

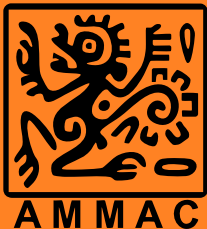
Therya

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

La información precisa sobre la distribución geográfica de las especies es esencial para esfuerzos de conservación y manejo. Aunque persisten vacíos de información considerables en Centroamérica, vale la pena realizar nuevos muestreos para conocer mejor la biodiversidad de la región. Este número presenta nuevos registros para cinco especies de murciélagos en bosques de Nicaragua, ampliando la diversidad conocida de la fauna de quirópteros en el país.

(Fotografía de José Gabriel Martínez-Fonseca)

Detailed knowledge of species' geographic ranges is essential for effective conservation and management. Although significant knowledge gaps remain in Central America, ongoing surveys are helping to map the region's biodiversity. This issue presents new records for five bat species in the forests of Nicaragua, expanding the known diversity of the country's bat fauna.

(Photograph by José Gabriel Martínez-Fonseca)

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 decimoprimer en la cosmogonía mexicana. "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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A new record of hypodontia in *Phyllostomus discolor* with notes on its evolutionary implications

Un nuevo registro de hipodoncia en *Phyllostomus discolor* con notas sobre sus implicaciones evolutivas

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Dental anomalies are disruptions in the normal development of teeth, primarily caused by genetic mutations, leading to variations in the number, shape, size, eruption, and formation of hard tissues. Although these abnormalities have been observed in various mammalian groups, their incidence and implications remain underexplored. We identified one specimen of *Phyllostomus discolor* with a dental anomaly. Following this discovery, we made a review of dental anomalies in Chiroptera searching for specific terms related to bats and dental anomalies and then conducted a linear regression to detect the trend of publications. Here, we report a new record of hypodontia in the Pale Spear-nosed bat *Phyllostomus discolor*. The hypodontia was identified in a male specimen of the Pale Spear-nosed bat from the Andean region of Colombia, characterized by a missing incisor adjacent to internal incisors in the mandible, resulting in three lower incisors—one fewer than normal. Understanding the patterns, incidence, and variations of dental anomalies across mammalian clades can enhance taxonomic studies and elucidate the mechanisms driving dental trait diversification. However, we highlight a low interest in publications barely averaging 0.73 reports per year. Contrary to what was expected, and unlike other genetic, eco-devo and evolutionary approaches used to investigate mammalian teeth, we evidence a clear reduction and possible lack of interest in this topic. We urge researchers and curators to document such anomalies that allow to challenge current hypotheses about their occurrence and evolutionary implications.

Key words: Bats; dental anomalies; developmental bias; hypodontia; tooth variation.

Las anomalías dentales son alteraciones en el desarrollo normal de los dientes, causadas principalmente por mutaciones genéticas, que provocan variaciones en el número, forma, tamaño, erupción y la formación de los tejidos duros. Aunque estas anomalías se han observado en diversos grupos de mamíferos, su incidencia e implicaciones siguen siendo poco exploradas. Se identificó un ejemplar de *Phyllostomus discolor* con una anomalía dental. Tras este descubrimiento, se realizó una revisión de las anomalías dentales en quirópteros buscando términos específicos relacionados con murciélagos y anomalías dentales, y posteriormente se realizó una regresión lineal para detectar la tendencia de las publicaciones. Reportamos un nuevo registro de hipodoncia en el murciélago *Phyllostomus discolor*. La hipodoncia se identificó en un ejemplar macho de murciélago de nariz de lanza pálida de la región andina de Colombia, caracterizado por la ausencia de un incisivo adyacente a los incisivos internos de la mandíbula, lo que resulta en tres incisivos inferiores, uno menos de lo normal. Comprender los patrones, la incidencia y las variaciones de las anomalías dentales en los clados de mamíferos puede enriquecer los estudios taxonómicos y aclarar los mecanismos que impulsan la diversificación de los rasgos dentales. Sin embargo, destacamos el bajo interés en las publicaciones, con un promedio de apenas 0,73 registros publicados al año. Contrariamente a lo esperado, y a diferencia de lo que ocurre con otros enfoques genéticos, de eco-devo y evolutivos utilizados para investigar los dientes de mamíferos, evidenciamos una clara reducción y posible falta de interés en este tema en particular. Recomendamos a investigadores y curadores a documentar estas anomalías que permitan cuestionar las hipótesis actuales sobre su ocurrencia e implicaciones evolutivas.

Palabras clave: Anomalías dentales; dentición; murciélago; sesgo del desarrollo; variación dental.

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Dental development is tightly regulated by genetic mechanisms that ensure the formation, growth and replacement of a specific number of teeth with precise shapes and positions in each species (Yu and Klein 2020; Yamanaka 2022). However, mutations in certain genes can

disrupt this normal development, leading to anomalies in tooth number, shape, size, eruption, internal structure, or the formation of hard tissues such as enamel, dentin, or cementum (Thesleff 2000). These deviations, commonly known as dental anomalies (Wolsan 1984), have been

observed in a diverse range of mammalian groups, including primates (both humans and non-human species; [Bateson 1892](#)), pinnipeds ([Drehmer, 2015](#)), pilosans (e.g., sloths; [McAfee 2014](#)), marsupials (such as opossums; [Martin and Chemisquy 2018](#)), felids ([Gomerčić et al. 2009](#)), and bats ([López-Aguirre 2014](#); [Esquivel et al. 2017](#)). Despite the different types of dental anomalies that can affect mammals (Table 1), the incidence and prevalence of dental anomalies are possibly much higher has been reported up to now, as many cases that have likely gone not published. Even with the fact that dental anomalies have not gone unnoticed by scientists ([Phillips 1971](#); [Rui and Drehmer 2004](#)), little interest has been given to their recording and implications. Traditionally, dental anomalies have been thought to be relatively rare phenotypes resulting from poorly understood genetic, environmental, or developmental processes ([McAfee 2014](#)). However, such anomalies may present the principal source of morphological variation in the teeth upon which natural selection may operate. A modern phylogenetic analysis on a dataset derived from 17,905 observations, examined the patterns of dental anomalies across bats, and tested for potential ecological and structural factors associated with the incidence of dental anomalies in this group ([Esquivel et al. 2021](#)). Remarkably, these authors found that dental anomalies have a significant phylogenetic signal, suggesting that they are not simply the result of random mutations or developmental disorders, but susceptibility may have genetic underpinnings resulting from shared developmental pathways among closely related species.

The presence of this lineage-specific patterns produces a developmental bias, that can drive morphological evolution in specific directions through nonrandom phenotypic transitions ([Brigandt 2020](#)). Intrinsic developmental differences between lineages, alongside selective pressures, are crucial factors in this process ([Brown 2014](#)). For instance, if some phenotypes, like hypodontia, are more likely to arise spontaneously than others, such as hyperdontia, this may drive dental trait evolution ([Brigandt 2020](#); [Esquivel et al. 2021](#)). This influence is relevant even in traits under selection, making some lineages more likely to change in response to new selective pressures ([Brown 2014](#)).

A deeper understanding of odontogenesis (tooth formation) can provide insights about occurrence of dental anomalies in mammals ([Thesleff 2000](#); [Bei 2009](#); [Juuri and Balic 2017](#)). Odontogenesis involves over 300 genes and more than 100 transcription factors ([Bei 2009](#)). However, there are no known genes for a specific tooth class, instead, different combinations of genes are involved ([Wakamatsu et al. 2019](#)). In addition, tooth formation results from interactions between two embryonic tissues: the ectodermal epithelium (dental lamina) and ectomesenchyme ([Mitsiadis and Smith 2006](#)). Therefore, dental anomalies are a complex phenomenon related to various genetic factors and regulatory pathways. There are

Table 1. Classification and diagnosis of the main dental anomalies that can affect bats and other mammals.

Category	What type of dental anomaly is it?	
	What name to use?	When to use?
By Number	Anodontia	Total lack of development of teeth (same as agenesis of teeth).
	Hypodontia	Having less than six missing teeth.
	Oligodontia	Six or more missing teeth.
	Hyperdontia	One or more extra teeth. Also called supernumerary teeth or Polyodontia.
By Size	Microdontia	Teeth that are smaller than normal. At least 40% or more.
	Macrodontia	Teeth that are larger than normal. At least 40% or more.
By Position	Transposition	Interchange in the position of two adjacent permanent teeth.
	Transmigration	Movement of an impacted tooth across the jaw midline.
	Diastema	Presence of an abnormal space between two adjacent teeth.
By Eruption	Ectopic	A tooth that erupts or develops in an abnormal position outside of the normal dental arch.
	Impaction	A condition where a tooth fails to fully emerge through the gum line and remains partially or completely trapped beneath the gum tissue and/or bone.
	Retained	A tooth that persists in the oral cavity beyond its expected time of exfoliation or replacement, failing to shed according to the normal timeline of dental development for the species.
By Morphology	Germination (twinning)	A single tooth germ attempts to divide into two, resulting in the formation of an oversized tooth with two distinct crowns. This is a type of "Double tooth" or "connate tooth".
	Fusion (Synodontia)	Two adjacent tooth germs fuse together, resulting in the formation of a single, larger tooth structure. This is a type of "Double tooth" or "connate tooth".
	Talon cusp	Cusp-like structure projecting from the cingulum area or lingual surface of an anterior tooth, commonly the maxillary lateral incisor. This extra cusp resembles a talon and can vary in size and shape.
	Dens evaginatus	Abnormal tubercle or cusp-like projection arising from the occlusal surface of a premolar tooth.
	Dens invaginatus	Deep invagination of the crown or root surface covered by enamel.
	Concrescence	Two or more adjacent teeth become fused together by cementum.
	Taurodontism	Elongation of the pulp chamber in a tooth, resulting in an enlarged pulp chamber and shortened roots.
Dilaceration	An abnormal and abrupt deviation in the root of a tooth.	
Enamel Pearl	A small, spherical or globular formation of excess enamel on the surface of a tooth.	

four main pathways that not only regulate odontogenesis but also interact with each other ([Zhang 2023](#)). The WNT signaling pathway plays a critical role in the initiation and morphogenesis stages; the Sonic Hedgehog (SHH) pathway is involved in the establishment of the dental field and the specification of tooth identity; the Bone Morphogenetic Protein (BMP) pathway is essential for the regulation of

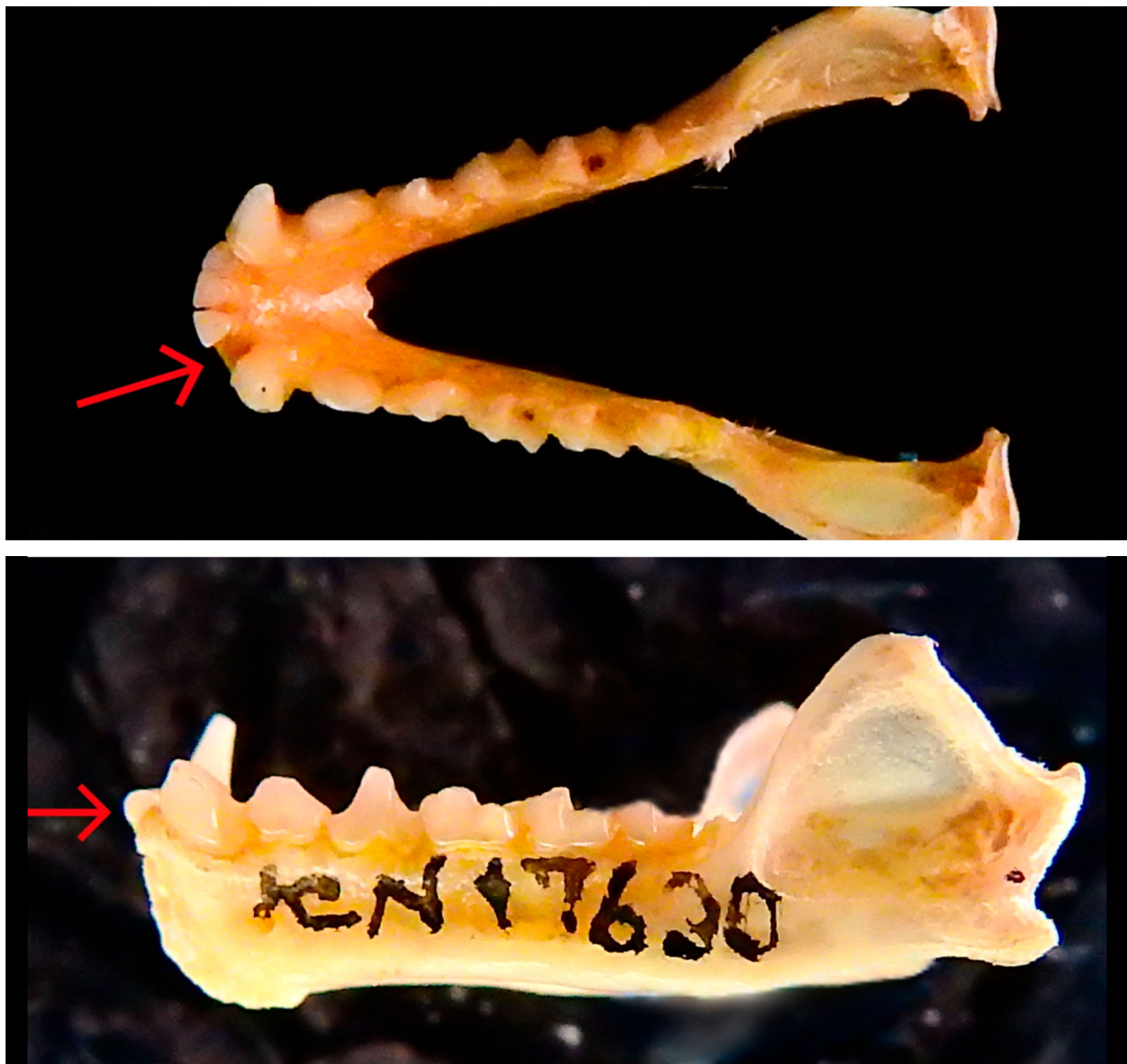


Figure 1. Lateral (A) and occlusal view (B) of the mandible of specimen ICN 5913♂, detailing the missing incisor.

mesenchymal-epithelial interactions; the Fibroblast Growth Factor (FGF) pathway plays a role in the regulation of cell proliferation and differentiation (Zhang 2023).

Knockout/knockdown mice studies reveal the relationships between these pathways and tooth phenotypes. For example, mutations in the *SOSTDC1* gene (a WNT inhibitor) result in supernumerary teeth (Hermans et al. 2021), while mutations in *GLI2* (a SHH activator) cause absent teeth (Hermans et al. 2021). These pathways are promising candidates for studying tooth anomalies and normal phenotypic variation within and among species.

Here, we present a new record of dental anomaly in *Phyllostomus discolor*, advancing knowledge on these types

of anomalies in the Phyllostomidae family. We also discuss temporal trends in publications, and interest among the scientific community.

During a taxonomic review of the neotropical bat genus *Phyllostomus*, we identified one specimen of *Phyllostomus discolor* (out of 260 analyzed) housed at the Instituto de Ciencias Naturales (ICN, Bogotá D. C., Colombia) with a dental anomaly in the mandible and take its morphometric measurements (in mm) are as follows: forearm (AB), total length (TL), ear length (E), foot length (FL), greatest length of skull (GLS), condyloincisive length (CIL), condylocanine length (CCL), zygomatic breadth (ZB), postorbital breadth (PB), palatal length (PL), and dentary length (DENL). Following this

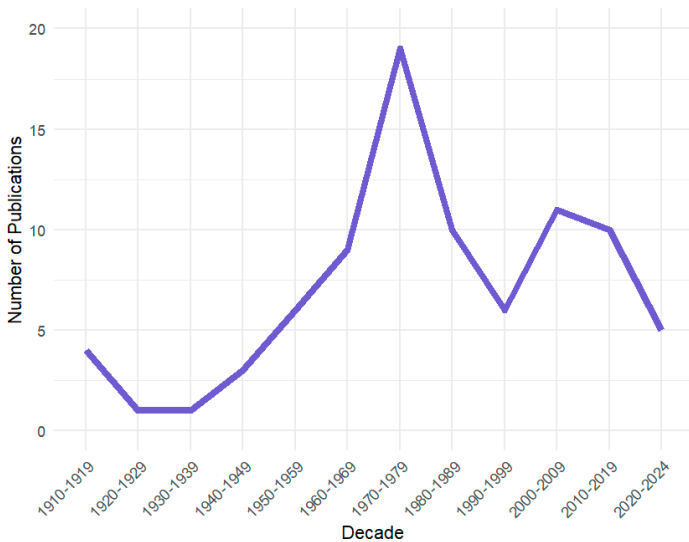


Figure 2. Historical trend of publications on dental anomalies in bats.

discovery, we reanalyzed the data from [Esquivel et al. \(2021\)](#) on publications about dental anomalies in bats, and updated it to identify temporal trends. We surveyed databases such as Google Scholar, ISI Web of Knowledge, Scopus, Biodiversity Heritage Library, and institutional repositories using keywords in Spanish, English, and Portuguese: “Bat” OR “Chiroptera” AND “dental anomalies”, “abnormal”, “extra teeth”, “hyperdontia”, “oligodontia”, “polyodontia”, “supernumerary teeth”, “hypodontia”, and “dental variation”. We calculated the number of publications per year and conducted a linear regression to test the hypothesis that research on this topic follows a positive trend, with an increasing number of publications over consecutive decades. All our analyses were performed using R software ([R Core Team 2024](#)).

The dental anomaly is reported from the specimen ICN 17630 which has a missing lateral incisor (I2) in the mandible, without alveoli, resulting in a total of 3 lower incisors in each side of the mandible— one fewer than normal (Figures 1 and 2). This specimen is an adult male, exhibiting cranial sutures with advanced degree of ossification and little wear on the tooth cusps. Its morphometric measurements (in mm) are as follows: AB = 63.95, TL = 94, E = 22, FL = 16, GLS = 31.3, CIL = 28.2, CCL = 26.3, ZB = 16.6, PB = 6.9, PL = 13.9, and DENL = 19.9. This individual was collected by M. E. Rodriguez, P. A. Otalora, A. Camargo on July 09, 2001, in Ocamonte, Santander, Colombia. The lack of a dental socket, combined with the number of incisors and minimal dental wear, leads us to conclude that the anomaly is hypodontia, instead of the loss by a traumatic event.

From our survey, we found 85 publications (Figure 2) reporting dental anomalies in bats along 114 years. The number of publications vary across different decades, though it is apparent that research in this area has been relatively sparse, with a rate of 0.73 publications per year. Each decade shows values ranging between 5 to 18 of publications, highlighting a significant underrepresentation in the scientific literature. Although there was a slight

increase in the 1980s, this trend has not been sustained. In fact, the number of publications has been declining steadily since the 1990s (Figure 2). Our regression analysis confirms that statement. The p-value indicates that the year is not a statistically significant predictor of the number of publications ($P > 0.05$) showing no increase in the number of publications over consecutive decades.

Our record of hypodontia in *Phyllostomus discolor* is the second documented case for this species. The first observation was reported by [Polaco et al. \(1992\)](#), who identified an individual from Mexico missing the second upper premolar (P4). This new finding not only augments the known reports within *Phyllostomus* but also contributes to the broader dataset of dental anomalies within the Phyllostomidae family, which currently includes 50 species exhibiting these type of anomalies ([Esquivel et al. 2021](#)). The standard dental formula for *Phyllostomus* is $2/2, 1/1, 2/2, 3/3 \times 2 = 32$ (Williams and Genoways, 2007). Notably, our report marks the first incidence of hypodontia affecting an incisor in this genus.

This dental anomaly may be attributable to an isolated mutation present in this individual that reduces the odontogenic potential of the continuous lamina causing punctual tooth loss ([Juuri and Balic 2017](#)). The lack of similar anomalies in other specimens from the study area suggests that this is an uncommon mutation within the population (Colombia, Santander, Ocamonte, Finca Macanal, Cueva la Virgen; 1,290 m, $6^{\circ} 17' 47''$ N, $73^{\circ} 8' 19''$ W). Notably, the occurrence of dental anomalies in Chiroptera is approximately 4.65 % ([Esquivel et al. 2021](#)), so while its occurrence is considered rare, it is actually a phenomenon that may be more common than thought.

Further research could involve identifying the genetic basis of dental anomalies in bats and other mammals, which could enhance our understanding of the evolution of teeth as well as other related traits. Moreover, comparative studies among different taxa could highlight the existence of phylogenetic signals and shed light on the mechanisms underlying the diversification of dental traits ([Sadier et al. 2023](#); [Marrelli 2024](#)). Understanding patterns and incidence of dental anomalies, as well as their variations across different clades, might also be of value for taxonomic studies in bats and other mammals. Despite its importance, it is concerning that the attention to documenting dental anomalies has declined in recent years. Indeed, 71 % of reports on dental anomalies in bats were published before the year 2000. In contrast, only one such report on average has been published per year over the past 24 years. Therefore, we earnestly call for increased reporting of these anomalies, given the current hypotheses about their incidence and their potential to contribute to our understanding of dental evolution in mammals. By documenting and analyzing these dental anomalies, we can contribute to a better understanding of their prevalence and implications.

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Fruit consumption by *Trachops coffini* (Chiroptera: Phyllostomidae) in Guatemala

Consumo de frutos por *Trachops coffini* (Chiroptera: Phyllostomidae) en Guatemala

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Carnivorous bats in the Neotropics, such as *Trachops coffini* (Phyllostomidae), are typically considered strict predators of small vertebrates and invertebrates. Nonetheless, isolated reports of frugivory have been reported in some carnivorous phyllostomid bats. Here, we report the first documented case of fruit consumption by *T. coffini* in Guatemala. This frugivory event was recorded during nocturnal mist-netting surveys conducted in the Selemín Nature Reserve, El Estor, Izabal, Guatemala. Captured individuals were temporarily held in cloth bags, and fecal samples were collected and examined under a stereomicroscope to assess dietary content. On November 23, 2024, three individuals of *T. coffini* were captured. Seeds of *Ficus maxima* were recovered from the feces of one individual. This finding provides direct evidence of dietary flexibility in *T. coffini* and is consistent with previous reports of frugivory in other carnivorous phyllostomid bats, including *T. cirrhosus* (now restricted to South America), *Chrotopterus auritus*, and *Vampyrum spectrum*.

Keywords: Dietary flexibility, frugivory, carnivorous bats, Neotropics, Selemín Nature Reserve.

Los murciélagos carnívoros del Neotrópico, como *Trachops coffini* (Phyllostomidae), suelen considerarse depredadores estrictos de pequeños vertebrados e invertebrados. No obstante, se han reportado casos aislados de frugivoría en algunas especies de murciélagos carnívoros filostómidos. En este estudio, reportamos el primer caso documentado de consumo de frutos por *T. coffini* en Guatemala. Este evento de frugivoría fue registrado durante muestreos nocturnos con redes de niebla en la Reserva Natural Selemín, El Estor, Izabal, Guatemala. Los individuos capturados fueron mantenidos temporalmente en bolsas de tela, para recolectar muestras fecales que posteriormente fueron examinadas bajo un estereomicroscopio para determinar restos del contenido alimentario. El 23 de noviembre de 2024 se capturaron tres individuos de *T. coffini*. Se recuperaron semillas de *Ficus maxima* de las heces de uno de ellos. Este hallazgo constituye evidencia directa de flexibilidad alimentaria en *T. coffini* y es consistente con reportes previos de frugivoría en otros murciélagos carnívoros filostómidos, incluyendo *T. cirrhosus* (ahora restringida a Sudamérica), *Chrotopterus auritus* y *Vampyrum spectrum*.

Palabras clave: Flexibilidad dietaria, frugivoría, murciélagos carnívoros, Neotrópico, Reserva Natural Selemín.

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Bats exhibit remarkable dietary diversity, encompassing insectivorous, nectarivorous, frugivorous, folivorous, hematophagous, and carnivorous species ([Fenton et al. 1992](#); [Simmons and Conway 2003](#); [Kunz et al. 2011](#); [Rodríguez et al. 2023](#)). Within the family Phyllostomidae, carnivorous bats constitute an ecologically distinct group, primarily feeding on vertebrates such as amphibians, birds, reptiles, and other mammals ([Gual-Suárez and Medellín 2021](#)). Among these, bats of the genera *Trachops*, *Chrotopterus*, and *Vampyrum* are recognized as specialized predators, although the extent of their dietary plasticity remains poorly understood.

Species of the genus *Trachops*, particularly *T. cirrhosus*, have traditionally been described as specialist predators that primarily feed on frogs and large invertebrates, and occasionally on small lizards and mammals ([Reid 2009](#); [Barbosa-Leal et al. 2018](#); [Jones et al. 2020](#)). Although the genus is predominantly associated with carnivory, frugivory has been reported in *T. cirrhosus* from South America and in *T. coffini* from Costa Rica. These records, based on fecal and stomach content analyses, are limited to observations of fruit ingestion without seed identification, and thus plant consumption in the genus remains rare, poorly documented, and its underlying drivers remain

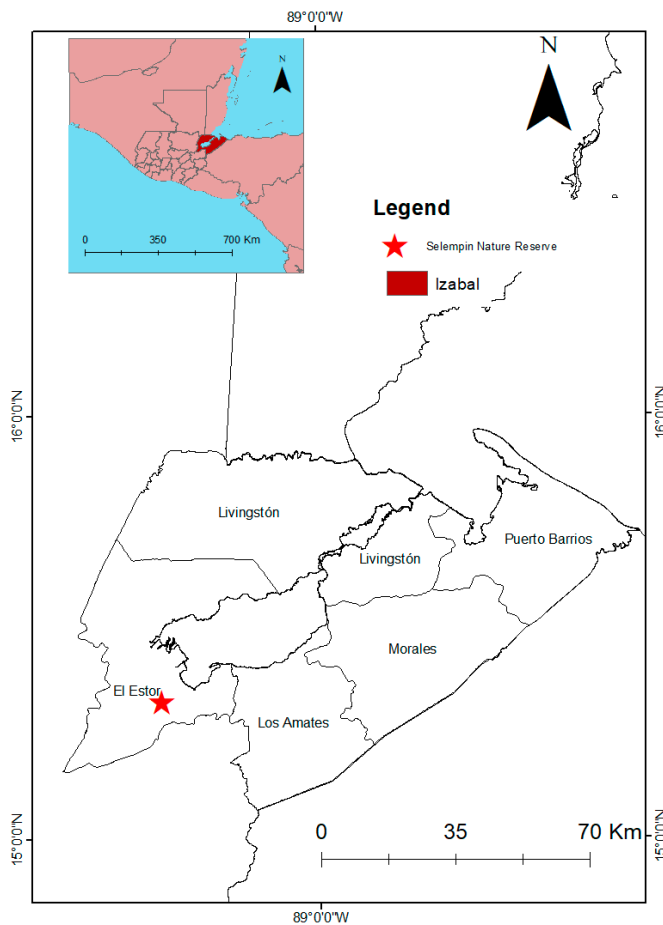


Figure 1. Geographic location of the Selempín Nature Reserve in the department of Izabal, Guatemala.

unclear (Gual-Suárez and Medellín 2021). In Guatemala, dietary information on *Trachops* is particularly limited, with only a single published record to date (Trujillo 2013; Trujillo and López 2014).

To date, there have been no documented records of fruit or seed consumption by the genus *Trachops* in Guatemala. Therefore, the objective of this note is to describe the first record of frugivory by *T. coffini* in the country. This observation contributes to the very limited records of plant consumption in Neotropical carnivorous bats, underscoring that such events remain rare and poorly documented.

The Selempín Nature Reserve is located in the municipality of El Estor, Izabal department, Guatemala, and encompasses 617 hectares of lowland tropical rainforest (Fundación Defensores de la Naturaleza 2003). Situated within the Caribbean region (15° 19' 26.98" N, 89° 23' 12.01" W; Figure 1), the reserve features evergreen vegetation characteristic of lowland tropical rainforest, with a canopy dominated by tree species from families such as Moraceae, Fabaceae, Lauraceae, Sapotaceae, Meliaceae, and Rubiaceae, along with palms (Arecaceae) that are highly represented and floristically dominant in humid forests of the region (IARNA-URL 2018). The climate is warm and humid throughout the year, with elevations ranging from

100 to 400 m above sea level (Fundación Defensores de la Naturaleza 2003).

Bats were captured using three 12-meter mist nets set at ground level along natural flyways, including forest trails and the edges of water bodies, following the methodology described by Kunz and Parsons (2009). Mist nets were set up and opened shortly before sunset (approximately 17:30 hr) and remained open for about five hours, with captures checked every 30 minutes.

Morphometric measurements were recorded for each bat, including head and body length (HB), forearm length (FA), ear length (E), tail length (T), hindfoot length (HF), and weight (Wt). All procedures followed the ethical guidelines of the American Society of Mammalogists (Sikes et al. 2016), and collection activities were conducted under permits issued by the Consejo Nacional de Áreas Protegidas (CONAP), co-administrators of the protected area (Government Decree No. 93-93).

Species identification followed the field guides and keys of Reid (2009), Medellín et al. (2008), and York et al. (2019), and taxonomic classification was based on Simmons and Cirranello (2025). Recent phylogeographic analyses have demonstrated that the taxon historically identified as *Trachops cirrhosus* comprises multiple distinct lineages, now recognized as *T. coffini*, *T. ehrhardti*, and *T. cirrhosus sensu stricto*, which exhibit substantial genetic, morphological, and ecological differentiation (da Silva Fonseca et al. 2024). In Mesoamerica, including Guatemala, populations belong to the lineage *T. coffini* (da Silva Fonseca et al. 2024). Accordingly, we adopt this revised taxonomy and refer to the Central American species as *T. coffini*.

Subsequently, individuals were placed in separate and previously cleaned cloth bags for up to 30 minutes to obtain fecal samples. Feces were preserved in 70% ethanol and later examined under a stereomicroscope to detect identifiable food remains such as seeds and body parts of arthropods and vertebrates. Seed identification was conducted by comparing specimens with reference images and descriptions from a seed catalogue developed for the study area (FODECYT 68-06; Cajas et al. 2008).

On November 23, 2024, three individuals of *T. coffini* were captured, and feces from one of them contained six *Ficus maxima* seeds, providing clear evidence of fruit consumption. The seeds measured 2–3 mm in length, were yellowish, and had a slight fold toward a narrower end that bore a paler coloration, a feature that distinguishes them from other *Ficus* seeds in the locality (Figure 2). This finding represents the first documented record of *F. maxima* consumption by this carnivorous species in the region.

The presence of *Ficus maxima* seeds in the feces of *T. coffini*, a predominantly gleaning carnivorous bat, provides direct evidence of the inclusion of plant material in its diet and indicates a degree of dietary flexibility. This represents the first documented record of *Ficus* consumption by a predominantly gleaning carnivorous bat. Other bats



Figure 2. Lateral view of an adult male of *Trachops coffini* (a), and *Ficus maxima* seeds collected from the feces of the same individual (b). Scale bar = 3 mm.

belonging to the same subfamily (Phyllostominae), such as *Tonatia bidens*, have been reported feeding on *Ficus*, but this species rarely preys on vertebrates and is not considered a true carnivore (Gual-Suárez and Medellín 2021). Although fruit consumption is typically associated with frugivorous bats, other guilds, such as nectarivores, are well known to complement their diets with fruits during certain times of the year (Simmons and Conway 2003; Lobova et al. 2009; Kunz et al. 2011). In contrast, confirmed reports of fruit consumption in carnivorous phyllostomids remain rare and poorly documented (Dobson 1878; Godwin 1946; Navarro 1979; Uieda et al. 2007; Witt and Fabián 2010; Munin et al. 2012; Gual-Suárez 2023).

In the genus *Trachops*, reports of fruit consumption exist from Costa Rica, Panama, and Brazil, although the plant remains were not identified to taxonomic level (Whitaker and Findley 1980; Humphrey et al. 1983; Bonato et al. 2004). The present finding from Guatemala is the first to confirm the identity of a fruit species consumed by the genus and, together with previous reports, indicates that frugivory is a broader, yet still rarely documented, alternative feeding strategy among carnivorous phyllostomids. The evidence was gathered at the end of the rainy season, when typical prey items for the species are abundant, highly active, and consistently producing acoustic or mechanical cues (Steen et al. 2013).

In other Neotropical carnivorous bats, evidence of fruit consumption remains limited but is increasingly reported (Table 1). *Chrotopterus auritus* is the best represented,

with at least four independent records documenting the consumption of *Piper*, *Cecropia*, *Solanum*, *Cestrum*, *Brosimum*, *Lucuma*, and members of the *Araceae*, based on fecal samples and food remains from Brazil and Mexico (Uieda et al. 2007; Witt and Fabián 2010; Munin et al. 2012; Gual-Suárez 2023). For *Vampyrum spectrum*, evidence is scarcer and consists of a recent report from Mexico identifying *Solanum* sp. (Gual-Suárez 2023), along with historical records from Mexico and Brazil noting fruit rind remains in the digestive tract but without taxonomic identification (Dobson 1878; Godwin 1946; Navarro 1979).

Phyllostomid bats exemplify an exceptional adaptive radiation, occupying one of the most diverse sets of dietary niches among mammals, with diets spanning insects, fish, frogs, lizards, rodents, other bats, birds, fruits, pollen, nectar, and blood (Kalko et al. 1996). Rather than representing a regular dietary component, our finding indicates that carnivorous phyllostomids are capable of exploiting plant resources under certain circumstances (Gual-Suárez and Medellín 2021), although the ecological factors and nutritional significance of this behavior remain poorly understood. While many species show marked specialization on particular food types, multiple studies have shown that, at certain stages of their life history, many species may incorporate alternative resources drawn from across this broad trophic spectrum (Howell and Burch 1974; Reid 2009; Hemingway et al. 2020).

This finding underscores the ecological flexibility of *T. coffini* as part of a broader behavioral pattern observed across

Table 1. Documented records of fruit consumption by carnivorous phyllostomid bats in the Neotropics, including the new record in this study. Evidence codes are as follows: FS = fecal sample, DTC = digestive tract content, RS = roost sample (material collected from below bat roosting sites), ND = not determined.

Species	Location	Fruit item	Evidence	Reference
<i>Chrotopterus auritus</i>	Brasil	<i>Piper</i> sp., <i>Cecropia</i> sp., <i>Solanum</i> sp., <i>Cestrum</i> sp.	FS	Uieda et al. (2007)
	Brasil	<i>Piper</i> sp.	DTC	Witt and Fabián (2010)
	Brasil	ND	FS	Munin et al. (2012)
<i>Trachops cirrhosus</i>	Mexico	<i>Manilkara zapota</i> , <i>Brosimum alicastrum</i> , <i>Araceae</i> sp., <i>Lucuma</i> sp.	RS	Gual-Suárez (2023)
	Panamá	ND	FS	Humphrey et al. (1983)
	Brasil	ND	DTC	Bonato et al. (2004)
<i>Trachops coffini</i>	Costa Rica	ND	FS	Whitaker and Findley (1980)
	Guatemala	<i>Ficus maxima</i>	FS	This study
<i>Vampyrum spectrum</i>	ND	ND	DTC	Dobson (1878)
	Costa Rica	ND	DTC	Godwin (1946)
	Mexico	ND	FS	Navarro (1979)
	Mexico	<i>Solanum</i> sp.	DTC	Gual-Suárez (2023)

phyllostomids, and highlights the value of documenting rare feeding events for a better understanding of resource use and trophic interactions in Neotropical carnivorous bats.

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Noteworthy acoustic records of *Eumops ferox* (Chiroptera: Molossidae) and *Mormoops megalophylla* (Chiroptera: Mormoopidae) in Mexico

Registros acústicos notables de *Eumops ferox* (Chiroptera: Molossidae) y *Mormoops megalophylla* (Chiroptera: Mormoopidae) en México

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Eumops ferox is a molossid previously considered restricted to the Neotropical region south of the Trans-Mexican Volcanic Belt. *Mormoops megalophylla* is a widespread distributed mormoopid species but restricted in the Baja California Peninsula to Baja California Sur. This note reports notable records of these two species in northern Mexico. By employing Robust Quadratic Discriminant Analysis and Welch's ANOVA, we analyzed and identified free-flying bat echolocation calls recorded during monthly surveys from January to November 2023 in two regions: Llera de Canales, Tamaulipas, and the Volcanic Complex "Las Tres Vírgenes" in Baja California Sur. Taxonomic identities were determined using frequency and temporal acoustic parameters. A total of 52 echolocation passes from *E. ferox* were documented in Llera de Canales, Tamaulipas, situated 170 km northwest of its closest previously known record and over 450 km north of its currently recognized distribution range. Additionally, 6 passes of *M. megalophylla* were identified in "Las Tres Vírgenes", located 35 km northwest of the nearest prior record. The *E. ferox* record extends its known range into northeastern Mexico, while the *M. megalophylla* record marks the northernmost occurrence of the species on the Baja California Peninsula. These findings enhance our knowledge of the distribution of both species in Mexico.

Keywords: Baja California Peninsula; echolocation; insectivorous bats; northernmost record; Tamaulipas.

Eumops ferox es un molósido que anteriormente se consideraba restringido a la región neotropical al sur de la Faja Volcánica Transmexicana. *Mormoops megalophylla* es una especie de mormópido ampliamente distribuida, pero restringida en la Península de Baja California a Baja California Sur. Esta nota reporta registros notables de estas dos especies en la región norte de México. Mediante el uso de Análisis Discriminante Cuadrático Robusto y el ANOVA de Welch, analizamos e identificamos las llamadas de ecolocalización de murciélagos en vuelo libre, registradas durante muestreos mensuales realizados de enero a noviembre de 2023 en dos regiones: Llera de Canales, Tamaulipas, y el Complejo Volcánico "Las Tres Vírgenes" en Baja California Sur. Las identidades taxonómicas se determinaron utilizando parámetros acústicos de frecuencia y temporales. Un total de 52 secuencias de ecolocalización de *E. ferox* fueron documentadas en Llera de Canales, Tamaulipas, ubicadas a 170 km al noroeste de su registro más cercano conocido y a más de 450 km al norte de su rango de distribución actualmente reconocido. Adicionalmente, se identificaron 6 secuencias de *M. megalophylla* en "Las Tres Vírgenes", situado a 35 km al noroeste del registro previo más cercano. El registro de *E. ferox* extiende su distribución conocida al noreste de México, mientras que el registro de *M. megalophylla* corresponde al registro más septentrional de la especie en la Península de Baja California. Estos registros mejoran el conocimiento de la distribución de ambas especies en México.

Palabras clave: Ecolocalización; murciélagos insectívoros; Península de Baja California; registro más septentrional, Tamaulipas.

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The effectiveness of bat surveys depends on the sampling method employed ([Flaquer et al. 2007](#)). Conventional techniques such as mist nets and harp traps may overlook certain species as foraging strategies, vertical stratification, and echolocation reduce capture success ([Berry et al. 2004](#)). Consequently, relying solely on these techniques can underestimate species diversity ([MacSwiney et al. 2008](#)).

Since the late 1990s, the analysis of bat echolocation calls has enhanced bat fauna inventories by detecting previously unrecorded species (e. g., [Leal-Sandoval et al. 2020](#); [Rodríguez-San Pedro et al. 2022, 2023](#)). With technological advancements and the decreasing cost of ultrasonic recording equipment, the combined use of acoustic monitoring and mist netting has become

increasingly common in bat surveys ([Zamora-Gutiérrez et al., 2021](#)). Consequently, our understanding of bat diversity and species distribution has improved and continues to be regularly updated (e.g., [González-Terrazas et al. 2016](#); [Trujillo et al. 2021](#)).

Through acoustic monitoring, this note reports two notable records in Mexico: *Eumops ferox*, a molossid bat previously thought to occur only in the Neotropical region south of the Trans-Mexican Volcanic Belt ([Solari 2019](#)), and *Mormoops megalophylla*, a widespread distributed mormoopid bat but restricted in the Baja California Peninsula to Baja California Sur ([Álvarez-Castañeda 1999](#); [Dávalos et al. 2019](#)).

Acoustic recordings resembling *E. ferox* and *M. megalophylla* were obtained in 2023 from monthly surveys (January through November) at Llera de Canales, Tamaulipas, and Mulegé, Baja California Sur, respectively. In Tamaulipas, surveys were carried out near the Guayalejo River (23° 19' 39.881" N, 99° 1' 0.469" W) in a Tamaulipan Thorny Scrub with riparian vegetation and crops, under a hot semi-arid climate with summer rains ([INEGI 2021](#)). In Baja California Sur, surveys took place around the Las Tres Vírgenes Volcanic Complex (27° 31' 59.263" N, 112° 33' 38.372" W) in xerophilous scrubland, featuring a hot desert climate with temperatures of 14–24 °C and annual rainfall below 500 mm ([INEGI 2010](#)).

Acoustic surveys were conducted to assess local spatial and temporal patterns of bat activity. At each site, four transects, each 4–6 km in length, were surveyed. Bat activity was recorded for 90 minutes per transect immediately after sunset using an Echo Meter Touch 2 Pro ultrasonic detector (Wildlife Acoustics Inc., Maynard, MA) set to a 256 kHz sampling rate and connected to a Motorola G60S smartphone running Android v11. No frequency or amplitude filters were applied.

Bat echolocation calls were recorded in WAV format and analyzed in BatSound Pro v.3.31 (Pettersson Elektronik AB, Uppsala, Sweden) using a 1024-point FFT, Hamming window, and 95 % overlap, parameters chosen for analytical consistency and user convenience. The shape and structural characteristics of pulses were examined directly in the spectrogram using these settings, along with threshold = 1 and contrast = 2. For some recordings, however, these visualization settings were adjusted up to threshold = 5 and contrast = 4, to improve the clarity of pulse structure. We measured five acoustic parameters commonly used in bat species identification, call duration (Dur), maximum frequency (Fmax), minimum frequency (Fmin), peak frequency (Pkf), and bandwidth (Bw) ([Orozco-Lugo et al. 2013](#); [Leal-Sandoval et al. 2020](#); [Ayala-Berdon et al. 2021](#); [Rodríguez-San Pedro et al. 2022](#)). Duration was measured in the oscillogram, beginning at the point where the signal amplitude rose abruptly above the background noise and ending when the amplitude returned to a level comparable to the noise floor, with no subsequent

immediate increase (i.e., in signals exhibiting multimodal amplitude peaks resembling a “violin” shape). To visualize the oscillogram, we used the cursor selection tool to define a time window with a width approximately twice the duration of the pulse as displayed in the sonogram. Fmax, Fmin, and Pkf were extracted from the power spectrum (using the same 1024-point FFT, Hamming window, and 95 % overlap). Both Fmax and Fmin were measured at - 10 dB below the peak intensity in the power spectrum ([Jensen and Miller 1999](#)), and considering the background noise level present during the specific pulse duration. Pulses were discarded when external noise sources (e.g., insect calls, human noises) interfered with reliable measurement. Bandwidth was defined as the frequency range over which the echolocation pulse occurred and was calculated as the arithmetic difference between Fmax and Fmin.

To identify species recorded in Tamaulipas, we applied Robust Quadratic Discriminant Analysis (rQDA; [Todorov and Filzmoser 2009](#); [Tharwat 2016](#)) using the R package rrcov ([Todorov and Pires 2007](#)) to build a discriminant model from a training dataset and to assign species identities. The rQDA extends classical QDA by using robust estimators for means and covariances, reducing sensitivity to outliers and assumption violations ([Todorov and Filzmoser 2009](#)). The training dataset comprised search-phase echolocation parameters of *Eumops ferox* recorded in 2020–2023 in La Venta, Oaxaca, Mexico (n = 24, unpublished data), supplemented with mean values from Cuban populations (n = 1, [Mora and Torres 2008](#)), and included parameters of sympatric species with similar calls previously recorded in the area: *Eumops perotis*, *Nyctinomops macrotis*, *Tadarida brasiliensis*, and *Lasiurus cinereus* ([Ayala-Berdon et al. 2021](#); [Szewczak 2018](#); [Jung et al. 2014](#); [Guzmán-Soriano et al. 2009](#); [Mora and Torres 2008](#)).

To ensure predictor independence, one pulse per date and site was used in the training data, and Tamaulipas recordings were averaged per pass, treating passes separated by silent gaps or different dates as independent. Principal Component Analysis was applied to reduce multicollinearity, and rQDA was conducted using the first three components of call signatures from *E. perotis*, *N. macrotis*, *T. brasiliensis*, *L. cinereus* and *E. ferox* (Oaxaca and Cuba) as training data, excluding PCA-scores of *E. ferox* from Tamaulipas. Model performance was assessed using accuracy and ROC AUC using the pROC package ([Robin et al. 2011](#)) in R ([R Core Team, 2025](#)). Species identity for Tamaulipas recordings was then inferred by applying the rQDA model's posterior probabilities to their PCA-scores.

We assessed each principal component's contribution to group discrimination using an index based on standardized mean differences. PCA loadings identified the acoustic parameters most linked to the discriminant component, which were then compared between Tamaulipas recordings and other reference species using Welch's ANOVA with Games-Howell post hoc tests for

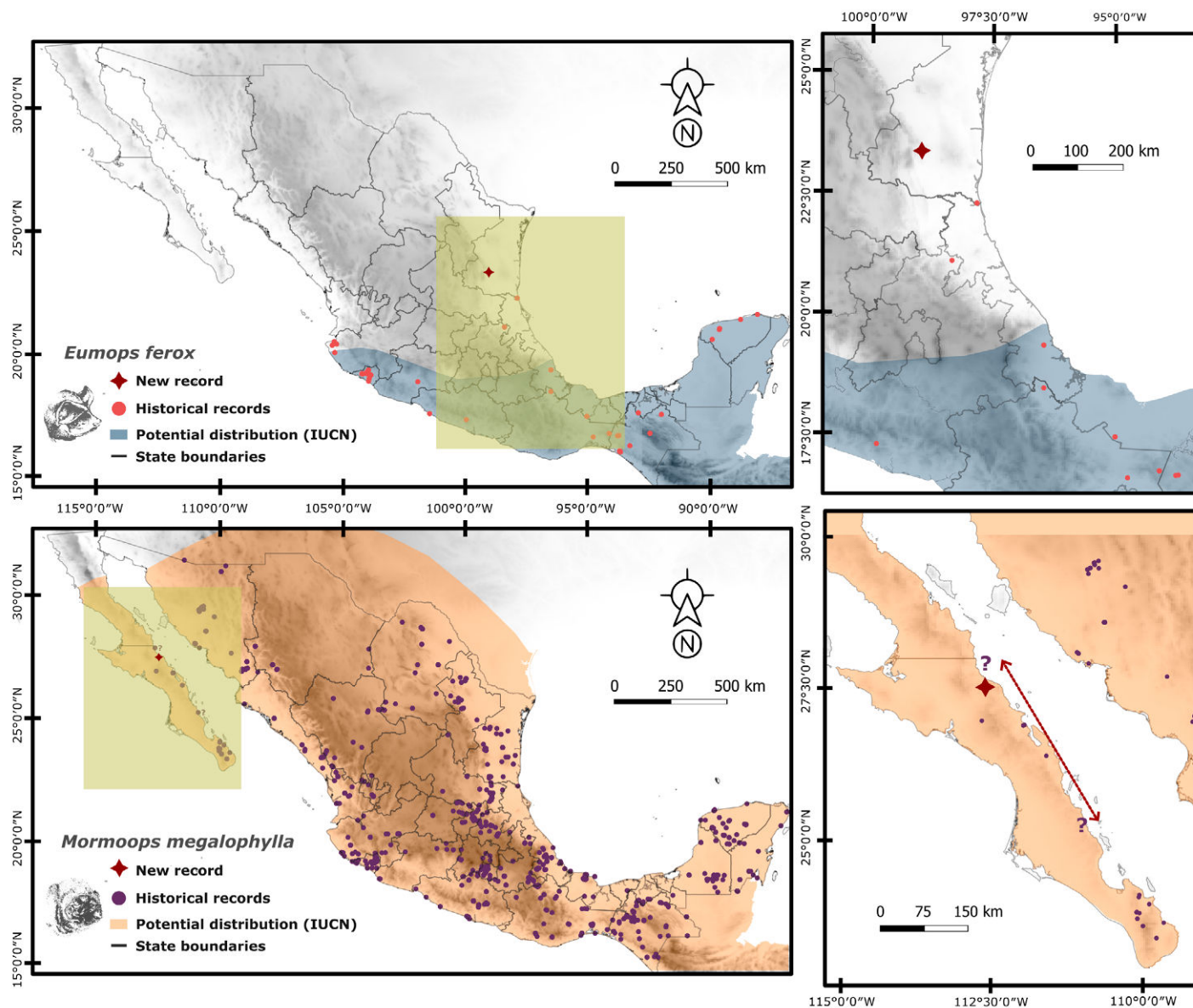


Figure 1. Norteworthy records of *Eumops ferox* (above) and *Mormoops megalophylla* (below) from Llera de Canales, Tamaulipas, and the Volcanic Complex Las Tres Vírgenes, Baja California, respectively. Circles represent historical records up to the current study (GBIF.org 2024 a,b,c), while red stars denote new records. The colored areas (blue or orange) indicate the geographic distribution ranges according to the IUCN for *E. ferox* (Solarí 2019) and *M. megalophylla* (Dávalos et al. 2019). For *M. megalophylla*, the two potential locations for the previously debated record from Bahía San Carlos, Costa Este (see main text) are marked with question marks and the red arrow indicate the distance between them.

unequal variances and non-normal data (Delacre et al. 2019; Shingala and Rajyaguru 2015).

For *M. megalophylla*, we applied the same methodology used for *E. ferox* in Tamaulipas. The rQDA training dataset included echolocation calls of *M. megalophylla* ($n = 23$) and *Pteronotus fulvus* ($n = 40$) recorded in La Mancha, Veracruz in 2022 (Echo Meter Touch 2 Pro, unpublished data). *Pteronotus fulvus* was included because it occurs in Baja California's Cape Region and its multi-harmonic, quasi-constant, modulated calls resemble those of *M. megalophylla* (Álvarez-Castañeda 1999; Arnaud-Franco et al. 2012; Orozco-Lugo et al. 2013).

We recorded 52 passes (268 calls) of free-flying *Eumops cf. ferox* in Llera de Canales, Tamaulipas, ~ 170 km northwest of the nearest previous record (Figure 1). Calls were single-harmonic, quasi-constant frequency (Figure 2a), averaging

16.23 ± 1.06 ms in duration, a minimum frequency of 13.57 ± 0.33 kHz, and 15.69 ± 0.39 kHz peak frequency (Table 1). Recordings occurred multiple times in January, February, July, and August 2023, and activity peaked shortly after sunset and 2-3 h later.

The training dataset violated assumptions of multivariate normality ($E = 6.423$, $P < 0.001$) and covariance homogeneity ($\chi^2 = 396.21$, $d.f. = 30$, $P < 0.001$), justifying the use of rQDA. The model achieved 93.02 % overall accuracy, with ROC AUC > 0.96 for most species except *T. brasiliensis* (AUC = 0.68); *E. ferox* reached 88 % accuracy (AUC = 0.97). Posterior classification assigned 51 passes (98.1 %) from Tamaulipas to *E. ferox* with high posterior probability (> 0.93) (Figure 3a). The first PC, primarily influenced by Fmin, Fmax, and Pkf, was the most effective for separating *E. ferox* from other species (Figure 3b,c). Welch's ANOVA with Games-Howell

Table 1. Acoustics parameters of echolocation calls for *Eumops ferox* (Llera de Canales, Tamaulipas) and *Mormoops megalophylla* (Las Tres Virgenes Volcanic Complex, Baja California) are highlighted in bold. Calls included in both rQDAs, as well as those from the training dataset, are presented with sample size (n) -indicating the number of calls and the number of passes in parentheses- along with the mean (X), standard deviation (SD), and coefficient of variation (CV). Abbreviation: *Eumops ferox* (Eufe), *Eumops perotis* (Eupe), *Lasiurus cinereus* (Laci), *Nyctinomops macrotis* (Nyma), *Tadarida brasiliensis* (Tabra), *Mormoops megalophylla* (Mome), *Pteronotus fulvus* (Pteful).

		Eufe (training dataset)	Eufe Tamaulipas	Eupe	Laci	Nyma	Tabra	Mome (training dataset)	Mome Baja California	Pteful
	n	25	268(52)	64	23	83	20	23	29(6)	40
Fmax	X	17.79	19.20	12.67	30.56	23.51	30.19	55.64	59.05	71.68
	SD	1.91	0.95	1.47	5.30	3.48	3.35	3.14	0.93	1.85
	CV	10.76	4.96	11.59	17.36	14.79	11.11	5.64	1.57	2.58
Fmin	X	13.97	13.57	10.42	22.47	18.30	23.29	42.64	38.96	57.04
	SD	0.79	0.33	1.39	1.51	0.96	1.53	5.10	0.69	1.66
	CV	5.63	2.41	13.36	6.72	5.26	6.57	11.95	1.76	2.91
Bw	X	3.71	5.63	2.24	8.09	5.21	6.90	13.00	20.10	14.63
	SD	1.09	1.01	1.34	4.72	3.32	2.98	7.36	1.47	1.99
	CV	29.26	17.89	59.83	58.33	63.79	43.23	56.63	7.31	13.61
Pkf	X	15.56	15.69	11.60	24.51	20.51	25.48	52.92	54.48	63.53
	SD	1.26	0.39	1.28	1.65	1.29	1.75	1.35	0.32	5.02
	CV	8.08	2.46	11.03	6.74	6.26	6.86	2.54	0.59	7.89
Dur	X	15.00	16.23	21.06	11.09	12.24	12.04	6.94	5.69	5.88
	SD	1.95	1.06	3.59	1.53	2.55	5.60	1.50	0.45	1.50
	CV	13.03	6.55	17.06	13.82	20.80	46.51	21.62	7.89	25.43

Table 2. Results of the Games-Howell post-hoc test comparing *E. ferox* from Tamaulipas with *E. ferox* from training dataset, and sympatric open-space aerial hawking species presented in Tamaulipas.

		Pkf			Fmin		Fmax	
	<i>n</i>	<i>q</i>	<i>P</i>	<i>q</i>	<i>P</i>	<i>q</i>	<i>P</i>	
<i>Eumops ferox</i> (training dataset)	25	0.732	0.995	-3.46	0.1748	4.92	0.017	
<i>Eumops perotis</i>	64	34.35	< 0.001	24.73	< 0.001	40.84	< 0.001	
<i>Lasiurus cinereus</i>	23	-35.77	< 0.001	-39.55	< 0.001	-14.42	< 0.001	
<i>Nyctinomops macrotis</i>	83	-45.24	< 0.001	-58.18	< 0.001	-15.11	< 0.001	
<i>Tadarida brasiliensis</i>	20	-35.11	< 0.001	-39.82	< 0.001	-20.41	< 0.001	

tests revealed significant differences in these parameters ($F = 580.66$, $d.f. = 5/73.70$, $P < 0.001$ for Pkf; $F = 686.41$, $d.f. = 5/74.25$, $P < 0.001$ for Fmin; $F = 294.52$, $d.f. = 5/75.51$, $P < 0.001$ for Fmax) relative to other aerial-hawking bats, but not compared to *E. ferox* from the training dataset (Table 2).

For *M. megalophylla*, we recorded 6 echolocation passes (29 calls) about 55 km north of a previous record in Santa Ana and 35 km northwest of another in Santa Rosalía, Baja California (Figure 1). Calls consisted of a quasi-constant segment followed by a steeply modulated portion; in some cases, a brief initial FM component was present. Up to three harmonics were usually visible, with the second harmonic being the most energetic (Figure 2b). The calls had an average duration of 5.69 ± 0.45 ms, a maximum frequency of 59.05 ± 0.93 kHz, and a peak frequency at 54.4 ± 0.32 kHz (Table 1). Recordings occurred in July, September, and November 2023, 90 min to 2 h after sunset.

The rQDA was applied as the training dataset violated normality ($E = 3.351$, $P < 0.001$) and covariance homogeneity ($X^2 = 96.41$, $d.f. = 12$, $P < 0.001$). The model

achieved 100 % classification accuracy and $AUC = 1$ for both *M. megalophylla* and *P. fulvus*. Posterior classification assigned all Baja California passes to *M. megalophylla* with probability 1. The first PC, primarily influenced by Fmin, Fmax, and Pkf, was the most effective for separating *M. megalophylla* from *Pteronotus fulvus* (Figure 3d,e). Welch's ANOVA ($F = 79.251$, $d.f. = 2/42.18$, $P < 0.001$ for Pkf; $F = 1091.9$, $d.f. = 2/24.57$, $P < 0.001$ for Fmin; $F = 467.04$, $d.f. = 2/20.52$, $P < 0.001$ for Fmax) with Games-Howell post hoc tests confirmed significant differences between Baja California *M. megalophylla* and *P. fulvus* (Pkf $q = -15.933$, $P < 0.001$; Fmin $q = -66.525$, $P < 0.001$; Fmax $q = -37.391$, $P < 0.001$), and also with Veracruz *M. megalophylla* for Pkf, Fmin, and Fmax (Pkf $q = 7.148$, $P < 0.001$; Fmin $q = -4.737$, $P < 0.001$; Fmax $q = 6.39$, $P < 0.01$).

In this note, we report noteworthy records of *E. ferox* and *M. megalophylla* in Mexico based on acoustic evidence, extending their known distribution. These findings underscore the importance of ongoing acoustic surveys to document bat diversity in Mexico, particularly in

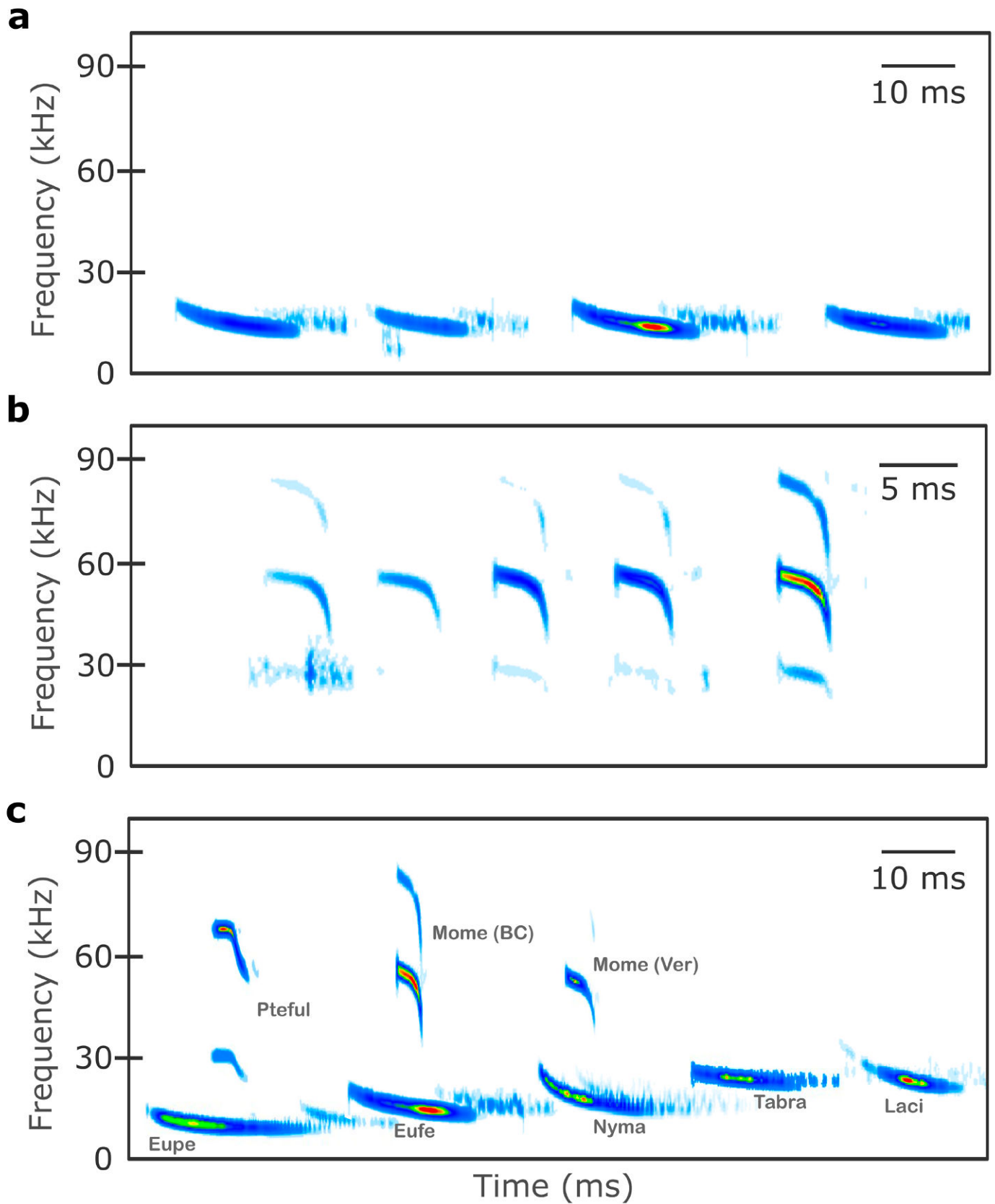


Figure 2. Sonograms of echolocation calls of (a) *Eumops ferox* recorded in Llera de Canales, Tamaulipas, and (b) *Mormoops megalophylla* recorded in the Las Tres Vírgenes Volcanic Complex, Baja California Sur. Panel (c) is a composition illustrating sonograms of echolocation calls from various species used as reference for species discrimination analysis based on acoustic parameters. The time between pulses in all panels is compressed and does not represent the actual interval separating them. Abbreviations: Mome (Ver): *M. megalophylla* from Veracruz; Mome (BC): *M. megalophylla* from Baja California; Pteful: *P. fulvus*; Eupe: *E. perotis*; Eufe: *E. ferox*; Laci: *L. cinereus*; Nyma: *N. macrotis*; Tabra: *T. brasiliensis*. Sonograms were generated using SonoBat Viewer (free version) with blue contrast settings.



Figure 3. (a) Posterior probability of identity assigned to *E. ferox* from Tamaulipas based on the rQDA model. Each bar represents a pass. (b) Variable importance, calculated through the mean standard distance of class, for discriminating *E. ferox* from other open-space aerial hawking species. (c) Scatter plot of the PCA-scores of PC1 and PC3 for *E. ferox* and other sympatric aerial hawking bat species analyzed in the rQDA. The plot is constructed based on variable importance. (d) Variable importance, calculated through the mean standard distance of class, for discriminating *M. megalophylla* from *P. fulvus*. (e) Scatter plot of the PCA-scores of PC1 and PC32 for *M. megalophylla* and *P. fulvus* analyzed in the rQDA. Similar to *E. ferox*, the scatterplot is based on variable importance according to the rQDA. In both cases, training and empirical data for *E. ferox* from Tamaulipas and Oaxaca, as well as *M. megalophylla* from Baja California Sur and Veracruz, are included.

historically underexplored regions with insectivorous bat species. Our models, constructed using Robust Quadratic Discriminant Analysis, successfully distinguished their calls from those of closely related species, strongly suggesting the presence of *E. ferox* in Tamaulipas and *M. megalophylla* in northern Baja California Sur.

Echolocation calls of *E. ferox* from Tamaulipas were clearly distinguished from sympatric aerial-hawking bats (Table 1). While *N. macrotis*, *L. cinereus*, and *T. brasiliensis* emitted higher frequencies (Ayala Berdon et al. 2021; Szewczak 2018), the congener *E. perotis* produced lower ones (Szewczak 2018; Rodríguez-San Pedro et al. 2023). These differences likely reflect negative allometry between body size and call frequency (Jones 1999; López-Cuamatzi et al. 2020), as *E. ferox* (Forearm [FA]: 55-63 mm; Body mass [BM]: 34-42 g; Lim 2019a) is larger than *L. cinereus* (FA: 50-57 mm; BM: 20-35 g; Cláudio 2019) and *T. brasiliensis* (FA: 36-47 mm; BM: 8-15 g; Lim 2019d), but smaller than *E. perotis* (FA: 72-83 mm; BM: 52-76 g; Lim 2019b). Interestingly, in comparison with *N. macrotis*, *E. ferox* has a similar forearm length but greater body mass (*N. macrotis* FA: 54-65 mm; BM: 17-34 g; Lim 2019c). Thus, allometry could be a contributing factor; however, it is important to note that this relationship may not apply uniformly across all comparisons, particularly among molossid bats (see Jung et al. 2014), and other factors may also influence the divergence in echolocation call frequencies within our dataset.

The acoustic traits of *E. ferox* in this study resemble those from Campeche (Guzmán-Soriano et al. 2009), though at slightly lower frequencies. Intraspecific variation in echolocation call parameters is well-documented and often linked to environmental factors (Jiang et al. 2015). For instance, higher frequencies are more prone to atmospheric attenuation under high humidity or wind (Gillam et al. 2009), while lower frequencies are more resilient (Goerlitz 2018). Lower call frequencies of *E. ferox* in Llera de Canales may reflect the impact of stronger winds (INEGI 2021), similar to observations from La Venta, Oaxaca, another windy site used for training data. Further studies are needed to verify this pattern and its driving factors.

Our multiple records of *E. ferox* in Llera de Canales, Tamaulipas, suggest its presence in northeastern Mexico. Although surveys covered nearly a full year, the species was detected only in January-February and July-August, indicating a possible seasonal pattern that warrants further year-round monitoring. Previous distribution models (Medellín et al. 2008) suggested the occurrence of *E. ferox* in the region based on records collected in Tampico, Tamaulipas, in 1923 (FMNH 124224-29), but no additional records existed until now. Combined with historical observations (Figure 1), our findings indicate that the range of *E. ferox* extends along the Gulf of Mexico slope beyond the limits currently recognized by the IUCN (Solari 2019) (Figure 1).

The shape, multi-harmonic structure, and frequency of *M. megalophylla* calls in our recordings match previous

descriptions from Mexico and the Neotropics (i.e., Orozco-Lugo et al. 2013). However, Games-Howell tests revealed significant differences between Veracruz and Baja California Sur populations, likely reflecting intraspecific geographic variation rather than species-level divergence (Jiang et al. 2015). Despite these differences, both populations remain clearly distinct from *P. fulvus*.

Previous records of *M. megalophylla* on the Baja California Peninsula are concentrated in southern Baja California Sur (BCS), including the Cape Region near La Paz and Comondón, as well as two northern BCS locations in Mulegé municipality (Santa Ana, Santa Rosalía, and the municipal head) (Figure 1). A controversial record of *M. megalophylla* on the Baja California Peninsula concerns a female captured on July 24, 1963, by Jamie Maya and deposited at the University of Arizona Museum of Natural History (UAZ 09941). Although labeled as collected at “Bahía San Carlos, East Coast”, BCS (Bucci 2024), the assigned coordinates (27° 55' 00.0" N 112° 43' 00.0" W) fall over water in the Gulf of California (Figure 1). This may represent the northernmost record of the species on the peninsula, but the exact collection site is uncertain. The assigned coordinates were taken from one of two potential locations for Bahía San Carlos in Baja California Sur (Melanie Bucci, curator of the Mammal Collection at the University of Arizona Museum of Natural History, pers. comm.). The second location (25° 16' 0.001"N, 110° 57' 0"W), provided by the curator as an alternative (but not shown in either GBIF or VertNet; Bucci, pers. comm.), lies 350 km south of the coordinates assigned to the specimen and 290 km south of our record from the “Las Tres Vírgenes” Volcanic Complex. Given the curator’s acknowledgment of the uncertainty around the location assigned to the UAZ 09941 specimen, reflected in GBIF’s “Georeference verification status” field indicating the need for verification (Bucci 2024), we consider that our record of *M. megalophylla* in the lowlands of the Volcanic Complex of “Las Tres Vírgenes” represents the most reliable northernmost record of occurrence of this species on the Baja California Peninsula.

Identifying bat species through comparative analyses of echolocation call parameters is a scientific practice that inherently involves some degree of uncertainty regarding taxonomic identity. Acknowledging this uncertainty, we consider that, although our quantitative analyses and the available ecological background on the distribution and ecology of the species discussed in this note support our inferences about these remarkable records, a thorough field exploration of the region is necessary to obtain voucher specimens. Such efforts would confirm the presence of these species and dispel any remaining skepticism. In this sense, our note emphasizes the importance of continued bat monitoring in the region to enhance our understanding of bat diversity and distribution in northern Mexico.

Based on a quantitative analysis of echolocation call parameters, this note reports noteworthy records of *E.*

ferox and *M. megalophylla* in northern Mexico. The record of *E. ferox* from Llera de Canales, Tamaulipas, represents the northernmost occurrence of this species and confirms its presence in northeastern Mexico, complementing previous records from Tampico, Tamaulipas. Regarding *M. megalophylla*, the record presented here constitutes the most reliable and northernmost occurrence of the species on the Baja California Peninsula. Furthermore, our quantitative analysis revealed significant differences in the acoustic parameters of echolocation calls between Baja California and reference data from Veracruz, suggesting the presence of geographic variation that warrants further investigation. The records presented here contribute substantially to understanding the geographic distribution of both species, extending their known ranges and adding new localities. These findings underscore the importance of continued field surveys in northern Mexico and highlight the value of acoustic monitoring for improving bat diversity inventories across the country.

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First photographic record of *Leopardus pardalis* (Mammalia: Felidae) in Nichupté Lagoon, Quintana Roo, Mexico

Primer registro fotográfico de *Leopardus pardalis* (Mammalia: Felidae) en la Laguna Nichupté, Quintana Roo, México

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The ocelot (*Leopardus pardalis*) is one of six species of felines found in Mexico. According to NOM-059-SEMARNAT-2010, it is currently endangered in the country. The objective of this study was to document the presence of ocelots in the Nichupté mangrove protected natural area in Quintana Roo, Mexico. From March to November 2024, 16 camera traps were used for faunal sampling in this ecosystem for 275 days and 6,600 hours. From May to July 2025, daytime surveys were conducted for 65 days and 455 hours. Independent photographs and videos of several species of fauna were obtained. However, the ocelot was observed in only one photograph and in a single footprint on one day. This is the first documented instance of ocelots in the Nichupté mangrove ecosystem, which is of high biological and ecological importance. Furthermore, the presence of this species suggests that the ecosystem is healthy, as the ocelot is mainly associated with its food sources, such as rodents and birds.

Keywords: Camera trap; conservation area; endangered species; feline; new record; ocelot.

Leopardus pardalis comúnmente conocido como ocelote, es una de las seis especies de felinos que se distribuyen en México y actualmente en el país se encuentra en peligro de extinción de acuerdo con la NOM-059-SEMARNAT-2010. Por lo que el objetivo del presente trabajo fue reportar la presencia del ocelote en el área natural protegida, manglares de Nichupté, en Quintana Roo, México. Mediante un muestreo faunístico con 16 cámaras trampa de marzo a noviembre 2024 (275 días y 6,600 horas) y recorridos diurnos durante mayo a julio 2025 (65 días/455 horas) en este ecosistema. Se obtuvieron fotografías y videos independientes con el registro de varias especies de fauna; sin embargo, el ocelote se observó solo en una fotografía y la huella en un solo día, este hallazgo es el primer registro de ocelote para el manglar de Nichupté, un área de gran importancia biológica y ecológicamente, además, la presencia de esta especie sugiere un buen estado de salud del ecosistema, ya que este felino se encuentra asociado principalmente a su alimentación (presas) como roedores y aves.

Palabras clave: Área de conservación; cámara trampa; especies en peligro; felino, nuevo registro, ocelote.

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The ocelot (*Leopardus pardalis*) is one of six species of the Felidae family found in Mexico ([Ramírez-Pulido et al. 2005](#); [Ramírez-Bravo et al. 2010](#); [Aranda 2012](#)). It is the third largest spotted cat in Mexico and the largest in the genus *Leopardus*. It can be found in a variety of habitats associated with dense vegetation, such as tropical forests, mangroves, thorny scrub, grasslands, and swamps ([Aranda 2005](#); [Martínez-Calderas et al. 2011](#); [Duarte-Muñoz et al. 2025](#)). Ocelots are mainly nocturnal but also active during the day. They are solitary, territorial, and carnivorous, feeding mainly on small vertebrates (< 2.0 kg), such as rodents and birds ([Murray and Gardner 1997](#)).

Its distribution ranges from southern Texas to northern Argentina ([Oliveira 1994](#); [Aranda 2005](#)). In Mexico, it is found along the Pacific and Gulf coasts, as well as in the states of Aguascalientes, Chiapas, Durango, Guanajuato, Hidalgo, Quintana Roo, Morelos, Nuevo León, Oaxaca, Puebla, San Luis Potosí, Sinaloa, Sonora, Tabasco, Tamaulipas, Veracruz, and Zacatecas ([Iglesias et al. 2008](#); [Bárcenas and Medellín 2010](#); [Martínez-Calderas et al. 2011](#); [Hernández-Flores et al. 2013](#); [Valdez-Jiménez et al. 2013](#); [Aranda et al. 2014](#); [Gordillo-Chávez et al. 2015](#); [Galindo-Aguilar et al. 2016](#); [García-Bastida et al. 2016](#); [Servín et al. 2017](#); [Torres-Romero et al. 2017](#); [Duarte-Muñoz et al. 2025](#)).

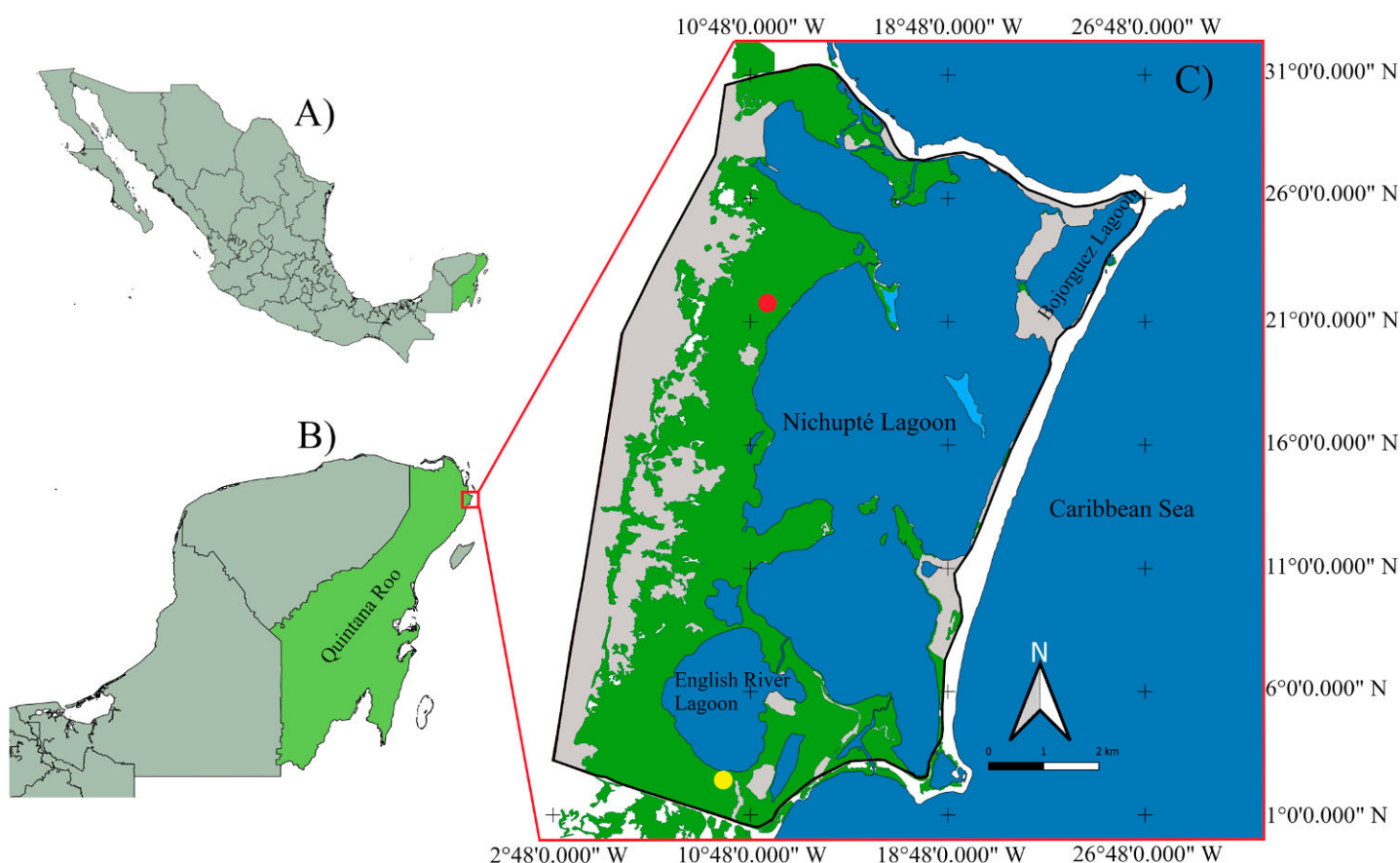


Figure 1. Geographic location of the sampling site. A) Mexico, B) Yucatan Peninsula and Quintana Roo state, C) Protected Natural Area, Nichupté Mangroves. Yellow circle: photographic record of *L. pardalis*, red circle: photographic record of the footprint.

Leopardus pardalis presents conservation challenges due to habitat loss and fragmentation, illegal hunting, and the illicit fur trade. These factors have caused population declines and local extinctions in many areas of the country (Sunquist and Sunquist 2002; Aranda 2005; Di Bitetti et al. 2008). In Mexico, it is currently classified as an endangered species, and hunting it is prohibited by Secretaría de Medio Ambiente y Recursos Naturales (NOM-059-SEMARNAT 2010). The International Union for Conservation of Nature and Natural Resources (IUCN 2025) classifies it as a species of least concern. Its commercialization is regulated by Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2024), which places it in Appendix I. The objective of this study is to document the presence of *L. pardalis* in the Nichupté Lagoon mangrove reserve in Quintana Roo, Mexico. An ecosystem with scarce research and ecological importance. Essential for biodiversity conservation, it functions as a refuge and reproduction area for flora and fauna. Furthermore, it protects the coast from erosion and mitigates the effects of storms and hurricanes. Additionally, this system filters sediments and contaminants, maintains water quality, and functions as a valuable carbon reservoir. Simultaneously, they represent cultural heritage linked to traditional management practices and environmental education.

Socially, they support fishing, tourism, and recreational activities. They contribute to the well-being and safety of the local population by reducing risks and maintaining the ecological productivity that sustains the regional economy.

The records were obtained from the Nichupté Mangrove Protected Natural Area, which is located in the northeastern part of Quintana Roo, Mexico (Figure 1). This area has a surface area of 4,257 ha, dedicated to the protection and preservation of biodiversity with dominant mangrove vegetation of the species *Avicennia germinans* (black mangrove), *Conocarpus erectus* (buttonwood mangrove), *Laguncularia racemosa* (white mangrove), and *Rhizophora mangle* (red mangrove), and an elevation range of 0 to 4 meters above sea level (SEMARNAT 2014).

From March to November 2024, 16 sampling stations equipped with Browning Dark Ops HD Pro X camera traps were installed. The camera traps were configured in hybrid mode with 1080p HD video recording at 30 frames per second for 20 seconds, as well as three 20-megapixel photographs every 30 seconds. These stations were set up in areas where various bird species were concentrated, at the edges of and across natural channels that serve as corridors for different animal species. In total, the stations accumulated 275 days and 6,600 hours of sampling effort. Additionally, from May 2025 daytime surveys were



Figure 2. Record of *L. pardalis* in the Nichupté mangrove protected natural area. A) Photographic record using a camera trap. B) Record using tracks.

conducted from 7 to 13 h. to detect traces of prey and tracks (paw prints) of this species in the ecosystem. Two people carried out these surveys, which covered a total of 65 days and 455 hours.

A clear photograph showing the size and pattern of the spots on the ocelot's body was obtained, but the animal's position did not allow its sex to be determined (Figure 2a). During daytime surveys, tracks of this species were identified (Figure 2b), indicating that the ocelot inhabits a large area in this region.

These records are the first to document the presence of *L. pardalis* in this natural area because it is not included among the 19 mammal species reported in the Nichupté mangroves (SEMARNAT 2014). The closest official records prior to these had been in the El Edén Ecological Reserve, located approximately 40 kilometers west of the mangroves (Torres-Romero et al. 2017).

The presence of *L. pardalis* in this protected natural area indicates the health of the local ecosystem because it regulates the population size of its prey (Pérez-Irineo and Santos-Moreno 2015). Similarly, the presence of ocelots suggests that the mangroves harbor a high diversity of prey, including small and medium-sized mammals, birds, and reptiles (Murray and Gardner 1997; Lima-Massara et al. 2015). Ocelots primarily consume prey weighing less than 2.0 kg. However, in the absence of larger carnivores, they are known to prey on larger mammals, such as coatis, raccoons, tepezcuinte, and opossums, which weigh up to 10 kg (Murray and Gardner 1997; De Cassia-Bianchi and Lucena-Mendes 2007). These mammals are very common in the Nichupté mangroves.

Like many ecosystems in the country, these mangroves are under anthropogenic pressure due to increased human construction. This restricts the distribution of the species, which is surrounded to the east, south, and north by human infrastructure and to the east by the Caribbean Sea. Consequently, the habitat of this feline and other species could be reduced, leaving them isolated and susceptible to disappearing over time (Pérez-Irineo and Santos-Moreno 2015).

These first records of the ocelot therefore indicate the urgent need to implement conservation measures, which would help maintain the habitat of this feline and its prey. Similarly, continued research in this area is recommended to provide more biological and ecological information on ocelots and other large mammals in this important area.

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New records of hypopigmentation in two captive squirrel monkeys (*Saimiri* spp.) in Brazil and Colombia

Nuevos registros de hipopigmentación en dos monos ardilla (*Saimiri* spp.) en Brasil y Colombia

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Despite the increasing frequency of reports of primates with anomalous pigmentation in scientific literature, there is still a lack of knowledge about these disorders in many primate species. Here, we report two cases of hypopigmentation in squirrel monkeys (genus *Saimiri*) in Brazil and Colombia. We describe two cases of hypopigmentation in individuals that came to our attention opportunistically. The first individual had leucistic characteristics (completely depigmented pelage, but normally colored eyes) and was observed in Macapá, in the Brazilian Amazon. The other individual showed characteristics of albinism (depigmented pelage and eyes) and was recorded in Armenia, central Colombia. Neither individual showed agonism towards humans, likely being captive primates, which may have favored their survival into adulthood. Our records are the first with images and exact coordinates for species of the genus *Saimiri*. The relative lack of knowledge about hypopigmentation in animals highlights the need for more research focused on them. In this context, given that most primate species are diurnal and relatively easy to observe, studies on primates may help elucidate ecological aspects related to the fitness of hypopigmented individuals. Moreover, there appears to be a growing number of reports of primates from different species with these disorders, and our reports may contribute to increase the knowledge about hypopigmentation in wild animals.

Keywords: Albinism; Leucism; Melanin; Pigmentation disorders; *Saimiri* spp.

A pesar de la creciente frecuencia de registros de primates con pigmentación anómala en la literatura científica, todavía se conoce poco sobre estos trastornos en muchas especies. Aquí reportamos dos casos de hipopigmentación en monos ardilla (género *Saimiri*) en Brasil y Colombia. Describimos dos casos de hipopigmentación de individuos registrados de forma oportunista. El primer individuo presentó características de leucismo (pelaje completamente despigmentado, pero con los ojos de color normal) y fue observado en Macapá, en la Amazonia brasileña. El otro individuo presentaba características de albinismo (pelaje y ojos despigmentados) y fue registrado en Armenia, en el centro de Colombia. Ambos individuos mostraron una conducta no agonista hacia los humanos, por lo que, probablemente eran primates cautivos, lo que pudo haber favorecido su supervivencia hasta la edad adulta. Nuestros registros son los primeros que incluyen imágenes y coordenadas exactas de especies del género *Saimiri*. La escasez de conocimientos sobre la hipopigmentación en animales pone de manifiesto la necesidad de realizar investigaciones centradas en ellos. En este sentido, dado que la mayoría de las especies de primates son diurnas y relativamente fáciles de observar, los estudios futuros podrían ayudar a esclarecer aspectos ecológicos relacionados con la aptitud y el significado adaptativo de los individuos hipopigmentados. Además, parece que está aumentando el número de informes de primates de diferentes especies con estos trastornos y nuestros reportes pueden contribuir a una mejor comprensión de la hipopigmentación en animales salvajes.

Keywords: Albinismo; Leucismo; Melanina; Trastornos de pigmentación; *Saimiri* spp.

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The color of mammals is primarily related to the production of two types of melanin: eumelanin, which is responsible for colors ranging from brown to black, and pheomelanin, which produces red to yellow pigments ([Sugumaran and Berek 2016](#)). Abnormal changes in vertebrate coloration (e.g., hypopigmentation, anomalous pigmentation) are mainly caused by disturbances in the melanin biosynthesis, which affects pigment production, resulting in little or no pigmentation ([Mikheil et al. 2017](#); [Britton and Davidowitz 2023](#)).

In vertebrates, although there is no consensus on the terminology, there are four types of hypopigmentation: albinism, leucism, piebaldism and hypomelanism ([Abreu et al. 2013](#); [Lucati and López-Baucells 2016](#)). The most well-known condition is albinism, characterized by the complete loss of pigmentation in the skin, hair, feathers, and nails/claws. It also affects eye coloration, which may appear reddish or bluish, and can sometimes result in reduced visual acuity ([Miller 2005](#); [Grouw 2021](#)). Leucism, in contrast,

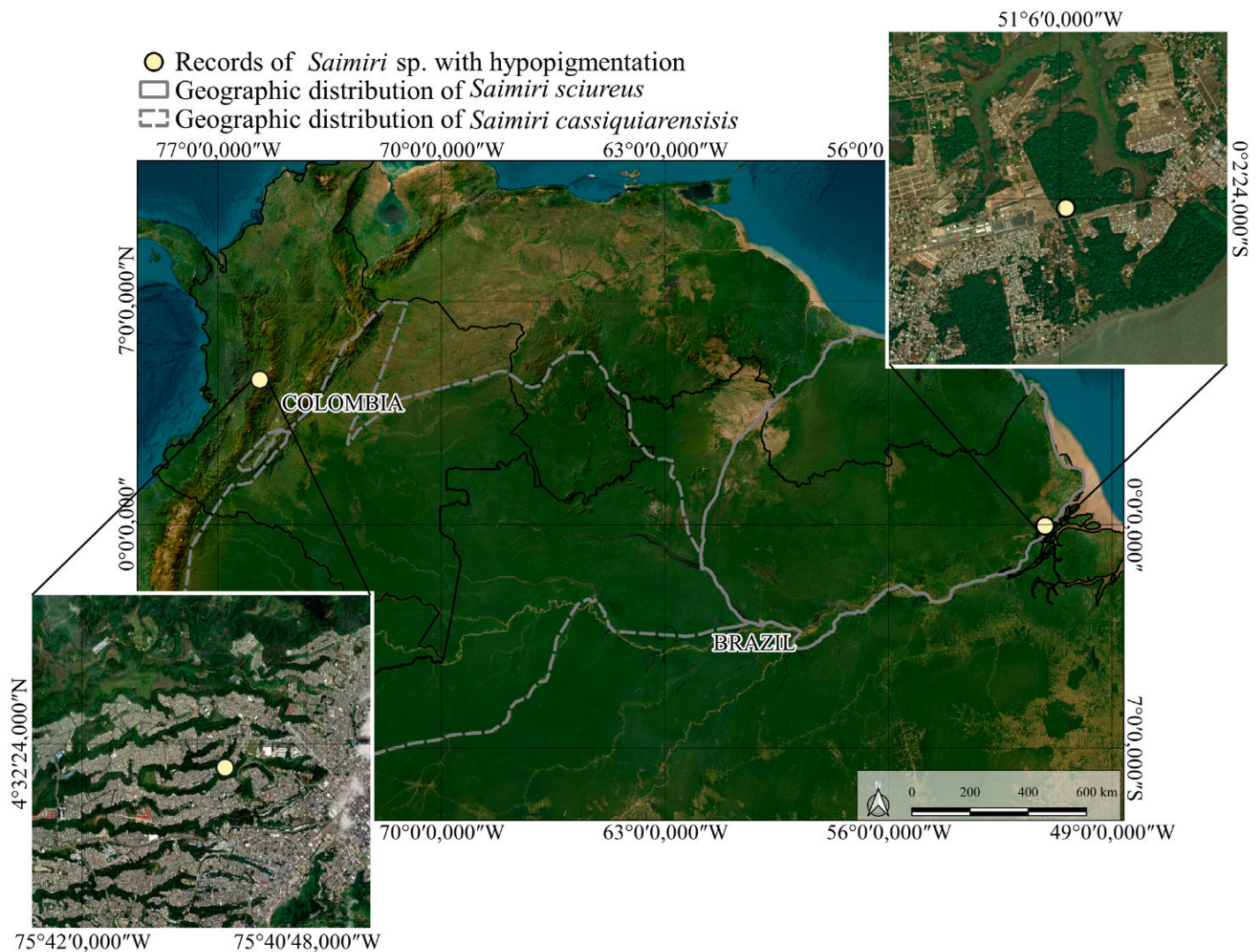


Figure 1. Map showing the location of the two records of *Saimiri* with abnormal pigmentation, and the geographic distribution of the two species possibly involved in these records: *Saimiri sciureus* (yellow - [Silva-Júnior et al. 2021](#)) and *Saimiri cassiquiarensis* (orange - [Paim et al. 2021](#)).

causes partial or complete loss of pigmentation in the skin and hair, but unlike albinism, it does not affect the eyes ([Miller 2005](#); [Abreu et al. 2013](#)). In contrast, piebaldism causes a reduction in melanin only in small areas of the body ([Fertl and Rosel 2008](#); [Abreu et al. 2013](#)). Finally, hypomelanism is characterized by beige, golden, yellowish or reddish, instead of whitish pigmentation ([Lucati and López-Baucells 2016](#)). Besides hypopigmentation disorders, there are also hyperpigmentation disorders, such as melanism and partial melanism ([Lucati and López-Baucells 2016](#)).

Hypopigmentation disorders have already been recorded in many species of Neotropical mammals ([Abreu et al. 2013](#)), including small flying mammals ([Lucati and López-Baucells 2016](#)), rodents, and marsupials ([García-Casimiro and Santos-Moreno 2020](#); [Vanstreels et al. 2021](#); [Barreto et al. 2023](#)), and large species such as deer ([Rodrigues et al. 1999](#); [Oliveira 2009](#)) and tapirs ([Tokuda et al. 2021](#); [Silva et al. 2022](#)). In the case of non-human primates, [Ramos-Luna et al. \(2022\)](#) reviewed cases of 44 individuals from nine species (*Alouatta palliata*, *Alouatta*

pigra, *Alouatta guariba clamitans*, *Ateles geoffroyi*, *Callithrix jacchus*, *Callithrix penicillata*, *Cebus imitator*, *Saimiri boliviensis*, *Sapajus apella*) and one hybrid (*Callithrix jacchus* x *Callithrix penicillata*) with anomalous pigmentation. In the same year (2022), five other cases were recorded for primates (*Alouatta palliata* - [Barros-Diaz et al. 2022](#); *Ateles chamek* - [Lange and Glynn 2022](#); *Callithrix jacchus* - [Leandro-Silva et al. 2022](#); *Aotus griseimembra* - [Montilla and Link 2022](#); *Leontocebus nigricollis graellsii* - [Tirira and Prado-Lita 2022](#)). Additionally, there are also unpublished cases, such as of a capuchin monkey (reported as *Sapajus libidinosus*) with leucistic characteristics was recorded on a citizen science website ([Biofaces 2017](#)), and a database of anomalous pigmentation in primates of Costa Rica (<https://www.flickr.com/photos/184305184@N02/>).

Despite the increasing frequency of reports of primates with anomalous pigmentation in scientific literature ([Ramos-Luna et al. 2022](#)), there are still only a few reports of anomalous pigmentation for many primate genera, including *Saimiri*. Here, we present two records of hypopigmentation in the



Figure 2. (a) Leucistic young male of *Saimiri sciureus* in captivity at the Wildlife Rehabilitation Center (CETAS/IBAMA) in Macapá, Amapá, Northern Brazil. Note the normal color of the eyes. (b) Albino individual of *Saimiri* sp., which was in a house in Armenia, Quindío, Central Colombia. Note the depigmented eyes. Photos: Aline E. O. de Souza and Sebastián O. Montilla.

genus *Saimiri*, involving captive individuals from distinct regions of South America (Figure 1).

We describe two cases of hypopigmentation in the genus *Saimiri* that came to our knowledge opportunistically. One of the records was made in the external area of the Public Veterinary Hospital of Macapá ($0^{\circ}02'27''S$ - $51^{\circ}05'58''W$ - Figure 1), in the city of Macapá, Amapá state, in the Northeastern Extreme of the Brazilian Amazon. This area is adjacent to a urban park (Bioparque da Amazonia), with roughly 60 ha of forest. The site is within the distribution of *Saimiri sciureus*, although it is not possible to confirm the species identification of an individual that does not present the typical color pattern of the species.

The second record was made in the city of Armenia, in the department of Quindío, central Colombia ($4^{\circ}32'16''N$ - $75^{\circ}41'13''W$ - Figure 1). This site is outside the normal distribution of the genus, being about 230 km away from the distribution limits of *Saimiri cassiquiarensis* (Paim et al. 2021 - Figure 1). Both hypopigmented individuals were photographed and the photos are available in a public repository (<https://doi.org/10.6084/m9.figshare.30604529.v1>).

A squirrel monkey individual (*Saimiri* sp.) with leucistic characteristics (i.e., completely depigmented skin and pelage, but normally colored eyes - Figure 2a) was recorded on May 30th, 2023, in the external area of the Public Veterinary Hospital of Macapá (see above). After being spotted by a local employee, the animal was retrieved by the park's biologist (Geraldo Otávio Biondi Filho) and transferred to the Wildlife Rehabilitation Center (CETAS/IBAMA) in Macapá, where it remains in captivity. According to the biologist, the

squirrel monkey showed signs of domestication, exhibiting neither aggression nor discomfort in the presence of humans. Therefore, it is likely that the animal had escaped from a property or had been abandoned in the area.

Another specimen of the genus (*Saimiri* sp.) was recorded by one of us (S.O.M.) on December 3, 2016, after the primate invaded a resident's house in the city of Armenia, Central Colombia. This individual showed characteristics of albinism, given that in addition to the depigmented skin and pelage, the eyes were also depigmented (Figure 2b). Similarly to the previous case, this squirrel monkey did not show agonistic or repulsive behaviors towards humans, likely indicating it was a captive primate. According to local residents, the animal may have escaped from a nearby house that harbored wild animals for trade. Once it was clear that it was a wild animal, a report was made to environmental authorities (Colombian Ministry of Environment and Sustainable Development and the Regional Autonomous Corporation of Quindío). However, before any rescue took place, the individual disappeared from the observation site.

Our records are the first with images and exact coordinates for species of the genus *Saimiri*. Although Ramos-Luna et al. (2022) reported a case of hypopigmentation in *Saimiri boliviensis* in Peru, it was described through an image posted on Facebook, not providing the image and the location of the occurrence. Thus, there are at least three hypopigmentation occurrences for the genus *Saimiri* in Brazil, Colombia and Peru.

Hypopigmentation disorders are relatively rare and most previous reports are based on opportunistic observations, which hampers formal testing of their causes. However,

some authors have proposed causes, such as exposure to chemical substances (e.g., sulfur - [Galván et al. 2018](#)), and inbreeding ([Prado-Martínez et al. 2013](#)). Reproduction among related individuals is often the result of population declines caused by habitat degradation and fragmentation ([Fortes and Bicca-Marques 2008](#); [Lange and Glynn 2022](#)). However, considering that we could not determine where the hypopigmented animals reported here were born, we cannot assess whether inbreeding may be a cause of the disorder, nor point other possible causes of these disorders.

Although we classified the anomalies of the two individuals reported here as leucism and albinism, genetic analysis is necessary for more precise classification. For example, a capuchin monkey (*Sapajus apella*), which could visually be classified as leucistic, was genetically identified as having oculocutaneous albinism ([Henriques et al. 2019](#)). However, the individual recorded in Colombia escaped from captivity, and it has not yet been possible to conduct genetic analysis of the individual recorded in Brazil.

The relative lack of knowledge about hypopigmentation in animals highlights the need for more research focused on these animals. In this regard, since most primate species are diurnal and more easily observed, primate studies may clarify ecological aspects related to the fitness of animals with hypopigmentation. Considering the relative rarity of hypopigmentation cases, citizen science platforms, such as iNaturalist (<https://www.inaturalist.org/>) and Biofaces (<https://www.biofaces.com/>), may have an important role in making more records available and increasing people's knowledge about hypopigmentation. Moreover, there appears to be a growing number of reports of primates from different species with these disorders, and our reports may contribute to a better understanding of the causes and consequences of these occurrences in wild animals.

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New bat (Mammalia: Chiroptera) records from Nicaragua: First records of *Pteronotus psilotis*, *Dermanura azteca* and *Uroderma davisii*

Nuevos registros de murciélagos (Mammalia: Chiroptera) en Nicaragua: Primer registro de *Pteronotus psilotis*, *Dermanura azteca* y *Uroderma davisii*

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Understanding species distributions is key for conservation and management, as well as necessary to examine their ecological associations. In recent decades, the increasing survey efforts across Nicaragua have expanded the known ranges of many Mesoamerican bat species. Here we aim to fill gaps in known distribution of bat species across their distribution in Nicaragua and Central America. We used single and triple high nets to capture bats in different vegetation formations across Nicaragua. We measured and identified each individual bat and compared their location to previously known localities available in international repositories. We provide the first record of *Pteronotus psilotis* (Dobson 1878), *Dermanura azteca* K. Andersen 1909, and *Uroderma davisii* R. J. Baker and McDaniel 1972. We also provide new records of *Centronycteris centralis* Thomas 1912, and *Artibeus inopinatus* Davis and Carter 1964. Our findings fill important gaps in the known distribution of the species. With our current additions, this elevates the number of bat species recorded in Nicaragua to 116. We recommend more capture and acoustic sampling efforts, specifically in areas near the north and southern borders of the country that have been historically underrepresented in surveys.

Key words: Aztec fruit-eating bat; Central America; *Centronycteris*; Davis's tent-making bat; *Dermanura*; Honduran fruit-eating bat; range extension.

El conocimiento de la distribución de las especies es primordial para la conservación, el manejo de las especies y para examinar sus asociaciones ecológicas. En las últimas décadas, el incremento de muestreo en Nicaragua ha permitido expandir el rango conocido de muchas especies de murciélagos. Aquí proveemos nuevos registros expandiendo el rango conocido de la distribución de murciélagos en Nicaragua y Centroamérica. Con el uso de redes de niebla, capturamos murciélagos en diferentes formaciones vegetativas en Nicaragua. Cada uno de los individuos fue procesado y comparamos sus localidades con otras previamente conocidas y disponibles en repositorios internacionales. Proveemos los primeros registros de *Pteronotus psilotis* (Dobson 1878), *Dermanura azteca* K. Andersen 1909 y *Uroderma davisii* R. J. Baker and McDaniel 1972 para Nicaragua. Adicionalmente, proveemos dos nuevas localidades para *Centronycteris centralis* Thomas 1912 y *Artibeus inopinatus* Davis and Carter 1964. Nuestros registros ayudan llenar vacíos en la distribución conocida de las especies. Estos registros elevan el número de especies de murciélagos en Nicaragua a 116. Recomendamos un mayor esfuerzo de muestreo con redes y acústica, en especial en las zonas fronterizas del país, las cuales han sido históricamente han sido subrepresentadas en los inventarios.

Palabras Clave: America Central; *Centronycteris*; *Dermanura*; extensión de rango; murciélago frutero azteca; murciélago frutero de Davis; murciélago frutero hondureño.

Nicaragua has faced many socio-economic challenges that have hindered the pace of scientific research in its territory ([Medina-Fitoria and Martínez-Fonseca 2019](#); [Martínez-Fonseca et al. 2024a](#)). However, increased collaboration, enhanced local capacity, and improved access to previously inaccessible regions have led to a more comprehensive documentation of the country's biodiversity ([Medina-Fitoria and Martínez-Fonseca 2019](#)).

Recent changes in taxonomy, driven by the combined use of morphological and genetic data, have elevated many bat subspecies to full species status ([Mantilla-Meluk 2014](#), [Pavan and Marroig 2016](#)). Despite recent surveys extending the known range of bat species into Nicaragua, ([Medina-Fitoria et al. 2015](#); [Loza et al. 2018](#); [Saldaña-Tapia et al. 2020](#)), the geographic boundaries for many other species are still unclear ([Baker and McDaniel 1972](#); [Arias-Aguilar and Ramos-Pereira 2022](#)). Here we present notable records from the country that both extend and fill gaps in the known distributions of five bat species, and include the first confirmed records for three species. This information highlights the need for more research and supports ongoing efforts to make specimens and genetic material from Nicaragua more accessible.

Our study areas are located in the Nicaraguan departments of Chinandega, Estelí, León, and Río San Juan (Figure 1). Sites in Rodeo Grande (Chinandega), Tolapa, El Sauce, and Nagarote (León), as well as San Juan de Limay (Estelí) are composed of lowland dry and arid forests with annual precipitations of ~1000 mm ([Holdridge 1967](#); [Martínez-Fonseca et al. 2024b](#)). Miraflor (Estelí) is dominated by premontane moist forests of broadleaf, pine (mostly *Pinus oocarpa*) and oaks (*Quercus* spp.), with ~2000 mm of annual precipitation ([Incer 1975](#)). Finally, Refugio Bartola (Río San Juan) contains lowland moist and wet forest with annual precipitation >4000 mm. Refugio Bartola was surrounded by a mix of pasture areas in the west and the Indio-Maíz Biosphere Reserve to the east ([Medina-Fitoria et al. 2015](#); [Martínez-Fonseca et al. 2024b](#)).

We captured bats using a combination of mist nets of different lengths (6-18 m; Avinet Research Supplies, NY, USA) set at ground and canopy level. Mist nets were set across natural flyways such as riverbeds, creeks, and forest openings, as well as cave entrances following [Kunz and Parsons \(2009\)](#). Nets were opened just before sunset and remained open for about 6 hours.

We placed bats individually in small fabric bags and then collected morphometric data to confirm identification. Measurements included forearm (FA), ear length (E), hind foot (HF) in millimeters using a wing ruler (Avinet Inc. USA) and mass in grams (Wt) using analog scales (PESOLA Präzisionswaagen AG, Switzerland). Ear length (E, mm), hind-foot (HF, mm), and notes on coloration were also recorded whenever needed. We recorded elevation and locality (WGS84) with a handheld Garmin InReach Mini 2 (Garmin Ltd. Schaffhausen, Switzerland).

We identified all bats in the field using field keys and species descriptions ([Reid 2009](#), [Medina-Fitoria 2014](#); [Mora 2017](#); [York et al. 2019](#)). Basic karyotypic analysis was conducted at the laboratories of the biology department at the Universidad Autónoma de Nicaragua for three samples of *Uroderma* spp., as this is the main technique to corroborate species ID ([Baker and McDaniel 1972](#)). Nomenclature and taxonomic arrangement were based on recent publications ([Bonaccorso 2019](#); [Wilson and Mittermeier 2019](#); [Martínez-Fonseca et al. 2020](#); [Ramírez-Fernández et al. 2023](#)). A full list of the other species and individuals captured at each sampling site is available in Table 1. We conducted all activities under permits from the Nicaraguan Ministerio de Ambiente y Recursos Naturales (DGPNB-090622-P2491-0, DGPNB-020824-P4496-0). We handled animals following the guidelines of the American Society of Mammalogists ([Sikes et al. 2016](#)) and approved by the Northern Arizona University Institutional Animal Care and Use Committee. Due to the lack of a natural history museum in Nicaragua where to deposit reference material and specimens, we obtained voucher numbers for each of the new records from the Photography Collection of the Universidad de San Carlos de Guatemala ([USAC 2025](#)) and the Portal de Biodiversidad de Guatemala (<https://biodiversidad.gt>). Vouchered photos of the collection are also available on the Global Biodiversity Information Facility platform ([GBIF.org](#)). We include a map with localities found in GBIF by using: "Species = XXXX", "Basis of record = Preserved specimens", "Location = Including coordinates" and "Country or Area = Nicaragua" ([GBIF.org 2024a, 2024b, 2025a, 2025b, 2025c](#)). Additional localities from [Martínez-Fonseca et al. \(2020\)](#).

Centronycteris centralis [Thomas 1912](#). On January 3, 2024, we captured a female individual (Figure 2a; USACF000020) in a mist net along a trail in Refugio Bartola, Río San Juan department (10°58'30.72"N, 84°19'38.28"W; 51 m). The captured individual was easily identifiable by its distinctive long and shaggy yellow fur, and pointy sickle-shaped ears ([Reid 2009](#); [Medina-Fitoria 2014](#)). It had a forearm length of 43 mm and a mass of 6 g and unlike other emballonurids in the area, lacked a pair of white longitudinal zig-zag lines on the back ([Reid 2009](#)). The uropatagium was very hairy at the base, and the wing membrane attached to the metacarpal-phalangeal joint of the toes, both of which are diagnostic characteristics ([Reid 2009](#); [Bonaccorso 2019](#)).

Pteronotus psilotis ([Dobson 1878](#)). On August 24, 2022, we captured an adult male individual (Figure 2b; USACF000021; FA 40.5 mm; Wt 6.5 g) on a mist net set over the San José River (12°50'32.28"N, 86°31'6.96"W; 177 m) near El Sauce, León department. On March 8, 2024, we captured a second adult male (FA: 42 mm; Wt: 8 g) on a mist net set over El Gallo riverbed in Rodeo Grande, Chinandega department (13° 8'38.76"N, 86°48'18.36"W; 123 m). A third individual was captured on March 11, 2024, an adult female (FA 41 mm; Wt 7 g) in a mine (La Grecia) in San Juan de Limay, Estelí department (13°11'13.56"N, 86°37'26.04"W; 276 m).

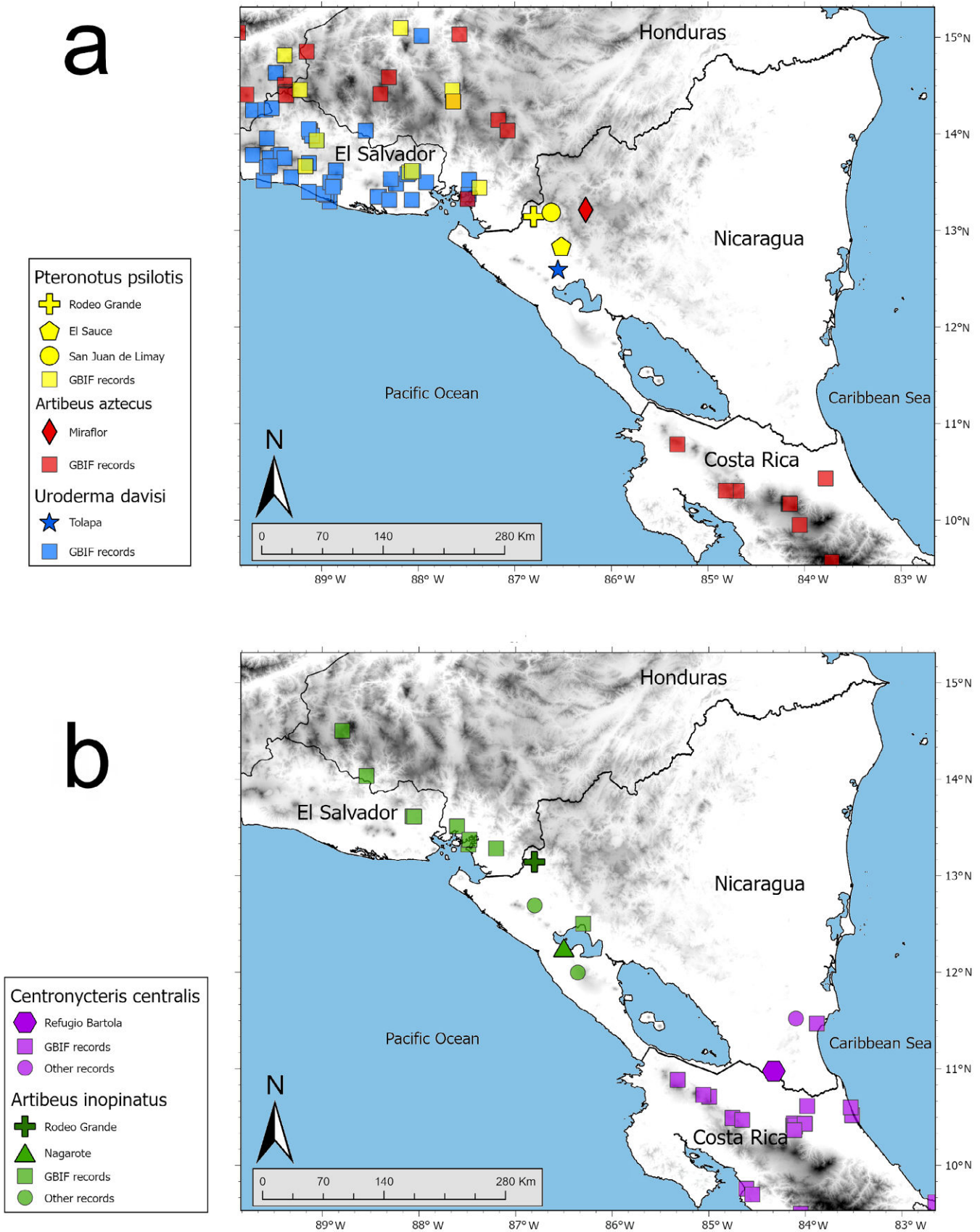


Figure 1. New bat localities in Nicaragua **a.** New localities for *Pteronotus psilotis* (Dobson 1878), *Dermanura azteca* K. Andersen 1909, and *Uroderma davis* R. J. Baker and McDaniel 1972 in Nicaragua. **b.** New localities within Nicaragua for *Centronycteris centralis* Thomas 1912 and *Artibeus inopinatus* Davis and Carter 1964. Reference occurrence localities outside Nicaragua are based on museum specimen data available on the Global Biodiversity Information Facility (GBIF.org). Other records within Nicaragua are based on Martínez-Fonseca et al. (2020).

Table 1. Total bat captures per species in new localities for *Centronycteris centralis* [Thomas 1912](#), *Pteronotus psilotis* ([Dobson 1878](#)), *Artibeus inopinatus* [Davis and Carter 1964](#), *Dermanura azteca* [K. Andersen 1909](#), and *Uroderma davisii* [R. J. Baker and McDaniel 1972](#) in Nicaragua. Sites correspond to the departments of Chinandega (Rodeo Grande), Estelí (San Juan de Limay -Mina La Grecia and Miraflores-Finca Beylla Vista), León (El Sauce, Nagarote, and Tolapa), Rio San Juan (Refugio Bartola). *Species with new localities. **Site was an abandoned mine, number of individuals shown here is only for captured individuals. Total number of individuals present was greater.

Species	Rodeo Grande	San Juan de Limay	Miraflores	El Sauce	Nagarote	Tolapa	Refugio Bartola
Emballonuridae							
<i>Centronycteris centralis</i> *							1
Noctilionidae							
<i>Noctilio albiventris</i>	4			5			
<i>Noctilio leporinus</i>				4			
Mormoopidae							
<i>Pteronotus gymnonotus</i>		4		2			
<i>Pteronotus mesoamericanus</i>		5					
<i>Pteronotus psilotis</i> *	1	1		1			
Phyllostomidae							
<i>Desmodus rotundus</i>	2	6					
<i>Diphylla ecaudata</i>		2					
<i>Lophostoma nicaraguae</i>						1	
<i>Macrophyllum macrophyllum</i>	1						
<i>Glossophaga commissarisi</i>						1	7
<i>Glossophaga leachii</i>						5	
<i>Glossophaga mutica</i>							
<i>Carollia castanea</i>							2
<i>Carollia perspicillata</i>	11	14			4	33	2
<i>Carollia sowelli</i>							3
<i>Carollia subrufa</i>						7	
<i>Artibeus jamaicensis</i>	24				6	18	
<i>Artibeus lituratus</i>	2					2	4
<i>Artibeus inopinatus</i> *	1				1		
<i>Artibeus intermedius</i>	2						1
<i>Dermanura azteca</i>			1				
<i>Dermanura toltecus</i>			2				
<i>Dermanura watsoni</i>	5			1		25	2
<i>Sturnira parvidens</i>	1					1	
<i>Uroderma convexum</i>	4			1		34	
<i>Uroderma davisii</i> *						1	
Molossidae							
<i>Molossus alvarezi</i>						1	
<i>Molossus molossus</i>	9						
<i>Molossus nigricans</i>				2			
Natalidae							
<i>Natalus mexicanus</i>		11					
Vespertilionidae							
<i>Rhogeessa bickhami</i>	1					2	
<i>Myotis nigricans</i>							1

All captured individuals were clearly identified based on having smaller forearm lengths (< 43 mm) compared to other hairy-backed *Pteronotus* species from Nicaragua. Forearm length for this species ranges from 40.8 to 45 mm, 55 to 63 mm for *P. mesoamericanus*, and 43 to 48 mm for *P. personatus* ([Reid 2009](#); [Pavan 2019](#)).

Artibeus inopinatus [Davis and Carter 1964](#). On February 2, 2018, we captured an adult male (Figure 3a;

USACF000024; FA 53mm; HF 15 mm; Wt 37 g) covered by yellow pollen which we presume came from Poro-poro trees (*Cochlospermum vitifolium*) which were blooming and abundant in the area. The site was in Nagarote, León department (12°16'4.44"N, 86°30'4.68"W; 85 m). On March 9, 2024, a second adult male individual (USACF000023; FA 50mm; Wt 31 g) was captured in Rodeo Grande, Department of Chinandega (13° 8'38.76"N, 86°48'18.36"W; 123 m).



Figure 2. New bat records of Emballonuridae and Mormoopidae from Nicaragua. **a.** *Centronycteris centralis* [Thomas 1912](#), USACF000020, from Refugio Bartola, Rio San Juan. **b.** *Pteronotus psilotis* ([Dobson 1878](#)), USACF000021, from El Sauce, León. Photos: Martínez-Fonseca JG.

Capture was on a mist net set over El Gallo riverbed (mostly dry at this time) and surrounded by lowland arid forest and cropland. *Artibeus inopinatus* is often confused with smaller *A. jamacensis* ([Turcios-Casco et al. 2020](#)). However, the captured individuals match the typical forearm length of *A. inopinatus* that ranges from 48 to 53 mm ([Reid 2009](#); [Medina-Fitoria 2014](#); [Solari et al. 2019](#)) and had faint facial stripes and evident hair fringes on the uropatagium. The only other species of *Artibeus* that have similar forearm sizes and occur in the area are *A. jamaicensis* (FA 55–67 mm), which lacks a hair fringe on the uropatagium, and *A. watsoni* and *A. phaeotis* (both with FA 35–41 mm); the latter two also have conspicuous facial stripes.

Dermanura azteca K. Andersen 1909. On July 16, 2016, we captured an adult male (Figure 3b; USACF000022) in Finca Beylla Vista in Mirafior, Estelí (13°15'5.04"N, 86°13'47.28"W; 1479 m). Our individual had a charcoal-brown body color, which is similar only to the similar sized *D. tolteca* and *Enchisthenes hartii* ([Reid 2009](#)). However, unlike *A. tolteca*, our individual had longer forearm (43 mm), greater mass

(29 g), longer dorsum fur, and a distinctively short but hairy tail membrane with long hairs (~5mm) along the edge ([Solari et al. 2019](#)). Unlike *E. hartii*, the captured individual had larger forearms, had unfused upper lip with nose leaf, and lacked the "dirty whitish" facial stripes ([Reid 2009](#)).

Uroderma davisii [R. J. Baker and McDaniel 1972](#). On March 8, 2024, an adult male (Figure 3c; USACF000025; FA 40 mm, E 16 mm, HF 11 mm, Wt 14 g) was captured in Tolapa, León department (12°35'58.56"N, 86°33'6.84"W; 87 m). The captured individual of *U. davisii* is distinguished from *U. magnirostrum* by the presence of well-marked facial stripes, which are faint or indistinguishable in the latter ([Reid 2009](#); [Solari et al. 2019](#)). Unlike *U. davisii* and *U. convexum*, *U. magnirostrum* can also be distinguished by its deep rostrum, which forms a continuation of the forehead, creating a "gradual, nearly straight-line slope between the crown and tip of snout" ([Solari et al. 2019](#)). Karyotype analysis of the individual of *U. davisii* is consistent with the original descriptions of the holotypes (48 fundamental arms in autosomal complement and 44 diploid) by [Baker](#)



Figure 3. New records of Stenodermatinae from Nicaragua. **a.** *Artibeus inopinatus* Davis and Carter 1964, USACF000024 from Nagarote, León (covered in yellow pollen). **b.** *Dermanura azteca* K. Andersen, 1909, USACF000022 from Miraflores, Estelí. **c.** *Uroderma davisii* R. J. Baker and McDaniel 1972, USACF000025 from Tolapa, León. Photos: Aguirre-Obando YS (A-B); Martínez-Fonseca JG (C).

and McDaniel (1972) and differs from that of *U. convexum* (44 fundamental and 38 diploid). Two individuals of *U. convexum* from the same locality were also confirmed to have the expected chromosomal structure. *Uroderma davisii* can be further distinguished from the superficially similar *U. convexum* by the relatively concave, short rostrum and less prominent forehead (Mora 2017). Additionally, only the base of the tragus and ears are tinted yellow, whereas those of *U. convexum* are “prominently edged with yellow or white” and much more evident (Reid 2009). *Uroderma davisii* also averages smaller forearm lengths (40–43 mm) than *U. convexum* (40–46 mm; Baker and McDaniel 1972; Solari et al. 2019). The individual of *U. davisii* was browner in color than the other *U. convexum* of the same locality.

Our fieldwork yielded novel records for five bat species in Nicaragua that help fill important gaps in the known distribution of the species in Central America. For *C. centralis*, this represents the fourth confirmed locality for the country (Martínez-Fonseca et al. 2020). The current records of *P. psilotis* represent the first confirmed localities for the species in Nicaragua close to the Honduras-Nicaragua border (8–50 km) and confirms a contact zone between *P. personatus* and *P. psilotis* (Martínez-Fonseca et al. 2020; Arias-Aguilar and Ramos-Pereira 2022). Although *D. azteca* has been listed as expected to occur in the highlands of the country (Medina-Fitoria and Saldaña-Tapia 2012; Medina-Fitoria 2014; Martínez-Fonseca et al. 2020), our record represents the first official record between Honduras and Costa Rica.

The record for *U. davisii* in Nicaragua expands the distribution of the species southwards ca. 128 km from

the closest record in Honduras (GBIF.org 2024b). *Uroderma davisii* has been listed as expected to occur in the lowlands of the Pacific of Nicaragua by several authors (see Medina-Fitoria 2014; Martínez-Fonseca et al. 2020) with a zone of sympatry with *U. convexum* suggested across El Salvador, Honduras, and Nicaragua (Baker and McDaniel 1972). Hybridization between the two species may also occur in this region (Barton 1982; Mantilla-Meluk 2014). Finally, both of our records of *A. inopinatus* represent new localities between previous Nicaraguan records and the recent locality from northern Costa Rica (Artavia Durán et al. 2023).

With the recent additions of *P. fulvus* (see Medina-Fitoria et al. 2020; Méndez-Rodríguez et al. 2021; Martínez-Fonseca et al. 2022) and the validity of *A. intermedius* as a species separate from *A. lituratus* (Perea-Martínez et al. 2013; Hedrick 2021; López-Cuamatzi et al. 2024) our records elevate the number of bat species in Nicaragua to 116. Our work contributes to the knowledge of *D. azteca* which is catalogued by International Union for Conservation of Nature (IUCN) as Least Concern (Solari 2016), and the Data Deficient *A. inopinatus* (Reid and Medina 2016). Currently, IUCN assessment for *C. centralis* (Arroyo-Cabrales et al. 2015), *P. psilotis* (Davalos et al. 2016), and *U. davisii* (Solari 2019) do not reflect the recent taxonomic splits.

Our findings highlight the outstanding biodiversity of Nicaragua and the need for additional sampling efforts in areas that historically have not been the focus of research. Currently, at least an additional 9 bat species are likely to be recorded in the country based solely on proximity to the Nicaraguan borders of Honduras, Costa Rica, or both

countries (Mora 2012; Martínez-Fonseca *et al.* 2020). The advances and ever-changing taxonomy and nomenclature based on genetic, morphological, and behavioral evidence of neotropical bats might continue to increase the number of bat species in Nicaragua and the rest of Central America.

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An unusual ocelot–opossum co-occurrence in the Chiquitano dry forest, Bolivia

Coocurrencia inusual entre Ocelote y Zarigüeya en el Bosque Seco Chiquitano, Bolivia

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Interspecific interactions among carnivores and their prey are rarely documented beyond classical predation or competition events. Recently, camera traps revealed an unusual spatial and temporal co-occurrence between ocelot (*Leopardus pardalis*) and common opossum (*Didelphis marsupialis*) in the Amazonian forest of Perú. Here, we report the first record of this co-occurrence in the Chiquitano dry forest of Bolivia, extending the known ecological context of this observation beyond the Amazonian ecosystem. The record was obtained as part of a long-term camera trap monitoring project carried out since 2017 in the Chiquitano dry forest. The project has 25 stations and spans across 23,025 ha, operating continuously, independent detections were defined using 60-minute intervals. On June 23rd, 2024, one camera trap station recorded the only co-occurrence between an ocelot and a common opossum detected among around 700 independent records of both species. This rare record highlights an unusual spatial and temporal co-occurrence between an ocelot and a common opossum and highlights the importance of long-term camera trap monitoring for documenting uncommon natural history events. Further studies are needed to determine how often and under what conditions such interactions occur and in which ecosystems. This record documents for the first time a spatial and temporal co-occurrence between an ocelot and a common opossum in the Chiquitano dry forest of Bolivia, extending the geographic range of previous reports from the Peruvian Amazon.

Key words: Interspecific interactions, Monitoring, Ethology, Camera Trap, Predator-Prey interactions

Las interacciones interespecíficas entre carnívoros y sus presas rara vez son documentadas más allá de los eventos clásicos de depredación o competencia. Recientemente, el uso de cámaras trampa reveló la coocurrencia espacial y temporal inusual entre el ocelote (*Leopardus pardalis*) y la zarigüeya común (*Didelphis marsupialis*) en la Amazonía del Perú. En este estudio, reportamos el primer registro de esta coocurrencia en el Bosque Seco Chiquitano de Bolivia, ampliando el contexto ecológico conocido de esta observación más allá del ecosistema amazónico. El registro se obtuvo como parte de un proyecto de monitoreo a largo plazo con cámaras trampa realizado desde el 2017 en el bosque seco chiquitano. El proyecto cuenta con 25 estaciones distribuidas en 23,025 ha, operando continuamente. Las detecciones independientes se definieron usando intervalos de 60 minutos. El 23 de junio de 2024, una cámara trampa registró la única co-ocurrencia entre un ocelote y una zarigüeya común entre 703 registros independientes de ambas especies. Este registro poco común destaca una coocurrencia espacial y temporal inusual entre un ocelote y una zarigüeya común, y resalta la importancia de los monitoreos a largo plazo mediante cámaras trampa para documentar eventos poco frecuentes de historia natural. Se requieren estudios adicionales para determinar con qué frecuencia y bajo qué condiciones ocurren estas coocurrencias, así como en qué ecosistemas. Este registro documenta por primera vez un co-ocurrencia espacial y temporal entre un ocelote y una zarigüeya en el bosque seco Chiquitano de Bolivia, ampliando el alcance geográfico de reportes previos en la Amazonía peruana.

Palabras clave: Interacciones interespecíficas, Monitoreo, Etología, Camaras trampa, Interacciones Predador-Presa

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Interspecific interactions in wildlife that do not result in direct predation or competition remain understudied despite the extensive literature on predator-prey relationships (Smith *et al.* 2020). However, the growing use of non-invasive camera traps in mammal studies

has significantly enhanced the ability of researchers to collect data from wildlife interactions that are difficult to observe directly (Smith *et al.* 2020). Especially related to Neotropical felids, which are typically elusive, cryptic and typically solitary (Castello 2020).

Among Neotropical felids, the ocelot (*Leopardus pardalis*) is one of the most common felid species in tropical and subtropical habitats (Paviolo et al. 2015). Its range extends from southern Texas in the United States through Mexico and Central America to northern Argentina (Magalhães and Srbek-Araujo 2022) and occupies a wide variety of ecosystems, including tropical forests, savannas, and shrublands (Paviolo et al. 2015). Although numerous ecological studies exist (e.g. Massara et al. 2016; Flores-Martínez et al. 2022), research on interspecific interactions between ocelots and other mammals has primarily focused on their role as predators. For example, ocelots have been recorded preying on agoutis (Aliaga-Rossel et al. 2006), bats and amphibians, and exhibiting hunting strategies such as stalking and ambushing prey (Macas-Pogo et al. 2023). In addition to their role as predators, competitive interactions with other carnivores, such as foxes have also been documented (Bolze et al. 2019). Notably, most of these insights into both predatory and competitive behaviour have largely relied on data from camera traps.

Rare and less conventional interspecific associations involving ocelots and other mammals are beginning to be documented. Recently, an unusual interspecific interaction was recorded using camera traps, where a single ocelot and a common opossum (*Didelphis marsupialis*) were observed moving in proximity across multiple independent records (Camerlenghi et al. 2025). However, this interaction has so far only been reported in the lowland Amazonian forest of Peru, and its broader occurrence across other ecosystems remains unknown.

The common opossum, involved in this observed association with ocelots, is one of the most widespread marsupial species in the Neotropics, ranging from Mexico to Bolivia and demonstrates a high tolerance for habitat modification (Astúa et al. 2021). Ecologically, it is an omnivorous, generalist and opportunistic forager with a broad dietary spectrum that includes insects, small vertebrates, fruit, and carrion (Cruz-Salazar et al. 2016). Beyond the documented interaction between the common opossum and the ocelot (Camerlenghi et al. 2025), the extent and nature of such associations are still under investigation.

Here, we expand upon these sparse observations by documenting for the first time in the ecosystem of the Chiquitano dry forest, an unusual spatial and temporal co-occurrence between an ocelot and a common opossum, in which no defensive behaviors were observed. This record expands the known geographic range of this unusual co-occurrence beyond the Amazonian forest and raises the possibility for broader behavioural associations between the two species.

The observation was made in the Chiquitano dry forest, an endangered ecoregion located in eastern Bolivia's Precambrian Shield, representing a transitional zone between moist and dry forest ecosystems (Jansen et al.

2020). Situated at an altitude of approximately 500 m above sea level, the region experiences a mean daily temperature of ~24.4 °C and an annual precipitation of approximately 1,200 mm (Killen et al. 2006).

Each year, this ecosystem faces increasing threats from uncontrolled fires and land-use conversion driven by agro-industrial expansion (Meißner et al. 2024), making it one of the most threatened ecosystems in the Neotropics. Despite these pressures, the Chiquitano dry forest the ocelot shares its habitat with other sympatric felids, including the jaguar (*Panthera onca*), puma (*Puma concolor*), margay (*Leopardus wiedii*), jaguarundi (*Herpailurus yagouaroundi*), pantanal cat (*Leopardus braccatus*), and Geoffroy's cat (*Leopardus geoffroyi*) (Nogales-Ascarrunz et al. 2024).

Camera trapping was conducted at the Centro de Investigaciones Ecológicas Chiquitos (CIEC) (Figure 1), where a long-term biomonitoring project was initiated in 2017. Initially comprising 13 camera trap stations and expanded in 2023 to 25 stations, covering approximately 23,025 hectares (Jansen et al. 2024). The stations were spaced at intervals of roughly 3 km² to maximize spatial independence; each station was equipped with paired camera traps (Meißner et al. 2024). Cameras were programmed to operate 24 hours per day with motion-trigger mode enabled and minimal lag between successive triggers. The dataset analyzed here spans from March 2017 to June 2025.

For data analysis, we applied a 60-minute camera trap interval to define independent detections (Smith et al. 2023). The lunar moon phase of the register was classified using the *lunar.phase* function in the *lunar* package in R (Lazaridis 2022). To evaluate temporal overlap between the species, the detection times were converted to decimal hours and used to estimate kernel density activity patterns over a 24-hour cycle. Temporal overlap was quantified using the coefficient of overlap (Δ ; Ross et al. 2013), within 95 % confidence intervals obtained via bootstrap resampling (1,000 iterations). Analyses were conducted in R, and activity patterns were visualised using circular kernel density plots with the *overlap* (Meredith et al. 2023) and *circular* (Agostinelli and Lund 2017) packages. Activity patterns were visualised using circular kernel density plots.

Across the entire sampling period, the cameras recorded 471 independent detections of ocelots (1000 images) and 232 of common opossum (561 images). On 23rd June 2024, at 00:21:34 hr, during the waxing gibbous lunar phase, a camera trap (model: Reconyx XR6 UltraFire; coordinates: 16°22'48" S, 62°02'07" W) captured the unusual event of an ocelot and a common opossum walking one after the other (Figure 2). Although slightly blurred, the opossum is identified as *D. marsupialis* based on diagnostic features, including the body shape, the coloration of its limbs and ears, which distinguish it from the similar-looking *D. albiventris* (Rocha and Rumiz 2019). This station is located at a rocky cascade that forms small natural pools, frequently used by

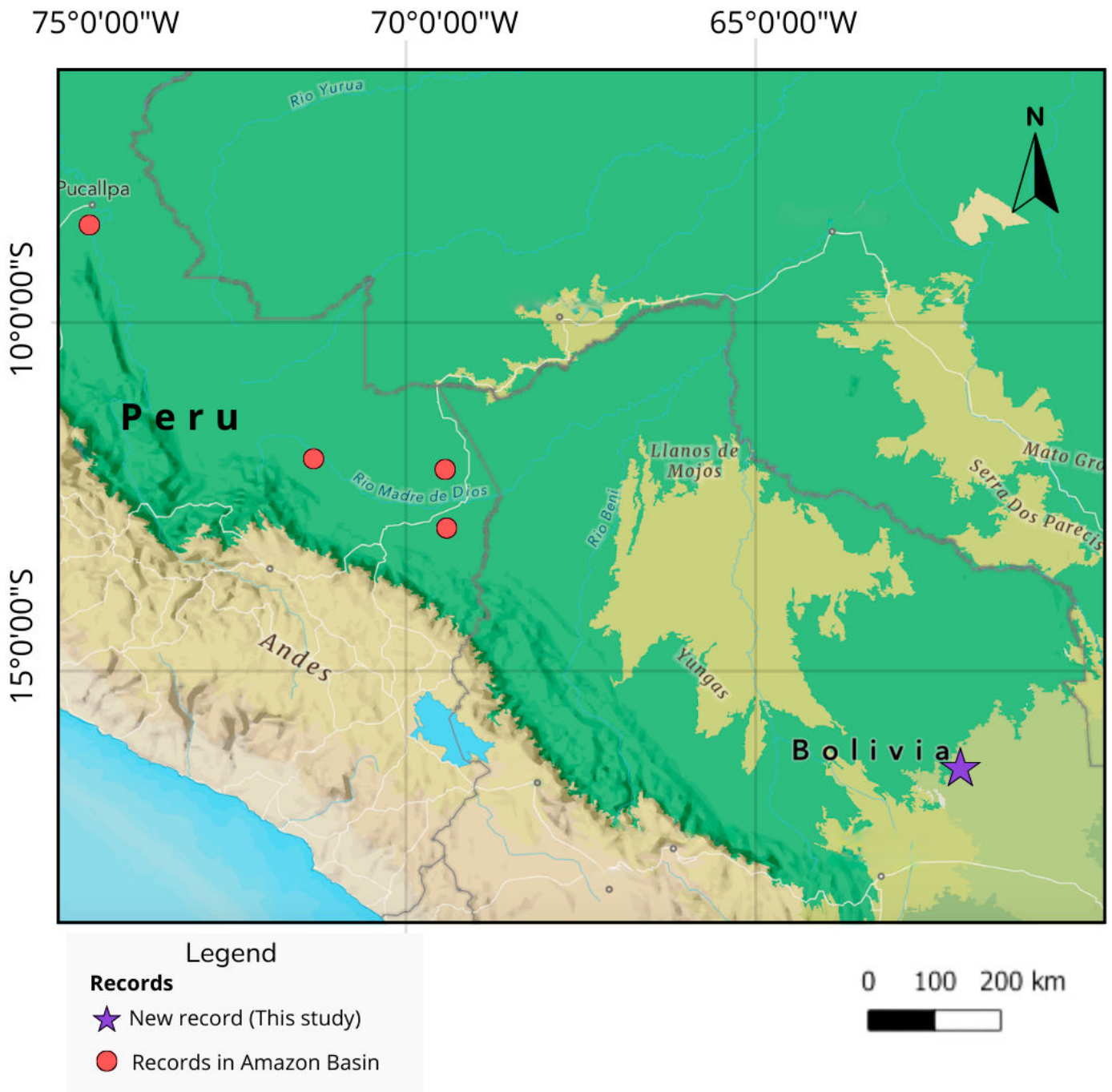


Figure 1. Geographic distribution of documented records of reported non-aggressive interactions between ocelots and common opossums in the Amazon (red dots; [Camerlenghi et al. 2025](#)), and the new camera-trap record reported here from the Chiquitano dry forest.

wildlife as water sources, resting areas, or shelter, which may have contributed to the likelihood of such an encounter. A visual screening of the entire camera-trap dataset did not reveal any additional records of simultaneous co-occurrence between the species, indicating that this event represents a rare observation within the study period.

Interestingly, the opossum did not exhibit typical defensive behaviors, such as freezing, open-mouth display, or erratic flight as described for this species ([McManus 1970](#)). Similarly, the ocelot does not display clearly identifiable predatory postures, such as crouching

or stalking, in this single frame ([Stanton et al. 2015](#); [Macas-Pogo et al. 2023](#)). Both individuals are documented in close spatial proximity, with no evident aggressive or defensive behaviors visible (Figure 2).

Beyond the single co-occurrence event, temporal activity analyses revealed a high degree of nocturnal overlap between ocelots and common opossums across the entire monitoring period (Figure 3). Both species showed a nocturnal activity, with peak activity occurring during the night. The estimated coefficient of temporal overlap was high ($\Delta = 0.77$; 95 % CI: 0.74-0.80), indicating



Figure 2. Camera trap image of the ocelot and the common opossum moving together in the Chiquitano dry forest.

substantial overlap in daily activity patterns. Despite this overall temporal overlap, only one instance of close spatial and temporal co-occurrence was detected, suggesting that simultaneous presence does not commonly translate into observable close encounters.

This record of an unusual ocelot-opossum co-occurrence, in which no clear aggressive or defensive behaviors were observed, not only extends the known geographic range of the ocelot-opossum association but also highlights their apparent rarity across a large data set. Despite over 703 independent detections of both species in the study area, only a single co-occurrence was recorded. This scarcity underscores the ecological rarity of such associations. While previous documentation is limited to the Amazonian forest (Camerlenghi et al. 2025), our record from a different ecosystem, such as the Chiquitano dry forest, extends the geographic context of this interaction.

Our observation took place in the waxing gibbous phase of the moon, which coincides with three out of the four Amazonian records (Camerlenghi et al. 2025). Lunar phases have a potential influence on the nocturnal activity patterns on carnivores (Patras-Santiago et al. 2017), and in the case of the ocelot, activity may decrease during full moons, likely due to a reduction in the activity of their primary prey species, which are often moon-phobic (Botts et al. 2020). The repeated occurrence of such non-aggressive encounters during similar lunar phases suggests a possible pattern worth further investigation in ways that were previously overlooked.

Temporal activity analyses indicate that ocelots and common opossums exhibit substantial nocturnal overlap in the study area. Temporal overlap, as quantified by the coefficient Δ , reflects similarity in activity patterns but does not imply direct interaction between species (Ross et al. 2013). Although overlapping activities schedules may increase opportunities for spatial coincidence, the extreme rarity of close co-occurrence observed in this study suggests that temporal overlap alone is insufficient to explain the reported event. A complementary explanation is site-based convergence, the camera trap station is located at a rocky cascade that forms small natural pools, frequently used by wildlife as water sources, resting areas, or shelter. Such locations can act as ecological attractors, concentrating species with overlapping habitat preferences regardless of trophic role. Under such circumstances, neutral coexistence may be favored over antagonism, especially if neither species perceives immediate threat or competition. However, the multiple encounters reported by Camerlenghi et al. (2025) may indicate that these encounters are not entirely random.

An additional, though still speculative, aspect that could explain the observed opossum behavior involves parasite-mediated manipulation. *Toxoplasma gondii*, a protozoan parasite, is known to reduce fear responses in its rodent hosts (Yai et al. 2003), potentially making them more susceptible to predation. Although the role of *T. gondii* in influencing the behavior of marsupials like the common opossum is less studied, previous studies have reported

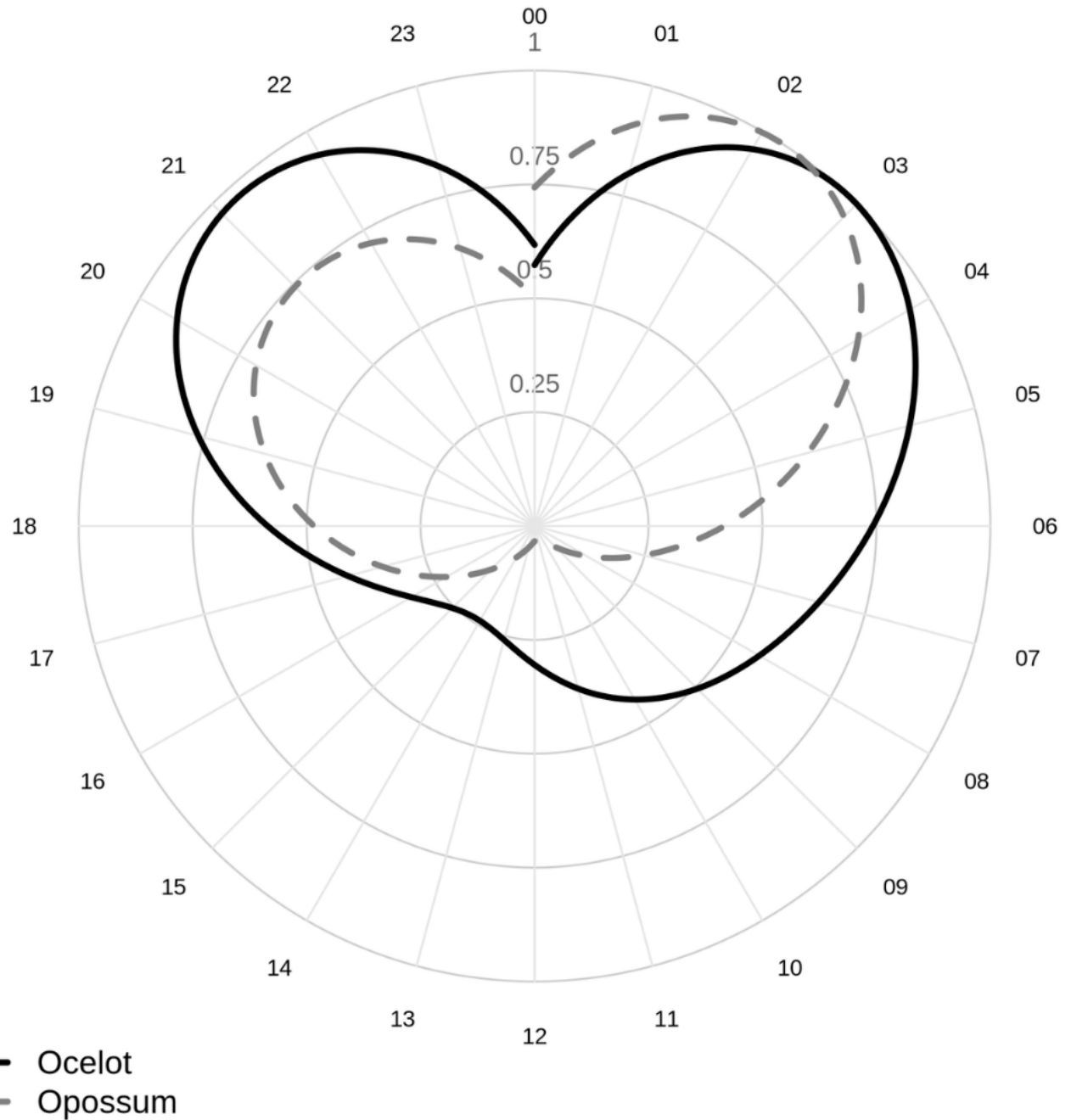


Figure 3. Circular kernel density estimates of daily activity patterns for ocelots (solid black line) and common opossums (dashed grey line) based on camera trap detections. Angles represent time day (00–23 h), and radial distance indicate relative activity intensity.

that opossums can serve as hosts for this parasite (Bezerra-santos *et al.* 2020; Cañon Franco *et al.* 2013; Sanchez-Cordero *et al.* 2024). The possibility that *T. gondii* could influence the opossum’s behavior in ways that make it more susceptible to interactions with ocelots merits further exploration. However, this hypothesis does not explain the lack of predatory intent from the ocelot, and the mechanism driving these non-predatory interactions remains unclear.

Interpretation of this record is inherently constrained by its single-image nature. While body posture and relative distance hint that behavioural flexibility and context-

dependent tolerance may occur between this species. For now, this finding should be viewed as an addition to the observations reported in the Amazonian forest of Perú. Future studies incorporating individual tracking and a broader set of environmental covariates will be essential to confirm and better characterise such interspecific interactions. Moreover, assessing their occurrence across other ecosystems and determining whether similar associations can involve different small felid species will provide critical insights into the ecological significance of these rare events.

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Morphological description of the lingual surface of *Platyrrhinus infuscus* under scanning electron microscopy (SEM)

Descripción morfológica de la superficie lingual de *Platyrrhinus infuscus* mediante microscopía electrónica de barrido (MEB)

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La morfología lingual en murciélagos constituye una estructura clave vinculada a sus hábitos alimentarios, aunque en varias especies neotropicales sigue siendo poco explorada. En este trabajo se describe la superficie lingual de *Platyrrhinus infuscus* mediante el uso de Microscopía Electrónica de Barrido (MEB). Se analizó tejido proveniente de un ejemplar depositado en la colección del Museo de Historia Natural de la Universidad Distrital Francisco José de Caldas (MHNUD). Las papilas fueron clasificadas siguiendo las categorías generales descritas en la literatura: circunvaladas, fungiformes, cónicas y filiformes. Se reconocen once tipos de papilas: circunvaladas; fungiformes con morfología triangular, circular y en cúspide; cónicas; filiformes; gigantes tricúspides y bicúspides; córneas; filiformes estrictas; digitiformes y bífidas. Las papilas de la región de raíz mostraron orientación lateral, mientras que en el ápice se dispusieron hacia la región medial de la lengua. La disposición topográfica de las papilas refleja el trayecto del alimento: las estructuras del ápice facilitan la fijación de frutos carnosos durante el vuelo, mientras que las papilas queratinizadas favorecen la retención y deglución. La zona posterior, dominada por papilas circunvaladas y fungiformes, estaría asociada a una mayor percepción sensorial. Los patrones observados refuerzan la relación de *P. infuscus* con una dieta frugívora e insectívora, aportando elementos funcionales de interés para investigaciones ecológicas y taxonómicas en murciélagos neotropicales.

Palabras clave: Chiroptera; Microscopía Electrónica de Barrido; morfología lingual; papilas; Phyllostomidae.

Lingual morphology in bats represents a key structure linked to their feeding habits, although it remains poorly explored in several Neotropical species. This study describes the tongue surface of *Platyrrhinus infuscus* using Scanning Electron Microscopy (SEM). Tissue from a specimen deposited in the collection of the Museo de Historia Natural de la Universidad Distrital Francisco José de Caldas (MHNUD) was analyzed. The papillae were classified according to the general categories described in the literature: circumvallate, fungiform, conical, and filiform. Eleven types of papillae were identified: circumvallate; fungiform with triangular, circular, and cusp-shaped morphologies; conical; filiform; giant tricuspid and bicuspid; horny; strictly filiform; digitiform; and bifid. Papillae in the root region showed lateral orientation, while those at the apex were directed toward the medial region of the tongue. The topographic arrangement of the papillae reflects the food trajectory: structures at the apex facilitate the fixation of fleshy fruits during flight, whereas keratinized papillae promote retention and swallowing. The posterior zone, dominated by circumvallate and fungiform papillae, appears to be associated with enhanced sensory perception. The observed patterns reinforce the association of *P. infuscus* with a frugivorous and insectivorous diet, providing functional evidence of interest for ecological and taxonomic studies of Neotropical bats.

Key words: Chiroptera; lingual morphology; papillae; Phyllostomidae; Scanning Electron Microscopy.

Chiroptera is one of the most diverse mammalian orders in Colombia, with 222 recognized species exhibiting a broad range of trophic niches, including a wide variety of food items such as small mammals, birds, amphibians, reptiles, insects, fish, blood, fruits, pollen, and nectar (Calonge 2009; Cerón-Hernández et al. 2022; Ramírez-Chaves et al. 2024). A fundamental aspect of mammalian evolution is related to feeding mechanisms (Dumont et al. 2012; Iwasaki 2022). For bats, the correlation between functional aspects of the skull, teeth and tongue with the different trophic guilds of the group has been extensively evaluated (Hill and Smith 1984; Fleming and Muchhala 2008; Dumont et al. 2012; González-Terrazas et al. 2012).

Anatomically, the tongue is a muscle that is one of the organs related to feeding and its importance in lingual echolocation has even been evaluated in bats of the genus *Rousettus* (Roberts 1975; Harper et al. 2013; Attaallah et al. 2023; Lee et al. 2017; Weinberg et al. 2023). In addition, the tongue plays a key role in both sensory and mechanical functions, since mechanical and taste buds constitute part of its surface epithelium. Several studies have demonstrated that the distribution of different types of papillae on the lingual surface varies between species and among individuals of the same species (Abumandour and El-Bakary 2013; Gregorin and Zanatta 2021). On the other hand, it has been suggested that the tongue of bats, being an organ with specialized patterns and microstructures that provide greater efficiency in food consumption, shows a close correlation between its morphology and diet, and even with phylogeny (Sonntag 1926; Doran 1975; Trzcielińska-Lorych et al. 2009; Abumandour and El-Bakary 2013). However, lingual morphology as a character related to trophic specialization remains an underexplored field.

The few studies conducted in the Neotropics have focused on the following families: Phyllostomidae, Molossidae, Noctilionidae (Gregorin 2003; Masuko et al. 2007), as well as Emballonuridae, Furipteridae, Thyropteridae, Mormoopidae, Natalidae and Vespertilionidae (Gregorin and Zanatta 2021). These investigations have enabled the evaluation of lingual anatomy as a morphological, diagnostic and phylogenetic reference (Birt et al. 1997; Elizalde-Arellano et al. 2004a). However, no such studies have been carried out in Colombia, despite its potential relevance for ecology, taxonomy, and physiology.

Platyrrhinus infuscus is a species of the family Phyllostomidae that is widely distributed in Colombia, Brazil, Bolivia, Ecuador, and Peru, mainly at medium and high elevation (Gardner 2008). Despite its wide distribution, the available information on its feeding ecology remains scarce. It is recognized as a predominantly frugivorous species, with records of consumption from Moraceae (*Ficus* spp.) and Solanaceae, as well as occasional insectivorous and nectarivorous habits (Rojas et al. 2011; Arias and Pacheco 2019). Nevertheless, current knowledge highlights notable gaps when compared

with other widely studied Neotropical frugivores, such as *Artibeus lituratus* or *Carollia perspicillata* (Estrada-Villegas et al. 2019), which hinders accurate assessments of its ecological role in forest dynamics.

This study of *P. infuscus* is significant because it combines dietary and morphological characteristics that differentiate it from other sympatric frugivores. Its association with *Ficus* spp. fruits, a key resource due to their year-round availability in the tropics (Shanahan et al. 2001), indicates an important role in seed dispersal and, consequently, in the regeneration of degraded forests. Likewise, the specialized tongue morphology, with the presence and arrangement of papillae adapted to fruit processing, represents a functional trait directly linked to its feeding ecology. Considering that tongue morphology in frugivorous bats has been associated with the ability to manipulate and exploit different types of fruit (Winter and von Helversen 2003), this study—being the first conducted in Colombia—provides a detailed description of the tongue surface of *P. infuscus* through the analysis of images obtained by scanning electron microscopy (SEM). Not only does it fill a gap in the literature at the morphological level, but it also contributes to morphological, taxonomic, ecological, physiological, and phylogenetic studies of *P. infuscus*.

The sample under study was obtained from a specimen of *Platyrrhinus infuscus* that is part of the collection of the Museo de Historia Natural de la Universidad Distrital Francisco José de Caldas (MHNUD) (Rodríguez-Bolaños 2020), catalogued under the code MUD-DOC M18. The specimen was previously identified through comparison with other specimens in the collection and by applying the taxonomic keys of Díaz et al. (2021) for Neotropical bats.

The tongue was dissected from the individual by taking as reference the origin of the trachea and performing an incision at the thoracic level over, above the sternum. The cut followed the midline of the abdomen down to the lower left quadrant and then extended to the right, forming a triangle. To ensure complete exposure and visibility of the internal organs, an incision was made at the basal part of the trachea, along with small cuts in the buccopharyngeal muscles that support the tissue. Once the organ was extracted, it was rehydrated through successive washes with distilled water. The sample was stored in a 1.5 ml Eppendorf tube with 90% alcohol for its subsequent analysis, and once the analysis was completed, it was returned to the scientific collection of the MHNUD, as part of the specimen.

In the initial analysis, the general aspects of the morphology of the lingual surface were described using stereoscopic observation (Zeiss) and quantitative data were recorded with a conventional caliper. Microscopic photomicrographs were obtained at the Testing and Assay Laboratory of the Pontificia Universidad Javeriana in Bogotá, the tongue was subjected to critical point drying for 90 minutes and then coated with palladium-gold using a sputter coater (Q150R, QuorumTech). Subsequently,

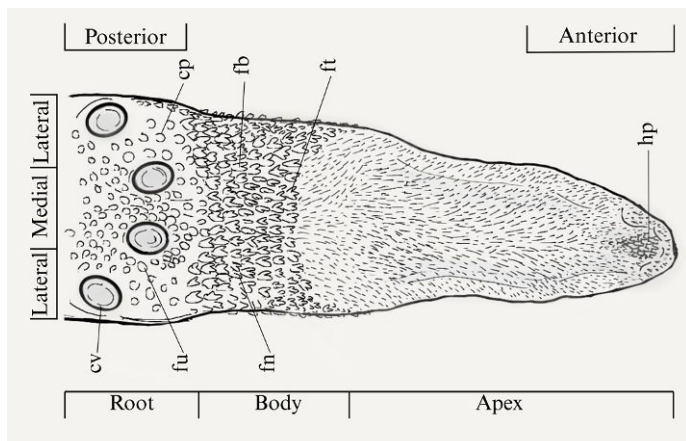


Figure 1. Dorsal view of the tongue of *P. infuscus* and distribution of the diverse types of papillae in the root, body, and apex regions; (cv) circumvallate papillae, (fu) fungiform papillae, triangular fungiform papilla (fn), (cp) conical papillae, (fb) giant bicuspid papillae, (ft) tricuspid papillae, and (hp) horny papillae.

high-resolution images of the papillary morphology of the tongue were captured with a scanning electron microscope (SEM, Zeiss Evo HD15) at 20 kV in high-vacuum mode.

The nomenclature was established based on the distribution of papillae described in the literature, the tongue was divided into three regions for analysis: apex (anterior, medial and lateral apex), body (medial and lateral region) and root (lateral, medial and posterior region) (Gunawan et al. 2020) (Figure 1). For the classification of the papillae, the adjusted nomenclature proposed by Gregorin (2003) was applied.

Macroscopically, the tongue is flat, elongated to a length of 18 mm and a rounded apex. Initially, four types of lingual papillae were identified: circumvallate and fungiform (gustatory), as well as conical and filiform (mechanical). Six subtypes of filiform papillae were found and three subtypes of fungiform papillae. In the posterior region of the root there are four circumvallate papillae (cv): two in the medial region, one in the right lateral region, and one in the left lateral region, all showing grooves and poorly developed epithelia in the surrounding area (Figure 2a).

Next to the circumvallate papillae there are circular fungiform papillae (fu) located in the posterior zone. Additionally, conical papillae (cp) are arranged towards the anterior zone of the root and the middle body, followed by giant bicuspid (fb) and tricuspid filiform papillae (ft), which are distributed across the transitional zone between the root and the body. Tricuspid giant filiform papillae were less numerous than bicuspid (Figure 2a).

In the body region, proximal to the root, numerous bicuspid and giant tricuspid filiform papillae were observed under stereoscopy. These papillae are robust, with central grooves, and arranged in the medial and lateral areas, accompanied by fungiform papillae forming a triangular pattern (Figure 2b). On the lingual borders, some fungiform papillae (mushroom or dome shaped) were also observed; in this region, it was evident that the bicuspid papillae decrease in size (Figure 2c). In the intermediate zone between the body and the apex, strictly filiform papillae

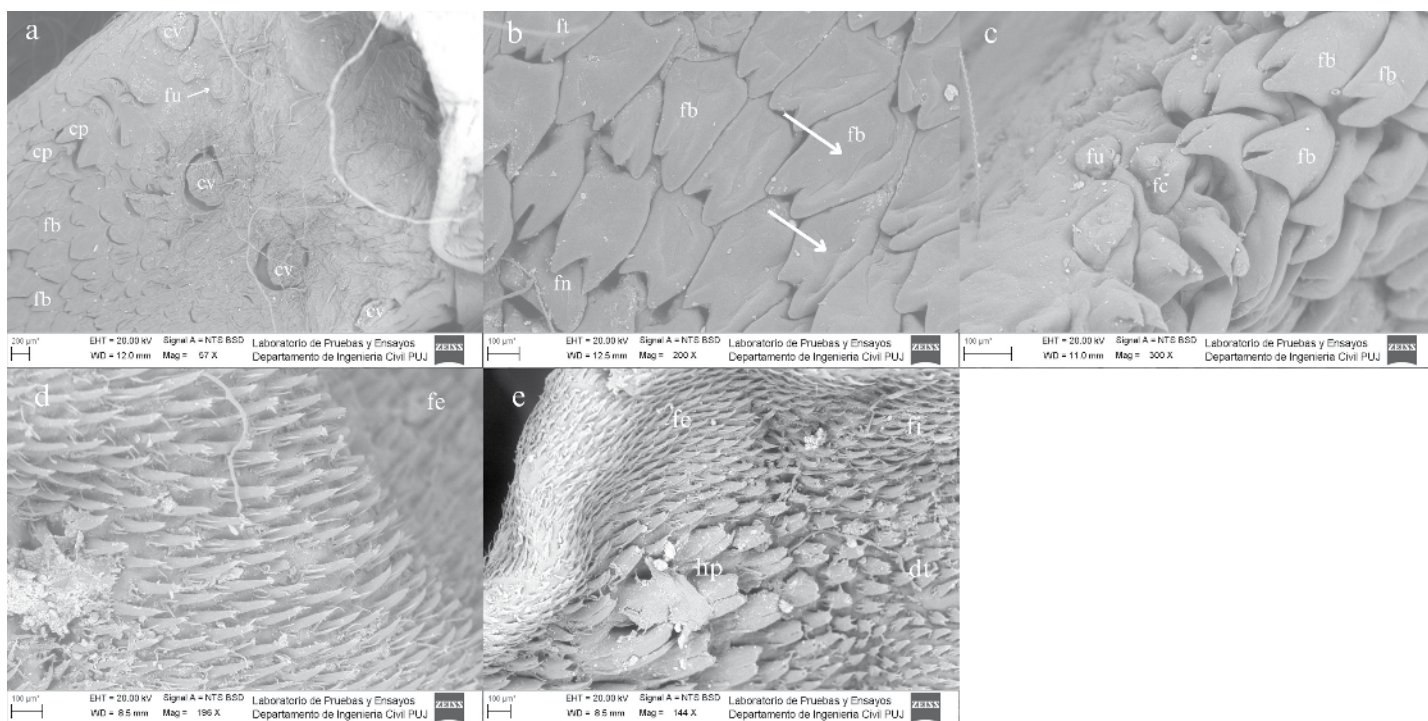


Figure 2. Scanning electron micrographs (SEM) of the tongue of *Platyrrhinus infuscus* showing the distribution and morphology of the different types of lingual papillae. a) Dorsal view of the central and lateral root region: (cv) circumvallate papillae, (fu) circular fungiform papillae, (cp) conical papillae, (fb) giant bicuspid filiform papillae. b) Mid-body region, dorsal view: (fb) giant bicuspid filiform papillae, (ft) tricuspid filiform papillae, (fn) triangular fungiform papilla, central sulci (white arrows). c) Lingual margin of the body near the root, right lateral view: (fc) vaulted fungiform papillae, (fu) circular fungiform papilla, (fb) giant bicuspid filiform papillae. d) Body-apex transitional region, dorsal view: (fe) strictly filiform papillae. e) Distal apex, dorsal view: (fe) strictly filiform papillae, (dt) finger-like papillae, (fb) bifid filiform papillae, (hp) horny papillae. High-vacuum SEM was performed at 20 kV.

(fe) with an elongated form, composed of two or more projections oriented towards the midline in the direction of the pharynx, were distributed (Figure 2d).

At the lingual apex there is evidence of an island of horny papillae (hp), large size and divided medially, surrounded by digitiform papillae (dt) of a smaller size, each consisting of more than five processes. The bifid papillae (fi) appear thick, with a V-shaped or two-pointed apex and only a few projections (Figure 2e). Strictly filiform papillae are distributed across the entire apex, surrounding the other papillae. They are also present along the lingual edges, extending laterally and posteriorly towards the ventral plane. The orientation of this entire set of papillae is directed towards the medial region of the body area (Figure 1).

The morphological characteristics of fruit bats suggest that the arrangement, quantity, location, shape, and microstructures of the lingual papillae contribute to increased feeding efficiency (Birt *et al.* 1997). The first type of papillae that come into contact with food are the filiform papillae, with at least 16 recognized subtypes (Birt *et al.* 1997; Gunawan *et al.* 2020; Gregorin and Zanatta 2021). One of these, known as horny papillae (also called giant papillae), has been previously described in the family Phyllostomidae in species such as *Carollia perspicillata*, *Glossophaga soricina* (Masuko *et al.* 2007), *Brachyphylla cavernarum*, *Phyllonycteris poeyi*, *Artibeus jamaicensis*, *Leptonycteris sanborni*, *Leptonycteris nivalis*, *Micronycteris megalotis*, and *Mimon bennettii* (Griffiths 1982), as well as in the families Mormoopidae and Noctilionidae in *Pteronotus rubiginosus* and *Noctilio albiventris*, respectively (Gregorin and Zanatta 2021). This type of papillae, together with the filiform papillae, are mechanical structures whose microstructures and processes are fundamental for adhesion, perforation, and fixation of food during flight (Birt *et al.* 1997; Abumandour and El-Bakary 2013). For this reason, their abundance and distribution between the apex and the body, along with their directionality, facilitate the movement of liquids and the fibers of fleshy fruits towards the pharynx (Birt *et al.* 1997; Mqokeli and Downs 2013).

The giant bicuspid filiform papillae are characterized by their large size and have previously been described only in *Artibeus jamaicensis* (Griffiths 1982). However, this term has also been used inconsistently to refer to horny papillae, although the two do not represent the same morphological type (Elizalde-Arellano *et al.* 2004a, b; Mqokeli and Downs 2013). The keratinization, abundance, and size of these papillae play essential roles in swallowing and food transport by squeezing and crushing fruits against the palate (Birt *et al.* 1997; Mqokeli and Downs 2013).

Circumvallate papillae, on the other hand, are characterized by the presence of taste buds on both their surface and sides (Greenbaum and Phillips 1974). Abumandour and El-Bakary (2013) suggested that an increase in the number of circumvallate papillae enhances

gustatory perception by broadening the sense of taste, thereby increasing the sensitivity and detection of food in the root region, while a greater number of fungiform papillae improves the perception of food before it progresses through the digestive system (Ojima *et al.* 2000; Ojima 2001).

The presence of four circumvallate papillae—two medial, one right lateral, and one left lateral—has also been reported for species of *Carollia perspicillata*, *Glossophaga soricina*, *Leptonycteris yerbabuenae* and *L. nivalis* of the family Phyllostomidae. In the family Molossidae, one pair of circumvallate papillae has been described (Abumandour and El-Bakary 2013), while in other families of aerial insectivores of the Neotropics, both one-pair and two-pair patterns have been documented (Gregorin and Zanatta 2021).

On the other hand, in the family Pteropodidae (Hutcheon and Kirsch 2006) there are species such as *Rousettus aegyptiacus*, *R. amplexicaudatus*, and *Cynopterus brachyotis* are recognized as frugivores but present three circumvallate papillae in a triangular pattern (Greenbaum and Phillips 1974; Gregorin 2003; Jackowiak *et al.* 2009; Abumandour and El-Bakary 2013).

Frugivorous and nectarivorous species tend to exhibit a greater number of circumvallate papillae. In addition, a pattern is observed where the family Pteropodidae generally has three circumvallate papillae, while families such as Phyllostomidae, Molossidae, Noctilionidae, Emballonuridae, Furipteridae, Thyropteridae, Mormoopidae, Natalidae and Vespertilionidae display greater variation in papillae number (Masuko *et al.* 2007; Gregorin and Zanatta 2021; Gregorin 2003), even reaching zero as in the case of *Desmodus rotundus* (Masuko *et al.* 2007). Probably species with frugivorous feeding habits possess a greater number of circumvallate papillae due to the need to determine the quality of food prior to ingestion.

The horny papillae are typically associated with the frugivorous habit; however, their presence has also been reported in specimens with insectivorous and piscivorous diets (Elizalde-Arellano *et al.* 2004a, b; Gregorin and Zanatta 2021). Similarly, giant bicuspid papillae, although recorded only in one frugivorous species, are thought to occur in other members of the family Phyllostomidae (Griffiths 1982). The location, shape, and arrangement of the mechanical papillae may be associated with the compensation for missing teeth across bat families, since their dental formulas vary considerably. These papillae are therefore essential for the adhesion and fixation of food during flight, a role fulfilled through the microstructures and processes present in the lingual papillae (Mqokeli and Downs 2013; Díaz *et al.* 2021).

This description links the morphology of the lingual papillae, their microstructures, and arrangement with frugivorous trophic habits, given that the topography and types of mechanical papillae serve critical roles.

In addition, the taste buds enhance the sensation and perception of fruit (Birt et al. 1997; Mqokeli and Downs 2013; Gunawan et al. 2020). For *P. infuscus*, there are records of fruit consumption from the families Moraceae and Solanaceae (Arias and Pacheco 2019). Based on the lingual morphological description, it also shares papillary types such as bifid, tricuspid, and horny papillae with bats of the insectivorous guild; this could indicate an occasional consumption of insects.

Several studies have shown that morphological changes can occur in the lingual papillae at the intraspecific level or even between subspecies, driven by the availability of resources in the environments they inhabit. Thus, individuals may consume one resource more frequently than another, and this pattern, when associated with geographical distribution, can influence tongue morphology, as described in *R. aegyptiacus* (Mohamed et al. 2013). Differences related to life stage have also been reported: while certain papillae, such as taste buds, are fully developed at birth, others, such as filiform papillae, are underdeveloped in newborns and only reach full maturation at later stages (Trzcielińska-Lorych et al. 2009). For this order, it has been suggested that adaptations in the lingual surface morphology—and specifically in papillary typology—are correlated with trophic habits and may even serve as valid taxonomic characters (Harper et al. 2013; Abumandour and El-Bakary 2013; Gregorin and Zanatta 2021; Attaallah et al. 2023).

Eleven types of papillae were identified on the lingual surface of *P. infuscus*. In the root region, circumvallate papillae were identified, along with circular fungiform papillae and conical papillae, the latter two being exclusive to the root and the transitional zone with the body. In the lingual body, giant bicuspid papillae predominated, and to a lesser extent tricuspid filiform papillae accompanied by triangular fungiform papillae. Along the edges of the tongue, giant bicuspid papillae decreased in size, while fungiform papillae were identified. The most abundant papillae in the lingual body were strictly filiform papillae, extending from the terminal region of the middle body to the apex of the tongue. The greatest diversity of papillae was observed at the apex, with an island of horny papillae surrounded by digitiform papillae and bifid filiform papillae, all of which were directed toward the central canal of the tongue and pharynx.

To continue this type of study, it is necessary to establish a clear and comprehensive nomenclature that provides a classification of papillae and facilitates their identification, since several synonymies and irregular descriptions are currently present for the different papillary types, hindering accurate description and subsequent data standardization.

Finally, it is necessary to increase the number of individuals studied within the same species to confirm that the description effectively corresponds to the species. A broader sample size could reveal intraspecific morphological

variation associated with factors such as age, sex, and geographical distribution. These sources of variation can significantly influence the interpretation of lingual traits and should therefore be carefully considered when establishing diagnostic characters at the species level.

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One small cat and 178 kilometers: longest-known displacement movement by an endangered ocelot (*Leopardus pardalis*)

Un gato pequeño y 178 kilómetros: el desplazamiento más largo de un ocelote (*Leopardus pardalis*) en peligro de extinción

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Successful protection of imperiled species and habitats is often hindered by a lack of current information. Ocelot (*Leopardus pardalis*) is a wide-ranging and elusive species that is federally endangered in Mexico and the United States, where it is facing growing conservation challenges. We maintained non-baited camera-traps at 89 locations in the Sky Islands of Southern Arizona between April 2024 and October 2025. We reviewed photos and videos to identify species and count individuals present and compared unique spot patterns to identify the ocelot individual. We detected a male ocelot in four different mountain ranges across 388 days, with a displacement distance of ≥ 178.4 km. We confirmed the ocelot was the same individual by matching unique spot patterns on the ocelot. These detections represent the longest-known displacement by an ocelot and a range expansion in Arizona. More importantly, these detections contribute to our understanding of ocelot distribution and provide useful information for the conservation of this endangered species. Conservation is often forced to be reactive rather than proactive. Yet, the opportunity exists to proactively protect suitable habitat in Arizona and ensure cross-border connectivity to facilitate protection of this endangered species.

Key words: Endangered species; camera-trap; dispersal; transboundary conservation.

La protección eficaz de las especies y hábitats en peligro comúnmente se ve obstaculizada por la falta de información actualizada. El ocelote (*Leopardus pardalis*) es una especie difícil de observar con amplia distribución, considerada en peligro de extinción a nivel federal en México y Estados Unidos, donde enfrenta desafíos cada vez más graves para su conservación. Mantuvimos 89 cámaras trampa en las Islas del Cielo, en el sur de Arizona, entre abril de 2024 y octubre de 2025. Revisamos las fotos y videos para identificar las especies y contar los individuos presentes, y comparamos patrones de manchas para identificar al ocelote. Detectamos un ocelote macho en cuatro montañas durante 388 días, y la distancia que se desplazó fue $\geq 178,4$ km. Confirmamos que se trataba del mismo individuo al identificar hasta cinco manchas distintas en el ocelote. Estas observaciones representan el desplazamiento más largo de un ocelote y una expansión de su distribución en Arizona. Más importante, estas observaciones contribuyen a nuestro entendimiento de la distribución del ocelote y brindan información útil a los para la conservación de esta especie. La conservación frecuentemente se ve obligada a ser reactiva en lugar de proactiva. Sin embargo, existe la oportunidad de proteger proactivamente el hábitat en Arizona y garantizar la conectividad transfronteriza para facilitar la protección de esta especie en peligro de extinción.

Palabras claves: Conservación transfronteriza; cámara trampa; especies en peligro de extinción; dispersión.

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The Endangered Species Act (ESA) of the United States provides for the protection of imperiled species and their habitats. Yet, successful implementation of the ESA is often hindered by a lack of accurate and current data to inform conservation decisions (Bottrill *et al.* 2008). Camera traps are a powerful tool to collect data that can facilitate implementation of the ESA, such as the occurrence and spatial ecology of terrestrial species (Burton *et al.* 2015). Camera-traps can be particularly useful to monitor rare or

elusive species because cameras are unobtrusive and can monitor continuously for prolonged periods (Sanderson and Trolle 2005; Lukacs *et al.* 2020). For example, trail cameras have documented the occurrence of jaguar (*Panthera onca*), margay (*Leopardus wiedii*), and American black bear (*Ursus americanus*) in Mexico (Ragan *et al.* 2022; Branney *et al.* 2023; Marín and Koprowski 2025).

Ocelots (*Leopardus pardalis*) occur throughout the Americas, reaching the extremes of its range in

northeastern Argentina, southern Brazil, southern Arizona and Texas, United States (USA; [US Fish and Wildlife Service 2016](#)). Ocelots are federally endangered in the USA ([US Fish and Wildlife Service 2016](#)) and Mexico ([SEMARNAT 2010](#)). The northernmost known breeding population in Mexico occurs in Rancho El Aribabi, a private conservation ranch in Sonora, Mexico ([Rorabaugh et al. 2020](#)). Other northern breeding populations occur in Chihuahua and Tamaulipas, Mexico ([Gomez-Ramirez et al. 2015](#); [Lombardi et al. 2022](#)), whereas the only known breeding population in the USA occurs in coastal South Texas ([US Fish and Wildlife Service 2016](#)). The ocelot population in coastal South Texas has been monitored for over 40 years ([Schmidt et al. 2020](#); [Veals et al. 2023](#); [Smith et al. 2025](#)), and recent research is elucidating ocelot distribution and ecology in northern Mexico ([Amador-Alcala et al. 2022](#); [Sternberg et al. 2023](#); [VanDevender et al. 2023](#)). However, little information exists about the occurrence and distribution of ocelots in Arizona.

Historical evidence of ocelots in Arizona is sparse with one fossil record and 11 historical records (e.g., carcass, skull, pelt, etc.) between 1887 and 1980. One historical record was confirmed as female, and the rest were male or of unknown sex ([US Fish and Wildlife Service 2016](#)). No ocelots were officially confirmed in Arizona between 1980 and 2009 with illegal hunting and habitat loss driving declines throughout their range ([US Fish and Wildlife Service 2016](#)). However, due in part to increased use of camera-traps, at least six unique ocelots have been detected in Arizona since 2009 ([Culver 2016](#); [Gamillo 2024](#)). All detections since 2009 have been males, presumably dispersing from breeding populations in Sonora, Mexico, the closest of which is roughly 55 km south of the international border ([Rorabaugh et al. 2020](#)). However, no genetic or telemetry studies have shown definitively the origin of these Arizona detections ([US Fish and Wildlife Service 2016](#)).

Given the scarcity of ocelot detections, any new information on the occurrence and spatial ecology of ocelots in Arizona is valuable for state and federal natural resources agencies tasked with protecting this endangered species. Such data will be particularly useful as climate change drives species distributions northward ([Chen et al. 2011](#)), habitat loss affects the northernmost breeding population of ocelots in Sonora ([Rorabaugh et al. 2020](#); [Ávalos 2023](#)), and border wall construction expands across the USA-Mexico border ([Harrity et al. 2024](#)). New data are especially important considering that no critical habitat for ocelots has been designated in Arizona despite the species being listed as endangered at the state and federal level for decades ([US Fish and Wildlife Service 2016](#)). Here, we report novel observations of the seventh confirmed ocelot in Arizona since 2009 to further conservation efforts.

We maintained non-baited camera-traps at 89 locations in the Madrean Sky Islands of southern Arizona between April 2024 and October 2025 (Figure 1). The Madrean Sky Islands are a global biodiversity hotspot

spanning the USA-Mexico border at the convergence of major biogeographical regions, including Sonoran Desert, Chihuahuan Desert, Rocky Mountains, and Sierra Madre Mountains ([VanDevender et al. 2013](#)). Camera model, settings, and spatial arrangement varied by organization. Phoenix Zoo maintained 50 Bushnell No-Glow cameras (Bushnell Holdings, LLC., Overland Park, Kansas) at randomized locations in the Atascosa Complex with a minimum distance between camera sites of two km. Cameras were set to capture 10-second videos with a 1-min delay. Sky Island Alliance maintained eight Reconyx UltraFire (Reconyx, Inc., Holmen, Wisconsin) and six Browning Strikeforce (Browning Trail Cameras, Birmingham, Alabama) cameras in the Patagonia Mountains arranged in two systematic grids with 0.5 - 1.0 km spacing between cameras ([Jansen et al. 2014](#)). All cameras maintained by Sky Island Alliance were programmed to capture 1 - 3 photos with a 1-min delay. University of Arizona Wild Cat Research and Conservation Center maintained 24 cameras in the Santa Rita and Whetstone Mountains as part of a regional spotted cat monitoring effort ([Culver 2016](#)). Cameras were placed in drainages or at water sources and set to collect 1 - 3 photos with a 1-min delay following methods described in [Culver \(2016\)](#). A private individual maintained an additional GardePro camera (GardePro, Hong Kong) in the Whetstone Mountains. All cameras, regardless of organization, were programmed to operate continuously, mounted 0.2 - 1.5 m above the ground on sturdy vegetation, and oriented to optimize terrestrial wildlife detection. We reviewed photos and videos to identify species detected and count individuals present. We identified the ocelot individual by matching at least three unique patterns of spots in each detection ([Trolle and Kéry 2003](#)). We calculated displacement distances (km) as straight-line distances between detection locations and calculated average daily displacement distances as the straight-line distance between sequential detections divided by days elapsed between the detections. We also characterized vegetation communities for all camera sites following [Brown and Lowe \(1980\)](#). Cameras on public land were permitted under US Forest Service Special Use Permits SUP2349, NOG2405, and SUP2388.

We detected a male ocelot four times in four different mountain ranges over 388 days (Figure 1; Table 1). We confirmed the ocelot was the same individual by matching up to five unique spot patterns on the back, flank, and inner leg (Figure 2) and determined sex by the presence of a scrotum. The minimum displacement distance was ≥ 178.4 km with step-lengths between subsequent detections of 78.9 km, 68.0 km, and 31.5 km respectively (Table 1). The minimum convex polygon of the detection locations was 1,085 km². Only seven days elapsed between the third and fourth detection, giving an average daily displacement distance of 4.5 km. All detections occurred at night during

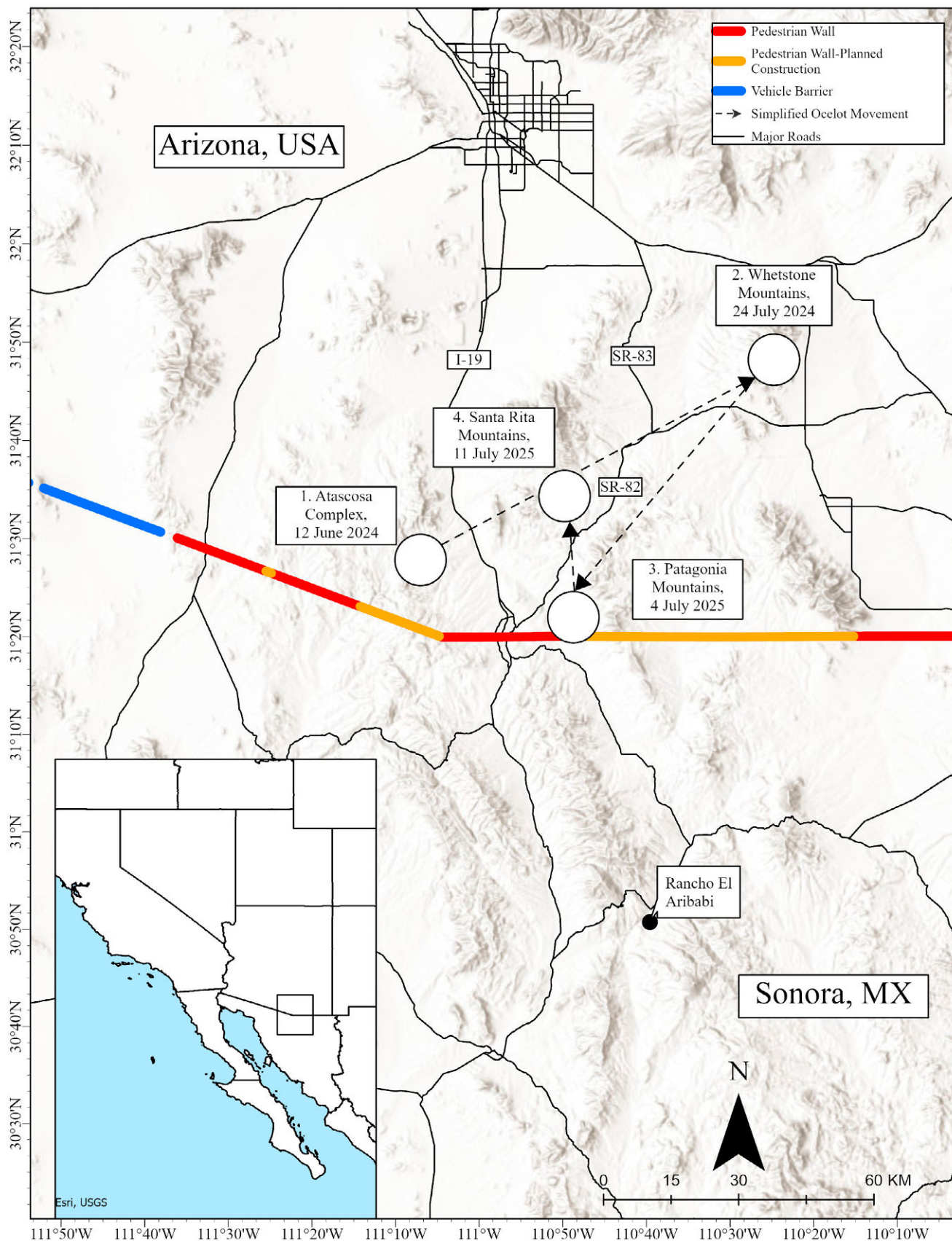


Figure 1. Four detections of the same male ocelot (*Leopardus pardalis*) in four different mountain ranges in Arizona, USA during 2024 and 2025. White dots represent detection locations and dashed lines represent simplified movements between detections. Rancho El Aribabi (black dot) is home to the northernmost breeding population of ocelots in Sonora, MX. Pedestrian walls (shown in red) are steel bollard-type walls between 5.5 - 9.1 m tall and with interstitial spaces averaging ≤ 10 cm. Yellow indicates where construction of pedestrian walls was announced or initiated in 2025. Vehicle barriers (shown in blue) are variable structures designed to stop vehicle but not pedestrian traffic.

Table 1. Camera-trap detection details of a male ocelot (*Leopardus pardalis*) in Arizona, USA in 2024 and 2025. Vegetation communities follow [Brown and Lowe \(1980\)](#). Step distances are the straight-line distance between sequential points.

Detection	Date and time	Mountain range	Minimum step distance (km)	Elevation (m)	Vegetation community
1	12 June 2024 04:47	Atascosa	NA	1,155	Encinal Oak
2	24 July 2024 04:32	Whetstone	78.9	1,568	Chihuahuan Desert Scrub
3	04 July 2025 01:58	Patagonia	68.0	1,152	Desert Scrub Grassland
4	11 July 2025 02:47	Santa Rita	31.5	1,569	Encinal Oak

summer months (June and July) and occurred in drainages. Dominant vegetation community of each detection location included, Encinal Oak, Chihuahuan Desert Scrub, and Desert Scrub Grassland, and elevation ranged from 1,152 - 1,569 m (Table 1).

These four detections contribute to our understanding of ocelot occurrence in Arizona and the spatial ecology of the species. Indeed, these observations represent the longest-known displacement by an ocelot anywhere within its range ([US Fish and Wildlife Service 2016](#)). Notably, this was the first confirmed ocelot in the Atascosa Complex, the second confirmed ocelot in the Whetstone Mountains (first since 2009; [Avila-Villegas and Lambertson-Moreno 2013](#)) and Santa Rita Mountains (first since 2015; [Culver 2016](#)), and the seventh ocelot in Arizona since 2009. Finally, these detections in four mountain ranges by four camera networks underscore the importance of maintaining connectivity throughout the region as well as the need for collaboration and data sharing to achieve conservation goals.

Our observations demonstrate the remarkable movement capacity of this species. For example, the ocelot covered ≥ 31.5 km between the Patagonia Mountains (detection three) and the Santa Rita Mountains (detection four) in seven days. This gives an average daily displacement of 4.5 km, greater than distances observed in telemetry studies (2.5 km; [Gonzalez-Borrajó et al. 2017](#)) and camera-trapping studies (e.g., 2.3 - 2.4 km; [Lombardi et al. 2022](#)). The minimum displacement distance of this ocelot was 178.4 km — more than two times greater than the next longest reported displacement (an 84-km round-trip movement in Arizona; [Culver 2016](#)). As no known breeding populations exist in Arizona, this ocelot presumably dispersed from the northernmost breeding population in Rancho El Aribabi, Sonora, which lies roughly 80 km south of our first detection ([Rorabaugh, et al. 2020](#)). Ocelots exhibit sex-based dispersal with males moving greater distances than females ([Gonzalez-Borrajó et al. 2017](#)), and this behavior probably explains why all ocelots confirmed in Arizona since 2009 (including our recent detections) have been male.

We detected the ocelot in Encinal Oak, desert grassland, and desert scrub vegetation communities, which is consistent with ocelot habitat preferences in Sonora ([VanDevender et al. 2023](#)). Moreover, the detections occurred in drainages, emphasizing the importance of riparian corridors for wildlife connectivity and access to water in arid regions ([Ragan et al. 2023](#)). Recent research from Sonora also documented ocelot use of riparian

corridors ([Rorabaugh et al. 2020](#)). Importantly, whereas the detection locations conformed with known ocelot habitat preferences, much of the landscape between the detection locations is predicted as low suitability for ocelots ([NatureServe and Heritage Network Partners 2021](#)). This highlights the need to protect suitable habitat and the movement corridors between habitat patches to successfully conserve mobile species.

Conservation of wide-ranging species is challenging because their movements may bring them into regular contact with human development and other stressors ([Nandintsetseg et al. 2019](#)). Indeed, vehicle collisions are a leading cause of mortality of ocelots in Texas ([Schmidt et al. 2020](#); [Veals et al. 2023](#)). The ocelot we observed must have crossed busy roadways multiple times when moving between the mountain ranges, including Interstate-19 (I-19), a multi-lane highway with abundant commercial traffic between Sonora and Arizona (Figure 1). Annual average daily traffic volumes in 2024 were $39,072.5 \pm 24,806.2$ vehicles/day (ADOT 2025), well above the threshold for avoidance by ocelots (5,000 vehicles/day) observed in Texas ([Veals et al. 2023](#)). In addition to I-19, this ocelot likely crossed State Routes 82 or 83 at least three times when moving between mountain ranges (Figure 1). Traffic volumes on these state routes are lower than I-19 ($2,333.9 \pm 1,229.6$ vs $39,072.5 \pm 24,806.2$ vehicles/day) and they are typically only two lanes, but maximum speed limits are high (90 km/h). The potential crossings by this ocelot emphasize the need for wildlife crossing structures to facilitate safe wildlife movement across transportation infrastructure.

Limitations of camera-traps are highlighted by our observations as we cannot know how this ocelot moved between camera locations, nor whence it came. The origin of this ocelot is particularly relevant because a railroad was constructed through Rancho El Aribabi in 2023 to connect with railroads near Nogales, Arizona ([Ávalos 2023](#)). The habitat loss and fragmentation from this development could negatively impact local ocelot populations ([Kotze et al. 2021](#); [Kuipers et al. 2021](#)) and may lead to increased ocelot dispersal away from the area (i.e., frustrated dispersal). Loss of ocelot habitat in Rancho El Aribabi, coupled with our detections in Arizona, reinforce the need for telemetry and genetic studies to elucidate movement corridors and connectivity between countries.

Beyond these threats, ocelots face multiple conservation challenges in the region. For example, ≥ 1000 km of border walls measuring 5.5 - 9.1 m tall and with interstitial spaces

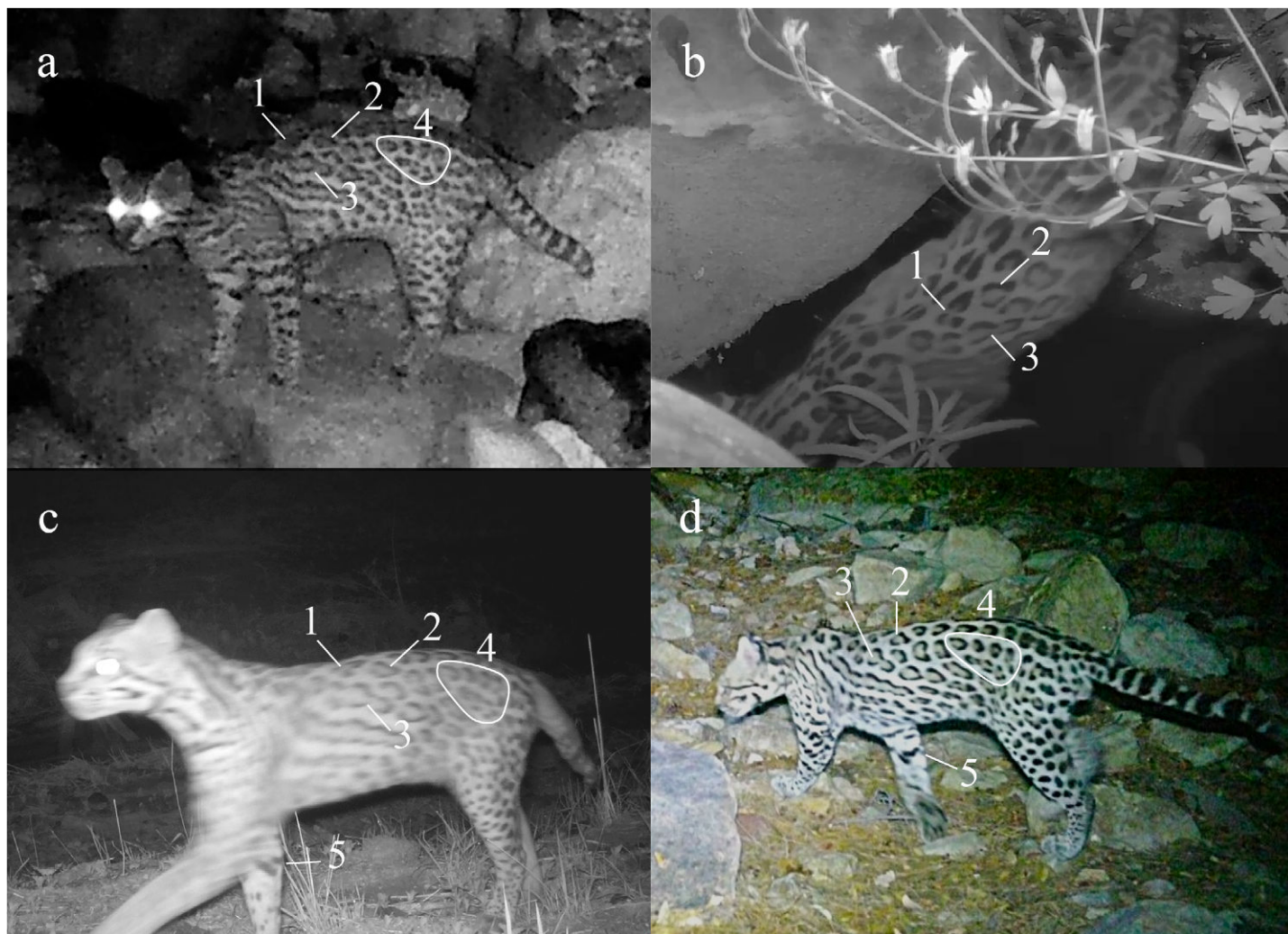


Figure 2. The identity of the ocelot (*Leopardus pardalis*) was confirmed in the four different mountain ranges in southern Arizona, USA during 2024 and 2025 by matching up to five distinguishing spot patterns. Spots 1 - 3 are unique single spots on the back, spot 4 is a cluster of spots on the flank, and spot 5 is a unique linear spot on the right inner-leg. At least three of the five spot patterns were matched in each detection. Note, image a and b are screenshots selected from the original videos and additional spot patterns were visible in other frames (a = Atascosa Complex, b = Whetstone Mountains, c = Patagonia Mountains, d = Santa Rita Mountains).

averaging ≤ 10 cm exist along the USA-Mexico border. Importantly, at least 450 km of new border wall projects were initiated in 2025 ([US Customs and Border Protection 2025](#)) that will dramatically reduce wildlife connectivity along the entire USA-Mexico border ([Flesch et al. 2010](#); [Peters et al. 2018](#); [Harrity et al. 2024](#)). Existing wildlife crossing structures improve crossing rates for some species but should be made larger and installed more frequently in existing and future walls to provide for some cross-border connectivity ([Harrity et al. 2024](#)). Mining operations are also expanding that will degrade or destroy potentially suitable ocelot habitat (e.g., Hermosa Mine in Arizona, Buenavista Copper Mine in Sonora, etc.). Additionally, southern Arizona has several inventoried roadless areas that support potentially suitable habitat for ocelot and many other imperiled species ([NatureServe and Heritage Network Partners 2021](#)). Recent efforts to rescind the Roadless Area Conservation Rule in the USA ([US Department of Agriculture 2025](#)) may have strong negative impacts to habitat quality of these areas by increasing anthropogenic

disturbance and activity ([Selva et al. 2015](#)). Finally, climate change may drive ocelot distribution northward ([Chen et al. 2011](#)) and into an increasingly fragmented and densely populated landscape in southern Arizona ([US Census Bureau 2024](#)). Rather than reacting to these conservation challenges if ocelots recolonize Arizona, the opportunity exists to proactively ensure suitable habitat and adequate connectivity exist within the region and across the USA-Mexico border. Additionally, the mounting evidence of ocelot occurrence and movement throughout the Madrean Sky Islands of southeastern Arizona could justify the designation of critical ocelot habitat in the region. Such actions would facilitate conservation of ocelots under the US ESA and would be an important step towards the successful recovery of this endangered species.

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Enhancing the knowledge of *Herpailurus yagouaroundi* for its conservation in Morelos, México

Mejorando el conocimiento de *Herpailurus yagouaroundi* para su conservación en Morelos, México

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The jaguarundi is one of the six wild feline species found in Mexico and is considered threatened, with population trends indicating a decline. It is a species difficult to capture, with very few recorded sightings. More studies on its ecology are needed. The data were obtained through photo-trapping samplings conducted at six ejidos (communal landholdings) within the Sierra de Huautla Biosphere Reserve (REBIOSH), in southern Morelos, from 2015 to 2022, using between 35 and 61 camera traps on each 30-60 day sampling periods. The cameras were deployed on sampling grids with a minimum separation of 500 m. We obtained 25 records of the species in 15 different sites within the REBIOSH. On average, its photographic capture rate in this protected natural area (PNA) was 0.63 ± 0.67 individuals per 1,000 trap days. Most of these new records were obtained in wide ravines within large fragments (ranging from 80 to over 1,500 ha) of preserved continuous dry forest, at altitudes below 1,200 m above sea level, and during the daytime. This increases knowledge of the species' distribution in Morelos and provides evidence that, in the REBIOSH, this species has a persistent population with a wide distribution, especially in its southern and northeastern portions, although it is low in abundance. We provide concrete suggestions to help conserve it within this PNA and in the state of Morelos.

Keywords: Camera trapping; dry forest; endangered species; jaguarundi; photographic capture rate; protected natural area; Sierra de Huautla.

El jaguarundi es una de las seis especies de felinos silvestres presentes en México considerada como amenazada, y sus poblaciones van en decremento. Existen muy pocos registros de su presencia. Es necesario realizar más estudios sobre su ecología. Los datos se obtuvieron mediante muestreos con fototrampeo realizados en seis ejidos de la Reserva de la Biosfera Sierra de Huautla (REBIOSH), en el sur de Morelos, entre 2015 y 2022. Se utilizaron entre 35 y 61 cámaras trampa por cada período de muestreo de 30 a 60 días. Las cámaras se desplegaron espacialmente en cuadrículas de muestreo con una separación mínima entre ellas de 500 m. Se obtuvieron 25 registros de la especie en 15 sitios diferentes dentro de la REBIOSH. En promedio, su tasa de captura fotográfica en esta área natural protegida (ANP) fue de 0.63 ± 0.67 individuos/1,000 días trampa. La mayoría de estos nuevos registros se obtuvieron en el periodo diurno; en fototrampas ubicadas en cañadas amplias, dentro de fragmentos grandes (de 80 a más de 1500 ha) de selva seca conservada continua en elevaciones menores a 1,200 msnm. Los resultados contribuyen a incrementar el conocimiento sobre la distribución de la especie en Morelos y se evidencia una población residente de la especie dentro de la REBIOSH, con una amplia distribución, sobre todo en su porción sur y noreste, aunque con baja abundancia. Damos sugerencias concretas para contribuir a su conservación tanto dentro de esta ANP como en Morelos.

Palabras clave: Área natural protegida; especie amenazada; fototrampeo; jaguarundi; selva seca; Sierra de Huautla; tasa de captura fotográfica.

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The jaguarundi (*Herpailurus yagouaroundi*) is one of the six wild felid species in the country. It is a medium-sized animal that weighs 3-9 kg and measures 80 - 130 cm in total length (its tail accounts for 30-45 % of that length). It has a small, flat head with rounded ears. Its legs are short

compared to its total length, and it has a short, coarse fur coat without markings throughout its life, with uniform coloration. However, the species shows notable coloration polymorphism with two main color morphs: one brown or reddish-brown and the other almost black or grayish.

It is distributed in tropical and subtropical zones, ranging from humid to dry, from northern Mexico to southern Brazil, Paraguay, Uruguay, and south through central Argentina (Caso et al. 2015). In Mexico, it occurs from Nuevo León to the Yucatán Peninsula, especially along the Pacific and Gulf coasts (Aranda and Caso 2014). It is not found in the Baja California Peninsula or in most of the Mexican highlands. It is considered threatened in Mexico (SEMARNAT 2019) and internationally as listed as Least Concern by the International Union for Conservation of Nature (IUCN; Caso et al. 2015), but with declining populations. Furthermore, its Central and North American populations are listed in Appendix I of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), as stated by Caso et al. (2015), meaning they are threatened with extinction and affected by trade.

The species is generally considered to have low abundances throughout its almost entire distribution range, with densities around 0.01-0.05 individuals/km² or lower (Caso et al. 2015), for this reason, and also because of its evasive behavior it is difficult to study using both camera traps and box traps (Giordano 2016; Lombardi et al. 2022; Branney et al. 2023), which is mainly why it is a species with few observations.

For example, a search on the GBIF platform (Global Biodiversity Information Facility) conducted on 27 January 2026 returned 610 records for the species across the country (GBIF Occurrence Download <https://doi.org/10.15468/dl.djntw>) and only five for the state of Morelos (GBIF Occurrence Download <https://doi.org/10.15468/dl.zpmxux>). Thus, providing more data on its presence in areas with few previous records is essential, which is why we report new records for Morelos here, obtained in six ejidos within the Sierra de Huautla Biosphere Reserve (REBIOSH), through photo trapping conducted between 2015 and 2022.

The REBIOSH is the largest protected natural area (PNA) in the state of Morelos, Mexico (Figure 1). It has received federal protection and international recognition as part of the UNESCO (United Nations Educational, Scientific and Cultural Organization) World Network of Reserves of the Man and Biosphere program since 2006. Decreed in 1999, it protects one of the most significant remnants of dry forest or tropical deciduous forest in central Mexico. It protects an area of 59,030 ha and is home to significant biological diversity, with more than 1,200 vascular plant species and over 380 vertebrate species, including 16 mammalian carnivores, and among them, all six wild feline species found in Mexico (CONANP 2005; Valenzuela-Galván et al. 2020).

Within its surface area or within its area of influence, there are 31 rural towns, with a total population of 24,646, according to data from the 2020 national population census conducted by the National Institute of Statistics and Geography (INEGI, by its acronym in Spanish). Of these, nearly 4,000 people reside within the PNA.

In 2009, we initiated wildlife monitoring in this PNA using camera traps, focusing on medium- to large-sized mammals. We used a variable number of cameras from different brands and models: Bushnell (Bushnell Outdoor Products 201 N 700 W, Hyde Park, UT 84318, USA; model Core DS-4K), Cuddeback (2256 American Blvd. De Pere, WI 54115, USA; models Attack Black Flash, Attack IR, C Black Flash, Capture, E2 long range IR and E3 Black Flash), DeerCam (DeerCam, Pak Falls, USA; model DC300), Forestry Suppliers (Forestry Suppliers, Inc. 205 West Rankin Street, Jackson, MS 39201, USA; model Wildlife Pro System, with analog camera), Moultrie (Moultrie Inc., Alabaster, AL, USA; models A-5, D444 and M880), Stealthcam (5250 Frye Road Irving, TX 75061, USA; model PX14), Reconyx (3828 Creekside Ln Holmen, WI 54636, USA; Hyperfire 2 model) and Wildview (Stealth Cam, LLC, Grand Prairie, Texas, US; Extreme and Infrared Extreme models).

Photo-trapping has been conducted in 11 ejidos within REBIOSH, covering almost 30,000 ha of the protected area. Between 35 and 61 camera traps were used per ejido (depending on availability) in each sampling period of 30 to 60 days (depending on logistical and financial constraints). Seven ejidos have been sampled in 2-4 different years, and four ejidos have been sampled in 5-10 different years. Sampling has been conducted during both the dry and rainy seasons.

The cameras were placed on tree trunks 40-100 cm above ground, in spatial arrangements corresponding to sampling grids with a minimum separation of 500 m between cameras. Most cameras were placed at sites in conserved dry forests, more than 600 m from villages. Each camera was configured to operate continuously throughout the sampling period, taking 2-3 photographs and a 20-30 second video per event (when the model permitted). The minimum time interval between detections was set to 1 minute.

We obtained the first photographic record of the jaguarundi in REBIOSH in 2015. From 2015 to 2022, we collected 67 photographic records of this species (in 2015, 2018, 2019, 2020, 2021, and 2022), with a total sampling effort of 29,985 trap days (ranging from 2,284 to 9,067 trap days per sample period). We recorded the jaguarundi in six of the 11 ejidos (Figure 1; Table 2): Ajuchitlán-Santiopa, Rancho Viejo, Huautla, Huixtla, and Huaxtla, all in the Municipality of Tlaquiltenango, and in El Limón de Cuauchichinola (Municipality of Tepalcingo).

These 67 photographic records correspond to 25 independent recordings, including individuals of both main color morphs (although the grayish form was more common) of the species (Figure 2), at 15 different recording sites. It was difficult to determine the sex or age of all the independent records. Still, among them, we identified individuals of both sexes and adults and juveniles (see Figure 2, where 2d shows an adult male and 2i shows a juvenile-like individual). The jaguarundi photographic capture rate in six samplings ranged from 0.20 to 1.99 individuals per

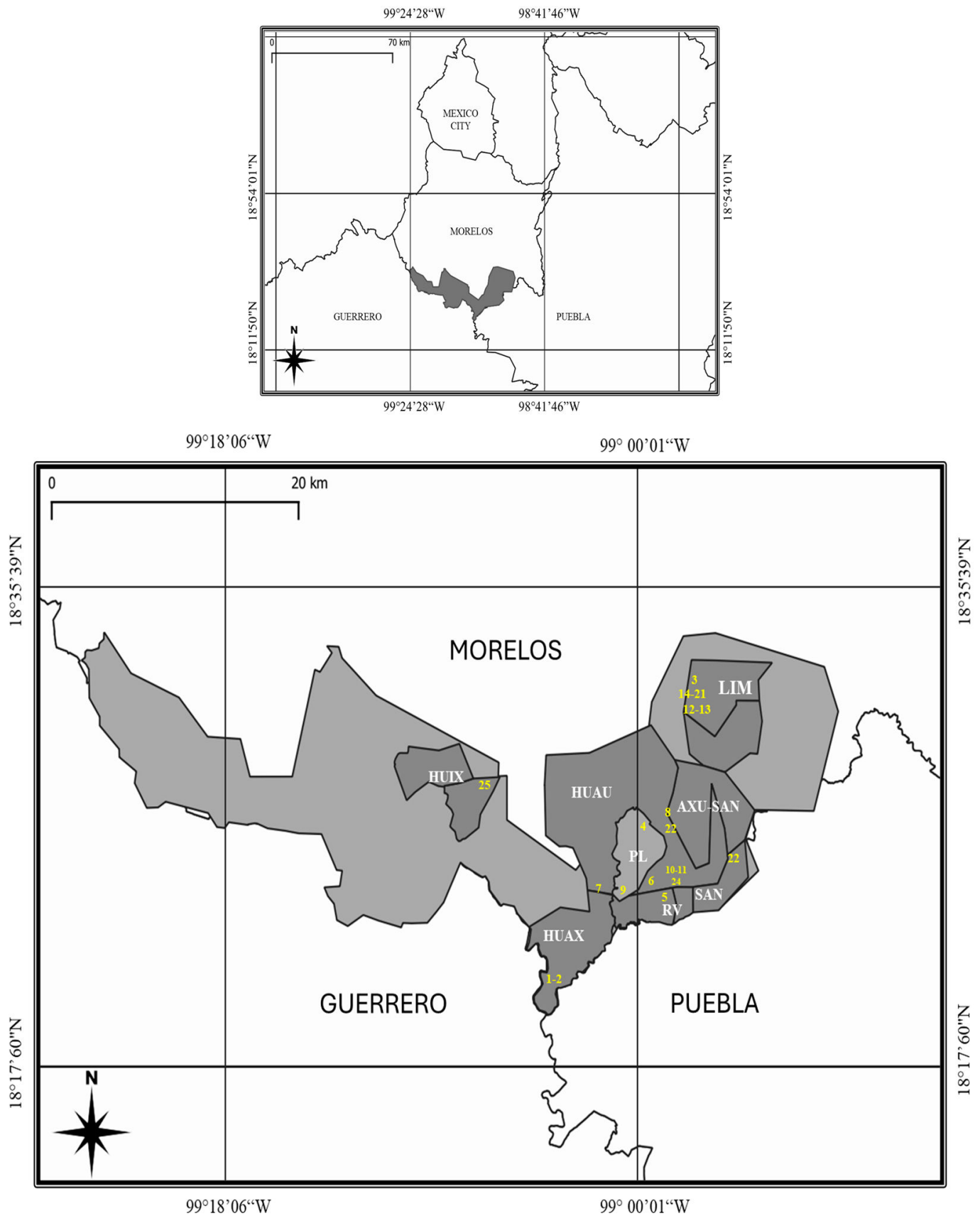


Figure 1. a) Location of the Sierra de Huautla Biosphere Reserve (REBIOSH; polygon shaded in gray) in the south of the state of Morelos, in central Mexico, bordering the states of Guerrero and Puebla. b) The ejidos (polygons shaded in dark gray) inside the REBIOSH (polygon shaded in light gray), where we obtained the 25 different records of jaguarundi (numbers in yellow correspond to the numbers in the Id column on Table 2). Ejidos: AXU-SAN = Ajuchitlán-Santiopa; LIM = El Limón de Cuauichinolola; HUAU = Huautla; HUAJ = Huaxtla; HUIX = Huixtla; RV = Rancho Viejo; SAN = Santiopa; PL = private lands.

Table 1. Capture rates (independent records per 1,000 trap days) for jaguarundis reported in the literature across different sites in Mexico. CR = Capture rate (individuals/1000 traps day); IR = Independent records (separated at least 24 hours apart in the same chamber); SE = Total sampling effort reported in trap days; TF = Temperate forest; MF = Medium forest; DF = Dry forest; TS = Thorn scrub; MANG = Mangrove; SV = Secondary vegetation; AGR = Agricultural area; POF = Pine-oak forest; ACAH = Acahual; CS = Crassicaule scrub.

CR	IR	SE	SITE	VEGETATION	YEAR	REFERENCE
3.76	126	33,488	Northeast Mexico (northeast Nuevo León and Sierra de Tamaulipas)	TF, DF, TS	2008-2010	Lombardi et al. (2022)
3.52	5	1,426	Estuary in Puerto Vallarta, Jalisco	MANG	2011-2012	García-Padilla et al. (2021)
2.80*	4	2,669	Calakmul Biosphere Reserve, Campeche	MF, DF	2021-2023	Méndez-Tun et al. (2025)
1.73*	15	8,669	Michoacán	TF, DF, MF, SV	2003-2013	Charre-Medellín et al. (2015)
1.7**	47	27,014	Sierra Madre del Sur, Guerrero	TF, DF, MF, SV, AGR	2009-2018	Ruiz-Gutiérrez et al. (2023)
1.50*	33	11,702	Tehuacán-Cuicatlán Biosphere Reserve, Puebla-Oaxaca	DF	2012-2014	Fariás et al. (2015)
0.97	5	5,103	Sierra Madre del Sur, Guerrero	POF, DF	2018-2019	Briseño-Hernández et al. (2015)
0.87*	1	1,152	El Edén Ecological Reserve, Quintana Roo	MF, ACAH	2010	Ávila-Nájera et al. (2015)
0.63 ± 0.67	25	27,789	Sierra de Huautla Biosphere Reserve, Morelos	DF	2009-2022	Present study
0.44	4	9,000	Los Chimalapas, Oaxaca	MF, SV	2009-2013	Briones-Salas et al. (2016)
0.29	1	3,486	Petatlán, Guerrero	DF, TF, AGR	2011	Ruiz-Gutiérrez et al. (2015)
0.30 ± 0.40	1	3,300	Tehuacán-Cuicatlán Biosphere Reserve, Puebla-Oaxaca	CS, DF	2012	Cruz-Jácome et al. (2015)
0.23*	1	4,380	Zicuirán-Infiernillo Biosphere Reserve, Michoacán	DF	2013-2014	Urrea-Galeano et al. (2016)

* = Capture rate inferred from reference data.

1,000 trap days, with a mean value (\pm standard deviation) of 0.63 ± 0.67 .

The details of each of the 25 independent jaguarundi records, including date, time, altitude, location, and site, are presented in Table 2. Most recordings were obtained from cameras located in ravines and within large fragments (ranging from 80 to over 1,500 ha) of preserved dry forest at elevations below 1,200 m. Of these independent photographic records, 23 were taken during the day, between 07:43 and 17:51 h., and the other two were taken at night, at 20:33 and 23:08 hr.

Other wildlife species were recorded with the jaguarundi on the same cameras. They coincided in five or more sites: white-nosed coati (*Nasua narica*), chachalaca (*Ortalis poliocephala*), white-tailed deer (*Odocoileus virginianus*), coyote (*Canis latrans*), and gray fox (*Urocyon cinereoargenteus*). In four sites: raccoon (*Procyon lotor*), margay (*Leopardus wiedii*), and northern opossum (*Didelphis virginiana*). And between 1 and 3 sites: armadillo (*Dasypus mexicanus*), collared peccary (*Dicotyles tajacu*), northern cacomixtle (*Bassariscus astutus*), American hog-nosed skunk (*Conepatus leuconotus*), southern spotted skunk (*Spilogale angustifrons*), southern striped skunk (*Mephitis macroura*), bobcat (*Lynx rufus*), and puma (*Puma concolor*).

Our data provide evidence of the jaguarundi's constant presence in the REBIOSH for at least seven years, suggesting a resident population, especially in the southern and northeastern areas of the reserve. However, the species' abundance was low, as indicated by the capture success rates for the species in each of the surveys in which it was recorded. Furthermore, the percentage of cameras that recorded jaguarundi was low, ranging from 0.4% to 3.0% of the total number of cameras used in each sampling (35-61).

The jaguarundi's low photographic capture rate appears typical across its range. [Harmsen et al. \(2024\)](#) compiled these data for different countries where the species is

present. They inferred that the species' photographic capture rate ranges from 0.86 to 5.74 detections per 1,000 trap days (with an average of 2.34 across 13 countries in Mesoamerica and South America).

In Mexico, the jaguarundi's photographic capture rate is also generally low, ranging from 0.23 to 3.76 independent records of the species per 1,000 trap days (see Table 1 for data and references). The REBIOSH capture rate falls at the lower end of the range reported across various locations in Mexico. However, this may partly be due to our sampling design, as most cameras were placed in large fragments of conserved dry forest. In contrast, fewer cameras were set in areas with mosaics of disturbed dry forest, agricultural areas, and secondary vegetation.

The jaguarundi tolerates moderate anthropogenic disturbances, preferring mosaics of tropical forests with small agricultural and grassland zones ([Giordano 2016](#); [Coronado-Quibrera et al. 2019](#)), but it requires primary forest habitats. The main threat to the species is habitat loss and fragmentation, especially from large-scale agriculture and pasture. Also, when small towns are near their habitat, jaguarundis can prey on poultry and are commonly killed in retaliation ([Caso et al. 2016](#)).

Additionally, it has been shown to prefer areas near water at low elevations, and with higher total edge and more landscape patches ([Coronado-Quibrera et al. 2019](#)). The fact that most of our records were from ravines and below 1,200 m is consistent with the species' preference for areas near water sources and at low altitudes, as reported by [Coronado-Quibrera et al. \(2019\)](#).

Furthermore, because the jaguarundi primarily consumes large sigmodontine rodents (e.g., *Sigmodon spp.*), which tend to be more abundant in agricultural or disturbed areas, the jaguarundi may frequently hunt in these areas ([Giordano 2016](#)). Regarding this, eight species of sigmodontine rats and mice have been reported in

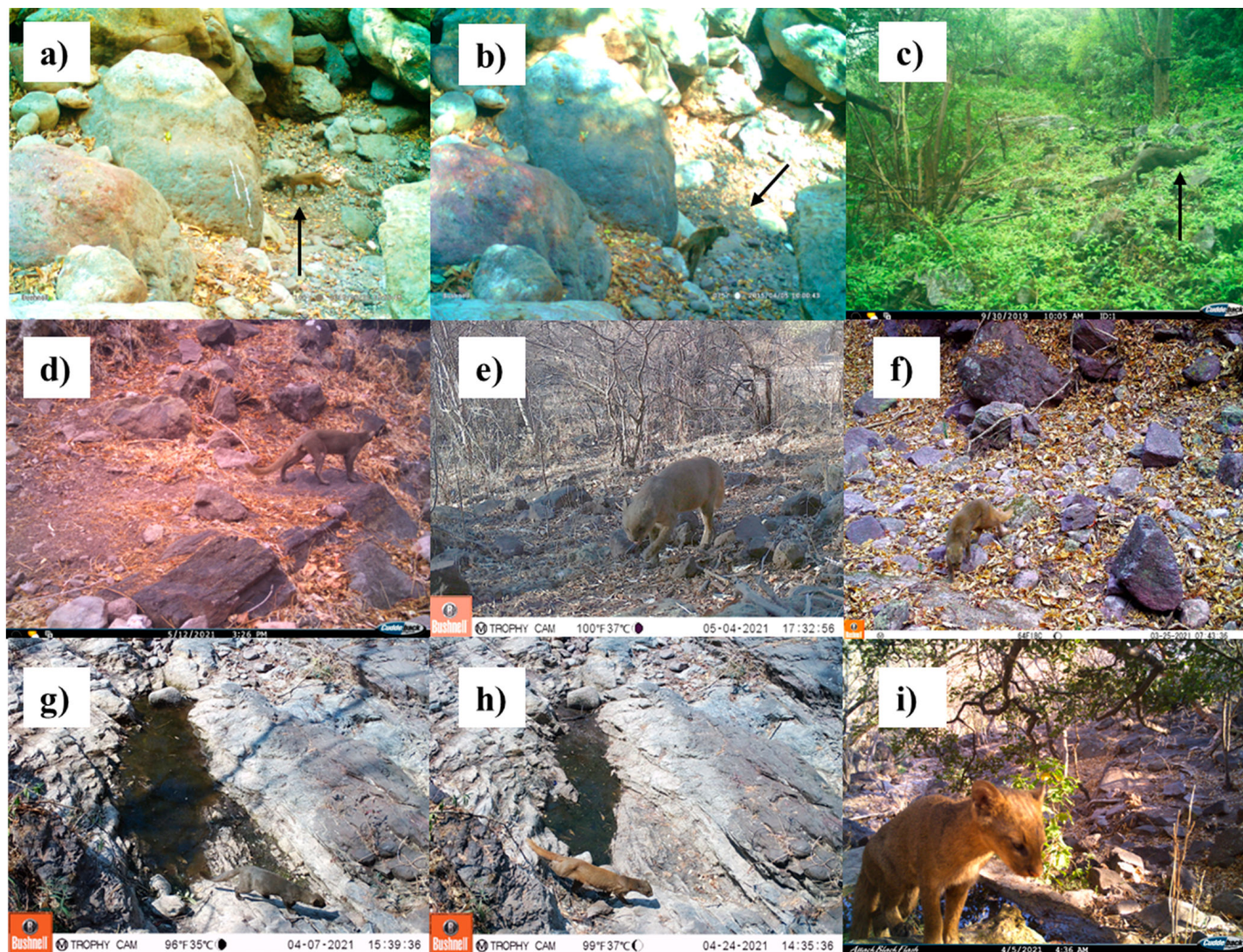


Figure 2. Some photo records of jaguarundi in the Sierra de Huautla Biosphere Reserve, Morelos: a) and b) Reddish and gray morph individuals, recorded in 2015 in Huaxtla; c) an individual of the gray morph recorded in Santiopa in 2019; d) and e) individuals recorded in Huautla in 2020 and 2021, respectively; f) a jaguarundi photographed in El Limón de Cuauchichinola in 2021; g) and h) individuals of the gray and reddish morphs, recorded in the same camera in a water pool in El Limón de Cuauchichinola in 2021; i) individual caught on a photo trap in Santiopa in 2021.

REBIOSH (CONANP 2005), and only three species are medium or large: *Hodomys alleni* (very rare in REBIOSH, with individuals weighing over 100 g); *Peromyscus melanophrys* (abundant in the area, with adult individuals weighing between 30 and 52 g), and *Sigmodon mascotensis* (formerly *S. hispidus*; Martínez-Chapital et al. 2017; not very abundant in REBIOSH, weighing 40-250 g).

Numerous studies on the rodent community confirm that medium- and large-sized sigmodontine rodents are rare in REBIOSH and are more abundant in sites with a certain degree of vegetation disturbance (Cadena 2003; Martínez-Garza et al. 2021; Chávez-Heredia 2024).

Therefore, it is possible that within REBIOSH, jaguarundi records could be obtained more frequently in transitional areas between forest and agricultural lands than within conserved tropical dry forest, where most of our cameras were located.

Within our records, there are individuals of both main color morphs of the species. The reddish form is considered

the ancestral phenotype. The grayish form is a melanistic variant, and the frequency of each color morph varies across different biomes and habitats, with the grayish form being more common in dry forests. The reddish form is more abundant in open habitats (da Silva et al. 2016). On average across its distribution range, in dry forests, the grayish and reddish morphs account for 77 % and 23 % of individuals, respectively.

The grayish form may be advantageous in habitats such as tropical dry forests. Still, the reddish form might be of adaptive value in certain types of more open habitats (da Silva et al., 2016), as could be the case for the extensive agricultural lands beyond the northern limit of the REBIOSH polygon or in the middle portion of Morelos. Whether the reddish form is dominant at those sites remains to be explored.

As expected, since the species has been reported as diurnal, most of our records occurred during the day, and only two were at night. Several studies have reported a clear

Table 2. Detailed data of the 25 independent jaguarundi records we report here for the Sierra de Huautla Biosphere Reserve in Morelos.

Id	Date	Hour	Altitude (masl)	Ejido / Municipality	Site details	Geographic coordinates
1	22/03/2015	15:53	767	Huautla / Tlaquiltenango	A ravine immersed in a fragment of preserved dry forest of approximately 600 ha	18°21'19.39"N / 99°03'43.94"W
2	05/04/2015	10:00				
3	13/01/2018	20:33	1,223	El Limón de Cuauichinola / Tepalcingo	A ravine within a fragment of preserved dry forest of approximately 1,200 ha	18°32'8.41"N / 98°57'29.43"W
4	01/08/2019	10:00	1,089	Huautla / Tlaquiltenango (on private lands used by Huautla)	A fragment of preserved dry forest of approximately 80 ha, surrounded by fragments of disturbed dry forest and secondary vegetation	18°26'55.09"N / 98°59'35.01"W
5	30/09/2019	10:05	1,395	Santiopa / Tlaquiltenango	A ravine descending the slope of a hill with preserved dry forest	18°24'41.73"N / 98°57'41.54"W
6	04/11/2020	16:31	1,025	Huautla / Tlaquiltenango	A ravine in the middle of a fragment of preserved dry forest of approximately 400 ha	18°24'47.28"N / 98°59'9.21"W
7	16/11/2021	09:22	1,162	Rancho Viejo / Tlaquiltenango	In a fragment of preserved dry forest of approximately 500 ha	18°24'36.70"N / 99° 1'38.51"W
8	20/11/2021	23:08	1,159	Axuchitlán-Santiopa / Tlaquiltenango	In a secondary ravine on a hillside within a fragment of preserved dry forest of approximately 80 ha	18°27'12.13"N / 98°58'42.74"W
9	25/03/2021	07:43	1,047	Rancho Viejo / Tlaquiltenango (on private lands used by Rancho Viejo)	In a ravine, between hillsides, within a fragment of preserved dry forest of approximately 750 ha	18°24'39.44"N / 99° 0'23.96"W
10	03/04/2021	14:24	1,167	Huautla / Tlaquiltenango	In a ravine descending a hillside in a fragment of preserved dry forest of approximately 95 ha	18°25'18.86"N / 98°57'59.80"W
11	04/05/2021	09:01				
12	05/04/2021	17:32	1,225	El Limón de Cuauichinola / Tepalcingo	In very wide ravines, within a hilly area in a fragment of preserved dry forest of approximately 1,300 ha	18°31'22.73"N / 98°57'50.63"W
13	11/04/2021	16:45	1,193			
14	07/04/2021	10:26	1,198	El Limón de Cuauichinola / Tepalcingo	In a wide ravine within a preserved dry forest fragment of more than 1,200 hectares	18°31'46.71"N / 98°57'37.59"W
15	07/04/2021	15:39				
16	12/04/2021	17:51				
17	13/04/2021	08:58				
18	24/04/2021	14:35				
19	30/04/2021	10:52				
20	02/05/2021	17:07				
21	08/05/2021	11:44				
22	05/04/2021	16:36	1,408	Santiopa / Tlaquiltenango	On a hillside within a fragment of approximately 70 ha with disturbed dry forest and secondary vegetation	18°26'0.74"N / 98°55'50.12"W
23	12/05/2021	15:26	1,155	Huautla / Tlaquiltenango	In a ravine running down a hillside in a fragment of preserved dry forest of approximately 80 ha	18°27'0.91"N / 98°58'32.58"W
24	13/05/2021	14:59	1,161	Ajuchitlán-Santiopa / Tlaquiltenango	In a secondary ravine running down a hillside within a fragment of preserved dry forest of approximately 80 ha, at the edge of a disturbed dry forest zone	18°25'17.76"N / 98°58'0.76"W
25	08/08/2022	15:09	1,118	Huixtla / Tlaquiltenango	In an area of disturbed dry forest	18°28'37.01"N / 99° 6'43.15"W

diurnal activity pattern for the species, with most records between 06:00 and 17:00 hr and scarce activity in the first hours of the night (Briones-Salas *et al.* 2016; Giordano 2016; Branney *et al.* 2023; Ruiz-Gutierrez *et al.* 2023). Even in human-modified environments, they do not alter their activity patterns when they overlap with those of humans (Cruz *et al.* 2018; Pardo *et al.* 2021).

In places where they coexist with the margay (as is the case of REBIOSH, where the margay is the most abundant wild felid), of very similar size and trophic niche to the jaguarundi, the patterns of both species differ significantly, with the margay restricting its activity almost entirely to the night, which appears to be a mechanism to reduce interspecific competition (Santos *et al.* 2019).

Records of other mammalian species at the same camera traps where the jaguarundi was photographed indicate a carnivore community dominated by mesocarnivores. Although the puma, a potential predator of jaguarundi, was recorded, it is not abundant in the area, and jaguarundi may be only occasional prey in the puma's diet (Magioli and Ferraz 2018).

Our results significantly increase the number of jaguarundi records in Morelos. Previously, there were very few records on the state. The only five records for the state reported on the GBIF (Global Biodiversity Information Facility) biodiversity data platform (GBIF Occurrence Download <https://doi.org/10.15468/dl.zpmxux>) include four photographic records in the i-Naturalist MX platform and a specimen that was hit by a car and collected in August 2009, on the Cuernavaca-Tepoztlán highway. The specimen was prepared for preservation and deposited in the CIByC-UAEM Mammal Collection (CMC-4004).

The records in the i-Naturalist MX platform are: 1) a jaguarundi documented in 2016 in Cuernavaca, Morelos; 2) an individual involved in a vehicular collision and rescued by personnel of the Federal Attorney's Office for Environmental Protection (PROFEPA for its acronym in Spanish) in 2017 on land in the community of Bonifacio García, Tlaltizapán, that later was released (once recovered) inside the REBIOSH (<https://www.gob.mx/profepa/prensa/rescata-y-libera-profepa-un-ejemplar-de-yaguarundi-en-morelos>); 3) another jaguarundi individual involved in a vehicle collision on June 27, 2022, near kilometer 43 on the Siglo XXI highway, approximately 2 km south of Tlaltizapán, as recorded by Biologist Alan Pérez García. Finally, 4) one individual was photographed near an apantle (an irrigation canal) in agricultural lands of the ejido Palo Blanco-Organera, municipality of Axochiapan, close to the border with Puebla state.

In scientific literature, there are also a few records of the species reported for Morelos. For example, Vargas *et al.* (1992) examined the skeletal remains of an individual found north of the town of Ticumán, municipality of Tlaltizapán. Sánchez-Hernández and Romero-Almaráz (1995) observed an individual in Ajuchitlán, within the REBIOSH. Finally, Altamirano-Álvarez *et al.* (2009) documented the species in the community of El Paredón, in the municipality of Miacatlán.

There are also sporadic records in nearby areas. Notably, PROFEPA personnel, with the help of CIByC-UAEM personnel, rescued a jaguarundi cub drowning in an apantle in Tlaquiltenango municipality in May 2010 (<https://www.launion.com.mx/morelos/zona-sur/noticias/5276-rescatan-a-un-jaguarundi-en-tlaquiltenango.html>). They also rescued another cub in Emiliano Zapata municipality in August 2020 (<https://www.facebook.com/watch/?v=1166557767041609>). And more recently, personnel of the National Institute of Archaeology and History (INAH, for its Spanish acronym) reported the first sighting of the species at the archaeological site of Xochicalco in August

2025 (<https://www.facebook.com/share/v/19HDoiTLU2/>).

Therefore, the present study enhances our understanding of the species' distribution in Morelos, indicating a persistent presence of jaguarundi at the REBIOSH over the years, suggesting a resident population with a broad distribution, particularly in the southern and northeastern portions, albeit with low abundance. This highlights the significance of REBIOSH for the conservation of Morelos' biological diversity and, in this case, for protecting this threatened wild feline species. We believe that for the jaguarundi to remain in the REBIOSH and to contribute to its conservation in Morelos, it is necessary to continue monitoring its presence within the PNA and include sampling in areas with disturbed dry forest, secondary vegetation, and agricultural zones to assess whether its abundance increases in these more heterogeneous environments.

Also, we consider that a relevant issue for the conservation of the jaguarundi in this protected area, and across Morelos, should be to conduct detailed research on rural residents' perceptions of the species in the region and to determine if there are any conflicts arising from the predation of poultry by the jaguarundi that could motivate hunting of its individuals in retaliation, given that predation of poultry is a known threat to the species (Caso *et al.* 2015; Giordano 2016; Flores-Armillas *et al.* 2020).

Finally, it is necessary to identify potential biological corridors through which this species could be moving toward nearby areas not yet protected, or even reaching other protected areas, such as the Sierra de Montenegro State Reserve (in whose vicinity it has been recorded). In these biological corridors, it will be crucial to implement Other Effective Area-based Conservation Measures (OECMs; Grupo de Trabajo de la UICN-CMAP sobre OMEC 2021), including, for example, Areas Voluntarily Set Aside for Conservation (ADVCS; <https://advc.conanp.gob.mx/sample-page/>).

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State of knowledge of the Mexican agouti (*Dasyprocta mexicana*): an understudied endemic mammal in Mexico

Estado de conservación del agutí mexicano (*Dasyprocta mexicana*): un mamífero endémico poco estudiado en México

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Dasyprocta mexicana is a rodent species endemic to Mexico, currently classified as Critically Endangered by the IUCN but absent from Mexican environmental legislation. Its distribution includes the states of Veracruz, Oaxaca, Chiapas, and Tabasco, and it has been introduced to Cuba. The species is characterized as a diurnal frugivore-granivore, playing a key ecological role as a seed disperser. A systematic review of 42 scientific articles was conducted to document the current state of knowledge regarding the distribution, ecology, and conservation of the species. Presence of *D. mexicana* was documented in 17 localities, mainly within protected natural areas, with variable abundances. Results indicate a preference for well-preserved forests, although some studies report a degree of adaptability to disturbed habitats. The species faces critical threats including deforestation, habitat fragmentation, and subsistence hunting, having lost over one third of its natural habitat. Despite increased research efforts in the past decade, significant knowledge gaps remain. The discrepancy between its critical global status and national lack of protection highlights the urgent need to revise conservation policies and implement long-term monitoring and research programs to ensure its survival.

Keywords: Conservation, endemic species, Mexican agouti, rodents, tropical forests.

Dasyprocta mexicana es un roedor endémico de México catalogado en peligro crítico por la UICN pero ausente en la legislación ambiental mexicana. Su distribución abarca los estados de Veracruz, Oaxaca, Chiapas, Tabasco y fue introducido en Cuba. Se caracteriza por ser un frugívoro-granívoro diurno, con un papel ecológico clave como dispersor de semillas. *Métodos:* Se realizó una revisión sistemática de 42 artículos científicos para documentar el estado actual de conocimiento sobre la distribución, ecología y conservación de la especie. Se documentó la presencia de *D. mexicana* en 17 localidades, principalmente en áreas naturales protegidas con abundancias variables. Los resultados muestran que la especie prefiere selvas conservadas, aunque algunos estudios indican cierta adaptabilidad a hábitats perturbados. La especie enfrenta amenazas críticas como deforestación, fragmentación y cacería de subsistencia, habiendo perdido más de un tercio de su hábitat natural. Aunque la investigación se ha intensificado en la última década, persisten importantes vacíos de conocimiento. La discrepancia entre su estado crítico global y su desprotección nacional evidencia la urgente necesidad de revisar políticas de conservación e implementar programas de monitoreo e investigación a largo plazo para garantizar su supervivencia.

Palabras clave: Agutí mexicano, bosques tropicales, conservación, especies endémicas, roedores.

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Dasyprocta mexicana, commonly known as the Mexican agouti, is a rodent of the family Dasyproctidae, endemic to Mexico, whose distribution is restricted to the south-southeastern region of the country, encompassing the states of Veracruz, Oaxaca, Tabasco, and Chiapas. It has also been introduced to Cuba ([Retana & Lorenzo 2002](#); [Sánchez-Cordero et al. 2005](#); [Borroto-Páez 2009](#); [Santos-Moreno 2014](#); [IUCN 2023](#)). However, recent phylogenetic studies based on mitogenomic analyses have questioned the taxonomic validity of several species within the genus *Dasyprocta*, suggesting that some traditionally recognized species may represent lineages within broader species complexes. Consequently, the specific identity of *D. mexicana* requires molecular taxonomic revision

([Ruiz-García et al. 2022](#)). Morphologically, the species is characterized by a predominantly dark coloration, with adults weighing between 2 and 4 kg (Figure 1) ([McWilliams 2009](#)). This species has demonstrated notable adaptability to various habitat types, particularly tropical environments, where it primarily inhabits tall, medium, and lowland rainforests, as well as ecosystems with evergreen, semi-evergreen, and deciduous vegetation, including secondary growth and disturbed areas ([Cortés-Marcial & Briones-Salas 2014](#); [Zambrano et al. 2015](#); [Hernández-Sánchez et al. 2017](#); [Pozo-Montuy et al. 2019](#); [Flores-Martínez et al. 2022](#); [Franquesa-Soler et al. 2023](#)). *Dasyprocta mexicana* exhibits frugivorous-granivorous feeding habits, playing a key ecological role as both seed disperser and seed predator in



Figure 1. *Dasyprocta mexicana* (Mexican agouti) recorded by camera trap at the El Zapotal Ecological Recreational Center, Chiapas, Mexico. February 2023.

tropical ecosystems. It establishes interspecific competition for food and space with other large-bodied rodents, particularly the paca (*Cuniculus paca*) (Santos-Moreno & Pérez-Irineo 2013; Zambrano *et al.* 2015; Gallina & González-Romero 2018; Hernández-López & López-Castilla 2025).

The geographic distribution of *D. mexicana* is confined to tropical and subtropical regions of Mexico, especially in forested areas, where tropical forests provide essential habitat for its survival. Its strong association with tropical forests—such as Los Tuxtlas (Veracruz), the Selva Zoque in Oaxaca, and protected areas in Chiapas like the Selva El Ocote Biosphere Reserve—highlights its dependence on well-preserved ecosystems, even in areas subject to hunting pressure (Lira-Torres & Briones-Salas 2011; Zambrano *et al.* 2014; Ríos-Solís *et al.* 2021; Rodas-Trejo *et al.* 2025a). Nevertheless, there are also records of its use of degraded habitats, including oil palm plantations (Franquesa-Soler *et al.* 2023).

Dasyprocta mexicana is currently classified as Critically Endangered (CR) on the IUCN Red List (2023); however, it is not listed under any risk category within the current Mexican environmental legislation (SEMARNAT, 2019). This discrepancy poses a challenge for implementing local and regional conservation strategies, as national policies do not adequately reflect the urgency of protecting the species.

This study conducted a comprehensive review of the scientific literature available on *D. mexicana*, with the aim of compiling and analyzing information related to its distribution, ecology, and conservation status. A

systematic search for scientific articles was carried out using databases such as Google Scholar, Scopus, Web of Science, SciELO, and AI-powered search engines such as ResearchRabbit and Semantic Scholar. The latter provided additional advantages by identifying non-obvious bibliographic connections through citation network analysis and suggesting relevant literature using machine learning algorithms, thereby helping to detect studies that might have been missed through traditional keyword-based searches (Rodas-Trejo, 2024).

The keywords used for the search included: "*Dasyprocta mexicana*", "Mexican agouti", "aguti mexicano", and "sereque mexicano". Additionally, the reference lists of the retrieved articles were reviewed to identify further relevant studies. Inclusion criteria comprised any studies that provided information on the species. Studies focusing solely on other *Dasyprocta* species were excluded. The information gathered was organized by Mexican state and synthesized in a comparative table displaying documented records of the species, type of record, abundance, and locality.

Furthermore, occurrence data for *D. mexicana* were retrieved from the Global Biodiversity Information Facility (GBIF), and the species' distribution range established by the IUCN was reviewed (Roach *et al.* 2024). Based on this information, a distribution map was created, integrating documented GBIF records, IUCN range maps, and localities reported in the reviewed scientific literature.

The systematic review included 42 scientific articles reporting records of *D. mexicana*, complemented by 1,050

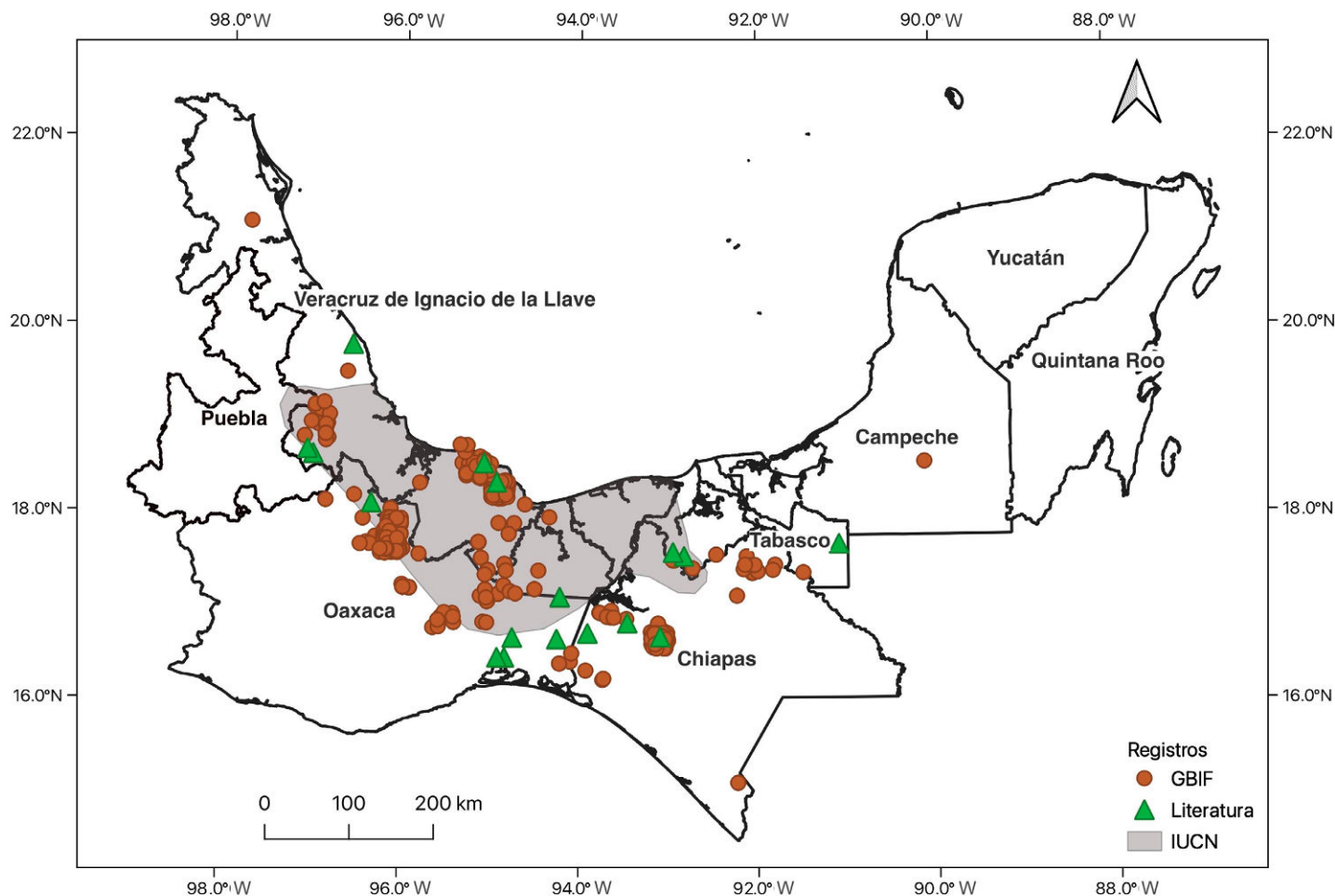


Figure 2. Known geographic distribution of *Dasyprocta mexicana* in southeastern Mexico. Brown circles represent occurrence records from the Global Biodiversity Information Facility (GBIF, 2025), green triangles indicate localities documented in the reviewed scientific literature, and the shaded area corresponds to the distribution map based on IUCN records (Roach et al. 2024).

occurrence records obtained from the Global Biodiversity Information Facility (GBIF, 2025). The distribution of records by state revealed the highest concentration in Oaxaca (705 GBIF records; six localities in the literature), followed by Veracruz (246 GBIF records; five localities), Chiapas (84 GBIF records; three localities), Tabasco (14 GBIF records; three localities), and Campeche (one GBIF record; one locality). GBIF records were clustered in four main areas: the Sierra de Juárez in northern Oaxaca (110 records), the Sierra de Santa Martha and the Los Tuxtlas Biosphere Reserve in Veracruz (89 and 60 records, respectively), and the El Zapotal Ecological and Recreational Center in the city of Tuxtla Gutiérrez, Chiapas (57 records) (Figure 2).

Both GBIF data and scientific literature revealed records outside the species' distribution range as defined by the IUCN, specifically in northern Chiapas near the municipality of Palenque, within the Selva El Ocote Biosphere Reserve, and in the southern region of Oaxaca. An additional record from the state of Campeche was documented, although it is likely the result of a misidentification.

Among the 42 reviewed studies, 23 reported sightings of *D. mexicana* as part of broader mammal community monitoring efforts. The remaining articles addressed topics such

as the traditional use of mammals by rural communities, the status of endemic species in Mexico, interspecific interactions, and activity patterns of wildlife species. Only three studies focused specifically on *D. mexicana*.

Studies indicate that *D. mexicana* exhibits predominantly diurnal activity patterns, with records between 05:00 and 19:00 h, although crepuscular and nocturnal activity has also been observed (McWilliams 2009; Lira-Torres & Briones-Salas 2012; Ríos-Solís et al. 2021). A comparative study conducted in two protected areas in Chiapas demonstrated that although the species maintains a generally diurnal pattern, it may exhibit temporal variation in activity in response to differing levels of anthropogenic disturbance (Rodas-Trejo et al. 2025b). Regarding home range, Estrada-Crocker and Naranjo-Piñera (1998) documented that *D. mexicana* occupies an estimated 3.65 hectares in El Zapotal Ecological and Recreational Center in Chiapas. From an ecological perspective, the species has been reported to act as both seed disperser and seedling predator, particularly for species such as *Poulsenia armata* (Asquith et al. 1999; Zambrano et al. 2015). It also serves as prey for mesopredators such as the ocelot (*Leopardus pardalis*) (Hernández-Sánchez et al. 2017).

Dasyprocta mexicana faces several threats, including deforestation, habitat fragmentation, and subsistence hunting (Sánchez-Cordero *et al.* 2005). The degradation of its natural habitat has resulted in a substantial loss of forest cover; it is estimated that the species has lost over one-third of its original habitat due to deforestation and land-use change, primarily from the conversion of forests to pastures, plantations, and agricultural fields (Sánchez-Cordero *et al.* 2005; Pedraza 2008). This habitat loss has increased the species' vulnerability, particularly in the state of Oaxaca, where it is among the four most vulnerable endemic mammal species (Ramírez-Bautista *et al.* 2020). Although *D. mexicana* has traditionally been associated with well-preserved tropical forests, recent records in oil palm plantations and disturbed areas suggest a certain degree of ecological plasticity, which warrants further investigation (Franquesa-Soler *et al.* 2023).

In addition to habitat loss, subsistence hunting represents a significant pressure, as *D. mexicana* is one of the most frequently consumed wild mammals in the dry forests of the Mexican Pacific, in the Selva Zoque of Oaxaca, and in the Lacandon Jungle in Chiapas (Naranjo & Cuarón 2010; Lira-Torres & Briones-Salas 2011; Lira-Torres *et al.* 2012; Palacios-Silva *et al.* 2017). Furthermore, Lira-Torres and Briones-Salas (2012) documented that *D. mexicana* is also hunted due to the damage it causes to crops in the Selva Zoque region of Oaxaca.

In terms of health, Cucchi-Stefanoni *et al.* (2008) reported mortality cases caused by severe anemia due to infestation with fleas of the genus *Echidnophaga*. They also documented skin lesions characterized by dorsal alopecia and hyperplastic perivascular dermatitis, highlighting the species' susceptibility to dermatological and hematological conditions associated with ectoparasites.

Research on *D. mexicana* remains limited. Most studies have focused on the states of Veracruz, Oaxaca, and Chiapas, with few records from Tabasco (Santos-Moreno & Pérez-Irineo 2013; Pozo-Montuy *et al.* 2019; Zagal-García *et al.* 2022; Franquesa-Soler *et al.* 2023). Furthermore, there are very few studies exclusively dedicated to this species; most records derive from broader mammal community surveys, primarily using camera traps and sign surveys. Of the three studies specifically focused on *D. mexicana*, one estimated population size and density, feeding habits, effects on understory vegetation, and home range at the "El Zapotal" Ecological and Recreational Center (Estrada-Crocker and Naranjo-Piñera 1998); another examined activity patterns by comparing an urban protected area and a wild area (Rodas-Trejo *et al.* 2025b), both conducted in Chiapas; and the third reported mortality associated with flea infestation (Cucchi-Stefanoni *et al.* 2008).

Regional Studies. In the state of Oaxaca, the presence of *D. mexicana* has been documented across various regions and ecosystems. In the Sierra Norte-Mixe, Hernández-Sánchez *et al.* (2017) recorded the species primarily in semi-evergreen forest, where it was positively associated

with *L. pardalis*, suggesting its key role in the food web as a prey species. In contrast, Cortés-Marcial and Briones-Salas (2014) recorded a single individual in the Isthmus of Tehuantepec, marking the first documentation of the species in deciduous lowland forest. Meanwhile, in Santa María Chimalapa, within tropical evergreen forest, Santos-Moreno and Pérez-Irineo (2013) recorded five individuals.

In the Zoque Forest of Oaxaca, several studies have focused on *D. mexicana*. Lira-Torres and Briones-Salas (2012), along with Lira-Torres *et al.* (2012), made significant contributions to the understanding of the species in this region, where it was identified as the third most abundant species in the Chimalapas region. These authors demonstrated that *D. mexicana* prefers well-preserved forests, even in areas with hunting pressure, while avoiding secondary vegetation. The study also identified *D. mexicana* as an important species for local subsistence, as it is used as a source of animal protein (bushmeat) in the region.

Regarding its altitudinal distribution, Ramírez-Bautista *et al.* (2020) reported that in Oaxaca, the species occurs between 50 and 650 meters above sea level, indicating a relatively narrow elevational range of 600 meters, which may increase its sensitivity to climate change. Furthermore, this study identified *D. mexicana* as one of four species classified as "highly vulnerable" under the most severe climate change scenario projected for the late century (2075–2099). In Cerro Tepezcutinte, in the municipality of San Miguel Soyaltepec, Pérez-Irineo and Santos-Moreno (2012) found *D. mexicana* to be the third most frequently recorded species. Finally, in San Lorenzo Pápalo, located in the municipality of Concepción Pápalo, within the Cuicatlán Valley, Solís and Casas (2019) documented *D. mexicana* as one of the hunted species in a study assessing traditional ecological knowledge and wildlife use.

In the state of Veracruz, research on *D. mexicana* has been especially abundant in the Los Tuxtlas region. Flores *et al.* (2014), working in the Los Tuxtlas Biosphere Reserve, obtained 2,863 independent records, while Flores-Martínez *et al.* (2022) recorded 318 individuals, and also found a negative relationship between *D. mexicana* and mesopredators such as the ocelot (*L. pardalis*) and the coyote (*Canis latrans*). Similarly, Zagal-García *et al.* (2022) documented its presence during the rainy season in experimental ecological restoration plots, specifically in plantations composed of animal-dispersed plant species. Ríos-Solís *et al.* (2021) conducted a study on medium- and large-sized mammal diversity and activity patterns in the same reserve and reported *D. mexicana* as one of the species with the highest capture rate. They recorded a primarily diurnal activity pattern (67.1% of records), with some crepuscular (25.6%) and nocturnal (7.3%) activity. *Dasyprocta mexicana* was described as a relatively common species in the tropical forests of the region. González-Christen and Coates (2019) also reported the species as part of the regional mammalian fauna of the Los Tuxtlas Biosphere Reserve.

In other areas of Veracruz, [Salazar-Ortiz et al. \(2020\)](#) detected only three individuals in the municipality of Tequila, classifying the species among “rare mammals” and noting that these records represented new localities within its potential distribution range. In contrast, [Gallina and González-Romero \(2018\)](#), during monitoring efforts in the La Otra Opción Ecological Reserve, identified *D. mexicana* as the fourth most common species. In the Sierra de Zongolica, [Mezhua-Velázquez and Bolívar-Cimé \(2023\)](#) documented its presence and classified it among the species potentially affected by anthropogenic pressures, particularly from feral dogs. In the same area, [Mezhua-Velázquez et al. \(2022\)](#) reported *D. mexicana* as the most frequently recorded species, and identified three types of uses by local residents: for food, commercial trade, and sport hunting.

[Peterson et al. \(2000\)](#), in a study aimed at identifying conservation priorities for endemic species in Veracruz, listed *D. mexicana* among the eight priority endemic mammal species, with a distribution area estimated at 1,712 km². [González Kuk and Neger \(2020\)](#) documented the integration of *D. mexicana* into conservation initiatives with sustainable use, such as Wildlife Management Units (UMAs), specifically in “La Otra Opción” in Los Tuxtlas, where the species is promoted through ecotourism.

In the state of Chiapas, [Estrada-Crocker and Naranjo-Piñera \(1998\)](#), in a study conducted at the El Zapotal Ecological and Recreational Center—where *D. mexicana* was accidentally introduced after escaping from an enclosure at the Miguel Álvarez del Toro Zoo (ZOOMAT)—reported population densities ranging from 3.2 to 5.4 individuals/ha. This research also provided dietary information, documenting the consumption of 44 plant species and ten fungal genera, with the latter representing the first recorded instances of mycophagy in this species. [Lorenzo et al. \(2017\)](#), in an assessment of the current status of terrestrial mammal diversity, distribution, and conservation in Chiapas, recorded *D. mexicana* in the Highlands and Sierra Madre of Chiapas, across various vegetation types, including tall, medium, and lowland tropical forests—evergreen, semi-evergreen, deciduous—as well as secondary vegetation and human settlements.

In the Selva El Ocote Biosphere Reserve, [Pozo-Montuy et al. \(2019\)](#) and [Rodas-Trejo et al. \(2025a\)](#) found *D. mexicana* to be the second most frequently recorded species after *C. paca*. However, these studies reported contrasting habitat preferences. While [Pozo-Montuy et al. \(2019\)](#) documented the species primarily in disturbed areas—suggesting a degree of adaptation to modified habitats—[Rodas-Trejo et al. \(2025a\)](#) found it to prefer less disturbed zones, located at lower elevations and further from major roads. Additionally, [Riechers-Pérez \(2004\)](#) reported its presence in the Laguna Bélgica Ecological Conservation Zone in Ocozocoautla.

In the state of Tabasco, [Franquesa-Soler et al. \(2023\)](#) documented the presence of *D. mexicana* in oil palm

plantations within a highly deforested region near the municipality of Tenosique. The species was photo-recorded in two out of eleven plantations surveyed and also reported by farmers in two additional localities, suggesting a certain degree of adaptability to anthropogenically modified environments. [Gordillo-Chávez et al. \(2023\)](#), on the other hand, recorded *D. mexicana* in the Sierra de Tabasco State Park, where it was documented across the three studied sierras (Madrigal, Poana, and Tapijulapa), both in medium-height evergreen forest and secondary vegetation.

Dasyprocta mexicana was introduced to Cuba in the 1930s alongside *D. punctata* and *C. paca*, in Sierra de Órganos and Sierra Cristal. It became established by 1967, primarily in the western part of the island—in San Diego, Soroa, and Guanahacabibes in Pinar del Río. Over time, its populations declined, with sporadic sightings reported in San Diego de los Baños between 1990 and 1993. In 2008, a specimen of *D. mexicana* was hunted near Soroa ([Borroto-Páez 2009](#)). However, contrasting these reports of population decline, [Mancina et al. \(2000\)](#) noted that the species was abundant in the Sierra del Rosario Biosphere Reserve.

Scientific literature reviewed documented *D. mexicana* in 17 different locations, mainly within protected natural areas, using primarily camera trap surveys (14 studies), complemented by direct observations and signs of presence. Detection rates varied widely—from a single record in the Isthmus of Tehuantepec to 2,863 records in the Los Tuxtlas Biosphere Reserve (Table 1). The information spans approximately three decades, from the work of [Estrada-Crocker and Naranjo-Piñera \(1998\)](#) to the most recent contributions by [Rodas-Trejo et al. \(2025b\)](#).

Scientific knowledge on *D. mexicana* remains limited, with significant gaps in key areas such as detailed population studies, genetic analyses to confirm taxonomic identity, assessments of its adaptability to disturbed habitats, and determination of specific habitat requirements and connectivity needs. These knowledge gaps hinder the development of effective conservation strategies for a species that has lost over one-third of its natural habitat due to deforestation and land-use change, emphasizing the urgent need to increase research efforts, especially considering its critical conservation status and ecological role in southeastern Mexico’s tropical forests.

The discrepancy between the species’ classification as Critically Endangered by the IUCN and its absence from Mexican environmental legislation reflects methodological differences in risk assessment: while international evaluations rely on distribution models and global population trends, Mexican regulations use more restrictive criteria that often underestimate extinction risk for endemic species ([García-Aguilar et al. 2017](#)). This situation, combined with the urgent need to confirm its taxonomic validity through molecular analyses ([Ruiz-García et al. 2022](#)), highlights the importance of revising and updating

Table 1. Documented records of *Dasyprocta mexicana* at different sites in Mexico. RAI = Relative Abundance Index.

Site	State	Record Type	Records	References
Santa María Chimalapas	Oaxaca	Camera trap	Records = 5	Santos-Moreno and Pérez-Irriego (2013)
Cerro Tepezcuintle, Municipality of San Miguel Soyaltepec	Oaxaca	Camera trap and tracks	Records = 16 RAI = 0.15	Pérez-Irriego and Santos-Moreno (2012)
Selva Zoque	Oaxaca	Camera trap	RAI = 20.16 Records = 98	Lira-Torres and Briones-Salas (2011)
Dry forest of the Isthmus of Tehuantepec	Oaxaca	Camera trap		Cortés-Marcial and Briones-Salas (2014)
Municipality of San Isidro Yolox	Oaxaca	Camera trap	Records = 412	Hernández-Sánchez et al. (2017)
Municipality of Tequila	Veracruz		Records = 3	Salazar-Ortiz et al. (2020)
Los Tuxtlas Biosphere Reserve	Veracruz	Camera trap	RAI = 2	Zagal-García et al. (2022)
Los Tuxtlas Biosphere Reserve	Veracruz	Camera trap	Records = 2,863	Flores et al. (2014)
Los Tuxtlas Biosphere Reserve	Veracruz	Camera trap	Records = 318	Flores-Martínez et al. (2022)
Municipality of Zongolica	Veracruz	Camera trap	Records = 265 RAI = 34.69	Mezhua-Velázquez et al. (2022)
Los Tuxtlas Biosphere Reserve	Veracruz	Camera trap	Records = 81	Ríos-Solís et al. (2021)
La Otra Opción Ecological Reserve	Veracruz	Camera trap	RAI = 1.12.	Gallina and González-Romero (2018)
El Ocote Biosphere Reserve	Chiapas	Camera trap	Area of influence RAI = 24.4 Buffer zone RAI = 15.8 Core zone RAI = 1.9	Pozo-Montuy et al. (2019)
El Ocote Biosphere Reserve	Chiapas	Camera trap	Records = 88	Rodas-Trejo et al. (2025a)
El Zapotal Ecological and Recreational Center	Chiapas	Direct observation and tracks		Estrada-Crocker and Naranjo-Piñera (1998)
Laguna Bélgica Ecological Conservation Zone	Chiapas	Direct observation and tracks		Riechers-Pérez (2004)
Municipalities of Balancán y Tenosique	Tabasco	Camera trap	Records = 67	Franquesa-Soler et al. (2023)
Municipalities of Tacotalpa y Teapa	Tabasco	Direct observation and tracks		Gordillo-Chávez et al. (2023)

national conservation policies to include *D. mexicana* in the NOM-059-SEMARNAT as a species at risk.

Advancing research focused on population demography, molecular genetics, habitat ecology, and responses to anthropogenic disturbances—along with the implementation of long-term monitoring programs—will be essential to generate the evidence-based knowledge needed to support conservation actions and resolve the taxonomic and ecological uncertainties currently limiting the species' effective protection.

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First record of piebaldism in *Corynorhinus townsendii* and mass occurrence of atypical coloration in cave-dwelling bats in Northern Mexico

Primer registro de piebaldismo en *Corynorhinus townsendii* y ocurrencia masiva de coloración atípica en murciélagos cavernícolas en el norte de México

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Chromatic disorders are phenotypically aberrant pigmentation in the skin, fur, or other parts of the integumentary system. More research is needed to understand the prevalence, causes, and consequences of atypical coloration in mammals. In bats, chromatic anomalies are reported globally, but regions such as Northern Mexico remain underrepresented or lacking any data altogether. To start exploring the ecology of atypical coloration in bats, we recorded the number of bats presenting atypical coloration and its prevalence by setting mist nets to capture bats. Also, as supplementary information, the number of bats detected in each cave with an infrared video camera was recorded. This study was conducted in two caves: Santa Catarina Cave in Nuevo León and Muzquiz Cave in Coahuila, Mexico. We recorded the prevalence of atypical coloration, sex, reproductive stage, and age of all the captured bats. Here we report high levels of occurrence of atypically colored *Tadarida brasiliensis*, as well as the first report of piebaldism in *Corynorhinus townsendii*. The prevalence of atypical coloration as a white collar in *T. brasiliensis* in Santa Catarina cave ranged from 0% in August 2023 up to 86.46% in May 2024. For the Muzquiz cave, the prevalence of atypical coloration was 0.17% on December 13th-14th, 2024, with one bat. To our knowledge, this is the first study to report a mass occurrence of atypical coloration that incorporates population composition data about atypically patterned bats in Latin America, including an estimation of the number of bats in the caves and prevalence of atypical coloration. We propose that the next steps for studies on atypical coloration in bats should record as much data as possible when these cases are encountered, with at least data about their age, reproductive stage, and behaviour.

Key words: Albinism; chromatic disorder; Coahuila; Molossidae; Nuevo León; piebaldism; Vespertilionidae.

Los trastornos cromáticos son pigmentaciones fenotípicamente aberrantes en la piel, el pelaje u otras partes del sistema tegumentario. Se necesita más investigación para comprender la prevalencia, las causas y las consecuencias de la coloración atípica en mamíferos. En los murciélagos, se han registrado anomalías cromáticas a nivel mundial, pero regiones como el norte de México siguen estando subrepresentadas o carecen de datos en absoluto. Para explorar la ecología de la coloración atípica en murciélagos, registramos el número de murciélagos que la presentan y evaluamos su prevalencia mediante la captura con redes de niebla. Además, como información complementaria, se registró el número de murciélagos detectados en cada cueva con cámara infrarroja. Este estudio se realizó en dos cuevas: la Cueva de Santa Catarina en Nuevo León y la Cueva de Múzquiz en Coahuila, México. Se registró la prevalencia de coloración atípica, el sexo, la etapa reproductiva y la edad de todos los murciélagos capturados. En este estudio se reportan altos niveles de ocurrencia de *Tadarida brasiliensis* con coloración atípica, así como el primer reporte de piebaldismo en *Corynorhinus townsendii*. La prevalencia de coloración atípica como collar blanco en *T. brasiliensis* en la cueva de Santa Catarina varió del 0 % en agosto de 2023 al 86.46 % en mayo de 2024. En la cueva de Múzquiz, la prevalencia de coloración atípica fue del 0.17 % entre el 13 y el 14 de diciembre de 2024, con un solo murciélagos. Hasta donde sabemos, este es el primer estudio que reporta una ocurrencia masiva de coloración atípica que incorpora datos de composición de la población sobre murciélagos con patrones de coloración atípicos en Latinoamérica, incluyendo una estimación del número de murciélagos en las cuevas además de la prevalencia de la coloración atípica. Proponemos que los próximos pasos para los estudios sobre coloración atípica en murciélagos deben registrar la mayor cantidad de datos posible cuando se detecten estos casos, incluyendo al menos datos sobre su edad, etapa reproductiva y comportamiento.

Palabras clave: Albinismo; alteración cromática; Coahuila; Molossidae; Nuevo León; piebaldismo; Vespertilionidae.

Chromatic disorders are phenotypically aberrant pigmentation in the skin, fur, or other parts of the integumentary system (Uieda 2000; Lucati and López-Baucells 2017). The definitions of the terms regarding chromatic disorders such as Piebaldism, Albinism, and Partial Albinism have been actively debated in the last decade (Zalapa *et al.* 2016). Here, we follow the terms and definitions by Lucati and López-Baucells 2017 and define Piebaldism as a chromatic disorder wherein the hypopigmentation occurs locally at either one or multiple parts of the body (Lucati and López-Baucells 2017). Generally, hypopigmentation in mammals is considered to have negative repercussions for the affected individuals, including increased susceptibility to certain disorders and conditions, being more conspicuous to predators, disrupted intraspecific interaction, and being rendered as unattractive for reproduction (Garipis & Hoffmann 2003; Caro 2005; Lucati and López-Baucells 2017). Despite the recent advancements in chromatic disorder research, the ecological functions of these conditions in mammals remain a subject of ongoing debate (Lucati and López-Baucells 2017). However, in bats, some authors claim that individuals exhibiting atypical coloration because of chromatic disorders are said to be unaffected by increased risks such as predation as they reach their reproductive maturity (Buys *et al.* 2002; Bravo-Salinas and Salas 2022). Notably, numerous reports document chromatic disorders in bats, with evidence confirming that affected individuals successfully mate and reproduce, including observations of pregnancy and lactation (Hernández-Mijangos *et al.* 2009; Marín-Vásquez *et al.* 2010; Sánchez-Hernández *et al.* 2010; García-Morales *et al.* 2012; López-Wilchis and León 2012; Zalapa *et al.* 2016; Biassi *et al.* 2017; Genelhú *et al.* 2022).

In bats, chromatic anomalies are reported globally (Lucati and López-Baucells 2017), and recent studies in Mexico have focused on examples of hypopigmentation such as albinism and piebaldism (Aguilar-López *et al.* 2021; Hernández-Aguilar *et al.* 2025). However, as visually shown in Lucati and López-Baucells (2017), the records of these anomalous colorations are geographically biased, with many regions remaining underrepresented or lacking any data altogether, such as Northern Mexico (Lucati and López-Baucells 2017). For instance, Northern Mexico is a notable region for research on bats, as karst formations are abundant, which provide crucial subterranean habitats such as caves (Elliot *et al.* 2023). Despite the ecological, cultural, and economic importance of cave-dwelling bats in Northern Mexico, bat surveys are limited, and more research effort is needed (Rivera-Villanueva *et al.* 2025).

To improve our baseline knowledge for the conservation of cave-dwelling bats in Northern Mexico, we have been monitoring several roosts to gather data about their richness, abundance, and population trends in Coahuila and Nuevo León states since 2019 to date. As an example of the lack of previous research efforts, we present the first

report of piebaldism in *Corynorhinus townsendii* (Cooper 1837) and the first mass occurrence of atypical coloration of *Tadarida brasiliensis* (L. Geoffroy 1824), with 543 captured individuals exhibiting a white collar-like pattern. Plus, as a supplementary way to understand how many bats were in each cave, we did an infrared video camera recording.

Our study sites were two caves in the Sierra Madre Oriental Mountain range in the municipalities of Muzquiz, Coahuila (28° 0' 0" N, 103° 9' 7.2" W) with 1,089 m, and Santa Catarina, Nuevo León states (26° 18' 0" N, 101° 26' 50.7084" W) with 1,128 m (Figure 1). The main vegetation type surrounding the cave in Coahuila is chaparral and submontane scrub in Nuevo León, Instituto Nacional de Estadística y Geografía (INEGI 2015). The main vegetation elements surrounding Santa Catarina cave are *Helietta parvifolia*, *Ungnadia speciosa*, and *Celtis pallida*. The main vegetation elements surrounding Muzquiz cave are *Leucaena greggii*, *Quercus* sp., and *Mentzelia aspera*. The site of the Muzquiz cave is characterized by a "BSohw" climate, semi-arid with a temperature between 18°C and 22°C, and Santa Catarina cave with a "BS1hw" climate, semi-arid with a mean annual temperature greater than 18°C, according to Köppen's climate classification (García 1998). For the Santa Catarina cave, the fieldwork for this project was conducted on August 12th, 2023; September 15th, 2023; November 1st, 2023, and May 14th, 2024. For Muzquiz Cave, the fieldwork was conducted on December 13-14, 2024.

The aberrantly colored individuals were captured using two 6-meter mist nets and one 12-meter mist net in Santa Catarina Cave, and two 6-meter mist nets in Muzquiz Cave. The sampling effort for Santa Catarina cave was 1,224 net-hours, and for Muzquiz cave was 90 net-hours. We recorded the prevalence of atypical coloration, sex, reproductive stage, and age of all the captured bats. Prevalence was defined as the number of bats that presented the white collar divided by the number of bats captured. The bats were identified using the bat field guide of Medellín *et al.* (2008).

To obtain the supplementary count of bats in flight, a Sony HXR-NX30N video camera with infrared vision, along with a set of battery-powered lamps, was positioned 3 meters from the entrance of each cave. Afterwards, it was positioned to have a complete view of the floor and roof. The filming coverage was during the first three hours of activity, coinciding with mist-netting efforts. We started the recording 5-15 minutes before sunset to make sure that the emergence was recorded. The number of bats recorded by the video was manually counted later in Windows Media Player frame by frame. To minimize counting errors, we followed a modified Ammerman *et al.* (2025) approach. To avoid counting more than once each individual, we counted the number of bats that entered the screen view (considered an entrance to the roost) and the number of individuals that left the screen view (considered as an exit of the roost), but here, it was only considered the

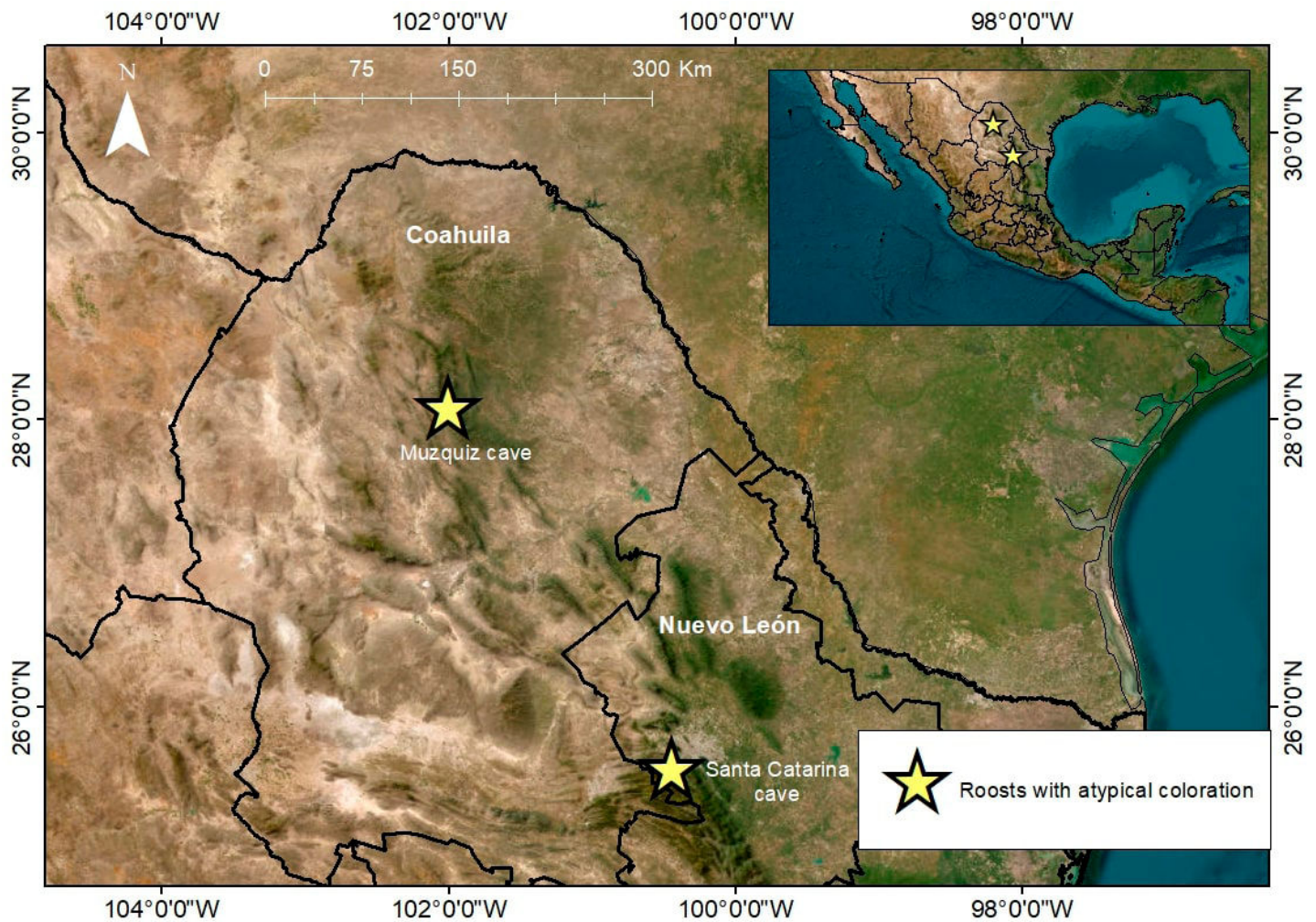


Figure 1. Map of the roosts with mass atypical coloration of cave-dwelling bats.

number of exits as the number of bats per cave. In both caves, all bats were assumed to be *T. brasiliensis*, although their size and shape were not distinguishable from other species. That is why we used the mist netting data as a cross-validation technique. Muzquiz cave is used mainly by *T. brasiliensis*, as has been confirmed by mist-netting we have recorded during the fieldwork of this article, with *Mormoops megalophylla* only present in small numbers in the winter season. For the Santa Catarina cave, *T. brasiliensis* is the most abundant species and has an estimated colony larger than 100,000 individuals, whereas *C. townsendii* has been captured only 5 times now of writing the article (Jimenez et al. 1999). To reduce stress and ensure that bats were handled ethically, we followed the guidelines of Sikes et al. (2016). All collection and handling of wildlife in this study followed the requirements of the General Wildlife Federal Law of Mexico (Ley General de Vida Silvestre) under collection permit SPARN/DGVS/09981/23. No bats were included as collection vouchers.

The prevalence of atypical coloration as a white collar in both males and females of *T. brasiliensis* in Santa Catarina cave ranged from 0% in August 2023 up to 86.46% (prevalence of 0.865) in May 2024 (Table 1; Figure 2). The

peak of captures was in May 2024 with a total of 628 individuals of *T. brasiliensis*: 415 non-reproductive males, 210 non-reproductive females, and 3 pregnant females, all adults. Whereas the lowest number of captures was in August 2023 (Table 1). Due to technical difficulties, the number of bats detected with the infrared video camera was recorded only once per site.

In May 2024, in the Santa Catarina cave, a post-lactating female of *C. townsendii* with piebaldism in both wings was incidentally captured (Figure 2d). The forearm was measured with a caliper to be 42 mm, and weighed 10 g.

Table 1. Prevalence of atypical coloration of *Tadarida brasiliensis* and its captures per site. In parenthesis is the number of bats with the white-collar.

Roost name	Date	Prevalence	Captures
Santa Catarina cave	August 12th, 2023	0.0	14
	September 15th, 2023	0.0172 (1)	58
	November 1st, 2023	0.0	35
	May 14th, 2024	0.865 (543)	628
Muzquiz cave	December 13-14th, 2024	0.0016 (1)	600

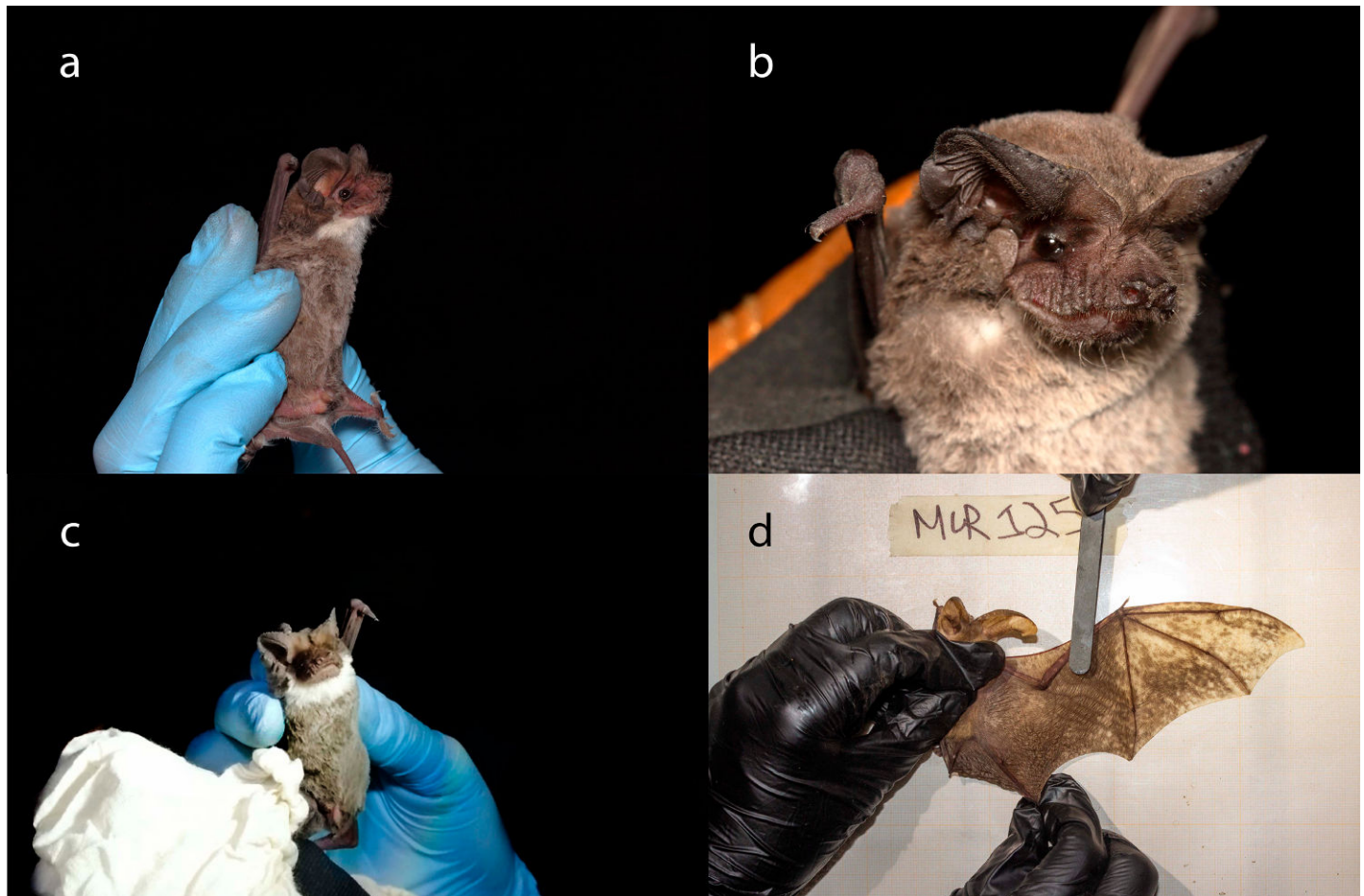


Figure 2. The captured bats with atypical colouration; a-c *Tadarida brasiliensis* exhibiting atypical colouration; d Piebald post-lactating female *Corynorhinus townsendii*.

Table 2. Number of bats detected with the infrared video camera. We considered entrances when we saw a bat flying towards the entrance of the main chamber and fully going inside and exit when we saw the bat going out of the field view and not coming back. Only the exits were considered as the colony size.

Roost name	Date	Entrances	Exits
Santa Catarina cave	November 1st, 2023	282	324
Muzquiz cave	December 13-14th, 2024	10,013	6,584

The piebaldism expressed in this individual as marbled patches of depigmentation on the membrane of the wings between the 5th and the 2nd metacarpal.

For the Muzquiz cave, the prevalence of atypical coloration was only on December 13th-14th 2024, with one bat (0.17%) presenting the atypical coloration, with a prevalence of 0.0016. The estimation of bats recorded with the infrared video camera during the emergence goes from 324 in Santa Catarina cave to 6,584 bats in Muzquiz cave (Table 2).

In *T. brasiliensis*, the atypical patterning was uniform across the surveys; a band of distinct, white-colored fur at the ventral side of the neck (Figure 2a and c). Some of the individuals, however, only exhibited random spots of white fur (Figure 2b).

It is crucial to note that we do not aim to determine the cause and/or the function of aberrant coloration herein, but we aim to report the unusual events that were observed in an underrepresented area that may

be of scientific interest. To our knowledge, this is the first study to report a mass occurrence of atypical coloration that incorporates population composition data about atypically patterned bats in Latin America, including an estimation of bats detected in the caves and the prevalence of atypical coloration. As there is no official definition of mass occurrence of atypical coloration, in our case, we use it when more than 50% of the captured bats present any chromatic disorder.

This interesting phenotypic aberrancy may be due to several factors, such as genetic and environmental influences, or a combination of these factors (Lucati and López-Baucells 2017). Moreover, more research is needed to understand the cause of the mass occurrence of this atypical patterning, as it was not clear from the efforts of this study, and all potential explanations are a matter of speculation. But we can note that our records of atypical colouration are higher than the ones presented in Hernández-Aguilar et al. (2025). Their highest report was in *Natalus mexicanus*, with 30% of piebaldism individuals. But in our case, our biggest record was on May 14th, 2024, where we recorded 543 of 628 (86.46%) individuals with piebaldism (Hernández-Aguilar et al. 2025).

However, interestingly, most aberrantly colored individuals are recorded in sheltered places such as



Figure 3. The Study sites and their surrounding habitats, a Muzquiz cave entrance; b Muzquiz cave surrounding habitat; c-d Abandoned waste at the cave; e Guano filtering equipment left by harvesters; f Santa Catarina surrounding habitat; g Santa Catarina cave entrance.

mines and caves, which some authors link to mitigation of the negative effects of hypopigmentation by the visual obstruction provided by the darkness in these structures (Uieda 2000; Lucati and López-Baucells 2017; Rose et al. 2017). Albeit tree-roosting bats are also known to sometimes show chromatic disorders (Rose et al. 2017; Smith et al. 2019). Furthermore, bats' nocturnal flight behavior renders them hidden from aerial predators that mostly rely on visual cues, thus atypical coloration potentially does not affect their survival (Lucati and López-Baucells 2017). As a result, chromatically aberrant individuals may successfully reproduce, generationally increasing their numbers (Lucati and López-Baucells 2017). Although the debate on the detrimental effect of hypopigmentation on bats' survival remains inconclusive (López-Baucells et al. 2013), the presence of reproductively active individuals (e.g., scrotal testes observed in male *T. brasiliensis* and the piebald *C. townsendii* was in the post-lactating stage) raises questions regarding the extent to which these atypical coloration and patterning affect longevity and reproductive success in bats as reported (Marín-Vásquez et al. 2010).

As methodological clarifications, it should be noted that there were no additional measures to minimize miscounting when processing the video recordings. Furthermore, all detections from the video recording of the emergence were assumed as *T. brasiliensis*, as they are by far the most abundant species in the caves

studied; although Muzquiz cave has recorded *Mormoops megalophylla* and Santa Catarina cave has six additional species, they are known to occur in much lower numbers (López-González et al. 2010). To highlight the effects of these methodological limitations of recording the emergence of *T. brasiliensis* in a cave with an entrance 16 meters wide, there were instances where the number of bats captured in mist nets exceeded the number detected by the infrared camera.

Lastly, we would like to emphasize that it is impossible to have a complete understanding of bats' ecology or population dynamics without appropriate protection and conservation efforts for their roosts. These two roosts face many threats, such as disturbance, vandalism, and guano harvesting (Figure 3c-e), and do not have any conservation scheme. Moreover, subterranean habitats such as caves are priority targets for the conservation of bats, especially in Mexico, where almost half of the native bat species are cave-dwelling species (Frick et al. 2020).

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Consumption of *Myrtillocactus geometrizans* by Frugivorous Bats of the genus *Sturnira* in a Tropical Deciduous Forest in the Bajío, Guanajuato, Mexico

Consumo de *Myrtillocactus geometrizans* por murciélagos frugívoros del género *Sturnira* en un Bosque Tropical Caducifolio en el Bajío, Guanajuato, México

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Frugivory interactions are essential in tropical ecosystems due to their impact on forest regeneration through seed dispersal. Frugivorous bats play a key role in these interactions because of their ability to travel long distances and consume a wide variety of fruits. This study assessed the diet of frugivorous bats in a tropical deciduous forest (TDF). Bats were captured over an annual cycle from May 2023 to March 2024, covering both the rainy and dry seasons. Four mist nets were set among the vegetation and in natural roosts from 18:00 to 01:00 hours. Captured bats were placed in cloth bags to obtain fecal samples. With a sampling effort of 5760 m/net/night, 35 bats from the families Phyllostomidae, Vespertilionidae, and Molossidae were recorded. *Sturnira hondurensis* was the most abundant species. Two genera of plants, *Solanum* and *Myrtillocactus*, were identified from fecal samples of captured individuals. The presence of garambullo (*Myrtillocactus geometrizans*) in the diet of *S. hondurensis* and *S. parvidens* is reported for the first time. The results suggest that the diet of these bats is composed mainly of *Solanum ferrugineum* fruits, supplemented with *M. geometrizans*, reflecting a sequential use of food resources according to plant phenology.

Key words: Bats; El Bajío; frugivory; garambullo; seed dispersal.

Las interacciones de frugivoría son fundamentales en los ecosistemas tropicales debido a su impacto en la regeneración de los bosques mediante la dispersión de semillas. Los murciélagos frugívoros desempeñan un papel clave en estas interacciones al desplazarse grandes distancias y consumir una variedad significativa de frutos. Este estudio evaluó la dieta de murciélagos frugívoros en un Bosque Tropical Caducifolio (BTC). La captura de murciélagos se realizó durante un ciclo anual a partir de mayo de 2023 a marzo de 2024, abarcando la temporada de lluvias y secas. Se instalaron 4 redes de niebla entre la vegetación y en refugios naturales, a partir de las 18:00 a 01:00 horas. Los murciélagos capturados fueron colocados en bolsas de manta para obtener muestras de excretas. Con un esfuerzo de 5,760 m/red/noche, se registraron 35 murciélagos de las familias Phyllostomidae, Vespertilionidae y Molossidae. *Sturnira hondurensis* fue la especie más abundante. A partir de excretas de los individuos capturados, se identificaron 2 géneros de plantas *Solanum* y *Myrtillocactus*. Se reporta por primera vez la presencia del garambullo (*Myrtillocactus geometrizans*) en la dieta de *S. hondurensis* y *S. parvidens*. Los resultados sugieren que la dieta de estos murciélagos se compone principalmente de frutos de *Solanum ferrugineum*, complementada por *M. geometrizans*, reflejando un uso temporal de los recursos alimenticios en función con la fenología de las plantas.

Palabras clave: Dispersión de semillas; El Bajío; frugivoría; Garambullo; murciélagos.

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Bats have established important mutualistic relationships with various Neotropical plants, playing a key role in their reproductive biology (Fleming and Heithaus 1981). The fruits consumed by these animals have specific morphological adaptations to attract them, including fruits exposed outside the foliage, inconspicuous colors such as green or brown, and intense or fermented fragrances (Kalko et al. 1996; Fleming 2005).

In tropical and subtropical ecosystems, fruit bats of the family Phyllostomidae are efficient dispersers of pioneer

plants (Muscarella and Fleming 2007; Kunz et al. 2011). Their diet includes fruits from the families Moraceae, Piperaceae, Urticaceae, and Solanaceae, with broad interactions across the genera *Cecropia*, *Ficus*, *Piper*, *Solanum*, and *Vismia* (Fleming 2004). However, their diet can be influenced by intrinsic and extrinsic factors, including fruit size and availability, inter-specific competition, and ecological habitat factors (Herrera 1989; Karina et al. 2016; Flórez-Montero et al. 2022).

Although this type of interaction has been widely documented in humid tropical areas, it is rare and of little

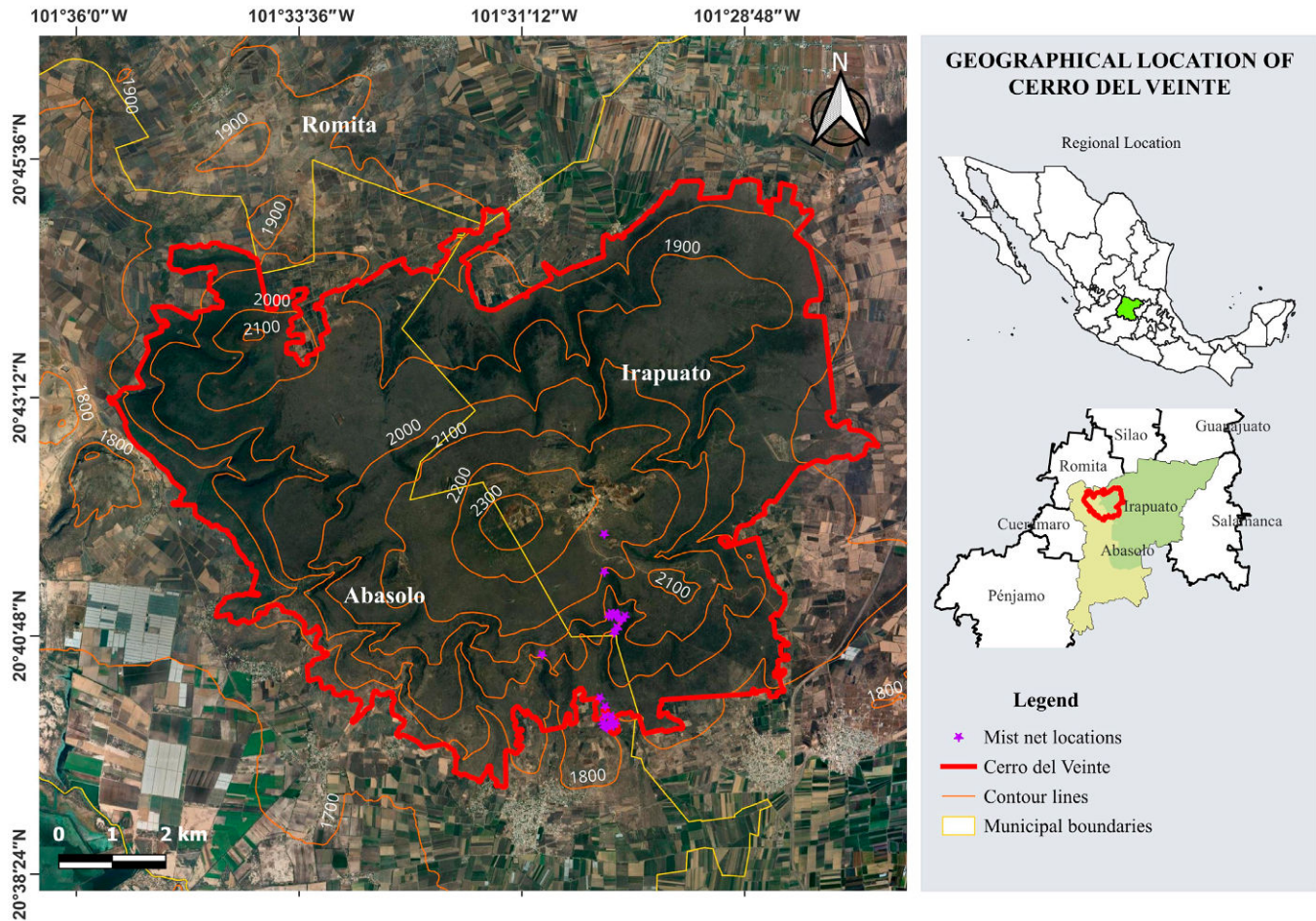


Figure 1. Location of the study area and bat capture sites in Cerro del Veinte, Irapuato, Guanajuato, Mexico.

relevance in arid and semi-arid environments, since most studies have focused on humid ecosystems (Heithaus *et al.* 1975; Heithaus 1982; Galindo-González 1998; Estrada and Coates-Estrada 2001). Numerous studies have addressed the interactions between bats and cacti, although most have focused mainly on nectarivorous species, mainly associated with the pollination of agaves and columnar cacti (Valiente-Banuet *et al.* 1996; Fleming and Valiente-Banuet 2002; Stoner *et al.* 2003), although the consumption of their fruits by bats of the genera *Sturnira* and *Artibeus* has also been reported (Cornejo-Latorre *et al.* 2011).

In this context, cacti acquire ecological relevance as a key resource in arid and semi-arid ecosystems. The family Cactaceae comprises approximately 130 genera and about 1850 species that are naturally distributed in the Americas (Nyffeler y Egli 2010; Hernández-Ledesma *et al.* 2015; Schwertner-Charão *et al.* 2022). Mexico stands out as the country with the highest richness of cactus species worldwide, followed by Brazil, Argentina, and Bolivia. Mexico has recorded 670 cactus species, of which 77 % are endemic to the country (Ortega-Baes *et al.* 2010; Arias and Aquino 2019; Guerrero *et al.* 2019).

This study reports the first documented consumption of *Myrtillocactus geometrizans* (Mart. Ex Pfeiff.) Console, 1897 fruits by bats of the genus *Sturnira* in a tropical

deciduous forest in the Bajío region, Guanajuato, Mexico. The garrambullo (*M. geometrizans*) is a species of columnar cactus endemic to Mexico. It has tubular-shaped flowers, with a characteristic greenish-white color, and produces edible berry-like fruits with a blue-reddish hue. Fruiting occurs between March and September, and a single adult plant has been reported to produce around 7650 fruits (Pérez-Villafaña and Valiente-Banuet 2009). The seeds of this species are dispersed mainly by birds and mammals (Bravo-Hollis 1978; Arias 2010).

The study was carried out in Cerro del Veinte (20°40'46.61" N, 101°29'50.80" W), located approximately 27 km west of the municipality of Irapuato, bordering the municipalities of Cuerámara and Abasolo, Guanajuato, within the Bajío region (Figure 1). It covers an approximate area of 6120 ha, with elevations between 1770 m and 2340 m a.s.l. The characteristic vegetation is tropical deciduous forest, with trees 4 m to 10 m high and marked seasonal phenology, along with cacti such as *Opuntia* and *Myrtillocactus*. The herbaceous stratum is scarce and grows mainly during the rainy season (Rzedowski and Calderón de Rzedowski 1987; Rzedowski *et al.* 1996).

The samplings were conducted monthly between May 2023 and March 2024, on two consecutive nights each month, from 6:00 p.m. to 1:00 a.m. In each sampling session,

four mist nets (12 m × 3 m) were placed at ground level and at heights up to 3 m, separated by 15 to 20 m. These were set in strategic sites, including areas near crops and zones with the presence of *Solanum ferrugineum* and *M. geometrizans*, as well as on dry riverbeds that function as flight corridors. In addition, two caves used as shelters were sampled. The nets were checked every 30 minutes; in the absence of captures, the revision interval was extended by 10 minutes.

The captured bats were handled following the guidelines for the use of wild mammals in research and education established by the American Mammalian Society (Sikes et al. 2016), the biosecurity protocol described in the manual entitled "Investigating the role of bats in emerging zoonoses" issued by the Food and Agriculture Organization of the United Nations (FAO 2011), and "The Field Manual of Bat Handling" published by the Latin American and Caribbean Network for the Conservation of Bats (RELCOM 2020). The captured bats were kept in cloth bags for processing, recording the time of capture, weight (g), sex, reproductive condition, age, and morphometric measurements (forearm) using a digital vernier (Stereon HER – 411, China). Species identification was conducted using the field guide by Medellín et al. (2008).

The consumed seeds were collected using two methods: 1) placement of nylon plastic sheets (12 m × 3 m) under the nets (Galindo-González et al. 2009), and 2) temporary retention of bats in cloth bags (20–30 minutes) until defecation (Castro-Luna and Galindo-González 2012). Fecal samples were stored in labeled Eppendorf tubes. In the laboratory, the excreta were rinsed in a Petri dish with chlorinated water solution to remove traces of fruit and pulp. Seeds were counted, sorted by morphotype, dried on absorbent paper, and examined under a trinocular stereo microscope with zoom (Velab VE – S5, Mexico) for identification. The identification was carried out by consulting online herbaria, such as the National Herbarium of Mexico (MEXU), Luz María Villareal de Puga Herbarium (IBUG), Herbarium of the BUAP Botanical Garden (HUAP), and the electronic repository of the Network of Herbaria of Mexico, as well as by comparison with excreted seeds and fruit seeds obtained by direct collection in the field.

Likewise, the germination rate of the seeds excreted by bats was evaluated and compared to the rate of seeds collected directly from fruits. In total, 368 seeds of *S. ferrugineum* and *M. geometrizans* were sown. To standardize the experimental design and ensure comparability between excreted and non-excreted seeds, the total number of seeds recovered from feces was quantified in each sample, and the same number of non-excreted seeds obtained directly from fruits were sown. In this way, each excreta sample had its respective reference sample with the same initial number of seeds.

Excreted and non-excreted seeds were placed in Petri dishes with agar-agar culture medium (30 seeds per Petri dish). In cases where the number of seeds exceeded this limit,

as many dishes as necessary were used to cover the entire sample. The dishes were maintained and checked daily until radicle growth was observed. The germination percentage was estimated by dividing the number of germinated seeds by the total number of seeds shown per sample.

When a sample failed to germinate during the initial observation period, the seeds were transferred to a new agar medium to extend monitoring and confirm the absence of germination. Subsequently, all the seedlings obtained were transplanted into germination trays and watered daily.

With a sampling effort of 5780 m/net/night, a total of 35 individuals were recorded, belonging to three families and five species, with Phyllostomidae being the most representative family (91.4 %). In contrast, the families Molossidae and Vespertilionidae were represented by only one species each. Catches occurred predominantly in November and December, mainly comprising the genera *Choeronycteris* and *Sturnira* (60 % and 31 % of the total catches, respectively). *C. mexicana* and *S. hondurensis* were the predominant species, with the latter being present in almost all samplings.

Feces collected from 11 fruit bat specimens yielded 368 seeds of two plant species: *S. ferrugineum* (Solanaceae) and *M. geometrizans* (Cactaceae). This study is the first to report the consumption and dispersal of *M. geometrizans* seeds (Figure 2 a, b, c), constituting a new record of the trophic interaction between fruit bats of the genus *Sturnira* and this columnar cactus in a tropical deciduous forest in the Bajío region.

Regarding the frequency of occurrence, *S. hondurensis* presented the highest proportion of feces samples with seeds (83 %), in addition to being the only species in which the simultaneous presence of seeds of *S. ferrugineum* (97 %) and *M. geometrizans* (3 %) was recorded. In the case of *S. parvidens*, although less frequently captured, the presence of *M. geometrizans* seeds was also observed; these were the only seeds collected for this species. These findings indicate that both species of the genus *Sturnira* actively participate in the consumption and, probably, in the dispersal of *M. geometrizans* seeds.

The germination assay showed marked differences between excreted and non-excreted seeds. Of six samples of excreted seeds, two germinated at 10 days (21 % for *M. geometrizans* and 2 % for *S. ferrugineum*), and a third from *S. ferrugineum* germinated at 20 days. The remaining seeds failed to germinate, even after being transferred to a new medium. In comparison, non-excreted seeds achieved 10 % germination at 10 days, compared to 21% of excreted seeds, suggesting a positive influence on the seed dispersal process and, potentially, on vegetation regeneration in the studied area (Figure 3).

This work reports for the first time the presence of *M. geometrizans* in the diet of two fruit bats of the genus *Sturnira* in a tropical deciduous forest in the Bajío region,

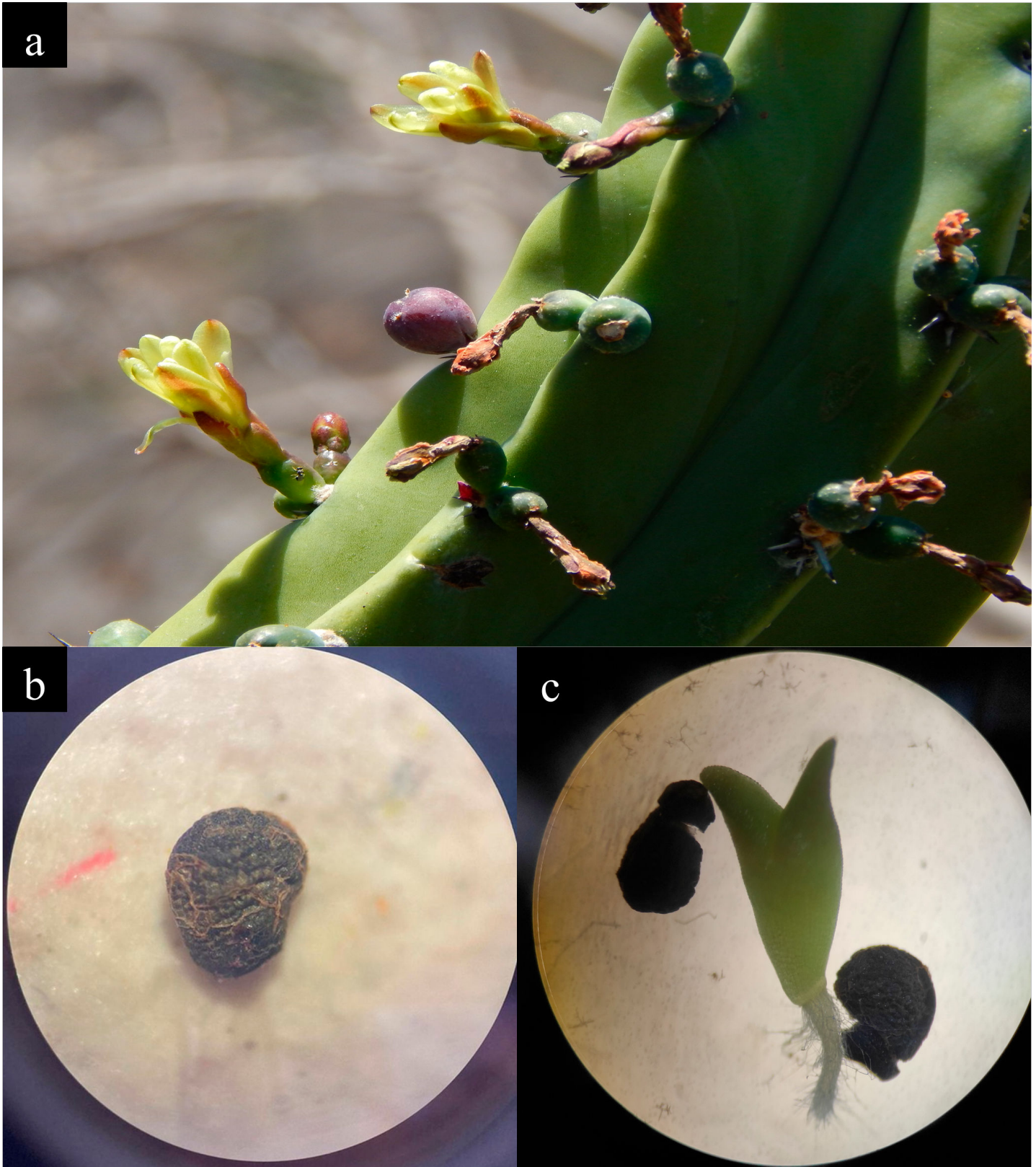


Figure 2. Fruit and seed of *Myrtillocactus geometrizans*: a) Fruit of *M. geometrizans*, b) seed of *M. geometrizans* excreted by the fruit bat (*Sturnira*), and c) seed excreted in bat feces with seedling in an early development stage.

Mexico. This finding represents a new trophic interaction between these bats and a columnar cactus and expands our knowledge about bat-plant interactions in arid and semi-arid regions.

This record coincides with the bat catch peaks observed during the transition between the dry and wet seasons, in which fruit production and availability increase, while the lowest catches occurred in the cold season, possibly due to

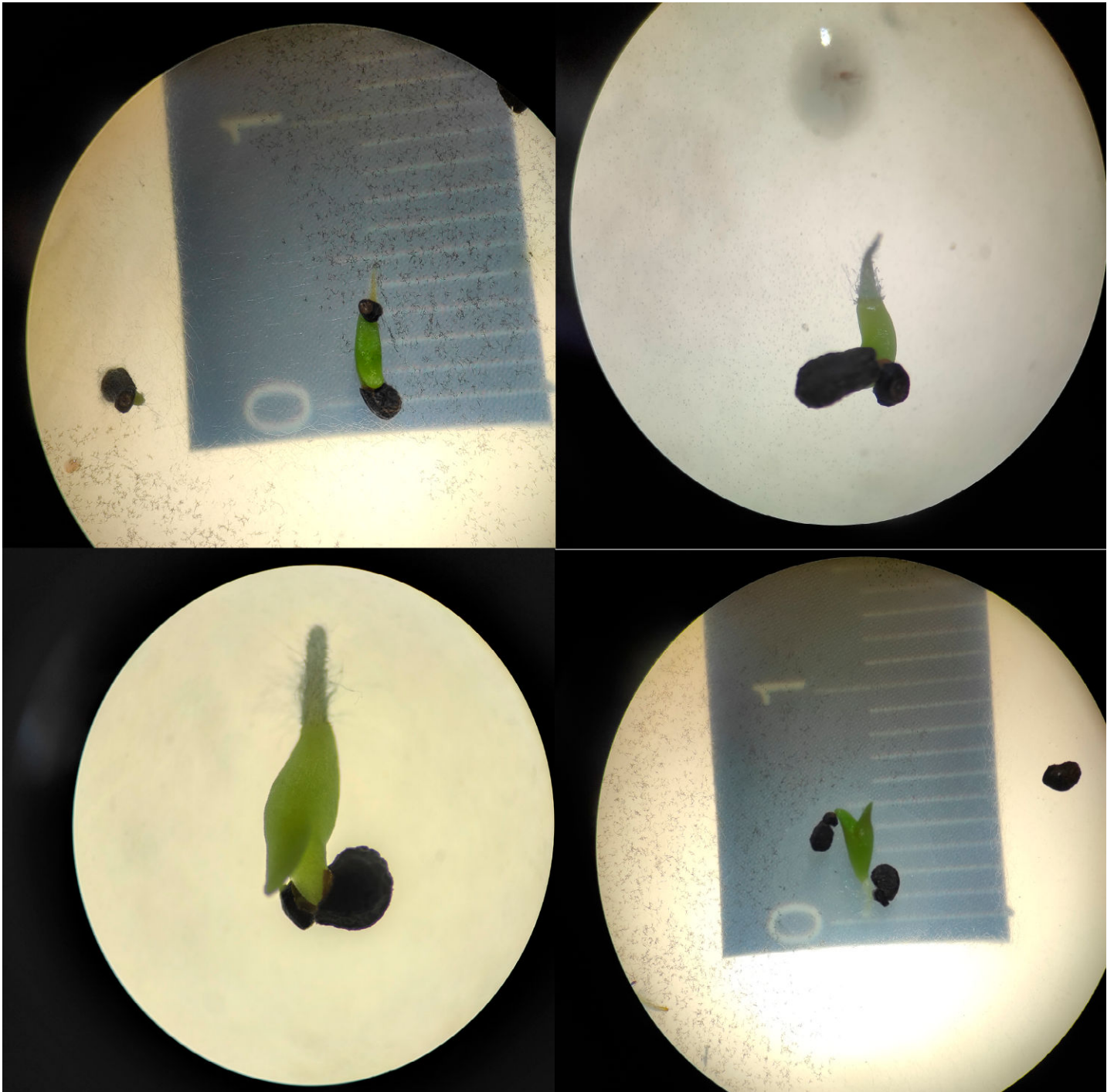


Figure 3. Germination test of *Myrtillocactus geometrizans* seeds excreted by fruit bats (*Sturnira*) grown in Petri dishes with agar-agar medium.

lower foraging intensity ([Sánchez-Cordero 2001](#); [Bejarano-Bonilla et al. 2007](#); [Ribeiro-Mello 2009](#); [Estrada-Villega 2010](#)).

In terms of diet, *S. ferrugineum* seeds were the most abundant in excreta, consistent with previous studies that identified species of the genus *Solanum* as a key component in the diet of fruit bats of the genus *Sturnira* ([Heithaus et al. 1975](#); [Medellín and Gaona 1999](#); [Salvador and Yurrita 2005](#)). *Solanum* fruits exhibit chiropterochory-syndrome characteristics ([Poulin and McNeil 1992](#)), which may explain this preference. In contrast, *M. geometrizans* represents a resource reported for the first time in the *Sturnira* diet.

This interaction suggests high dietary flexibility, in which bats exploit alternative resources in response to seasonal availability, as proposed by [Heithaus \(1982\)](#) and [Fleming \(1986\)](#). The presence of these seeds indicates that *Sturnira* not only consumes them but potentially contributes to their effective dispersal ([Dumont 1999](#)).

Although interactions between bats and cacti have been widely documented, most studies have focused on nectarivorous species of the genera *Leptonycteris*, *Choeronycteris*, and *Glossophaga*, mainly associated with the pollination of agaves and columnar cacti ([Valiente-](#)

Banuet *et al.* 1996; Fleming and Valiente-Banuet 2002; Stoner *et al.* 2003). However, it has been observed that the fruits of some cacti are consumed by fruit bats, as recorded here for the genus *Sturnira*. In this context, our record represents an important contribution by demonstrating that *Sturnira* interacts with the fruits of *M. geometrizans* and has the potential to act as a seed disperser, providing supplementary ecological functions in these ecosystems (Godínez-Álvarez and Valiente-Banuet 2000; Sánchez-Casas and Álvarez 2000; Cornejo-Latorre *et al.* 2011).

Given that *M. geometrizans* is a columnar cactus endemic to Mexico with a high fruit production during several months of the year (Pérez-Villafaña and Valiente-Banuet 2009), its use by fruit bats could represent an alternative feeding strategy with mutual benefits for both species. In disturbed or fragmented vegetation, these interactions could favor natural regeneration, particularly in the tropical deciduous forest, where zoochoric dispersal is essential.

In addition, our results show that passage of seeds through the digestive tract of bats increases their germination, consistent with observations by Traveset and Verdú (2002). In *M. geometrizans*, excreted seeds had higher germination percentages than seeds obtained directly from the fruit, a pattern similar to that described by Naranjo *et al.* (2003) for *Stenocereus* and *Subpilocereus* species. This same pattern was also observed in the study by Pérez-Villafaña and Valiente-Banuet (2009), where the seeds of *M. geometrizans* ingested by *Sturnira lilium* reached 75 % germination, a figure considerably higher than that for non-ingested seeds (15 %). These differences may be associated with the experimental conditions or the selection and manipulation of fruits by bats (Dumont 1999). Therefore, we recommend replicating the germination experiment with a larger number of seeds and a more rigorous control of the germination conditions.

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Turgida turgida (Nematoda: Physalopteridae) parasitizing Water Opossum (*Chironectes minimus* Zimmermann, 1780) in the Western Cordillera of Colombia and updated checklist of its associated parasites

Turgida turgida (Nematoda: Physalopteridae) parasitando zarigüeya acuática (*Chironectes minimus* Zimmermann, 1780) en la Cordillera Occidental de Colombia y lista actualizada de sus parásitos asociados

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Chironectes minimus is the only marsupial species of a semi-aquatic nature and is widely distributed in tropical and subtropical habitats from Central to South America. Although it has a wide distribution, little is known about aspects of its biology, as well as its parasites because it is considered a difficult species to sample. In this study, we report for the first time the presence of the nematode *Turgida turgida* in *C. minimus* in an area of the Western Cordillera in Colombia and compile a list of its other associated parasites. While preparing a specimen of *C. minimus* to enter the Mammal Collection of the Corporación Universitaria Santa Rosa de Cabal (CUS-M), six individuals of *T. turgida* were found when their stomach contents were checked. For scanning electron microscope analysis (SEM), all the samples were cleaned in saline solution and mounted on supports using carbon adhesive tape, coated with gold by sputtering in a cathodic sputtering machine. The nematodes found in the stomach of *C. minimus* were identified as *Turgida turgida* and correspond to five males and one female with a mean length of 2.45 cm and 4.59 cm, respectively. SEM revealed structures that characterize this species, such as ventrocaudal ornamentation patterns, and the presence of the 22nd broad, truncated caudal papilla on the male tail. We emphasize the importance of biological collections and recommend closer examination of specimens during the collection process, given the possibility of gathering relevant information on specimen-associated parasites, which could provide valuable insights into host-parasite relationships, ecological interactions and potential disease transmission pathways, ultimately allowing us to understand their implications for both public health and animal health.

Key words: Cloud forests; biological collections; neotropical marsupial; parasitic helminths; scanning electron microscope.

Chironectes minimus es la única especie de marsupial de carácter semiacuático y se encuentra ampliamente distribuida en hábitats tropicales y subtropicales desde Centroamérica hasta Sudamérica. A pesar de su amplia distribución, poco se conoce sobre aspectos de su biología, así como de sus parásitos debido a que es considerada una especie difícil de muestrear. En este estudio reportamos por primera vez la presencia del nematodo *Turgida turgida* en *C. minimus* en un área de la Cordillera Occidental en Colombia y compilamos una lista de sus otros parásitos asociados. Mientras se preparaba un espécimen de *C. minimus* para ingresar a la Colección de Mamíferos de la Corporación Universitaria Santa Rosa de Cabal (CUS-M), se encontraron seis individuos de *T. turgida* al revisar su contenido estomacal. Para el análisis de microscopía electrónica de barrido (MEB), todas las muestras fueron limpiadas en solución salina y montadas sobre soportes utilizando cinta adhesiva de carbono, recubiertas con oro por pulverización catódica. Los nematodos encontrados en el estómago de *C. minimus* fueron identificados como *Turgida turgida* y corresponden a cinco machos y una hembra con una longitud media de 2,45 cm y 4,59 cm, respectivamente. La MEB reveló estructuras que caracterizan a esta especie, como los patrones de ornamentación ventrocaudal y la presencia de la 22 papila caudal ancha y truncada en la cola del macho. Destacamos la importancia de las colecciones biológicas y recomendamos un examen más minucioso de los especímenes durante el proceso de recogida, dada la posibilidad de recopilar información relevante sobre los parásitos asociados a los especímenes, lo que podría aportar información valiosa sobre las relaciones huésped-parásito, las interacciones ecológicas y las posibles vías de transmisión de enfermedades, permitiéndonos en última instancia comprender sus implicaciones tanto para la salud pública como para la sanidad animal.

Palabras clave: Bosque de niebla; colecciones biológicas; helmintos parásitos; marsupial neotropical; microscopía electrónica de barrido.

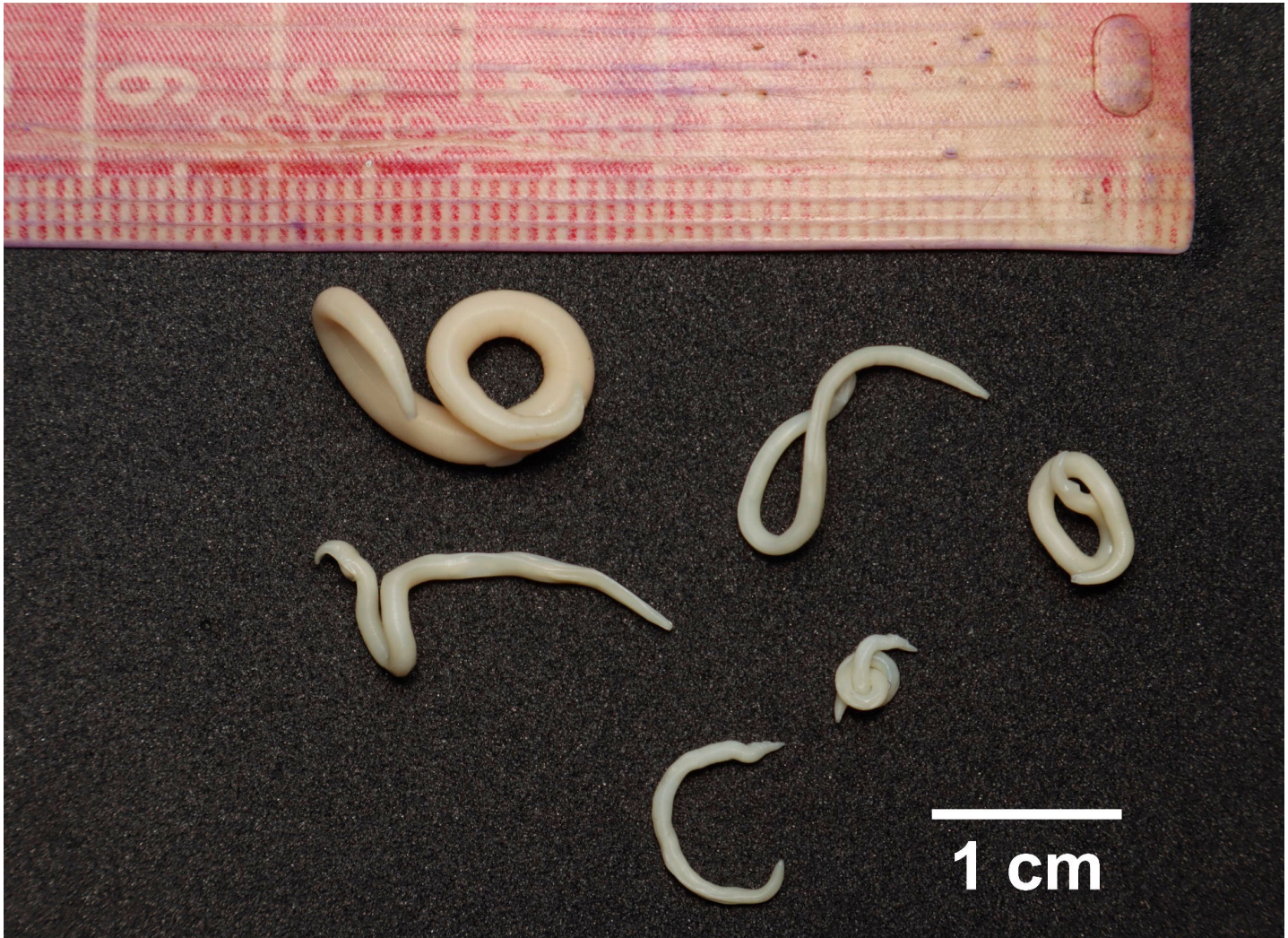


Figure 1. Adult individuals of *Turgida turgida* found in the stomach wall of *Chironectes minimus* (CUS-M 0514) in Pueblo Rico, Risaralda, Colombia.

The Water Opossum, *Chironectes minimus* Zimmermann, 1780 (Mammalia: Didelphidae) is the only marsupial species of a semi-aquatic nature and is widely distributed in tropical and subtropical habitats from Central America to South America (Ardente *et al.* 2013). It is mainly associated with riverbeds with stony substrates, clear water, and preserved riparian vegetation (Prieto-Torres and Pinilla-Buitrago, 2017). Although it has a wide distribution, little is known about aspects of its biology, as well as its parasites (Fernandez *et al.* 2015) because it is considered a difficult species to sample given that it is not attracted by conventional baits and because it mainly inhabits water sources, which makes it difficult to set traps (Bressiani and Graipel 2008). Parasites are essential in ecosystems because they participate in the regulation and structuring of the host population, intervening in processes such as competition, migration, reproduction and speciation (Bennati *et al.* 2023), and both biotic and abiotic factors influence their interaction with hosts (Cirino *et al.* 2020).

The literature documents that parasitic helminths in wildlife are rare and there are few reviews of them (Beveridge and Spratt 2015). This may be due to the fact

that many species are cryptic and require molecular techniques for identification, and to the scarce availability of active taxonomists who can determine them by morphological characteristics (Kim and Byrne 2006). This results in the fact that many helminth species deposited in biological collections have not yet been described and numerous marsupial species have not been examined for parasites (Beveridge and Gasser 2014), making it difficult to understand the biology and interaction between the two groups. The family Physalopteridae (Nematoda: Spiruroidea) comprises 22 genera and around 314 valid species (Hodda 2022), among which *Turgida turgida* Rudolphi, 1819 stands out as it is widely recorded in marsupials such as *Didelphis aurita* (Gomes *et al.* 2003), *D. virginiana* (Gray and Anderson 1982), among others. In this study, we report for the first time the presence of *T. turgida* in *C. minimus*, confirmed by scanning electron microscopy (SEM) in an area of the Western Cordillera in Colombia and compile a list of its other associated parasites.

While preparing a specimen of *C. minimus* to enter the Mammal Collection of the Corporación Universitaria Santa Rosa de Cabal (CUS-M), six individuals of *T. turgida*

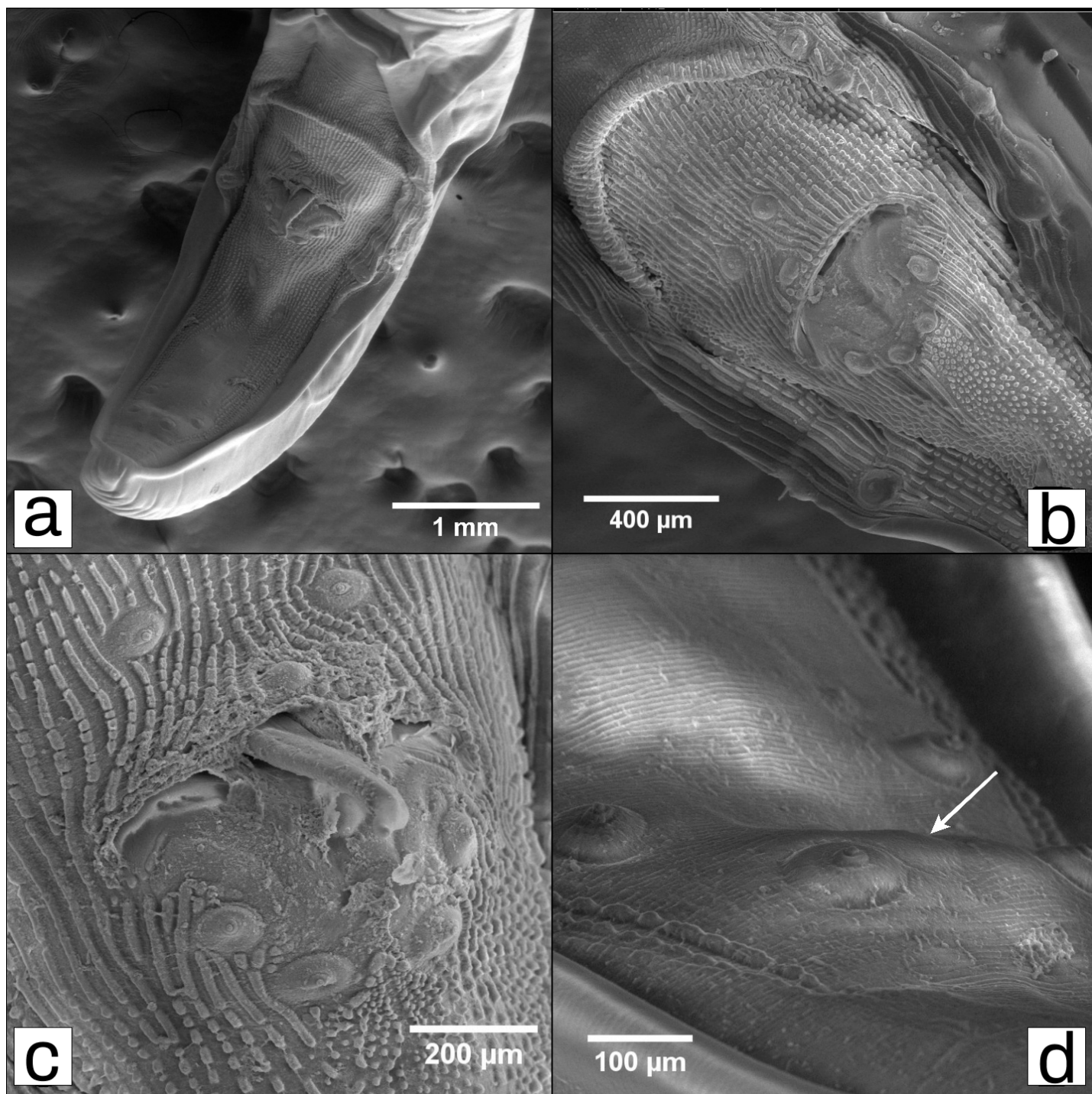


Figure 2. SEM micrographs of male specimens of *Turgida turgida*. (a) General view of the posterior end of the male, ventral side. The distribution of papillae can be seen, (b, c) Cloacal region, (D) Postcloacal papillae, including the broad, truncated papilla (white arrow).

were found when their stomach contents were checked (Figure 1). The specimen, a male *C. minimus* from the municipality of Pueblo Rico, Risaralda, Colombia (5° 16' 21.0" N, 76° 1' 36.0" W; 1169 m), was collected under the Framework Permit for the collection of wildlife specimens for scientific research purposes, Res 2004/2016 granted by the Corporación Autónoma Regional de Risaralda (CARDER), then was catalogued with the code CUS-M 0514; and samples of its parasitic helminths were preserved and fixed in a solution of 70 % alcohol and

5 % formaldehyde. For scanning electron microscopy analysis, the samples were cleaned in saline solution and mounted on supports using carbon adhesive tape, coated with gold by sputtering in a cathodic sputtering machine (Quorum model SC7620) and examined with a scanning electron microscope (Fei Quanta 250) at 12.5kV at the Laboratorio de Microscopía Electrónica of the Universidad de Caldas. Subsequently, the works of [Matey et al. \(2001\)](#), [Chaubad \(2009\)](#) and [Humberg et al. \(2011\)](#) were used for taxonomic identification.

A literature review was conducted to compile the species of parasites reported in *C. minimus*, and the information is drawn from nine scientific articles retrieved from the Dialnet, Elsevier, Google Scholar, PubMed, Redalyc, and SciELO databases using the following keywords: arthropods, *Chironectes minimus*, Didelphidae, Didelphimorphia, helminths, marsupials, nematodes, parasites, hosts, Physalopteridae, *Turgida turgida*. The records were obtained from papers that addressed aspects of the natural history of the species (Marshall 1978; Smith 2009) and checklists or reports of specific parasite groups (Miyazaki et al. 1974; Pinto et al. 2011; Lindardi 2012; Chero et al. 2017; Noronha et al. 2002; Varella et al. 2022; Jiménez et al. 2024).

The nematodes found in the stomach of *C. minimus* were identified as *Turgida turgida* and correspond to males (n = 5) and one female (n = 1), with a mean length of 2.45 cm (2.90; 3.18; 2.42; 1.85; 1.88 cm) and 4.59 cm, respectively (Figure 1). No other parasites were found in the specimen. SEM revealed structures that differentiate *T. turgida* from other Physalopteridae species, such as ventrocaudal ornamentation patterns (Figure 2a, Figure 2b, Figure 2c), and the presence of the 22nd broad, truncated caudal papilla on the male tail (Figure 2d). The specimen examined had no apparent lesions on the stomach.

According to the literature review, *C. minimus* has been reported to have 18 parasites in different areas of the body (Table 1). Most of them are helminths, with 14 species (77.78 %) predominantly belonging to the genera *Aspidodera* and *Cruzia*, and the remaining four are arthropods. This distribution highlights a marked predominance of helminth parasites in *C. minimus*, suggesting that gastrointestinal and other internal parasitic infections constitute the most commonly documented host-parasite associations in this species. In contrast, arthropod parasites account for 22.22 % of the total diversity of parasites documented in the literature. Records indicate that helminths are found in internal anatomical regions, particularly associated with the gastrointestinal tract, while arthropods are mainly associated with external regions of the body.

This data corresponds to information collected over more than 20 years, most of which comes from occasional records. They appear in brief mentions in studies on specific parasites and host lists and are often part of supplementary information when the main subject of the study is on other species of Didelphimorphia. Although not all papers specify the location where the parasite and host were recorded, there is information on the parasites *Rhopalialis caballeri*, *Spirura guianensis* and *Travassostrongylus callis* in Bolivia, *Adoratopsylla antiquorum*, *Aspidodera raillieti*, *Cruzia tentaculata*, *Dipetalonema* sp., *Litomosoides* sp., *Trichuris minuta* and *Turgida turgida* in Brazil; and *Paragonimus amazonicus* in Peru.

Turgida turgida is a parasite reported in several species of marsupials such as *Didelphis albiventris*, *D. aurita*, *D. marsupialis*, *D. virginiana* and *Philander opossum*, being

Table 1. List of parasites found in *Chironectes minimus*.

Species/Taxon	Infection site	References
Arthropoda		
Ctenophthalmidae		
<i>Adoratopsylla antiquorum</i>	Tegument	(Linardi 2012)
<i>Adoratopsylla</i> sp.	Tegument	(Marshall 1978; Smith 2009)
<i>Doratopsylla</i> sp.	Tegument	(Marshall 1978; Smith 2009)
Trombiculidae		
<i>Dolosisia</i> sp.	Tegument	(Marshall 1978; Smith 2009)
Cestoda		
Diphyllobothriidae		
<i>Ligula</i> sp.	Small intestine	(Marshall 1978; Smith 2009)
<i>Sparganum</i> sp.	Muscle and subcutaneous tissue	(Marshall 1978; Smith 2009)
Nematoda		
Aspidoderidae		
<i>Aspidodera raillieti</i>	Large intestine	(Chero et al. 2017; Noronha et al. 2002; Pinto et al. 2011; Varella et al. 2022)
Heligmosomidae		
<i>Travassostrongylus callis</i>	Small intestine	(Jiménez et al. 2024)
Kathlaniidae		
<i>Cruzia tentaculata</i>	Excrements	(Noronha et al. 2002; Pinto et al. 2011)
Onchocercidae		
<i>Dipetalonema</i> sp.	Peritoneum	(Noronha et al. 2002; Pinto et al. 2011)
<i>Litomosoides</i> sp.	Lungs	(Noronha et al. 2002; Pinto et al. 2011)
Physalopteridae		
<i>Turgida turgida</i>	Stomach	(Noronha et al. 2002; Pinto et al. 2011; this work)
Spiruridae		
<i>Spirura guianensis</i>	Stomach	(Jiménez et al. 2024)
Trichuridae		
<i>Trichuris minuta</i>	Cecum	(Noronha et al. 2002; Pinto et al. 2011)
Trematoda		
Opisthorchiidae		
<i>Amphimerus</i> sp.	Bile ducts	(Marshall 1978; Smith 2009)
Paragonimidae		
<i>Paragonimus amazonicus</i>	Lungs	(Chero et al. 2017; Miyazaki et al. 1974)
Rhopaliidae		
<i>Rhopalialis</i> sp.	Small intestine	(Marshall 1978; Smith 2009)
<i>Rhopalialis caballeri</i>	Small intestine	(Jiménez et al. 2024)

present from North America to South America and normally associated with the greater curvature of the stomach (Gray and Anderson 1982). In the family Physalopteridae the species appear to be selective to the site of infection, differing from the genus *Physaloptera*, which can infect the lesser covering of the stomach, the pylorus, or the fundic region (Humberg et al. 2011). These parasitic helminths can cause gastric perforations and sepsis, thus Nichelason et al. (2008) highlight *T. turgida* as a species with the ability to significantly influence morbidity and mortality in didelphids. Its life cycle is indirect, beginning when an insect ingests the parasite's eggs, whose larvae subsequently become encysted in the external wall of the intestine (Anderson 2000), the definitive host consumes the insect and then the nematode matures sexually and begins to produce eggs that will be released into the environment through the feces, thus completing the cycle (Gray and Anderson 1982). As intermediate hosts, the orders Blattodea, Coleoptera, and Orthoptera have been reported (Zago-Filho 1958; Anderson 2000). On the other hand, paratenic hosts such as amphibians and reptiles have also been reported (Widmer 1970; Humberg et al. 2011). *Chironectes minimus* has mainly a carnivorous diet, frequently consuming different aquatic organisms such as fish, crustaceans, frogs and insects (Hume 2005), therefore, it is possible that in the case of *T. turgida* the form of infection towards *C. minimus* is through its diet, given the wide diversity in its diet which could be a factor for this species to be more vulnerable to prey that are intermediate hosts, thus enhancing the spectrum of infections (Álvarez-Coto 2018), in the same way that happens in other didelphids (Gomes et al. 2003). Previously, Noronha et al. (2002) and Pinto et al. (2011) report *T. turgida* as a stomach parasite of *C. minimus* in Brazil in State of Rio de Janeiro, municipality of Santo Antônio, State of Pará. In addition, there are records of arthropods, cestodes, trematodes, and other nematodes parasitizing different areas of the body (Table 1). According to the literature, *T. turgida* has high prevalence rates in other Didelphimorphia (Table 2) in countries such as Bolivia (Jiménez et al. 2024), Brazil (Silva and Costa 1999; Boullosa et al. 2017; Costa-Neto et al. 2019; Freitas et al. 2022), Mexico (Cañeda-Guzmán 1997; Monet-Mendoza et al. 2005), and the United States (Gray and Anderson 1982). This high prevalence may be related to the ecological and trophic characteristics of these marsupials, which could increase their exposure to infectious stages present in the environment or in intermediate hosts. It may also suggest that this nematode is well adapted to these hosts and that its transmission is relatively efficient, playing a significant role within the parasitic community associated with them (Freitas et al. 2022). From a population perspective, infections with high prevalence could influence the physiological condition of individuals, especially when parasite loads are high, which could potentially affect

Table 2. Prevalence of *Turgida turgida* in other Didelphimorphia.

Species	Prevalence	Country	Reference
<i>Didelphis albiventris</i>	33%	Bolivia	(Jiménez et al. 2024)
	73%	Brazil	(Silva and Costa 1999)
<i>Didelphis aurita</i>	70%	Brazil	(Boullosa et al. 2017)
	75%	Brazil	(Costa-Neto et al. 2019)
<i>Didelphis marsupialis</i>	75%	Bolivia	(Jiménez et al. 2024)
	59%	Brazil	(Freitas et al. 2022)
	50%	Mexico	(Cañeda-Guzmán 1997)
<i>Didelphis virginiana</i>	50%	Mexico	(Cañeda-Guzmán 1997)
	60%	Mexico	(Monet-Mendoza et al. 2005)
	72%	United States	(Gray and Anderson 1982)
<i>Philander opossum</i>	9.5%	Mexico	(Cañeda-Guzmán 1997)

their survival or reproductive success (Boullosa et al. 2017). The higher number of *T. turgida* records in countries such as Bolivia, Brazil, Mexico and the United States does not necessarily reflect its actual distribution on the continent, but rather differences in sampling effort and the intensity of parasitological studies conducted in these areas. In this regard, the absence of records in other countries of the Americas could be associated with a smaller number of studies focused on the parasitic fauna of Didelphimorphia, rather than a true absence of the nematode.

Spratt and Beveridge (2016) estimate that about 26 % of the global marsupial fauna has not yet been examined for parasites. The lack of representativeness of this group in some biological collections may be because they are rare or threatened, limiting the opportunity to collect parasites from them (Beveridge and Spratt 2015). Although the diversity of helminths and other parasites is well documented in Australian marsupials (Beveridge and Gasser 2014; Beveridge and Spratt 2015; Spratt and Beveridge 2016), in contrast, for the Neotropics, having fewer species, efforts to know the parasites of marsupials have been focused mainly on the genus *Didelphis* (Jiménez et al. 2011; Acosta-Virgen et al. 2015; Freitas et al. 2022) because these species inhabit peri-urban areas, in addition to being compatible hosts and reservoirs of diseases that affect humans (Bezerra-Santos et al. 2021). Previous studies suggest that the family Didelphidae are frequent hosts of helminths (Benatti et al. 2023).

Chironectes minimus has been considered a rare or infrequent species, however, the capture method proposed by Bressiani and Graipel (2008) demonstrates that it may be more common than previously thought; representing an opportunity to better understand the parasites associated with this species and other aspects of its biology. Considering that the last recorded occurrence of the helminth *T. turgida* in *C. minimus* was

more than two decades ago, this record contributes to the knowledge of parasite-host relationships between these species, in addition to being the first record in Colombia. Furthermore, we emphasize the importance of biological collections and recommend further examination of specimens during the collection process, given the possibility of gathering relevant information regarding the parasites associated with the specimens, allowing us to understand their possible implications for public and animal health (Benatti et al. 2023).

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