Therya Notes

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
Como la mayor parte de los mamíferos pequeños, los tlacuachines del género *Tlacuatzin* construyen sus propios nidos o bien reutilizan refugios preexistentes para criar, protegerse y descansar. En el presente número se reporta por primera vez el hallazgo de un individuo de *Tlacuatzin balsasensis* anidando en un panal de avispas en la región Mixteca, Oaxaca (México).
(Fotografía de Aketzali Martínez Martínez)

Like most small mammals, mouse opossums of the genus *Tlacuatzin* build their own nests or reuse pre-existing shelters to breed, protect themselves, and rest. This issue reports the first record of an individual of *Tlacuatzin balsasensis* nesting in a wasp comb in the Mixteca region, Oaxaca (Mexico).
(Photograph by Aketzali Martínez Martínez)

El logo de la AMMAC: "Ozomatli"
El nombre de "Ozomatli" proviene del náhuatl,se refiere al símbolo astrológico del mono en el calendario azteca, así como al dios de la danza y del fuego. Se relaciona con la alegría, la danza, el canto, las habilidades. Al signo decimoprimero en la cosmogonía mexica. "Ozomatli" es una representación pictórica delmono 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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CONTENIDO

New records of atypical coloration in bats (Chiroptera) from Colombia

Nuevos reportes de coloración atípica en murciélagos (Chiroptera) de Colombia

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In mammals, changes in melanocyte regulation have been reported to generate variation in skin and coat pigmentation, which may result from genetic abnormalities or environmental factors. These include albinism, leucism, piebaldism, melanism, and hypomelanism. This study expands the record of bats with atypical coloration in Colombia, based on local biological collections. Specimens deposited in the Mammal Collection of the Museo de Ciencias Naturales de La Salle, the Teriological Collection of the Universidad de Antioquia, and the Mammal Collection of the Instituto de Investigación de Recursos Biológicos Alexander von Humboldt were reviewed. The identification and classification of atypical coloration followed the criteria described by Lucati and López-Baucells (2016). From the review of the collections, 12 species of bats with atypical coloration were recorded, 6 of which represent new records of atypical coloration in bats for Colombia. The most frequently reported atypical coloration was the presence of white spots, a condition known as piebaldism. Understanding the long-term frequency of atypical colorations contributes to knowledge about bat populations. These findings not only enrich the taxonomic inventory of Colombian bats but also raise new questions about the causes and effects of these pigmentation variations. The classification of these atypical colorations is crucial, as the inconsistent use of these terms can lead to confusion in literature.

Keywords: Atypical; bats; Chiroptera; leucism; piebaldism.

Se ha reportado que, en los mamíferos, los cambios en la regulación de los melanocitos generan una variación en la pigmentación de la piel y el pelaje, los cuales pueden ser resultado de anomalías genéticas o factores ambientales. Estas incluyen albinismo, leucismo, piebaldismo, melanismo e hipomelanismo. Este estudio amplía el registro de murciélagos con coloraciones atípicas en Colombia, basado en colecciones biológicas locales. Se revisaron ejemplares depositados en la Colección de Mamíferos del Museo de Ciencias Naturales de La Salle, Colección Teriológica de la Universidad de Antioquia y Colección de Mamíferos del Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Para la identificación y clasificación de diferencias en la coloración, se utilizó el criterio descrito por Lucati y López-Baucells (2016). Se registraron 12 especies de murciélagos con coloración atípica, de los cuales 6 son nuevos registros de murciélagos con coloración atípica para Colombia. Las coloraciones atípicas más comúnmente reportadas son la presencia de manchas blancas, conocidas como piebaldismo. Conocer la frecuencia con la que ocurren las coloraciones atípicas a largo plazo contribuye al conocimiento de las poblaciones de murciélagos. Estos hallazgos no sólo enriquecen el inventario taxonómico de los murciélagos colombianos, sino que también plantean nuevas preguntas sobre las causas y efectos de estas variaciones en la pigmentación. La clasificación de estas coloraciones atípicas es crucial, ya que el uso amplio de los términos puede generar confusión en la literatura.

Palabras clave: Atípico; Albinismo; Chiroptera; Leucismo; Piebaldismo.

La pigmentación basada en melanina es un sistema complejo y bastante conservado entre los vertebrados, que involucra la creación, migración y regulación de melanocitos (Hoekstra 2006). En mamíferos, la coloración depende principalmente de la cantidad y distribución de melanina en la piel, el pelo y los ojos (Fertl y Rosel 2009). Las variaciones en la pigmentación pueden originarse por alteraciones genéticas que afectan la síntesis o regulación de la melanina y otros pigmentos, a través de la acción de genes como el *MC1R* y otros involucrados en la vía de señalización de melanocitos (Lamoreux *et al.*, 2010). Sin embargo, la pigmentación no está determinada únicamente por factores genéticos. Los factores ambientales (Moller y Mousseau 2001), y la deficiencia dietaria (Clapp 1974) también pueden influir en la expresión y distribución de los melanocitos, lo que tiene consecuencias en la pigmentación de los individuos.

Estos cambios en la coloración han sido descritos en la literatura bajo distintos términos, tales como: coloraciones atípicas (Idoeta *et al.* 2011; Velandia-Perilla *et al.* 2013; Zalapa *et al.* 2016; Marín 2021), desórdenes cromáticos o de pigmentación (Rocha *et al.* 2013; Lucati y López-Baucells 2016; Rose *et al.* 2016; García-Restrepo *et al.* 2023) y aberraciones cromáticas (Veloso-Frías *et al.* 2020). Entre estas coloraciones atípicas se encuentran a) las asociadas a una biosíntesis anormal de melanina, como el hipomelanismo, melanismo y b) la falta de melanina, como el leucismo, el albinismo y el piebaldismo.

De acuerdo con Lucati y López-Baucells (2016), el albinismo es una condición genética y hereditaria asociada a la ausencia de la enzima tirosinasa, responsable de sintetizar melanina. Esta condición se manifiesta en la ausencia total de la coloración en el pelaje y tejidos, como la piel y los ojos. El leucismo, por su parte, se define como la pérdida de coloración completa, mostrando un fenotipo en el pelaje blanco o blancuzco y los ojos siempre de color normal, debido a la falla en la migración de los melanocitos (Lucati y López-Baucells 2016). El piebaldismo se describe como una aberración cromática que se expresa con manchas hipopigmentadas en el cuerpo, debido a la ausencia de melanocitos en la parte afectada. El melanismo es el exceso de melanina en el pelo, produciendo un fenotipo de pigmentación oscura, que puede ser genético o dado por el ambiente (Lucati y López-Baucells 2016). Por último, el hipomelanismo es un trastorno hereditario que afecta la biosíntesis de la melanina y produce individuos de color beige, dorado, amarillento o rojizo con una piel insuficientemente pigmentada (Lucati y López-Baucells 2016). Si bien cada coloración presenta un patrón cromático diferenciado, de la revisión realizada por Lucati y López-Baucells (2016) señalaron que el término piebaldismo ha sido utilizado deliberadamente en el 60 % de 609 individuos analizados, sugiriendo la necesidad de correcciones en su clasificación.

En mamíferos se han reportado mustélidos (Sobroza *et al.* 2016), roedores (Marín 2021), quirópteros (Mejía-Quintanilla, 2018, Medina y López, 2010) entre otros, con algún tipo de coloración atípica. De acuerdo con los reportes de literatura, en Colombia se han registrado 14 especies de murciélagos con alguna coloración atípica. Entre los casos documentados, se han reportado a *Anoura caudifer, Lonchophylla robusta, Carollia brevicauda, Artibeus lituratus*, *A. planirostris* y *Dermanura rosenbergi* con leucismo (Olarte-González *et al.* 2014; Chacón *et al.* 2015; García-Restrepo *et al.* 2023). Además, se ha registrado piebaldismo en *C. perspicillata, Glossophaga commissarisi, Hsunycteris thomasi, Phyllostomus elongatus, Trachops cirrhosus* y *Tonatia saurophila* (García-Restrepo *et al.* 2022). También se ha reportado albinismo en *C. perspicillata* (Calderón-Álvarez y Marin-Vasquez 2018). Partiendo de este marco de referencia, el objetivo de este trabajo es complementar el inventario con nuevos registros de especies de murciélagos que presentan coloraciones atípicas, a partir de ejemplares depositados en colecciones biológicas locales de Colombia.

Se realizó una revisión sistemática de ejemplares del orden Chiroptera en tres colecciones biológicas colombianas: la Colección de Mamíferos del Museo de Ciencias Naturales de La Salle (MCNS), la Colección Teriológica de la Universidad de Antioquia (CTUA) y la Colección de Mamíferos del Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH-M).

Se revisaron ejemplares preservados en piel seca o en líquido. Para la identificación y clasificación de las diferentes categorías de anomalías en la coloración se siguió el criterio descrito por Lucati y López-Baucells (2016). Además, se registraron datos de cada espécimen, incluyendo localidad de captura, fecha y colector. Asimismo, se tomó un registro fotográfico de cada caso.

En total, se registraron 17 individuos con coloraciones atípicas en las colecciones biológicas consultadas: 11 se encontraron en CTUA, cinco en la MCNS y uno en la IAvH. Estos ejemplares corresponden a 12 especies, de las cuales seis no habían sido reportadas previamente con coloraciones atípicas en la literatura científica para Colombia. Los nuevos registros corresponden a: *Chiroderma salvini, Dermanura phaeotis, Glossophaga soricina, Lasiurus ega, Molossus molossus* y *Sturnira bakeri* (Tabla 1; Figura 1).

Las especies registradas pertenecen a tres familias: Molossidae, Phyllostomidae y Vespertilionidae. De estas, la familia Phyllostomidae fue la más representativa tanto en número de especies como en abundancia de individuos (88.23 %), mientras que para las familias Vespertilionidae y Molossidae solo se encontró un individuo. Se observa un mayor número de especies con piebaldismo (*n* = 7), seguida de hipomelanismo (*n* = 5), leucismo (*n* = 3) y albinismo (*n* = 2).

A. planirostris fue la especie con mayor número de registros (*n* = 4), observándose casos con piebaldismo y leucismo parcial, seguido por *A. lituratus* con tres registros (Tabla 1). Estos especímenes fueron registrados en diferentes regiones naturales de Colombia, siendo la región Andina la

Tabla 1. Registros de coloración atípica en murciélagos en tres colecciones de Colombia: Colección Teriológica, Universidad de Antioquia (CTUA): Colección de Mamíferos del Museo de Ciencias Naturales de La Salle (MCNS) con código de colección CSJ-m y la Colección de Mamíferos, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH-M). Hembras (H), Machos (M). * Nuevos registros para Colombia.

Familia	Nombre científico	Sexo	Etapa de vida	Tipo de coloración atípica	Departamento	Municipio y localidad	Número de catalogo
Molossidae	*Molossus molossus**	H	Adulto	Piebaldismo	Antioquia	Guatapé	CTUA-6581
Phyllostomidae	*Artibeus lituratus*	H	Juvenil	Hipomelanismo	Antioquia	Medellín, Universidad de Antioquia	CTUA-3374
	Artibeus lituratus	M	Adulto	Hipomelanismo	Santander	Cimitarra, Termocentro	CTUA-6095
	Artibeus lituratus	M	Adulto	Hipomelanismo	Chocó	Riosucio	CTUA-0311
	Artibeus planirostris	M	Adulto	Piebaldismo	Santander	La Mesa, borde del rio Sogamoso	CTUA-2347
	Artibeus planirostris	H	Adulto	Leucismo	Santander	Piedecuesta	CTUA-2348
	Artibeus planirostris	H	Adulto	Piebaldismo	Norte de Santander	Salazar, Finca San Pablito	CSJ-m-0731
	Artibeus planirostris	H	Adulto	Piebaldismo	Norte de Santander	Salazar, Finca San Pablito	CSJ-m-0730
	Carollia brevicauda	M	Adulto	Hipomelanismo	Córdoba	Montelíbano, Mina Cerro Matoso, Embalse J-K y quebrada El Tigre	CTUA-5758
	Carollia perspicillata	H	Adulto	Piebaldismo	Antioquia	Valparaíso, Finca La Fabiana	CSJ-m-1280
	*Chiroderma salvini**	H	Adulto	Leucismo	Chocó	Quibdó, Pecurita	CTUA-2155
	*Dermanura phaeotis**	H	Adulto	Leucismo	Bolívar	Cantagallo, Finca el Salado	CTUA-3573
	Dermanura rosenbergi	M	Adulto	Hipomelanismo	Chocó	Lloró	CTUA-2312
	*Glossophaga soricina**	M	Adulto	Piebaldismo	Antioquia	Caramanta, Predio el Chumbimbo vereda Chirapoto	CSJ-m-1354
	Platyrrhinus umbratus	H	Adulto	Piebaldismo	Antioquia	Urrao,Vereda Calles, El macho	CSJ-m-0957
	*Sturnira bakeri**	H	Adulto	Albinismo	Antioquia	Cocorná	CTUA-3091
Vespertilionidae	*Lasiurus ega**	M	Adulto	Albinismo	Caquetá	San Vicente del Caguán, Vereda Cristo Rey, finca Andalucía, margen izquierda Río Pato	IAvH-M-07948

que presentó mayor número de casos (*n* = 11), seguida por la región Pacífica (*n* = 3) y la región Caribe (*n* = 2), mientras que en la Amazonía solo se encontró un registro.

Las coloraciones atípicas más comúnmente reportadas son la presencia de manchas blancas (Lucati y López-Baucells 2016; Zalapa *et al.* 2016), conocidas como piebaldismo. Las consecuencias que generan la aparición de estas coloraciones atípicas son desconocidas y poco estudiadas; sin embargo, se hipotetiza que podría reducir la eficiencia biológica de los individuos (Bensch *et al.* 2000), incrementando el riesgo a la depredación (Vignieri *et al.* 2010) y disminuyendo el éxito de apareamiento (Hoekstra 2006). Esta hipótesis aún no ha sido refutada; aunque algunos estudios reportan murciélagos adultos y de hembras gestantes, lo que sugiere que no interfiere en la reproducción y supervivencia de los individuos (López-Wilchis y León 2012; Reis *et al.* 2019; Martínez-Coronel *et al.* 2020; Marin-Vasquez *et al.* 2020). Lo

anterior coincide con nuestro estudio ya que 16 individuos se reportaron como adultos.

En el presente estudio, la familia con mayor número de registros y de especies fue la familia Phyllostomidae, y en menor proporción las familias Vespertilionidae y Molossidae. Una posible explicación, como señala Hernández-Aguilar (2023), es que, en los monitoreos de fauna silvestre, como murciélagos, al emplear redes de niebla, los integrantes capturados usualmente corresponderán a la familia Phyllostomidae, por lo que, si este es el método utilizado entonces esperaríamos que la mayor cantidad de individuos con alguna coloración atípica se encontraran en la familia Phyllostomidae. Esto sugiere un sesgo debido al método de captura empleado.

De acuerdo con Suárez-Castro *et al.* (2021), las regiones como la Amazonía y la Orinoquía están pobremente muestreadas cuando de mamíferos se trata, lo que
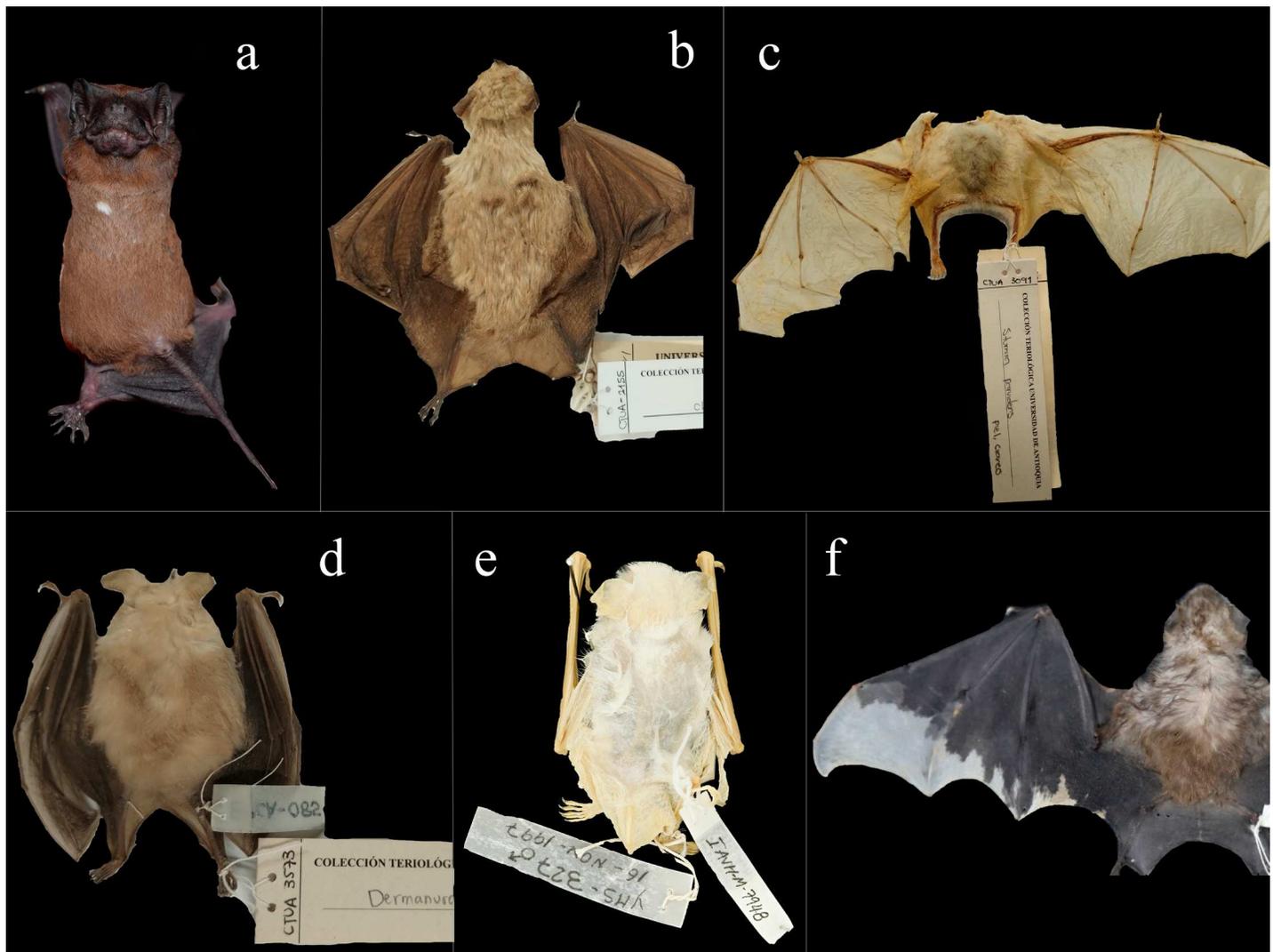
Figura 1. Nuevos registros de murciélagos con coloración atípica en Colombia. a) *Molossus molossus*; b) *Chiroderma salvini*; c) *Sturnira bakeri*; d) *Dermanura phaeotis*; e) *Lasiurus ega* ; f) *Glossophaga soricina*. Los individuos a y f corresponden a piebaldismo, b y d a leucismo y c y e a albinismo.

podría explicar por qué solo se cuenta con un registro en la Amazonia y en la Orinoquía ninguno. Además, en las colecciones revisadas, estas regiones podrían estar subrepresentadas ya que la CTUA tiene un énfasis en el estudio de los pequeños mamíferos del noroccidente del país (Solari y Bonilla-Sánchez 2020) y el MCNS alberga ejemplares principalmente de las regiones Andina, Caribe y Pacífica y sólo dos ejemplares de la Amazonía y ninguno de la Orinoquía (Zurc 2023). En Colombia hay aproximadamente 23 colecciones biológicas que albergan mamíferos, por lo que sería importante revisar otras colecciones del país para obtener más información de estas áreas poco muestreadas y aumentar la cantidad de registros de especies con algún tipo de coloración atípica.

Conocer la frecuencia con la que se presenta este tipo de coloraciones atípicas a largo plazo, analizando su variación espacial y temporal, permitirá identificar patrones consistentes en su ocurrencia asociados a posibles causas, como factores ambientales, genéticos, antropogénicos o climáticos. Este tipo de información puede ser clave para

comprender la dinámica de las poblaciones de murciélagos, evaluar su estado de salud y resiliencia, y establecer estrategias de conservación más efectivas.

Este estudio amplía el conocimiento sobre las coloraciones atípicas en murciélagos de Colombia, documentando 12 especies con coloraciones atípicas, donde el piebaldismo prevalece sobre el albinismo. La incorporación de seis nuevas especies con estas coloraciones atípicas en varias regiones del país destaca la importancia de las colecciones biológicas como herramientas claves para la investigación en biodiversidad. Sin embargo, se recomienda revisar otras colecciones del país con el fin de ampliar el conocimiento de estos registros. Estos hallazgos además de enriquecer el inventario taxonómico abren nuevas líneas de investigación y plantean nuevas preguntas sobre las causas, efectos, e implicaciones ecológicas de este fenómeno. Así mismo, el uso de la estandarización en la clasificación de estas coloraciones es crucial para evitar confusiones en la literatura científica y garantizar una terminología precisa y consistente. A futuro, será necesario profundizar en estudios

que evalúen la frecuencia, las implicaciones ecológicas y el papel de los factores ambientales en la manifestación de estas coloraciones, aportando así a un conocimiento integral de la biología y conservación de estos mamíferos.

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Potential predation of a mud turtle by a jaguar (*Panthera onca*): evidence from camera traps in the Mexican Maya Forest

Depredación potencial de una tortuga de pantano por un jaguar (*Panthera onca*): evidencia de cámaras trampa en la Selva Maya mexicana

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The jaguar (*Panthera onca*) is a large felid widely distributed throughout the Americas. Across its range, the species primarily preys on mammals, birds, and reptiles. Although reptile consumption is well documented in the southern portions of its distribution, such behavior is rarely reported in Mexico, particularly in the case of chelonians. In this study, we present photographic records suggesting the potential predation and/or consumption of a mud turtle (*Kinosternon* sp.) by a jaguar in the Mexican Maya Forest. Between November 2022 and February 2024, we conducted camera trap surveys to monitor wild vertebrates inhabiting the Maya Forest within the Calakmul Biosphere Reserve, Campeche, México. At the end of the monitoring period, we retrieved the digital data recorded by the devices to identify the documented species. We achieved a sampling effort of 4,700 trap-nights, during which we obtained photographic records of the vertebrate species inhabiting the region. In November 2023, we recorded an event involving a subadult jaguar holding a mud turtle (Testudines: Kinosternidae) in its jaws. Although species-level identification was not possible, we determined that the turtle belonged to the genus *Kinosternon*. Our finding contributes to the limited documentation of jaguar predation on turtles in Mexico and highlights the need for further research on the species' feeding ecology in the tropical forest ecosystems of the Selva Maya.

Key words: Calakmul; Campeche; Felidae; feeding habits; *Kinosternon*; photo-record; prey; reptile; tropical forest.

El jaguar (*Panthera onca*) es un felino con amplia distribución en América. A lo largo del continente, la especie se alimenta principalmente de mamíferos, aves y reptiles. Aunque el consumo de reptiles ha sido extensamente documentado en regiones del sur de su distribución, los reportes de este tipo de presas en México son raros, particularmente en el caso de los quelonios. En este estudio, presentamos registros fotográficos que sugieren la posible depredación o consumo de una tortuga de pantano (*Kinosternon* sp.) por un jaguar en la Selva Maya de México. Entre noviembre de 2022 y febrero de 2024, colocamos cámaras trampa para el monitoreo de vertebrados silvestres que se distribuyen en la Selva Maya de la Reserva de la Biosfera Calakmul, Campeche, México. Al final del monitoreo, recuperamos la información digital obtenida por los dispositivos para la identificación de las especies registradas. Logramos un esfuerzo de muestreo de 4,700 noches/trampa, con lo que obtuvimos registros fotográficos de las especies de vertebrados que se distribuyen en la región. En noviembre de 2023, registramos el evento de un jaguar subadulto sosteniendo una tortuga de pantano (Testudines: Kinosternidae) en sus fauces. Aunque no logramos su identificación a nivel de especie, determinamos que la tortuga pertenece al género *Kinosternon*. Nuestro hallazgo contribuye a incrementar la información limitada sobre la depredación de tortugas por parte del jaguar en México y hace patente la necesidad de continuar investigando los hábitos alimentarios de este felino en los ecosistemas de bosques tropicales de la Selva Maya.

Palabras clave: Bosque tropical; Calakmul; Campeche; Felidae; hábitos alimentarios; *Kinosternon*; presa; registro fotográfico; reptil.

Despite continental-scale population declines, the jaguar (*Panthera onca*) remains widely distributed, ranging from the southern United States to central Argentina in the Americas (Seymour 1989; Quigley *et al*. 2017; Jędrzejewski *et al*. 2018). Across its distribution, the jaguar inhabits a variety of habitat types (Sanderson *et al*. 2002; Quigley *et al*. 2017; Castelló 2020), where its feeding habits can vary considerably (Seymour 1989; de Oliveira and Medellín 2002; Hayward *et al*. 2016). Jaguars are obligate carnivores and are widely regarded as opportunistic predators, exploiting prey in relation to its availability in the environment (Rabinowitz and Nottingham 1986; Astete *et al.,* 2007;

Carrillo *et al.* 2009; Hayward *et al.* 2016; Ferreti *et al.* 2020; Entringer *et al.* 2022; Foster and Harmsen 2022). However, at a population-level, jaguar feeding behavior may also reflect ecological specializations, relying on foraging strategies that target specific prey species (Aranda 1994; de Oliveira and Medellín 2002; Novack *et al.* 2005; Weckel *et al.* 2006; de Azebedo 2008) based on their morphological (Carbone *et al.* 1999) and behavioral traits such as group size and gregariousness (Hayward *et al.* 2016), rather than solely on opportunistic encounters (Weckel *et al.* 2006).

Based on the above, jaguar prey selection and diet composition appear to be context-dependent, varying primarily with habitat type, prey availability, and the ecological traits of potential prey species (Seymour 1989; Hayward *et al.* 2016; Entringer *et al.* 2022). Throughout its distribution, the jaguar has been recorded consuming at least 111 prey species, ranging from small rodents to livestock (Seymour 1989; Weckel *et al.* 2006; Hayward *et al.* 2016; Entringer *et al.* 2022; Foster and Harmsen 2022). While its diet primarily consists of medium- to large-sized terrestrial mammals, typically averaging 32 ± 13 kg (López-González and Miller 2002; Hayward *et al.* 2016), in habitats with low mammalian abundance—such as wetlands, coastal areas, and floodplains—jaguars may incorporate armored reptiles, including crocodilians and chelonians (Emmons 1989; Cavalcanti and Gese 2010; Da Silveira *et al.* 2010; Azevedo and Verdade 2012; Brito *et al.* 2018).

Reptile consumption by jaguars in South America has been extensively documented (e.g., Troëng 2000; Garla *et al.* 2001; Weckel *et al.* 2006; Da Silveira *et al.* 2010; Veríssimo *et al.* 2012; Herrera *et al.* 2016; Brito *et al.* 2018; Morera-Chacón *et al.* 2019; Entringer *et al.* 2022). However, such reports from northern populations, particularly in México, remain scarce. In southeastern Mexico, the main prey species identified in the jaguar's diet include the collared peccary (*P. tajacu*), armadillo (*Dasypus novemcinctus*), coati (*Nasua narica*), brocket deer (*Mazama temama* and *M. pandora*), and white-tailed deer (*Odocoileus virginianus*; Aranda and Sánchez-Cordero 1996; Hernández 2008). In contrast, records of reptile predation in this region are limited to cases involving sea turtles—*Caretta caretta*, *Chelonia mydas*, and *Eretmochelys imbricata*—in Quintana Roo (Cuevas *et al.* 2014; Rosales-Hernández *et al.* 2022) and Morelet's crocodiles (*Crocodylus moreletii*) within the Calakmul Biosphere Reserve (CBR) in Campeche, located in the Mexican Maya Forest (Pérez-Flores 2018; Simá-Pantí *et al.* 2020). Reports of predation on terrestrial chelonians are even scarcer, with only a single documented event, in which the tortoise could not be identified to the species level (Aranda and Sánchez-Cordero 1996), also occurring within the CBR region.

In this study, we report a case of a mud turtle (*Kinosternidae*) captured by a jaguar, based on photographic evidence obtained from camera traps in the CBR region. This key record contributes to the very limited knowledge of terrestrial turtle potential consumption by jaguars in northern populations and within Mexico.

The study was conducted in the Calakmul Biosphere Reserve (CBR), located in the Maya Forest region of Campeche, southeastern México (18° 38′–18° 08′ N, 89° 44′–89° 31′ W). The protected area covers 7,231.85 km² and is characterized by a tropical subhumid climate (Aw), with an average annual temperature of 24.6 °C (SEMARNAP 2000). Rainfall is concentrated between June and November, with an average annual precipitation ranging from 1,000 to 1,500 mm (García *et al.* 2002). The CBR includes a mosaic of tropical forests with diverse characteristics, where the main vegetation types are Medium Sub-Perennial Forest, Low-Flooded Forest, and Medium and Low Semi-Deciduous Forests (Martínez and Galindo-Leal 2002).

Between November 2022 and February 2024, we conducted 10 camera trap sampling sessions to monitor medium- and large-sized vertebrate species distributed within the CBR. The duration of each of the ten sampling sessions varied: the shortest period lasted 31 days (October–November 2022), while the longest extended over 86 days (July–October 2023; Table 1). The average sampling duration was 47 ± 18.6 days. During each session, 10 camera trap stations (Reconyx™ HyperFire 2 Professional Covert IR, Holmen, WI, USA) were deployed within the buffer zone of the CBR, spaced at an average distance of 1.16 ± 0.1 km, collectively covering approximately 19 km². Camera traps were mounted on trees at a height of 30–60 cm above ground level in locations showing signs of wildlife activity, to maximize the likelihood of detecting target species (Zimmerman and Rovero 2016). Each camera trap was programmed to operate continuously, 24 hours per day, capturing two images per trigger event with a 60-second delay between activations. At the end of each sampling session, the digital data recorded by the devices were retrieved, and the species detected—along with the date, time, and location of each capture—were identified.

We achieved a total sampling effort of 4,700 trap-nights, during which we obtained photographic records of medium- and large-sized vertebrate species within the CBR. Among these, we documented 15 independent jaguar presence events, defined as at least one detection within a 24-hour period. These events represented a minimum of six distinct individuals: 1 adult male, 3 adult females, and 2 subadult males.

Of particular interest were two sequential jaguar records obtained on November 3, 2023, at a monitoring station located at 18°30′46.3″ N and 89°52′05.1″ W. These images were captured in a low-lying, flood-prone area within a transitional zone between Medium Sub-Perennial Forest and Low Semi-Deciduous Forest. In the first image, taken at 12:16 h, an adult female jaguar was photographed moving in a northwest–southeast direction through the Low Semi-Deciduous Forest (Figure 1). Two minutes later (12:18 h), a subadult male was recorded following the same trajectory.

Table 1. Start and end dates of 10 camera-trap sampling periods used to monitor medium- and large-sized vertebrate species in the Calakmul Biosphere Reserve, Campeche, Mexico.

Season	Number of camera traps	Start date	End date	Duration (days)	Sampling effort (night-traps)
1	10	01/11/2022	04/12/2022	33	330
2	10	05/12/2022	15/01/2023	41	410
3	10	18/01/2023	21/02/2023	34	340
4	10	05/03/2023	16/05/2023	72	720
5	10	05/06/2023	23/07/2023	48	480
6	10	25/07/2023	19/10/2023	86	860
7	10	22/10/2023	22/11/2023	31	310
8	10	25/11/2023	17/01/2024	53	530
9	10	19/01/2024	20/02/2024	32	320
10	10	21/02/2024	01/04/2024	40	400
			Total	470	4700

This individual was carrying a mud turtle in its jaws (Figure 2), which was identified to the genus *Kinosternon* (Testudines: Kinosternidae) based on visible morphological traits. However, due to photographic limitations, species-level identification was not possible.

Our record contributes to the scarce documentation of jaguar potential predation on turtles in Mexico—an interaction rarely reported within the Mexican Maya Forest. It also underscores the value of camera traps in providing direct, non-invasive insights into jaguar hunting behavior, particularly in relation to potential prey detection and recognition (Mills *et al.* 2004; Smith *et al.* 2020). While camera traps provide valuable information on specific aspects of predation, such as encounter rates and behavioral cues preceding attacks, their ability to evaluate prey selection is inherently constrained. Prey selection involves complex ecological and behavioral processes that often require complementary approaches—such as scat analysis, prey availability surveys, or integrative modeling frameworks—for robust evaluation (Kelt *et al.* 2019). Continued documentation of such predation events and behavioral interactions is essential to deepen our understanding of the trophic ecology and behavioral plasticity of jaguar populations in this region.

The photographic evidence reported here was obtained shortly after the peak of the rainy season (September), in a transitional ecotone between Medium Sub-Perennial and Low Semi-Deciduous forest. During the wettest months, this habitat develops temporary wetland-like conditions that facilitate the presence of aquatic and semi-aquatic fauna, including freshwater turtles. The scarcity of records documenting jaguar predation on such prey in Mexico may be partly attributed to suboptimal monitoring of habitats such as seasonally flooded habitats, wetlands, and floodplains, where reptiles, including crocodiles, caimans, and turtles are more frequently found (De Azevedo and Murray 2007; Azevedo and Verdade 2012; Simá-Pantí *et al.*

Figure 1. Photographic record of an adult female jaguar (*Panthera onca*) in the Calakmul Biosphere Reserve, Selva Maya region, Campeche, Mexico. The image was captured at 12:16:15 h on 3 November 2023, in an area characterized by low semi-deciduous forest.
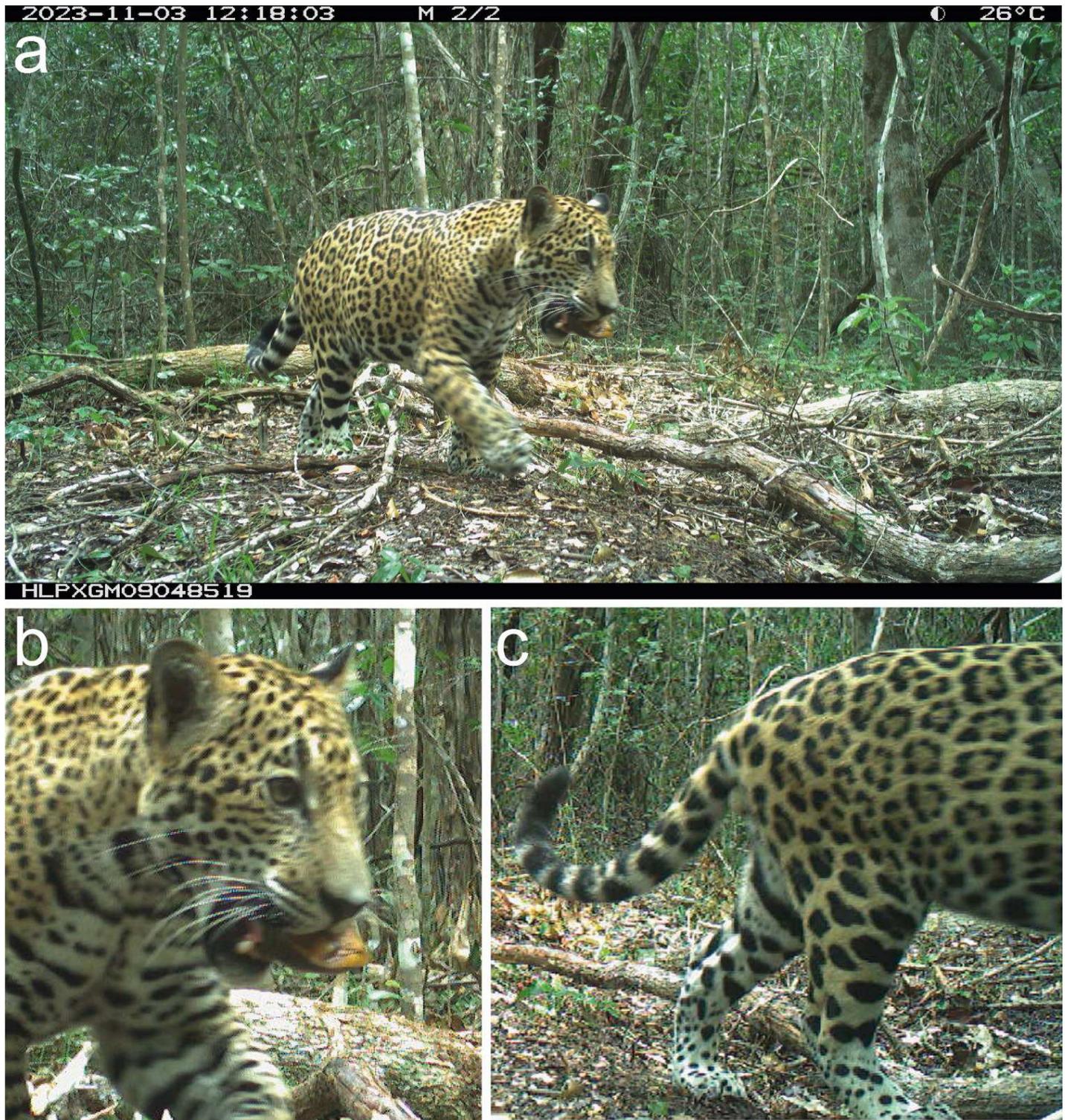
Figure 2. Photographic record of a sub-adult male jaguar (*Panthera onca*) in the Calakmul Biosphere Reserve, Selva Maya region, Campeche, Mexico. The individual was recorded at 12:18:03 h on 3 November 2023. The images show: (a) the jaguar moving through an area of low semi-deciduous forest; (b) the same individual carrying a mud turtle (Testudines: Kinosternidae), presumably *Kinosternon* sp., in its jaws; and (c) a clearer view of the genital region, confirming the individual's sex.

2020). Alternatively, it could reflect the broader availability of other prey species within the jaguar's range, rendering turtles a comparatively limited food resource that jaguars exploit opportunistically under favorable conditions— such as peaks in abundance associated with seasonal flooding, increased susceptibility to predation as individuals disperse farther from water bodies, and prolonged use of terrestrial habitats (Azevedo and Verdade 2012; Guilder *et al*. 2015). Such ecological scenarios have been widely documented in the southern range of the species in South America (Emmons 1987, 1989; Da Silveira *et al*. 2010; Azevedo and Verdade 2012; Guilder *et al*. 2015).

As a wide-ranging apex predator, the jaguar regularly consumes large-bodied prey (32 ± 13 kg; Hayward *et*

al. 2016) to meet its substantial energetic demands, consistent with allometric models linking predator energy requirements to prey size (Carbone *et al.* 1999). Nevertheless, its diet exhibits a degree of flexibility, with smaller-bodied taxa incorporated opportunistically as their availability fluctuates, reflecting responses to spatiotemporal variation in prey assemblages (Entringer *et al.* 2022). Within this context, our photographic records suggesting potential predation and consumption of a mud turtle (*Kinosternon* sp., 100–750 g; Buhlmann *et al.* 2008) likely represents a low-cost, opportunistic foraging event rather than a targeted strategy. Such behavior aligns with ecological opportunism, wherein suboptimal prey are exploited when encounter rates or handling costs favor inclusion (Stevens and Krebs 1986; Chan *et al.* 2017). Previous observations of jaguar predation on crocodylians in flood-prone areas of the CBR (Pérez-Flores 2018; Simá-Pantí *et al.* 2020), further highlight the species' ecological plasticity in response to seasonal pulses in the availability of armored reptiles and indicate that armored reptiles could be included into its diet at least occasionally.

In the CBR, at least 10 terrestrial turtle species have been documented, belonging to 4 families and 6 genera, with the family Kinosternidae and the genus *Kinosternon* being the most represented (40%; Colston *et al.* 2015; Barão-Nóbrega *et al.* 2022). In our record, species-level identification of the mud turtle was not possible due to photographic limitations, as part of the turtle's body was obscured within the jaguar's jaws. However, visible features include: (*i*) the absence of the head, limbs, and neck, suggesting the turtle had fully retracted into its shell to minimize predation damage; (*ii*) a yellowish-brown plastron with darker joints; and (*iii*) observable axillary and inguinal scutes, indicating the plastron is not reduced in size or cruciform but instead connected to the carapace by a bridge. These characteristics are consistent with the four *Kinosternon* species distributed in the study area: Tabasco Mud Turtle (*K. acutum*), Creaser's Mud Turtle (*K. creaseri*), White-lipped Mud Turtle (*K. leucostomum*), and Red-Cheeked Mud Turtle (*K. scorpioides*; Iverson 1976; Hutchison and Bramble 1981; Lee 1996; Colston *et al.* 2015; Díaz-Gamboa *et al.* 2020; Barão-Nóbrega *et al.* 2022). While the turtle in question likely belongs to one of these species, differentiating among species within this genus is notoriously challenging (Legler and Vogt 2013), and thus we identify it conservatively as *Kinosternon* sp.

Natural predation events are inherently rare and challenging to document in the wild due to their unpredictable occurrence and the limitations of conventional methods such as scat analysis and stable isotope analysis, which do not capture predator behavior (Lima 2002; Akcali *et al.* 2019). The use of camera traps has substantially advanced the study of predator–prey interactions by providing direct, non-invasive observations of hunting behavior, including prey detection and recognition (Mills *et al.* 2004; Smith *et al.* 2020). Notably, camera traps have yielded valuable evidence of predation events—the final stage in the predation sequence (Suraci *et al.* 2022)—which may result in successful prey capture, prey escape, or injury to either the predator or the prey (Lima and Dill 1990). However, although camera traps are valuable tools for documenting predator–prey interactions, actual predation events are rarely captured (Akçali et al. 2019). This limitation constrains their utility for systematically monitoring predation behavior and highlights the importance of integrating complementary methodologies to gain a more complete understanding of predator–prey dynamics (Kelt et al. 2019; Smith et al. 2020).

In this study, we present camera trap evidence of a mud turtle being captured by a jaguar in southeastern Mexico. Similar photographic records are increasingly appearing in the scientific literature, documenting jaguars capturing and potentially preying upon a wide range of vertebrate species in the Selva Maya region, including crocodilians (Simá-Pantí *et al.* 2020), black vultures (*Coragyps atratus*; González-Gallina *et al.* 2017), and nine-banded armadillos (*Dasypus novemcinctus*; Briceño-Méndez and Puc-Kauil 2021). Additionally, other reports from the region have documented jaguar predation on a variety of prey species, including crocodilians (Pérez-Flores 2018), marine turtles (Rosales-Hernández et al. 2022), and Baird's tapir (Tapirus bairdii; Pérez-Flores et al. 2020).

Collectively, these records contribute to a growing body of evidence supporting the jaguar's trophic flexibility in the Mexican Maya Forest and highlight the utility of camera traps in advancing our understanding of predator–prey interactions in tropical ecosystems. Our observation provides the first photographic evidence of a jaguar capturing a mud turtle in southeastern Mexico, offering a rare and direct account of potential reptile predation in the region. This record complements previous reports of jaguars preying on unconventional species—such as crocodilians, vultures, and armadillos— and broadens the ecological context by highlighting the species' opportunistic feeding behavior. Taken together, our finding and related evidence emphasize the need for further research on jaguar feeding ecology, particularly with respect to prey diversity, habitat-specific seasonality, and resource availability in southern Mexico. A more comprehensive understanding of the jaguar's dietary ecology is essential for elucidating its interspecific interactions, ecological and energetic requirements, and the breadth and variability of its trophic niche in response to spatial and temporal fluctuations in prey availability. Such insights are critical for developing effective conservation strategies for large carnivores, particularly in landscapes like the Maya Forest, where jaguar populations are increasingly threatened by anthropogenic pressures— even within protected areas such as the Calakmul Biosphere Reserve.

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The giant returns: Rediscovery of the largest yellow-shouldered bat in the world

El retorno del gigante: Redescubrimiento del murciélago de hombros amarillos más grande del mundo

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Sturnira aratathomasi is a rare species of bat distributed in Venezuela, Colombia, Ecuador, and Peru. Herein we report new records for *S. aratathomasi* species in Colombia and Ecuador, updating its geographic distribution. During a field expedition to Cayambe Coca National Park in eastern Ecuador, a bat with difficult taxonomic identification was collected. To find additional specimens for comparison, museum collections in Ecuador and Colombia were reviewed. These specimens were identified as *S. aratathomasi* based on a forearm length equal to or greater than 55 mm and the presence of pointed upper inner incisors. Furthermore, an updated distribution map was generated. A total of 27 geographic records for *S. aratathomasi* were obtained. We report four new records of *S. aratathomasi*: two from Ecuador and two from Colombia. The first records from Ecuador are based on a specimen collected during fieldwork in Cayambe Coca National Park and a voucher specimen from Cosanga. The new records from Colombia are based on two voucher specimens from Quebrada La Colosa and Corregimiento Juntas. Investing more time and resources in both curatorial work and field expeditions is essential for analyzing the distribution of *S. aratathomasi* and for implementing effective conservation strategies. The Cayambe Coca National Park and Los Nevados National Natural Park are considered as priority areas for the conservation and research of this rare species in the Neotropics.

Key words: Coca Codo Sinclair; epaulettes; mountain forests; Neotropics; rare species; ribs; Salado River; *Sturnira aratathomasi*; *Sturnira magna*; vertebrae

Sturnira aratathomasi es una especie rara de murciélago distribuida en Venezuela, Colombia, Ecuador y Perú. En este artículo reportamos nuevos registros para *S. aratathomasi* en Colombia y Ecuador, actualizando su distribución geográfica. Durante una expedición de campo al Parque Nacional Cayambe Coca, en el este de Ecuador, se recolectó un murciélago de difícil identificación taxonómica. Para encontrar especímenes adicionales para comparar, se revisaron colecciones de museos en Ecuador y Colombia. Estos especímenes se identificaron como *S. aratathomasi* con base en una longitud del antebrazo igual o mayor a 55 mm y la presencia de incisivos superiores internos puntiagudos. Además, se generó un mapa de distribución actualizado. Se obtuvieron un total de 27 registros geográficos para *S. aratathomas*i. Reportamos cuatro nuevos registros de *S. aratathomasi*: dos en Ecuador y dos en Colombia. Los primeros registros de Ecuador se basan en un ejemplar colectado durante el trabajo de campo en el Parque Nacional Cayambe Coca y un ejemplar testigo de Cosanga. Los nuevos registros de Colombia se basan en dos ejemplares testigo de la Quebrada La Colosa y el Corregimiento Juntas. Invertir más tiempo y recursos tanto en el trabajo curatorial como en las expediciones de campo es esencial para analizar la distribución de *S. aratathomasi* e implementar estrategias de conservación efectivas. El Parque Nacional Cayambe Coca y el Parque Nacional Natural Los Nevados son áreas prioritarias para la conservación e investigación de esta rara especie en el Neotrópico.

Palabras Clave: bosques montanos; Coca Codo Sinclair; Charreteras; costillas; especie rara; Neotrópico; Río Salado; *Sturnira aratathomasi*; *Sturnira magna;* vértebra

The genus *Sturnira* comprises 25 recognized species and is one of the most diverse within the Phyllostomidae family (Gardner 2008, Velazco and Patterson 2013, Solari *et al.* 2019, Yánez-Fernández *et al.* 2023). Despite this great diversity, information on the biology, foraging strategies, roosting sites, distribution, and population ecology of many *Sturnira* species occurring in Ecuador remains limited (Albuja-V 1999, Carrera *et al.* 2010, Rodríguez-Segovia 2022). Even some *Sturnira* species are considered rare in scientific collections and are rarely captured during field expeditions (Jarrín-V and Kunz 2011). The lack of recent field expeditions hinders understanding of the distribution of rare species and the identification of priority areas for research and conservation (Burneo and Tirira 2014).

In Ecuador, there are 14 species of *Sturnira*, ten are listed as least concern: *S. bakeri*, *S. bidens*, *S. bogotensis*,

S. erythromos, *S. giannae*, *S. ludovici*, *S. luisi*, *S. magna*, *S. oporaphilum* and *S. tildae*; two are listed as endangered: *S. perla*, *S. boadai*; one is considered vulnerable *S. koopmanhilli*; and one as data deficient *S. aratathomasi* (Tirira 2021). The last one due to the absence of records with precise geographic information.

Sturnira aratathomasi, was described based on one specimen collected in 1966 from Pance, Department of Valle in southwestern Colombia at 1,650 m (type locality) and two additional specimens from an unspecified locality in Ecuador collected prior to 1874 (Peterson and Tamsitt 1968). In the following years up to the present, records of this species have been scarce and sporadic over time. A study collected six specimens near the type locality (Thomas and McMurray 1974). One specimen collected in Monte Zerpa, expanded the distribution of this species to western Venezuela (Soriano and Molinari 1984). A few years later, two specimens were collected from the Departments of Huila and Cauca, representing the first records from the central and eastern Andean cordilleras of Colombia (Tamsitt *et al.* 1986).

Fieldwork carried out in Departamento del Cauca, Colombia, allowed the collection of five specimens, ranging from 1,800 to 2,600 m, from Cordillera Central and Occidental (Alberico 1987). On August 29, 1978, a juvenile male was collected from the Departamento de Amazonas at 3,165 m, in northern Peru (McCarthy *et al.* 1991). Solari *et al.* (2001) reported the presence of this species in the Department of San Martín, Peru. Pacheco and Hocking (2006) mentioned that the two specimens collected by Solari *et al.* (2001) in this locality, (MUSM 7305 and 7306, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos), were captured at 2,000 and 2,100 m, respectively. Pacheco & Hocking (2006) also mentioned three specimens collected at Cconoc in the Department of Apurimac, at 1,925 m, in the eastern slopes of the Peruvian Andes.

A study conducted at "Recinto El Pensamiento" in the Department of Caldas, Colombia, collected one female at 2,180 m (Castaño *et al.* 2004). A study in the Santuario de Fauna y Flora Otún-Quimbaya, in the Central Andes of Colombia captured five individuals at 2,100 m. Three specimens were collected; two were measured and released. This study also reported the presence of seeds of *Solanum sycophanta* (Solanaceae) in fecal samples of *S. aratathomasi* (Estrada-Villegas *et al.* 2007), being the only known dietary record for this bat species (Castaño *et al.* 2018). Another study conducted in the Reserva Hidrográfica Río Blanco in the Central Andes of Colombia, reported three additional specimens at 2,500 m, in a mixture of sub-Andean and Andean Mountain Forest and plantations of *Eucaliptus globulus* and *Alnus glutinosa* (Rodríguez-Posada 2010).

An evolutionary study suggests that *S. aratathomasi* diverged about 5.4 Ma (4.4 - 6.7 Ma) in the Late Miocene and represents one of the earliest divergence species of the genus (Velazco and Patterson 2013). This study also analyzed DNA samples from one of the specimens collected

by Thomas and McMurray (1974), (Royal Ontario Museum, ROM-70874 ⚥), and one unreported specimen collected by Alberico (1987), (Field Museum of Natural History, FMNH 189778 ⚥), from Quebrada Charco Azul in the Department of Valle del Cauca, at 1,800 m, as is inferred. A taxonomy study of the genus *Sturnira* in Colombia cited two specimens deposited in the Colección Teriológica de la Universidad de Antioquia (CTUA/MUA: MUA11311 and MUA11094) (Martínez-Arias 2011). However, no geographic details were provided. Therefore, only 31 voucher specimens with accurate locality information are available.

Furthermore, there are additional mentions of *S. aratathomasi* in the literature (see Alfonso and Cadena 1994; Cuartas 1997; Muñoz-Arango 2001; Bejarano and Yate 2003; Otálora-Ardila 2004), and there is a human observation from the lowland Amazonia of Peru that deserve further research to verify the presence of *S. aratathomasi* in this region (Montenegro and Escobedo 2004; Pacheco and Hocking 2006). A study considered that there are over 46 records of this species in Colombia and Peru; however, it did not list the specimens or provide geographic information (Molinari and Lew 2015). Certainly, there are numerous unconfirmed records from Colombian institutions deposited in GBIF (2025) that warrant formal revision.

Herein we report new records for *S. aratathomasi* from Ecuador and Colombia, updating its geographic distribution. We also present valuable data to identify this species in the field and museum collections.

On January 17, 2023, a field expedition was conducted in the Cayambe Coca National Park, eastern Ecuador. A total of eight mist nets of 12 meters length were used to collect and document bat faunas in the bridge of the Gringo River, a tributary of the Salado River, west of the Coca Codo Sinclair Power Plant, Napo Province. The surrounding area was composed by remnants of native evergreen lower montane forest and pastures (MAE 2013). Following the Guidelines of the American Society of Mammalogists and the Ecuadorian Association of Mammalogy (Sikes 2016; Erazo *et al.* 2022), voucher specimens were collected, curated, identified, and deposited in the mammal collection of the Museo de Zoología QCAZ at Pontificia Universidad Católica (PUCE) del Ecuador with the research permit MAAE-DBI-CM-2021-0165 granted by the Dirección Nacional de Biodiversidad del Ministerio de Ambiente Agua y Transición Ecológica del Ecuador (MAATE). Frozen tissues, parasites and flies from these specimens are available at QCAZ.

One QCAZ specimen, obtained during 2023 fieldwork and of uncertain taxonomic identification, was compared with the original species description of *S. aratathomasi* and field guides (Peterson & Tamsitt 1968; Gardner 2008, Solari *et al.* 2019; Díaz *et al.* 2021). The diagnostic anatomical characters used for identification were a forearm length equal to or greater than 55 mm, pointed upper inner incisors, and serrated lower molars (Peterson and Tamsitt 1968; Soriano and Molinari 1987). All the available voucher specimens
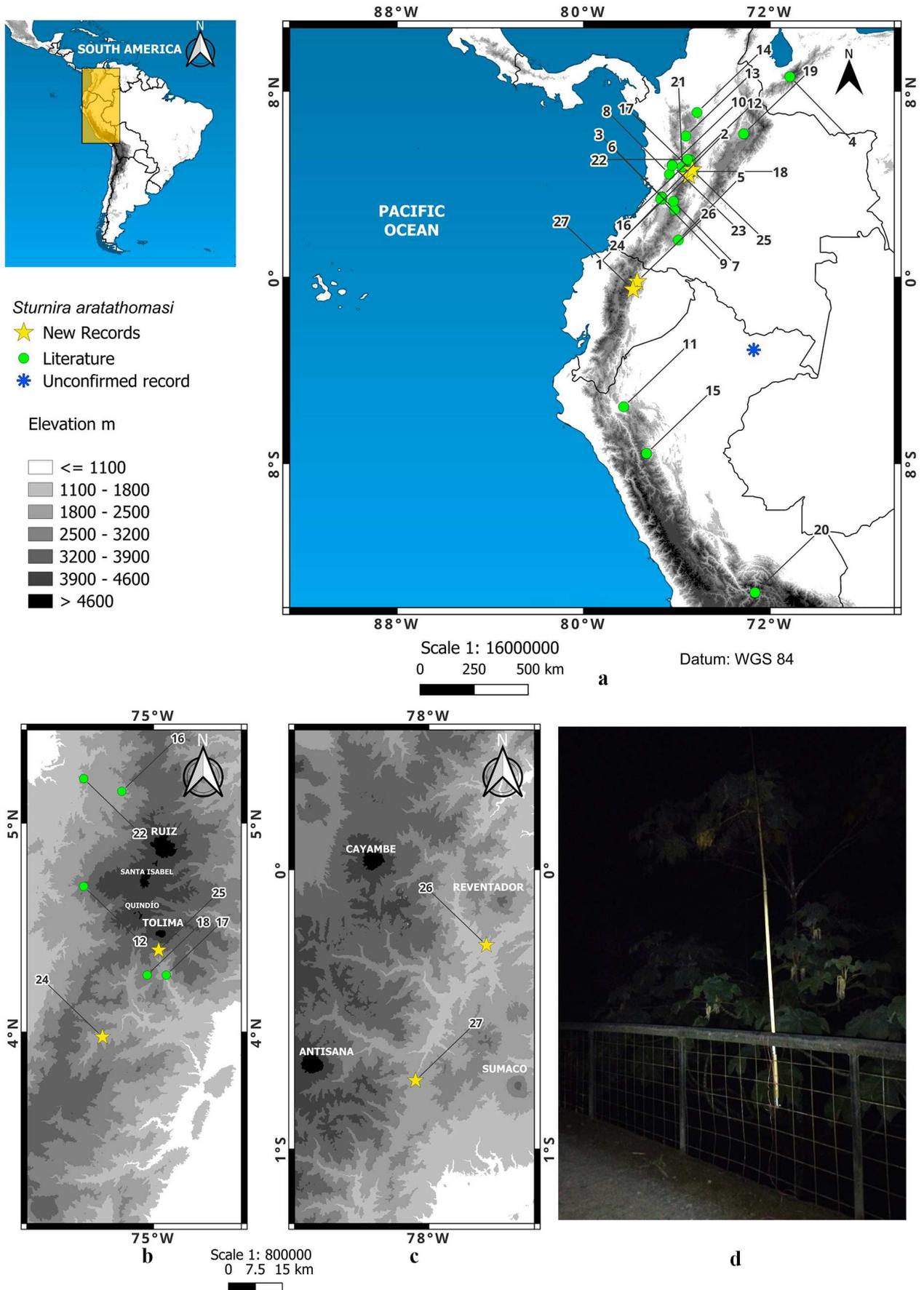
Figure 1. Distribution of *Sturnira aratathomasi.* Localities are detailed in Appendix 1. Green dot 1 corresponds to the type locality. Known records of *S. aratathomasi* (a), new records in the Central Andes of Colombia (b), and new records in eastern Ecuador (c). Detail of the bridge of the Gringo River (d) where some *Cecropia* trees with mature fruits can be seen in the image.

from large *Sturnira* species, including *S. koopmanhilli* (n = 6) and *S. magna* (n = 76), deposited in the QCAZ until January 31, 2025, were reviewed with the objective of finding any additional confused specimen (see Rodríguez-Segovia and Pilatasig 2025). *S. koopmanhilli* can be distinguished from *S. aratathomasi* by its very elongated and procumbent upper inner incisors, conspicuous diastemata between the molars, and molars with a flat appearance (McCarthy *et al.* 2006; Rodríguez-Segovia *et al.* 2025). *S. magna* can be identified by the presence of broad, bilobed upper inner incisors and flat molars (Díaz *et al.* 2021). The age and reproductive status of each specimen were determined by seeing the fused degree of hand-wing epiphyses, pelage color, tooth eruption, and the development of nipples (Kunz and Parsons 2009; Rodríguez-Segovia 2022). Photographs of the skulls, skeletons, and the skins of the *Sturnira* specimens were obtained to observe details on their anatomy.

The nomenclature for dental, vertebrae, and rib bones was based on information from literature (Walton and Walton 1970; Duque-Osorio *et al.* 2011; Velazco and Patterson 2014; Gaudioso *et al.* 2017; Louzada and Pessôa 2022). Standard body and cranial measures were measured with ®Trupper digital caliper (± 0.01 mm accuracy) and following the definitions of McCarthy *et al.* (2006). Geographic information and individual data were extracted from the label of each specimen. The terminology and symbology of this paper follows the original species description (Peterson and Tamsitt 1968).

Additional records, measurements, and photographs, were obtained from Museo de Historia Natural, Universidad de Caldas (MHNUC) and Instituto de Ciencias Naturales (ICN) at Universidad Nacional de Colombia (see Castaño *et al.* 2004; Estrada-Villegas *et al.* 2007; Rodríguez-Posada 2010). Measurements of the specimens analyzed in the QCAZ, MHNUC and ICN were compared qualitatively with available published records (Appendix 1, Pacheco and Hocking 2006, Rodríguez-Segovia and Pilatasig 2025). The R package MorphoTools2 was used to summarize the data (Šlenker *et al.* 2022; R Core Team 2024). Furthermore, our records plus the compiled information obtained from the literature review, allowed us to update the distribution map for *S. aratathomasi* (see, Rodríguez-Segovia and Pilatasig 2025).

A total of 27 geographic records for *S. aratathomasi* were compiled from the literature, specimen examinations, and fieldwork conducted at the Gringo River (Figure 1a, Appendix 1), this species occurs since 08° 37′ 00″ N to 13° 32′ 47″ N and 078° 17′ 00″W to 071° 09′ 00″W. Voucher specimens' elevation ranged from 1,301 to 3,165 m. We found two previously unreported adult specimens from Department of Tolima in the Central Andes of Colombia. The first corresponds to a specimen of unknown sex collected in Quebrada La Colosa, (MHNUC 1954), and the second to a female specimen from Corregimiento Juntas, (MHNUC 1408), (Figure 1b, localities 24 and 25, Appendix 1). Furthermore, we add two new records from Napo Province in Eastern Ecuador. The first

record, (QCAZ 19838) was an adult female collected on the bridge of the Gringo River. The second record (QCAZ 7725), is also a female specimen, initially misidentified as *S. magna,* collected 12 km northwest of Cosanga (Figure 1c - d localities 26 and 27, Appendix 1).

All the voucher specimens reviewed were identified as *S. aratathomasi* based on the following morphological characters: cranium and mandible robust (Figure 2a, c, e; j - l); depressed and elongated rostrum; canines long and directed anteriorly (Figure 2g - i); long and narrow nasal aperture (Figure 2a, c, e); posterior palate ending V shaped (Figure 2b, d, f); upper inner incisors (I1) are pointed, procumbent, and not in contact; and the outer upper incisors (I2) are tricuspidate (Figure 2m, n); tricuspidate lower inner incisors (i1) have a smaller and distinctive middle cusps wedged between lateral lobes; outer lower incisors (i2) are bicuspidate (Figure 2o, p), except in QCAZ 7725 because the left i2 is tricuspidate; serrated lower molars; m1 and m2 with a metaconid and entoconid divided by a deep notch (Figure 2q, r). QCAZ 7725 and 19828 have 7 cervical, 13 thoracic, 6 lumbar vertebrae, and 9 sacral (Figure 2t - w). The thoracic region has 13 ribs: 6 true ribs, 4 false ribs, and 3 floating ribs (Figure 2t - v).

The QCAZ and MHNUC specimens lack conspicuous shoulder glands (epaulettes). In *S. magna* QCAZ 6940 ⚥, the horseshoe is fused to the upper lip, but its edge remains distinguishable (Figure 3a). In contrast, in QCAZ 7725 ⚥ and QCAZ 19838 ⚥, the edge is not distinguishable (Figure 3b, c), exhibiting a higher degree of fusion. QCAZ 19838 was dark grayish-brown dorsally and paler ventrally (Figure 3i - k). QCAZ 7725 was brownish dorsally and paler ventrally (Figure 3 d, g, h). The holotype USNM 395158 ⚥ was very similar to this specimen dorsally and ventrally (Figure 3e, f).

The Pelage of QCAZ 7725 and QCAZ 19838 is soft and woolly. Dorsally between the shoulders of QCAZ 7725 we observed a pattern of four color bands: a whitish basal band, a dark-gray epibasal band, a whitish subdistal band, and a brown distal band (Figure 3l). Ventrally, in the abdominal region, we observed a pattern of three color bands: there was a whitish an almost imperceptible basal band, a gray subdistal band, and a whitish distal band (Figure 3m). Compared to QCAZ 7725, specimen QCAZ 19838 exhibited a similar dorsal color pattern (Figure 3n). QCAZ 19838 had four to three colors ventrally, with an almost imperceptible whitish basal band, a dark grayish epibasal band, a whitish subdistal band, and a grayish to brown distal band (Figure 3o). Both specimens have sparse hairs on the foot (Figure 3g, i). These specimens have a short fringe of hairs in the posterior edge of the uropatagium, measuring 3 mm in QCAZ 7725, 3.4 mm in QCAZ 19838, similar to 4 mm in the holotype (according to Peterson and Tamsitt 1968). The dorsal and ventral hair length of QCAZ 7725 and QCAZ 19838 were 8.23 and 4.77, and 8.51 and 4.63 mm, respectively. Our measurements were similar to those from previous records in Peru (Table 1).
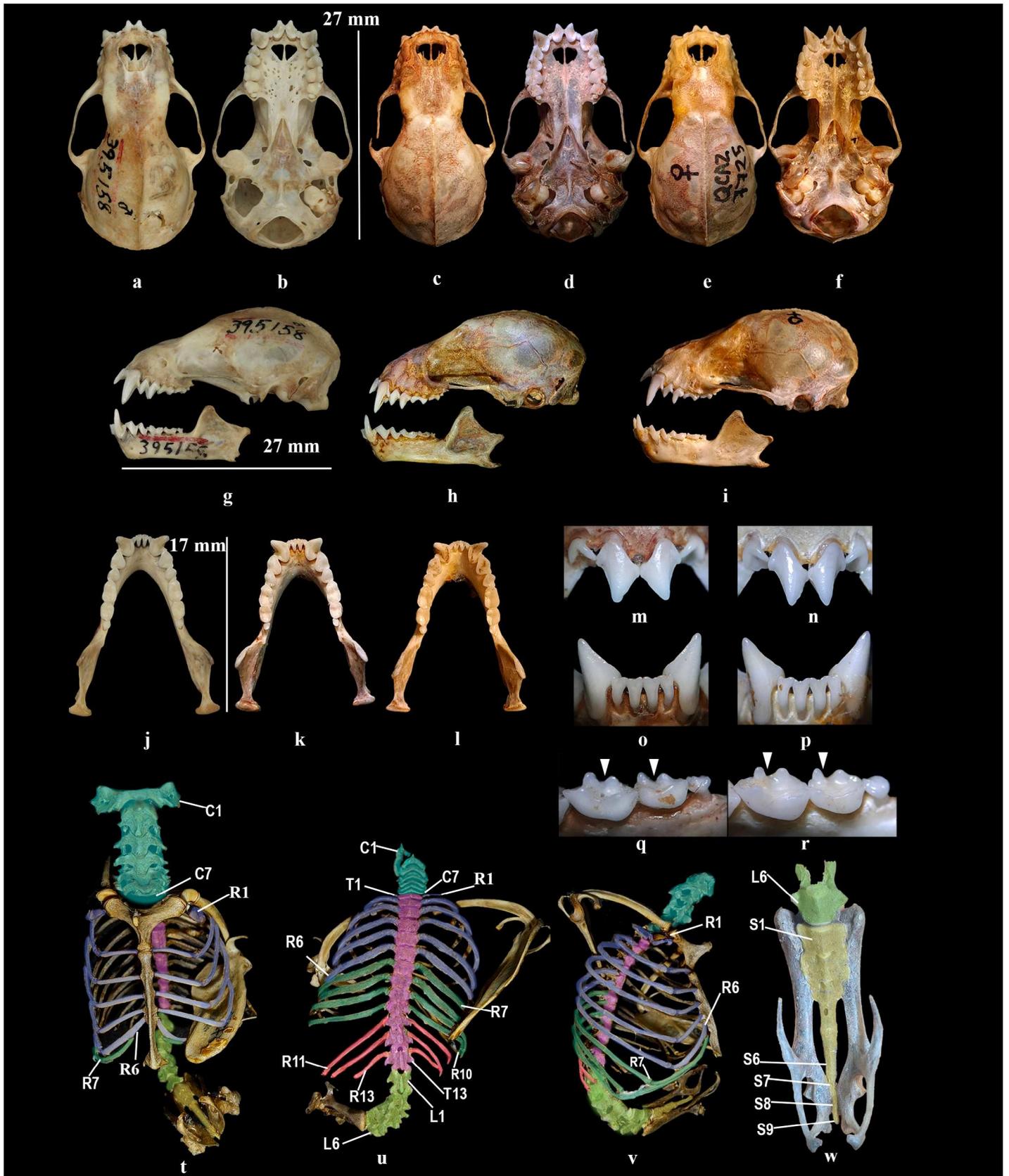
Figure 2. Details of the skull and skeleton of *Sturnira aratathomasi*. Dorsal and ventral views of the cranium of USNM 395158 ⚤ Holotype (a - b), QCAZ 19838 ⚤ (c - d), and QCAZ 7725 ⚤ (e - f). Lateral left view of the cranium and the lower jaw of USNM-395158 ⚤ (g), QCAZ 19838 ⚤ (h), and QCAZ 7725 ⚤ (i). Dorsal view of the mandible of USNM 395158 ⚤ (j), QCAZ 19838 ⚤ (k), QCAZ 7725 ⚤ (l). Upper inner incisors are pointed and non in contact in QCAZ 19838 ⚤ (m) and QCAZ 7725 ⚤ (n). Lower inner incisors are tricuspidate in QCAZ 19838 ⚤ (o) and QCAZ 7725 ⚤ (p). Triangles are showing a deep notch between the metaconid and entoconid of m1 and m2 in QCAZ 19838 ⚤ (q) and QCAZ 7725 ⚤ (r). Ventral, dorsal, and lateral view of the skeleton of QCAZ 7725 ⚤ (t - v). Only the first 6 ribs are directly connected to the sternum (t, v). Ventral view of the pelvis of QCAZ 19838 ⚤ (w), L5 and L6 are observed at the top of the image. Abbreviatures: cervical vertebrae (C1 - C7, light blue), thoracic vertebrae (T1 - T13, pink), lumbar vertebrae (L1 - L6, light green), sacra vertebrae (S1 – S9, yellow), true ribs (R1 - R6 blue), false ribs (R7 - R10, dark green), floating ribs (R11 - R13, red). Photos: K. Sayers (a - b, g, j), MAR-S (c - f, h, I, k - w)

Figure 3. Dry skin details of *S. magna and S. aratathomasi*. Frontal view of the head: *S. magna* QCAZ 6940 ⚥ (a), QCAZ 19838 ⚥ (b), QCAZ 7725 ⚥ (c). Triangles show how the horseshoe of noseleaf is fused to the upper lip in *S. aratathomasi*, while in *S. magna* this character is fused, but with a distinguishable edge. Dorsal and ventral views of the skin of USNM 395158 ⚥ Holotype (e - f), QCAZ 7725 ⚥ (g - h), and QCAZ 19838 ⚥ (i - j). QCAZ 7725 ⚥ in live (d) QCAZ 19838 ⚥ in live (k). Detail of the dorsal and ventral pattern color in QCAZ 7725 ⚥ (l - m) and QCAZ 19838 ⚥ (n - o). Abbreviations: basal band (1), epibasal band (2), subdistal band (3), distal band (4). Photos: courtesy of T. E. Lee Jr. (d), AL-P (k), MAR-S (a - c, g - j, l - o), K. Sayers (e - f)

Table 1. Morphometric measurements (in mm) of *Sturnira aratathomasi* specimens. Data was obtained from the museum records analyzed, scientific literature, and personal communication with curators (see Rodríguez-Segovia and Pilatasig 2025).

Measurements	Present Study Data from 26 specimens Range (MEAN ± SD) (sample)	Pacheco and Hocking (2006) Data from MUSM 7305 and 7306 at San Martin (Peru) Range (MEAN ± SD) (sample)	Pacheco and Hocking (2006) Data from MUSM 19151 - 19153 at Apurimac (Peru) Range (MEAN ± SD) (sample)
Head and Body Length	83 - 101 (91.14 ± 4.67) (n = 18)	74 - 89 (81.5 ± 10.61) (n = 2)	90 - 95 (91.7 ± 2.89) (n = 3)
Hind Foot Length	12.2 - 21 (17.22 ± 2.45) (n = 22)	18 - 18.5 (18.3 ± 0.35) (n = 2)	18.5 - 19 (18.7 ± 0.29) (n = 3)
Ear	16 - 22.43 (19.87 ± 1.53) (n = 23)	22 - 22 (22 ± 0.00) (n = 2)	20 - 20 (20 ± 0.00) (n = 3)
Tibia	18.86 - 23.8 (22.18 ± 1.73) (n = 9)	-	-
Forearm	49 - 62 (58.36 ± 2.52) (n = 26)	58.1 - 58.7 (58.4 ± 0.42) (n = 2)	55.5 - 58.7 (57.3 ± 1.61) (n = 3)
Metacarpal 3rd Digit	54.2 - 60.7 (57.27 ± 1.96) (n = 14)	53.3 - 54.8 (54.1 ± 1.06) (n = 2)	54.5 - 54.9 (54.7 ± 0.20) (n = 3)
1st Phalanx 3rd Digit	20.5 - 22.5 (21.39 ± 0.54) (n = 12)	20.3 - 21.5 (20.9 ± 0.85) (n = 2)	20.7 - 22.8 (21.6 ± 1.13) (n = 3)
2nd Phalanx 3rd Digit	26.3 - 29.66 (28.28 ± 0.91) (n = 12)	27.5 - 28.6 (28.1 ± 0.78) (n = 2)	27.9 - 28.7 (28.3 ± 0.40) (n = 3)
Metacarpal 4th Digit	53.7 - 58.8 (56.14 ± 1.64) (n = 14)	-	-
1st Phalanx 4th Digit	16.74 - 19.7 (17.69 ± 0.89) (n = 12)	-	-
2nd Phalanx 4th Digit	19.5 - 22.5 (20.25 ± 0.81) (n = 12)	-	-
Metacarpal 5th Digit	56.4 - 61 (58.44 ± 1.53) (n = 14)	-	-
1st Phalanx 5th Digit	11.65 - 14.1 (12.55 ± 0.72) (n = 12)	-	-
2nd Phalanx 5th Digit	14.1 - 18.2 (15.37 ± 1.22) (n = 12)	-	-
Greatest Length of the Skull	25.75 - 29.9 (28.29 ± 1.08) (n = 16)	27.8 - 28.3 (28.1 ± 0.37) (n = 2)	27.3 - 28 (27.7 ± 0.33) (n = 3)
Braincase Breadth	13.05 - 13.21 (13.15 ± 0.09) (n = 3)	13 - 13 (13 ± 0.00) (n = 2)	13 - 13.1 (13.1 ± 0.07) (n = 3)
Cranial Heigh	10.43 - 11.68 (11.22 ± 0.69) (n = 3)	-	
Condyloincisive Length	26.52 - 27.8 (27.2 ± 0.42) (n = 15)	-	
Condylocanine Length	25.56 - 26.46 (26.01 ± 0.64) (n = 2)	25.1 - 25.8 (25.4 ± 0.52) (n = 2)	24.4 - 25.1 (24.8 ± 0.37) (n = 3)
Condylobasal Length	24.2 - 26.42 (25.33 ± 1.11) (n = 3)	25.7 - 26.8 (26.2 ± 0.71) (n = 2)	25.1 - 26 (25.7 ± 0.51) (n = 3)
Palatal Length	10.15 - 13.38 (12.55 ± 0.82) (n = 13)	11.2 - 11.7 (11.4 ± 0.35) (n = 2)	11.3 - 11.6 (11.5 ± 0.16) (n = 3)
Zygomatic Breadth	16.68 - 17.8 (17.23 ± 0.37) (n = 15)	16.8 - 17.3 (17.1 ± 0.32) (n = 2)	16.7 - 16.9 (16.8 ± 0.10) (n = 3)
Mastoid Breadth	12.8 - 17.1 (15.07 ± 1.04) (n = 10)	-	
Least Interorbital Breadth	7.5 - 8.2 (7.67 ± 0.21) (n = 12)	7.3 - 7.3 (7.3 ± 0.00) (n = 2)	7.8 - 8 (7.9 ± 0.09) (n = 3)
Postorbital Process	7.8 - 8.5 (8.03 ± 0.2) (n = 12)	8.3 - 8.4 (8.3 ± 0.06) (n = 2)	7.4 - 7.6 (7.5 ± 0.10) (n = 3)
Postorbital Constriction	7 - 7.51 (7.21 ± 0.12) (n = 15)	-	-
M1-M1	9.4 - 10.4 (10.04 ± 0.27) (n = 15)	-	-
M2-M2	8.91 - 9.32 (9.12 ± 0.29) (n = 2)	9.6 - 9.6 (9.6 ± 0.00) (n = 2)	9.6 - 9.8 (9.7 ± 0.08) (n = 3)
C-M^3	7.6 - 8.66 (8.26 ± 0.25) (n = 16)	7.7 - 8.1 (7.9 ± 0.27) (n = 2)	7.9 - 8.1 (7.9 ± 0.11) (n = 3)
C-C (upper)	7.94 - 8.7 (8.37 ± 0.2) (n = 11)	7.9 - 8.3 (8.1 ± 0.28) (n = 2)	7.7 - 7.9 (7.8 ± 0.09) (n = 3)
Length of Mandibles	17.49 - 19.5 (18.21 ± 0.46) (n = 15)	17.8 - 18.2 (18 ± 0.23) (n = 2)	17.4 - 18.1 (17.8 ± 0.34) (n = 3)
Height of Coronoid Process	7.44 - 7.45 (7.44 ± 0.01) (n = 2)	7.2 - 7.2 (7.2 ± 0.00) (n = 2)	7 - 7.2 (7.1 ± 0.10) (n = 3)
C-M$_3$ (lower)	8.96 - 9.4 (9.16 ± 0.15) (n = 13)	8.7 - 8.8 (8.8 ± 0.08) (n = 2)	8.6 - 8.9 (8.7 ± 0.12) (n = 3)
Height of C1	4.18 - 4.7 (4.42 ± 0.23) (n = 4)	-	-
Height of c1	3.6 - 4.09 (3.85 ± 0.2) (n = 4)	-	-
Weight	34.5 - 67.1 (48.14 ± 8.15) (n = 16)	47.5 - 57.5 (52.5 ± 7.07) (n = 2)	46 - 50 (47.7 ± 2.08) (n = 3)

This study provides valuable data on *S. aratathomasi*, reporting for the first time precise geographic information from Ecuador and extending its known geographic distribution in Colombia. It also offers useful photographic references for identifying this species in the field and in museum collections. Implications for the conservation of this species and its anatomy are addressed.

All the characters and measurements analyzed in this paper coincide with previous reports (Solari *et al.* 2001; Pacheco and Hocking 2006). Few studies have analyzed the post-cranial osteology of bats and there are variations in the number of vertebrae and ribs within and among species (Walton and Walton 1970; Gaudioso *et al.* 2017; Louzada and Pessôa 2022). In general, mammals possess 7 cervical, 12 - 14 thoracic, 5 - 7 lumbar, 2 - 5 sacral, and a variable number of caudal vertebrae (Romer 1966). For the genus *Sturnira,* a study considers 7 cervical, 12 thoracic, and 5 lumbar vertebrae (Walton and Walton1970). Therefore, our data fall outside the range reported for mammals (Romer 1966) and for the genus *Sturnira* (Walton and Walton 1970), as the specimen QCAZ 7725 exhibits nine sacral vertebrae. This anatomical variation is novel for the genus. Examples of bats with more than five sacral vertebrae are rare in the literature. As an example, *Molossus fluminensis* has been reported to possess five to six sacral vertebrae (Louzada and Pessôa 2022).

The dentition and the woolly pelage of *S. aratathomasi* seems to be highly specialized in the rich vegetation and climate of the montane forests of the Andes (McCarthy *et al.* 2006; Jarrín and Kunz 2011). However, the feeding habits of this species remain mostly unknown (Castaño *et al.* 2018). Additional zoological expeditions along the Salado and the Quijos River, and the Coca Codo Sinclair Power Plant are recommended to monitor the population status, natural history, ecology, and behavior of *S. aratathomasi* in Ecuador.

Natural history scientific collections are fundamental for the understanding of biological diversity over time (Bradley *et al.* 2014). A study suggests that investing more time and resources in curatorial work may be more efficient than investing in field expeditions when researchers aim to fill the biodiversity data gap (Vargas *et al.* 2023). Based on our experience, it is very common for researchers to lack both qualified personnel and sufficient funding to carry out fieldwork, making the review of natural history collections an essential alternative. Certainly, there are hundreds of unreviewed specimens deposited in other Ecuadorian and Colombian institutions, as well as in foreign collections. These materials could be sufficient for other researchers to carry out a systematic revision in search of rare species. Currently, some noteworthy records found in Ecuadorian mammal collections support this investment (Rodríguez-Segovia and Montenegro-García 2024; Vivas-Toro *et al.* 2024; Rodríguez-Segovia *et al.* 2025). However, we believe that both types of investments are essential

for analyzing the distribution of endangered species and for implementing conservation strategies (IUCN 2012, Camacho *et al.* 2018).

The specimen QCAZ 7725 was reported as *S. magna* by a previous study, which stated that this was the highest known record for the species at 1,900 m; the prior maximum elevation was about 1,090 m (Lee Jr *et al.* 2006). Considering our findings, we hypothesize that many specimens occurring in evergreen montane forests on the eastern slopes of the Andes are likely being misidentified as *S. magna*. In this context, ecological niche modeling is highly recommended to better understand the past, present, and future distribution of *S. aratathomasi* in the Neotropics (Molinari *et al.* 2023). Based on available records, it is highly probable that *S. aratathomasi* occupies montane forest habitats along the western slopes of the Ecuadorian Andes. The Cayambe Coca National Park and Los Nevados National Natural Park are considered as priority areas for the conservation and research of this rare species. In these reserves, there are remnants of premontane to montane forest suitable for its survival (MAE 2013).

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Appendix

Appendix 1. Gazetteer for *Sturnira aratathomasi*. Numbered localities (#), as shown in Figure 1, are listed in the first row of the following table. Further details are provided by Rodríguez-Segovia and Pilatasig (2025).

#	Type of Record	Localities	Specimen	Institution	Latitude	Longitude	Elevation	Reference
-	Unconfirmed record	Departamento de Loreto, Río Apayacu	Released individual	-	03° 07′ 00″ S	072° 42′ 00″ W	120 - 250	Montenegro and Escobedo (2004)
-	Literature	Unknown locality	IRSBN 237/3267 ♂	Institut Royal des Sciences Naturelles de Belgique	-	-	-	Peterson and Tamsitt (1968)
-	Literature	Unknown locality	IRSNB 237/3267 / ROM 46349 ♀	Institut Royal des Sciences Naturelles de Belgique/Royal Ontario Museum	-	-	-	Peterson and Tamsitt (1968)
1	Literature	Department of Valle, Colombia, 2 km south of Pance (approximately 20 km southwest of Cali) (Type Locality)	TU 635/USNM 395158 ♂ Holotype	Universidad del Valle-Tulane/ United States National Museum	03° 21′ 00″ N	076° 38′ 00″ W	1,650	Peterson and Tamsitt (1968)
2	Literature	Departamento del Valle, dense forest over 10kms southwest of Felidia, over a small Stream (Río Felidia)	USNM 501064 ♀	United States National Museum	03° 27′ 32.2 ″ N	076° 38′ 32.9″ W	1,800	Thomas and McMurray (1974)
3	Literature	Departamento del Valle, 15 km southwest of Cali, near Peñas Blancas (Río Pichindé)	ROM 70874 ♀, ROM 70875 ♂, ROM 70876 ♂	Royal Ontario Museum	03° 25′ 57.5 ″N	076° 38′ 54.9 ″W	1,800	Thomas and McMurray (1974)
			USNM 501066 ♀, USNM 501065 ♂	United States National Museum	03° 25′ 57.5 ″N	076° 38′ 54.9 ″W	1,800	Thomas and McMurray (1974)
4	Literature	Merida, Monte Zerpa, 4 km NW of Merida	CVULA-I-1303 ♂	Colección de Vertebrados de la Universidad de los Andes	08° 37′ 00″ N	071° 09′ 00″ W	2,000	Soriano and Molinari (1984, 1987)
5	Literature	Departamento del Huila, El Parque Nacional Natural de la Cueva de Los Guácharos	INDERENA / IAVH 2298 ♀	Instituto de Desarrollo de los Recursos Naturales Renovables y del Ambiente/ Instituto de investigación de recursos biológicos Alexander von Humboldt	01° 36′ 00″ N	075° 56′ 00″ W	1,800	Tamsitt *et al*. (1986)
6	Literature	Department of Cauca, Municipality of Páez (Belálcazar), near Irlanda, Parque Nacional Natural Nevado de Huila	ICN ♂	Instituto de Ciencias Naturales, Universidad Nacional de Colombia	02° 54′ 00″ N	076° 06′ 00″ W	2,820	Tamsitt *et al*. (1986)
7	Literature	Departamento del Valle del Cauca, Hacienda Los Alpes, 6 km S, 11 km E of Florida	UV 3482 ♀	Universidad del Valle	03° 16′ 00″ N	076° 09′ 00″ W	2,400	Alberico (1987)
8	Literature	Departamento del Valle del Cauca, Cordillera Occidental: Betania, 10 km N, 15 km W Bolivar	UV 3876 ♀	Universidad del Valle	04° 26′ 00″ N	076° 19′ 00″ W	1,800	Alberico (1987)
9	Literature	Departamento del Valle del Cauca, Parque Nacional "Los Farallones de Cali",1 km S, 1 6 km W Cali,	UV 3373 ♀	Universidad del Valle	03° 22′ 00″ N	076° 41′ 00″ W	2,600	Alberico (1987)
10	Literature	Departamento del Valle del Cauca, Paso de Galapagos, 8 km N and 4 km E of El Cairo	UV 4131 ♂, UV 4133 ♂	Universidad del Valle	04° 50′ 00″ N	076° 12′ 00″ W	1,800	Alberico (1987)
11	Literature	Departamento de Amazonas, Cordillera Colán, east of La Peca	LSUMZ 21484 ♂	Museum of Zoology Louisiana State University	05° 34′ 00″ S	078° 17′ 00″ W	3,165	McCarthy *et al.* (1991)
12	Literature	Departamento de Risaralda, Parque Regional Natural Ucumarí	-	-	04° 47′ 00″ N	075° 32′ 00″ W	2,100	Alfonso and Cadena (1994)
13	Literature	Departamento de Antioquia, Municipio de Caldas, Monte San Miguel	-	-	06° 04′ 00″ N	075° 37′ 00″ W	1,950 – 2,700	Cuartas (1997)
14	Literature	Antioquia, Anorí	-	-	07° 05′ 00″ N	075° 08′ 00″ W	1,535	Muñoz-Arango (2001)
15	Literature	Departamento de San Martín, ca. 32 km NE de Pataz, Las Palmas, Parque Nacional del Río Abiseo	MUSM 7305 ♂, MUSM 7306 unknown sex	Museo de Historia Natural, Universidad Nacional Mayor de San Marcos	07° 34′ 12.65′ S	077° 17′ 50.64′ ′W	2,000 - 2,100	Solari *et al*. (2001), Pacheco and Hocking (2006)
16	Literature	Departamento de Caldas, Municipio de Manizales, Recinto el Pensamiento	MHNUC 312 ♀	Museo de Historia Natural, Universidad de Caldas	05° 02′ 00″ N	075° 26′ 00″ W	2,180	Castaño *et al*. (2004)
17	Literature	Departamento de Tolima, Municipio de Ibagué, Sito las Juantas	-	-	04° 33′ 00″ N	075° 19′ 00″ W	1,900	Bejarano and Yate (2003)

#	Type of Record	Localities	Specimen	Institution	Latitude	Longitude	Elevation	Reference
18	Literature	Departamento de Tolima, Municipio de Ibagué, Sito El Filtro	-	-	04° 36′ 00″ N	075° 22′ 00″ W	2,950	Bejarano and Yate (2003)
19	Literature	Departamento de Santander, Municipio El Encino, Finca La Desdichada	-	-	06° 10′ 00″ N	073° 08′ 00″ W	2,000	Otálora-Ardila (2004)
20	Literature	Department of Apurímac, Cconoc, at the border of the Río Apurímac	MUSM 19151 ♂, MUSM 19152 ♂, MUSM 19153 ♀	Museo de Historia Natural, Universidad Nacional Mayor de San Marcos	13° 32′ 47″ N	072° 38′ 39″ W	1,925	Pacheco and Hocking (2006)
21	Literature	Departamento de Risaralda, Municipio de Pereira, Santuario de Fauna y Flora Otún Quimbaya	MUJ 1111 ♂, MUJ 1117 ♂, MUJ 1128 ♂	Museo de Historia Natural de la Pontificia Universidad Javeriana	04° 45′ 00″ N	075° 46′ 00″ W	2,100	Estrada-Villegas *et al.* (2007)
			Released/ Measured individuals (n = 2)	-	04° 45′ 00″ N	075° 46′ 00″ W	2,100	Estrada-Villegas *et al.* (2007)
22	Literature	Departamento de Caldas, ciudad de Manizales, vereda Las Palomas, Reserva Hidrográfica Río Blanco, Fundación Ecológica Gabriel Arango Restrepo, estación Viveros	ICN 16988 ♀, ICN 16989 ♀, ICN 16990 ♀	Instituto de Ciencias Naturales, Universidad Nacional de Colombia	05° 04′ 00″ N	075° 32′ 00″ W	2,500	Rodríguez-Posada (2010)
23	Literature	Departamento de Valle del Cauca, Quebrada Charco Azul, approx. 5 km E Alto de Galápagos, El Cairo	FMNH 189778 ♂	Field Museum of Natural History	04° 48′ 00″ N	076° 12′ 00″ W	1,800	Velazco and Patterson (2013)
24	New Record	Department of Tolima, Municipality of Cajamarca, La Colosa, Quebrada La Colosa	MHNUC 1954 unknown sex	Museo de Historia Natural, Universidad de Caldas	04° 23′ 13.9″ N	075° 29′ 02″ W	2,309	Present Study
25	New Record	Department of Tolima, Municipality of Ibagué, Corregimiento Juntas	MHNUC 1408 ♀	Museo de Historia Natural, Universidad de Caldas	04° 36′ 56.4″ N	075° 20′ 11.1″ W	2,648	Present Study
26	New Record	Napo, El Chaco, Santa Rosa, Cayambe Coca National Park, Salado, Guataringo, Bridge of the Gringo River	QCAZ 19838 ♀	Museo de Zoología QCAZ de la Pontificia Universidad Católica del Ecuador	00° 11′ 20.6″ S	077° 42′ 20.5″ W	1,301	Present Study
27	New Record	Napo, 12 km NW Cosanga	QCAZ 7725 ♀	Museo de Zoología QCAZ de la Pontificia Universidad Católica del Ecuador	00° 31′ 42″ S	077° 52′ 59.4″ W	1,900	Present Study

First record of nesting of a marsupial *Tlacuatzin balsasensis* (Didelphidae) in a wasp comb

Primer registro de anidación de un marsupial *Tlacuatzin balsasensis* (Didelphidae), en un nido de avispas

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Mammals construct, reuse, or adapt nests for purposes such as maternity, rest, and protection from environmental factors. American marsupials can either construct their own nests or occupy those abandoned, but the use of wasp combs as structural support has not been previously observed. In this study, we document the construction of a nest by a small Neotropical marsupial utilizing a wasp comb as support. While carrying out field surveys at Yerba santa, Municipality of Yosondúa, Oaxaca, México, we were noticed by residents of a wasp nest. We went to the sighting site to measure the height of the branch supporting the nest. The nest was examined, measurements were taken (length, width, and diameter of the entrance), and photographic records were obtained of the small mammal inside. The wasp nest was located on a thin branch 4 m above the ground. It measured 25 cm in length and 15 cm in width, with an entrance opening of 7 cm positioned on the underside. Inside a single individual of a small marsupial was observed. The individual was identified as *Tlacuatzin balsasensis* based on its small size, brownish slightly gray dorsal fur and yellow buff underparts, and geographic range. The nest fitted to known descriptions of *Tlacuatzin* nests, as the size, entrance, and location above the ground. However, the base material consisted of wasp comb, an animal-built material. Wasp nests provide robust material that may also offer environmental protection and refuge from predators for the small marsupial. To our knowledge, this represents the first recorded instance of a mammal nesting in a wasp nest.

Key words: Behavior; Deciduous forests; Mixteca region; Oaxaca; *Polybia*; refuge.

Los mamíferos construyen, reutilizan o adaptan sus nidos para la maternidad, el descanso y la protección frente a factores ambientales. Los marsupiales americanos pueden construir sus propios nidos u ocupar los abandonados, pero el uso de panales de avispa no se había observado anteriormente. Documentamos la construcción de un nido por parte de un pequeño marsupial neotropical utilizando un panal de avispa. Durante muestreos de campo en Yerba Santa, Municipio de Yosondúa, Oaxaca, México, los habitantes del lugar nos notificaron de un nido de avispas. Después de inspeccionarlo, encontramos un pequeño mamífero en su interior. Se inspeccionó el nido, se tomaron medidas (largo, ancho y diámetro de la entrada) y se obtuvieron registros fotográficos del individuo. El nido de avispas se localizó sobre una rama delgada a 4 m del suelo. Medía 25 cm de largo por 15 cm de ancho, con una entrada de 7 cm posicionada en la parte inferior. En su interior se observó un individuo de un pequeño marsupial. El individuo fue identificado como *Tlacuatzin balsasensis* con base en su tamaño pequeño, pelaje dorsal ligeramente gris parduzco y partes inferiores de color beige amarillento y rango geográfico. El nido se ajusta a las descripciones conocidas, en cuanto al tamaño, entrada y ubicación sobre el suelo. Sin embargo, el material de base consistió en un panal de avispa, el cual proporciona un material resistente que también puede ofrecer protección ambiental y refugio contra los depredadores. Hasta donde sabemos, este es el primer caso registrado de un mamífero anidando en un panal de avispa.

Palabras clave: Comportamiento; Oaxaca; *Polybia*; refugio; región Mixteca; selva baja caducifolia.

Marsupials use nests as shelters and to protect and lactate their young until they can provide themselves with food (Tyndale-Biscoe and Renfree 1987). Therefore, females build better-quality nests (Kimble 1997) and change nests less frequently than males (Reid 1997). For females, the search for appropriate nesting sites is vital to protect their numerous offspring and is more stressing for those species that lack a pouch (Astúa and Guilhon 2022). Marsupials can build nests (Kimble 1997) but more commonly exhibit opportunistic nesting behavior by appropriating and reconditioning the nests of other species (Hunsaker II and Shupe 1977; Monticelli and Gasco 2018). Therefore, the

Figure 1. Geographical location of Yerba Santa, Municipality of Yosondúa, in the Mixteca region, State of Oaxaca, México.

discovery of their nests is usually by chance (Armstrong and Jones 1971; Zarza *et al.* 2003).

The location of marsupial nests is related to the stratum they use (Pine 1981; O'Connor *et al.* 1982), for example, the semi-aquatic species *Chironectes minimus* (Zimmermann, 1780) usually makes underground cavities with entrances above the water level (Reid 1997); while the four-eyed opossum *Metachirus nudicaudatus* (É. Geoffroy Saint-Hilaire 1803), of terrestrial habits, builds nests with dry leaves intertwined with pieces of roots, which are spherical, and apparently without an entrance (Loretto *et al.* 2005). The descriptions of small marsupial nests agree that the nests are located more than 0.7 m above the ground, are spherical (approximately 20 cm in diameter), with openings of 3-4 cm at the bottom, and for their conditioning they use dry leaves (Hunsaker II and Shupe 1977; Husson 1978; Jiménez and Rageot 1979; Redford and Eisenberg 1992; Engstrom *et al.* 1994; Zarza *et al.* 2003). They can also use holes in banks of ground, branches, or cactus, and the use of abandoned bird nests is also common (Alonso-Mejía and Medellín 1992; Reid 1997). Additionally, the use of artificial nests (wooden boxes; Brito-Vera *et al.* 2022) has been recorded. In all cases, marsupial species seem to share the behavior

of transporting organic material for nesting with the help of their tails (Redford and Eisenberg 1992; Kimble 1997; Pereira and Schlindwein 2016).

Ramírez-Pulido et al. (2014) recognize that nine species of marsupials inhabiting México. However, molecular genetic studies carried out by Arcangeli et al. (2018) on the genus *Tlacuatzin* Voss and Jansa, 2003 suggest that in México this taxon is formed by five phylogenetic clades in México, two of which are distributed in the state of Oaxaca: *Tlacuatzin canescens* (Allen 1893) and *Tlacuatzin balsasensis* Arcangeli et al. 2018

Tlacuatzin is an endemic taxon to México (Arcangeli *et al.* 2018); the species of this genus are small (20-60 g) and have mainly nocturnal, semi-arboreal, and solitary habits; they are considered omnivores, feeding mainly on insects and fruits and occasionally on small vertebrates (Zarza *et al.* 2003). These species frequent the ground more than others and in western México, the reproductive season runs from August to October, and they have 8 to 13 young (Reid 1997).

The nests of *Tlacuatzin* species have been described as spherical and constructed of dry leaves and twigs lined with plant remains (Nelson 1899; Armstrong and Jones 1971; Reid 1997; Zarza *et al.* 2003). The species *Tlacuatzin*

Figure 2. a) Individual of *Tlacuatzin balsasensis*. inside a wasp comb of *Polybia* sp.; b) close-up.

insularis (Merriam, 1898), from the Islas Marías, nests in cactus, and abandoned nests of birds, such as orioles (Armstrong and Jones 1971; Zarza *et al.* 2003). In Chamela, Jalisco, the nests of *Tlacuatzin sinaloae*. have been found on trees (*Cenostigma eriostachys* (Benth.) Gagnon & G.P.Lewis, *Bonellia macrocarpa* subsp. *pungens* (A.Gray) B.Ståhl & Källersjö), shrubs (*Neltuma juliflora* (Sw.) Raf.) and cacti *Opuntia excelsa* Sánchez-Mej.), at 0.70-5.0 m above the ground (Zarza *et al.* 2003). In this note, we document the use and conditioning of a *Polybia* sp. wasp comb by the *Tlacuatzin balsasensis* for use as a nest.

The record was carried out in the community of Yerba Santa in the Municipality of Santiago Yosondúa, in the Mixteca region, in the central west of the state of Oaxaca, México. Its geographical location is between the coordinates 16º 48' N and 16º 49' N, and 97º 34' W and 97º 33' W (Figure 1). It is located at a distance of 96.8 km SW

from the City of Oaxaca. The topography is heterogeneous, with an altitudinal gradient that varies from 1,200 m in the lowest area to 1,750 m in the highest area. The site has tropical deciduous forests in the lower parts, while in the middle elevations, it changes to oak or oak-pine forests, and in the higher parts, there is pine forest.

During wildlife monitoring activities in Yerba Santa, local residents reported the accidental discovery of a wasp comb on a recently cut branch during clearing work. Based on this report, the following were carried out: (1) locating and georeferencing the site of the discovery; (2) measuring the height of the branch supporting the comb; (3) conducting a detailed examination of the comb, recording its morphometric variables in centimeters (length, width, and diameter of the entrance); and (4) photographing the resident specimen. Additionally, wasp remains present inside the nest were collected to determine their taxonomic

identity. Taxonomic identification was performed through comparative morphological analysis of adult specimens collected at the site.

On March 5, 2021, the first author was notified of the remains of a wasp comb that had been removed from a tree during land-clearing activities. According to the report, the nest was extracted due to concerns over potential wasp. The Site inspection revealed that the wasp comb was suspended 4 meters above ground on a *Lonchocarpus* sp. branch; it had an opening underside, and inside an individual of opossum was discovered. The geographic coordinates of the record were 16°48'5.40" N, 97°35'14.28"W. The individual was determined as *Tlacuatzin* due to its small size and grayish fur color, instead of reddish as presented in *Marmosa mexicana* Merriam, 1897 (Zarza *et al.* 2003). As the specimen was not collected, morphometrics (e.g., skull dimensions, molar lengths) were unavailable. Species identification was therefore based on fur coloration and range criteria from Arcangeli *et al.* (2018) as *T. balsasensis* due to the specimen possessing a brownish slightly gray dorsal fur and yellow buff underparts (Figure 2) and near of the range of this species. The dimensions of the nest were: width 15 cm, length 25 cm, and diameter 15 cm; the opening of the nest was 7 cm in diameter. The exact depth of the nest is unknown, but it was observed that the individual could stay completely inside. The edges and interior of the nest were covered with leaves that partially separated the nest cells (Figure 2).

Videos and photographs of the species were obtained and subsequently, the nest was placed on a high branch of an *Ehretia tinifolia* L. tree near the location of the discovery to allow the animal to continue their cycle life.

When reviewing published information on the nests occupied by species of the genus *Tlacuatzin*, we found that these have been described as balls of dry leaves and twigs lined with crushed leaves and arranged in the fork of small trees and shrubs, or holes in cactus or branches (Nelson 1899; Armstrong and Jones 1971; Reid 1997). Nests have been found 0.9 to 2.4 m above the ground (Nelson 1899) and usually have a small opening on the underside. The nest described here was found 4 m above ground and in other characteristics, it conforms to previous descriptions, in terms of the flattened leaves lining the entrance and interior, and the position of the opening. However, the base material of the nest consisted mainly of wasp comb. The use of these combs had not previously been reported in nests of marsupials or other small mammals, so this is the first record of the use of wasp combs as a nesting site for a marsupial or any other mammal.

Both mammals and birds often resort to wasp combs in search of larvae as a food source (Jeanne 2009; Kratzer 2022). There are also mutualistic interactions, in which birds and wasps find benefit from building nests nearby (Hindwood 1955; Quinn and Ueta 2008). In Africa, it was found that vertebrates and wasps preferred artificial nests that were not previously occupied by the other species, suggesting that they avoided each other (Veiga *et al.* 2013). Brito-Vera *et al.* (2022) reported the use of artificial nest boxes with the presence of abandoned wasp nests by *Marmosa simonsi* Thomas 1899, but not utilizing the comb as in the present findings.

The nesting record that we present, together with the report by Brito-Vera *et al.* (2022), suggests that there is no rejection by small marsupials to occupy sites previously used by wasps as nests. On the other hand, the documented finding reinforces the conception of the opportunistic behavior of *Tlacuatzin* sp. to occupy pre-constructed sites as nesting and/or refuge sites (Armstrong and Jones 1971).

Finally, our nesting record of *T. balsasensis* in wasp combs represents the first documented report for the genus *Tlacuatzin*. However, further ecological studies are required to confirm if the use of this organic material is common in species of the *Tlacuatzin* genus and if it provides them with any nutrients or advantages over others plant materials or to deter predators.

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First record of alopecia in *Artibeus jamaicensis* and *Choeronycteris mexicana* (Chiroptera: Phyllostomidae) in Puebla, Mexico

Primer registro de alopecia en *Artibeus jamaicensis* y *Choeronycteris mexicana* (Chiroptera: Phyllostomidae) en Puebla, México

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Alopecia refers to partial or total hair loss in mammals. It is an autoimmune disease that prevents hair follicle growth and causes hair loss. In this study, we report partial hair loss in three bats: two of the frugivorous species *A. jamaicensis* and one of the nectarivorous species *C. mexicana*, collected in the southern area of a protected area in the state of Puebla, Mexico. Bats with alopecia were observed in May and November 2024 during field trips of a project aimed at assessing the conservation status of bat species in the state of Puebla. Bats were captured at a site with low deciduous forest vegetation and mango and banana plantations in Atotonilco, municipality of Huehuetlán el Grande, Puebla. We captured 27 bats of different species. Among them, two adult females of *A. jamaicensis* without evidence of reproductive activity had partial or total alopecia in the abdominal area. Another individual, an adult male of *C. mexicana* with scrotal testes, presented with alopecia on the face, neck, and abdomen. This is the first report of alopecia in bats from Puebla, the third for *A. jamaicensis* in Mexico, and the first for *C. mexicana* in Mexico. In previous studies on bats in the state of Puebla, there have been no reports of alopecia. Alopecia in these individuals is likely due to environmental stress caused by anthropogenic activities in Atotonilco that probably affect nutritional processes.

Key words: frugivore, hair loss, nectarivore, Phyllostomidae.

La alopecia es la pérdida parcial o total de pelo en mamíferos, es una enfermedad autoinmune que evita el crecimiento del folículo piloso y causa la caída de pelo. En este estudio reportamos la pérdida parcial de pelo en tres murciélagos: 2 frugívoros de la especie *Artibeus jamaicensis* y 1 nectarívoro de la especie *Choeronycteris mexicana*, en el extremo sur de un área estatal protegida del estado de Puebla, México. Los murciélagos con alopecia se registraron en los meses de mayo y noviembre de 2024, durante las salidas de campo de un proyecto en el que se evalúo el estado de conservación de las especies de murciélagos del estado de Puebla. Las capturas de murciélagos se hicieron en un sitio con vegetación de selva baja caducifolia con plantaciones de mango y plátano en Atotonilco, municipio de Huehuetlán el Grande, Puebla, México. Se capturaron 27 murciélagos de diferentes especies. Entre ellos, 2 hembras adultas de *A. jamaicensis* sin evidencia de actividad reproductiva, presentaron alopecia parcial y total en la zona abdominal. Otro individuo, 1 macho adulto con los testículos escrotados de *C. mexicana*, presentó alopecia en el rostro, cuello y abdomen. Este reporte representa el primer registro de alopecia en murciélagos de Puebla, el tercer registro de *A. jamaicensis* y el primero de *C. mexicana* en México. En estudios previos efectuados con murciélagos del estado de Puebla no existen reportes de alopecia. Es probable que la alopecia en estos individuos se deba a estrés ambiental causado por las actividades antropogénicas que se llevan a cabo en Atotonilco, las cuales pueden interferir con los procesos nutricionales.

Palabras clave: frugívoro; nectarívoro; perdida de pelo; Phyllostomidae.

Alopecia is partial or total hair loss in mammals (Corrales-Escobar and Saavedra-Rodríguez 2020). In bats, alopecia has been attributed to several causes, including reproductive stress, ectoparasites, urbanization, and the presence of fungi (da Silva *et al.* 2010; Monteiro *et al.* 2016; Nunes *et al.* 2017; Guedes *et al.* 2020). Worldwide, alopecia has been recorded in 38 species of bats belonging to the families Phyllostomidae (15), Vespertilionidae (13), Molossidae (5), Emballonuridae (2), Mormoopidae (2), and Pteropodidae (1) (Martin-Regalado *et al.* 2022; Hernández-Aguilar *et al.* 2023). The family Phyllostomidae, where the highest number of species with alopecia has been recorded, includes frugivorous species such as *Artibeus jamaicensis* and nectarivores such as *Choeronycteris mexicana* (Siles and Rios 2018; Nowak 1994; Freeman 1995).

The fruit bat *A. jamaicensis* is one of the species with the highest number of alopecia records, although only two correspond to Mexico. Of these, the first was in 73 individuals from Villahermosa, Tabasco, related to nutritional and endocrine alterations associated with urbanization
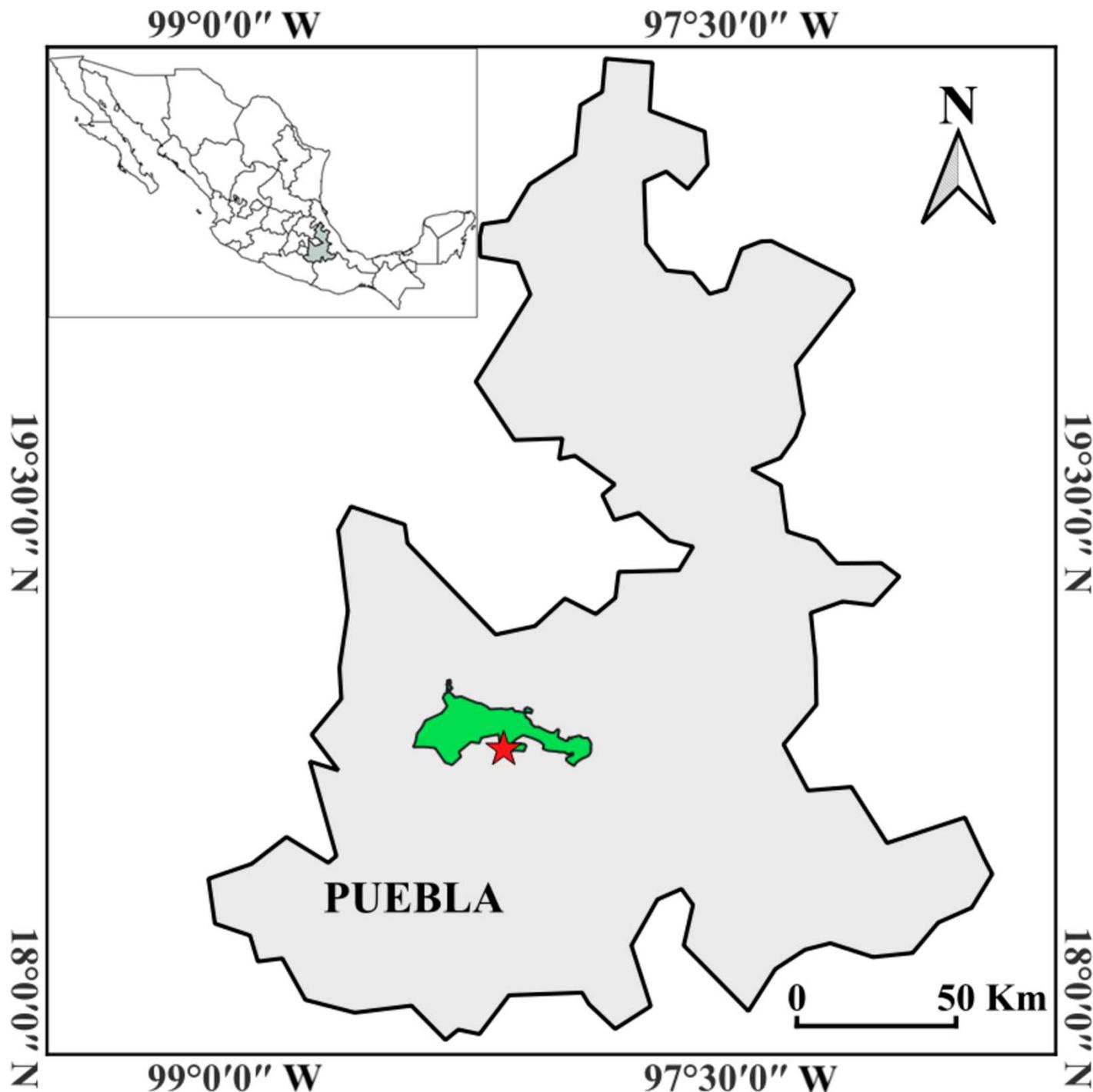
Figure 1. Geographic location of the new records of alopecia in *A. jamaicensis* and *C. mexicana* in Atotonilco, municipality of Huehuetlán el Grande, state of Puebla, Mexico (red star). The area corresponding to the "Sierra del Tentzo" State Reserve is marked in green.

(Bello-Gutiérrez *et al*. 2010); the second report refers to an individual from Córdoba, Veracruz, who exhibited a chest lesion that spread to other parts of his body, causing a bacterial or fungal infection (Hernández-Aguilar *et al*. 2024). *A. jamaicensis* is distributed from Sinaloa, Michoacán, and Tamaulipas in Mexico, southward to northwestern Colombia, the Greater and Lesser Antilles (south of Grenada), and southern Bahamas (Miller *et al*. 2016).

The crested bat, *C. mexicana*, is a nectivorous species distributed in the southwestern United States, Mexico (except for the Gulf slope and the Yucatan Peninsula), Honduras, and El Salvador (Solari 2018). There are no previous reports of alopecia in nectivorous species. Bats play a central ecological role: *A. jamaicensis* feeds on fruits and acts as a seed disperser, while *C. mexicana* is relevant in arid and semi-arid ecosystems of Mexico, where it pollinates key plants such as agaves and cacti (Galindo-González 1998; Gómez-Ruiz *et al*. 2015). This note reports three cases of alopecia in bats living in the state of Puebla, Mexico; two in individuals of *A. jamaicensis* and the first record of alopecia in *C. mexicana*.

Figure 2. Alopecia in two bat species captured in Atotonilco, Huehuetlán el Grande, Puebla. (a and b) Adult females of *A. jamaicensis* with partial or total alopecia in the abdomen. (c, d, e) Adult male of *C. mexicana* with alopecia on the face, neck. and abdomen. Photographs: L. Torres-Morales.

The cases of alopecia in bats reported here were recorded during field trips of a project aimed at evaluating the conservation status of bat species in the state of Puebla, Mexico. This project was carried out between September 2023 and August 2025. During field trips in May and November 2024, bats were captured in Atotonilco, a town in the municipality of Huehuetlán el Grande, in the southern area of the "Sierra del Tentzo" State Reserve (Official Newspaper of the State of Puebla, 2011). The town of Atotonilco is located 32 km south of Puebla City at coordinates 18°45'22.89" N and 98°10'33.32" W, at an altitude of 1353 meters above sea level, and is home to 22 inhabitants. The dominant vegetation in the study area is low deciduous forest, alternating with mango and banana plantations (Figure 1; INEGI 2020).

During the sampling, which lasted three nights, two mist nets measuring 2 m × 12 m and one measuring 2 m × 6 m were installed and left open from 6:00 p.m. to 11:30 p.m. The nets were placed in adjacent mango and banana plantations. The bats captured were handled following the proper handling protocols recommended for wild mammals (Sikes *et al.* 2011). For each captured bat, the parameters recorded were weight (g), forearm length (LA), and reproductive status. Bats were identified at the species level using the key of Medellín *et al.* (2007). All bats, including those showing alopecia, were released at the capture site after analysis. The permit to conduct this work was granted by SEMARNAT through the General Directorate of Wildlife under the memorandum SPARN/DGVS/05957/24 addressed to Dr. Jesús Martínez Vázquez. The incidence of alopecia in the affected species was calculated according to Bello-Gutiérrez *et al.* (2010), i.e., by dividing the number of individuals affected with alopecia of a given species by the total number of recorded individuals of that species.

In total, 27 bats belonging to 8 species were captured: *Sturnira parvidens* (n = 3 ♀ and 9 ♂), *Choeroniscus godmani* (n = 7 ♂), *Artibeus jamaicensis* (n = 3 ♀), *Pteronotus parnellii* (n = 1 ♂), *Anoura geoffroyi* (n = 1 ♂), *C. mexicana* (n = 1 ♂), *Leptonycteris yerbabuenae* (n = 1 ♂), and *A. lituratus* (n = 1 ♂). Of these, 3 individuals had alopecia. The 3 specimens of *A. jamaicensis* were adult females with no signs of reproductive activity, which were captured in a mango plantation on 2 May 2024. The weights of these females were 51 g, 46 g, and 48 g. The corresponding forearm length was 62 mm, 60 mm, and 62 mm. In two females, alopecia was observed in the ventral region of the body. In both, hair loss occurred in the thorax and abdomen, although it was more apparent in one of them (Figure 2a and 2b). The incidence of alopecia in this species was 66.7%. On the other hand, the specimen of *C. mexicana* was an adult male with scrotal testes, weighing 22 g, and with a forearm length of 44.4 mm. This individual was captured near a banana plantation on 6 November 2024, and alopecia was observed on the face, neck, and abdomen (Figure 2c-2e). The incidence of alopecia in this species was 100%.

In previous studies on bats in the state of Puebla, alopecia had not been reported in any species (Rojas-Martínez and Valiente-Banuet 1996; Valiente-Banuet *et al.* 1996; Valiente-Banuet *et al.* 1997a, b; Valiente-Banuet *et al.* 2007; Vargas-Miranda *et al.* 2008; Saldaña-Vázquez *et al.* 2021). In addition, three previous studies were conducted specifically in the municipality of Huehuetlán el Grande before our sampling, and none of them recorded alopecia in the bats analyzed (Santos-Reyes 2014; Cruz-Pérez 2015; Calvario-Carillo 2016). Therefore, the present report represents the first record of alopecia in *A. jamaicensis* in the state of Puebla and the third in Mexico; for *C. mexicana*, this report is the first record of alopecia for a nectarivorous bat in Puebla, in Mexico, and across its entire known range.

It is worth mentioning that *C. mexicana* is listed in the *Threatened* category in the Official Mexican Standard (NOM-059-SEMARNAT, 2010) and as *Near Threatened* by the International Union for Conservation of Nature (IUCN; Solari 2018) because it depends on fragile and threatened habitats (arid thorny shrublands, tropical deciduous forests), and with an estimated 30% decline in its populations over the past ten years due to human activities and the transformation of its natural habitat across its range (Solari 2018). For its part, *C. mexicana* plays a central ecological role in Mexico's arid and semi-arid ecosystems by pollinating key plants such as agaves and cacti (Gómez-Ruiz *et al.* 2015).

In bats in captivity, alopecia has been attributed to poor nutrition, endocrine disruption (Olsson and Barnard 2009), and fungal infections (Robert 2016). In free-living bats, several causal factors have been suggested, including hormonal fluctuations related to reproduction (Haarsma and Van Alphen 2009; Hernández-Aguilar *et al.* 2023), volcanic ash ingestion (Pedersen *et al.* 2012), environmental stress associated with urbanization (Acosta 2016; Martin and Wolters 2022), ectoparasites (Corrales-Escobar and Saavedra-Rodríguez 2020), and fungal infections (de Souza-Suguiura *et al.* 2023; Hernández-Aguilar *et al.* 2024).

Our review of the specimens of *A. jamaicensis* and *C. mexicana* affected by alopecia in Atotonilco did not reveal the presence of ectoparasites that could have caused alopecia in these organisms. Unfortunately, we lacked the necessary materials and equipment to take samples for subsequent histological studies or cultures of fungi and bacteria, so it was not possible to identify any of these as the underlying cause of hair loss. The use of pesticides prohibited in other countries for pest and weed control in crops and fruit plantations in Huehuetlán el Grande, as well as the excessive use of chlorine in water bodies and recreational areas that attract tourists to Atotonilco (Marín and Marín 2020), could adversely affect the fauna of the region, including bats. This trend is alarming, as pesticides and herbicides have been reported to promote abnormalities and cancer, and insecticides are considered potent neurotoxic chemicals in humans (Bejarano 2017; Marín and Marín 2020). On the other hand, another

possible cause of alopecia in the bat individuals observed in this study is the disruption of their natural environment, since a mining stockpile was established in 2023 (L. Marín pers. comm.), 160 m from the locality where the bats with alopecia were captured.

There is scarce information about the current status of the bat populations that inhabit the state of Puebla. The latest study addressing the conservation status of bat populations was published 17 years ago (Vargas-Miranda *et al*. 2018). The research work evaluating the current conservation status of bat species in the state of Puebla, of which this work belongs, is relevant because it is the first to record alopecia in two species of bats in Puebla and within the "Sierra del Tentzo" State Reserve. However, specific studies are needed to determine the underlying causes of alopecia in these bats.

Acknowledgments

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First record of *Seuratum* sp. (Nematoda: Seuratidae) in *Chrotopterus auritus* (Chiroptera: Phyllostomidae) from Mexico

Primer registro de *Seuratum* sp. (Nematoda: Seuratidae) en *Chrotopterus auritus* (Chiroptera: Phyllostomidae) de México

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Chrotopterus auritus is a rare carnivorous species in the Neotropical region. The helminth fauna of this bat is poorly known, with only 1 published record in Peru. In Mexico, *C. auritus* is classified as endangered, mainly due to deforestation. The study of helminths in wildlife is relevant, as they can influence behavior, population dynamics, and evolution of their hosts, regulating populations and contributing to the maintenance of biodiversity. As a part of a DNA barcoding survey of bats in Mexico, a specimen of *C. auritus* was examined for helminths. Only three adult female nematodes were recovered from the intestine of this bat. Nematodes were morphologically studied using light microscopy and scanning electron microscopy. In addition, the 28S ribosomal RNA (28S) gene and the cytochrome c oxidase subunit 1 (COI) gene of 1 specimen were amplified and sequenced. Nucleotide sequences obtained from our specimen were used for phylogenetic analyses. The morphology observed in 2 specimens (*e. g.* cephalic structures, esophagus, rows of spines, vulva, and tail) agreed with characteristics established for the genus *Seuratum*. Phylogenetic analyses of the superfamily Seuratoidea grouped our 28S and COI sequences of *Seuratum* sp. with *Paraquimperia* sp., a species of the family Quimperiidae. The morphology observed in the female specimens differ from those reported for *Seuratum cancellatum*, the only species reported from Neotropical bats. This suggests that the specimens found in Yucatan represent a distinct, potentially new species. However, additional specimens, particularly males, are needed to confirm this hypothesis. This study provides the first helminthological record in *C. auritus* from Mexico, as well as the first 28S and COI sequences for members of the family Seuratidea.

Key words: Carnivorous bat; molecular phylogeny; morphology; nematode; Yucatan.

Chrotopterus auritus es una especie carnívora rara en la región Neotropical. La helmintofauna de este murciélago es poco conocida, con solo 1 registro publicado en Perú. En México, *C. auritus* está clasificada como amenazada, principalmente debido a la deforestación. El estudio de los helmintos en fauna silvestre es relevante ya que pueden influenciar la conducta, dinámica de población y evolución de sus hospederos, regulando sus poblaciones y contribuyendo al mantenimiento de la biodiversidad. Como parte de un estudio de código de barras de DNA de murciélagos en México, un espécimen de *C. auritus* fue examinado por helmintos. Solo tres especímenes hembra de nematodos fueron recolectados del intestino de este murciélago. Los nematodos fueron estudiados morfológicamente con microscopía óptica y microscopía electrónica de barrido. Además, el gen 28S de RNA ribosomal (28S) y el gen citocromo oxidasa subunidad 1 (COI) de 1 espécimen fueron amplificados y secuenciados. Las secuencias de nucleótidos obtenidas de nuestro espécimen fueron usadas en análisis filogenéticos. La morfología observada en 2 especímenes (*e. g.* estructuras cefálicas, esófago, fila de espinas, vulva y ano) concuerdan con las características establecidas para el género *Seuratum*. Los análisis filogenéticos de la superfamilia Seuratoidea agruparon nuestras secuencias de 28S y COI de *Seuratum* sp. con *Paraquimperia* sp., una especie de la familia Quimperiidae. La morfología observada en los especímenes hembra difieren de las características reportadas para *Seuratum cancellatum*, la única especie reportada en murciélagos neotropicales. Esto sugiere que los especímenes encontrados en Yucatán representan una especie distinta, potencialmente nueva. Sin embargo, se requieren especímenes adicionales, particularmente machos para confirmar esta hipótesis. Este estudio proporciona el primer registro helmintológico en *C. auritus* en México, así como las primeras secuencias de 28S and COI para miembros de la familia Seuratidea.

Palabras clave: Filogenia molecular; morfología; murciélago carnívoro; nematodo; Yucatán.

Chrotopterus auritus (Chiroptera: Phyllostomidae) is one of the largest bats in the Neotropical region (Medellín 2014). Its distribution extends from southeastern Mexico through Central America to South America, reaching northern Argentina (Medellín 1989, 2014). This bat is an opportunistic hunter that primarily feeds on small mammals, birds, and large insects, but it can also consume reptiles, amphibians, fruits, and pollen (Medellín 1988; Vleut *et al.* 2019). *Chrotopterus auritus* forms small groups of 1 to 3 individuals that roost in caves, mines, abandoned buildings, hollow termite nests, and hollow trees (Medellín 1989). This bat is considered a rare species threatened in many countries within its range, including Mexico, mainly due to deforestation (Vleut *et al.* 2019).

Helminths are an important component of ecosystems, as they can shape the behavior, population dynamics and evolution of their hosts, regulating populations and sustaining biodiversity (Smit and Sures 2025). In addition, studying helminths provides insight into the effects of global change, such as climate change and habitat destruction, on disease dynamics (Smit and Sures 2025). Nevertheless, our knowledge of helminths associated with Neotropical bats remains limited, particularly for threatened species.

Knowledge about parasites associated with *C. auritus* remains limited and varies widely across studies. Ectoparasites, such as flies and ticks, have been reported in several studies on *C. auritus* from Mexico to Brazil (see Frank *et al.* 2014; Webb and Loomis 1977). In contrast, there are only 1 published record for this bat species, the trematode *Neodiplostomum vaucheri* in Peru (Dubois 1983). This contrast may be explained by the fact that ectoparasites can be collected from live animals, whereas helminthological studies typically require the collection of helminths from the organs of recently euthanized hosts, while the helminths are still alive to allow for proper relaxation and fixation (Sepulveda and Kinsella 2013). This poses a particular challenge for conducting helminthological research on threatened host species, such as *C. auritus*.

In recent years, concerns have been raised about the risk posed by unnecessary collection of organisms, such as bats. This practice can, in some cases, add pressure to already small populations, further threatening and pushing them toward extinction (Russo *et al.* 2017). To address these concerns, various recommendations have been proposed to promote the comprehensive use of voucher specimens. These include the collection of additional sample types, beyond the primary target samples regardless of the study's specific goals (Thompson *et al.* 2021). In recent years, we have formed a research group consisting of chiropterologists and parasitologists to study bat helminths in Mexico. This group seeks to maximize the use of voucher bats used for ecological, genetic, and morphological studies by also gathering additional tissues for helminthological research. In this context, the present study aimed to provide a helminthological record for *C. auritus* in Mexico.

As a part of a DNA barcoding survey of bats in Mexico, an adult female *C. auritus* was collected on 9 August 2023 in the Cuxtal Ecological Reserve (2302144.91 N, 232481.23 W), Merida, Yucatan, Mexico. The bat was anesthetized with isoflurane and euthanized with sodium pentobarbital. Stomach, liver and intestines were removed, immersed in 0.9% sodium chloride solution, and examined under a stereomicroscope. Fieldwork was conducted according to the guidelines for the use of wild mammals in research of the American Society of Mammalogists (Sikes and the Animal Care and Use Committee of the American Society of Mammalogists 2016) procedural summaries, and reporting requirements. Included are details on capturing, marking, housing, and humanely killing wild mammals. It is recommended that Institutional Animal Care and Use Committees (IACUCs. The bat specimen was collected under license from the Mexican Ministry of Environment (SEMARNAT) (scientific collection permit SPARN/DGVS/03632/23).

Only three female nematodes were found in the intestine of the bat. Cuts were made from one specimen to extract DNA and examine by scanning electron microscopy (SEM), the other two specimens were cleared and mounted temporally in lactophenol. The morphology of the specimens was studied and drawn with the aid of a light microscope (Leica DM500) with a drawing tube (Leica Microsystems, Wetzlar, Germany). For SEM, fragments of one specimen were dehydrated using a graded ethanol series, critical-point dried with carbon dioxide, sputter-coated with a gold-palladium mixture, and examined at an accelerating voltage of 10 kV with a Hitachi SU1510 (Hitachi, Tokyo, Japan) scanning electron microscope at the Laboratorio de Microscopía y Fotografía de la Biodiversidad, Instituto de Biología, Universidad Nacional Autónoma de México (IBUNAM), Mexico City. One nematode specimen was deposited in the Colección Nacional de Helmintos (CNHE-12235), Universidad Nacional Autónoma de México. Skull and skin of the bat were deposited in the Museo de Zoología of the Universidad Autónoma de Yucatán, Mexico (FMVZ-UADY-1664).

Total genomic DNA of the nematode was extracted using DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany). The D1-D3 region of the 28S rRNA gene (28S) and the cytochrome c oxidase subunit 1 (COI) gene were amplified using the polymerase chain reaction (PCR). The 28S fragment was amplified using the primers 391 (Nadler *et al.* 2003) / 536 (García-Varela and Nadler 2005). The COI fragment was amplified using primers LCO1490/ HC02198 (Folmer *et al.* 1994). Thermo-cycling profiles followed the protocols described by Hernández-Mena *et al.* (2017) for 28S and by Folmer *et al.* (1994) for COI. The PCR primers, along with additional internal primers 503 (Nadler *et al.* 2003) and 504 (Hernández-Mena *et al.* 2017) for 28S, were used for Sanger sequencing at Macrogen (Seoul, Korea).

Consensus sequences obtained in this study and other
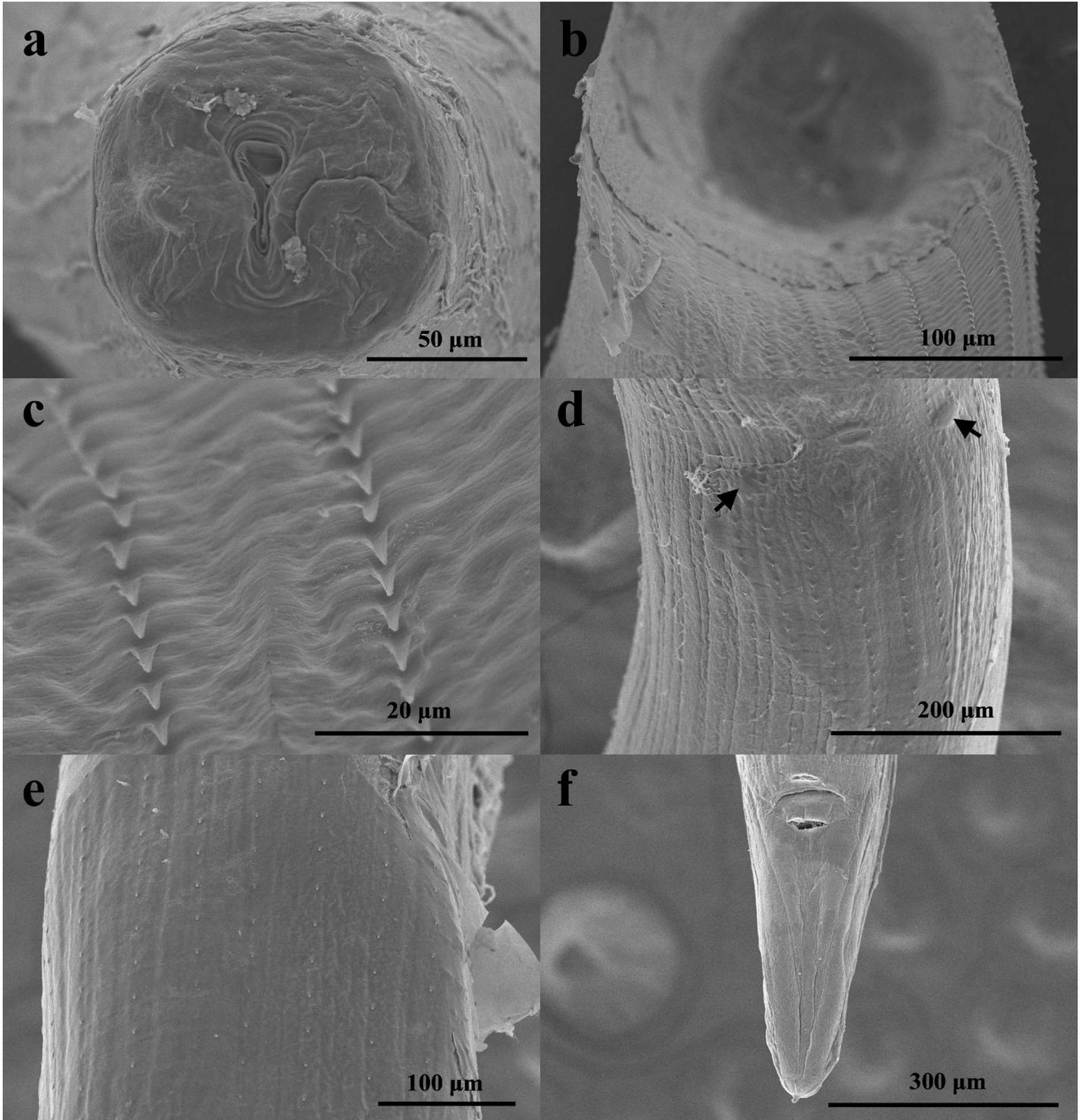
Figure 1. SEM micrographs of females of *Seuratum* sp. a) Head, apical view. b) Anterior part, apical view. c) Spines of the anterior part, ventral view. d) Middle section of the body showing the vulva and two latero-ventral papillae (arrows), ventral view. e) Posterior section of the body, ventral view. f) Posterior part, ventral view.

sequences of the superfamily Seuratoidea available in GenBank were used for phylogenetic analyses; trimmed sequences of the domains D2–D3 were used for the 28S gene. The best-fitting nucleotide substitution model was selected for each data set with jModelTest v2, under Akaike information criterion. Phylogenetic affinities for each data set were evaluated by maximum likelihood (ML) analysis with 1,000 bootstrap replicates using RAxML v. 7.0.4. Bootstrap

support values were estimated by running 1000 bootstrap resamples. Genetic variation within the 28S and COI data sets was calculated using p-distances with MEGA 11.

Two gravid specimens (1 adult female and 1 juvenile female) were studied morphologically. Below we present a brief description of the specimens. Triangular oral opening, surrounded by 4 double papillae (Figure 1a). Vestibule and denticles not observed. Esophagus rounded and swollen
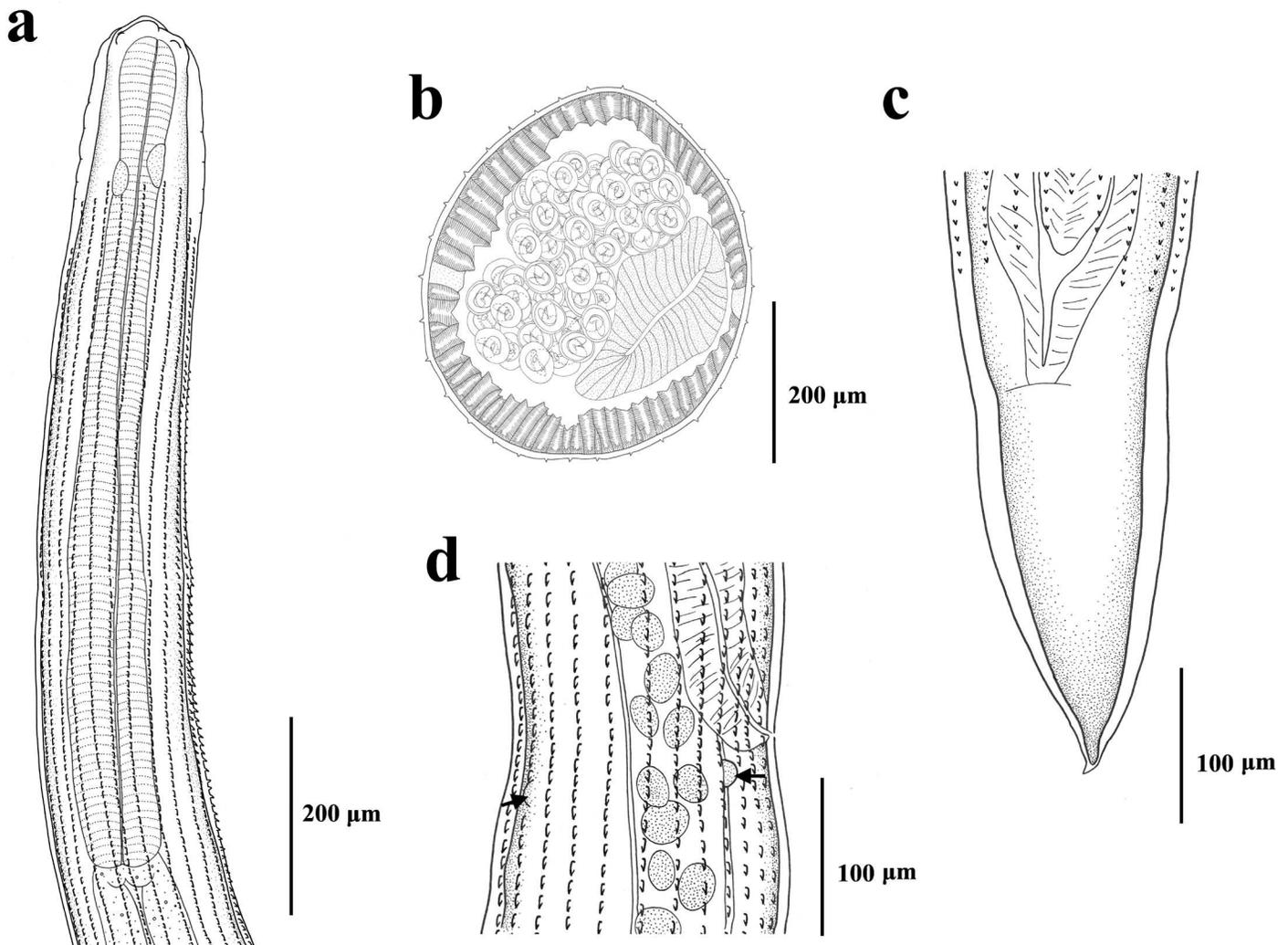
Figure 2. Drawings of females of *Seuratum* sp. a) Anterior part, lateral view. b) Transverse section, at mid-body. c) Posterior part, ventral view. d) Vulvar region, showing two papillae (arrows), right lateral view.

anteriorly (Figure 2a). Body with 32 rows of cuticular spines (Figure 2b) extending from slightly posterior to nerve ring throughout the mid-body (Figure 2a) and disappearing anterior to anus (Figure. 2c). Spines oriented posteriorly, longer in the anterior region, while in the middle and posterior parts, decreasing in size and the distance between them increases (Figure 1b-e). The main measurements of the adult female are presented in micrometers, followed by those of the juvenile female. Body 26,975 and 11,750 long, and 500 and 230 wide (at vulva level). Esophagus 1,430 and 890 long, and 120 and 68 wide at anterior end. Nerve ring situated 350 and 125 from anterior end. Deirids not observed. Vulva 10,750 and 5660 from anterior end, surrounded by two pairs of papillae located laterodorsally and lateroventrally (Figures 1d, 2d). Anus 570 and 250 from posterior end with short terminal spike 25 and 10 long (Figures 1f, 2c). Eggs with juvenile stage, 38–40 long by 35–38 wide, only observed in the adult female.

The 28S sequence generated from *Seuratum* sp. was 1,164 pb in length (PQ893537). After trimming to the D2-D3

expansion domains, the final alignment was 896 pb long. The 28S sequence of *Seuratum* sp. was aligned with other 11 sequences of nematodes belonging to the superfamily Seurotoidea. In the resulting phylogenetic tree, *Seuratum* sp. was positioned as a sister taxon to *Paraquimperia* sp. (Quimperiidae), isolated from the frog *Xenopus laevis*, though with low bootstrap support (57) (Figure 3a). The newly generated 28S sequence of *Seuratum* sp. showed a 19 % genetic difference from that of *Paraquimperia* sp. Unfortunately, the lack of representativeness of 28S gene sequences has limited the ability to achieve a more comprehensive phylogenetic relationships among the family Seuratidae.

The newly generated COI sequence of *Seuratum* sp. was 655 pb in length (PQ893890). After trimming to the shortest sequence, the final alignment was 401 bp long. The COI dataset of seuratoid nematodes included 9 sequences. In the phylogenetic tree based on COI, *Seuratum* sp. was positioned as a sister taxon to *Paraquimperia* sp. from *X. laevis* with high support (bootstrap = 100) (Figure 3b).
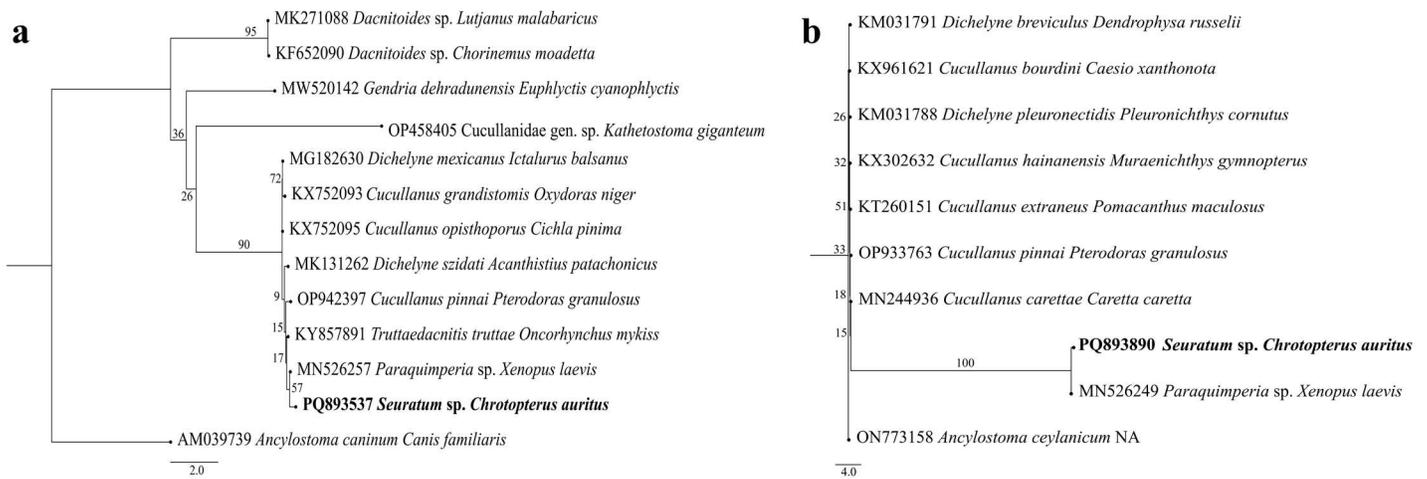
Figure 3. Maximum likelihood (ML) phylogenetic trees of Seuratoidea. a) Inferred with 28S sequence data using the TIM3 + G model (In likelihood -6879.440063). b) Inferred with COI sequence data using the GTR + G model (In likelihood -2249.908230). GenBank accession numbers precede species name, followed by host name. Bootstrap support values for ML are provided at the nodes. The new sequence of the present study is in bold.

The genetic difference between these taxa was 16.6 %. Unfortunately, the limited availability of COI sequences from members of Seuratidae limited the ability to achieve a resolved phylogeny.

The genus *Seuratum* includes nine species that parasitize rodents, bats, shrews, and hedgehogs (Noor-un-Nisa *et al.* 2006). In the Americas, *Seuratum cancellatum* is the only species previously recorded in bats. This nematode has been reported from *Antrozous pallidus*, *Eptesicus fuscus*, *Eumops perotis*, *Myotis californicus*, *Myotis yumanensis*, *Parastrellus hesperus* (syn. *Pipistrellus hesperus*), *Corynorhinus townsendii* (syn. *Plecotus townsendii*), and *Tadarida brasiliensis* in Texas (Specian and Ubelaker 1976), *Myotis septentrionalis* (McAllister *et al.* 2004), and *Myotis leibii* (McAllister *et al.* 2017) in Arkansas, USA, and *Natalus mexicanus* in Yucatan, Mexico (Chitwood 1938). Unidentified species of *Seuratum* have been reported from *Myotis keaysi* in Venezuela (Guerrero 1985), *Phyllostomus discolor*, *Gardnerycteris crenulata*, *Myotis nigricans*, and *Lophostoma occidentale* in Peru (Minaya Angoma *et al.* 2020).

The morphological characteristics observed in the female specimens studied align with the genus *Seuratum*. Compared with *S. cancellatum*, our specimens have more cuticular spines rows (20 *vs*. 32) and longer (29–33 *vs*. 38–40) and wider (17–29 *vs*. 35–38) eggs. These differences suggest that the specimens represent a distinct, potentially new species. However, additional specimens, particularly males, are needed to confirm this hypothesis.

The life cycle of *Seuratum* species parasitizing bats (*S. cancellatum*, *S. mucronatum* and *S. congolense*) remains unknown. Experimental studies have shown that the locust *Locusta migratoria* (Orthoptera) acts as intermediate host of *Seuratum cadarachense*, a parasite of the rodent *Eliomys quercinus* in Europe (Quentin 1970). Similarly, the cockroaches *Blatta orientalis* and *Periplaneta americana* (Blattodea) have been identified as intermediate hosts of *Seuratum nguyenvanaii*, a parasite of the shrew *Suncus*

murinus in Southeast Asia (Le-Van-Hoa 1966). Although *C. auritus* primarily consumes small vertebrates (Medellín 1988; Bonato *et al.* 2004), insects (*e. g.*, Coleoptera, Diptera, Lepidoptera) can represent 44 % of its diet, increasing to 75 % during the wet season (Bonato *et al.* 2004). The presence of the genus *Seuratum* in *C. auritus* suggests that some insects in its diet may act as intermediate hosts for these nematodes.

The use of DNA sequences as genetic markers has proven to be useful for species identification, especially when the biological material is limited (Chan *et al.* 2021). In this study, we provided 28S and COI DNA sequences, complementing the morphological characterization of the female specimens. These barcoding genes have been used to resolve helminth phylogenies, discover cryptic species, and elucidate patterns of gene flow among helminth populations (Poulin *et al.* 2019). Although morphological analysis was restricted to females, the sequences confirmed the genetic relationship of *Seuratum* with other nematode species of the superfamily Seuratoidea. These sequences will also serve as a resource for future studies that generate additional data on members of the family Seuratidae.

This study reports the first helminthological record for *C. auritus* in Mexico and the first published record of the genus *Seuratum* in this bat species within the Neotropical region. It provides a new helminthological record for *C. auritus*, an endangered bat species in Mexico, using both morphological and molecular data. Although a specific identification could not be achieved, the information generated will be valuable for future studies on bat helminths.

Acknowledgements

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Record of margay (*Leopardus wiedii*) in a periurban Ecological Reserve in the central mountain region of Veracruz, Mexico

Registro de margay (*Leopardus wiedii*) en Reserva Ecológica periurbana en la zona montañosa del centro de Veracruz, México

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Biodiversity worldwide is affected by human activities, species that inhabits in Protected Natural Areas are not exempt to human impact. Habitat resources are limited, species that requires large territories and a constant food availability cannot survive for long. The objective of this work is to point out and describe the occasional record of a specimen of margay (*Leopardus wiedii*) as a result from a systematic long-term survey in the periurban Ecological Reserve "La Martinica", in the central mountainous area of the state of Veracruz (Mexico). For about 25 months (May 2021 to June 2023), a non-invasive survey focused on terrestrial and arboreal mammals was deployed in "La Martinica". The camera traps were installed at ground (terrestrial stations) and in the canopy (arboreal stations), with an average distance of 300 m between them. The 24-hour cycles in which each camera operated correctly and uninterruptedly were considered 1 trap-day. After a sampling effort of 2,525 trap days, and an effective sampling area of 0.5 km², in January 2023, at an altitude of 1,553 m, a specimen of margay was recorded in "La Martinica". Due to the presence of other carnivores (exotic, introduced, and native) and the scarce mammal diversity at the study site ($n = 12$ species), it is unlikely that a resident population of *Leopardus wiedii* inhabit in the region. The specimen was probably passing through during its dispersal. This record is the northernmost of the species obtained through systematic monitoring in the state of Veracruz.

Key words: Carnivore; feline; mammal; Neotropics; scansorial.

Globalmente la biodiversidad es afectada por actividades antrópicas, especies que habitan Áreas Naturales Protegidas no están exentas del impacto humano. Los recursos en un hábitat son limitados, especies que requieren una disponibilidad constante de recursos alimentarios y espaciales no pueden perdurar mucho tiempo. El objetivo de este trabajo es señalar y describir el registro ocasional de un espécimen de margay (*Leopardus wiedii*), resultado de un monitoreo extensivo en la Reserva Ecológica periurbana "La Martinica", en la zona montañosa central del Estado de Veracruz (México). Durante poco más de 25 meses (Mayo 2021 a Junio 2023) se implementó un monitoreo no invasivo enfocado en mamíferos arborícolas y terrestres. Las cámaras-trampa se instalaron a nivel del suelo y en dosel, a una distancia promedio de 300 m entre ellas. Ciclos de 24 hr en que cada cámara funcionó correcta e ininterrumpidamente fueron considerados 1 día-trampa. Después de un esfuerzo de muestreo de 2,525 días-trampa, y un área efectiva de muestreo de 0.5 km², en Enero de 2023, se registró un espécimen de margay en "La Martinica". Debido a la presencia de otros carnívoros (exóticos- introducidos y nativos) y a la escasa riqueza mastozoológica en la localidad de estudio ($n = 12$ especies), es poco probable que exista una población residente de *Leopardus wiedii* en la región. El espécimen probablemente estaba de paso durante su proceso de dispersión. El registro obtenido es el más septentrional de la especie obtenido mediante un monitoreo sistematizado en el estado de Veracruz.

Palabras clave: Carnívoro; escansorial; felino; mamífero; Neotrópico.

The impacts of anthropogenic activities as the increase of human population, growth of human settlements, change in land use, generation of waste have altered the biotic and abiotic factors available to biodiversity (Vázquez and Gaston 2006), which implies unprecedented threats to multiple species of flora and fauna throughout the world. Despite several conservation efforts to establish Protected Natural Areas, these locations are also subject to intense anthropogenic pressure (Jones *et al.* 2018).

One on the most critical threats to wildlife populations is the habitat loss (Wright 2005), due to the considerable resource requirements and low population densities mammalian carnivores could be specialty vulnerable to habitat destruction (Crooks *et al.* 2011).

Among the six species of felines recorded in Mexico, the margay (*Leopardus wiedii*) is the smallest, adult specimen weighs less than 5 kg (de Oliveira 1998), is also the only one physiologically adapted to arboreal life (Sunquist

Figure 1. Photo capture of *Leopardus wiedii* (margay) in "La Martinica" Ecological Reserve, obtained in January of 2023.

and Sunquist 2002). In Mexico, the species is classified as "Endangered" by the Norma Oficial Mexicana NOM-059 (SEMARNAT 2010). Human activities as agriculture, livestock raising, and infrastructure development are the principal threats to the species, as they fragment and reduce the available habitat (Ávila-Nájera *et al*. 2024).

Although the extensive distribution of *L. wiedii* across the American Continent its detection rates are universally low (Harmsen *et al*. 2021), for that reason, population dynamics studies of *L. wiedii* are scarce, the data are focused on estimates of relative abundance. Camera traps are one of the most versatile and widely used tools for survey terrestrial mammals, and demonstrate the presence of rarest or elusive terrestrial species (Wearn *et al*. 2013) in a locality. The objective of this work is to point out and describe the occasional camera-trap record of *L. wiedii* in the periurban Ecological Reserve "La Martinica", located in the central mountainous area of the state of Veracruz (Mexico). Additionally, digital repositories of biological information were consulted in search of records of *L. wiedii* in the state of Veracruz (during the XXI Century) to determine the exceptionality of the photo-capture obtained.

The record obtained in January 2023 is the result of a long-term survey with camera traps focused on terrestrial and arboreal mammals, which began in May 2021 in the periurban Ecological Reserve "La Martinica" (19° 35' 12.4" N, 96° 57' 8.6" W; altitude between 1,550 to 1,650 m, and an area of 0.52 km²), located and partially surrounded by the municipality of Banderilla, Veracruz. The vegetation of

the region is composed by tropical and subtropical humid broadleaf forests (Olson *et al*. 2001); within the Ecological Reserve there are disturbed remnants of mesophilic mountain forest. The climate is semi-warm-humid (*Cfb*, Kottek *et al*. 2006), the average annual rainfall is 1,100 to 1,600 mm, the temperature ranges from 18 °C to 24 °C, the dry season occurs between November and April, the rainy season occurs between May and October (INEGI 2010).

In January of 2023, five camera stations (composed by one camera trap) were installed within the vegetation of "La Martinica", far from human trails (at a distance between six and 20 m). All the camera traps were set up to obtain only photographic records, the camera stations were unbaited, the distance between cameras was on average 300 m to avoid spatial overlapping between sampling areas. The terrestrial stations ($n = 2$; Model Terra8, Wildgame INNOVATIONS ®, Texas, EE. UU.), were installed at an average height of 50 cm due to the slope of the soil. The arboreal stations ($n = 3$; Model BTC-7A, Browning ®, Utah, EE. UU.) were installed at an average height of six meters. The 24-hour cycles in which each camera worked correctly and uninterruptedly were considered one trap-day; the effective sampling area of each camera station corresponded to a circle of 300 m in diameter (equals to an area of 0.07 km²; individual camera buffer method; Silver *et al*. 2004); the camera stations were relocated every 60 days to completely survey the area of "La Martinica". In order to determine the exceptionality of the record, a search was carried out for sightings of *L. wiedii* in the state of Veracruz obtained during the XXI Century. The
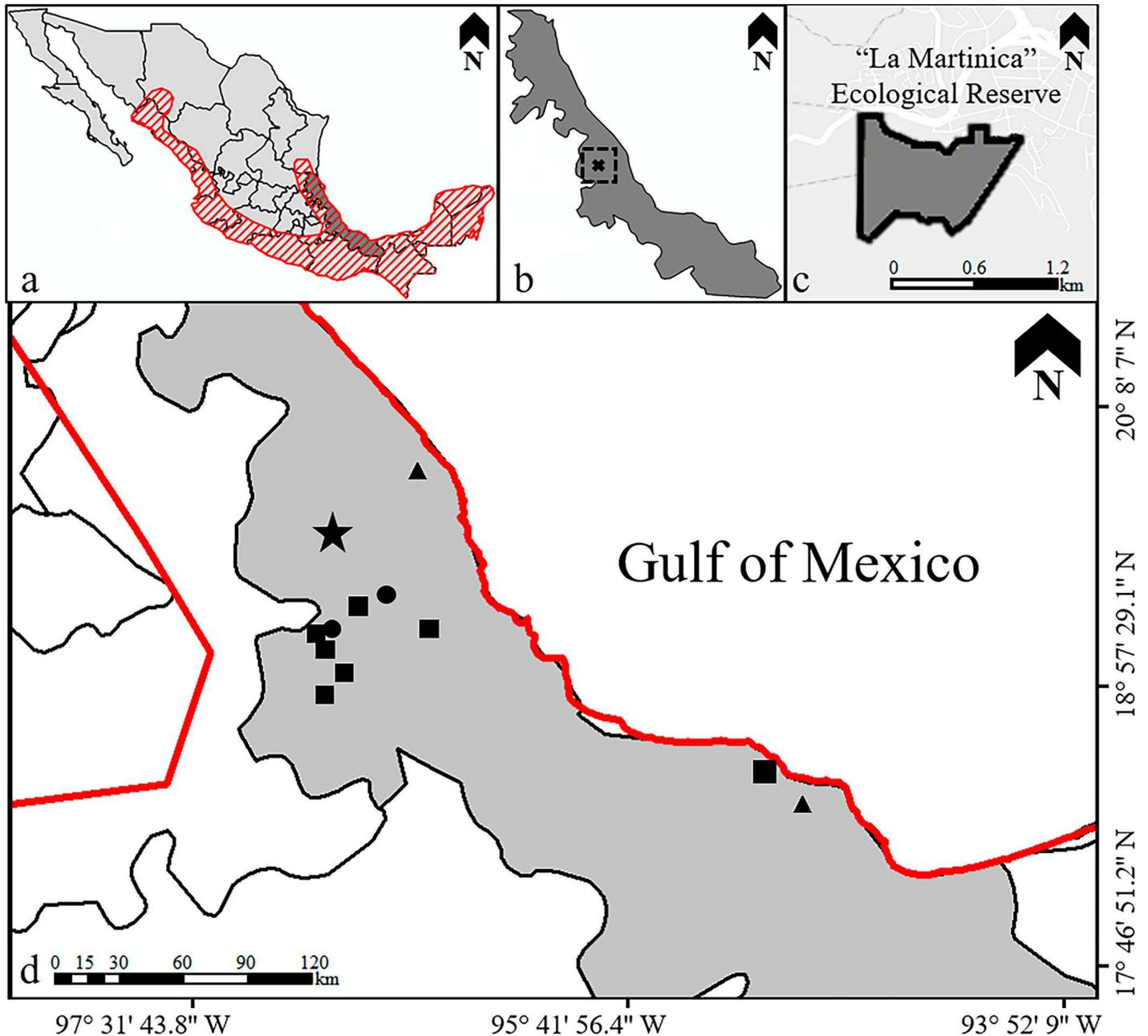
Figure 2. a) Distribution of *Leopardus wiedii* in México. b) Location of the study area in the state of Veracruz. c) Study area, "La Martinica" Ecological Reserve. d) Distribution of the records of *Leopardus wiedii* in the state of Veracruz obtained during XXI Century: ▲ = Sighting, ● = Road-killed specimen, ★ = Photocapture in "La Martinica". ■ = Photographic records.

biological databases consulted were iNaturalist (https://www.inaturalist.org) and the Global Biodiversity Information System (GBIF; https://www.gbif.org). Only records that provided documentary evidence were included.

After a sampling effort of 2,525 trap-days, over a period of 18 months (of a total of 25 months), 50 different locations of camera stations (terrestrial stations $n = 25$; arboreal stations n= 25), and surveyed more than > 95 % of the surface of "La Martinica" (effective sampling area of 0.5 km^2) a notable record of *L. weidii* was obtained in January 02 of 2023, at 03:32 hr (Figure 1). The species was identified by its size, thin shape, long-thick tail, and distinctive thick spotted pattern on its coat (Ávila-Nájera *et al.* 2024) these are specific characteristics of the species, that allow their

differentiation from ocelot (larger and heavier body, big head, small eyes, large spots, slim-short tail; Leyhausen 1990; Ramírez-Barajas *et al.* 2014).

The record was obtained from a terrestrial station, installed in a scrubland with abundant leathery colicwood trees (*Myrsine coriacea*), at an altitude of 1,553 m. Due to the position of the specimen in the photograph, its sex is unknown due to it was not possible to observe genitals.

Form the biological databases consulted, 19 records of *L. wiedii* in the state of Veracruz were found between March 2016 and November 2023 (Table 1; Figure 2; there are no records available between 2000 and 2016); the records correspond to camera trap captures ($n = 14$), roadkill specimens ($n = 2$), and direct observations ($n = 3$). After

compared the location between the records found with the one reported in this work, it was identified that the photo-capture obtained in "La Martinica" is the northernmost record of the species in the state of Veracruz.

Camera traps allows rare or elusive species to be recorded in an ecosystem, in some researches, the sampling effort invested to obtain records is relatively small (Rowcliffe et al. 2008), sometimes the capture frequency is related to the abundance and density of the target species in the study location. Researches that points out the presence of *L. wiedii* in localities throughout the species distribution are based upon different type of records: roadkill (Aguilar-López et al. 2015), dissected specimens (Tapia-Ramírez et al. 2013), or camera trap studies that required different survey efforts to obtain the first record of the species (between 61 and 3,220 trap-days). Those investigations documented between 1 and 10 individuals at the same locality: 2 records in 61 trap-days (mountain mesophyll forest with fragments of secondary vegetation, Puebla, Mexico; Hernández-Hernández et al. 2022); 4 records in 228 trap-days (cloud forest, Morelos, Mexico; Aranda and Valenzuela-Galván 2015); 1 record in 350 trap-days (tropical deciduous forest, Guanajuato, Mexico; Iglesias et al. 2008); 4 independent records from to 2 individuals in 796 trap-days (tropical deciduous forest, and surroundings from an oak forest, Nayarit, Mexico; Luja and Zamudio 2019), 5 independent records in 2,970 trap-days (high-altitude, humid and evergreen forests, Huanúco, Peru; Cossios and Ricra 2019); 85 records from 10 individuals in 3,220 trap-days (agricultural and pasture lands, primary and secondary forests, slopes of the Andes, Ecuador; Vanderhoff et al. 2011).

Table 1. Records and sightings of *Leopardus wiedii* in Veracruz (Mexico) obtained between 2000 and 2023.

Record type	Date	Locality	Latitude	Longitude	Vegetation	Reference
Camera-trap	March 15, 2016	San Andrés Tuxtla	18° 35′ 9″ N	95° 7′ 20.1″ W	Tropical and Subtropical Moist Broadleaf Forests	https://www.inaturalist.org/observations/120574706
	August 27, 2019	Tenampa	19° 16′ 43.1″ N	96° 50′ 25.9″ W		https://www.inaturalist.org/observations/39319202
	August 28, 2019	Tenampa	19° 16′ 43″ N	96° 50′ 25.9″ W		https://www.inaturalist.org/observations/39319201
	December 31, 2020	Paso de Ovejas	19° 11′ 0.3″ N	96° 32′ 22.6″ W	Tropical and Subtropical Dry Broadleaf Forests	https://www.inaturalist.org/observations/67548949
	February 11, 2022	Huatusco	19° 9′ 41.3″ N	97° 0′ 27″ W		https://www.inaturalist.org/observations/149770482
	February 21, 2022	Huatusco	19° 9′ 41.2″ N	97° 0′ 27″ W		https://www.inaturalist.org/observations/149770494
	February 21, 2022	Huatusco,	19° 9′ 41.2″ N	97° 0′ 27″ W		https://www.inaturalist.org/observations/149770501
	February 25, 2022	Huatusco	19° 9′ 41.3″ N	97° 0′ 27″ W		https://www.inaturalist.org/observations/149770503
	September 10, 2022	Huatusco	19° 6′ 11.5″ N	96° 58′ 41.8″ W	Tropical and Subtropical Moist Broadleaf Forests	https://www.inaturalist.org/observations/135852729
	January 02, 2023	Banderilla	19° 35′ 12.4″ N	96° 57′ 8.6″ W		This research
	February 14, 2023	Huatusco	19° 9′ 53.7″ N	97° 0′ 29.1″ W		https://www.inaturalist.org/observations/149739771
	February 15, 2023	Huatusco	19° 9′ 53.7″ N	97° 0′ 29.1″ W		https://www.inaturalist.org/observations/149739772
	February 18, 2023	Huatusco	19° 9′ 53.7″ N	97° 0′ 29.1″ W		https://www.inaturalist.org/observations/149739774
	June 03, 2023	Cordoba	18° 54′ 36.2″ N	96° 58′ 38.4″ W		https://www.inaturalist.org/observations/176373025
	September 27, 2023	Cordoba	18° 59′ 45.3″ N	96° 53′ 51.1″ W		https://www.inaturalist.org/observations/191231073
Road-killed specimen	April 22, 2021	Apazapan	19° 19′ 43.6″ N	96° 42′ 57.4″ W	Tropical and Subtropical Dry Broadleaf Forests	https://www.inaturalist.org/observations/74905091
	January 11, 2022	Sochiapa	19° 11′ 13.9″ N	96° 57′ 13.6″ W	Tropical and Subtropical Moist Broadleaf Forests	https://www.inaturalist.org/observations/104775953
Direct observations	October 31, 2016	Catemaco	18° 26′ 17.7″ N	94° 57′ 44.3″ W		http://conabio.inaturalist.org/observations/4510229
	October 31, 2016	Ejido Adolfo López Mateos, Catemaco	18° 26′ 14.4″ N	94° 57′ 53.5″ W	Tropical and Subtropical Moist Broadleaf Forests	http://conabio.inaturalist.org/observations/4515007
	November 28, 2016	Vega de Alatorre	19° 50′ 53.6″ N	96° 35′ 5.7″ W		https://www.inaturalist.org/observations/34068188

Although the margay is included in the list of species present in the state of Veracruz (González-Christen and Delfín-Alfonso 2016), the survey carried out in "La Martinica" required a sampling effort of 2,525 trap-days to obtain a single record; the trap-days from arboreal stations were included because *L. wiedii* is physiologically adapted to display arboreal activity (de Oliveira 1998; Domínguez-Castellanos and Ceballos 2005), for that reason is considered the most arboreal among the New World felid (Hodge 2014).

The record reported here is considered occasional, the entire survey lasted over 25 uninterrupted months in which the terrestrial mammal community present in the area was monitored, after the record of margay in the eighteenth month no additional traces (corpses, feces, footprints, and scratching posts) were documented. Therefore the existence of resident populations of *L. wiedii* within "La Martinica" is ruled out due to: 1) the survey in the region indicates a reduced abundance and richness of mammals, composed by of carnivores: *Bassariscus astutus*, *Canis familiaris*, *Felis catus*, *Neogale frenata*, *Procyon lotor*, *Urocyon cinereoargenteus*; cingulates: *Dasypus novemcinctus;* didelphids: *Didelphis* spp, *Marmosa mexicana*; lagomorphs: *Sylvilagus floridanus*; and rodents: *Peromyscus* spp, *Sciurus aureogaster*); so the margay have several competitors and low availability of preys, 2) *L. wiedii* has a preference for localities whose native vegetation has a dense cover (Morales-Delgado *et al.* 2021), this attribute does not occurs in "La Martinica", the Reserve is fragmented, partially surrounded by the town of "Banderilla", and the extraction of biodiversity for economic (obtain raw materials, or derivatives that are marketed), or subsistence purposes (edibles, or elements for medicinal use) is permanent. Therefore, it is speculated that the specimen was photographed during its dispersion process to a site with more favorable conditions.

The IUCN Red List of Threatened Species (de Oliveira *et al.* 2015) indicates that wild populations of *L. wiedii* are declining due to human-induced conversion of native forest habitats to agriculture, pasture, and urban development (de Oliveira *et al.* 2015). Although the state of Veracruz occurs within the species' potential range (Morales-Delgado *et al.* 2021), availability of suitability habitat is low (<0.69) across most of the state. The status of *L. pardalis* populations occurring in the state of Veracruz is currently unknown.

The 19 records of *L. wiedii* in the state of Veracruz during the XXI Century corresponds to researches, opportunistic sightings, and reports of roadkill specimens. The photo capture from "La Martinica" along with the record reported for Vega de Alatorre (46 km away) in 2016 (direct observation, November 28, 2016; Table 1), are the northernmost records of the species within the state of Veracruz. It is necessary to design and implement studies focused on *L. wiedii* to generate ecological knowledge about the species that can be used for conservation strategies for the species and its habitat.

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Ingestion of *Ixodes keiransi* (Acari: Ixodidae) by *Peromyscus yucatanicus* (Rodentia: Cricetidae)

Ingestión de *Ixodes keiransi* (Acari: Ixodidae) por *Peromyscus yucatanicus* (Rodentia: Cricetidae)

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This paper aims to report the ingestion of *Ixodes keiransi* by *Peromyscus yucatanicus*. Fragments of two tick larvae were collected from the intestinal content of a *P. yucatanicus* captured in Yucatan, Mexico. Genetic material was obtained from both specimens, and a fragment of 400 bp of the *16S-rDNA* gene was amplified and sequenced. Bioinformatics analyses were performed, and a phylogenetic tree was constructed to determine the identity of the collected ticks. *Peromyscus yucatanicus* is a wild rodent endemic to the Yucatan Peninsula. It carries vector-borne pathogens and the arthropods that transmit them. Its diet consists of different elements, including arthropods. However, this is the first report of this rodent's ingestion of *Ixodes keiransi*. This tick is a biological vector of important public health pathogens, including *Rickettsia* and *Borrelia*. This finding opens questions and hypotheses about alternative enzootic transmission mechanisms of tick-borne pathogens through tick ingestion in endemic areas.

Keywords: Ingestion; rodent; ticks; *Ixodes*; *Peromyscus*; ectoparasite.

Este trabajo tiene como objetivo reportar la ingestión de *Ixodes keiransi* por *Peromyscus yucatanicus*. Se recolectaron fragmentos de dos larvas de garrapatas del contenido intestinal de un *P. yucatanicus* capturado en Yucatán, México. Se obtuvo material genético de ambos especímenes y se amplificó y secuenció un fragmento de 400 pares de bases del gen *16S-rDNA*. Se realizaron análisis bioinformáticos y se construyó un árbol filogenético para determinar la identidad de las garrapatas recolectadas. *Peromyscus yucatanicus* es un roedor silvestre endémico de la Península de Yucatán. Es portador de patógenos transmitidos por vectores y de los artrópodos que los transmiten. Su dieta consiste en diferentes elementos, incluidos artrópodos. Sin embargo, este es el primer reporte de la ingestión de *I. keiransi* por parte de este roedor. Esta garrapata es vector biológico de patógenos importantes para la salud pública, entre ellos *Rickettsia* y *Borrelia*. El hallazgo abre interrogantes e hipótesis sobre mecanismos alternativos de transmisión enzoótica de patógenos transmitidos por garrapatas a través de la ingestión de estos ectoparásitos de áreas endémicas.

Palabras clave: Ingestión; roedor; garrapatas; *Ixodes*; *Peromyscus*; ectoparásito.

Figure 1. Ventral and dorsal views of *Ixodes keiransi* larvae specimens (A, B) collected from the intestinal contents of *Peromyscus yucatanicus* in Yucatan, Mexico. The scale is 600 microns.

Ticks (Parasitiformes: Ixodida) are hematophagous ectoparasites that are highly diverse and abundant among vertebrates, particularly in small and medium mammals. About 900 species of ticks have been found across different ecosystems. They are divided into three leading families: Ixodidae (hard ticks), Argasidae (soft ticks), and Nuttalliellidae (Boulanger *et al.* 2019).

Ixodidae includes the *Ixodes* genus, which includes approximately 266 species (Guglielmone *et al.* 2023). Many of these are recognized as biological vectors of zoonotic pathogens responsible for several emerging or re-emerging diseases significant to public or animal health (Dantas-Torres *et al.* 2012; Madison-Antenucci *et al.* 2020; Aguilar-Tipacamú *et al.* 2025). *Ixodes keiransi* is a member of the complex *Ixodes affinis*, previously referred to as *I.* cf. *affinis*, *I.* near *affinis* or *I. affinis* (only in Mexico) (Nava *et al.* 2023; Rodríguez-Vivas *et al.* 2023). This tick species occurs in tropical and subtropical regions from Belize, Mexico, and southeastern USA. It has been found specifically in Mexico across Campeche, Chiapas, Hidalgo, Quintana Roo, Veracruz, and Yucatan. It is an ectoparasite that affects many animal hosts, including wildlife, farm animals like cattle and horses, and pets such as dogs and cats (Rodríguez-Vivas *et al.* 2023, 2024). Adult ticks are primarily associated with members of the Cetartiodactyla and Carnivora, such as cervids and carnivores, while larvae and nymphs tend to infest birds, reptiles, as well as small and medium-sized mammals (Martínez-Ortiz *et al.* 2019; Flores *et al.* 2020; Rodríguez-Vivas *et al.* 2024), including members of the Rodentia (Clark 2004; Harrison *et al.* 2010; Rodríguez-Vivas *et al.* 2023).

In the southeastern and northeastern USA, *I. keiransi* is known to be one of the main vectors that support the enzootic cycle of *Borrelia burgdorferi* sensu stricto among rodents (Clark 2004; Maggi *et al.* 2010). Other bacterial genera of public health significance found in *I. keiransi* include *Rickettsia* and *Bartonella* (Martínez-Ortiz *et al.* 2019; Rodríguez-Vivas *et al.* 2024).

Wild rodents host several tick species that transmit pathogens, causing emerging or re-emerging zoonotic diseases (Burri *et al.* 2011; Aguilar-Tipacamú *et al.* 2025). In Yucatan, some rodents had been identified as hosts of certain pathogenic microorganisms transmitted through biological vectors like ticks, lice, and fleas (Panti-May *et al.* 2015; Torres-Castro *et al.* 2018; Panti-May *et al.* 2021; Arroyo-Ramírez *et al.* 2023). *Peromyscus yucatanicus* (Mexican deer mouse) is a rodent endemic species distributed throughout the Yucatan Peninsula, Guatemala, and Belize (MacSwiney-G *et al.* 2012). This species inhabits various environments, ranging from well-preserved ecosystems to anthropogenically altered areas (Zaragoza-Quintana *et al.* 2022).

On the other hand, some elements from the diet of *P. yucatanicus* captured in Mexican tropics (Zaragoza-Quintana *et al.* 2022) were described. Notably, this is the first international record of tick ingestion by *P. yucatanicus*.

In a study to identify the helminth fauna of small rodents from the Yucatan Peninsula, we examined the gastrointestinal contents of wild rodents captured in Panabá and Tekax, Yucatan. Characteristics of the study sites are described in Yeh-Gorocica *et al.* (2024). Briefly, Panabá (grassland landscape) and Tekax (forest with secondary vegetation landscape) have a warm and subhumid climate throughout the year, with two defined climatic seasons (rainy and dry).

During the examination of the gastrointestinal content of 104 small rodents, two partially digested tick larvae (Figure 1) were collected from the gastrointestinal contents of an adult male *P. yucatanicus* captured at the Panabá site in July 2023. These were preserved in 96% ethanol and stored at -25°C until used. The capture and extraction of rodents were conducted with permission from the Secretariat of Environment and Natural Resources (SEMARNAT) of Mexico (documents: SPARN/DGVS/06447/22 and SPARN/DGVS/09663/23). This study was approved by the Bioethics Committee of the Faculty of Veterinary Medicine of the

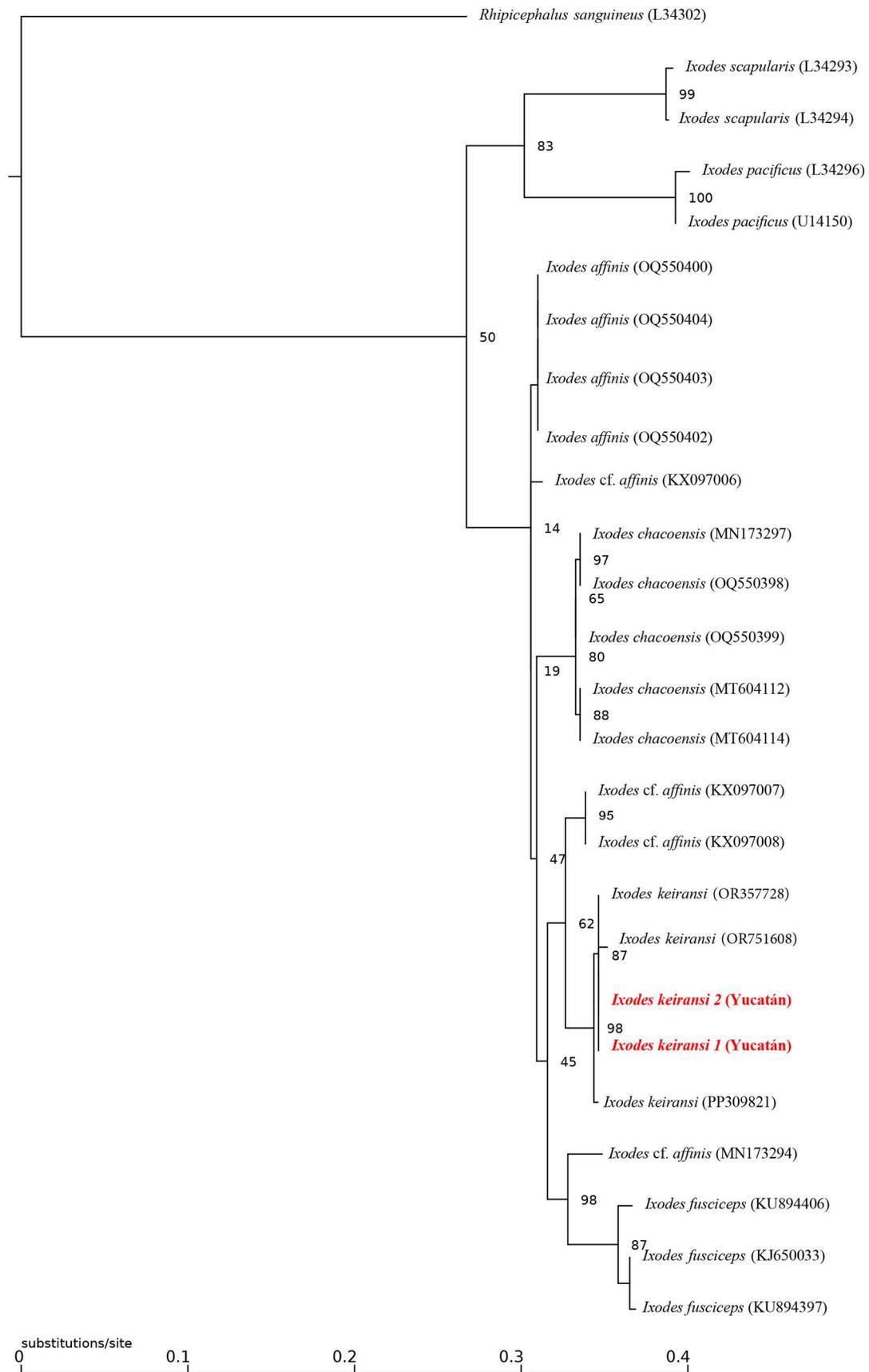**Figure 2.** Phylogenetic tree constructed from a partial fragment (340-350 pb) of the *16SrDNA* gene using the maximum likelihood method and the K3Pu+F+R2 nucleotide substitution model. Bootstrap values greater than 0.4 are indicated at the nodes of the tree. The scale bar represents nucleotide substitutions per site. It includes the sequences recovered in this study in red (accessions PQ299193.1 and PQ299194.1).

Autonomous University of Yucatan (official document: CB-CCBA-D-2022-004).

Genomic DNA was extracted from each specimen using Chelex 100 resin® solution (Bio-Rad®, United States of America) as described by Grostieta *et al.* (2024). To identify the tick species, a fragment of 400 bp of the mitochondrial *16S-rDNA* gene was amplified using polymerase chain reaction (PCR), following the criteria outlined by Norris *et al.* (1996) and the primers 16S+ (CTGCTCAATGATTTTTTAAATTGCTGTGG) and 16S- (CCGGTCTGAACTCAGATCAAGT). The *16S-rDNA* region is adequate to investigate the tick diversity because it is commonly sequenced for several species (Rodríguez-Vivas *et al.* 2023).

Both PCR products were sent for sequencing to Macrogen, Inc. in Seoul, South Korea. The resulting sequences measuring 350 base pairs (bp) were visualized and manually edited using the MEGA-X® software. After editing, each sequence was compared with sequences available in the NCBI database using BLASTn (Basic Local Alignment Search Tool) using the NCBI core nucleotide database (core_nt) to determine identity and coverage percentages (Altschul *et al.* 1990). The organism or taxon of interest was not specified for the sequence search, and the Models (XM/XP) and uncultured/environmental sample sequences were not excluded. Both sequences were submitted to GenBank under Accession numbers PQ299193 and PQ299194.

The edited sequences were globally aligned with several neotropical *Ixodes* sequences obtained from GenBank using the CLUSTAL-W algorithm in MEGA-X® (Kumar *et al.* 2018), and the phylogenetic tree was constructed in IQ-TREE (http://www.iqtree.org/) using the maximum likelihood method with 1,000 Bootstrap replicates (Tamura *et al.* 2004).

As illustrated in the phylogenetic tree (Figure 2) derived from the partial sequences of the *16S-rDNA* gene, both specimens were identified as *I. keiransi*. The identity and coverage percentages yielded from BLASTn were 100% for both sequences.

The parasitism of *I. keiransi* (reported as *I. affinis*) has been described in wild rodents at several sites in Yucatán, but there are no records of *I. keiransi* parasitizing *P. yucatanicus* in the region (Palomo-Arjona *et al.* 2024; Núñez-Corea *et al.* 2024); however, the present study is the first to identify the ingestion of this tick by *P. yucatanicus*, underscoring the need for further research into oral route transmission of tick-borne diseases. In this study, neither the rodent nor the tick were tested for the detection of *Borrelia*, *Rickettsia*, or *Bartonella*.

Several families and genera of small rodents, including *Peromyscus*, are reservoirs of several vector-borne pathogens and are essential for generating and maintaining transmission cycles and the epidemiology of the diseases they cause (Panti-May *et al.* 2021). These animals are a food source for immature stages of ectoparasites (larvae and nymphs) (Palomo-Arjona *et al.* 2024) and contribute to maintaining the horizontal transmission of microorganisms when these immature stages without infection, especially larvae, become infected by feeding on rodents with the bacteria circulating in their bloodstream (Kiran *et al.* 2024; Perumalsamy *et al.* 2024).

Small rodents are known to incidentally ingest immature stages of ticks and other ectoparasite vectors, such as fleas (Siphonaptera), lice (Anoplura), and mites (Mesostigmata) through grooming (Panti-May *et al.* 2015). With this behavior, they manage to regulate the number of ectoparasites that reach the adult stage and, therefore, reduce the risk of transmission of pathogens that can affect susceptible hosts, including humans and other host animals (Krawczyk *et al.* 2020).

Another possible route for *P. yucatanicus* to ingest *I. keiransi* larvae is through the consumption of leaves and other vegetal or plant elements found in the soil (Zaragoza-Quintana *et al.* 2022). *Ixodes keiransi* larvae detach from their host and drop to the ground to molt for the first time, transforming into nymphs (Rodríguez-Vivas *et al.* 2023).

Most vector-borne pathogens are transmitted indirectly through fecal contamination or inoculation with a bite (vectorial route) during the feeding process (Meerburg *et al.* 2009). In the specific case of members of the genus *Hepatozoon* (Apicomplexa: Adeleina), infection occurs through the consumption of ticks or some of their parts (Smith 1996). This protozoan genus has previously been reported in two rodent species in the southern United States of America (*Peromyscus leucopus* and *Sigmodon hispidus*), evidencing the participation of the *Peromyscus* genus in the enzootic cycle of this parasite (Modarelli *et al.* 2020).

Zaragoza-Quintana *et al.* (2022) evaluated fecal samples of *P. yucatanicus*, where they found a higher proportion of fruit pulp, followed by chitin remains, several types of epidermis, seeds, remains of appendages of other arthropods (mites and ants) and, finally, fibers. These findings help us to suggest that the ingestion of *I. keiransi* by one of the specimens evaluated could have been accidental during the grooming process, as indicated by Panti-May *et al.* (2019) in the commensal rodents *M. musculus* and *R. rattus* captured in Yucatan.

The oral route is vital in transmitting pathogens to animals (i.e., *Hepatozoon canis*) (Vásquez-Aguilar *et al.* 2021), and this finding highlights the need for further investigation into this emerging paradigm in tick-borne disease research. In addition to the oral transmission pathway, it is crucial to consider the ecological dynamics that facilitate tick-borne diseases. For instance, the role of reservoir hosts in maintaining and amplifying pathogen populations cannot be overstated. *Peromyscus yucatanicus* harbors pathogens and may contribute to the interactions between ticks and their environments. Furthermore, as urbanization encroaches on wildlife habitats, increased

human-wildlife interactions may lead to higher rates of ectoparasitic feeding and accidental ingestion of infected ticks, thereby exacerbating disease transmission risks. This shift underscores the necessity for interdisciplinary research that integrates ecology, veterinary science, and public health perspectives to devise effective intervention strategies against emerging zoonotic threats linked to ticks.

Acknowledgements

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Density, activity patterns, and habitat selection of Puma (*Puma concolor*) in the high-altitude plateaus of Tarapacá, Chile

Densidad, patrones de actividad y selección de hábitat del puma (*Puma concolor*) en los bofedales de Tarapacá, Chile

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We investigated the ecology of the puma (*Puma concolor*) in the high-altitude plateaus of Tarapacá, northern Chile, with a focus on population density, daily activity patterns, and habitat selection. We hypothesized that prey scarcity and human presence would result in low population density, predominantly nocturnal activity, and a preference for shrubland ("tolar") habitat. Systematic camera-trap surveys were conducted during two seasonal periods in 2012, totaling 1,602 trap-nights. Puma density was estimated using capture-recapture methods based on Maximum Mean Distance Moved (MMDM) and Minimum Convex Polygon (MCP). Activity patterns were analyzed by hour, and habitat selection was assessed using the Ivlev Selection Index and logistic regression. A total of 72 independent detection events were recorded, corresponding to four identified individuals. Density estimates ranged from 0.2 to 0.6 individuals per 100 km²—the lowest reported for *Puma concolor* in Chile. Eighty percent of detections occurred between 20:00 and 04:59 h, indicating a bimodal nocturnal activity pattern. Shrublands were preferred (Ivlev Index = +0.15), wetlands were avoided (–0.35), and detection probability was higher in areas with over 40% tolar cover. The low population density likely reflects limited wild prey availability and indirect competition with livestock. Nocturnality appears to be a behavioral adaptation to avoid human activity. The broad spatial distribution of detections suggests wide-ranging movements. Although fieldwork was conducted in 2012, ecological conditions have remained relatively stable, supporting the relevance of our findings, despite emerging threats such as infrastructure development and wildlife decline. This study provides essential baseline data on puma ecology in the Tarapacá highlands and supports evidence-based management. We recommend implementing long-term monitoring with telemetry, improving nighttime livestock protection, and conserving tolar corridors to promote puma persistence in high Andean environments.

Keywords: Andean highlands, apex predator, carnivore ecology, human-wildlife conflict, non-invasive monitoring.

Investigamos la ecología del puma (*Puma concolor*) en el altiplano de la región de Tarapacá, en el norte de Chile, con un enfoque en la densidad poblacional, los patrones de actividad diaria y la selección de hábitat. Se planteó la hipótesis de que la escasez de presas y la presencia humana resultarían en una baja densidad poblacional, actividad predominantemente nocturna y preferencia por hábitats arbustivos de "tolar". Se realizaron muestreos sistemáticos con cámaras trampa durante dos periodos estacionales en 2012, acumulando un total de 1.602 noches-trampa. La densidad fue estimada mediante métodos de captura-recaptura basados en la Distancia Máxima Promedio de Movimiento (MMDM) y el Polígono Mínimo Convexo (MCP). Los patrones de actividad fueron analizados por hora y la selección de hábitat se evaluó mediante el Índice de Selección de Ivlev y regresión logística. Se registraron 72 eventos independientes de detección, correspondientes a cuatro individuos identificados. Las estimaciones de densidad variaron entre 0.2 y 0.6 individuos por cada 100 km², los valores más bajos reportados para *Puma concolor* en Chile. El 80 % de las detecciones se produjo entre las 20:00 y las 04:59 h, lo que indica un patrón de actividad nocturna bimodal. Se observó preferencia por el tolar (*Índice de* Ivlev = +0.15), evitación de bofedales (–0.35) y una mayor probabilidad de detección en áreas con más del 40 % de cobertura de tolar. La baja densidad poblacional probablemente refleja una disponibilidad limitada de presas silvestres y competencia indirecta con el ganado. La nocturnidad parece ser una adaptación conductual para evitar la actividad humana. La amplia distribución espacial de las detecciones sugiere movimientos de largo alcance. Aunque el trabajo de campo se realizó en 2012, las condiciones ecológicas se han mantenido relativamente estables, lo que respalda la vigencia de los hallazgos, a pesar de amenazas emergentes como el desarrollo de infraestructura y la disminución de fauna silvestre. Este estudio proporciona datos de línea base esenciales sobre la ecología del puma en el altiplano de Tarapacá y contribuye al manejo basado en evidencia. Recomendamos implementar monitoreos de largo plazo con telemetría, mejorar la protección nocturna del ganado y conservar los corredores de tolar para favorecer la persistencia del puma en ambientes altoandinos.

Palabras clave: Altiplano andino, conflicto humano-fauna, depredador tope, ecología de carnívoros, monitoreo no invasivo.

Top predators, particularly large carnivores, play key ecological roles as ecosystem regulators through prey population control and facilitation of ecological processes (Fortuna *et al.* 2024; Romero-Muñoz *et al.* 2024). However, these species face global declines due to habitat loss, prey depletion, and human-wildlife conflicts (Torres *et al.* 2018; Chinchilla *et al.* 2022).

The puma (*Puma concolor*), the most widely distributed felid in the Americas, exemplifies these conservation challenges. As solitary territorial carnivores, pumas require extensive home ranges (Elbroch & Kusler 2018; Guerisoli *et al.* 2019). Neotropical studies report minimum densities of ~0.6 individuals/100 km², reflecting territorial spacing strategies (Guarda *et al.* 2017; Zanón-Martínez *et al.* 2023).

In Chile, pumas serve as apex predators across multiple ecosystems (Osorio *et al.* 2020). Yet ecological knowledge remains scarce for arid northern regions. While density estimates exist for central and southern Chile (Guarda *et al.* 2017), only Villalobos (2006) reported data for high-altitude plateaus (0.9 ind/100 km² in Arica-Parinacota). This information gap hinders conservation planning in Tarapacá, where puma-livestock conflicts persist (Ohrens *et al.* 2016). Camera-trapping offers a non-invasive solution for studying this cryptic species across large ranges (Hending 2024; Harley *et al.* 2024).

Although our fieldwork was conducted in 2012, the ecological insights derived remain relevant due to the long-term stability of high-Andean ecosystems. These environments exhibit minimal interannual variation in vegetation structure and prey composition, providing a consistent ecological baseline. Biomass estimates were derived from bibliographic averages, which may introduce a potential bias in precise seasonal quantification. Nonetheless, these proxies allow for valid spatial comparisons and provide a robust framework for understanding predator-prey dynamics in remote regions.

Given the lack of ecological information for *P. concolor* in northern Chile, we asked: What is the density of pumas in the high-altitude plateaus of Tarapacá? What are their daily activity patterns, and which habitats do they preferentially use in this landscape? We hypothesized that puma density would be lower than in central and southern Chile due to prey scarcity and human presence, that activity would be predominantly nocturnal, and that shrublands would be preferred over wetlands or grasslands. Based on these questions, this study aimed to: (1) estimate puma density using camera traps, (2) characterize activity patterns, and (3) assess habitat selection in the high-altitude plateaus of Chile. The research was conducted in Tarapacá's high-altitude plateaus (3,500–5,000 m), dominated by *tolar* shrubs (*Adesmia spinosissima*) and *pajonal* grasses (*Festuca orthophylla*). Mean annual temperatures range from 0–10 °C, with 250–300 mm of concentrated rainfall (December–March).

We conducted two surveys in 2012: autumn–winter (April–August) and spring (September–November). Eighteen Bushnell cameras (119455 Trophy Cam XLT) were deployed in a systematic grid (5–10 km spacing), placed along wildlife trails (40–70 cm height, 7 m focal distance). Cameras were set to capture 3-photo bursts (5-min interval), operating continuously with commercial carnivore lures. Individuals were identified via unique pelage patterns. Independent captures required: (1) different individuals in consecutive photos, (2) same individual ≥30 min apart, or (3) same individual at different stations. Density was estimated using Maximum Mean Distance Moved (MMDM) and Minimum Convex Polygons (MCP). Activity patterns were analyzed across four temporal windows, and habitat selection via Ivlev's Index.

To determine differences in detection probability among habitat types, we conducted a logistic regression analysis using the presence or absence of *Puma concolor* in each camera station as the binary response variable. The main predictor was vegetation structure, categorized as tolar-dominated (>40% cover) versus other habitats. Odds Ratios (OR) and confidence intervals (95% CI) were computed to assess the strength and significance of habitat associations. Analyses were performed in R using the glm() function (family = binomial), following methodological frameworks used in carnivore ecology (e.g., Harmsen *et al.*, 2011; Kelly *et al.*, 2008).

All statistical analyses were performed using R 4.3.1 (R Core Team, 2013), with bio-statistical procedures executed using the BioestadisticaR package (Femia Marzo *et al.*, 2012).

We recorded 72 independent detection events across both seasons: 42 in autumn–winter (0.88 captures/100 trap-nights) and 30 in spring (0.6 captures/100 trap-nights) (Figure 1). These correspond to seven puma detections in the first period and five in the second, totaling twelve records. Four individuals were identified overall (3 adults, 1 subadult), based on pelage and facial markings (Figure 2). Density estimates ranged from 0.5–0.6 ind/100 km² in autumn–winter (707–772 km²) and 0.2–0.4 ind/100 km² in spring (855–1,672 km²) (Table 1).

Table 1. Puma density estimates based on Maximum Mean Distance Moved (MMDM) and Minimum Convex Polygons (MCP) methods in two sampling periods.

|	Period 1 (Atumm-winter)	Period 2 (Spring)
Sampling effort	792 trap nights	810 trap nights
Capture success / 100 trap days	0.88 records	0.6 records
Puma records	7	5
Stations with records	3	4
Identified pumas	4	3
MMDM	5.5 km	8.4 km
Total MMDM area	707 km²	1,672 km²
Minimum MMDM density	0.6 puma/100 km²	0.2 puma/100 km²
Total MPC area	772 km²	855.28 km²
Minimum MPC density	0.5 puma/100 km²	0.4 puma/100 km²
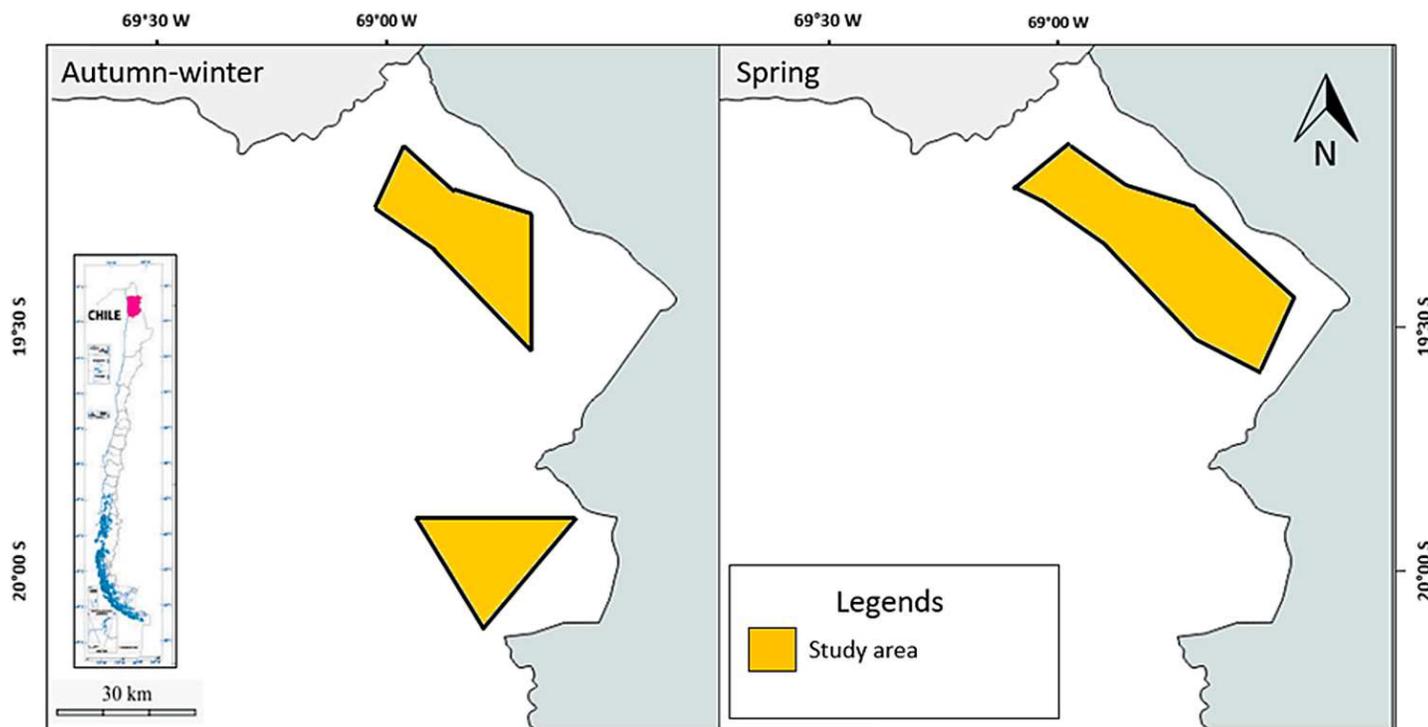
Figure 1. Study area in the high-altitude plateaus of Tarapacá surveyed in autumn-winter and spring seasons.

Confidence intervals were not presented for these estimates due to the limited number of spatial recaptures, which prevented robust variance estimation. Given this constraint, densities are reported as minimum values and should be interpreted as a conservative baseline for future monitoring.

Pumas exhibited strongly nocturnal behavior, with 80% of records occurring between 20:00 and 04:59 h. Activity peaks were concentrated at 21:00–23:00 h ($\chi^2 = 15.3$, P < 0.01) and 03:00–05:00 h ($\chi^2 = 12.7$, P < 0.05), indicating a bimodal pattern centered around midnight and pre-dawn hours. Notably, these intervals fall well outside solar daylight windows, as sunrise during the sampling periods ranged from approximately 06:30 to 07:00 h, and sunset occurred between 18:00 and 18:45 h. Diurnal (13.3%) and crepuscular (6.6%) activity was limited (Figure 3), supporting temporal avoidance of human activity.

"Tolar" shrublands were preferred (50% detections, Ivlev = +0.15), wetlands avoided (–0.35), and grasslands showed neutral selection (–0.02) (Table 2). The probability of detection was significantly higher in areas with >40% tolar cover (OR = 2.3, 95% CI: 1.4–3.8).

Table 2. Habitat preference based on the Ivlev Selection Index.

Vegetation Type	Percentage of Records	Ivlev Selection Index
Tolar	50%	0.15
Pajonal	16.50%	-0.02
Bofedal	33.50%	-0.35

Our density estimates (0.2–0.6 ind/100 km²) are Chile's lowest reported, potentially reflecting: (1) limited wild prey (Vicugna vicugna, Lagidium viscacia), (2) livestock competition, or (3) methodological constraints. Regarding point (2), competition with livestock likely reflects indirect ecological displacement of wild prey, rather than direct interference. The intensive presence of llamas and alpacas in the bofedales may lead to habitat degradation, reduced vegetative cover, and altered resource availability for native species, particularly for herbivores that form the puma's natural prey base. Additionally, constant human activity associated with pastoralism can suppress wildlife activity and limit prey abundance through behavioral avoidance. These conditions constrain the trophic flexibility of *P. concolor*, potentially increasing its dependence on domestic livestock and thereby intensifying conflict with local herders.

The pronounced nocturnality (80% activity) likely represents temporal segregation to avoid humans, as observed in other high-conflict areas (Procko *et al*. 2023). "Tolar" preference reflects its value for hunting, cover, and movement corridors.

Importantly, the fieldwork was conducted in 2012, and while some aspects of the landscape have remained ecologically stable—such as vegetation structure and altiplano livestock presence—there is growing concern over emerging pressures. These include expanding mining infrastructure, declining vicuña populations, and increasing human-livestock interactions at higher elevations. Although long-term trends are not fully documented, anecdotal

Figure 2. Adult male puma detected by camera trap, identified through distinctive facial features: a spotted pattern on the left cheek and a pale stripe across the forehead.
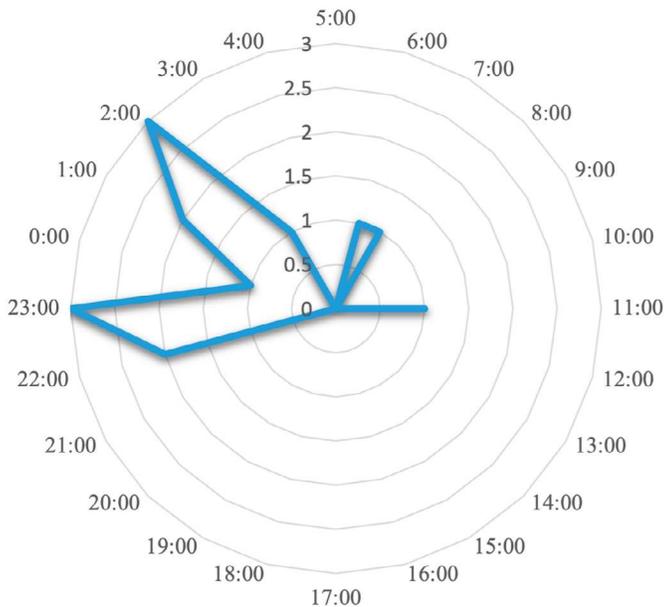
Temporal distribution of records

Figure 3. Hourly distribution of puma detections from camera traps.

reports from herders and field teams suggest conservation challenges may be intensifying in the region.

Furthermore, only four of the 18 camera stations recorded puma presence across both seasons. These stations were not spatially clustered but were distributed across the broader sampling polygon (Minimum Convex Polygon), encompassing varied habitat types and elevation gradients. This spatial dispersion supports the interpretation that individuals operate across wide-ranging territories and those detections represent genuine habitat use rather than proximity bias.

However, some limitations must be considered when interpreting these findings. The relatively short sampling period (eight months) may not capture seasonal or interannual variation in density and activity. In addition, the spatial distribution of camera traps was not entirely random, which could bias detection probabilities toward more accessible sites. It is also possible that transient or dispersing individuals were underrepresented due to the stationary sampling design. Finally, the small number of identified individuals (n = 4) and limited spatial recaptures

restrict the precision of density estimates, which should be interpreted conservatively.

Despite these limitations, our results provide valuable baseline data and suggest key directions for future conservation efforts. We recommend the implementation of long-term monitoring programs incorporating satellite telemetry to better understand movement ecology and landscape use. In parallel, reinforced nighttime livestock enclosures could help mitigate conflicts with herders, particularly in zones of high nocturnal puma activity. Additionally, preserving and restoring "tolar" shrubland corridors should be prioritized, given their ecological importance as preferred habitats and movement pathways for pumas in the Andean highlands.

Future research should consider expanding spatial coverage and increasing sampling duration across multiple years to improve density estimates and capture potential interannual variability. The use of rotating camera stations and integration of occupancy modeling could further strengthen inference, particularly in low-density or wide-ranging species such as *P. concolor*.

Although our study is based on data collected in 2012, we emphasize its value as an ecological baseline for the Tarapacá highlands. The region's relative environmental stability, particularly in vegetation structure and climate, supports the relevance of the findings. However, emerging anthropogenic pressures such as infrastructure development and wildlife population shifts underscore the need for updated information. We highlight the urgency of implementing long-term monitoring to track changes in puma ecology and habitat use. These updated efforts will be essential to evaluate trends over time and support adaptive conservation planning in this vulnerable ecosystem.

Acknowledgements

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First record of *Perimyotis subflavus* in Nuevo León, Mexico with additional ecological notes on hibernacula

Primer registro de *Perimyotis subflavus* en Nuevo León, México, con notas ecológicas adicionales sobre sus hibernáculos

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Perimyotis subflavus, is a species that is currently listed as Vulnerable by the IUCN Red List due to the population decline that is causing the White-Nose Syndrome (WNS). However, in Mexico, its ecology and distribution are poorly understood. Despite its distribution in Mexico being mainly in the east, in Nuevo León has never been recorded until now. The individual's capture was done during a speleologist exploration on March 18th, 2025, in a cave in Laguna de Sánchez, Santiago, Nuevo León. We described the microclimatic characteristics of the roost by measuring the temperature and relative humidity. We also measured individuals fur temperature and roost's surface temperature where the bat was roosting. Our observation of *P. subflavus* is the first one in the Nuevo León state. The individual was an adult non-reproductive male in an apparent torpid state. Its fur temperature was 11.1°C, and the roost surface temperature was 13.1°C. The cave's microclimate at the moment of the capture had a temperature of 12.5°C and a relative humidity of 79.8%. The nearest historical observation of *P. subflavus* in Tamaulipas state is 146.63 km from our record and 251.08 km from the record in Coahuila state. With our new addition, Nuevo León now has 36 bat species already recorded. The individual was apparently torpid, meaning there are conditions suitable for WNS growth, as it demonstrates that northeast of Mexico could be vulnerable to WNS invasion. Our finding underscores the urgent need to continue studying bat populations in these poorly surveyed regions to anticipate potential threats and establish effective conservation strategies.

Key words: Cave; hibernation; Sierra Madre Oriental; torpor; Vespertilionidae.

Perimyotis subflavus es una especie actualmente clasificada como Vulnerable en la Lista Roja de la UICN debido a la disminución poblacional que ha ocasionado el Síndrome de la Nariz Blanca (SNB). Sin embargo, en México, su ecología y distribución son deficientes. A pesar de que su distribución en México se centra principalmente en el este, en Nuevo León nunca se había registrado hasta la fecha. La captura del individuo se realizó durante una exploración espeleológica el 18 de marzo de 2025 en una cueva en la Laguna de Sánchez, Santiago, Nuevo León. Describimos las características microclimáticas del refugio midiendo la temperatura y la humedad relativa. También medimos la temperatura del pelaje y la temperatura de la superficie del refugio donde el murciélago se encontraba posado. Nuestra observación de *P. subflavus* es la primera en el estado de Nuevo León. El individuo era un macho adulto no reproductivo en aparente estado de torpor. La temperatura de su pelaje fue de 11.1 °C y la temperatura de superficie del refugio fue de 13.1 °C. El microclima de la cueva en el momento de la captura presentaba una temperatura de 12.5 °C y una humedad relativa del 79.8 %. Nuestro registro amplía la distribución de *P. subflavus* en 146.63 km desde su observación histórica más cercana en el estado de Tamaulipas y en 251.08 km desde el estado de Coahuila. *Discusión*: Con nuestra nueva observación, Nuevo León cuenta ahora con 36 especies de murciélagos. El hecho de que este individuo se encontrara en probable letargo, resalta que existen las condiciones propicias para el crecimiento del SNB, ya que demuestra que los hábitats del noreste de México podrían ser vulnerables a su invasión. Nuestro hallazgo subraya la urgente necesidad de continuar estudiando las poblaciones de murciélagos en estas regiones con escasos estudios para anticipar posibles amenazas y establecer estrategias de conservación eficaces.

Palabras clave: Cueva; hibernación; Sierra Madre Oriental; torpor; Vespertilionidae.

The Eastern Pipistrelle bat, *Perimyotis subflavus,* is a *vespertilionid* species that can be distinguished from smaller *Myotis* species by its tricolored hair: dark at the base, lighter and yellowish-brown in the middle, and dark at the tip. The interfemoral membrane is furred in its first third and the calcar is unkeeled (Fujita and Kunz 1984).

Perimyotis subflavus is currently listed as Vulnerable by the IUCN Red List due to population declines caused by White-Nose Syndrome (WNS) (Solari, 2018). This disease has drastically increased mortality rates, reaching over 90% in some populations in the USA since its detection in this species in 2013 (Perea *et al.*, 2022).
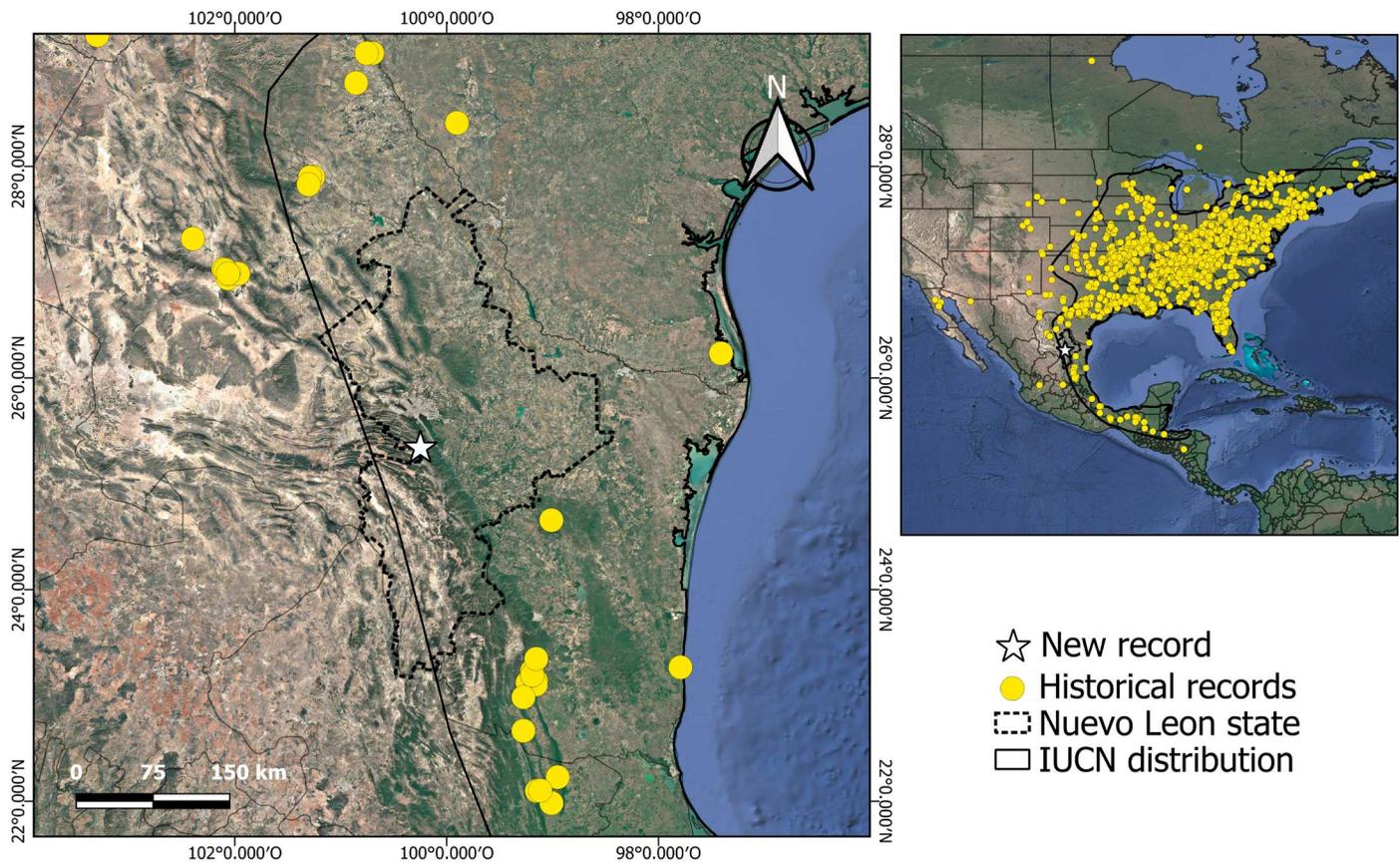
Figure 1. Map of the GBIF records of *Perimyotis subflavus* and our new record in Nuevo León, México showed with a star.

Its distribution goes from eastern Canada, North and Central United States, and eastern Mexico, following the Sierra Madre Oriental mountain range. It continues down into the tropical lowlands and mountains of northeastern Nicaragua (Fujita and Kunz 1984; Solari, 2018). Despite not being part of its main distribution, *P. subflavus* can also be found in other regions of Mexico, such as Baja California, Chiapas, Guanajuato, Sonora, and Oaxaca (GBIF 2025). The species can roost in subterranean habitats, trees, and even in artificial places (Fujita and Kunz 1984). *Perimyotis subflavus* is an obligate hibernator in winter, even under warm conditions (13-18°C) that overlaps with the optimal temperature of the *Pseudogymnoascus destructans*, the fungus that causes the White-Nose Syndrome (12.5-15.8°C) (Verant *et al.* 2012; Smith *et al.* 2021). For this reason, it is crucial not only to record its occurrence but also to gather ecological data about its roosts to identify the potential hibernacula sites vulnerable to the White-Nose Syndrome in Mexico (Rivera-Villanueva *et al.* 2025). Environmental modeling has projected the region of the Sierra Madre Oriental as the most likely entry point for WNS into Mexico (Gómez-Rodriguez *et al.,* 2022). Identifying the hibernacula and their ecological conditions for one of the most affected species by WNS could help prevent the spread of the disease and mitigate its impacts (Perea *et al.* 2022). Research on hibernacula has recently advanced, mainly through the work of Ramos-H *et al.* (2024), who

increased the number of torpid bat species known to hibernate in Mexico by over 50% and quadrupled the number of known hibernacula in the country.

However, in order to assess the ecology and vulnerability of this species in Mexico, baseline knowledge of the species' distribution is first required. Although *P. subflavus* is primarily found in eastern North America, it has never been recorded in the state of Nuevo León, México. This state is part of the Sierra Madre Oriental mountain range in northeastern Mexico (Jiménez-Guzmán *et al.,* 1998; Wilson *et al.,* 1985). The potential distribution of *P. subflavus* according to the IUCN includes Nuevo León; however, there is no previous record of the species in the state (Jiménez-Guzmán *et al.,* 1998). Given its distribution across the nearby and ecologically similar states of Coahuila, San Luis Potosí, Tamaulipas, and Veracruz, the species is also expected to occur in Nuevo León (Fujita and Kunz 1984).

In terms of bat diversity in Nuevo León, 35 species have been recorded in the past, including the endemic *Corynorhinus leonpaniaguae* (Jiménez-Guzmán *et al.,* 1998; López-Cuamatzi *et al.,* 2024). Here we provide the first record of *Perimyotis subflavus* in the state, with some ecological observations of its potential hibernacula site, thereby increasing the known bat diversity of Nuevo León to 36 species.

Laguna de Sanchez is a locality in the Santiago municipality in Nuevo León state, Mexico, with pine-oak forest, a yearly

Figure 2. a) and c) *Perimyotis subflavus* captured to confirm reproductive stage; b) uropatagium covered with sparse fur in the first third of the femoral region; d) The adult non-reproductive male of *P. subflavus* in a probably torpid state. Photos authoring not disclosed for review.

precipitation of 643.4 mm, and a mean annual temperature of 10-15°C (Instituto Nacional de Estadistica y Geografia, 2024). Laguna de Sanchez is at 1896.9 m.a.s.l, it is part of the Sierra Madre Oriental. Despite the locality being characterized by a Cw1, temperate subhumid climate with an annual temperature between 12°C and 18°C according to Köppen's climate classification (García 2004), the area has experienced several droughts, leaving the previously permanent lake almost always dry. Fieldwork was part of the expeditions of Laguna de Sanchez Cave Project, which includes more than 130 caves explored in the region (Kennedy 2025).

We recorded the roost microclimate at the time of the finding of *P. subflavus*. Temperature and relative humidity were taken with a data logger Elitech RC-51H (with an

accuracy of ±1º C and ±3.0% relative humidity). We determined the bat to be in an apparent torpid state due to its motionless and cold state (Ramos-H *et al.,* 2024). To gather baseline data on the apparent torpor behavior in this locality, we recorded the bat's fur temperature while roosting and the surface temperature where the bat was roosting using an infrared thermometer ThermoPro TP30 (with an accuracy of ±1.5°C from -10 to 100°C, and ±2% outside this range) at a distance of approximately 5 cm. The capture was following the guidelines of Sikes and the Animal Care and Use Committee of the American Society of Mammalogists (2016).

Protective equipment (gloves and a face mask) was used at all times. The bat was gently removed by hand as it began to wake up and was handled quickly to minimize stress. Forearm length was measured with a digital caliper (with an accuracy of ±0.2 mm). It was identified at the moment using the taxonomic keys Medellin *et al.* (2008). Due to its IUCN Red List category and decreasing population trends, the bat was not included as a collection voucher, but photographs and key measures were taken for identification. Photographs were taken of the uropatagium, dorsal color bands, dental row, full body, and face for documentation. After processing, the bat was released inside the roost. The study followed the requirements of the General Wildlife Federal Law of México (Ley General de Vida Silvestre) under collection permit SPARN/DGVS/09981/23.

To confirm its distribution range, we searched in GBIF (GBIF 2025) records using the scientific name "*Perimyotis subflavus*", and searched in the Mammals Collection of the Facultad de Ciencias Biológicas of the Universidad Autónoma de Nuevo León (UANL). We confirmed the name of collection localities, identified the incorrectly georeferenced records, and verified the identification of preserved specimens when available through digitized scientific collections.

The finding was near the end of the winter season on March 18th, 2025, approximately at 5:00 PM, in a cave located in an area called Mesa Colorada, within Laguna de Sanchez. The cave is located at 25° 20' 17.628"N, 100° 14' 53.667"W; 2151 m.a.s.l (Figure 1). Its entrance is a small hole on the ground, but the interior opens into a narrow crevice with high ceilings. The cave was inspected as thoroughly as possible, up to the areas accessible to humans, but only one individual was observed. The individual was an adult non-reproductive male in an apparent torpid state, alone in a crevice on a wall at an approximate height of 7 meters (iNaturalist 2025). Its fur temperature was 11.1°C and surface temperature was 13.1°C. The specimen forearm had a length of 31 mm. It was identified by the uropatagium covered with sparse fur and with a calcar unkeeled (Figure 2b). Three color bands (brown-yellow-brown) were also observed (Medellin *et al.* 2008).

The microclimate of the site where the bat was found had a temperature of 12.5°C and relative humidity 79.8%.

From GBIF (2025), we obtained 138 records of *P. subflavus* from Mexico and 4,576 from the rest of its distribution. Our observation of *P. subflavus* is the first one in the Nuevo León state and with our new addition, Nuevo León now has 36 bat species, being the 22nd species of Vespertilionidae family in the state. Our record is the first for the state of Nuevo León; the nearest records of *P. subflavus* are 146.63 km to the East in Tamaulipas state and 251.08 km to the west in Coahuila state.

P. subflavus has been captured in the east of Mexico, including Coahuila, San Luis Potosí, Tamaulipas, Veracruz, but it is the first time that is recorded in Nuevo León state, probably because of the lack of research in subterranean habitats such as caves, culverts, and mines. Our study site is found in the Sierra Madre Oriental mountain range, which is the region with the most bat captures in the state (Jimenez *et al.* 1999). There are recent efforts to monitor bat diversity and activity in municipalities near Nuevo León's capital, Monterrey, such as Santiago, where this finding was made has been conducted. However, its most southern part, such as Doctor Arroyo, General Zaragoza, Mier y Noriega, are the municipalities with the fewest bat captures. We encourage researchers to fill these gaps and increase bat research efforts, not only in subterranean habitats, but also in trees, bridges, and other types of roosts. Considering that *P. subflavus* also roosts in trees and bridges in other parts of its distribution, such as in the United States, we do not know if its behavior is similar in Mexico (Fujita and Kunz 1984; Newmann *et al.* 2021). Recent studies record *P. subflavus* roosting in caves (Ramos-H *et al.,* 2024). Whereas, from the GBIF records, there are no clear patterns of *P. subflavus* roosting behavior.

This record offers further information on the species' winter behavior and local distribution, which is relevant given its current conservation status. The fur temperature of the recorded individual was 11.1°C, which is lower than the temperature recorded by Meierhofer *et al.* (2019) in Texan populations (15.07 ± 2.87ºC). Whereas our substrate temperature (13.1°C) is similar to previously recorded (15.79 ± 3.69ºC; 13 ± 4.4ºC) (Meierhofer *et al.* 2019; Smith *et al.* 2021). But has also been recorded in lower substrate temperatures, going from approximately 7 ± 0.5ºC Langwig *et al.* (2016) to 9.5 ± 1.9ºC (Brack 2007). This means that *P. subflavus* has a large range of microclimate preferences. Ramos-H *et al.* (2024) found a strong positive relationship between substrate temperature and fur temperature in Mexican torpid bats.

Although the substrate temperature is not indicative of WNS infection, it has been recorded that *P. subflavus* uses colder roosting temperatures after WNS infection (Loeb and Winters 2022; Brown *et al.* 2025). The roosting temperatures of the species overlap with the range of optimal temperature growth of *Pseudogymnoascus destructans* (Sirajuddin *et al.* 2025). This means that it is needed to continue researching the microclimate preference of *P. subflavus,* especially

in Mexico, where the WNS is still not recorded. The fact that this individual was found in an apparent torpid state within a roost with environmental conditions suitable for *P. destructans* growth raises concern, as it demonstrates that northeastern Mexico habitats are vulnerable to *P. destructans* invasion. Population studies of the eastern pipistrelle bat are of interest for WNS research, as they are considered one of the potential pathways for the entry of WNS into Mexico (Gómez-Rodriguez *et al.,* 2022). Moreover this species is believed to have the ability to undertake regional and long-distance migrations along a latitudinal gradient, and is expected to be more common in males as they can withstand greater metabolic stress by not having to endure the strain caused by pregnancy and lactation (Fraser *et al.,* 2012), which that comes to our attention since the recorded bat was an adult male.

Perimyotis subflavus tends to hibernate singly, not in clusters. Also, during hibernation (winter) tends not to be sex segregated, contrary to the maternity season. And their hibernacula and maternity sites are usually different roosts (Fujita and Kunz 1984). For this reason, we consider our record of only one adult male to be a potential indication that more research needs to be done to understand its ecology. One of the possible explanations for our single recording is that more *P. subflavus* use the roost but were not found. But to test this hypothesis, the area and the cave need more exploration to understand the behavior of the species in Nuevo León. Our finding underscores the urgent need to continue studying bat populations in these poorly surveyed regions to anticipate potential threats and establish effective conservation strategies.

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Habitat use between two sympatric species of squirrels (*Sciurus aureogaster* and *Sciurus deppei*) in a tropical rainforest in Los Tuxtlas, Veracruz, Mexico

Uso de hábitat entre dos especies de ardillas simpátricas (*Sciurus aureogaster* y *Sciurus deppei*) en un bosque tropical en Los Tuxtlas, Veracruz, México

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The coexistence of species depends on niche partitioning for food and space. Among related species, competition may be higher since similar needs drive homologous traits. Studying these processes offers insights into factors that contribute coexistence. Since human-modified landscapes increase environmental differences, we expected the sympatric squirrels *Sciurus aureogaster* and *Sciurus deppei* to exhibit differences in their associations with habitat characteristics. We set 21 camera traps in the canopy of a rainforest at the Los Tuxtlas Tropical Biology Station from August 2022 to October 2024. Environmental and vegetation variables were included, and spatial variations in the number of records were analyzed according to three zones (Z1, Z2, and Z3). A Principal Component Analysis (PCA) was performed to detect spatiotemporal responses of both species. A total of 594 species-level squirrel records were differentially obtained across zones: *S. aureogaster* was more frequent in Z1, while *S. deppei* dominated in Z3. Although more records occurred in the rainy season, no statistically significant differences were found. The PCA showed that all environmental variables were related to squirrels, with distinct species-specific associations across survey years. Squirrel species were relatively frequent at the site, showing high spatiotemporal variation. Vertical space use may be a component favoring spatial segregation, as *S. deppei* occupies both canopy and understory, while *S. aureogaster* is strictly arboreal. No seasonal effects were observed in capture frequency, though interannual variation occurred in relation to environmental variables.

Keywords: Arboreal camera trapping, canopy ecology, coexistence, human-modified landscapes, Los Tuxtlas Biosphere Reserve, sympatric squirrels.

La coexistencia de especies depende de la partición de nicho por alimento y espacio, siendo mayor la competencia entre especies emparentadas por su similitud en rasgos y requerimientos ecológicos. Estudiar estos procesos aporta información sobre su coexistencia. Dado que los ambientes antropizados generan variabilidad ambiental, se esperan diferencias en la asociación de *Sciurus aureogaster* y *S. deppei* con las características del hábitat. Se instalaron 21 fototrampas en el dosel de la Estación de Biología Tropical Los Tuxtlas desde agosto de 2022 a octubre de 2024. Se consideraron variables ambientales y de vegetación y, se analizaron variaciones espaciales en el número de registros en tres zonas (Z1, Z2, y Z3). Un Análisis de Componentes Principales (ACP) fue realizado para detectar respuestas espaciotemporales en ambas especies. Se obtuvieron 594 registros de ardillas identificables a nivel especie distribuidos diferencialmente entre zonas: *S. aureogaster* fue más frecuente en Z1, mientras que *S. deppei* predominó en Z3. Aunque se registraron más individuos en temporada de lluvias, no se observaron diferencias estadísticamente significativas. El ACP mostró que todas las variables ambientales se relacionaron con las ardillas, con asociaciones especie-específicas distintas entre años. Las especies de ardillas fueron relativamente frecuentes en el sitio, mostrando alta variación espacio temporal. El uso diferencial del espacio vertical podría favorecer la segregación espacial, ya que *S. deppei* ocupa tanto el dosel como el sotobosque. No se observaron efectos estacionales en la frecuencia de captura, aunque hubo variación interanual relacionada con variables ambientales.

Palabras clave: Ambientes antropizados; ardillas simpátricas; coexistencia; ecología del dosel; fototrampeo arbóreo; Reserva de la Biosfera Los Tuxtlas.

Species coexistence is the ability of multiple species to occupy the same habitat simultaneously and is a dynamic ecological process that is shaped by both intra- and interspecific interactions (Holt 2001; McPeek 2022). Phylogenetically related species often exhibit morphological and behavioral similarities, leading to overlapping resource requirements such as space and food. As a result, competition tends to intensify (Darwin 1859; Blomberg and Garland Jr. 2002). In such cases, particularly among congeneric species, spatial and temporal segregation can serve as key mechanisms to mitigate competitive pressures (Perrin 1980; Castro-Arellano and Lacher Jr. 2009).

Squirrels demonstrate remarkable ecological plasticity and are capable of utilizing both terrestrial and arboreal strata across a broad spectrum of habitats from boreal forests to tropical ecosystems (Best 1995; Lurz *et al.* 2005). Their adaptability extends even to human-modified landscapes, where they continue to prosper (Koprowski *et al.* 2017). This flexibility is complemented by complex communication systems, which facilitate frequent intra- and interspecific interactions (McRae and Green 2014; Mazzamuto *et al.* 2017).

Research on squirrel coexistence has revealed that resource partitioning strategies vary depending on the species involved and the forest structure. These strategies may include differentiation in diet, in vertical space use, and activity patterns (Edwards *et al.* 1998; Abdullah *et al.* 2001; Sovie *et al.* 2019). Such ecological adjustments enable sympatric squirrel species to coexist within shared environments, reducing direct competition and promoting long-term stability in community composition.

Ground-based camera trapping has become a widely used method for studying various aspects of squirrel biology, including abundance, habitat preferences (Shannon *et al.* 2023), their impact as an invasive species (Beatham *et al.* 2023), and the expansion of knowledge of the natural history of lesser-known species (Alvarado-Ortíz *et al.* 2024), across both temperate and tropical regions. More recently, arboreal camera trapping has broadened the scope of mammal monitoring to include both arboreal and terrestrial species (Moore *et al.* 2021).

In Mexico, the application of arboreal camera trapping has significantly enhanced our understanding of canopy-dwelling mammalian communities (Astiazarán-Azcárraga *et al.* 2020; Cudney-Valenzuela *et al.* 2021; Hidalgo-Mihart *et al.* 2022; García-Casimiro and Santos-Moreno 2024; Rojas-Sánchez *et al.* 2025). Although squirrel species have been documented in all of these studies, sympatric species were specifically reported only by Cudney-Valenzuela *et al.* (2021) and Rojas-Sánchez *et al.* (2025). However, both studies focused on broader mammalian assemblages, and research focused on squirrel ecology remains scarce.

Therefore, studies on the ecology of two sympatric, closely related squirrel species at a local scale present a valuable opportunity to explore spatiotemporal segregation in relation to environmental and vegetation characteristics. Such focused studies can deepen our understanding of niche partitioning and coexistence mechanisms in tropical forest canopies.

In this study, we examined the local frequency and occupancy patterns of two sympatric squirrel species, *Sciurus aureogaster* and *Sciurus deppei,* within the limits of the Los Tuxtlas Tropical Biology Station (LTTBS). Our aim was to identify spatiotemporal variations in the use of arboreal habitats in relation to environmental and vegetation characteristics. Specifically, we wanted to quantify how each species utilized vertical and horizontal space over time. We hypothesized that these closely related species would exhibit spatiotemporal segregation as a strategy to reduce competition and facilitate coexistence within the shared landscape.

This study was conducted within the Los Tuxtlas Tropical Biology Station (LTTBS), a privately protected area of tropical rainforest owned and operated by the Institute of Biology of the National Autonomous University of Mexico (Coates 2017). The 644-ha reserve is located within the larger Los Tuxtlas Biosphere Reserve (CONANP 2006; Coates 2017; Figure 1). The LTTBS is surrounded by a heterogeneous landscape: the eastern and central portions are bordered by a matrix of pastureland, while the extreme western edge is connected to a remnant of approximately 9,000 hectares of original rainforest, partially surrounding the San Martín Tuxtla volcano (Von Thaden *et al.* 2020). Notable topographical features include a pronounced slope on the eastern boundary and a seasonal lagoon situated in the central portion of the reserve. Regrettably, on both boundaries (north and south) of the reserve near the central area, the landscape has been modified by the human settlements of the communal lands of Lázaro Cárdenas and the Laguna Escondida.

To monitor arboreal activity, a total of 21 canopy-level camera traps were installed throughout the LTTBS, with one camera per site. These were operated continuously from August 2022 to October 2024. We used a single rope climbing technique for canopy access. The camera models used were the following: 9 - Bushnell Trophy Trail Cameras HD119717, 8 - UOVision Green 30, 3 - Mixmart HC801, and 1 - LTL Acorn 6210. Sites were revisited bi-monthly to replace batteries and memory cards to ensure uninterrupted operation, as well as to restore any inactive units. Cameras were programmed to record 15-second videos per trigger event, without the use of bait. Vegetation was minimally trimmed only when necessary to prevent false triggers.

Site selection was based on three criteria: (1) the geographic location of a pre-established point grid to ensure systematic placement (Figure 1), (2) the presence of canopy bridges as indicators of arboreal transit (Gregory *et al.* 2017), and (3) the absence of broken branches or colonies of harmful animals such as stinging insects (Moore *et al.* 2021). Camera heights ranged from 6 to 20.9 meters
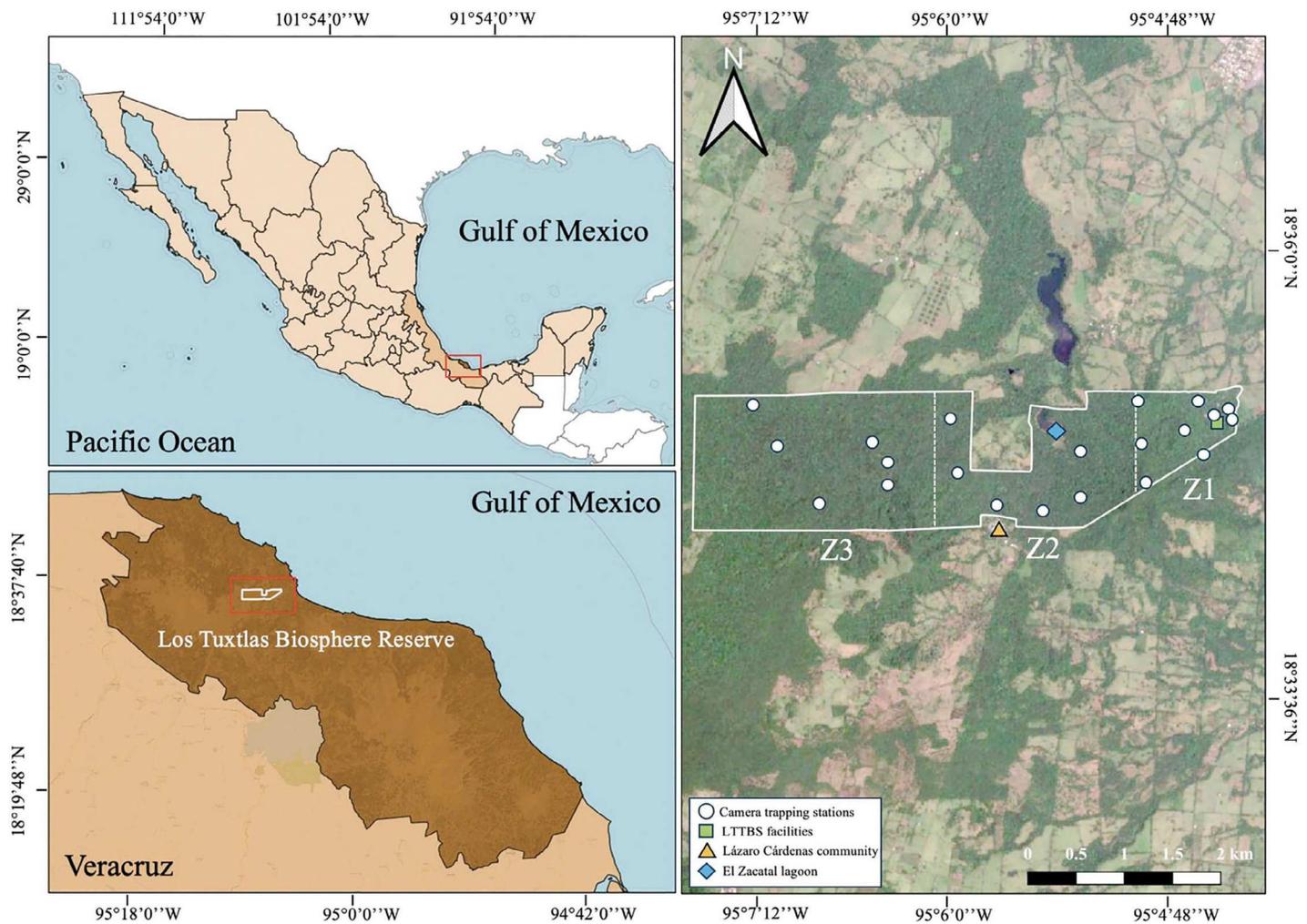
Figure 1. Maps depicting the study site near Los Tuxtlas Tropical Biology Station (LTTBS) and its geographic location within Los Tuxtlas Biosphere Reserve (LTBR), Veracruz, Mexico.

(mean = 13.80 m, SD = 4.53 m). This was measured *in situ* using a calibrated measuring tape The mean distance between camera sites was 560.62 meters.

In order to assess environmental variation and its influence on species distribution patterns, the LTTBS reserve was divided into three distinct zones based on topographic and landscape characteristics: Zone 1 (Z1: Cameras 1–9) was located in the eastern portion of the reserve and has the lowest altitude and a pronounced slope that separates it from Zone 2. Zone 2 (Cameras 10–15) was situated in the central portion of the reserve and is in close proximity to the seasonal lagoon "Zacatal", the Lázaro Cárdenas human settlement, and a larger notable vegetation gap nearby Laguna Escondida in its central-northern boundary. The Zone 3 (Z3: Cameras 16–21) was located in the western portion which is connected to the remnants of original vegetation surrounding the San Martín Tuxtla volcano (Figure 1).

Species were identified using morphological descriptions provided by Coates-Estrada and Estrada (1986), with body size serving as a key distinguishing trait:

Sciurus aureogaster — Typically larger in size, this species exhibits two distinct color morphs: (1) A mixed grey dorsal fur with reddish fur on the ventral side, and (2) A melanistic

morph with entirely black fur (Figure 2). *Sciurus deppei* – Smaller in size it displays a brownish coat with lighter fur on the belly and limbs (Figure 2).

All identifications were validated through comparison with specimens housed in the LTTBS mammal reference collection. Only records with confident species identifications were included in the final database (Figure 2).

A relative abundance index (RAI) was used as a capture frequency *proxy* and it was estimated as the quotient of the effective records (*i.e.* number of records after a 24-hour exclusion criterion), and the sampling effort multiplied by 100. The RAI was calculated considering only the effective records to avoid pseudo-replication and to compare the results with previous reports from the area (Flores-Martínez *et al.* 2022; Rojas-Sánchez *et al.* 2025). This RAI was calculated for the complete dataset including both species, as well as grouped separately based on the camera location zone (Figure 1). Seasonal variation in capture frequency was evaluated by dividing the complete dataset (2022 to 2024) into two periods: the dry season (March to July), and the wet season (August to February; Soto and Gama 1997). The differences in number of detections between seasons were assessed with a paired t-test in the statistical software R (R

Figure 2. A-C) Individuals recorded of A) melanistic *S. aureogaster*, B) bicolor *S. aureogaster,* and C) *S. deppei* in the canopy of the LTTBS.

Core Team 2023) for both species. A log-transformation was applied only to the effective records of *S. aureogaster* in the dry season to meet the statistical assumption of normality. No transformation was required for the remaining subsets.

To evaluate the influence of environmental factors on species presence, several variables were measured at each of the 21 camera trap sites: (1) distance to forest edge, (2) distance to the nearest road, (3) distance to human settlements, and (4) camera height. All spatial variables were obtained using Google Earth Pro (Google LLC 2025), while the camera height was recorded directly at each site.

A Principal Component Analysis (PCA) was conducted to explore patterns and relationships among environmental variables and species presence. The analysis was performed using the FactoMineR and factoextra packages in R (Le et al. 2008; Kassambara and Mundt 2020) and visualized with ggplot2 (Wickham 2016). Additionally, a seasonal component was incorporated into the analysis to account for temporal variation in species detection.

A total of 594 species-level records were obtained for both squirrel species across a sampling effort of 5,147 camera trap days (Figure 2). Site Z1 yielded the highest number of records and detection frequency for both species, followed by Z3 and Z2 (Table 1). The total number of records for *S. aureogaster* was 278, of which 166 were effective records, and had an overall RAI of 3.23. A decreasing gradient in the number of records and RAI for *S. aureogaster* was observed from Z1 to Z3 (Table 1) and was detected by 6 of the 9 cameras used at Z1 (66%), 4 of 6 at Z2 (66%), and 1 of 6 at Z3 (16%). In the case of *S. deppei*, 316 total records were obtained, 182 were effective records with an overall RAI of 3.54. This species showed its highest frequency at Z3, followed by Z1 (Table 1), and it was observed by 5 of 9 cameras deployed at Z1 (55%), 3 of 6 at Z2 (50%), and 5 of 6 at Z3 (83%). Furthermore, both species only co-occurred in 5 of the total 21 cameras (24%), 3 of 9 at Z1 (33%), and 1 of 6 at both, Z2 and Z3 (16%).
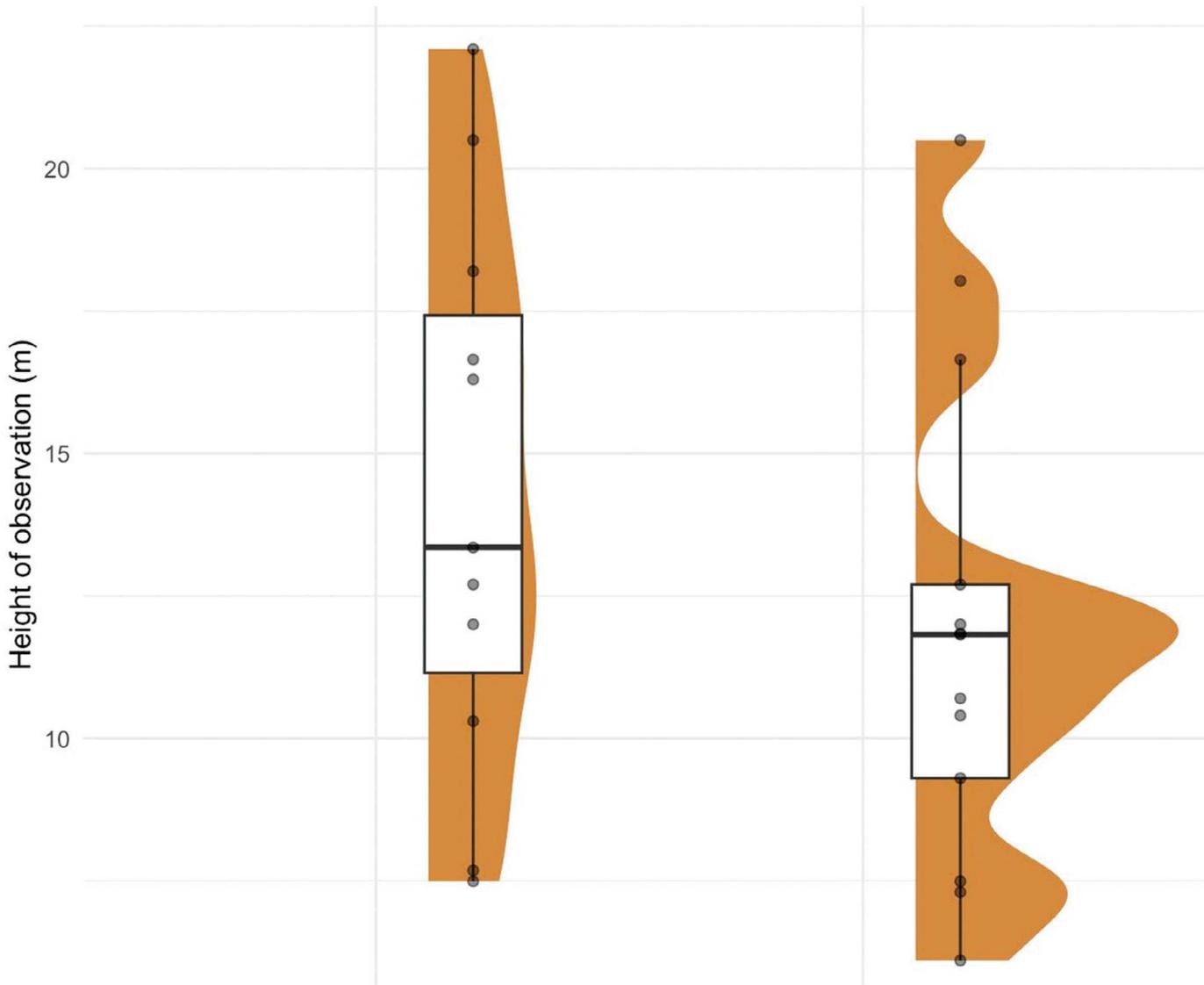
Figure 3. Comparison of height of observation for *S. aureogaster* and *S. deppei*. Orange half-violins show the density of height of observation, and the boxplots indicate the median and the Interquartile Range.

Table 1. Total number of records for each squirrel species in the LTTBS. N = total number of records, n = effective records, RAI = Relative Abundance Index with 24-hour exclusion criterion.

Species	N	n	RAI	Z1	RAI in Z1	Z2	RAI in Z2	Z3	RAI in Z3
S. aureogaster	278	166	3.23	143	2.78	21	0.41	2	0.04
S. deppei	316	182	3.54	50	0.97	15	0.29	117	2.27
Total	594	348	6.76	193	3.75	36	0.70	119	2.31

The camera height at which individuals were detected varied between species (Figure 3). Observations of *S. aureogaster* occurred at heights ranging from 7.49 to 22.1 m (mean = 14.29 m, SD = 4.88), while *S. deppei* was recorded at lower heights, ranging from 6.1 to 20.5 m (mean = 11.91 m, SD = 4.27). These differences suggest potential vertical stratification in habitat use between the two species.

Regarding seasonal variation, the rainy season yielded the highest number of records for *S. aureogaster*. In contrast, *S. deppei* showed only slight differences in detection rates between seasons (Table 2). However, paired t-tests revealed no statistically significant differences in the number of effective records between seasons for either species (*S. aureogaster*: $t = 1.321$, $P = 0.317$, and *S. deppei*: $t = 0.419$, $P = 0.715$ respectively).

Table 2. Total number of records for each squirrel species in the LTTBS among seasons. N: total number of records, n: effective records, RAI: Relative Abundance Index with 24-hour exclusion criterion.

Species	Rainy			Dry		
	N	n	RAI	N	n	RAI
S. aureogaster	177	92	1.79	101	74	1.44
S. deppei	159	93	1.81	157	89	1.73
Total	336	185	3.59	258	163	3.17

The Principal Component Analysis (PCA) revealed that the first principal component (Dim1) accounted for 77.9% of the total variance, while the second principal component (Dim2) explained an additional 18.6%, resulting in a cumulative explained variance of 96.5%. In
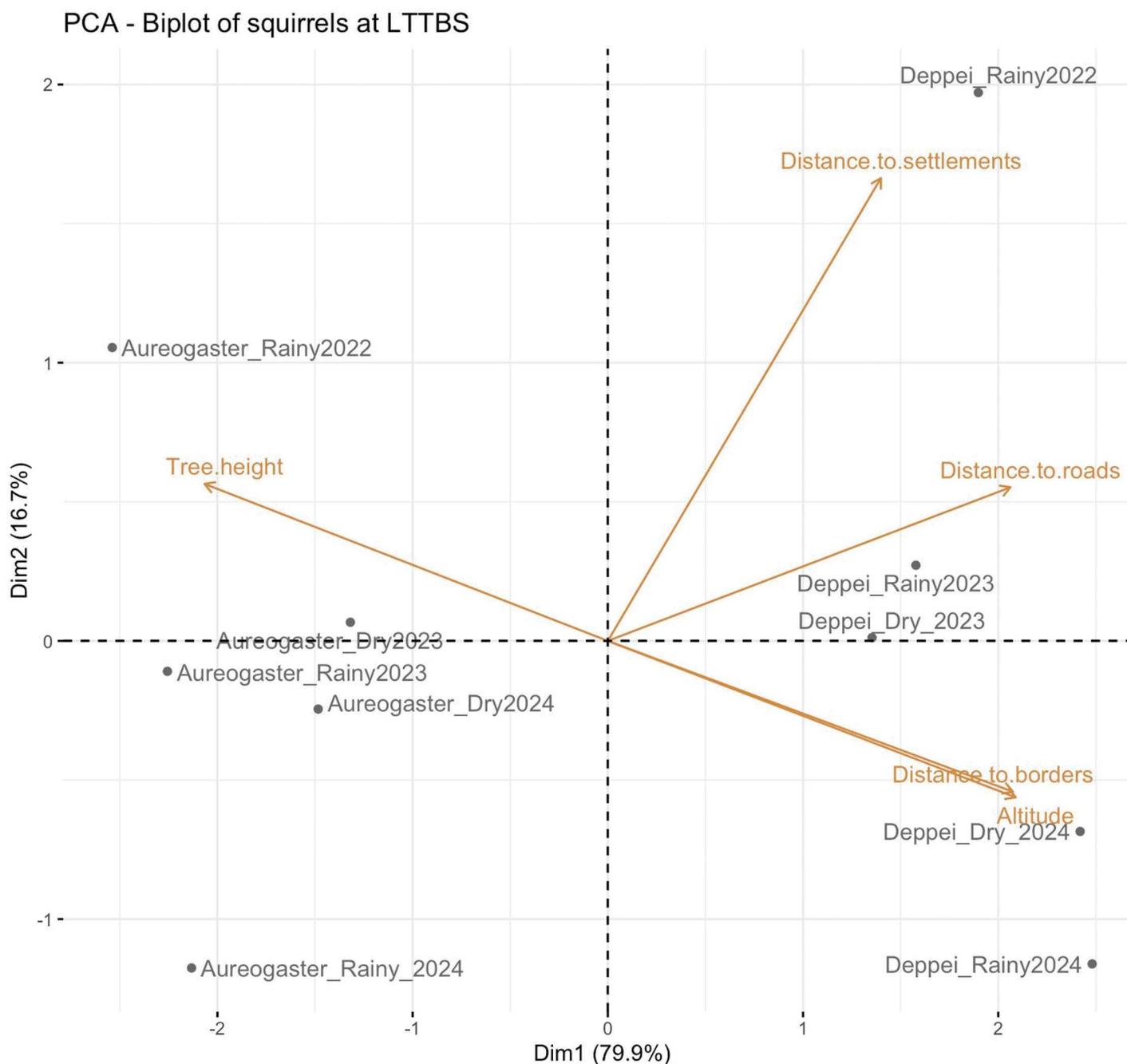
Figure 4. PCA - Biplot of the data of squirrels at the LTTBS and their relationship with spatial variables.

Dim1, all environmental variables showed significant correlations, however, distance to human settlements had a relatively low contribution to the variance of this component. In contrast, Dim2 was primarily influenced by distance to human settlements, which exhibited the highest contribution and was the only variable with a significant correlation in this dimension (Table 2). These results suggest that while most environmental variables are strongly associated along a shared gradient (Dim1), distance to human settlements may represent a distinct ecological axis influencing species presence independently.

Table 3. PCA associations between *S. aureogaster* and *S. deppei* occurrences and the spatial variables based on the R-square values and their corresponding p-value.

Variable	Dim1	p-value	Dim2	p-value
Distance to the nearest road	0.960	1.06 e-5	0.160	> 0.05
Distance to forest edge	0.918	1.76 e-4	-0.343	> 0.05
Distance to human settlements	0.714	2.02 e-2	0.688	0.02
Camera height	-0.917	1.85 e-4	0.360	> 0.05

The PCA biplot (Figure 4) revealed a species-specific segregation along Dim1, while Dim2 primarily reflected temporal variation in species associations with environmental variables. *S. aureogaster* was predominantly

located on the left side of the biplot, indicating a positive association with camera height. Conversely, it showed a negative relationship with distance to forest edges, distance to the nearest road, and distance to human settlements.

This spatial positioning suggests that *S. aureogaster* tends to occupy strata at higher heights and closer proximity to forest edges, being more associated with anthropogenically influenced zones. The temporal component represented by Dim2 may reflect seasonal shifts in habitat use or detectability patterns for both species. Thus, increased camera height was positively associated with the presence of *S. aureogaster* throughout the monitoring period, with this relationship being especially pronounced during the rainy season of 2022.

For *S. aureogaster*, an increase in both distance to human settlements and distance to the nearest road exhibited negative associations, indicating a tolerance for more disturbed habitats. These relationships varied across seasons since distance to the nearest road was more strongly associated with clusters from the dry season of 2023, rainy season of 2023, and dry season of 2024, while distance to human settlements showed a particularly strong negative association during the rainy season of 2024, suggesting increased tolerance to anthropogenic disturbance during this period (Figure 4).

In contrast, *S. deppei* demonstrated a positive relationship with all environmental variables except camera height, indicating a broader sensitivity or avoidance for more open or disturbed areas, as distance to human settlements was positively associated with *S. deppei* during the rainy season of 2022. Records showed that the increase in distance to an nearest road had a positive effect, especially during the rainy season of 2023 and the dry season of 2023. During both the dry and rainy seasons of 2024, *S. deppei* was positively associated with distance to forest edges, while camera height showed an inverse relationship, suggesting a preference for lower strata or ground-level activity.

Squirrel species are common and relatively frequent in the Los Tuxtlas Tropical Biological Station (LTTBS), as previously documented (Curiel *et al*. 1997a, b; Martínez-Gallardo *et al*. 1997). An earlier arboreal camera-trapping survey conducted by Rojas-Sánchez *et al*. (2025) identified *S. aureogaster* as the most frequently observed species (RAI = 2.11), surpassing *S. deppei* (RAI = 1.68). However, our expanded dataset, which includes an additional 10 months of sampling, reveals a shift in relative abundance: *S. deppei* was slightly more frequent than *S. aureogaster* (Table 1).

This shift suggests a rapid increase in detections of *S. deppei* relative to *S. aureogaster*, potentially reflecting changes in activity patterns, habitat use, or population dynamics. The notable rise in photo-capture rates of *S. deppei* in recent months underscores the dynamic nature of species interactions and habitat use within the LTTBS.

In squirrels, reproductive processes are influenced by both resource availability and body mass. However, the duration of resource availability appears to play a more critical role than the mere presence of resources (Hayssen 2008). This may partially explain the observed seasonal and temporal shifts in detection rates, particularly for *S. deppei*, which showed increased activity during periods associated with greater distance from forest edges and human disturbances.

For instance, we believe that year-to-year phenological variations in food availability within the LTTBS (Dunn *et al*. 2010) may help explain the observed differences in capture frequency between *S. aureogaster* and *S. deppei*. These fluctuations likely influence foraging behavior, movement patterns, and seasonal activity. To validate this hypothesis, future research should incorporate phenological monitoring of food resources from a seasonal perspective, enabling a more nuanced understanding of resource-driven dynamics.

Habitat use between these squirrel species was notably differential, even if both species were present in the three zones within the LTTBS. *S. aureogaster* exhibited greater occupancy of disturbed areas as in Z1 (Coates-Estrada and Estrada 1986; Koprowski *et al*. 2017; Curiel *et al*. 1997a, b). In contrast, *S. deppei* showed a stronger association with well-conserved habitats, particularly in the western region of the LTTBS (Best 1995; Figure 1). These patterns suggest that habitat specialization may play a role in the coexistence of closely related species.

The ongoing forest fragmentation and landscape transformation at the LTTBS likely create environmental gradients that influence species occupancy and detection rates (Table 1). Previous studies have reported that human-induced habitat fragmentation can increase the abundance of certain vertebrates, including both ground-dwelling and arboreal mammals (Estrada *et al*. 1984; Rojas-Sánchez *et al*. 2025). While such changes may reflect habitat degradation, they also offer valuable ecological insights that could provide important information for restoration and management strategies.

Importantly, our findings suggest that *S. aureogaster* and *S. deppei* may serve as potential indicators of habitat quality in human-modified landscapes. Their contrasting habitat uses and responses to environmental variables highlight their utility in assessing ecosystem health and directing conservation efforts in tropical forest regions.

Significant correlations between anthropogenic variables —including distance to forest edges, distance to the nearest road, and distance to human settlements— further reinforce the patterns observed in habitat use and species distribution (Table 3; Figure 4). *S. aureogaster* exhibited positive associations with proximity to these features, aligning with its synanthropic tendencies and documented adaptability to human-modified environments (Hortelano-Moncada *et al*. 2009; Koprowski *et al*. 2017). This species' ability to exploit disturbed habitats may contribute to its persistence in fragmented landscapes.

In contrast, increases in the distance to human disturbance variables such as forest edges, roads and settlements, showed a negative association with *S. aureogaster* and a positive association with *S. deppei*. This pattern likely reflects the habitat heterogeneity of the LTTBS, driven by human disturbance, where the most well-conserved forest patches are located at the western portion. Thus, these variables may act as *proxies* for habitat quality rather than a direct ecological driver, with *S. deppei* favoring these more pristine areas.

Despite the positive relationship observed between *S. deppei* and areas with a higher proportion of forest cover, a landscape-scale analysis by Cudney-Valenzuela *et al.* (2021) reported a negative association between this species and patch size. This apparent contradiction highlights the complexity of habitat selection and suggests that *S. deppei* may favor smaller, well-connected patches or specific structural features within forested landscapes rather than large, continuous blocks at landscape scale.

To better understand these ecological patterns, an expanded spatial scope within the Los Tuxtlas region is essential. Increasing the range of the study area would allow for a more representative assessment of habitat use and distribution for both species of squirrels, and would enable more robust comparisons with findings from other studies. Such integration is critical for refining conservation strategies and understanding species responses to landscape heterogeneity at multiple scales.

On the other hand, camera height may be considered a non-anthropogenic variable that significantly influences detection, particularly for *S. aureogaster*, a strictly arboreal species (Koprowski *et al.* 2017). In contrast, *S. deppei* frequently descends to the ground for foraging activities (Coates-Estrada and Estrada 1986; Flores-Martínez *et al.* 2014, 2022), suggesting a spatial segregation that reflects differential vertical space use (Best 1995). Although *S. deppei* was recorded with high frequency relative to Rojas-Sánchez *et al.* (2025), higher Relative Abundance Index (RAI) values were consistently observed at ground level (Flores-Martínez *et al.* 2022), indicating that this species, at least within the LTTBS, exhibits a strong affinity for the understory.

For squirrel species, vertical stratification is a key factor driving niche segregation. Our findings align with patterns of vertical space differentiation reported among sympatric squirrel genera in tropical Malaysian forests (Abdullah *et al.* 2001). However, in pine-oak forests of Mexico, sympatric sciurids such as *S. aureogaster* and *S. oculatus* do not exhibit such vertical segregation (Ramos-Lara and López-González 2017), suggesting that forest type plays a critical role in shaping vertical space use and interspecific interactions.

The lack of significant seasonal variation in records for both squirrel species suggests that seasonality exerts relatively weak influence on their capture frequency within the LTTBS. However, results from the Principal Component Analysis (PCA) revealed a gradual variation in the relationships between squirrels and environmental metrics, underscoring the dynamic nature of habitat requirements (Figure 4). To better understand these patterns, the incorporation of microclimatic data is essential, as abiotic climate-related variables—particularly those differing between canopy and ground-level strata—may play a more nuanced role in shaping ecological responses (Vinod *et al.* 2023).

Arboreal camera trapping, as employed in our study, has proven to be an effective tool for investigating ecological aspects of canopy-dwelling species (Moore *et al.* 2021). The ecological responses of squirrels are influenced by multiple dimensions of environmental variation, which interact with morphological, behavioral, and species-specific resource requirements (Edwards *et al.* 1998). These responses are temporally dynamic, occurring across daily cycles (Sovie *et al.* 2019), as well as seasonal and annual intervals, as suggested by our findings. Although seasonal differences may not be evident in metrics such as frequency, they may still affect environmental preferences and resource availability. When considered alongside niche partitioning, these subtle shifts could contribute to resource fluctuations that facilitate coexistence between sympatric squirrel species (Edwards *et al.* 1998).

Temporal multi-scale studies, particularly those involving long-term monitoring, are essential for deepening our understanding of coexistence dynamics among closely related species. Such approaches can help elucidate the environmental drivers behind various ecological patterns such as activity rhythms (Sovie *et al.* 2019) and are critical for documenting the impacts of climate change and human-induced habitat alterations on arboreal and forest-dwelling mammal species. Integrating these insights can significantly enhance the characterization of squirrels as potential indicator species, offering valuable tools for ecosystem monitoring and conservation planning (Halme *et al.* 2009).

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First photographic record of *Puma concolor* L. (Carnivora: Felidae) in Celaque Mountain National Park, Lempira, Honduras

Primer registro fotográfico de *Puma concolor* L. (Carnívora: Felidae) en Parque Nacional Montaña de Celaque, Lempira, Honduras

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The cougar, also known as mountain lion (*Puma concolor*, Linnaeus 1771), is one of the largest wild felines inhabiting the American continent. In Honduras, this species has been recorded in seven departments, according to various sources; however, its presence in Montaña de Celaque National Park had not been documented. The objective of this study was to confirm the presence of cougars in the core zone of the park using photographic records. Camera traps were used in the cloud forest of the core area of Montaña de Celaque National Park, municipality of San Manuel de Colohete, Lempira. Camera traps were installed at 2,414 m and operated for a period of 492 nights/camera; the captured images were analyzed to confirm the species based on morphological traits. Records of *P. concolor* were obtained in six photo captures. The photographic evidence confirms the presence of this species in the protected area. These records suggest a pattern of diurnal activity. The photographic record of *P. concolor* in the PNMC supports its presence in conserved cloud forests. The species, listed as Endangered in Honduras, is an important ecological indicator. Conserving its habitat is essential, as well as implementing continuous monitoring programs in protected areas. The confirmed presence of cougars in the PNMC reinforces the relevance of this protected area as a refuge for key fauna. This finding reinforces the need to strengthen conservation and surveillance actions in the park, with particular focus on prioritizing large carnivores as flagship species for the protection of ecosystems.

Keywords: biological corridor; Celaque; Honduras; Lempira; mammal; camera traps**.**

El puma o león de montaña (*Puma concolor,* Linnaeus 1771) es uno de los felinos silvestres de mayor tamaño que habitan en el continente americano. En Honduras esta especie se ha registrado en siete departamentos del país de acuerdo con diversas fuentes, pero su presencia en el Parque Nacional Montaña de Celaque no había sido documentada debidamente. Esta investigación tuvo como objetivo confirmar su presencia en la zona núcleo del parque mediante registros fotográficos. Se utilizaron cámaras trampa en el bosque nuboso correspondiente al área núcleo del parque, municipio de San Manuel de Colohete, Lempira. Las cámaras trampa fueron colocadas a 2,414 msnm las que permanecieron activas durante un periodo de 492 noches/cámara, analizando las imágenes obtenidas para confirmar morfológicamente la especie registrada. Se obtuvieron 6 registros mediante foto capturas del *P. concolor* desde el 3 de julio de 2024. Las evidencias fotográficas confirman la presencia de esta especie en el parque. Dichos registros también sugieren un patrón de actividad diurna. El registro fotográfico de *P. concolor* en el Parque Nacional respalda su presencia en bosques nubosos conservados. La especie, categorizada como en peligro de extinción en Honduras, representa un importante indicador ecológico. La conservación de su hábitat es esencial, al igual que la implementación de programas de monitoreo continuo en zonas protegidas. La presencia del puma en el parque refuerza el valor de esta área como refugio de fauna clave. Este hallazgo impulsa la necesidad de reforzar acciones de conservación y vigilancia en el parque, priorizando a los grandes carnívoros como especies bandera para la protección del ecosistema

Palabras clave. Corredor biológico; Celaque; Honduras; Lempira; Mamífero; Trampas cámara.

The cougar (*Puma concolor*), also known as the mountain lion, is one of the largest mammals that is widely distributed in the American continent, from southern Canada to southern Chile and Argentina (Haag *et al.* 2009; Barceló *et al.* 2025), in an altitudinal range from sea level to more than 5800 meters (Currier 1983). The cougar is potentially distributed in 40 % of the Honduran territory (Portillo and Elvir 2022); however, it should be noted that the distribution of this feline in Honduras has not been determined with certainty. *Puma concolor* thrives in various habitats, including different types of forests, lowlands, and mountainous deserts. Although several studies indicate
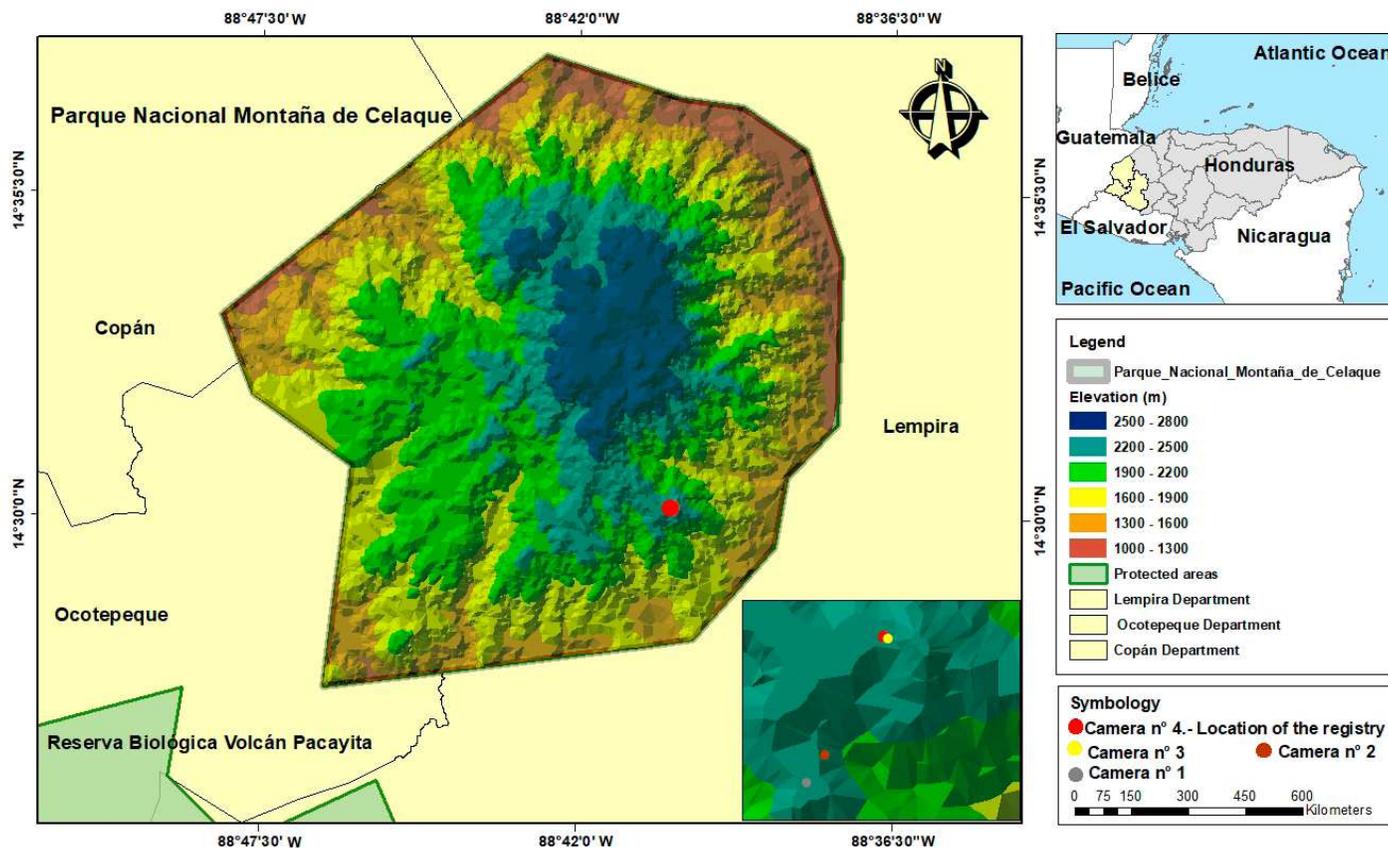
Figure 1. Location of the camera trap at the site where six photographs were captured, evidencing the presence of a cougar (*Puma concolor*).

that cougars prefer habitats with dense understory, they also inhabit open environments with sparse vegetation cover (Nowell and Jackson 1996). The size of the area occupied by this species varies significantly across regions, being smaller in places where prey density is high (Sunquist *et al.* 2002).

Cougars play a central role in the biodiversity and balance of ecosystems, as they support the conservation and preservation of these habitats. This species significantly contributes to the balance of ecosystems by controlling prey populations, including deer, rabbits, and wild boars. Cougars help prevent the spread of diseases among herbivores and promote forest health by keeping the populations of these prey species at adequate levels (Pérez and Santos 2016; Morenno and Flores 2024).

Cougar records within protected areas in Honduras correspond to the Caribbean, west, and Moskitia regions (Portillo and Elvir 2013). The species has been recorded in the Opalaca Biological Reserve (D. Espinoza pers. comm), which is the closest record to the Montaña de Celaque National Park. There are additional records in the Azul Meámbar National Park (Midence 2019), the Misoco Biological Reserve (Alvarado *et al.* 2024), the Río Plátano Biosphere Reserve (Gonthier and Castañeda 2013), four localities of the La Unión corridor (Guinope, Oropolí, and Yuscarán): La Tigra National Park, Francisco Morazán, in the municipality of Aguanqueterique, La Paz, Honduras (Portillo

and Elvir 2022), and the area of El Jilguero Biological Reserve (Sánchez *et al.* 2023).

The ability of cougars to adapt and coexist in areas with human presence makes them extremely vulnerable because they are surrounded by areas constantly modified by humans (Portillo and Elvir 2022). In Honduras, there is limited available information on the cougar. In the department of Lempira, and particularly in the Montaña de Celaque National Park, cougar records are scarce; consequently, there is a lack of knowledge about its distribution, abundance, and local threats. The Montaña de Celaque National Park is part of a mountainous complex of great ecological relevance, belonging to the Lempira Biological Corridor, which connects five protected areas in western Honduras, the study area: the Montaña de Puca Wildlife Refuge, the Pacayita Volcano Biological Reserve, the Opalaca Biological Reserve, and the Montaña Verde Wildlife Refuge. This biological corridor facilitates the connectivity of feline populations and their prey, making it a priority to generate information on the distribution of cougars within the area (UICN *et al.* 2021).

The main objective of the study was to document the presence of *P. concolor* in Cerro Guatemalía and Cerro de La Cruz, located within the jurisdiction of the municipality of San Manuel de Colohete, Lempira, in the core zone of the Montaña de Celaque National Park, Honduras.

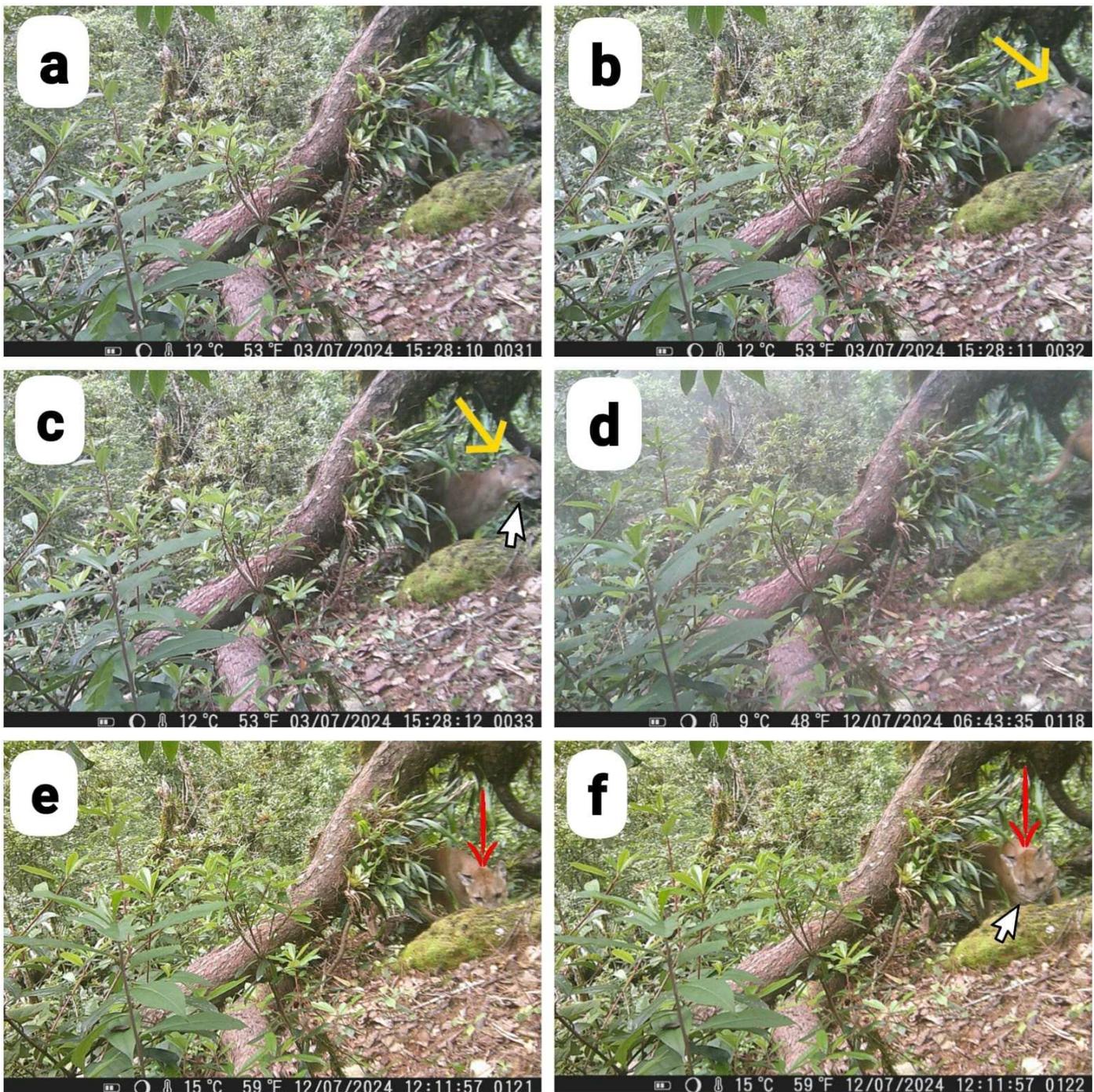The study area is situated within the core zone of

Figure 2. Records of *Puma concolor* showing that the same individual was captured in (a, b, c). (d) A partial image of one individual was recorded at 06:43 hrs., so it was impossible to confirm that it was the same individual recorded on the day at 12:11 hr. This individual shows coinciding traits (e and f) (yellow and red arrows); the records captured on 3 July and 12 July share similar characteristics, allowing us to infer that both correspond to the same individual.

the Montaña de Celaque National Park (PNMC), in the southwestern region of Honduras (14°32′08″N; 88°42′26″W). The protected area encompasses an extension of 26 378.42 ha across 5 municipalities within the departments of Ocotepeque, Copán, and Lempira (Figure 1). This region has been recognized for its high biodiversity since its creation in 1987 (ICF 2016). According to the 2016–2027 management plan, the vegetation cover in the park comprises seasonal evergreen tropical forest, lower montane evergreen tropical forest, upper and lower montane evergreen tropical forests,

mixed highland evergreen tropical forest, and agricultural systems (ICF and MAPANCE, 2016). The PNMC is home to rich biodiversity, with 67 species of continental mammals (Marineros and Martínez Gallegos 1998). Some studies have reported the presence of 18 species of flying mammals (bats) and 50 species of terrestrial mammals; 200 species of birds, 60 of them migratory; 27 species of amphibians and 45 species of reptiles; and unique ecosystems that are part of the habitat of multiple species of wildlife, which have become its main conservation targets (MAPANCE 2016).

As part of the study to determine the presence of *P. concolor* in the park, four camera traps (property of MAPANCE) were installed for a fourth-month period from 24 April to 24 August 2024. Two types of equipment were used: Moultrie camera model M999i 20MP with wireless connectivity, and SuntekCam camera model MINI 301, a mini camera for hunting tracking. These cameras were code-labeled to keep control of the stations; additionally, the geographical coordinates of each station were recorded. The cameras were distributed according to the area to be monitored and the topography of the terrain, leaving 0.5 to 1 km between them. The installation sites were selected based on the knowledge of the accompanying personnel who were familiar with the zone, and on indirect evidence, such as accounts from local inhabitants. Each camera trap was set to capture three images with a five-second interval between shots with a high-sensitivity motion sensor. The traps were installed on tree trunks at a height between 35 and 80 cm above the ground, depending on the topography, oriented to cover potential cougar transit routes.

The camera traps were in operation 24 hours a day throughout the study. For each capture, the camera recorded the percentage of battery or energy, temperature, and capture date and time. Camera traps were reviewed once a month.

In the study period, the sampling effort was 492 trap days, capturing six photographs that showed the presence of the cougar (*P. concolor)* at Station 2, located in Cerro Guatemalía, The records were obtained in a cloud forest altitude coniferous (>2000 meters above sea level), which comprises mixed vegetation with a dense understory where the dominant trees are *Pinus pseudostrobus, Pinus hartwegii, Podocarpus oleifolius, Quercus cortesii,* and *Ocotea sp*. The records of the species were captured 71 days after the camera traps were installed.

The first images of *P. concolor* were recorded on 3 July 2024, consisting of three photographs captured at approximately the same time, a few seconds apart (Figure 2) at 15:28 hr at an altitude of 2,414 meters above sea level (14°30'11.41"N; 88°40'23.02"W) in the core area of the PNMC, belonging to the Cerro Guatemalía site. The second record, including two photographs, was captured on 12 July 2024 at 12:11 hr at the photo trapping station where the first record

was documented. The third record was obtained on 12 July 2024 at 6:43 hr. This same photo trapping station captured the presence of a raccoon, *Procyon lotor* ([Linnaeus 1758](#)), a potential prey, and a camera trap installed approximately 1 km from the site where *P. concolor* was recorded, captured images of two additional species: opossum, *Didelphis marsupialis* ([Linnaeus 1758](#)), and tepezcuintle, *Cuniculus paca* ([Linnaeus 1766](#)).

The cougar presented a mostly diurnal activity pattern along with a crepuscular activity pattern, as detailed in (Table 1).

The presence of cougar (*P. concolor*) in the Montaña de Celaque National Park represents a significant finding for the conservation of biodiversity in Honduras. This study provides the first photographic record of the cougar in the park, which is highly relevant because this species plays a crucial role in biodiversity conservation ([Naughton-Treves *et al.* 2005](#); [Pino-Del-Carpio *et al.* 2014](#)).

In Honduras, the presence of five wild felines has been reported: jaguar (*Panthera onca*), cougar (*P. concolor*), ocelot (*Leopardus pardalis*), margay (*Leopardus wiedii*), and jaguarundi (*Herpailurus yagouaroundi*). The cougar is considered the second-largest feline in Honduras, and its presence in 6 protected areas has been documented using camera traps ([Portillo and Elvir 2013](#)). Four of the five feline species reported for the country have been recorded in the Montaña de Celaque National Park, including the cougar, the ocelot, the margay, and the yaguarundi ([MAPANCE 2013](#)). However, information on their ecology and population status is still limited, underscoring the need to strengthen monitoring efforts.

The ecological niche-partitioning mechanisms that enable felines to coexist are essential for supporting conservation strategies. Given their quiet and elusive behavior, the use of camera traps has become a strategic non-invasive technique for studying these species ([Alberti *et al.* 2023](#)). This type of research enables the identification of patterns of activity and habitat occupancy, as well as the evaluation of spatial and temporal interactions between felines that coexist in the same ecosystem ([Reyes and Hernández 2011](#)).

The six records obtained in the PNMC, Honduras, indicate that this area offers suitable conditions for cougar

Table 1. Records of *Puma concolor* on Cerro Guatemalía, San Manuel de Colohete, Lempira –Montaña de Celaque National Park, Honduras.

Date	Time	Vegetation type	Geographic coordinates		Observed activity
			N Latitude	W Longitude	
3/7/2024	15:28 hrs.	Cloud forest	14°50'27.97"	88°67'27.45"	Prowling
3/7/2024	15:28 hrs.	Cloud forest	14°50'27.97"	88°67'27.45"	Prowling
3/7/2024	15:28 hrs.	Cloud forest	14°50'27.97"	88°67'27.45"	Prowling
12/7/2024	6:43 hrs.	Cloud forest	14°50'27.97"	88°67'27.45"	Part of one specimen was observed
12/7/2024	12:11 hrs.	Cloud forest	14°50'27.97"	88°67'27.45"	Prowling
12/7/2024	12:11 hrs.	Cloud forest	14°50'27.97"	88°67'27.45"	Prowling

survival, such as forest cover and access to prey in its areas of activity (Elbroch and Wittmer 2012).

The records reported here underscore the great conservation potential within the park and highlight the importance of systematic wildlife monitoring programs. Likewise, ecological connectivity is essential for ensuring the viability of populations of large felines such as the cougar, as it facilitates gene flow and access to resources across diverse ecosystems. Therefore, it is essential to maintain or improve the five biological corridors that exist today: Guajiquiro-Goldfinch, Anillo Verde, Trifinio-Fraternidad Joya de las Américas, Joya de Los Lagos, and Lempira Biological Corridor (SERNA 2024). The Montaña de Celaque National Park is part of the latter, aimed at facilitating the movement of species, especially of felines, which require large areas for displacement (Macdonald *et al.* 2010).

In this context, it is worth noting that the photographic records closest to the Montaña de Celaque National Park correspond to the Opalaca Biological Reserve (D. Espinoza pers. comm), an area that is also part of the Lempira Biological Corridor. These significant findings confirm the functional connectivity between Celaque and other areas in western Honduras.

Since its creation in 1987, the PNMC has implemented various conservation actions, including the delimitation of core and buffer zones, regulation of extractive activities, and promotion of community environmental education programs (ICF 2016). In addition, local organizations such as MAPANCE have developed forest restoration and wildlife monitoring projects that utilize camera traps, thereby strengthening the knowledge of biodiversity in the park (MAPANCE 2013). These actions have contributed to reinforcing the Lempira Biological Corridor. However, a long-term systematic monitoring program is still needed to assess population trends and threats to this species.

The records of cougars in the park underscore the importance of strengthening conservation actions aimed at maintaining biological corridors, habitat management, and mitigating threats such as poaching and forest wildfires. Camera traps have proven to be an indispensable tool for research and monitoring felines, providing crucial information to support management decision-making and public policies. Ensuring connectivity and protecting suitable habitats will be key to ensuring the persistence of these top predators in western Honduras.

Acknowledgements.

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Failed predation attempt by a Northern raccoon, *Procyon lotor*, on a green iguana, *Iguana iguana*

Intento fallido de depredación por parte de un mapache, *Procyon lotor*, sobre una iguana verde, *Iguana iguana*

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The Northern raccoon, *Procyon lotor*, is distributed from southern Canada to Panama. It occupies a wide range of habitats, including temperate forests, tropical rainforests, dry forests, and disturbed areas, often associated with aquatic environments. The species has also successfully adapted to urban settings. Raccoons are among the most omnivorous mammals known, taking advantage of seasonally abundant food sources. During a guided tour with tourists, we observed a predation attempt by a Northern raccoon on a green Iguana, *Iguana iguana*, in the Playa Blanca sector of Cahuita National Park, Limón, Costa Rica. This area is part of a well-preserved tropical forest on the Caribbean coast of Costa Rica. The Life Zone is classified as Tropical Moist Forest. On January 7, 2025, at 10:00 hr, we observed a Northern raccoon lunging at a green iguana and biting it on the nape. For approximately 10 secs, the raccoon attempted to subdue the iguana, trying to drag it into the forest. Two seconds later, the iguana broke free and slowly walked toward the edge of the forest and the beach. Raccoons have been reported to prey on mammals up to hare size, but no record exists of them attacking or attempting to prey on animals as large as a green Iguana. However, they are known to prey on turtles reaching 50 cm and 15 kg. This demonstrates that raccoons are capable of preying on relatively large reptiles and mammals.

Key words: Cahuita National Park; Costa Rica; mammals; omnivorous; reptiles; urban adaptation

El mapache, *Procyon lotor*, se distribuye desde el sur de Canadá hasta Panamá. Ocupa una amplia variedad de hábitats, incluidos bosques húmedos y lluviosos, bosques secos y áreas perturbadas, a menudo asociadas con ambientes acuáticos. La especie también se ha adaptado exitosamente a entornos urbanos. Los mapaches son uno de los mamíferos más omnívoros conocidos y aprovecha fuentes de alimento disponibles estacionalmente. Durante una visita guiada con turistas, observamos un intento de depredación por parte de un mapache sobre una iguana verde, *Iguana iguana*, en el sector de Playa Blanca, Parque Nacional Cahuita, Limón, Costa Rica. Esta área forma parte de un bosque tropical bien conservado en la costa caribeña de Costa Rica. La zona de vida se clasifica como Bosque Húmedo Tropical. El 7 de enero de 2025, a las 10:00 hr, observamos a un mapache lanzarse sobre una iguana verde y morderla en la nuca. Durante aproximadamente 10 segundos, el mapache intentó someter a la iguana y arrastrarla hacia el bosque. Dos segundos después, la iguana logró liberarse y caminó lentamente hacia el borde del bosque y la playa. Se sabe que el mapache depreda mamíferos de hasta el tamaño de liebres, pero no existen registros de ataques o intentos de depredación sobre animales tan grandes como una iguana verde. Sin embargo, se ha reportado mapaches que depredan tortugas de hasta 50 cm y 15 kg. Esto demuestra que los mapaches son capaces de depredar reptiles y mamíferos relativamente grandes.

Palabras clave: adaptación urbana; Costa Rica; mamíferos; omnívoro; Parque Nacional Cahuita; Reptiles.

The Northern raccoon, *Procyon lotor* (Linnaeus 1758), is widely distributed from southern Canada to Panama and occurs at elevations ranging from 0 to 2,800 m (Reid 2009). It has been introduced to several other countries (Stope 2023). In Costa Rica, the Northern raccoon is primarily found in lowland and mid-elevation areas (Mora 2000). It occupies a wide range of habitats, including tropical rainforests (humid and rainy forests), dry forests, and disturbed areas, often associated with aquatic environments (Kays 2009). The species has also successfully adapted to urban settings (Mora 2000).

Raccoons are medium-sized mammals characterized by their distinctive black facial masks and ringed tails (Kays 2009). Their body length ranges from 440 to 620 mm, with a tail length of 190 to 360 mm, and they weigh between 2.7 and 10.4 kg (Kays 2009). This variation in size is largely
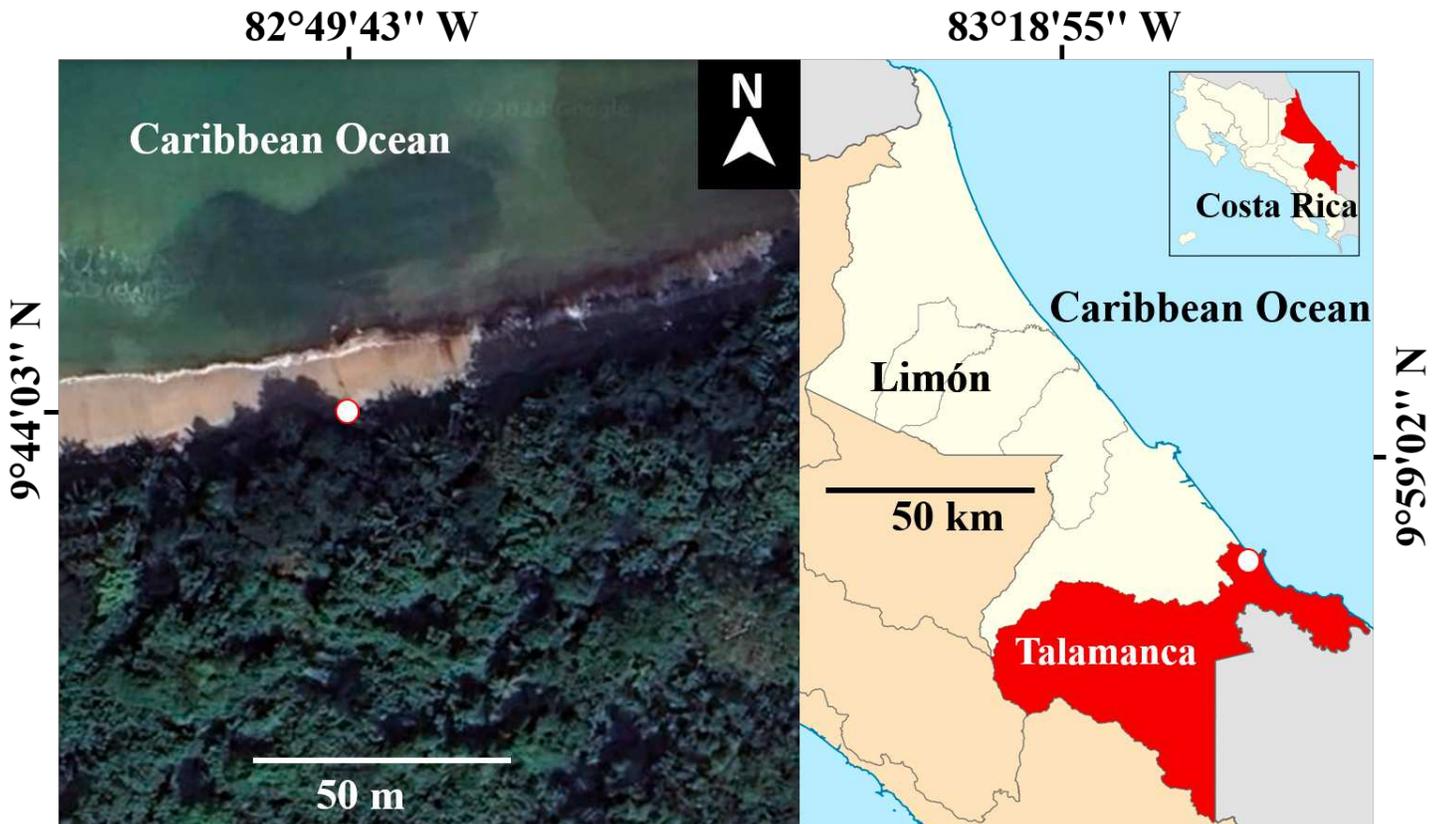
Figure 1. Location (white dot) where a Northern raccoon, *Procyon lotor*, attempted to prey on a green iguana, *Iguana iguana*, near the forest edge adjacent to Blanca Beach, Cahuita National Park, in Talamanca County (highlighted in red on the map to the right), Limón Province (outlined in white and shown in red on the map of Costa Rica). The figure was prepared by the author using Google Earth (left section) and Wikipedia under the Creative Commons Attribution-ShareAlike 3.0 license (right section).

attributed to their extensive geographic distribution (Helgen and Wilson 2005; Kays 2009).

The raccoon is among the most omnivorous mammals known (Kays 2009; Valenzuela 2014), taking advantage of seasonally abundant food sources (Gerht *et al.* 2002). The raccoon's diet is well documented especially in native North America (Gerht 2003). Its diet includes a wide variety of plant materials, such as fruits, nuts, and grains, which constitute most of its year-round diet (Kays 2009). It also consumes a diverse array of invertebrates, including insects and their larvae, terrestrial crabs, crayfish, and occasionally annelids and mollusks (Valenzuela 2014). Aquatic invertebrates, particularly crabs and crayfish, form a significant part of its diet when near water sources, where it also captures fish (Kays 2009). Occasionally, raccoons prey on frogs, lizards, and other small terrestrial vertebrates, though these make up a smaller portion of their diet compared to invertebrates (Kays 2009).

Additionally, raccoons feed on small birds, turtles, mice, squirrels, rabbits, and hares (McAlpine 2011; Valenzuela 2014). They are also known to feed on bats of several genera, such as *Myotis* in Canada and Indiana, USA (Munson and Keith 1984; McAlpine *et al.* 2011), and *Tadarida* in Texas, USA (Winkler and Adams 1972), all of which are relatively small. With its keen sense of smell, the raccoon locates and consumes eggs and nestlings of birds, as well as eggs of

turtles, iguanas, and ground-nesting birds (Kays 2009). It also scavenges carcasses of large animals, such as deer, cows, and horses (Valenzuela 2014).

The raccoon is a terrestrial and arboreal species that is primarily nocturnal and generally solitary or found in family groups (Reid and Gómez Zamora 2022). However, individuals may gather in areas with abundant food resources (Kays 2009). Occasionally, raccoons may become active during the day to exploit specific food opportunities, such as foraging during low tide (Kays 2009). In Manuel Antonio National Park on Costa Rica's Pacific coast, raccoons have adapted their activity patterns to align with visitor hours and days, taking advantage of the increased availability of food provided by human presence (Carrillo and Vaughan 1993).

The green iguana, *Iguana iguana* (Linnaeus 1758), is the largest lizard species native to Central America. Adult males can reach a total length of up to 2,010 mm (with a standard length of 250–580 mm) and weigh as much as 4 kg (Savage 2002). Females are generally smaller, growing to about 1,440 mm in total length (236–411 mm standard length) and weighing up to 2.9 kg (Savage 2002). This species is easily recognized by its prominent crest of comb-like spines running along the neck, back, and tail, as well as by a large, smooth scale located near the rear margin of the head below the ear opening on the throat (Savage

Figure 2. A Northern raccoon, *Procyon lotor*, attempting to subdue an adult male green iguana, *Iguana iguana*, near the forest edge adjacent to Blanca Beach, Cahuita National Park, Limón Province, Costa Rica.

2002). Adults are typically green—like the juveniles—and often exhibit dark wavy crossbands across the back, bluish shoulder streaks, black abdominal stripes, and dark rings on the tail (Savage 2002). Exceptionally large males may appear uniformly gray, gold, or tan, and during the breeding season, they often develop striking reddish-orange or golden hues along the back (Savage 2002).

During a guided tour with tourists in Cahuita National Park, we observed a predation attempt by a Northern raccoon on a green iguana. The observation took place in the Playa Blanca sector of the park, located in Limón Province, Costa Rica (9° 44′ 03″ N, 82° 49′ 43″ W, 7 m; Figure 1). This area is part of a well-preserved tropical forest on the Caribbean coast of Costa Rica (Mora *et al.* 2020). The Life Zone, according to Holdridge's system (Holdridge 1967), is classified as a Tropical Moist Forest. Precipitation in this life zone ranges from 1,800 to 4,000 mm annually, with consistently high temperatures and a dry period lasting from 0 to 2 months (Hartshorn 1983). The forest is evergreen and

characterized by very high density and typically comprises 4 to 5 distinct strata (Bolaños *et al.* 2025). The understory is abundant and predominantly composed of evergreen species. The average canopy height ranges between 30 and 40 m, with emergent trees reaching heights of 40 to 50 m (Hartshorn 1983). These canopy trees have wide and elevated crowns, remaining unbranched for the first 25 to 35 m. Their diameters at breast height (DBH) are generally less than 100 cm, and they feature tall, slender, and smooth buttresses (Bolaños *et al.* 2025).

On January 7, 2025, at 10:00 hr we observed a male green iguana standing in the middle of a trail as several tourists passed by. The tourists paused to watch, with some taking photographs. The iguana displayed its uniform gold to red-orange coloration, typical of adult males during the breeding season (Savage 2002). Only 6 s later, a Northern raccoon lunged at the iguana, biting it on the nape in a manner resembling the hunting behavior of felid carnivores. Upon noticing the approaching raccoon, the iguana raised

its body but did not flee.

For approximately 10 s, the raccoon attempted to subdue the iguana, trying to drag it into the forest, where 3 additional raccoons were present, presumably 3 juveniles observing their mother's hunting behavior. The iguana resisted, struggling to escape toward the opposite side of the trail. At 18 s into the attack, one of the juvenile raccoons approached but retreated when the iguana rolled onto its side in an attempt to free itself. Throughout the encounter, the mother raccoon maintained its grip on the iguana's nape, occasionally readjusting its bite (Figure 2).

Two seconds later, the iguana broke free and slowly walked toward the edge of the forest and the beach. The raccoon retreated along the trail, while one of the juveniles followed the iguana at a distance of approximately 1 m, sniffing and observing it before returning to the group. The iguana appeared unharmed and exhibited normal behavior. It perched on a log, showing no visible injuries to its nape despite being held in the raccoon's jaws for several seconds. A video of the predation attempt can be viewed at the following link: https://www.instagram.com/reel/DEi8grzIF4h/?igsh=Y3QxZGN0dWk3azht.

A potential explanation for the observed predation attempt by a raccoon on a green iguana may involve the participation and behavioral development of juvenile individuals within the group. Juvenile raccoons often engage in social learning, acquiring essential foraging and hunting skills through the observation and imitation of conspecifics (Stanton *et al.* 2024). This process may be part of an extended learning period or "training", where younger raccoons experiment with different prey and strategies, even when the prey is larger or more challenging to subdue (Daniels *et al.* 2019; Stanton *et al.* 2024). Such behavior has been noted in other mammal species where juveniles mimic adults or engage in exploratory behavior that, while not always successful, is crucial for skill development (Thornton and Clutton-Brock 2011).

Another explanation could relate to resource scarcity or changes in local food availability. Raccoons are highly opportunistic and adaptable, and in areas where their usual food sources are reduced—whether due to seasonal variation or human impact—they may broaden their dietary niche and take greater risks in pursuing large or non-traditional prey (Daniels *et al.* 2019). Nutritional stress or competition for food can increase boldness and lead to novel predatory attempts (Prange *et al.* 2003; Bateman and Fleming 2012). This may be particularly relevant in disturbed or human-altered environments, where ecosystem balance and food availability fluctuate unpredictably.

Although raccoons have been reported to prey on mammals up to the size of a hare (Valenzuela 2014), there are few documented cases of attacks on larger vertebrates. Notably, a raccoon was observed preying on a juvenile green iguana in Florida, U.S.A., where the species was introduced (Smith *et al.* 2006). Just a month later, another raccoon attacked a large adult male green iguana in the same location, although the iguana managed to escape (Smith *et al.* 2006).

Raccoons have also been identified as predators of adult snapping turtles (*Chelydra serpentina* Linnaeus 1758), a species considered at risk in Canada (Karson *et al.* 2018). Adult snapping turtles can reach shell lengths of approximately 50 cm and weigh up to 15 kg (Campbell 1998), illustrating that raccoons are capable of preying on relatively large reptiles and mammals. Nevertheless, this represents the first documented case of an attempted, albeit unsuccessful, predation by a raccoon on a green iguana within its native range.

A male green iguana, such as the one observed during the raccoon attack in Cahuita National Park, can exceed 2 m in length (Savage 2002). This considerable size likely enabled the iguana to escape its attacker. Nevertheless, raccoons are clearly capable of preying on smaller iguanas, including females and especially juveniles. Other potential raccoon prey in Cahuita includes basilisks, such as the green basilisk, *Basiliscus plumifrons* (Cope 1875), and the brown basilisk, *Basiliscus basiliscus* Linnaeus, 1758, whose maximum male sizes are 900 mm and approximately 600 g, respectively (Savage 2002).

Both iguanas and basilisks are diurnal reptiles (Savage 2002), whereas raccoons are primarily nocturnal (Reid and Gómez Zamora 2022). However, raccoons have been observed shifting their activity patterns toward increased diurnal behavior (Carrillo and Vaughan 1993), potentially increasing the vulnerability of these lizards to predation. The Northern Raccoon is now one of the most frequently observed mammals along the trails of Cahuita National Park at any time of day. In such conditions, raccoons may compete with other predators in the area, including mammals and birds of prey. They are also well-known predators of both continental and marine turtle eggs and ground-nesting birds, particularly when raccoon populations are high (Erickson and Scudder 1947; Stancyk 1982; MacLaren 1992; Kauhala 1996; Rogers and Caro 1998; Engeman *et al.* 2002, 2005; Schmidt 2003; Beltrán-Beck *et al.* 2012; Munscher *et al.* 2012; Kudaktin 2019; Stope 2023). Understanding these dynamics is essential for interpreting raccoon behavior within broader ecological systems.

While it is unclear whether raccoons have been reported in human settlements near Cahuita, their potential presence could influence conservation efforts for vulnerable species. Rather than their feeding habits alone, it is the population density of raccoons that may have the most significant ecological impact, especially in sensitive environments like Cahuita National Park. High raccoon densities can intensify predation pressure on native fauna and disrupt predator-prey dynamics (Riley *et al.* 1998; Rosatte *et al.* 2000; Stope 2023). Consequently, management actions must be implemented to protect key species, with local community involvement playing a vital role in ensuring success.

In this context, it is essential to implement regular raccoon population surveys to detect increases in abundance. Where necessary, humane population control measures—such as live trapping and relocation or sterilization programs—should be carried out, particularly in ecologically sensitive areas. Reducing human-related food sources (e.g., unsecured trash, compost, pet food) that artificially sustain raccoon populations is also critical. Waste management should be improved within and around protected areas, including the installation of raccoon-proof bins. Additionally, educating local residents and visitors about the ecological impacts of feeding wildlife is vital. Promoting citizen science initiatives that engage communities in monitoring raccoon activity and reporting predation events can further strengthen conservation efforts.

This study highlights the need for greater attention to the ecological role of raccoons, particularly their predatory impact on vulnerable species such as the green iguana. Understanding raccoon behavior and population dynamics is essential for implementing effective conservation strategies to protect local biodiversity in Cahuita National Park.

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An unusual record of *Cuniculus paca* in the state of Michoacán, Western México

Un registro insólito de *Cuniculus paca* en el estado de Michoacán en el oeste de México

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This note reports on the camera-trapping recording of *Cuniculus paca* in the El Bejuco community in the municipality of Lázaro Cárdenas on the coast of Michoacán. This location is approximately 500 km from the nearest reported records. As part of the monitoring efforts associated with releasing a *Tamandua mexicana* specimen, four camera traps were set up on the Proyecto Maloca property in El Bejuco from March to May of 2024. We unexpectedly recorded the presence of a *Cuniculus paca* on nine different days; it appeared to be a juvenile. These records were concentrated in two of the four cameras set up at the site, which were 500 meters apart between 22:26 and 05:06 hr. Given the distance at which these records were obtained from the species' known distribution, we hypothesize that human intervention likely facilitated the arrival of this *C. paca* individual to the monitored area. However, it is necessary to monitor the presence of this species and enhance monitoring in regions where information on their mammal community is lacking.

Key words: caviomorphs; camera trapping; dispersal; distribution range; rodents.

El objetivo de esta nota es dar a conocer el registro, mediante fototrampeo, de un ejemplar de *Cuniculus paca* en la comunidad de El Bejuco, Municipio de Lázaro Cárdenas, en la costa del estado de Michoacán, ubicada a una distancia aproximada de 500 km de los registros más cercanos reportados. Como parte de las labores de seguimiento vinculadas con la liberación de una ejemplar de *Tamandua mexicana*, se colocaron cuatro cámaras trampa en el predio Proyecto Maloca en la localidad de El Bejuco, Municipio de Lázaro Cárdenas, durante marzo-mayo del 2024. De manera imprevista registramos la presencia, en 9 días distintos, de un individuo de la especie *Cuniculus paca*, aparentemente juvenil. Estos registros se concentraron en dos de las cuatro cámaras dispuestas en el sitio, que estaban separadas por 500 m. Los registros se obtuvieron entre las 22:26 y 05:06 horas. Dada la distancia a la que se obtuvieron estos registros de la distribución conocida de la especie consideramos que lo más probable es haya existido alguna intervención humana que haya facilitado la llegada de este individuo de *C. paca* a la zona bajo monitoreo. Sin embargo, se requiere darle seguimiento a la presencia de esta especie.

Palabras clave: ámbito de distribución; caviomorfos; dispersión; fototrampeo; roedores.

En los últimos años se ha alcanzado un gran avance en generar y sistematizar la información que permite describir los patrones de distribución de las especies animales con un nivel de detalle nunca visto (Oliver *et al.* 2021). Sin embargo, persisten importantes vacíos de información ya que aún hay regiones donde los muestreos de la fauna silvestre son escasos o nulos (Mendoza *et al.* 2022). En las décadas recientes, la extensión de las áreas de distribución de las especies se ha modificado drásticamente por el impacto humano (Ceballos *et al.* 2017; Pacifici *et al.* 2020). La tendencia más común es hacía la disminución, debido a la destrucción de su hábitat, la cacería o el desplazamiento por la competencia con especies no

nativas (Ceballos *et al.* 2017). Sin embargo, existen algunos casos en los que la extensión de las áreas de distribución geográfica de algunas especies aumenta debido a que se benefician de las modificaciones generadas por el cambio climático, las perturbaciones generadas por la actividad humana o porque son transportadas voluntaria o involuntariamente por los humanos (Pacifici *et al.* 2020). Por ejemplo, de manera reciente se ha documento una expansión del área de distribución del coyote (*Canis latrans*) en el continente americano, lo cual se ha asociado con la conversión de bosques a zonas de agricultura y la reducción en la abundancia de depredadores tope como lobos, pumas y jaguares (Hody y Kays 2018). Otro caso

Figura 1. Registro mediante fototrampeo de *Cuniculus paca* en la localidad de El Bejuco, Municipio de Lázaro Cárdenas, Michoacán.

donde la intervención humana ha sido más directa es de los perros (*Canis lupus familiaris*), que se han convertido en los carnívoros más abundantes en un gran número de áreas naturales protegidas del mundo (Doherty et al. 2017).

En esta nota científica damos a conocer un registro del roedor *Cuniculus paca* (Linnaeus 1766), a una distancia notable de su ámbito de distribución conocido en México. *Cuniculus paca* es uno de los roedores más grandes del mundo ya que puede alcanzar un peso corporal entre los 6 y 12 kg (Pérez 1992). En México, se le conoce con el nombre común de tepezcuintle o tuza real. Esta especie tiene una distribución que va del norte-centro de México, por la vertiente del Golfo, y sigue por Centroamérica hasta el sur del continente en Argentina (Emmons 2016). La distribución de *C. paca* está vinculada con la presencia de distintas variantes de bosque tropical, pero es capaz de utilizar una amplia gama de hábitats como los manglares y los bosques riparios (Pérez 1992; Figueroa-de-León et al. 2017). Se alimenta principalmente de frutos por lo que puede jugar un importante papel ecológico como depredador y dispersor de semillas (Camargo-Sanabia y Mendoza 2016). Es una presa de otras especies como felinos (Aranda y Sánchez-Cordero 1996) y, por otra parte, es pieza de cacería sumamente valorada por el sabor de su carne (Gallina *et al.* 2012). Está catalogada como "preocupación menor" (LC) por la Unión Internacional de la Conservación de la Naturaleza (Emmons 2016) y a nivel de México no se encuentra en alguna categoría de protección (SEMARNAT 2019).

Como parte de un plan para dar seguimiento a la liberación de un oso hormiguero (*Tamandua mexicana*), rescatado de un incendio forestal, se colocaron cuatro cámaras trampa en el predio Proyecto Maloca en la localidad de El Bejuco, Municipio de Lázaro Cárdenas, Michoacán. La localidad de El Bejuco se encuentra en la región denominada Sierra-Costa, perteneciente a la provincia fisiográfica Sierra Madre del Sur. Es una región muy accidentada con altitudes que van desde el nivel del mar hasta los 2600 m. El tipo de vegetación predominante es la selva baja y mediana caducifolia con distintos grados de perturbación antropogénica, principalmente por la actividad pecuaria. El clima en El Bejuco, de acuerdo con la clasificación de Köppen modificada por García (1998), es del tipo AW (w) que corresponde al cálido subhúmedo con lluvias en verano (Bautista *et al.* 2019). La temperatura promedio anual es mayor a los 26°C y la precipitación promedio anual es de 1,295.3 mm, las máximas precipitaciones se registran en el mes de agosto con cerca de 500 mm, mientras que las mínimas ocurren en los meses de febrero y abril pudiendo ser nula (Bautista *et al.* 2019).

Las cuatro cámaras trampa (Suntek, modelo HC-802A) que se utilizaron se configuraron para estar activas las 24 horas y tomar tres fotografías y un video de 10 s en cada activación. Se colocaron en la zona donde fue liberado el individuo de *T. mexicana*, fijadas en troncos de árboles a alturas entre 1.60 y 2 m ya que la especie focal es escansorial. Los sitios seleccionados presentaban pequeñas pozas de agua que se formaron de manera natural por la
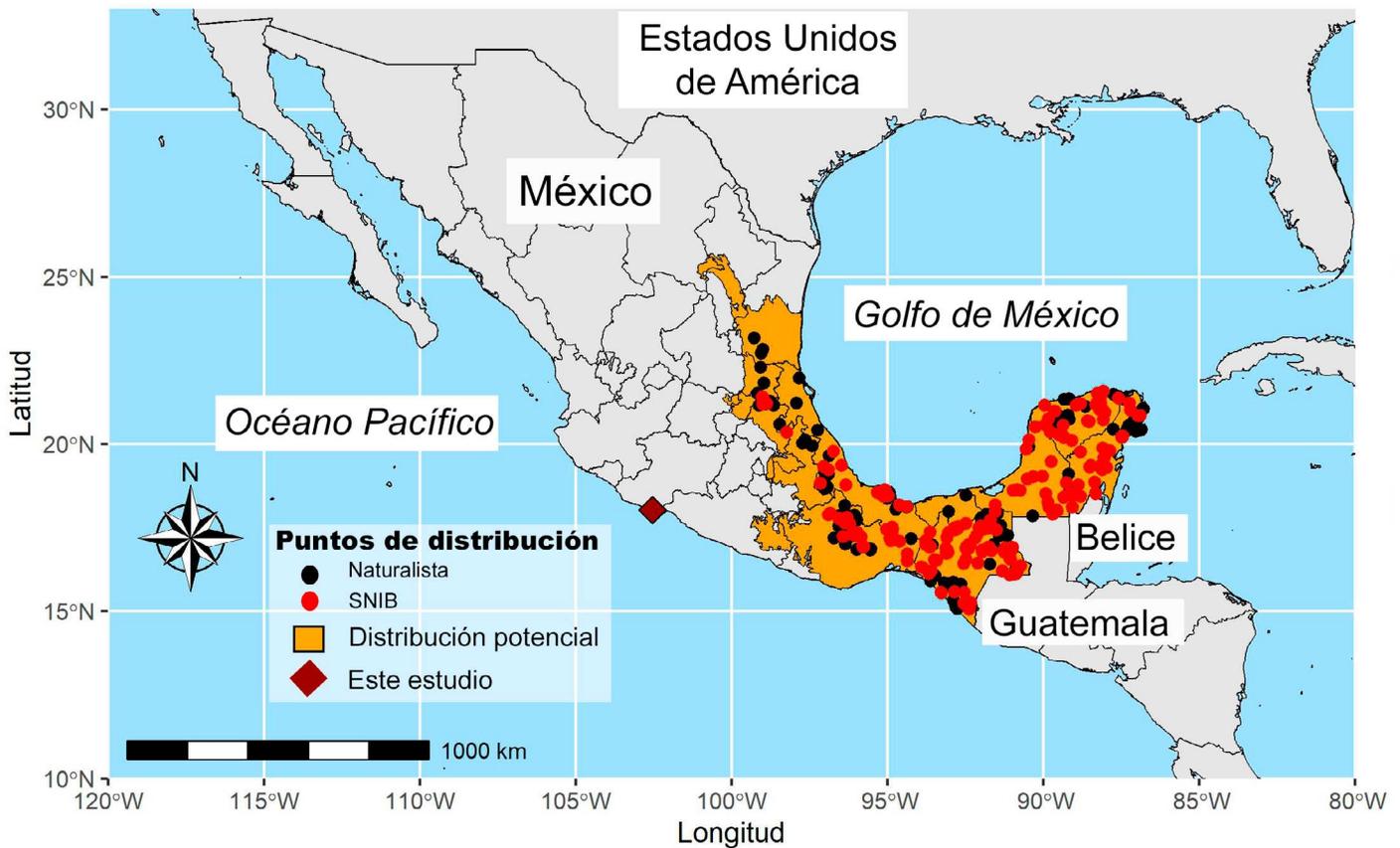
Figura 2. Registros de presencia de *Cuniculus paca* en México del Sistema Nacional de Información sobre Biodiversidad (SNIB) de la Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) e iNaturalisMx y distribución potencial para México (Sánchez- Cordero *et al.* 2020; https://enciclovida.mx/especies/34488-cuniculus-paca).

lluvia, lo cual se aprovechó estratégicamente por el posible acercamiento de la fauna.

El primer registró de la presencia de *C. paca* se obtuvo el 8 de marzo y el último el 20 de mayo del 2024, dentro de este periodo se registró a la especie en nueve días distintos (Figura 1). Los registros se obtuvieron entre las 22:26 y 05:07 horas, en total se obtuvieron 24 registros (fotos + vídeos). La ubicación geográfica en donde se obtuvieron estos registros es 18°2′3.35″ latitud norte y 102°31′46.76″ longitud oeste (Figura 2). La revisión de los registros permitió determinar que se trataba de un solo individuo, aparentemente juvenil. Estos registros se concentraron en dos de las cuatro cámaras dispuestas en el sitio, que estaban separadas 500 m.

En años recientes distintos estudios han permitido alcanzar un mayor grado de conocimiento de la distribución de *Cuniculus paca* en México. Por ejemplo, Botello *et al.* (2005) documentaron la presencia de *C. paca* en el norte del estado de Oaxaca, a 60 km al oeste del límite que se suponía tenía su distribución. A su vez, Jiménez-Maldonado y López González (2011) reportaron por primera vez la presencia de *C. paca* en el estado de Querétaro, lo que a su vez desplazó cerca de 34 km el límite de su distribución conocida. Rodríguez-Ruíz *et al.* (2012) confirmaron la presencia de la especie en los estados de Hidalgo y Tamaulipas, lo que permitió alcanzar una mejor definición de su límite de distribución norteño. Por su parte, el estudio de Ramírez-Bravo y Hernández-Santín

(2012) reveló que *C. paca* se distribuía ampliamente en el norte de Puebla. Más adelante, Padilla-Gómez *et al.* (2019) registraron a la especie en un área de Oaxaca en donde no se había reportado previamente pero que formaba parte del área de su distribución predicha por modelos de nicho ecológico. Dentro de este contexto el registro de *C. cuniculus* que reportamos resulta insólito porque se aleja cerca de 500 km de los registros más cercanos en el estado de Oaxaca, contenidos en las bases de datos del Sistema Nacional de Información sobre Biodiversidad (SNIB) de la Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) y de iNaturalisMx (https://enciclovida.mx/especies/34488-cuniculus-paca) (Figura 1).

Una primera posibilidad obvia es que el factor humano haya intervenido para que esta especie lograrán llegar a la localidad de El Bejuco. Existe la posibilidad de que el animal haya escapado después de haber sido transportado desde otra localidad para ser utilizado como mascota o con el fin de consumirlo, ya que su carne es sumamente apreciada. Se preguntó a algunos de los pobladores de la localidad, incluyendo cazadores, si reconocían a la especie o si sabían de alguien que la hubiera tenido en cautiverio. En todos los casos la respuesta fue negativa, no encontrándose evidencia de que alguien hubiera tenido al individuo en cautiverio en esta localidad, pero tampoco de su presencia previa en esta zona.

La otra posibilidad, que luce mucho más remota, es que el individuo registrado de *C. paca* se haya desplazado desde alguno de los estados que mantienen poblaciones naturales de la especie, como es el caso de Oaxaca. Existen casos documentados de mamíferos herbívoros con eventos de dispersión a distancias inusuales. Por ejemplo, Moll *et al.* (2021) documentaron el caso de un individuo adulto de venado cola blanca (*Odocoileus virginianus*) que se desplazó 300 km en el centro de los Estado Unidos en un lapso de 22 días. Este desplazamiento inusual sucedió durante la temporada de cacería y requirió que el venado cruzara un río caudaloso siete veces, así como varias carreteras y autopistas. Conforme se da una mayor perturbación de los hábitats naturales por la deforestación, cacería y los impactos del cambio climático la presión para dispersarse para encontrar los recursos necesarios para la subsistencia (p.ej., alimento y refugio) es mayor (Abrahms 2021). El estado de Michoacán cuenta con importantes antecedentes históricos en términos del conocimiento de su mastofauna, sin embargo, persisten regiones como la Costa donde son aún son escasos los estudios de fototrampeo (Monterrubio *et al.* 2014). Una situación similar sucede en el vecino estado de Guerrero, que sería una posible ruta de dispersión de la especie (Ramírez-Pulido *et al.* 1977; Ruiz-Gutiérrez *et al.* 2020). El contar con una cobertura geográfica mayor y más actualizada de la presencia de especies de la fauna silvestre—con métodos como el fototrampeo—en estas regiones del país sería de gran utilidad para evaluar con mayor certeza las posibilidades de que sucediera un evento de desplazamiento de la magnitud que se requeriría para que *C. paca* llegara de manera natural a la localidad de El Bejuco.

Hasta no tener más información disponible, la posibilidad que luce más plausible es que la llegada del individuo de *C. paca* registrado en la comunidad de El Bejuco haya sido facilitada por la intervención humana. No obstante, este registro, hace surgir reflexiones interesantes. Por una parte, subraya la necesidad de contar con una red amplia de monitoreo de la fauna silvestre, a nivel nacional, que incluya zonas poco estudiada como la Costa de Michoacán de manera que se pueda contar con información actualizada sobre los cambios en la distribución y abundancia de especies de la fauna silvestre nativa y sobre la presencia de especies foráneas (Steenweg *et al.* 2017). Por otra parte, resulta también de gran importancia el fortalecer las regulaciones encaminadas a controlar la extracción ilegal de fauna silvestre, comercio y tenencia no reglamentada con el fin de evitar eventos de liberación accidental. Es importante, hacer el esfuerzo para mantener el fototrampeo en este sitio con el fin de monitorear el destino de este organismo. Por otra parte, sería importante, evaluar la posibilidad de capturarlo para determinar su estado de salud y tomar muestras para realizar análisis genéticos que permitieran trazar su población de origen (Ogden y Linacre 2015).

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Noteworthy records of the kinkajou (*Potos flavus*) extend its northernmost Pacific slope distribution

Registros notables de martucha (*Potos flavus*), que extienden su distribución más al norte en la vertiente del Pacífico

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The kinkajou (*Potos flavus*) is a nocturnal arboreal carnivore, well adapted to forest canopies through its prehensile tail and flexible joints. Its distribution and ecology along the Mexican Pacific slope remain poorly understood due to its cryptic behavior. This study aims to define the species' geographic range in this region more precisely. We reviewed all historical and recent records from scientific collections, digital platforms, and literature. Recent records were obtained through camera trap monitoring. Spatial data were analyzed using GIS to determine distribution by ecoregion and municipality. Records were categorized as historical (before 2000), contemporary (2001-2020), and recent (2021-2024), each included coordinates, habitat, and behavioral observations when available. The records confirm the species' presence along northwestern Michoacán, including new localities extending its known range into Coahuayana. Historical evidence (1889) indicates past presence in the Balsas Basin, though no recent records exist there. Current distribution spans the Sierra Madre del Sur to coastal Michoacán. Camera traps revealed ground activity and site fidelity near springs during the dry season. This study refines the known distribution of *Potos flavus*, confirming its persistence despite recent forest loss and maintaining its Pacific northern limit. New behavioral observations suggest adaptations to hot, dry conditions, emphasizing the importance of conserving the species in its northernmost, drier range, where environmental pressures may shape its ecological responses.

Key words: Area fidelity; kinkajou; Michoacán; Procyonidae; water source.

La martucha (*Potos flavus*) es un carnívoro nocturno y arborícola, bien adaptado al dosel forestal gracias a su cola prensil y articulaciones flexibles. Su distribución y ecología a lo largo de la vertiente del Pacífico mexicano siguen siendo poco conocidas debido a su comportamiento críptico. Este estudio tiene como objetivo definir con mayor precisión el rango geográfico de la especie en esta región. Se revisaron todos los registros históricos y recientes provenientes de colecciones científicas, plataformas digitales y literatura. Los registros recientes se obtuvieron mediante monitoreo con cámaras trampa. Los datos espaciales se analizarán mediante SIG para determinar la distribución por ecorregión y municipio. Los registros se categorizaron como históricos (antes de 2000), contemporáneos (2001-2020) y recientes (2021-2024), incluyendo coordenadas, hábitat y observaciones de comportamiento cuando estuvieron disponibles. Los registros confirman la presencia de la especie en el noroeste de Michoacán, incluyendo nuevas localidades que amplían su distribución conocida hasta Coahuayana. Evidencias históricas (1889) indican su presencia pasada en la cuenca del Balsas, aunque no existen registros recientes allí. Su distribución actual abarca la Sierra Madre del Sur y la costa michoacana. Cámaras trampa registraron actividad terrestre y fidelidad al sitio cerca de manantiales durante la temporada seca. Este estudio refina la distribución conocida de *Potos flavus*, confirmando su persistencia a pesar de la reciente pérdida de bosques y el mantenimiento de su límite norte en el Pacífico. Nuevas observaciones conductuales sugieren adaptaciones a condiciones cálidas y secas, destacando la importancia de conservar la especie en su rango más septentrional y árido, donde las presiones ambientales pueden influir en sus respuestas ecológicas.

Palabras clave: Fidelidad de área; fuente de agua; martucha; Michoacán; Procyonidae.

The kinkajou (*Potos flavus*), also known as "Mico de noche" in Mexico, or kinkajou (Ford and Hoffmann 1988; Emmons and Feer 1997), is the most specialized arboreal carnivore in Mexico (Figueroa and Arita 2005). It uses its prehensile tail as an additional arm, in addition to

adaptations such as flexible knees and ankle joints that allow the hind limbs to rotate, enabling the kinkajou to descend head-first into vegetation (Ford and Hoffmann 1988; Wainwright 2002). Although taxonomically a carnivore, its herbivore diet is broad and includes fruits,
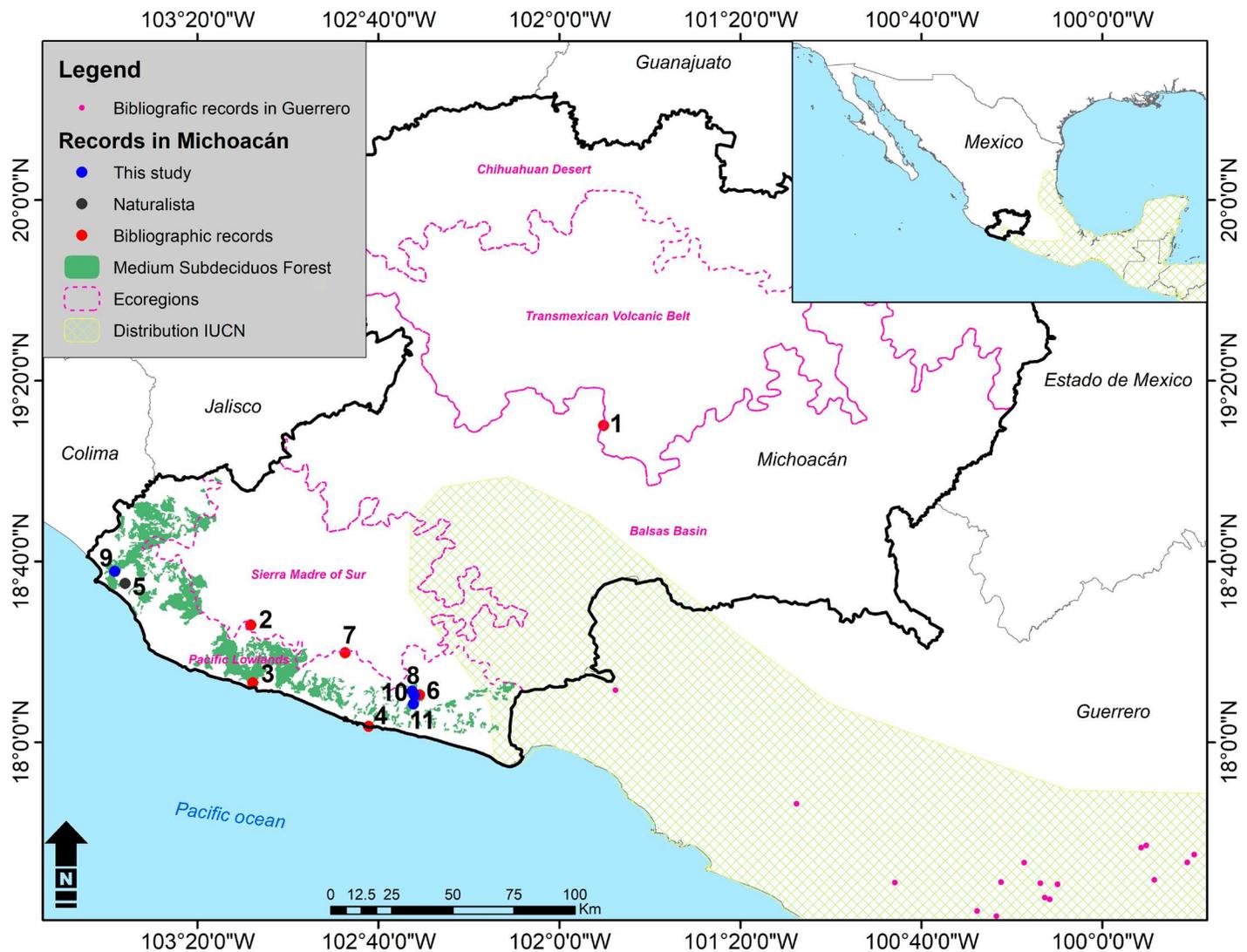
Figure 1. Geographic context of the distribution of martucha (*Potos flavus*) in Michoacán, Mexico. The numbering corresponds to ID locations in Table 1. Distribution IUCN ([Helgen *et al.* 2016](#)). Bibliographic records in Guerrero ([Nagy-Reis *et al.* 2020](#); [Osorio-Rodríguez *et al.* 2023](#)).

flowers, nectar, and leaves, from at least 119 plant species in 50 families, and to a lesser extent, small vertebrates, arthropods, and bird eggs ([Janzen 1983](#); [Reid 1997](#); [Wainwright 2002](#); [López-Cumatzi *et al*. 2025](#)). The population ecology, actual distribution and conservation status of the species remain poorly understood in its Pacific range in Mexico, partly due to its strict nocturnal and arboreal habits ([Monterrubio-Rico *et al.* 2013](#)).

Historically, the distribution of *P. flavus* in Mexico extended from southern Tamaulipas to the Yucatan Peninsula, including Eastern San Luis Potosí, and Veracruz. For Western Mexico, the northern distributional limit was situated in Southeast Michoacán on the Pacific slope to Chiapas ([Figueroa and Arita 2005](#); [Monterrubio-Rico *et al*. 2013](#); [Osorio-Rodríguez *et al*. 2023](#)). The species in Mexico inhabits a variety of forest types, including tropical rainforests, cloud forests, tropical semi-deciduous forests, riparian forests, secondary vegetation, and sometimes orchards ([Ford and Hoffman 1988](#); [Figueroa and Arita](#)

[2005](#)), from elevations at sea level to 2,200 m ([Reid 1997](#); [Figueroa and Arita 2005](#)). The species is listed under special protection status in Mexico, NOM-059-SEMARNAT-2010 ([SEMARNAT 2010](#)), due to forest loss, and hunting pressures, as reported in recent research ([Hernández-Flores *et al.* 2018](#); [Osorio-Rodríguez *et al.* 2023](#)). And the species is internationally considered as of Least Concern, but with decreasing populations ([Helgen *et al.,* 2016](#)).

The historic and actual distribution of kinkajou for the state of Michoacán was relatively uncertain for the northern portion of the Michoacan coast (northwestern Aquila and Coahuayana municipalities) ([Monterrubio-Rico *et al.* 2013](#)). The historic (before 2000) research effort occurred mainly on the remote wilderness areas of central and southern Michoacán coast, in particular on the Lazaro Cardenas and a report for Coalcomán fur trade, however, their presence was assumed as localities relatively near were reported for the neighboring Guerrero state ([Ávila-Nájera 2006](#)). In the absence of wildlife monitoring programs, and the increase

Figure 2. New records of kinkajou *(Potos flavus)* in Michoacán, Mexico. IDs correspond to locality numbers in table 1. a) Feeding on a black sapote tree (*Diospyros digyna*) (ID 8), b) Juvenile (ID 9), c) Drinking from a spring (ID 10), d) Drinking from a spring (ID 11).

in contemporary forest loss rates in the state (Loya-Carrillo and Mas-Caussel 2020), the aims of this report included to examine updated information in the context of previous reports (Monterrubio-Rico *et al.* 2013). To analyze new distributional records which implies modifications of the species observed range. In addition, to describe unusual behavioral ground level activity recordings.

In order to update the species status and distribution in Michoacán, we analyzed all available historical records, including those described in previous reports (Monterrubio-Rico *et al.,* 2013) and combined data from field research including records from camera trap sampling, these records originated from a camera trap monitoring program designed primarily for the study of wild felids in the coastal–mountain region of Michoacán. Cameras were strategically placed along trails, dirt roads, and near springs within fragments of tropical forests, which also allowed for the incidental detection of other nocturnal and arboreal mammals such as *Potos flavus*. We also reviewed and included all kinkajou records available in databases and

open online databases (Álvarez-Solórzano and López-Vidal 1998; Nagy-Reis *et al*. 2020), or platforms GBIF: Global Biodiversity Information Facility (www.gbif.org), MANIS: Mammal Networked Information System (www. manisnet. org), INaturalist Mexico (https://mexico.inaturalist. org/), and Portal de Datos Abiertos: UNAM: (http://datos abiertos.unam.mx), as well as scientific literature (Brand 1961; Sánchez-Hernández and Gaviño de la Torre 1988; Álvarez-Solórzano and López-Vidal 1998). *P. flavus* records were considered historic if they corresponded to an event (collected specimen, photograph, documented sighting) that occurred before year 2000, contemporary if occurred between 2000 and 2020, and recent if corresponded to the last five years. To determine the spatial distribution of *Potos flavus* in Michoacán, all georeferenced records (historical and contemporary) were plotted and analyzed in a Geographic Information System (GIS). Each record was inspected for its overlap with the corresponding ecoregion, of type vegetation and municipality boundaries following (Morrone *et al*., 2017; INEGI 2021).

Table 1. Records of kinkajou (*Potos flavus*) in Michoacán, Mexico. Agr = Agriculture, PF = Pine Forest, MSF = Medium Subdecidous Forest, DF = Deciduous forest, POF = Pine-Oak Forest.

ID	Location	Longitude	Latitude	Elevation	Municipality	Vegetation/land use	Year	Reference (Source)
1	Los Otates	-101.835876	19.167938	909	Nuevo Urecho	Agr	1889	Arroyo-Cabrales 2010 (Online database)
2	San José de la Montaña	-103.135474	18.431715	794	Coalcomán	PF	1961	Brand 1961 (Literature review).
3	Tizupán	-103.128397	18.218728	21	Aquila	MSF	1979	Sánchez-Hernández and Gaviño de la Torre 1988 (Literature review)
4	El Carrizalillo	-102.701667	18.058333	21	Lázaro Cárdenas	DF	1998	Álvarez-Solórzano and López-Vidal 1998 (Online database)
5	San Juan de Alima	-103.59855	18.58514	99	Aquila	DF	2009	Nasua 2025 (Online databases)
6	San José de Los Pinos	-102.514788	18.174446	858	Arteaga	POF	2010	Monterrubio-Rico *et al.* 2013 (Field survey)
7	El Naranjal	-102.788722	18.32926	792	Arteaga	POF	2011	Monterrubio-Rico *et al.* 2013 (Field survey)
8	Cayaco	-102.54165	18.1881	235	Arteaga	MSF	2017	This study (Field survey)
9	El Ticuiz	-103.636265	18.629961	255	Coahuayana	MSF	2019	This study (Field survey)
10	Cayaco	-102.532781	18.171727	307	Arteaga	MSF	2024	This study (Field survey)
11	Cayaco	-102.53689	18.141016	246	Arteaga	MSF	2024	This study (Field survey)

A total of 11 unique coordinates records were examined including field research, camera trap monitoring, observations documented in database portals, literature review and all the compiled records published previously (Monterrubio-Rico *et al.* 2013) (Table 1).

The oldest historic record corresponds to a male specimen collected from the Balsas Basin in the Municipality of Nuevo Urecho housed in the Natural History Museum in London, England, collected by H.H. Smith in 1889; catalog number NHM: 19457 (Arroyo-Cabrales 2010). The coordinates of the record constitute the most interior locality in the state (Record No.1, Figure 1). No other kinkajou record is available from the Balsas region.

During 2013, a comprehensive research note on the *Potos flavus* status in Michoacán was published (Monterrubio-Rico *et al.* 2013). It included three compiled historic records (2, 3 and 4; Table 1) from databases and scientific literature (Brand 1961; Sánchez-Hernández and Gaviño de la Torre 1988; Álvarez-Solórzano and López-Vidal 1998). Contemporary records number 6 and 7 from wildlife surveys (Table 1), which included a specimen collected and available at the mammal collection in the Museo de Zoología, Facultad de Ciencias, UNAM, with a preliminary catalog number: MZFC-10737 (Monterrubio-Rico *et al.* 2013), but now corresponds to the 10748 catalog number (Departamento de Biología Evolutiva, Facultad de Ciencias 2025).

The first contemporary record corresponded to an individual photographed near the Aquila town on December 2009, but was not uploaded to the "iNaturalist" plataform until July 2014 https://mexico.inaturalist.org/observations/738691, by a contributor identified as "Nasua" (Nasua 2025). The record coordinates correspond to northernmost location of the species on the coast (Record 5: Figure 1).

Four of the unpublished reports were obtained by wildlife monitoring efforts carried out during the 2012-2024 period. Record number eight was obtained by placing a camera trap in a zapote prieto tree (*Diospyros digyna*) to record nocturnal mammals feeding from its fruit. The recorded activity included three kinkajous, an adult male, and an adult female with a juvenile. The feeding behavior was recorded in the same tree since February 12, to March 3, 2017, during 16 different nights (Figure 2a), in the Cayaco locality (Table 1). All recorded feeding behavior events were nocturnal, initiating approximately at 20:30 to 05:00 hr of the following date, with evidence of soncoya fruit (*Annona purpurea*), and cecropia tree (*Cecropia peltata*), locally named as "yoyote" consumed by kinkajous as fruit remains were observed on the ground and local settlers confirmed the kinkajou feeding observations.

The three most recent records corresponded to ground activity, which occurred during the driest days with high temperature during the dry season (2019 and 2024 respectively). Record number 9 (the northernmost recent location, Figure 1.) corresponds to a young kinkajou (Figure 2b) abandoned by its mother after being surprised by sunrise laborers. It is assumed that the kinkajous were on their way returning from a nearby spring.

The last two records came from camera traps located to survey faunal activity on the ground, including the use of springs during the dry season (April and May) (Charre-Medellín *et al.* 2021) (Figures 2c and d). In record 11, the site was monitored by a camera trap programmed in video format during a 34 day-survey period, in which a pair of adult kinkajous were recorded using a water spring during 19 nights (55.8% of survey effort). The kinkajous were hydrating from April 14 to May 16, 2024, and the activity varied among the different nights and hours, the earliest occurred at 20:32, but most commonly initiated around 22:00 hr. Permanence on the spring ranged from three minutes to seven hours.

Although some of the records obtained in this study, correspond to areas near previous reports confirming that the species maintain activity in the area after the publication of Monterrubio-Rico *et al*. (2013), some records also expand the species observed distribution into Coahuayana municipality (Table 1). In this study, we outlined with higher certainty the kinkajou distribution northern limit in western Mexico, both historically and currently. We hypothesized how the kinkajou distribution in the 19th century included the Balsas Basin (Tierra Caliente), a large tropical dry area of 7,003 km2 (Ihl and Bautista-Zúñiga 2019), as the oldest record available corresponds to Nuevo Urecho, but no other report has been documented from the region. However, it's also true that research effort and surveys in the region have been limited due to inaccessibility of the rugged terrain in remote areas, and insecurity. In addition, the kinkajous nocturnal and arboreal behavior may limit their detection.

On the other hand, historically, fragments of tropical semideciduous forests, (the kinkajou main habitat in western Mexico) occurred in the most humid areas of the region, and today those areas are now covered by cattle ranches and agricultural areas (Ihl and Bautista-Zúñiga 2019). However, surprisingly kinkajous also wander into dry areas, as in Barranca de Metztitlan Reserve, as a recent individual was observed on a riparian canyon in trees of *Prosopis leviagata* and *Salix humboldtiana*, in a landscape with arid scrubland (Hernández-Flores *et al*. 2018). Therefore, isolated kinkajou groups may likely wonder into the Zicuiran-Infiernillo reserve vast forests, persisting today, as some remote and inaccessible canyons with riparian forests occur adjacent to Guerrero state. Future research should test such hypothesis when additional effort on the region.

This analysis enhances our understanding of the northern distributional limit of the species along the Pacific coast. We can now define this boundary with greater precision near El Ticuiz, in the municipality of Coahuayana, approximately 100 km northwest from the previously recorded limit in El Naranjal (Monterrubio-Rico *et al*. 2013). Two potential explanations arise from all available kinkajou data, the species historic distribution included the northern tropical forests of the Michoacan coast, but was previously undetected due to limited sampling research effort. A second more speculative explanation is a distributional expansion. It remains unclear the relative importance, use and selection of the remaining patches of tropical semi-deciduous forest by *Potos flavus*. However, based on INEGI (2021), 143,160 hectares of tropical sub-deciduous forest are still available in Michoacán. Forests available constitute actual potential habitats, and are large enough for the species home range requirements estimated at eight has. (Ford and Hoffmann 1988). Targeted surveys with balanced sampling designs should be conducted across coastal forest fragments along the year to examine seasonal forest use.

Another research topic for the kinkajou presence in the region is how habitat use and selection is influenced by tree species composition, as well as ground water availability. Three camera trap records illustrated area fidelity by the kinkajous, at least during the camera survey period, when a specific fruiting tree or water source were selected. The direct water consumption on the ground is a considerably unusual behavior (Ford and Hoffmann 1988), and the high proportion of surveyed nights detecting their prolonged presence at the water sources may explain the area fidelity observed. Heat stress may explain water spring use. Temperatures of 33°C and above constitute stressful conditions for the species due its limited ability to dissipate heat through evaporation. The documented responses to heat stress in the humid tropics consist in the search for cooler den sites (Ford and Hoffman 1988), making water spring suitable sites to refresh, explaining its presence for several hours. No other reports have evidenced such behavior on Guerrero or the Pacific (Osorio-Rodríguez *et al*. 2023).

The degree to which kinkajous respond to periods of atypical drought and heat is essential to understand, as the species low metabolic rates are physiologically adapted to stable climatic conditions. In addition, water availability in general for wildlife in the region may experience a decline in the future with climate change. Species populations occurring on the ecological margins of fundamental climatic conditions (temperature and humidity), such as the kinkajou in Michoacán, are considered as relevant in the species responses to climatic changes (Travis and Dytham 2004; Hampe and Petit 2005).

The presence of a viable kinkajou population in Michoacán is important for the entire species range in Mexico. Protected Areas in the region are urgently needed, as forest loss rates have drastically reduced tropical forests (Trejo and Dirzo 2000; Loya-Carrillo and Mas-Caussel 2020), and extensive cattle ranching and extensive agriculture cover 66% of the coastal region and 14% in the Sierra Madre del Sur (Ihl and Bautista-Zúñiga 2019).

Today, no records of kinkajous have been reported for the protected areas of the state, and the coast and Sierra Madre del Sur still present areas that could be considered biodiversity rich. Conserving *Potos flavus* in Michoacán requires urgent attention to habitat protection and connectivity. As the species shows reliance on water sources and specific fruiting trees, conservation strategies should prioritize the preservation of tropical semi-evergreen forests and the maintenance of ecological corridors that ensure access to these critical resources. Furthermore, the identification and inclusion of potential habitats within protected areas will be essential to strengthen long-term population viability. Collaborative efforts among government agencies, local communities, ONGs and researchers, will be key to safeguarding this ecologically significant species.

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First record of *Gardnerycteris keenani* in the North Pacific of Costa Rica and southern range extension of *Artibeus inopinatus*

Primer registro de *Gardnerycteris keenani* en el Pacífico Norte de Costa Rica y extensión del ámbito de distribución sur de *Artibeus inopinatus*

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The National Ecological Monitoring Program (PRONAMEC) of the National System of Conservation Areas (SINAC) in Costa Rica aims to generate scientific information for biodiversity management in Protected Wildlife Areas. In 2023, the first structured bat survey was conducted in 4 protected areas of the Tempisque Conservation Area (ACT), recording *Gardnerycteris keenani* for the first time in the North Pacific of Costa Rica and the southernmost record of *Artibeus inopinatus*. Between July and October 2023, 6 mist nets were set up in the Iguanita National Wildlife Refuge (RNVSI), Guanacaste. The nets were placed at two sites: "Sendero Manglar" and "Quebrada Grande", covering mangroves and deciduous dry forests areas, accomplishing a survey effort of 101.6 net-hours. An adult male *Gardnerycteris keenani* was recorded on July 14 and an adult female *Artibeus inopinatus* on October 16, both in good health. The finding of *Gardnerycteris keenani* extends its known distribution in Costa Rica, while the discovery of *Artibeus inopinatus* reinforces its association with tropical dry forests. These records highlight the ecological importance of the RNVSI and reveal information gaps due to limited previous sampling efforts. The presence of these species underscores the need to continue monitoring programs to support management decisions, especially in the face of anthropogenic threats.

Key words: Culebra Bay: dry forest; ecological integrity; ecological monitoring national program; Tempisque Conservation Area.

El Programa Nacional de Monitoreo Ecológico (PRONAMEC) del Sistema Nacional de Áreas de Conservación (SINAC) de Costa Rica busca generar información científica para la gestión de la biodiversidad en Áreas Silvestres Protegidas. En 2023, se realizó el primer monitoreo estructurado de quirópteros en 4 áreas silvestres protegidas del Área de Conservación Tempisque (ACT), registrándose por primera vez *Gardnerycteris keenani* en el Pacífico Norte de Costa Rica y logrando el registro más austral de la distribución conocida de *Artibeus inopinatus*. Entre julio y octubre de 2023, se instalaron seis redes de niebla en el Refugio Nacional de Vida Silvestre Iguanita (RNVSI), Guanacaste. Las redes se colocaron en dos sitios: "Sendero Manglar" y "Quebrada Grande", abarcando áreas adyacentes a un manglar dominado por *Rhizophora mangle* y áreas de bosque seco caducifolio secundario. El esfuerzo de muestreo consistió de 101.6. horas/red. Se registró un macho adulto de *Gardnerycteris keenani* el 14 de julio y una hembra adulta de *Artibeus inopinatus* el 16 de octubre, ambos en buen estado de salud. El hallazgo de *Gardnerycteris keenani* amplía su distribución conocida en Costa Rica, mientras que el de *Artibeus inopinatus* refuerza su asociación con bosques secos tropicales. Estos registros destacan la importancia ecológica del RNVSI y evidencian vacíos de información debido a limitados esfuerzos de muestreo previos. La presencia de estas especies subraya la necesidad de continuar con programas de monitoreo para apoyar decisiones de manejo, especialmente frente a amenazas antropogénicas.

Palabras clave: Área de Conservación Tempisque; Bahía Culebra; bosque seco; integridad ecológica; Programa Nacional de Monitoreo Ecológico.

The National Ecological Monitoring Program (PRONAMEC) of the National System of Conservation Areas (SINAC) of Costa Rica was established as a national strategy in 2016 (SINAC 2021). Its objective is to generate and disseminate scientific information on the state of biodiversity conservation in the country, serving as a decision-making tool for the management of protected wildlife areas and their areas of influence. Under this program, during 2023, the first structured monitoring of chiropterans was conducted in four wildlife protected areas within the Tempisque Conservation Area (ACT; northwestern Costa Rica).

Gardnerycteris keenani is a phyllostomid bat belonging to the Phyllostominae subfamily. Globally, its distribution ranges from southern Mexico to eastern Brazil and northern
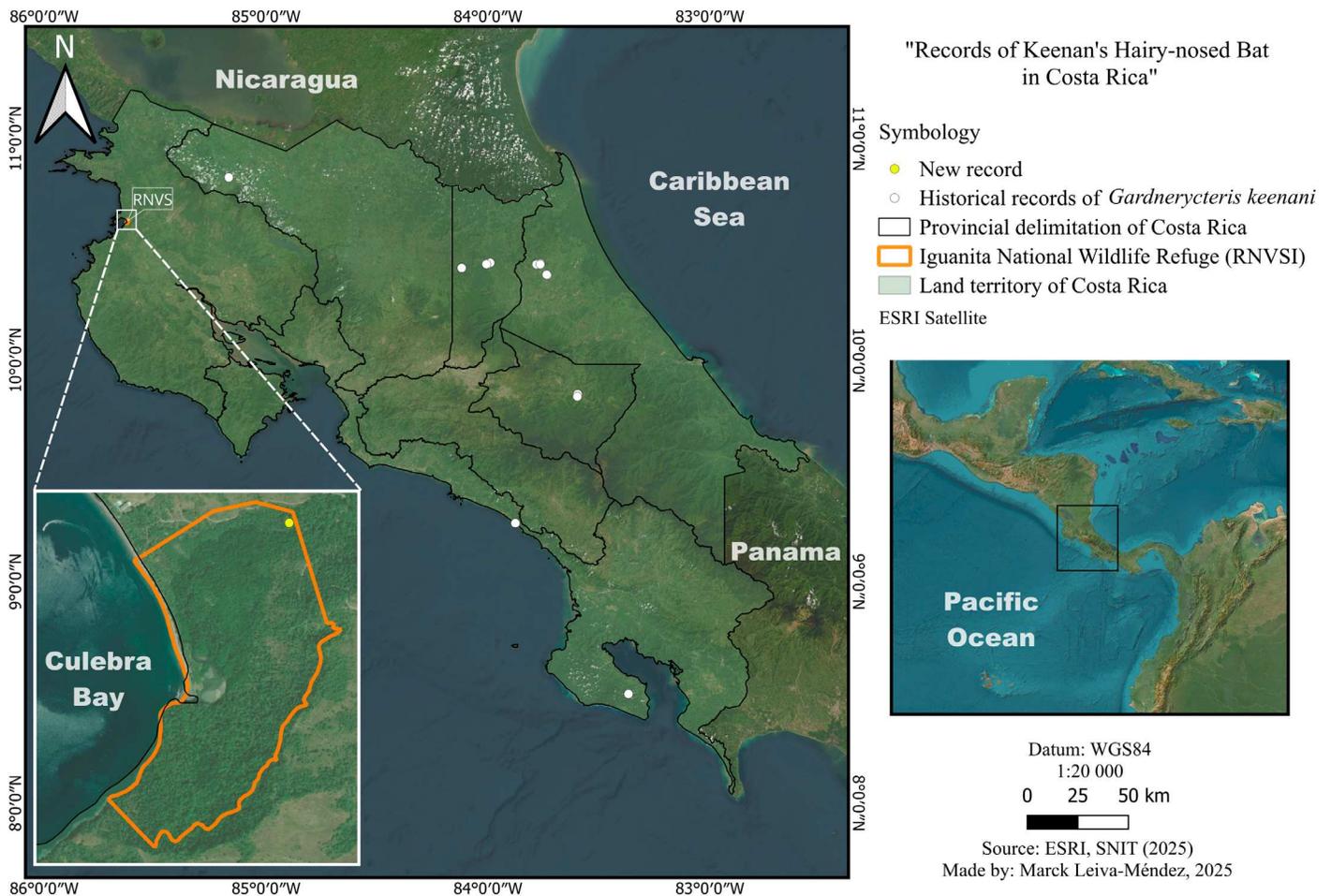
Figure 1. Historical records of *Gardnerycteris keenani* in Costa Rica and location of the Iguanita National Wildlife Refuge.

Peru and Bolivia. In Costa Rica, it was previously classified as *Mimon crenulatum* ([Hurtado and Pacheco 2014](#); [Hurtado and D'Elía 2018](#); [Mora and Ruedas 2023](#)), with records limited to the Caribbean and southern Pacific lowlands ([Rodríguez and Montero 2001](#); [LaVal and Rodríguez 2002](#); [Reid and Gómez 2022](#); [GBIF 2023](#); [MNCR 2025](#)) (Figure 1). It is a gleaning insectivore that includes beetles, flies, moths, and lizards in its diet ([LaVal and Rodríguez 2002](#)). Like other species in the subfamily, *G. keenani* is sensitive to deforestation and other ecosystem disturbances, showing higher abundances in mature forests ([Medellín *et al.* 2000](#); [Medellín and Víquez 2014](#)).

Artibeus inopinatus is a frugivorous phyllostomid bat belonging to the subfamily Stenodermatinae. Its known distribution includes only dry forest regions of the Pacific in Honduras, El Salvador, and Nicaragua and it is hypothetically considered for Guatemala ([Webster and Knox 1983](#); [Artavia *et al.* 2023](#)). In Costa Rica, there are only two records of the species, both in the Santa Rosa National Park (North Pacific) ([Artavia *et al.* 2023](#)). Data on its natural history and conservation status are scarce ([Webster and Knox 1983](#); [Reid and Medina 2016](#)); however, in Honduras it is considered an endangered species due to its restricted range and habitat loss ([Portillo *et al.* 2019](#)).

The Iguanita National Wildlife Refuge (RNVSI) is a protected wildlife area within the ACT, Costa Rica. It is located in the province of Guanacaste, within Bahía Culebra (Figure 1), having an area of 118.3 ha ([SNIT 2025](#)), of which 44,6 ha correspond to mangrove forest. The RNVSI is situated in a lowland region with flat to undulating topography ranging from 40 to 600 m, where vegetation is mostly deciduous, with small patches of evergreen or gallery forests, as well as wooded savannas limited by edaphic conditions ([Zamora 2008](#)).

Climatically, the region presents a drought pattern, with five dry months ([SINAC 2022](#)). Rainfall decreases from December to March, with peak precipitation periods occurring between May–June and August–October. The average annual rainfall ranges from 1,000 to 2,200 mm.

Between July and October 2023, six nylon mist nets (Avinet® Inc.), measuring 12 × 2.6 m with a 36 mm mesh size, were set up for capturing bats at two sites known as "Sendero Manglar" (10° 37' 46.24" N; 85° 37' 43.97" W) and "Quebrada Grande" (10° 37' 56.99" N; 85° 37' 22.25" W) within the RNVSI, between 17:30 and 22:00 hr. The first site is a trail crossing a mangrove area dominated by *Rhizophora mangle* and a secondary coastal dry forest

Figure 2. *Gardnerycteris keenani* captured at the Iguanita National Wildlife Refuge, Costa Rica. a) Frontal view of individual in mist net, b) close-up of lateral view.

area (SNIT 2025) dominated by *Prosopis juliflora*, *Sterculia apetala*, *Enterolobium cyclocarpum*, *Guazuma ulmifolia* and *Canavalia maritima*. The second site is located in a secondary forest, dominated by species such as *G. ulmifolia*, *Handroanthus ochraceus*, *Lonchocarpus* sp., *Spondias mombin*, *Bombacopsis quinata*, *Vachellia collinsii*, *Bursera simarouba*, *Cordia alliodora* and *Gliricidia sepium*, within 50 m of a riverbed that feeds a mangrove area (SNIT 2025).

Captured individuals were examined to record their forearm length using a digital caliper (Steren, 0.2mm precision), age (through the inspection of metacarpal epiphyseal fusion), and sex and reproductive condition by external examination of genitals and mammary glands. Species identification followed the field key of York *et al.* (2019) and Mora and Espinal (2021).

On July 14, an adult male *G. keenani* (Figure 2), with scrotal testes and a forearm length of 52 mm, was recorded. The individual appeared healthy and was released after examination. On October 16, an adult non-reproductive female *A. inopinatus* (Figure 3), with a forearm length of 48 mm, was recorded. The bat also appeared healthy and was released after examination.

The record of *G. keenani* extends the species' known range in Costa Rica by approximately 230 km, from its southernmost record (MNCR 2025). While the record made in the RNVSI was in a predominantly deciduous forest, within one of the driest regions of the country, the historic southernmost record is from the humid Central Pacific lowland region (~400 m), which is a floristic ecotone where elements of the deciduous vegetation of the Pacific Northwest converge with vegetation from the more humid Pacific Southwest (Zamora 2008). Noteworthy, most of the northern records of the species in Costa Rica (MNCR 2025) are from the Caribbean plains, an area that exhibits practically no dry season during the year.

Another issue worth analyzing, is the fact that the captured *G. keenani* showed scrotal testes. As stablish by Krutzch (2000), the reproductive readiness of male bats is generally in synchrony with that of females. Also, as established by Heideman (2000), opportunistic reproduction may be rare in bats, because the relatively long gestation periods make it unlikely that a female could complete a full reproductive cycle (from follicle production to weaning) before good conditions have passed. Instead, most seasonally reproducing bats (*e.g* many Phyllostomids) probably react to cues that predict oncoming periods when environmental conditions permit successful reproduction. In accordance with the above, we suggest that the captured

Figure 3. *Artibeus inopinatus* captured at the Iguanita National Wildlife Refuge, Costa Rica.

male may not be an occasional individual, but rather part of a potentially established population.

Regarding *A. inopinatus*, its known regional distribution primarily includes Central American Pacific tropical dry forests ([Artavia *et al*. 2023](#)), such as those found in Santa Rosa National Park, where the species was first recorded in Costa Rica (~30km north from the RNVSI record). Its presence in the RNVSI provides further evidence supporting an association of this species with seasonally dry tropical forests.

The discovery of two unrecorded species in the area, highlights the ecological importance of the Iguanita Wildlife Refuge. The documented records are relevant for increasing knowledge of the natural history of both species. By generating ecological information, keeping monitoring programs can improve management decisions for wildlife areas.

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