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The value of xeroriparian habitats in the Llanos de Ojuelos, southern portion of the central plateau of Mexico in the light of new mammal records

El valor de los hábitats xerorribereños en los Llanos de Ojuelos, en la porción sur de la mesa central de México a la luz de nuevos registros de mamíferos

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ABSTRACT. The Llanos de Ojuelos, in the southern part of the central plateau of Mexico is a complex, semiarid, anthropized landscape, in which native habitats persist as remnants within a diffuse farmland matrix. Approximately 0.1% of the landscape is covered by riparian habitats, which in arid and semiarid regions are known as xeroriparian. They are mostly fragmented remnants of a historically much larger xeroriparian network. Xeroriparian habitats generally play a disproportionate role as wildlife habitat, although their value for many groups, including mammals, has not been assessed in the southern part of the central plateau of México. Since 2003 we conducted some opportunistic observations in

xeroriparian habitats, and from 2017 to 2023 we deployed 15 automatic trail cameras at five xeroriparian systems for different periods of time. We also surveyed these and other such systems in search of mammal signs. Among the many species whose records we obtained, those of Virginia opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), ringtail (*Bassariscus astutus*), American badger (*Taxidea taxus*), puma (*Puma concolor*), collared peccary (*Pecari tajacu*), and Peters´ squirrel (*Sciurus oculatus*) were important in improving our understanding of the conservation value of xeroriparian systems. They either were new records for these systems or complemented the scanty data previously generated. The data fill important information gaps on mammal distribution and habitat use and contribute to a better knowledge of the mammal composition of the region and the conservation role of its xeroriparian systems. Some species, such as the American badger and ringtail, may have always inhabited the region, but remained undetected due to their cryptic nature. Others, like the puma and collared peccary, appear to be recolonizing large areas from which they had been extirpated. In contrast, at least the armadillo seems to be a recent colonizer. The origin of Peters´ squirrel requires further study. Although much remains unknown about the value of xeroriparian habitats in the southern part of the central plateau of Mexico for mammals, their disappearance, reduction, or strong transformation would impact this group negatively. Our new data underscore that despite the extended anthropization of the Llanos de Ojuelos, xeroriparian habitats play an important role in the conservation of mammalian biodiversity.

Key words: *Bassariscus astutus*; *Dasypus novemcinctus*; *Didelphis virginiana*; *Pecari tajacu*; *Puma concolor*; *Sciurus oculatus*; *Taxidea taxus*

RESUMEN. Los Llanos de Ojuelos, en la parte sur de la mesa central de México, son un paisaje antropizado, semiárido y complejo, en el que los hábitats nativos persisten como remanentes dentro de una matriz agrícola difusa. Aproximadamente el 0.1% del paisaje está ocupado por hábitats ribereños, conocidos como xerorribereños en regiones áridas y semiáridas, principalmente como fragmentos de una red xerorribereña históricamente mucho más grande. Los hábitats xerorribereños generalmente desempeñan un papel crítico como hábitat para la fauna silvestre, pero no se había evaluado su importancia para muchos grupos animales, incluidos los mamíferos en la parte sur del Altiplano Central de México. Desde 2003 hemos realizado algunas observaciones oportunistas en hábitats xerorribereños de la región, y de 2017 a 2023 colocamos 15 cámaras trampas en cinco sistemas xerorribereños durante diferentes períodos de tiempo y examinamos estos y otros sistemas similares en busca de rastros de mamíferos. Entre las muchas especies cuyos registros obtuvimos, los de zarigüeya (*Didelphis virginiana*), armadillo (*Dasypus novemcinctus*), cacomixtle (*Bassariscus astutus*), tejón (*Taxidea taxus*), puma (*Puma concolor*), pecarí de collar (*Pecari tajacu*) y ardilla de Peters (*Sciurus oculatus*) fueron importantes para ampliar nuestra comprensión del valor de conservación de estos sistemas, ya sea porque obtuvimos nuevos registros o al complementar la escasa información generada anteriormente. Los registros llenan un vacío importante de información sobre la distribución de los mamíferos y el uso del hábitat y contribuyen a un mejor conocimiento de la composición de los mamíferos de la región y el papel ecológico de los sistemas xerorribereños en ella. Algunas de las especies, como el tejón y el cacomixtle, posiblemente siempre han habitado la región, pero son muy crípticas y habían escapado la detección de los investigadores. Otros, como el puma y el pecarí, aparentemente están recolonizando grandes áreas de las que habían sido extirpados. En cambio, al menos el

armadillo parece ser un colonizador reciente. Y, por último, aclarar el origen de la ardilla de Peters requiere más estudios. Aunque aún queda mucho por conocer sobre el valor de los hábitats xerorribereños en la parte sur del Altiplano Central de México para los mamíferos, su desaparición, reducción o transformación fuerte impactaría negativamente a este grupo. Nuestros registros nuevos subrayan que, a pesar de la antropización extensa de los Llanos de Ojuelos, los hábitats xerorribereños juegan un papel importante en la conservación de la biodiversidad de mamíferos.

Palabras clave: *Bassariscus astutus*; *Dasypus novemcinctus*; *Didelphis virginiana*; *Pecari tajacu*; *Puma concolor*; *Sciurus oculatus*; *Taxidea taxus*

INTRODUCTION

The Llanos de Ojuelos, in the southern part of the central plateau of Mexico is a complex, semiarid, anthropized landscape, in which native habitats persist as remnants within a diffuse farmland matrix (Riojas-López *et al*., 2011). Over the past 500 years the region´s landscape has undergone significant transformation: wetlands have been modified dramatically in form and extension; native grasslands have been impacted severely by grazing or transformed into farmland, arborescent nopaleras (communities of wild nopales) were felled to establish agriculture or were thinned to allow the entrance of livestock; and forests have been cleared for lumber and firewood (Riojas-López & Mellink, 2005, 2014, 2023; Mellink *et al*., 2018; Mellink & Riojas-López, 2020). In addition to the most common drivers of landscape change, agriculture and animal grazing, recent threats are the establishment of wind turbines and large areas of photovoltaic solar farms. The latest trend in landscape change is the clearing of land to grow tequila agave on an industrial scale.

The mammal fauna of this area has not been thoroughly surveyed, and most recent reports have derived from ecological studies and occasional observations (Riojas-López, 2006; Riojas-López *et al*., 2011, 2018, 2019); as well as those reported in the citizen science platform Naturalista (https://mexico.inaturalist.org/). Formal mammal collection has been limited to the 1965-1967 collections by Percy Clifton at a few locations. The lack of comprehensive data hinders the preparation of a pertinent conservation plan, which is increasingly urgent due to the widespread and intensive transformation of the area (Mellink & Riojas-López, 2020; Riojas-López & Mellink, 2005, 2023).

One landscape component in arid and semiarid lands that has remained especially understudied in Mexico is xeroriparian habitats. These systems cover small portions of landscapes (e.g. less than 1% in southwestern United States in the 1980; Knopf et al. 1988), yet despite their rarity, they are greatly important for wildlife (Soykan *et al*., 2012; Sánchez-Montoya *et al*., 2017). In many of these systems water flow is intermittent or ephemeral, but the plant communities associated with them are lush in comparison with the surrounding landscape. These habitats provide food and shelter for many mammals, as well as for other animals. In arid and semiarid regions where water is naturally scarce, the demands of livestock production and agriculture place significant demands on xeroriparian systems (Patten *et al*., 2018). As a result, an estimated 95% of lowland riparian habitat in western North America has been altered, degraded, or destroyed within the past one hundred years (Krueper, 2000).

In the Llanos de Ojuelos, the biodiversity supported by xeroriparian habitats has been scarcely surveyed. These habitats currently cover approximately 0.1% of the landscape (Riojas-López et al., 2024). While their original distribution and transformation have not been assessed, a comparison of early accounts and place names (such as Ojuelos, Ciénega de Mata, and several

localities named "Ojo de agua de …") with current conditions reveals a significant reduction in the flowing and free-standing water in small streams fed by artesian wells, seeps, and pools. In contrast, large dams and water tanks have notably increased since colonial times (EM & MERL, unpub. obs.).

In the southern part of the central plateau of Mexico xeroriparian systems are important for birds (Riojas-López & Mellink 2019; Riojas-López et al. 2024). Some locations have provided valuable information on their use by mammals, including species like puma (*Puma concolor* [Linnaeus, 1771]), raccoon (*Procyon lotor* [Linnaeus, 1758]), white-tailed deer (*Odocoileus virginianus* [Zimmermann, 1780]) (Riojas-López et al. 2019), and collared peccary (*Pecari tajacu* [Linnaeus, 1758]) (Carrasco-Ortiz et al. 2021;). However, this information remains insufficient for effective management and conservation, and further data are needed to provide a clearer understanding of the habitat´s value for biodiversity. The objective of this contribution is to present new data on seven mammal species in xeroriparian habitats that were either previously undocumented in the region or had only a few records. These data help fill critical gaps in our knowledge on mammal distribution and habitat use, contributing to a better understanding of the region´s mammal composition.

MATERIALS AND METHODS

Our records pertain to the Llanos de Ojuelos in the southern part of the central plateau of Mexico (extreme coordinates of 21.4545° and 22.4103° N and 101.3526° and 101.7974° W), a semiarid tableland for the most part above 2000 m asl, characterized by low mountains and valleys (Nieto-Samaniego *et al*., 2005). The natural vegetation of the region consists of grasslands (42.6% of the region's surface), largely overgrazed (Mellink & Riojas-López, 2020), xerophytic shrublands (15.66%) and stands of dwarf oaks (*Quercus* spp. L.; 4.61%). The grasslands are composed primarily by species of the genera *Bouteloua* Lag., *Aristida* L., *Lycurus* Kunth, and *Muhlenbergia* Schreb. The regions´ shrublands are dominated by catclaws (*Mimosa* spp. L.), silver dalea (*Dalea bicolor* Humb. & Bonpl. ex Willd.), leatherstem (*Jatropha dioica* Sessé), huisache (*Vachellia* spp. Wight & Arn.), nopales (*Opuntia* spp. Mill), Peruvian peppertree (*Schinus molle* L.; peppertree from here on) (Harker *et al*., 2008; MERL and EM, pers. obs.). Xeroriparian habitats persist as small remnants scattered throughout the region. All xeroriparian systems we have studied in the region are subject to grazing and browsing by domestic animals.

We obtained information from the following xeroriparian systems (Fig. 1): La Laborcilla (22.090590°, -101.724236°), an ephemeral stream that has a straight, steep-sloped streambed covered predominantly by boulders. Both the system and adjacent land support junipers (*Juniperus deppeana* Steud.), dwarf oaks, yuccas, and huisaches. The range is used for raising sheep and goats, along with a few cattle. Santoyo (21.919544º, -101.7918886º), a slow-flowing, straight stream on sand and tepetate streambed and low slope, with permanent water in parts of it. The dominant plant species go from willows (*Salix* spp. L.), peppertrees and nopales near the spring that feeds the system, to dense stands of willow ragwort (*Barkleyanthus salicifolius* (Kunth) H.Rob. & Brettell), broom (*Baccharis* sp. L.) and other shrubs, and further downstream, grassy seeps with dispersed catclaw, huisache and nopales. The surroundings are overgrazed grassland with huisaches, and shrubland with arboreal nopales, huisaches, and peppertrees. The range is used to raise fighting bull cattle. La Colorada (21.791682°, -101.625996°), an ephemeral, sinuous stream, with a low slope, on a sand and tepetate streambed. Xeroriparian components are primarily peppertrees, arboreal nopales and huisaches. It is surrounded by grasslands, some overgrazed and some in good condition, and farmland. The range is used mostly for the raising of fine horses. Huerta

Grande (21.743761°, -101.857599°), a river system enclosed by low mountains, at the sides of a straight tepetate-sand streambed with a low slope. Its main riparian components are willows, ash (*Fraxinus* sp. Tourn. Ex L.), and pepper trees. The immediate surroundings support a small stand of ahuehuetes (sabino or Montezuma cypress, *Taxodium mucronatum* Ten), and Mexican cypress (*Cupressus lusitanica* Mill.), open orchards, some farmland, a thick community of mesquite (*Prosopis* sp.), catclaw and huisache, and, on the mountain´s slopes, severely grazed remnants of shrublands. The land immediate to the stream is grazed and browsed by cattle, while the hills are used by goats, cattle, and sheep. El Mayal (21.825915º, -101.622037º), a small reservoir fed by an artesian spring surrounded by a fringe of cottonwoods (*Populus* sp. L.), eucalypts (*Eucalyptus* spp. Dietz, 1891), and tree tobacco (*Nicotiana glauca* Graham). The immediate surroundings are covered by xerophytic shrubland. La Luz (21.74201º, -101.67650º), composed of oaks, nopales and peppertrees along a moderately sinuous streambed with a low slope through a rocky ravine. The surroundings are hilly and are covered by a thick community of catclaw with some yuccas, nopales and peppertrees, and, farther from the stream, grassland. The area is used for the raising of beef cattle.

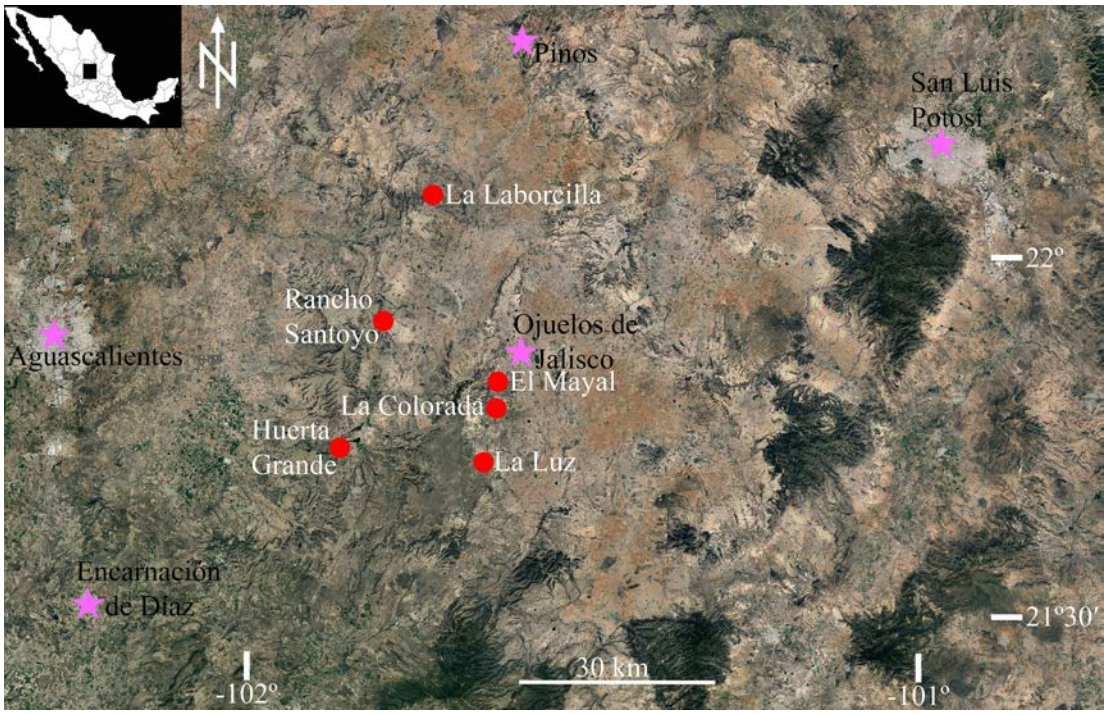

Figure 1. Localities in the Llanos de Ojuelos, Jalisco indicated in the article. Dots are our localities, and a stars indicate reference cities.

To contribute to the knowledge of the region´s biodiversity, we have deployed automatic trail cameras in xeroriparian habitats since 12 July 2015, when we placed five such cameras at Santoyo. Relevant data of mammals and birds from that date until 23 May 2017 were included in Riojas-López *et al*. (2019), and Riojas-López & Mellink (2019). Three of these cameras continued operating thereafter. On 25 Jul 2019 we deployed three cameras at La Laborcilla, and three at La Colorada. These cameras and those at Santoyo were removed on 6 Nov 2021. Subsequently, we deployed three cameras at Huerta Grande from 17 September 2023 to 11 March 2024, and three cameras at La Luz from 20 December 2023 to 12 March 2024 (Table 1). All cameras were set to record images day and night, triggered by motion sensors. In addition, from 2015 to April 2024

we recorded other evidence at all locations, such as tracks and dens. The detailed results are presented in the supplementary file.

RESULTS

We obtained 44 records of Virginia opossum (*Didelphis virginiana* Kerr, 1792) from three localities (Table 1), which add to a 2003 record of one individual caught in a pitfall trap in a fruit-oriented nopal orchard (21.726200°, -101.664612°; MERL, unpubl. obs.). Most observations were nocturnal, although some were diurnal. Two records involved an adult with young.

Table 1. Placing of individual trail cameras in five xeroriparian systems in the southern part of the Central Plateau of Mexico, and period active (in reference to this article).

Location	Section	Coordinates	Period
La Laborcilla	Upper	22.092206°, -101.725935°	25 Jul 2019 – 6 Nov 2021
	Middle	22.090644°, -101.724483°	25 Jul 2019 – 6 Nov 2021
	Lower	22.090206°, -101.721542°	25 Jul 2019 – 6 Nov 2021
Rancho Santoyo	Upper	21.916864°, -101.792325°	23 May 2017 – 8 Nov 2021
	Middle	21.919911°, -101.792022°	23 May 2017 – 8 Nov 2021
	Lower	21.924475°, -101.790661°	23 May 2017 – 8 Nov 2021
La Colorada	Upper	21.797200°, -101.637263°	25 Jul 2019 – 6 Nov 2021
	Middle	21.796092°, -101.635049°	25 Jul 2019 – 6 Nov 2021
	Lower	21.791689°, -101.626794°	25 Jul 2019 – 6 Nov 2021
Huerta Grande	Upper	21.743959°, -101.852094°	17 Sep 2023 – 11 Mar 2024
	Middle	21.743761°, -101.857599°	17 Sep 2023 – 11 Mar 2024
	Lower	21.744291°, -101.861033°	17 Sep 2023 – 11 Mar 2024
La Luz	Upper	21.742154°, -101.679267°	20 Dec 2023 – 12 Mar 2024
	Middle	21.742035°, -101.676230°	20 Dec 2023 – 12 Mar 2024
	Lower	21.743356°, -101.675832°	20 Dec 2023 – 12 Mar 2024

Figure 2. Nine-banded armadillo (*Dasypus novemcinctus*) recorded at the xeroriparian habitat at the arroyo at Huerta Grande, Jal. Photo by an automatic trail camera on 27 September 2023.

We obtained 93 records of nine-banded armadillos (*Dasypus novemcinctus* Linaeus, 1758) from four localities (Table 2). Of these, 90 were photographs from trail cameras (Fig. 2), 2 were carapaces, and 1 was a track. Eighty-six percent of our armadillo photographs were taken at night, though five were obtained during morning twilight hours, one during evening twilight, and four

during daylight (until 10:25). Most of the photographs were from La Colorada and Santoyo (Table 1). Armadillos were photographed mostly between July and January, with almost none at other times (Fig. 3). An old armadillo den was found in Huerta Grande, where adult armadillos along with young have been observed (Jesús Capuchino, pers. com. Huerta Grande, 2 Feb. 2024), although the numbers here have diminished lately (Juan Tavares, pers. com. Huerta Grande, 3 Feb. 2024). Additionally, an old digging in the bank of an ephemeral xeroriparian system in La Luz (5 Feb. 2024) had the characteristics of an armadillo den but was currently occupied by a white-toothed packrat (*Neotoma leucodon* Merriam, 1894).

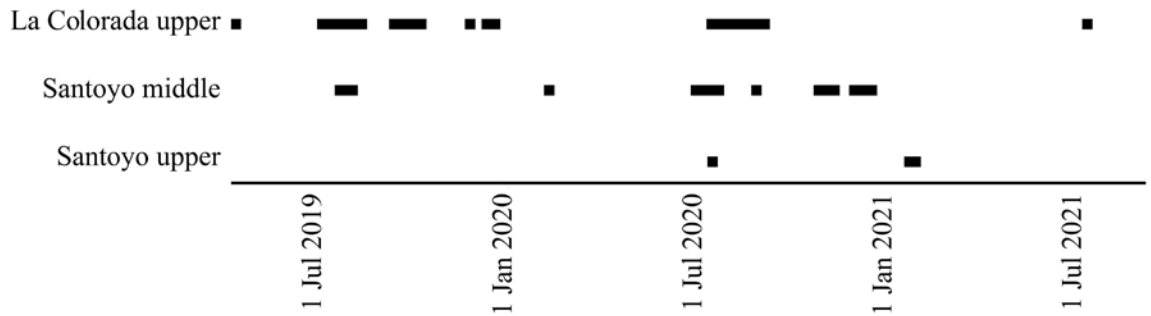

Figure 3. Chronological sequence of photographic records by trail cameras of nine-banded armadillos in the Llanos de Ojuelos, Jalisco and Zacatecas, between 18 April 2019 and 6 November 2021.

We surveyed the stream at Huerta Grande on 7 occasions totaling 19 days since 8 July 2023. On all of them we observed Peters´ squirrels (*Sciurus oculatus* Peters, 1863) both in the riparian habitat and in the ahuehuete stand. Additionally, two of our trail cameras at this site also recorded them (Fig. 4).

Figure 4. Peters´ squirrel (*Sciurus oculatus*) from the xeroriparian habitat at arroyo at Huerta Grande, Jal. The clean back that distinguishes it as *S. o. shawi* is clearly visible. Photo by an automatic trail camera on 18 December 2023.

We recorded evidence of ringtail (*Bassariscus astutus* [Lichtenstein, 1830]) at four different localities (Table 2; Fig. 5). All records were at night.

Figure 5. Ringtail (*Bassariscus astutus*) from the xeroriparian habitat at arroyo La Laborcilla. Photo by an automatic trail camera on 2 January 2020.

American badgers (*Taxidea taxus* [Schreber, 1777]) were recorded by our cameras on 11 occasions, and we found 10 dens, both at two localities (Table 2; Fig. 6). Only two photographs were taken before midnight (at 20:49 and 23:11), while all the others were taken between 2:59 and 6:57. The last record was obtained during daylight, and the three records before it were taken during morning twilight.

Figure 6. Badger (*Taxidea taxus*) from the xeroriparian habitat at Rancho Santoyo. Photograph by an automatic trail camera on 27 Apr 2019.

We recorded puma on eight occasions from two localities (Table 2). One record was a track, and seven were photographs taken by trail cameras. Six of the seven "photographs" were taken during the night, while one was taken in the early morning. This morning record was of a 6–7-month-old cub closely followed by an adult (Fig. 7). The cub and adult were separated 11 seconds (7:37:14 and 7:37:25, respectively).

Figure 7. Cub and adult puma (*Puma concolor*) from the xeroriparian habitat at La Colorada. The photograph of the adult was taken 11 seconds later than that of the cub by the same camera (7:37:14 and 7:37:25, respectively). The edge of the cub´s tail is visible in the upper part of the second photograph (right). Photographs by an automatic trail camera on 1 Nov 2020.

Table 2. Noteworthy mammal records in xeroriparian habitats in the Llanos de Ojuelos, Jalisco and Zacatecas, in the southern portion of the Central. Column letters are: L, lower part of the system, M, middle part of the system, and U, upper part of the system. An X indicates that several individuals were seen on multiple occasions, and a V, that we were informed verbally about the presence of the species.

Species	**La Laborcilla**			**Santoyo**			**La Colorada**			**Huerta Grande**			**La Luz**	**El Mayal**
	L	**M**	**U**	**L**	**M**	**U**	**L**	**M**	**U**	**L**	**M**	**U**	**n/a**	**n/a**
Opossum		6			16	1			21					
Armadillo					32	5		1	53			1		1
Peters´ squirrel											X	X		
Ringtail		2	1		1	1	1		1					
Badger	2			1	2	3	2	3	10					
Puma					2			2	4					
Peccary										V			1	

We obtained photographic evidence of peccary at La Luz and verbal confirmation of its presence at Huerta Grande (Table 2).

DISCUSION

Xeroriparian systems in the Llanos de Ojuelos are used by several species of large and medium mammals, despite being greatly diminished and impacted. Previous records include pumas, raccoons, white-tailed deer, bobcats (*Lynx rufus* [Schreber, 1777]), southern spotted skunks (*Spilogale angustifrons* Howell, 1902), hooded skunks (*Mephitis macroura* Lichtenstein, 1832),

American hog-nosed skunks (*Conepatus mesoleucus* [Lichtenstein, 1832], American badgers, gray foxes (*Urocyon cinereoargenteus* [Schreber, 1775]), coyotes (Riojas-López *et al*., 2019), and collared peccaries (Carrasco-Ortiz et al. 2021) . The data we present here not only further highlight the value of xeroriparian habitats for puma, American badger, and collared peccary, but also add Virginia opossum, nine-banded armadillo, Peters´ squirrel, and ringtail to the list.

The Virginia opossum appears to be relatively common in the region, yet surprisingly only two records have been uploaded to Naturalista, one of which was by us. The second was uploaded twice by different people, once indicating only the region and once specifying a precise location (https://mexico.inaturalist.org/observations/55649302 and 55568339, respectively. The supporting photographs show it to be the same individual). Our records came from three xeroriparian locations.

The nine-banded armadillo is a species of tropical affinity, widely distributed in South and Central America and much of México (McBee & Baker, 1982). In México its reported range extends along the coastal slopes from southern Sonora and eastern Coahuila southward, and from Michoacán southward to Central America (Leopold, 1977; Hall, 1981; McBee & Baker, 1982). Hall (1981), Mendoza Durán (2005) and Chávez-Andrade *et al*. (2015) included the state of Aguascalientes in its distribution, while Martínez de la Vega (2022) indicated that it was in "part of" the San Luis Potosí arid region, but neither provided specific locations. On the other hand, the published information and lack of its collection by Percy Clifton suggest that the nine-banded armadillo was absent from the southern part of the as late as the 1970s (Dalquest, 1953; Matson & Baker, 1986). Until 2006, when we found a carapace at El Mayal, it was not clear that the species occurred in the Llanos de Ojuelos. Armando Esparza, knowledgeable about the region´s wildlife, recalls armadillos as very rare, with sightings only in the last ~15 years. The 2006 piece of carapace was found in a thicket near a water tank with xeroriparian vegetation, while the 2021 carapace in La Colorada was on the bank adjacent to an ephemeral stream. In addition to our records there are two on Naturalista. The first is from Las Cardoncitas, located between Huerta Grande and Santoyo (https://www.naturalista.mx/observations/57793012, 21.806935º, -101.817598º), while the second was indicated only as being from the region (https://www.naturalista.mx/observations/168937361).

Our records, along with the two posted on Naturalista, confirm that Nine-banded armadillos are present in the southern part of the Central plateau of Mexico, not as accidental visitors, but as an established population. Its current presence in the region suggests a recent expansion of its distribution. Nine-banded armadillos are highly capable of territorial expansion. Before the mid-19th Century, they crossed the Rio Grande barrier into Texas (Audubon & Bachman, 1854), eventually reaching the Atlantic coast to the east and Illinois to the north (Clark *et al*., 2008). More recently, the species expanded its distribution in Sonora as well (Gallo-Reynoso *et al*., 2018).

The geographical origin of the individuals of this species that colonized the Llanos de Ojuelos is unknown. To explain a nine-banded armadillo record in Nochistlán, in southwestern Zacatecas, Matson and Baker (1986) speculated that the species might have arrived by following the Juchipila River from Nayarit. It is possible that, from the southwest of Zacatecas, the species continued its expansion toward the Llanos de Ojuelos, 125 km to the northeast. The Gulf of México slope appears to be a less likely source due to its much greater distance and the presence of large areas that seemingly lack suitable habitat for the species. The broader geographical distribution records in Naturalista appear consistent with such a southwesterly origin.

The factors enabling the expansion of the nine-banded armadillo in the U.S.A. and Sonora are not clear, but it has been argued that the conversion of grasslands to shrublands created suitable habitat that contributed to it (Taber 1945). In the Llanos de Ojuelos, transformation of the original grasslands into shrubbier plant communities began with the arrival of the Spanish but intensified after the agrarian land distribution in the mid-20th Century (Mellink & Riojas-López, 2020). Such an increase in cover by shrublands may have played an important role in the current presence of nine-banded armadillos in the area. While the development of shrubs on grasslands might have facilitated the colonization by the species, its presence in xeroriparian conditions might be favored by water and an abundance of insects, as well as soft, easily diggable soil (Taber, 1945; Leopold, 1977; McBee & Baker, 1982). The near absence of photographs of armadillos at our sites between January and July (Fig. 3) coincides with the dry season in the region.

Arboreal squirrels have been understudied in México, and information on their populations is urgently needed (Ramos-Lara & Koprowski, 2014). Therefore, our records of Peters´ squirrels are particularly significant. All our observations come from a single location that lies between the known distribution of this species and that of the Nayarit squirrel (*S. nayaritensis* J.A. Allen, 1890) (Leopold, 1977; Hall, 1981). These two species are very similar (Álvarez, 1961; Leopold, 1977; Aragón, 2005; Hall, 1981) and detailed studies might someday justify their synonymizing (Lee & Hoffmeister, 1963). Until such a taxonomic revision occurs, both species remain valid and are distinguished based on geographical distribution. Peters´ squirrel occurs from the center of the state of San Luis Potosí southward, while the Nayarit squirrel inhabits the Sierra Madre Occidental, ranging from southeastern Arizona southern of Jalisco. According to Alfonso Rincón Gallardo (pers. com., Ciénega de Mata, 3 Feb 2024) this squirrel has been present in Huerta Grande for at least six decades, based on his earliest memories.

Nayarit squirrels in Zacatecas are primarily a montane species living in oak and pine-oak forests (Matson & Baker, 1986). In contrast, Peters´ squirrels not only inhabit pine and oak forests, but are also found in arid mountains in San Luis Potosí, Guanajuato, and Querétaro (Nelson, 1899), as well as in valley streams in San Luis Potosí (Dalquest, 1953). Since the Llanos de Ojuelos are geographically and ecologically more closely related to the San Luis Potosí-Guanajuato plains than to the Sierra Madre Occidental, and given the habitat of the squirrels we recorded, we identify them as Peters' squirrels.

The specimens we have recorded lack a distinct dark central stripe along their back (Fig. 4), a characteristic that aligns them with *S. o. shawi* Dalquest, 1950, following Dalquest (1950). The closest records of *S. o. shawi* in Naturalista come from the mountain ranges south of San Luis Potosí, about 90 km NE of the Llanos de Ojuelos. Meanwhile other Peter´s squirrel records from northern Guanajuato, 46 km to the SSE, correspond to the distribution of *S. o. tolucae* Nelson, 1898 (Dalquest, 1950). Recent observations of Peters´ squirrels from both regions have not been assigned to subspecies.

Peters´ squirrel was considered between rare and fragile (Ceballos & Navarro, 1991) and is listed as "under special protection" in México´s catalog of species at risk (SEMARNAT, 2010). However, this category does not prevent the legal hunting of *S. o. shawi* (*sensu* Dalquest, 1950) in the state of San Luis Potosí (Martínez de la Vega *et al*., 2016). The habitat of Peters´ squirrels at Huerta Grande is different from the pine, oak and, or fir forests that it typically inhabits (Nelson, 1899). This population is the only known one in a large semiarid area and is isolated from any other populations. Given these factors, it should be of significant conservation concern.

The ringtail occurs throughout most of México (Leopold, 1977; Hall, 1981; Poglayen-Neuwall & Toweill, 1988). It was suspected to be present in the region, but only a specimen from

Matanzas, just south of the Llanos de Ojuelos, existed. This specimen was collected by Percy Clifton on 11 May 1966 (https://www.gbif.org/occurrence/686436624). No confirmed observations have been reported from our study region, except for a photograph of a scat that was attributed this species uploaded on 21 July 2019, but which remains unverified and uncommented (https://www.naturalista.mx/observations/29265538).

Ringtails typically inhabit rocky outcrops, canyons, and talus slopes with oaks, pines, and junipers, and they also use riparian habitats (Dalquest, 1953; Leopold, 1977; Poglayen-Neuwall & Toweill, 1988). At La Colorada and La Laborcilla the habitat consists of rocky ravines with junipers, peppertrees, and willows, while our Santoyo and Huerta Grande records come from riparian habitats on level terrain, lacking rocks, and characterized by willows, ash, and peppertrees. All the sites where we recorded ringtails had nopales, whose tunas (the fruits) they feed on (Dalquest, 1953).

The reported distribution of the American badger includes the entire Mexican Plateau (Leopold, 1977; Hall, 1981; Jiménez Guzmán & List, 2005), but no specimens were found to support its presence in the Llanos de Ojuelos, until Riojas-López *et al*. (2019) presented evidence of it. Since then, no additional records have been published in the literature or uploaded to Naturalista. The observations we present here (Table 2, Fig. 5) come from two localities, different from those in Riojas-López *et al*. (2019), and indicate that the species is widespread. American badgers are listed as threatened in México´s list of species at risk (SEMARNAT, 2010).

A relevant record of puma presence in the region was published by Riojas-López *et al*. (2019). Additionally, we received reports of two puma sighting between Huerta Grande and Santoyo in 2020 (Armando Esparza Govea, pers. com., Ojuelos de Jalisco, Jal., 13 Sep 2021) and of two individuals in a roadkill in the same area in December 2022 (Alfonso Rincón Gallardo, pers. com., Ciénega de Mata, 9 Sep 2023; they might have been the same). Our data, along with these verbal reports, further support the presence of widespread puma population in the region, particularly in xeroriparian systems.

Collared peccaries were reportedly common in the region until the 1950s, after which their population was decimated to the point of extirpation or near-extirpation (Roberto García Maldonado, pers. com. San Luis Potosí, S.L.P., 1980; see also Leopold, 1977, and Dalquest, 1953). In addition to the collared peccary that we recorded on a trail camera image at La Luz, we received verbal reports of groups of 15 and more peccaries at Huerta Grande (Alfonso Rincón Gallardo, pers. com., Ciénega de Mata, 3 Feb 2024; Jesús Capuchino, pers. com., Huerta Grande, 2 Feb 2024). These records, along with those reported by Carrasco-Ortíz *et al*. (2021), suggest that the species is regaining its presumed former distribution to a greater extent than previously believed.

The species reported on in this paper align with three key aspects of the limited knowledge about biodiversity in this highly anthropized region. First, some species escaped formal detection and are thus absent from scientific literature, such as Peters' squirrels, ringtails and American badgers. Second, some species colonized the region as habitat conditions changed, as the nine-banded armadillo. Third, certain species who were extirpated from the region or whose population was greatly reduced –likely as a result of hunting–have recently increased or recolonized former habitats in the area, such as the collared peccary and the puma. The fact that we continue to generate relevant information on the presence of mid-size and large mammal species highlights the urgent need for further surveys, not only on mammals but also other animal groups in the region.

Xeroriparian habitats in the region are used by mammals of all taxonomic orders, though most of our findings pertain to medium and large mammals, and we still have little information

on smaller species. All but one species from the mammalian orders of (usually) medium and large mammals (Mammalia: orders Didelphimorphia, Cingulata, Carnivora and Artiodactyla) are known to inhabit xeroriparian systems. Some species use xeroriparian habitats as their preferred environment, others as part of a broader range of habitats, and other species seem to use them as corridors.

The origin of the Peters´ squirrel population is uncertain–whether it is a Pleistocene remnant or a human introduction warrants further investigation. Regardless, given the limited data on other populations of the species, the Huerta Grande population holds clear conservation value. The role of xeroriparian habitats in the region for other mammal groups not addressed here–such as rodents (Mammalia: Rodentia), shrews (Mammalia: Eulipotyphla: Soricidae), rabbits and jackrabbits (Mammalia: Lagomorpha), and bats (Mammalia: Chiroptera)–remains to be assessed.

Although much remains unknown on the relative value of xeroriparian habitats in the southern part of the Central Plateau of Mexico for mammals, we can safely state that their disappearance, reduction, or severe transformation would have negative impacts. Despite existing knowledge gaps, the data presented in this article, along with other recent publications by us indicate that, despite the extensive anthropization of the Llanos de Ojuelos (Riojas-López *et al*., 2011), xeroriparian habitats play a crucial role conserving mammalian biodiversity.

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Supplementary file

Species	Locality	Section	Evidence	Date	Time
Bassariscus astutus	La Colorada	Lower	Scat	15/07/2021	n/a
Bassariscus astutus	La Colorada	Upper	Track	22/03/2021	n/a
Bassariscus astutus	La Laborcilla	Middle	Trail camera	20/12/2019	00:38
Bassariscus astutus	La Laborcilla	Middle	Trail camera	02/01/2020	04:31
Bassariscus astutus	La Laborcilla	Upper	Trail camera	16/12/2020	22:05
Bassariscus astutus	Santoyo	Middle	Trail camera	24/04/2019	22:54
Bassariscus astutus	Santoyo	Upper	Visual	02/04/2022	≈21:00
Dasypus novemcinctus	El Mayal	n/a	Carapace	19/10/2006	n/a
Dasypus novemcinctus	La Colorada	Middle	Track	17/09/2023	n/a
Dasypus novemcinctus	La Colorada	Upper	Trail camera	20/04/2019	21:05
Dasypus novemcinctus	La Colorada	Upper	Trail camera	12/07/2019	00:58
Dasypus novemcinctus	La Colorada	Upper	Trail camera	21/07/2019	23:45
Dasypus novemcinctus	La Colorada	Upper	Trail camera	28/07/2019	01:07
Dasypus novemcinctus	La Colorada	Upper	Trail camera	06/08/2019	05:22
Dasypus novemcinctus	La Colorada	Upper	Trail camera	09/08/2019	23:45
Dasypus novemcinctus	La Colorada	Upper	Trail camera	13/08/2019	04:39
Dasypus novemcinctus	La Colorada	Upper	Trail camera	17/08/2019	03:35
Dasypus novemcinctus	La Colorada	Upper	Trail camera	18/08/2019	04:08
Dasypus novemcinctus	La Colorada	Upper	Trail camera	19/08/2019	03:37
Dasypus novemcinctus	La Colorada	Upper	Trail camera	19/09/2019	21:15
Dasypus novemcinctus	La Colorada	Upper	Trail camera	26/09/2019	20:42
Dasypus novemcinctus	La Colorada	Upper	Trail camera	02/10/2019	20:55
Dasypus novemcinctus	La Colorada	Upper	Trail camera	06/10/2019	21:59
Dasypus novemcinctus	La Colorada	Upper	Trail camera	07/10/2019	04:16
Dasypus novemcinctus	La Colorada	Upper	Trail camera	08/10/2019	04:27
Dasypus novemcinctus	La Colorada	Upper	Trail camera	10/10/2019	21:36
Dasypus novemcinctus	La Colorada	Upper	Trail camera	15/10/2019	19:52
Dasypus novemcinctus	La Colorada	Upper	Trail camera	01/12/2019	04:50
Dasypus novemcinctus	La Colorada	Upper	Trail camera	17/12/2019	03:43
Dasypus novemcinctus	La Colorada	Upper	Trail camera	25/12/2019	03:00
Dasypus novemcinctus	La Colorada	Upper	Trail camera	20/07/2020	02:31

Dasypus novemcinctus	La Colorada	Upper	Trail camera	20/07/2020	22:36
Dasypus novemcinctus	La Colorada	Upper	Trail camera	21/07/2020	04:52
Dasypus novemcinctus	La Colorada	Upper	Trail camera	21/07/2020	23:33
Dasypus novemcinctus	La Colorada	Upper	Trail camera	24/07/2020	04:03
Dasypus novemcinctus	La Colorada	Upper	Trail camera	26/07/2020	00:05
Dasypus novemcinctus	La Colorada	Upper	Trail camera	26/07/2020	00:41
Dasypus novemcinctus	La Colorada	Upper	Trail camera	28/07/2020	01:29
Dasypus novemcinctus	La Colorada	Upper	Trail camera	31/07/2020	09:10
Dasypus novemcinctus	La Colorada	Upper	Trail camera	01/08/2020	08:08
Dasypus novemcinctus	La Colorada	Upper	Trail camera	01/08/2020	03:55
Dasypus novemcinctus	La Colorada	Upper	Trail camera	01/08/2020	04:28
Dasypus novemcinctus	La Colorada	Upper	Trail camera	01/08/2020	21:51
Dasypus novemcinctus	La Colorada	Upper	Trail camera	06/08/2020	23:42
Dasypus novemcinctus	La Colorada	Upper	Trail camera	08/08/2020	01:43
Dasypus novemcinctus	La Colorada	Upper	Trail camera	09/08/2020	02:58
Dasypus novemcinctus	La Colorada	Upper	Trail camera	11/08/2020	23:29
Dasypus novemcinctus	La Colorada	Upper	Trail camera	12/08/2020	00:43
Dasypus novemcinctus	La Colorada	Upper	Trail camera	12/08/2020	22:32
Dasypus novemcinctus	La Colorada	Upper	Trail camera	12/08/2020	05:50
Dasypus novemcinctus	La Colorada	Upper	Trail camera	13/08/2020	04:59
Dasypus novemcinctus	La Colorada	Upper	Trail camera	13/08/2020	22:35
Dasypus novemcinctus	La Colorada	Upper	Trail camera	15/08/2020	03:43
Dasypus novemcinctus	La Colorada	Upper	Trail camera	18/08/2020	22:03
Dasypus novemcinctus	La Colorada	Upper	Trail camera	19/08/2020	07:17
Dasypus novemcinctus	La Colorada	Upper	Trail camera	20/08/2020	22:05
Dasypus novemcinctus	La Colorada	Upper	Trail camera	22/08/2020	23:44
Dasypus novemcinctus	La Colorada	Upper	Trail camera	25/08/2020	00:46
Dasypus novemcinctus	La Colorada	Upper	Trail camera	27/08/2020	01:09
Dasypus novemcinctus	La Colorada	Upper	Trail camera	04/09/2020	05:37
Dasypus novemcinctus	La Colorada	Upper	Trail camera	09/09/2020	22:28
Dasypus novemcinctus	La Colorada	Upper	Carapace	16/07/2021	n/a
Dasypus novemcinctus	La Duquesa	Upper	Trail camera	22/10/2023	03:45
Dasypus novemcinctus	Santoyo	Middle	Trail camera	29/07/2019	22:05

Dasypus novemcinctus	Santoyo	Middle	Trail camera	31/07/2019	01:11
Dasypus novemcinctus	Santoyo	Middle	Trail camera	31/07/2019	03:33
Dasypus novemcinctus	Santoyo	Middle	Trail camera	04/08/2019	03:17
Dasypus novemcinctus	Santoyo	Middle	Trail camera	04/08/2019	04:58
Dasypus novemcinctus	Santoyo	Middle	Trail camera	05/08/2019	00:21
Dasypus novemcinctus	Santoyo	Middle	Trail camera	10/08/2019	01:13
Dasypus novemcinctus	Santoyo	Middle	Trail camera	10/08/2019	06:10
Dasypus novemcinctus	Santoyo	Middle	Trail camera	15/02/2020	02:39
Dasypus novemcinctus	Santoyo	Middle	Trail camera	05/07/2020	00:58
Dasypus novemcinctus	Santoyo	Middle	Trail camera	05/07/2020	03:00
Dasypus novemcinctus	Santoyo	Middle	Trail camera	06/07/2020	02:59
Dasypus novemcinctus	Santoyo	Middle	Trail camera	08/07/2020	00:49
Dasypus novemcinctus	Santoyo	Middle	Trail camera	09/07/2020	04:44
Dasypus novemcinctus	Santoyo	Middle	Trail camera	09/07/2020	21:19
Dasypus novemcinctus	Santoyo	Middle	Trail camera	12/07/2020	03:39
Dasypus novemcinctus	Santoyo	Middle	Trail camera	13/07/2020	21:41
Dasypus novemcinctus	Santoyo	Middle	Trail camera	16/07/2020	21:33
Dasypus novemcinctus	Santoyo	Middle	Trail camera	19/07/2020	06:03
Dasypus novemcinctus	Santoyo	Middle	Trail camera	27/07/2020	01:13
Dasypus novemcinctus	Santoyo	Middle	Trail camera	01/09/2020	03:33
Dasypus novemcinctus	Santoyo	Middle	Trail camera	31/10/2020	10:25
Dasypus novemcinctus	Santoyo	Middle	Trail camera	01/11/2020	00:27
Dasypus novemcinctus	Santoyo	Middle	Trail camera	06/11/2020	20:00
Dasypus novemcinctus	Santoyo	Middle	Trail camera	09/11/2020	22:50
Dasypus novemcinctus	Santoyo	Middle	Trail camera	11/11/2020	01:51
Dasypus novemcinctus	Santoyo	Middle	Trail camera	12/11/2020	20:21
Dasypus novemcinctus	Santoyo	Middle	Trail camera	15/11/2020	20:13
Dasypus novemcinctus	Santoyo	Middle	Trail camera	04/12/2020	23:59
Dasypus novemcinctus	Santoyo	Middle	Trail camera	14/12/2020	22:30
Dasypus novemcinctus	Santoyo	Middle	Trail camera	16/12/2020	22:54
Dasypus novemcinctus	Santoyo	Middle	Trail camera	21/12/2020	01:01
Dasypus novemcinctus	Santoyo	Upper	Trail camera	21/07/2020	01:35
Dasypus novemcinctus	Santoyo	Upper	Trail camera	26/01/2021	03:21

Dasypus novemcinctus	Santoyo	Upper	Trail camera	29/01/2021	20:30
Dasypus novemcinctus	Santoyo	Upper	Trail camera	30/01/2021	21:10
Dasypus novemcinctus	Santoyo	Upper	Trail camera	01/02/2021	19:55
Didelphis virginiana	La Colorada	Upper	Trail camera	17/07/2019	04:23:00
Didelphis virginiana	La Colorada	Upper	Trail camera	19/07/2019	06:12:00
Didelphis virginiana	La Colorada	Upper	Trail camera	22/07/2019	00:31:00
Didelphis virginiana	La Colorada	Upper	Trail camera	24/07/2019	02:33:00
Didelphis virginiana	La Colorada	Upper	Trail camera	27/07/2019	03:46:00
Didelphis virginiana	La Colorada	Upper	Trail camera	28/07/2019	23:36:00
Didelphis virginiana	La Colorada	Upper	Trail camera	29/07/2019	04:50:00
Didelphis virginiana	La Colorada	Upper	Trail camera	04/08/2019	05:12:00
Didelphis virginiana	La Colorada	Upper	Trail camera	09/08/2019	04:04:00
Didelphis virginiana	La Colorada	Upper	Trail camera	19/09/2019	21:45:00
Didelphis virginiana	La Colorada	Upper	Trail camera	14/10/2019	18:30:00
Didelphis virginiana	La Colorada	Upper	Trail camera	14/10/2019	19:45:00
Didelphis virginiana	La Colorada	Upper	Trail camera	07/12/2020	02:27:00
Didelphis virginiana	La Colorada	Upper	Trail camera	10/12/2020	00:33:00
Didelphis virginiana	La Colorada	Upper	Trail camera	10/12/2020	01:24:00
Didelphis virginiana	La Colorada	Upper	Trail camera	11/12/2020	02:08:00
Didelphis virginiana	La Colorada	Upper	Trail camera	14/12/2020	22:16:00
Didelphis virginiana	La Colorada	Upper	Trail camera	22/12/2020	05:20:00
Didelphis virginiana	La Colorada	Upper	Trail camera	23/12/2020	06:32:00
Didelphis virginiana	La Colorada	Upper	Trail camera	28/01/2021	23:45:00
Didelphis virginiana	La Colorada	Upper	Trail camera	31/01/2021	04:05:00
Didelphis virginiana	La Laborcilla	Middle	Trail camera	05/11/2019	01:42:00
Didelphis virginiana	La Laborcilla	Middle	Trail camera	06/11/2019	01:21:00
Didelphis virginiana	La Laborcilla	Middle	Trail camera	07/11/2019	02:45:00
Didelphis virginiana	La Laborcilla	Middle	Trail camera	08/11/2019	04:11:00
Didelphis virginiana	La Laborcilla	Middle	Trail camera	08/11/2019	23:41:00
Didelphis virginiana	La Laborcilla	Middle	Trail camera	06/10/2020	20:50:00
Didelphis virginiana	Santoyo	Middle	Trail camera	25/06/2019	01:34:00
Didelphis virginiana	Santoyo	Middle	Trail camera	26/09/2019	03:12:00
Didelphis virginiana	Santoyo	Middle	Trail camera	29/09/2019	05:40:00

Didelphis virginiana	Santoyo	Middle	Trail camera	30/09/2019	03:48:00
Didelphis virginiana	Santoyo	Middle	Trail camera	30/09/2019	23:47:00
Didelphis virginiana	Santoyo	Middle	Trail camera	01/10/2019	02:14:00
Didelphis virginiana	Santoyo	Middle	Trail camera	01/10/2019	22:06:00
Didelphis virginiana	Santoyo	Middle	Trail camera	01/11/2019	23:34:00
Didelphis virginiana	Santoyo	Middle	Trail camera	17/11/2020	22:31:00
Didelphis virginiana	Santoyo	Middle	Trail camera	21/11/2020	02:32:00
Didelphis virginiana	Santoyo	Middle	Trail camera	23/11/2020	03:58:00
Didelphis virginiana	Santoyo	Middle	Trail camera	26/11/2020	20:35:00
Didelphis virginiana	Santoyo	Middle	Trail camera	27/11/2020	03:40:00
Didelphis virginiana	Santoyo	Middle	Trail camera	30/11/2020	03:47:00
Didelphis virginiana	Santoyo	Middle	Trail camera	03/12/2020	19:46:00
Didelphis virginiana	Santoyo	Middle	Trail camera	24/05/2021	00:24:00
Didelphis virginiana	Santoyo	Upper	Trail camera	11/08/2019	04:39:00
Puma concolor	La Colorada	Upper	Track	19/04/2019	n/a
Puma concolor	La Colorada	Middle	Trail camera	01/11/2020	19:03
Puma concolor	La Colorada	Middle	Trail camera	01/11/2020	21:23
Puma concolor	La Colorada	Upper	Trail camera	13/10/2019	03:43
Puma concolor (cub)	La Colorada	Upper	Trail camera	02/11/2020	07:37
Puma concolor	La Colorada	Upper	Trail camera	01/11/2020	07:37
Puma concolor	Santoyo	Middle	Trail camera	17/12/2020	00:44
Puma concolor	Santoyo	Middle	Trail camera	08/02/2021	23:19
Taxidea taxus	La Colorada	Upper	Trail camera	12/08/2019	05:49
Taxidea taxus	La Colorada	Upper	Trail camera	28/09/2019	03:00
Taxidea taxus	La Colorada	Upper	Trail camera	06/10/2019	05:43
Taxidea taxus	La Colorada	Upper	Trail camera	07/10/2019	05:12
Taxidea taxus	La Colorada	Upper	Trail camera	07/10/2019	20:49
Taxidea taxus	La Colorada	Upper	Trail camera	08/10/2019	03:53
Taxidea taxus	La Colorada	Upper	Trail camera	08/10/2019	05:10
Taxidea taxus	La Colorada	Upper	Trail camera	09/10/2019	05:35
Taxidea taxus	La Colorada	Upper	Trail camera	14/08/2020	06:57
Taxidea taxus	La Colorada	Upper	Trail camera	19/01/2021	02:59
Taxidea taxus	Santoyo	Middle	Trail camera	27/04/2019	23:11

Taxidea taxus	Santoyo	Middle	Trail camera	21/07/2019	22:19
Taxidea taxus	La Colorada	Lower	Den	20/01/2021	n/a
Taxidea taxus	La Colorada	Lower	Den	22/03/2021	n/a
Taxidea taxus	La Colorada	Middle	Den	20/01/2021	n/a
Taxidea taxus	La Colorada	Middle	Den	16/05/2021	n/a
Taxidea taxus	La Colorada	Middle	Den	16/07/2021	n/a
Taxidea taxus	La Laborcilla	Lower	Den	19/03/2021	n/a
Taxidea taxus	La Laborcilla	Lower	Den	19/03/2021	n/a
Taxidea taxus	Santoyo	Upper	Den	15/05/2021	n/a
Taxidea taxus	Santoyo	Upper	Den	15/05/2021	n/a
Taxidea taxus	Santoyo	Upper	Den	21/02/2021	n/a
Taxidea taxus	Santoyo	Lower	Den	21/02/2021	n/a
Pecari tajacu	La Luz	Middle	Trail camera	14/12/2023	