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Medium and large-sized mammals in montane habitats of Oaxaca, México

Mamíferos medianos y grandes en hábitats montanos de Oaxaca, México

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Local inventories constitute the baseline to understand the distribution of species and the ecological and historical processes underlay. Such information, in association with the documentation of motivations for hunting, is needed to design long-term conservation strategies. This study provides novel data on medium and large-sized species for the Cerro Piedra Larga (CPL), an interior mountain massif located in Oaxaca, México. We obtained data from direct observations in transects, seeking for indirect evidence, and camera-trapping in tropical dry forest, dry oak-pine forest, and mesic oak-pine. We recorded the hunting motivations of mammals by local people through informal interviews. We quantified the number of species and identified those that are in some category of risk to its conservation. We report the presence of 26 medium and large-sized species in the CPL. Seven species are in some category of risk. Local people recognized 23 species, of which 14 are hunted to prevent damage to domestic animals and crops. Five species are hunted for consumption as bushmeat. Direct observations, camera-trapping, and interviews were complementary methods for improving the species checklist. Seven species constitute the first records for the entire subprovince. The record of *Cuniculus paca* represents a range extension to central-south Oaxaca. Considering the small, flying, and medium and large-sized mammals, the CPL has 24.9 % of the total terrestrial mammals recorded in Oaxaca. This study highlights the importance of this mountain massif by its diversity of mammals, which is under threat because of slash-and-burn agriculture and road development.

Key words: Camera-trapping; direct observations; local knowledge; Montañas y Valles del Centro de Oaxaca; species checklist.

Los inventarios locales constituyen la base para entender la distribución de las especies y los procesos ecológicos e históricos subyacentes. Esta información, en asociación con la documentación de los motivos de caza de las especies, es necesaria para el diseño de estrategias de conservación. Este estudio provee datos nuevos de las especies de mamíferos medianos y grandes del Cerro Piedra Larga (CPL), un macizo montañoso interior en Oaxaca, México. Obtuvimos datos de observaciones directas en transectos, búsqueda de rastros y fototrampeo en bosque tropical caducifolio, bosque seco de pino-encino y en bosque de pino-encino. Registramos los motivos de caza de los mamíferos por la gente local a través de entrevistas informales. Cuantificamos el número de especies e identificamos aquellas que están en alguna categoría de riesgo para su conservación. Reportamos la presencia de 26 especies de mamíferos medianos y grandes en el CPL. Siete especies están en alguna categoría de riesgo. Los habitantes reconocieron la presencia de 23 especies, de las cuales 14 son cazadas para prevenir daños sobre animales domésticos y cultivos. Cinco especies son cazadas por su carne. Las observaciones directas, el fototrampeo y las entrevistas fueron métodos complementarios que ayudaron a tener una mejor lista de las especies. Siete especies constituyen los primeros registros para toda la subprovincia. El registro de *Cuniculus paca* representa una extensión de su distribución hacia el centro-sur de Oaxaca. Considerando a los mamíferos pequeños, los voladores y los medianos y grandes, el CPL tiene el 24.9 % del total de mamíferos terrestres registrados en Oaxaca. Este estudio destaca la importancia de este macizo montañoso por su diversidad de mamíferos, la cual es amenazada por agricultura de roza-tumba y quema, y actividades de desarrollo carretero.

Palabras clave: Conocimiento local; fototrampeo; lista de especies; Montañas y Valles del Centro de Oaxaca; observaciones directas.

Local inventories constitute the baseline information to understand the distribution of species and the ecological and historical processes involved, such information is also needed to design adequate long-term conservation strategies (Sánchez-Cordero 1993). This information is even more important in regions with high biodiversity and a high rate of habitat loss such as Oaxaca, in southeastern México (Briones-Salas *et al.* 2015). Oaxaca holds the highest mammalian diversity in México, more than 45 % of all Mexican mammals distributes in Oaxaca (Briones-Salas *et al.* 2015). Besides, Oaxaca constitutes the most biodiverse region in the northern portion of the Mesoamerica hotspot (Myers *et al.* 2000). Despite Oaxaca´s rich mammalian history (Goodwin 1969; Ramírez-Pulido *et al.* 1986; Briones-Salas and Sánchez-Cordero 2004), there is still a significant lack of information on species distribution, especially for some remote areas of the state.

The Cerro Piedra Larga (CPL) is an interior mountain massif located in the Montañas y Valles del Centro physiographic subprovince (Ortiz-Pérez *et al.* 2004). This mountain range stands out because it represents one of the first mountain habitats after the plains of the Isthmus of

Tehuantepec, a major geographic barrier for several taxa (García-Moreno *et al.* 2004). It also contains the most isolated patches of cloud forest in México and represents the montane connection between the Sierra Madre del Sur and Sierra Madre de Oaxaca physiographic subprovinces (Peterson *et al.* 2004). Despite this biogeographical importance, only three mammal studies have been conducted in the area. Goodwin (1969) cited records of mammal species for the region in a review of specimens collected in the state; Peterson *et al.* (2004) performed a 15-days survey at the mountaintop for a multitaxon inventory; Ramírez-Bautista and Williams (2019) surveyed small rodents on the eastern side of this mountain.

Thus, the known checklist of mammals of CPL includes mostly small rodents and bats. As elusive species, medium and large-sized mammals are difficult to record, but complementary survey methods, such as seek for tracks and feces, camera trapping, and interviews, could allow us to achieve a more complete species list in a region (Hoffmann *et al.* 2010).

Medium and large-sized mammals comprised species usually weighting >100 gr able to leave indirect evidence potentially observable in the field (Aranda 2000). In México, this group includes all the species in the orders Cingulata, Pilosa, Primates, Lagomorpha, Carnivora, Artiodactyla, and Perissodactyla; and species in the families Caluromyidae, Didelphidae (order Didelphimorphia), Agoutidae, Cuniculidae, Erethizontidae, and Sciuridae (order Rodentia) are included (Aranda 2000). By their biomass and the ecological services they perform, such as herbivory, fruits and seeds consumers and dispersers, and predation, the medium and large-sized mammals are very important in structuring ecosystems (Lacher *et al.* 2019). The objective of this study was to provide a list of the medium and large-sized mammals inhabiting the CPL and to record the hunting motivations of mammals by local people. Finally, we discuss the conservation implications for this region.

The Cerro Piedra Larga (also known as Cerro Sacamecate) is an interior mountain massif located 100 km east of Oaxaca´s capital city, in the Montañas y Valles del Centro physiographic subprovince (Figure 1; Ortiz-Pérez *et al.* 2004). The altitudinal range of CPL goes from 100 to 2,800 m. This altitudinal range together with climate and topography has made possible the existence of three main vegetation types: tropical dry forest (up to 1,000 m), dry oak-pine forest (up to 1,900 m), and mesic oak-pine forest with patches of cloud forest (above 2,000 m; Peterson *et al.* 2004; Ramírez-Bautista and Williams 2019).

The area explored falls in the communal lands of San Pedro Jilotepec, El Sauce Jilotepec (both of the municipality of Magdalena Tequisistlán), and San Sebastián Jilotepec (municipality of Nejapa de Madero; Figure 1). In combination, these localities had a human population of 335 persons of the Zapotec, Mixe and Chontal ethnic groups (INEGI 2010). They speak Zapotec of the Sierra Sur variant and Chontal of Oaxaca Alto (de Ávila and Moreno 2008).

Data collection. From October 2015 to September 2018, we explored the eastern side of the CPL (from 300 to 2,550 m) while surveying small rodents (Ramírez-Bautista and Williams 2019). During these surveys, we recorded indirect evidence of medium and large-sized mammals, such as feces, tracks, and direct observation along non-systematic walks. In addition, from August to December 2019 we deployed 12 single camera-trapping stations. Camera-traps (Bushnell Trophy Cam) were set to trees at 30-40 cm above the ground. Camera-traps were separated by 1 km on average and covered the main type of forests: tropical dry forest (4 cameras), dry oak-pine forest (6 cameras), and mesic oak-pine (2 cameras). The number of cameras per vegeta-

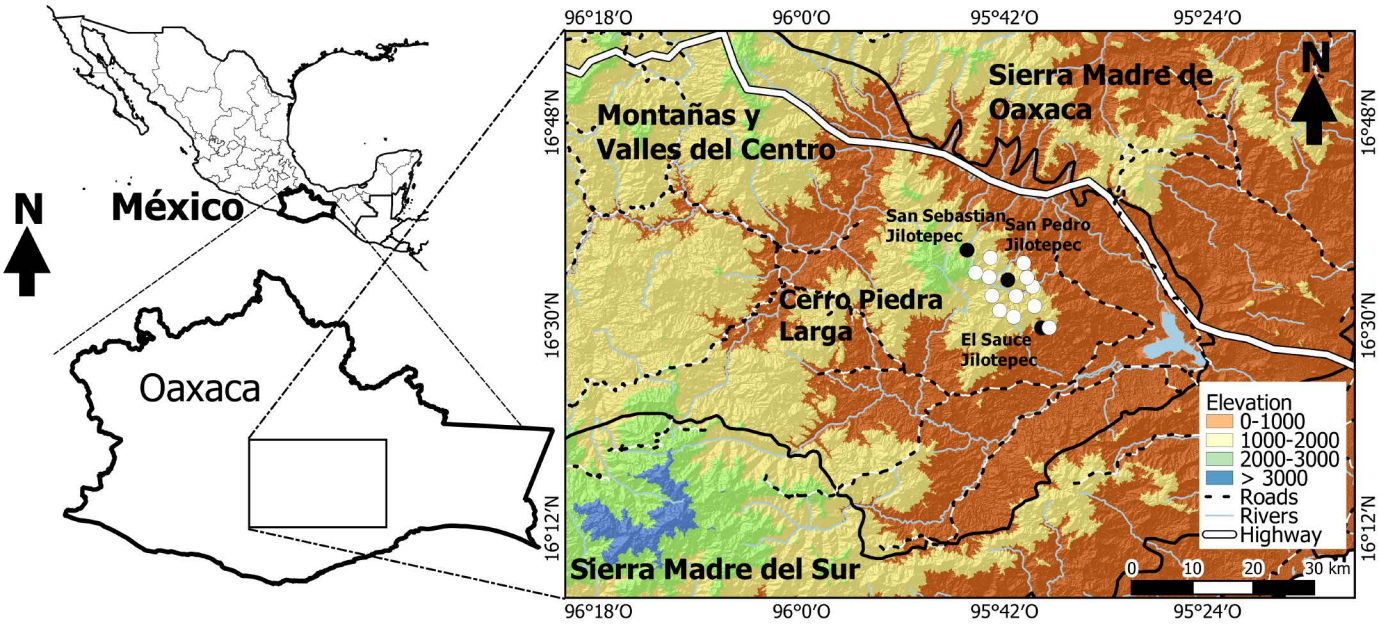

Figure 1. Localization of Cerro Piedra Larga. Black circles are the human localities. White circles are the camera-trap stations. Highway redrawn from https://www.proyectosmexico.gob.mx/proyecto_inversion/083-tramo-carretero-libre-de-peaje-mitla-entronque-tehuantepec/.

tion type was in function with the accessibility to sites. For instance, the low number of cameras corresponded to the far pine-oak forest (Figure 1). To identify species, we used the guide of Aranda (2000) for indirect evidence and the guide of Reid (2006) for photographs from camera-traps.

To inquire about the hunting motivations of mammals among local people, we performed 11 informal talks. Most people engaged were men recognized for their knowledge of territory and wildlife (key informants). We specifically asked about the presence, species hunted, and the motivations (*e. g.*, bushmeat acquisition, agricultural pests).

Species nomenclature follows Ramírez-Pulido *et al.* (2014). For the conservation and regulation status of species, we consulted the Mexican Official Norm NOM-059-ECOL-2010 (SEMARNAT 2010) and the red list of the International Union for the Conservation of Nature (IUCN 2019).

The species richness of medium and large-sized mammals was obtained by the sum of species recorded throughout direct observations, indirect evidence (tracks and feces), camera trapping, photographs, and biological material in possession of local people. We quantified the number of species based on three hunting motivations: bushmeat acquisition, to control agricultural pests, and to control predation of domestic animals. We calculated the proportion of species number with concerning to the total in the subprovince and the state, according to Briones-Salas *et al.* (2015).

We recorded 26 medium and large-sized mammals, distributed in 14 families and seven orders (Table 1). Plus, we photographed individuals of one small mammal, *Tlacuatzin canescens*. Twenty species were recorded with camera traps, eleven by direct observations, and four by feces (Figure 2a, b, c, d, e, f). Of the total species recorded with camera traps, 12 were exclusively recorded with this method. In comparison, five species were exclusively recorded with direct observation. Ten species were recorded with both methods. Fifteen species were recorded in the dry oak-pine forest, 14 in the mesic oak-pine forest and, seven species in the tropical dry forest (Table 1).

Local people recognized 23 out of 26 species reported in this study; three species were not identified by local people as part of the mammals inhabiting the Cerro Piedra Larga: *Cuniculus paca*, *Bassariscus astutus*, and *Mephitis macroura*. Among the species recorded, local people identified 12 species as predators of domestic animals (*e. g.*, *Puma concolor* and *Canis latrans*), five species are considered agricultural pests (*e. g.*, *Sciurus aureogaster* and *Procyon lotor*), and five species are hunted for consumption as bushmeat (*Dasypus novemcinctus*, *Sylvilagus* spp., *Nasua narica*, *Dicotyles angulatus,* and *Odocoileus virginianus*). Most of the species fall in only one hunting category, but *C. latrans* and *P. lotor* are considered crop damagers and predators of backyard animals; also, *Dicotyles angulatus* is considered an agricultural pest and important for bushmeat acquisition. Only *N. narica* fits in the three hunting motivations (agricultural pest, a predator of backyard animal, and bushmeat).

Table 1. List of medium and large-sized mammals recorded in the Cerro Piedra Larga, Oaxaca, México. Type of record: feces (F), direct observation (D), and camera-trapping (C). Vegetation types: tropical dry forest (TDF), dry oak-pine forest (DOPF), and mesic oak-pine (MOPF). Hunting motivations: bushmeat acquisition (B), agricultural pests (A), predators on livestock and backyard animals (P).

No.	Species	Type of record	Vegetation types			Hunting motivations
			TDF	DOPF	MOPF	
	Didelphimorphia					
	Didelphidae					
1	*Didelphis marsupialis*	C, D	X			P
2	*Didelphis virginiana*	C			X	P
	Cingulata					
	Dasypodidae					
3	*Dasypus novemcinctus*	C, D		X	X	B
	Pilosa					
	Myrmecophagidae					
4	*Tamandua mexicana*	C, D	X	X		
	Lagomorpha					
	Leporidae					
5	*Sylvilagus* spp.	C, D, F		X	X	B
	Rodentia					
	Sciuridae					
6	*Glaucomys volans*	D		X		
7	*Sciurus aureogaster*	C, D	X	X	X	A
	Erethizontidae					
8	*Coendou mexicanus*	D	X			
	Cuniculidae					
9	*Cuniculus paca*	C			X	
	Carnivora					
	Felidae					
10	*Herpailurus yagouaroundi*	D		X		P
11	*Leopardus pardalis*	C			X	P
12	*Leopardus wiedii*	C				
13	*Lynx rufus*	D		X		
14	*Puma concolor*	C		X	X	P
	Canidae					
15	*Canis latrans*	C, F		X		A, P
16	*Urocyon cinereoargenteus*	C, F		X		P
	Mephitidae					
17	*Conepatus leuconotus*	C		X		P
18	*Mephitis macroura*	C			X	P
19	*Spilogale angustifrons*	C			X	
	Mustelidae					
20	*Lontra longicaudis*	C, F	X			
21	*Mustela frenata*	C, D		X	X	P
	Procyonidae					
22	*Bassariscus astutus*	D			X	
23	*Nasua narica*	C, D	X		X	A, B, P
24	*Procyon lotor*	C		X		A, P
	Artiodactyla					
	Tayassuidae					
25	*Dicotyles angulatus*	C		X	X	A, B
	Cervidae					
26	*Odocoileus virginianus*	C	X	X	X	B
	Total		7	15	14	

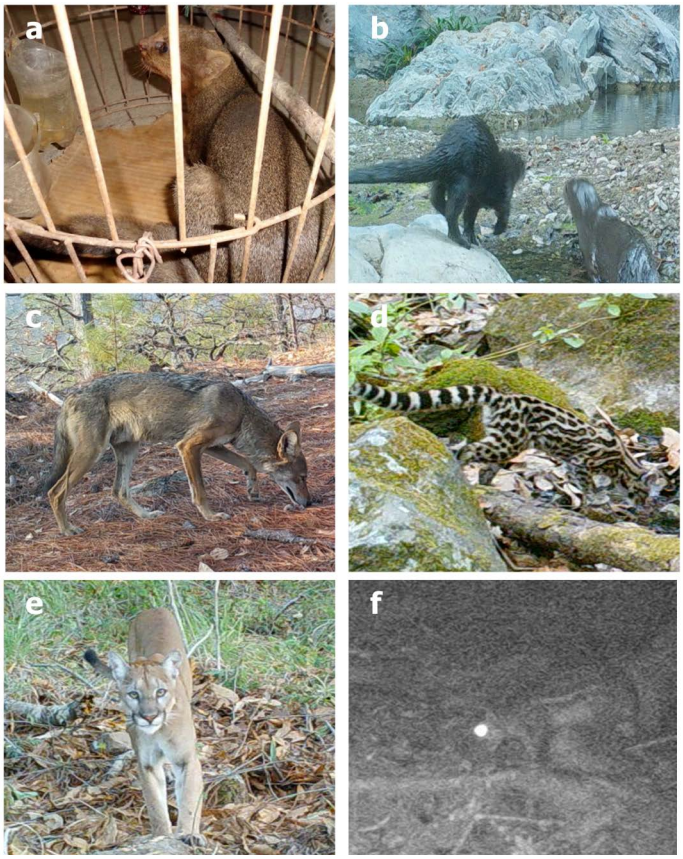

Figure 2. Evidence of medium and large-sized mammals of the Cerro Piedra Larga, Oaxaca, Mexico. a) *Herpailurus yagouaroundi* maintained in captivity, b) two individuals of *Lontra longicaudis*, c) *Canis latrans*, d) *Leopardus wiedii*, e) *Puma concolor*, and f) *Cuniculus paca*. Photographs b-f were obtained with camera-traps.

Among the species reported, seven are under some category of protection by the Mexican law, three under the endangered category (*Tamandua mexicana, Leopardus pardalis,* and *L. wiedii*), and four under the threatened category (*Glaucomys volans*, *Coendou mexicanus*, *Herpailurus yagouaroundi*, and *Lontra longicaudis*; SEMARNAT 2010). Globally only *L. longicaudis* and *L. wiedii* appear as Near Threatened (NT) by the IUCN red list (IUCN 2019).

We report the presence of 26 species of medium and large-sized mammals for the Cerro Piedra Larga. Mammal records were obtained mainly throughout camera-trapping (20 species) and bycatch direct observations during walks along transects (15 species). Several studies support the suitability and complementary of these methods to record medium and large-sized mammals (Silveira *et al.* 2003; Espartosa *et al.* 2011; Cortés–Marcial *et al.* 2014). Walks for seeking indirect evidence and direct observations are the most feasible and low-cost method for rapid assessment surveys, whereas camera-trapping had a better cost-benefit relation for long-term studies (Silveira *et al.* 2003).

In our study, direct observations allowed us to record species that for their locomotion behavior or biological rarity are scarcely recorded in camera-trapping surveys. For example, the arboreal *G. volans, T. mexicana*, *C. mexicanus,* and *B. astutus*. Despite its bias to ground-dwelling species, camera-traps cause minimal interference on behavior of animals, contrary to other methods, such as walks or trapping. Camera-trapping had the capability of record species with nocturnal and / or very evasive behaviors due to local human persecution. For instance, *C. paca*, *L. pardalis*, *L. wiedii, P. concolor*, *D. angulatus*, and *O. virginianus* were only recorded by camera-trapping.

For the Cerro Piedra Larga, Goodwin (1969) cited specimens of *G. volans*, *Urocyon cinereoargenteus*, *B. astutus*, and *N. narica*, and Peterson *et al.* (2004) reported *O. virginianus, S. aureogaster*, and *D. angulatus*. Consequently, the remaining 19 species reported in this study are new records for the region. Besides, seven species are reported for the first time to the Montañas y Valles del Centro physiographic subprovince according to Briones-Salas *et al.* (2015): *L. pardalis*, *L. wiedii*, *P. concolor*, *Conepatus leuconotus*, *D. novemcinctus*, *Didelphis virginiana*, and *L. longicaudis*.

In addition, among the species here reported stands out the presence of *G. volans* and *C. paca* (Figure 2f). Although, the record of *G. volans* is based on a direct observation, the misidentification is improbable. In the region, only *Sciurus aureogaster* is co-occurring with *G. volans*; however, *S. aureogaster* is a large diurnal squirrel, has the tail covered by fur sponged, and its pelage coloration is dorsally gray and rufous in the ventral region; *G. volans* is a small squirrel, with a colorful mainly ante, the tail has short hair and is nocturnal. The type locality of the subspecies *G. v. oaxacensis* is in this mountain (Goodwin 1969), thus our record represents the first in 60 years (Figure 3a). According to local people, *G. volans* is quite rare, inhabiting dry oak-pine forests. The main threat to this species is the wildfires promoted by the slash-and-burn agriculture practiced in the area (A. Ramírez-Bautista, pers. obs.). In the case of *C. paca* our record extends their geographical distribution at 80 km western of historical records in the Isthmus of Tehuantepec (Goodwin 1969) and 35 km southern of citizen science records in the Sierra Madre de Oaxaca (GBIF 2020; Figure 3b). It is known that *C. paca* distributes along the Atlantic versant in México (Emmons 2016), but recently the species was recorded in a pine-oak forest in the central Oaxaca (Padilla-Gómez *et al.* 2019). Besides, records obtained throughout citizen science show *C. paca* is distributed in southern parts of the Sierra Madre de Oaxaca subprovince (GBIF 2020). The aforementioned records show *C. paca* distribution extends more far (*ca.* 40 km SW) than indicated by the IUCN maps (Emmons 2016).

Considering flying, small, medium, and large mammals reported for the Cerro Piedra Larga (Goodwin 1969; Peterson *et al.* 2004; Ramírez-Bautista and Williams 2019), the species richness reaches 54 species. This accounts for 24.9 % of all the terrestrial mammals recorded in the state of Oaxaca, in less than 2 % of its territory. However, we believe this number will surely increase with long-term studies for specific groups such as bats, the most diverse order in southern México (Briones-Salas *et al.* 2015).

People recognized almost all the species recorded in the field, with exception of *C. paca*, *B. astutus*, and *M. macroura*. These species seem to be rare in the Cerro Piedra Larga, a

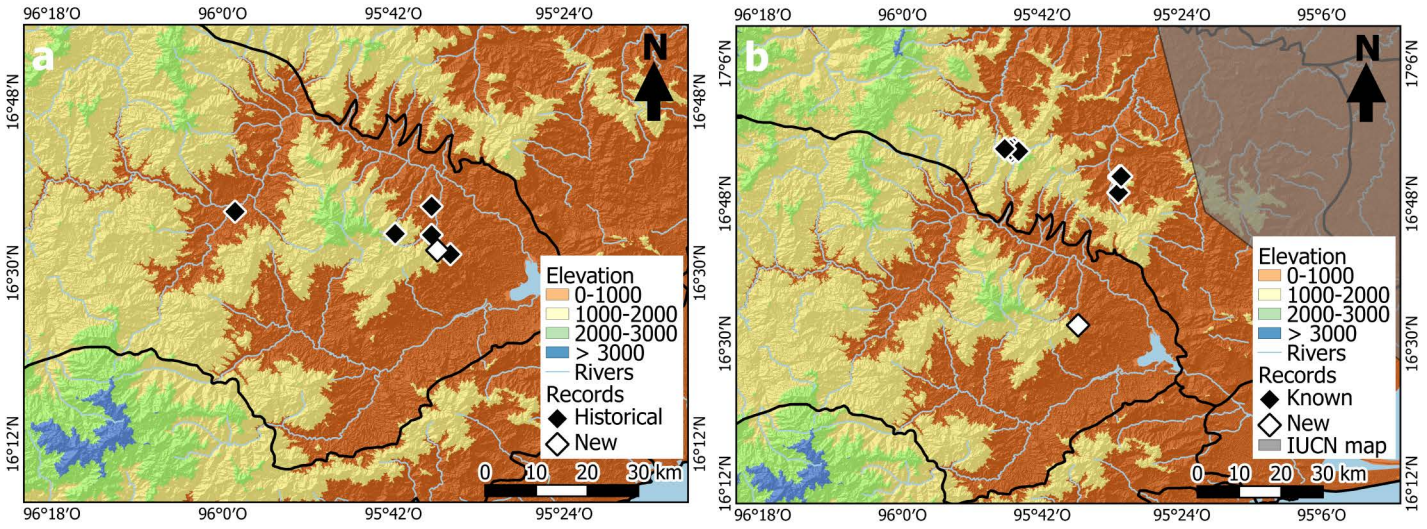

Figure 3. Records of a) *Glaucomys volans* and b) *Cuniculus paca* in and around the Cerro Piedra Larga, Oaxaca, México.

region dominated by pine-oak forest, oak forest, and dry forest, since *C. paca* is a common species in humid lowlands (Pérez 1992) and *M. macroura* is most abundant in pasturelands (List and Macdonald 1998; Cervantes *et al.* 2002; Lorenzo *et al.* 2005). In addition, the three species are mainly nocturnal with a low probability of being observed by people.

The relevance of CPL for its biodiversity has been noted previously. For instance, the mountaintop of the CPL is considered an Important Bird Area (CONABIO 2020), designated because of the presence of globally endangered bird species with low population and restricted distribution. Also, CPL holds a valuable diversity and endemism of amphibians and reptiles (Calzada-Arciniega *et al.* 2017). In this study we evidence the diversity of mammals and the presence of species of conservation concern in CPL, reinforcing the overall conservation importance of this mountain massif. Besides, high-mountain habitats are considered the most vulnerable habitats against climate change because of spatial constraints (Nogués-Bravo *et al.* 2007).

Despite its biological importance, there are no protected areas in CPL (Briones-Salas *et al.* 2016), and the only protection to natural resources comes from local government laws, as in many regions of Oaxaca (Robson 2007). While these local laws enhance the conservation of sites of overall importance for the communities, such as areas of water supply or sites with religious connotations, they generally do not contain specific rules for biodiversity conservation, especially for hunting and extraction of individuals. For example, among the three communities explored in this study, only San Pedro Jilotepec specifically prohibits the hunting of *O. virginianus* within its territory from January to October, while the rest of the animals are hunted all year round (San Pedro Jilotepec 2020). Hunting represents a major problem for mammals in CPL. Animals not only are hunted for bushmeat acquisition (*e. g.*, *O. virginianus* and *D. angulatus*) but also for being considered agricultural pests (*e. g.*, *S. aureogaster* and *P. lotor*) or predators on livestock and backyard animals (*e. g.*, *C. latrans* and *P. concolor*). Fourteen out of 26 species reported in this study have a negative conception among local people and they may suffer from hunting. A worth mentioning case is that of the *P. concolor*, local people mentioned that more than ten individuals have been killed from 2010 to 2019. Besides, many species are also killed with no apparent purpose, for example, *L. wiedii*, *C. mexicanus*, and *T. mexicana*.

Perhaps, an even major threat to the mammalian fauna (and to the overall biodiversity) of CPL is the geographical isolation that is taking place rapidly. As the highway Mitla-Tehuantepec is projected to be finished in the next five years or less (López 2019), this will likely limit the terrestrial montane connection between the Sierra Madre de Oaxaca and Sierra Madre del Sur subprovinces through the CPL. The negative impact of highways on terrestrial vertebrates has been demonstrated elsewhere (Cunha *et al.* 2010; González-Gallina *et al.* 2013) both by directly killing animals that attempt to cross them and by affecting the population dynamics. Besides, *Agave* plantation for mezcal production is promoting the rapid deforestation of the tropical dry forest (Meave *et al.* 2012) at low and intermediate elevations of CPL, exacerbating the isolating of the montane habitats and making more difficult the altitudinal migration of terrestrial species. Therefore, the construction of wildlife crossings and land-uses should be a mitigation actions to alleviate threats on fauna.

Due to its ecological attributes and geographical position, the CPL may serve as a refuge area for biodiversity as the Isthmus of Tehuantepec is projected to experience negative impacts from climate change (Williams *et al.* 2018). The creation of natural protected areas (NPAs) in this area could not be an adequate option as this top-down strategy frequently ignores the social characteristics of local communities, this may promote conflicts that undermine the conservation goals (García-Frapolli *et al.* 2009). Also, it has been observed that NPAs frequently fail to give protection to overall biodiversity, and sometimes negative impacts are higher in NPAs than in similar non-protected

areas (Figueroa and Sánchez-Cordero 2008). Instead, community-based conservation initiatives (Briones-Salas *et al.* 2016) could be the best way to achieve mammal conservation in this area. This strategy has proved to be effective in other regions with similar overall conditions (Bray *et al.* 2008; Martin *et al.* 2011). We hope this work motivates local and regional authorities to focus on this area for future conservation actions if mammals and other vertebrates are to be conserved.

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Literature cited

Aranda, M. 2000. Huellas y otros rastros de mamíferos grandes y medianos de México. Instituto de Ecología. Xalapa, México.

Bray, D., E. Duran, S. Anta, G. J. Martin, and F. Mondragón. 2008. A new conservation and development frontier: Community protected areas in Oaxaca, Mexico. Current Conservation 2:7-9.

Briones-Salas, M. A. and V. Sánchez-Cordero. 2004. Mamíferos. Pp. 423-447 *in* Biodiversidad de Oaxaca (García-Mendoza, A. J., M. Ordoñez, and M. A. Briones-Salas, eds.). Instituto de Biología, Universidad Nacional Autónoma de México- Fondo Oaxaqueño para la Conservación de la Naturaleza-World Wildlife Fund. México City, México.

Briones-Salas, M., M. Cortés-Marcial, and M. C. Lavariega. 2015. Diversidad y distribución geográfica de los mamíferos terrestres del estado de Oaxaca, México. Revista Mexicana de Biodiversidad 86:685-710.

Briones-Salas, M., M. C. Lavariega, M. Cortés-Marcial, G. Monroy-Gamboa, and C. Masés-García. 2016. Iniciativas de conservación para los mamíferos de Oaxaca, México. Pp. 329-366 *in* Riqueza y Conservación de los Mamíferos en México a Nivel Estatal (Briones-Salas, M., Y. Hortelano-Moncada, G. Magaña-Cota, G. Sánchez-Rojas, and J. E. Sosa-Escalante, eds.). Instituto de Biología, Universidad Nacional Autónoma de México, Asociación Mexicana de Mastozoología A. C. y Universidad de Guanajuato. México City, México.

Calzada-Arciniega, R. A., E. Recuero, M. G. Garcia-Castillo, and G. Parra-Olea. 2017. New records and an updated list of Herpetofauna from Cerro Piedra Larga, an isolated mountain massif in Oaxaca, Mexico. Herpetology Notes 10:651-658.

Cervantes, F. A., J. Loredo, and J. Vargas. 2002. Abundance of sympatric skunks (Mustelidae: Carnivora) in Oaxaca, Mexico. Journal of Tropical Ecology 18:463-469.

Comisión Nacional para la Conservación y Uso de la Biodiversidad (CONABIO). 2020. Important Bird Area. www.conabio.gob.mx. Consulted 23 November 2019.

Cortés-Marcial, M., Y. M. Martínez-Ayón, and M. Briones-Salas. 2014. Diversity of large and medium mammals in Juchitán, Isthmus of Tehuantepec, Oaxaca, Mexico. Animal Biodiversity and Conservation 37:1-12.

Cunha, H. F. da, F. G. A. Moreira, and S. de S. Silva. 2010. Roadkill of wild vertebrates along the GO-060 road between Goiânia and Iporá, Goiás State, Brazil. Acta Scientiarum. Biological Sciences 32:257-263.

de Ávila, and N. G. Moreno. 2008. Distribución de las lenguas indígenas de México. Jardín Etnobotánico de Oaxaca- Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México City, México.

Emmons, L. 2016. *Cuniculus paca*. *In*: IUCN 2016. The IUCN Red List of Threatened Species version 2016. www.iucnredlist.org. Consulted 6 November 2019.

Espartosa, K. D., B. T. Pinotti, and R. Pardini. 2011. Performance of camera trapping and track counts for surveying large mammals in rainforest remnants. Biodiversity and Conservation 20:2815.

Figueroa, F., and V. Sánchez-Cordero. 2008. Effectiveness of natural protected areas to prevent land use and land cover change in Mexico. Biodiversity and Conservation 17:3223.

García-Frapolli, E., G. Ramos-Fernández, E. Galicia, and A. Serrano. 2009. The complex reality of biodiversity conservation through Natural Protected Area policy: Three cases from the Yucatan Peninsula, Mexico. Land Use Policy 26:715-722.

García-Moreno, J., A. G. Navarro-Sigüenza, A. T. Peterson, and L. A. Sánchez-González. 2004. Genetic variation coincides with geographic structure in the common bush-tanager (*Chlorospingus ophthalmicus*) complex from Mexico. Molecular Phylogenetics and Evolution 33:186-196.

Global Biodiversity Information Facility (GBIF). 2020. GBIF occurrence download. https://doi.org/10.15468/dl.89za4n

González-Gallina, A., G. Benítez-Badillo, O. R. Rojas-Soto, and M. Hidalgo-Mihart. 2013. The small, the forgotten and the dead: highway impact on vertebrates and its implications for mitigation strategies. Biodiversity and Conservation 22:325-342.

Goodwin, G. G. 1969. Mammals from the State of Oaxaca, Mexico, in the American Museum of Natural History. Bulletin of the AMNH 141. New York, U.S.A.

Hoffmann, A., J. Decher, F. Rovero, J. Schaer, C. Voigt, and G. Wibbelt. 2010. Chapter 19: Field methods and techniques for monitoring mammals. Pp. 482-529 *in* Manual on Field Recording Techniques and Protocols for All Taxa Biodiversity Inventories and Monitoring. Abc Taxa Publisher. Brussels, Belgium.

Instituto Nacional de Estadística y Geografía (INEGI). 2010. Censo de población y Vivienda 2010. Instituto Nacional de Estadística y Geográfica. San Luis Potosí, México.

International Union for Conservation of Nature (IUCN). 2019. IUCN Red list categories. IUCN. Available at https://iucn.org.

Lacher, Jr., T. E., A. D. Davidson, T. H. Fleming, E. P. Gómez-Ruiz, G. F. McCracken, N. Owen-Smith, C. A. Peres, and S. B. Vander Wall. 2019. The functional roles of mammals in ecosystems. Journal of Mammalogy 100:942-964.

List, R. H., and D. W. Macdonald. 1998. Carnivora and their larger mammalian prey: species inventory and abundance in the Janos-Nuevo Casas Grandes praire dog complex, Chihuahua. Revista Mexicana de Mastozoología 3:95-112.

López, P. J. 2019. Empresas de Slim terminarán la carretera Mitla-Tehuantepec. Milenio. https://www.milenio.com/negocios/empresas-carlos-slim-terminaran-carretera-mitla-tehuantepec. Consulted on 26 November 2019.

Lorenzo, C., J. E. Bolaños, E. C. Sántiz, and F. A. Cervantes. 2005. Distribución y densidad de zorrillos en el Istmo de Tehuantepec, Oaxaca, México. Pp. 317-324 *in* Contribuciones Mastozoológicas en Homenaje a Bernardo Villa (Sánchez-Cordero,

V., and R. A. Medellín, eds.). Instituto de Biología, Instituto de Ecología, Universidad Nacional Autónoma de México, Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México City, México.

Martin, G. J., C. I. Camacho, C. A. Del Campo, S. Anta, F. Chapela, and M. A. González. 2011. Indigenous and community conserved areas in Oaxaca, Mexico. Management of Environmental Quality: An International Journal 22:250-266.

Meave, J. A., M. A. Romero-Romero, S. H. Salas-Morales, E. A. Pérez-García, and J. A. Gallardo-Cruz. 2012. Diversidad, amenazas y oportunidades para la conservación del bosque tropical caducifolio en el estado de Oaxaca, México. Revista Ecosistemas 21:85-100.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. Da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Nogués-Bravo, D., M. B. Araújo, M. P. Errea, and J. P. Martínez-Rica. 2007. Exposure of global mountain systems to climate warming during the 21st Century. Global Environmental Change 17:420-428.

Ortiz-Pérez, M. A., J. R. Hernández, and J. M. Figueroa. 2004. Reconocimiento fisiográfico y geomorfólogico. Pp. 43-54 *in* Biodiversidad de Oaxaca (García-Mendoza, A., M. Ordoñez, and M. A. Briones-Salas, eds.). Instituto de Biología, Universidad Nacional Autónoma de México-Fondo Oaxaqueño para la Conservación de la Naturaleza-World Wildlife Fund. México City, México.

Padilla-Gómez, E., J. Santiago-Velasco, M. C. Lavariega, and A. Ramírez-Bautista. 2019. Noteworthy records of jaguar (*Panthera onca*), tayra (*Eira barbara*), and paca (*Cuniculus paca*) from southern Mexico. Notas sobre mamíferos Sudamericanos 20:e-536.

Pérez, M. 1992. *Agouti paca*. Mammalian Species 404:1-7.

Peterson, A. T., L. Canseco, J. L. Contreras, G. Escalona-Segura, O. Flores-Villela, J. García-López, B. Hernández-Baños, C. A. Jiménez, L. León-Paniagua, S. Mendoza, A. G. Navarro-Sigüenza, V. Sánchez-Cordero, and D. E. Willard. 2004. A preliminary biological survey of cerro Piedra Larga, Oaxaca, México: birds, mammals, reptiles, amphibians, and plants. Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoológica 75:439-466.

Ramírez-Bautista, A., and J. Williams. 2019. The importance of productivity and seasonality for structuring small rodent diversity across a tropical elevation gradient. Oecologia 190:275-286.

Ramírez-Pulido, J., C. Britton, and A. Castro. 1986. Guía de los mamíferos de México: referencias hasta 1983. Universidad Autónoma Metropolitana, Unidad Iztapalapa. México City, México.

Ramírez-Pulido, J., N. González-Ruíz, A. L. Gardner, and J. Arroyo-Cabrales. 2014. List of recent land mammals of Mexico. Special Publications Museum of Texas Tech University 63:1-69.

Reid, F. 2006. A field guide to mammals of North America, north of Mexico. Houghton Mifflin Harcourt. New York, U.S.A.

Robson, J. P. 2007. Local approaches to biodiversity conservation: lessons from Oaxaca, southern Mexico. International Journal of Sustainable Development 10:267-286.

San Pedro Jilotepec. 2020. Ordenamiento Territorial Comunitario de San Pedro Jilotepec. 2020. Available at aramirezbta@gmail.com.

Sánchez-Cordero, V. 1993. Biological surveys and conservation in Mexico. Association of Systematic Collection Newsletter 21:54-58.

Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT). 2010. Norma Oficial Mexicana NOM-059-ECOL-2010, Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Diario Oficial de la Federación 2454:1-77.

Silveira, L., A. T. A. Jácomo, and J. A. F. Diniz-Filho. 2003. Camera trap, line transect census and track surveys: a comparative evaluation. Biological Conservation 114:351-355.

Williams, J. N., R. Rivera, H. Choe, M. W. Schwartz, and J. H. Thorne. 2018. Climate risk on two vegetation axes—Tropical wet-to-dry and temperate arid-to-moist forests. Journal of Biogeography 45:2361-2374.

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