Therya Notes

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AMMAC
Asociación Mexicana de Mastozoología A.C.

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

En la Portada

Para conocer y conservar a las musarañas mexicanas es necesario conocerlas bien, aunque su identificación taxonómica es difícil. Sin embargo, las herramientas citogenéticas pueden ayudar a discriminar las especies. En la imagen se muestran los cromosomas en metafase de un macho de musaraña mexicana de orejas pequeñas (*Cryptotis magnus*), visto fotomicroscópicamente a 100x.
(Imagen de Cervantes et al. 2023)

El logo de la AMMAC: "Ozomatli"

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

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CONTENIDO

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First detailed record of food items in the diet of the dwarf coati (*Nasua nelsoni*) of Cozumel Island, México

Primer registro detallado de alimentos en la dieta del coatí enano (*Nasua nelsoni*) de Isla Cozumel, México

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The dwarf coati (*Nasua nelsoni*) is an endemic mammal to Cozumel Island, Quintana Roo, México. Although dwarf coati is critically threatened with extinction, there are still important knowledge gaps about its biology and ecology. We are unaware of relevant published aspects of its trophic ecology and there is no information on its feeding habits. Therefore, our objective was to report, for the very first time, details on food items in the diet of the dwarf coati. Between September 2013 and December 2014, we recorded sightings of groups and solitary individuals of dwarf coati. Some of these sightings allowed us to directly record the consumption of food items, mainly fruits, which were later identified by collecting samples of the consumed material and the fruiting plant. We recorded a total of 25 sightings of dwarf coati while consuming food items. In 88 % (*n* = 22) of the records, we recorded the consumption of fruit from 8 species, represented by 8 families of wild plants. Additionally, we obtained records of the species consuming sea turtle eggs (*n* = 1) and organic waste of anthropic origin (*n* = 2). The evidence of the consumption of fruit and food items of different origin supports the expectation that the dwarf coati has an omnivorous diet mainly based on fruit, which coincides with that reported for other species of the same genus, the white-nosed coati (*N. narica*) and brown-nosed coati (*N. nasua*).

Key words: Carnivore; insular endemic; pizote; procyonid; threatened species; trophic niche.

El coatí enano (*Nasua nelsoni*) es un mamífero endémico de Isla Cozumel, Quintana Roo, México. A pesar de que el coatí enano es una especie críticamente amenazada con la extinción, aún existen importantes vacíos de conocimiento sobre su biología y ecología. Se desconocen aspectos relevantes de su ecología trófica y no existe información específica sobre sus hábitos alimentarios. Por ello, nuestro objetivo fue reportar, por primera vez, detalles sobre los alimentos que conforman parte de la dieta del coatí enano. Entre septiembre de 2013 y diciembre de 2014, registramos avistamientos de grupos e individuos solitarios de coatí enano. Algunos de estos avistamientos nos permitieron registrar directamente el consumo de alimentos, principalmente frutas, que luego fueron identificados mediante la recolección de muestras del material consumido y de la planta madre. Registramos 25 avistamientos de individuos de coatí enano mientras consumían alimentos. En 88 % (*n* = 22) de esos avistamientos, registramos el consumo de frutos de 8 especies, representadas por 8 familias de plantas silvestres. Adicionalmente, obtuvimos registros del coatí enano mientras consumía huevos de tortuga marina (*n* = 1) y desechos orgánicos de origen antrópico (*n* = 2). La evidencia del consumo de frutas aunado al consumo de alimentos de diferente origen apoya la idea de que el coatí enano tiene una dieta omnívora basada principalmente en el consumo de frutas, lo que coincide con información reportada para otras especies del género, como el coatí de nariz blanca (*N. narica*) y el coatí sudamericano (*N. nasua*).

Palabras clave: Carnívoro; endémico insular; especie amenazada; nicho trófico; pizote; prociónido.

The dwarf coati (*Nasua nelsoni*) is a mammalian carnivore of the Procyonidae family, endemic to Cozumel Island, Quintana Roo, México. It is a species classified as Endangered, according to Mexican legislation (SEMARNAT 2010), and listed in Appendix III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; Valenzuela-Galván *et al.* 2014). In México, the species has been considered as a priority in terms of conservation among terrestrial mammals of the order Carnivora (Valenzuela-Galván and Vázquez 2007). The dwarf coati is an insular species similar to its continental congener, the white-nosed coati (*Nasua narica*), but with significantly less weight, and smaller size and tooth length, compared to the latter (Valenzuela-Galván *et al.* 2014). It is a species that faces severe conservation problems related to the introduction of exotic species, loss of natural habitat, stochastic events (mainly hurricanes) and to its low population size, which is estimated has not recovered from historical genetic bottlenecks, and hence further reduction of its population is possible (Cuarón *et al.* 2004, 2009; McFadden *et al.* 2010; Flores-Manzanero *et al.* 2022). Available genetic information about the dwarf coati strongly supports that its taxonomic position as a distinct species should be considered (something that has been recently debated; see Valenzuela-Galván *et al.* 2023 and Ruiz-García *et al.* 2023). Also, its status in the IUCN Red List of Threatened species should be recognized as a Critically Endangered species, and its population managed in accordance, or at the very least as an Evolutionary Significant Unit (*sensu* Moritz 1994; Flores-Manzanero *et al.* 2022).

Despite its endemism and vulnerability, it is a species for which little is known about its natural history, biology, behavior, and ecological aspects. Research efforts have focused on determining its population size (Cuarón *et al.* 2004) and more recently spatio-temporal ecology (Rodríguez-Luna 2015) and conservation genetics (Flores-Manzanero *et al.* 2022). Conservation work has resulted in the creation of an extensive system of state and federal protected areas and the recognition of the entire Cozumel Island and surrounding sea as a Biosphere Reserve of UNESCO's Man and Biosphere Program (Cuarón *et al.* in press). However, there is still an important knowledge gap about its trophic niche. Regarding its feeding habits, it is considered that they could be similar to those of *N. narica* (Cuarón *et al.* 2009): an omnivorous species that feeds mainly on fruits and arthropods (Valenzuela-Galván *et al.* 2014). Nevertheless, fieldwork is still needed to demonstrate this.

Knowledge about the feeding habits of animals helps to understand ecological niche relationships, since they play an important role in segregation, competition, coexistence (Schoener 1974), population dynamics (Taper and Marquet 1996), habitat use and even the social organization of a species (Mills 1992; ; Manfredi *et al.* 2004; Casella and Cáceres 2006). Besides, it is valuable information to support conservation actions. Therefore, our objective in this work was to report the very first records of food items ingested by the dwarf coati of Cozumel Island, obtained through direct observation.

The study area was Cozumel Island, Quintana Roo, México (Figure 1). It is an oceanic island located in the Mexican Caribbean Sea with *ca.* 478 km^2 and extreme coordinates 20° 16' 18.2" – 20° 35' 32.28" N and 86° 43' 23.3" – 87° 01' 31.1" W (Cuarón 2009). The vegetation on the island consists of a well-defined gradient that begins from the eastern coastal strip with coastal dune vegetation followed by areas of tasistal (*Acoelorhaphe wrightii*), mangrove (*Rhizophora mangle*, *Laguncularia racemosa*), tropical dry forest and medium sub-deciduous forest in the central portion of the island, which is the predominant vegetation type (Téllez *et al.* 1989; Figure 1). Climate type is AmW(I), warm humid with abundant rains in summer; average annual temperature is 27.5 °C and average annual precipitation is 1,403 mm (INEGI 2016).

Between September 2013 and December 2014 in Cozumel Island, we carried out a study on the spatial ecology of the dwarf coati for which it was necessary to capture and radio tag several individuals of the species (Rodríguez-Luna 2015). During the development of the fieldwork to obtain radiotracking locations, we recorded sightings of groups and solitary individuals of the species at different places on the island. For some of the sightings we observed individuals of dwarf coati foraging and even consuming food items. For each of these sightings, we recorded the geolocation, vegetation type, and, when possible, we took photographic evidence with a portable camera (Nikon^{TM} mod. P100). When we recorded an observation of the consumption of fruits, we collected samples of them as well as of the fruiting plant for the subsequent identification of the species. For plant identification, we used the Catalogo de Flora de la Península de Yucatán of the Centro de Investigación Científica de Yucatá A. C. (https://www.cicy.mx/sitios/flora%20digital/index.php), as well as reference material with specialized support from personnel of the Laboratorio de Ecología de Plantas from the Cozumel campus of the Universidad Autónoma de Quintana Roo.

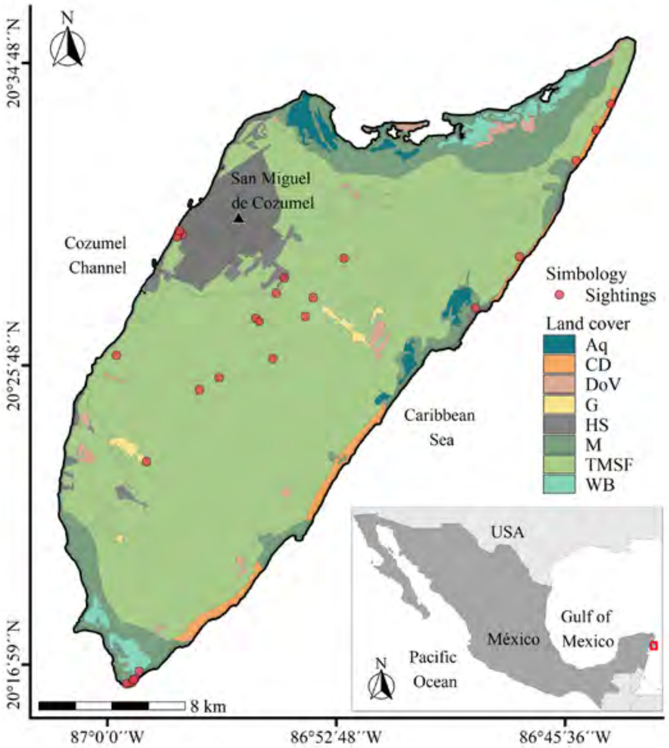

Figure 1. Study area in Cozumel Island, Quintana Roo, México, and spatial locations of the sighting points (red dots) where we recorded the food intake by the dwarf coati (*Nasua nelsoni*). In the figure we show the town of San Miguel de Cozumel (black triangle) and the land cover according to freely available information on Land Use and Vegetation (sVII) from the Instituto Nacional de Estadística y Geografía (INEGI), available at https://www.inegi.org.mx/temas/usosuelo/#Descargas. Land cover is described as: Aq, aquatic vegetation; CD, coastal dune; DoV, area devoid of vegetation; G, grasslands; HS, human settlements; M, mangroves; TMSF, tropical medium sub-deciduous forest; WB, water bodies.

We obtained a total of 25 georeferenced sightings of dwarf coati where we observed the consumption of food items by the species (Figure 1). Most of the sightings (56 %; *n* = 14) occurred in areas covered by tropical medium sub-deciduous forest, 32 % (*n* = 8) occurred in coastal dune areas, 8 % (*n* = 2) in secondary vegetation and one sighting (4 %) occurred on a beach in the east coast with no apparent vegetation (Table 1).

We were able to identify the consumption of fruits (Figure 2) of 8 wild plant species, represented by 8 genera, 8 families and 7 orders (Table 1): *Xylopia frutescens* Aubl., *Byrsonima bucidifolia* Standl., *Cordia sebestena* L., *Coccoloba uvifera* (L.) L., *Diospyros salicifolia* Humb. & Bonpl. ex Willd., *Cascabela gaumeri* (Hemsl.) Lippold, *Scaevola plumieri* (L.) Vahl and *Jacquinia arborea* Vahl.

In addition, we recorded 1 sighting in which a dwarf coati consumed sea turtle eggs (most probably of *Chelonia mydas*, since the majority of nests at Cozumel are from this species) on an open beach and 2 sightings of the species consuming organic food waste of anthropic origin (Figure 3).

Our records of dwarf coati consuming fruits, sea turtle eggs and organic waste of anthropic origin, represents the first report of food items identified in detail in the species diet. Other species of the genus *Nasua* have a high consumption of fruits (Gompper 1995; Gompper and Decker 1998). The white-nosed coati (*N. narica*) consumes predominantly fruits, but also invertebrates and small vertebrates in variable proportions, both in the northernmost part of

Figure 2. Photographic records of dwarf coati of Cozumel Island (*Nasua nelsoni*), prior to the consumption of fruits (marked in red circles) of species a) *Xylopia frutescens* and b) *Diospyros yucatanensis*.

Table 1. Records of food items consumed by the dwarf coati (*Nasua nelsoni*) of Cozumel Island, México by vegetation type. * Indicates this is the first time this species and plant family is reported to be consumed by a species in the genus *Nasua*. Vegetation types are designated as follows: CD, coastal dune; DoV, area devoid of vegetation; TMSF, tropical medium sub-deciduous forest; SV, secondary vegetation.

Food type	Order	Family	Species		Number of records	Percentage of records	Vegetation type
Fruits	Asterales	Goodeniaceae*	*Scaevola plumieri**		1	4	CD
	Boraginales	Boraginaceae*	*Cordia sebestena**		2	8	CD
	Caryophyllales	Polygonaceae	*Coccoloba uvifera*		2	8	CD
	Ericales	Ebenaceae	*Diospyros salicifolia*		2	8	TMSF
		Primulaceae	*Jacquinia arborea*		1	4	CD
	Gentianales	Apocynaceae*	*Cascabela gaumeri**		2	8	CD
	Magnoliales	Malpighiaceae	*Byrsonima bucidifolia*		4	16	TMSF
	Malpighiales	Annonaceae	*Xylopia frutescens*		8	32	TMSF
Sea turtle eggs	-	-	-		1	4	DoV
Anthropic waste	-	-	-		2	8	SV
				Total	25	100	4

its distribution in the United States of America (Wallmo and Galliziolli 1954; Kaufmann *et al.* 1976), México (Delibes *et al.* 1989; Valenzuela-Galván 1998; Valenzuela-Galván *et al.* 2014) and in the southernmost part of its distribution in Central America (Kaufmann 1962; Smythe 1970; Gompper 1995, 1996). On the other hand, the brown-nosed coati (*N. nasua*) also feeds mainly on fruit and consumes a variable proportion of invertebrates in its diet (Gompper and Decker 1998; Alves-Costa *et al.* 2004; Alves-Costa and Eterovick 2007; Hirsch 2009; Aguiar *et al.* 2011; Bianchi *et al.* 2013; Ferreira *et al.* 2013).

Among the 8 species that we report in the diet of the dwarf coati, fruits from 5 families have a previous record of consumption in *Nasua spp.*: Polygonaceae, Ebenaceae, Primulaceae, Malpighiaceae and Annonaceae (Russell 1982; Valenzuela-Galván 1998; Hirsch 2009; Bianchi *et al.* 2013), but for 3 species and plant families, our study reports for the first time their consumption by a species in the genus *Nasua* (Table 1). We also recorded the consumption of sea turtle eggs in the northern part of the east coast of Cozumel Island. Nest predation is well known by people who are related to sea turtle (*i.e., Chelonia mydas, Caretta caretta, Eretmochelys imbricata*) conservation work on the island; however, there are no previous published data on nest predation in the study area by the dwarf coati, although consumption of sea turtle eggs by *N. narica* has been reported for different zones across its geographical distribution (Fowler 1979; Valenzuela-Galván 1998; García *et al.* 2003; Ruthig 2019). Finally, we recorded individuals of dwarf coati feeding on organic waste of anthropic origin inside garbage containers in the southern portion of the island (Figure 3), although we were unable to identify the elements ingested. Coati's omnivorous diet allows it to obtain food supplementation in urban environments, where they frequently feed on organic waste of anthropic origin (Alves-Costa *et al.* 2004; Hirsch 2009); this represents one of the factors that can favor the establishment of the species and even the maintenance of stable population density over time in urban areas (Barreto *et al.* 2021).

Figure 3. Photographic record of dwarf coati of Cozumel Island (*Nasua nelsoni*), prior to the consumption of organic waste of anthropic origin in the southern part of the island.

Thus, with our records of the consumption of fruits, sea turtle eggs, and organic waste of anthropic origin, the idea that the dwarf coati has an omnivorous diet based mainly on fruit consumption is reinforced. This fact coincides with information reported for other species of the genus *Nasua*. However, the detailed study of the feeding habits of the species must be deepened to contribute to the knowledge of its basic ecology and sustain conservation actions for this critically endangered endemic species.

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Filling the gap: medium and large mammals from a Cerrado remnant in Central Brazil

Llenando el vacío: mamíferos medianos y grandes de un remanente del Cerrado en el centro de Brasil

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Biodiversity in the Cerrado biome is threatened by deforestation and the conversion of native vegetation by agricultural and urban areas. Unfortunately, in some areas such as the state of Tocantins, there is a sampling gap of mammalian fauna, resulting in a lack of knowledge. The present study contributes to reducing this gap by providing information about medium and large-sized mammals from the Rio Formoso region, Tocantins. In January 2019, we carried out a field survey in 7 sampling points in the municipality of Dueré, southern Tocantins. We installed 4 camera traps which remained active for a period of 7 days. Additionally, diurnal and nocturnal active censuses were carried out. The relative completeness of the inventory was assessed through the species' cumulative curves. We recorded 21 species of medium and large-sized mammals over 7 days of sampling in a region under the influence of agricultural activities, including endangered species such as jaguars, giant armadillos, giant otters and marsh deer. The presence of species of large and medium mammals that play important ecosystem roles highlights that Cerrado remnants still maintain good environmental conditions even with anthropic actions occupying the landscape. These results highlight the importance of field studies at the regional level and provide information about an underexplored region.

Key words: Agricultural; Cerrado; inventory; large-sized mammals; Tocantins.

La diversidad del bioma Cerrado está amenazada por la deforestación y el reemplazo de la vegetación nativa por áreas agrícolas y urbanas. Desafortunadamente, áreas como parte del estado de Tocantins, permanecen como un vacío de muestreo para la fauna de mamíferos, que resulta en una falta de conocimiento. El presente estudio contribuye con información sobre mamíferos medianos y grandes de la región de Río Formoso, Tocantins. En enero de 2019, realizamos un levantamiento de campo en 7 puntos de muestreo en el municipio de Dueré, sur de Tocantins. Instalamos 4 cámaras trampa las cuales permanecieron activas por un periodo de 7 días. Adicionalmente, se realizaron censos activos diurnos y nocturnos. La relativa completitud del inventario se evaluó a través de las curvas acumulativas de las especies. Registramos 21 especies de mamíferos medianos y grandes durante 7 días de muestreo en una región bajo la influencia de actividades agrícolas, incluidas especies en peligro de extinción como jaguares, armadillos gigantes, nutrias gigantes y ciervos de los pantanos. La presencia de especies de mamíferos grandes y medianos, que tienen un papel importante en el ecosistema evidencia que el entorno local del Cerrado mantiene cierto equilibrio aún con las acciones antrópicas en el paisaje. Estos resultados muestran la importancia de los estudios de campo a nivel regional y brindan información sobre una región poco explorada.

Palabras clave: Agrícola; Cerrado; inventario; mamíferos de gran tamaño; mastozoología.

The Cerrado biome occupies parts of Paraguay, Bolivia, and approximately 24 % of Brazil, encompassing a high phytophysiognomic diversity, that features grassland, savanna and forest vegetation (Buttler *et al.* 2012). The environmental heterogeneity observed throughout its distribution allows for the occurrence of at least 251 species of mammals in this biome, 22 of which are endemic (Gutiérrez and Marinho-Filho 2017). This diversity is under threat due to the high rates of deforestation (Ferreira *et al.* 2017), resulting from the openings of agricultural areas and urbanization, converting the natural landscapes into mosaics with fragments of natural vegetation limited by agricultural activities and urban landscapes (Brady *et al.* 2011).

Although some studies have already been carried out in several areas of the Cerrado, the mammal fauna remains poorly known and poorly documented in many regions of this biome (Oliveira *et al.* 2019). Some of these regions do not even have a list of species, which is necessary to carry out field surveys (Cabral *et al.* 2017). In addition to the list of species occurring in a location, faunal inventories can provide useful information to assess the level of disturbance in an area, given that changes in the species composition of an environment over time can provide clues about the influence of anthropogenic activities on it (Silva and Passamani 2009). Interestingly, even though it appears as the most common contribution in event abstracts, most inventories of mammal fauna are not subsequently published in papers (Brito *et al.* 2009). In general, these studies usually occur in preserved areas, such as conservation units (Carmignotto and Aires 2011).

Among the regions still lacking information about the mammal fauna is the Cerrado in the state of Tocantins. This state has an area of 277,423 km^2, with approximately 72 % of native vegetation preserved and composing one of the largest remnants of the biome in the country (Ministério do Meio Ambiente 2014). Currently, a new agricultural frontier has been established in the Cerrado of the states of Maranhão, Tocantins, Piauí and Bahia (named as MATOPIBA; Pereira *et al.* 2018). In these places, native vegetation is being rapidly replaced by agricultural crops. Some inventories of medium and large mammals in Tocantins were carried out outside of conservation units showing richness between 42 (Mercês *et al.* 2020) and 47 species (Santiago *et al.* 2019). Although these previous studies have sampled some areas across Tocantins, the state has a very large territory most of which remains unexplored. Furthermore, the fieldwork for these surveys took place in 2011 and did not assess the presence of mammals in agricultural areas. In this sense, our study differs from previous surveys and contributes to a better understanding of the mammalian fauna in this state by exploring an unsampled region under the influence of agricultural activities in the municipality of Dueré.

In January 2019, a field survey was carried out for the inventory of medium and large size mammals at São Bento Farm and surrounding areas, in the municipality of Dueré, in the southern region of the state of Tocantins (11° 15' 31.69" S, 49° 44' 16.48" W; Figure 1). The vegetation contains savannas, forests, sporadically flooded grasslands, and *veredas* (palm swamps, *Mauritia flexuosa*; Resende *et al.* 2013). The climate is tropical humid (Aw), according to the Köppen classification (Alvares *et al.* 2013). The predominant land-use in this area is cattle ranching, but grains such as soy and rice are also present.

The inventory was carried out in 7 sampling points. In points 1 and 2, we installed 4 camera traps with movement and heat sensors (Bushnell model 119436) regulated to be active 24 hr and to capture images when triggered. Cameras remained active for a period of 7 days, totaling a sampling effort of 675 hr. Additionally, diurnal and nocturnal active censuses were carried out covering trails and

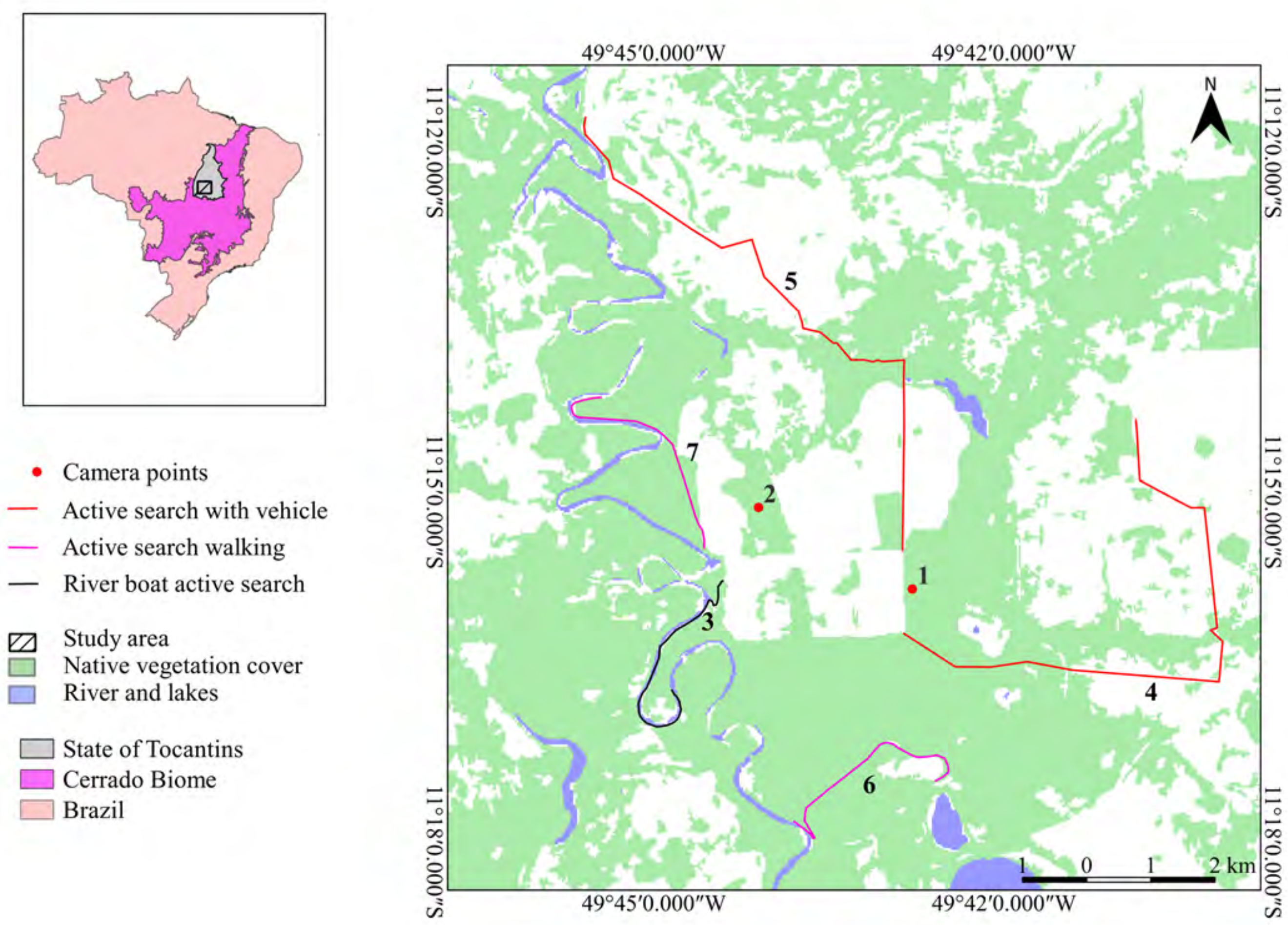

Figure 1. Sampling sites (1-7) and field methods employed at the study area, Farm São Bento, in Dueré, Tocantins, Brazil.

unpaved roads in search of sightings of animals or vestiges, such as tracks or feces, totaling a sample effort of 64 km. The points covered comprised heterogeneous areas, including areas close to crops, flooded grasslands, ponds, riparian forests, legal reserves, and one point in the river, covered using a boat. Point 3 was covered 4 km upstream, and points 4 and 5 were covered with a vehicle, covering 10 km each, on rural roads. In points 6 and 7, we used trails inside agricultural properties, covered by walking, covering 4 km each. The points were sampled sequentially over the field days, and the nocturnal censuses with the aid of a lantern. The relative completeness of the inventory was assessed through the inspection of the topology of cumulative curves using the species number estimator (Jackknife 1) in the EstimateS software (version 9.1, R. K. Colwell, https://www.robertkcolwell.org/pages/estimates).

Twenty-one species of medium and large mammals were recorded, divided into 9 orders and 14 families (Table 1). Among the species recorded, 6 are considered vulnerable and 1 endangered, according to the IUCN classification (2022). The marsh deer (*Blastocerus dichotomus*) was recorded only in wet rice crop areas.

Among the species registered, 26.5 % are classified as VU (Vulnerable), and the giant otter species (*Pteronura brasiliensis*) is classified as EN (Endangered). In one of the sites, the active search was carried out with a boat, having registered some species that presented total or partial foraging in aquatic habitats, such as the grey river dolphin (*Inia araguaiaensis*), giant otter (*P. brasiliensis*) and capybara (*Hydrochoerus hydrochaeris*). The topology of the estimated species' accumulation curves constructed based on our captures does not show an asymptotic tendency, suggesting that the area still has the potential to harbor a higher species richness (Figure 2).

Most species (*n* = 12) were registered exclusively by active search, followed by camera trap captures (Figure 3A-J). Two other species, *Mazama gouazoubira* and *Leopardus pardalis*, were recorded in both survey methods (active search and cameras), emphasizing the importance of diversifying inventory methods (Lyra-Jorge *et al.* 2008).

Although the sampling effort period had been relatively short when compared to other studies, this number of species is high when compared to that reported by Cabral *et al.* (2017) in a private conservation unit in the municipality of Cavalcante, in the state of Goiás, which recorded 16 species; or when compared to the 19 species found by Laurindo *et al.* (2019) in Cerrado fragments under pasture influence, in the state of Minas Gerais. Nogueira *et al.* (2011) also recorded 41 species in mammalian inventories inside of protected areas in Tocantins. A study by Santiago *et al.* (2019), covering several sample sites distributed throughout the state, reported the occurrence of 47 species.

Table 1. Checklist of mammalian species recorded in the municipality of Dueré, Tocantins, Brazil. Conservation status according to the IUCN Red List (2022). IUCN abbreviations: LC = least concern, NT = near threatened, VU = vulnerable, DD = data deficient, EN = endangered, NE = not evaluated.

Order	Family	Scientifc name	Common name	IUCN
Artiodactyla	Cervidae	*Mazama gouazoubira*	Gray Brocket	LC
		Blastocerus dichotomus	Marsh Deer	VU
	Tayassuidae	*Pecari tajacu*	Collared Peccary	LC
		Tayassu pecari	White-lipped Peccary	VU
Carnivora	Felidae	*Panthera onca*	Jaguar	VU
		Leopardus pardalis	Ocelot	LC
	Mustelidae	*Pteronura brasiliensis*	Giant Otter	EN
	Procyonidae	*Procyon cancrivorus*	Crab-eating Raccoon	LC
		Nasua nasua	South American Coati	LC
Cetacea	Iniidae	*Inia araguaiaensis*	Grey river dolphin	NE
Cingulata	Dasypodidae	*Dasypus novemcinctus*	Nine-banded Armadillo	LC
		Priodontes maximus	Giant Armadillo	VU
		Euphractus sexcintus	Yellow Armadillo	LC
Didelphimorphia	Didelphidae	*Didelphis albiventris*	White-eared Opossum	LC
		Philander opossum	Gray Four-eyed Opossum	LC
Perissodactyla	Tapiridae	*Tapirus terrestris*	Brazilian Tapir	VU
Pilosa	Myrmecophagidae	*Myrmecophaga tridactyla*	Giant Anteater	VU
Primates	Atelidae	*Alouatta caraya*	Black-and-gold Howler Monkey	NT
	Cebidae	*Sapajus libidinosus*	Bearded Capuchin	LC
Rodentia	Caviidae	*Hydrochoerus hydrochaeris*	Capybara	LC
	Dasyproctidae	*Dasyprocta azarae*	Agouti	DD

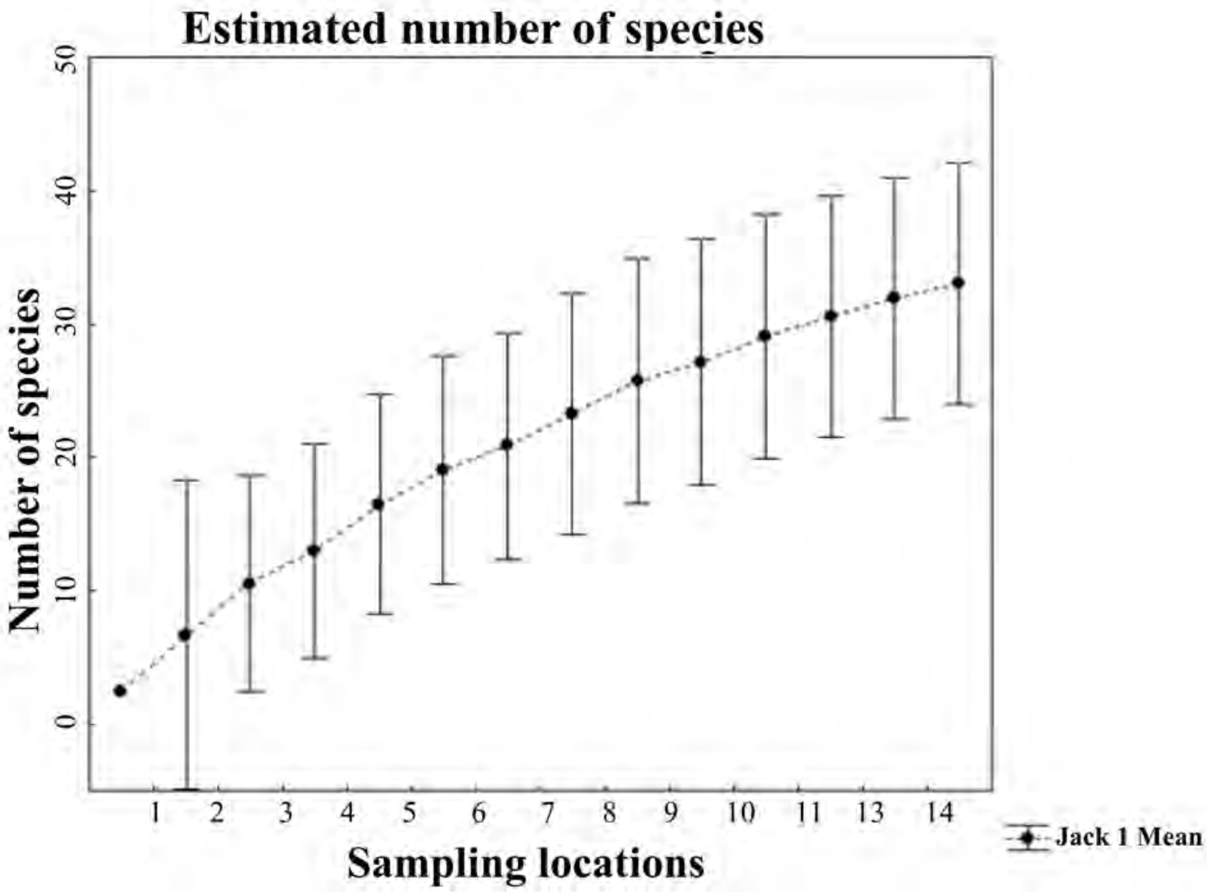

Figure 2. Estimated species accumulation curve (Jackknife1) medium and large mammals in Farm São Bento, in Dueré, Brazil.

Studies carried out in different areas of the Cerrado biome recorded medium and large mammal species ranging from 10 to 39 species (Cabral *et al.* 2017). However, this variation may be a consequence of the different methods (active and passive methods) and sampling effort employed, as well as the different phytophysiognomies assessed in these areas (Bocchiglieri *et al.* 2010). Some species can search for food in anthropic areas to complement their diet with livestock and domestic animals or agricultural crops. As a response to the economic losses caused by these habits, the local population hunts these species, increasing the number of wild animals injured and dead (Cavalcanti and Gese 2010). In the present study, we registered large carnivores, such as *Panthera onca*, in environments inserted in pasture areas. We also recorded large herbivores, such as *B. dichotomus* and *H. hydrochaeris*, in grain crop areas.

It is interesting to note that, in 7 days of sampling, the present study reached 75 % of the number of species observed by Silveira *et al.* (2003), in which 28 species of medium and large mammals were recorded in the Emas National Park, after 44 days of sampling. When compared with data from other surveys of medium and large mammals outside conservation units in Tocantins, our data, collected in a single region, also represent 56.7 % of the richness recorded by Santiago *et al.* 2019, which recorded 37 species at several sample points present throughout the state in a decade of sampling.

Furthermore, it is likely that the number of species in the studied region will increase with a greater sampling effort, as suggested by the diversity estimates and the species accumulation curve that did not reach an asymptote in this period. Because large mammals need larger areas to forage and diversified environments to explore a wide variety of resources (Brady *et al.* 2011), the study area proved to be relatively rich for this group, even with anthropogenic interventions present. Thus, the animals of this region may be undergoing foraging adaptations or may be at greater risk to inhabit these anthropic environments (Shamoon *et al.* 2018).

We observed *B. dichotomus* only in rice crop fields, recording several individuals in this type of environment, which may suggest this species is using these flooded fields because they resemble swampy areas and provide food

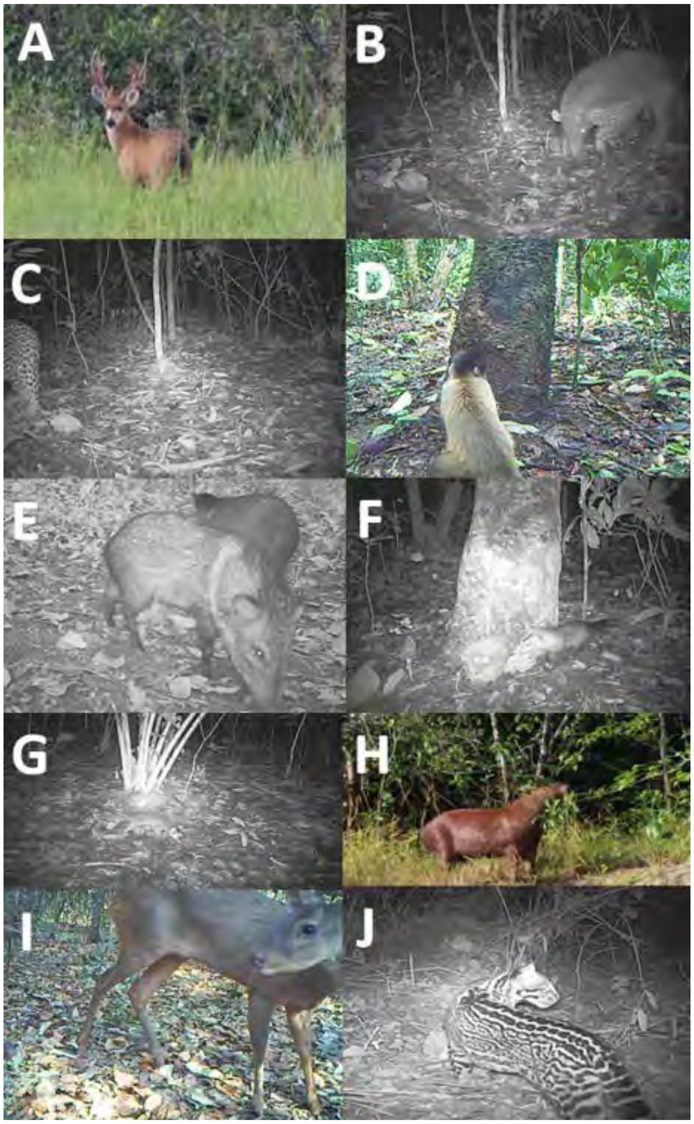

Figure 3. Some medium and large mammals recorded in the municipality of Dueré, state of Tocantins, Brazil. A) *Blastocerus dichotomus,* B) *Priodontes maximus*, C) *Panthera onca*, D) *Sapajus libidinosus*, E) *Pecari tajacu*, F) *Didelphis albiventris*, G) *Philander opossum*, H) *Hydrochoerus hydrochaeris*, I) *Mazama gouazoubira*, J) *Leopardus pardalis*.

resources. Actually, the matrix effect can benefit some species (Borges-Matos *et al.* 2016). We observed that 7 of the species recorded are classified within some threaten category (IUCN 2022), drawing attention to the need for conservation measures. Some of these species face conflicts with the local population and agricultural activities, such as *P. brasiliensis* (Rosas-Ribeiro *et al.* 2011) and *Panthera onca* (Zimmermann *et al.* 2005). However, the presence of these top-chain predators (Ripple *et al.* 2014), together with game species, such as *Priodontes maximus* (Desbiez and Kluyber 2013) and large seed dispersers such as *Tapirus terrestris* (O'Farrill *et al.* 2013) and *Tayassu pecari* (Keuroghlian and Eaton 2008), play important roles in the ecosystem balance, reinforcing the importance of the studied area. Further studies and field efforts in the region are necessary for a deeper analysis of its mammalian diversity, as well as its potential relevance for the biodiversity of Tocantins and the Cerrado biome.

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Predation attempt by a long-tailed weasel *Neogale frenata* on a *Holcosus gaigeae* lizard

Intento de depredación de la comadreja de cola larga *Neogale frenata* sobre la lagartija *Holcosus gaigeae*

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The long-tailed weasel, *Neogale frenata*, is a small mammal occurring from southern Canadá to northern South America, whose diet consists mainly of small mammals, and occasional consumption of reptiles. We herein describe the attempted predation by a *N. frenata* on a *Holcosus gaigeae* lizard. Our observation was made during an *ad libitum* bird watching in the municipality of Felipe Carrillo Puerto, Quintana Roo, México. Two events were recorded in which the weasel was observed approaching the lizard, trying to position itself for an approach from behind and actively chasing it around. This predation behavior coincides with previously reported hunting strategies for *N. frenata* for medium-sized prey and represents the first record of interaction between these 2 species.

Key words: Predation behavior; predator; prey; trophic ecology; Yucatán Peninsula.

La comadreja de cola larga, *Neogale frenata* es un mamífero pequeño que se distribuye desde el sur de Canadá hasta el norte de Sudamérica, cuya dieta consiste principalmente de pequeños mamíferos, alimentándose ocasionalmente de reptiles. En este documento se describe el intento de depredación de *N. frenata* sobre la lagartija *Holcosus gaigeae*. La conducta se registró durante un recorrido de observación de aves en el municipio de Felipe Carrillo Puerto, Quintana Roo, México. Se registraron 2 eventos en los que se observó a la comadreja tratar de posicionarse atrás de la lagartija para aproximarse y perseguirla activamente. Este comportamiento de depredación coincide con las estrategias de caza reportadas previamente para *N. frenata* para presas de tamaño mediano y representa el primer registro de interacción entre estas 2 especies.

Palabras clave: Comportamiento de depredación; depredador; ecología trófica; Península de Yucatán; presa.

The long-tailed weasel, *Neogale frenata*, is a small-sized mustelid mammal (300 - 550 mm, with males larger than females) that occurs consistently from southern Canadá to northern South America. The tail is thin and almost the same length as the body. Its coloration is light or orange-brown in the dorsum with a cream-colored venter, it has a yellow spot on the chest, the tip of the tail is black, and on the face it has a white mask bordered by black. Inhabits tropical dry and evergreen forests, xerophytic scrubs, grasslands, coniferous forests, and moorlands at altitudes from sea level to about 4,200 m (Sheffield and Thomas 1997; Ceballos and Oliva 2005). In the Mexican Yucatán Peninsula, this species has been registered in all 3 states (Campeche, Quintana Roo and Yucatán) in flooded, deciduous, semideciduous, and evergreen forests, and secondary vegetation (Sosa-Escalante *et al.* 2013; Contreras-Moreno *et al.* 2015).

Neogale frenata is a generalist predator, with a diet mainly focused on small mammals (species from the orders Chiroptera, Eulipotyphla, Rodentia, Lagomorpha). However, this species has been registered to feed on other taxa, including beetles, grasshoppers, and other insects; small vertebrates such as birds and their eggs (from the orders Anseriformes, Galliformes, Passeriformes, Piciformes) and even carrion (Sheffield and Thomas 1997; Muths 1998; Ceballos and Oliva 2005; Pasch and Pino 2013; Proulx 2019; Troy and Conover 2019; Vaca-León *et al.* 2019), if the abundance of their preferred mammalian prey is low. Regarding herpetofauna prey, although this species has been registered feeding upon salamanders, snakes (*Lampropeltis* spp., *Pituophis* spp.) and lizards, these records are considered uncommon (Sheffield and Thomas 1997).

The lizard *Holcosus gaigeae* is part of the rainbow ameiva (*Holcosus undulatus*) complex, a species group distributed throughout the lowlands of México to Costa Rica (Meza-Lázaro and Nieto-Montes de Oca 2015). *Holcosus gaigeae* is a diurnal lizard of moderate body size (snout-vent length -SVL- ranging from 80 to 130 mm, tail length more than twice SVL) and endemic to the Mexican portion of the Yucatán Peninsula (Lee 1996; González-Sánchez *et al.* 2017). Species specific knowledge of its biology is still limited for *H. gaigeae*, mainly due to its recent separation from *H. undulatus*; however, it is known that it feeds mainly on small invertebrates (insects and arachnids), and some specific observations on its reproduction and predation were already made (Nahuat-Cervera and Pérez-Martínez 2021).

Occasional events of predation of *Holcosus* lizards have been recorded in the Yucatán Peninsula, mainly by Colubridae, Dipsadidae and Elapidae snakes (Gómez de Regil and Escalante-Pasos 2017; Carbajal-Márquez *et al.* 2019). Other predators include wolf spiders (Lycosidae), birds of prey (Accipitriformes) and feral cats (Nahuat-Cervera *et al.* 2020; Nahuat-Cervera and Pérez-Martínez 2021). We herein describe the attempted predation by a *N. frenata* on a *Holcosus gaigeae* lizard.

The area of the observation event took place on a dirt road surrounded by semi-deciduous tropical forest and secondary vegetation 3.3 km east from the Señor community (19° 50′ 26″ N, 88° 06′ 10″ W, WGS 84, 27 m) in the Municipality of Felipe Carrillo Puerto, Quintana Roo, México. On 1 July 2018 at 09:16 hr, during a birdwatching tour, we observed an adult *N. frenata* chasing an adult male *H. gaigeae*.

At this first observation event, the lizard rapidly crossed the road while being chased by the *N. frenata* and entered the dense vegetation at the other side. The weasel did not dive into the vegetation in pursuit but rather held on the edge of the vegetation and began to walk and sniff alongside the road.

A second observation event took place a few minutes after the first and while *N. frenata* was still walking over the road, what we assumed to be same *H. gaigeae* exited the forest around 3 meters from the original entry point, crossed the road again in the opposite direction and stopped in the middle. *Neogale frenata* noticed the lizard coming out cautiously started to walk towards it (the lizard was standing at this point) and tried to position itself for an approach from behind (Figure 1A-C). As the weasel slowly approached the lizard, the latter slowly flattened its body, possibly (we think) with the intention of going unnoticed. Once *N. frenata* was approximately 40 cm away from *H. gaigeae*, the lizard fled in our direction (Figure 1D) for approximately 7 meters and then darted sideways into the dense vegetation by the road. The weasel repeated its previous behavior of walking and stopping while sniffing the road's edges. Approximately 4 minutes afterward the weasel seemed to give up and enter the forest in the opposite side of the road to where the lizard was.

Figure 1. Attempted predation of *Holcosus gaigeae* by *Neogale frenata*. A-B) Approach of the long-tailed weasel to the lizard, C) its positioning behind it, and D) the chase.

The occasional observations of the different species contribute to the knowledge of the biology and natural history of the wildlife mammals; for example, the rediscovery of *Lepus altamirae* after a century from its description (Silva-Caballero and Rosas-Rosas 2022). Due the records of *N. frenata* preying on herpetofauna are not common (Sheffield and Thomas 1997), the observation reported in this manuscript contributes to the knowledge about the consumption of reptiles by this mammal.

The behavior exhibited by *N. frenata* coincides with the hunting strategies described for the species while hunting above-ground for small and medium-sized prey (which when captured are usually subdued and killed by biting the back of the neck; Sheffield and Thomas 1997). As highlighted in Figure 1, *H. gaigeae* can be considered a medium-sized prey in relation to the own body size the *N. frenata*, and as such the weasel sought to position itself behind the lizard likely attempting an undetected approach to bite its prey on the back of the neck. To our knowledge, this observation represents the first interaction record between these 2 species, thus providing valuable information on their natural history, particularly for *H. gaigeae*.

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The low chromosome number of a relict shrew (*Cryptotis magnus*) isolated in a cloud forest of México

El bajo número cromosómico de una musaraña relicto (*Cryptotis magnus*) aislada en un bosque mesófilo de México

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To know and conserve Mexican shrews it is necessary to know them well, although their taxonomic identification is difficult. However, cytogenetic tools can help to discriminate species. There are no known karyotypes of Mexican shrews, so we decided to initiate the study of their chromosomes starting with *Cryptotis magnus*. Shrews were collected in the cloud forest of Oaxaca and chromosomal metaphases were prepared from bone marrow, stained with Giemsa, examined microscopically, and photographed. Chromosomes were examined and counted to calculate the $2n$, determine their morphology, and estimate the FN; finally, a karyotype was prepared. Specimens of *C. magnus* were cataloged in the Colección Nacional de Mamíferos, Instituto de Biología, UNAM. Results showed numerous metaphase cells and conspicuous chromosomes. The diploid chromosome number found was $2n = 26$, consisting of 24 biarmed autosomal chromosomes (18 metacentric and 6 submetacentric) and 2 sex chromosomes (X: large subtelocentric; Y: small telocentric). Adding the number of chromosome arms of the autosomes the resulting FN was 48. The chromosomal complement of *C. magnus* is distinctive and its $2n$ is one of the smallest in the family Soricidae. The current conformation of its chromosomal profile may have originated from Robertsonian chromosomal rearrangements that reduced the ancestral $2n$ (46) to $2n = 26$ producing autosomes of biarmed morphology. Geographic isolation in a small geographic region of Oaxaca may have facilitated this evolutionary process.

Key words: Cytogenetics; Eulipotyphla; Evolution; karyotype; New World; Oaxaca; Soricidae.

Para conocer y conservar a las musarañas mexicanas es necesario conocerlas bien, aunque su identificación taxonómica es difícil. Sin embargo, las herramientas citogenéticas pueden ayudar a discriminar las especies. No se conocen cariotipos de musarañas de México, por lo que decidimos iniciar el estudio de sus cromosomas comenzando con *Cryptotis magnus*. Se colectaron musarañas en bosque de niebla de Oaxaca y se prepararon metafases cromosómicas de médula ósea, se tiñeron con Giemsa, se examinaron microscópicamente y se fotografiaron. Se contaron los cromosomas para calcular el $2n$, se determinó su morfología, se estimó el FN y se elaboró un cariotipo. Los especímenes de *C. magnus* fueron catalogados en la Colección Nacional de Mamíferos, Instituto de Biología, UNAM. Los resultados mostraron numerosas células metafásicas y cromosomas conspicuos. El número cromosómico diploide encontrado fue de $2n = 26$, formado por 24 cromosomas autosómicos birrámeos (18 metacéntricos y 6 submetacéntricos) y 2 cromosomas sexuales (X: subtelocéntrico grande; Y: telocéntrico pequeño). Sumando el número de brazos cromosómicos de los autosomas el número fundamental (FN) resultante es 48. El complemento cromosómico de *C. magnus* es distintivo y su $2n$ es uno de los más pequeños de la familia Soricidae. La conformación actual de su perfil cromosómico puede haberse originado a partir de reordenamientos cromosómicos Robertsonianos que redujeron el $2n$ ancestral (46) a $2n = 26$ produciendo autosomas de morfología birrámea. El aislamiento geográfico en una pequeña región geográfica de Oaxaca puede haber facilitado este proceso evolutivo.

Palabras clave: Cariotipo; Citogenética; Eulipotyphla; Evolución; Nuevo Mundo; Oaxaca; Soricidae.

Shrews (Soricidae) are small mammals widely distributed in most terrestrial ecosystems in México, belong to one of the orders (Eulipotyphla) with the highest number of species (Sánchez-Cordero *et al.* 2014) and have phylogenetic importance as they conserve the morphotype of primitive mammals. In addition, they play an important ecological role as both predators of many invertebrates and prey of reptiles, birds, and mammals. Over half of Mexican shrew species are endemic and listed in some risk category (Guevara *et al.* 2015). Therefore, they are an important component of Mexican biodiversity that should be studied and protected. However, shrews are little studied since it is infrequent to observe them alive in their natural environment; but mainly because it is not easy to collect them in the field. Likewise, their taxonomic identification is problematic even for specialists, since most of them are usually highly similar in morphology.

Historically, cytogenetic approaches have been used as additional tools to complement the taxonomic identification of mammals (Genoways *et al.* 2020). This perspective provides a complementary view of the degree of chromosomal differentiation between taxa, allowing taxonomic boundaries and phylogenetic relationships to be hypothesized (Graphodatsky *et al.* 2011; Biltueva and Vorobieva 2012). To this end, the representation of the chromosomal pattern of a species or karyotype has proven to be a useful and important tool in characterizing cytogenetic attributes that help distinguish different species of mammals (Levan *et al.* 1964).

Unfortunately, the karyotype of only 3 of the 42 shrew species currently recognized for México is known, but no specimen examined so far has come from Mexican territory. Therefore, to begin to fill this gap in the cytogenetic knowledge of Mexican soricids, we studied the karyotype of the big Mexican small-eared shrew (*Cryptotis magnus*), a member of the *C. mexicanus* species group characterized by its relatively large size compared to other *Cryptotis* from North America (He *et al.* 2021). It has a very restricted distribution in the north-central part of the state of Oaxaca, in southern México, and inhabits the cloud forest between 1,200 and 3,000 m (Carraway 2007; Guevara *et al.* 2015). Its long tail and primitive cranial and dental characteristics would seem to indicate that *C. magnus* is the only surviving representative of an ancient lineage (Choate 1970). The Mexican government and the IUCN classify this small mammal in the risk categories "under special protection" and "vulnerable", respectively (Cuarón and de Grammont 2018; Trujillo Segura 2019).

Specimens of shrews were collected in the vicinity of the village Santa Catarina Ixtepeji (17° 13' 18" N, 96° 35' 2" W), municipality Santa Catarina Ixtepeji, Oaxaca, México, at 2,304 m (Figure 1). The climate is temperate sub-humid (Instituto Nacional de Estadística y Geografía; INEGI 2013) with an average annual temperature of 12.8 °C and average annual precipitation of 1,299 mm (Fick and Hijmans 2017). The typical vegetation of the place is cloud forest characterized by the presence of the oak *Quercus* aff. *laurina* (Zacarías-Eslava and del Castillo 2010).

Shrews were trapped using pitfall traps (Martin *et al.* 2011) placed in patches of preserved forest and prepared in a conventional way for scientific study (Hall 1981). We

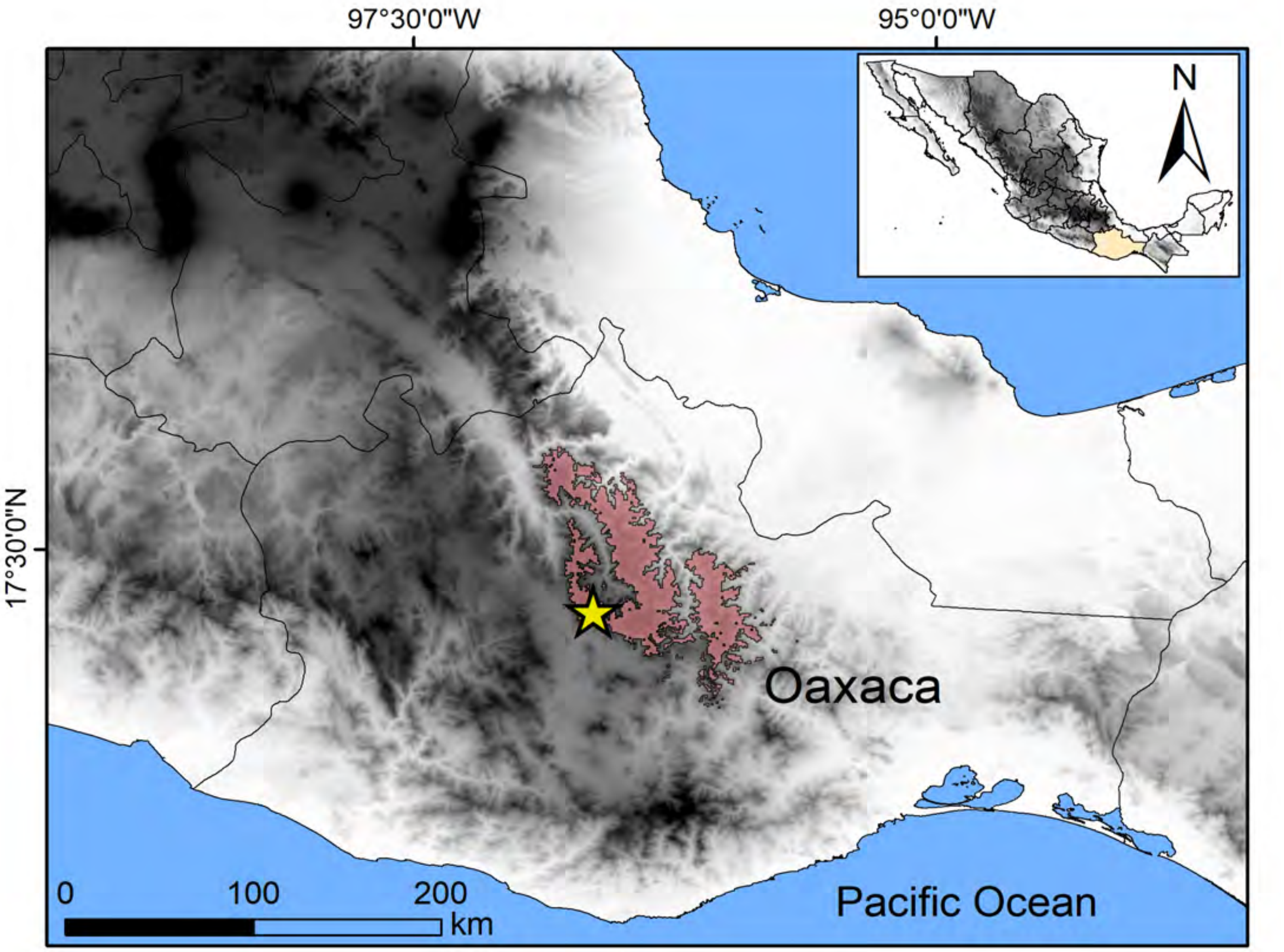

Figure 1. Potential geographic distribution of the big Mexican small-eared shrew (*Cryptotis magnus*; modified from Sánchez-Cordero *et al.* 2013). The yellow star indicates the site where specimens to prepare karyotypes were collected.

followed conventional guidelines for using wild mammals in research (Sikes *et al.* 2016) and regulations of a collecting permit of the Mexican government (FAUT-0002). Taxonomic identity of the specimens was confirmed using identification guides by Carraway (2007) and Álvarez-Castañeda *et al.* (2017).

Metaphase chromosomes of the shrews were obtained from bone marrow cells following procedures by Patton (1967) and Baker *et al.* (2003) with modifications. The entire procedure for obtaining cell samples was performed in the field.

Briefly, cell samples from each specimen were extracted from bone marrow perfused from the femur with an insulin syringe (27G x 13 mm) and 3 ml of RPMI-1640 transport medium (Sigma-Aldrich); the mixture was collected in a sterile 15 ml centrifuge tube (Eppendorf) and vigorously mixed to homogenize; 0.2 ml colchicine (Sigma, 0.05 µg/ml final concentration) was added, mixed again and incubated at 37 °C for 45 min, after which 5 ml of hypotonic solution (0.05 M KCl, Merck) was added, and incubated again at 37 °C for 30 min. After that, 1 ml of cold fixative solution (methanol / glacial acetic acid, 3:1 v/v, JT Baker) was added to the suspension for prefixation; the blend was homogenized and allowed to stand for 3 min. The sample was then centrifuged for 5 min at 1,000 rpm in a manual centrifuge; the supernatant was removed, and the blend was re-suspended. Finally, 5 ml of fixative solution was added, and the mixture was homogenized. At last, slides were prepared to obtain chromosomal metaphases conventionally stained with 2.5 % Giemsa (Sigma; Baker and Qumsiyeh 1988).

Chromosomes were searched for in the slides with a Zeiss Axioskop optical microscope at 10X and 40X and photographed at 100X with a Zeiss Axiocam Erc5s digital camera and the Zen lite software. Counts were made from the photographs to determine the diploid chromosome number (2*n*) and the morphological characterization (long arm and short arm measurements) of the chromosomes to classify them and determine the fundamental number (FN); then, a karyotype was elaborated based on the position of the centromere and size of the chromosomes (Levan *et al.* 1964; Baker and Hafner 1994).

Specimens of *C. magnus* from which the karyotype was obtained were cataloged in the National Collection of Mammals (CNMA) of the Institute of Biology, National Autonomous University of México as follows: CNMA49304-49307, 9.3 km SW Santa Catarina Ixtepeji; CNMA49308-49309, 9.7 km SW Santa Catarina Ixtepeji; CNMA49310-49312, 10.7 km SW Santa Catarina Ixtepeji; CNMA49313, 11.5 km SW Santa Catarina Ixtepeji; CNMA49314-49316, 11.8 km SW Santa Catarina Ixtepeji.

We obtained many metaphase cells from the cell samples of *C. magnus*. Eight metaphases useful for chromosome counting were selected as they showed acceptably separated and dispersed chromosomes (Figure 2a). The total number of chromosomes per metaphase counted for this species was 24 autosomes (non-sex chromosomes) and two sex chromosomes (X and Y), thus, its 2*n* = 26. All autosomes are biarmed (with 2 chromosome arms each), of which 18 are metacentric and 6 submetacentric. Therefore, the autosomal fundamental number (FN), or summation of all chromosome arms of the autosomes, is 48. The sex chromosome pair comprises a large biarmed subtelocentric and a small uniarmed telocentric (with only one chromosome arm; pair 13; Figure 2b). Of the 26 chromosomes, the longest length was 8.7 µm and that of the smallest was 1.5 µm.

Although there is scant comparative information in the literature, the chromosomal complement of *C. magnus* is quite distinctive, including that its 2*n* (26) is one of the lowest known so far (Table 1). The only other known cytogenetic study in this genus of soricids concerns a specimen of *C. parvus* from central Texas (Genoways *et al.* 1977). Its reported 2*n* was 52, twice that of *C. magnus*, the low chromosome number of a relict shrew (*C. magnus*) isolated in a cloud forest of México with all autosomes of the uniarmed

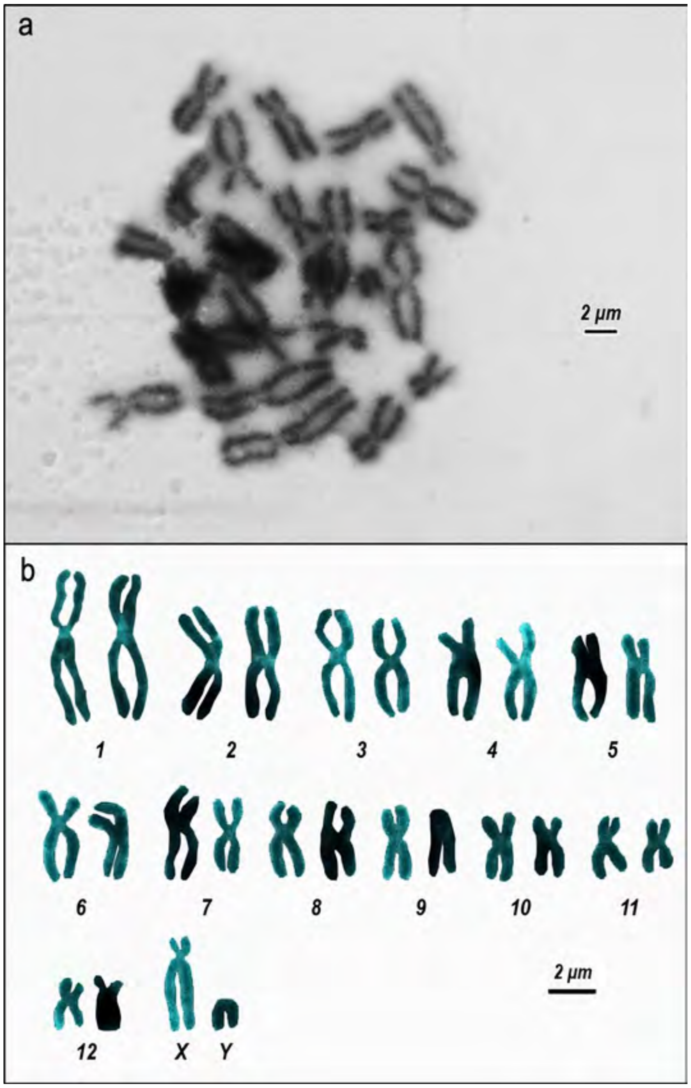

Figure 2. Chromosomes of a male big Mexican small-eared shrew (*Cryptotis magnus*; CNMA_ 49306). a) Metaphase viewed photomicroscopically at 100x. b) Karyotype (2*n* = 26 and FN = 48) showing chromosome morphology of the 24 biarmed autosomes and the sex chromosome pair (X and Y).

Table 1. Diploid chromosome number (2*n*) and fundamental number (FN) of shrew species (Eulipotyphla, Soricidae), and geographical area from which the reported karyotype was obtained.

Species	2*n*	FN	México	USA	Old World	Literature source
Cryptotis magnus	26	48	X			Present study
Cryptotis parvus	52	-		X		Genoways *et al.* (1977)
Sorex ornatus	54	-		X		Owen and Hoffmann (1983)
Sorex monticolus	54	-		X		Smith and Belk (1996)
Notiosorex crawfordi	34	38		X		Baker and Hsu (1970)
Sorex cinereus	66	70		X		Volobouev and Jong (1994)
Sorex haydeni	64	66		X		Volobouev and Jong (1994)
Sorex merriami	32	34		X		Rausch and Rausch (2004)
Sorex pacificus	54	58-59		X		Carraway (1985)
Sorex trowbridgi	34	38		X		Rausch and Rausch (2004)
Sorex vagrans	54	58		X		Owen and Hoffmann (1983)
Blarina hylophaga	52	60-62		X		George *et al.* (1982)
Blarina brevicauda	48-50	48		X		George *et al.* (1982)
Blarina carolinensis	34-52	41-62		X		George *et al.* (1982)
Sorex alpinus	56	54			X	Lukacova *et al.* (1996)
Sorex granarius	36-37	-			X	Biltueva and Vorobieva (2012)
Sorex araneus	20-50	-			X	Biltueva and Vorobieva (2012); Wójcik *et al.* (2003)
Blarinella griselda	44	-			X	Biltueva and Vorobieva (2012)
Crocidura watasei	26	56			X	Biltueva *et al.* (2001)
Crocidura dsinezumi	40	56			X	Biltueva *et al.* (2001)
Crocidura suaveolens	40	50			X	Biltueva *et al.* (2001)
Suncus murinus	40	56			X	Biltueva *et al.* (2001)

type, whereas those of *C. magnus* are all biarmed. Yet, the variation in autosome size in *C. parvus* (from 1 large pair to several small pairs) is proportionally greater than that observed in *C. magnus*. Also, the sex chromosomes of these species show some minor differences. In contrast to *C. magnus*, *C. parvus* has a large metacentric X chromosome and a small subtelocentric chromosome.

The karyotype of *Blarina*, sister genus to *Cryptotis* in the tribe Blarinini (Woodman 2018), also shows similar differences with *C. magnus*. *Blarina brevicauda* in Nebraska and Pennsylvania has a 2*n* of 49 or 50 (Genoways *et al.* 1977), whereas *B. carolinensis* in Nebraska and Kansas has a 2*n* of 52. In both species, the X chromosome is also a large metacentric and the Y chromosome is a small acrocentric. The FN of the above 3 species (*C. parvus* = 50, *B. brevicauda* = 48, and *B. carolinensis* = 62) are distinct due to their differences in the number of biarmed and uniarmed elements.

As to the cytogenetics of the 5 shrew species of the tribe Notiosoricini (genera *Megasorex* and *Notiosorex*), endemic to México and the USA, only *N. crawfordi* is known to have a 2*n* of 68 (FN = 102) and 62 (FN = 94), in Texas and Arizona, respectively (Baker and Hsu 1970). These diploid chromosome numbers also double that reported here for *C. magnus*.

The shrew genus *Sorex* is holarctic in distribution. Of the 49 New World species of *Sorex* (Woodman 2018), 16 inhabit México (Guevara *et al.* 2015), of which only the 2*n* (= 54) of *S. ornatus* and *S. monticola* are known (Table 1); however, the reported specimens correspond only to American localities. On the other hand, it is interesting that *S. merriami* and *S. trowbridgii* have 2*n* = 32 and 34, respectively, numbers close to, but even higher than, those of *C. magnus*.

On the other hand, the 2*n* of *C. magnus* is far from the ancestral mammalian karyotype of 2*n* = 46 proposed by Ferguson-Smith y Trifonov (2007). Therefore, several chromosomal rearrangements were required to reduce its 2*n* to 26. Chromosome numbers can increase or decrease by chromosome fission or fusion (Robertsonian events), respectively (Zima 2000), as has been documented in the chromosomal evolution of Eulipotyphla (Biltueva and Vorobieva 2012), suggesting that chromosomal variation may contribute to speciation. *Cryptotis magnus* had been considered a relict species geographically isolated in a relatively small region of the cloud forest of northern Oaxaca, México (Choate 1970). However, its karyotype suggests a chromosomal set with a remarkable number of changes. Whether centromeric fusion events in the chromosomal complement of *C. magnus* resulted in a shrew species with one of the lowest known chromosomal numbers accompanied of biarmed autosomes after geographic isolation remains to be investigated.

Our research is the first cytogenetic study of a shrew species from Mexican territory. We hope this result will promote research on the karyotypes of the other 41 recognized species of Mexican shrews to know and interpret the intra- and interspecific similarities and differences among soricid species of the New World. Chromosomal studies are still an important tool to record and describe biological diversity and often represent a simple and indispensable method for identifying various taxa (Zima 2000; Biltueva and Vorobieva 2012), and the elucidation of their phylogenetic relationships (Biltueva *et al.* 2001).

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Distribution extension of a rare species, *Eumops auripendulus* in the province of Santa Fe, Argentina

Extensión de la distribución de una especie rara, *Eumops auripendulus* en la provincia de Santa Fe, Argentina

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The presence of *Eumops auripendulus* (Chiroptera, Molossidae) in the province of Santa Fe, Argentina, is recorded. Until now, this species in Santa Fe was known from a single record from Esperanza in 1978. A new specimen was obtained in the town of Florencia, located about 400 km NE of Esperanza, near the border with the province of Chaco. This new record corresponds to an animal that was found dead and sent to the Laboratorio Central de la Dirección General de Bioquímica y Farmacia of Santa Fe in 2019 as part of the rabies virus surveillance protocol. The species was identified based on its morphometric variables and its general aspect. On the other hand, its geographical location was plotted on a map together with the rest of the records of this species in the country; the ecoregional context was also considered. This new record confirms the current presence of the species in the province and helps to clarify its geographic distribution range as well as its ecological preferences, considering that both localities are situated in different ecoregions: Espinal (Esperanza) and Humid Chaco (Florencia). It is important to mention that *E. auripendulus* has been poorly studied in Argentina, being known only from 10 records in 3 provinces: Chaco, Misiones, and Santa Fe.

Key words: Argentina; New record; Santa Fe; Shaw's Mastiff Bat.

Se registra la presencia de *Eumops auripendulus* (Chiroptera, Molossidae) en la provincia de Santa Fe, Argentina. Hasta ahora, esta especie era conocida en la provincia de Santa Fe a partir de un solo registro en la localidad de Esperanza en 1978. Se obtuvo un nuevo ejemplar en la localidad de Florencia, ubicada a unos 400 km al NE de Esperanza, cerca del límite con la provincia del Chaco. Este nuevo registro corresponde a un animal encontrado muerto y enviado al Laboratorio Central de la Dirección General de Bioquímica y Farmacia de Santa Fe en 2019 como parte del protocolo de vigilancia del virus de la rabia. La especie fue identificada con base en sus variables morfométricas y por su aspecto general. Por otro lado, la ubicación geográfica del registro fue trazada en un mapa junto al resto de los registros de la especie en el país; también se consideró el contexto ecorregional. Este nuevo registro confirma la presencia actual de la especie en la provincia y ayuda a esclarecer su rango de distribución geográfica así como sus preferencias ecológicas, considerando que ambas localidades se encuentran en diferentes ecorregiones: Espinal (Esperanza) y Chaco Húmedo (Florencia). Es importante mencionar que *E. auripendulus* ha sido poco estudiada en Argentina, siendo conocida a partir de 10 registros en 3 provincias: Chaco, Misiones y Santa Fe.

Palabras claves: Argentina; nuevo registro; Santa Fe; moloso oscuro.

Santa Fe province occupies the central region of Argentina. It covers an area of 132,638 km^2 and includes 5 ecoregions: Humid and Dry Chaco, Espinal, Pampas, and Delta and Islands of Paraná (Burkart *et al.* 1999; Biasatti *et al.* 2015). Out of the 69 species of bats recorded in Argentina (Barquez and Díaz 2020; Montani *et al.* 2021; Novaes *et al.* 2022), 28 (40 %) are found in the province of Santa Fe (Barquez and Díaz 2020; Montani *et al.* 2021; Pavé *et al.* 2021; Pavé and Gavazza 2022).

Among the molossid bats, the genus *Eumops* Miller, 1906, is the most diverse in the New World, exhibiting many shapes and sizes (Eger 1977) in its 17 recognized species (Gregorin *et al.* 2016). Sixteen of these are found in the Neotropics (Eger 2007; Díaz *et al.* 2021), all of them are fast-flying insectivorous species that forage above the forest canopy (Sodré *et al.* 2008), and occupies a wide range of environments, from natural to urban (Eger 1977; Best *et al.* 2002).

Within the genus *Eumops*, species can be divided into small, medium, and large, according to their body size (Gregorin *et al.* 2016). In Argentina, this genus is represented by 6 species; small: *E. bonariensis* (Peters, 1874) and *E. patagonicus* Thomas, 1924; medium: *E. auripendulus* (Shaw, 1800) and *E. glaucinus* (Wagner, 1843); large: *E. dabbenei* Thomas, 1914 and *E. perotis* (Schinz, 1821).

Eumops auripendulus is distributed in Argentina, Brasil, Bolivia, Colombia, Ecuador, French Guiana, Guyana, Paraguay, Perú, Surinam, and Venezuela (Díaz *et al.* 2021). Two subspecies are currently recognized, *E. a. auripendulus* distributed from central Bolivia northward to Central America, and *E. a. major*, in eastern Brazil, southern Paraguay, and northeastern Argentina (Eger 1977, 2007; Barquez *et al.* 1999, Best *et al.* 2002; Barquez and Díaz 2020).

In Argentina, *Eumops auripendulus* is poorly known due to the scarcity of available data, with only 10 historical records from 3 provinces: Chaco, Misiones, and Santa Fe, comprising 3 ecoregions, respectively: Delta and Islands of Paraná, Paranaense Forests, and Espinal (Burkart *et al.* 1999; Morello *et al.* 2018). In Chaco it was collected in the town of Resistencia in 1937 (*n* = 1; pers. comm. I. Olivares); in Misiones (*n* = 8), 2 specimens in Campo Viera locality in 1968, 1 specimen from an unknown locality in 1968, 1 specimen in Bompland locality in 1969, 3 specimens in Colonia Mártires locality in 1969, and 1 specimen in El Dorado locality (prior to 1974; pers. comm. S. Bogan and B. K. Lim); and 1 specimen in the town of Esperanza in Santa Fe (*n* = 1; pers. comm. P. Teta; Figure 1).

Besides its medium body size within the genus, there are other morphological features that characterize this species. Ranging between 61 to 69 mm (Barquez *et al.* 1999), the length of the forearm of *E. auripendulus* is similar to that of the other medium-sized species present in Argentina, such as *E. glaucinus* (between 61-68 mm), but the darker pelage and membranes of the former, easily differentiates it from the latter. The dorsal pelage is blackish brown or blackish cinnamon, with hairs lighter at their bases (Barquez *et al.* 1999; Best *et al.* 2002).

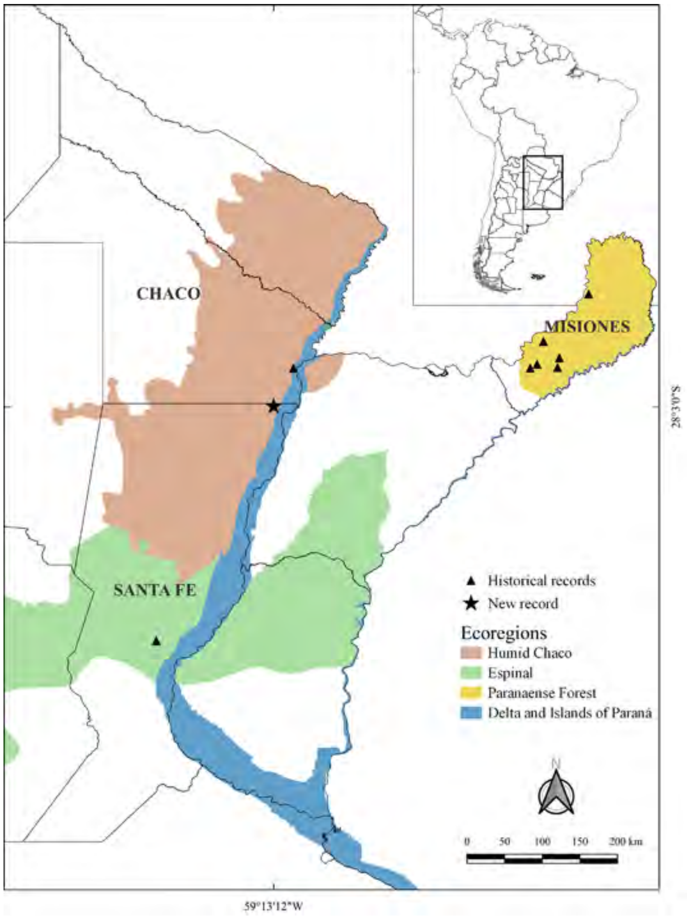

Figure 1. Records of *Eumops auripendulus* from Santa Fe province, Argentina. Triangles = records listed in Barquez and Díaz (2020); star = new locality (Florencia, General Obligado department, Santa Fe province).

The previous locality cited of *E. auripendulus* in Santa Fe province (Esperanza) corresponds to the Espinal ecoregion, characterized by a flat to slightly undulating lowland landscape, composed of low and non-stratified xerophytic forests, savannas, and grasslands, which have now been largely replaced by croplands. This zone of the ecoregion has a humid temperate plain climate, characterized by abrupt weather changes, and cold air saturated with moisture (Burkart *et al.* 1999; Matteucci 2018).

The specimen was collected on May 14, 1978, by the Instituto de Virología de Córdoba and deposited in the Mammals collection of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN-Ma 16547; Teta and Rodríguez 2021).

Eumops auripendulus was globally categorized as Least Concern (LC; Barquez *et al.* 2015), while at local scale, the species was categorized as Data Deficient (Díaz and Barquez 2019), due to the scarcity of records as mentioned above.

The specimen was collected on December 3, 2019 by personnel of the Central Laboratory of the Dirección General de Bioquímica y Farmacia of Santa Fe and donated to the Museo Provincial de Ciencias Naturales "Dr. Ángel Gallardo" (MG-ZV-M), Rosario, Argentina. The specimen was stored in the mammal collection in accordance with a license to collect dead animal and their parts granted by the Ministerio de Ambiente y Cambio Climático of Santa Fe (Resolution Nº 466/2019). It was preserved as stuffed skin, skull, and complete skeleton.

Because the specimen was previously dissected to extract brain samples for rabies virus analysis, some measurements of the skull, such as the height of the sagittal crest, were missing. External and cranial measurements were taken following Barquez *et al.* (1999, 2021), systematic identification followed Díaz *et al.* (2021) and description followed Barquez *et al.* (1999) and Best *et al.* (2002).

The new record of *E. auripendulus* comes from Florencia city (28º 3′ 0″ S; 59º 13′ 12″ W; 54 m). This locality is included in the Humid Chaco ecoregion (Burkart *et al.* 1999), subdivision Complejo Dorsal Oriental. The climate is sub-humid with low thermal amplitude. The annual mean precipitation ranges from 1000 - 1050 mm and the annual mean temperature is 18 °C. Different types of vegetation alternate in the region: floodable palm groves of *Copernicia alba* (Aracaceae), forests of *Schinopsis balansae* (Anacardiaceae; willow-leaf red quebracho or Quebracho Colorado) and ancient floodplain xeric forests (Rodríguez *et al.* 2018).

The specimen (MG-ZV-M:415) was an adult female (Anthony 1988; Brunet-Rossinni and Austad 2004), with perforated vagina ([Barquez *et al.* 2021](#)), active mammary glands, and distended uterus at the time of dissection. The distinctive character of this species is the length of the forearm, which reaches 68.20 mm (Table 1). The general coloration is blackish brown and membranes are dark, almost black. The plagiopatagium is attached at the medial part of the tibia (Figure 2). The ears are shorter than the length of the head, and do not surpass the tip of the snout when laid forward. The antitragus has a semicircular shape and is wider than high. The tragus is small and pointed, unlike to that of *Eumops glaucinus* in which it is bigger and square. The dental formula is I 1/2, C 1/1, P 2/2, M 3/3 (Figure 3).

Table 1. Mean, standard deviation and number of specimens (*n*) of the external and cranial measurements (mm) of *E. auripendulus major* from Argentina ([Barquez *et al.* 1999](#)), and the new record from Santa Fe province (MG-ZV-M:415).

Variable	Barquez *et al.* (1999)	MG-ZV-M:415
Total length	138.60 ± 8.38 (*n* = 5) 125.00 - 148.00	139.00
Tail length	50.8 ± 4.54 (*n* = 5) 47.00 - 58.00	53.00
Hindfoot length	10.80 ± 2.04 (*n* = 5) 9.00 - 13.00	14.00
Ear length	19.80 ± 4.08 (*n* = 5) 13.00 - 23.00	21.00
Forearm length	65.00 ± 3.08 (5) 61.00 - 69.00	68.20
Weight		36.00
Condylobasal length	26.10 ± 5.10 (*n* = 4) 23.50 - 33.80	25.20
Least interorbital breadth	8.20 ± 0.05 (*n* = 3) 8.20 - 8.30	7.88
Zygomatic breadth	15.50 ± 0.50 (*n* = 5) 14.90 - 16.20	15.50
Greatest length of skull	25.30 ± 0.45 (*n* = 5) 24.60 - 25.70	25.66
Postorbital constriction	5.10 ± 0.15 (*n* = 5) 5.00 - 5.30	5.16
Breadth of braincase	12.00 ± 0.15 (*n* = 3) 11.90 - 12.20	12.00
Length of maxillary toothrow	9.90 ± 0.28 (*n* = 3) 9.60 - 10.10	10.20
Palatal length	9.90 ± 0.41 (*n* = 3) 9.50 - 10.30	10.64
Mastoidal breadth	13.40 ± 0.45 (*n* = 3) 13.00 - 13.90	13.22
Length of mandibular toothrow	10.90 ± 0.35 (*n* = 3) 10.60 - 11.30	11.10
Length of mandible	19.30 ± 0.84 (*n* = 5) 18.20 - 20.30	19.72
C-C (width across canines)	6.50 ± 0.37 (*n* = 3) 6.30 - 7.00	6.62
M-M (width across molars)	10.50 ± 0.15 (*n* = 3) 10.40 - 10.70	10.06

Figure 2. Ventral and dorsal view of the skin of *Eumops auripendulus* (MG-ZV-M:415) from Florencia, General Obligado department, Santa Fe province, Argentina. Scale bar = 10 mm.

Due to their similar sizes, *E. glaucinus* is the only species that can be confused with *E. auripendulus*. This new record matches with the descriptions made by [Barquez *et al.* (1999)](#) and [Best *et al.* (2002)](#) for *E. auripendulus*, both in external and cranial measurements (Table 1). In contrast to *E. glaucinus*, which has a paler fur coloration, this specimen has a dark brown color, and the ears are shorter than the head when laid forward, not exceeding in length the tip of the snout. The skull, although similar to that of *E. glaucinus*, shows a more developed sagittal crest ([Eger 1977](#); [Barquez *et al.* 1999](#); [Best *et al.* 1997](#), [2002](#)), which was evident although it could not be measured due to the fracture of the upper part of the skull for rabies virus analysis.

Eumops auripendulus is a species poorly known in Argentina, only 10 historical records between 1968 and 1978. This new record of *E. auripendulus* in Santa Fe province is particularly important, partly because this species has not been reported for 41 years in Argentina, but also because it occurs within the southernmost limits of the known distribution of the species. In addition, the species is added to an ecoregion where it was not previously reported (Humid Chaco), about 400 km NE of the southernmost known record (Esperanza - Santa Fe - Espinal ecoregion), 70 km S of the Chaco province record (Delta and Islands of Paraná ecoregion), and 395 km SW of the closest Misiones province record (Paranaense Forests ecoregion).

Although the knowledge about the richness and distribution of these mammals in Santa Fe has increased in recent years ([Barquez *et al.* 1999](#), [Barquez 2006](#); [Pautasso 2008](#); [Pautasso and Arnaudo 2009](#); [Pautasso *et al.* 2009](#); [Pavé *et al.* 2017](#), [2021](#); [Montani *et al.* 2018](#), [2020](#), [2021](#); [Pavé and Gavazza 2022](#)), most of the specimens were collected

Figure 3. Lateral, dorsal, and ventral views of the skull and lateral view of the mandible of *Eumops auripendulus* (MG-ZV-M:415) from Florencia, General Obligado department, Santa Fe province, Argentina. Scale bar = 10 mm.

accidentally. Consequently, there is still an important lack of information related to the knowledge of bats in the province, so field work and cooperation between institutions and researchers, as is the case of this research, are essential tools to achieve a deeper understanding of the bat fauna of Santa Fe province.

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Ampliación del límite noroeste de distribución de *Phyllostomus hastatus* y descripción de sus pulsos de ecolocalización

Extension of the north-western distribution limit of *Phyllostomus hastatus* and description of its echolocation pulses

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Phyllostomus hastatus es la segunda especie de murciélago de mayor tamaño en el continente americano. Su límite de distribución norte se encuentra entre Belice y Guatemala. En noviembre de 2022, capturamos un individuo con una trampa de arpa en la cueva Senahí, municipio de Lanquín, Alta Verapaz, Guatemala. Determinamos su sexo, edad, condición reproductiva, longitud de antebrazo, peso, y obtuvimos grabaciones acústicas. Caracterizamos los pulsos de ecolocalización y proveemos una contextualización geográfica. Se trató de una hembra adulta, no reproductiva, con longitud de antebrazo de 92.74 mm y peso de 140 g. Los pulsos de ecolocalización son de frecuencia modulada descendente con armónicos múltiples. El segundo armónico presentó la mayor energía, sin alternancia, con frecuencias por debajo de los 50 kHz y duración entre 2.3 y 4.8 ms. El sitio de captura se encuentra a una distancia aproximada de 119 km de la recolecta más cercana en el país, y ampliamos el límite noroeste de distribución de la especie. La estructura de los pulsos de ecolocalización coincidió con lo reportado en la literatura, y para las diferencias encontradas de los parámetros acústicos explicamos las posibles fuentes de variación. Por la ubicación de la captura, las recolectas previas y los tipos de vegetación donde se ha registrado esta especie, esperamos su presencia en sitios intermedios entre Alta Verapaz e Izabal, y la porción sureste de Petén, en Guatemala. Finalmente, resaltamos la importancia de la investigación y acciones de conservación del ecosistema subterráneo en el país.

Palabras clave: Ecosistema subterráneo; grabación acústica; Lanquín; micrófono ultrasónico; trampa de arpa.

Phyllostomus hastatus is the second largest bat species in the American continent. Its northern distribution limit is between Belize and Guatemala. In November 2022, we captured one individual with a harp trap in the Senahí cave, municipality of Lanquín, Alta Verapaz, Guatemala. We determined its sex, age, reproductive condition, forearm length, weight, and obtained acoustic recordings. We characterize the echolocation pulses and provide a geographic context. It was an adult female, non-reproductive, with forearm length of 92.74 mm and weight of 140 g. The echolocation pulses are of descending modulated frequency with multiple harmonics. The second harmonic presented the highest energy, without alternance, with frequencies below 50 kHz and duration between 2.3 and 4.8 ms. The capture site is at an approximately distance of 119 km from the nearest collection in the country, and we extend the north-western distribution limit of the species. The structure of the echolocation pulses coincides with the reported in literature, and for the acoustic parameters differences we explain potential variation sources. Due to the location of the capture, the previous collections, and the types of vegetation in which this species has been recorded, we expect its presence in intermediate sites between Alta Verapaz and Izabal, and the southeastern portion of Petén, in Guatemala. Finally, we emphasize the importance of research and conservation actions on the subterranean ecosystem in the country.

Key words: Acoustic recording; harp trap; Lanquín; subterranean ecosystem; ultrasound microphone.

Phyllostomus hastatus (Pallas, 1767) es la segunda especie de murciélago de mayor tamaño en el continente americano, después de *Vampyrum spectrum* (Linnaeus, 1758). Se distribuye desde Belice hasta el este de Brasil, el norte de Argentina y en casi todo Perú, con excepción de sus costas (LaVal y Rodríguez-Herrera 2002). Los registros en Centroamérica provienen en su mayoría de Panamá, Costa Rica, Nicaragua y Honduras, y en Belice y Guatemala son escasos, representando estos últimos países el límite norte de distribución de la subespecie *P. h. panamensis* Allen, 1904 (Santos *et al.* 2003; Barquez y Díaz 2015; Kraker *et al.* 2021; Jennings 2022).

Se trata de un murciélago filostómido (Phyllostomidae) de aspecto robusto, fácilmente distinguible de sus congéneres por su tamaño, y de especies de tamaño similar, como *Chrotopterus auritus* (Peters, 1856) y *Phylloderma stenops* Peters, 1865, por la fisonomía del rostro y las puntas de las alas blancas en este último (ver Timm *et al.* 1999; Santos *et al.* 2003; Kraker *et al.* 2021). Presenta una hoja nasal simple y bien desarrollada cuya herradura no se encuentra fusionada con el labio superior; su labio inferior tiene forma de V con protuberancias; las orejas son triangulares y puntiagudas y éstas, junto con las membranas y la piel del rostro, son negras (Santos *et al.* 2003). Sin embargo, la característica principal para reconocer a la especie es la longitud del antebrazo, que va de los 88 a los 93 mm (Timm *et al.* 1999; LaVal y Rodríguez-Herrera 2002). Produce pulsos de ecolocalización de intensidad alta y frecuencia relativamente baja (la mayor energía por debajo de 50 kHz), con una duración que puede variar dependiendo del espacio acústico (con obstáculos *vs*. abierto) a más de 5 ms (Kalko 2002).

Phyllostomus hastatus se reporta en variedad de hábitats en tierras bajas hasta una altitud aproximada de 1,000 m y utiliza como sitios de percha cavidades de árboles, termiteros y cuevas (Santos *et al.* 2003; LaVal y Rodríguez-Herrera 2002). Esta especie es considerada de preocupación menor por la Unión Internacional para la Conservación de la Naturaleza (UICN) debido a su distribución amplia, población presumiblemente grande, presencia en áreas protegidas, y cierto grado de tolerancia a la modificación del hábitat (Barquez y Díaz 2015).

En Guatemala, se cuenta con pocos registros de *P. hastatus*. En 1990, Marshall *et al.* (1991) capturaron un individuo en la aldea San Antonio, Montaña del Espíritu Santo, Los Amates, Izabal, a una elevación aproximada de 560 m (~ 15° 11′ 44.4″ N y 88° 55′ 58.2″ O), cuyo ejemplar de referencia, preparado como piel y material óseo, se encuentra depositado en la colección de la Texas Tech University (TTU 58315). En 2000, G. Martínez y E. Salguero (com. pers.) capturaron un individuo en un cultivo de banano en la localidad Entre Ríos, Finca Hopay, Puerto Barrios, Izabal, a una elevación aproximada de 20 m (~ 15° 36′ 56.3″ N y 88° 31′ 32.9″ O), cuyo ejemplar de referencia, preparado como piel, se encuentra depositado en la Colección de Mamíferos de la Universidad de San Carlos de Guatemala (USAC 01906). En 2011, S. G. Pérez-Consuegra capturó un individuo en la estación de la Reserva Hídrica y Forestal Sierra Caral, Morales, Izabal, a una elevación de 520 m (15° 24′ 25.92″ N y 88° 41′ 45.24″ O), cuyo ejemplar de referencia está preparado como piel y material óseo (USAC 05505).

En 2022, capturamos un ejemplar de *P. hastatus* en el centro-norte de Guatemala, el cual representa el cuarto registro de esta especie en el país. En esta nota, integramos la información concerniente al evento de captura, presentamos una caracterización acústica a partir de grabaciones obtenidas mediante la liberación del individuo, y establecemos la distancia geográfica a la recolecta más cercana en el país y la ubicación con relación al límite norte de distribución propuesto para la especie.

El 24 de noviembre de 2022 colocamos una trampa de arpa de doble marco y 4.2 m^2 de superficie de captura (Faunatech Austbat, Australia), entre las 17:45 hr y 19:00 hr, en la primera cámara de la cueva Senahí, ubicada en las coordenadas 15° 33′ 56″ N y 89° 58′ 55″ O, a una elevación de 450 m, en el municipio de Lanquín, Alta Verapaz, Guatemala (Figura 1). Este municipio está dominado por un ecosistema de bosque muy húmedo premontano tropical (IARNA-URL 2018), y se caracteriza por un suelo kárstico y un sistema de cuevas. La cueva Senahí se encuentra ubicada en un cerro a la orilla de una carretera construida a mediados de 2022 (Figura 2a, 2b), y es utilizada por los pobladores Maya Q'eqchi' con fines ceremoniales. En el exterior de ésta, hay presencia de especies vegetales como copal, *Protium copal* (Schltdl. & Cham.) Engl.; guarumo, *Cecropia* sp.; y palo de jiote, *Bursera* sp. En el estrato arbustivo hay presencia de palmas, *Chamaedorea* spp. y piperáceas, *Piper* spp. (obs. pers.).

Capturamos un individuo de *P. hastatus*, el cual fue procesado siguiendo los lineamientos de la American Society of Mammalogists (Sikes y the Animal Care and Use Committee of the American Society of Mammalogists 2016) y los protocolos sanitarios recomendados por el Grupo de Especialistas en Murciélagos de la UICN (Kingston *et al.* 2021; https://www.iucnbsg.org/bsg-publications.html). Medimos el antebrazo con un calibrador digital Preciva con límite de 150 mm y precisión de 0.01 mm, y tomamos el peso con una báscula Digital Hanging Scale ES-PS01 con capacidad de 50 kg y precisión de 10 g. Posteriormente, una hora después de la captura, obtuvimos grabaciones acústicas del murciélago mediante la técnica de liberación en mano.

Utilizamos un micrófono ultrasónico USB Pettersson M500 (Pettersson Elektronik AB, Suecia), en modalidad direccional, conectado a una Tablet PC con sistema operativo Windows, lo cual nos permitió visualizar los pulsos de ecolocalización en tiempo real y almacenar los archivos de grabación en formato WAV de 16 bits, a través del programa BatSound® Touch Lite (Pettersson Elektronik AB, Suecia). Procedimos con la grabación en un área abierta y amplia cercana a la cueva, cerca de un montículo con una altura aproximada de 1 m. La persona conteniendo al murciélago lo liberó desde el montículo y el operador del micrófono, a una distancia aproximada de 10 m, siguió la trayectoria de vuelo del murciélago hasta que dejó de obtener pulsos de ecolocalización en el espectrograma.

Los pulsos de ecolocalización que obtuvimos los describimos cualitativa y cuantitativamente utilizando el oscilograma, espectrograma y espectro de poder, a través del programa BatSound Standard – Sound Analysis v. 3.31 (Pettersson Elektronik AB, Suecia). En el espectrograma, procedimos a visualizar la grabación completa y seleccionamos la porción de interés, configuramos el campo visual a 100 kHz máximo en el dominio de la frecuencia, 140 ms en el dominio del tiempo, ventana tipo Hanning, umbral de 20, contraste de amplitud de 3 y FFT (Fast Fourier Transformation) de 512 muestras. Descartamos los pulsos de ecolocalización iniciales con la finalidad de su estabilización después de la liberación (Yoh *et al.* 2020), y seleccionamos aquellos que mostraron una relación sonido-ruido alta, por arriba de 20 % (Kraker-Castañeda *et al.* 2020).

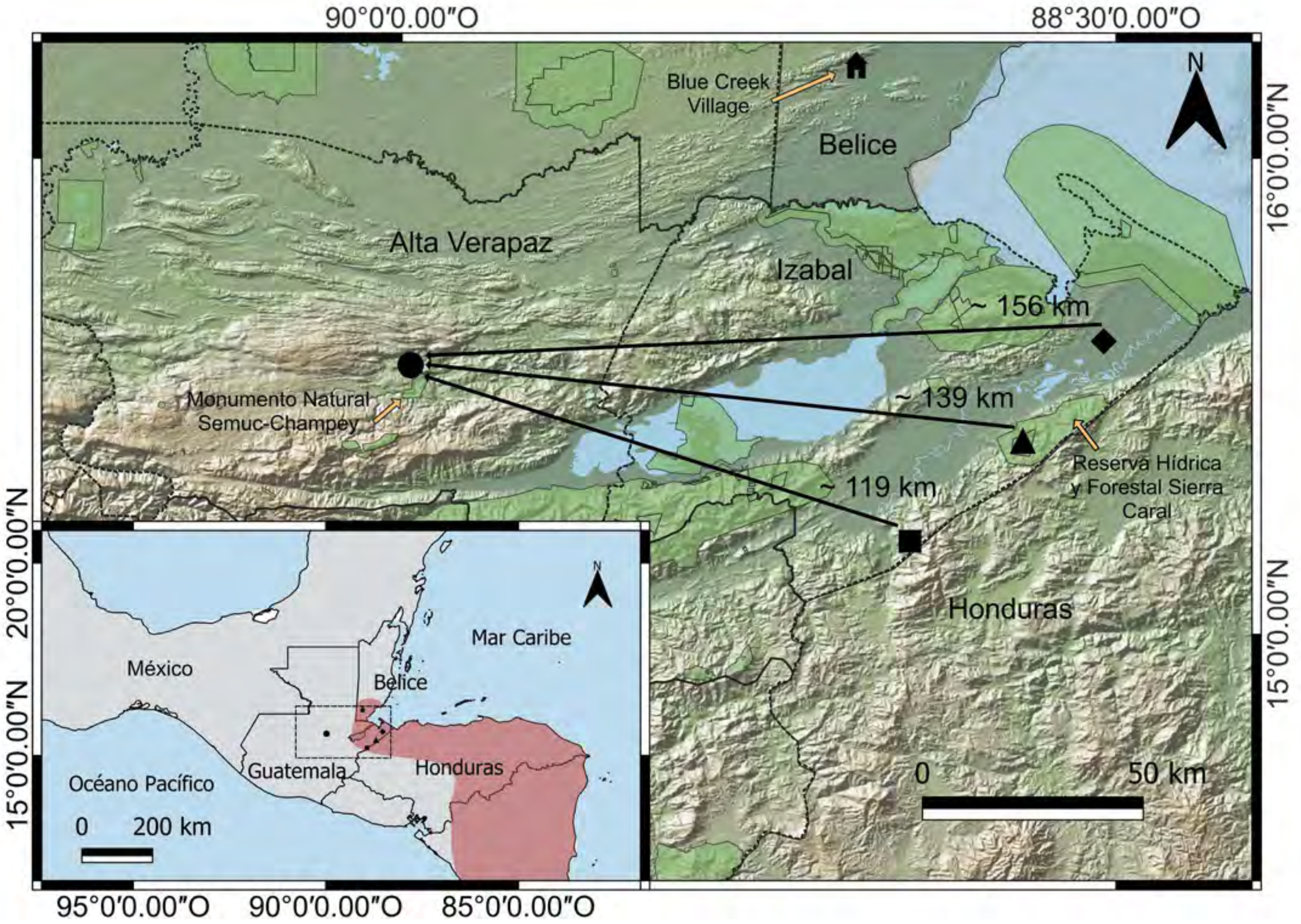

Figura 1. Sitio de captura de *Phyllostomus hastatus*, representado por un círculo, en Lanquín, Alta Verapaz, Guatemala. En el departamento de Izabal, el cuadrado indica el sitio de recolecta en la aldea San Antonio, Los Amates, el triángulo en la Reserva Hídrica y Forestal Sierra Caral, Morales, y el rombo en la Finca Hopay, Puerto Barrios. En el recuadro de la esquina inferior izquierda se puede apreciar el límite norte de distribución propuesto para la especie (UICN 2008; Barquez y Díaz 2015). En el mapa principal se integra el Sistema Guatemalteco de Áreas Protegidas (https://conap.gob.gt/direccion-de-analisis-geoespacial/) y una capa topográfica (Ryan et al. 2009; Global Multi-Resolution Topography, https://gmrt.org/). Elaboración: E. Leiva.

Siguiendo los criterios de Pinilla *et al.* (2013) y Yoh *et al.* (2020), a partir de una secuencia, en cada pulso de ecolocalización obtuvimos la frecuencia de máxima energía o FME (también conocida como frecuencia pico, medida en el espectro de poder), la frecuencia mínima o FMIN (a 20 dB por debajo de la FME), la frecuencia más baja o Lof y la frecuencia más alta o Hif (medidas en el espectrograma), y la duración del pulso o DUR (medida en el espectrograma). Omitimos la frecuencia máxima o FMAX debido a la superposición de frecuencias del segundo armónico (de mayor energía) y el tercer armónico (Figura 3), lo cual nos impidió obtener mediciones precisas en el espectro de poder. Resumimos los datos con estadísticos de tendencia central y dispersión, y comparamos los valores calculados con los de Pinilla *et al.* (2013) y Yoh *et al.* (2020). La grabación se encuentra disponible en la plataforma Arbimon (Rainforest Connection, Texas, EE. UU.) como parte del repositorio acústico del Programa para la Conservación de los Murciélagos de Guatemala (https://arbimon.rfcx.org/project/pcmg-repositorio).

Adicionalmente, determinamos la distancia de nuestra captura a la recolecta más cercana. Asimismo, sobrepusimos el polígono de distribución de *P. hastatus* (UICN 2008; Barquez y Díaz 2015) para determinar su ubicación con respecto al límite norte propuesto para la especie, y complementamos el mapa con el Sistema Guatemalteco de Áreas Protegidas (https://conap.gob.gt/direccion-de-analisis-geoespacial/) y una capa topográfica (Ryan *et al.* 2009; Global Multi-Resolution Topography, https://gmrt.org/).

A las 18:30 hr capturamos un individuo de *P. hastatus* (Figura 2c), el cual fue reconocido inmediatamente por su fisonomía y tamaño, y por capturas previas en otros países de Centroamérica por miembros del equipo de investigación. Procedimos a contenerlo en una bolsa de manta para trasladarlo al sitio de procesamiento, cercano a la cueva. Se trató de una hembra, adulta, no reproductiva, con longitud de antebrazo de 92.74 mm y peso de 140 g. Verificamos que los caracteres de la especie y las mediciones coincidieran con lo reportado por Timm *et al.* (1999), LaVal y Rodríguez-Herrera (2002) y Santos *et al.* (2003).

Figura 2. Cueva Senahí y ejemplar de *Phyllostomus hastatus* capturado en Lanquín, Alta Verapaz, Guatemala: a) inicio del trayecto hacia la cueva al lado de una carretera construida en 2022 (Fotografía: L. Nuñez); b) entrada de la cueva (Fotografía: L. Nuñez); c) extracción del ejemplar de una bolsa de manta (Fotografía: G. Guzmán).

Mediante la técnica de liberación en mano, obtuvimos una grabación de 7.92 s y 7.55 MB. Determinamos que los pulsos de ecolocalización de *P. hastatus* son de frecuencia modulada descendente con armónicos múltiples (Figura 3). El segundo armónico presentó la mayor energía, sin alternancia. Seleccionamos una secuencia (muestra) de 19 pulsos de ecolocalización y describimos los parámetros acústicos en la Tabla 1.

Establecimos que la superposición de los parámetros acústicos con los reportados en la literatura es mínima o inexistente: en el dominio de la frecuencia, en comparación con Pinilla *et al.* (2013) para Lof = 0 kHz y Hif = 2.8 kHz y con Yoh *et al.* (2020) para FME = 0.4 kHz y FMIN = 0 kHz (Tabla 1), y en el dominio del tiempo, en comparación con Pinilla *et al.* (2013) para DUR = 0 kHz y con Yoh *et al.* (2020) para DUR = 1 ms (Tabla 1).

Con base en el análisis geográfico, nuestra captura se localiza a una distancia aproximada de 119 km de la recolecta más cercana, la cual corresponde al ejemplar de la aldea San Antonio, Montaña del Espíritu Santo, Los Amates, Izabal. Con relación al límite norte de distribución propuesto para la especie (UICN 2008; Barquez y Díaz 2015), se trata de la localidad más alejada al noroeste hasta ahora registrada, representando una ampliación geográfica (Figura 1).

En 2022, la cueva Senahí fue afectada por la construcción de un libramiento que dirige hacia el Monumento Natural Semuc Champey, que implicó quemas controladas y el desgaje del cerro donde se ubica, como se puede observar en la Figura 2a. A pesar del impacto, determinamos que ésta sigue ocupada por varias especies de murciélagos además de *P. hastatus*, como *Artibeus* sp., *Carollia* sp., *Desmodus rotundus* (E. Geoffroy, 1810), *Pteronotus mesoamericanus* Smith, 1972 y *Balantiopteryx io* Thomas, 1904. *Balantiopteryx io* y *P. hastatus* destacan, la primera, por su dependencia de hábitats forestados y cuevas (Lim 2015), y porque está clasificada como vulnerable por la UICN y catalogada EDGE (Evolutionarily Distinct and Globally Endangered); y la segunda, porque representa el cuarto registro de una especie rara en el país y una ampliación del límite propuesto de distribución geográfica.

En el pasado, en otros países, han habido distintos esfuerzos de investigación acústica enfocados en especies de murciélagos filostómidos. Un ejemplo es el murciélago polinectarívoro *Glossophaga soricina* (Pallas, 1766),

Tabla 1. Parámetros acústicos obtenidos de una grabación de *Phyllostomus hastatus* en Lanquín, Alta Verapaz, Guatemala y de publicaciones previas. Presentamos los cálculos en el siguiente orden: promedio, desviación estándar, valor mínimo-máximo. FME = frecuencia de máxima energía; FMIN = frecuencia mínima (a 20 dB por debajo de la FME); Lof = frecuencia más baja; Hif = frecuencia más alta; DUR = duración.

Parámetro	Este estudio, *n* = 19, 1 individuo, liberación en mano, 2do. armónico	Pinilla *et al.* (2013), *n* = 10, 1 individuo, línea de vuelo, 2do. armónico	Yoh *et al.* (2020), *n* = 30, 3 individuos, liberación en mano, 3er. armónico
FME	41.16, 1.64, 38.3-43.4	-	47, 2, 43-52
FMIN	36.12, 1.46, 34.3-40.7	-	54, 2, 51-58
Lof	33.2, 0.89, 31.8-34.7	36.3, 0.4, 35.9-36.9	-
Hif	49.77, 0.89, 47.7-51	48.9, 1.2, 47.3-50.5	-
DUR	3.24, 0.79, 2.3-4.8	1.4, 0.3, 1.0-1.7	2.3, 0.5, 1.5-3.3

específicamente por el interés sobre cómo ciertas estructuras de las flores de las que se alimenta son reconocidas mediante la ecolocalización como resultado de un proceso de co-evolución (von Helversen *et al.* 2003; von Helversen 2004). Por otro lado, se ha analizado la flexibilidad del comportamiento de *Macrophyllum macrophyllum* (Schinz, 1821) para cazar insectos en pleno vuelo además de obtenerlos de superficies de agua (*trawling*), comprobándose que utiliza la ecolocalización como el sentido primario para la detección y localización del alimento, con evidencia de zumbidos terminales asociados a los intentos de captura (Weinbeer *et al.* 2013). De forma similar, el comportamiento de *Lonchorhina aurita* Tomes, 1863, que exhibe una adaptación a la cacería aérea al producir pulsos de ecolocalización que se asemejan a zumbidos terminales de murciélagos insectívoros aéreos (Gessinger *et al.* 2019).

Otras investigaciones se han enfocado en las vocalizaciones con función social en especies como *P. hastatus* (*e.g.*, Boughman 1997; Bohn *et al.* 2004). Esta especie forma harenes estables que durante las primeras horas de la noche utilizan áreas determinadas para alimentarse (se trata de una especie omnívora), y las hembras producen vocalizaciones de frecuencia audible (4-18 kHz) que parecen facilitar el reconocimiento de individuos no relacionados y que son estructuradas a través del aprendizaje vocal (Boughman 1997; LaVal y Rodríguez-Herrera 2002; Santos *et al.* 2003; Bohn *et al.* 2004). Este tipo de vocalizaciones representan verdaderos "llamados" (*s. str.*) ya que cumplen una función de comunicación, en contraste con los "pulsos", cuya función es la orientación, detección de obstáculos y localización de presas (ver Zurc *et al.* 2017).

A pesar de esfuerzos como los compendios que incluyen grabaciones de referencia de varias especies de murciélagos filostómidos (*e.g.*, Ortega *et al.* 2022), los monitoreos acústicos convencionales, como los enfocados en los murciélagos insectívoros aéreos (*e.g.*, Vespertilionidae, Molossidae, Mormoopidae, Emballonuridae), no son viables para esta familia taxonómica mediante micrófonos ultrasónicos. Para Kalko (2002) y Yoh *et al.* (2020), las diferencias de los parámetros acústicos entre géneros, subfamilias y gremios tróficos de murciélagos filostómidos son prácticamente imperceptibles. Esto se debe a que producen pulsos de ecolocalización de frecuencia alta y modulada, que son cortos y de intensidad baja (son denominados "murciélagos susurradores"); lo anterior, principalmente como una adaptación para la orientación en espacios con obstáculos, ya que para la búsqueda del alimento (frutos e insectos inmóviles en las superficies) utilizan una combinación de sentidos que incluyen la vista, el olfato y los sonidos de las presas, lo que resulta en la convergencia de la estructura de los pulsos de ecolocalización por la similitud de las tareas sensoriales (Kalko 2002).

Las excepciones propuestas al patrón relativamente uniforme de los pulsos de ecolocalización producidos por los murciélagos filostómidos son las especies *Ametrida centurio* Gray, 1847, *L. aurita* y *P. hastatus* (Kalko 2002; Gessinger *et al.* 2019; Yoh *et al.* 2020). En el estudio de Yoh *et al.* (2020), *P. hastatus* fue la única especie que no presentó superposición de la frecuencia pico tomada en el tercer armónico entre 40 especies de murciélagos filostómidos. Además, existe evidencia de que los individuos de esta especie pueden ser detectados a una distancia mayor de 10 m (Kalko 2002).

Al contrastar los parámetros acústicos de nuestra grabación con otros obtenidos de la misma especie, específicamente los presentados por Pinilla *et al.* (2013) y Yoh *et al.* (2020), encontramos que algunos de nuestros cálculos no se superponen o lo hacen mínimamente con los valores reportados. Este sesgo puede deberse a distintas fuentes de variación, entre las que podemos mencionar las siguientes relacionadas con el método entre estudios: 1) las condiciones particulares de la manipulación, que pueden generar una situación de estrés en el individuo y vocalizaciones atípicas (línea de vuelo *vs.* liberación en mano; B. Miller, com. pers.), 2) el espacio acústico (con obstáculos *vs.* abierto), lo cual puede influir en la adecuación de los pulsos de ecolocalización en tiempo y frecuencia (Barclay *et al.* 1999; Kalko 2002; Kraker-Castañeda *et al.* 2018), y 3) el armónico en el cual se toman las mediciones, ya que, por ejemplo, en el estudio de Yoh *et al.* (2020) la mayor energía en los pulsos de ecolocalización de *P. hastatus* predominó en el tercer armónico.

Por otro lado, existe una potencial variabilidad geográfica relacionada con factores intrínsecos, como el tamaño de los individuos entre poblaciones, y extrínsecos, como el tipo de presas, hábitats y el efecto de condiciones físicas (Barclay *et al.* 1999; López-Baucells *et al.* 2018). La acústica, integrada con análisis genéticos y morfológicos, también tiene el potencial de brindar información útil para diferenciar especies crípticas en extensiones geográficas amplias (ver López-Baucells *et al.* 2018). De esta manera, distintos factores pueden provocar sesgo para el reconocimiento acústico de las especies, por lo que es importante continuar con la integración de bibliotecas de referencia, principalmente en los países con vacíos de información y en el caso

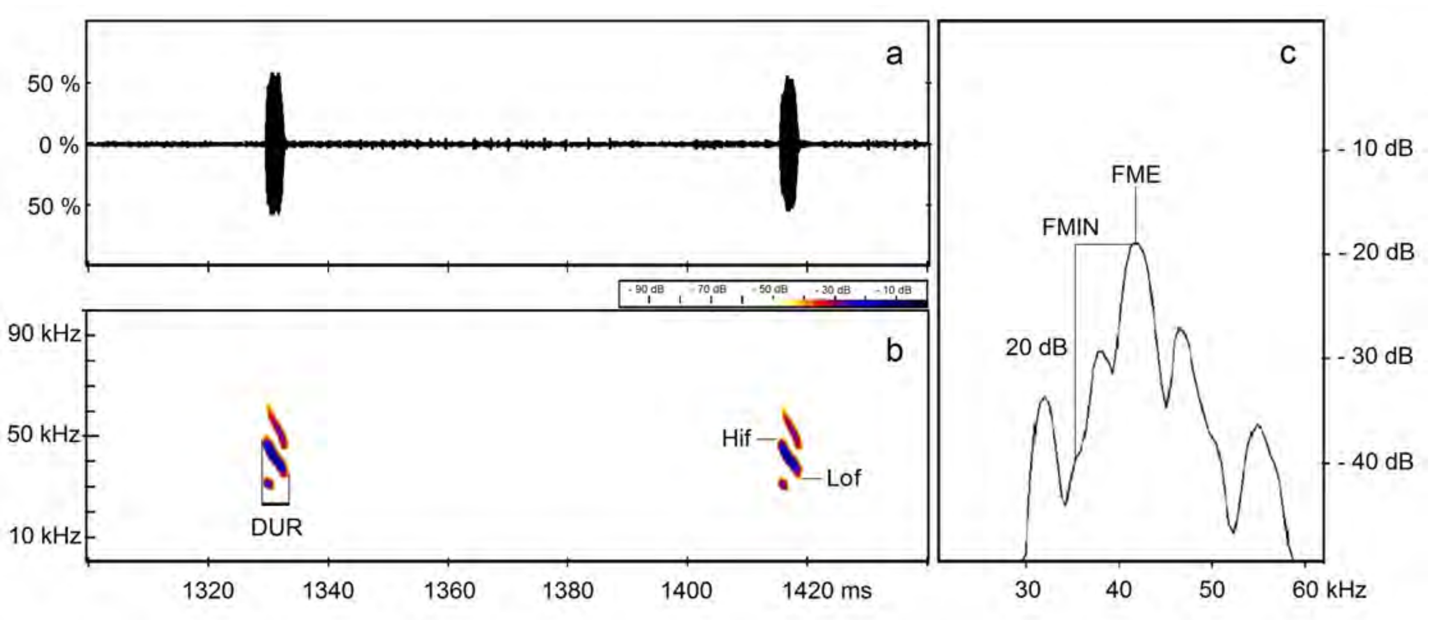

Figura 3. Pulsos de ecolocalización de *Phyllostomus hastatus* grabados tras liberación en mano, visualizados como a) oscilograma (amplitud *vs.* tiempo), b) espectrograma (frecuencia *vs.* tiempo), y c) espectro de poder (amplitud *vs.* frecuencia), correspondiente al primer pulso. El espectrograma está configurado con una ventana tipo Hanning, 100 kHz máximo en el dominio de la frecuencia, 140 ms en el dominio del tiempo, umbral de 20, contraste de amplitud de 3 y FFT (Fast Fourier Transformation) de 1,024 muestras, esto último con el propósito de mejorar la resolución (Parsons *et al.* 2000). Se señalan los parámetros acústicos considerados para las mediciones siguiendo los criterios de Pinilla *et al.* (2013) y Yoh *et al.* (2020): duración (DUR), la frecuencia más baja (Lof), la frecuencia más alta (Hif), y la frecuencia mínima (FMIN) a 20 dB por debajo de la frecuencia de máxima energía (FME). Se utilizó el programa BatSound Standard – Sound Analysis v. 3.31 (Pettersson Elektronik AB, Suecia).

de complejos taxonómicos no resueltos.

Consideraciones finales. Con este registro, ampliamos el límite de distribución de *P. hastatus* hacia el noroeste, en Guatemala. Por la ubicación de la captura, las recolectas descritas previamente en la frontera con Honduras y en Blue Creek Village, Belice (WNMU:Mamm:4824, sin coordenadas geográficas; Figura 1; Barquez y Díaz 2015; Kraker *et al.* 2021; Jennings 2022), y por los tipos de vegetación en los cuales se ha registrado esta especie (*e.g.*, bosque deciduo, bosque lluvioso, hábitats modificados; Santos *et al.* 2003), esperamos su presencia en sitios intermedios entre los departamentos de Izabal y Alta Verapaz, y la porción sureste del departamento de Petén, en Guatemala.

En cuanto a la caracterización acústica de *P. hastatus*, nuestros resultados coincidieron de manera general con lo reportado en la literatura, principalmente la estructura de los pulsos de ecolocalización y la frecuencia con mayor energía característicamente por debajo de 50 kHz (Kalko 2002). Sin embargo, encontramos diferencias considerables, por lo que explicamos el sesgo que puede surgir al comparar grabaciones entre estudios por fuentes de variación como el tipo de manipulación y la técnica de grabación (línea de vuelo *vs.* liberación en mano), el espacio acústico de grabación (con obstáculos *vs.* abierto), la falta de estandarización de las mediciones, y una potencial variabilidad geográfica determinada por factores intrínsecos y extrínsecos. En Guatemala, el campo de la bioacústica, específicamente enfocado en el estudio de los murciélagos, es incipiente, por lo que la integración de las bibliotecas de referencia es relevante para mejorar el conocimiento de la riqueza y distribución de las especies.

En términos de conservación, la cueva Senahí tiene presencia de especies de murciélagos de interés y un nivel relativamente bajo de presión humana directa ya que es visitada únicamente por pobladores con fines ceremoniales, aunque debe enfatizarse en una mayor protección. Sin embargo, cuevas cercanas, como las Grutas de Lanquín, en las cuales hemos establecido la presencia de *B. io*, *Natalus mexicanus* Miller, 1902, la cual es considerada especialista de bosque y sensible a la perturbación del hábitat (López-Wilchis *et al.* 2021), y de las especies de la familia Mormoopidae reportadas en el país, específicamente *Mormoops megalophylla* (Peters, 1864), *Pteronotus fulvus* (Thomas, 1892), *Pteronotus psilotis* (Dobson, 1878), *Pteronotus gymnonotus* (J.A. Wagner, 1843) y *P. mesoamericanus*, experimentan una carga alta de turistas y niveles altos de perturbación, por lo que es prioritaria la evaluación de su manejo.

Según el estudio de Muniz Pacheco *et al.* (2020), las Grutas de Lanquín tienen el potencial de ser reconocidas como el primer *hotspot* de biodiversidad subterránea en Centroamérica, y éstas, junto con la cueva Senahí y otras en el área, se presume que están interconectadas por los murciélagos, con implicaciones ecológicas en el ecosistema exterior y subterráneo, y genéticas en sus poblaciones. Es así como, en un primer paso hacia la protección de las colonias de murciélagos presentes en el área, logramos recientemente el reconocimiento de las Grutas de Lanquín como un Sitio de Importancia para la Conservación de los Murciélagos (SICOM S-GU-002 2023) por parte de la Red Latinoamericana y del Caribe para la Conservación de los Murciélagos

(RELCOM). Sin embargo, consideramos importante un diagnóstico más amplio y una estrategia de conservación del sistema de cuevas.

Por último, resaltamos que se debe dirigir una mayor atención al ecosistema subterráneo en el país para mejorar el conocimiento sobre su riqueza biológica, importancia ecológica y fragilidad, ya que los esfuerzos de investigación han sido pocos y aislados (*e.g.*, Cajas-Castillo *et al.* 2015; Muniz Pacheco *et al.* 2020). Consideramos que desde las instituciones públicas y académicas debe existir un mayor acercamiento y un diálogo horizontal con los actores locales para el manejo sustentable de las cuevas, respetando la significación de éstas en la cultura y el derecho sobre el territorio de los pueblos originarios.

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Exploring new sites: the neotropical otter (*Lontra longicaudis annectens*) in Bahía del Tóbari, Sonora, México

Explorando nuevos sitios: la nutria neotropical (*Lontra longicaudis annectens*) en Bahía del Tóbari, Sonora, México

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Neotropical otter (*Lontra longicaudis annectens*) has a wide distribution in México, the species inhabits rivers, lagoons, estuaries, wetlands, and bays. And from pine-oak woods, subtropical cloud forests to mangroves, from sea level to heights of 2,617 m. The objective of this study was to report the finding of the neotropical otter in a brackish water environment, including artificial islets or tarquinas for foraging and resting at Bahía del Tóbari, Sonora. Otter tracks were recorded while conducting bird census and surveys of nesting sites for seabirds and shorebirds at channels and shores of Bahía del Tóbari, Sonora. We found otter tracks in a small islet tarquina at Bahia El Tóbari, Sonora. We were shown by local inhabitants an almost complete neotropical otter skeleton with dry skin, found on a beach near the locality. We complete the study with previously unpublished records of Neotropical otters in the area. These artificial islets or tarquinas provide otters with available prey since otters eat a variety of aquatic birds, and these structures also offer resting sites. Using brackish water habitats by neotropical otters show the species' plasticity to explore new sites to obtain alternative food resources.

Key words: Brackish water; exploratory behavior; food sources; sea level.

La nutria neotropical (*Lontra longicaudis annectens*) tiene una amplia distribución en México, la especie habita en ríos, lagunas, esteros, humedales y bahías. Desde bosques de pino-encino, bosques mesófilos de montaña subtropicales hasta manglares, y desde los 2,617 m hasta el nivel del mar. El objetivo del estudio fue reportar la presencia de nutrias neotropicales en un medio ambiente salobre, incluyendo islotes artificiales o tarquinas para alimentarse y descansar. Se encontraron rastros de nutria neotropical mientras se hacían conteos de aves y la estimación de la anidación de aves marinas y playeras, en los canales y playas de la Bahía del Tóbari, Sonora. Encontramos rastros de nutria en una isleta o tarquina en la Bahía de El Tóbari, Sonora. Los habitantes de la zona nos mostraron un esqueleto con piel seca casi completo de una nutria neotropical encontrado en una playa cercana a la localidad. Completamos el estudio con algunos registros previos no publicados de la nutria neotropical cercanos a la localidad. Estos islotes artificiales o tarquinas proveen a las nutrias presas disponibles, ya que las nutrias depredan sobre una variedad de aves acuáticas, además de que estas estructuras proveen lugares de descanso a las nutrias. Al usar hábitats de aguas salobres, las nutrias muestran la plasticidad de la especie para explorar nuevos sitios y obtener fuentes alternas de alimentos.

Palabras clave: Agua salobre; comportamiento exploratorio; fuentes de alimento; nivel del mar.

Neotropical otter (*Lontra longicaudis annectens*) favors hipohaline habitats, such as rivers, lakes, dams, and wetlands, occasionally is found on hypersaline waters or completely isolated from hypohaline waters (Gallo-Reynoso 1997; Gallo-Reynoso and Casariego 2005). The limiting factor for neotropical otter's distribution in brackish waters is not the availability and abundance of prey, there is good diversity of fishes, crustaceans, and water birds susceptible of being preyed by otters (Gallo-Reynoso *et al.* 2008; Vázquez-Maldonado and Delgado-Estrella 2022). Thus, the limiting factor for their distribution must be physiological, hypersaline water affects renal physiology, Neotropical otters lack the presence of multilobed kidneys, able to remove the excess of salt when prey (fish and crustaceans) are ingested together with hypersaline waters (Echenique *et al.* 2018).

It is known that their habitat include large portions of mangrove woods in southeastern México, such as Área de Protección de Flora y Fauna Laguna de Términos (Términos Lagoon Protected Area for Flora and Fauna) where individuals have been found in waters with a low salinity of 2.0 ppm (Vázquez-Maldonado *et al.* 2021), also neotropical otter inhabits the northern coast of Yucatán, at Sisal, San Crisanto and Dzilam de Bravo near to sinkholes with hipohaline waters which flows towards the Gulf of México and Caribbean Ocean (Ortega-Padilla *et al.* 2022). In the western coast of the Gulf of California at Sinaloa state there have been observations of tracks of several individuals at El Verde Estuary, in brackish waters inhabited by river crocodiles, *Crocodylus acutus* (Gallo-Reynoso pers. obs.).

In Sonora neotropical otters inhabit several major rivers such as Bavispe, Aros, Yaqui and Mayo, middle sized rivers like Sahuaripa, Mátape and Cuchujaqui, in many creeks, and in on all the larger dams, and in temporary rainy season water courses (Gallo 1996; Gallo-Reynoso *et al.* 2008; Rangel-Aguilar and Gallo-Reynoso 2013). Since the second half of the past century the area of Bahía del Tóbari has experienced several modifications related to economic activities for urban development (Escofet and Bravo-Peña 2007). The irrigation system and wastewater drainage of the agricultural area became a sediment trap and agrochemical wastes flow to the lagoon complex (García-Hernández 2004; Jara-Marini *et al.* 2013). There are also several shrimp farms which add wastewater to the system, their establishment involved the modification of the environment by clearing of coastal vegetation which included mangroves and halophytes (García-Hernández 2004; Escofet and Bravo-Peña 2007). Moreover, the construction of a rock-based dirt road together with a concrete bridge for a tourist development program that involved connecting the continent to Isla Huivulai (1965-1966), had negatively affected the lagoon complex. This dirt road divided Bahía del Tóbari by altering the water flow pattern of circulation and sedimentation, greatly increasing the sedimentation rate and the increment of shallow water and marshes, the bay retained silt and sand and diminished the amount and residence time of water in the complex (Escofet and Bravo-Peña 2007).

To counter the social and environmental problems created by the rock-based dirt road and bridge, several governmental organizations (CONAGUA, CONAPESCA, CONANP) and the fishing cooperatives (Federación Regional de Sociedades Cooperativas de Producción Pesquera y Acuícola Paredones Unidos, S. C. de R. L. (FRSCPPAPU)) presented a project to solve the problem; the aims were 2 main activities: 1) the total removal of the bridge and the rock-based dirt road, and 2) the dredging of the lagoon's principal channels to increase the flow of water along the bay. The project was realized from 2010 to 2012, when the rock-based dirt road and the bridge were completely removed, and the dredging consisted of making 2 channels. The first channel with a length of 17.37 km, producing 937,833.56 m^3 of dredged material, and the second channel with a length of 8.3 km, producing 281,378.58 m^3 of dredged material. A suction dredge pumped the sediments to 11 sedimentation areas made with a perimetral wall built with geotextil mesh. This sedimentation area produced a series of small artificial islets called tarquinas (CIBNOR 2013).

The newly built tarquinas (Figure 1 and 2) promoted new habitats, resting and nesting areas for marine and shorebirds. Also gave a new ecosystem's configuration for their biotic and abiotic factors and conservation of original characteristics, involving their use by different bird species, creating interactions, and serving other secondary functions (Hobbs *et al.* 2009). There has been a monitoring program of these artificial islets and their use by birds since 2017; of 11 tarquinas, 10 are used by birds, with exception of tarquina number 8 which is partially covered during high tide and remain as a sandy shallow area only uncovered by seasonally very low tides (García-Hernández and Leyva-García 2017; Leyva-García and García-Hernández 2018). The dry surface of all remaining tarquinas has been estimated from 1.18 to 6.54 ha (measured by us via Google Earth®).

The neotropical otter in México is listed as a threatened species by NOM-059-SEMARNAT-2010 (SEMARNAT 2010), it

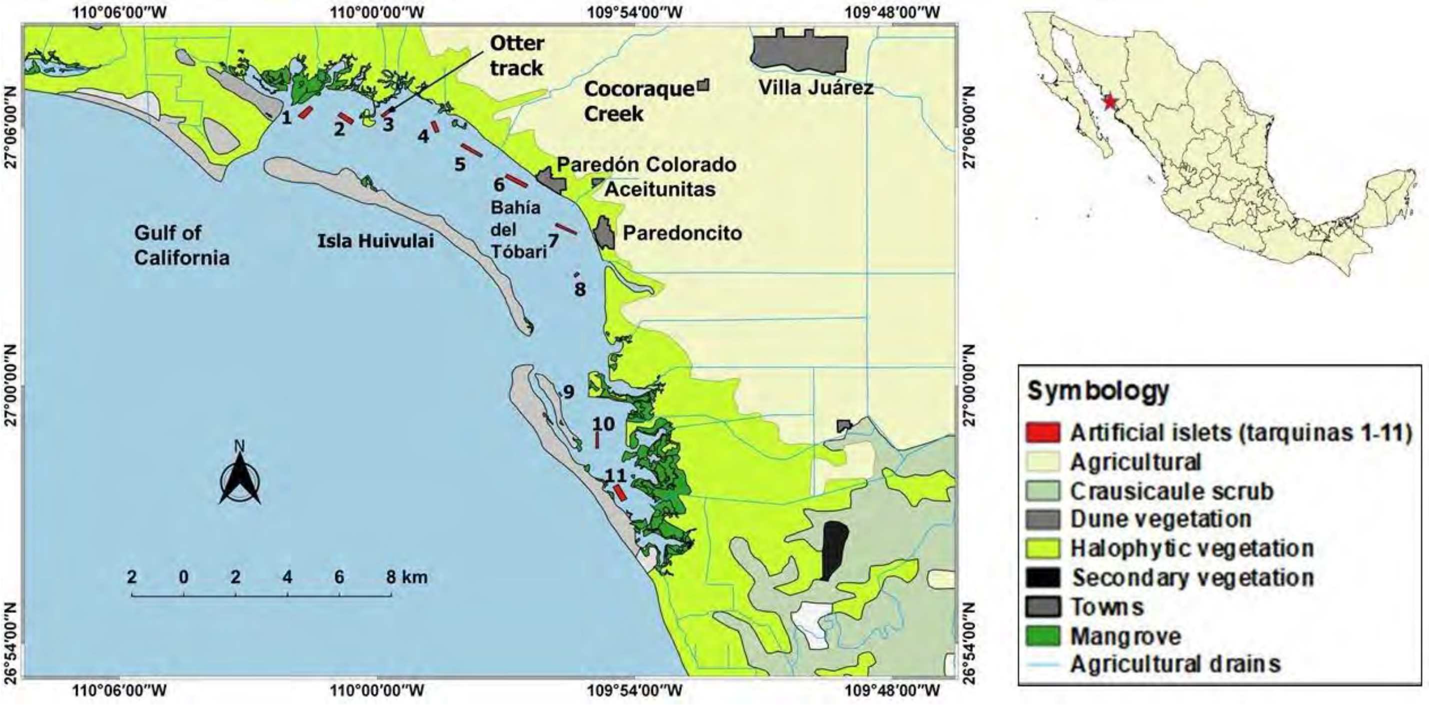

Figure 1. Location of man-made islets or tarquinas (1 to 11), neotropical otter tracklocation is indicated at tarquina number 3.

Figure 2. The general view of a tarquina or artificial islet, with new vegetation, shows the area used by several species of mammals, birds, and reptiles. Photo by I. Acuña.

is also registered in the red list of the IUCN as near threatened (Rheingantz *et al.* 2021). The neotropical otter has a wide distribution in México, it has been recorded from sea level to heights of 1,989-2,617 m in pine-oak woods and subtropical cloud forests (Hernández-Romero *et al.* 2018; Esparza-Carlos *et al.* 2022). Also inhabits rivers, lagoons, wetlands, rocky shores and areas with some anthropogenic activities and impacts, showing some tolerance to them, *e.g.*, ponds, channels and drainages close to human settlements (Gallo-Reynoso 1997; Larivière 1999), near homes, bridges, fishing settlements and ranching activities (Mayagoitia-González *et al.* 2013; Gallo-Reynoso *et al.* 2019). The objective of this study was to report the presence of the neotropical otter on this brackish water environment, including tarquinas and their bird fauna for probable foraging.

The Bahía del Tóbari estuarine system is found in southern Sonora, it has an area of 16,700 ha, of which 8,200 ha are formed by subtidal wetlands made up of non-consolidated substrate. The system is delimited by the Gulf of California, and by Isla Huivulai, which is a 14 km long and 0.5 km wide sand barrier island with dunes covered by different types of vegetation, from halophytes to several species of Sonoran Desert cacti, thorn brush, and trees, introduced date palms and red mangrove (*Rhizophora mangle*). The island has a northern and a southern mouth that led to Bahía del Tóbari inner lagoon complex. This lagoon complex involves 15 coves and estuaries. The coastal vegetation is represented by red mangrove, halophytes, coastal dunes, bushes, Sonoran Desert cacti and trees (CIBNOR 2013). Behind the coastal vegetation, land is used in wide agriculture and cattle growing areas (Arizmendi and Márquez-Valdelamar 2000). There are 3 human rural settlements in the area: Paredón Colorado, Paredoncito and Aceitunitas, the overall number of human inhabitants is near to 6,000, which are direct users of the lagoon complex for artisanal fishery (INEGI 2020).

We have conducted 4 surveys of aquatic and shore birds in several nesting areas, channels, coast and at tarquinas from fiberglass skiffs at Bahía del Tóbari, from 2017 to 2022; in summer of 2017, upon observing mammal tracks at the tarquina, we walked at the tarquinas following tracks and observing scats of mammals, which were identified with specialized guides (Aranda 2012).

Complementary we conducted some informal interviews with fishermen and our boat conductors to know about the neotropical otter in the area. Additionally, we added not published reports of neotropical otters in upriver areas of the Río Yaqui's basin which irrigation channels drains to the Tóbari lagoon complex.

On July 6, 2017, at the Tóbari lagoon complex (Figure 1) and at tarquina number 3 (Figure 2), we found tracks of a neotropical otter (*L. l. annectens*; Figure 3a), tarquina number 3 is found in a brackish water environment. This tarquina number 3 is an important nesting site for least tern (*Sternulla antillarum*), snowy plover (*Charadrius nivosus*), Wilson's plover (*C. wilsonia*) and American oystercatcher (*Haematopus shoshone*), these species are enlisted with a conservation status at NOM-059-SEMARNAT-2010 (SEMARNAT 2010). To this moment (2017-2022) there are 11 species of nesting birds in these tarquinas, *Thalasseus elegans*, *T. maximus*, *Sternula antillarum*, *Gelochelidon nilotica*, *Leucophaeus atricilla*, *Larus heermanni*, *Rynchops niger*, *H. shoshone*, *Charadrius wilsonia*, *C. nivosus* and *Eudocimus albus*, with a maximum of 17,968 reproductive pairs counted in 2018 (Leyva-García pers. obs.), which is potential food for the neotropical otter.

The most recent record of a neotropical otter in the area, was obtained by local inhabitants of Paredoncito on April 4, 2022, consisting in a dead otter that was found in a beach of Bahía del Tóbari, the carcass of the otter was already dry but presented key characteristics for its identification such as the typical otter's skull, elongated with forward eye sockets and large carnassial teeth, and the presence of an interdigital membrane between the fingers (Figure 3b). Regardless of if the carcass was brought to the area by rains through a channel output, or if the otter died there, it is an important sign of the species presence in the area.

Our study area is a potential site for neotropical otters' occupation due to the presence of riparian habitat consisting in mangrove forests and large extensions of aquatic vegetation such as cattail (*Thypha domingensis*) forests, agriculture irrigation channels, shrimp farm drainages, and the Cocoraque creek, which is a natural effluent of the hydrological Cocoraque sub-basin that flows to Bahia El Tóbari. The closest record of a reproductive neotropical otter population is found at the Oviachic dam, on the Río Yaqui, 78 km northeast from Bahía del Tóbari (Gallo-Reynoso *et al.* 2008) which waters are used for the irrigation of Valle del Yaqui, major irrigation channels are interconnected, and waters from the Oviachic Dam reach Bahía El Tóbari, therefore the presence of otters are likely in the vicinity of the bay. At El Oviachic area, neotropical otters predates on several species of abundant birds such as neotropical cormorant (*Phalacrocorax brasilianus*), Mexican duck (*Anas diazi*); great egret (*Ardea alba*); yellow-crowned night heron (*Nyctanassa violacea*), brown pelican (*P. occidentalis*), and several fish species (Gallo-Reynoso *et al.* 2008; Rangel-Aguilar and Gallo-Reynoso 2013). Down water from the Oviachic dam, we have found records of the neotropical otter's presence, at 45 km to the northwest, from Bahía del Tóbari, involving their use of irrigation channels and drainages that stream to Dren Esperanza which flows to Bahía El Tóbari. The record consists in tracks and two otter spraints on a bridge (27° 26′ 0.729″ N, 110° 18′ 0.156″ W) that crosses above that drainage. The analyses of the sprints showed that they feed mainly on tilapia (*Oreochromis* sp.) and common carp (*Cyprinus carpio*), but also feed on other items such as regal horned lizard (*Phrynosoma solare*), grasshoppers (*Schistocerca shoshone*), and insects (Isoptera, Odonata and Coleoptera; Gallo-Reynoso, pers. obs., August 24, 2006).

Although neotropical otters forage mainly on fish and crustaceans, foraging on birds has been documented by several authors that describe their feeding on cormorants, brown pelicans, ducks, egrets, coots and other birds in several rivers of México and on the Rio Yaqui in Sonora (Gallo-Reynoso 1997; Gallo-Reynoso *et al.* 2008); as well as coots and flamingos in the northern coast of Yucatán (Ortega-Padilla *et al.* 2022), showing the trophic adaptability of neotropical otters and their probable ecological value as a regulator of bird populations (Vázquez-Maldonado and Delgado-Estrella 2022). The presence of neotropical otters at this particular tarquina generates the hypothesis of the otter's exploratory behavior over the presence of available prey, such as marine bird's nesting and resting there, similar to what have been reported by Gallo-Reynoso *et al.* (2008) upriver in the same Yaqui River basin and in other areas of México such as the northern coast and marshes of the Yucatán peninsula (Ortega-Padilla *et al.* 2022).

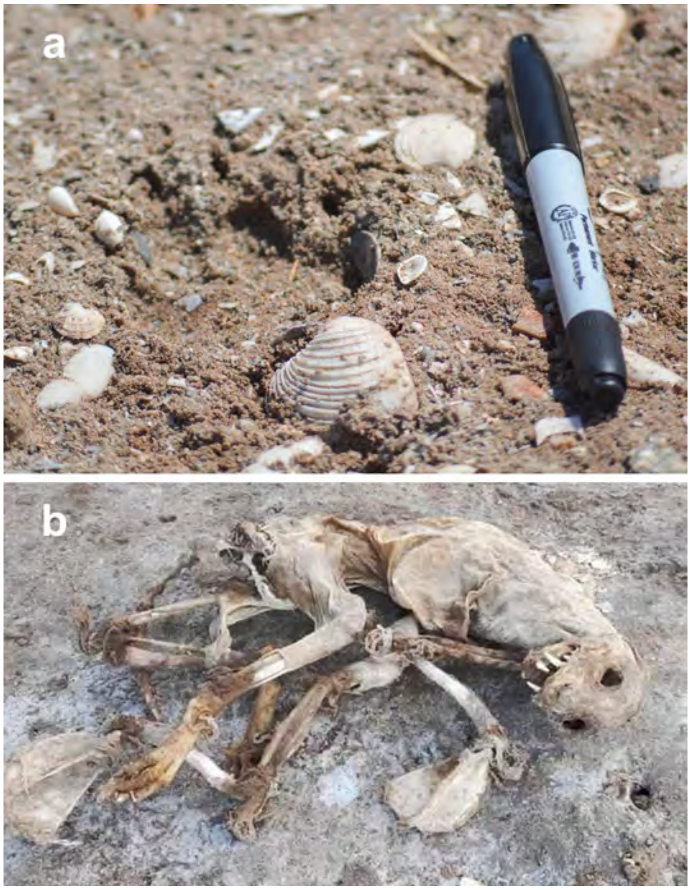

Figure 3. Neotropical otter (*Lontra longicaudis*) records at Bahía del Tóbari, Sonora: a) Right front footprint of a neotropical otter showing the interdigital membrane and claws at tarquina number 3 (Photo by G. Leyva); b) Weathered carcass of a neotropical otter found in a beach near Paredoncito fishing town (Photo by L. Enrique Ortiz).

There are other mammals that visit that tarquina, we recorded tracks of coyote (*Canis latrans*), dog (*Canis familiaris*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*) and jackrabbits (*Lepus* sp.); these species can get across from the continent to the islet due that their distance is of few hundred meters (0.15 a 0.44 km). Tarquina number 3, is at 155 m from the coast, a short distance for these mammals, and the surface is exposed in low tide which gives access to colonizers and potential predators.

The artificial islets or tarquinas might provide otters with available prey due that otters eat a variety of sea birds, and that these structures also might offer resting sites. The use of brackish water habitats by neotropical otters shows the species' plasticity to explore new sites to obtain alternative food resources. The probable impact of seabird predation by neotropical otters on these modified habitats must be the objective for future studies at Bahia del Tóbari.

Finally, these 2 records show that neotropical otters can exploit marginal areas such as drainages of wastewater from irrigation areas and brackish water habitats to find their prey in this and other areas and coasts of México, and that together with anthropogenic impacts, such as irrigation areas, the presence of otters in these areas must be thoroughly explained.

Acknowledgements

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A morphologically atypical great fruit-eating bat *Artibeus lituratus* from Paraguay

Un murciélago frutero grande *Artibeus lituratus* morfológicamente atípico de Paraguay

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Morphological abnormalities and their underlying causes are well documented and understood in humans and some domesticated animals but are less often reported within wild populations. This is likely because many abnormalities lead to the early death of individuals and typically are only encountered within large samples of specimens. Here, we report an adult female great fruit-eating bat *Artibeus lituratus* (Chiroptera, Phyllostomidae) collected from Paraguay with notable skull and post-cranial abnormalities. Specimens, including the atypical *A. lituratus*, were collected from eastern Paraguay and prepared as skin and skull museum voucher specimens and deposited in the Natural Science Research Laboratory of the Museum of Texas Tech University. Sequences of Cytochrome *b* (Cyt *b*) were generated and uploaded to BLAST to confirm species identification. We then quantitatively compared the atypical individual with 15 typical females collected from the same locality using 13 wing measurements and 13 skull measurements. The Cyt *b* sequence of the atypical specimen was a 100 % match to *A. lituratus*. The atypical specimen was much smaller from the perspective of overall body size and wing morphology. The skull was also qualitatively different, much smaller and less robust than other female *A. lituratus* from this site. Mastoids and the sagittal crest were greatly reduced, and the frontal shield was absent in the atypical individual. We encourage reports of morphological abnormalities to be made as determining rates of abnormalities within populations may indicate their overall health.

Key words: Morphological deformity; morphometrics; New World bats; skeletal deformity; skull morphology; wing morphology.

Las anormalidades morfológicas y sus causas subyacentes están ampliamente conocidas y documentadas en humanos y animales domésticos; sin embargo, no se reportan frecuentemente en poblaciones silvestres. Este fenómeno se debe a que muchas anormalidades conducen a la muerte temprana del individuo y generalmente solo se las observa cuando se colecta un gran número de especímenes. Aquí reportamos una hembra adulta del murciélago frutero *Artibeus lituratus* (Chiroptera, Phyllostomidae) de Paraguay con anormalidades craneales y post-craneales notorias. Los especímenes, incluyendo al individuo atípico de *A. lituratus*, fueron preparados como ejemplares científicos de piel y cráneo, y depositados en el Natural Science Research Laboratory de la Universidad de Texas Tech. Las secuencias de Citocromo *b* (Cyt *b*) fueron cargadas en BLAST para la identificación de la especie. Comparamos cuantitativamente al individuo atípico con otras 15 hembras normales colectadas en la misma localidad usando 13 medidas alares y 13 craneales. La secuencia del Cyt *b* del espécimen atípico obtuvo 100 % de coincidencia con *A. lituratus*. El ejemplar atípico fue de tamaño menor en las medidas convencionales del cuerpo y morfología de alas. El cráneo fue más pequeño y menos robusto comparado con otras hembras de *A. lituratus* del mismo sitio. Los huesos mastoideos y las crestas sagitales fueron notablemente reducidos y el escudo frontal estuvo ausente en el individuo atípico. Recomendamos que las anormalidades morfológicas se reporten con mayor frecuencia ya que la obtención de la tasa de anormalidad puede indicar el estado de salud poblacional.

Palabras claves: Deformidad esquelética; deformidad morfológica; morfología alar; morfología craneal; morfometría; murciélagos del Nuevo Mundo.

Morphological abnormalities and their underlying genetic and/or environmental causes are well documented and understood in humans and some domesticated animals (Mortier *et al.* 2019). Because many abnormalities can lead to an individual being aborted early in development, dying shortly after birth, or the complete dysfunction of systems essential to survival (Kunz and Chase 1983; Eissa *et al.* 2021), reports of morphological abnormalities in wild populations are rare and are typically only encountered within large samples of specimens. For example, only 2 individuals with deformed tails were detected from a sample of 150,000 Mexican free-tailed bats (*Tadarida brasiliensis*; Mitchell and Smith 1966). Atypical individuals have been reported in wild populations of fish (Eissa *et al.* 2021), amphibians (Soto-Rojas *et al.* 2017), reptiles (Clark *et al.* 2011), birds (Pourlis 2011), and mammals (Kunz and

Chase 1983; Stephens *et al.* 2018; Esquivel *et al.* 2021). This indicates that morphological abnormalities do not always result in immediate death (Pourlis 2011; Stephens *et al.* 2018; Eissa *et al.* 2021).

The Neotropical bat family Phyllostomidae is one of the most diverse families of bats (Order Chiroptera) with over 227 species in 61 genera (Simmons and Cirranello 2022). The genus *Artibeus* is one of the most species rich genera within Phyllostomidae with 13 species, all of which are frugivorous. The great fruit-eating bat (*Artibeus lituratus*) is the largest New World fruit bat and ranges from México through Argentina (Larsen *et al.* 2013). Herein, we report a case of an individual *A. lituratus* collected during a field study in Paraguay (Stevens *et al.* 2004) with notable skull and post-cranial abnormalities (Figure 1) for which we characterize, report, and make quantitative comparisons with typical *A. lituratus* individuals from the site where it was collected.

Specimens, including an atypical adult female *A. lituratus*, were collected from the Reserva Natural del Bosque Mbaracayú, in the Departamento de Canindeyu in eastern Paraguay. The habitat was interior Atlantic Forest and further details as to the site and other bat species encountered can be found in Stevens *et al.* (2004). The atypical individual was captured on 20 November 1997, prepared as a skin and

Figure 1. Picture of the skull of an atypical female *Artibeus lituratus* (right) compared to a typical female *A. lituratus* (left) collected from the Reserva Natural del Bosque Mbaracayú, in the Departamento de Canindeyu in eastern Paraguay.

skull museum voucher specimen, and deposited into the Natural Science Research Laboratory (NSRL) at Texas Tech University (TTU 94274). We took 13 wing measurements including length of the forearm, thumb, and the elements of each digit (2-1, 3-1, 3-2, 3-3, 3-4, 4-1, 4-2, 4-3, 5-1, 5-2, 5-3) and 13 skull measurements including greatest length of skull (GLS), condylo-basal length (CBL), breadth of upper canines (BUC), breadth of the post-orbital constriction (POC), breadth of braincase (BBC), breadth across mastoids (BAM), breadth of upper molars (BUM), length of maxillary tooth row (LMT), height of cranium (HOC), total length of mandible (TLM), breadth of lower canines (BLC), breadth of lower molars (BLM) and breadth of the coronoid process (COP). Measurements were taken from the atypical *A. lituratus* individual as well as 15 typical female individuals collected from the same locality. Each measurement was taken 3 times using EZ Cal® 6" fractional digital calipers and then the mean was calculated for each individual. The mean and standard deviation of each measurement was taken from 15 typical *A. lituratus* individuals and compared to the measurements of the atypical individual (Table 1). A principal components analysis was used to illustrate morphological relationships of typical and the atypical specimens.

The atypical individual of *A. lituratus* was so different that at first its species-specific designation was unclear. Moreover, 3 *Artibeus* spp. are syntopic in Eastern Paraguay (Owen *et al.* 2022) and typical *A. fimbriatus* and *A. planirostris* are more similar to typical *A. lituratus* than to the atypical individual. Thus, species identification could not be confirmed morphologically due to the nature of the abnormalities. We sequenced the mitochondrial gene Cytochrome *b* (Cyt *b*) to confirm species identification as *A. lituratus*. Genomic DNA was extracted from a wing punch taken from the atypical *A. lituratus* specimen (TTU 94274) using a DNEasy Blood and Tissue Extraction Kit (Qiagen Inc., Valencia, California). We amplified Cyt *b* using HotStarTaq (Qiagen Inc., Valencia, California) and primers 400F (Edwards *et al.* 2001) and 700H (Peppers *et al.* 2002) and the thermal profile: hot start of 80 °C, initial denaturation at 95 °C for 2 min, followed by 34 cycles of denaturation at 95 °C for 30 s, annealing 42 °C for 45 s, extension at 73 °C for 1 min, and a final extension at 73 °C for 15 min. Amplification products were purified using ExoSAP-IT (Applied Biosystems, Foster City, California). Purified products were sequenced using ABI Prism Big Dye® Terminator v3.1 Cycle Sequencing Kit (Thermofisher, Waltham, MA, USA). Sequence products were purified using Sephadex columns (Princeton Separation, Adelphia, New Jersey) and centrifugation, followed by dehydration and resuspension in formamide. Purified sequencing products were analyzed using an ABI Prism 310 automated sequencer (Biotechnology Resource Center, Institute of Biotechnology, Cornell University, Ithaca,

Table 1. Summary of measurements taken from the atypical female *Artibeus lituratus* individual to 15 typical female *A. lituratus* individuals collected from the Reserva Natural del Bosque Mbaracayú, in the Departamento de Canindeyu in eastern Paraguay. Number abbreviations refer to digit components with the first number indicating the digit number and the second number indicating the specific element of that digit (*e. g.*, 3-1 refers to the metacarpal, 3-2 to the first phalanx, 3-3 to the second phalanx, and 3-4 to the third phalanx of the third digit).

	Population		**Atypical *A. lituratus***
Character	**Mean**	**S.D.**	**Mean**
Forearm	71.38	2.97	60.58
Thumb	13.56	1.05	13.13
02-1	56.1	4.01	50.89
03-1	67.32	2.16	60.25
03-2	22.52	0.98	17.62
03-3	34.79	3.92	28.03
03-4	21.73	1.55	20.88
04-1	65.6	2.04	60.78
04-2	18.74	0.74	14.82
04-3	25.09	1.35	19.75
05-1	67.56	1.96	61.28
05-2	14.28	0.74	11.31
05-3	20.6	1.05	16.06
Length of skull	31.36	0.38	29.37
Condylo-basal length	29.76	0.47	28.4
Breadth across upper canines	7.66	0.37	7.53
Post-orbital constriction	6.64	0.31	6.22
Breadth of braincase	13.41	0.39	12.89
Breadth across mastoids	16.7	0.57	14.16
Breadth across upper molars	13.5	0.53	12.16
Length of maxillary tooth row	12.47	0.39	12.11

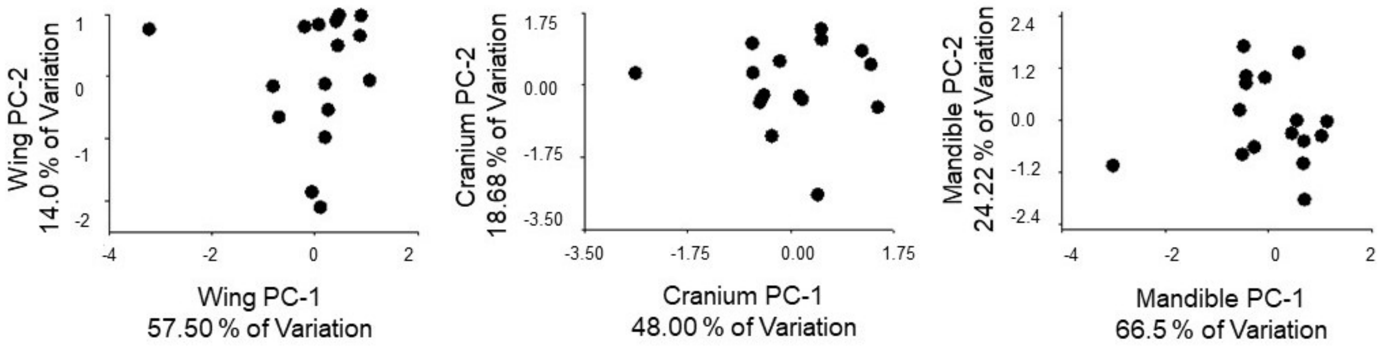

Figure 2. Results of principal components analysis comparing the atypical female *Artibeus lituratus* individual to 15 typical female *A. lituratus* individuals collected from the Reserva Natural del Bosque Mbaracayú, in the Departamento de Canindeyu in eastern Paraguay.

New York). Sequences were aligned and annotated in Sequencher 4.10.1 software (Gene Codes Corporation, Ann Arbor, Michigan) and final sequences were uploaded to BLAST® (Madden 2002) for species confirmation.

The atypical specimen had lower body and wing measurements compared to other *A. lituratus* females captured at the same site (Table 1). For example, the average forearm length for the 15 typical individuals was 15 % larger (71.38 mm) than for the atypical female (60.58 mm). The skull was also qualitatively different, much smaller and less robust than other female *A. lituratus* from this site. Mastoids and the sagittal crest were greatly reduced, and the frontal shield was absent in the atypical individual. The first two principal components for wing, cranial and mandibular characteristics accounted for between 67 and 91 percent of the variability among individual *A. lituratus* (Figure 2). The atypical individual was very different with respect to typical individuals in all three ordination spaces. The Cyt *b* sequence for the atypical specimen was a 100 % match to *A. lituratus* based on a BLAST search.

This atypical individual was one of more than 4,300 *A. lituratus* (< 0.001 %) captured at the Reserva Natural del Bosque Mbaracayú during our field effort (Stevens *et al.* 2004). Despite the severity of the phenotypic abnormalities, the atypical female *A. lituratus* was captured while foraging and was lactating, which suggests successful reproduction. The survival of this individual suggests that outliers may survive in natural populations more frequently than previously thought; however, being able to record such anomalies represents substantial collecting efforts, as has been suggested in previous case reports (Mitchell and Smith 1966; Kunz and Chase 1983).

Many factors may result in morphological abnormalities including genetic mutations (Pourlis 2011; Eissa *et al.* 2021), environmental factors such as pollution (Pourlis 2011; Eissa *et al.* 2021), illness or parasites, nutritional deficiencies, stress (Eissa *et al.* 2021), and trauma or injury (Stephens *et al.* 2018; Eissa *et al.* 2021), among others. Examples of abnormalities specific to the skeletal system include conjoined twins (Nogueira *et al.* 2017), dental anomalies such as polydontia or oligodontia (Esquivel *et al.* 2021), the gain or loss of limbs or digits, and deformities of the skull or skeleton (Kunz and Chase 1983; Gonçalves *et al.* 2011).

Although intensive effort is needed to capture atypical individuals, reporting such abnormalities within wild populations is worthwhile and could have multiple benefits. For example, in some instances, skeletal anomalies such as gain or loss of teeth or changes in teeth or skull morphology can represent ecological adaptations that enhance fitness, are selected and ultimately lead to adaptive evolutionary changes (Esquivel *et al.* 2021). Finally, while unlikely at this large (66,000 ha) and fairly undisturbed forest fragment in Paraguay, deformities may serve as an indicator of poor health of populations and indicate underlying stressors such as environmental degradation and mismanagement (Pourlis 2011; Soto-Rojas *et al.* 2017; Eissa *et al.* 2021) or low genetic diversity and inbreeding (Clark *et al.* 2011).

Therefore, morphological abnormalities detected within wild populations should be reported in order to determine the frequency in populations. This will provide information on the quality of habitat and health of populations while enabling better monitoring and management efforts (Pourlis 2011; Soto-Rojas *et al.* 2017; Eissa *et al.* 2021). Understanding factors resulting in abnormalities, such as those of the individual reported here, could help implement conservation efforts that help decrease the prevalence of such abnormalities in wild bat populations.

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Mother's defense of a juvenile rock squirrel (*Otospermophilus variegatus*) against a rattlesnake (*Crotalus molossus*)

La defensa de una madre de un ardillón de roca juvenil (*Otospermophilus variegatus*) contra una serpiente de cascabel (*Crotalus molossus*)

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Predation of rock squirrels (*Otospermophilus variegatus*) by rattlesnakes (*Crotalus* sp.) has led to a coevolutionary process during which rock squirrels have developed resistance to the rattlesnake venom and a series of behaviors that allow squirrels to protect themselves against predation. In this note, we describe an observation of such behavior; how a squirrel mother protects a juvenile against a rattlesnake attack. We witnessed a confrontation between a mother squirrel and a rattlesnake over a juvenile that was attacked by the snake and the squirrel's strategy used to guide her offspring away from danger. The mother squirrel threatened the rattlesnake by moving its tail and retreated laterally to a nearby tree. The juvenile followed the mother, guided by its smell. When they reached a safe distance, they jumped from the tree and went away, keeping their distance. Before withdrawing, the mother attempted to interact with the observers; local workers confirm that rock squirrels warn them about rattlesnake presence. The defensive behavior we observed was complex and effective. The mother squirrel was able to guide the juvenile out of danger, and the strategy was well planned since they retired to a nearby tree where the rattlesnake would be at a disadvantage. Therefore, rock squirrels have a well-developed behavior to protect their offspring against snake attacks.

Key words: Attack; behavior; mammals; predation; reptile; warning.

La depredación de ardillones de roca (*Otospermophilus variegatus*) por serpientes de cascabel (*Crotalus* sp.) ha llevado a un proceso coevolutivo durante el cual los ardillones han desarrollado resistencia al veneno de serpiente de cascabel y una serie de comportamientos complejos que les permiten protegerse contra la depredación. En esta nota describimos una observación de tal comportamiento; cómo una madre ardillón protege a un joven contra el ataque de una serpiente de cascabel. Fuimos testigos de un enfrentamiento entre una madre ardillón y una serpiente de cascabel por un juvenil que fue atacado por la serpiente, y la estrategia utilizada para guiar a su cría lejos del peligro. La madre ardillón amenazó a la serpiente de cascabel moviendo su cola y se retiró lateralmente a un árbol cercano. El juvenil siguió a la madre guiado por su olor. Cuando llegaron a una distancia segura, saltaron del árbol y se alejaron manteniendo la distancia. Antes de retirarse, la madre intentó interactuar con los observadores. Trabajadores locales confirman que las ardillas les advierten sobre la presencia de serpientes de cascabel. El comportamiento defensivo que observamos fue complejo y efectivo. La madre pudo guiar al joven ardillón fuera del peligro, y la estrategia estuvo bien planeada, ya que se retiraron a un árbol cercano donde la serpiente de cascabel estaría en desventaja. Se concluye que los ardillones de roca tienen un comportamiento bien desarrollado para proteger a sus crías contra los ataques de serpientes.

Palabras clave: Advertencia; ataque; comportamiento; depredación; mamíferos; reptil.

Prey-predator interaction between *Otospermophilus* (for this study, we refer to the genus as ground squirrels and rock squirrels to the species *O. variegatus*) and *Crotalus* sp. (rattlesnakes) has shaped the biochemical evolution and behavior of ground squirrels. Previous studies show that ground squirrels are a preferred alimentary item for rattlesnakes and can account for up to 80 % of the total biomass consumed (Diller and Wallace 1996). However, this predation contributed to exerting a selective pressure that led to the development by the ground squirrels of resistance to rattlesnake venom (Martinez *et al.* 1999; Biardi *et al.* 2006; Biardi and Coss 2011) and elaborated behaviors to avoid and confront this threat (Owings *et al.* 2001).

During encounters, ground squirrels attempt to intimidate the snakes by raising their tail, moving it from side to side, and harassing them by throwing substrate or even direct attacks (Owings *et al.* 2001). At the same time, ground squirrels use snake scent to protect against predation by applying on themselves substrate on which the snake rested (Owings *et al.* 2001) or by chewing rattlesnake skins and licking their fur (Clucas *et al.* 2008). All this reveals a strong interaction between those 2 genera that shaped recent evolution and ecological patterns of ground squirrels. However, previous studies suggest that adult ground squirrels are well prepared to confront rattlesnakes but are vulnerable during the first stages of their lives as kittens and juveniles (Swaisgood *et al.* 1999; Owings *et al.* 2002; Clucas *et al.* 2008), despite that there is very limited information on how these vulnerable groups respond to a rattlesnake threat and even less on how ground squirrel mothers defend their offspring (see Swaisgood *et al.* 1999; Clucas *et al.* 2008). In this work we report an observation of an attack by a *Crotalus molossus* rattlesnake on a *Otospermophilus variegatus* juvenile and the response by its mother.

The observation was made inside Pedregal de San Ángel (PSA) Ecological Reserve, a lava field supporting a temperate xeric scrub ecosystem in México City, Mexico. Both rock squirrels and rattlesnakes are common to this reserve, and predation of rock squirrels was reported (Balderas-Valdivia *et al.* 2009; Hortelano-Moncada *et al.* 2009). The encounter took place inside the west core zone of the reserve (an area of 95 ha of natural vegetation and 17 ha of managed vegetation; Figure 1) on edge between natural vegetation (xerophytic shrubs) and managed vegetation (grass plantation) at 17:08 hr on November 14, 2022, and was observed by S. I. González-Jaramillo and I. Lozano-Amaro.

During an unrelated work in the area, a strange behavior of a rock squirrel cached our attention. The squirrel had its tail upward and moved it vigorously; upon closer examination, we found that there were 2 squirrels, a bigger one (apparently the mother) and a smaller one (the offspring), and a large rattlesnake (*ca.* 135 cm in length). We consider that the squirrels were a mother-offspring pair due to their difference in sizes (that could only be attributed to age since sexual dimorphism in this species is small; Oaks *et al.* 1987) and previous studies show that *O. variegatus* females became territorial when taking care of youngs (Johnson 1981); therefore, it is unlikely that a young rock squirrel will

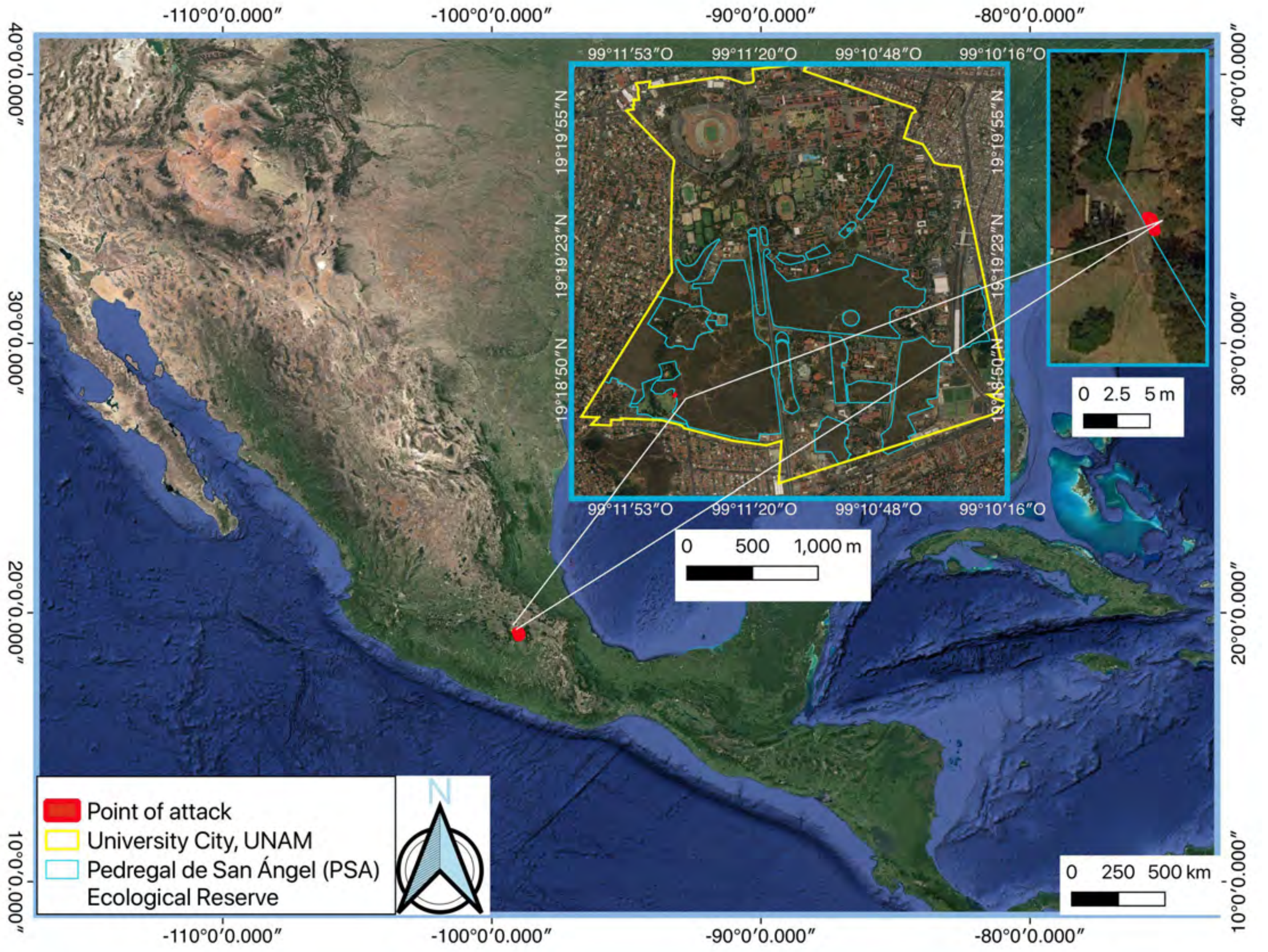

Figure 1. Location of the encounter between a rock squirrel (*Otospermophilus variegatus*) and a rattlesnake (*Crotalus molossus*) in Pedregal de San Ángel Ecological Reserve, located inside México City, México. Elaborated by: S. I. González-Jaramillo.

be in contact with an adult other than its mother. The small squirrel had clear marks of a recent snake bite, its face had blood and was swollen (a classical early sign of rattlesnake poisoning; Gil-Alarcón *et al.* 2011; Figure 2). The mother was moving laterally, climbing a fallen tree (Figure 2) with its tail up and moving it to the sides and up and down (Figure 3).

The small squirrel followed closely but made no attempts to intimidate the rattlesnake. After reaching a safe distance from the rattlesnake (~2 m) the mother jumped from the tree and guided the smaller squirrel around the rattlesnake, always maintaining a 2-2.5 m safe distance. Apparently, the smaller squirrel couldn't see clearly due to the attack; therefore, it was guided by its mother's smell; when climbing the tree, it had its head close to the mother's tail, and when the mother jumped off the tree the youngling couldn't follow so the mother returned and put its tail in front of the youngling's face after that it was able to follow the mother.

The rattlesnake was rattling its tail during the entire duration of the encounter (notice that this is a defensive behavior, not a hunting one; Owings *et al.* 2002) and appeared to move forward, but was dissuaded by the mother's attitude. When the squirrels were clearly out of reach, the rattlesnake turned around and retreated from the encounter.

Interestingly enough, before leaving the site the mother squirrel approached us to a close distance (~ 50 cm) and tried to interact either to ask for help or warn about the danger. To clarify this behavior, we interviewed the gardeners that commonly work in this place, and they mentioned that they typically find rattlesnakes there; however, they are warned by the squirrels close to them, which make a loud click with their snouts and move their tails with the same pattern described to warn of the presence of the snake.

Previous studies have shown that ground squirrels warn other individuals of the same species about rattlesnakes (Swaisgood *et al.* 1999; Owings *et al.* 2001); however, this data suggests that this warning behavior can extend to other species like humans (although this needs to be proved by further studies).

Rock squirrels and ground squirrels, in general, have complex and effective strategies to confront rattlesnakes (Owings *et al.* 2001; Clucas *et al.* 2008); however, this observation suggests that their behavior is equally well developed to protect their younglings. In our opinion, four aspects of this encounter should be carefully considered. First, the mother was able to guide the youngling despite it was unable to see by using scent, a valuable ability in this case, and if the attack was performed in the dark, for example, inside a burrow (notice that rattlesnakes can detect heat, therefore, are less affected by the darkness; Ebert and Westhoff 2006). Second, the mother retreated laterally to a high ground despite being able to go backward on an open field; this appears to be a calculated move since rock squirrels are great climbers while rattlesnakes generally are found on the ground, therefore making a pursuit by

Figure 2. Mother squirrel (*Otospermophilus variegatus*) protecting offspring from rattlesnake (*Crotalus molossus*) attack in Pedregal de San Ángel Ecological Reserve, located inside México City, México. Photography and video by: S. I. González-Jaramillo. The video can be seen at this link: https://www.instagram.com/reel/CtqJ5RgsdYW/?igshid=MzRlODBiNWFlZA%3D%3D.

Figure 3. Mother squirrel (*Otospermophilus variegatus*) moving her tail up and down and to the sides during a rattlesnake (*Crotalus molossus*) attack in Pedregal de San Ángel Ecological Reserve, located inside México City, México. Notice that the juvenile is hiding behind the mother and apparently following her scent. Photography by: S. González-Jaramillo.

the rattlesnake very unlikely. Third, the mother had a well-established safe distance from the rattlesnake 2-2.5 m; at this distance, it stopped the confrontation while surrounding it always kept a safe distance from the danger. It is not clear why the squirrel chose this distance and whether this is based on the personal experience of the individual or not, but, given the normal attack range of a rattlesnake of 50 cm (Owings *et al.* 2001), a 2 m distance appears to be quite safe. And fourth, the attempt of interaction with human observers suggests (although more research is needed on this topic) that rock squirrels are willing to work together with other species to confront the common enemy.

In conclusion, we observed an efficient and elaborated behavior of the rock squirrel to save its youngling which suggests that the defense of the offspring against rattlesnakes is well-developed conduct in this species, and future studies on this interaction should be performed.

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Noteworthy record of melanism in *Leopardus tigrinus* from El Cocuy National Natural Park, Colombia

Registro notable de melanismo en *Leopardus tigrinus* en el Parque Nacional Natural El Cocuy, Colombia

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Melanism is the excess of dark pigmentation that partially or completely covers the body of an animal. The presence of melanic individuals is relatively common in several feline species. The objective of this note is to report the second case of melanism in free-living *Leopardus tigrinus* in Colombia. For the country, there is only one published record for the Department of Caldas. Between June 2012 and March 2020, 158 single camera-trap stations were set up in 5 protected areas in the Eastern Cordillera of Colombia. After almost 8 years of monitoring and with a sampling effort of 60,704 nights/trap, we recorded one melanic individual of *L. tigrinus*, in El Cocuy National Natural Park. So far, the presence of melanic individuals of *L. tigrinus* has been recorded mainly in Brazil (although once its taxonomy is clarified it may correspond to a different species). For Colombia, there is one documented record more than 350 km away from ours (Department of Boyacá). It is considered that this phenomenon may be an adaptive response of the species to environmental evolutionary pressures and has been proposed as a niche segregation strategy; however, given the rarity of this phenotype in the study area, and in general throughout its distribution, it is necessary to gather more evidence that could potentially explain the selective forces that favor or limit this type of phenotypic expression.

Key words: Boyacá; camera-trapping; dark pigmentation; National Natural Parks; ocelot.

El melanismo es el exceso de la pigmentación oscura que cubre parcial o totalmente el cuerpo de un animal. La presencia de individuos melánicos es relativamente común en varias de las especies de felinos. El objetivo de esta nota es reportar el segundo caso de melanismo en *Leopardus tigrinus* en vida libre para Colombia. Para el país solo existe un registro publicado para el departamento de Caldas. Entre junio de 2012 y marzo de 2020 se colocaron 158 estaciones simples de fototrampeo, en 5 áreas protegidas en la Cordillera Oriental de Colombia. Después de casi 8 años de monitoreo y con un esfuerzo de muestreo de 60,704 noches/trampa, registramos un individuo melánico de *L. tigrinus*, en el Parque Nacional Natural El Cocuy. Hasta ahora, la presencia de individuos de *L. tigrinus* melánicos se ha registrado principalmente en Brasil (aunque una vez se aclare su taxonomía pueda corresponder a una especie diferente). Para Colombia se cuenta con un registro documentado a más de 350 km de distancia del nuestro (departamento de Boyacá). Se considera que este fenómeno puede ser una respuesta adaptativa de las especies a presiones evolutivas del ambiente, y ha sido propuesta como una estrategia de segregación de nicho; sin embargo, dada la rareza de este fenotipo en el área de estudio, y en general a lo largo de su distribución, es necesario recabar mayor evidencia que pueda potencialmente explicar las fuerzas selectivas que favorecen o limitan este tipo de expresión fenotípica.

Palabras clave: Boyacá; cámaras trampa; parques nacionales naturales; pigmentación oscura; tigrillo.

Northern tiger cat (*Leopardus tigrinus,* Schreber 1775) is one of the 7 wild felids of Colombia (Ramírez-Chaves *et al.* 2016), considered the smallest species and one of the least known both at national and global scale (Clavijo and Ramírez 2012; Cossíos *et al.* 2012; Suárez-Castro and Ramírez-Chaves 2015; González-Maya *et al.* 2022), despite its relatively large distribution from northern Argentina to Costa Rica, covering a significant portion of Brazil (although with pending taxonomic issues), in an elevational range between 0 and 3,626 m (Payán-Garrido and González-Maya 2011; Payan and de Oliveira 2016). In Colombia, Northern tiger cat occurs through the Eastern, Central and Western ranges of the Andes (González-Maya *et al.* 2022), mainly associated with open and closed forested areas (Bellani 2019). The species feeds primarily on birds and mammals, mainly small rodents, and occasionally reptiles and invertebrates, and even traces of plant material have actually been reported in its diet (Trigo *et al.* 2013). The Northern tiger cat is characterized by having light yellow-gray fur, with black stripes on the neck that extend towards the back and sides, with elongated black spots of brown color, and with the length of the tail representing 60 % of the head-body length (Bellani 2019) and neck hair directed backwards, contrary to *L. wiedii*, a very similar species that is also sympatric on certain areas of their distributions (Pacheco *et al.* 2001). Although this color pattern is the typical one reported in the literature for most of its distribution (Nascimento and Feijó 2017), occasionally it is possible that chromatic anomalies appear in this species (Graipel *et al.* 2014), as in other spotted felids (Eizirik *et al.* 2003; Schneider *et al.* 2012; González-Maya *et al.* 2018).

There are several types of chromatic abnormalities in mammals, among which albinism, leucism and melanism stand out (Uieda 2000; Brito and Valdivieso-Bermeo 2016; Mahabal *et al.* 2019). The first two of them are chromatic disorders caused by recessive genes that generate snow tones in organisms, causing total or partial absence of pigmentation in the fur (Binkley 2001; Guevara *et al.* 2011); while melanism is the excess of dark pigmentation that partially or totally covers the body of an animal, due to the mutation of various genes such as the melanocortin-1-receptor (MC1R) and the agouti signaling protein (ASIP; Rubio-Gutiérrez and Guevara-Chumacero 2017; Valdivia and Pacheco 2019). Other previous explanations indicate that this phenomenon may also be due to the expression of a recessive gene, which may be hereditary (Rubio-Gutiérrez and Guevara-Chumacero 2017). The presence of melanistic individuals is considered relatively common among several felid species (Eizirik *et al.* 2003; Rubio-Gutiérrez and Guevara-Chumacero 2017) and their presence may be due to recessive monogenic expression in a polymorphic population, which could be being refined (Roulin *et al.* 2011; Dreiss *et al.* 2012; Kaelin *et al.* 2012). It has also been documented that melanism could provide certain adaptive and ecological advantages: resistance to viral infections and other diseases (Miyazawa 2002), greater absorption of solar radiation and thus greater adaptation to living at higher altitudes, improvements in temperature regulation in humid environments (Majerus and Mundy 2003), or advantages such as anti-predator strategies (Van den Brink *et al.* 2012). In this work we document a notable record of melanism in the free-living Northern tiger cat (*L. tigrinus*) in the Eastern Cordillera of Colombia.

The study area is located in the extreme north of the Eastern Cordillera of Colombia, in which 5 protected areas were included: Parque Nacional Natural (PNN) Tamá, PNN El Cocuy, PNN Pisba, Santuario de Fauna Flora Guanenta Alto Río Fonce (SFF GARF) and Área Natural Única Los Estoraques (ANULE); including their buffer zones in the departments of Santander, Norte de Santander and Boyacá (Figure 1). The sampling consisted of the installation of 158 simple Bushnell Trophy Cam (Agressor HD, Reconyx RM45 y HC500) and Primos Truth (Cam 35) camera-trap sta-

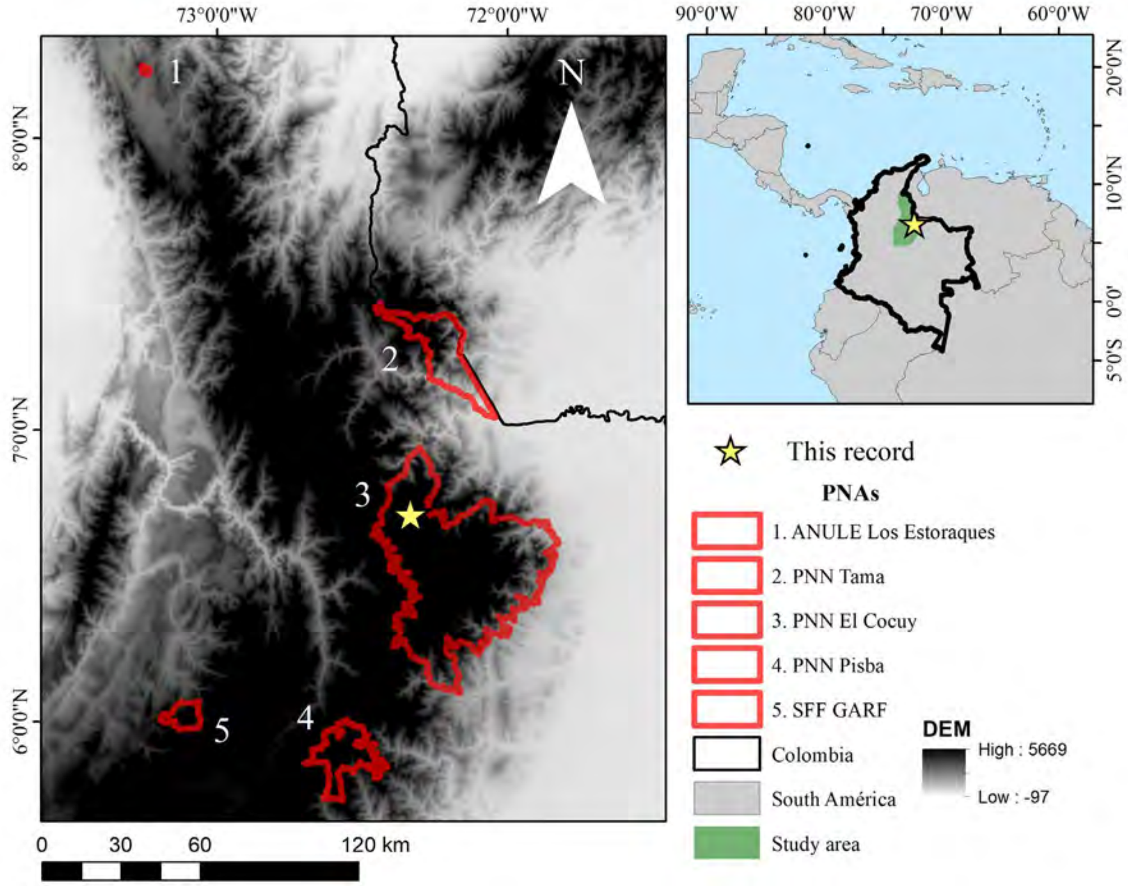

Figure 1. Study area location and locality of the melanistic *Leopardus tigrinus* record in El Cocuy National Natural Park, Colombia. Protected areas (PA) are marked and delimited in red.

tions, in 3 time-periods: i) June 2012 throughout May 2015; ii) October 2017 throughout June 2018; and iii) January 2019 throughout March 2020. The stations were distributed like this: 85 simple stations at PNN Tamá, 16 at PNN El Cocuy, 20 at PNN Pisba, 27 at SFF GARF and 10 stations at ANULE. Each camera was configured with automatic sensitivity level, active during the 24 hr and configured on video with 15 sec length and 15 sec as interval between events. Likewise, we reviewed whether there are other records in the country, both in scientific literature and records in the media, in order to contextualize the rarity of the phenomenon in the country.

We obtained a total sampling efforts of 60,704 trap-nights (t-n) for the entire study, distributed in: 29,032 t-n for PNN Tamá, 2,770 t-n for ANULE, 9,080 t-n for PNN Pisba, 12,558 t-n for SFF GARF and 7,264 t-n for PNN El Cocuy. During the sampling period, on September 19, 2019 at 4:53 hr, in vereda Las Tapias, Chiscas municipality, Boyacá, at 4,254 m within PNN El Cocuy (06° 42′ 31.6″ N, 72° 20′ 30.1″ W, WGS84; Figure 1), we recorded one individual of *L. tigrinus* with evident melanism on the face (Figure 2a, b). We should note that during the sampling period at the same camera trapping station, 3 individuals were also recorded but all presented typical coloration (Figure 2c, d). Likewise, during the entire study, 33 individuals of the species with the typical coloration were recorded; however, this melanistic individual was recorded in a single event and it was not possible to obtain a photographic record of its entire body.

The quick review of the press articles allowed us to identify some occasional records of melanism in *L. tigrinus* in departments such as Antioquia, Huila, Cauca and Valle del Cauca, along with records for Valle del Cauca for *L. wiedii* (Table 1); recently, in addition, 2 records for the Eastern Cordillera reported in the press were made public (Santander and Boyacá departments), although there is not much information about them, and they have not been documented in the literature or adequately validated (Table 1).

Although in Brazil this type of phenotypic expression seems to be common in both *L. tigrinus* and in similar species (Graipel *et al.* 2014), in Colombia there is only one report documented by Ramírez-Mejía and Sánchez (2015), who reported the presence of one melanistic individual in the "CHEC" reserve, in the department of Caldas, in the Central Cordillera of Colombia, 350.5 km northeast from this record (05° 01' 0.5" N, 75° 23' 0.0" W, WGS84). On the other hand, González-Maya *et al.* (2018) reported this phenomenon for *L. wiedii* in the department of Magdalena, Colombia (~ 500 km away), so this would be the second and most recent

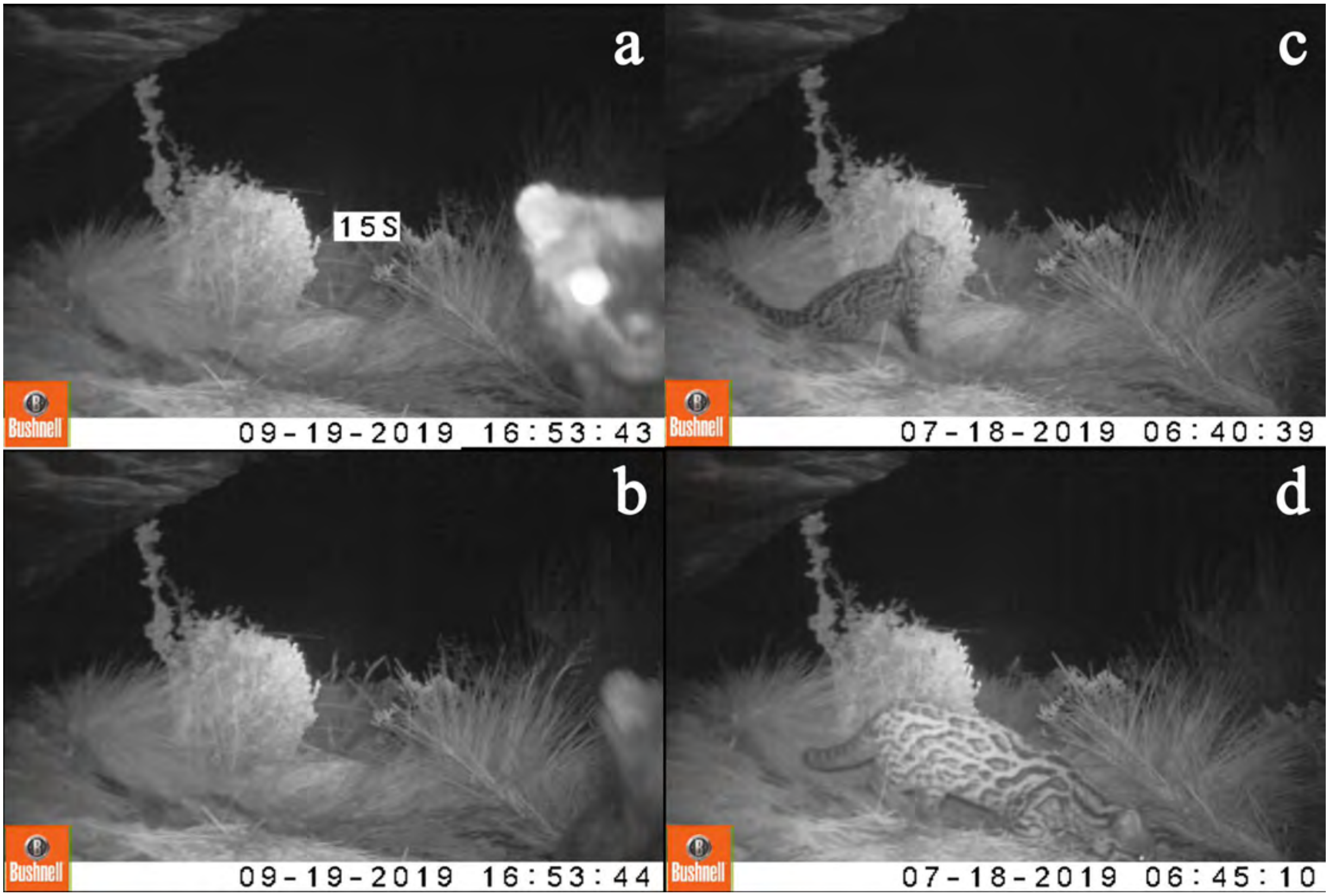

Figure 2. a) and b) Melanistic *Leopardus tigrinus* recorded in camera-traps, with clear pigmentation in the face in El Cocuy National Natural Park, Colombia; c) and d) *L. tigrinus* individual with typical coloration also recorded in the same area.

Table 1. Press sources regarding melanistic records according to departments in Colombia.

Species	Departament	Source
Leopardus tigrinus	Antioquia, Boyacá, Cauca, Huila, Santander, Valle del Cauca	https://www.semana.com/actualidad/articulo/felino-melanico-camaras-captan-por-primera-vez-la-presencia-de-un-tigrillo/58657/ https://noticias.caracoltv.com/antioquia/la-leccion-de-un-campesino-de-amalfi-que-salvo-a-este-tigrillo-melanico-de-una-jauria-de-perros https://www.metropol.gov.co/Paginas/Noticias/tigrilla-lanuda-melanica-ahora-vive-libre-en-el-alto-de-san-miguel.aspx https://www.elcolombiano.com/medio-ambiente/tigrillos-melanicos-en-antioquia-CO20597225 https://www.bluradio.com/nacion/en-video-quedaron-registrados-tiernos-tigrillos-melanicos-en-el-huila-rg10 https://www.semana.com/actualidad/articulo/felino-melanico-camaras-captan-por-primera-vez-la-presencia-de-un-tigrillo/58657/ https://www.bcnoticias.com.co/registrado-por-primera-vez-un-tigrillo-melanico-en-el-parque-nacional-natural-pisba/ https://www.vanguardia.com/area-metropolitana/bucaramanga/la-historia-del-fascinante-tigrillo-negro-rescatado-en-santander-FI6486447
Leopardus wiedii	Valle del Cauca	https://www.semana.com/medio-ambiente/articulo/en-video-tigrillo-melanico-ocelote-y-cusumbos-son-captados-en-valle-del-cauca/54345/

record of melanism in *L. tigrinus* formally documented. According to our review, there are only a few isolated observations or unpublished reports in press releases and other media for both species in Colombia; some of these interesting records are worth having them properly identified (Table 1), but at the same time they confirm the need to further study the subject and continue adequately documenting this phenomenon in the country.

Although Graipel *et al.* (2014) state that these phenotypic variations may be part of temporary niche segregation strategies within the same species and with other competing species, the rarity of the records in the study area may indicate that they are random expressions of the genetic code, which could also be demonstrating an evident presence of polymorphisms (Wellenreuther *et al.* 2014; Yuxing *et al.* 2021) in Colombia. However, the considerable elevation of the record (4,170 m) could be related to the advantages that melanism represents to deal with high elevations and low temperatures (Eizirik *et al.* 2003; Majerus and Mundy 2003; Schneider *et al.* 2015); nevertheless, there is not enough information to support this claim. Since several individuals of *L. tigrinus* with typical coloration were recorded at the site where the melanistic individual was recorded, it is recommended to increase the sampling in this area of El Cocuy PNN, in order to know how common this phenotypic expression is. Likewise, in a subsequent study, it seems warranted that is necessary to evaluate the effect that this characteristic may have on the ecological fitness, ecology and survival of the individuals that present this unique condition.

Acknowledgements

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Mammals in a cloud forest patch and a restored area in central Veracruz, México

Mamíferos en un fragmento de bosque mesófilo de montaña y una zona restaurada en el centro de Veracruz, México

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Cloud forests (CF) are home to 53 % of the mammal species recorded in México. Mammals are adversely affected by different causes, some of which are listed in a risk category. This study assessed the richness and abundance of a mammal community in a CF patch and a restoration area (RA) in Huatusco, Veracruz, México. Mammals were monitored by camera traps and track search (September 2019–May 2020). A taxonomic list was elaborated, including the risk category (NOM-059-SEMARNAT-2010 and IUCN). Species richness was compared using species accumulation curves and a similarity index between treatments. Fifteen species were recorded: 13 in camera traps and 2 through tracks. It is worth highlighting the presence of *Leopardus wiedii* (Endangered / Near Threatened), *Dasyprocta mexicana* (Critically Endangered), *Potos flavus* (Threatened), *Galictis vittata* (Special Protection), and *Mazama temama*, a species of hunting value. The CF and RA recorded 9 and 12 species with 96 % and 100 % completeness, respectively, yielding a similarity value of 63 %. The species richness in the area is complementary between treatments. We found opportunistic species in the RA and species less tolerant to disturbance in the CF. The presence of carnivores reflects the importance of this area for mammal conservation.

Key words: Camera traps; diversity; habitat; Huatusco; mammals; species richness.

En el bosque mesófilo de montaña (BMM) se reporta el 53 % de las especies de mamíferos de México. Los mamíferos han sido afectados negativamente por diferentes causas, y algunos están clasificados en categoría de riesgo. El objetivo del estudio fue conocer la riqueza y abundancia de una comunidad de mamíferos en un fragmento de BMM y una zona de restauración (ZR), en Huatusco, Veracruz, México. Se utilizó fototrampeo y búsqueda de huellas para el registro de mamíferos (septiembre 2019-mayo 2020). Se realizó un listado taxonómico incluyendo la categoría de riesgo (NOM-059-SEMARNAT-2010 y IUCN). Se comparó la riqueza de especies mediante curvas de acumulación de especies y se calculó un índice de similitud entre los tratamientos. Se registraron 15 especies: 13 mediante cámaras trampa y 2 por huellas. Destacan *Leopardus wiedii* (peligro de extinción/casi amenazada), *Dasyprocta mexicana* (peligro crítico), *Potos flavus* (amenazada), *Galictis vittata* (protección especial) y *Mazama temama* (especie cinegética). El BMM y la ZR presentaron 9 y 12 especies, con una completitud del 96 % y el 100 %, respectivamente, y una similitud de 63 %. Se determinó que la riqueza de especies en el área se ve complementada entre ambos tratamientos. En la ZR encontramos especies oportunistas, mientras que en el BMM especies con menor tolerancia a la perturbación. La presencia de carnívoros es un indicativo de la importancia de esta área para la conservación de los mamíferos.

Palabras clave: Cámaras trampa; diversidad; hábitat; Huatusco; mastofauna; riqueza de especies.

The cloud forest (CF) is one of the most diverse vegetation types in México; it is a complex biotic community located in areas with constant rainfall, fog, and high atmospheric humidity, mainly at high elevations (Rzedowsky 2006; Gual-Díaz and Rendón-Correa 2017). CF are key for biodiversity conservation and provide multiple ecosystem services, such as provision, cultural and recreational uses, environmental regulation, water collection and filtration, reduction of soil erosion, maintenance of the hydrological cycle, and ecotourism promotion (González-Espinoza *et al.* 2012; González-Ruíz *et al.* 2014; Williams-Linera 2015).

More than 50 % of the original CF coverage has been converted to other land uses, including agriculture, urban areas, and agribusiness development. Today, it covers less than 1 % of México's territory considering the associated secondary vegetation, and less than 0.4 % if only primary forests are accounted for (Gual-Díaz and Rendón-Correa 2017). Additionally, CFs are being affected by climate change, agriculture, and habitat reduction, threatening the native species (Williams-Linera *et al.* 2002; Pérez-Lustre *et al.* 2006; García-Burgos *et al.* 2014; Gual-Díaz and Rendón-Correa 2017).

In Veracruz, México, CF fragments are located in the transition zone between the Nearctic and Neotropical biogeographic regions, characterized by the distribution of endemic and rare mammals (Ceballos *et al.* 2002). In this area, and particularly in central Veracruz, CFs have experienced disturbances due to agriculture, urbanization, the establishment of industries, and the illegal exploitation of wild flora and fauna (Williams-Linera 1993; Williams-Linera *et al.* 2002, 2007).

Cloud forests are characterized by high mammal species richness. Some of these species are indicators of ecosystem quality due to their sensitivity to anthropic changes (Phelps and McBee 2009; Macario-Cueyactle *et al.* 2019; Willig *et al.* 2019). An example are medium and large-sized mammals whose species richness and abundance are affected by disturbance (Mezhua-Velázquez *et al.* 2022). Some mammal species with particular habitat requirements have become locally extinct while the population size of some disturbance-tolerant species has increased as top carnivores become extinct (Di Bitteti 2008; Macario-Cueyactle *et al.* 2019).

In recent decades, biodiversity loss has been observed in different regions of Veracruz. The richness of mammals has declined in different ecosystems, and populations are being decimated to the extreme of defaunation (Tlapaya and Gallina 2010). The study of mammal communities supports the conservation of these and other biological groups since several species function as "umbrellas", additionally, it allows inferring the conservation status of forests (Pérez-Irineo and Santos-Moreno 2010; González-Christen and Delfín-Alfonso 2016). However, ecological studies focused on the CFs and restored areas of central Veracruz are scarce (González-Ruíz *et al.* 2014), although this knowledge is key for decision-making concerning the protection of their populations and habitats (Zapata-Ríos *et al.* 2006; Macario-Cueyactle *et al.* 2019).

In recent years, patches of CF have been restored in central Veracruz through active and passive techniques. Seedlings of *Quercus xalapensis* and *Alnus acuminada* are planted for active restoration (RA). In contrast, passive restoration is taking place through natural succession in land owned by persons interested in the conservation and management of the ecosystem and its species (López-Barrera *et al.* 2016). This study compared the species richness and relative abundance of medium-sized mammals in a cloud forest fragment and an actively restored area within the Centro Agroecológico Las Bellotas, located in the Huatusco municipality, Veracruz.

Study area. The present study was conducted in a 100 ha land in the locality known as Centro Agroecológico Las Bellotas (19° 10' 40.123" N, 96° 58' 35.606" W), municipality of Huatusco, Veracruz, México (Figure 1). The prevailing climate is semi-warm-humid with temperature ranging between 16 ºC and 26 °C and an annual mean precipitation between 1,100 mm and 1,600 mm (INEGI 2020). The site comprises 50 ha of CF dominated by trees of more than 40 m in height (measured *in situ*), a large number of epiphytes, and a closed canopy (compared to the RA, characterized by a heterogeneous tree canopy). The soil is covered by herbaceous and shrub vegetation, and most of the ground contains organic matter derived from litter.

Adjacent to the Las Bellotas CF patch, there is the RA covering 50 ha, where restoration initiatives such as reforestation with native trees were performed approximately 20 years ago. This area is currently home to trees 25 m high on average (measured *in situ*), with an open and heterogeneous canopy, and few epiphytic plants. To note, the RA was previously used as pastureland for extensive cattle raising for over 25 years, but livestock was excluded in 2005 to implement restoration efforts (López-Barrera *et al.* 2016). However, pastures still dominate the landscape in some areas, both on the edges and within the RA.

Mammal monitoring. Six camera traps (Bushnell® and Cuddeback®) were installed at Las Bellotas to record the species richness and relative abundance of mammals, with 3 traps installed in the CF and three in the RA, leaving a separation of approximately 500 m between traps (Figure 1). Camera traps were set to capture 3 photographs per event with a minimum three-second interval between photographs; traps remained operational 24 hr a day from 5 September 2019 to 28 May 2020. Camera traps were placed in sites with characteristics previously identified as suitable to increase the success of mammal recording, such as the presence of fruit species, proximity to water bodies, and presence of tracks on paths (Hernández-Hernández *et al.* 2018; Lizcano 2018). Camera traps were affixed on tree trunks 50 cm above the ground, slightly bent towards the ground to detect small and medium-sized species, and with a separation of at least 500 m between them to avoid duplicate species counts (Chávez *et al.* 2013).

To increase the success of species richness records, mammal tracks were surveyed along 4 km of the trails set in the CF, the RA and near water bodies. Tracks were identified using the guide by Aranda-Sánchez (2012).

Analysis of mammal species richness and relative abundance. Mammal photographs and tracks were taxonomically identified and are listed according to the nomenclature of Ramírez-Pulido *et al.* (2014). This list includes the risk category of each species according to the NOM-059-SEMARNAT-2010 (SEMARNAT 2019a) and the International Union for the Conservation of Nature (IUCN 2022).

Given the area comprised by the treatments (100 ha in total: 50 ha of CF and 50 ha of RA), photographs were considered independent records when there was a three-hour difference for the same species and when more than one individual was characterized based on physical marks or traits, such as sex. Individual photographs were sorted by species, and each separate record was considered a record in each sampling zone (Moreno *et al.* 2011; Chávez *et al.* 2013).

The relative abundance was calculated using the following equation: IAR = C/EM*1,000 trap days, where C = total number of species records; EM = sampling effort (number

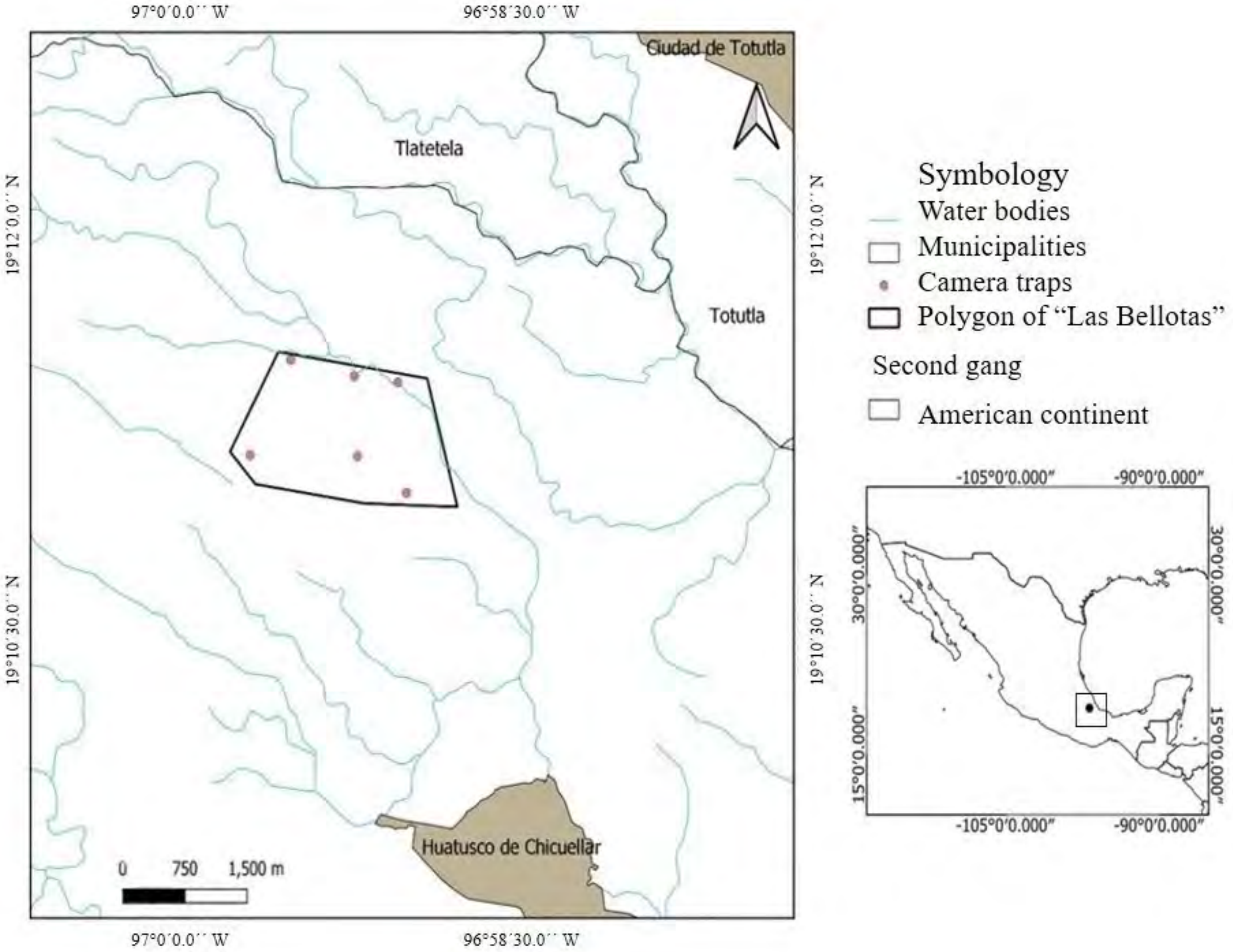

Figure 1. Centro Agroecológico Las Bellotas, Veracruz, México, indicating the camera trap sites for mammal monitoring.

of camera traps); 1,000 trap days (standard measure). IAR values were plotted by treatment and species (Lira-Torres and Briones-Salas 2012).

The species richness and total mammal records were compared between CF and RA using species accumulation curves based on individuals. These plots comparing the species richness with 95 % confidence intervals calculated through data iterations (Serna-Lagunes *et al.* 2019). These analyses were performed through the interpolation/extrapolation algorithm of the iNEXT software (Chao *et al.* 2016).

Finally, Sorensen's index was calculated using binary data (0, 1) to estimate the richness similarity between treatments using the following equation: IS = ((c)/(a+b+c)) * 100, where a = number of species in the CF, b = number of species in the RA, and c = species richness of mammals in both vegetation types (Moreno 2001).

With a sampling effort of 266 days and 1,596 trap days, we recorded 6,073 photographs and 323 separate records involving 15 mammal species, 11 families, and 6 taxonomic orders (Table 1). The following 13 species were recorded with camera traps: *Sciurus aureogaster*, *S. deppei*, *Dasyprocta mexicana*, *Cuniculus paca*, *Sylvilagus floridanus*, *Leopardus wiedii*, *Procyon lotor*, *Nasua narica*, *Potos flavus*, *Urocyon cinereoargenteus*, *Galictis vittata*, *Didelphis* spp., and *Dasypus novemcinctus* (Figure 2). *Canis latrans* and *Mazama temama* were identified based on tracks.

It is worth highlighting the presence of *Leopardus wiedii*, *Potos flavus,* and *Galictis vittata*, listed as endangered, threatened, and subjected to special protection, respectively, in the NOM-059-SEMARNAT-2010. *Sciurus aureogaster* (IAR = 78.32) and *Cuniculus paca* (IAR = 61.4) were the most abundant species (Figure 3a). Furthermore, *Mazama temama*, *P. flavus*, *Canis latrans*, *G. vittata* and *Urocyon cinereoargenteus* showed IAR values lower than 1.25 (Figure 3). Last, *Dasypus novemcinctus*, *L. wiedii*, *Sciurus deppei*, *Dasyprocta mexicana, Nasua narica*, *Didelphis* spp., *Procyon lotor*, and *Sylvilagus floridanus* attained an IAR value between 2.5 and 14.4 (Figure 3a).

Nine species and 83 individuals were recorded in the CF, with a sample completeness of 96 %. On the other hand, 12 species and 240 individuals were recorded in the RA, with a

Table 1. Taxonomic list, scientific and common name, and number of mammal records in the cloud forest (CF) and a restored area (RA) at Centro Agroecológico Las Bellotas, Veracruz, México. The conservation status is indicated according to the NOM-059-SEMARNAT-2010 (NOM-059; SEMARNAT 2019a) and the International Union for Conservation of Nature (IUCN 2022). P = Endangered; PE = Special Protection; A = Threatened; LC = Least Concern; CE = Critically Endangered; NT = Near Threatened; DD = Data Deficient.

Orden	Family	Scientific name	Common name	CF	RA	NOM-059	IUCN
Rodentia	Sciuridae	*Sciurus aureogaster*	Mexican gray squirrel	24	101	-	LC
		Sciurus deppei	Deppe's squirrel	0	4	-	LC
	Dasyproctidae	*Dasyprocta mexicana*	Mexican agouti	14	0	-	CE
	Cuniculidae	*Cuniculus paca*	Spotted paca	25	73	-	LC
Lagomorpha	Leporidae	*Sylvilagus floridanus*	Eastern cottontail	0	7	-	LC
Carnivora	Felidae	*Leopardus wiedii*	Margay	1	8	P	NT
	Procyonidae	*Procyon lotor*	Northern raccoon	0	11	-	LC
		Potos flavus	Kinkajou	2	0	PE	LC
		Nasua narica	White-nosed coati	1	4	-	LC
	Canidae	*Canis latrans*	Coyote	0	1	-	LC
		Urocyon cinereoargenteus	Grey fox	0	1	-	LC
	Mustelidae	*Galictis vittata*	Greater grison	1	0	A	LC
Didelphimorphia	Didelphidae	*Didelphis* spp.	Opossum	9	9	-	LC
Cingulata	Dasypodidae	*Dasypus novemcinctus*	Nine-banded armadillo	4	19	-	LC
Artiodactyla	Cervidae	*Mazama temama*	Central American red brocket	0	2	-	DD

sample completeness of 100 %. According to the accumulation curves, there are no significant differences in species richness between the CF and the RA because confidence intervals overlap (Figure 3b).

The CF and the RA shared 6 species: *S. aureogaster*, *C. paca*, *L. wiedii*, *N. narica*, *D. novemcinctus,* and *Didelphis* spp. Only 3 species were recorded exclusively in the CF: *P. flavus*, *G. vittata,* and *D. mexicana*, and 6 species were found exclusively in the RA: *S. deppei*, *P. lotor*, *C. latrans*, *U. cinereoargenteus*, *M. temama,* and *S. floridanus* (Table 1). According to Sorensen's index, there was a 63 % similarity between the CF and the RA.

The 15 species of terrestrial mammals recorded at Centro Agroecológico Las Bellotas represent 3 % of the species reported for México (Ramírez-Pulido *et al.* 2014), 8 % of the 195 species documented for Veracruz (González-Christen and Delfín-Alfonso 2016), and 6 % of the mammal species recorded in the CFs of México (González-Ruíz *et al.* 2014). There was no previous information about mammal richness in this locality of the Huatusco municipality, but this area can be considered important due to the presence of endangered carnivores.

The richness of mammals recorded in this study is consistent with the one reported for the Las Cañadas locality in Huatusco, located approximately 2 km away from our study area. Las Cañadas also harbors a CF and a RA of more than 15 years (García-Burgos *et al.* 2014). The species richness recorded in the present study is higher than values reported for other regions of central Veracruz with CF, such as the Zongolica municipality and the Pico de Orizaba National Park (adjacent to the study area), where 11 and 10 mammal species were recorded, respectively (Macario-Cueyactle *et al.* 2019; Serna-Lagunes *et al.* 2019). However, it was lower than the richness reported for the Tequila municipality, with 16 species (Salazar-Ortiz *et al.* 2020).

The presence and abundance of 7 mammal species of the order Carnivora are indicators of the conservation level of the CF and the RA because they are species more susceptible to anthropic changes and the first to become locally extinct (Briceño-Méndez *et al.* 2017; Cruz-Bazán *et al.* 2017). The local extinction of these species may lead to an increase in rodent populations to such an extent that these are considered pests (Pérez-Irineo and Santos-Moreno 2013). This phenomenon may be occurring with *L. wiedii*, which feeds on *S. aureogaster*. In the absence of a natural predator, the latter may become a pest even in relatively well-conserved ecosystems (Cinta-Magallón *et al.* 2012; Hidalgo-Milhart *et al.* 2012) and thrives in altered sites where there are no predators (Garcés-Restrepo and Saavedra-Rodríguez 2013).

Another abundant rodent in the study area was *C. paca*. The populations of this species can be more abundant in sites with fewer predators and competitors such as *D. mexicana* (Santos-Moreno and Pérez-Irineo 2013). In this sense, this study recorded no predators of this species, such as jaguars or ocelots (which have been reported for the CF). However, it has been documented that *L. wiedii* occasionally feeds on *C. paca* hatchlings. *Leopardus wiedii* and *C. latrans* (potential predators of *C. paca*) were recorded with low abundances (Martínez-Ceceñas *et al.* 2018). The abundance of *C. paca* indicates that it is not impacted by activities such as hunting (Martínez-Ceceñas *et al.* 2018), which is prohibited in the study area.

The recorded abundance of *M. temama* may be due to its cryptic behavior, elusive habits, and susceptibility to human presence since it prefers well-preserved forested areas (Contreras-Moreno *et al.* 2016; Muñoz-Vázquez and

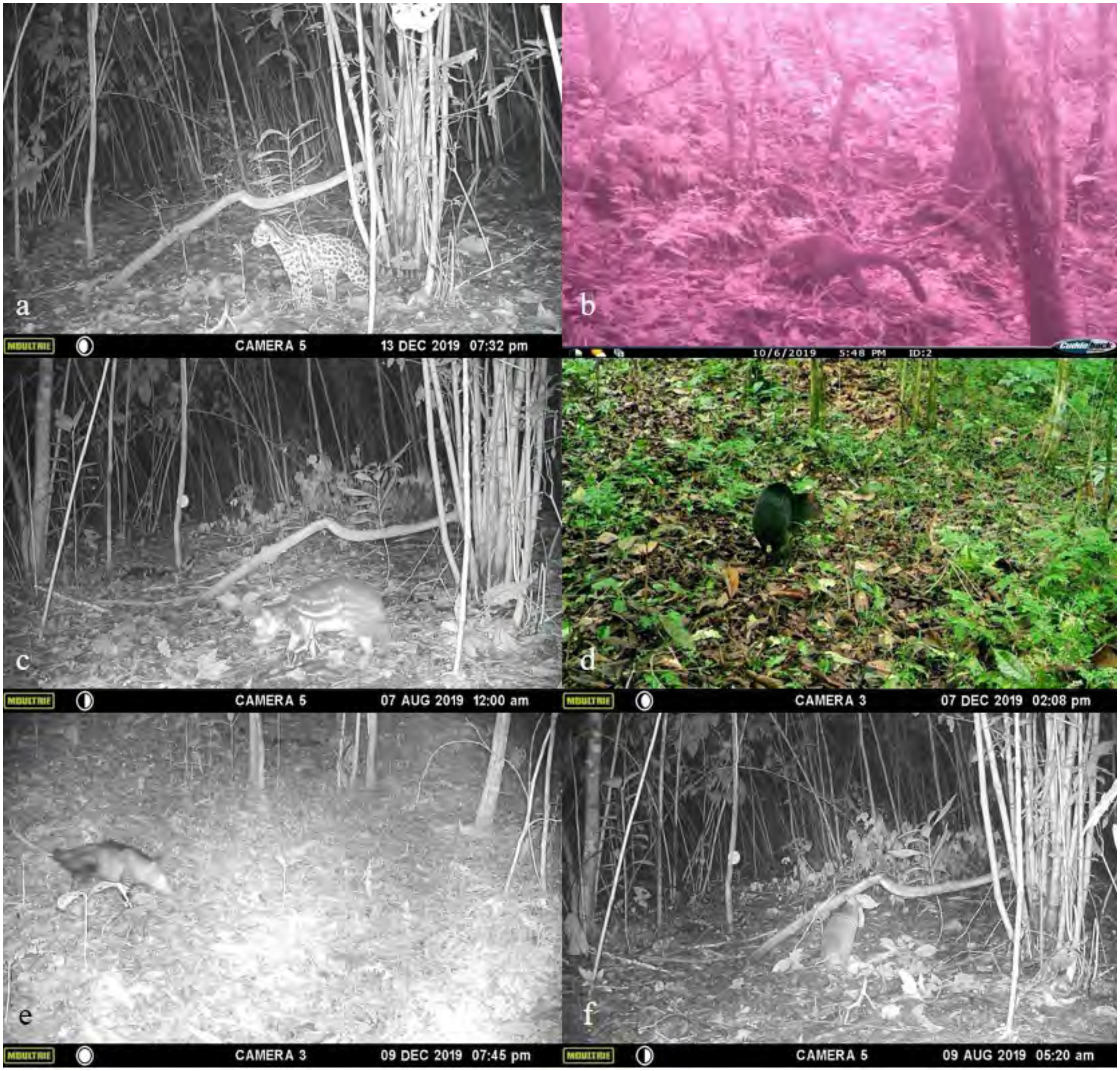

Figure 2. Main records of mammals at Centro Agroecológico de las Bellotas, Huatusco, Veracruz, México: a) *Leopardus wiedii*; b) *Nasua narica*; c) *Cuniculus paca*; d) *Dasyprocta mexicana*; e) *Didelphis* spp.; f) *Dasypus novemcinctus*.

Gallina-Tessaro 2016). In this sense, it is likely that the study site with CF and RA lacks the minimum surface area required for this species or that the habitat conditions are unsuitable to sustain high abundances. The presence of this species may be due to the fact that it occasionally uses the area as a corridor and refuge from threats in surrounding areas (Salazar-Ortiz *et al.* 2022).

Only a single record of the grison, *G. vittata*, was obtained, which was expected as it is considered a scarce species (Lucas-Juárez *et al.* 2021). However, it could also be because this species is usually found in the proximity of water bodies (Hidalgo-Milhart *et al.* 2006). The present study did not consider water bodies due to their difficult access and because some were close to human settlements.

Additionally, *C. latrans* showed low abundance values because this species prefers open areas bordered by vegetation, even being better adapted to anthropic areas and avoiding CFs (Peña-Mondragón *et al.* 2014). By contrast, the two records of kinkajou, *P. flavus*, indicate that CFs provide the tree cover that favor its presence (Monterrubio-Rico *et al.* 2013; Cruz-Bazán *et al.* 2017).

The species richness recorded in this study could be explained because mammal species use complementary resources, thus being distributed in both vegetation types (Macario-Cueyactle *et al.* 2019). There were more records per species in the RA, maybe due to a higher abundance of resources. However, each area has unique biotic and abiotic conditions that favor the presence of different species (Gardner *et al.* 2009). The RA showed more records of opportunistic species (Hidalgo-Milhart *et al.* 2013; Pérez-Irineo and Santos-Moreno 2013; Peña-Mondragón *et al.* 2014).

Considering that low values of the similarity index indicate less similarity (Moreno 2001), we can conclude that these vegetation types complement each other. These differences may be related to the fact that opportunistic species or those that are more active in open sites were recorded in the RA, such as *C. latrans*, *U. cinereoargenteus*, and *P. lotor* (Hidalgo-Milhart *et al.* 2013; Pérez-Irineo and Santos-Moreno 2013; Peña-Mondragón *et al.* 2014). On the other hand, we recorded species more susceptible to habitat changes in the CF, which are found in more densely forested areas because they require more specific habitat resources (Jiménez-Alvarado *et al.* 2016). For instance, *P. flavus* is able to feed in any strata and is usually found in the forest canopy, preferring trees with fruits throughout the year (Hernández-Flores *et al.* 2018). Species of the genus *Didelphis* and *D. novemcinctus* can adapt to habitat changes and have been reported inhabiting both vegetation types (López-Ramírez *et al.* 2020).

Some mammals reported in this study play central ecological roles in the CF, including the dispersal of large seeds by *C. paca* and *D. mexicana* and of smaller seeds by species of the genus *Sciurus* (Rojas-Robles *et al.* 2012; Bonilla-Morales *et al.* 2013). A carnivore species, the gray fox *U. cinereoargenteus*, is an incidental disperser (Villalobos-Escalante *et al.* 2014).

About 44 % of the mammals recorded in this study belong to the order Carnivora. This group is more susceptible to anthropic changes and is one the first groups of species to become locally extinct (Briceño-Mendéz *et al.* 2017). In this sense, the Centro Agroecológico Las Bellotas should be certified as an Área Destinada Voluntariamente a la Conservación (ADVC) y el Programa de Acción para la Conservación de Especies prioritarias (PACE): small felines (SEMARNAT 2019b). This certification would support the study, management, and conservation of the wildlife populations inhabiting this area by research and education institutions, along with the owners of this and adjacent land. Additionally, an environmental awareness program should be implemented aimed at the ecological restoration of the CF in the region.

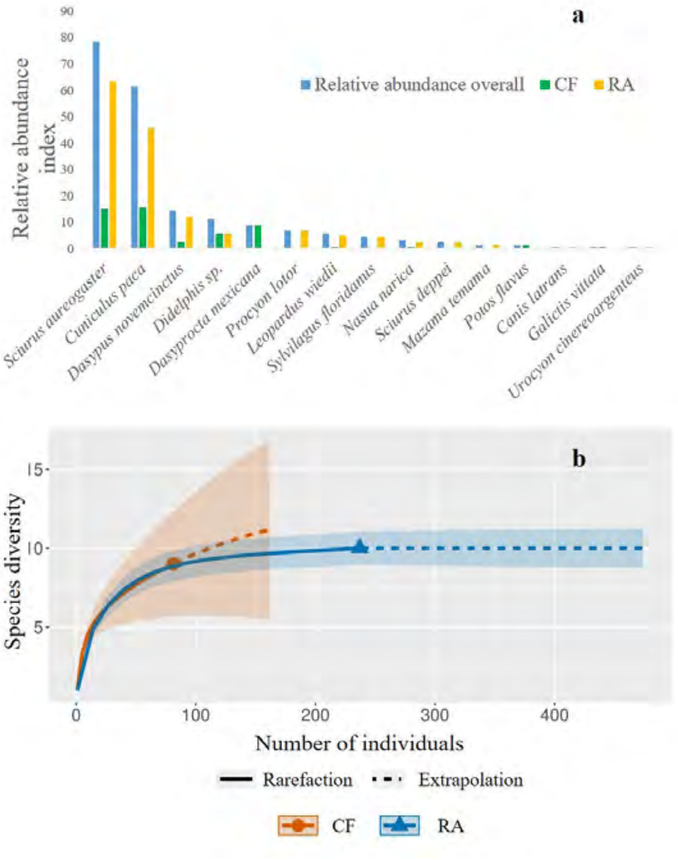

Figure 3. a) Combined relative abundance index by zone of the mammal species recorded in the CF and the RA; b) Interpolation/extrapolation curve of the mammal community in the CF and the RA at Centro Agroecológico Las Bellotas, Veracruz, México.

Fifteen mammal species were recorded in the Centro Agroecológico Las Bellotas. The Mexican gray squirrel (*S. aureogaster*) showed the highest abundance of all the mammals in the CF and the RA, indicating that it is a markedly modified area. The CF harbors species that depend on well-preserved sites or the tree stratum, such as *P. flavus* and *G. vittata*. On the other hand, the RA had a higher richness of opportunistic species that prefer disturbed sites, such as *P. lotor*, *U. cinereoargenteus*, and *C. latrans*. Both sites can be considered complementary, providing habitat to species with different ecological requirements. Protection measures for the species recorded in the study area, such as *L. wiedii*, *P. flavus,* and *G. vittata*, should focus on increasing reforestation with native trees that provide food for wildlife, implementing corridors between the different patches of CF, avoiding the entry of poachers and cattle, and conducting population studies.

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First record of the genus *Metachirus* in Guatemala

Primer registro del género *Metachirus* en Guatemala

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The genus *Metachirus* has a wide distribution throughout the Americas, but there are significant gaps in its distribution in northern Mesoamerica, having only been documented in a few localities in Honduras and México. During biological expeditions in northern and northeast Guatemala, we gathered evidence about the presence of the genus *Metachirus* in the country. We observed and photographed a brown four-eyed opossum individual, *M. myosuros*, in Sierra Caral Water and Forest Reserve, Izabal, Guatemala. Our observation of *M. myosuros* helps to fill in some of the gaps in the distribution of the northern populations of the species and represents the addition of a new genus to the mammal fauna reported for the country.

Key words: Didelphidae; Laguna del Tigre National Park; marsupial; Metachirini; Sierra Caral.

El género *Metachirus* tiene una amplia distribución en toda América, pero existen grandes vacíos en su distribución en el norte de Mesoamérica, donde sólo ha sido documentado en algunas localidades de Honduras y México. Durante expediciones biológicas en el norte y noreste de Guatemala, recolectamos evidencia sobre la presencia del género *Metachirus* en el país. Observamos y fotografiamos un individuo de la zarigüeya café de cuatro ojos, *M. myosuros*, en la Reserva Hídrica y Forestal de Sierra Caral, Izabal, Guatemala. Nuestra observación de *M. myosuros* llena vacíos en la distribución de las poblaciones norteñas de la especie y representa la adición de un nuevo género a la fauna de mamíferos reportada para el país.

Palabras clave: Didelphidae; marsupial; Metachirini; Parque Nacional Laguna del Tigre; Sierra Caral.

The genus *Metachirus* Burmeister, 1854 currently comprises 3 Neotropical species: *M. nudicaudatus* É. Geoffroy Saint-Hilaire, 1803, *M. myosuros* Temminck, 1824 and *M. aritanai* Miranda, Nunes, Machado, Farias, Menezes, Ardente, Dos Santos-Filho, Bredin and da Silva, 2023 (Voss *et al.* 2019; Voss 2022; Miranda *et al.* 2023). For a long time, the genus was considered monotypic, with all of its known diversity included in a single species, *M. nudicaudatus* (Gardner 2005; Gardner and Dagosto 2007; Voss and Jansa 2009, 2021). Several phylogeographic studies demonstrate significant genetic divergence among *M. nudicaudatus*, identifying different monophyletic clades across its distribution (Patton *et al.* 2000; Patton and Costa 2003; Voss *et al.* 2019). After these studies and different integrative taxonomic approaches, the clade *M. myosuros* was revalidated and delimited as a species, as well as *M. aritanai* which was recently described (Miranda *et al.* 2023).

The genus *Metachirus* has a wide geographical range with records ranging from northern Argentina to Chiapas in southern México. Nonetheless, the known distribution of the species shows fragmented patterns with large gaps in northern Mesoamerica, a region where knowledge of the group is scarce (Voss *et al.* 2019; Bautista-Alcantara *et al.* 2022; Voss 2022; Miranda *et al.* 2023). Recent studies have revealed that *M. nudicaudatus* is limited to northeastern Amazonia (Voss *et al.* 2019; Voss 2022; Miranda *et al.* 2023). As currently understood, and based on available information, *M. myosuros* has a wide distribution from México through the humid ecosystems of Central America to South America (Voss *et al.* 2019; Voss 2022). Furthermore, the recently described species *M. aritanai* is restricted to the Xingu-Tocantins interfluve, within the Xingu endemism center *sensu* Silva *et al.* (2005; Miranda *et al.* 2023), in the Brazilian Amazon.

Brown four-eyed opossums, as defined by Voss and Jansa (2009), can be distinguished from other large marsupials in the subfamily Didelphinae by a combination of external and internal morphological features. These include a pair of small cream-colored spots above the eyes, a general brown color, short fur, little or no hair extension at the base of the tail, light to dark brown tail color without a distinction between the basal and distal portions, and the absence of a marsupium in females (Emmons 1997; Eisenberg and Redford 1999; Reid 2009; Voss and Jansa 2009, 2021). One unique characteristic of the genus *Metachirus* is the contact between the frontal and squamous bones in the lateral region of the braincase (Voss and Jansa 2009).

The primary objective of this report is to provide the first record of the brown four-eyed opossum in Guatemala, specifically in Sierra Caral Water and Forest Reserve located in Morales municipality, Izabal department. Additionally, this contribution aims to fill gaps in the distribution of *M. myosuros* in Central America.

During a night walk in La Firmeza (15° 24' 18.4" N, 88° 41' 53.4" W, 472 m), a private reserve located in Sierra Caral, part of the Merendón mountain range, we observed and photographed a specimen of *Metachirus myosuros*. This walk was made together with local park rangers of San José Bonanza community, as part of the joint monitoring and conservation actions that Panthera (a worldwide organization dedicated to the conservation of wild cats and their habitat) has been carrying out in the area since 2017 with the support of the Foundation for Ecodevelopment and Conservation (FUNDAECO), the co-manager institution of this protected area. Sierra Caral is a 190 km^2 area located in the Guatemalan Caribbean region that presents tropical humid forest with altitude varying between 200 and 1,260 m (Figure 1). Izabal and its low tropical humid mountains are characterized by an average temperature of 26.5 °C and a mean annual precipitation of 3,461 mm (Instituto Nacional de Sismología, Vulcanologia, Meteorología e Hidrología, INSIVUMEH 2010; Pérez-Consuegra *et al.* 2017). It is considered one of the most biodiverse forest remnants in Central America (International Conservation Fund of Canada; ICFC 2023), and is home to endemic beetles and amphibians, migratory bird species, as well as endangered and rare mammal species (Pellecer *et al.* 2019; Sasso *et al.* 2020; Smith 2021; ICFC 2023).

On June 19, 2019, at 22:49 hr, we had an encounter with and photographed an individual of *M. myosuros* standing on a tree at around 2.5 m above ground, with its tail partially coiled around a branch. The identification of the individual was based on external morphological characteristics that distinguish species within the genus *Metachirus* from those of *Philander*, which is the most similar genus (Reid 2009; Voss and Jansa 2009; Figure 2). The observed individual exhibited an overall chestnut-brown color, a relatively thin and hairless tail without a color division between the basal and distal portions, and a larger size relative to their body and head. The photographed individual presented the dorsal portion of the tail darker than the ventral portion with the basal color fading to whitish distally (Figure 2). We observed the individual for around 5 min until we decided to leave the area to continue our walk. During that time the individual remained motionless in the tree and we did not observe any additional behavior.

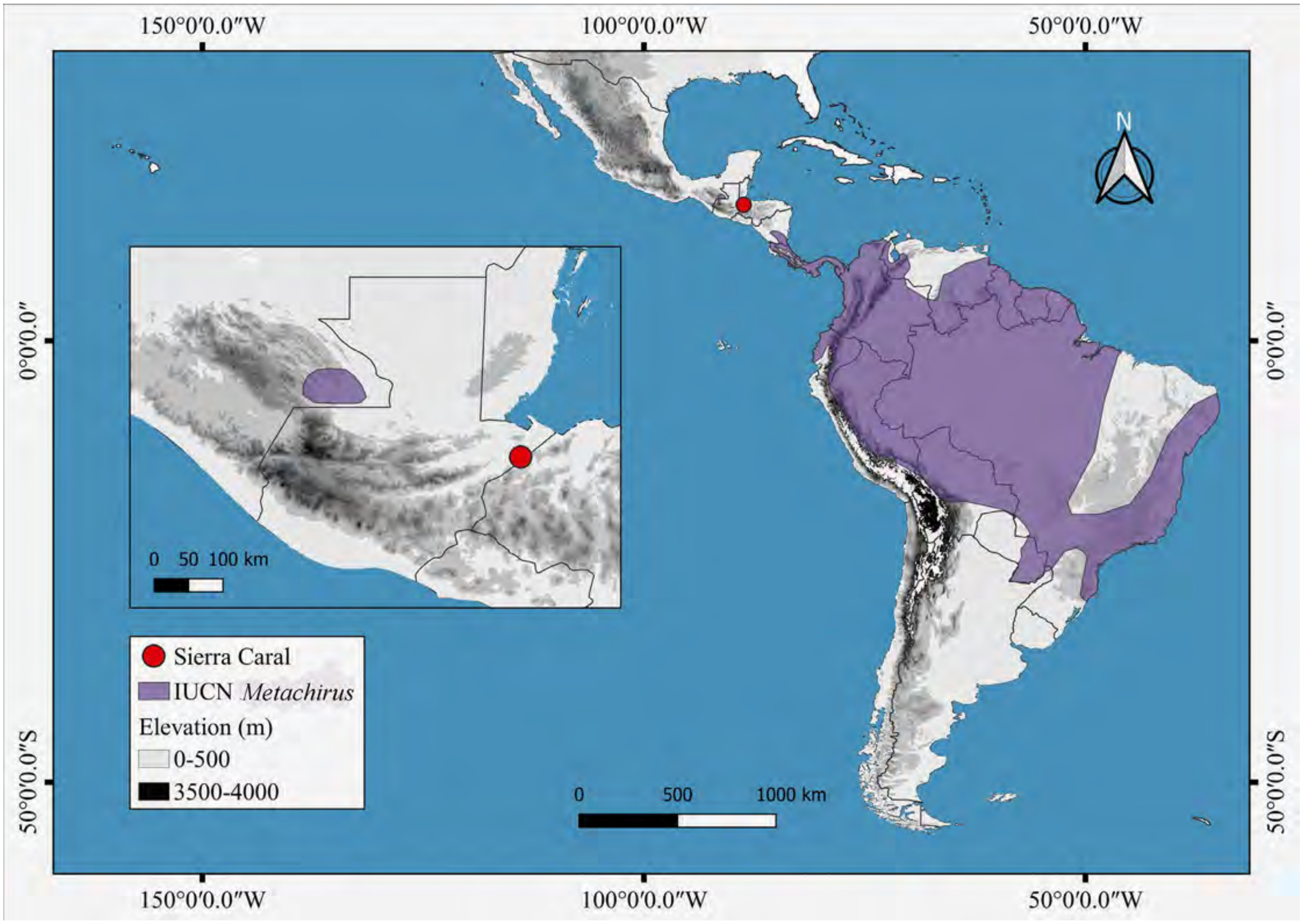

Figure 1. Distribution of the genus *Metachirus* according to IUCN (obtained from Brito *et al.* 2021). Red dot: record of *M. myosuros* in Sierra Caral Water and Forest Reserve.

Marsupials are one of the least studied groups of mammals in Guatemala, with almost no information available about the species that inhabit the country. Based on current knowledge, there are confirmed records of 6 species of marsupials distributed across 5 genera in Guatemala: *Chironectes minimus*, *Didelphis marsupialis*, *D. virginiana*, *Caluromys derbianus*, *Philander vossi* and *Marmosa mexicana* (McCarthy and Pérez 2006; Astúa *et al.* 2022). Our photographic record has allowed us to confirm the presence of the genus *Metachirus* in the country. The confirmation of *M. myosuros* in Guatemala is a significant discovery, as this species had been previously identified as expected in the last country's mammal review and in the last taxonomic checklist of living American Marsupials (McCarthy and Pérez 2006; Astúa *et al.* 2022). This finding increases the country's marsupial list to 7 species and 6 genera.

As currently understood, *M. myosuros* is a widely distributed species, with records ranging from southern México to northern Argentina (Voss *et al.* 2019; Voss 2022). However, huge gaps exist in its distribution, especially in northern Mesoamerica, where previous to this note, only few records from México and Honduras have been documented (Mérida and Cruz 2015; Marineros *et al.* 2019; Bautista-Alcantara et al. 2022). Our record provides novel evidence on the distribution of the species' northern populations and offer insights into the ecosystems they inhabit. It should be noted that on March 25, 2012, around 18:00 hr, we observed during a few minutes an individual of *M. myosuros* feeding on organic waste that included beans, fruit residues, and remains of fried fish near the kitchen of the Wildlife Conservation Society (WCS) biological station in El Perú, Laguna del Tigre National Park, Petén, Guatemala. However, when the brown four-eyed possum noticed our presence, it jumped twice before running up a nearby tree and we were unable to capture a good quality photo of the individual. Therefore, efforts should be directed towards this area to confirm the presence of this species, since it would represent one of the northern most records. This underscores the importance of collecting individuals and gathering more comprehensive information about the species in these specific localities and the broader region.

Notwithstanding the lack of a voucher specimen, the photographic record provides the necessary evidence to formerly include *M. myosuros* in the Guatemalan marsupial's checklist. Conspicuous external morphological characters allow to clearly distinguish between the species within the genus *Metachirus* and *Philander* (Reid 2009; Voss and Jansa 2009; Figure 2). One particularity of our photographic record is that the individual was walking through a low branch with its tail partially coiled in it. This is an unusual behavior because the genus *Metachirus* is considered mainly terrestrial and most of the reports are from individuals captured or seen on the ground (Reid 2009; Voss and Jansa 2009, 2021; Miranda *et al.* 2023). Although it has been considered that this genus does not have a prehensile tail (Reid 2009; Voss and Jansa 2009), all didelphids are perhaps capable of caudal prehension to some extent (Voss and Jansa 2009). Evidence of this is 1 video recording of *M. nudicaudatus* carrying vegetal material on its tail, presumably for nest construction (Delgado *et al.* 2014) and records of other didelphid species carrying nest material with their tails (Voss and Jansa 2009; Delgado *et al.* 2014). Now, our observation provides new evidence for this and the flowability of prehension for these species.

Figure 2. Comparison between a) *Metachirus myosuros* photographed in Sierra Caral Water and Forest Reserve protected area, Morales, Izabal, Guatemala, and b) *Philander vossi* from south México. Photo credits: B. I. Escobar-Anleu and J. Cruzado-Cortés. The arrows point to 2 of the characteristics that distinguish the genera *Metachirus* and *Philander*: the different coloration pattern between the tail of both genera and the general coat color of the species.

Investing in exploration, monitoring, and biological research is necessary to better understand the distribution patterns of wildlife. Only a comprehensive knowledge about biodiversity will ensure the long-term preservation and conservation of Guatemala's natural resources. Information about species distribution is vital to protect ecosystems and promote data-based conservation and action plans.

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As biologists graduated from USAC, the only public university in Guatemala, we thank those who throughout history have fought to defend its autonomy, but especially those who do so at this time of crisis when we do not have a rector. We would like to thank J. Cruzado-Cortés for sharing the photo of *Philander vossi*. We also want to thank FUNDAECO for their conservation efforts in the area, as well as for their support to Panthera's work in recent years. A special thanks to the FUNDAECO team in Sierra Caral: E. Pérez, F. Rivas and J. Díaz. We also thank A. Cerezo for his support and comments in the preparation of this manuscript and 4 anonymous reviewers that helped improve earlier versions of this note.

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Predation on neotropical lizards *Tropidurus* sp. by tamarin primate *Leontocebus weddelli* in Brazil

Depredación sobre la lagartija neotropical *Tropidurus* sp. por el primate tamarino *Leontocebus weddelli* en Brasil

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The diet of tamarin primates is predominantly frugivorous and insectivorous; it may include other elements in its diet such as nectar, seeds and arthropods, while vertebrate consumption is occasional. We present an unpublished record of the consumption of neotropical lizards (*Tropidurus* sp.) by the tamarin pichico (*Leontocebus weddelli*) in Porto Velho, Rondônia, Brazil. The record was conducted in 2022 at the José Ribeiro Filho campus of the Federal University of Rondônia, which is located in the peri-urban area, 9.5 km from the city of Porto Velho. The *ad libitum* method was used, continuously recording all important behavioral aspects of the primate. An adult individual of undetermined sex of *Leontocebus weddelli* was observed on the ground, completely consuming an adult individual of *Tropidurus* sp. for approximately 6 minutes. Representatives of the genus *Leontocebus* consume fruits and insects, and lizards are not the main items in their diet but represent an important energy source. This note reinforces the adaptive potential of this genus, in addition to the seasonal exploration of prey in highly disturbed environments.

Key words: Amazon; diet; forest edge; Rondônia; vertebrates.

La dieta de los primates tamarinos es predominantemente frugívora e insectívora, puede incluir otros elementos en su dieta como néctar, semillas y artrópodos, mientras que el consumo de vertebrados es ocasional. Se presenta un registro inédito de consumo de lagartijas neotropicales (*Tropidurus* sp.) por parte del tamarino pichico (*Leontocebus weddelli*) en Porto Velho, Rondônia, Brasil. El registro se realizó en el año 2022 en el campus José Ribeiro Filho de la Universidad Federal de Rondônia, la cual está situada en la zona periurbana, a 9.5 km de la ciudad de Porto Velho. Se utilizó el método *ad libitum*, registrando continuamente todos los aspectos conductuales importantes del primate. Se observó en el suelo a un individuo adulto de sexo indeterminado de *Leontocebus weddelli,* que durante aproximadamente 6 minutos consumió por completo a un individuo adulto de *Tropidurus* sp. Los representantes del género *Leontocebus* consumen frutas e insectos, y las lagartijas no son los principales ítems en su dieta, pero representan una importante fuente de energía. Esta nota refuerza el potencial adaptativo de este género, además de la exploración estacional de presas en entornos muy alterados.

Palabras claves: Amazonia; borde del bosque; dieta; Rondônia; vertebrados.

Tamarin primates, which include the genera *Leontocebus* and *Saguinus*, have a frugivorous and insectivorous diet, including other items such as nectar, seeds, arthropods, and occasionally vertebrates (Egler 1992; Lopes and Ferrari 1994; Oliveira and Ferrari 2008; García-Castillo and Defler 2018). Records of lizard consumption by tamarin primates include the consumption of *Anolis fuscoauratus* and *Gonatodes humeralis* by *Leontocebus illigeri* in Perú (Soini 1987). Heymann *et al.* (2000) recorded the consumption of 6 species of lizards *Anolis* spp., *Kentropyx pelviceps*, *Mabuya nigropunctata*, *Norops fuscoauratus*, *N. nitens* and 1 unidentified species by *Saguinus mystax* and *Leontocebus fuscicollis* in Perú. For Brazil, there is only 1 documented ancient record by Peres (1992) documented the consumption of *Anolis* sp. by *Leontocebus fuscicollis* and *S. mystax* in the state of Amazonas.

Among the different species from the genus *Leontocebus*, we highlight *L. weddelli*. This is a small primate, weighing on average 400 gr in Brazil, considered an insectivore, frugivore, and gumivore (Ferrari and Martins 1992; Paglia *et al.* 2012). Its distribution includes Bolivia, Perú and Brazil (including the states of Acre, Amazonas and Rondônia); it is categorized as Least Concern by the International Union for Conservation of Nature and Natural Resources (Ravetta *et al.* 2021). Until 2022, there are no records in the literature of the consumption of lizards by *L. weddelli*.

Given this scenario, this report aims to present the predation of lizard *Tropidurus* sp. by Weddell's saddle-back tamarin (*Leontocebus weddelli*) in a peri-urban area of the city of Porto Velho, Rondônia, Brazil.

The record was made at the José Ribeiro Filho campus of the Universidade Federal de Rondônia, Brazil (8° 50' 11.96" S, 63° 56' 24.89" W; WGS84), located 9.5 km (direction Rio Branco - Acre, in the southwestern portion) from the city of Porto Velho, in its peri-urban area (Figure 1). The campus has approximately 1 km^2, of which 20 % have different buildings. The predominant vegetation type of the area is Lowland Open Ombrophylous Forest (Veloso *et al.* 1991), and there are large areas composed of secondary vegetation and illegal logging, as well as unfinished buildings and open areas.

A study carried out in 2008 showed that the primate fauna of the campus is of 6 species: *Plecturocebus brunneus*, *Pithecia mittermeieri*, *Saimiri ustus*, *Sapajus apella*, *Mico rondoni* and *Leontocebus weddelli,* the latter two being the 2 most abundant species (Alencar 2008). There have yet to be published scientific papers on the lizard fauna in the area. The identification of the genus of the lizard was based on its external characteristics, such as the size and shape of its body and head, and its cryptic color (Frost *et al.* 2001).

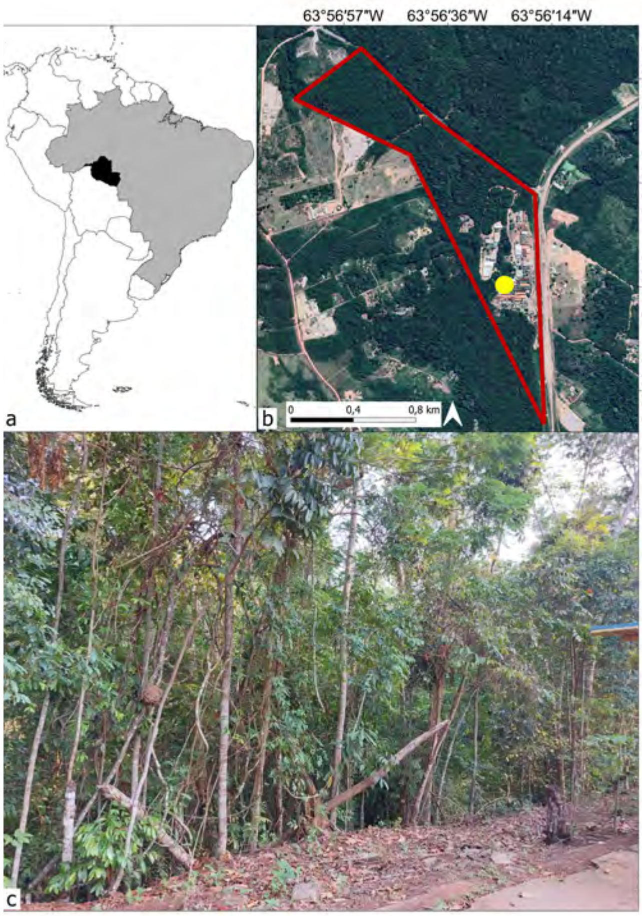

Figure 1. Geographic location of the observation site of the predation event. In a) the location of Brazil (gray) and the state of Rondônia (black). In b) the José Ribeiro Filho campus of the Universidade Federal de Rondônia (red) with emphasis on the recording site (yellow point). In c) characteristics of the registration site.

The *ad libitum* method proposed by Altmann (1974) was adopted to record the primate's behavior, recording all behaviors observed and deemed relevant by the observer, plus rare and significant records, such as the event documented here.

The observation was made on September 13, 2022 at 13:37 hr, during the dry season. The recording site was close to a bus stop. An adult individual of *L. weddelli* of undetermined sex was observed inspecting a tree trunk 50 cm high. An adult *Tropidurus* sp. of about 25 centimeters was observed in this trunk, which used cracks and holes in the trunk to hide from the primate. After 6 capture attempts, at 13:51 hr, *L. weddelli* managed to capture the lizard with his hands. The primate remained on the ground seated on the hind limbs and started to eat the head, followed by the rest of the body (Figure 2a, 2b). The process lasted approximately 6 min. After the total consumption of lizard, the individual from *L. weddelli* returned to the forest. The consumption starting from the head is already reported in *L. weddelli* and other species of callitrichids such as *Saguinus mystax*, to immobilize the prey, reducing the risk of the predator being attacked and reducing the possibility of prey escape (Steklis and King 1978; Clarke 1987; Heymann *et al.* 2000).

Among the items of animal origin, insects are the most exploited by representatives of the genus *Leontocebus* (Soini 1987; Garber 1993; Heymann *et al.* 2000) and lizards are not the main items in the diet of these primates, but they represent an important energy source (Peres 1992). The consumption of lizards and other vertebrates by species of the genus *Leontocebus* and *Saguinus* is occasional. For example, Porter (2001) found that vertebrate consumption accounts for < 1 % of the diet of *L. weddelli,* with vertebrate predation being on time. Garbino *et al.* (2022) also agree that the consumption of vertebrates by primates has a seasonal aspect, occurring mainly in the dry season, where some fruits are unavailable.

On the other hand, Heymann *et al.* (2000) highlighted the ability of these primates to exploit open micro-habitats, capturing exposed prey. The genera *Tropidurus* include diurnal species, of terrestrial habits and that can be observed in open areas, rocks, vertical walls and anthropized environments favorable for its development having an association of the species with artificial structures (Meira *et al.* 2007). The predation observation environment presents components that both favor the development of lizards and primates. *Tropidurus* spp. present higher densities in urbanized areas compared to rural ones, and the artificial structures associated with secondary and edge vegetation of the campus favor their development (Ribeiro-Júnior and Amaral 2016). At the same time, representatives of

Figure 2. a) Adult individual of *Leontocebus weddelli* exploring the trunk; b) and later consuming the individual of *Tropidurus* sp.

the genus *Leontocebus* are excellent explorers of forest edge and secondary vegetation environments (Sussman and Kinzey 1984) and show high densities in anthropized or regenerating environments (Ferronato *et al.* 2018; Silva *et al.* 2021). The scenario was favorable for the encounter between these 2 species, but it had not been previously documented due to the absence of studies on the primate diet. Studies are currently being carried out with primates of the genus *Leontocebus* in large forest blocks. The present record was only possible because both species explored an open environment, favoring total visualization of the predation event. These data reinforce the adaptive potentiality of genus *Leontocebus*, besides the seasonal exploration of prey in highly altered environments.

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Geographic distribution extension of *Anoura cadenai* and comments on *Sturnira giannae* distribution in Colombia

Extensión de la distribución de *Anoura cadenai* y comentarios sobre la distribución de *Sturnira giannae* en Colombia

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Although Colombia holds a high richness of Chiroptera, many taxa and geographic areas remain unexplored. In this study, we confirm the presence of *Anoura cadenai* and *Sturnira giannae* in new geographical regions and update the information about its distribution in the country. Through the review of field-collected individuals and specimens deposited in the Mammal Collection of the C. J. Marinkelle Natural History Museum (ANDES-M), we evaluated the concordance and variations of several external and craniodental traits with respect to the original descriptions. The records of *A. cadenai* on the eastern mountain range showed a distributional extension from the western and central mountain ranges. *Sturnira giannae* is widely distributed along the eastern mountain range, the inter-Andean valley of the Magdalena River, and the western mountain range's western slope. Unlike the original descriptions of both bat species, we found our specimens had smaller external and craniodental sizes. This is the first report of *Anoura cadenai* in the Eastern Mountain Range and in sympatry with *A. latidens*. Regarding *S. giannae*, we report its occurrence in the inter-Andean valley of the Magdalena River and reaching the western slope of the Western Mountain Range. This broadens the previously suggested distribution up to the eastern slopes of the Andes. More extensive specimen reviews in biological collections could provide new information about the distribution of these species in Colombia.

Key words: Glossophaginae; leaf-nosed bats; Phyllostomidae; Sturnirini.

Aunque Colombia alberga una gran riqueza de especies de murciélagos, muchos taxa y áreas geográficas permanecen poco exploradas. En este trabajo confirmamos la presencia de *Anoura cadenai* y *Sturnira giannae* en nuevas regiones geográficas y actualizamos la información sobre su distribución en el país. A partir de la revisión de individuos recolectados en campo y de especímenes depositados en la Colección de Mamíferos del Museo de Historia Natural C. J. Marinkelle (ANDES-M), evaluamos la concordancia y la variación de caracteres externos y craneodentales con respecto a las descripciones originales. Los registros de *A. cadenai* en la cordillera oriental constituyen una extensión de distribución desde las Cordillera Occidental y Central. *Sturnira giannae*, es una especie con amplia distribución en Colombia a lo largo de la Cordillera Oriental, el valle del río Magdalena, y sobre la vertiente occidental de la Cordillera Occidental. En comparación con las descripciones originales de ambas especies, encontramos variaciones morfológicas que comprenden menores tamaños en rasgos externos y craneodentales. Este es el primer reporte de *A. cadenai* en la Cordillera Oriental y en simpatría con *A. latidens*. En cuanto a *S. giannae*, reportamos su ocurrencia en el valle del río Magdalena y hasta la vertiente occidental de la Cordillera Occidental, lo que amplía el rango de distribución previamente sugerido hasta la vertiente oriental de los Andes. Revisiones más extensas en colecciones biológicas podrían aportar nueva información acerca de la distribución de estas especies en Colombia.

Palabras clave: Glossophaginae; murciélagos de hoja nasal; Phyllostomidae; Sturnirini.

Anoura cadenai Mantilla-Meluk and Baker 2006 is a nectarivorous bat species endemic to Colombia. It was described from an adult male collected near the Rio Bravo at 1,000 m in the department of Valle del Cauca, Colombia. At the type locality, *A. cadenai* is sympatric with *A. caudifer*, and *A. cultrata*, but can be distinguished by some characteristics: the larger size, and upper canines with a longitudinal sulcus of *A. cadenai* compared with *A. caudifer*, while is considerably smaller, with a less robust skull, and smaller upper canines compared with *A. cultrata* (Mantilla-Meluk and Baker 2006).

While *A. cadenai* was thought to occur along the western slope of the southwestern Colombian Andes in an altitudinal range between 800 and 1,400 m (Mantilla-Meluk and Baker 2006), other specimens have been reported from Nariño, Putumayo, Huila, and the central mountain range in Risaralda and Antioquia, which corresponds to its northernmost record (Figure 1a; Mantilla-Meluk and Baker 2006; Calderón Leytón *et al.* 2021; Pérez Torres *et al.* 2021; Rodríguez-Bolaños and Solórzano 2021; Ruano Meneses *et al.* 2021; Rueda Isaza *et al.* 2022).

Sturnira giannae Velazco and Patterson 2019 is mostly a frugivorous bat species from the humid forests of Amazonia and the lowlands of the Orinoquia region, occupying a wide variety of forests, including primary and secondary forests below 2,000 m (Burneo 2021). The species was described from an adult male collected near Sinnamary, Cayenne, French Guiana, at 210 m, and can be distinguished from other sympatric species (*S. magna*, *S. oporaphilum*, *S. sorianoi*, and *S. tildae*) from its external and craniodental characteristics. Some of these are: all overlap somewhat in size but are distinguished by pelage and craniodental characteristics (Tables 15 and 17 in Velazco and Patterson 2019); the dorsal fur between the shoulders of *S. giannae* is short (5.0–6.0 mm) whereas it is long (> 8 mm) in *S. magna*, *S. sorianoi*, *S. oporaphilum*, and *S. tildae*; dorsal hairs are bicolored in *S. giannae* whereas they are 4-colored in *S. magna*, *S. sorianoi*, *S. oporaphilum*, and *S. tildae*; ventrally the hairs are short (3–5 mm) and monocolored in *S. giannae* and *S. tildae*, whereas they are long (6–8 mm) and tricolored in *S. sorianoi*, and *S. oporaphilum*, and short (3–5 mm) and 4-colored in *S. magna*; the ventral fur is pale brown to reddish brown in *S. giannae*, whereas is pale brown in *S. magna*, *S. sorianoi*, *S. oporaphilum*, and *S. tildae*; the metaconids and entoconids of m1 and m2 are well defined and separated by a deep notch in *S. giannae*, whereas they are well defined but separated by a shallow notch in *S. tildae*, and poorly defined and not separated by a notch in *S. magna*, *S. oporaphilum*, and *S. sorianoi*; the anterior process of the glenoid fossa is well developed in *S. giannae* and *S. magna*, whereas it is weakly developed in *S. sorianoi*, and *S. tildae* (some specimens of *S. oporaphilum* lack the anterior process of the glenoid fossa while in others it is weakly developed); the I1 is slender in *S. giannae*, and broad in *S. oporaphilum*, *S. sorianoi*, *S. tildae*, and *S. magna* (Velazco and Patterson 2019).

Although the *S. giannae* description mentioned its distribution range from "eastern slopes of the Andes and adjacent Amazonian lowlands from Colombia to northern Bolivia", it did not include Colombian records (Velazco and Patterson 2019). However, several specimens have been recorded from Arauca, Caquetá, Putumayo, Risaralda, Santander, and Tolima (Figure 1b; Morales Martinez and Díaz 2020; García-Herrera *et al.* 2021; Niño Reyes and Corral Gómez 2022; Ramírez-Chaves *et al.* 2022). In this note, we update the distribution of the bat species *A. cadenai* and *S. giannae* in Colombia and compare morphological characters to earlier descriptions.

Field sampling was conducted out in 2019 in the Municipality of La Mesa, Cundinamarca, during a study about vector-borne and zoonotic diseases (Carrasquilla *et al.* 2023). We used 3 mist nets (12 m x 3 m) for 5 nights from 18:00 hr to midnight. We captured 1 adult female of *A. cadenai* on 31 July (4° 38' 33.36'' N, 74° 27' 0.72'' W, 1,271 m; Figure 1a; Appendix 1), and 1 adult male of *S. giannae* on 20 May (4° 38' 54.20'' N, 74° 31' 10.67'' W, 637 m; Figure 1b; Appendix 2). The individuals were collected following the proce-

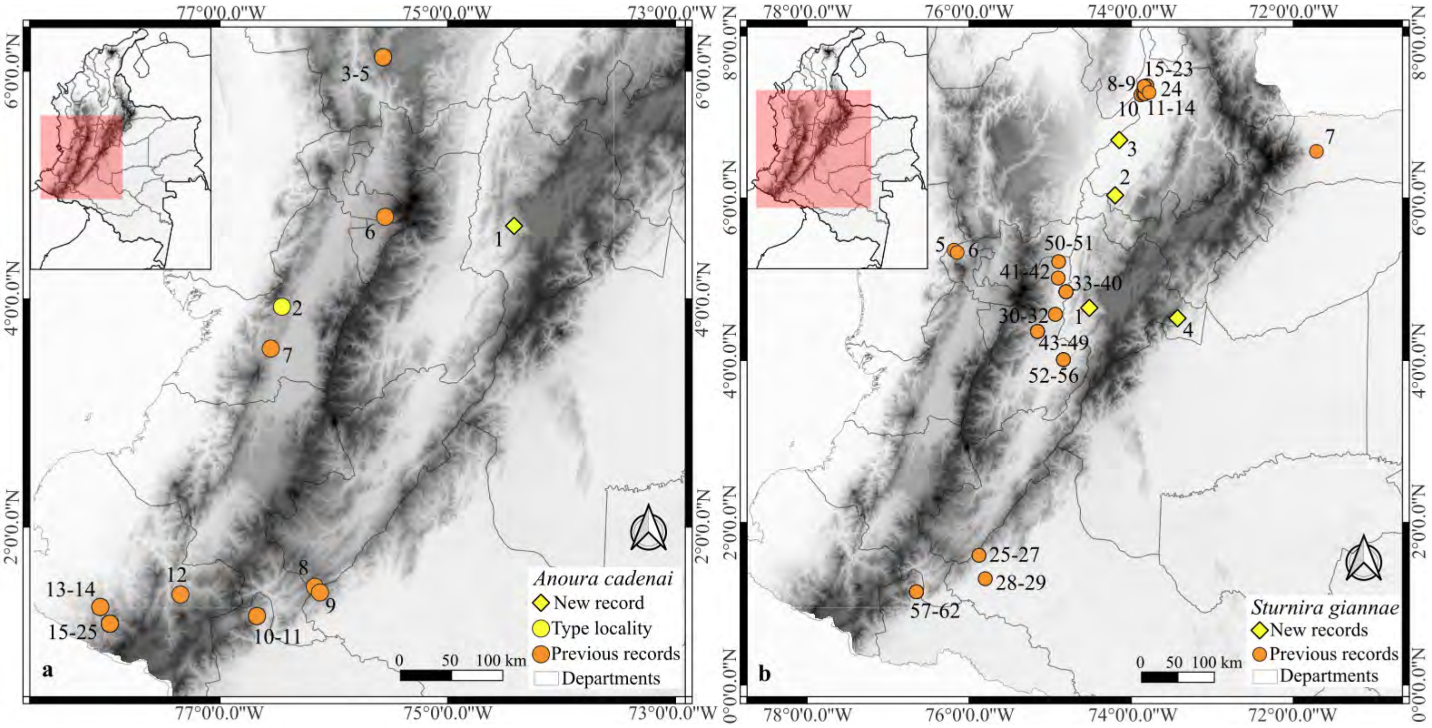

Figure 1. Distribution of a) *Anoura cadenai* and b) *Sturnira giannae* in Colombia. The numbers correspond to the localities (see Appendix 1). For *A. cadenai*: 1) La Mesa (Cundinamarca), on the western slope of the eastern mountain range; and for *S. giannae*: 1) La Mesa (Cundinamarca), on the western slope of the eastern mountain range; 2) Bolívar (Santander), 3) Cimitarra (Santander) from the middle Magdalena valley; and 4) Medina (Cundinamarca), on the eastern slope of the eastern mountain range.

dure described by Carrasquilla *et al.* (2023), prepared as dry skin and skull removed and deposited in the Mammal Collection of the C. J. Marinkelle Natural History Museum of the Universidad de los Andes (ANDES-M). The research project was approved by the Ethics Committee from Universidad de los Andes No. 839–2018, the Institutional Animal Care and Use Committee from Universidad de los Andes CICUAL (FUA 18–006), and the National Environmental Licensing Authority of Colombia (ANLA; Permits No. P06249S3811_N0001, P06249S4071_N0002).

We found 3 additional specimens of *S. giannae* in the ANDES-M collection, 1 adult female from Cundinamarca, recently cataloged as *Sturnira* sp., preserved in dry skin and with the skull removed (ANDES-M 2703), and 2 formerly identified as *S. lilium*: 1 adult male from Santander, dry skin and skull removed (ANDES-M 1869), and 1 adult female from Santander, preserved in alcohol with the skull removed (ANDES-M 2429; Appendix 2).

All specimens were identified based on the cranial, dental, and external morphological diagnostic characters following Mantilla-Meluk and Baker (2006), Gardner (2007), Velazco and Patterson (2019), and Díaz *et al.* (2021). Lineal measurements were taken directly from the specimens (Table 2). External and craniodental measurements were taken using a caliper (to the nearest 0.05 mm) following Mantilla-Meluk and Baker (2006) for *A. cadenai*, and Velazco and Patterson (2019) for *S. giannae*. The lineal measurements are listed in Tables 1 and 2. To evaluate the concor-

Table 1. Measurements of the specimen collected in La Mesa, Cundinamarca, compared to the type series of *Anoura cadenai* deposited in the Instituto de Ciencias Naturales (ICN) of the Universidad Nacional de Colombia, Bogotá. *Data were taken from Mantilla-Meluk and Baker (2006).

	Holotype ICN 9152 ♂	Paratype ICN 9151 ♂	Paratype ICN 9153 ♂	Paratype ICN 9154 ♂	Mean measurements of the type series*	Mean measurements by Calderón-Acevedo and Muchhala (2018)	ANDES-M 2591 ♀
External measurements							
Total length	59	60	60	61	60	-	55.2
Tail length	0	0	0	0	0	-	0
Hind foot length	11	10	10	10	10	-	9.5
Ear length	12	14	12	10	12	-	9.6
Forearm length	36.85	36.97	36.7	36.12	36.66	36.81	36.5
Tibia length	12.04	12.43	11.28	10.19	11.49	11.77	12.1
Third digit							
Metacarpal length	36.46	36.99	36.05	36.46	36.49	36.1	34.6
Length first phalanx	12.37	12.11	12.1	12.58	12.29	12.86	12.5
Fourth digit							
Metacarpal length	35.01	32.83	35	34.14	34.25	34.14	33.5
Length first phalanx	8.45	9.66	8.48	8.57	8.79	8.9	9
Fifth digit							
Metacarpal length	30.41	29.91	30.07	29.29	29.92	29.71	29.2
Length first phalanx	7.96	7.98	8.2	7.46	7.9	7.8	7.1
Calcar length	4.9	4.22	4.33	5.33	4.70	-	3.8
Craniodental measurements							
Greatest skull length	23.8	23.4	23.1	23.2	23.4	23.06	21.9
Cranium height	8	8	8	8	8	7.23	8.3
Palatal length	12	13	12	12	12	12.01	11.2
Rostrum width	4	5	4	4	4	-	3.9
Post-orbital width	4.53	4.46	4.57	4.58	4.53	4.59	4.4
Zygomatic width	9.71	10.4	10.27	-	10.13	-	9.3
Cranium width	8.66	8.5	8.4	8.82	8.96	9.06	8.7
Mastoid width	9.69	9.76	9.34	9.66	9.61	9.53	9.3
Upper canine-canine distance	4.27	4.44	4.21	4.33	4.31	4.24	4.1
Mandible tooth row length	ND	7.78	7.87	8.52	8.05	9.06	8.6
Mandible length	16.9	17.7	17.1	16.4	17	16.87	16.5
Mandible height	3.9	4.12	4.48	4.2	4.18	-	3.8

dance of our specimens' measurements with the original descriptions, we have considered that a deviation of more than 1 mm with respect to the average of the type series is a different value. Finally, to map the species occurrences in Colombia, we accessed previous records of preserved specimens of *A. cadenai* and *S. giannae* in Colombia through the Global Biodiversity Information Facility (Calderón Leytón *et al.* 2021; Pérez Torres *et al.* 2021; Rodriguez-Bolaños and Solórzano 2021; Ruano Meneses *et al.* 2021; Niño Reyes and Corral Gómez 2022; Ramírez-Chaves *et al.* 2022; Rueda Isaza *et al.* 2022).

Anoura cadenai Mantilla-Meluk and Baker 2006: specimen ANDES-M 2591 was captured and collected along with individuals of the species *Anoura latidens* Handley 1984, *Artibeus lituratus* (Olfers 1818), *Carollia castanea* Allen 1890, *Carollia perspicillata* (Linnaeus 1758), and *Glossophaga soricina* (Pallas 1766). The specimen is an adult female with the craniodental and external morphological characters reported by Mantilla-Meluk and Baker (2006): a) coloration blackish brown-3 and black throughout the body; b) individual dorsal hairs pale grayish on basal two thirds, brown tips; c) those hairs of underparts black to base; d) pelage short and crisp; e) interfemoral membrane narrow with some hairs and external tail non visible; f) braincase tapered anteriorly with broad and heavy rostrum and zygomatic complete but slender (broken in most specimens); g) braincase raising smoothly; h) broad and rounded occipital region; i) outer upper incisor enlarged; j) upper canine enlarged and projected, roughly triangular in cross-section at the base, with distinct anterointernal, anteroexternal, and posterior basal cusps; and k) internal face anteroposteriorly concave, and anterior face flat, with a longitudinal sulcus from the base of the crown to near tip that resembles the sulcus of canines of *A. cultrata* but less prominent.

The external and craniodental measurements match with those reported for the type series by Mantilla-Meluk and Baker (2006) and with mean values for the species by Calderón-Acevedo and Muchhala (2018). However, we found the following morphological variation: smaller total length, ear length, third digit metacarpal length, and calcar length, as well as the smaller greatest skull and palatal length (Table 1).

Sturnira giannae Velazco and Patterson 2019: specimen ANDES-M 2557 was captured and collected along with individuals of *Artibeus lituratus*, and *Carollia perspicillata*. The individual was an adult male that coincides with the craniodental and external morphological characters reported by Velazco and Patterson (2019), as well as specimens ANDES-M 1869, ANDES-M 2429, and ANDES-M 2703: a) medium-sized yellow-shouldered bat; b) a slender rostrum and a globular braincase; c) dorsal pelage brown to reddish brown, dorsal hairs bicolored with a long and pale brown base (approx. 80 % of the length of each hair), and a short dark-brown terminal band (approx. 20 % of each hair); d) ventral pelage brown to reddish brown, and ventral hairs monocolored that vary from gray to pale brown; e) fur long 5-6 mm between the shoulders and 4 mm on the chest; f) the trailing edge of the uropatagium was covered by short hairs (5.0 mm); g) the proximal portion of the forearm is densely furred with short hairs; h) the dorsal surfaces of the tibia and feet were sparsely covered with long hairs; i) the III and IV metacarpals are subequal in length but shorter than

Table 2. Measurements of the specimens in ANDES-M collection compared to the type series of *Sturnira giannae*. Data of the type series and mean measurements from males and females were taken from Velazco and Patterson (2019). AMNH: American Museum of Natural History; ANDES-M: Mammal Collection of the C. J. Marinkelle Natural History Museum of the Universidad de los Andes; FMNH: Field Museum of Natural History; MUSM: Museo de Historia Natural, Universidad Nacional Mayor de San Marcos.

	Holotype AMNH 268545 ♂	Paratype FMNH 203582 ♀	Paratype MUSM 13260 ♀	Paratype MUSM 39228 ♂	Mean ♀ measurements	Mean ♂ measurements	ANDES-M 2557 ♂	ANDES-M 1869 ♂	ANDES-M 2429 ♀	ANDES-M 2703 ♀
External measurements										
Weight	25.3	14	18	22	19.3	20	19	18.5	-	-
Total length	73	67	65	73	64.9	65.8	57.1	65	53	54.2
Hind-foot length	15	13	13	12	12.7	12.8	11.9	12	11.2	11.8
Ear length	17	16	17	14	16.2	16	13	12.4	12.6	12.1
Forearm length	45	45	45	44	43.8	44.8	42.9	41.6	40.1	42
Craniodental measurements										
Greatest length of skull	22.7	22.6	22.3	22.2	22.2	22.8	22	22	21.6	21.7
Condyloincisive length	21.2	21.3	20.6	21.2	20.8	21.2	20.25	20.35	19.5	19.9
Condylocanine length	20.4	20.4	19.9	20.5	20	20.4	19.35	19.6	18.9	19
Postorbital breadth	6.1	5.8	5.5	6.1	5.8	6	6	5.8	5.6	5.6
Zygomatic breadth	14.4	14	13.2	13.9	13.5	14.1	13.8	13.7	13	13.2
Braincase breadth	10.5	10.4	9.8	10.3	10.2	10.4	10.3	10.3	9.9	9.8
Mastoid breadth	12.7	12.2	11.5	11.9	12	12.4	12	12	11.6	10.5
Maxillary toothrow length	6.6	6.8	6.8	6.8	6.7	6.7	6.6	6.4	6.3	6
Breadth across molars	8.1	8.1	8.2	8.3	8.1	8.2	7.8	7.8	7.4	7.8
Dentary length	15.2	14.8	14.6	15	14.7	15.3	14.9	14.8	14.2	14.3
Mandibular toothrow length	7.5	7.8	7.6	7.7	7.6	7.8	7.1	7	6.8	6.5

the V metacarpal; j) the basisphenoids pits are divided by a narrow midline septum; and k) sphenorbital fissure oval (in ANDES-M 2557) or circular (in ANDES-M 1869, ANDES-M 2429, and ANDES-M 2703).

All revised specimens showed some morphological variations compared with the mean measurements reported by Velazco and Patterson (2019) which include: ANDES-M 2557 had less weight and a smaller total length, smaller ear length, and smaller forearm length; ANDES-M 1869 had less weight, smaller ear length, and smaller forearm length; ANDES-M 2429 had smaller total, hind-foot, ear, and forearm length, as well as the smaller condyloincisive and condylocanine length; and ANDES-M 2703 had a smaller total, ear, and forearm length, as well as the smaller condyloincisive length and mastoid breadth (Table 2).

Anoura cadenai has been recorded mainly in the south of the Andes Mountain range in Colombia, with some reports on the western slope of the western mountain range and north of the central mountain range. Our Cundinamarca record confirms the species' presence in the eastern mountain range (Figure 1a). This specimen was found in sympatry with *A. latidens*, adding to other reports of sympatry with *A. caudifer* and *A. cultrata* at the type locality (Mantilla-Meluk and Baker 2006). The main characteristics that distinguished both species were the forearm size (> 40 mm in *A. latidens*), and the narrow, semicircular, and visible uropatagium of *A. cadenai* compared to the reduced and barely visible uropatagium of *A. latidens*. Concerning the altitudinal distribution of *A. cadenai*, the information we gathered suggests elevations between 1,000 m in the type locality, and 2,900 m in El Tambo, Nariño (Appendix 1), which expands on the information provided by Mantilla-Meluk and Baker (2006). Morphologically, this female seems smaller in some external and craniodental characters compared to the type series (Mantilla-Meluk and Baker 2006) and to the mean values reported for the species (Calderón-Acevedo and Muchhala 2018). However, it is important to note that all the specimens in the type series correspond to male individuals.

Regarding *S. giannae*, previous records in collections and literature, as well as the new records presented here, coincide with the original distribution (eastern slopes of the Andes and adjacent Amazonian lowlands; Velazco and Patterson 2019), but adding localities from the inter-Andean valley of the Magdalena River, and on the western slope of the western mountain range (Figure 1b). These records suggest an altitudinal range in Colombia between 78 m in the Middle Magdalena Valley, and 980 m in Medina, Cundinamarca (Appendix 2) that extends 132 m the lower altitudinal limit reported for the species by Velazco and Patterson (2019). The reviewed specimens are smaller in some external and craniodental characters, compared to the description by Velazco and Patterson (2019). They also differ in the state of some characters, such as a) the proximal portion of the forearm not densely furred with short hairs in ANDES-M 1869 and ANDES-M 2429; b) a low sagittal crest (not "well-developed") in ANDES-M 2557; and c) the upper central incisor is slightly bilobed in ANDES-M 2429 and not bilobed in ANDES-M 1869 and ANDES-M 2703 (Figure 2). However, it should be noted that Velazco and Patterson (2019) mentioned that the cusps are "noticeable only in younger individuals without pronounced tooth wear". Morphological variations in shape and size have also been reported in populations of *S. giannae* in Perú by Olaya-Orihuela (2021) and could correspond to geographic variations promoted by environmental and spatial differences (Morales *et al.* 2018).

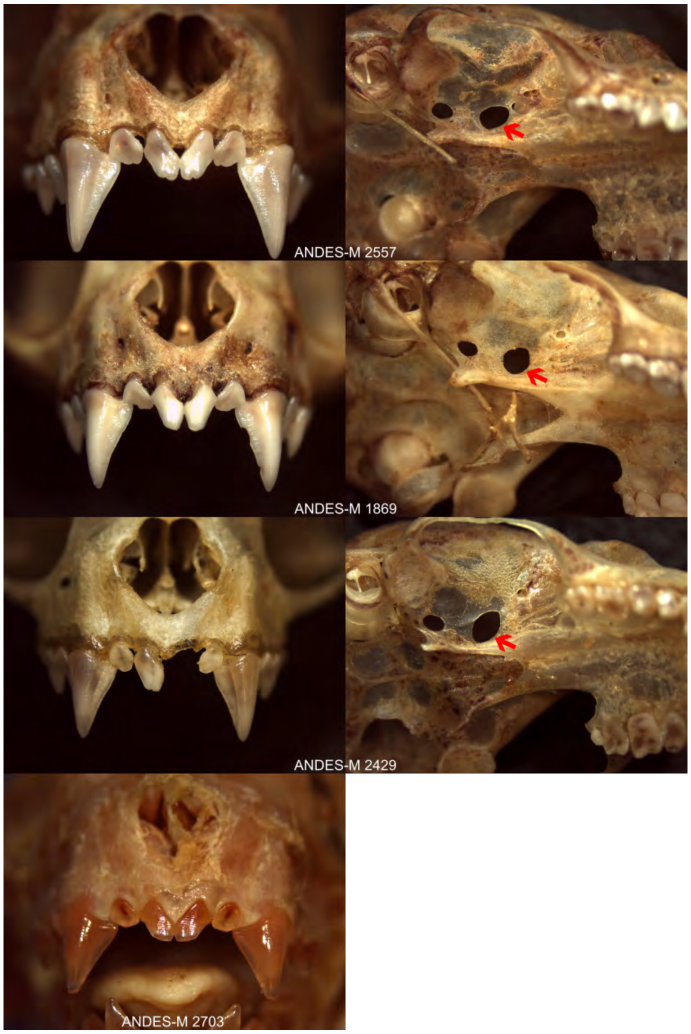

Figure 2. Variation in the upper central incisors and sphenorbital fissure of *Sturnira giannae* specimens. Red arrows indicate the sphenorbital fissure.

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Appendix 1

Records of *Anoura cadenai* in Colombia. ANDES-M: Colección de mamíferos del Museo de Historia Natural C. J. Marinkelle; EAFIT: Colección Biológica Universidad EAFIT; ICN: Instituto de Ciencias Naturales; MPUJ_MAMM: Colección de mamíferos del Museo de Historia Natural de la Pontificia Universidad Javeriana; MUD-M: Colección Mastozoológica de la Universidad Distrital Francisco José de Caldas; PSO-CZ: Colección de mamíferos voladores y no voladores de la Universidad de Nariño; UV: Colección de mamíferos de la Universidad del Valle.

Specimen	Map	Locality	Latitude	Longitude	Elevation (m)	Reference
ANDES-M2591	1	Cundinamarca, La Mesa, San Nicolás	4° 38′ 33.60″N	74° 27′ 0.67″W	1,271	Carrasquilla *et al*. 2023
ICN9152 (Holotype)	2	Valle del Cauca, between the municipalities of Calima and Restrepo near the Rio Bravo	3° 56′ 3.01″N	76° 29′ 17.99″W	1,000	Mantilla-Meluk and Baker 2006
EAFIT-M0929	3	Antioquia, Sabaneta, La Doctora, Parque ecológico y recreativo La Romera	6° 7′ 21″N	75° 36′ 1″W	2,000	Rueda Isaza *et al*. 2022
EAFIT-M0968	4	Antioquia, Sabaneta, La Doctora, Parque ecológico y recreativo La Romera	6° 7′ 21″N	75° 36′ 1″W	2,000	Rueda Isaza *et al*. 2022
EAFIT-M0966	5	Antioquia, Sabaneta, La Doctora, Parque ecológico y recreativo La Romera	6° 7′ 21″N	75° 36′ 1″W	2,000	Rueda Isaza *et al*. 2022
MPUJ_MAMM:1109	6	Risaralda, Pereira, Corregimiento La Florida, Vereda La Suiza, Santuario de Flora y Fauna Otún Quimbaya, Montaña Cauca, filo de la montaña	4° 43′ 19.84″N	75° 34′ 57.32″W	-	Pérez Torres *et al*. 2021
UV-14761	7	Valle del Cauca, La Cumbre, Finca La Minga, Reserva Forestal Bitaco, Vereda Chicoral, Corregimiento Bitaco	3° 33′ 59.10″N	76° 35′ 12.4″W	-	Ruano Meneses *et al.* 2021
MUD-M1924	8	Huila, San Agustín, La Castellana	1° 28′ 37.78″N	76° 11′ 57.55″W	2,344	Rodriguez-Bolaños and Solórzano 2021
MUD-M1975	9	Huila, Pitalito, El porvenir	1° 25′ 40.15″N	76° 9′ 13.61″W	1,926	Rodriguez-Bolaños and Solórzano 2021
MUD-M1403	10	Putumayo, Mocoa, Campucana	1° 13′ 14.29″N	76° 42′ 26.97″W	1,087	Rodriguez-Bolaños and Solórzano 2021
MUD-M1400	11	Putumayo, Mocoa, Campucana	1° 13′ 14.29″N	76° 42′ 26.97″W	1,087	Rodriguez-Bolaños and Solórzano 2021
PSO-CZ-613	12	Nariño, El Tambo, Reserva Natural Municipal Pocahurco	1° 24′ 32″N	77° 22′ 45.99″W	2,900	Calderón Leytón *et al*. 2021
PSO-CZ-615	13	Nariño, Barbacoas, Corr. Altaquer, Vda. El Barro, Reserva Natural Río Ñambí	1° 18′ 0″N	78° 4′ 59.99″W	1,300	Calderón Leytón *et al*. 2021
PSO-CZ-467	14	Nariño, Barbacoas, Corr. Altaquer, Vda. El Barro, Reserva Natural Río Ñambí	1° 18′ 0″N	78° 4′ 59.99″W	1,550	Calderón Leytón *et al*. 2021
PSO-CZ-907	15	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,750	Calderón Leytón *et al*. 2021
PSO-CZ-456	16	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021
PSO-CZ-457	17	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021
PSO-CZ-458	18	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,800	Calderón Leytón *et al*. 2021
PSO-CZ-466	19	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021
PSO-CZ-460	20	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021
PSO-CZ-461	21	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,800	Calderón Leytón *et al*. 2021
PSO-CZ-462	22	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021
PSO-CZ-463	23	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021
PSO-CZ-464	24	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,725	Calderón Leytón *et al*. 2021
PSO-CZ-465	25	Nariño, Ricaurte, Reserva Natural La Planada	1° 9′ 15.00″N	77° 59′ 57.00″W	1,775	Calderón Leytón *et al*. 2021

Appendix 2

Records of *Sturnira giannae* in Colombia. The presence of vouchers for the specimens reported in the Niño Reyes and Corral Gómez (2022) data set was directly corroborated with the IAVH-M collection management. *Coordinates from Google Earth. ANDES-M: Colección de mamíferos del Museo de Historia Natural C. J. Marinkelle; CZUT-M: Colección de mastozoología de la Universidad del Tolima; IAvH-M: Colección de mamíferos del Instituto de Investigación de Recursos Biológicos Alexander von Humboldt; ICN: Instituto de Ciencias Naturales; MHNUCa: Colección de Mamíferos del Museo de Historia Natural de la Universidad de Caldas; ROM: Royal Ontario Museum.

Specimen	Map	Locality	Latitude	Longitude	Elevation (m)	Reference
ANDES-M2557	1	Cundinamarca, La Mesa, San Joaquin	4° 38′ 54.20″N	74° 31′ 10.678″W	637	Carrasquilla *et al*. 2023
ANDES-M1869	2	Santander, Bolívar, Vereda La Guinea / Caño La Guinea	6° 2′ 7.01″N*	74° 12′ 2.88″W*	-	This study
ANDES-M2429	3	Santander, Cimitarra	6° 43′ 0″N	74° 9′ 0″W	150	This study
ANDES-M2703	4	Cundinamarca, Medina, Vereda Periquitos / Reserva La Fortuna	4° 31′ 13.73″N	73° 25′ 52.28″W	980	This study
MHNUCa2980	5	Risaralda, Pueblo Rico, Santa Cecilia	5° 21′ 34.68″N	76° 11′ 21.12″W	320	Ramírez-Chaves *et al*. 2022
MHNUCa2981	6	Risaralda, Pueblo Rico, Santa Cecilia	5° 19′ 53.64″N	76° 8′ 59.22″W	377	Ramírez-Chaves *et al*. 2022
MHNUCa2592	7	Arauca, Tame, Vereda Santa Inés, Finca La Porfia	6° 34′ 36.52″N	71° 43′ 0.01″W	253	Ramírez-Chaves *et al*. 2022
IAvH-M-10812	8	Santander, Puerto Wilches, Corredor	7° 16′ 30.50″N	73° 52′ 54.52″W	81	Niño Reyes and Corral Gómez 2022
IAvH-M-10821	9	Santander, Puerto Wilches, Corredor	7° 16′ 23.16″N	73° 52′ 57.86″W	80	Niño Reyes and Corral Gómez 2022
IAvH-M-10794	10	Santander, Puerto Wilches, El Danubio Ponderosa	7° 17′ 9.96″N	73° 51′ 14.04″W	98	Niño Reyes and Corral Gómez 2022
IAvH-M-10883	11	Santander, Puerto Wilches, El Tesoro	7° 17′ 14.1″N	73° 50′ 5.06″W	96	Niño Reyes and Corral Gómez 2022
IAvH-M-10884	12	Santander, Puerto Wilches, El Tesoro	7° 17′ 13.78″N	73° 50′ 3.55″W	92	Niño Reyes and Corral Gómez 2022
IAvH-M-10886	13	Santander, Puerto Wilches, El Tesoro	7° 17′ 10.28″N	73° 50′ 4.27″W	93	Niño Reyes and Corral Gómez 2022
IAvH-M-10889	14	Santander, Puerto Wilches, El Tesoro	7° 17′ 12.08″N	73° 50′ 2.36″W	97	Niño Reyes and Corral Gómez 2022
IAvH-M-10718	15	Santander, Puerto Wilches, Miraflores	7° 23′ 16.01″N	73° 48′ 31.32″W	84	Niño Reyes and Corral Gómez 2022
IAvH-M-10737	16	Santander, Puerto Wilches, Miraflores	7° 23′ 7.15″N	73° 48′ 35.86″W	78	Niño Reyes and Corral Gómez 2022
IAvH-M-10741	17	Santander, Puerto Wilches, Miraflores	7° 23′ 7.15″N	73° 48′ 35.86″W	78	Niño Reyes and Corral Gómez 2022
IAvH-M-10714	18	Santander, Puerto Wilches, Santa Isabel	7° 22′ 34.10″N	73° 50′ 27.42″W	80	Niño Reyes and Corral Gómez 2022
IAvH-M-10725	19	Santander, Puerto Wilches, Santa Isabel	7° 22′ 34.10″N	73° 50′ 27.42″W	80	Niño Reyes and Corral Gómez 2022
IAvH-M-10735	20	Santander, Puerto Wilches, Santa Isabel	7° 22′ 33.6″N	73° 50′ 27.6″W	78	Niño Reyes and Corral Gómez 2022
IAvH-M-10739	21	Santander, Puerto Wilches, Santa Isabel	7° 22′ 33.6″N	73° 50′ 27.6″W	78	Niño Reyes and Corral Gómez 2022
IAvH-M-10740	22	Santander, Puerto Wilches, Santa Isabel	7° 22′ 33.6″N	73° 50′ 27.6″W	78	Niño Reyes and Corral Gómez 2022
IAvH-M-10742	23	Santander, Puerto Wilches, Santa Isabel	7° 22′ 33.6″N	73° 50′ 27.6″W	78	Niño Reyes and Corral Gómez 2022
IAvH-M-10842	24	Santander, Puerto Wilches, Sogamosito	7° 18′ 11.92″N	73° 46′ 52.5″W	130	Niño Reyes and Corral Gómez 2022
ICN23780	25	Caquetá, Belén de los Andaquíes, Parque Andakí	1° 35′ 56.43″N	75° 52′ 50.91″W	764	Morales Martínez and Diaz 2020
ICN23781	26	Caquetá, Belén de los Andaquíes, Parque Andakí	1° 35′ 56.43″N	75° 52′ 50.91″W	764	Morales Martínez and Diaz 2020
ICN23782	27	Caquetá, Belén de los Andaquíes, Parque Andakí	1° 35′ 56.43″N	75° 52′50.91″W	764	Morales Martínez and Diaz 2020
ICN21949	28	Caquetá, Belén de los Andaquíes, vereda La Mono	1° 18′ 35.52″N	75° 48′ 12.09″W	273	Morales Martínez and Diaz 2020
ICN21950	29	Caquetá, Belén de los Andaquíes, vereda La Mono	1° 18′ 35.52″N	75° 48′ 12.09″W	273	Morales Martínez and Diaz 2020
CZUT-M2146	30	Tolima, Alvarado	4° 34′ 6.75″N	74° 56′ 18.3″W	-	García-Herrera *et al*. 2021
CZUT-M2147	31	Tolima, Alvarado	4° 34′ 6.75″N	74° 56′ 18.3″W	-	García-Herrera *et al*. 2021
CZUT-M2172	32	Tolima, Alvarado	4° 34′ 6.75″N	74° 56′ 18.3″W	-	García-Herrera *et al*. 2021
CZUT-M1116	33	Tolima, Ambalema	4° 50′ 48.32″N	74° 48′ 24.03″W	-	García-Herrera *et al*. 2021
CZUT-M1117	34	Tolima, Ambalema	4° 50′ 48.32″N	74° 48′ 24.03″W	-	García-Herrera *et al*. 2021
CZUT-M1118	35	Tolima, Ambalema	4° 50′ 48.32″N	74° 48′ 24.03″W	-	García-Herrera *et al*. 2021
CZUT-M1296	36	Tolima, Ambalema	4° 50′ 48.32″N	74° 48′ 24.03″W	-	García-Herrera *et al*. 2021
CZUT-M1310	37	Tolima, Ambalema	4° 50′ 48.32″N	74° 48′ 24.03″W	-	García-Herrera *et al*. 2021

Appendix 2

Specimen	Map	Locality	Latitude	Longitude	Elevation (m)	Reference
CZUT-M1318	38	Tolima, Ambalema	4° 50’ 48.32”N	74° 48’ 24.03”W	-	García-Herrera *et al*. 2021
CZUT-M1342	39	Tolima, Ambalema	4° 50’ 48.32”N	74° 48’ 24.03”W	-	García-Herrera *et al*. 2021
CZUT-M1343	40	Tolima, Ambalema	4° 50’ 48.32”N	74° 48’ 24.03”W	-	García-Herrera *et al*. 2021
CZUT-M1129	41	Tolima, Armero Guayabal	5° 0’ 56.5”N	74° 54’ 10.9”W	-	García-Herrera *et al*. 2021
CZUT-M1403	42	Tolima, Armero Guayabal	5° 0’ 56.5”N	74° 54’ 10.9”W	-	García-Herrera *et al*. 2021
CZUT-M2014	43	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’ 31.3”W	-	García-Herrera *et al*. 2021
CZUT-M2015	44	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’ 31.3”W	-	García-Herrera *et al*. 2021
CZUT-M2016	45	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’31.3”W	-	García-Herrera *et al*. 2021
CZUT-M2021	46	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’31.3”W	-	García-Herrera *et al*. 2021
CZUT-M2022	47	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’31.3”W	-	García-Herrera *et al*. 2021
CZUT-M2023	48	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’31.3”W	-	García-Herrera *et al*. 2021
CZUT-M2028	49	Tolima, Ibagué	4° 21’ 28.8”N	75° 9’31.3”W	-	García-Herrera *et al*. 2021
CZUT-M1056	50	Tolima, Sebastián de Mariquita	5° 13’ 4.34”N	74° 53’ 52.8”W	-	García-Herrera *et al*. 2021
CZUT-M1061	51	Tolima, Sebastián de Mariquita	5° 13’ 4.34”N	74° 53’ 52.8”W	-	García-Herrera *et al*. 2021
CZUT-M0234	52	Tolima, Suárez	4° 0’ 36.58”N	74° 50’ 19.51”W	-	García-Herrera *et al*. 2021
CZUT-M0246	53	Tolima, Suárez	4° 0’ 36.58”N	74° 50’ 19.51”W	-	García-Herrera *et al*. 2021
CZUT-M0307	54	Tolima, Suárez	4° 0’ 36.58”N	74° 50’ 19.51”W	-	García-Herrera *et al*. 2021
CZUT-M0362	55	Tolima, Suárez	4° 0’ 36.58”N	74° 50’ 19.51”W	-	García-Herrera *et al*. 2021
CZUT-M1236	56	Tolima, Suárez	4° 0’ 36.58”N	74° 50’ 19.51”W	-	García-Herrera *et al*. 2021
ROM40313	57	Putumayo, Mocoa	1° 8’ 57.88”N	76° 39’ 8.94”W	-	García-Herrera *et al*. 2021
ROM40349	58	Putumayo, Mocoa	1° 8’ 57.88”N	76° 39’ 8.94”W	-	García-Herrera *et al*. 2021
ROM40373	59	Putumayo, Mocoa	1° 8’ 57.88”N	76° 39’ 8.94”W	-	García-Herrera *et al*. 2021
ROM40374	60	Putumayo, Mocoa	1° 8’ 57.88”N	76° 39’ 8.94”W	-	García-Herrera *et al*. 2021
ROM40375	61	Putumayo, Mocoa	1° 8’ 57.88”N	76° 39’ 8.94”W	-	García-Herrera *et al*. 2021
ROM49184	62	Putumayo, Mocoa	1° 8’ 57.88”N	76° 39’ 8.94”W	-	García-Herrera *et al*. 2021

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

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

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

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

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

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

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

The margay is widely distributed in tropical and temperate environments, from the tropical lowlands of México to southern Brazil and Paraguay; unfortunately, its populations have been declining (de Oliveira 1998; Ávila-Najera *et al.* 2015; de Oliveira *et al.* 2015). In México, one of the highest-altitude records is located in the mountain cloud forest of northwest Morelos, in the Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I, at 2,750 m (Aranda and Valenzuela-Galván 2015).

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

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

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

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

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

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

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

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

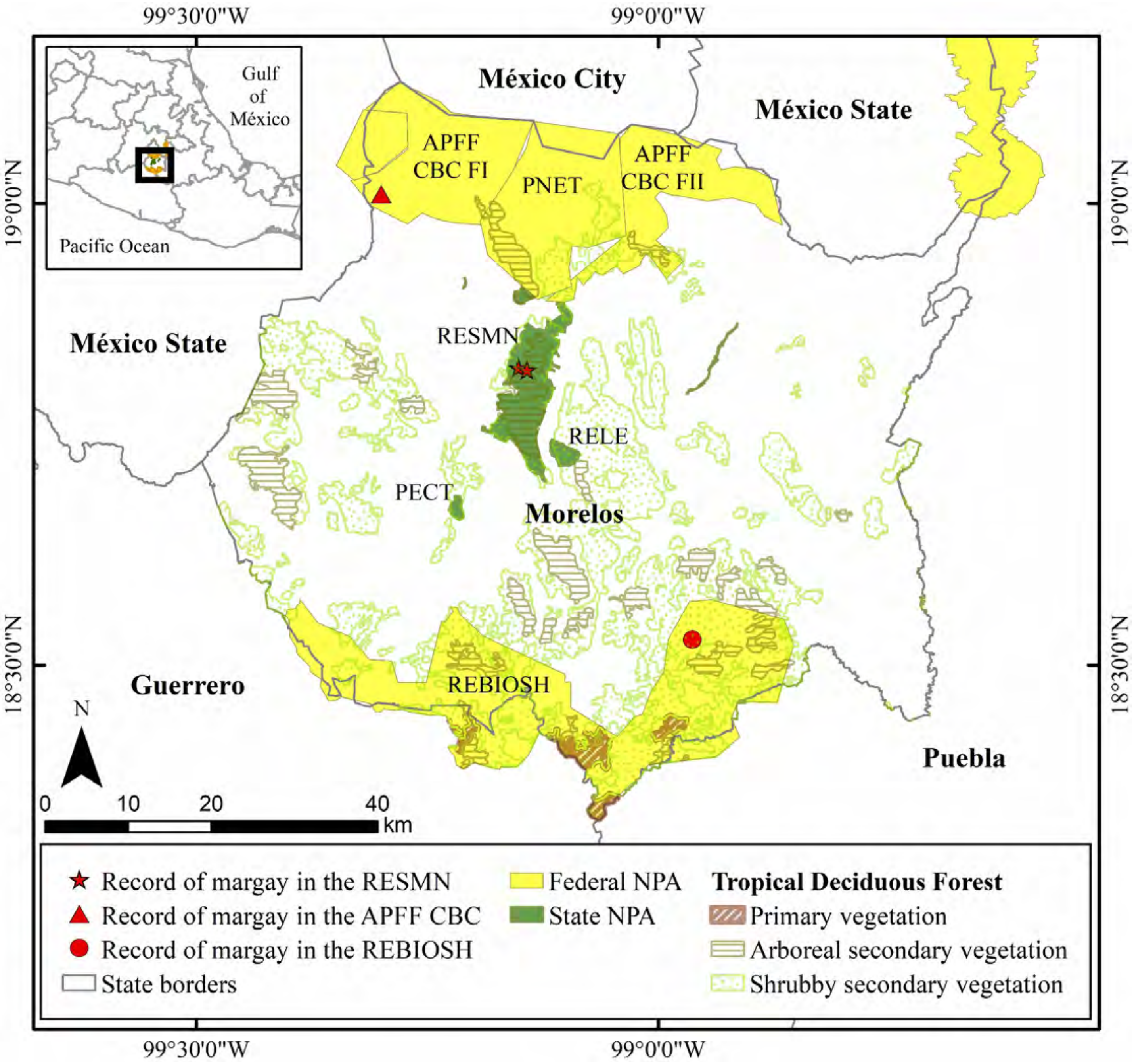

Figure 1. Geographic location of margay records in the State of Morelos. Areas marked in yellow correspond to the Federal Natural Protected Areas: Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I (APFF CBC FI) and Fraction II (APFF CBC FII), Tepozteco National Park (PNET),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

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

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

In this paper, we report for the first time the presence of a male margay (*L. wiedii*) in the Sierra Monte Negro State Reserve, which is the third report of this species in the state of Morelos. The presence of margay in the state of Morelos has been reported previously on 2 occasions in PNAs adjacent to our study area. The first was recorded between 2009 and 2010 on a site 30 km to the southeast, within the Sierra de Huautla Biosphere Reserve (Valenzuela *et al.* 2013). The second corresponds to a site 42 km northwest, within the Chichinautzin Biological Corridor Flora and Fauna Protection Area, Fraction I, recorded in 2014 (Aranda and Valenzuela-Galván 2015). To determine whether the individual recorded in the RESMN was one of those recorded previously, the spot pattern of the RESMN margay was compared with those of the individual captured in the Biological Corridor Flora and Fauna Protection Area, concluding that they are different individuals. A comparison of this sort with the individual reported for the Sierra de Huautla Biosphere Reserve was impossible because no photographs were available for the latter report. Considering that the maximum home range reported for the species in Brazil is 15.9 km^2 (de Oliveira *et al.* 2010) and the one reported for México is 6 km^2 (Carvajal-Villarreal *et al.* 2012), it is unlikely that the individual captured in the present study is the same recorded in the Sierra de Huautla Biosphere Reserve, given the distance between both records. In addition, the margay lives an average of 10 years in the wild (de Oliveira 1998), and the record in this study was captured 10 years after the one of the Sierra de Huautla Biosphere Reserve and 6 years after those of the Chichinautzin Biological Corridor Flora and Fauna Protection Area.

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

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

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

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

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

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

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Contribution to the knowledge on the diet of the collared peccary (*Dicotyles tajacu*) at the La Selva Biological Station, Costa Rica

Aportes al conocimiento sobre la dieta del pecarí de collar (*Dicotyles tajacu*) en la Estación Biológica La Selva, Costa Rica

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The diet of the collared peccary (*Dicotyles tajacu*) in the Neotropics is poorly known, although palm fruits are frequently reported. This study aimed to evaluate the diet of collared peccary groups at La Selva Biological Station (LSBS), Costa Rica. Between July and December 2021, 30 km of LSBS trails were traveled each month. A list of plant species consumed by peccaries was elaborated from direct visual observations. Samples of plant or fruit species collected in the field were identified at the family, genus, or species level. The diet of the collared peccary inhabiting the LSBS consisted of 38 species belonging to 18 families. The most consumed species belong to the family Arecaceae. *Socratea exorrhiza*, *Ficus colubrinae*, *Dussia macroprophyllata, Sacoglottis trichogyna, Iriartea deltoidea*, and *Dipteryx panamensis* were the predominant species in the peccary diet. The most important plant component was fruits. The dispersal mode of most species consumed was Endo-*stricto*. For 53 % of plant species consumed by peccaries have no information on their IUCN conservation status. Given the diverse diet of the collared peccary, conservation actions should consider the protection of primary forests as food sources, in addition to restoration projects of tropical ecosystems to promote tree species that provide fruits attractive to peccaries.

Key words: Eating habits; fruits; palms; saino; wet tropical forest.

La información disponible sobre la dieta del pecarí de collar (*Dicotyles tajacu*) en el neotrópico es escasa, aunque se sabe que los frutos de palma son reportados con frecuencia. El objetivo de esta investigación fue evaluar la dieta de los grupos de pecaríes de collar en la Estación Biológica La Selva (EBLS), Costa Rica. Entre julio y diciembre de 2021 se recorrieron 30 km por mes en los senderos de la EBLS. Mediante el método de observación directa se realizó un listado de especies de plantas consumidas por los pecaríes. Las muestras de las especies de plantas o frutos colectadas en campo se identificaron a nivel de familia, género y/o especie. La dieta del pecarí de collar en la EBLS estuvo conformada por 38 especies, pertenecientes a 18 familias. Las especies de la familia Arecaceae fueron las de mayor consumo. *Socratea exorrhiza*, *Ficus colubrinae*, *Dussia macroprophyllata, Sacoglottis trichogyna, Iriartea deltoidea* y *Dipteryx panamensis* fueron las especies más consumidas. El componente de mayor importancia fueron los frutos. El modo de dispersión de la mayoría de las especies consumidas fue Endo-*stricto*. El 53 % de las especies de las plantas consumidas no presenta información sobre su categoría de conservación según la UICN. Dada la diversidad en la dieta del pecarí de collar, las acciones de conservación deben considerar la protección de bosques primarios como fuentes de alimento, así como proyectos de restauración de ecosistemas tropicales en función de promover especies de árboles que brindan frutos atractivos para los pecaríes.

Palabras claves: Bosque tropical húmedo; frutos; hábitos alimentarios; palmas; saíno.

The collared peccary (*Dycotyles tajacu*) is a medium-sized, compact-bodied ungulate (Aranda 1994) belonging to the family Tayassuidae (Mammalia, Artiodactyla) and previously considered in the genus *Tayassu* (Mayer and Wetzel 1987; Torrealba-Suárez 1993; Sowls 1997). This species inhabits a wide variety of biomes and is listed as Least Concern according to the International Union for Conservation of Nature (IUCN) Red List (Gongora *et al.* 2011). Its current distribution stretches from southwestern United States of America to the northern-central area of Argentina (Gasparini *et al.* 2013; Ontiveros *et al.* 2020), with stable distribution ranges of between 38 ha and 685 ha (Torrealba-Suárez 1993; Carrillo *et al.* 2002; Beck 2006). These ungulates are components of the dynamics of Neotropical forests as key herbivores governing plant diversity, spatial distribution, and demography (Clark and Clark 1989; Torrealba-Suárez 1993; Roldán and Simonetti 2001; Beck 2005, 2007; Paine and Beck 2007; Briceño-Méndez *et al.* 2017).

The diet of collared peccaries is one of the main research topics among the scholars studying these ungulates since it plays a major role in the reproductive success and evolutionary adaptation of the species, as well as in its ecological relationships with other animal and plant species (Pérez-Cortez and Reyna-Hurtado 2008). In the Neotropics, peccaries are generally frugivorous, and their diet varies according to the habitat (Beck 2005). Throughout their distribution, these ungulates consume up to 128 species of plants belonging to 38 families, preferring palm fruits of the family Arecaceae (Kiltie and Terborgh 1983; Beck 2005, 2006, 2007; Keuroghlian and Eaton 2008; Queenborough *et al.* 2012), in addition to other species of the families Fabaceae, Sapotaceae, and Moraceae, among others (Beck 2005).

In this sense, peccaries consume a wide variety of plant foods such as pulp, roots, tubers (Torrealba-Suárez 1993; Altrichter *et al.* 2000; Beck 2005, 2006; Romero *et al.* 2013), and palm seeds (Queenborough *et al.* 2012). Their diet also includes animals, including invertebrates, frogs, snakes, turtles, fish, eggs, lizards, birds, and small rodents (Romero *et al.* 2013). In places with prolonged droughts, collared peccaries have been observed consuming mainly succulents, especially prickley-pear cactus, *Opuntia lindheimeri*, to meet their water and energy needs (Gallagher *et al.* 1984; Corn and Warren 1985), as well as cactus roots and pulp (Desbiez *et al.* 2009).

The La Selva Biological Station (LSBS) is under protection, and surveillance actions have been implemented, fostering the growth of local peccary populations since the 1980s (Michel *et al.* 2014; Romero *et al.* 2013). In addition, the National Wildlife Conservation Act prohibits the wildlife hunting (MINAE 2008), contributing to the abundance of this species. In LSBS, peccaries are easily observed on forest trails and near laboratories and office areas due to the abundance of food resources such as fig (*Ficus colubrinae*), chonta or walking palm (*Socratea exorrhiza*), bombona or pona palm (*Iriartea deltoidea*) and *Philodendron* sp. (Romero *et al.* 2013). Among these resources, palm fruits have been frequently reported as part of the collared peccary diet, and although it consumes a wide variety of plant species in Neotropical forests, the abundance of each species is less well-known (Beck 2005; Queenborough *et al.* 2012). This study aimed to evaluate the diet of collared peccary groups at La Selva Biological Station (LSBS) in Costa Rica.

The LSBS is located in the province of Heredia on the Caribbean slope of northern Costa Rica and is physically connected with the Braulio Carrillo National Park (Torrealba-Suárez 1993). It comprises an area of 1,600 ha, of which 73 % is wet tropical forest (wtf–T; Hartshorn 1983), and the remaining area comprises experimental forest plantations (Figure 1; Arroyo-Arce *et al.* 2013). The temperature ranges between 24.7 ºC and 27.1 °C, with maxima

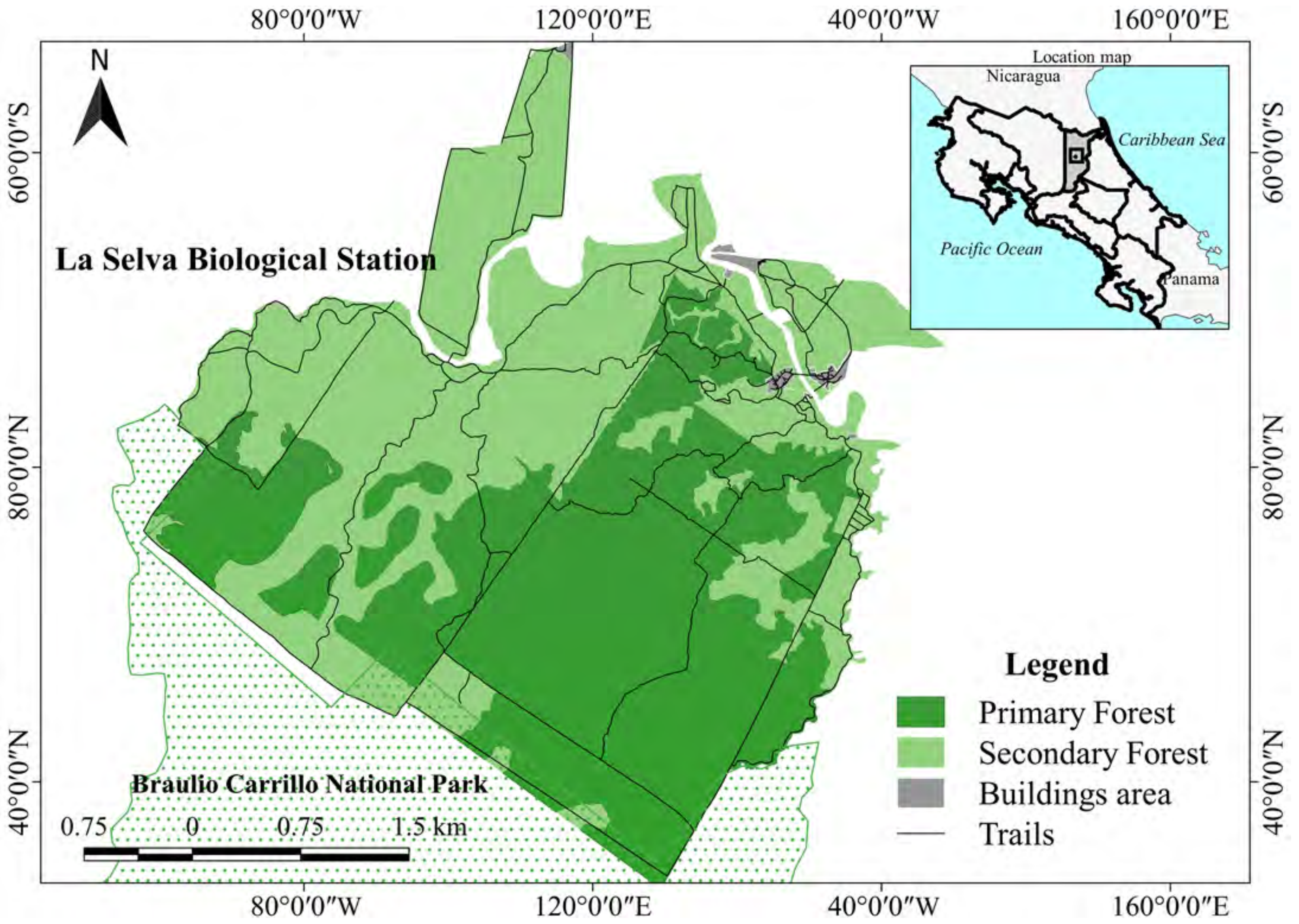

Figure 1. La Selva Biological Station, Puerto Viejo, Sarapiquí, Costa Rica.

between 30 ºC and 34 °C, and the mean annual rainfall varies between 3,800 mm and 4,000 mm (Robinson *et al.* 2018; Armstrong *et al.* 2020), with a period of low rainfall between January and April (Clark *et al.* 2013; Armstrong *et al.* 2020) and the highest precipitation between June and November (McClearn *et al.* 2016). The vegetation consists of different successional stages and the topography goes from flat to undulating (Oviedo-Pérez 2008; Arroyo-Arce *et al.* 2013; Romero *et al.* 2013; Raich *et al.* 2014).

The study on the diet of peccaries was conducted from July 9 to December 9, 2021. All the EBLS trails were traveled, with intervals of 350 m to 6 km between hikes. Trails included primary forest, secondary forest, managed forest, building areas, abandoned agroforestry, *arboretum*, clean wooded marshland, successional plots, grasslands with and without trees, forest plantations of native species, the mature forest ecological reserve, and urbanized areas. Hikes were walked over 9 hours between 8:00 and 17:00 hr, at 1 km/hr, covering an average of 30 km per month. When coming across a solitary peccary or a group of peccaries, we directly observed the nearest individual every 5 min (Figure 2a, b). We recorded the consumption of fruits, vegetative parts (leaves and stems), leaf litter or biomass in the soil, animals (invertebrates and small vertebrates), the frequency with which each food type was consumed. Samples of the species of plants or fruits consumed by peccaries were collected and identified at the family, genus, or species level with the assistance of LSBS staff.

A list of plant species consumed by peccaries was elaborated accompanied by their IUCN conservation status. Besides, the dispersal category of each was also noted, considering the 5 dispersal categories defined by Hawes *et al.* (2020): a) Endo-*stricto* or "true endozoochory", where seeds are dispersed by animals, either through seed ingestion (endozoochory) or via accumulation (synzoochory); b) Endo-*lato* or "possible endozoochory", where, in addition to dispersal by animals, this can also occur through other means such as water transport (hydrochory) or auto-dispersal (autochory); c) Synzoochory, where seeds are dispersed by animals through seed accumulation, although it also considers other means such as autochory, hydrochory, and ant dispersal (myrmecoria); d) Others: dispersal that does not involve animals, including anemochory (wind dispersal), autochory, baracory (dispersal through gravity), and hydrochory; and, e) no information available.

Finally, the most frequently consumed plant species were determined according to three categories: fruits, leaves, and flowers. The descriptive analysis was performed in Python 3.9 (Python Software Foundation 2023).

In the LSBS, the diet of the collar peccary consists of 38 species of plants belonging to 18 families (Table 1). The plant species with the highest frequency of consumption belonged to the families Arecaceae (31 %), followed by Araceae (10 %) and Moraceae, Fabaceae, Sapotaceae, Myristicaceae, Phytolaccaceae and Piperaceae (5 % each). The species consumed most frequently by peccaries were *Socratea exorrhiza* (18 observations), *Ficus colubrinae* (14 observations), *Dussia macroprophyllata, Sacoglottis trichogyna, Iriartea deltoidea* (3 observations each), and *Dipteryx panamensis* (2 observations; Table 1; Figure 3). The dominant components in the diet of collared peccaries were fruits (77 %), followed by leaves (20 %) and flowers (3 %). The fruits most consumed by peccaries in building areas were *Ficus colubrinae*.

The dispersal mode of most species consumed by peccaries was Endo-*stricto* (60.53 %), followed by synzoochory (18.42 %), Endo-*lato* (2.63 %), no information available (10.53 %), and others (7.89 %). According to IUCN conservation categories, 53 % of the plant species consumed by peccaries are not listed, 37 % are listed as Least Concern, 5 % Endangered, 2.5 % Vulnerable, and the rest are classified as Near Threatened (2.5 %).

Most of the species consumed by collared peccaries in the LSBS belong to the family Arecaceae, compared to fruits

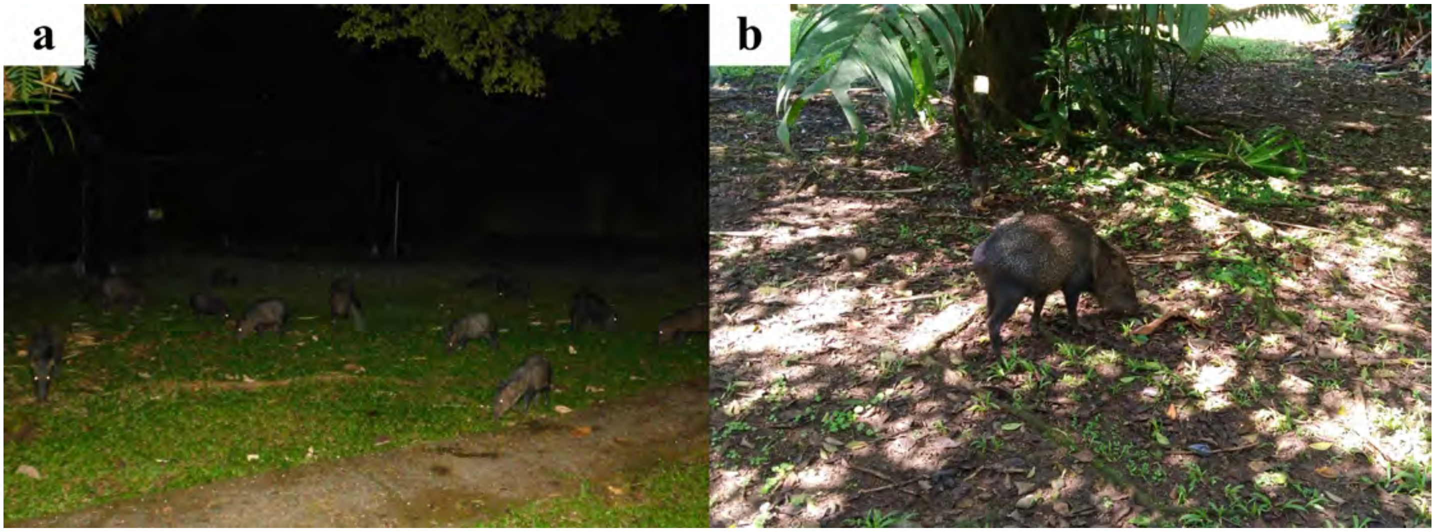

Figure 2. Collared peccaries, *Dicotyles tajacu,* feeding at La Selva Biological Station, Costa Rica. a) A group of peccaries, b) a solitary peccary.

Table 1. List of species consumed by *Dicotyles tajacu* at La Selva Biological Station, Costa Rica.

Species	Type of organism	Dispersal Category	Conservation status according to the IUCN Red List
Family Araceae			
Philodendron alliodorum	Bush	Others	No information
Philodendron jodavisianum	Creeper	Others	No information
Philodendron radiatum	Creeper	Synzoochory	No information
Philodendron sp.	Bush	Synzoochory	No information
Family Arecaceae			
Asterogyne martiana	Palm	Endo-*stricto*	No information
Astrocaryum alatum	Palm	Synzoochory	Near threatened
Astrocaryum confertum	Palm	Synzoochory	Endangered
Bactris coloradonis	Palm	Endo-*stricto*	No information
Bactris gasipaes	Palm	Endo-*stricto*	No information
Bactris longiseta	Palm	Endo-*stricto*	Endangered
Calyptrogyne ghiesbreghtiana	Palm	No information	No information
Chamaedorea pinnatifrons	Palm	Endo-*stricto*	Least concern
Iriartea deltoidea	Palm	Endo-*stricto*	Least concern
Socratea exorrhiza	Palm	Endo-*stricto*	Least concern
Synechanthus warscewiczianus	Palm	No information	No information
Welfia regia	Palm	Endo-*stricto*	No information
Family Burceraceae			
Protium pittieri	Tree	Endo-*stricto*	Vulnerable
Family Fabaceae			
Dipteryx panamensis	Tree	Endo-*stricto*	No information
Dussia macroprophyllata	Tree	Endo-*lato*	Least concern
Family Humiriaceae			
Sacoglottis trichogyna	Tree	Endo-*stricto*	Least concern
Family Lamiaceae			
Aegiphila falcata	Bush	No information	Least concern
Family Malvaceae			
Pachira aquatica	Tree	Synzoochory	Least concern
Family Menispermaceae			
Abuta panamensis	Liana	Synzoochory	No information
Family Moraceae			
Brosimum alicastrum	Tree	Endo-*stricto*	Least concern
Ficus colubrinae	Tree	Endo-*stricto*	Least concern
Family Myristicaceae			
Virola sebifera	Tree	Endo-*stricto*	Least concern
Virola koschnyi	Tree	Endo-*stricto*	Least concern
Family Nyctaginaceae			
Neea laetevirens	Bush	Endo-*stricto*	No information
Family Passifloraceae			
Passiflora arbelaezii	Liana	Synzoochory	No information
Family Phytolaccaceae			
Trichostigma polyandrum	Bush	Endo-*stricto*	No information
Phytolacca rivinoides	Bush	Endo-*stricto*	No information
Family Piperaceae			
Piper sp.	Bush	Endo-*stricto*	No information
Piper sp.	Bush	Endo-*stricto*	No information
Family Primulaceae			
Clavija costaricana	Bush	Endo-*stricto*	Least concern
Family Rubiaceae			
Faramea suerrensis	Bush	Endo-*stricto*	Least concern
Family Sapindaceae			
Paullinia granatensis	Liana	No information	No information
Family Sapotaceae			
Chrysophyllum venezuelanense	Tree	Endo-*stricto*	Least concern
Family Solanaceae			
Merinthopodium neuranthum	Bush	Others	No information

and seeds of other families (Beck 2006). This is because the fruits and seeds of palm trees are rich in carbohydrates, which provide energy, and are available throughout the year, even drought periods when fruits of other species are scarce (Beck 2005, 2006).

With regard to the species consumed, we concluded that *D. tajacu* consumes a few species when they are abundant. This was the case of *S. exhorriza*, the species most consumed by peccaries in the LSBS; in this zone, it was previously reported that peccaries consume the roots of this species, mainly when fruits are scarce (Méndez-Figueroa 2014; Ávalos *et al.* 2016).

On the other hand, *F. colubrinae*, the second most consumed species by *D. tajacu* in this study, is commonly found in areas of the LSBS with buildings. It produces fruits in all seasons so that these are readily available for consumption by peccaries throughout the year (Quesada *et al.* 1997). It should be noted that the family Araceae includes toxic species such as *Philondendron* spp. (Escobar 1972), which were consumed by peccaries in a smaller proportion. This may be related to the evolutionary adaptation of these animals, which allows feeding on plant tissues of species containing high amounts of compounds, only digestible through bacterial fermentation (Sowls 1997; Altrichter *et al.* 2000). In this sense, the number of plant species used by peccaries in the LSBS demonstrates that the collared peccary is an opportunistic species capable of using fruits and seeds across a wide morphological and taxonomic range (Sowls 1997; Keuroghlian *et al.* 2004; Beck 2005).

Our results are similar to those reported by Beck (2005) in previous studies in the Neotropics, who also found that peccaries fed preferentially on fruits of the family Arecaceae, although in a lower percentage (19 %) than the frequency reported in this note. Beck (2005) also reported the consumption of fruits of the families Fabaceae, Sapotaceae, and Moraceae in higher frequencies than those reported in the present study. With respect to the main components in the diet of the collared peccary in the LSBS, Torrealba-Suárez (1993) reported 53 % fruit consumption, while Méndez-Figueroa (2014) noted that leaves were the plant tissue most consumed (58 %), followed by fruits (31 %); these percentages differ from the figures reported herein.

As expected, endozoochory is the dispersal mode of most species consumed by peccaries in LSBS. The role of peccaries in forest regeneration in the Neotropics has been demonstrated in previous studies, both within the LSBS and elsewhere, since it has been observed that seeds of different species are resistant to the digestive process of peccaries (Beck 2005; Platt *et al.* 2014) and have successfully germinated in stool samples. For example, Beck (2005) identified seeds of *Ficus* sp., *Brosimun* spp., *Phytolacca dioica*, and *Dipteryx panamensis* in collared peccary feces. Other authors also reported the presence of seeds of *Socratea* sp. (Kiltie 1981), *Ficus* spp. (Martínez-Romero and Mandujano 1995), *Brosimum alicastrum*, *Piper* sp., and *Chamaedorea* sp. (Pérez-Cortez and Reyna-Hurtado 2008).

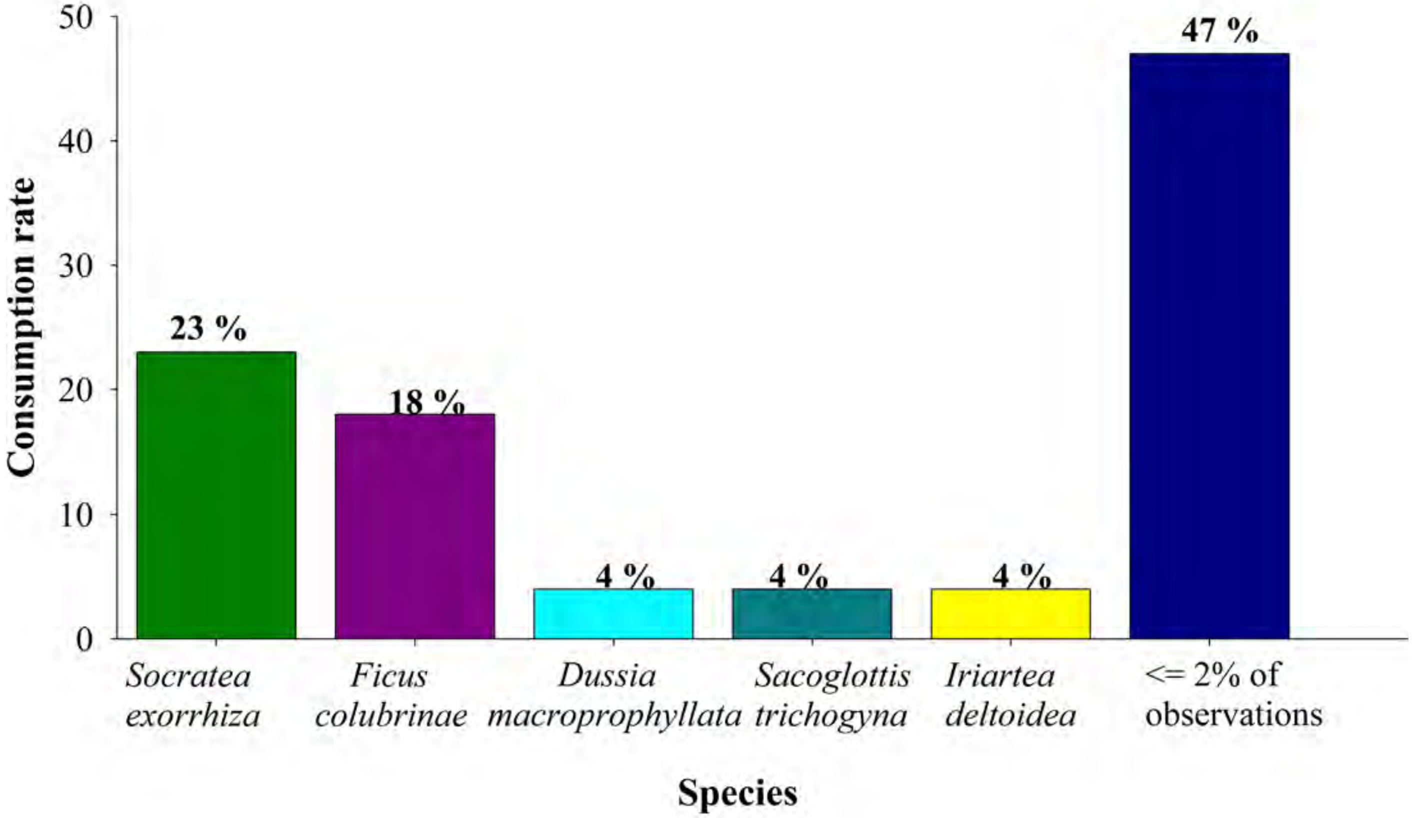

Figure 3. Number of observations for each plant species consumed by *Dicotyles tajacu* at La Selva Biological Station, Costa Rica.

Stomach analyses of collared peccaries have revealed the presence of large intact seeds of *Socratea* sp. and *I. deltoidea*, but no germination tests have been performed on them (Beck 2005). According to Kiltie (1981), peccaries thoroughly chew their food and rarely function as effective dispersers of large seeds. However, we suggest carrying out germination studies of seeds present in peccary feces to gain a better understanding of their role as seed dispersers (*e.g.*, Liu *et al.* 2004; Myers *et al.* 2004; Beck 2005). The potential of the collared peccary as a seed disperser is clear, as in the case of large seeds of *S. exhorriza, D. panamensis, B. alicastrum,* and *I. deltoidea*, and small seeds of *Phytolacca rivinoides* and *F. colubrinae*, based on the frequency of consumption reported in the present study and previous research (Kiltie 1981; Martínez-Romero and Mandujano 1995; Beck 2005; Pérez-Cortez and Reyna-Hurtado 2008).

Our results show that, in the LSBS, the diet of the collared peccary includes 38 plant species, mainly of the family Arecaceae, with fruits being the plant component most consumed in all species. Therefore, conservation actions for this ungulate species should consider restoring forest ecosystems and protecting primary forests as these represent their main food source. Finally, the connectivity between LSBS and other forest fragments should be promoted through local biological corridors to facilitate the natural restoration of plants important in the diet of peccaries, given its ecological importance in wet tropical forests.

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