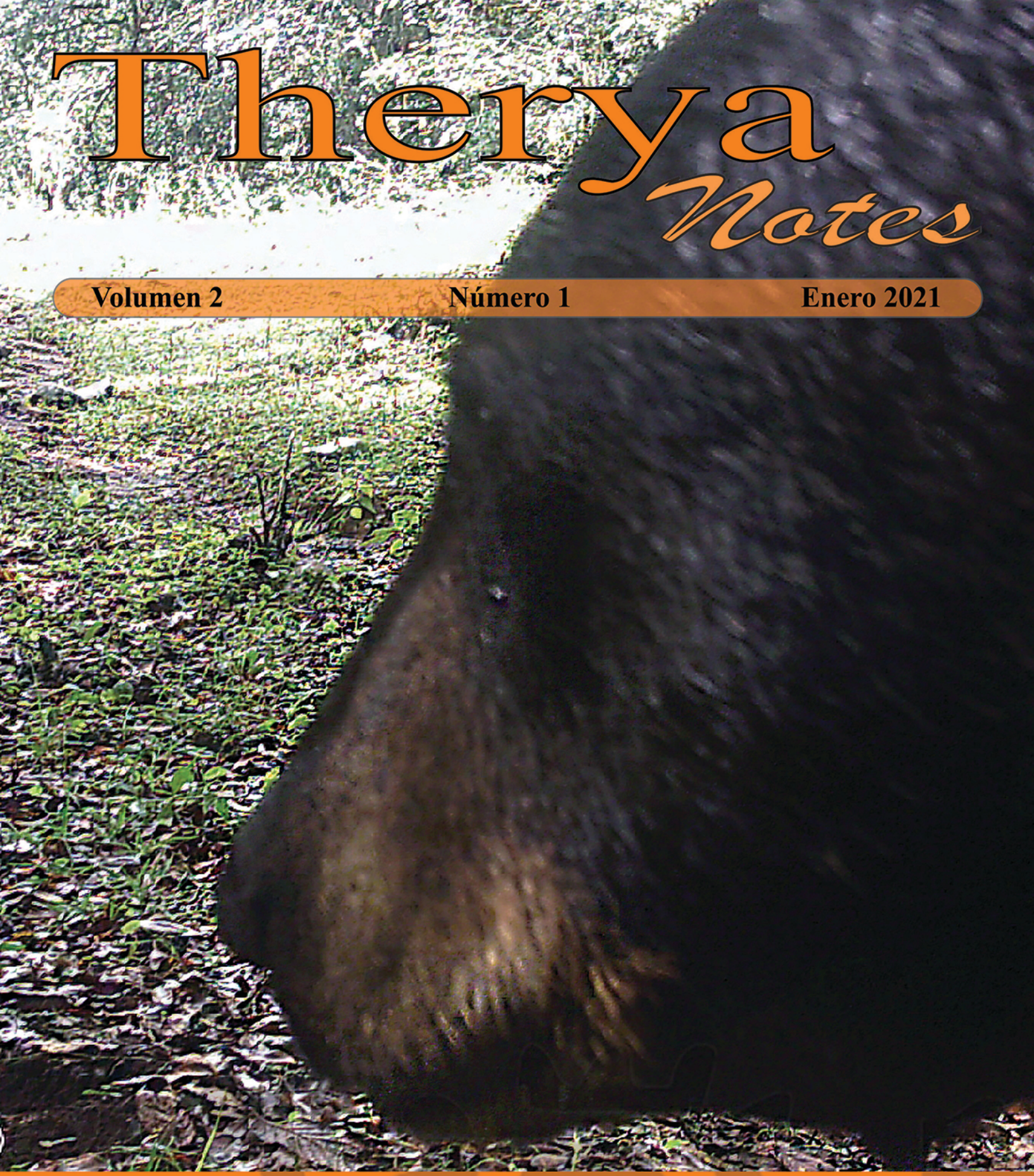

Therya Notes

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AMMAC
Asociación Mexicana de Mastozoología A.C.

THERYA NOTES tiene como propósito difundir exclusivamente notas científicas con información original e inédita relacionada con el estudio de los mamíferos en todas las disciplinas que contribuyen a su conocimiento. Es un foro abierto para profesores, investigadores, profesionales y estudiantes de todo el mundo, en el que se publican notas académicas en español e inglés. THERYA NOTES es una revista digital de publicación cuatrimestral (tres fascículos por año) que recibe propuestas para publicación durante todo el año. Tiene un sistema de evaluación por pares a doble ciego y es de acceso abierto.

En la Portada

El oso negro (*Ursus americanus*) redujo significativamente su área de distribución en México en el siglo XX. En los últimos años, sin embargo, hay evidencia de su presencia en áreas fuera del rango de distribución propuesto. Recientes esfuerzos de monitoreo permitieron detectar osos negros en los estados de Guanajuato, Querétaro y San Luis Potosí, en México, en un área cercana a la distribución más sureña para esta especie en el Continente Americano. La presencia de oso negro en el centro-este de México señala la necesidad de intensificar el monitoreo sistemático de la biodiversidad en la SMO y en áreas protegidas de la región a través de programas de monitoreo y conservación.
(Fotografía de Charre-Medellín et al. 2021)

El logo de la AMMAC: "Ozomatli"

El nombre de "Ozomatli" proviene del náhuatl, se refiere al símbolo astrológico del mono en el calendario azteca, así como al dios de la danza y del fuego. Se relaciona con la alegría, la danza, el canto, las habilidades. Al signo decimoprimero en la cosmogonía mexica. "Ozomatli" es una representación pictórica del mono araña (*Ateles geoffroyi*), la especie de primate de más amplia distribución en México. "Es habitante de los bosques, sobre todo de los que están por donde sale el sol en Anáhuac. Tiene el dorso pequeño, es barrigudo y su cola, que a veces se enrosca, es larga. Sus manos y sus pies parecen de hombre; también sus uñas. Los Ozomatin gritan y silban y hacen visajes a la gente. Arrojan piedras y palos. Su cara es casi como la de una persona, pero tienen mucho pelo."

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EQUIPO EDITORIAL

CONTENIDO

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The tropical pocket gopher (*Geomys tropicalis*) on the brink of extinction

La tuza tropical (*Geomys tropicalis*), al borde de la extinción

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The tropical pocket gopher (*Geomys tropicalis*) is a rodent with fossorial habits that lives only in a small region of the southern coastal area of Tamaulipas, México. It is a distinctive mammal with unique morphological, genetic and ecological characteristics that makes it a relevant species. Unfortunately, it is not studied or monitored and its existence in the region is unknown. Currently, the growth of agriculture, urbanization and industrialization in the vicinity of the cities of Altamira and Tampico have severely fragmented and reduced its habitat, which is why it is considered that its population is continuously decreasing; consequently, it is listed as a species at high risk of extinction. Previous estimates of its potential distribution indicate the existence of areas surrounding its original distribution with appropriate abiotic characteristics for its presence where it can be protected. Therefore, it is urgent that the public be aware of this situation and that residents, authorities, academics and non-governmental organizations join forces proposing and activating actions for their conservation.

Key words: Altamira; conservation; Geomyidae; habitat loss; mound; Tampico; underground.

La tuza tropical (*Geomys tropicalis*) es un roedor de hábitos fosoriales que habita únicamente una pequeña región de la zona costera del sur de Tamaulipas, México. Es un mamífero con características morfológicas, genéticas y ecológicas únicas que lo hace una especie relevante. Desafortunadamente, no se estudia ni monitorea y se desconoce su existencia en la región. Actualmente el crecimiento de las prácticas de agricultura, urbanización e industrialización de las ciudades de Altamira y Tampico han fragmentado y reducido severamente su hábitat y se considera que su población disminuye continuamente; en consecuencia, se le clasifica como especie en alto riesgo de extinción. Estimaciones previas sobre su distribución potencial indican la existencia de áreas aledañas a su distribución original con características abióticas apropiadas para su presencia en donde puede ser protegida. Por lo tanto, es urgente que el público en general conozca esta situación y que pobladores, autoridades, académicos y organizaciones no gubernamentales unan esfuerzos para proponer y activar acciones para su conservación.

Palabras clave: Altamira; conservación; Geomyidae; montículo; pérdida de hábitat; subterráneo, Tampico.

The tropical pocket gopher (*Geomys tropicalis*) is a rodent (Family Geomyidae) described at the beginning of the 20th century with specimens collected in Altamira, Tamaulipas, by Edward A. Goldman (Figure 1a). Originally it was called "Tamaulipas gopher" and considered taxonomically to correspond to a subspecies of *Geomys personatus* (*G. p. tropicalis*; Goldman 1915); almost 50 years later, it was recognized as a taxonomic entity at the species level (*G. tropicalis*; Álvarez 1963). This species lives exclusively in México and has no subspecies (Figure 2a). Currently, 105 years after its description, it continues to be a practically unknown mammal in danger of extinction, mainly due to the destruction of its habitat. Therefore, the objectives of this document are to disclose its existence, report on the critical state of its population and stimulate sectors of society to initiate actions in favor of its conservation.

Characteristics of the tropical pocket gopher. The tropical pocket gopher is medium in size and adapted to live almost all the time below the surface of the soil (fossorial). Its face is short and broad and its fur is velvety, short and with cinnamon to cinnamon buff color that becomes lighter towards the ventral parts; it has highly sensory whiskers and its tail is hairless (Baker and Williams 1974). The dark and relatively quiet environment of the interior of its galleries and narrow spaces have selected adaptations in all species of pocket gophers such as the presence of proportionally small eyes and ears. Adult specimens measure an average of 245.2 mm in total length, with males (255.9 mm) slightly larger than females (234.5 mm; Williams and Genoways 1977). Males are, on average, slightly heavier than females (268.3 and 189.4 gr, respectively); its tail measures 82 mm on average and the right hind leg 33.8 mm (Álvarez 1963). Its original geographic distribution is allopatric in relation to other species of pocket gophers (Figure 2a).

The pectoral musculature and the developed claws of the front legs allow it to dig long underground galleries that it uses as burrows (Figure 1b). They have five toes on each leg and calluses on the palm of the forelimbs that make it easier for them to push the dirt. Like other pocket gopher species, it has an external pouch or pocket-shaped fold of skin on each cheek where it stores freshly cut food to reduce the time of exposure to possible predators when it collects food outside its burrow (Hafner 2016). This pocket gopher is most active at dawn and dusk and

feeds mainly on aerial parts such as stems and leaves, roots and bulbs of herbaceous plants; it also consumes soft, thin stems of shrubs (Bradford 2017).

Its powerful teeth consist of 20 teeth that grow continuously due to their intense wear. It has four large incisors with a dense layer of frontal enamel that provides additional toughness (Figure 1c). This allows it to cut through all kinds of plant matter when it surfaces; even using them to "break" the earth when digs. The remaining 16 teeth are relatively flat oval molariforms that use to finely grind the materials on which it feeds on (Hafner 2016).

Evidence of their presence are the mounds of earth on the surface of the soil that are easily visible and recognizable. These are unmistakable traces of earth that they extract from the construction of underground burrows and that accumulate at the entrance and exit of their tunnels (Bradford 2017). At the top of some fresh mounds one can see the trace of a small plugged hole through which the gopher appeared for the last time. They are generally found in natural open fields and growing areas; they are rarely found on stony or wooded areas. In other species of pocket gophers of the genus *Geomys*, it is common to observe up to a dozen of these mounds in natural areas of around 40-50 m^2 (Hafner 2016). In all the pocket gopher species of the Geomyidae family, the adults are solitary individuals, so this condition normally corresponds to the activity of a single adult individual.

Figure 1. a) The tropical pocket gopher (*Geomys tropicalis*; photograph by G. Ceballos from the Image Bank of the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México). b) Right lateral and ventral views of the anterior part of the body of *G. tropicalis*. Note the development of the claws (photograph by K. E. Juárez). c) Dorsal, ventral and lateral views of the skull and mandible of *G. tropicalis* (collection catalog number: CNMA_37203, adult female). Note the large front incisor teeth and the thick orange enamel coating on the front surface (photograph by K. E. Juárez).

Its natural habitat is the coastal plain of southern Tamaulipas (Figure 2b), with deep sandy soil and typical arid adapted vegetation. The ground is covered with halophile vegetation, including herbaceous plants and grasses; in some areas the landscape also contains shrub forms and isolated trees such as mesquite (*Prosopis*), cactus (*Opuntia*), and acacia (*Vachellia*; Arriaga *et al.* 2000).

From a genetic point of view, this pocket gopher is also unique and distinctive. Its karyotype consists of a diploid chromosome number (2*n*) of 38 and a fundamental number (FN) of 72 (Davis *et al.* 1971). This set of genetic information is comparatively different from that of other species of pocket gopher by its low number of chromosomes and by the biarmed condition (two arms on each side of the centromere) of the autosomes (36 non-sexual chromosomes); in addition, several of the subtelocentric chromosomes have secondary constrictions. The analysis of its "G" and "C" chromosome bands showed that this chromosomal arrangement is the product of a complex chromosomal evolution not observed in other species of its genus, where the main probable mechanism was many centric fusions of acrocentric chromosomes (Davis *et al.* 1971).

Biological variation among species of the genus *Geomys* is moderate, so their phylogenetic relationships have been difficult to assess, even using morphometric, chromosomal and genetic data (Davis *et al.* 1971). However, a general opinion was that the chromosomal characteristics of *G. tropicalis* were the strongest criteria for the continuous recognition of the tropical pocket gopher as an independent evolutionary lineage sufficiently different from other species of the genus *Geomys* (Jolley *et al.* 2000).

The use of molecular markers in mammal systematics provided phylogenetic information revealing that *G. tropicalis* is part of the group of species of the Texas pocket gopher (*G. personatus*), together with Strecker's pocket gopher (*G. streckeri*), and Attwater's pocket gopher (*G. attwateri*; Sudman *et al.* 2006). This research approach using mitochondrial and nuclear genes indicated that the phylogenetic position of the tropical pocket gopher places it as the sister taxa of a subspecies of the Texas pocket gopher (*G. personatus davisi*; Chambers *et al.* 2009). Additional comparisons between these two species showed that some of their genes share identical nucleotide sequences, which supports the hypothesis of their common ancestry; they also identified other unique sequences of the evolutionary lineage of each species. This molecular process led to a low genetic distance between this pair of species compared to that recorded for other combinations of sister species of the *personatus* species group; inclusive, even more, the topology of the phylogenetic reconstruction suggests that the tropical pocket gopher could be recognized as part of *G. personatus* (Chambers *et al.* 2009).

However, the decision to recognize *G. tropicalis* as a complete taxonomic and evolutionary entity standed also because its geographic distribution is completely isolated from any other *Geomys* species, and because *G. personatus davisi* is proposed to be promoted to species status, which would leave the phylogenetic recognition of *G. tropicalis* as a complete species unrestricted (Chambers *et al.* 2009). To better support these hypotheses, a broad sampling of genes would have to be carried out, examining a greater number of individuals and from different geographical origins.

Ecological importance. The tropical pocket gopher is relevant for the structure and function of its ecosystem (Huntly and Inouye 1988). By removing the soil, this rodent promotes the dynamics of the physical and chemical characteristics of the soil and favors the presence of wild plants (primary producers of the ecosystem; Mielke 1977). Likewise, it contributes to the regulation of plant populations due to the selective removal of plants that it carries out for their food and the collection of plant material for nesting (Hafner 2016).

On the other hand, as part of the food web in its habitat, this pocket gopher is predated by snakes (*Crotalus*), owls (*Bubo*), weasels (*Mustela*), foxes (*Urocyon*) and skunks (*Mephitis*; Vaughn 1961; Hafner 2016). As in other species of pocket gophers, *G. tropicalis* becomes potential prey for predators when it emerges from its burrow to search for food at the ground's surface (Hafner 2016). Additionally, its abandoned tunnels generate protection and shelter spaces for many species of invertebrates (*i.e.*, worms, spiders, crickets, mealybugs, ants, snails, among others) and vertebrates, *i.e.*, mice (*Peromyscus*), squirrels (*Urocitellus*), toads (*Bufo*), lizards (*Cnemidophorus*), snakes (*Pituophis*); Vaughn 1961; González-Romero 2018). The presence of all these species, in turn, generates predator-prey relationships between them (Vaughn 1961). Consequently, the tunnels of abandoned *G. tropicalis* burrows can also become foraging routes for small predators.

Therefore, tropical pocket gophers are essential to contribute to the presence of different trophic levels of its ecosystem and the necessary energy flow. The biotic part of its habitat has a delicate and fragile ecological balance on which all species of halophile vegetation and associated fauna depend, including *G. tropicalis*.

Extinction risk. One of the problems for the conservation of many species at some risk of extinction is that they go unnoticed in their natural environment because they are not known to the public. This produces that what is not known is not investigated and, therefore, is not preserved and disappears. This circumstance greatly affects the tropical pocket gopher, because by not knowing its risk of extinction, it can be lost without realizing it.

The Mexican federal government considers the tropical pocket gopher as a mammal placed in the category of "Threatened" (Trujillo-Segura 2019). This means that this rodent "could find itself in danger of disappearing in the short or medium term, if the factors that negatively affect its viability continue to operate, by causing the deterioration or modification of its habitat or directly reducing the size of its populations" (SEMARNAT 2020).

On the other hand, the International Union for the Conservation of Nature (IUCN) has kept the tropical pocket gopher in one of its categories of extinction risk for many years now. During the period 2008-2017, this organiza-

Figure 2. a) Geographical distribution of the tropical pocket gopher (*Geomys tropicalis*) and the Texan gopher (*G. personatus*), the closest phylogenetically species (modified from Lacher 2016, and Roach 2018). b) Priority land region "Laguna San Andrés", located in the municipalities of Aldama, Altamira and Ciudad Madero, State of Tamaulipas (red vertical rectangle; Arriaga *et al.* 2000), and Protected Natural Area "La Vega Escondida", in the Municipality of Tampico, Tamaulipas (red circle; De la Garza-Govela 2003). Three federal protected natural areas are also shown in the same federal entity: a Sanctuary (SANT), a Flora and Fauna Protection Area (APFF), and a Biosphere Reserve (RB; modified from CONANP 2019).

tion placed *G. tropicalis* in the category of "critical danger of extinction". In its last assessment in 2018, the IUCN classified the tropical pocket gopher as "endangered" (Roach 2018). The criteria for making this decision were that its geographic distribution area is less than 5,000 km^2 and that its area of occupation is less than 150 km^2; both small areas. Also, that their populations are fragmented, isolated and associated with a very specific type of habitat.

This scenario by itself is a threat due to intrinsic factors of the species related to population size, distributional area and isolation; a severe problem is the decrease in gene flow and the loss of genetic variation. If there is not a minimum number of reproductive adults and connections between populations, there is a risk that interbreeding and genetic drift will affect the level of genetic variability necessary for populations of this species to remain healthy in their natural habitat. Especially now that wild species require more than ever to conserve their full genetic potential to successfully face the ongoing challenges of climate change.

Additionally, the IUCN highlighted that its environment suffers a continuous degradation in quantity and quality. Agriculture and industrialization are eliminating their area of occupation, which is rapidly contributing to the fragmentation of their habitat. Various sites that have been reported in the past by field biologists as locations of occurrence of the tropical pocket gopher (*e.g.*, Altamira; 1 mi S Altamira; 2.4 mi S Altamira; 2.5 mi SSE Altamira; 2.5 mi SW Altamira; 1 mi N Tampico; 10 mi. NW Tampico; Williams and Genoways 1977), have now become urban areas of the cities of Altamira and Tampico, Tamaulipas. Consequently, the IUCN mentioned that *G. tropicalis* could return to the maximum level of extinction risk: "critical danger of extinction" (Critically Endangered), as its presence continues to decrease and its populations remain isolated (Roach 2018). However, they think it is necessary to gather more information about their population status before making that decision.

Also reporting to the IUCN, a group of specialists, nationals and foreigners, from the Small Mammal Specialist Group and the Conservation Planning Specialist Group led a workshop in Puebla in 2018 to gather available information on the conservation of Mexican small mammals, identify their research priorities and plan mechanisms for the implementation of actions for their conservation (SMSG 2018). They identified 17 Mexican rodent species as critically endangered, including *G. tropicalis*. However, they selected only 6 for the development of conservation strategies and their financial support; among the selection criteria used, the phylogenetic distinction, population size and trend, number of localities and threats, among others, stand out. Although *G. tropicalis* shared the highest "urgency value" result with other species, the "feasibility value" was not the highest, nor was the "number of other threatened species that would benefit" value. Therefore, the tropical pocket gopher was out in 8th place.

There are no published studies on the biology of *G. tropicalis* in almost 20 years, nor has its presence been documented in its original range; it has not been mentioned in any technical or scientific disclosure paper, except for the report by Fernández *et al.* (2014), who claimed to have seen in 1993 only a few small fragments of habitat suitable for *G. tropicalis* in the surroundings of Altamira, Tamaulipas. Therefore, they agreed to report it as a critically endangered species and recommended urgent distribution and abundance studies to prevent its disappearance.

A detailed updated assessment of the conservation status of this mammal is necessary. It is worrying that no project or program of any sector of society dedicated to this task is publicly known. The evaluation of the risk of extinction of the native species of México must be considered a priority action in terms of the conservation of biodiversity (García-Aguilar *et al.* 2017). Unfortunately, what does exist is information about other species of pocket gopher and the damage they cause (Hafner 2016), as they are considered a pest species and are fought with unnecessary cruel methods. We should not wait for this situation to be repeated with *G. tropicalis*.

Perspectives. The extinction of native flora and fauna species in their natural habitat continues to be a matter of concern in México in terms of biodiversity conservation. On occasions, a supposed disappearance of a species is reported because in several years it has not been seen or recorded in its natural environment. In other cases, because no one studies them there are no mentions of their existence. These examples almost always refer to species that have a small and little explored geographic distribution.

Such is the case of the Omiltemi rabbit (*Sylvilagus insonus*) known only from a small area of the cloud forest of Guerrero, México, and declared extinct in 1977 (MacPhee and Fleming 1997). Shortly after, this mammal was searched in its natural habitat and rediscovered (Cervantes *et al.* 2003). Similarly, the San Quintin kangaroo rat (*Dipodomys gravipes*), which was known only from a small strip of desert in the northwestern state of Baja California, was considered an extinct species by the Mexican government; in April 2018 it was rediscovered (Tremor *et al.* 2019). Another case is the Los Tuxtlas shrew (*Cryptotis nelsoni*), whose presence had never been documented for more than 100 years. It was not until 2002 that its presence was confirmed in the San Martín Tuxtla Volcano, Veracruz (Cervantes and Guevara 2010).

Unfortunately, no recent record has been reported for the tropical pocket gopher, meaning its presence has not been scientifically documented for many years; the most likely reason it is that is not inhabiting the same area where it existed before (Fernández *et al.* 2014). Available public information indicates that it is an unknown species. The latest evidences of its existence are more than 100 specimens conventionally prepared for scientific study in some American biological collections, which were collected shortly after the year 2000. In all of México, however, there is only one specimen at the National Mammal Collection of the Institute of Biology, National Autonomous University of México (catalog: CNMA37203, female; Figures 1b and 1c), reflect-

ing the ignorance surrounding these species. Although the government of México and the IUCN considered the tropical pocket gopher in some category of risk of extinction, it is not enough with names on paper to save this important and distinctive rodent of Mexican biodiversity from probable extinction.

In principle, it would not be necessary to collect specimens to confirm the taxonomic identity of the species until ensuring that its populations maintain a similar size to that of other pocket gopher species; however, an individual could be captured, somatic measurements and tissue samples for DNA lab work taken, photographed, and released immediately. Next, it would be necessary to verify their presence at short intervals and keep a record for their monitoring.

Protected natural areas: alternative. An alternative to help conserve the tropical pocket gopher is to promote its protection and management in a protected natural area. None of the three federal reserves in the Coastal Plain and Gulf of Mexico region (Sierra de Tamaulipas, Playa de Rancho Nuevo, Laguna Madre and Delta del Río Bravo; CONANP 2016) would be an option, since none coincides with the geographical distribution of *G. tropicalis*.

However, the municipal reserve called "La Vega Escondida", located in the municipality of Tampico, Tamaulipas (De la Garza-Govela 2003), could be a viable option (Figure 2b). It is a special area subject to ecological conservation due to the importance it represents for its biodiversity, which is located northwest of the City of Tampico and coincides with the distribution area of *G. tropicalis*; this is important because all published field records of the tropical gopher are from Altamira city to the south. By a decree of the municipal authorities it is known that "the inhabitants of the Tampico-Madero-Altamira conurbation, including the users of the lagoons, as well as environmental groups and the scientific community, have expressed interest in establishing a protection regime in at least one part of the lagoon system of the Tamesí River, which allows stopping or limiting the degradation of this ecosystem" (De la Garza-Govela 2003). In addition, as an environmental policy of that level of government, it was known that "The establishment of priority areas for the preservation and restoration of the ecological balance and the care of the sites necessary to ensure the maintenance of the diversity of flora and fauna is of public utility, wild and aquatic fauna, and that it be incorporated at the regional level in efforts to promote and strengthen environmental education" (De la Garza-Govela 2003). If the presence of the tropical pocket gopher is confirmed in that area, this scenario could already be used as a platform to seek support in favor of its protection, counting with the endorsement of an authority and, on the other hand, in a site of its potential distribution.

In addition, the Laguna San Andrés priority terrestrial region could also help conserve the tropical pocket gopher (Figure 2b). Although administratively it is not a protected area, it is a site whose purpose is the ecological conservation of areas of biological richness, highlighting the presence of endemic and threatened species (Arriaga *et al.* 2000). Even in the designation of this region, the presence of the tropical pocket gopher was considered as one of several criteria to select that place as a priority land region in Tamaulipas (Arriaga *et al.* 2000). Until now, the presence of the tropical pocket gopher to the north of the city of Altamira has not been documented, but the potential distribution estimated with curatorial records of scientific collections by two different working groups (Ballesteros-Barrera 2016; Ceballos-González 2008) indicates that the distribution of *G. tropicalis* almost adjoins Laguna San Andrés, for which it is necessary to carry out inventories to confirm the presence of the tropical pocket gopher in that priority terrestrial region.

At present, a work team made up of students and academics from the Altamira Technological Institute, the Institute of Biology, UNAM, and personnel from some civil organizations have initiated actions to advocate these recommendations. They intend to search and document the presence of the tropical pocket gopher in the municipalities of Altamira and Tampico, characterize its current habitat, factors that modify it, and percentage of loss thereof.

Conclusions. The tropical pocket gopher *Geomys tropicalis* is an exclusively Mexican species with unique characteristics and its presence in its ecosystem is necessary. Unfortunately, it is an endangered species and its continuous existence is not warranted. However, there are options to start planning actions aimed at protecting this species. It should begin by carrying field work to confirming its existence in its original range and, without a doubt, the active participation of personnel from the state reserve and the priority land region mentioned above should be incorporated. Identifying the presence of the tropical pocket gopher would not be difficult as finding mounds of earth in the field would reveal its presence; they are unmistakable traces that would allow us to update our knowledge of their distributional area.

Thereupon it is necessary to summon various sectors of society to plan and formally participate in actions aimed at the investigation of *G. tropicalis* for its conservation and management. The authorities of the three levels of government, local people, the academic sector and non-governmental organizations should be the main actors in an initiative of this nature. It is therefore urgent to disseminate both the knowledge of the existence of the tropical pocket gopher and its status as a species at risk of extinction and promote citizen participation in this matter. If this paper helps to achieve these objectives, it will have served its purpose.

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colleague and friend; his work for the knowledge and conservation of Mexican wildlife left an indelible mark.

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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-

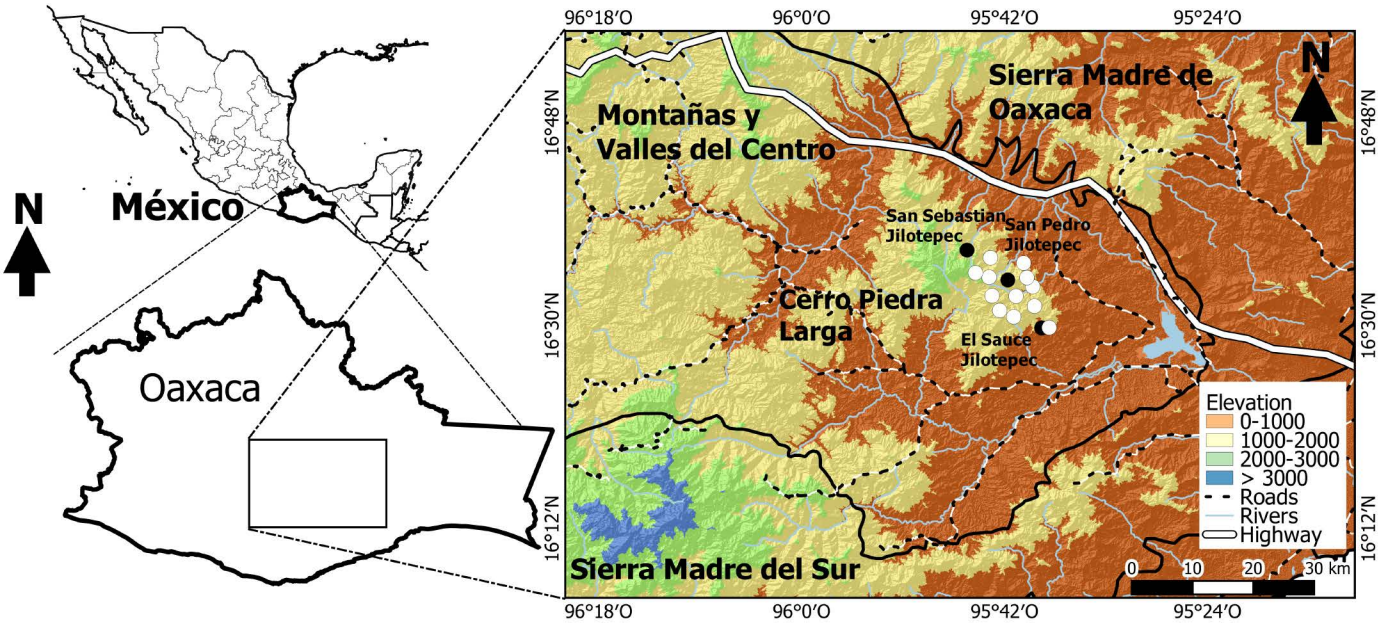

Figure 1. Localization of Cerro Piedra Larga. Black circles are the human localities. White circles are the camera-trap stations. Highway redrawn from https://www.proyectosmexico.gob.mx/proyecto_inversion/083-tramo-carretero-libre-de-peaje-mitla-entronque-tehuantepec/.

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	

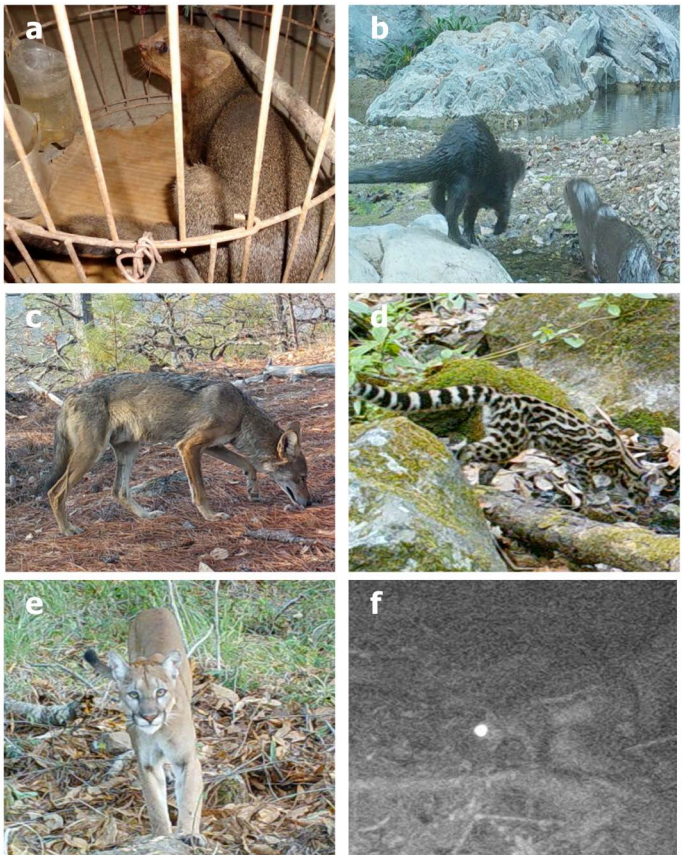

Figure 2. Evidence of medium and large-sized mammals of the Cerro Piedra Larga, Oaxaca, Mexico. a) *Herpailurus yagouaroundi* maintained in captivity, b) two individuals of *Lontra longicaudis*, c) *Canis latrans*, d) *Leopardus wiedii*, e) *Puma concolor*, and f) *Cuniculus paca*. Photographs b-f were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

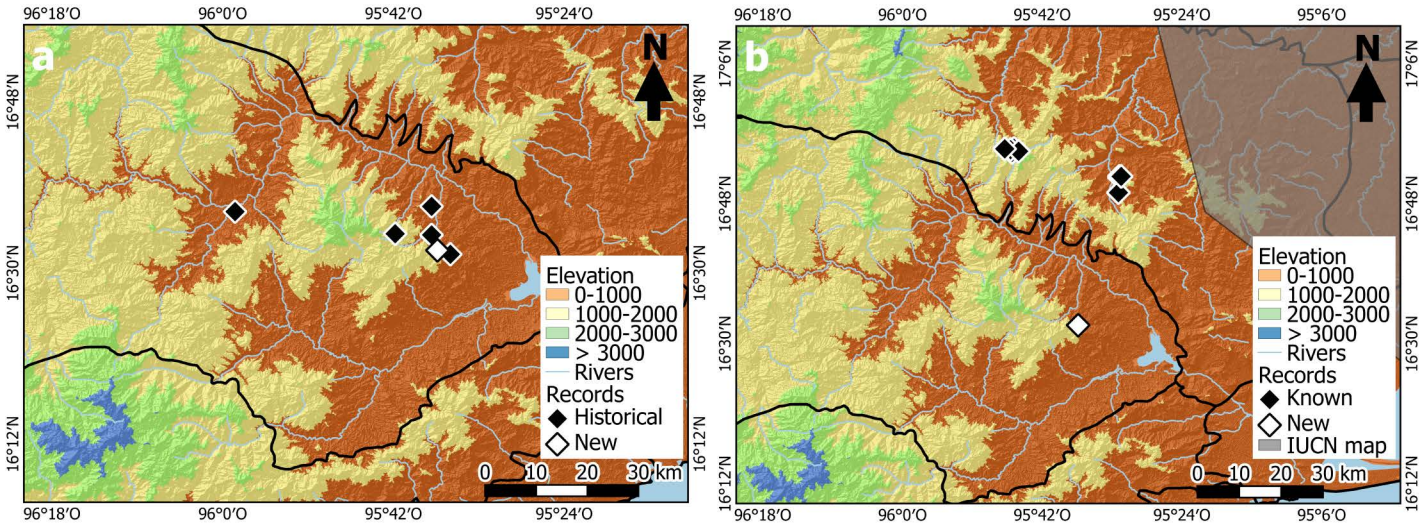

Figure 3. Records of a) *Glaucomys volans* and b) *Cuniculus paca* in and around the Cerro Piedra Larga, Oaxaca, México.

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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Central American woolly opossum (*Caluromys derbianus*): distribution, ecology and conservation threats in Panamá

Zarigüeya lanuda centroamericana (*Caluromys derbianus*): distribución, ecología y amenazas para su conservación en Panamá

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Little is known about the distribution and ecology of the Central American woolly opossum (*Caluromys derbianus*) in Panamá. Therefore, the aim of this study is to update geographical data and ecological information to fill this gap. Based on examinations of museum specimens, published data and field observations, we obtained 362 records of *C. derbianus* in Panamá. Our results suggest a wide distribution of *C. derbianus* across both natural and disturbed lowland environments. Moreover, we provide baseline information about its potential anthropogenic and natural threats, as well as general aspects of its diet in Panamá.

Key words: Central America; depredation; Didelphidae; diet; environments; synanthropic; threats.

Existe poco conocimiento de la distribución y ecología de la zarigüeya lanuda centroamericana (*Caluromys derbianus*) en Panamá. Por lo tanto, el objetivo de este trabajo es actualizar datos geográficos e información ecológica para llenar este vacío. Con base en revisiones de especímenes de museos, datos publicados y observaciones de campo, obtuvimos 362 registros de *C. derbianus* en Panamá. Nuestros resultados muestran una amplia distribución de *C. derbianus* entre ambientes de tierras bajas tanto naturales como perturbados. Adicionalmente, proporcionamos información base de sus amenazas potenciales naturales y antrópicas, así como aspectos generales sobre su dieta en Panamá.

Palabras clave: Ambientes; amenazas; América Central; depredación; Didelphidae; dieta; sinantropía.

American marsupials include the orders Microbiotheria (1 species) and Didelphimorphia (18 genera and 110 species), which are primarily known as opossums (Voss and Jansa 2009; Amador and Giannini 2016). The most commonly found opossums belong to the genus *Didelphis* due to their synanthropic behavior; however, other species may go unnoticed or be known only by sporadic findings (Reid 2009). This is the case of the Central American woolly opossum *Caluromys derbianus* (Waterhouse 1841), a species with a distribution that extends from southern México to Ecuador, occupying regions ranging from sea level to 2,600 m (Bucher and Hoffmann 1980; Fonseca and Astúa 2015). Through its wide distribution, very little is known about their biology. Some studies have looked at its distribution (Fonseca and Astúa 2015; Marineros *et al.* 2016), ecological importance in the predation of insects, small vertebrates, seed disperser and as a pollinating agent (Lessa and da Cota 2010; Kays *et al.* 2012). In addition, it plays an important role as a prey for other species (Moreno *et al.* 2006; Marineros *et al.* 2016).

In Panamá, the diversity of opossums includes 10 species in 8 genera. Of these, *C. derbianus* has 4 subspecies: *C. d. derbianus*, *C. d. nauticus*, *C. d. centralis*, and *C. d. pallidus* (Bucher and Hoffmann 1980). Apart from sporadic anecdotes, only few studies provide information on the geographic distribution, ecology and conservation threats of this species. Therefore, the aim of this work is to update the known distribution of *C. derbianus* in Panamá by providing a comprehensive set of historical and current records, and to expand on the basic ecological and conservation threats.

For the historical data, we reviewed specimens of *C. derbianus* deposited in the "Dr. Eustorgio Méndez" Zoological Collection of the Gorgas Commemorative Gorgas Institute for Health Studies (CoZEM-ICGES), in Panamá. Besides, we systematically reviewed the literature on this species using databases (BioOne, Smithsonian Libraries, and PubMed), including digital databases of the Smithsonian National Museum of Natural History (USNM), Washington, D. C., U. S. A.; American Museum of Natural History (AMNH), New York, U. S. A.; Philip L Wright Zoological Museum (UMZM), Montana, U. S. A., and the Museum of Vertebrate Zoology (MVZ), California, U. S. A.

Further, we collected recent data from personal observations, animals captured in scientific field studies, photos from camera traps, and revision of dead individuals (which were road-killed, electrocuted, preyed or hunted). We also used confirmed records from iNaturalist Panamá (an online citizen science platform, https://Panamá.inaturalist.org/). For each occurrence point, we recorded data on vegetation cover, type of environment and number of individuals. Finally, we used these historical (1884-1999) and current (2000-2020) data for *C. derbianus* in Panamá to create a map using ArcGis 10.3 software (Esri, Redlands, California, U. S. A.).

We obtained a total of 362 records of *C. derbianus* in Panamá, of which 174 are historical records (1884-1999) and 188 are current records (2000-2020; Figure 1). We obtained photographs of *C. d. centralis* (Figure 2A) and of an individual that showed a pale gray coloration (Figure 2B), which corresponds to an adult of the subspecies *C. d. pallidus* (Bucher and Hoffmann 1980; Fonseca and Astúa 2015).

The broad distribution of the records across Panamá indicate that the species occurs in different types of environments and at elevations that range from sea level to more than 2,000 m. The distribution range included urban and rural sites, primary forest (*e. g.,* Darien National Park), in addition to the islands of the Gulf of Montijo and Chiriqui (Pacific Ocean), the archipelago of Bocas del Toro, and the island of Escudo de Veraguas (Caribbean Sea; Figure 1). Rural areas corresponded to 31.4 % of the data, followed by primary forests (30.3 %), secondary forests (15.9 %), gallery forests (8.0 %), suburban areas (8.0 %) and urban areas (6.4 %; Figure 1).

Of the 188 current records from photos and direct field observations, 11.2 % provided information on the diet of *C. derbianus* (n = 21; Figures 2C, 2D), including bananas (*Musa* sp.; 1.6 %), oranges (*Citrus* sp.; 1.1 %), guavas (*Psidium guajava*; 0.5 %), figs (*Ficus* sp.; 0.5 %), guabas (*Inga* sp.; 0.5 %), jobos (*Spondias mombin*; 0.5 %), mangos (*Mangifera indica*; 0.5 %), cashew fruits (*Anacardium occidentale*; 0.5 %), pink poma (*Syzygium jambos*; 0.5 %), Malay rose apple (*Syzygium malaccense*; 0.5 %), palm seeds (0.5 %) and other fruits (0.5 %). We also found evidence of consumption of nectar in raft flowers (*Ochroma pyramidale*; 1.6 %), poultry eggs (1.1 %), and insects (Orthoptera, Tettigoniidae; 0.5 %).

Current records came mainly from direct sightings (75.5 %), road-kills (6.9 %), captures for scientific purposes (5.3 %), electrocuted individuals (4.8 %), wildlife rescues (2.1 %), camera traps detections (1.6 %), predation by dogs (1.6 %), predation by spectacled owl (*Pulsatrix perspicillata*; 1.1 %), predation by domestic cats (0.5 %), and individu-

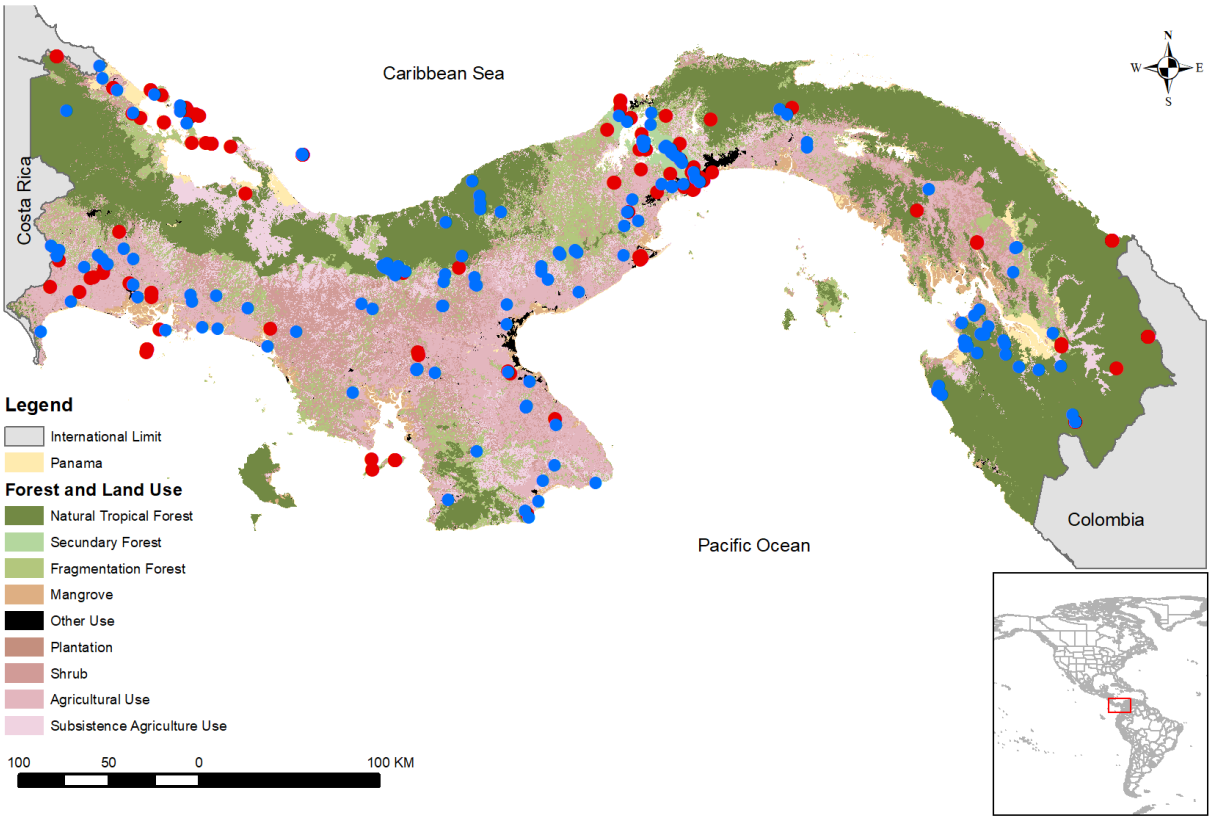

Figure 1. Historical occurrence (red dots, 1884-1999) and current occurrence (blue dots, 2000-2020) of *Caluromys derbianus* in Panamá.

Figure 2. Morphology and subspecies of *Caluromys derbianus* in Panamá: *C. d. centralis* in Changuinola, Bocas del Toro province (A); *C. d. pallidus,* in Breñon, Chiriqui province (B). Diet evidenced in photographs: eating Orthoptera Tettigonidae, Donoso, Colon, province (C); eating palm seeds in Darien National Park (D). Threats and risks: electrocuted, Parita, Herrera province (E); road-killed in La Colorada, Veraguas province (F); killed by domestic cat, Panama province (G). Maternal care in El Valle de Anton, Cocle province (H). Photograph by M. Ponce (A) and (C), M. de Landis (B), J. Ortega (D) and (F), O. Rodríguez (E), S. Roles (G), M. Urriola (H).

als hunted by humans (0.5 %). We present photographic evidence of electrocuted individuals, road-kills, and predation by domestic cats in Figures 2E-2G. Some photographic records show events such as 4 young on the body of their mother (Figure 2H).

In addition, we describe two predation events of a spectacled owl (*P. perspicillata*) on a Central American woolly opossum in Panamá. The first incident occurred on Barro Colorado Island, where a spectacled owl attacked a male Central American woolly opossum that managed to escape into a water drainage culvert. Pictures from a camera trap which was set up in the drainage to monitor a bat roost, showed that the opossum was heavily injured on the head and the forelimbs (Figures 3A-3D). The second event occurred when as a Central American woolly opossum was searching for *S. malaccense* fruits. A spectacled owl landed on the opossum and grabbed it. The opossum began to scream and fight. The owl took off with the opossum in its claws, while the opossum was still alive, screaming and fighting. The owl landed on a distant tree, where the screaming stopped shortly after.

Caluromys derbianus shows a high adaptability to survive and thrive in a variety of ecosystems, which can explain its wide distribution in the Neotropics (Bucher and Hoffmann 1980; Fonseca and Astúa 2015; Marineros *et al.* 2016). The data obtained here confirmed the capacity of adaptation of this species in Panamá, which includes continental areas and islands such as Paridas, Brava, Cebaco and Gobernadora (Pacific coast), the archipelago of Bocas del Toro, and the island Escudo de Veraguas (Caribbean coast; Handley 1966; Bucher and Hoffmann 1980; Fonseca and Astúa 2015). The presence of *C. derbianus* on Coiba island, offshore Panamá (Pacific Ocean), remains to be confirmed (Juste and Guillén-Servent 1997), and based on Bucher and Hoffman (1980) it may correspond with the subspecies *C. d. nauticus*.

Compared to scansorial species like *Didelphis marsupialis*, the preference for inhabiting the canopy allows *C. derbianus* to usually go unnoticed (Steiner 1981; McClearn *et al.* 1994; Voss and Jansa 2009; Aranda-Sánchez 2012). Moreover, the arboreal habits of *C. derbianus* may lead them to frequently climb on power lines, as evidenced by records of electrocuted individuals (Saavedra-Rodríguez *et al.* 2013). However, when there is little canopy connectivity and an absence of artificial passages in human-dominated habitats, individuals may be forced to move on the ground, increasing their risk of being hit by a vehicle or being predated by domestic animals (Artavia *et al.* 2015; Hernández 2018).

Similar to other mesomammals, *C. derbianus* is prey of larger carnivores such as ocelots (Moreno *et al.* 2006) or birds of prey (Marineros *et al.* 2016). To our knowledge, we report the first two records of a spectacled owl (*P. perspicillata*) as a predator of *C. derbianus* in Panamá, which has also been observed in Honduras (Marineros *et al.* 2016). In addition, we show that it is also preyed upon by domestic animals such as cats and dogs (Figure 2H). Although *C. derbianus* might function as an important prey species in the trophic web of Neotropical forests, its ecological contributions as a seed disperser and a pollinating agent are likely more significant but remain poorly studied and mostly anectodical (Steiner 1981; Lessa and da Cota 2010; Aranda-Sánchez 2012; Kays *et al.* 2012). Our diet data suggest *C. derbianus* is mostly frugivorous, but it might also feed on small vertebrates or insects, flowers and nectar (Bucher and Hoffmann 1980; Kays *et al.* 2012). Finally, during our survey, we did not find any evidence of *C. derbianus* value for food, commercial, cultural, religious or domestic use. Nonetheless, it may be threatened by loss of habitat, persecuted for being considered detrimental to poultry farming or simply due to a lack of knowledge about the species. Our data compilation sheds more light on the distribution, ecology and conservation threats on *C. derbianus* in Panamá and could serve as a baseline for future studies.

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Figure 3. Photographic sequence, from A to D, of a deadly attack by a spectacled owl (*Pulsatrix perspicillata*) arrowed at C on a Central American woolly opossum in the island of Barro Colorado, province of Colon, Panamá. Photograph by I. Geipel.

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Additional records of black bear (*Ursus americanus*) in central-eastern México

Registros adicionales de oso negro (*Ursus americanus*) en el centro-este de México

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The distribution range of the black bear (*Ursus americanus*) in México showed a significant reduction in the 20th century. However, growing evidence of its presence in areas outside the known range of distribution has emerged in recent years. This note documents a set of new records of black bear for the States of Guanajuato, Querétaro, and San Luis Potosí in central-eastern México. Black bears were spotted from monitoring that included camera traps, sightings, and indirect evidence (tracks and depredation events) between the years 2000 and 2019. We detected the presence of black bear through six records in the States of Guanajuato, Querétaro, and San Luis Potosí, in an area close to the southernmost distribution for this species in the American continent. Five of these observations occurred within protected natural areas. With these observations, the number of mammal species recorded in the State of Guanajuato increases to 95 and confirm the presence of black bear in the States of Querétaro and San Luis Potosí. The observations provide evidence supporting the hypothesis that black bear populations from northeastern México are moving toward central-eastern México through the Sierra Madre Oriental (SMO). The presence of black bear in central-eastern México points to the need for closer systematic monitoring of biodiversity in the SMO and protected areas of the region through monitoring and conservation programs.

Key words: Camera trap; distribution; protected natural area; Sierra Madre Oriental.

El oso negro (*Ursus americanus*) redujo significativamente su área de distribución en México en el siglo XX. En los últimos años, sin embargo, hay evidencia de su presencia en áreas fuera del rango de distribución propuesto. El objetivo es documentar un conjunto de registros nuevos de oso negro para los estados de Guanajuato, Querétaro y San Luis Potosí en el centro-este de México. Se detectaron osos negros como resultado de acciones de monitoreo que incluyeron cámaras trampa, avistamientos y observación indirecta (huellas y eventos de depredación), realizados entre los años 2000 y 2019. Detectamos la presencia de oso negro a través de seis registros en los estados de Guanajuato, Querétaro y San Luis Potosí, en un área cercana a la distribución más sureña para esta especie en el Continente Americano. Cinco de las observaciones ocurrieron dentro de áreas naturales protegidas. Las observaciones aumentan el número de especies de mamíferos registrados en el estado de Guanajuato a 95 y confirman la presencia del oso negro en los estados de Querétaro y San Luis Potosí. Las observaciones proveen evidencia que respalda la hipótesis de que las poblaciones de oso negro del noreste de México se mueven hacia el centro-este de México a través de la Sierra Madre Oriental (SMO). La presencia de oso negro en el centro-este de México señala la necesidad de intensificar el monitoreo sistemático de la biodiversidad en la SMO y en áreas protegidas de la región a través de programas de monitoreo y conservación.

Palabras clave: Área natural protegida; cámara trampa; distribución; Sierra Madre Oriental.

The American black bear (*Ursus americanus*, Pallas, 1780) is the only ursid (Mammalia, Ursidae) and the largest carnivorous mammal distributed in México (Gavito-Pérez *et al.* 2012; Garshelis *et al.* 2016). The distribution of black bear in México is fragmented and restricted to small areas of the Sierra Madre Occidental (SMOcc) and Sierra Madre Oriental (SMO); the distribution and population size of the bear in much of the country are currently unknown (Gavito-Pérez *et al.* 2012; Garshelis *et al.* 2016). The black bear is considered an endangered species and a priority for conservation at the national level (SEMARNAT 2010; Gavito-Pérez *et al.* 2012). Currently, two subspecies of black bear are recognized in México, *U. a. machetes* and *U. a. eremicus* (Larivière 2001; Medellín *et al.* 2005; Ramírez-Pulido *et al.* 2014). The subspecies *U. a. machetes* is found in the States of Chihuahua, Durango, Sonora, Sinaloa, and Zacatecas in the SMOcc; the subspecies *U. a. eremicus* is located in the States of Coahuila, Nuevo Leon, Tamaulipas, and San Luis Potosí in the SMO (Gavito-Pérez *et al.* 2012; Juárez-Casillas and Varas 2013; Monroy-Vilchis *et al.* 2016).

During the 20th century, black bear populations in México declined significantly due to deforestation, hunting, and poisoning over livestock-predation issues. However, since 1980, these populations have recovered in some regions of northern México (Doan-Crider and Hewitt 2005; Delgadillo-Villalobos 2011; Delfín-Alfonso *et al.* 2012; Gavito-Pérez *et al.* 2012; Garshelis *et al.* 2016). Over the past 50 years, the density of black bear populations in regions of northwestern México has increased to reach the same levels reported for some areas of the United States (Doan-Crider 1996). This population growth is likely due to a reduction in the threats facing the species (hunting and poisoning), its high birth rate, and its natural dispersal from the available habitat in northern México (Hewitt and Doan-Crider 2007).

Recent genetic analyses have shown that black bear populations are displacing southward through the SMO in search of food, from northeast México to the center of the country (Aguilar-López *et al.* 2019; López-González *et al.* 2019). To date, the presence of bears had not been recorded in States such as Guanajuato. This paper reports new records of black bear in the southernmost portion of its range in the American continent and documents the presence of this species in four natural protected areas in central-eastern México.

The Sierra Madre Oriental (SMO) is one of the main mountain ranges of México, stretching from the border with the United States of America to central México, encompassing the states of Coahuila, Nuevo León, Tamaulipas, San Luis Potosí, Guanajuato, Querétaro, Hidalgo, and central Veracruz (Ruiz-Jiménez *et al.* 2004). The center of the SMO includes the Carso Huasteco physiographic subprovince that includes the region known as "Sierra Gorda", located east of Guanajuato, south of San Luis Potosí, north of Querétaro, and west of Hidalgo (Arreguín-Sánchez and Fernández-Nava 2004). It is characterized by its climatic and topographical variation associated with the presence of temperate, tropical, and cloud forest, and xeric shrublands, ranging from 300 to 3,100 m (Arreguín-Sánchez and Fernández-Nava 2004).

The biodiversity of the Sierra Gorda has warranted the creation of Natural Protected Areas (ANP, for its acronym in Spanish) aiming to conserve the species richness in the region and maintain the connectivity of vegetation types and ecological processes (Arreguín-Sánchez and Fernández-Nava 2004). There are four main ANP in the Sierra Gorda region: Sierra Gorda Biosphere Reserve (RBSG) in Querétaro, Sierra Gorda de Guanajuato Biosphere Reserve (RBSGG) in Guanajuato, Los Mármoles National Park in Hidalgo, and The Sierra de Álvarez Flora and Fauna Protection Area in San Luis Potosí; altogether, these areas protect an area of approximately 644,600 ha (Bezaury-Creel and Gutiérrez-Carbonell 2009).

Fieldwork has been conducted seeking to gain a more detailed insight into the biodiversity in States of central-eastern México, such as Guanajuato, Querétaro, and San Luis Potosí, particularly in the Sierra Gorda region, between 2000 and 2019. These have gathered records of black bears obtained through various research projects, which are described below.

In the State of Guanajuato, RBSGG staff, in collaboration with the civil association Conservación del Patrimonio Natural para el Bienestar Social (Natural Heritage Conservation for Social Welfare; COPANABIS), installed six camera traps (Black Flash, 20 MP, Cuddeback, WI; Wildgame Innovations Infrared, 6.0 MP, Wildgame Innovations, LA) in the towns of El Carricillo and El Charco, municipality of Atarjea, between July and September 2018. All camera traps were placed along trails, ravines, and areas associated with water bodies, approximately one meter above ground level, and separated by a minimum distance of 500 m between them. In the case of San Luis Potosí and Querétaro, the records presented in this paper come from incidental encounters and not from a systematic sampling effort.

Additionally, to document and supplement the known distribution of black bear in the SMO — particularly in the area corresponding to the states of Guanajuato, San Luis Potosí, and Querétaro —, we searched the scientific literature for presence records (direct observations, photographs, skulls, tracks, excreta, and/or scientific collections). Combinations of key words such as "*Ursus americanus*", "oso negro", "black bear", "Guanajuato", "Querétaro", and "San Luis Potosí" were entered in search engines such as SciELO, Redalyc, and Google Scholar. In addition, records of the presence of black bear were gathered from Enciclovida, the National Commission for the Knowledge and Use of Biodiversity (CONABIO) (http://enciclovida.mx/), and the Global Biodiversity Information Facility (https://www.gbif.org/). Black bear records were projected on a map of the region as new and historical records: also marked were the distribution range of the species according to the International Union for the Conservation of Nature (IUCN), and the limits of the SMO and ANP (Figure 1).

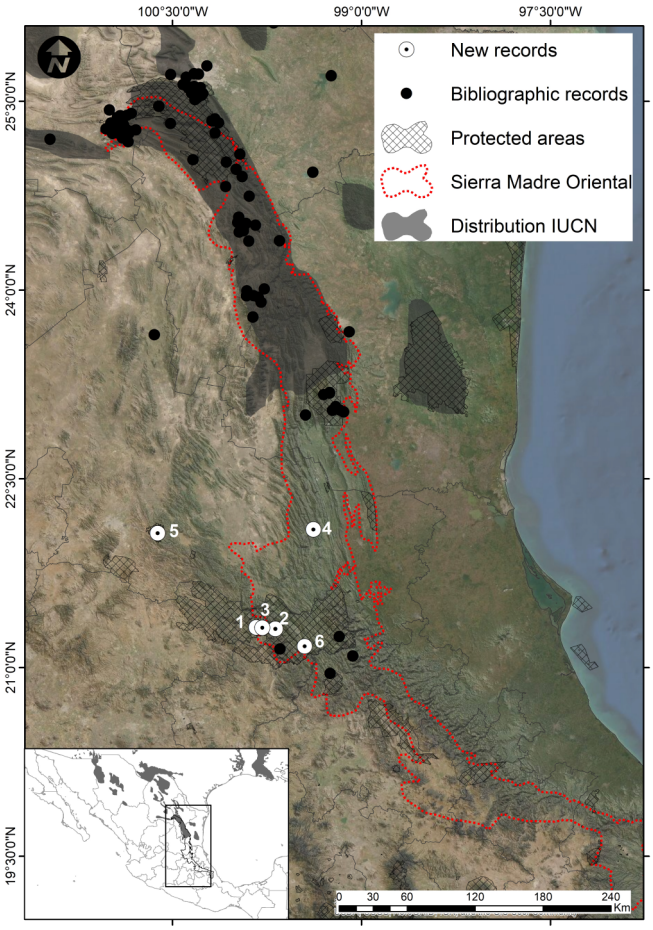

Figure 1. Geographic location of the new black bear records, *Ursus americanus* (white dots) in central-eastern México, and literature records in the Sierra Madre Oriental (black dots). 1 RBSGG, 2 RBSGG, 3 RBSGG, 4 Tamasopo, San Luis Potosí, 5 APFF Sierra de Álvarez, San Luis Potosí, 6 RBSG. RBSGG = Sierra Gorda de Guanajuato Biosphere Reserve; RBSG = Sierra Gorda Biosphere Reserve; APFF = Flora and Fauna Protection Area.

This work resulted in six new direct (observations and photographs) and indirect (tracks, livestock predation events, and hunted specimens) records of black bear for central-eastern México between 2000 and 2019 (Table 1). These records are located in Guanajuato (n = 3), Querétaro (n = 1), and San Luis Potosí (n = 2; Table 1). Five records are located within an ANP (Table 1).

Three records of black bear were obtained within the RBSGG in the municipality of Atarjea, Guanajuato. The first corresponds to a sighting by members of the *Biodefensores* group of the *Ecochavos* network in El Carricillo at 2,265 m on 11 July 2018. This observation was validated by RBSGG staff that assisted in the registration verification and obtained a plaster cast of the footprints (Figure 2A). According to the testimonies of people who watched the bear, it was an individual in good physical condition. Later, on 12 September 2018 and with a sampling effort of 420 camera trap days, we obtained two photographs of an American black bear at 10:37 hr in El Charco, at an altitude of 2,109 m. The photographs suggest it was an adult individual (Figure 2B). Finally, on 6 October 2018, the reserve staff and COPANABIS found another black bear track in El Durazno at 2,379 m (Figure 2C). All reports of black bear for RBSGG refer to mixed oak-pine forests dominated by pinyon pine (*Pinus cembroides*).

For the State of Querétaro, on 30 May 2019 the RBSG staff verified and validated the observation of a black bear individual in El Carrizal, municipality of Jalpan de Serra, located at 893 m in a dry tropical forest (Figure 2D). This record is the first reported for this State in a tropical forest.

For San Luis Potosí, a black bear was hunted in 2000 by inhabitants of San Nicolás de Los Montes, municipality of Tamasopo. This record was validated from a photograph of the specimen, hunted at 860 m in the transition zone between oak forest and sub-deciduous tropical forest. Subsequently, in December 2009, the predation of a domestic pig by a black bear was reported in Valle de los Fantasmas, municipality of Zaragoza; the local inhabitants contacted the Wildlife Office of the State government to report the predation event because the bear was scared off with the help of domestic dogs. The report was verified and validated through testimonies and photographs of the predation taken by the locals. This record is located at 2,321 m in an oak forest within the Sierra de Álvarez Flora and Fauna Protection Area (Figure 1). These records represent the most recent and reliable evidence of the presence of black bear in San Luis Potosí.

The confirmed reports of black bear presence in the SMO that are geographically closest to the new records reported in this study are located at a distance of approximately 184 ± 40 km north of El Cielo protected area, State of Tamaulipas (Vargas-Contreras and Hernández-Huerta 2001; Figure 1).

Table 1. Records of black bear (*Ursus americanus*) in central-eastern México. BE = oak forest, BP-E = pine-oak forest, BTS = dry tropical forest. RBSGG = Sierra Gorda de Guanajuato Biosphere Reserve; RBSG = Sierra Gorda Biosphere Reserve; APFF = Flora and Fauna Protection Area.

Record	Locality	Longitude	Latitude	Elevation (m)	Vegetation	Year	Type of record
1	El Carricillo, Atarjea, Guanajuato, RBSGG	-99.83574	21.31857	2,265	BP-E	2018	Sighting and track
2	El Charco, Atarjea, Guanajuato, RBSGG	-99.83574	21.31857	2,109	BP-E	2018	Camera trap
3	El Durazno, Atarjea, Guanajuato, RBSGG	-99.78617	21.31600	2,379	BP-E	2018	Track
4	San Nicolás de los Montes, Tamasopo, San Luis Potosí	-99.38139	22.09778	860	BE	2000	Photograph of hunted specimen
5	Valle de los Fantasmas, Zaragoza, San Luis Potosí, APFF Sierra de Álvarez	-100.61778	22.06806	2,321	BE	2009	Domestic pig predation
6	Carrizal, Jalpan de Serra, Querétaro, RBSG	-99.45077	21.16851	893	BTS	2019	Sighting and photo

Figure 2. Evidence of the new records of black bear (*Ursus americanus*) in central-eastern México A) plaster casts of the footprint in the locality of El Carricillo, RBSGG, B) photograph taken at El Charco, RBSGG, C) footprint recorded in El Durazno, RBSGG, D) sighting in El Carrizal, RBSG. RBSGG = Sierra Gorda de Guanajuato Biosphere Reserve; RBSG = Sierra Gorda Biosphere Reserve.

The black bear records in central-eastern México presented here are located near the southernmost portion of the distribution of this species in the American continent (Lackey *et al.* 2013; Scheick and McCown 2014), and support the hypothesis raised by López-González *et al.* (2019) about the displacement of black bear from populations in northeastern México heading to central México through the SMO. These displacements possibly occur through temperate forests in the SMO mountain range, as most of the new and literature records are associated with this type of vegetation. Other authors have documented movements of black bear in search of food or territory in both México and the United States (Liley and Walker 2015; Camargo-Aguilera *et al.* 2017).

Natural stochastic events, such as forest fires, droughts, and hurricanes, could pose a threat to bears. However, they are likely to play a major role in the expansion of populations by promoting their movements from certain regions, which is essential for the long-term viability of the populations in the SMO. Movements occur more frequently in young individuals and adult males, which may be the case in the Sierra Gorda, as the presence of females in the area has not been documented so far (Liley and Walker 2015; Servín *et al.* 2018).

The Sierra Gorda and its surroundings are currently protected by at least four ANP. However, in the area between the RBSGG in Guanajuato and the El Cielo ANP in Tamaulipas, where the black bear population closest to the localities reported here is located, there are no protected areas greater than 1,000 km^2 — the size required to ensure connectivity between black bear populations in this SMO region (Hewitt and Doan-Crider 2007; Figure 1). Therefore, it is essential to identify the likely routes of movement and dispersion of black bear through the SMO, especially in the State of San Luis Potosí, where only historical or anecdotal reports of the black bear are available besides the records reported in this work (Juárez-Casillas and Varas 2013; Martínez de la Vega *et al.* 2016). Identifying potential corridors in regions where no ANP exist should be a priority for black bear conservation actions in México because the species needs between 200 and 1,000 km^2 of habitat with food availability to survive (Hewitt and Doan-Crider 2007; Delgadillo-Villalobos 2011).

New records in central-eastern México confirm the presence of black bear in the State of Guanajuato, increasing the number of mammals reported for the state to 95 species (Sánchez *et al.* 2016; Magaña-Cota *et al.* 2018), and confirm the current presence of the species in San Luis Potosí, adding to the anecdotal reports by Dalquest (1953). In addition, these reports add to those for the States of Querétaro and Hidalgo, where the presence of black bear was recently reported (Rojas-Martínez and Juarez-Casillas 2013; Aguilar-López *et al.* 2019; López-González *et al.* 2019).

The records reported in this work on the presence of black bear add to those for other carnivorous species in the region reported over the past 10 years, including ocelot (*Leopardus pardalis*), margay (*Leopardus wiedii*), and jaguarundi (*Herpailurus yagouaroundi*) in Guanajuato (Iglesias *et al.* 2008; Charre-Medellín *et al.* 2012). In the State of Hidalgo, the presence of tayra (*Eira barbara*) and jaguar (*Panthera onca)* was recently reported (Aguilar-López *et al.* 2015; Morales-García *et al.* 2014). These findings highlight the importance of the region as a priority for the conservation of large mammals.

The presence of black bear in central-eastern México points to the need for closer systematic monitoring of biodiversity in the SMO and ANP in this region through monitoring and conservation programs. These programs will facilitate the establishment of the species in the mid and long term, especially in areas where favorable habitat conditions are maintained, such as temperate forests.

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Abnormal pelage color in mantled howler monkey (*Alouatta palliata mexicana*) in Veracruz, México

Coloración no convencional en mono aullador de manto (*Alouatta palliata mexicana*) en Veracruz, México

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Leucism is a total or partial depigmentation of the coat; in contrast, albinism is the total loss of pigments throughout the body; the abnormal conditions of pigment deficiency are usually due to the expression of recessive genes. Expedition *ad libitum* was carried out in the Ejido Álvaro Obregón, on the southwest of Nuevo Cantón, Uxpanapa municipality, Veracruz on December, 2019. We present the first record of abnormal pelage colour (maybe leucismo or albinism) in mantled howler monkey (*Alouatta palliata mexicana*), observed in a wild troop in the Uxpanapa Valley region, Veracruz, México. The coloration of the oral mucosa and the eyelid show no pigmentation and may be the result of the expression of recessive genes in the individual, therefore, conducting more in-depth studies on the expression of recessive genes would broaden the understanding of the phenomenon.

Key words: Albinism; Atelidae; depigmentation; leucism; Primates; Uxpanapa.

El leucismo es una despigmentación total o parcial del pelaje, mientras que el albinismo es la pérdida total de pigmentos en el cuerpo entero; las condiciones anormales de la carencia del pigmento se deben a la expresión de genes recesivos. Se realizó una expedición *ad libitum* en el Ejido Álvaro Obregón, al suroeste de Nuevo Cantón, municipio de Uxpanapa, Veracruz en diciembre de 2019. Presentamos el primer registro de un individuo de mono aullador de manto (*Alouatta palliata mexicana*) con coloración no convencional (probablemente leucismo o albinismo), observado en una tropa silvestre en la región del Valle de Uxpanapa, Veracruz, México. La coloración de la mucosa oral y palpebral no muestran pigmentación y pueden ser resultado de la expresión de genes recesivos en el individuo, por lo que realizar estudios más profundos sobre la expresión de genes recesivos ampliaría la comprensión del fenómeno.

Palabras clave: Albinismo; Atelidae; despigmentación; leucismo; Primates; Uxpanapa.

Leucism is a genetic abnormality that affect colour expression due to a recessive gene; in this condition, animals have partial or total loss of pigmentation in the skin or coat but maintains the normal coloration in eyes and claws (García-Morales *et al.* 2012; Silva-Caballero *et al.* 2014; Liu *et al.* 2019). In the other hand, albinism is characterized by the total loss of pigments throughout the body (García-Morales *et al.* 2012; Silva-Caballero *et al.* 2014). The patterns of pigmentation in primates can be the result of a combination of three factors: haemoglobin, structural coloration, and melanin pigmentation (Bradley and Mundy 2008).

In the past ten years, a variety of forms or types of abnormal pigmentation have been reported in monkeys (Mammalia: Primates). In monkeys such as *Alouatta guariba clamitans* (Fortes and Bicca-Marques 2008; Aximoff and Vaz 2016), *Ateles geoffroyi* (Espinal *et al.* 2016), *Callithrix penicillata* (do Vale *et al.* 2018), *Callithrix jacchus*, *Callithrix penicillata* (Primates, Callitrichidae) and their hybrids (Aximoff *et al.* 2020), abnormal pigmentation in the coat has presented. Atypical conditions in coat colour are the result of pleiotropic effects, due to the origin of melanocytes and neurocytes in the neural crest and are associated with a loss of genetic diversity in isolated and captive populations due to inbreeding (Dunn *et al.* 2014).

For 30 years, the loss and fragmentation of the habitat of *Alouatta palliata* in southern México (Rylands *et al.* 2006) has decimated its populations and formed a metapopulation (subspecies) with biogeographic limits in the states of Tabasco, Oaxaca, Chiapas, and Veracruz. In the latter, the subspecies *A. p. mexicana*, was classified as Critically Endangered by the IUCN (Cuarón *et al.* 2008). Furthermore, Dunn *et al.* (2014) and Melo-Carrillo *et al.* (2020) report low genetic diversity in wild populations of *A. p. mexicana* of México. For the state of Veracruz, a genetic variability from low to moderated is reported in populations isolated, fragmentated and with populations groups reduced (Argüello-Sánchez 2012; Argüello-Sánchez and García-Feria 2014; Jasso-del Toro *et al.* 2016). Loss of genetic diversity and inbreeding in monkey populations can increase the likelihood of abnormal colorations such

as albinism, leucism or piebaldism, which have been little studied due to the lack of a complete genome of the genus *Alouatta*.

Expedition *ad libitum* was carried out in the Ejido Álvaro Obregón, on the southwest of Nuevo Cantón (Poblado 7), Uxpanapa municipality, Veracruz (17°19'16.22" N, 94°32'2.4" W; Figure 1a-c) on December 23, 2019 at 3:00 p.m. The original vegetation in the Uxpanapa region was tropical rainforest (high and middle), but since 1970s, through colonization and relocation programs, deforestation, and changes in land use increase (mainly for rubber and citrus plantations). Nowadays, derived from agricultural, livestock and other anthropogenic activities, the original vegetation is about 30 % (Figure 1c; Hernández *et al.* 2013).

We observed approximately for twenty minutes a family of mantled howler monkeys (*Alouatta palliata mexicana* Merriam, 1902, Primates: Atellidae). The family consisted of six individuals, two adult males, two adult females (one with a baby monkey; Figure 2d) and one adult individual (whose sex could not be determined) that shows a condition abnormal pelage color (Figure 2a-d). These monkeys were in a rubber plantation (*Hevea brasiliensis*) between high evergreen forest, secondary vegetation, paddocks, and the urbanized area (Figure 1c). We observed to the family crossing the secondary vegetation area and resting in the treetops of *H. brasiliensis*. We also hear two adult males roaring several times and they finally leave the area heading to the high forest. The photographs of the specimen of *A. p. mexicana* were taken with a digital camera (Sony Alpha 58® of 20 megapixels).

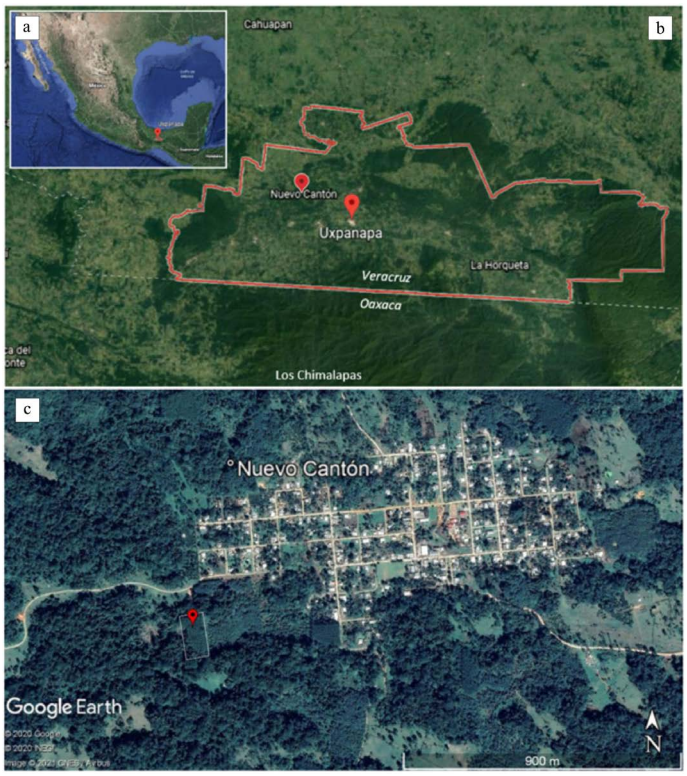

Figure 1. a) Location of the study area in southern Veracruz, México. b) Location of "Nuevo Cantón" in west of Uxpanapa. Municipal territorial limits in red. c) Location of sighting site (red point) within the "Ejido Álvaro Obregón", municipality of Uxpanapa, Veracruz, México.

Leucism is a hereditary disorder in the deposition of pigments (melanine) responsible for the colour of the coat, skin and eyes, due to the expression of recessive genes, that it could increases due to the lack of genetic exchange due to isolation, intraspecific competition, and fitness decrease (Dunn *et al.* 2014). In *A. palliata* there are records of coloration patterns with depigmentation that are considered normal; however, the species is known to have normal depigmented coloration patterns that have been used for individual identification (Rodríguez-Luna 1997; SEMARNAT 2012), but due to the characteristics of the coat of the observed individual, they coincide with an abnormal coat condition rather than with a condition of leucism (lack of pigmentation in the skin) or albinism (pigmentation light of fur and skin, with blue, red or pink eyes; Shapley 2004).

For many years, mantled howler monkeys have been observed in different places with anomalous colorations (Bradley and Mundy 2008), but there has been no record of an individual with complete coloration throughout the body, being this the first report of this condition. The expression of recessive genes in this individual may be the result of a lack of genetic exchange due to isolation, where the inbreeding process is possibly increasing the homozygous condition in the population and consequently, the loss of alleles (Dunn *et al.* 2014). In fragmented sites in the Chontalpa region, Tabasco, México, two individuals of *A. palliata* presented a lighter coloration that brings advantages in thermoregulation since they retain less heat than their darker congeners (Sánchez-Soto 2018), this anomalous coloration leans towards piebaldism (light coloration of the coat on any limb of the animal) or aberrations in the coat patterns colours because both individuals only had

Figure 2. a, b) Individual of mantled howler monkey (*Alouatta palliata mexicana*) with abnormal pigmentation condition. c) Albino or leucistic individual and adult female. d) Albino or leucistic individual and adult female with a baby monkey.

light coloration in some extremities (Hull 1978).

A conservation program for the populations of southern Veracruz should be carried out, for example, restoring the connectivity of the area in collaboration with the owners through a silvopastoral management program would help reduce the pressure of genetic decline in populations. In parallel, more in-depth studies on population genetics should be carried out focused on the presence or absence of these traits.

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First record of margay (*Leopardus wiedii*) in cloud forest of Guatemala

Primer registro de margay (*Leopardus wiedii*) en bosque nuboso de Guatemala

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The margay (*Leopardus wiedii*) is a small to medium-sized Neotropical felid classified as endangered in Guatemala. Non-invasive methods have been recommended to detect elusive species with nocturnal habits in tropical environments. In this work, we present the first photographic record of margay in the Mario Dary Rivera University Biotope for Quetzal Conservation, department of Baja Verapaz using camera traps. This record represents the highest altitude observation for this species in the cloud forests of Guatemala. We used 7 camera traps, 4 LeafRiver ™ model C-1BU with Canon © Sure Shot Owl camera, and 3 DeerCam (860 Park Lane, Park Falls WI 54551). The camera traps were installed for 16 consecutive days (February 21 to March 8, 2008), and programmed to take pictures and with the date and hour of each photo recorded automatically. With a total effort of 110 traps/night, we obtained one record of margay in one camera trap in a cloud forest, confirming the presence of this feline at 1,770 m. This photographic record is the first confirmed evidence of the presence of margay in the cloud forest of the Mario Dary Rivera University Biotope for Quetzal Conservation, at 3.3 km southeast of the municipal town of Purulhá. We recommend the implementation of long-term monitoring programs within the area using camera traps, aiming to investigate elusive species with nocturnal-crepuscular habits to promote conservation strategies.

Key words: Altitude; camera trap; carnivore; felidae; record.

El margay (*Leopardus wiedii*) es un felino Neotropical de tamaño pequeño a mediano clasificado como en peligro de extinción en Guatemala. Para detectar especies sigilosas o de hábitos nocturnos en ambientes tropicales se ha recomendado utilizar métodos no invasivos. En este trabajo, presentamos el primer registro fotográfico de margay en el Biotopo Universitario Mario Dary Rivera para la Conservación del Quetzal, departamento de Baja Verapaz, utilizando trampas cámara. Este registro representa la observación a mayor altitud para esta especie en bosques nubosos de Guatemala. Utilizamos 7 trampas cámara, 4 LeafRiver™ modelo C-1BU con cámara Canon© Sure Shot Owl y 3 DeerCam (860 Park Lane, Park Falls WI 54551). Las trampas cámara fueron instaladas durante 16 días consecutivos (21 de febrero al 8 de marzo de 2008) y fueron programadas para obtener fotografías con la hora y fecha impresa. Con un esfuerzo total de 110 trampas/noche, obtuvimos un registro de margay en una trampa cámara en bosque nuboso, confirmando la presencia de este felino a 1,770 m. Este registro fotográfico es la primera evidencia confirmada de la presencia de margay en el bosque nuboso del Biotopo Universitario Mario Dary Rivera para la Conservación del Quetzal, a 3.3 km al sureste del poblado municipal de Purulhá. Recomendamos la implementación de programas de monitoreo a largo plazo utilizando trampas cámara dentro del área, con el objetivo de investigar especies esquivas con hábitos crepusculares, nocturnos, para promover estrategias de conservación.

Palabras clave: Altitud; carnívoro; Felidae; registro; trampa cámara.

The margay or tigrillo (*Leopardus wiedii*; Schinz, 1821) is one of the five wild cat species inhabiting Guatemala (Reid 2009). The margay ranges from the tropical lowlands of México south through Central America and the Amazon basin to southern Brazil and Paraguay (Nowell and Jackson 1996). The margay is strongly associated with forest habitat/tree cover, from continuous forest to small forest fragments in savanna ecosystems, both evergreen and deciduous, and occasionally recorded outside forested areas (Nowell and Jackson 1996; de Oliveira 1998, 2011). Margays have morphological adaptations that make them excellent climbers, such as long tails that they use for balance and ankles that rotate up to 180° (Hunter 2015).

This felid lives from sea level up to 1,500 m height but rarely has been recorded up to 3,000 m in the Andes (de Oliveira 1994; Espinosa *et al.* 2018). Previous photographic record for Guatemala in cloud forest was reported at 1,750 m (Mármol-Kattán *et al.* 2019). Due to its elusive characteristics, it is one of the most difficult animals to observe. For this reason, it is suggested the use of camera traps to document its presence, abundance, and distribution (Tobler *et al.* 2008; Vanderhoff *et al.* 2011). In Guatemala, the margay is classified in Category 2, risk of extinction, of the threatened species list by the Consejo Nacional de Áreas Protegidas (CONAP 2009). The International Union for the Conservation of Nature assess this cat as Near Threatened with a decreasing population trend (de Oliveira *et al.* 2015). The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES 2020) lists the margay in Appendix I that includes the most endangered species.

In Guatemala, the margay has been documented by photographic records in private natural reserves of the volcanic mountain range and Zacapa (Escobar-Anleu *et al.* 2017), Izabal (Escobar-Anleu 2019), Petén (Moreira-Ramírez *et al.* 2009, 2011), and Baja Verapaz (Mármol-Kattán *et al.* 2019). In order to advance in margay conservation strategies, we need evidence about its occurrence and thus define research and management policies. Here we present the first photographic record of margay in the Mario Dary Rivera University Biotope for Quetzal Conservation, being the first record higher than 1,750 m in a cloud forest of Guatemala. This reliable record will help to update the distributional range and conservation programs.

The Mario Dary Rivera University Biotope for Quetzal Conservation (BQ) is located in central Guatemala, northeast of Sierra Chuacús between the municipalities of Purulhá and Salamá, in Baja Verapaz department (15° 12′ 47.45″ N, 90° 13′ 2.21″ W; Figure 1). Since 1976, BQ has been managed by the Center for Conservation Studies of the University of San Carlos de Guatemala. It includes 1,017 ha of cloud forest with a buffer zone of 5,241 ha and an altitude range between 1,500 and 2,348 m. The average annual rainfall is 2,092 mm, with January-April with the least precipitation. The annual average temperature is 18 °C, with range between 14 and 20 °C. The average relative humidity ranges between 89.5 and 98.9 %. Average annual humidity is 93.9 %. Vegetation includes ferns, mosses, lichens, orchids that grow abundant on trees up to 30 m height such as *Engelhardia guatemalensis*, *Magnolia guatemalensis*, *Quercus* spp., and *Dendropanax arboreus* (Basterrechea 1999).

To evaluate the presence of mammals, we used 7 camera traps, 4 LeafRiver ™ model C-1BU with Canon © Sure Shot Owl camera, and 3 DeerCam (860 Park Lane, Park Falls WI 54551). We placed camera traps for 16 consecutive days (21 February to 8 March 2008). To avoid data loss, on the seventh day of sampling, we checked the camera traps, changing batteries and rolls. The location of camera traps was based on the presence of animal signs (*e.g.*, tracks, scratches, caves) as indicators (Moreira-Ramírez *et al.* 2009). Camera traps were set up along the sides of interpretive trails and spaced 50 to 400 m apart. For the 2 models of

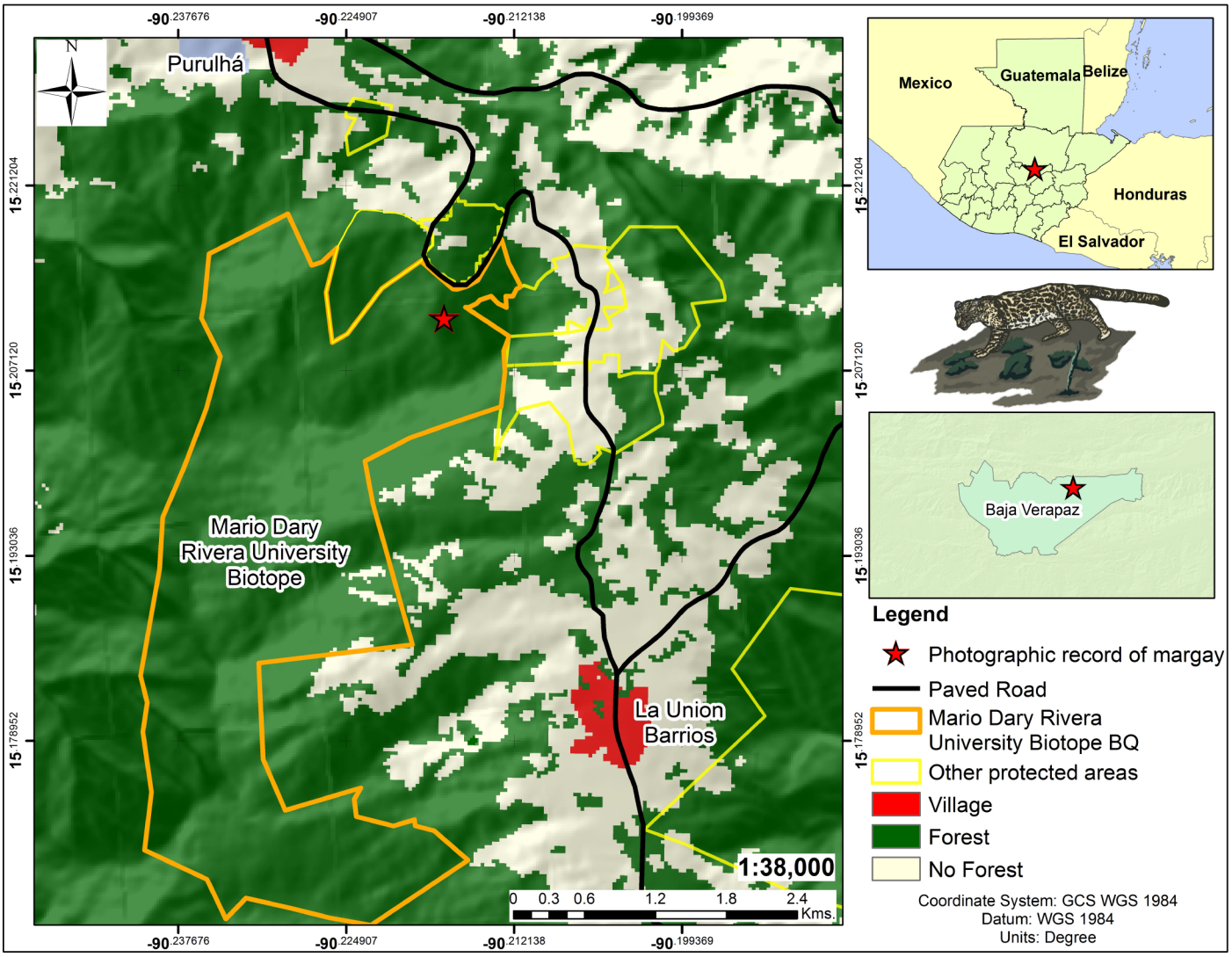

Figure 1. Map of the Mario Dary Rivera University Biotope for Quetzal Conservation, Baja Verapaz, Guatemala, showing the site of the margay photographic record (red star).

camera traps, we used rolls of 24-print, 400 ASA 35-mm film. The camera traps were set for 24-hour operation with a delay of one minute between consecutive photographs at a height of 30 to 40 cm. The photographs were stored in the database of WCS Guatemala Program.

The total trapping effort was 110 trap/nights. During the sampling period, we photographed for the first time a margay in the BQ. The record of margay was obtained in 1 camera trap at an altitude of 1,770 m (15° 12' 40.05" N, 90° 13' 2.85" W) in the cloud forest, 3.3 km southeast of the municipal town of Purulhá, Baja Verapaz. The photographic record was obtained on February 26, 2008, at 23:41 hr (Figure 2). We identified the species based on the distinguishing features of margays: very large and bulging eyes, and very long tail measuring up to 70 % of the head and body length and which is usually thick in appearance (de Oliveira 1998).

The margay is uncommon to rare throughout its range (de Oliveira *et al.* 2015). Our record of margay is important because it is the first record to confirm its presence in the BQ, a protected area declared in 1976. It is also one of the few records in the cloud forest and the highest in Guatemala. Previously, there was no evidence in scientific literature documenting the presence of this species in the BQ (Nagy-Reis *et al.* 2020; SNIBgt 2020), although comments from local rangers indicated a certain probability. This record confirms for the second time the presence of margay in Baja Verapaz department. Additional photographic records were obtained in the Ranchitos del Quetzal Natural Reserve between 2017 to 2019 at 1,680 - 1,750 m (Mármol-Kattán *et al.* 2019). This nature reserve borders the north of the BQ and embraces a continuous protected cloud forest of approximately 1,300 ha. Our record confirms a new altitude for this species, obtained at 1,770 m in cloud forest, being higher than reported in 2019. In México, there are records of margays in cloud forests for the states of Guerrero, Jalisco, Morelos, Oaxaca, and San Luis Potosí, at elevations between 800 and 2,750 m (Aranda *et al.* 2012; Carvajal-Villarreal *et al.* 2012; Cinta-Magallón *et al.* 2012; Almazán-Catalán *et al.* 2013; Aranda and Valenzuela-Galván 2015). In Costa Rica and Colombia, this cat was documented at altitudes of 1,529 and 2,313 m, respectively (González-Maya *et al.* 2018).

The margay is strongly associated with forest habitat/tree cover, from continuous forest to small forest fragments (de Oliveira 2011), under moderate levels of habitat modi-

Figure 2. Photographic record of margay (*Leopardus wiedii*) in the Mario Dary Rivera University Biotope for Quetzal Conservation, Baja Verapaz, Guatemala. The distinguishing features of margays include a very long tail measuring up to 70 % of the head and body length.

fication and human disturbance (Horn et al. 2020). The presence of margay suggests that the BQ still maintains habitat in good conservation status. We recommend the implementation of long-term monitoring programs within the BQ and adjacent protected areas aiming to investigate elusive species with nocturnal-crepuscular habits. This research tool will contribute to generating robust information and conservation strategies. Finally, we suggest evaluating margay as a possible conservation element for the BQ.

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Patrones de actividad de murciélagos filostómidos en un bosque seco en Honduras

Activity patterns of phyllostomid bats in a dry forest in Honduras

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En Honduras, los estudios sobre murciélagos son escasos y se desconoce cómo la actividad de los murciélagos filostómidos es influenciada por factores ambientales. Describimos patrones de actividad de especies de murciélagos filostómidos en Ciudad Universitaria, Francisco Morazán (centro de Honduras). Realizamos 21 jornadas y capturamos murciélagos con 2 redes de niebla del 26 de febrero de 2015 al 29 de abril de 2016. En total, se registraron 114 individuos en 1,428.24 horas/red/metro. Con base en el análisis ANOVA, los murciélagos filostómidos se encontraron entre 58 % y 93.5 % de humedad relativa del aire, y entre 17.4 ºC y 22.8 ºC de temperatura del aire. Nuestros resultados indican diferencias interespecíficas en la actividad de los murciélagos filostómidos en el área de estudio. Este es el primer intento en describir sus patrones de actividad en un bosque seco en Honduras.

Palabras clave: Ecología; factores ambientales; Honduras; patrones de actividad.

In Honduras, studies about bats are scarce, and it is unknown how the activity of phyllostomid bats is influenced by environmental factors. We describe activity patterns of phyllostomid bat species in Ciudad Universitaria, Francisco Morazán (central Honduras). We did 21 surveys and captured bats with 2 mist-nets from 26 February 2015 to 29 April 2016. Overall, 114 individuals were recorded in 1,428.24 net hours/meter. Based on ANOVA analysis, phyllostomid bats were found between 58 % and 93.5 % of the relative humidity of the air, and between 17.4 ºC and 22.8 ºC of the temperature of the air. Our results indicate interspecific variations in activity of phyllostomid species in the study area. This is the first attempt to describe their activity patterns in a dry forest in Honduras.

Key words: Activity patterns; ecology; environmental factors; Honduras.

La familia Phyllostomidae se caracteriza por la presencia de una hoja nasal, a excepción de algunas especies (por ejemplo, *Centurio senex*, *Desmodus rotundus*, *Diphylla ecaudata*, *Diaemus youngii*), la cual puede estar reducida o ser rudimentaria (Arita 1990). La hoja nasal es una estructura que les permite emitir y dirigir ultrasonidos para orientarse en el vuelo, encontrar su alimento y realizar vocalizaciones de carácter social (Galindo-González 1998; Orozco-Lugo *et al.* 2013). Además, pueden aprovechar diversos recursos alimenticios que les permiten participar en procesos ecológicos que incluyen dispersión y establecimiento de semillas, polinización y disminución de poblaciones de insectos (Neuweiler 1989; Arita y Fenton 1997; Kalko y Condon 1998; Vargas-Espinoza *et al.* 2008; Novoa *et al.* 2011; Cirranello *et al.* 2016). Ciertos factores como la disponibilidad de recursos alimentarios o variables climáticas pueden influenciar directamente su actividad, la cual se ve reflejada en la condición física, dieta y en los patrones de actividad (Estrada-Villegas *et al.* 2007; Muñoz-Romo y Herrera 2010; Novoa *et al.* 2011; García-García y Santos-Moreno 2014).

Si bien Amorim *et al.* (2012) mencionan que la temperatura y la humedad relativa del aire están relacionadas con la actividad de los murciélagos, en donde la actividad incrementa con altas temperaturas, no se conoce cuál es la relación entre las variables ambientales y la actividad de los murciélagos filostómidos en Honduras. Además, la información disponible en el país en los últimos años sobre este grupo es insuficiente, debido que sólo se conocen registros esporádicos de diversas especies, por ejemplo: Goodwin (1942), Davis *et al.* (1964), Carter *et al.* (1966) y LaVal (1969). Estos estudios aportaron los primeros registros de distribución de murciélagos en Honduras. Aunque los registros se mantienen, no se han generado estudios sobre comportamiento, alimentación y ecología con las 113 especies reportadas para el país (Turcios-Casco *et al.* 2020).

Debido a la escasez de información sobre las condiciones ecológicas en las que se pueden capturar murciélagos filostómidos en Honduras, el objetivo de este estudio fue describir algunos patrones de actividad (hora de captura, temperatura y humedad relativa del aire) de 7 especies de murciélagos filostómidos en Ciudad Universitaria de la Universidad Nacional Autónoma de Honduras (CU–UNAH), Honduras.

La CU–UNAH está ubicada en el municipio del Distrito Central (14º 5′ 13.63″ N y 87º 9′ 59.72″ O; Figura 1), en el Departamento de Francisco Morazán (centro de Honduras), a una elevación promedio de 1,061 m. El suelo se caracteriza por ser arcilloso, la precipitación anual en esta zona es de 869 mm, con una temperatura anual de 22.1 ºC y humedad relativa anual de 77.7 % (Canales 2011); y la evapotranspiración potencial anual es de 1,463 mm

(DARNA 2013). Sin embargo, al ser un área urbana inmersa en un bosque seco, presenta sitios alterados con predominancia de las siguientes especies vegetales: *Lonchocarpus sanctuarii*, *Acacia farnesiana*, *Psidium guajava*, *Muntingia calabura*, *Solanum erianthum*, *S. torvum*, *Tabebuia rosea*, *Tecoma stans* y *Spathodea campanulata* (Ferrufino *et al.* 2015).

Realizamos capturas desde el 26 de febrero de 2015 hasta el 29 de abril de 2016, con un total de 21 jornadas. Los sitios se alternaban para no repetir el mismo en la jornada siguiente, y seleccionamos los días de captura de acuerdo con la fase lunar (Erkert 1982; Elangovan y Marimuthu 2001; Ciechanowski *et al.* 2007) para evitar fobia lunar por parte de los murciélagos, y la presencia de lluvia para que la red no fuese fácilmente detectada (Parsons *et al.* 2003; Ciechanowski *et al.* 2007; Voigt *et al.* 2011). Esto permitió reducir el impacto de dichas variables ambientales sobre la abundancia de las especies. Los únicos meses que no se muestrearon fueron de junio a agosto ya que la universidad permaneció cerrada los días adecuados para la captura de murciélagos de acuerdo con las condiciones anteriormente mencionadas.

Seguimos a Kunz y Kurta (1988) para la posición y colocación de las redes de acuerdo con la vegetación, topografía y cuerpos de agua. Utilizamos dos redes de niebla (14 x 2.5 m, con ojo de malla de 22 mm) que permanecieron abiertas desde las 16:30 hr hasta las 00:30 hr para abarcar diferentes ámbitos temporales de acuerdo con los gremios tróficos, y se revisaron cada 20 minutos para disminuir la probabilidad de muerte de los individuos o el escape de la red. Seguimos a Bracamonte (2010) en el tiempo de apertura de las redes al comenzar la actividad de los murciélagos y permanecieron así por 6 horas, aprovechando el período de mayor actividad. El esfuerzo de muestreo en horas/red por metro de red se calculó según Medellín (1993). Para la toma de medidas y la identificación de individuos seguimos a Timm *et al.* (1999)y Medellín *et al.* (2008). Todos los individuos fueron manipulados según las pautas de la American Society of Mammalogist para el uso de mamíferos silvestres (Sikes *et al.* 2016).

Realizamos una prueba de ANOVA de una sola vía con el programa estadístico R 3.4.2 (R Core Team 2015) para determinar la media de los datos de temperatura y la humedad relativa del aire de las horas de inicio y finalización durante cada jornada de los informes del 2015 y 2016 del higrotermográfo de la Estación Meteorológica Experimental (EME) de la UNAH. Ésta se encuentra a una distancia entre 247 – 732 m de los sitios seleccionados.

Se capturaron 114 individuos (0.08 individuos/horas/metro/red) en 1,428.24 horas/metro/red, pertenecientes a 7 especies (0.005 especies/hora/metro/red) en 21 jornadas de trabajo. Según el análisis ANOVA, la media de la temperatura de las horas de capturas de los murciélagos filostómidos fue entre 17.4 ºC y 22.8 ºC, y la humedad relativa del aire fue entre 58 % y 93.5 % (Figura 2).

La mayor actividad de murciélagos se registró entre las 18:00 - 21:59 hr, en el cual se capturó el 84 % de los individuos, y el otro 16 % fue capturado entre 17:00 – 17:59 hr y 22:00 –

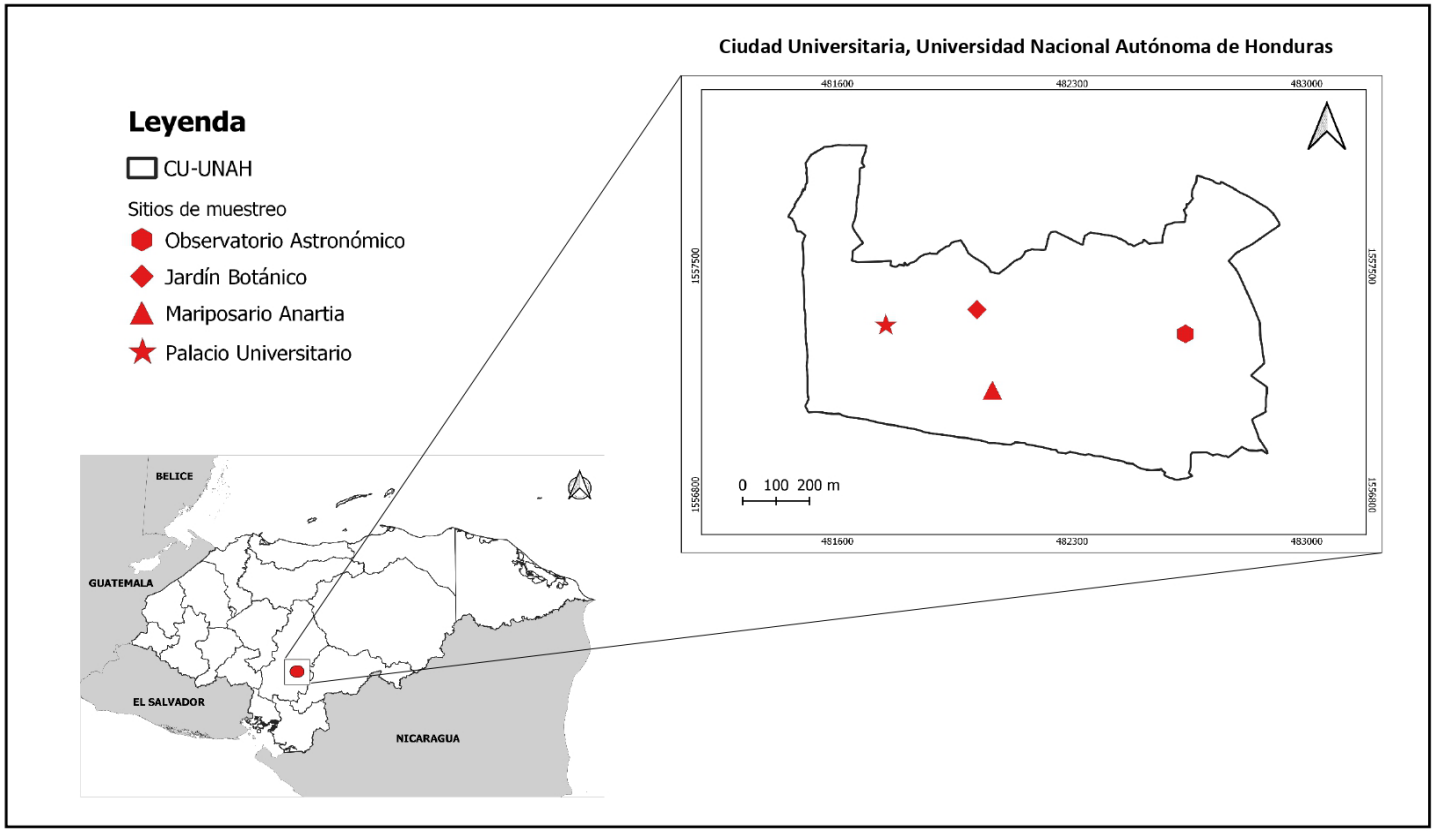

Figura 1. Mapa de los 4 sitios de muestreo en Ciudad Universitaria de la Universidad Nacional Autónoma de Honduras (CU-UNAH) en el Departamento de Francisco Morazán. Alrededor de los sitios de muestreo hay edificios y calles transitadas por carros y personas. Sin embargo, toda la universidad se caracteriza por tener un bosque seco subtropical con abundantes áreas alteradas, y ciertas zonas de bosques en donde se encuentra la mayor cantidad de árboles frutales (por ejemplo, el Jardín Botánico representado por un rombo).

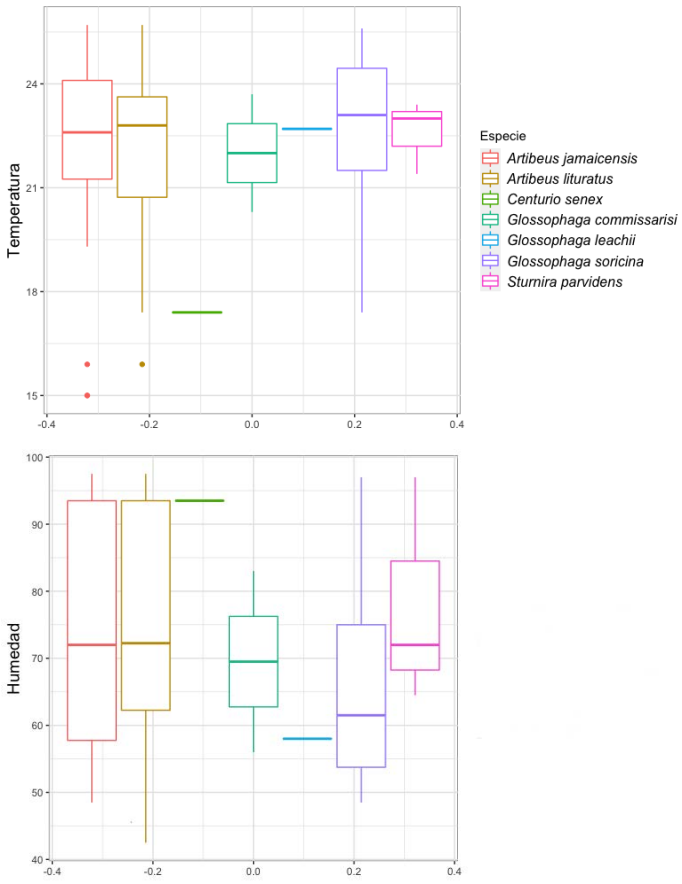

Figura 2. Medias de la humedad relativa (arriba) y temperatura del aire (abajo) en las que se capturaron los murciélagos filóstomidos en Ciudad Universitaria de la Universidad Nacional Autónoma de Honduras (CU-UNAH) en el Departamento de Francisco Morazán en el centro de Honduras. Las líneas horizontales representan la media de las temepraturas; las líneas horizontales superiores e inferiores son los quartiles; y las líneas verticales inferiores y superiores son los rangos respectivos. Los puntos son valores atípicos con respecto a la media.

00:59 hr. Las horas de captura variaron para cada especie; por ejemplo, el 86 % de los individuos (n = 47) de *A. jamaicensis* y el 89 % de los individuos (n = 34) de *A. lituratus* se capturaron entre las 17:00 y 20:59 hr. Y el 50 % de las capturas de *G. soricina* se realizaron entre 19:00 y 20:49 hr. Los rangos de las otras especies de murciélagos filostómidos se describen en la Tabla 1. El 22.5 % de las capturas se realizó en febrero, 11.7 % en marzo, 9 % en abril, 12.6 % en octubre, 32.43 % en noviembre y 11.7 % en diciembre.

Artibeus jamaicensis, *A. lituratus* y *Glossophaga soricina* fueron las especies más comunes y dos especies fueron representadas por solamente una captura: *G. leachii* y *Centurio senex*. *Artibeus jamaicensis* fue la especie que se capturó en un ámbito temporal más amplio, y *C. senex* la que se capturó a la temperatura más baja y a la humedad relativa más alta. Sin embargo, *G. soricina* fue la especie que se capturó en la temperatura más alta y *G. leachii* en la humedad relativa más baja.

A diferencia de nuestros resultados, Amorim *et al.* (2012) encontraron correlaciones estadísticamente significativas entre la actividad de murciélagos de la familia Vespertilionidae con la temperatura y la humedad relativa del ambiente. Se debe considerar que la subfamilia Stenodermatinae (*Artibeus*, *Centurio*, *Sturnira*) y Glossophaginae (*Glossophaga*) contiene especies generalistas (Reid 2009), por lo que invierten menos tiempo en la búsqueda de alimento (Townsend *et al.* 2008), a diferencia de especies especialistas como la familia Vespertilionidae, que tienen horarios específicos (vespertinos) para la búsqueda de alimento. La actividad de los murciélagos depende del tiempo en que los murciélagos buscan su alimento, refugio, agua, entre otros recursos, por lo que el tiempo invertido en la búsqueda de alimentos podría estar influenciado por las variables climáticas en algunas especies de murciélagos (Filho *et al.* 2010; Vela-Vargas y Pérez-Torres 2012). Greenhall (1976) menciona que las humedades relativas del aire entre 55 y 95 % y temperaturas ambientales entre 21.1 y 29.4 ºC son adecuadas para mantener *A. jamaicensis* en cautiverio. Suárez-Payares y Lizcano (2011) registraron un promedio de humedad relativa de 73.7 % y una temperatura ambiental de 24.6 ºC en refugios de *A. jamaicensis*. En México, *G. leachii* se ha capturado en lugares donde las temperaturas mensuales promedio oscilan entre 23.8 y 25.8 ºC (García-García y Santos-Moreno 2014). Este estudio es el primero en describir los patrones de actividad en CU–UNAH. El único estudio que se ha llevado a cabo sobre murciélagos en CU-UNAH fue la descripción de la dieta de murciélagos filóstomidos por Turcios-Casco *et al.* (2019). Las especies del género *Artibeus*, consideradas por Emmons y Feer (1999) como especies típicas de áreas perturbadas, resultaron ser las más abundantes representando el 79.8 %. Las especies

Tabla 1. Medias de la temperatura y humedad relativa del aire del análisis ANOVA, ámbitos temporales, abundancias relativas y número de individuos capturados de murciélagos filostómidos en Ciudad Universitaria de la Universidad Nacional Autónoma de Honduras (CU-UNAH) en el Departamento de Francisco Morazán en el centro de Honduras.

Especie	Ámbito temporal (h)	Media de la temperatura del aire (ºC)	Desviación estándar	Media de la humedad relativa del aire (%)	Desviación estándar	Abundancia relativa	Abundancia total
Artibeus jamaicensis	17:36–00:10	22.35	±2.38	74.74	±17.24	0.48	55
Artibeus lituratus	17:50–22:25	22.23	±2.44	75.02	±17.45	0.32	36
Centurio senex	20:28	17.4	0	93.5	0	0.01	1
Glossophaga commissarisi	19:22–21:56	22	±2.40	69.5	±19.09	0.02	2
Glossophaga leachii	18:56	22.7	0	58	0	0.01	1
Glossophaga soricina	18:40–23:14	22.83	±2.31	66.16	±16.95	0.14	16
Sturnira parvidens	21:14–22:14	21.47	±1.13	75.33	±22.98	0.03	3

de *Artibeus* son consideradas importantes para la regeneración del paisaje debido a que son dispersores de semillas en bosques tropicales (Flores-Martínez *et al.* 1999). Además de las variables estudiadas, la actividad de los murciélagos puede estar influenciada por la altitud (Linden *et al.* 2014), tipo de bosque (Owen *et al.* 2004), o actividad antropológica (Gehrt y Chelsvig 2003; Berthinussen y Altringham 2012). Los resultados de este trabajo demuestran que podrían haber variaciones en los patrones de actividad en las siete especies de murciélagos filostómidos. Recomendamos estudiar la actividad de murciélagos filóstomidos con relación a otros factores ecológicos (*e.g.*, fenofases en las que se encuentran las plantas, cuerpos de agua más cercanos), considerando variaciones estacionales, e incluyendo otros aspectos de comportamiento (*e.g.*, selección de refugios) y ecológicos (*e.g.*, variación en la dieta).

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Noteworthy records of puma (*Puma concolor*) in Morelos, México

Registros notables de puma (*Puma concolor*) en Morelos, México

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We present noteworthy records of puma (*Puma concolor*) within the Sierra de Huautla Biosphere Reserve (SHBR), Morelos, México, captured in photo-trapping samplings done in 2019 at ejidos, within this natural protected area and Morelos. These records were obtained few years after the first record of jaguar (*Panthera onca*) for this natural protected area and Morelos. Two potentially different adult individuals of puma were identified. These records are the first confirmed photographic evidence of this species for the SHBR and for Morelos. There is little confirmed evidence of the presence of the species which is considered rare or absent in many sites throughout the state. In the case of the SHBR, although there are a few anecdotal reports by local inhabitants of sightings or tracks, the presence of pumas had never been confirmed photographically. We consider that these records are related to evidence from recent studies, showing that the ecological integrity of the area is, on average, moderately high as a consequence of the increase of the tropical deciduous forest cover. This has presumably led to an increase in populations of different species that compose the puma's diet. Furthermore, it has been estimated that the quality of habitat for this predator in the SHBR has been increasing. Therefore, we consider that our photographic records of puma in this natural protected area indicate that the efforts focused on the conservation of the biological diversity have had positive results and strongly suggest that the presence of puma in the area may increase in the medium term.

Key words: Conservation; ecology; Felidae; photo-trapping; tropical dry forest.

Presentamos registros notables de puma (*Puma concolor*) en la Reserva de la Biósfera Sierra de Huautla (REBIOSH), Morelos, México obtenidos en fototrampeos hechos en 2019 en ejidos, dentro de esta reserva. Estas fotografías de puma se obtienen pocos años después del primer registro de jaguar (*Panthera onca*) para esta área natural protegida y para Morelos. Identificamos potencialmente a dos individuos adultos de puma. Estos registros son la primera evidencia fotográfica de puma para la REBIOSH y para Morelos. Existe poca evidencia confirmada de la presencia de la especie, considerada rara o ausente en diferentes sitios del estado. En el caso de la REBIOSH, a pesar de escasos informes anecdóticos por parte de habitantes locales de avistamientos o registros de huellas, su presencia nunca había sido confirmada fotográficamente. Consideramos que estos registros están relacionados con evidencia de estudios recientes que sugieren que la integridad ecológica es, en promedio, moderadamente alta como consecuencia del aumento de la cubierta de bosque tropical caducifolio. Es de suponer que esto ha llevado a un aumento de las poblaciones de diferentes especies que componen la dieta del puma. Además, se ha estimado que la calidad del hábitat de este depredador en la REBIOSH ha ido aumentando. Por lo tanto, consideramos que nuestros registros fotográficos de puma en esta área natural protegida indican que los esfuerzos enfocados en la conservación de la diversidad biológica tienen resultados positivos y sugieren fuertemente que la presencia de puma en el área puede aumentar en el mediano plazo.

Palabras clave: Conservación; ecología; Felidae; fototrampeo; selva baja caducifolia.

Natural Protected Areas (NPA) are clearly defined geographical spaces that are recognized, dedicated and managed through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values (Dudley 2008). Their success depends, partially, on maintaining the ecological integrity of the environments they protect (Parrish *et al.* 2003). Large carnivorous mammals in a particular NPA indicate that this objective is being achieved. Large predators have an important ecological role as population regulators of their prey species and are considered to contribute to natural environment's stability (Ritchie *et al.* 2012).

The puma (*Puma concolor*) is the second largest and most widely distributed wild cat species in America (Nielsen *et al.* 2015), ranging from British Columbia, Canadá and the northeastern United States to Argentina and Chile. In México, puma has been historically reported in all states (Chávez-Tovar and Ceballos 2014), in practically all vegetation types and at an altitudinal range from sea level to 3,500 m.

The International Union for Conservation of Nature (IUCN) considers the species in the category of Least Concern (LC). However, recent evidence indicates that its populations are declining over most of its distribution range (Nielsen *et al.* 2015). In México, its populations have been decreasing or extirpated from many areas, mostly due to depletion of their prey species, conflicts with humans over livestock predation or disturbance of their habitat (Laundré and Hernández 2010; Chávez-Tovar and Ceballos 2014; Guerisoli *et al.* 2020). There are currently few studies on this species, and existing information is insufficient to determine its presence and abundance across the country (Soria-Diaz *et al.* 2010).

The first record of puma for the state of Morelos was provided by Davis and Russell (1954), reporting the examination of the skin of an individual apparently in Yautepec, noting that the puma was not abundant in the state. Sánchez-Hernández and Romero-Almaráz (1995), considered that there was potential for the presence of puma in Sierra de Huautla, Morelos. However, these authors consider that its presence in the area might be restricted mostly to sites with conserved vegetation and high prey abundance. Álvarez-Castañeda (1996) considered puma to be present in Morelos in his book "The Mammals of Morelos" based on the report by Davis and Russell (1954). The few reports of puma for Morelos after this book are based on records of tracks and feces (Altamirano-Álvarez *et al.* 2009; Hernández-Silva *et al.* 2011) or ethnomastozoological interviews (Martínez *et al.* 2012; García-Flores *et al.* 2014, 2018). A search for *Puma concolor* records in Morelos in the databases of the Global Biodiversity Information Facility (GBIF 2021), the Sistema Nacional de Información sobre Biodiversidad (SNIB; CONABIO 2020) and the Naturalista online platform produced no additional reliable records of puma for Morelos.

Better documentation of the puma's presence in the state is essential to direct conservation strategies and provide baseline information to prevent potential threats that can arise from human-puma conflicts, especially with cattle ranchers. Such conflicts are likely to occur even within NPA (Guerisoli *et al.* 2020). In this work, we report recent notable records of puma (*Puma concolor*) for the Sierra de Huautla Biosphere Reserve (SHBR) in Morelos, using camera traps. We consider that our photographic records of puma are relevant because, in addition to being one of the very few reliable records of the species in the state, they provide evidence that the efforts that have been implemented to protect SHBR's biodiversity and its habitats have produced positive outcomes. By documenting the presence of pumas in this NPA and Morelos state may also allow us to plan strategies to mitigate potential puma-livestock conflicts before they arise and result in retaliatory killings, and hence facilitate the coexistence of pumas and humans in Morelos.

SHBR protects 59,030 ha covered mostly by tropical dry forest (TDF). It is one of the largest NPAs established to protect this type of vegetation, which is rich in endemic species of plants and animals. However, it is under strong transformation pressure due to human activities (Janzen 1988; Trejo and Dirzo 2000; Ceballos and Valenzuela-Galván 2010). Although it has some level of human disturbance, its rugged topography and difficult accessibility favor preserving large fragments of TDF. Steep slopes have prevented transforming some areas into pastures or agricultural fields, whereas more accessible areas have been transformed (Trejo and Dirzo 2000).

The Sierra de Huautla is considered a priority terrestrial region for conservation (Arriaga *et al.* 2000) and has a carnivore community made up of 16 species. However, before this report, the presence of puma in SHBR has been considered potential, and no previous report had provided conclusive evidence (Sánchez-Hernández and Romero-Almaráz 1995; Valenzuela-Galván *et al.* 2020).

We conducted our photo-trapping from July to September 2019 by installing 89 camera traps, of different models and characteristics: Cuddeback (models 1151, E and H-1453; Non Typical, Inc., Park Falls, Wisconsin) and Moultrie (Models D444 and D880; EBSCO Industries, Inc., Alabaster, Alabama). We installed them within SHBR in 29 single sampling stations and 30 double sampling stations, distributed in 4 ejidos (a mode of communal land tenancy in México used by a group of people for common services such as crops or cattle pastures; Schumacher *et al.* 2019): El Limón de Cuauchichinola, Tepalcingo municipality; and the ejidos of Huautla, Santiopa and Rancho Viejo, all three at Tlaquiltenango municipality (Figure 1). The distance between each camera varied between 0.5 km and 1 km. We placed olfactory attractants, on the ground at a close range (1.5-2 m) in front of each camera trap. The olfactory attractants we used were 425 g cans of sardine with tomato (GUAYMEX ™) with holes punched in the top of the can, and small strips of cloth dipped in commercial Cat Passion and Gumbo attractants (O'Gorman Enterprises Inc., Montana, USA). Additionally, we conducted a community monitoring sampling between October and December 2019 in the ejido El Limón de Cuauchichinola. For this monitoring, we used 19 Bushnell camera traps (Trophy Cam E3; Bushnell Corporation, Overland Park, Kansas, USA), spaced 0.5 km to 1 km apart, with no olfactory attractants.

A database for each photo-trapping sampling was built using the software Wild.ID (TEAM Network 2009). All wildlife images obtained were analyzed to determine independent records and trapping efforts (sum of days that each camera trap effectively operated). We estimated basic information derived from photo-trapping, such as naive occupancy, relative abundance indexes, activity patterns and number of species recorded (Mandujano 2019).

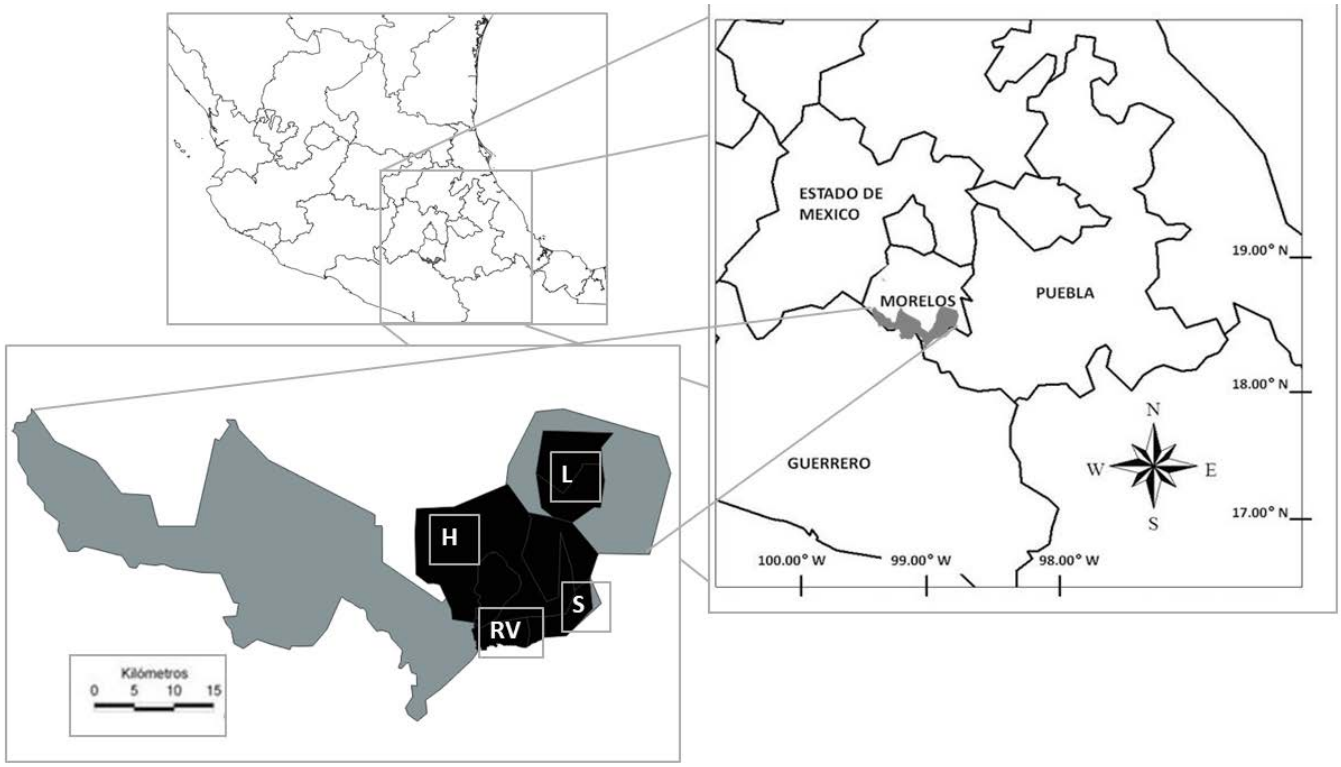

Figure 1. Location of the study area, the Sierra de Huautla Biosphere Reserve (gray polygon) in the south of Morelos state, central México and the 4 ejidos where the photo-trapping was done (polygons in black): El Limón de Cuauchichinola (L; Tepalcingo municipality), Huautla (H), Rancho Viejo (RV) and Santiopan (S; Tlaquiltenango municipality), inside the SHBR.

In the first sampling, after accumulating 5,645 trap days of sampling effort, we obtained two records of puma in two different sites. The first record was from July 15, 2019 at 10:48 hr in a double station, within the ejido of El Limón de Cuauchichinola (18° 29′ 24.00″ N and 98° 56′ 24.00″ W; 1,400 m). The recorded individual is an adult male, based on visible scrotal testicles, that appears to be relatively old and in good condition (Figure 2a, b; P1 in Figure 3).

The second record was obtained from a camera installed in the ejido of Huautla, about 8 km southwest of the site of the previous record (18° 26′ 60.00″ N and 99° 0′ 0.00″ W; 1,100 m), on September 8, 2019, at 19:30 hr. A male puma was caught in video footage (Figure 2 c, d, e; P2 in Figure 3), displaying a Flehmen response in which lift their lips and hold the mouth slightly open while doing a long sniff. This behavior is associated with the search for a mate and the detection of urine from an individual of the other sex, which may suggest that this individual identified a female in the area or that it has detected another male as a potential competitor (Allen *et al.* 2016). We suspect that this puma is a different individual based on a larger black-brown mark on its right cheek and that his head seems smaller than that of the individual recorded at El Limón de Cuauchichinola (P2 in Figure 3).

In the community monitoring sampling in El Limon de Cuauchichinola, we accumulated 1,368 trap days of photo-trapping effort. We recorded an individual drinking from a small water pool (18° 32′ 24.00″ N and 98° 54′ 36.00″ W; 1,600 m). The images show a robust adult puma, whose sex could not be determined (Figure 2f, g, h; P1? In Figure 3). It could be the same individual recorded on July 15, 2019 in the same ejido, considering that in both records there is a similar faint dark line down the middle of the head, from the ears to the front of the eyes (P1 and P1? in Figure 3). This record was obtained on October 9, 2019, at 23:59 hr (the date and time of this camera were initially misprogrammed but based on the installation data we recalculated the correct date and time).

The three records were in large fragments of tropical dry forest, classified as conserved. Some of the abundant tree species in the area are: *Conzattia multiflora*, *Amphipterigyium adstringens*, various species of *Bursera*, *Jacaratia mexicana,* and *Lysiloma divaricata* (CONANP 2005). In the camera traps where we recorded puma, we also obtained photos of several species frequently reported as prey for the puma, such as white-tailed deer (*Odocoileus virginanus*), collared peccary (*Dicotyles angulatus*), white-nosed coati (*Nasua narica*) and nine-banded armadillo (*Dasypus novemcinctus*). In addition, other species of carnivores were also recorded such as coyote (*Canis latrans*), margay (*Leopardus wiedii*), jaguarundi (*Herpailurus yagouaroundi*), northern raccoon (*Procyon lotor*), grey fox (*Urocyon cinereoargenteus*), southern spotted skunk (*Spilogale angustifrons*). Also, species from other taxa: Virginia opossum (*Didelphis virginiana*), Mexican grey squirrel (*Sciurus aureogaster*), West Mexican chachalaca (*Ortalis poliocephala*), Turkey vulture (*Cathartes aura*) and American black vulture (*Coragyps atratus*). There were also records of domestic species such as donkey (*Equus asinus*) and cattle (*Bos taurus*).

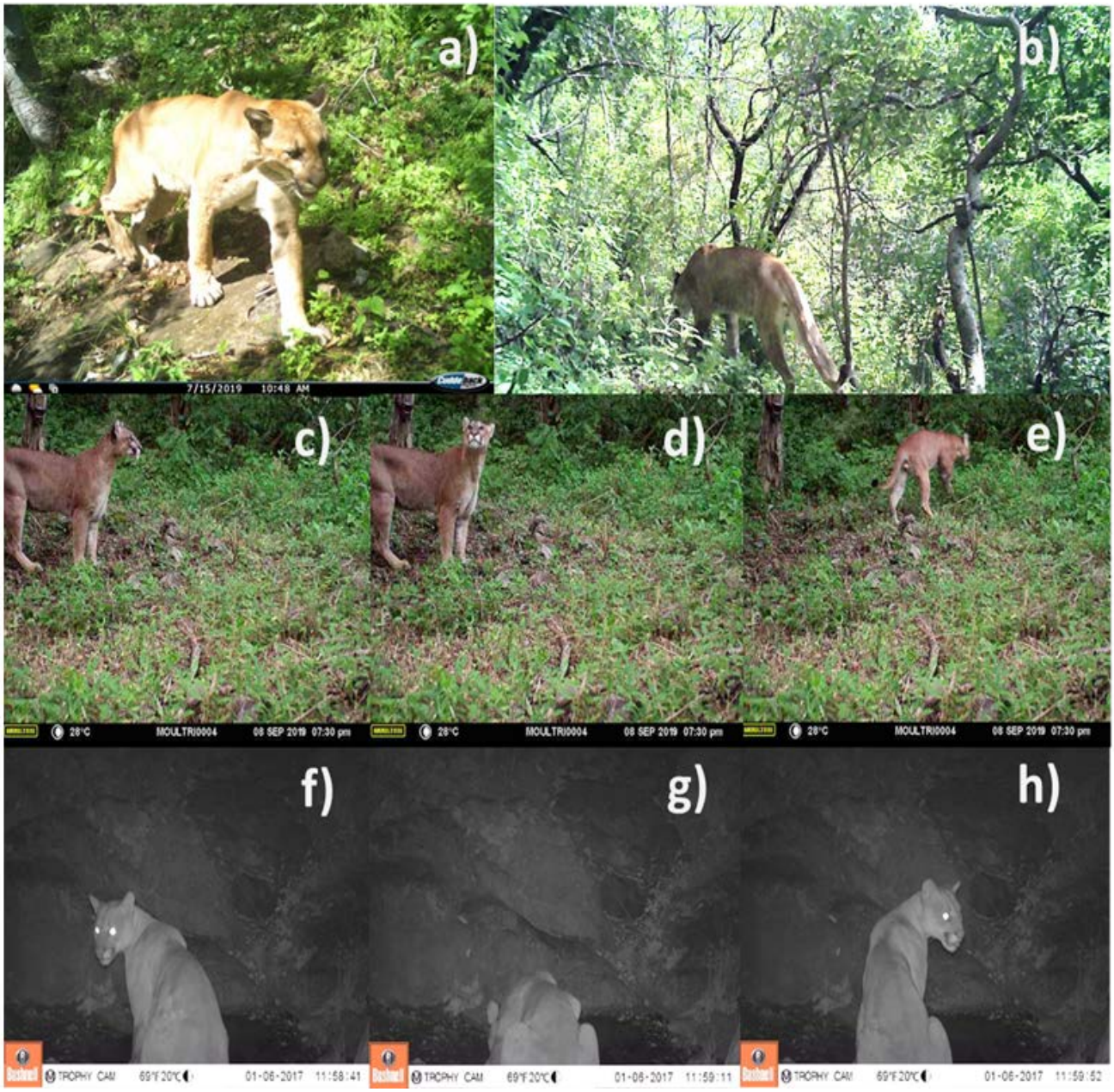

Figure 2. Sequence of recent photographic records of puma (*Puma concolor*) obtained in tropical dry forest sites of the Sierra de Huautla Biosphere Reserve, Morelos, México: a) and b) an adult male recorded at the ejido of El Limón de Cuauchichinola, July 15, 2019; c), d) and e) frame photos from an adult male individual, recorded at the ejido of Huautla, September 8, 2019; f), g) and h) photographs of an adult individual (sex could not be determined), also recorded at the ejido of El Limón de Cuauchichinola, in a community monitoring sampling, on October 9, 2019.

Despite more than 15,000 camera trap-days of sampling effort between 2009 and February 2018 (Valenzuela-Galván *et al.* 2020; D. Valenzuela-Galván, pers. obs.), there were no photographic records of puma in the SHBR prior to the three we report here. Thus, the records presented here are the first photographic evidence confirming the current presence of puma in this NPA and more importantly, in Morelos state.

Our records of puma, probably of two different individuals, at three different photo-trapping stations suggest that the species might be increasing in abundance in the area of the SHBR. Although we suspect that these were two different individuals, species that are not striped or spotted can be misidentified (see Oliveira-Santos *et al.* 2010), also the quality of the images we recorded is not optimal to allow the detection of more details. Therefore, we cannot be completely sure that the photographic records we have correspond to two different individuals.

It is also possible that the recorded individuals do not reside within the state, but rather are from neighboring populations belonging to México State, Puebla or Guerrero. Puma has been recorded as abundant in the Sierra de Nanchititla Natural Reserve in México State, about 145 km west of the current record sites (Monroy-Vilchis *et al.* 2011). In Puebla, Farías *et al.* (2015) reported the presence of puma, with the detection of adults of both sexes and young, at the Tehuacán-Cuicatlán Biosphere Reserve in the southern part of the state, about 180 km southwest of the present reg-

istry of puma in Morelos. Ramírez-Bravo *et al.* (2018) also reported puma for the Sierra del Tentzo and for a locality in the Mixteca Baja Poblana, located about 78 km NW and 30 km SW, respectively, of the records that we now report. In Guerrero, Almazán-Catalán *et al.* (2013), obtained five records of skins and a puma skull from different localities within the state; the closest localities to the SHBR were Teloloapan and Leonardo Bravo, about 95 km to the E and 117 km SE of the SHBR's records we report here.

Although it has been reported that the puma is tolerant to moderate levels of human disturbance in its habitats, its abundance may be linked to areas with an abundance of potential prey, low hunting pressure or low abundance of potential competitors (see Miotto *et al.* 2014; Smith *et al.* 2019). There is evidence that puma was hunted in the area before the formation of the SHBR in 1999. Some potential preys have been locally extirpated by hunting pressure, such as white-lipped peccary (*Dicotyles angulatus;* Sánchez-Hernández and Romero-Almaráz 1995; Álvarez-Castañeda 1996). However, since the SHBR was established, different conservation actions have been implemented, including promoting reforestation and ecological restoration projects, supporting actions to retain soil and reduce water runoff speed in deforested areas, and strong support to alternative productive projects for sustainable development of local communities (*e. g.*, wildlife management units, which require proper management of forested habitats).

We consider that all these actions have maintained and increased the NPA's biodiversity since its decree in 1999. The rate of transformation of the vegetation has been very low and there has been a moderate increase in the area of conserved TDF (Sorani *et al.* 2020). An increase in the abundance of wildlife species has also been reported (Castro-Campos 2016; López-Medellín *et al.* 2017) including species that are potential prey for puma. For example, the white-tailed deer (*Odocoileus virginianus*) has a high population density (21.3 to 28 ind. / km^2; Corona *et al.* 2010; Hernández-Silva *et al.* 2011), and the white-tailed coati (*Nasua narica*) present the second highest value of relative abundance among carnivore species in the SHBR (Valenzuela-Galván *et al.* 2020). In addition, species that had no previous records or were considered locally extinct are now frequently

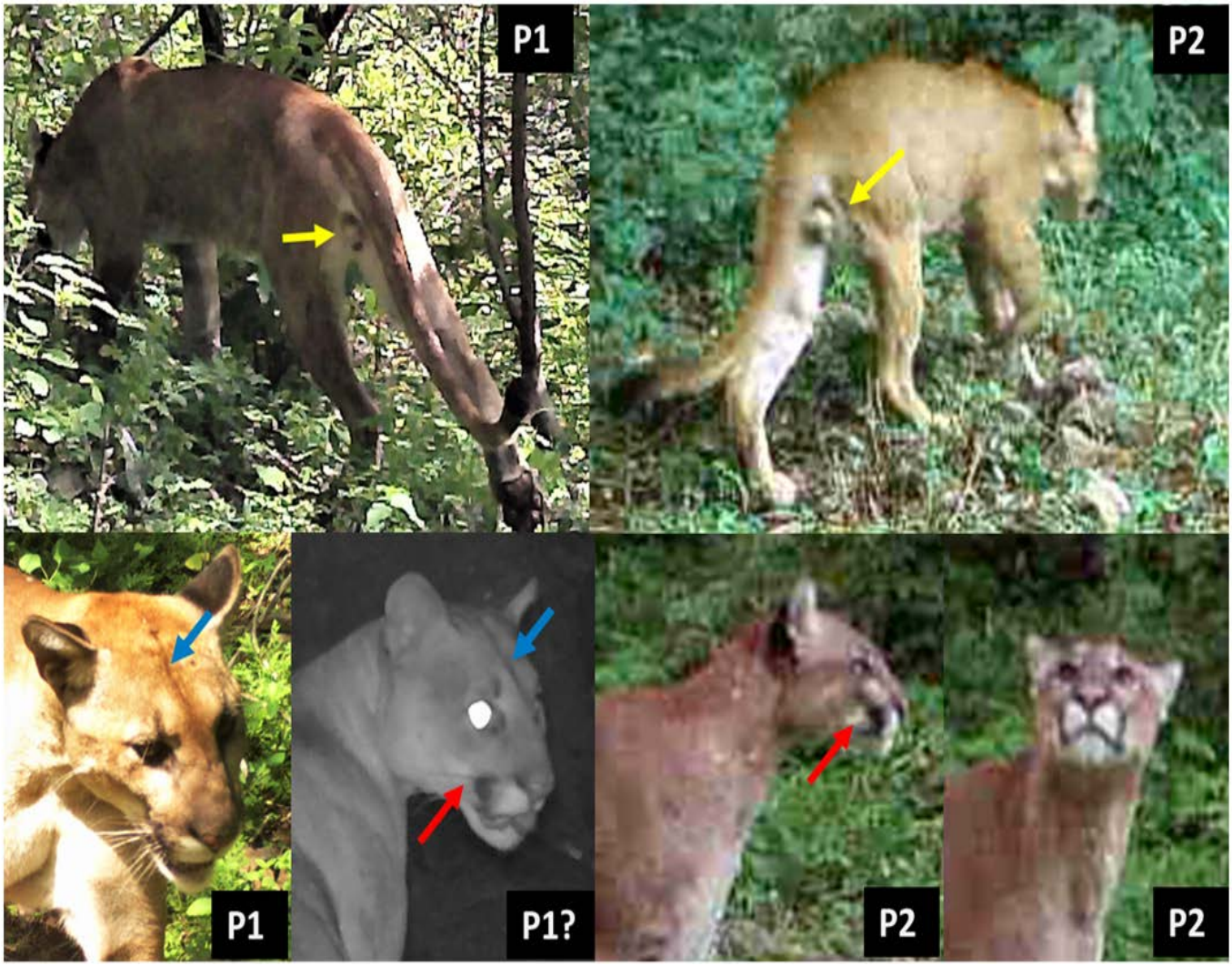

Figure 3. Differences between recorded individuals of *Puma concolor*. We suspect that we photographed two different individuals, P1 at the ejido of El Limón de Cuauchichinola and P2 at the ejido of Huautla. Both were adult males based on their noticeable scrotal testicles (yellow arrows). We consider that P1 and P2 are likely different individuals. The photographs obtained on October 9, 2019, of an individual of unidentified sex (P1?) might be the same as P1, recorded on the same ejido and on both, it is noticeable a faint dark line, that goes from the middle of the head to the front of the eyes (blue arrows).

recorded, for example, margay (*Leopardus weidii*), jaguar (*Panthera onca*) and collared peccary (*Dicotyles angulatus "Pecari tajacu"*; Mason-Romo *et al.* 2008; Valenzuela-Galván et al. 2013; Valenzuela-Galván *et al.* 2015).

All this suggests that the ecological integrity of the SHBR has improved, favoring the presence of large predators. A recent analysis by CONABIO (National Commission for the Use and Knowledge of Biodiversity; https://monitoreo.conabio.gob.mx/i-efectividad/reportes_html/6104.html, accessed on October 25, 2020) supports this assumption. They found that the rate of transformation of the vegetation in SHBR was close to zero in the last five years. Also, the average value of ecosystem integrity (Equihua *et al.* 2014) of the reserve is higher than 0.6 (1 being the maximum value), and the quality of the habitat for puma increased steadily between 2008 and 2014 (analysis period).

The presence of puma in SHBR as well as the recent record of jaguar (*Panthera onca*; Valenzuela-Galván *et al.* 2015), also in this NPA, strongly suggest that both species could need large areas covered with tropical deciduous forest. Although both species do not need exclusively forested areas, both prefer sites with primary forest over areas heavily disturbed by human activities. Especially in the case of jaguar, large areas of primary forest should be guaranteed to ensure its long-term conservation (De la Torre *et al.* 2017).

Only a few kilometers at the southeast of the sites where we recorded puma, there are large unprotected fragments of conserved TDF, in the area known as the Mixteca Baja Poblana (MBP), in the state of Puebla. The TDF in that area may be beneficial for the conservation of puma, but needs to be protected. In fact, an extensive study has already been done to support the establishment of a new NPA of nearly 60,000 ha, mostly covered by TDF, in the MBP. That study, done by researchers from the Centro de Investigación en Biodiversidad y Conservación, coordinated by the second author of this note, and financed by the Volkswagen Program "For the love of the planet" was presented to the pertinent area of Comisión Nacional de Áreas Naturales Protegidas (CONANP-CIBYC-UAEM 2013). We are also aware that there is a similar proposal for a new state natural protected area in the northern portion of Guerrero state (along the southwest border of the SHBR) that also contains large tracts of well-preserved TDF (V. Sorani, pers. com.).

We consider that our present records of puma in the SHBR provide even further justification for the establishment of the new NPA. Which in turn, would also help to maintain a large biological corridor for felines, such as the one proposed by Ramírez-Bravo *et al.* (2010) or the one proposed for jaguars by Ceballos *et al.* (2018). This area extends from the Zicuarain-Infiernillo Biosphere Reserve in the state of Michoacán, through northern Guerrero, southeastern México State, and southern Morelos state, to connect to the Tehuacán-Cuicatlán Biosphere Reserve in Puebla and Oaxaca. We are confident that our records suggest that this predator may become more abundant locally in the medium term and indicate that the management and conservation actions implemented in the SHBR have been effective.

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