1961; Anderson 1972). These specimens are the types for the subspecies, but we could find no additional records. Anderson (1972) noted that "neither specimen bears an original field tag", making it difficult to corroborate the records. The lack of additional records may be due to extirpation, but it is also possible that the description of *G. volans madrensis* is based on specimens collected on the Sierra Madre Oriental, where flying squirrels do occur.

The black-footed ferret *Mustela nigripes* (Audubon and Bachman, 1851) was recently listed as occurring in Chihuahua (Ceballos and Oliva 2005). According to most authors, this species historically was distributed across the Great Plains, as far south as southern Texas and Arizona (Hillman and Clark 1980; Anderson *et al.* 1986; Owen *et al*. 2000), but not in Mexico. The only evidence available for Mexico is from a fossil specimen from a cave near Jiménez, Chihuahua (Messing 1986), dated "late Pleistocene-Holocene", and considered by Messing to be the first record of *M. nigripes* for Mexico. Nonetheless, *M. nigripes* started to appear in the literature in 2002 after a report of the successful reintroduction of black-footed ferrets in Janos, Chihuahua (Pacheco *et al*. 2002). It was called a reintroduction because Pacheco *et al*. (2002) considered the Jiménez record, as well as one from Arizona (Harris 1978) historical, and probably by extrapolation concluded that *M. nigripes* inhabited northern Chihuahua in historical times. Living specimens were released in Janos under the assumption of an obligated relationship between black-footed ferrets and prairie dogs *Cynomys ludovicianus* (Ord, 1815), of which a large colony exists in the area (Pacheco *et al*. 2002). Owen *et al*. (2000) however, have demonstrated that the relationship is not necessarily an obligate one. On the other hand, if the black-footed ferret, a relatively large mammal, inhabited northern Mexico in historical times, it seems unusual that its presence had not been reported by missionaries or naturalists since the arrival of Europeans. Although in terms of conservation the success of the Janos population is certainly an accomplishment (Lockhart *et al*. 2003), it is not clear whether these animals represent a reintroduction or an introduction into Mexico.

Peromyscus melanocarpus Osgood, 1904 was reported by López-Wilchis and López-Jardines (1999) for Chihuahua. Because of the nature of the publication (a compilation of records from museum databases with no direct examination of specimens), there is no information on the accuracy or origin of this record. Additionally, this is a species endemic to the highlands of Oaxaca (Ceballos *et al*. 2005a), thus it is unlikely to occur in Chihuahua, and the record probably represents a museum misidentification.

Chavez Tovar (2005) reported *Peromyscus nasutus* (J.A. Allen, 1891) as occurring in Chihuahua. Nonetheless, as currently understood *P. nasutus* occurs from Colorado and SE Utah to NW Coahuila, not including Chihuahua (Musser and Carleton 2005). Some authors have mapped the distribution including Chihuahua (Hall 1981; Wilson and Ruff 1999; Chavez Tovar 2005), but as far as we could ascertain, no records exist for the state. Finally, *Nyctinomops aurispinosus* (Peale, 1848) was reported by López-González and García-Mendoza (2006) from southern Chihuahua. A more recent examination of the specimen on which this record is based revealed that the specimen actually belongs to *N. femorosaccus* (Merriam, 1889).

Anderson (1972) proposed a list of 17 species that were not yet recorded from Chihuahua, but were likely to occur in there. Thirteen of those species have yet to be recorded for the state: *Tlacuatzin canescens* (J.A. Allen, 1893); *Dasypus novemcinctus* Linnaeus, 1758; *Pteronotus davyi* Gray, 1838; *P. personatus* (Wagner, 1843); *Lasionycteris noctivagans* (Le Conte, 1831); *Lasiurus ega* (Gervais, 1856); *Rhogeessa parvula* H. Allen 1866; *Euderma maculatum* (J.A. Allen, 1891); *Eumops perotis* (Schinz, 1821); *Molossus rufus* É. Geoffroy St.-Hilaire, 1805; *Leopardus pardalis* (Linnaeus, 1758); *Ictidomys mexicanus* (Erxleben, 1777) and *Peromyscus merriami* Mearns, 1896. Most of these species are of tropical affinity, have been captured near Chihuahua, and likely have the northern limits of their geographic distributions within the southern portions of the state. The paucity of records is likely to be a function of the scant collecting efforts in the Quebradas region, and highlights the need to continue survey and inventory work in the area. *Onychomys torridus* (Coues, 1874) and *Chaetodipus penicillatus* (Woodhouse, 1852) as currently understood (Hinesley 1979; Lee *et al*. 1996) have not been recorded for the State, but have been collected in neighboring Sonora, and are likely to occur in Chihuahua as well. Similarly, *Peromyscus schmidlyi* Bradley *et al.*, 2004 is known from the highlands of Durango and Sonora (Bradley *et al.* 2004; Cabrera *et al.* 2007), and it is likely to occur in Chihuahua.

Final remarks

Chihuahua is home to nearly 30% of the terrestrial mammal species known for Mexico, and includes one of the highest diversities of Artiodactyla in the country. Moreover, many tropical species reach their northern termini in the state. This represents an area where mammals experience environmental stress that is not present elsewhere in their ranges, which may promote speciation or differentiation to actively occur in these populations. Chihuahua has a long tradition of hunting wild game, and management of wildlife to maintain viable populations is active in many

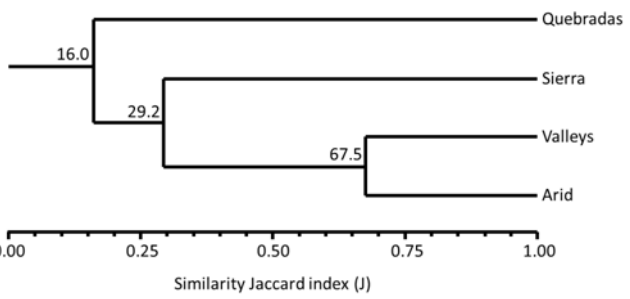

Figure 4. Cluster analysis (UPGMA) of mammalian species assemblages for four ecological regions in Chihuahua, Mexico. The Jaccard index was used as a measure of similarity. Numbers on nodes indicate percentage of species shared by branches.

parts of the state. Nevertheless, for most mammals our knowledge on their local distribution, ecology, evolution, and response to anthropogenic modification in Chihuahua is scant or nonexistent. This situation is of particular concern as Chihuahua is home to biomes (*e.g.* prairies and dune vegetation) that are unique in Mexico. Nonetheless, the proportion of its territory that is protected is low (7.2%, CONANP 2010), and it does not include all the major ecoregions of the state. No protected area exists for the Quebradas region, although the Mexican National Commission for Biodiversity (CONABIO) has designated six areas in Chihuahua that include the Quebradas region as priorities for conservation (Arriaga *et al*. 2000). Moreover, Quebradas has one of the least studied faunas and floras due in part to its inaccessibility. In contrast, the Valleys and Arid regions have long histories of agricultural and livestock activity, which has resulted in considerable fragmentation and habitat loss. The effects of these changes in the mammalian fauna have not been quantified. Even worse, in the most recent federal plan for land-use planning in Mexico (SEMARNAT 2011), the entire state of Chihuahua, including tropical areas and prairies, are considered low conservation or protection priorities. A reconsideration of conservation priorities for the state is urgent if the persistence of Chihuahua's biodiversity is to be ensured.

Table 1. Mammals of Chihuahua, Mexico. * Species extirpated from the state. Conservation status (Status) according to NOM-ECOL 059-2010 (SEMARNAT 2010): A = threatened, Pr = Special protection, E = Extinct, P = Endangered. Classification and endemic species according to Ceballos *et al.* (2005a). Ecoregions as defined by González-Elizondo *et al.* (2007) and CCA (1997). Source of records refers to author (reference) or collection (acronym) from which data were obtained.

TAXON	REGION				MEXICO ENDEMIC	STATUS	SOURCE OF RECORDS
	Quebradas	Sierra	Valleys	Arid			
Order Didelphimorphia							
Family Didelphidae							
Subfamily Didelphinae							
Didelphis virginiana Kerr, 1792	X	X					Anderson (1972), CRD
Order Soricomorpha							
Family Soricidae							
Subfamily Soricinae							
Sorex arizonae Diersing and Hoffmeister, 1977		X				P	Carraway (2007)
Sorex monticolus Merriam, 1890		X					Carraway (2007)
Notiosorex crawfordi (Coues, 1877)			X	X		A	Carraway (2007)
Order Chiroptera							
Family Emballonuridae							
Subfamily Emballonurinae							
Balantiopteryx plicata Peters, 1867	X						Anderson (1972), CRD, KU
Family Mormoopidae							
Mormoops megalophylla (Peters, 1864)	X			X			Anderson (1972), CRD, TTU
Pteronotus parnellii (Gray, 1843)	X						Anderson (1972), López-González and García-Mendoza (2006), CRD, KU
Family Phyllostomidae							
Subfamily Macrotinae							
Macrotus californicus[a] Baird, 1858	X						Anderson (1972), López-González and García-Mendoza (2006), CRD, KU
Subfamily Desmodontinae							
Desmodus rotundus (É. Geoffroy St.-Hilaire, 1810)	X						Anderson (1972), López-González and García-Mendoza (2006), CRD, ENCB, CNMA, KU
Subfamily Phyllostominae							
Tribe Glossophagini							
Choeronycteris mexicana Tschudi, 1844	X					A	Anderson (1972), CRD
Glossophaga soricina (Pallas, 1766)	X						Anderson (1972), López-González and García-Mendoza (2006), KU, CRD
Leptonycteris yerbabuenae Martínez and Villa-R., 1940	X					A	Anderson (1972), López-González and García-Mendoza (2006), CRD
Tribe Stenodermatini							
Artibeus hirsutus Andersen, 1906	X				X		Anderson (1972), López-González and García-Mendoza (2006), CRD, KU
Chiroderma salvini Dobson, 1878	X						Anderson (1972), KU
Dermanura azteca (Andersen, 1906)		X					López-González and García-Mendoza (2006), CRD
Dermanura tolteca (de Saussure, 1860)	X						López-González and García-Mendoza (2006), CRD

Table 1. ***Continued.***

TAXON	REGION				MEXICO ENDEMIC	STATUS	SOURCE OF RECORDS
	Quebradas	Sierra	Valleys	Arid			
Sturnira lilium (É. Geoffroy St.-Hilaire, 1810)	X						Anderson (1972), López-González and García-Mendoza (2006), CRD, KU
Family Natalidae							
Natalus lanatus Tejedor, 2005	X						Tejedor (2005)
Natalus mexicanus Miller, 1902	X						Anderson (1972), López-González and García-Mendoza (2006), KU, CRD
Family Vespertilionidae							
Subfamily Vespertilioninae							
Corynorhinus mexicanus G.M. Allen, 1916		X			X		Tumilson (1991), CRD, KU
Corynorhinus townsendii (Cooper, 1837)		X	X	X			Anderson (1972), CRD, KU
Eptesicus fuscus (Palisot de Beauvois, 1796)		X	X				Anderson (1972), López-González and García-Mendoza (2006), KU, CRD
Idionycteris phyllotis (G.M. Allen, 1916)		X	X				Anderson (1972), KU
Lasiurus blossevillii (Lesson and Garnot, 1826)	X						Anderson (1972), López-González and García-Mendoza (2006), CRD
Lasiurus cinereus (Palisot de Beauvois, 1796)		X	X	X			Anderson (1972), López-González and García-Mendoza (2006), KU, CRD, ENCB
Myotis auriculus Baker and Stains, 1955	X	X					Anderson (1972), López-González and García-Mendoza (2006), CRD, KU
Myotis californicus (Audubon and Bachman, 1842)	X	X	X	X			Anderson (1972), López-González and García-Mendoza (2006), CRD, KU, ENCB
Myotis fortidens Miller and G.M. Allen, 1928	X						López-González and García-Mendoza (2006), CRD
Myotis melanorhinus (Merriam, 1886)		X	X	X			Anderson (1972), López-González and García-Mendoza (2006), KU, CRD
Myotis occultus Hollister, 1909		X	X				Anderson (1972)
Myotis thysanodes Miller, 1897		X	X	X			Anderson (1972), ENCB, TTU, KU
Myotis velifer (J.A. Allen, 1890)	X	X	X	X			Anderson (1972), López-González and García-Mendoza (2006), CRD, ENCB, KU
Myotis volans (H.A. Allen, 1866)		X	X				Anderson (1972), ENCB, KU
Myotis yumanensis (H.A. Allen, 1864)	X	X	X	X			Anderson (1972), López-González and García-Mendoza (2006), ENCB, CNMA, CRD
Parastrellus hesperus (H.A. Allen, 1864)	X		X	X			Anderson (1972), López-González and García-Mendoza (2006), ENCB, CNMA, CRD, KU
Subfamily Antrozoinae							
Antrozous pallidus (Le Conte, 1856)	X		X	X			Anderson (1972), López-González and García-Mendoza (2006), CNMA, ENCB, CRD, KU
Family Molossidae							
Subfamily Molossinae							
Nyctinomops femorosaccus (Merriam, 1889)	X						López-González and García-Mendoza (2006), CRD
Nyctinomops macrotis (Gray, 1839)			X	X			Anderson (1972), Easterla (1972)
Eumops underwoodi Goodwin, 1940	X						Anderson (1972)
Subfamily Tadarinae							
Tadarida brasiliensis (I. Geoffoy Saint-Hilaire, 1824)	X	X	X	X			Anderson (1972), López-González and García-Mendoza (2006), ENCB, CNMA, CRD, KU
Order Carnivora							
Family Canidae							
Canis latrans Say, 1823		X	X	X			Anderson (1972), ENCB, CNMA, KU, MSU
Canis lupus Linnaeus, 1758*		E	E	E		E	Anderson (1972), KU, CNMA

Table 1. ***Continued.***

TAXON	REGION				MEXICO ENDEMIC	STATUS	SOURCE OF RECORDS
	Quebradas	Sierra	Valleys	Arid			
Urocyon cinereoargenteus (Schreber, 1775)	X	X	X	X			Anderson (1972), ENCB, CNMA, CRD, KU
Vulpes macrotis Merriam, 1888			X	X		A	Anderson (1972), MSU
Family Felidae							
Subfamily Felinae							
Leopardus wiedii (Schinz, 1821)	X					P	Anderson (1972), KU
Lynx rufus (Schreber, 1777)	X	X	X				Anderson (1972), ENCB, CNMA, KU
Puma concolor (Linnaeus, 1771)		X	X	X			Anderson (1972), ENCB, CNMA, KU
Subfamily Pantherinae							
Panthera onca (Linnaeus, 1758)	X					P	CNMA
Family Mustelidae							
Subfamily Lutrinae							
Lontra longicaudis (Olfers, 1818)	X	X				A	Anderson (1972), KU
Subfamily Mustelinae							
Mustela frenata Lichtenstein, 1831		X					Anderson (1972)
Mustela nigripes (Audubon and Bachman, 1851)			X				Lockhart et al. (2003)
Subfamily Taxidiinae							
Taxidea taxus (Schreber, 1778)			X	X		A	Anderson (1972), CNMA, MSU
Family Mephitidae							
Conepatus leuconotus (Lichtenstein, 1832)		X	X				Anderson (1972), ENCB, CNMA, KU
Mephitis macroura Lichtenstein, 1832	X	X	X	X			Anderson (1972), CRD, KU, ENCB
Mephitis mephitis (Schreber, 1776)		X	X	X			Anderson (1972), ENCB, KU
Spilogale gracilis Merriam, 1890	X	X		X			Anderson (1972)
Family Procyonidae							
Subfamily Procyoninae							
Bassariscus astutus (Lichtenstein, 1830)		X	X	X			Anderson (1972)
Nasua narica (Linnaeus, 1766)	X	X					Anderson (1972)
Procyon lotor (Linnaeus, 1758)	X	X	X				Anderson (1972), ENCB
Family Ursidae							
Subfamily Ursinae							
Ursus americanus Pallas, 1780		X	X				Anderson (1972), ENCB, CNMA
Ursus arctos Linnaeus, 1758*		E	E			E	Anderson (1972)
Order Artiodactyla							
Family Antilocapridae							
Antilocapra americana (Ord, 1815)			X	X		P	Anderson (1972), ENCB, CNMA
Family Bovidae							
Subfamily Bovinae							
Bison bison (Linnaeus, 1758)			X			P	Anderson (1972), CNMA
Subfamily Caprinae							
Ovis canadensis Shaw, 1804*			E			Pr	Anderson (1972)
Family Cervidae							
Subfamily Odocoileinae							
Odocoileus hemionus (Rafinesque, 1817)			X	X			Anderson (1972), ENCB
Odocoileus virginianus (Zimmermann, 1780)	X	X	X	X			Anderson (1972), CNMA, ENCB, KU
Family Tayassuidae							
Subfamily Tayassuinae							
Pecari tajacu (Linnaeus, 1758)	X	X					Anderson (1972), KU
Order Rodentia							
Family Sciuridae							
Subfamily Sciurinae							
Ammospermophilus interpres (Merriam, 1890)				X			Anderson (1972), KU
Cynomys ludovicianus (Ord, 1815)			X			A	Anderson (1972), CNMA
Sciurus aberti Woodhouse, 1853		X				Pr	Anderson (1972), CNMA, ENCB, KU
Sciurus colliaei Richardson, 1839	X				X		Anderson (1972)
Sciurus nayaritensis J.A. Allen, 1890		X					Anderson (1972), KU, CNMA
Callospermophilus madrensis (Merriam, 1901)		X			X	Pr	Anderson (1972), KU, CNMA
Xerospermophilus spilosoma Bennett, 1833			X	X			Anderson (1972), KU, CNMA

Table 1. ***Continued.***

TAXON	REGION				MEXICO ENDEMIC	STATUS	SOURCE OF RECORDS
	Quebradas	Sierra	Valleys	Arid			
Otospermophilus variegatus (Erxleben, 1777)	X	X	X	X			Anderson (1972), CNMA, ENCB, KU
Tamias dorsalis (Baird, 1855)[b]		X					Anderson (1972), ENCB, CRD, CNMA
Tamias durangae (J.A. Allen, 1903)[b]		X			X		Anderson (1972), MSU
Family Castoridae							
Subfamily Castorinae							
Castor canadensis Kuhl, 1820		X	X	X		P	Anderson (1972)
Family Geomyidae							
Subfamily Geomyinae							
Geomys arenarius Merriam, 1895				X			Anderson (1972)
Cratogeomys castanops (Baird, 1852)				X			Anderson (1972)
Thomomys bottae (Eydoux and Gervais, 1836)			X	X			Anderson (1972), KU, ENCB
Thomomys umbrinus (Richardson, 1829)		X	X	X			Anderson (1972), KU, MSU, TTU, CNMA , CRD
Family Heteromyidae							
Subfamily Dipodomyinae							
Dipodomys merriami Mearns, 1890			X	X			Anderson (1972), MSU, KU, TTU, CNMA, ENCB
Dipodomys nelsoni Merriam, 1907				X	X		Anderson (1972)
Dipodomys ordii Woodhouse, 1853			X	X			Anderson (1972) KU, MSU, TTU, CRD
Dipodomys spectabilis Merriam, 1890			X	X			Anderson (1972), MSU, KU, TTU
Subfamily Heteromyinae							
Liomys irroratus (Gray, 1868)			X	X			Anderson (1972), CNMA, KU
Liomys pictus (Thomas, 1893)	X						Anderson (1972), KU
Subfamily Perognathinae							
Chaetodipus artus (Osgood, 1900)	X				X		Anderson (1972), KU
Chaetodipus eremicus (Mearns, 1898)			X	X			Anderson (1972), KU MSU, CNMA
Chaetodipus goldmani Osgood, 1900	X				X		Anderson (1972)
Chaetodipus hispidus (Baird, 1858)		X	X				Anderson (1972), KU, MSU
Chaetodipus intermedius Merriam, 1889			X	X			Anderson (1972), KU, CNMA
Chaetodipus nelsoni (Merriam, 1894)			X	X			Anderson (1972), MSU, KU, CNMA, ENCB
Perognathus flavescens Merriam, 1889			X	X			Anderson (1972)
Perognathus flavus Baird, 1855			X	X			Anderson (1972), KU, MSU
Perognathus merriami J.A Allen, 1892			X	X			Anderson (1972), KU
Family Muridae							
Subfamily Arvicolinae							
Microtus mexicanus (de Saussure, 1861)		X					Anderson (1972), MSU
Microtus pennsylvanicus (Ord, 1815)			X			P	Anderson (1972)
Ondatra zibethicus (Linnaeus, 1766)*			E	E		A	Anderson (1972)
Subfamily Sigmodontinae							
Baiomys taylori (Thomas, 1887)			X				Anderson (1972), MSU, KU, CNMA, ENCB
Nelsonia neotomodon Merriam, 1897		X			X	Pr	García-Mendoza and López-González (2005), CRD
Neotoma albigula Hartley, 1894	X		X	X			Anderson (1972), TTU, KU, CNMA, MSU
Neotoma goldmani Merriam, 1903				X	X		Anderson (1972)
Neotoma leucodon Merriam, 1894			X	X			Anderson (1972), ENCB, KU
Neotoma mexicana Baird, 1855		X					Anderson (1972), KU CNMA, CRD
Neotoma micropus Baird, 1855				X			Anderson (1972), CNMA
Onychomys arenicola Mearns, 1896			X	X			Anderson (1972), KU, MSU, ENCB, CNMA
Onychomys leucogaster (Wied-Neuwied, 1841)			X	X			Anderson (1972), Wilson and Ruff (1999), CNMA
Peromyscus boylii (Baird, 1855)		X	X				Anderson (1972), CRD, CNMA, ENCB, KU, MSU,

Table 1. ***Continued.***

TAXON	REGION				MEXICO ENDEMIC	STATUS	SOURCE OF RECORDS
	Quebradas	Sierra	Valleys	Arid			
Peromyscus difficilis (J.A. Allen, 1891)		X			X		Anderson (1972), CRD, CNMA, MSU, KU
Peromyscus eremicus (Baird, 1858)	X		X	X			Anderson (1972), KU, CNMA
Peromyscus gratus Merriam, 1898		X					Anderson (1972), KU, CNMA, CRD
Peromyscus leucopus (Rafinesque, 1818)			X				Anderson (1972), KU, CNMA
Peromyscus maniculatus (Wagner, 1845)		X	X	X			Anderson (1972), KU, CNMA, TTU, CRD, ENCB
Peromyscus melanotis J.A. Allen and Chapman, 1897		X					Anderson (1972), KU, CNMA, TTU, CRD, MSU
Peromyscus pectoralis Osgood, 1904			X	X			Anderson (1972), MSU, CNMA
Peromyscus polius Osgood, 1904		X			X		Anderson (1972), KU, CNMA
Peromyscus spicilegus J.A. Allen, 1897	X				X		KU
Reithrodontomys fulvescens J.A. Allen, 1894	X		X	X			Anderson (1972), MSU, KU, CNMA, ENCB
Reithrodontomys megalotis (Baird, 1858)		X	X	X			Anderson (1972), CNMA
Reithrodontomys montanus (Baird, 1855)			X	X			Anderson (1972)
Reithrodontomys zacatecae Merriam, 1901		X			X		Anderson (1972), KU, CRD
Sigmodon fulviventer J.A. Allen, 1889			X	X			Anderson (1972), KU, MSU, CNMA
Sigmodon hispidus Say and Ord, 1825			X	X			Anderson (1972), KU, MSU
Sigmodon leucotis Bailey, 1902		X			X		Anderson (1972), CRD
Sigmodon ochrognathus Bailey, 1902		X	X				Anderson (1972), KU, CRD
Family Erethizontidae							
Subfamily Erethizontinae							
Erethizon dorsatum (Linnaeus, 1758)			X	X		P	Anderson (1972)
Order Lagomorpha							
Family Leporidae							
Lepus alleni Mearns, 1890	X						Anderson (1972)
Lepus californicus Gray, 1837		X	X	X			Anderson (1972), CRD, CNMA, ENCB, KU
Lepus callotis Wagler, 1830		X	X				Anderson (1972), CRD, KU
Sylvilagus audubonii (Baird, 1858)			X	X			Anderson (1972), CNMA, ENCB, KU
Sylvilagus floridanus (J.A. Allen, 1890)		X	X	X			Anderson (1972), ENCB, KU
TOTAL	**47**	**59**	**72**	**62**	**15**	**22**	

a – As *Macrotus waterhousii californicus* in Anderson (1972).
b – Though recently considered a single taxon, under the name *Tamias dorsalis* (Piaggio and Spicer 2001); morphological evidence from specimens deposited at CRD (unpublished data) does not support this decision, and we chose to recognize these two species as distinct.

Acknowledgments: We thank curators and collection managers at the University of Kansas (R. Timm); Michigan State University (B. Lundrigan and L. Abraczinskas); The Museum, Texas Tech University (R. J. Baker and H. Gardner); National Mammal Collection, Instituto de Biología, UNAM, Mexico City (F. A. Cervantes and Y. Hortelano); and Mammal Collection, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, Mexico City (J. C. López-Vidal and C. Elizalde-Arellano) for allowing access to the specimens under their care. S. J. Presley thoroughly revised English grammar on the manuscript. Two anonymous reviewers provided advice that helped improve the manuscript. Funding for examination of museum specimens and this paper was provided by CONABIO project GT015 and Secretaría de Investigación y Posgrado, Instituto Politécnico Nacional projects SIP 2010-0434 and 2011-0349 to CLG.

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Received: January 2012
Accepted: October 2012
Published online: November 2012
Editorial responsibility: Ana Paula Carmignotto