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Mammals in tropical dry forest on the central coast of Oaxaca, Mexico

Miguel Briones-Salas, **Natalia Martín-Regalado** and **Mario C. Lavariega***

Instituto Politécnico Nacional, Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional-Unidad Oaxaca, Laboratorio de Vertebrados Terrestres (Mastozoología), Hornos 1003, Santa Cruz Xoxocotlán, Oaxaca, Mexico 71230

* Corresponding author. E-mail: mariolavnol@yahoo.com.mx

Abstract: The tropical dry forests of Mexico are one of the world's biodiversity hotspots. To contribute to the knowledge of mammal diversity and conservation of the central coast of Oaxaca State, southern Mexico, we conducted field surveys in the area. Additional information was obtained from literature and museum databases. In order to compare the taxonomic similitude between areas along the Planicie Costera del Pacífico province we performed a taxonomic similarity analysis using data from the literature and the present study. A total of 49 species of mammals belonging to 19 families and eight orders were recorded. The maximum number of species was recorded in deciduous forest (n = 46), followed by semideciduous forest (n = 11). The similarity index was low (<50%) between areas along the Planicie costera del Pacífico, indicating higher species turnover. The high mammal diversity, the presence of endemic (8%), threatened species (16%), and voluntary conservation areas highlight the importance of this region.

Key words: Planicie costera del Pacífico; shade coffee; taxonomic similarity; voluntary conservation areas

INTRODUCTION

The tropical dry forests of Mexico are characterized by a pronounced seasonality, as well as a high species richness, and endemic and threatened species (Murphy and Lugo 1995; Dirzo and Ceballos 2010; Meave et al. 2010); for these reasons this ecosystem had been considered a biodiversity hotspot (Olson and Dinerstein 2002). The tropical dry forest biodiversity is threatened by the high deforestation rate, forest fires, overhunting, wildlife trade, human population growth, and tourism development. These forests occupy 16% of the territory of the Oaxaca State, Mexico, and occur on the Depresión del Balsas, Montañas y Valles del Centro, Depresión del Istmo de Tehuantepec, Valles Centrales, Planicie costera de Tehuantepec and Planicie costera del Pacífico physiographic subprovinces (Ortiz-Pérez et al. 2004). In the Planicie costera del Pacífico (PCP), the tropical dry forest exist as two types of forest: deciduous tropical forest, and semi-deciduous tropical forest (Torres-Colín 2004; Trejo 2010).

With respect to animal diversity, the PCP occupies the first places at the state level in species richness of amphibians, reptiles, birds, and mammals (González-Pérez et al. 2004). The mammal species richness is 121, which represents 63.6% and 25.4% of the total species recorded in Oaxaca, and Mexico, respectively (Briones-Salas and Sánchez-Cordero 2004).

There had been several studies on mammals from PCP, for example, Cervantes and Yépez (1995) recorded 65 species in vicinity of Salina Cruz, Lira et al. (2005) reported 52 species from the Cerro de la Tuza de Monroy, Lira et al. (2008) detected 61 species in low basin of Cacaluta river, and Buenrostro-Silva et al. (2012) recorded 42 species in Lagunas de Chacahua National Park and La Tuza de Monroy. However, there is little information on the central region of PCP. Therefore, in this work we describe species richness, composition and conservation status of terrestrial mammals in the central coast of Oaxaca; besides we compare the taxonomic assemblage of the study area with other areas along the Planicie Costera del Pacífico province.

MATERIALS AND METHODS

Study site

The study area is located in southern Oaxaca State, Mexico (between 15°50′ and 16°20′ N, and 095°40′ and 096°10′ W), between Río Astata and Río Copalita hydrologic basins, in the Planicie Costera del Pacífico physiographic subprovince (Figure 1). The PCP is characterized by an essentially plain topography, which presents mountains axis (NW–SE direction) dispose perpendicular to the plain decline (Ortiz-Pérez et al. 2004). The climate is warm sub-humid, with an annual

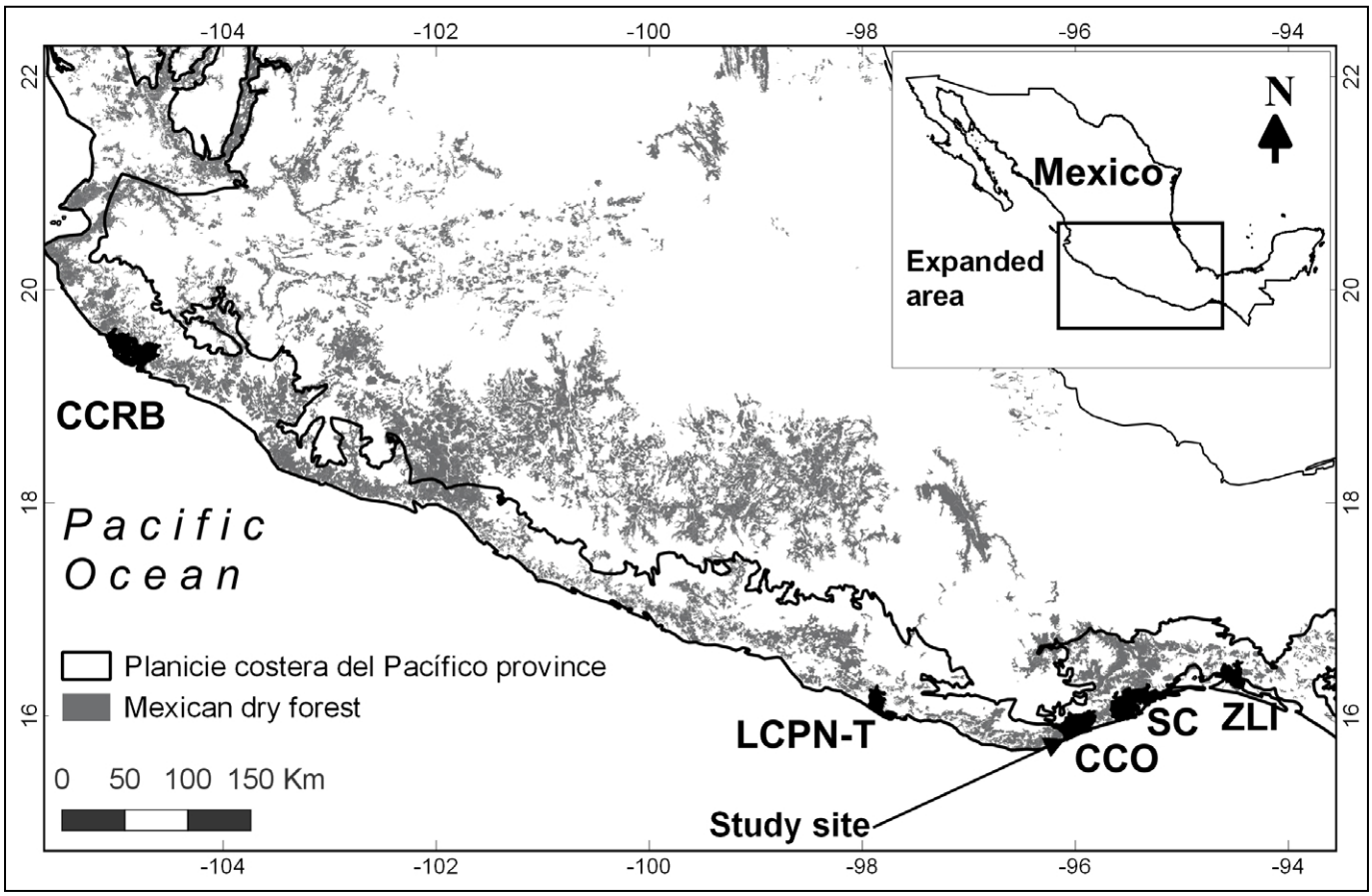

Figure 1. Areas along Planicie costera del Pacífico province used in the analysis of similitude. CCRB: Chamela-Cuixmala Reserve Biosphere, Jalisco; LCNP-T: Lagunas de Chacahua National Park and La Tuza de Monroy, Oaxaca; CCO: central coast of Oaxaca, present study; SC: Salina Cruz, Oaxaca y ZLI: Zona lagunar del Istmo de Tehuantepec, Oaxaca.

mean temperature of 26.8°C, and an annual mean precipitation of 2,245 mm (García 1973). Deciduous tropical forest (0–200 m above sea level [a.s.l.]), semi-deciduous tropical forest (400–600 m a.s.l), and shade coffee crops (400–600 m a.s.l.) are the predominant land use and vegetation. However, semi-deciduous tropical forest and shade coffee crops are in the form of patches with reduced surface (Rzedowski 1978; Torres-Colín 2004). Some tree species in deciduous tropical forest are: *Bursera excels* (Kunth) Eng., *B. simaruba* (L.) Sarg., *Ceiba parvifolia* Rose, *Lysiloma divaricata* (Jacq.) J. F. Macbr. and *Plumeria rubra* L.. The basic forms in these forest are shrubs, vines and cacti (Trejo 1998); predominant species are *Acacia cochliacantha* Willd., *A. farnesiana* (L.) Willd., *A. cornigera* (L.) Willd., *Ziziphus amole* (Sessé & Moc.) M. C. Johnst., *Guaiacum coulteri* A. Gray, *Amphipterygium adstrigens* (Schld.) Standl., *Caesalpinia coccinea* G. P. Lewis & J. L. Contr., *Capparis flexuosa* (L.) L., *Forchhammeria pallid* Liebm., *Cordia trucantifolia* Barlett, *Pachycereus pecten-aboriginum* (Engelm. Ex S. Watson) Britton & Rose, *Pilosocereus collinsii* (Britton & Rose) Byles & G. D. Rowley, *Pereskiopsis diguetii* (F. A. C. Weber) Britton& Rose, *Opuntia decumbens* Salm-Dyck and *Pereskia lychnidiflora* DC. (Salas-Morales et al. 2003). Semi-deciduous tropical forest is characterized by the presence of *Lonchocarpus* aff. *magallenesii* M. Sousa, *Euphorbia calyculata* Kunth, *Gyrocarpus americanus* Jacq., *Cordia sonorae* N. E. Rose and *C. tinifolia* Willd. Ex Roem. & Schult., on the high arboreal stratum, and *Albizia occidentalis* Brandegee, *Amphipterygium adstrigens*, *Bucida macrostachya* Standl., *Bursera excelsa*, *B. graveolens* (Kunth) Triana & Planch., *B. heteresthes* Bullock, *B. simaruba*, *Cochlospermum vitifolium* (Willd.) Spreng. and *Comocladia macrophylla* (Hook. & Arn.) L. Riley on the medium arboreal stratum (Salas-Morales et al. 2003).

Data collection

Between May 1999 and March 2000, 11 visits to the study area were realized; subsequently during 2010, four additional visits were conducted. In both periods, dry season (November–April) and rainy season (May–October) were included. Each visit had a duration of six days and five nights; the three principal types of vegetation and land use (deciduous tropical forest, semi-deciduous tropical forest and shade coffee plantations) were sampled, and between sea level and 600 m a.s.l.

Small mammals were captured with 50 Victor® traps and 50 Sherman® traps; traps were collocated during five consecutive nights in two lineal transects of 100

m each one. Traps were bait with a mixture of peanut butter, vanilla essence and oat. The total trapping effort was about 7,500 trap-nights.

Bats were caught with three mist nets (6 × 2 and 12 × 2.4 m) set near water bodies or vegetation. The mist nets were opened during six hours each night (20:00 to 02:00 h), representing a total of 31,968 net/h of sampling effort. Also, diurnal roosts were visited, such as caves, constructions and bananas crops, in which bats were caught with hand nets.

Captured individuals were identified with identification keys (Goodwin 1969; Hall 1981; Álvarez et al. 1994; Medellín et al. 1997; Ceballos and Miranda 2000). Some specimens (n = 150) were collected and deposited in the Colección de Mamíferos del Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca, Instituto Politécnico Nacional (OAX.MA.026.0497; CIIDIR-Oaxaca, IPN; Table 1), the rest were liberated at the capture site.

For sampling medium and large sized mammals (weight > 500 g), in each visit to the study area two transects of two kilometers each were walked to search for indirect signs (e.g., footprints, feces) and biological remains (e.g., skeletons, shells, horns); existing human-made trails were used preferably. A total of 60 km were walked during the study period. Indirect signs identification was realized using specialized guides (Reid 1997; Aranda 2000). Footprints were preserved with the use of plaster casts (Aranda 2000), and deposited in the OAX.MA. Feces were tried to be associated to footprints for the correct identification.

Surveyed localities were georeferenced with a GPS receiver (Garmin® 76). Specimens were collected under the authorization of the Secretaria de Medio Ambiente y Recursos Naturales of Mexico through the license number FAUT-0037. Furthermore, historical records were obtained from the Colección de Mamíferos del CIIDIR-Oaxaca database, which includes information of 28 mammal museums: four nationals and 28 internationals, besides bibliographic records (Briones-Salas and Sánchez-Cordero 2004; Briones-Salas et al. 2015). All records obtained were taxonomically revised and updated; the species list was ordered based on the taxonomic agreement of Ramírez-Pulido et al. (2014). To identify the threat status of the species, the Norma Oficial Mexicana 059 (NOM-059-2010; SEMARNAT 2010) and the Red List of the International Union for the Conservation of Nature (IUCN 2014) were consulted.

Data analysis

The total species richness recorded was compared with the total number of mammal species in Oaxaca State. The best represented orders, families and species were determined. To analyze the altitudinal species richness patterns, arbitrary bands of 200 m were used.

In order to estimate the total species richness, a species accumulation models were performed (Soberón and Llorente 1993). To eliminate the effect of the order in which data was recorded, data was randomized 100 times in EstimateS (Colwell 2009). The mean of the observed species was entered into Species Accumulation Functions Version Beta (CIMAT 2003) to assess the data fitting to Clench, logarithmic, and exponential models, as well as to create accumulation curves.

Taxonomic similarity between areas along the Planicie costera del Pacífico province was realized at two taxonomic levels: first, at the species level, using the Jaccard index (complete linkage); and second, at the supraespecifc level, using the Izsák and Price index (2001) modified by Bacaro et al. (2007).

The following study sites were used (Figure 1):

1. Salina Cruz, Oaxaca: It has mangrove, tropical deciduous forest, tropical thorn scrub, halophytic grassland, and dune vegetation. The climate is tropical with mean annual temperature of 25°C and mean annual precipitation of 800 mm. The mammal community is composed of 70 species, 54 genera, 24 families, and eight orders (Cervantes and Yépez 1995).
2. Zona lagunar del Istmo de Tehuantepec, Oaxaca. It has distinct vegetation types, such as: pastures, riparian vegetation, thorny vegetation, and palms. The climate is warm, sub-humid, the mean annual temperature is 27.6°C, and the annual precipitation is 932.3 mm. It is composed of 59 species, 47 genera, 18 families and eight orders (López et al. 2009).
3. Lagunas de Chacahua National Park and La Tuza de Monroy, Oaxaca. The dominant vegetation is deciduous tropical forest, semievergreen forest, mangroves and flooding vegetation. The climate of the region is warm sub-humid with a mean annual temperature above the 28°C and an annual precipitation of 1000 mm. The mammal community is composed of 42 species, belonging to 36 genera, 19 families and eight orders (Buenrostro-Silva et al. 2012).
4. Chamela-Cuixmala Biosphere Reserve, Jalisco. The dominant vegetation is tropical dry forest, but there are also semievergreen tropical forest, gallery forest, mangrove, xeric scrub, thicket and palms. The predominant climate is warm-humid, with mean annual temperature of 25°C, and an annual precipitation which ranges from 700 to 1,000 mm. The mammal fauna is composed of 70 species, 59 genera, 21 families and eight orders (Ceballos and Miranda 2000).

Before the analysis, taxonomy was updated according to Ramírez-Pulido et al. (2014). The similitude analysis was realized in the statistical program PAST (Hammer et al. 2009), using unweighted pair-group average (UPGMA).

RESULTS

Mammal species richness

A total of 49 mammal species were recorded belonging to 19 families and eight orders, which represent 22.8, 65.5 and 80.0% of the species, families and orders in the Oaxaca State, respectively. The families Phyllostomidae and Cricetidae contain the greatest number of species (15 and 10 species, respectively); while *Peromyscus, Glossophaga* and *Artibeus* were the best represented genera in terms of species number (Table 1).

Regarding the methods to survey mammals, more species were recorded on mist nets (21 species) and traps (12 species), followed by indirect methods: biological remains (11) and footprints (2). We obtained additional records of seven species from museums, which are noteworthy, because of their arboreal habits: *Potos flavus*, *Nyctomys sumichrasti*, and *Tylomys nudicaudus*. Only *Peromyscus melanophrys* was recorded exclusively based on literature (Goodwin 1969; Hall 1981).

The model that best fits to data was Clench, followed by logarithmic and exponential. Clench model predicted an asymptote in 63 species and the exponential in 45 species; so that in surveys it was recorded 65.7 and 91.11% of estimated total richness, respectively (Figure 2).

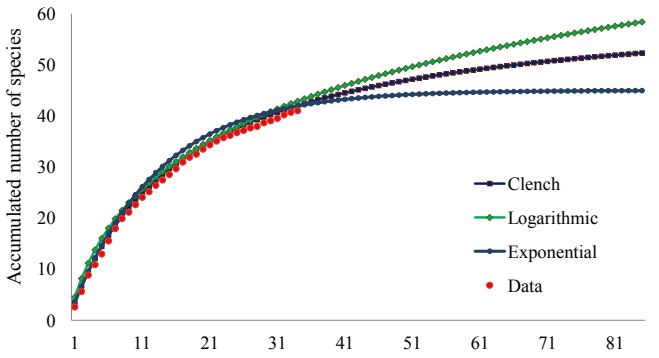

Figure 2. The species accumulation curves for mammals from the central coast of Oaxaca.

The vegetation type with the largest number of species was the deciduous tropical forest with 46, while in semi-deciduous tropical forest 11 species were recorded, and in shaded coffee plantation eight species were found. Thirty one species were registered exclusively in the deciduous tropical forest (e.g., *Peromyscus melanophrys*, *Micronycteris microtis*, and *Leopardus pardalis*). *Leopardus wiedii* was only observed in the semi-deciduous tropical forest and *Puma yagouaroundi* only in shaded coffee plantations (Table 1). The highest species richness was

Table 1. List of mammal species on the central coast of Oaxaca, Mexico. The list is based on the taxonomic arrangement of Ramírez-Pulido et al. (2014). Distribution: [MEX]= Endemic to Mexico. Type of records: C= Collected; R= Biological remains; FO= Footprints F= Feces; LC= Literature; M= Museums. Museum acronyms: OAX.MA, Mammal Collection of the CIIDIR-Oaxaca, Instituto Politécnico Nacional; CNMA: National Mammal Collection of the Instituto de Biología, Universidad Nacional Autónoma de México; UK, Mammal Collection, Kansas University. Vegetation type: DTF= Deciduous tropical forest; STF= Semi-deciduous tropical forest; CC= Shade coffee plantations.

Taxonomic category	Record type	Catalog number	Vegetation type	Elevation (m)
ORDER DIDELPHIMORPHIA				
Family Didelphidae				
Didelphis virginiana Kerr, 1792	R, C	OAX.MA:2313	DTF, STF	60–600
Tlacuatzin canescens (J. A. Allen, 1893) [MEX]	C	OAX.MA:2283	DTF, STF	200–300
ORDER CINGULATA				
Family Dasypodidae				
Dasypus novemcinctus Linnaeus, 1758	R		DTF, STF	60–600
ORDER PILOSA				
Family Myrmecophagidae				
Tamandua mexicana (de Saussure, 1860)	C, R	OAX.MA:2427	DTF, STF	30–600
ORDER CHIROPTERA				
Family Emballonuridae				
Balantiopteryx plicata Peters, 1867	C	OAX.MA:2111, 2133, 2157, 2159, 2160, 2307, 3132-3134	DTF, STF, CC	10–100
Family Mormoopidae				
Mormoops megalophylla (Peters, 1864)	C	OAX.MA:2174, 2223		
Pteronotus davyi Gray, 1838	C	OAX.MA: 3568	DTF	40
Pteronotus parnellii (Gray, 1843)	C	OAX.MA:3968, 2100-2102, 2118, 2215, 2224-2226	DTF, STF	10–600
Family Noctilionidae				
Noctilio leporinus (Linnaeus, 1758)	C	OAX.MA: 2091, 2095, 2109, 2110, 2358	DTF	40
Family Phyllostomidae				
Carollia subrufa (Hahn, 1905)	C	OAX.MA:2234, 3515, 3517, 3969, 3970	DTF	40-300
Desmodus rotundus (È. Geoffroy Saint-Hilaire, 1810)	C	OAX.MA:2068-2070, 2153-2155, 3531, 3532, 3543	DTF	10–300
Anoura geoffroyi Gray, 1838	C	OAX.MA:2222, 2397, 3971	DTF	300
Glossophaga commissarisi Gardner, 1962	M	OAX.MA: 3965	DTF	10–20
Glossophaga morenoi Martínez and Villa, 1938 [MEX]	C	OAX.MA:2120, 3975-3579	DTF	40

Continued

Table 1. *Continued.*

Taxonomic category	Record type	Catalog number	Vegetation type	Elevation (m)
Glossophaga soricina (Pallas, 1766)	C	OAX.MA:2093, 2156, 2228, 2279, 3464-3466, 3482, 3498, 3558	DTF	10–300
Leptonycteris yerbabuenae Martínez and Villa, 1940	C	OAX.MA:2220, 2274, 2275	DTF, CC	300
Macrotus waterhousii Gray, 1843	C	OAX.MA:2067, 2158, 2161, 2162	DTF	10–100
Micronycteris microtis Miller, 1898	C	OAX.MA:2167	DTF	300
Artibeus jamaicensis Leach, 1821	C	OAX.MA:2071-2074, 2096, 2098, 2115, 2116, 2126, 2197, 2198, 2214, 2395, 2396, 2453, 2459	DTF	10–300
Artibeus lituratus (Olfers, 1818)	C	OAX.MA:2086, 2097, 2235	DTF, CC	10–500
Dermanura phaeotis Miller, 1902	M	CNMA: 5704	DTF	10–20
Dermanura tolteca (de Saussure, 1860)	C	OAX.MA:2099, 2173, 3980	DTF	40
Vampyressa thyone Thomas, 1909	C	OAX.MA:2316, 3210, 3398, 3405, 3406, 3500	DTF	10–300
Sturnira parvidens Goldman, 1917	C	OAX.MA:2196, 2219, 2221, 2237, 2280, 3309, 3312, 3313, 3320, 3329, 3982	DTF	10–300
Family Vespertilionidae				
Rhogeessa parvula H. Allen, 1866 [MEX]	C	OAX.MA:2123	DTF	10–300
ORDER LAGOMORPHA				
Family Leporidae				
Sylvilagus floridanus (J. A. Allen, 1890)	M	OAX.MA:212	DTF	100
ORDER RODENTIA				
Family Sciuridae				
Sciurus aureogaster F. Cuvier, 1829	C	OAX.MA:2291	STF, CC	600
Family Heteromyidae				
Heteromys pictus pictus Thomas, 1893	C	OAX.MA:2117, 2119, 2121, 2122, 2165, 2168, 2179, 2182-2184, 2189, 2193, 2194, 2308, 2315, 2359, 2446-2448, 2450, 2452, 2455, 2456, 2458, 2467-2472, 2475-2478	DTF, CC	100–600
Family Cricetidae				
Baiomys musculus (Merriam, 1892)	C	OAX.MA:3985	DTF	300
Peromyscus aztecus (de Saussure, 1860)	C	OAX.MA:2163, 2164, 2166, 2169, 2170, 2178, 2180, 2181, 2185-2187, 2191, 2192, 2318	DTF	300
Peromyscus difficilis (J. A. Allen, 1891)	C		DTF	300
Peromyscus levipes Merriam, 1898	M	OAX.MA:2574	DTF	300
Peromyscus melanophrys (Coues, 1874)	L	Goodwin (1969)	DTF	20–145
Peromyscus mexicanus (de Saussure, 1860)	C; M	OAX.MA: 2106, 2481, 2482; UK: 62894-62899, 62912	DTF	600
Reithrodontomys fulvescens J. A. Allen, 1894	C	OAX.MA:2090	DTF	300
Oryzomys couesi (Alston, 1877)	C	OAX.MA:2319, 2551, 3519-3521, 3528, 3552, 3556, 3984	DTF, CC	100–300
Nyctomys sumichrasti (de Saussure, 1860)	M	OAX.MA:3533	DTF, STF	1100
Tylomys nudicaudus (Peters, 1866)	M	UK:63081-6383	DTF	1100
ORDER CARNIVORA				
Family Felidae				
Herpailurus yagouaroundi (É. Geoffroy Saint-Hilaire, 1803)	C	OAX.MA:2272	CC	300
Leopardus pardalis (Linnaeus, 1758)	R		DTF	400
Leopardus wiedii (Schinz, 1821)	R	OAX.MA:2171	STF	600
Family Canidae				
Urocyon cinereoargenteus (Schreber, 1775)	F		CC	200
Family Mephitidae				
Spilogale pygmaea Thomas, 1898 [MEX]	C	OAX.MA: 2309	DTF	100
Family Mustelidae				
Lontra longicaudis (Olfers, 1818)	FO		DTF	100–300
Family Procyonidae				
Potos flavus (Schreber, 1774)	M	OAX.MA:2380	DTF, STF	50
Nasua narica (Linnaeus, 1766)	R	OAX.MA:3233	DTF	100–600
Procyon lotor (Linnaeus, 1758)	FO		DTF	10–200
ORDER ARTIODACTYLA				
Family Tayassuidae				
Dicotyles angulatus	R	OAX.MA:3091, 3508, 3959	DTF, STF	600
Family Cervidae				
Odocoileus virginianus (Zimmermann, 1780)	R	OAX.MA:3951, 3954, 3955, 3990	DTF, STF	10–600

at 10 to 200 m altitudinal band (32 species), followed by 201 to 400 m altitudinal band (15 species); whereas only 13 species were recorded in 401–600 m altitudinal band (Table 1).

Endemism and conservation status

Four endemic species of Mexico were recorded: *Tlacuatzin canescens*, *Spilogale pygmaea*, *Glossophaga morenoi* and *Rhogeessa parvula*). Regarding the conservation status, eight species are classified under some threat category by the Mexican government (SEMARNAT 2010): *Tamandua mexicana*, *Leopardus pardalis* and *L. wiedii* are endangered; *Leptonycteris yerbabuenae*, *Spilogale pygmaea*, *Lontra longicaudis* and *Puma yagouaroundi* are threatened; and *Potos flavus* is under special protection. In the IUCN Red List *Leptonycteris yerbabuenae* and *Spilogale pygmaea* are vulnerable, and *Leopardus pardalis* is near threatened (IUCN 2014).

Similarity between areas along Planicie costera del Pacífico province

The specific similitude of the five sites along Planicie costera del Pacífico measured with the Jaccard index was low (<50%; correlation coefficient r = 0.648). The most similar areas were the ones that are found in the coast of Oaxaca, with the exception of Salina Cruz, that showed the lowest similitude with the rest of the areas (42%). The mammal fauna of the coast of Oaxaca and Lagunas de Chacahua National Park, and La Tuza de Monroy formed a cluster with 49% of similitude; both sites joined to Zona Lagunar del Istmo de Tehuantepec with 45% of similitude, Chamela-Cuixmala Reserve Biosphere to this cluster with 42%, and then to Salina Cruz with 40% (Figure 3).

Furthermore, at the supraspecific level the similitude increased slightly (<63%; correlation coefficient r =0.718), and two clusters were formed, one with a subgroup formed by the present study and Lagunas de Chacahua National Park, and La Tuza de Monroy (63%), to which it joined with Zona Lagunar del Istmo de Tehuantepec (54%). The other cluster includes Salina Cruz and Chamela-Cuixmala Reserve Biosphere (55%) (Figure 3).

DISCUSSION

In the present study 49 mammal species were recorded in the central coast of Oaxaca, representing 34.5% of the species in the Planicie costera del Pacífico subprovince (142 species; Briones-Salas et al. 2015), as well as 22.8% of mammal richness recorded in Oaxaca (215 species; Briones-Salas et al. 2015), and 26.7% of species found in the dry forests of Mexico (183 species; Ceballos and Martínez 2010). If we consider 496 land mammal species in the country (Ramírez-Pulido et al. 2014), the study site contains 9.9% of the Mexican land mammals.

However, the Clench model predicted the presence of 63 species. This model was the best to fit to data and it is more suitable when the study site is large (Soberón and Llorente 1993), like in the present study. Therefore, the species number predicted is possible considering that several groups of mammals are recorded occasionally by traditional methods, for example species that forage in high altitudes (MacSwiney et al. 2008) or with arboreal or cryptic behaviors (Woodman et al. 1995; Kays 1999; Tobler et al. 2008).

In this study, the mammal richness recorded in the deciduous tropical forest was higher (46 species) than in the semi-deciduous tropical forest (11 species) or in shaded coffee plantations (8 species). This difference may be due to both the semi-deciduous tropical forest and shaded coffee plantations have a small representation in the study site (Rzedowski 1978; Torres-Colín 2004). In other regions, the semi-deciduous tropical forest is one of the most species-rich habitats, in terms of mammals (Sánchez-Cordero 2001; Galetti et al. 2009); and shaded coffee plantations usually have a similar diversity to the original forests (Moguel and Toledo 1998; Pineda et al. 2006; Gordon et al. 2007). Thus, the observed species richness in these habitats is probably more due to a species-area effect (Connor and McCoy 1979) than to a real lower diversity.

The dry forests of the Planicie costera del Pacífico province have a high number of endemic mammals, with at least 50 species (Ceballos and Martínez 2010). Based on ecological niche modeling projections, at least eight

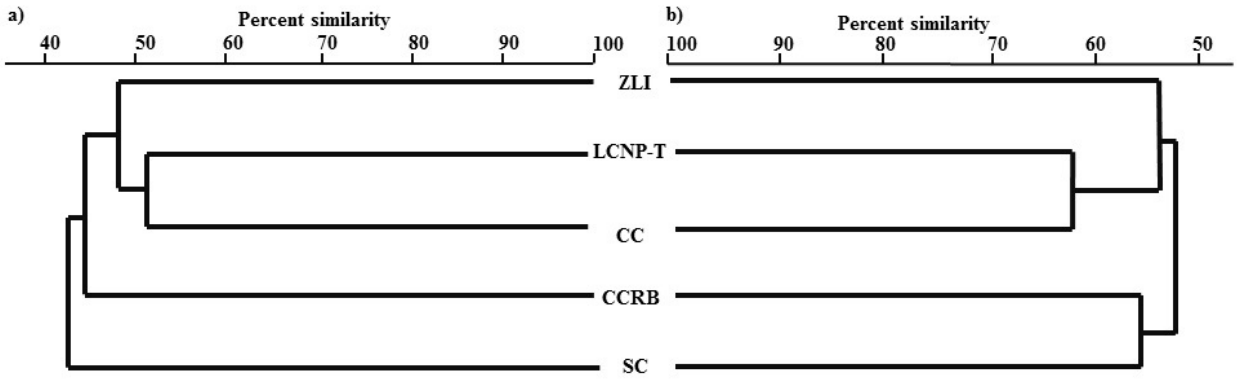

Figure 3. Mammals taxonomic similarities in areas along the Planicie costera del Pacífico province. **a:** Specific similarity (Jaccard index). **b:** Supraspecific similarity (Isák and Price index). as Area acronym follow Figure 1.

endemic species are predicted in the Oaxaca coast (Koleff et al. 2008). Four of these were recorded in the present study: *Spilogale pygmaea,* that is exclusively distributed in the Planicie costera del Pacífico, from southern Sinaloa to Oaxaca (Ávila and Medellín 2005); *Tlacuatzin canescens,* ranges from southern Sonora to Chiapas and the Península de Yucatán (Ceballos 2005); *Rhogeessa parvula* is present in the Planicie costera del Pacífico and lowlands of central Mexico (Arroyo-Cabrales and Baker 2005; Roots and Baker 2007); and *Glossophaga morenoi* that ranges from central Mexico to western Chiapas (Arita 2005). Other endemic species that have been recorded in the southern mountains or coastal plains of Oaxaca are *Cryptotis phillipsii, Peromyscus melanurus, Rheomys mexicanus*, and *Sigmodon alleni* (Briones-Salas and Sánchez-Cordero 2004).

In respect of studies in the Planicie costera del Pacífico of Mexico, species richness in the central coast of Oaxaca (49 species) was less than that observed in Salina Cruz (61 species; Cervantes and Yépez, 1995), in Chamela-Cuixmala Reserve Biosphere (70 species), in Zona Lagunar del Istmo de Tehuantepec (57 species; López et al. 2009), and Lagunas de Chacahua National Park and La Tuza de Monroy (54 species; Lira et al. 2005; Buenrostro-Silva et al. 2012). The largest difference was observed between Chamela-Cuixmala Reserve Biosphere, which have 21 species more than the species detected in the central coast of Oaxaca. One of the reasons may be that Chamela-Cuixmala is one of the most studied areas in Mexico, with about 40 years of mammal research (Miranda 2002), and mainly, because it is located in a region with a high concentration of endemic mammals, with almost 19 species (Ceballos et al. 2005; Koleff et al. 2008), which contributes to its high species richness, both in Mexico and Central America (Miranda 2002).

However, the species composition in these areas does not have the same pattern between mammals groups, because Salina Cruz has the highest number of medium and large size mammal species (30 species), followed by Lagunas de Chacahua National Park and La Tuza de Monroy (24 species), and Chamela-Cuixmala Reserve Biosphere (23 species). Regarding bats, 34 species inhabit Chamela-Cuixmala Reserve Biosphere inhabits, in Zona Lagunar del Istmo de Tehuantepec 27 species, and in the central coast of Oaxaca 21 species; and for small non-flying mammals, there are more species in the Chamela-Cuixmala Reserve Biosphere (13 species), followed by the central coast of Oaxaca (12 species) and Zona Lagunar del Istmo de Tehuantepec (11 species). Also, it is noteworthy that some species with large geographic range and considered endangered were not recorded in all the areas. *Panthera onca*, for example, was observed only in Chamela-Cuixmala Reserve Biosphere and Salina Cruz, *Ateles geoffroyi* and *Bassariscus sumichrasti* only in Salina Cruz, and *Tapirella bairdii* only in Lagunas de Chacahua National Park and La Tuza de Monroy. Furthermore, in the study of Salina Cruz, records of *Cyclopes didactylus*, *Mazama temama* and *Sciurus deppei* are doubtful, because these have a general geographic range in the slope of Golfo de México, central of the Isthmus of Tehuantepec and heading to south, but not in Planicie costera del Pacífico (Ceballos and Oliva 2005).

The similarity observed between the areas was moderate. The higher similarity was between the central coast of Oaxaca and Lagunas de Chacahua National Park and La Tuza de Monroy, with a total of 34 shared species, perhaps because of their proximity (170 km approximately). On the other side, the presence of species such as *Panthera onca, Ateles geoffroyi, Cyclopes didactylus, Diphylla ecaudata, Eumops underwoodi, Lasiurus cinereus, Molossus aztecus,* just to mention some, affected the mammal similarity of the present study with Salina Cruz (Cervantes and Yépez 1995).

Particularly in Chamela-Cuixmala Reserve Biosphere, the number of endemic species is high, because it is located in a region with a high endemic mammal concentration, with up to 19 species, such as the bats *Artibeus hirsutus* and *Musonycteris harrisoni* and the rodents *Osgoodomys banderanus* and *Pappogeomys buller* that are not found in the south of México (Miranda 2002). Therefore, the similarity analysis can evidence the high beta diversity in the Planicie costera del Pacífico province, for the high species turnover.

Eight species, which constitute 15.68% of the recorded species, are threatened at some level. Six of them belong to Carnivora, among these, there are two species of *Leopardus*, whose main threats are habitat loss and sport hunting or for the skin commerce (Murray and Gardner 1997; De Oliveira 1998; Aranda 2005a, 2005b). Also, in the present work *Lontra longicaudis* was recorded, a threatened species which has an estimated density from 0.03 to 0.95 individuals/km linear for the principal rivers in the central coast of Oaxaca (Casariego-Madorell et al. 2006; Briones-Salas et al. 2008). In this sense, Oaxaca represents an important area for carnivore conservation, because it presents the highest species richness for this group and the human population density is low (Valenzuela and Vázquez 2008).

Due to the high species richness recorded and estimated, the coast of Oaxaca should be considered in the conservation policies, particularly because this region it is under hard pressure due to land use change (Salas-Morales and Casariego-Madorell 2010). Peralta et al. (2011) estimated that the evergreen tropical forest and deciduous tropical forest of the coast of Oaxaca region has an annual deforestation rate of 13.6 and 5% respectively, higher than other types of vegetation.

It seems that the threats are slowing down due to the locals' initiatives, like appointing voluntarily areas for conservation under the program of Áreas Certificadas de Conservación, which in this region covers a total of 23,437 ha (Ortega et al. 2010). This action benefits the species survival, mainly those that are endemic to the country and/or are nationally or internationally threatened such as *Spilogale pygmaea* and the species of the genus *Leopardus*.

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