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First record of the desert shrew *Notiosorex crawfordi* in México City

Primer registro de la musaraña *Notiosorex crawfordi* en la Ciudad de México

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The genus *Notiosorex* comprises 5 species typical of xeric habitats in northern México, except for *N. crawfordi*, whose previous southernmost record is located in the state of Hidalgo. This study reports the first record of this species in a more southern locality, México City. The corpse of a shrew specimen was found in the Tecuautzin Volcano and transported to the Universidad Autónoma Metropolitana-Iztapalapa to recover the skin and skeleton. We took 22 measurements of the skull and jaw with the ImageJ 1.8.0 software. The specimen was deposited in the National Collection of Mammals at Universidad Nacional Autónoma de México. The specimen was an adult male of the genus *Notiosorex* with lateral skin glands in the body, three unicuspid maxillary teeth, and maxillary premolar with partial reddish pigmentation, which are traits typical of the genus. The specimen was identified as *N. crawfordi* based on the glenoid fossa extending laterally and the free paraoccipital process protruding from the exoccipital. The skull and jaw morphometrics lie within the variation reported for the species by other authors. This record of *N. crawfordi* expands its distribution range to the south and increases to 81 the number of mammal species recorded in México City. The species is listed as Threatened by the Mexican environmental authority, and the sampling site is affected by anthropogenic activity, which jeopardizes the maintenance of the local population. The relevant authorities are encouraged to consider expanding the area of the Sierra de Santa Catarina natural protected area.

Key words: Conservation; diversity; Iztapalapa; Sierra de Santa Catarina; Soricidae.

El género *Notiosorex* comprende 5 especies actuales, típicas de las áreas xerófilas del norte de México, a excepción de *N. crawfordi* cuyo registro más sureño es de Hidalgo. Damos a conocer el primer registro de esta especie en una localidad aún más sureña, en la Ciudad de México. Encontramos un ejemplar muerto de musaraña en el Volcán Tecuautzin y fue trasladado a la Universidad Autónoma Metropolitana-Iztapalapa para recuperar la piel y el esqueleto. Del cráneo y mandíbula tomamos 22 medidas con el programa ImageJ versión 1.8.0. El ejemplar fue depositado en la Colección Nacional de Mamíferos, Universidad Nacional Autónoma de México. El ejemplar es un macho adulto del género *Notiosorex* con glándulas cutáneas laterales en el cuerpo, 3 dientes maxilares unicúspides y el premolar maxilar con pigmentación rojiza parcial, rasgos típicos del género. Por tener una extensión lateral en la fosa glenoidea y el proceso paraoccipital libre sobresaliendo del exoccipital lo asignamos a *N. crawfordi*. Las medidas morfométricas del cráneo y mandíbula están dentro de la variación reportada para la especie por otros autores. Este registro de *N. crawfordi* amplía hacia el sur la distribución geográfica de la especie y aumenta a 81 el número de especies de mamíferos con registro en la Ciudad de México. La especie está clasificada como amenazada por la autoridad ambiental mexicana y el sitio de recolecta presenta actividad antropogénica, que pone en peligro la continuidad de esta población. Se invita a las autoridades correspondientes a evaluar la ampliación del área natural protegida de Sierra de Santa Catarina.

Palabras clave: Conservación; diversidad; Iztapalapa; Sierra de Santa Catarina; Soricidae.

Notiosorex is a genus of North American shrews with 5 known species: *N. cockrumi, N. crawfordi, N. evotis, N. tataticuli,* and *N. villai* (Camargo and Álvarez-Castañeda 2020). These shrews are distributed in arid and semi-arid areas from southwestern United States and the Baja California peninsula southward across the Mexican Pacific to Jalisco and the Mexican highlands to Hidalgo. These shrews thrive in various habitats, including grasslands, xeric shrublands, and pine-oak forests from sea level to altitudes above 2,200 m (Carraway and Timm 2000; Baker *et al.* 2003; Rojas-Martínez *et al.* 2014; Camargo and Álvarez-Castañeda 2020). Several morphological characteristics differentiate *N. crawfordi, N. evotis,* and *N. villai* (Carraway and Timm 2000). To recognize *N. cockrumi* and *N. tataticuli*. a molecular approach should be applied (Baker *et al.* 2003; Camargo and Álvarez-Castañeda 2020).

Notiosorex crawfordi is the most widespread species of the genus, ranging from southern United States to northern México, with isolated records in the states of Zacatecas, Durango, and Hidalgo (Carraway and Timm 2000; Álvarez and González-Ruiz 2001; Carraway 2007; Rojas-Martínez *et al.* 2014; Álvarez-Córdoba *et al.* 2020). Traditionally, specimens from Zacatecas, Durango, and Hidalgo have been identified as *N. crawfordi* based on cranial morphology (Carraway and Timm 2000; Álvarez and González-Ruiz 2001; Rojas-Martínez *et al.* 2014). Recently, Álvarez-Córdoba *et al.* (2020) confirmed the presence of this species in Zacatecas

based on molecular characteristics. This note reports the first record of the genus *Notiosorex* for México City (CDMX).

On 30 January 2022, we found a dead adult male specimen lying on a sidewalk on the northeast slope of the Tecuautzin Volcano, in the Sierra de Santa Catarina, municipality of Iztapalapa, CDMX (19° 19' 45.48" N; 99° 0' 36.97" W, 2,448 m.; Figure 1). The local vegetation at the sampling site was grassland growing on Lithosol soil. The specimen was transported to Universidad Autónoma Metropolitana, campus Iztapalapa, where the skin and skull were recovered and deposited in the National Mammal Collection (CNMA, in Spanish), of the Institute of Biology at Universidad Nacional Autónoma de México, under catalog number CNMA 50001.

Using the ImageJ 1.8.0 software (Schneider *et al.* 2012), we recorded 22 measurements from skull and jaw photographs according to Camargo and Álvarez-Castañeda (2020): condylobasal length (LC), rostral breadth (AR), least interorbital breadth (AMI), breadth across M2–M2 (AM2), length of P4-M3 (LPM), palatilar length (LP), length of unicuspid toothrow (LDU), length of U1-M3 (LUM), length of coronoid process–posterior point of upper condylar facet (LCC), length of coronoid process–ventral point of lower condylar facet (LCV), length of upper articular condyle –posterior edge of m3 (LAM), height of dentary at m1 (AD), height of coronoid process (APC), height of coronoid valley (AVC), height of articular condyle (ACA), jaw length (LM), length of c1–m3 (LCM), length of c1 (LC1), length of P4 (LP4), length of M1 (LM1), length of M2 (LM2), and length of M3 (LM3). The standard external measurements were also recorded: total length (LT), vertebral tail length (CV), hind limb length (PT), ear length (O), all these in millimeters and weight in grams.

The specimen is an adult male with dorsal fur dark gray at the base with brownish tips and ventral fur gray at the base

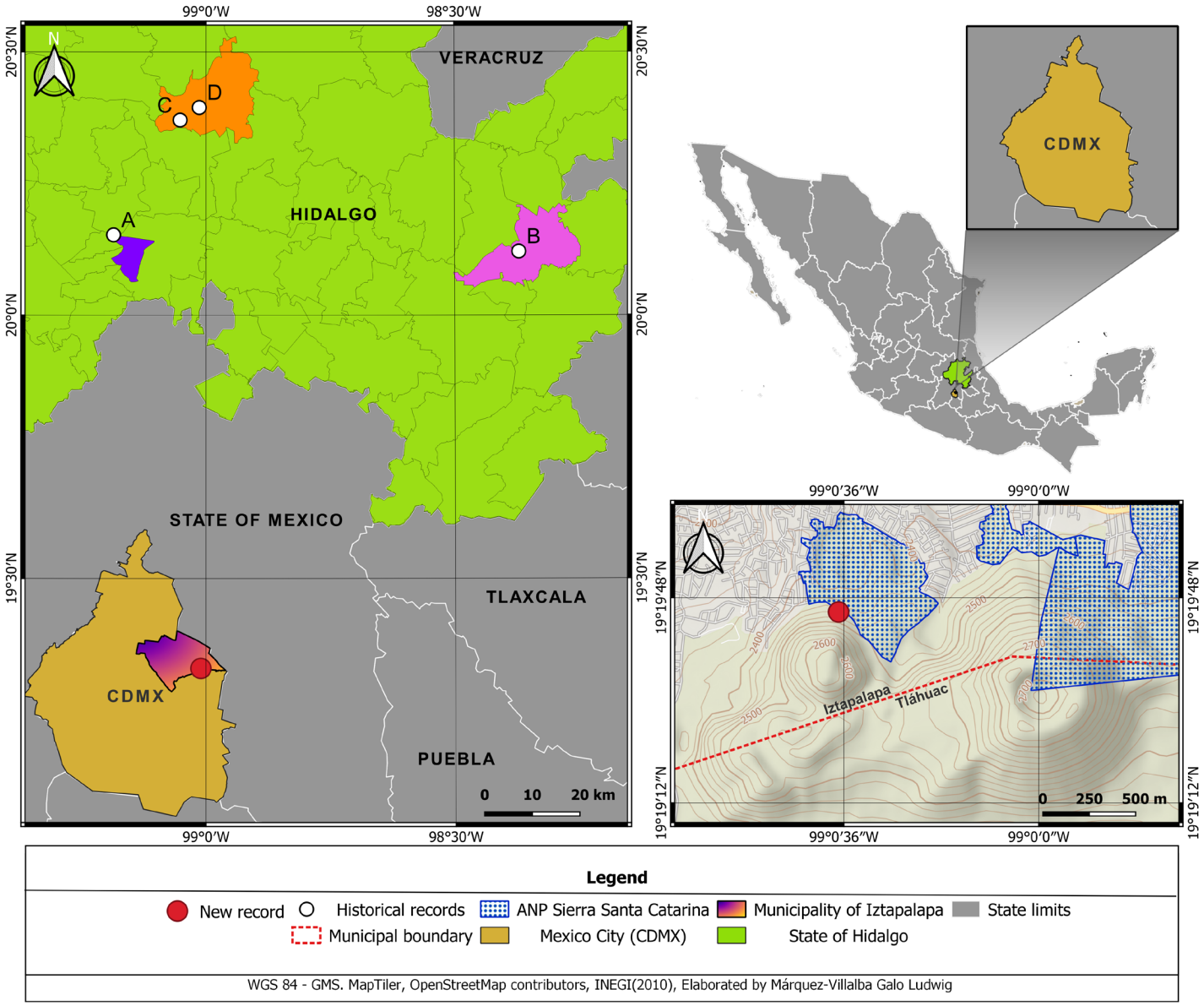

Figure 1. Geographic location of the sampling site of *Notiosorex crawfordi* in Sierra de Santa Catarina, Iztapalapa, México City, and of sites where the species was previously recorded in Hidalgo (Álvarez and González-Ruiz 2001; Rojas-Martínez *et al.* 2014). From the nearest to the farthest: a) Juandho, municipality of Tetepango; b) Ejido Huapalcalco, municipality of Tulancingo de Bravo; c) Patria Nueva and d) Cueva de Xoxafi, municipality of Santiago de Anaya.

with whitish tips. The following standard measurements were recorded: LT, 77; CV, 28; PT, 9; O, 7; and weight, 4.2 g.

The specimen was assigned to the genus *Notiosorex* based on the presence of lateral skin glands (Figure 2; Hoffmeister and Goodpaster 1962) and the partially reddish pigmentation of the 3 unicuspid and premolar maxillary teeth (Armstrong and Jones 1972). It was further identified as *N. crawfordi* due to the glenoid fossa extending laterally and the free paraoccipital process protruding from the exoccipital. This species is similar to *N. villai,* the main difference being the lack of the lateral extension of the glenoid fossa in the latter. Likewise, *N. crawfodi* can be distinguished from *N. evotis* because the former is smaller; in fact, it is the smallest shrew within the living species of the genus (Figure 2; Carraway and Timm 2000; Carraway 2010; Rojas-Martínez *et al.* 2014; Álvarez-Córdoba *et al.* 2020).

This record of *N. crawfordi* from México City is important because it expands its known distribution range to the south. Until now, the southern limit of its distribution range covered localities in the state of Hidalgo, located approximately 94 km from Juandho in a straight line (Rojas-Martínez *et al.* 2014) and 111 km from Ejido Huapalcalco (Álvarez and González-Ruiz 2001). The fossil remains of a smaller form of *Notiosorex* recorded in Chihuahua, Nuevo León, Tamaulipas, and Zacatecas correspond to a date after an interglacial period in the late Pleistocene and are considered *N. crawfordi* (Carraway 2010). It is likely that during that period, some *Notiosorex* specimens reached further south to the Trans-Mexican Volcanic Belt, where the most recent records of *N. crawfordi* in Hidalgo are located and which also comprises the CDMX. The Trans-Mexican Volcanic Belt is located in the transition zone between the Nearctic and Neotropical regions, characterized as a center of diversification, endemism, and biogeographic transition for a wide variety of taxa (Gámez *et al.* 2012). The great variability of volcanic styles and the differences in volcanic arcs and chemical components (Ferrari 2000) confer considerable environmental heterogeneity to the area (Gámez *et al.* 2012). These conditions may have favored the territorial expansion of *N. crawfordi*, a species characterized by the following physiological adaptations: kidneys capable of retaining more water, tolerance to higher environmental temperatures, and regulated hypothermia in times of food scarcity. These adaptations allow the species to colonize environments that are unsuitable for other species of the order Eulipotyphla (Carraway 2010). This probably facilitates the expansion of *N. crawfordi* into territories farther away from those previously recorded, such as CDMX. However, further studies addressing these physiological adaptations are needed to confirm a hypothesis on the colonization of *N. crawfordi* to new regions.

Carraway and Timm (2010) and Rojas-Mártinez *et al.* (2014) reported that this species prefers semi-arid environments with xeric shrubland. Similarly, in Sierra de Santa Catarina, we found grasslands in the lowlands and shrubland patches at higher altitudes, with a rocky substratum

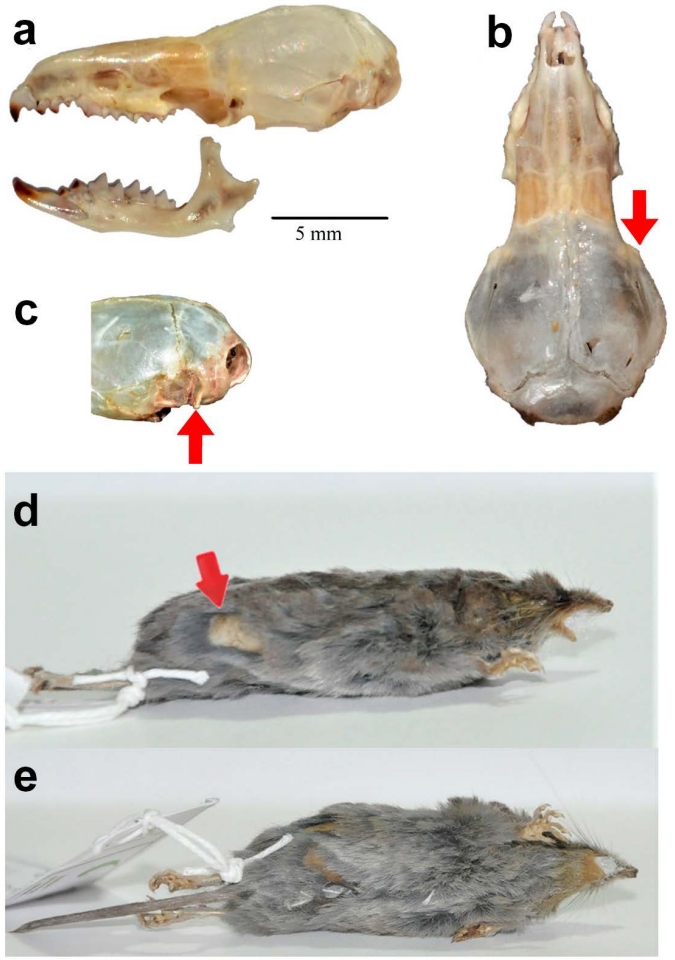

Figure 2. Lateral and dorsal views of the skull, jaw, and skin of an adult male specimen of *Notiosorex crawfordi* (CNMA 50001) collected in Sierra de Santa Catarina, México City. a) The arrow indicates the partial pigmentation of the 3 unicuspid and premolar maxillary teeth; b) lateral extension of the glenoid fossa; c) free paraoccipital process protruding from the exoccipital. Lateral d) and dorsal e) views of the skin. The arrow indicates a lateral skin gland.

of volcanic origin. The dominant vegetation includes the shrubby stonecrop (*Sedum praealtum*), nolina (*Nolina parviflora*), broomstick tree (*Pittocaulon praecox*), white Tepozan (*Buddleia cordata*), Tepozan (*B. parviflora*), woollyjoint pricklypear (*Opuntia tormentosa*), and huizache (*Acacia farnesiana*; GODF 2005).

Sorex and *Cryptotis* are the other 2 genera of shrews recorded in the CDMX. Shrews of the genus *Sorex* have 5 unicuspid teeth in the upper jaw, and all their teeth are pigmented. The genus *Cryptotis* is characterized by 3 or 4 upper unicuspid teeth, but the first 3 have secondary cusps, and all the teeth are pigmented. On the other hand, the genus *Notiosorex* has 3 upper unicuspid teeth with a faint reddish pigment in their unicuspid and molar teeth (Álvarez-Castañeda *et al.* 2017). Moreover, the morphometric measurements of the skull and jaw recorded here for *Notiosorex* are within the variation reported for the species by other authors (Table 1). Nevertheless, molecular analyses should be conducted with the samples from Hidalgo and CDMX to compare them with specimens collected in more northern locations to confirm the phylogenetic and taxonomic status of these populations either within *N. crawfordi*

Table 1. Skull and jaw measurements of an adult male specimen of *Notiosorex crawfordi* (CNMA 50001) from Sierra de Santa Catarina, México City. Measurements are in mm and were taken according to Carraway (2010). The mean (± standard error) and variation (as available, in parentheses) of three sources that provide morphometric data for the species are presented. The parameters measured are defined in the text.

Measurements	CNMA 50001	Álvarez-Córdoba *et al.* 2020	Carraway 2010	Rojas *et al.* 2014
LC	16.62	15.25 ± 0.65	16.08 ± 0.04 (14.95 - 17.25)	
AR	5.07	5.27 ± 0.60	4.84 ± 0.01 (4.4 - 5.2)	5.0, 5.0
AI	4.02	3.87 ± 0.13	3.76 ± 0.01 (3.4 - 4.1)	4.1
AM2	5.03	4.68 ± 0.28	4.83 ± 0.01 (4.4 - 5.1)	5.0, 5.0
LPM	4.19	4.15 ± 0.007	4.31 ± 0.01 (4.1 - 4.6)	
LP	6.91		6.79 ± 0.02 (6.2 - 7.3)	
LDU	1.94	1.93 ± 0.07	1.88 ± 0.01 (1.5 - 2.2)	2.1, 2.2, 1.9
LUM	6.15		6.03 ± 0.05 (5.1 - 6.8)	
LCC	3.07	3.38 ± 0.02	3.3 ± 0.02 (2.7 - 3.9)	
LCV	3.62	3.27 ± 0.04	3.74 ± 0.02 (3.2 - 4.3)	3.6, 3.5
LAM	3.52		3.46 ± 0.02 (3.1 - 3.9)	
AD	1.13		1.12 ± 0.01 (0.9 -1.4)	
APC	3.9	4.13 ± 0.16	4.02 ± 0.01 (3.4 - 4.6)	3.9, 3.7, 4.0
AVC	2.41		2.25 ± 0.02 (1.8 - 2.7)	
ACA	2.85		2.79 ± 0.03 (2.5 - 3.5)	
LM	7.3	8.25 ± 0.15	7.04 ± 0.02 (6.4 - 7.7)	6.92, 7.44, 3.6
LCM	4.82		4.71 ± 0.01 (4.4 -5.1)	
LC1	0.73		0.76 ± 0.29 (0.6 - 0.9)	
LP4	0.9		1.01 ± 0.01 (0.9 - 1.2)	
LM1	1.43		1.44 ± 0.01 (1.1 - 1.6)	
LM2	1.34		1.36 ± 0.01 (1.2 - 1.5)	
LM3	0.92		0.98 ± 0.01 (0.9 - 1.0)	

or as a separate undescribed species. The latter is a possibility because the most recent species of this genus have been described based on molecular traits: *N. cockrumi*, *N. tataticuli*, and *N. villai*, which are morphologically cryptic with *N. crawfordi*.

The record of this shrew increases to 81 the number of mammal species distributed in México City (Hortelano-Moncada *et al.* 2016). This species is listed as Least Concern by the IUCN due to its wide distribution, assumed population abundance, presence in several protected areas, and because it is unlikely to be declining at the rate required for inclusion under a Threatened category (Timm *et al.* 2016). However, it is listed as Threatened in México according to the Mexican standard NOM-059-2010 issued by the Board of the Environment and Natural Resources (SEMARNAT 2019). The Sierra de Santa Catarina (SSC) is currently isolated by extensive urban growth, so there is no biological corridor around it. This area is also affected by anthropogenic activities such as mining (exploitation of stone material, tezontle), cropland, and illegal open dumps. Although an area of 748.55 ha named Sierra de Santa Catarina Natural Protected Area (ANP-SSC, in Spanish) was designed for conservation purposes according to the Federal District Official Gazette (GODF 2005), the sampling site of the shrew specimen reported here is located at 100 m from the border of the ANP-SSC polygon. We consider that the SSC population of this species is threatened by induced fires, mining, agricultural activities, and the expansion of the urban frontier associated with illegal housing (Figure 3). We encourage the relevant authorities to consider expanding the area of the ANP-SSC as a first step to ensure the protection of this shrew species, which represents the southernmost population of the taxon.

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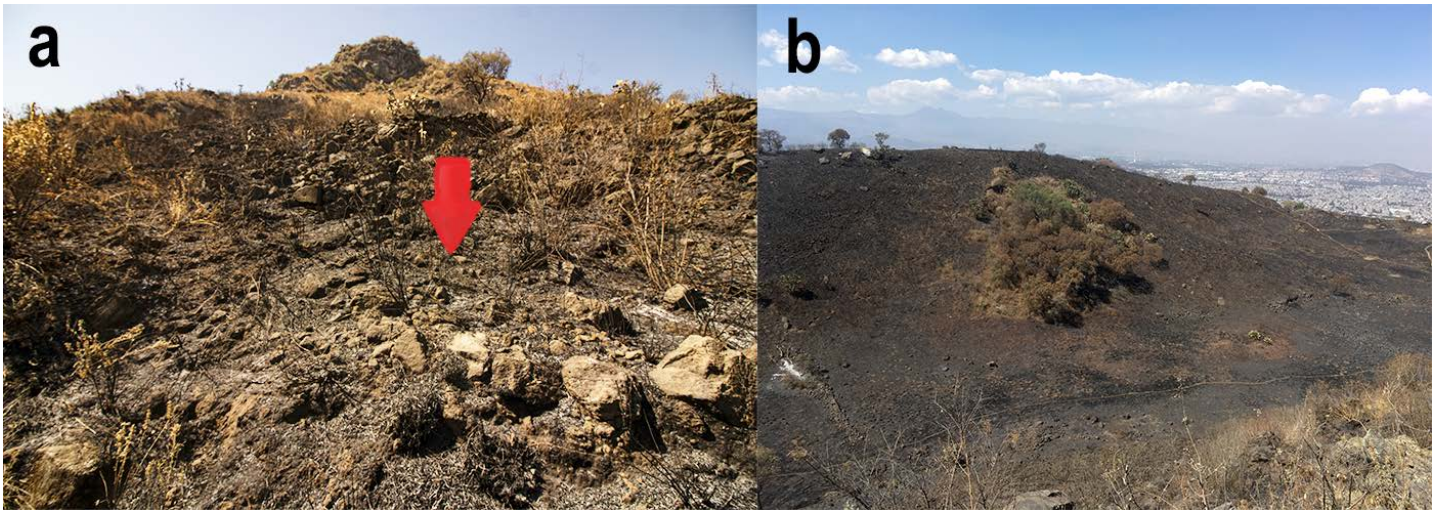

Figure 3. a) View of the area where the *Notiosorex crawfordi* male specimen was collected; b) frequent fires at approximately 30 m from the site of the new record that usually spread around the Tecuautzin Volcano (Iztapalapa municipality) and reaching Mazatepec (mostly in the Tláhuac municipality).

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