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First record of margay (*Leopardus wiedii*) in the Sierra Monte Negro State Reserve; Morelos, México: the importance of low deciduous forest relicts for conserving the species

Primer registro de margay (*Leopardus wiedii*) en la Reserva Estatal Sierra Monte Negro, Morelos, México: la importancia de los relictos de selva baja caducifolia para la conservación de la especie

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The margay (*Leopardus wiedii*), locally known as tigrillo, is a small wild felid distributed from México to South America, mainly in tropical and temperate environments. In Morelos, its presence was previously recorded in 2 federal protected natural areas: the Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I (APFF-CBC) to the north and the Sierra de Huautla Biosphere Reserve (REBIOSH) to the south. To obtain information on the presence of wild mammals in the Sierra Monte Negro State Reserve (RESMN), monitoring was carried out using camera traps. RESMN is an important State Protected Natural Area for its potential role as a biological corridor between APFF-CBC and REBIOSH. However, few studies have been conducted on the species of wild mammals distributed in RESMN. The monitoring was performed between November 2020 and November 2021, placing 10 camera-trap monitoring stations with a total sampling effort of 3,650 trap-days. A single margay individual was recorded in 2 monitoring stations between November 2020 and April 2021, indicating that this individual used the RESMN at least during the dry season. The presence of this margay individual demonstrates the importance of RESMN, which may serve as a habitat or corridor for felids of this species.

Key words: Biological corridor; low deciduous forest; Protected Natural Area; tigrillo.

El tigrillo o margay (*Leopardus wiedii*) es un pequeño félido silvestre que se distribuye desde México hasta Sudamérica, principalmente en ambientes tropicales y templados. En Morelos se tiene registro previo de su presencia en 2 áreas naturales protegidas federales, el Área de Protección de Flora y Fauna Corredor Biológico Chichinautzin Fracción I (APFF CBC), al norte y la Reserva de la Biosfera Sierra de Huautla (REBIOSH), al sur. Con la finalidad de obtener información sobre la presencia de mamíferos silvestres en la Reserva Estatal Sierra Monte Negro (RESMN), se realizó un monitoreo a través de cámaras-trampa. La RESMN es un Área Natural Protegida de carácter estatal de gran importancia debido a su papel potencial como corredor biológico entre el APFF CBC y la REBIOSH. Sin embargo, pocos estudios se han realizado sobre las especies de mamíferos silvestres que se distribuyen en la RESMN. El monitoreo se llevó a cabo entre noviembre de 2020 y noviembre de 2021, colocando un total de 10 estaciones de monitoreo con cámaras-trampa, con un esfuerzo de muestreo acumulado de 3,650 días-trampa. Se obtuvo el registro de 1 individuo de margay en 2 estaciones de monitoreo entre los meses de noviembre de 2020 y abril de 2021, por lo que al menos durante la temporada de estiaje el individuo hizo uso de la RESMN. La presencia de este individuo de margay muestra la importancia de la RESMN, la cual puede estar actuando como hábitat y/o corredor para estos felinos.

Palabras clave: Área Natural Protegida; corredor biológico; selva baja caducifolia; tigrillo.

The margay (*Leopardus wiedii*) is the smallest wild felid distributed in México. Measuring between 51 cm and 79 cm and weighing between 1.3 kg and 5.0 kg (SEMARNAT 2018a), this mottled felid has a slender body, a small head, large eyes, a large body and a long thick tail, measuring on average almost 40 % of the total body length. It differs from the ocelot (*Leopardus pardalis*), a very similar wild felid that is larger in size and with a shorter tail (29 % of its body length, on average; Sunquist and Sunquist 2002; Ramírez-Barajas *et al.* 2014; SEMARNAT 2018a). The ocelot is a strict carnivore, and its diet is composed mainly of small mammals, birds, and reptiles (Wang 2002).

The margay is widely distributed in tropical and temperate environments, from the tropical lowlands of México to southern Brazil and Paraguay; unfortunately, its populations have been declining (de Oliveira 1998; Ávila-Najera

et al. 2015; de Oliveira *et al.* 2015). In México, one of the highest-altitude records is located in the mountain cloud forest of northwest Morelos, in the Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I, at 2,750 m (Aranda and Valenzuela-Galván 2015).

The margay is listed in the Near Threatened category on the IUCN (International Union for Conservation of Nature) Red List and in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora CITES (de Oliveira 1998; de Oliveira *et al.* 2015). The Mexican legislation lists the margay as Endangered of Extinction in the Official Mexican Standard NOM-059-SEMARNAT-2010 (SEMARNAT 2018b).

Some of the most important threats to this species are habitat loss and fragmentation, illegal trade, poaching, and susceptibility to disease outbreaks (de Oliveira 1998; de Oliveira *et al.* 2015). Free-ranging dogs and cats also pose a threat to the margay; domestic dogs and cats can adversely affect their populations as they compete for prey and can be disease vectors; besides, cattle impacts vegetation by overgrazing, hence reducing the available habitat for wildlife (Horn *et al.* 2020).

Despite its conservation status in México, the margay is a species scarcely studied in the country. The camera-trap technique has allowed for generating more information about the species. For example, several works published recently have recorded the species in sites with no previous evidence of its presence (Botello *et al.* 2006; Valenzuela-Galván *et al.* 2013; Aguilar-López *et al.* 2015; Aranda and Valenzuela-Galván 2015; Farías *et al.* 2015; Luja and Zamudio 2019). Estimates of its potential distribution area in some sites have been published (Charre-Medellín *et al.* 2015; Martínez-Calderas *et al.* 2016; Morales-Delgado *et al.* 2021) and also estimates of relative abundance in some states of the country (Ávila-Najera *et al.* 2015; Briones-Salas *et al.* 2016). In this paper, we report the first record of the margay in the Sierra Monte Negro State Reserve (RESMN, for its acronym in Spanish), located in the center of the state of Morelos.

Medium and large-sized mammals were monitored using camera traps placed within the RESMN, a state-run protected natural area (PNA) covering an area of 7,725 ha. The dominant vegetation is low deciduous forest (LDF), and there is also a small area covered by oak forest to the north. The RESMN harbors one of the last LDF areas in central Morelos, characterized by low-height trees (no more than 15 m) and marked seasonality, with most trees losing their leaves during the dry season and regrowing them in the rainy months (García-Flores *et al.* 2021). The rainy season spans from May to October, while drought can last up to 8 months in some regions. The RESMN runs transversely from north to south across the Sierra Madre del Sur province; it is an orographically rugged area with several ravines and covering an altitudinal range from 1,000 m to 1,775 m in the highest areas (Arias-Ataide and Díaz 2016). The northern area of the RESMN has a semi-warm, subhumid climate with an annual temperature of 22 °C and rains in summer, while to the south the climate is warm subhumid, with an annual temperature of 24 °C and a mean precipitation of 890 mm to 1,000 mm (Arias-Ataide and Díaz 2016). The RESMN is relevant for LDF conservation in Morelos and the country (Valenzuela-Galván *et al.* 2010) and also contributes to the conservation of biodiversity in Morelos and the local regulation of the climate (González-Flores and Contreras-MacBeath 2020).

At the regional level, it provides a broad range of ecosystem services, including the provision of drinking water for 5 communities through the El Salto, El Zapote, and Chihuahuita springs (Arias-Ataide and Díaz 2016). Likewise, its location in the center of the State confers to it the potential function of a biological corridor because it is connected with the PNAs of northern Morelos (Contreras-MacBeath and Ríos 2010). However, several stressors threatening biodiversity conservation have been identified within the RESMN and its area of influence, such as the operation of a cement plant (installed in the area 20 years ago), illegal logging, urban growth, and the expansion of the agricultural frontier. In addition, the presence of livestock and dogs in some areas is a serious issue because there is no control over them (Arias-Ataide and Díaz 2016).

For monitoring, 10 stations with camera traps (Stealth Cam P18CMO) were established, with a minimum separation distance of 1 km between them. The cameras were placed as a grid covering an area of approximately 600 ha, and each was georeferenced with a GPS (Garmin eTrex 10). In each station, 1 camera trap was attached to a tree; these trees were located between hills and ravines covered with LDF. Cameras operated 24 hr a day during an annual cycle between November 2020 and November 2021 and were reviewed each month to back up the information recorded and replace the batteries. Since camera traps could only be activated in photo or video mode, some were set to capture photographic records and others to capture video records.

During the monitoring period, the total sampling effort was 3,650 trap days, yielding a series of photographic and video records of margay for 2 different monitoring stations, both sites separated by 1 km (Figure 1). The individuals recorded were identified by comparing the tail length versus the total body length, since in the margay the tail represents 40 % of its total length, while in the ocelot the tail corresponds to 29 % of its total length (Ramírez-Barajas *et al.* 2014). These records are the first confirmed evidence of the presence of *L. wiedii* within the RESMN.

The first recording of the margay in the RESMN occurred on 20 November 2020 at 02:30 hr by means of 3 photographs in the monitoring station located at coordinates 18° 49' 19.75" N, 99° 9' 5.36" W at 1,600 m on a hill with LDF where there are trails apparently travelled by inhabitants of the nearby communities (Figure 2a). Two additional records were captured at this same monitoring station: 1 on 14 January 2021 at 12:42 hr, consisting of 3 15-second video clips (Figure 2b) and another on 20 April 2021 at 05:53 hr, with 1 15-second video clip (Figure 2c).

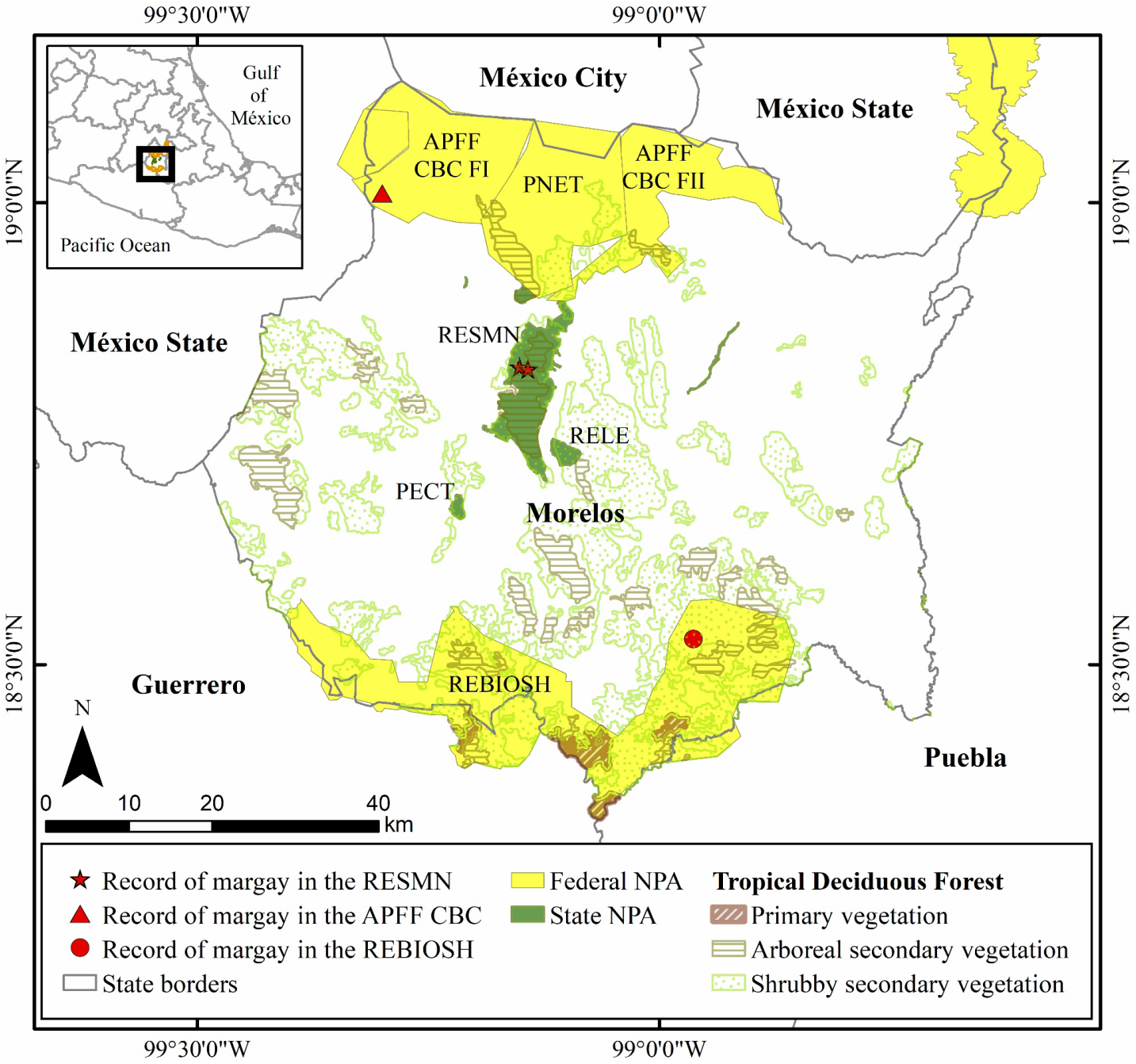

Figure 1. Geographic location of margay records in the State of Morelos. Areas marked in yellow correspond to the Federal Natural Protected Areas: Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I (APFF CBC FI) and Fraction II (APFF CBC FII), Tepozteco National Park (PNET), and Sierra de Huautla Biosphere Reserve (REBIOSH). Areas in green correspond to state-run Protected Natural Areas: Sierra Monte Negro State Reserve (RESMN), Las Estacas State Reserve (RELAY), and Cerro de la Tortuga State Park (PECT). The primary, secondary arboreal, and secondary shrub vegetation of the Low Deciduous Forest in the State of Morelos is represented, according to INEGI (2021). Acronyms correspond to the names in Spanish (translator's note).

The second monitoring station where the margay was recorded is located at coordinates 18° 49' 11.84" N, 99° 8' 32.14" W, at 1,450 m within a ravine with LDF, with less evidence of human activity because of denser vegetation that restrains access. The presence of the margay in this station was first recorded on 20 March 2021 at 01:34 hr and then at 01:55 hr, both being 15-second video clips (Figure 2d).

The detailed analysis of these images and videos revealed that the records captured in the 2 sites correspond to the same individual based on the match of the spot patterns observed. Likewise, some of these videos show that the individual captured was a male. It is remarkable how the individual used the area for a considerable time between November 2020 and April 2021 (Figure 2).

In this paper, we report for the first time the presence of a male margay (*L. wiedii*) in the Sierra Monte Negro State Reserve, which is the third report of this species in the state of Morelos. The presence of margay in the state of Morelos has been reported previously on 2 occasions in PNAs adjacent to our study area. The first was recorded between 2009 and 2010 on a site 30 km to the southeast, within the Sierra de Huautla Biosphere Reserve (Valenzuela *et al.* 2013). The

second corresponds to a site 42 km northwest, within the Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I, recorded in 2014 (Aranda and Valenzuela-Galván 2015). To determine whether the individual recorded in the RESMN was one of those recorded previously, the spot pattern of the RESMN margay was compared with those of the individual captured in the Biological Corridor Flora and Fauna Protection Area, concluding that they are different individuals. A comparison of this sort with the individual reported for the Sierra de Huautla Biosphere Reserve was impossible because no photographs were available for the latter report. Considering that the maximum home range reported for the species in Brazil is 15.9 km^2 (de Oliveira *et al.* 2010) and the one reported for México is 6 km^2 (Carvajal-Villarreal *et al.* 2012), it is unlikely that the individual captured in the present study is the same recorded in the Sierra de Huautla Biosphere Reserve, given the distance between both records. In addition, the margay lives an average of 10 years in the wild (de Oliveira 1998), and the record in this study was captured 10 years after the one of the Sierra de Huautla Biosphere Reserve and 6 years after those of the Chichinautzin Biological Corridor Flora and Fauna Protection Area.

Some margay individuals are likely living in the RESMN on a permanent or seasonal basis since the margay identified herein was recorded in 2 different monitoring stations within a 5-month interval. We believe the RESMN may serve as a corridor for the dispersal of species such as the margay

Figure 2. Evidence of the presence of margay in the Sierra Monte Negro State Reserve (RESMN), Tepetzingo, Emiliano Zapata, Morelos. a) Photographic record at site 1 on 20 November 2020; b) video clip record at site 1 on 14 January 2021; c) video clip record at site 1 on 20 April 2021; d) video clip record at site 2 on 20 March 2021.

that move across great distances, facilitating the extended distribution of this and other species between the northern, central, and southern regions of the state of Morelos. To the north, the RESMN borders the El Tepozteco National Park and the Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction II, and extends to the central area of the state of Morelos, near two other state-run PNAs: the Cerro de la Tortuga State Park and the Las Estacas State Reserve. In addition, the southeast of the RESMN harbors several LDF patches varying in size and conservation status, which, despite not being PNAs, may facilitate the connection with REBIOSH (Figure 1; Albino-Miranda *et al.* 2021) and the movement of individuals between the ecosystems located in the north and south of the state of Morelos.

The records obtained in the present study broaden our knowledge of the distribution of margay in the state of Morelos and are useful for the implementation of conservation policies in the areas where it is distributed, as it is an endangered species. In addition, they highlight the importance of state-run PNAs as habitat reservoirs for biodiversity and potential structural corridors facilitating the movements of wild felines and other species across federal PNAs. According to a study by Morales-Delgado *et al.* (2021) on the potential distribution of *L. wiedii* in different PNAs in México, the conditions in these PNAs are suitable for the presence of *L. wiedii*. Of a total of 97 sites with analyzed records, 39 were located in a federal PNA and 1 in a private PNA; however, no record was found within a state-run, municipal, or ejido PNA. Therefore, monitoring efforts should address local PNAs to determine the importance of these areas in the distribution of species such as margay.

In addition to the margay, records were also captured for other wild mammals such as Virginia opossum (tlacuache; *Didelphis virginiana*), North American ringtail (cacomixtle; *Bassariscus astutus*), coati (*Nasua narica*), southern spotted skunk (*Spilogale angustifrus*), white-tailed deer (*Odocoileus virginanus*), gray fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*). The presence of cattle and dogs was also recorded at monitoring sites. The presence of free-range or feral dogs is one of the main threats facing wildlife, especially for species such as the margay because they compete for available prey species, in addition to being disease reservoirs (Lenth *et al.* 2008; Vanak and Gompper 2010; Horn *et al.* 2020). However, the information available is insufficient to determine whether the dogs recorded in the camera traps are feral or belong to people from nearby communities who constantly travel across the RESM; in any case, dogs are considered a risk factor. Cattle also pose a threat, as the impacts on vegetation cover from overgrazing lead to habitat loss for multiple species, hence influencing the availability of margay prey (Horn *et al.* 2020).

The present study provides evidence of the presence of margay in the RESMN. However, further studies are required in this PNA to determine whether there is a resident population in the area, know how they use the habitat in space and time, the species with which it interacts, and identify those sites that contribute to the connectivity for this species. Our work also demonstrates the relevance of assessing the risks for the margay associated with domestic or feral fauna to establish conservation strategies for the margay specifically within the RESMN and potentially applicable in other PNAs where it has been previously reported.

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