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AMMAC
Asociación Mexicana de Mastozoología A.C.

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

En la Portada

La coloración anómala es un fenómeno que se observa con regularidad en los mamíferos, sin embargo, para el caso del albinismo, esta es una condición relativamente infrecuente; por citar un ejemplo, se ha reportado menos del 2% de las especies de roedores con esta condición. En este fascículo se presentar el reporte por primera vez de un caso de albinismo en un puercoespín de la especie *Coendou quichua*, a partir de un espécimen capturado en el noroeste de Ecuador.
(Fotografía de J. Crespo)

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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First record of albinism in the Quichua Porcupine, *Coendou quichua* in Ecuador

Primer registro de albinismo en el Puercoespín Quichua, *Coendou quichua* en Ecuador

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Anomalous coloration is a phenomenon that is regularly observed in mammals. Cases of albinism are relatively uncommon; for example, they have been reported in less than 2 % of rodent species. For the first time, we report a case of albinism in a porcupine, based on a specimen collected in northwestern Ecuador. An injured Quichua Porcupine exhibiting anomalous coloration was rescued in a roadway in proximity to the Bosque Protector La Perla, situated within the province of Santo Domingo de los Tsáchilas. It was preserved as a museum specimen in skin, skull and skeleton. Identification was confirmed by external skull characters, but we also sequenced the molecular marker cytochrome b (Cyt *b*) for phylogenetic support. The specimen is an old female. The animal exhibited yellowish dorsal quills and white quills on the belly. The eyes are red, while the face, ears, hands, and feet are pink. Genetic analysis of the mitochondrial marker Cyt *b* confirmed the identification of the specimen as *Coendou quichua*. This report presents the first documented case of albinism in *Coendou quichua*. Furthermore, this report increases the number of species of the genus *Coendou* with cases of albinism to 3, and represents the third mammal species reported in Ecuador with this condition. We also present a phylogeny and comment on the possibility of cryptic diversity within the genus.

Key words: Color aberration; Neotropical mammals; Northwestern Ecuador.

La coloración anómala es un fenómeno que se observa con regularidad en los mamíferos. Los casos de albinismo son relativamente infrecuentes; por ejemplo, se han descrito en menos del 2 % de las especies de roedores. Informamos por primera vez de un caso de albinismo en un puercoespín, a partir de un espécimen recogido en el noroeste de Ecuador. Un puercoespín Quichua herido que presentaba una coloración anómala fue rescatado mientras atravesaba una carretera en las proximidades del Bosque Protector La Perla, situado en la provincia de Santo Domingo de los Tsáchilas. Se conservó como espécimen de museo en piel, cráneo y esqueleto. La identificación se confirmó por los caracteres externos y del cráneo, pero también secuenciamos el marcador molecular citocromo b (Cyt *b*) para obtener apoyo filogenético. El espécimen es una hembra vieja. El animal exhibe púas amarillentas en el dorso y púas blancas en el vientre. Los ojos son rojos, mientras que el hocico, las orejas, las manos y los pies son rosados. El análisis genético del marcador mitocondrial Cyt *b* confirmó la identificación del espécimen como *Coendou quichua*. Este reporte presenta el primer caso documentado de albinismo en la especie de roedor *Coendou quichua*. Además, este reporte incrementa a 3 el número total de especies del género *Coendou* con casos de albinismo, y añade a 3 especies de mamíferos registradas en Ecuador con esta condición. También presentamos una filogenia y comentamos la posibilidad de diversidad críptica dentro del género.

Palabras clave: Aberración cromática; mamíferos neotropicales; noroeste de Ecuador.

Chromatic fur disorders, including albinism, melanism, and leucism, are teratologic conditions that have been documented in vertebrates such as fishes (Manoel *et al.* 2017), reptiles (García-Roa 2020), amphibians (Culebras and Angiolani-Larrea 2023), birds (Cadena-Ortíz *et al.* 2015), and various mammal groups, including rodents (Abreu *et al.* 2013; Brito and Valdivieso-Bermeo 2016; Romero *et al.* 2018; Medina and Medina 2019; Sanmartín *et al.* 2024). Aberrant colorations are the consequence of genetic mutations that disrupt various stages of melanogenesis, the metabolic pathway responsible for the synthesis of melanin, the pigment that produces mammalian coloration (Slominski *et al.* 2004). Anomalous colorations are regularly observed in mammals. Cases of albinism are relatively uncommon (Romero *et al.* 2018; Pommer-Barbosa *et al.* 2022), and for rodents they have been reported in less than 2 % of species (Romero *et al.* 2018).

A mammal who is albino lacks melanin in their skin, hairs, and eyes and is incapable of producing normal, viable melanosomes (Jackson 1994). Coloration may be relevant in predator avoidance and camouflage, as well as in the regulation of some physiological processes (Caro 2005;

Harris *et al.* 2019). In this context, it is possible that the occurrence of aberrant coloration may compromise individual fitness (Galante-Rocha *et al.* 2017).

Some instances of the albino phenotype have been documented in New World porcupines (Erethizontidae), including *Erethizon dorsatum* (Dunn 1921; Struthers 1928; Reeks 1942; Shadle 1946; Hewston 1962; Roze 2012), *Coendou rufescens* (Romero *et al.* 2018), and *C. longicaudatus* (Pommer-Barbosa *et al.* 2022). The Quichua porcupine, *Coendou quichua*, is one of 16 species that compose the genus *Coendou*, as outlined by Voss (2015), and Menezes *et al.* (2021). It is characterized by dorsal fur appears completely spiny, with defensive quills bicolored and tricolored (Voss 2015), and coloration anomalies have never been reported for this species. The species is endemic to the Neotropics and is distributed from Panamá, across the Andean region of Colombia, to western Ecuador (Voss 2015; Ramírez-Chaves *et al.* 2016). The species ranges from sea level to about 3,300 m (Voss 2015). This paper reports a case of albinism for *C. quichua*, based on a specimen collected in northwestern Ecuador.

On December 18, 2023 (18:40 hr), an adult female of *C. quichua* was rescued exhibiting anomalous coloration (Figure 1a) while traversing a roadway in the vicinity of the Bosque Protector La Perla (0° 2' 15.38" S, 79° 24' 21.73" W; 220 m), situated within the province of Santo Domingo de los Tsáchilas in northwestern Ecuador. The animal was kept in captivity at an animal rescue center, but unfortunately succumbed to its injuries while undergoing veterinary care. The specimen was preserved as skin, skull, and skeleton, and subsequently deposited in the mammal collection (MECN) of the Instituto Nacional de Biodiversidad (INABIO) in Quito, Ecuador. DNA extraction, PCR amplification and sequencing with Oxford Nanopore Technologies were performed at the Nucleic Acid Sequencing Laboratory of the Instituto Nacional de Biodiversidad (INABIO) in Quito.

DNA was extracted from the liver using GeneJET Genomic DNA Purification Kit (K0722). The amplification was achieved through Polymerase Chain Reaction (PCR), using the primers MVZ05 and MVZ16 (Smith and Patton 1993), and the GoTaq ® Green Master Mix 2X kit to amplify the sequence of the cytochrome b (Cyt *b*). PCR conditions were initial denaturation at 95 °C for 2 min, 35 cycles at 95 °C/30 sec, 45 °C/30 sec, and 72 °C/80 sec with final extension of 72 °C/5 min. The expected amplicons length is about 1200 bp. The sequencing of the mitochondrial cytochrome b (Cyt *b*) marker of the individual was performed using a minION mk1c with Flongle Flow Cells R10.4.1 and Rapid Barcoding Kit 96 (SQK-RBK114.96) following standard protocols. Data was High-accuracy (HAC) basecalled. The resulting fastq file were filtered at a Q score of 9, and consensus sequences were produced with NGSpecies ID (Sahlin *et al.* 2021).

We used a total of 30 sequences of genus *Coendou* for phylogenetic analysis. We downloaded available sequences of closely related individuals for Cyt *b* and we obtained additional outgroup sequences from GenBank (http://www.ncbi.nlm.nih.gov/genbank/). The alignment was performed by the MAFFT algorithm in Mesquite version 3.81 (Maddison and Maddison 2023) to edit. We generated a maximum-likelihood tree in IQ-TREE (Trifinopoulos *et al.* 2016), under default settings. We employed 3 models corresponding to 3 different data partitions. The models and their associated sequence partitions are: Model TNe+G4 for codon position 1, Model TN+F+I for codon position 2 and Model TN+F+I for codon position 3. For each analysis, we utilized a bootstrap approach with 1000 replicates. Uncorrected p-distances were calculated using MEGA 11 (Tamura *et al.* 2021).

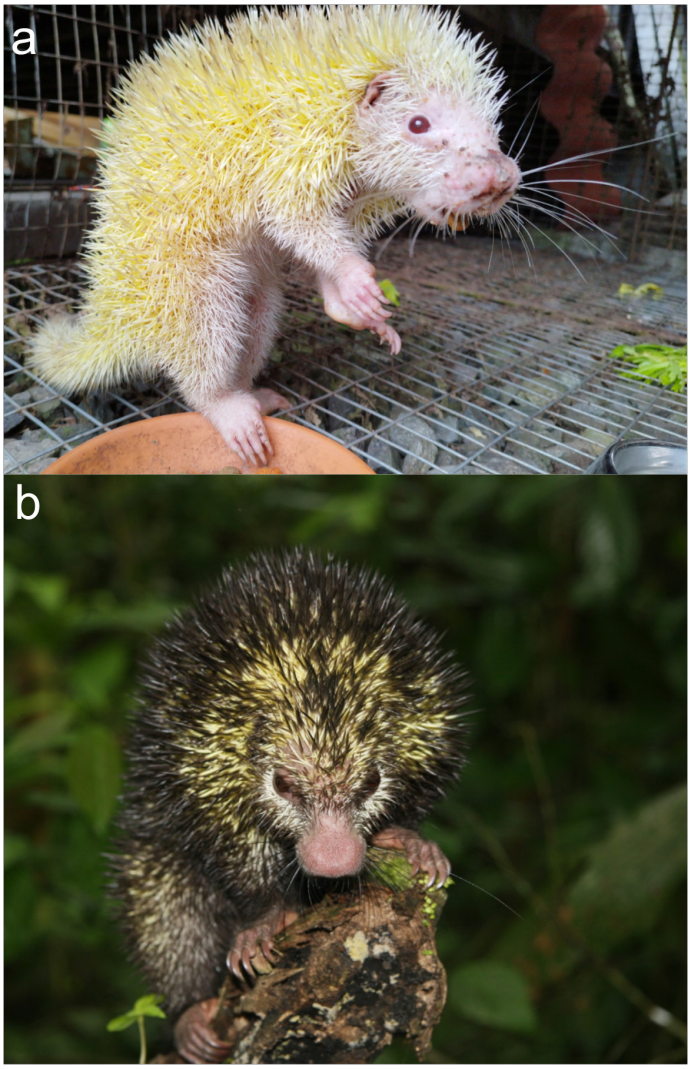

Figure 1. Albino (a) and normal (b) coloration of *Coendou quichua*, from Bosque Protector La Perla, Ecuador. Photographs by J. Crespo. Images available at jcrespo.w@hotmail.com.

The specimen (MECN 7959) is an old female with well-worn molars (Figure 2), with the following standard measurements: head-body length = 350 mm, tail length = 245 mm, hind leg length = 60 mm, ear length = 10 mm, and weight = 998 g. It exhibited the presence of yellowish dorsal quill and white quills on the belly. The eyes are red, while the face, ears, hands, and feet are pink (Figure 1a), contrast-

ing with the typical coloration of the species (Figure 1b).

We sequenced 1140 base pairs (pb) of the Cyt *b* marker (GenBank accession PQ046267). The phylogenetic analysis has confirmed the identity of *C. quichua* (Figure 3) with an uncorrected mean intraspecific genetic distance of 0.4 % with specimen KMH 2218 from Cotopaxi, Ecuador (Jarrín 2001).

The fact that the specimen of *C. quichua* (MECN 7959) reached adulthood suggests an exception to the hypothesis of selection against the albino phenotype, considering that albino mammals are negatively selected due to their difficulty in hiding from predators (Harris *et al.* 2019). However, some authors (Peles *et al.* 1995) argue that selection against the albino phenotype may be less effective in species that occupy habitats with high productivity and good vegetation cover (Peles *et al.* 199). Perhaps in *C. quichua* this hypothesis is plausible to explain the survival of the albino individual to sexual maturity, since this individual was recorded in a typical biogeographic Chocó rainforest with high primary productivity and abundant vegetation cover (Quinto-Mosquera and Moreno 2017). Furthermore, Tinbergen (1960) suggested that some predators may avoid albino prey because of a kind of neophobia.

This is the second DNA sequence of *C. quichua* for Ecuador and constitute the first DNA sequence of the Ecuadorian Pacific lowlands. The uncorrected mean intraespecific distance is 3.8 % with specimen LACM 27376 from Cesar, Colombia (Voss 2013); and 2.2 % with specimen USNM 296308 from Panamá (Voss 2013). Our phylogeny results were similar to those published by Cardoso *et al.* (2024). These values are within the range found in mammalian sister species (Bradley and Baker 2001) and have been used to show the presence of cryptic diversity within the genus *Coendou* (Leite *et al.* 2011; Voss 2013). Therefore, it is possible that 3 species compose *C. quichua*, and the application of the available name *C. rothschildi* for specimens from the Chocó rainforest need to be reevaluated, in accordance with the suggestions made by Ramírez-Chaves *et al.* (2016).

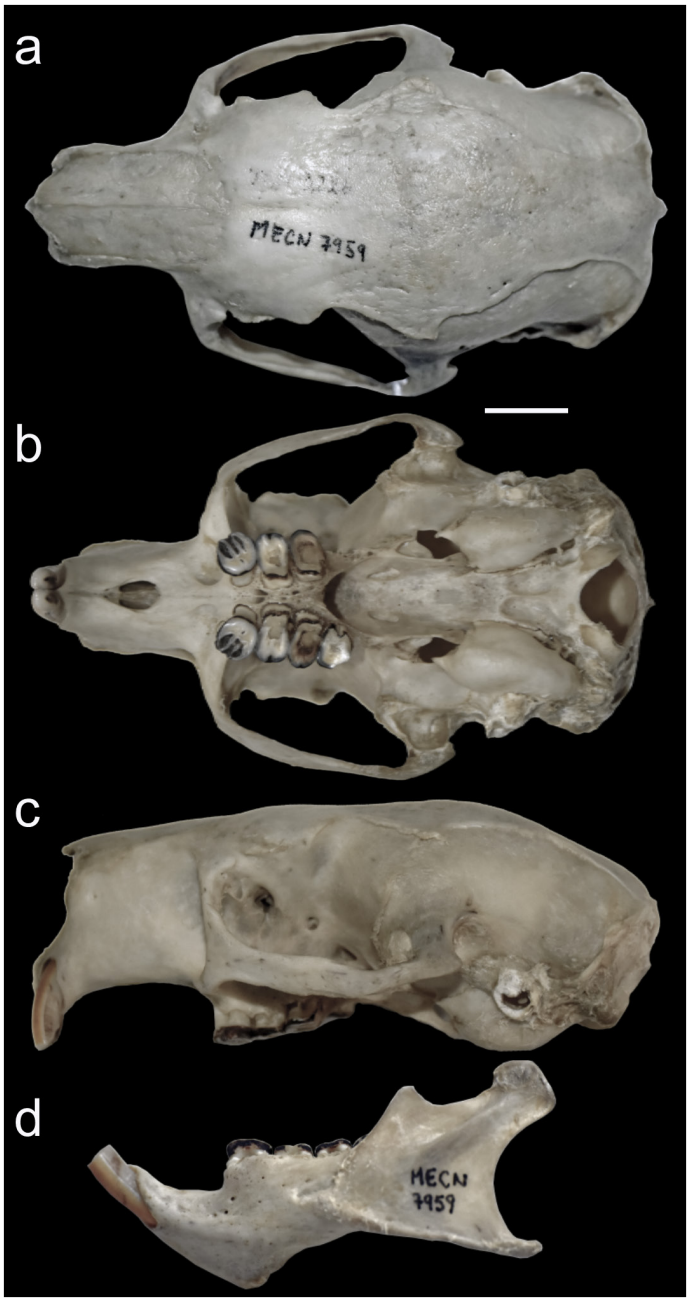

Figure 2. Dorsal (a), ventral (b), and lateral (c) cranial views, and (d) mandibular lateral view of albino *Coendou quichua* (MECN 7959, Bosque Protector La Perla, Ecuador). Note the wear of the molars and incisors. Scale bar = 10 mm. Photographs by J. Brito. Images available at jorgeyakuma@yahoo.es.

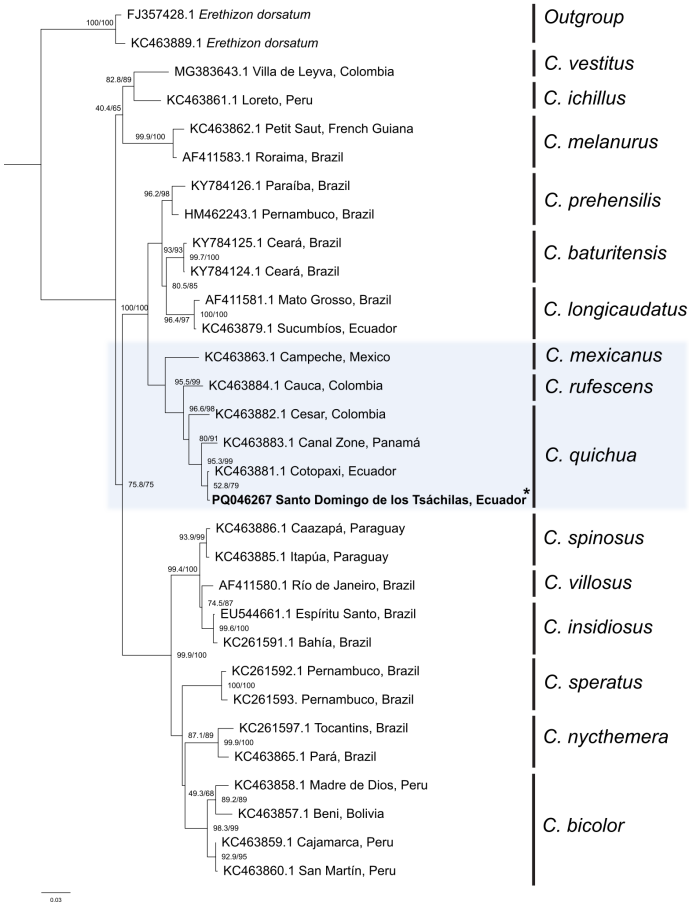

Figure 3. Phylogenetic tree of the Erethizontidae family obtained by Maximum-likelihood (ML) tree with Cyt *b* sequences. The sequence of the albino *Coendou quichua* clusters within the same clade as *Coendou quichua* from Cotopaxi, Ecuador, Colombia, and Panamá along with *C. rufescens* and *C. mexicanus*. The numbers along the branches represent a SH-aLRT (Shimodaira-Hasegawa approximate likelihood radio test) support (%) followed by ultrafast bootstrap support (%). This entire clade is highlighted in gray.

In conclusion, this is the first documented case of albinism in the species *C. quichua*, which also represents the third record of albinism for the genus and the fourth for Erethizontidae. This record also represents the third documented case of albinism in mammals from Ecuador (Brito and León 2014; Romero *et al.* 2018; this study). Prior to this, albinism was reported in *C. rufescens* (Romero *et al.* 2018) and *Vampyrum spectrum* (Brito and León 2014). To gain a deeper understanding of this phenomenon in natural populations, further studies on albinism, particularly in rodents, are needed.

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The Yucatán mouse opossum (*Tlacuatzin gaumeri*) in Quintana Roo, México

El tlacuache ratón de Yucatán (*Tlacuatzin gaumeri*) en Quintana Roo, México

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The Yucatán mouse opossum (*Tlacuatzin gaumeri*) is a little-known species so far reported only from the Mexican states of Campeche and Yucatán in the Yucatán Península. Due to the geographic proximity of these states to the state of Quintana Roo and their similar climate and vegetation, the presence of this marsupial in Quintana Roo would be expected. Scientific literature, curatorial records of scientific collections in México, in the GBIF, and observations of the citizen science portal iNaturalistMX were consulted. The curatorial records and one field observation were ordered in a table and a map was elaborated with QGIS 3.36.2. Curatorial records of the scientific collection of *T. gaumeri* were found in the Mexican state of Quintana Roo. Similarly, one citizen science observation (research grade) was found for Quintana Roo, near the western portion of the Sian Ka'an Biosphere Reserve. The records extend the known geographic distribution of *T. gaumeri* 139 km (average) eastward from the Yucatán Península. The data record *T. gaumeri* for the first time in Quintana Roo and confirm its endemicity in that state; they also extend the known geographic distribution of this marsupial. Although its presence coincides with only one natural protected area, it may contribute to its conservation. It still needs to be determined if it applies to any risk category, but the results contribute to the faunal inventory of the Yucatán Península.

Key words: Citizen science; Didelphidae; Didelphimorphia; dry tropical forest; museum specimen; new record.

El tlacuache ratón de Yucatán (*Tlacuatzin gaumeri*) es una especie poco conocida hasta ahora, reportada solamente de los estados mexicanos de Campeche y Yucatán en la Península de Yucatán. En virtud de la vecindad geográfica de estas entidades con el estado de Quintana Roo y por su similitud climática y de vegetación, se esperaría la presencia de este marsupial en territorio quintanarroense. Se consultaron la literatura científica, los registros curatoriales de colecciones científicas en México, en el GBIF y las observaciones del portal de ciencia ciudadana iNaturalistMX. Los registros curatoriales y una observación de campo se ordenaron en una tabla y se elaboró un mapa con QGIS 3.36.2. Se encontraron registros curatoriales de colección científica de *T. gaumeri* para el estado mexicano de Quintana Roo. Similarmente, se encontró una observación (grado investigación) de ciencia ciudadana para Quintana Roo, cerca de la porción occidental de la Reserva de la Biosfera de Sian Ka'an. Los registros amplían la distribución geográfica conocida de *T. gaumeri* 139 km (en promedio) hacia el este de la Península Yucateca. Los datos registran por primera vez a *T. gaumeri* en Quintana Roo y confirman su endemicidad en ese estado; asimismo amplían la distribución geográfica conocida de este marsupial. Aunque su presencia coincide solo con un área natural protegida, puede contribuir a su conservación. Se requiere todavía determinar si aplica para alguna categoría de riesgo, pero los resultados contribuyen al inventario faunístico de la Península Yucateca.

Palabras clave: Bosque tropical seco; ciencia ciudadana; Didelphidae; Didelphimorphia; ejemplar voucher; nuevo registro.

Mexican tlacuaches are marsupial mammals (Order Didelphimorphia) in the family Didelphidae. They are taxonomically grouped into 12 species in the genera *Didelphis* (2), *Philander* (1), *Caluromys* (1), *Metachirus* (1), *Chironectes* (1), *Marmosa* (1) and *Tlacuatzin* (5) (Arcangeli *et al.* 2018; Burgin *et al.* 2018). In contrast to the medium body size of most of their specimens, species of the latter 2 genera are small in size and because of their appearance are commonly mistaken for mice (Gaumer 1917). Species such as *Marmosa mexicana* have a wide geographic distribution in México and therefore are somewhat better known to the scientific community (Mejía and Medellín 1992). However, other species are poorly known, reflected in their scarce or null mentions in the scientific literature and the scarce collection of their morphological evidence documenting biodiversity in scientific collections.

Such is the case of the Yucatán mouse opossum (*Tlacuatzin gaumeri*), also known as tlacuachín, tlacuache ratón yucateco (Álvarez-Castañeda and González-Ruiz 2018) and holioch (Mayan word; Gaumer 1917), a species endemic to the Yucatán Península, México (Arcangeli *et al.* 2018). Known until recently as *T. canescens* (Martin 2017), *T. gaumeri* has been little studied and is therefore poorly known, despite its remarkable ecological and evolutionary relevance and its neotropical affinity (Voss and Jansa 2003). The Mexican government does not consider this

small tlacuachín in any risk category (Secretaría de Medio Ambiente y Recursos Naturales; SEMARNAT 2010), nor does the IUCN Red List (IUCN 2024).

Detailed research by González Christen and Rodríguez Santiago (2014) reported that *T. canescens gaumeri* inhabits the states of Campeche and Yucatán, but not Quintana Roo; the extensive report by Sosa-Escalante *et al.* (2013) on the terrestrial mammals of Yucatán also agrees with this result. However, since the 3 states of the Yucatán Península share similar vegetation types and climatic patterns, it is to be expected that *T. gaumeri* also occurs in the territory of Quintana Roo.

Most of the surface area of Yucatán, and to a lesser extent in Campeche and Quintana Roo, is covered by low deciduous forests (CICY 2010). Between the low deciduous forest and the high evergreen forest, there are intermediate associations known as medium forest, which can be deciduous or sub-evergreen. In general, the height and physiognomy are intermediate between one and the other and also in terms of spatial distribution, occupying an intermediate strip between the dry extreme north of the Península and the humid extreme, to the south (CICY 2010; Flores Guido *et al.* 2010).

It is also known that the presence of *T. c. gaumeri* in much of its range is associated with dry and sub-humid forests, including in the Yucatán Península (Gaumer 1917; Hernández-Cardona *et al.* 2007; Sosa-Escalante *et al.* 2013). Complementing this information are several citizen science contributions that provide interesting images of *T. c. gaumeri* (iNaturalistMX 2024) in geographic areas of the Yucatán Península that correspond to different tropical forests.

Therefore, the purpose of this study was to corroborate or refute the existence of records of the occurrence of *T. gaumeri* in Quintana Roo in scientific collections and in one of México's citizen science platforms that include research-grade records.

We searched curatorial records of the presence of *T. gaumeri* in the GBIF (Global Biodiversity Information Facility 2024) web portal for non-Mexican mammal collections. In addition, we requested information directly from the curators of the following Mexican scientific collections identified by the acronyms recognized in the Directory of Western Hemisphere mammal collections (Dunnum *et al.* 2018): CM-UAC, UADY, ECO-SC-M, MZ-ICACH, ENCB, UAMI, MZFC-M, and CNMA. At the same time, with the same purpose, we consulted the research-grade observations reported in the iNaturalistMX platform (https://mexico.inaturalist.org/). iNaturalistMX shares "Research Grade" licensed observations with a range of data partners for use in science and conservation, where the quality grade summarizes the location accuracy, completeness, relevance, and suitability of an iNaturalistMX observation as biodiversity data. Emphasis was given to the information from the state of Quintana Roo.

We also confirmed the taxonomic identity and curatorial data of the specimens with the curator of the corresponding mammal collection. We verified the nomenclature and classification of the specimens according to the current update 2024 (ASM 2024) of the publication of Burgin *et al.* (2018). The geographic position of the records found was illustrated on a map produced with QGIS 3.36.2 software (QGIS 2024).

We found 4 curatorial records of *T. gaumeri* for the Mexican state of Quintana Roo in the Colección Mastozoológica de El Colegio de la Frontera Sur (ECO-SC-M; San Cristóbal de Las Casas, Chiapas; Table 1). According to the geographic position of their collection localities and the contribution of Ek Díaz (2011) on the vegetation of Quintana Roo, specimens ECO-SC-M 5479, 5480, and 5670, were collected in medium sub evergreen forest (selva mediana subperennifolia), while specimen ECO-SC-M 6119 was captured in low thorny sub evergreen forest (selva baja espinosa subperennifolia). Additionally, we found 1 citizen science record (research grade) that indicates the recent presence of *T. gaumeri* in Quintana Roo (Table 1). The vegetation of the site where this specimen was observed corresponds to medium sub evergreen forest.

Table 1. Evidence of the presence of the Yucatán mouse opossum (*Tlacuatzin gaumeri*) in the Mexican state of Quintana Roo in the Mastozoological Collection of El Colegio de la Frontera Sur (ECO-SC-M; San Cristóbal de Las Casas, Chiapas) as well as in the citizen science platform (research grade) iNaturalistMX.

Catalog number	Date of collection	Preservation type	Sex	Locality of collection	Geographic coordinates
ECO-SC-M 5479	13 March 1987	Fluid (skin, skull, and body	Male	Rancho Las Palmas, 30 km S Felipe Carrillo Puerto, Municipio Felipe Carrillo Puerto	19° 15' 36" N, 88° 7' 57" W
ECO-SC-M 5480	17 March 1987	Fluid (skin, skull, and body)	Female	Rancho Las Palmas, 30 km S Felipe Carrillo Puerto, Municipio Felipe Carrillo Puerto	19° 15' 36" N, 88° 7' 57" W
ECO-SC-M 5670	19 November 1995	Only skin	Male	27 km Chumpón-La Glorieta, Municipio Felipe Carrillo Puerto	19° 37' 0" N, 87° 47′ 0″ W
ECO-SC-M 6119	29 June 1998	Fluid (skin, skull, and body)	Female	Santuario del manatí, Rancho Monte Calvario, 8 km N Raudales, Municipio Othón P. Blanco	18° 46' 26" N, 87° 54′ 57″ W
iNaturalistMX observation 141657844	10 November 2022	Image	Undetermined	Municipio Felipe Carrillo Puerto	19° 53′ 7.2″ N, 87° 50′ 43.9″ W

Of the 5 records, 4 correspond to the east and southeast of the Municipality of Felipe Carrillo Puerto and only 1 to the northeast of the Municipality of Othón P. Blanco in the vicinity of Belize (Figure 1); only 1 record falls within a protected natural area (4; Figure 1) and 2 closer to the boundaries with the same (2-3, 5; Figure 1). The evidence found includes specimens in different preservation types and representing both sexes (Table 1).

The type locality of *T. gaumeri* is Yaxcabá, in the state of Yucatán (Zarza *et al.* 2003) and its holotype specimen (catalog number: Field Museum of Natural History_19995) consists of the skin and skull of a subadult (or young adult) of undetermined sex published in 1913 (Voss 2022). Of the new records reported here, the closest to that locality is: 27 km Chumpón - La Glorieta, and is at a distance of 126.5 km to the southeast (5; Figure 1).

For many years *T. gaumeri* was considered, first, a subspecies of *Marmosa canescens* and, later, a subspecies of *Tlacuatzin canescens*. Currently, few formal publications recognize the proper nomenclature and classification of *T. gaumeri* (Arcangeli *et al.* 2018; Burgin *et al.* 2018). Undoubtedly, this taxonomic situation contributed to generating little interest in the taxonomic and geographic study of this little-known Mexican mammal.

In fact, until before this study, *T. gaumeri* was known only from the states of Campeche and Yucatán. Now, the results of our research reveal the presence of this small marsupial also in the state of Quintana Roo, confirming its endemicity to Yucatán Península, México. The records together extend, on average, 139 km eastward from the Yucatán Península the geographic distribution of *T. gaumeri*. This is one of several examples that illustrate the importance of having curatorial information available from scientific collections. This allows us to verify the presence of a species without duplicating fieldwork. It should be noted that citizen science observations, on the other hand, complemented the results of our research. However, because of the difficulty involved in field recording of this species, the limited biological knowledge of the species and the non-academic taxonomic determination of the general public, citizen science observations should be taken with caution.

According to scientific collection records, one of the collection sites of *T. gaumeri* (4; Figure 1) is located within a protected natural area, the Sian Ka'an Biosphere Reserve. This data is relevant because it implies that part of the habitat of this Mexican mammal is in a protected natural area that can contribute to its conservation.

A complete field exploration of the Yucatán Península is still pending to define the presence-absence of *T. gaumeri*, to detail its association with specific vegetation types, and to estimate the conservation status of its populations. Especially because although the citizen science field observation is recent (2022; Table 1), the last record of scientific collection of this tlacuachín is, on average, 30 years ago (Table 1). Therefore, as with other poorly known species, it is necessary to determine whether the species is in any risk category (García-Aguilar *et al.* 2017) and identify factors that may be threatening its survival.

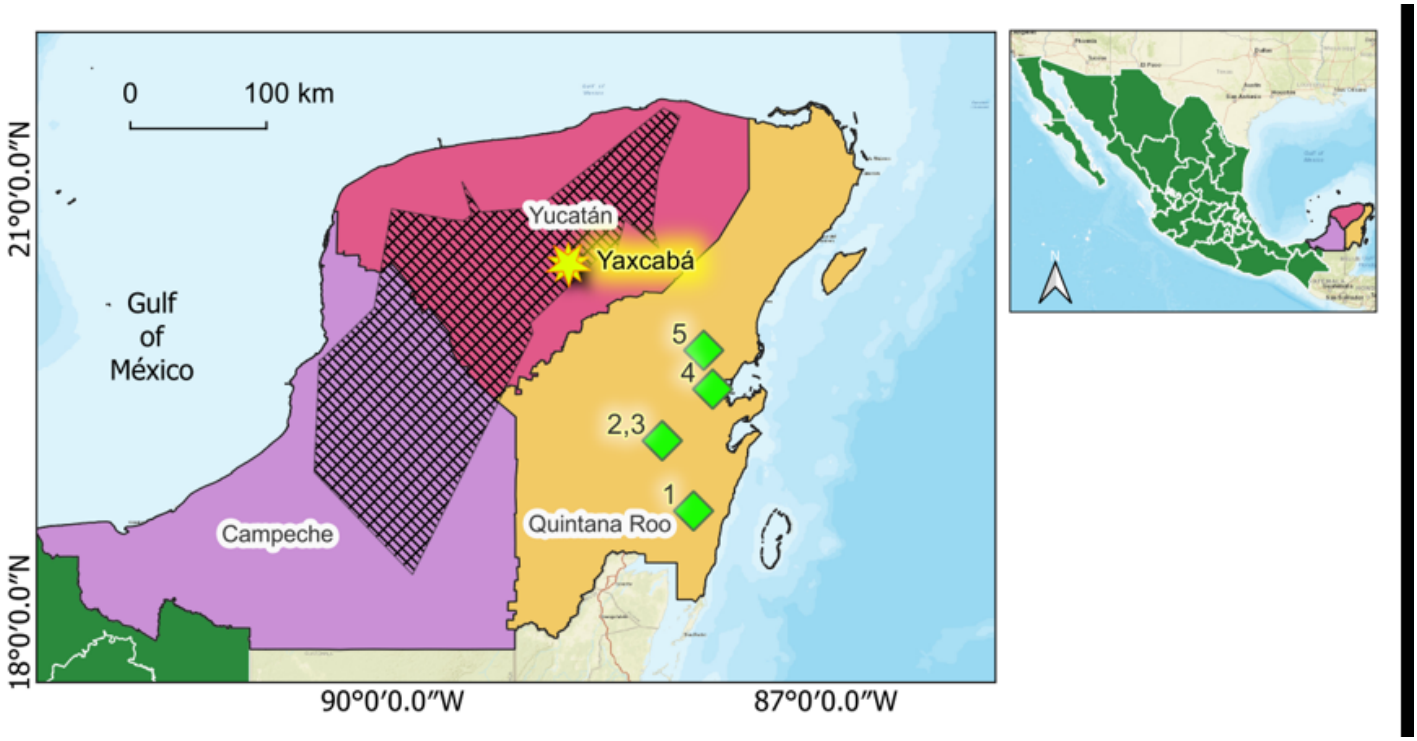

Figure 1. New records (green rhombi) of the presence of the Yucatán mouse opossum (*Tlacuatzin gaumeri*) in Quintana Roo, México. Rhombi 1 - 4 correspond to records kept in the Mammal Collection of El Colegio de la Frontera Sur (ECO-SC-M; San Cristóbal de Las Casas, Chiapas). Records 2 and 3 were collected at the same locality. Rhombus 5 is an observation (research grade) reported in iNaturalistMX. Yaxcabá (star) is the type locality of *T. gaumeri* (Zarza *et al.* 2003). The black shading indicates the known geographic distribution before the present study reported by González Christen and Rodríguez Santiago (2014) and by observations (research grade) from iNaturalistMX.

It is our wish then that, by having corroborated our expectations, this report will promote the recognition of *T. gaumeri* at a specific level and that the new records will help to provide appropriate information for faunal inventories and biodiversity assessments at the municipal and state level in the Yucatán Península.

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First record of a Physalopteridae parasitizing a specimen of *Bassariscus astutus from* Hidalgo, México

Primer registro de un Physalopteridae parasitando a un ejemplar de *Bassariscus astutus* de Hidalgo, México

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The study of helminths in the Procyonidae of México is scarce, with 4 species of acanthocephalans, 8 species of nematodes, and 6 species of flatworms being recorded. For *Bassariscus astutus*, the cestodes *Mesocestoides bassarisci* and *Taenia pencei* are known, as well as unidentified nematode larvae. The objective of this work is to add a new record of a nematode to the helminth fauna that parasitizes *B. astutus*. Four dead *B. astutus* were obtained from 3 locations in the state of Hidalgo. The viscera of the hosts were examined, and a nematode was found in the stomach of one host. The helminth was fixed and kept in 70 % alcohol for identification. A third-stage larva of the Physalopteridae family was identified by having 2 lateral pseudolabiums in the cephalic region, formed by 3 lips. The middle lip has 4 teeth, 3 internal and 1 external. Each lateral lip has a rough area. Finally, the cephalic region is surrounded by a cuticular fold called a hood. This is the first record of a Physalopteridae parasitizing *B. astutus* in México. The Physalopteridae family includes the genera *Physaloptera* and *Turgida*, both of which have 4 teeth on the middle lip. Our specimen, as it exhibits the above features in addition to the presence of a hood, could be considered a member of the genus *Turgida*. However, due to the absence of the number of uterine branches that differentiate adults of both genera, we cannot confirm that it is a *Turgida*.

Key words: Helminths; larvae; nematode; ringtail.

El estudio de helmintos en los Procyonidae de México es escaso, registrándose 4 especies de acantocéfalos, 8 especies de nematodos y 6 especies de platelmintos. Para *Bassariscus astutus* se conocen los céstodos *Mesocestoides bassarisci* y *Taenia pencei*, así como larvas de nematodos sin identificar. El objetivo del presente trabajo es agregar un nuevo registro de un nematodo a la helmintofauna que parasita *B. astutus*. Se obtuvieron 4 *B. astutus* muertos en 3 localidades del estado de Hidalgo. Las vísceras de los hospederos fueron revisadas, encontrándose un nematodo en el estómago de un hospedero. El helminto fue fijado y mantenido en alcohol al 70 % para su identificación. Una larva, en tercer estadio de desarrollo, de la familia Physalopteridae fue identificada por contar con 2 pseudolabios laterales en la región cefálica, formados por 3 labios. El labio medio tiene 4 dientes, 3 internolabiales y 1 externolabial. Cada labio lateral presenta un área rugosa. Por último, la región cefálica se encuentra rodeada por un pliegue cuticular llamado capuchón. Este es el primer registro de un Physalopteridae parasitando *B. astutus* en México. En la familia Physalopteridae se encuentran los géneros *Physaloptera* y *Turgida*, ambos exhiben 4 dientes en el labio medio, nuestro ejemplar al exhibir los rasgos anteriores además de la presencia de un capuchón, se podría considerar miembro del género *Turgida*. Sin embargo, debido a la ausencia del número de ramas uterinas que diferencian a los adultos de ambos géneros, no podemos confirmar que se trate de *Turgida*.

Palabras clave: Cacomixtle; helmintos; larva; nematodo.

Bassariscus astutus (Lichtenstein, 1830) is a species of procyonid widely distributed in the United States of America and México, ranging from southern Oregon and California to the state of Texas, crossing the southwestern states (Ceballos and Nava 2014). In México, its range covers all the northern and central states of the Mexican Republic up to Oaxaca. Three islands in the Gulf of California are included in its distribution: Tiburón, Espíritu Santo, and San José. In México it has been registered in several states: Baja California, Baja California Sur, Chiapas, México City, Colima, Durango, Guerrero, Hidalgo, Jalisco, Michoacán, Morelos, Nuevo León, Oaxaca, Puebla, Querétaro, San Luis Potosí, Sinaloa, Tamaulipas and Veracruz (Ceballos and Nava 2014; León-Paniagua *et al.* 1990). The species has been found at elevations up to 2,900 m (Reid *et al.* 2016) and inhabits mountainous areas and rugged slopes (Ceballos and Nava 2014).

The study of helminths that parasitize *B. astutus* is scarce; in a period of 76 years only 7 studies have been conducted (Table 1) within 24 articles focused on parasites, with ectoparasites standing out (Duran-Irigoyen and

Martínez-Calderas 2023). Regarding endoparasites only 7 species of helminths have been found: 1 acanthocephalan, 3 cestodes and 3 nematodes, along with some unidentified larvae (García-Prieto *et al.* 2012; Duran-Irigoyen and Martínez-Calderas 2023; González-Roa *et al.* 2023; Table 1); therefore, a greater effort is necessary to know the helminths harbored by these mammals. The presence of helminths in a host allows us to understand the biology of the host through the life cycle of the parasite, for example, the Physalopteridae family has a complex life cycle (parasite uses 2 or more hosts in life cycle) that involves intermediate host such as beetles, cockroaches, crickets or grasshoppers; the existence of this family of nematodes indicates the type of food ingested by the host. Nematodes with a simple life cycle (parasite only infects a single host in its life cycle) can be transmitted due to caecotrophy (also known as cecotrophy), a behavior of animals that eat fecal material for nutritional value. This behavior has been observed in rodents from several families: Aplodontidae, Arvicolidae, Bathyergidae, Castoridae, Caviidae, Cricetidae, Geomyidae and Heteromyidae (Kenagy and Hoyt 1980; Anderson 2000; Iturbe-Morgado *et al.* 2017; Bolek *et al.* 2024).

For the reasons mentioned above, the study of helminths in the wild is important because they represent an important component of biological diversity, in addition to helping to understand the history of parasite-host associations, as a means of providing information about the hosts they parasitize and the regions where they live, which can be used in conservation initiatives (Pérez-Ponce de León and García-Prieto 2001a, b). Finally, the objective of the present work is to add a new record of a nematode to the helminth fauna already known as *B. astutus* parasites.

Four specimens of *B. astutus* were found dead, 2 in Cerro de la Rufina, municipality of Mineral del Monte (20º 7′ 50.29″ N, 98º 40′ 8.21″ W; 1 on May, 1 on June 2015); 1 more run over in Santa María la Palma, municipality of Alfajayucan (20º 22′ 21.11″ N, 99º 23′ 4.43″ W; April 2023) and the last one drowned in a cistern in San Antonio Oxtoyucan, municipality of Zempoala (19º 55′ 46.14″ N, 98º 40′ 5.69″ W; January 2023; Figure 1), all in the Mexican state of Hidalgo. The skins and skulls of the specimens collected in Mineral del Monte and Zempoala were deposited in the Museo de Mamíferos del Centro de Investigaciones Biológicas of the Universidad Autónoma del Estado de Hidalgo (UAEH), with the numbers UAEH-CIB-M 2055, 2152 and 2384. The Alfajayucan specimen was dissected at the collection site, obtaining the viscera that were placed in 70 % alcohol to transport them to the laboratory, the ringtail was buried in the collection area due to its advanced state of putrefaction without assigning it a collection number. The digestive tract of the specimens from the other 2 localities was removed and examined in the year of collection. A dead nematode was recovered from the stomach of 1 of the ringtails from the locality of Mineral del Monte, the nematode was fixed in glacial acetic acid and stored in a vial with 70 % alcohol. For identification in 2024, the material was mounted in semi-permanent preparations with lactophenol to clarify and observe important morphological characters. Taxonomic identification was corroborated by comparing the traits with specialized literature, *e.g.*, Anderson (2000) and Chabaud (1975). The measurements are given in millimeters (mm) and micrometers (µm), and the specimen was deposited in the Colección Nacional de Helmintos (CNHE 8485) of the Universidad Nacional Autónoma de México.

The nematode was identified as a third-stage female larva belonging to the Physalopteridae family (prevalence of 25 %). The measurements were: 26.8 mm in length, 680 µm wide at mid-body, esophagus 5.24 mm in length, and anus located 450 µm from the posterior end of the body. The organism is characterized by the presence of 2 lateral pseudolabia in the cephalic region, each formed by 3 lips fused. On the middle lip, 4 teeth can be seen, 3 on the edge of each lip (interlabial teeth [il]) and one behind them (external labial tooth [el]). The single el is large and

Table 1. Records of parasitic helminths of *Bassariscus astutus* and its geographical location. The classification used is the one proposed by Brusca *et al.* 2023.

Phylum	Family	Genus and species	Locality	Reference
Rotifera	Oligacanthorhynchidae	*Macracanthorhynchus ingens*	West Texas	Pence and Willis 1978
Platyhelminthes	Mesocestoididae	*Mesocestoides* sp.	West Texas	Pence and Willis 1978
		M. bassarici	Zoo, México	MacCallum 1921
	Taeniidae	*Taenia pencei*	México City	García-Prieto *et al*. 2012
			West Texas	Rausch 2003
Nematoda	Ancylostomatidae	*Placoconus lotoris*	West Texas	Price 1928; Pence and Willis 1978
	Pneumospiruridae	*Pneumospirura bassarisci*	West Texas	Pence and Stone 1977; Pence and Willis 1978
	Physalopteridae	*Physaloptera* sp.	West Texas	Pence and Willis 1978
		Unknown	Cerro de la Rufina, Hidalgo	This work
	Unknown	Unknown larvae	Puebla, México	González-Roa *et al*. 2023

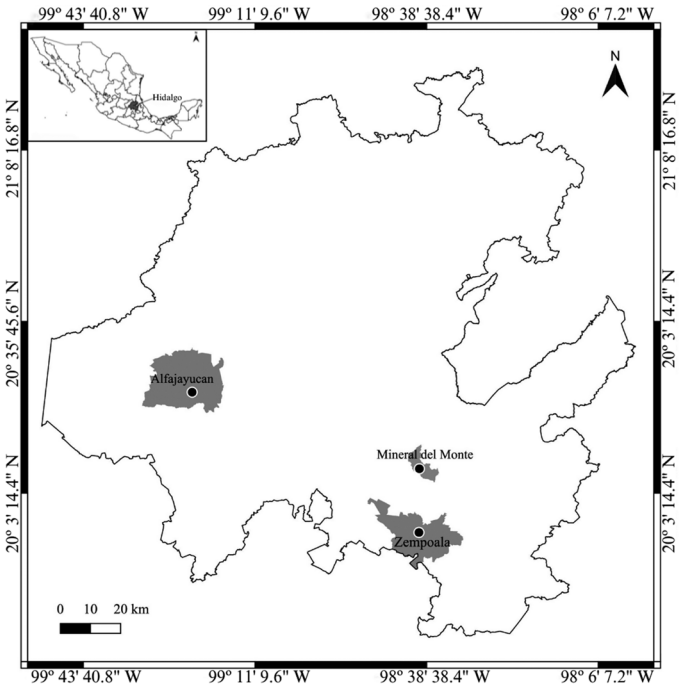

Figure 1. Map of the localities where specimens of *Bassariscus astutus* were found in the state of Hidalgo, México.

pyramid-shaped, and the il are unequal in size (Figure 2a). On the lateral lips, there are areas identified as rugose areas (ra), in an external circle 4 prominent papillae are observed, and at the base of the middle lips are the amphids; finally, the cephalic region is surrounded by a striated cuticular fold that resembles a hood [h] (Figure 2a and 2b). Based on the characteristics described for the organism, we consider that this larva belongs to the genus *Turgida*; however, we cannot confirm this because, in the larval stage in which the nematode is found, the uterine branches have not developed, a feature that differentiates the adults of this genus from those of *Physaloptera* (Anderson 2000).

Additionally, we found in the intestine of the host, pirul (*Schinus molle*) seeds, traces of spiders, caterpillars, insect wings, grasshoppers of the Acrididae family, and flowers. Some of the insects mentioned can serve as intermediate or paratenic hosts for the nematode found. The stomach content found in the *B. astutus* reviewed had already been previously recorded in forest areas and semiarid regions (Nava *et al.* 1999; Castillo-Picazo and García-Collazo 2019), environments where the hosts' bodies were recovered.

In the present work, a larva from the Physalopteridae family was identified in a specimen of *B. astutus* from Cerro de la Rufina, municipality of Mineral del Monte in Hidalgo. The family Physalopteridae includes the genera *Physaloptera* and *Turgida*, both are characterized by having 4 teeth, 3 at the edge of each pseudolip and 1 behind them. The difference between the genera is a cuticular thickening (hood) present in *Turgida* (Chabaud 1975).

The *Physaloptera* genus comprises a total of 144 species that are found parasitizing amphibians, birds, reptiles, and mammals that include in their diet some insects that can be used by the nematode as intermediate hosts (Anderson 2000; Kalyanasundaram *et al.* 2018) since some mammals that are not definitive hosts become occasionally infected by consuming infected insects. On the other hand, in the genus *Turgida*, 2 species have been recorded: *T. turgida*

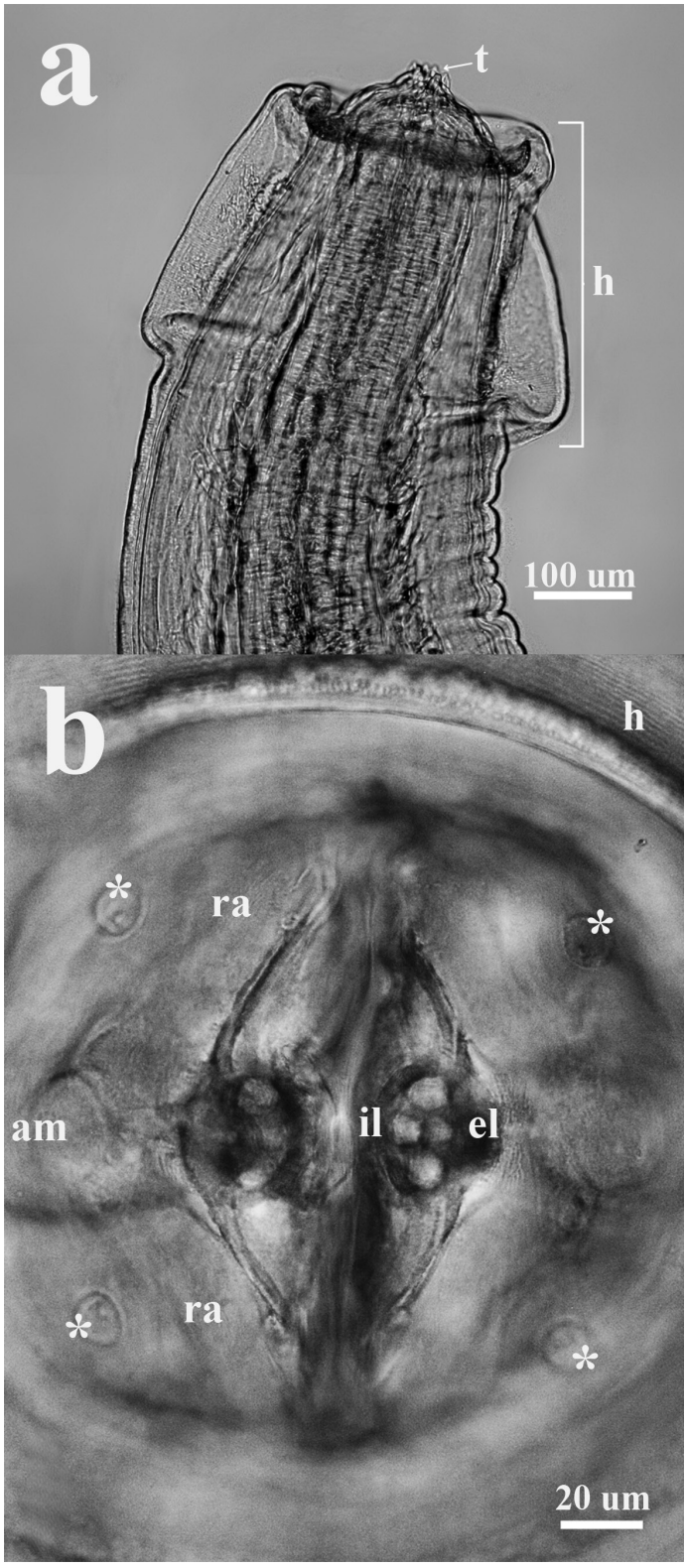

Figure 2. a) Head region of a third instar larva of the Physalopteridae family showing the striated cuticular thickening (h) and the four teeth of the middle pseudolip (t). b) Frontal view of the cephalic region showing the arrangement of the internal labial teeth (il), the external labial tooth (el), rugose area (ra), amphids (am), and papillae (*).

mainly parasitizes representatives of the genus *Didelphis* and *T. torresi* which parasitizes *Cuniculus paca* in neotropical areas (Chabaud 1975; Anderson 2000; Goncalves *et al.* 2006; García-Prieto *et al.* 2012; Hodda 2022).

The larva found has the cephalic characteristics of an adult that allows us to recognize it as Physalopteridae (Anderson 2000), and due to the presence of a hood, we would consider it a larva of the genera *Turgida*, which we cannot confirm because the uterine branches are not developed. In the adult state, the genera can be differentiated by the number of uterine branches present in females, which is 2 to 4 in *Physaloptera* and more than 4 in *Turgida*, (Chabaud 1975), a feature that we could not observe in the organism. This would be the second time that a larva of the Physalopteridae family has been recorded in a specimen of *B. astutus*, the first one was in West Texas as *Physaloptera* sp. (Pence and Willis 1978) where the record was the sole mention of its presence without morphological description, as in the present study.

We consider that the presence of the larva in *B. astutus* is an accidental infection, based on the work of Gray and Gray and Anderson (1982), who obtained adults of *T. turgida* from opossums, and from the collected nematodes they obtained eggs with which they infected previously cultured crickets and fed these insects to different types of hosts such as mammals (*Cavia porcellus*, *Felis catus*, *Marmota monax*, *Procyon lotor*, among others), amphibians (*Rana pipiens*) and reptiles (*Thamnophis sirtalis*), finding numerous undeveloped third-stages larvae in the stomach of all these host. Some of these animals could serve as a host where the development of the nematode does not occur (*i.e.*, it could be a paratenic host), and their role in the transmission of the parasite is unknown (Gray and Anderson 1982; Anderson 2000). *Bassariscus astututs* are likely serving as paratenic hosts, just like the animals mentioned above.

Finally, the study of nematodes that parasitize *B. astutus* is scarce, only larvae of the Physalopteridae family have been recorded in Texas (Pence and Willis 1978), and unidentified larvae from a copro parasitological study in *B. astutus* from Puebla (González-Roa *et al.* 2023). With copro parasitological analysis, the parasites of different hosts can be known; however, it is difficult to characterize helminths morphologically if they are obtained in this way, as happens in the work of González-Roa *et al.* (2023) where they mention them as larvae, while we are reaching a taxonomic level in the organisms obtained. Studies such as the one presented here allow us to learn about the nematofauna of wildlife.

Acknowledgements

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New field records document the survival of the Altamira jackrabbit (*Lepus altamirae*)

Nuevos registros de campo documentan la sobrevivencia de la liebre de Altamira (*Lepus altamirae*)

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Lepus altamirae is a little-known jackrabbit from northeastern México. Its taxonomic validity was recently reestablished and the absence of its field records was noted. It was recently rediscovered, but its geographic distribution is unknown, and it is uncertain whether it survives in its type locality. This study aims to confirm its presence in its type locality and encourage their study. We searched for jackrabbits on roads and trails using a car and by walking in natural and disturbed areas in and around Altamira (June - August 2020). We noted visual records of jackrabbits encountered and sought permission from falconers who encountered incidentally to use their capture data according to recommendations for using wild mammals in research. We confirmed identification with specialized references. We did not find jackrabbits at the type locality, whose habitat is already degraded, but we visually recorded specimens near Altamira. We also found additional records of *L. altamirae* in the scientific literature and in a citizen science portal that show previously unknown occurrence localities in different geographic directions from the type locality, including the state of Veracruz. *Lepus altamirae* no longer exists in its type locality, where the level of urbanization has increased. However, it is known to occur in areas that increase its previously known geographic distribution. It is necessary to encourage their study to propose appropriate measures for its conservation, as well as to promote the inclusion of its name in the lists of Mexican mammals.

Key words: Conservation; endemic; Lagomorpha; Leporidae, México; Tamaulipas; threatened; type locality.

Lepus altamirae es una liebre poco conocida del noreste de México. Recientemente se restableció su validez taxonómica y se alertó sobre la ausencia de sus registros de campo. Se redescubrió recientemente, pero desconocemos su distribución geográfica completa y si sobrevive en su localidad tipo. Este estudio pretende confirmar su presencia en su localidad tipo y contribuir con recomendaciones para su supervivencia. Buscamos liebres en caminos y brechas utilizando un carro y caminando en áreas naturales y perturbadas en Altamira y sus alrededores de junio a agosto de 2020. Anotamos los registros visuales de las liebres encontradas y pedimos permiso a cetreros encontrados casualmente para usar sus datos de captura de liebres. Confirmamos la identificación taxonómica de las liebres con referencias especializadas. No encontramos liebres en la localidad tipo, cuyo habitat ya se encuentra degradado, pero registramos visualmente ejemplares en las inmediaciones de Altamira. Asimismo, encontramos registros adicionales de *L. altamirae* en la literatura científica y en un portal de ciencia ciudadana que muestran localidades donde previamente se desconocía su presencia en distintas direcciones geográficas de la localidad tipo, incluyendo el estado de Veracruz. *Lepus altamirae* ya no existe en su localidad tipo, en donde se ha incrementado su nivel de urbanización. Sin embargo, se sabe de su presencia en áreas que incrementan su distribución geográfica previamente conocida. Se requiere continuar explorando su distribución potencial para proponer medidas apropiadas para su conservación, además de promover la inclusión de su nombre en las listas de mamíferos mexicanos.

Palabras clave: Amenazada; conservación; endémica; Lagomorpha; Leporidae; localidad tipo; México; Tamaulipas.

The jackrabbit *Lepus altamirae* Nelson, 1904 is a mammal (Leporidae, Lagomorpha) originally described as the subspecies *L. merriami altamirae*; its common name, "Alta Mira Jack Rabbit", refers to its type locality: "Altamira, Tamaulipas, Mexico" (Nelson 1904). In 1898 Altamira was a small town near sea level on the shore of extensive fresh-water lagoons connected with the Río Tamesí in extreme southern Tamaulipas, where immediately about the town and stretching away for many miles to the north is a gently rolling, rather sandy plain (Goldman 1951). A low, thin growth of scrubland peculiar to a dry climate covers the greater part of the plain near Altamira. The distribution of this jackrabbit reported then (Nelson 1904) was a small region of the arid tropical zone of extreme northern Veracruz, eastern San Luis Potosí, and coastal plains in the southern part of Tamaulipas, probably not as far north as Victoria town (*ca*. 190 km NW Altamira).

Shortly after, Nelson (1909) raised its status to a specific level as *L. altamirae*. In contrast, Hall (1951) later concluded that it should stay at a subspecific level but as *L. californicus altamirae*, a result supported a few years later by Álvarez (1963). The latter also reported 2 specimens from near Soto la Marina, Tamaulipas (1-2; Figure 1; *ca*.153 km N Altamira) and emphasized that until then *L. c. altamirae* had been known previously only from Altamira. Afterward, this jackrabbit remained virtually unknown and without an appearance in the scientific literature.

It took 56 years until Vargas *et al.* (2019) proposed the reinstatement of *L. altamirae* as they concluded that this mammal could not be a subspecies of the black-tailed jackrabbit because it is more related to the group of white-sided jackrabbits. Therefore, it was confirmed that *L. altamirae* is a valid taxonomic entity that stands for a species of jackrabbit, endemic to a small region of northeastern México. However, they also expressed concern about whether this jackrabbit still existed in its natural habitat, given that no evidence of field records in more than 100 years in or near its type locality. Fortunately, Silva-Caballero and Rosas-Rosas (2022) recently reported the presence of *L. altamirae* from ca. 100 km WSW Altamira, in northeastern San Luis Potosí.

In parallel, several records have been uploaded to the iNaturalist México platform in the last few years of the occurrence of *L. altamirae* in localities where its presence was unknown (Figure 1; iNaturalistMX 2022). Some records (3-6; Figure 1) stand out as extending the known geographic area of *L. altamirae* to *ca*. 100 km W of the town of Altamira. By the way, 3 research grade records (8-10; Figure 1; https://www.inaturalist.org/observations/105780393, 21 June 2021; 105780171, 30 June 2021, and 182281485, 24 August 2023) from this iNaturalist México contribution documented the presence of *L. altamirae* in the state of Veracruz for the first time.

The fact of having considered this mammal as a subspecies and not a species for so many years may have caused a lack of interest and attention on the subject; *e.g.*, the

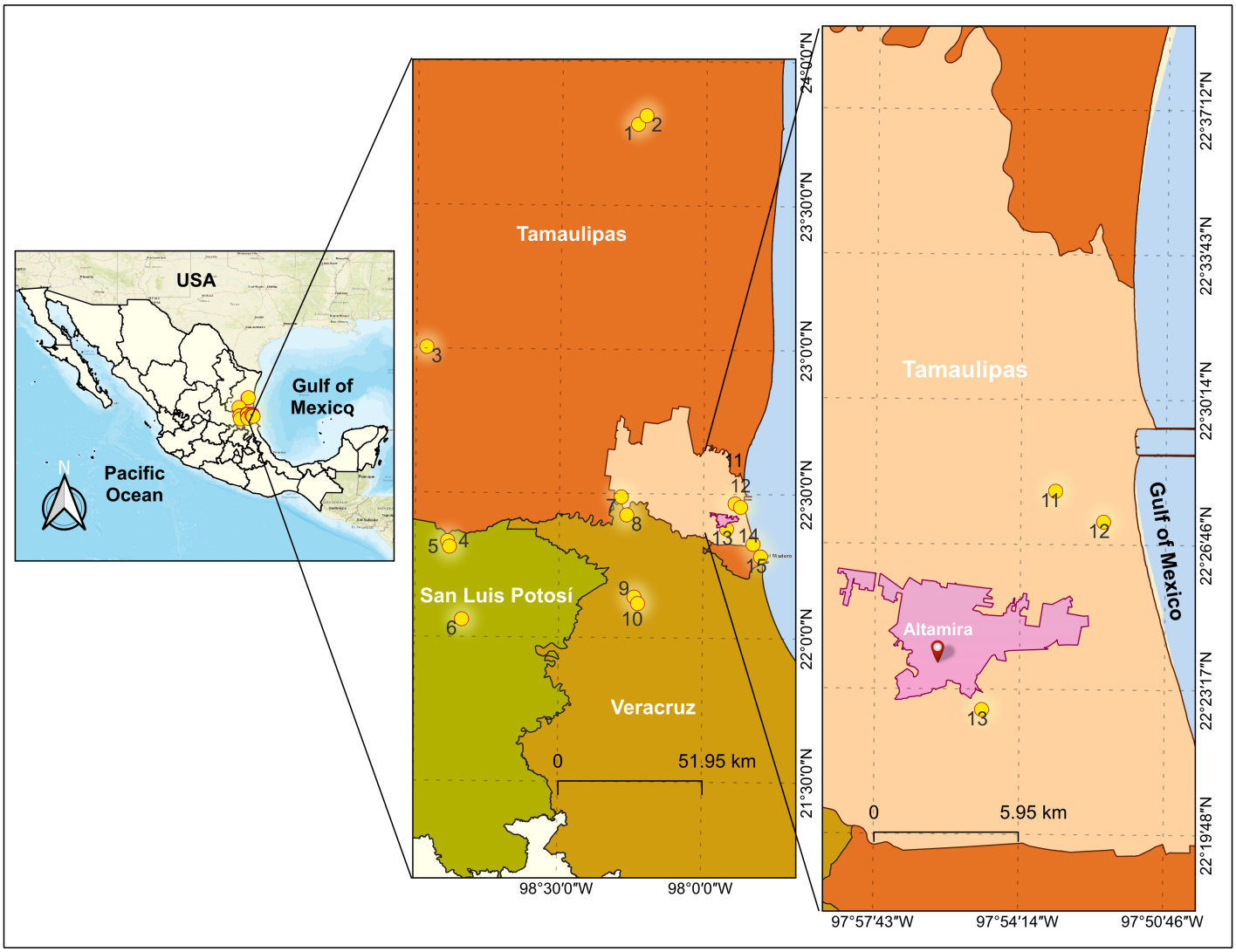

Figure 1. Field records (yellow circles) of the Altamira jackrabbit (*Lepus altamirae*) in the Mexican states of Tamaulipas, San Luis Potosí, and Veracruz. From the scientific literature: 1, 2 (Álvarez 1963) 4, and 6 (Silva-Caballero and Rosas-Rosas 2022). From iNaturalist México (research grade): 3, 5, 7, 8, 9, 10, 12, 15 (see text for references). From the authors' fieldwork: 11, 13, 14. Type locality: Altamira (red pin; Hall 1951). Light pink: Municipality of Altamira, Tamaulipas.

absence of specimens in scientific collections is remarkable. Unfortunately, this lack of records of occurrence may have also been due to the loss of its populations, which would be a conservation concern. Therefore, it is necessary to document the existence of *L. altamirae* throughout its originally reported range. Without this information, it will be difficult to recognize this species as part of the endemic fauna of the state of Tamaulipas and plan research actions to know its conservation status. Thus, our research aimed to explore the type locality and surroundings of *L. altamirae* to corroborate or refute the presence of the jackrabbit in that region.

The study area was Altamira City and its surroundings, which is currently a small city (22° 24′ 27.89″ N, 97° 55′ 16.17″ W) of 1,667 km^2 at 26 m above sea level, on the Tamaulipan coast of the Gulf of México. We scouted this area for a total of 3 weeks from June to August 2020 in a southeast-northwest direction along the main Altamira - Mante road and back. We also explored in a southwest-northeast direction along the road to the Altamira Industrial Port, as well as suburban and wilderness sites on the city limits and periphery of the city; in some cases extending to the border with the municipalities of Tampico and Ciudad Madero, where the habitat conditions resembled those in previous reports (Nelson 1909). We drove a motor vehicle for approximately 90 min after sunrise and before dusk and did cross-country walking tours on the same schedule. In addition, we ran into falconers in areas with difficult access in the field and to whom we requested permission to witness catches of their Harris's hawks (*Parabuteo unicinctus*) and use their data. If a jackrabbit was sighted or captured, we took photographs and recorded the locality, and geographical coordinates. To confirm the taxonomic identity of the jackrabbit and compare its occurrence records, we consulted Brown *et al.* (2018) and the previous references cited. This study followed the recommendations of Sikes *et al.* (2016) for the use of wild mammals in research.

Our searches with the motorized vehicle on roads did not record *L. altamirae*, nor live specimens crossing the road or running over on the road; no jackrabbits were observed within the city limits. However, we were able to find jackrabbits during our walks in the countryside and when we ran into falconers. In cases where information was collected from specimens killed by falconer hunting, it took place so that no additional mortality occurred as a result of our research, either directly or indirectly, this included our searches with the motorized vehicle on roads and our walks.

On July 22, 2020 at 6:40 hr, walking through a thorn scrub site we spotted an adult jackrabbit (22° 28′ 2.615″ N, 97° 53′ 24.648″ W; field record 11 in Figure 1; Figure 2a) inside the grounds of the industrial port of Altamira (7.4 km N Altamira, Municipality Altamira). Although this area lies near the border of the urban areas of Altamira and it has not been developed yet, it is well-preserved and there is a small patch of scrubland. However, anyone can enter this site, but activities that disturb the environment are not allowed. A few meters away, in the construction yards where the Industrial Port platforms are made, we observed jackrabbits on several days both at dawn (between 6:13 hr and 8:01 hr) and at dusk (between 5:05 hr and 18:17 hr). These observations are very close to the site reported by iNaturalist México on June 23, 2022 (field record 12 in Figure 1; https://www.inaturalist.org/observations/124415922) for the presence of *L. altamirae*.

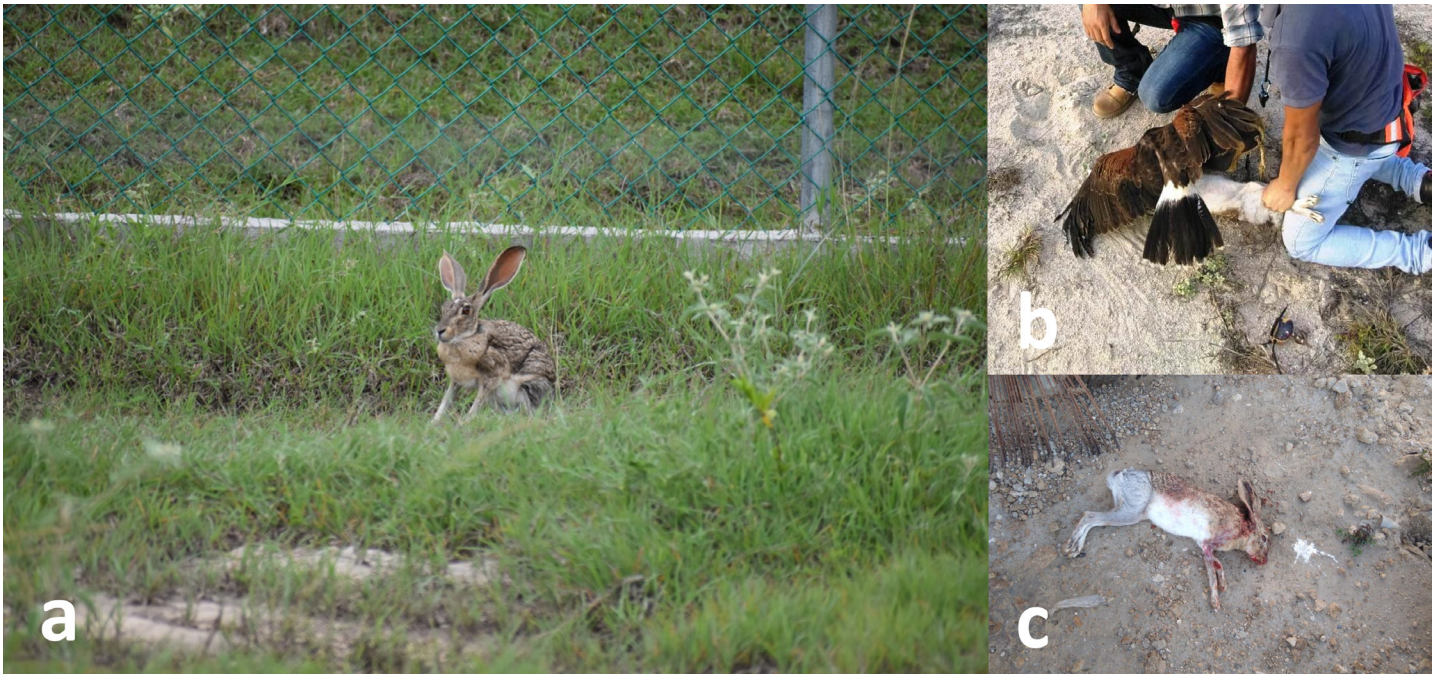

Figure 2. Altamira jackrabbit (*Lepus altamirae*). a) specimen in its natural habitat on August 21, 2020 (photo by G. Cruz-Reséndiz); b) Harris's hawk (*Parabuteo unicinctus*) holding a freshly captured specimen on March 2, 2020 (photo by M. Hernández); c) specimen recovered from the Harris's hawk capture on April 7, 2020 (photo by M. Hernández). Images available at fac@ib.unam.mx.

The result of the falconers' activities produced the capture by Harris's hawk of 3 adult jackrabbit specimens. Two of these were captured on April 7 and 8, 2020 (respectively) at 1 km NNE Fraccionamiento 17 de enero, municipality Ciudad Madero, Tamaulipas (22° 19′ 37.650″ N, 97° 49' 35.300″W; field record 15 in Figure 1), at 13 km SE Altamira. These specimens were captured by Harris's hawk at 8:11 hr and 6:58 hr, respectively in a place with grassland and halophilic vegetation. Similarly, at a nearby site in the same municipality (field record 15 in Figure 1) again a contribution in iNaturalist reported the presence of a specimen of *L. altamirae* in the area known as Playa Miramar (22º 17′ 2.350″ N, 97º 48′ 1.010″ W). Even though this record has research grade status, it should be taken with caution as the quality of the image is not good.

The third individual (Figure 2b) was caught at 7:14 hr on March 2, 2020, in the Altamira industrial corridor, 3.1 km S Altamira (22° 22′ 47.420″ N, 97° 55′ 8.680″ W; field record 13 in Figure 1) where we were able to observe between 3 and 4 jackrabbits more. The vegetation on the site was mesquital with patches of grassland.

All jackrabbit specimens observed during our fieldwork were positively identified as adult individuals of *L. altamirae* according to pelage characteristics summarized by Vargas *et al.* (2019). In short, the white coloration of the flanks of the body from the chest to the belly, the light gray coloration of the thighs, the dark to light buff color of the back of the body, the light buff coloration of the throat, the absence of the large black spot both on the tips of the ears and on the tail and lower part of the hip; likewise, the nape with two lateral black bands extending back from the base of ears and separated by a median band of buffy (Figure 3a, 3b) that characterizes *L. altamirae*, a condition confirmed by Silva-Caballero and Rosas-Rosas (2022). This character also supports the genetic analyses by Vargas *et al.* (2019) who showed that *L. altamirae* is phylogenetically closer to *L. flavigularis* than to any other *Lepus* species.

As expected, *L. altamirae* does not occur in the City of Altamira, its type locality. However, we did confirm its presence in the surrounding area, being the closest record to the city in the Altamira industrial corridor, Municipality Altamira (field record 13 in Figure 1). In agreement, the scientific literature shows no record of another jackrabbit species in the southeastern region of Tamaulipas, and we did not observe any jackrabbit specimen that could be different from *L. altamirae*. Therefore, our data support that *L. altamirae* is a representative of the group of "white side" species in the tropical-subtropical zone of the southeastern coastal plain of Tamaulipas and northeastern San Luis Potosí (Vargas *et al.* 2019; Silva-Caballero and Rosas-Rosas 2022). As Brown *et al.* (2018) stated, this information is relevant for the taxonomic, evolutionary, and biogeographic assessment of the genus *Lepus* in North America and the knowledge and conservation of jackrabbit species of restricted distribution.

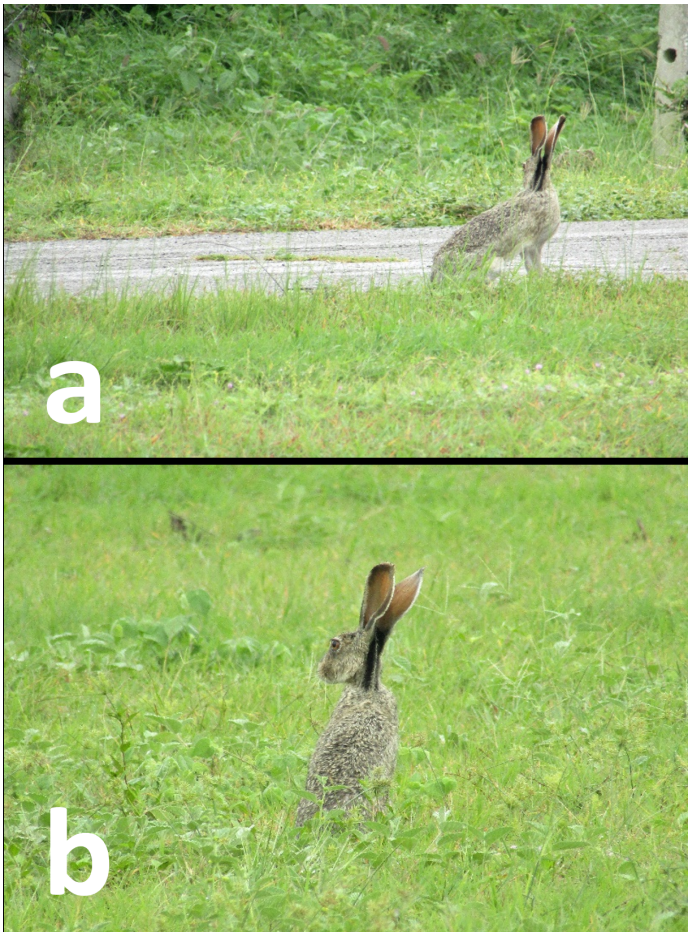

Figure 3. a) and b) Specimens of the Altamira jackrabbit (*Lepus altamirae*) from near the Altamira Industrial Port (7.4 km N Altamira) shows the typical black stripes behind the ears. Photos by G. A. Cruz-Reséndiz. Images available at fac@ib.unam.mx.

Unfortunately, so far the name *L. altamirae* has not appeared yet in any updated list of Mexican mammals other than a brief mention in a recent report on the rabbit hemorrhagic disease in Mexican leporids (Lorenzo *et al.* 2024); nor has its conservation status been assessed by the IUCN or by the Mexican government (García-Aguilar *et al.* 2017). However, it is recognized in The Mammal Diversity Database of the American Society of Mammalogists (ASM; Burgin *et al.* 2018).

Its originally reported range (Nelson 1909) is a small region that is currently being modified by anthropogenic factors that may be reducing its population (Gobierno del Estado de Tamaulipas 2009). The establishment of international companies in the region led to urban development and changes in land use, mainly in the municipality of Altamira. The presence of *L. altamirae* on the grounds of the Industrial Port of Altamira suggests that this leporid is resistant to some environmental changes in its original habitat. Still, it will not be for long as the urbanization of the area continues proliferating. Other agents of ecological deterioration that can be easily noticed in the surroundings of Altamira are cattle ranching, expansion of the agricultural frontier, and deforestation. In addition, this jackrabbit has recently been identified as a potential victim of rabbit viral

hemorrhagic disease that threatens the survival of lagomorph populations in northern México (Lorenzo *et al.* 2024).

Therefore it is important to explore the localities for *L. altamirae* mentioned by Vargas *et al.* (2019) to confirm the presence of the species on those sites, which would considerably increase the known scope of its geographic distribution. Also, it is necessary to evaluate the conservation status of their populations and habitat and the main causes threatening their survival there (Sánchez-Salas *et al.* 2013). Consequently, the local people and government must be made aware of this concern to plan actions and preserve this unique and distinctive mammal. According to our data, today, 120 years after the first scientific evidence of the existence of *L. altamirae*, this mammal no longer exists in its type locality, but survives in the surrounding area of the Altamira municipality. It is confirmed that it is an endemic species of the Tamaulipan mezquital ecosystem from the coastal plain of southern Tamaulipas and west to the eastern border of San Luis Potosí (Silva-Caballero and Rosas-Rosas 2022). It also incorporates the contribution of iNaturalist México records that reveal the presence of *L. altamirae* in the state of Veracruz for the first time. It is therefore another medium-sized mammal that stands out for its endemism and for inhabiting a reduced distribution area. Although the type locality of another mammal has been erased by urban development, its survival deserves attention and consideration for its integral knowledge and conservation since we now know of new localities of its presence.

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Domestic dog (*Canis lupus familiaris*) conflicts with sheep (*Ovis orientalis aries*) production: use of camera traps to inform mitigation actions

Conflictos de perros domésticos (*Canis lupus familiaris*) con la producción ovina (*Ovis orientalis aries*): uso de cámaras trampa para informar acciones de mitigación

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The issue of damage caused by dogs (*Canis lupus familiaris* Linnaeus, 1758) to other animals is becoming increasingly alarming. This study aims to demonstrate the attack by domestic canids on a flock of sheep belonging to a farmer in the north-central region of Argentina, using non-invasive technologies. Two field visits were made, one on October 23, 2023, and another on November 10, 2023, to photograph the damaged sheep. Then, 2 generic trail cameras were installed on the fence posts. The flock of sheep was attacked on November 18, 2023, so we immediately traveled to the ranch and examined footprints and/or signs in the vicinity and inside the sheep pen. After installing the trap cameras, during the early hours of November 29, 2023, a new attack on 2 sheep from the same ranch was recorded. The recorded images confirmed that the attacks were not from native animals but from 2 of the farmer's domestic dogs: a Doberman, assisted by a Border Collie. Initially, the blame for the damage to the flock was attributed to native wildlife, particularly the puma, and a plan for its hunting and death was being set up. This case study reinforces the conclusion that the first fundamental step in mitigating fauna-human conflicts is to listen to those affected and seek solutions together with them that do not involve the use of lethal tools against wild carnivores.

Key words: Attack by dog; camera traps; human-wildlife conflict; sheep production.

El problema del daño causado por perros (*Canis lupus familiaris* Linnaeus, 1758) sobre otros animales es cada vez más alarmante. Este estudio tiene como objetivo demostrar el ataque de cánidos domésticos a un rebaño de ovejas perteneciente a un agricultor en la región centro-norte de Argentina, utilizando tecnologías no invasivas. Se realizaron 2 visitas en el campo, una el 23 de octubre 2023 y otra el 10 de noviembre 2023 para fotografiar las ovejas dañadas. Luego se instalaron 2 cámaras trampa genéricas sobre los postes de los alambrados. El rebaño de ovejas tuvo un ataque el 18 de noviembre de 2023, por lo que viajamos inmediatamente al rancho y se examinaron huellas y/o señales en las cercanías y dentro del corral de las ovejas. Luego de instalar las cámaras trampa, durante la madrugada del 29 de noviembre de 2023, se registró un nuevo ataque a 2 ovejas del mismo rancho. Las imágenes grabadas confirmaron que los ataques no eran de animales nativos sino por 2 de los perros domésticos del agricultor: un Doberman, asistido por un Border Collie. Inicialmente, se atribuyó la culpa del daño al rebaño a la fauna silvestre nativa, particularmente al puma, y se planeó su caza y muerte. Este estudio de caso refuerza la conclusión de que el primer paso fundamental para mitigar los conflictos fauna-humano, es escuchar a los afectados y buscar soluciones junto con ellos que no impliquen el uso de herramientas letales contra los carnívoros silvestres.

Palabras claves: Ataque por perro; cámaras trampa; conflicto humano-fauna silvestre; producción ovina.

The conflicts between humans and carnivores are among the main threats affecting wildlife populations (Quiroga *et al.* 2016; Lucherini *et al.* 2018; Conover and Conover 2022; Davoli *et al.* 2022). Additionally, they have been identified as a problem by livestock producers worldwide, including most of Argentina (De Lucca and Nigro 2013; Doherty *et al.* 2017; Weise *et al.* 2018; Smith *et al.* 2019; Llanos *et al.* 2020). Livestock mortality can become particularly significant in small herds, where a single attack can end the entire animal stock of a property (Wierzbowska *et al.* 2016; Guerisoli *et al.* 2017; Lucherini *et al.* 2018). This phenomenon involves environmental and socio-cultural factors, and resolving it requires reconciling the interests of livestock producers with wildlife conservation (Carter and Linnell 2016; Gordon 2018; Lozano *et al.* 2019; Cravino *et al.* 2024).

The pumas (*Puma concolor*) and foxes (*Lycalopex culpaeus* and *L. gymnocercus*) are the species of wild carnivores considered most harmful to livestock production in Argentina (Travaini *et al.* 2000; Llanos *et al.* 2020; Nanni et al. 2020; Ballejo *et al.* 2022). However, the problem of damage caused by dogs (*Canis lupus familiaris*) is becoming increasingly alarming (Cravino *et al.* 2024), suggesting that the attacks of dogs on wildlife affect many species and all ecoregions in Argentina (Zamora-Nasca *et al.* 2021). Untrained dogs tend to behave instinctively like their ancestor, the wolf (*Canis lupus*). Specifically, domestic dogs have contributed to the extinction of at least 11 vertebrates and are a known risk to 188 threatened species (Doherty *et al.* 2017). Free-ranging dogs mainly attack goats, sheep, and poultry, but in packs, they can kill almost any medium or large-sized mammal (Ritchie *et al.* 2013; Wierzbowska *et al.* 2016). In the Argentine and Chilean Patagonia, free-ranging dog predation causes significant livestock losses (Zanini and Pérez 2005; Plaza *et al.* 2019; Rodriguez *et al.* 2019; Cortés *et al.* 2021; Arona and Schiavini 2023). While sheep killing is common, cases of mutilation and severe trauma leading to bleeding and infectious processes resulting in animal deaths have also been reported (Gáspero *et al.* 2019; Rodríguez *et al.* 2019; Smith *et al.* 2019; Arona and Schiavini 2023; Díaz *et al.* 2023; Gonzaga *et al.* 2024).

Carnivore species have different ways of hunting and consuming their prey. Although some carnivores exhibit high behavioral plasticity, there have repetitive patterns that often allow identification of the predator responsible for an animal's death based on the shape and distribution of wounds, as well as the method of consumption (Arilla *et al.* 2023; Khorozyan and Heurich 2023). However, in some cases, identifying the predator can be ambiguous or lead to disagreements among different stakeholders. In such cases, confirming the perpetrator of the attacks is important to identify the most appropriate measures and ultimately, mitigate conflicts (Treves *et al.* 2016; van Eeden *et al.* 2018; Fletcher and Toncheva 2021; Lambertucci *et al.* 2024).

Recent technological advancements have enabled significant progress in monitoring animal behavior, particularly through the use of camera traps that capture photos and videos (*e.g.*, O'Connell *et al.* 2011; McCallum 2012; Meek *et al.* 2014; Apps and McNutt 2018; Lizcano 2018; Akcali *et al.* 2019). These cameras have proven to be an essential and highly effective non-invasive tool for species identification (Steenweg *et al.* 2017; Sparkes and Fleming 2022; Paton *et al.* 2024).

This study aims to demonstrate the importance of using non-invasive technologies (camera traps) to correctly assess a case of carnivore-livestock conflict, identify the species responsible for an attack on a flock of sheep belonging to a producer in the north-central region of Entre Ríos, Argentina, and how this was instrumental to properly managing the conflict. We also provide new details regarding the behavior of a breed of domestic dogs that can be useful for practitioners involved in the evaluation and mitigation of conflicts concerning livestock production.

The study area corresponds to a fragmented landscape of native forests, typical of the central-northern region of Entre Rios province in Argentina, along with cereal and oilseed crops (such as, soybean, corn, wheat, sorghum, another's), where the main activity is small and medium-scale cattle. A sheep rancher from the Las Garzas city (Entre Ríos province, Argentina; Figure 1) contacted the authors in early October 2023. Field visits were carried out on 2 occasions (October 23, 2023 and November 11, 2023 corresponding to spring season) to photograph the damaged sheep. On this occasion, the authors of this report suggested the immediate installation of trail cameras inside and outside the pen. Since the producer agree to follow this suggestion but mentioned that he did not have the means to do it by himself, on November 25, 2023, we set up 2 camera traps in the enclosure pen following another attack on sheep occurred 2 days earlier. Two trap cameras (Marca Gadnic, Model 4k Lumix) were installed on the fence posts. Both were configured to capture 3 photographs and 20-sec videos when detecting movement. They were equipped with a 32 GB memory card. During the early hours of November 29, 2023, the authors received a report of a new attack on 2 sheep from the same ranch, prompting a new visit to the affected estate to retrieve the memory cards from the camera traps.

A sheep rancher mentioned a conflict with his flock due to the attack of an animal causing severe injuries and even sheep mortality. Initially, based on his perspective and previous experiences, he considered a large animal like a puma responsible for the attacks. Following several phone calls by the producer, personnel from the Natural Protected Area 'La Esmeralda' (NPA La Esmeralda, hereinafter) visited the sheep farm and took note of the farmer's family members accounts regarding the timings and method of attack, as well as the reaction of their domestic dogs during those events. Photographs of the injuries on the animals were also taken (Figure 2).

According to the NPA 'La Esmeralda' staff, most of the wounds did not seem consistent with a puma due to their location on the flanks, sides, ears, and when wounds were on the neck, they did not break it. This seemed an atypical behavior for a puma, and could possibly occur only if the individual had been disturbed before being able to kill its prey, which was not in line with the producer's accounts. Figure 1 details the position of the enclosure pen (where most of the attacks occurred), the owner's house, and the shed. We observed that the distance between the pen and the house (where the farmer kept his dogs at night) is less than 40 m, which made us even more doubtful that the attack had been executed by a puma, and human influence is limited, as would be the case in our study area where relatively abundant populations of axis deer, wild boars, hares, and gray brocket exist. On the other hand, some of the sheep showed only marks from canines on the neck, which could be consistent with the affected producer's hypothesis.

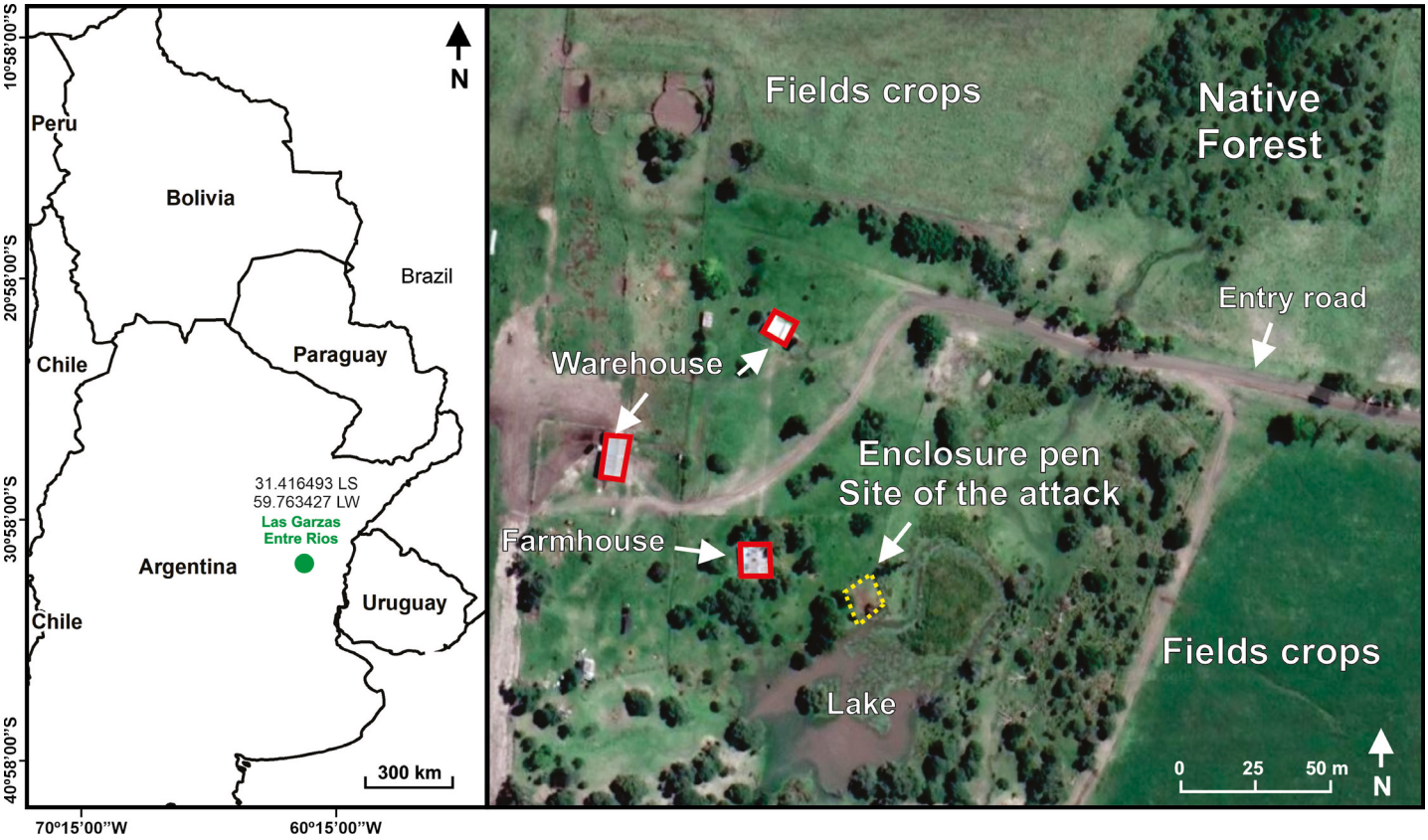

Figure 1. High-resolution satellite image locating key points of the Las Garzas city, Entre Ríos province, Argentina.

As a result of a new attack occurred on November 18, 2023, we promptly traveled to the ranch again and recorded the producer's accounts. Footprints and/or signs were examined in the vicinity and inside the sheep enclosure pen. None of them was attributable to a native feline; they belonged to large canids. Between November 25 and 28, 2023, videos and photographs were obtained depicting the normal movement of the flock inside the pen, displaying typical behaviors for their species. The images recorded by the cameras confirmed that the attacks had occurred around midnight (00:02 hr to 00:36 hr) and had been carried out by 2 of the rancher's domestic dogs: a Doberman, assisted by a Border Collie (Figure 3). The attached videos illustrate the mechanics of the attacks, consistent with the documented wounds from previous visits.

Each predator exhibits different predatory and feeding behaviors, leaving traces and signs that allow its identification, such as footprints, bite and claw mark patterns, as well as their locations on the body, and the condition of the dead prey, among others (Fonseca *et al.* 2015; Cristescu *et al.* 2022). Wild felids tend to avoid preying on livestock if the environment they live in offers abundant wild prey (Thompson *et al.* 2009; Veals Dutt *et al.* 2023). In particular, to identify the predator, bite marks should be examined in terms of their location and the distances between canine punctures (Nallar *et al.* 2008; Toledo González *et al.* 2021).

The bite force is a biomechanical parameter that indicates the amount of force applied during the mastication (Lindner *et al.* 1995; Paschetta and González-José 2013). The Doberman (dolichocephalic) is capable of a bite force of up to 245 - 790 PSI (228 kg; Brassard *et al.* 2020), whereas a puma has a bite force of approximately 1660 PSI (426 kg). A puma attack is usually directed at the base of the throat, where it constricts to asphyxiate the victim, and frequently leaves claw marks on the prey's back or sides (Guarda *et al.* 2010), which were not observed on the attacked animals up to that date, or it may deliver a lethal bite to the base of the skull, severing the neck and spinal cord (Mazzolli 2013). In contrast, when attacks are by dogs, the prey typically shows various scratches and tears (Barrera 2018; Valderrama-Vásquez *et al.* 2018).

Dogs often inflict significant and unnecessary wounds on their prey, but some have a stronger instinct to kill, becoming efficient killers after repetition (Nallar *et al.* 2008). Aggression towards people or livestock are examples of behaviors that are not expected to occur in an adult dog (Caffrey *et al.* 2019; Baslington-Davies *et al.* 2023).

Records of dog attacks on native fauna are abundant in different parts of the world (Aliaga-Rossel *et al.* 2012; Doherty *et al.* 2017; Carrasco-Román *et al.* 2021; Zamora-Nasca *et al.* 2021; Díaz *et al.* 2023). However, information published regarding the negative implications of dogs on native fauna in scientific journals is still uncommon, especially in Argentina. Recently, reports of dog predation events on Magellanic penguins (*Spheniscus magellanicus*; Morgenthaler *et al.* 2002) and choiques (*Rhea pennata*

Figure 2. Photographs showing evidence of the attacks on both alive and dead sheep held in a ranch in the northeastern Argentine province of Entre Ríos. a) and b) damage inflicted on the animal's neck; c) and d) injuries to the base of the face and their consequence, infection; e) depth of the injury to the sheep's neck; f) sheep attacked and in medical treatment with injuries to the neck. Images available at julian.sabattini@uner.edu.ar.

pennata; Procopio *et al.* 2022) in the Argentine Patagonia have been published. However, this problem is frequent in neighboring countries of the region, where attacks on domestic and native vertebrates have been recorded. In Bolivia, attacks by dogs on Andean deer (*Hippocamelus* sp.) and other wild ungulates have been reported (Aliaga-Rossel *et al.* 2012). In Uruguay, the killing of sheep by dogs is recurrent, and this country's Rural Code authorizes the

killing of aggressive animals if found within the property and in an attacking attitude. In Chile, farmers from different parts of the country maintain that the major conflict is with pumas, foxes, and domestic dogs, a situation similar throughout the territory (Muñoz-Pedreros *et al.* 1995; Ohrens *et al.* 2015; Zapata-Ríos and Branch 2016; Silva-Rodríguez *et al.* 2023). Nevertheless, there is still some reluctance on the part of society to objectively accept cases of attack, death, or predation by pet dogs, due to natural sympathy of humans towards this species (Hare *et al.* 2002; Jarić *et al.* 2020; Sogliani *et al.* 2023) and there is urgent need of effective strategies to address this threat to wildlife (Degeling *et al.* 2021; Marshall *et al.* 2022; Lambertucci *et al.* 2024; Cravino *et al.* 2024).

In the analyzed case here, initially, the blame for the damage to livestock was attributed to native wildlife, namely a puma, and a plan had already been initiated by the rancher for the hunting and killing of the predator. In the region, pumas are uncommon (Muzzachiodi *et al.* 2020) and subject to severe hunting pressure, and the killing of another individual without any justification would have been regrettable. The use of a simple and not very expensive methodology allowed for a correct and accurate diagnosis of the conflict and avoided the hunting of native wildlife. This case study also highlights the importance of raising awareness on the need of a proper husbandry and training of the dogs used by rural residents and on the potential negative effects of feral or poorly cared for dogs on domestic livestock and wildlife (Silva-Rodríguez *et al.* 2023). Finally, this case study reinforces the conclusion that the first fundamental step in convincing stakeholders to adopt no-lethal tools in mitigating conflicts with wild carnivores is to listen to them, build trust, and actively involve them in the search of alternative solutions (McQuinn *et al.* 2023).

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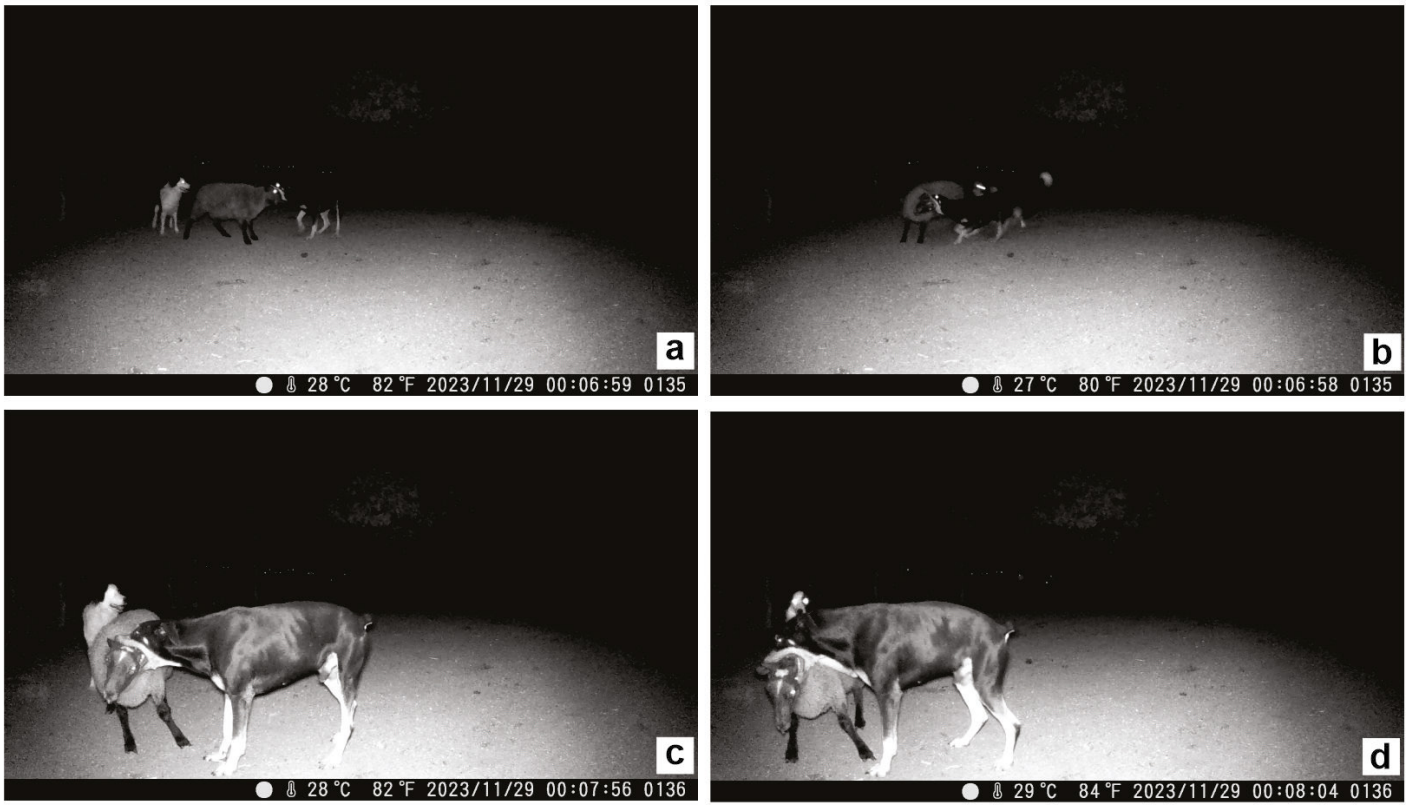

Figure 3. Captures of footages from a camera trap showing the moment when a domestic dog is attacking a sheep in a ranch in the northeastern Argentine province of Entre Ríos. a) It was the moment when the collie border is surrounding the sheep along with the attacking dog; b) the Doberman grabs the sheep with its teeth, c) and d) the Doberman settles and tightens its teeth and makes zigzag movements to paralyze the prey. Images available at julian.sabattini@uner.edu.ar.

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Observations of feeding attempts on Baird's tapirs (*Tapirella bairdii*) by common vampire bats (*Desmodus rotundus*) in Corcovado National Park, Costa Rica

Observaciones de intentos de alimentación en la danta centroamericana (*Tapirella bairdii*) por parte de murciélagos vampiros comunes (*Desmodus rotundus*) en el Parque Nacional Corcovado, Costa Rica

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Amit and Valverde-Zúñiga reported the first observations of common vampire bats (*Desmodus rotundus*) attempting to feed on Baird's tapirs (*Tapirella bairdii*) in Costa Rica. They reported behaviors they believed to be consistent with anti-parasitism behaviors for the species. We provide additional evidence validating their observations, making the case that such anti-parasitism behaviors may have been selected for and may be widespread within neotropical mammals. As part of a long-term wildlife monitoring and conservation effort, we maintained a camera trap network within Corcovado National Park, Costa Rica since 2015. Our camera trap network consisted of 13 to 56 paired or unpaired cameras placed in a 4 x 4 km grid. In 2021, we captured video footage of one *D. rotundus* crawling up to a *T. bairdii* in an apparent feeding attempt as a second *D. rotundus* appeared to be waiting nearby. The feeding attempt was evaded due to what appears to be behaviors consistent across species, time, and space, suggestive of an evolved behavioral response to feeding attempts by *D. rotundus*. In 2023, we documented a second event of an apparent feeding attempt by a single *D. rotundus* on a juvenile *T. bairdii* walking through our camera's detection area. Our observation combined with the observations of others suggests that a sudden movement that forces *D. rotundus* off the body may be an effective strategy for preventing an attack. Some neotropcial wild mammals may have adapted specific avoidance strategies for dealing with *D. rotundus*.

Key words: Camera trap; defensive behavior; feeding attempt; group-feeding; interspecific interaction; rabies virus.

Amit y Valverde-Zúñiga reportaron las primeras observaciones de *Desmodus rotundus* intentando alimentarse de *Tapirella bairdii* en Costa Rica. Ellos reportaron comportamientos que creían consistentes con comportamientos de antiparasitismo para las dantas. Proporcionamos evidencia adicional que argumenta que tales comportamientos antiparasitarios pueden haber sido seleccionados y estar extendidos entre los mamíferos neotropicales. Mantuvimos una red de cámaras trampa dentro del Parque Nacional Corcovado, Costa Rica desde 2015. Nuestra red consistió en 13 a 56 cámaras emparejadas o no emparejadas, colocadas en una cuadrícula de 4 x 4 km. En 2021 capturamos vídeo de un *D. rotundus* arrastrándose hasta un *T. bairdii* en un aparente intento de alimentación, mientras un segundo *D. rotundus* parece estar esperando cerca, mostrando una táctica de alimentación en grupo bien conocida de esta especie. Sin embargo, la danta evadió el intento de alimentación debido a lo que parece ser un comportamiento consistente a través de algunas especies en el tiempo y el espacio. Esto sugiere una respuesta conductual evolutiva a los intentos de alimentación por parte de *D. rotundus*. En 2023, documentamos un segundo evento entre un individuo de *D. rotundus* y un *T. bairdii* juvenil que caminaba por el área de detección de nuestra cámara. Nuestras observaciones, combinadas con las observaciones de otros, sugieren un movimiento repentino que obliga a *D. rotundus* a apartarse del cuerpo de la danta, lo cual es una estrategia eficaz para evitar un ataque.

Palabras clave: Alimentación grupal; cámara trampa; comportamiento de defensa; intento de alimentación; interacción interespecífica; virus de la rabia.

Interactions between parasitic vampire bats (family Desmodontidae) and their hosts are only recently being understood. Amit and Valverde-Zúñiga (2022) recently documented the first observations of interactions between the common vampire bat (*Desmodus rotundus*) and Baird's tapir (*Tapirella bairdii,* also referred to as *Tapirus bairdii*). They observed *T. bairdii* behaviors such as bucking, shaking, charging, running, and spinning to avert *D. rotundus* feeding attempts. Such observations alone provide insights into how potential hosts avoid feeding attempts by vampire bats. Taken independently, these observations are interesting, but when examined within the broader literature on the topic we may begin to gain further insights into the prevalence of such behaviors. For example, Gnocchi and Srbek-Araujo (2017) reported some of the same behaviors for lowland tapirs (*Tapirus terrestris*) of the Amazon. Herein, we contribute additional observations to this growing body of literature regarding *D. rotundus* feeding attempts on wild and domestic prey, and we draw comparisons amongst the published observations to suggest an evolved behavioral response to *D. rotundus* feeding attempts that spans species, space, and time.

Desmodus rotundus is a hematophagous bat species (Turner 1975), with its preferred prey being medium-to-large-sized mammals (Gnocchi and Srbek-Araujo 2017). While mainly feeding on livestock due to abundance and availability (Galetti *et al.* 2016), *D. rotundus* also feeds on other domestic animals and both native and non-native wildlife (Gnocchi and Srbek-Araujo 2017). Attacks on wildlife are typically documented via bite scars on prey (Sánchez-Cordero *et al.* 2011; Castellanos and Banegas 2015) which are characterized by the sharp incisors of the species (Arellano-Sota 1988). However, some researchers have opportunistically documented feeding attempts via camera traps.

During a feeding event, *D. rotundus* consume between 50 % and 100 % of their body weight in blood (Wilkinson 1990). If *D. rotundus* does not feed within 50 to 60 hr after a prior feeding, the individual will not have enough energy to maintain proper body temperature, resulting in death (Carter and Wilkinson 2013). Thus, *D. rotundus* cannot go longer than 2 nights without feeding (Wilkinson 1990; Carter and Wilkinson 2013). To improve feeding and survival success, *D. rotundus* are known to return to the same site to feed multiple nights in a row or to share feeding sites (Gnocchi and Srbek-Araujo 2017). Thus, the blood loss impacts of *D. rotundus* parasitism may be considerable for some species (*i.e.*, smaller bodied species) and are generally poorly understood.

As part of a long-term wildlife monitoring and conservation effort (*i.e.*, JaguarOsa project), we have implemented and maintained a camera trap network within Corcovado National Park, Costa Rica since 2015 (Olson *et al.* 2022; see also Olson *et al.* in press). Corcovado National Park is one of Costa Rica's largest national parks (424 km^2; Figure 1; Olson *et al.* 2022). It consists of a sizeable and globally rare

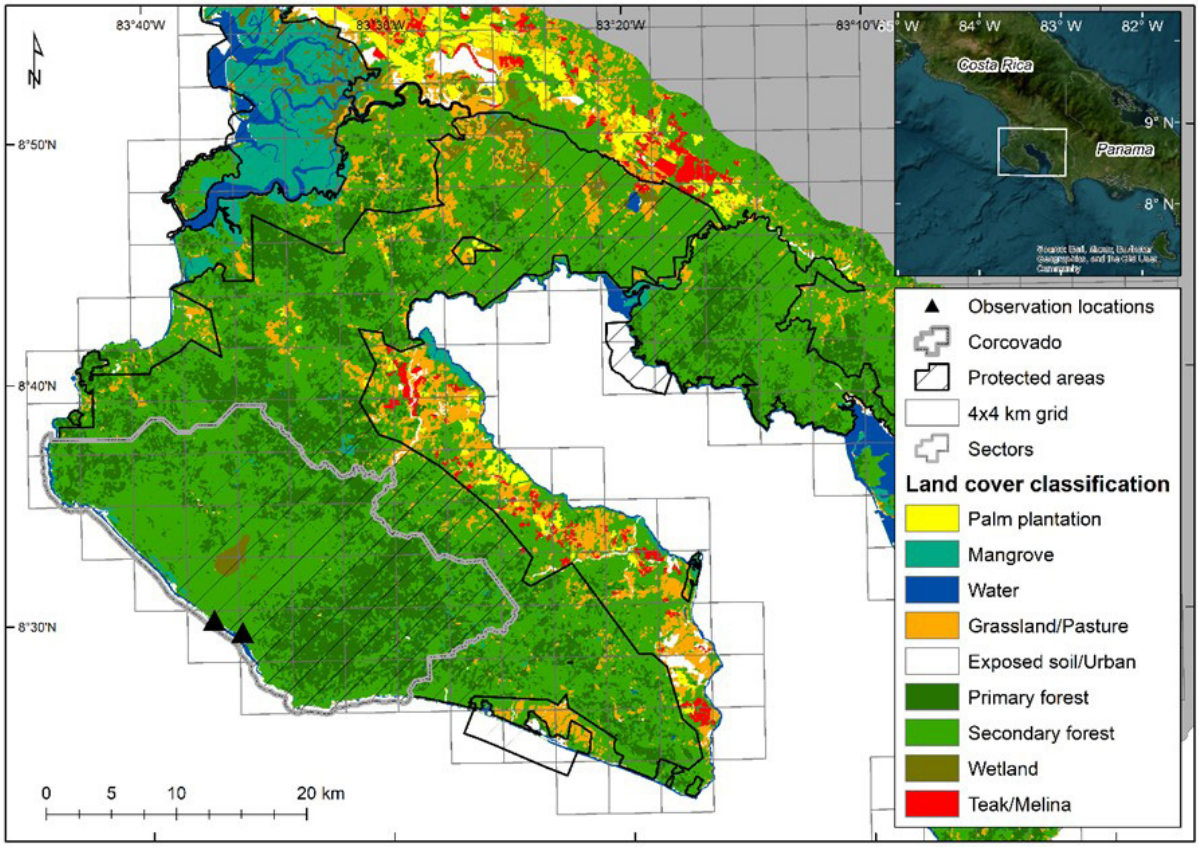

Figure 1. Location of observations of common vampire bat *Desmodus rotundus* feeding attempts on Baird's tapirs *Tapirella bairdii* in Corcovado National Park, Costa Rica (2015-2023).

lowland tropical forest surrounded by a mountainous evergreen tropical forest. These habitats support a plethora of species, including the globally endangered *T. bairdii* (García *et al.* 2016; Olson *et al.* 2022). Considered a core habitat area for *T. bairdii*, Corcovado is estimated to support a density of 0.81 tapirs/km^2 (Schank *et al.* 2017). Our camera trap network consisted of 13 to 56 paired or unpaired (*i.e.*, 1 or 2 cameras, either Reconyx, Bushnell, or UOVision camera traps) camera stations depending on survey year, with an average survey effort of 1,453 trap nights from 2015 to 2021 (Olson *et al.* 2022). Historically, our surveys were mainly run from February to June or July and cameras with photo or video capability are placed within a 4 x 4 km wildlife monitoring grid (see Olson *et al.* 2022 and Olson *et al.* in press for detailed summaries of survey efforts). We installed cameras to cover between 23 % and 59 % of grid cells within the park, depending on the survey year (Olson *et al.* 2022; Figure 1). In 2021, 2022, and 2023, we ran surveys from January to December with a total of 34, 56, and 45 camera stations, respectively.

On March 7, 2021 at 01:20 hr near Corcovado Beach (8° 30' 03.6" N, 83° 37' 15.6" W, we observed an adult female *T. bairdii* (Figure 2) resting on the ground when one *D. rotundus* crawled towards it on the forest floor and contacted the right posterior side of the body in an apparent effort to make a feeding attempt (Figure 2; see also Galetti *et al.* 2016). The *T. bairdii* made a sudden movement and stood up, spun, and took an aggressive stance (front feet spread more than shoulder width apart and bent at the elbow). These actions resulted in the *D. rotundus* retreating and an unsuccessful feeding attempt. The female *T. bairdii* then investigated (*i.e.*, smelled) the area where the *D. rotundus* made contact. After a while, 2 *D. rotundus* individuals flew through the frame causing the *T. bairdii* to spin and investigate. The 2 *D. rotundus* are then seen following the *T. bairdii* as it runs away and out of the camera frame. In November 2023 at 03:56 hr, near Laguna Cocovado (8° 29' 34.8" N, 83° 36' 10.8" W) we documented a second event of an adult female tapir walking through our camera's detection area followed closely by a juvenile. An individual *D. rotundus* closely followed the juvenile tapir as it walked through the detection area first on the ground and then in flight, in what we believe was a clear attempt to parasitize the juvenile (Figure 3). However, in this observation, both the adult and juvenile tapirs seem to be unaware or unbothered by the presence of the bat (see Appendix 1 for full video of both events). Of the 1,891 events of *T. bairdii* (*i.e.*, 30 min window of time with a *T. bairdii* detection) between 2015 and 2023 (~77 % of which have occurred between 18:00 and 06:00 hr), these are the only observations we have of such an interaction (~ 0.14 % of nighttime events). We have observed at least 2 additional events with *T. bairdii* and flying bats but are unable to confirm the species of bat. It is possible that we failed to detect additional *D. rotundus* events due to either poor quality imagery or the cryptic nature and small size of the species.

Figure 2. a) Frame of a video documenting a common vampire bat *Desmodus rotundus* crawling up to an adult female Baird's tapir T*apirella bairdi*i in an apparent feeding attempt in Corcovado National Park, Costa Rica in 2021. To see the full-length video of the interaction with annotations click here; b) adult female *T. bairdii* standing up after attempted parasitism by a *D. rotundus* in Corcovado National Park, Costa Rica 2021.

The observations by Amit and Valverde-Zúñiga (2022) document behaviors such as shaking, running, charging, and spinning as a defense utilized by *T. bairdii* to prevent a successful feeding attempt by *D. rotundus*. A similar movement in response to feeding attempts by *D. rotundus* has been documented with 2 other species via camera traps in Brazil; *Tapirus terrestris* (Gnocchi and Srbek-Araujo 2017) and *Mazama temama* (Galetti *et al.* 2016). Both incidents resulted in failed feeding attempts for *D. rotundus*. These observations are similar to ours and those of Amit and Valverde-Zúñiga (2022) and help to validate these behaviors as an effective strategy for preventing an attack by *D. rotundus*. Our additional observation of *D. rotundus* attempting to feed on a juvenile tapir may indicate that these behaviors are not yet obvious to juveniles. It is possible that *D. rotundus* may have more success feeding on naïve juveniles compared to adults but given that this is the only documented interaction so far, we are limited in our understanding.

Galetti *et al.* (2016) also report that *D. rotundus* has been observed chasing adult capybaras (*Hydrochoerus hydrochaeris*). These observations across species, space, and time, suggest that some neotropical mammals have adapted specific avoidance strategies for dealing with *D. rotundus*. Compared to wild mammals, we know that domestic mammals generally have reduced anti-predator responses- likely as a result of domestication for less risky behaviors for human handlers (Geffroy *et al.* 2020). The loss of stress responses and other behaviors appears to

make domestic mammals more vulnerable to wild predators (Kaiser *et al.* 2015; Geffroy *et al.* 2020; Solberg *et al.* 2020). The same seems plausible for behaviors that could result in failed feeding attempts or even injury or mortality for *D. rotundus*. Such a difference could also help explain why *D. rotundus* tends to prefer domestic mammals over wild mammals in sites where both are present (Amit and Valverde-Zúñiga 2022). Our observations also suggest that juvenile wild neotropical mammals may be more vulnerable than adults to *D. rotundus* parasitism; however, further research is required.

The main risk associated with interactions between *D. rotundus* and wildlife is the potential for transmission of dangerous pathogens, particularly rabies virus (RABV), a viral zoonotic disease that attacks the central nervous system (Fisher *et al.* 2018) and is known to be carried by *D. rotundus* (Gnocchi and Srbek-Araujo 2017; León *et al.* 2021). While feral and domestic dogs are typically the main transmitter of RABV across Central America (León *et al.* 2021), recent efforts by the government of Costa Rica have eliminated canine rabies outbreaks. Now, *D. rotundus* serves at the main reservoir of RABV across Costa Rica (León *et al.* 2021). RABV vaccinations remain an effective tool for preventing outbreaks and death for livestock and humans (Gnocchi and Srbek-Araujo 2017), but mitigation of rabies outbreaks in the wild is far more complicated. Using their estimate of a *T. terrestris'* chance of being attacked by *D. rotundus* (0.11) and *D. rotundus*–RABV prevalence of 0.014, Galetti *et al.* (2016) estimated the probability of rabies transfer to *T. terrestris* in the Pantanal at 0.15 %. While we are not able to assess the probability of RABV transfer to *T. bairdii*, we suspect the probability is much lower because we have only detected 2 interactions of many *T. bairdii* events (2 of at least 1,456 events). Furthermore, we suspect that *D. rotundus* is found at lower densities in Costa Rica compared to Brazil because of Brazil's larger domestic livestock populations (O'Donoghue *et al.* 2019). RABV is well-studied in human and domestic animal populations, but studies regarding RABV in the wild are still lacking. Our observations may provide insights into potential RABV transmission for wild neotropical mammals in this region of Costa Rica and may inspire researchers and practitioners in the One Health field to further explore the importance of such findings.

Our observations confirm that *D. rotundus* feeds, or at least attempts to feed, on *T. bairdii* in the wild. When put within the context of the broader published behavioral observations, failed *D. rotundus* feeding attempts on wild mammals suggest that defensive behaviors such as those reported by Galetti *et al.* (2016), Gnocchi and Srbek-Araujo (2017), and Amit and Valverde-Zúñiga (2022), *i.e.*, bucking, charging, spinning, running, shaking, and even kicking and biting – may reduce successful parasitism attempts by *D. rotundus*. While the implications of such interactions remain less clear, these similar observations across species, space, and time provide a strong basis for understanding how these cryptic and rare scenarios unfold. We encourage further reporting of such observations and future research into the degree and implications of such interactions.

Figure 3. A frame of a video documenting a common vampire bat *Desmodus rotundus* following a juvenile Baird's tapir *Tapirella bairdii* in an apparent feeding attempt in Corcovado National Park, Costa Rica in 2023. To see the full-length video of the interaction with annotations click here.

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Appendix 1

Video documenting two feeding attempts by common vampire bats, *Desmodus rotundus* on Baird's tapirs *Tapirella bairdii* in Corcovado National Park, Costa Rica, in 2021 and 2023. https://www.youtube.com/watch?v=9refUJASudY.

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Presence of gastrointestinal parasites in *Dicotyles tajacu* in conservation areas and backyards of Campeche and Yucatán, México

Presencia de parásitos gastrointestinales en *Dicotyles tajacu* en áreas destinadas para la conservación y traspatios de Campeche y Yucatán, México

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Dicotyles tajacu faces habitat destruction, free-range poaching, and parasitism in captive animals, which causes diarrhea, weight loss, and death. This study aimed to determine the presence of nematodes and protozoa in peccaries in captivity in Campeche and Yucatán, México. The study was carried out in 2 Management Units for Wildlife Conservation (UMAs, from its name in Spanish) and 1 backyard located in Campeche, and in a Wildlife Management Farm and Facility (PIMVS, from its name in Spanish) in Yucatán, where fecal samples from 47 individuals were collected and placed in labeled polyethylene bags. In the laboratory, feces were processed by sedimentation and flotation, and gastrointestinal parasites were identified based on morphometric characteristics. The data obtained were analyzed using the χ^2 test ($P \leq 0.05$) in the Statistica v. 9.1 software. The peccaries of PIMVS showed a higher prevalence of parasites, with 53.3 % positive individuals, and the highest parasite load ($P \leq 0.05$) due to eggs of the helminth *Strongylida* sp. and oocysts of the protozoan *Eimeria* sp. The prevalence recorded and the parasites *Strongylida* sp. and *Eimeria* sp. observed in peccaries of the PIMVS were similar to those in zoos in other countries, implying that captive peccaries are more vulnerable to endoparasitism. The determination of endoparasites in *D. tajacu* is relevant for animal health management in PIMVS, UMAs, and backyards to avoid zoonoses, especially before merging common spaces for the management of 2 or more species.

Key words: Captivity; parasitosis; wildlife; wild pig; zoonosis.

Dicotyles tajacu se enfrenta a la destrucción de su hábitat, cacería furtiva en vida libre y al parasitismo en cautiverio, que provoca diarreas, pérdida de peso y la muerte. El objetivo fue determinar la presencia de nemátodos y protozoos en individuos en cautiverio en Campeche y Yucatán, México. El estudio se realizó en 2 Unidades de Manejo para la Conservación de la Vida Silvestre (UMAS) y 1 traspatio ubicados en Campeche y 1 Predio e Instalación que Maneja Vida Silvestre (PIMVS) en Yucatán, donde se obtuvieron muestras de heces de 47 individuos, que se colocaron en bolsas de polietileno rotuladas. Las heces fueron procesadas mediante sedimentación y flotación, y para la identificación de parásitos gastrointestinales se usaron los caracteres morfométricos. Los datos obtenidos se analizaron mediante la prueba de χ^2 ($P \leq 0.05$) en el software Statistica v. 9.1. Los pecaríes del PIMVS presentaron mayor prevalencia con 53.3 % individuos positivos y la carga parasitaria más elevada ($P \leq 0.05$) debido a la presencia de huevos del helminto *Strongylida* sp. y ooquistes del coccidio *Eimeria* sp. La prevalencia registrada y los parásitos de los géneros *Strongylida* sp. y *Eimeria* encontradas en el PIMVS, fue similar a zoológicos de otros países, lo que implica que estos animales en espacios cerrados son más vulnerables al endoparasitismo. La determinación de endoparásitos en *D. tajacu* es relevante para el manejo zoosanitario en PIMVS, UMAS y traspatios, para evitar zoonosis, sobre todo antes de fusionar espacios comunes para el manejo de 2 o más especies.

Palabras clave: Cautiverio; fauna silvestre; parasitosis; puerco de monte; zoonosis.

The collared peccary (*Dicotyles tajacu*), which belongs to the family Tayassuidae, is a wild pig that plays an important role in ecosystems as a seed disperser, contributing to the spatial distribution of the plants on which it feeds (Beck 2005; Jones and Gutiérrez 2007). It also serves as a link in the food chain, being consumed by predators such as the jaguar (*Panthera onca*) and the puma (*Puma concolor*; Moreno *et al.* 2006). From a socioeconomic standpoint, *D. tajacu* is among the 20 most important species used in México; its fur is used to manufacture coats and footwear (Fang *et al.* 2008; Naranjo *et al.* 2010; Siruco *et al.* 2011), while its meat is sold in rural areas of Yucatán and Campeche, since pecca-

ries are subjected to poaching (Reyna-Hurtado and Tanner 2007; Fang *et al.* 2008; Montes and Mukul 2010; Barranco-Vera *et al.* 2023).

To prevent this species from being included in a population risk category due to indiscriminate poaching in México, the Official Mexican Norm NOM-059-SEMARNAT-2010 (SEMARNAT 2010) has established Management Units for Wildlife Conservation (UMAs, from its name in Spanish) and Wildlife Management Farms and Facilities (PIMVS). These are areas or spaces for the legal management of species where preservation strategies are promoted through maintenance, reproduction, repopulation, environmental education, and reintroduction to natural areas (SEMARNAT 2010). Studies on captive mammals suggest that before releasing animals from UMAs to natural areas, they are tested for parasites to avoid diseases and potential zoonotic risks to wildlife (Mukul-Yerves *et al.* 2014; Liatis *et al.* 2017; Sierra *et al.* 2020), or even death (Menajovsky *et al.* 2023).

There are records of the presence of endoparasites such as *Strongyloides* sp. in free-living collared peccary and UMAs, *Strongyloides* sp., Strongylida (*Oesophagostomum* sp.), and Eucoccidiorida (*Eimeria*, *Isospora*) in the state of Yucatán (Mukul-Yerves *et al.* 2014). Other endoparasites, such as *Ascaris suum, Balantidium* sp., *Entamoeba polecki, Iodamoeba bütschlii,* and *Entamoeba polecki*, have been reported in captive individuals in Brazil (Silveira *et al.* 2024). However, studies that have determined parasites in captive peccaries kept in UMAs, PIMVS, and backyards of Campeche and Yucatán, México are scarce, which hinders decision-making about the release of captive specimens or the consumption of their meat. Therefore, this study aimed to determine the presence of gastrointestinal parasites (nematodes and protozoa) in peccaries living in conservation areas and backyards in Campeche and Yucatán, México.

The study was carried out from August to December 2023 in 2 UMAs and 1 backyard in the state of Campeche, and in 1 PIMVS in the state of Yucatán. The characteristics of each site are as follows: Site 1. UMA Ecoturística Monte Nuevo, Senderos Interpretativos y Observaciones de Flora y Fauna (Monte Nuevo Ecotourism UMA, Interpretive Trails and Observations of Flora and Fauna; DGVS-UMA-VL-3699.-CAMP), located in the municipality of El Carmen, Campeche (18° 24' 26.65" N, 91° 10' 57.39" W), with a warm subhumid climate, mean annual temperature of 25.7 °C, mean annual precipitation of 1,540 mm, and altitude of 24 m (INEGI 2010a). Site 2. UMA Casados Ranch Wildlife Conservation Center (SEMARNAT-UMA-IN-0024-CAMP), located in the municipality of Escárcega, Campeche (18° 36' 7.23" N, 90° 42' 4.54" W), mean annual temperature of 26 °C, mean annual precipitation of 1,200 mm, and altitude of 24 m (INEGI 2009). Site 3. Backyard located in ejido José de la Cruz Blanco, Escárcega, Campeche (18° 37' 02.33" N, 90° 46' 53.3" W), mean annual temperature of 26 ºC, mean annual precipitation of 1,150 mm, and altitude of 95 m (INEGI 2009). Site 4. PIMVS La Reina Zoological and Botanical Park (SEMARNAT-PIMVS-0185-YUC-10), located in the municipality of Tizimín, Yucatán (21º 08' 53.13" N, 88º 09' 38.18" W, at 19 m), mean annual temperature of 27 ºC, mean annual precipitation of 1,000 mm, and altitude of 20 m (INEGI 2010b; Figure 1).

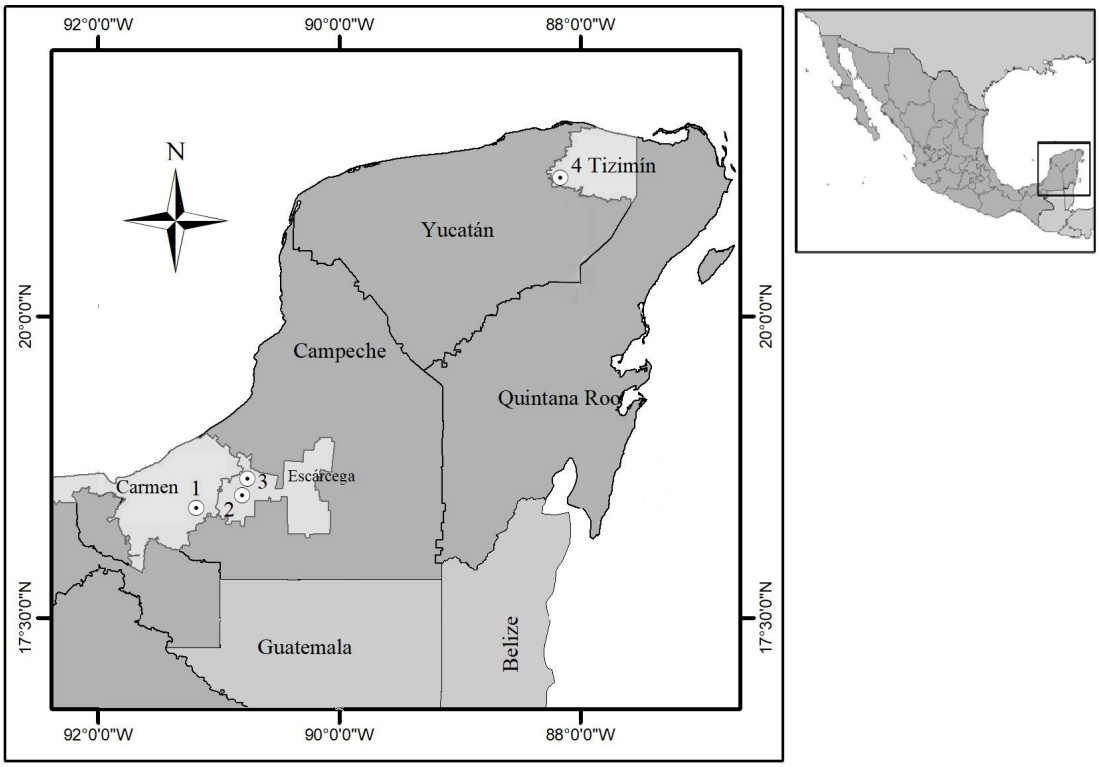

Figure 1. Map with the geographic location of the 4 sampling sites of *Dicotyles tajacu* at site 1. UMA Carmen, Campeche; site 2. UMA Escárcega, Campeche; site 3. Backyard Escárcega, Campeche; site 4. PIMVS Tizimín, Yucatán.

At Site 1, the facilities consist of four 30 m^2 yards with cement floor, galvanized-mesh walls, and part of the roof made of galvanized sheets; each yard has drinking troughs and feeders. The diet comprises a mixture of fruits and vegetables, and animals have been born in captivity for more than 10 years. In Site 2, peccaries have been born and live in the wild; there are natural and artificial drinking troughs in the dry season. Site 3 is a 6 m^2 yard with an unpaved floor and walls and roof made of galvanized sheets; the drinking trough is a tire split in half. The peccaries kept in this yard were captured from the wild and do not have a feeder; they are fed herbs, tortillas, or vegetable waste. Site 4 is an area of 616 m^2 with unpaved floor, galvanized mesh walls, drinking troughs, and cement feeders. The diet comprises a mixture of fruits and vegetables, and animals have been born in captivity for more than 20 years (Figure 2).

Fecal samples were obtained using a non-invasive method. Each animal was observed for 4 hr (6:00 hr to 10:00 hr); when it defecated, its feces were collected with a polyethylene bag labeled with the number and sex of the animal and the site of collection. All samples were kept in an ice box and transported to the Animal Science Laboratory of the College of Postgraduates, Campeche Campus.

In the laboratory, each fecal sample was first homogenized. Then, 2 g was collected for the quantification of protozoan oocysts using the sedimentation methodology (Rodríguez-Vivas *et al.* 2011); for nematode eggs, the McMaster flotation method was used (Alpízar *et al.* 1993). Afterward, the McMaster cameras were read, and parasites were identified under a Leica light microscope using the 40x lens and following the taxonomic keys of Soulsby (1987) and Quiroz (1989). The prevalence rate was deter-

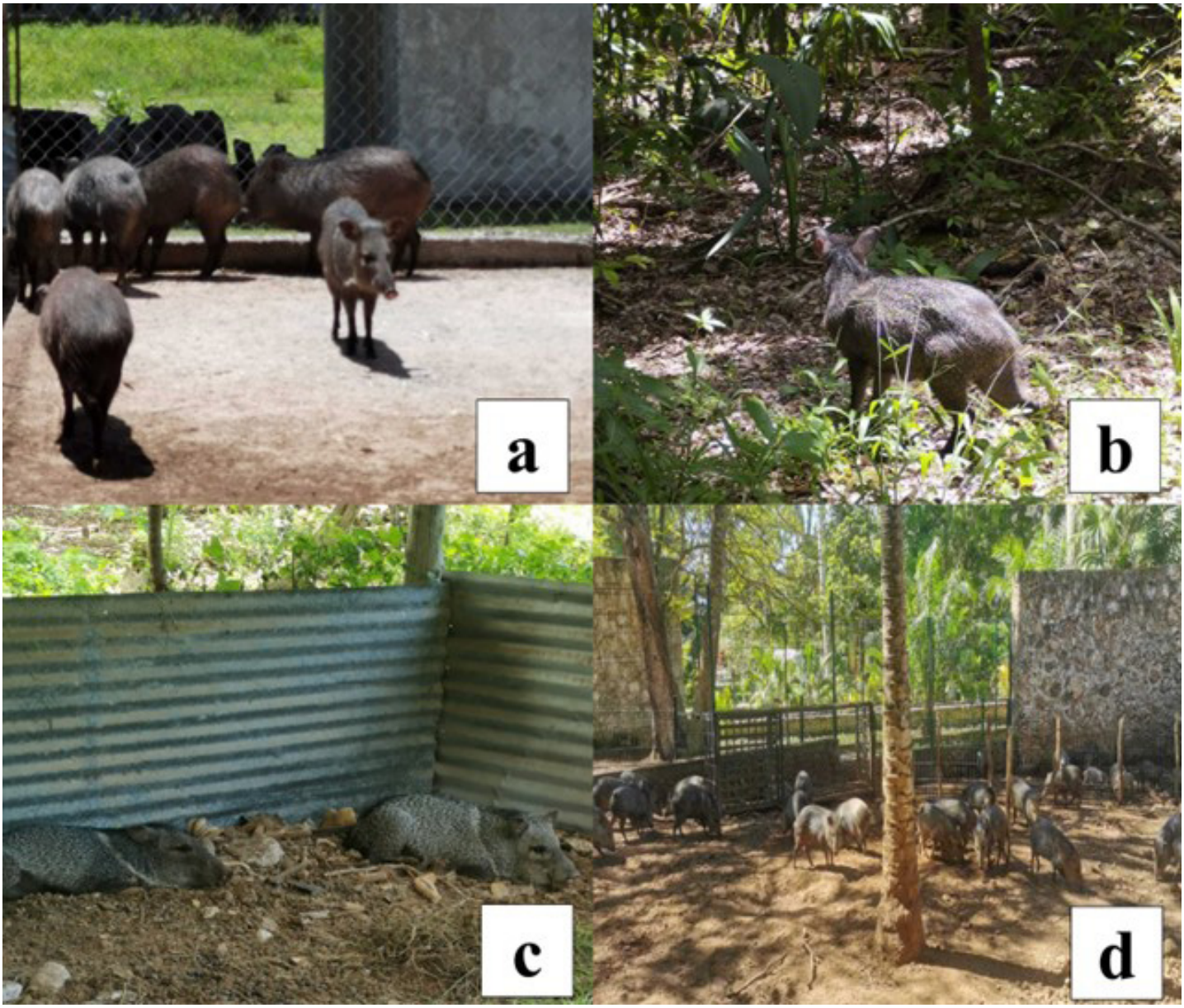

Figure 2. Specimens of collared peccaries, *Dicotyles tajacu* at the sampling sites, a) site 1, UMA in Carmen, Campeche; b) site 2, UMA in Escárcega, Campeche; c) site 3, Backyard in Escárcega, Campeche; and d) site 4, PIMVS in Tizimín, Yucatán. Images available on cflota@colpos.mx.

mined using the formula (Datta *et al.* 2024): Prevalence = (number of parasitized individuals / number of individuals sampled per site) x 100.

Likewise, photographs of protozoa and cysts were taken from the most representative observations for future studies on parasites (Figure 3). Finally, the parasite load was compared between sites using the χ^2 test (León *et al.* 2019) applying a significance criterion of $P \leq 0.05$ in the software Statistica v. 9.1 (STATISTICA 2005). The objective was to determine which management type (UMA, PIMVS, or backyard) concentrated the largest number of gastrointestinal parasites.

In total, fecal samples were collected from 47 collared peccaries. Of these, 25.5 % were positive for gastrointestinal parasites, with the highest prevalence at Site 4, where 53.3 % of individuals were positive for endoparasites (Table 1).

Table 1. Percentage of prevalence of gastrointestinal parasites in *Dicotyles tajacu* in 2 Management Units for Wildlife Conservation (UMAs) and 1 backyard located in Campeche and one Wildlife Management Farm and Facility (PIMVS) in Yucatán, México.

Sites	*n*	Number of positive animals	% prevalence	Confidence interval (95 %)
1 UMA	12	1	8.3	0.00- 24.65
2 UMA	10	2	20	0.00-46
3 Backyard	10	2	20	0.00-46
4 PIMVS	15	8	53.3	58-289
Total	47	13	25.5	23.26-108.63

The parasites quantified in collared peccaries included eggs of the helminth *Strongylida* sp. and oocysts of the protozoan *Eimeria* sp. (Figure 3). The site with the highest number of parasites was Site 4, with 173.33 parasites ($P \leq 0.05$). The number of eggs of *Strongylida* sp. was not significantly different ($P \geq 0.05$) between sites, while the highest number of *Eimeria* sp. oocysts was recorded at Site 4, with an average of 166.64 oocysts ($P \leq 0.05$). This was the only site where peccaries were parasitized with both *Strongylida* sp. and *Eimeria* sp. (Table 2).

Table 2. Load of parasitic nematodes and protozoa in *Dicotyles tajacu* from Campeche and Yucatán, México. *n* (number of individuals), SD (standard deviation). [a,b]Different literals in columns indicate significant differences between sites.

Sites	*n*	*Strongylida* sp. Average ± SD	*Eimeria* sp. Average ± SD	Total parasites ± SD
1	12	8.3 ± 28.67[a]	0[a]	8.33 ± 28.87[a]
2	10	20 ± 42.16[a]	0[a]	19 ± 42.16[a]
3	10	0[a]	20 ± 42.16[a]	20 ± 42.16[a]
4	15	6.7 ± 25.82[a]	166.67 ± 225.72[b]	173.33 ± 228.24[b]
		$\chi^2 = 2.69$	$\chi^2 = 15.15$	$\chi^2 = 7.76$
		$P = 0.44$	$P = 0.0017$	$P = 0.05$

Of the 4 study sites, the collared peccaries of Site 4 (PIMVS, Yucatán) had a parasite prevalence of 53.3 % and a higher parasite load of *Strongylida* sp. eggs and *Eimeria* sp. oocysts than the UMAs and backyard of Campeche. This is probably because at Site 4, peccaries coexist in the same yard with goats (*Capra hircus*) and donkeys (*Equus asinus*), which are potential hosts of these parasites (Quiroz *et al.* 2011) and excrete them through the feces. Furthermore, since the floor is unpaved, trampling promotes the volatility of oocysts and eggs in the dust and their deposition in the water and food consumed by captive animals (Botero and Restrepo 2012). This environment promotes the proliferation of helminths and coccidia and, therefore, involves a greater possibility of parasite dispersal (Mukul-Yerves *et al.* 2014). A higher prevalence was found in a Rio de Janeiro Zoo, Brazil, with 100 % of peccaries giving positive for nematode larvae and eggs of *Strongylida* sp., as well as another endoparasite, *Balantioides coli* (Barbosa *et al.* 2020). In this sense, Ortiz-Pineda *et al.* (2019) noted that wild animals are more vulnerable to endoparasitism when they are in closed captivity, such as in PIMVS, zoos, and UMAs (Salmorán-Gómez *et al.* 2019).

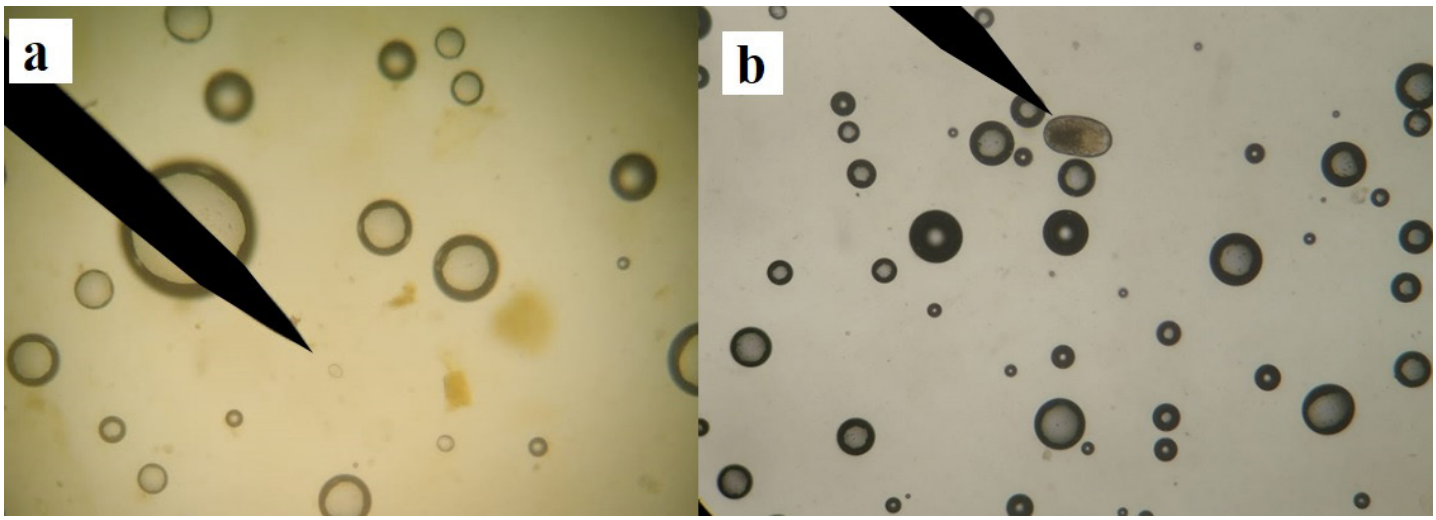

Figure 3. Gastrointestinal parasites in collared peccary, *Dicotyles tajacu*: a) oocyst of *Eimeria* sp.; b) egg of helminth *Strongylida* sp. Images available on cflota@colpos.mx.

No infestation scales have been established to differentiate the parasite loads caused by gastrointestinal parasites in Tayassuidae. However, when comparing the parasite load recorded in the present study with those previously reported for other domestic species (sheep and cattle; a mild load of 50 to 200 eggs per gram (epg) of feces; moderate, > 200 to < 800 epg; and high, > 800 epg; Morales *et al.* 2006), the load recorded in collared peccaries from Site 4 (PIMVS) corresponds to a mild-to-moderate infestation (Morales *et al.* 2006; Boldbaatar *et al.* 2021). Therefore, it is recommended that collared peccaries be tested for parasites prior to their release. We recommend including leaves of *Leucaena leucocephala* (Lam.) de Wit (Fabaceae; de Castro *et al.* 2024) in the diet, as it functions as a natural antiparasitic agent in other species, such as sheep, cattle, and pigs (Sandoval-Castro *et al.* 2012; Soares *et al.* 2015).

The results recorded in this study suggest that the sites where peccaries are kept in captivity should be disinfected, mainly the area where drinking troughs and feeders are installed. Feces should be cleaned weekly to avoid accumulation on the ground, reduce parasitic proliferation that affects their health, and thus avoid zoonoses.

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Traces of coyote *Canis latrans* in the subalpine altitudinal gradient of Parque Nacional Chirripó, Costa Rica, and altitudinal review of the distribution area

Rastros de coyote *Canis latrans* en el gradiente altitudinal subalpino del Parque Nacional Chirripó, Costa Rica, y revisión altitudinal del área de distribución

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The coyote is one of the American canids with the broadest geographic distribution. Although it is a common species, the upper limit of its altitudinal distribution has yet to be established. This study aims to contribute to the recording of coyote traces in a subalpine forest in the Cordillera de Talamanca, Costa Rica, and reviews its altitudinal distribution in México and Central America. We traveled 4.36 km between elevations of 3,118 to 3,821 m (the maximum altitude), to georeference and photograph coyote traces in the Parque Nacional Chirripó, Costa Rica. We asked locals and park rangers about coyote traces or sightings. In addition, we reviewed coyote reports in 2 research projects in Costa Rica and biodiversity platforms that covered México and Central America to contextualize the results. Indirect evidence was gathered of the presence of coyote in most of the walk up to the top of Cerro Chirripó. The evidence recorded at 3,821 m corresponds to a scat with length and diameter characteristic of this canid. In addition, we noted that the reports of coyotes in subalpine areas available on biodiversity platforms are scarce. The record in this study is consistent with the high dispersal capacity of this species and raises some questions about the use of resources, behavior, and altitudinal range of the coyote in Central America.

Key words: Altitudinal range; Central America; coyote; feces; México; subalpine forest; Talamanca mountain range.

El coyote es uno de los cánidos americanos con mayor distribución geográfica. A pesar de ser una especie común, su máxima distribución altitudinal no ha sido claramente establecida. Nos propusimos contribuir con el registro de rastros de coyote en un bosque subalpino de la Cordillera de Talamanca, Costa Rica, y con la revisión de su distribución altitudinal en México y Centro América. Recorrimos 4.36 km entre 3,118 - 3,821 m hasta alcanzar la máxima altitud, para georreferenciar y fotografiar rastros de coyote en el Parque Nacional Chirripó en Costa Rica. Consultamos a personas locales y guardaparques acerca de rastros o avistamientos de coyote. Además, revisamos los reportes de coyote en 2 proyectos de investigación en Costa Rica y en las plataformas de biodiversidad, abarcando México y Centroamérica, para contextualizar los resultados. Obtuvimos evidencia indirecta de presencia de coyote en la mayor parte del recorrido hasta alcanzar la máxima altitud del Cerro Chirripó. La evidencia registrada a 3,821 m corresponde a una excreta que posee la longitud y el diámetro característicos para este cánido. Además, observamos que los reportes de coyote en las plataformas de biodiversidad siguen siendo deficientes en el piso subalpino. Este registro concuerda con la alta capacidad de dispersión de esta especie y, además, plantea algunas interrogantes sobre el uso de recursos, comportamiento, y distribución altitudinal del coyote en Centro América.

Palabras clave: Bosque subalpino; Centro América; Cordillera de Talamanca; coyote; distribución altitudinal; heces; México.

The coyote *Canis latrans* (Say 1823) is one of the canids with the broadest distribution in the American continent. This remarkably adaptable mammal has been recorded from Alaska to Darién, Panamá, with fossil records from the Holocene, precolonial archaeological evidence, and documents from the colonial period throughout its range (Bekoff 1977; Monge-Nájera and Morera-Brenes 1986; Lucas *et al.* 1997; Emery 1999; Hidalgo-Mihart *et al.* 2004; Ordóñez-Garza *et al.* 2008; Hody and Kays 2018; Hody *et al.* 2019; Thiel 2020). As an omnivorous and opportunistic species, *C. latrans* moves between natural and anthropic environments, including crops, rural roads, and, to a lesser extent, urban areas, in search of prey or to establish territories (Hancock and Hedrick 2018; Zepeda *et al.* 2021; Reid and Gómez-Zamora 2022). These environments are part of its home range, with an area between 1.7 km^2 and 60 km^2 (Grinder and Krausman 2001; Zepeda *et al.* 2021; Lloyd *et al.* 2022). Given its highly adaptable behavior and ability to move, the coyote will probably be recorded further south of Darién in the near future (Vaughan 1983; Monroy-Vilchis *et al.* 2020).

In Costa Rica, the coyote is widely distributed from the northwest to the southern Pacific, as well as in the Guanacaste, Tilarán, Central Volcanic, and Talamanca mountain ranges, in addition to the North Caribbean (Cove *et al.* 2012; Carazo-Salazar *et al.* 2020; Reid and Gómez-Zamora 2022). The coyote shows a continuous altitudinal distribution in Costa Rica, from basal region to the subalpine areas, with altitudes of up to 3,400 m in Cerro de la Muerte, south of the central belt of the Talamanca mountain range (Vaughan 1983; Wainwright 2007). This canid has also been spotted at altitudes above 3,000 m in the Sierra del Ajusco, south of México City; Pico de Orizaba, east of México City; Santa Catarina Ixtepeji, southern México; Sierra de los Cuchumatanes, western Guatemala; and Cabricán, in the western plateau of southwest Guatemala (Handley 1950; Aranda *et al.* 1995; Ordóñez-Garza *et al.* 2008; Cruz-Espinoza *et al.* 2010; Martínez-Vázquez *et al.* 2010; Marín-Sánchez *et al.* 2015). At these altitudes, subalpine environments pose a challenge to the tolerance of wildlife (Martin 2001). However, in this fragile life zone, coyotes coexist with a rich assemblage of herbivorous, omnivorous, and carnivorous mammals (González *et al.* 2021).

As with other mammals, reports of coyote sightings in subalpine regions are scarce, and its presence is usually detected mainly by footprints, feces, vocalizations, and, to a lesser extent, through camera traps. In the case of Costa Rica, the altitudinal limits along the highest mountain ranges, *i.e.*, the Central Volcanic and Talamanca mountain ranges, have yet to be established. For the latter mountain range, this study aimed to contribute to the recording of coyote traces (feces, footprints, sightings, and vocalizations) in the subalpine area of Parque Nacional Chirripó (PNC). In addition, to contextualize the data collected in the field and contribute to the knowledge of the ecology of this species in Costa Rica, particularly concerning its altitudinal distribution, we reviewed the records of the research projects "Ethnoecology of *C. latrans*" of the Universidad Nacional (UNA) and "Moorlands" of the Museo Nacional de Costa Rica (MNC), as well as the records available on the online biodiversity platforms that cover México and Central America.

The PNC stretches over 50 thousand ha, ranging from premontane to subalpine altitudes, and is located between the cantons of Pérez Zeledón, Turrialba, Limón, and Talamanca (Tosi 1969; Sistema Nacional de Áreas de Conservación, SINAC, n.d.). The mean annual temperature in the PNC is 8 °C, and the mean annual precipitation varies between 2,000 mm and 5,500 mm (IMN 2008). The subalpine area of the PNC is located at 9° 26' 53"–9° 32' 51" N and 83° 27' 78"–83° 32' 94" W (Figure 1). This area is characterized by stunted vegetation, abundant grasses, slopes made up of rounded rocks, and valleys and lagoons of glacial origin (Barquero and Ellenberg 1985). Regarding the composition of mammals in the PNC, the species recorded in addition to the coyote include jaguar (*Panthera onca*), puma (*Puma concolor*), clouded oncilla (*Leopardus pardinoides*), Baird's tapir (*Tapirus bairdii*), red brocket (*Mazama temama*), collared peccary (*Dicotyles tajacu*), Dice's cottontail rabbit (*Sylvilagus dicei*), shrew (*Cryptotis* sp.), and several species of rodents, *e.g.*, *Scotinomys xerampelinus* and species of *Reithrodontomys*, such as *R. creper* and *R. sumichrasti* (Chaverri 2008; González-Maya and Schipper 2008; González *et al.* 2021; Mora *et al.* 2021). The nearest town is San Gerardo de Rivas, located approximately 14 km from the study area. The presence of feral dogs has not been recorded in the PNC by park rangers, nor has control of domestic dogs been required, as in other protected areas or private reserves.

As part of UNA's project "Ethnoecology of *C. latrans*", which covered the basal, premontane, montane, and subalpine regions of Costa Rica, we carried out a tour from 23 to 25 September 2021 in the subalpine belt of the PNC. Previously, we reviewed MNCR's "Moorlands" project records obtained in the PNC during 2018 to confirm coyote observation sites. Furthermore, during the field trip, we asked a local inhabitant, 2 muleteers, and a park ranger about coyote traces. In the subalpine belt, 2 observers worked in an area of approximately 17.4 km^2, walking trails and open zones of the moorland ecosystem, mainly during the mornings, to avoid afternoon winds, fog, and freezing precipitation. We covered 4.36 km in 3 days, organizing the walks during the hours of best visibility to maximize the detection of traces. The altitudinal range walked was 3,118 m to 3,821 m to the top of Cerro Chirripó. On day 1, the search for traces started on the El Jardín trail and continued along the Los Arrepentidos trail. On day 2, we explored the surroundings of the Base Crestones lodge and Valle de Los Conejos. Finally, on day 3, we walked the trail that leads to Cerro Chirripó. All the studied sites have a typical moorland ecosystem. Some trails are harder to climb, while others, such as the surroundings of the Base Crestones lodge, have flat areas with slopes. On the other hand, the Valle de Los Conejos is flat and open, as its name suggests.

During the tours, we georeferenced and photographed each trace, placing a 50-colon coin on one side to facilitate estimating the dimensions of the trace, considering the diameter of the coin (27.5 mm) and using the package tpsDIG2 version 2.32 (Rohlf 2018). Finally, we compared the measurements recorded in this study with those reported by Chame (2003) and Aranda (2012) to confirm field identification. In the case of scats, we applied 2 criteria to differentiate the coyote from other wild and domestic species. The first assumes that coyote scats could be misidentified as those of other wild species such as the gray fox (*Urocyon cinereoargenteus*) and the puma (*P. concolor*). However, gray fox scats are rare and smaller, whereas puma feces tend to have many more constrictions than those of coyotes, so they are commonly misidentified as jaguar feces rather than coyote scats (Aranda 2012). The second criterion relates to differences in diet between wild and domestic species. Generally, coyote scats contain many hairs and some skeletal remains of small mammals, while the feces of domestic dogs are homogeneous, with no visible undigested fragments. Therefore, examining feces in the field allowed us to rule out domestic dogs. Photographs of coyote scats and one video were deposited on the ResearchGate site of the first author.

The coyote traces found were projected onto a topographic map of the study area elaborated in QGIS version 3.16.15. T (QGIS.org 2022). Additionally, we made descriptive comparisons of the number of reports using Holdridge's altitudinal levels (Holdridge 1978), namely basal (0–700 m), premontane (700–1,400 m), montane (1400–2,800 m), subalpine (2,800–3,880 m), and alpine (>3,880 m) in México and Central America. To this end, we used reports for *C. latrans*, such as sightings, traces, or collection specimens reported at the Global Biodiversity Information Facility (GBIF 2024) and iNaturalist (2024), in addition to the records of UNA and MNCR research projects for several regions of Costa Rica. Data from biodiversity platforms were downloaded with the R packages rgbif version 3.7.9 (Chamberlain *et al.* 2024) and rinat version 0.1.9 (Barve and Hart 2022). We refined the database generated using the R packages dplyr version 1.3.1 (Wickham *et al.* 2023) and elevatr version 0.99.0 (Hollister 2023). This refinement consisted of eliminating invalid geographic coordinates and assigning altitudes when they were absent. Finally, we used the R package ggplot2 version 3.4.4 (Wickham 2016) to design elevation frequency plots for México and Central America.

Twenty-two coyote scats were recorded during the 4.36 km walk (Table 1; Figure 1). No footprints or sightings were observed between El Jardín and the top of Cerro Chirripó; however, vocalizations were heard on the second day. We measured 9 scats (Figure 2); the rest of the recorded feces were not measured due to their state of decomposition and high moisture content, which can increase their volume and, therefore, bias their true dimensions (Table 1). However, the location of these traces on the trails is consistent with the defecation behavior of this canid; in addition, the

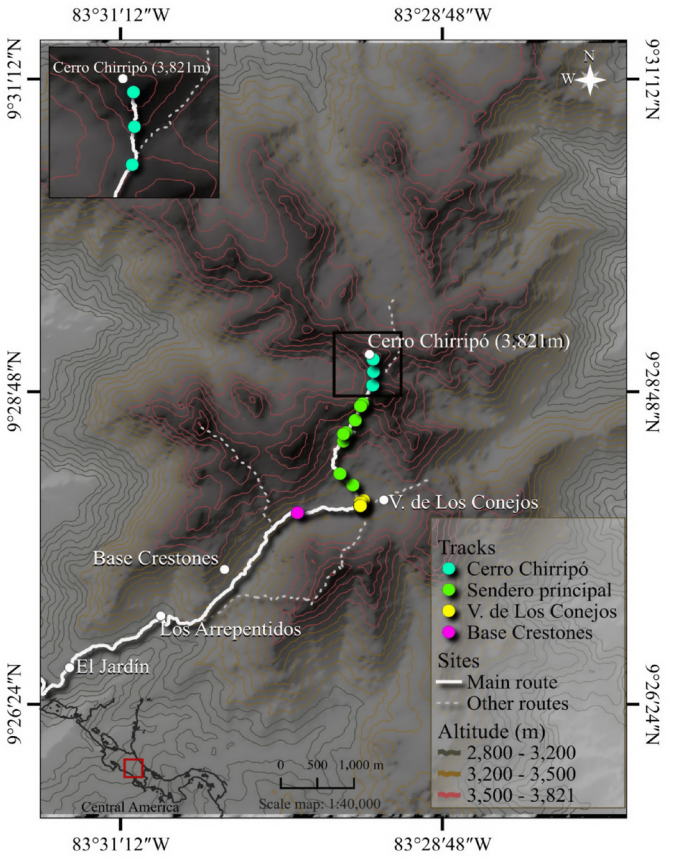

Figure 1. Map of the subalpine layer of Parque Nacional Chirripó, Costa Rica, with georeferenced traces of the coyote, *Canis latrans*.

scat morphology and contents (items consumed), identified *in situ*, were consistent with the descriptions reported. Traces were detected from the Base Crestones lodge, in Valle de Los Conejos, and on the trail leading to the top of Cerro Chirripó (Figure 1). However, the sources consulted reported previous sightings in the first 2 sectors, *i.e.*, El Jardín and Los Arrepentidos.

We confirmed the existence of coyote latrines in Valle de Los Conejos based on the information provided by a park ranger and documented in MNCR's Moorlands project. This site, located at approximately 3,470 m, was the only one where we observed groups of scats separated from each other by approximately 2 m (Table 1). The highest frequency of scats was observed between the Base Crestones lodge and Valle de Los Conejos, on trails located between 3,400 m and 3,550 m and between 3,600 m and 3,700 m, with a total of 10 and 8 scats in each altitudinal range, respectively. Above 3,700 m, only 4 coyote scats were observed, 3 of them at the highest altitude recorded in Costa Rica, 3,821 m, at the top of Cerro Chirripó (Table 1).

Regarding our survey about the reported *C. latrans* traces in México and Central America, we found a total of 9,499 records of *C. latrans* with valid geographic coordinates after downloading and cleaning data from GBIF and iNaturalist on August 26, 2024. Of these, 9,036 records (95 %) correspond to México since June 20, 1818, including fossils, preserved specimens, sightings, and traces. Costa Rica ranks

Table 1. Geographic location, altitude, and description of the traces of the coyote (ID), *Canis latrans*, found in the subalpine layer of the Parque Nacional Chirripó, Costa Rica, 2021. SM = no measurements. Photographs available at https://www.researchgate.net/publication/384244021_Figs2Rastrosconmediciones_Chirripo; *video available at https://www.researchgate.net/publication/384244019_Canislatrans_Chirripo.

ID	X	Y	Altitude (m)	Diameter (mm)	Size (mm)	Trail
a	83° 29' 52.857"	9° 27' 52.247"	3,440	18.03 – 27.94	78.48	Base Crestones
b	83° 29' 23.33"	9° 27' 57.996"	3,470	16.08 – 19.43	48.02 – 71.77	Valle de Los Conejos
c	83° 29' 24.691"	9° 27' 57.121"	3,471	SM	SM	Valle de Los Conejos
d	83° 29' 25.076"	9° 27' 55.494"	3,471	SM	SM	Valle de Los Conejos
e	83° 29' 25.026"	9° 27' 55.472"	3,473	SM	SM	Valle de Los Conejos
f	83° 29' 24.914"	9° 27' 55.39"	3,473	SM	SM	Valle de Los Conejos
g	83° 29' 24.716"	9° 27' 55.292"	3,473	21.85 – 28.94	112.29	Valle de Los Conejos
h	83° 29' 24.701"	9° 27' 55.472"	3,474	SM	SM	Valle de Los Conejos
i	83° 29' 28.064"	9° 28' 4.991"	3,490	22.97 – 26.69	83.43	Main trail
j	83° 29' 33.863"	9° 28' 10.2"	3,519	23.48 – 25.14	94.28 – 100.26	Main trail
k	83° 29' 31.099"	9° 28' 29.161"	3,625	SM	SM	Main trail
l	83° 29' 32.283"	9° 28' 25.151"	3,627	24.85 – 27.08	143.22	Main trail
m	83° 29' 32.316"	9° 28' 28.466"	3,636	SM	SM	Main trail
n	83° 29' 27.002"	9° 28' 34.846"	3,657	SM	SM	Main trail
o	83° 29' 24.64"	9° 28' 41.261"	3,687	SM	SM	Main trail
p	83° 29' 19.215"	9° 28' 50.941"	3,689	78.98	30.85	Main trail
q	83° 29' 23.726"	9° 28' 42.521"	3,692	SM	SM	Main trail
r	83° 29' 24.637"	9° 28' 41.394"	3,697	27.18 – 28.18	67.7 – 115.23	Main trail
s	83° 29' 18.851"	9° 28' 57.212"	3,722	SM	SM	Cerro Chirripó
t	83° 29' 19.01"	9° 29' 2.94"	3,821	22.64 – 23.65	90.91	Cerro Chirripó
*j	83° 29' 19.01"	9° 29' 2.94"	3,821	SM	SM	Cerro Chirripó
*k	83° 29' 19.01"	9° 29' 2.94"	3,821	SM	SM	Cerro Chirripó

second, with 296 reports (3 %) since July 11, 1967, including sightings, traces, and a single preserved specimen. The countries with scarce data are Panamá (n = 57) since May 4, 2019; Honduras (n = 41) since March 25, 1946; Guatemala (n = 37) since May 17, 1986; El Salvador (n = 17) since December 29, 1926; Belize (n = 10) since September 15, 2015; and Nicaragua (n = 5) since January 10, 1996 (Figure 3a-c). It should be noted that Guatemala, Honduras, and Nicaragua have records of sightings and preserved specimens; Belize and Panamá only have records of sightings; and for El Salvador the type of material is not indicated. For its part, data from the "Moorlands" (2004-2019) and "Ethnoecology of *C. latrans*" (2019-2023) research projects totaled 1,047 and 184 coyote records, respectively, from various altitudinal regions of Costa Rica, including sightings, footprints, scats, and vocalizations.

When considering the altitudinal levels of Holdridge (1978), it was observed that the reports collected from the platforms surveyed mainly correspond to the layer between the basal (0 m to 700 m) and montane (1,400 m to 2,800 m) levels. In the most mountainous countries, such as México, Guatemala, and Costa Rica, the reports cover all altitudinal levels, including subalpine (2,800 m to 3,879 m) and alpine (from 3,885 m to 4,578 m) areas, with records for the latter only in México (Figure 3a-c). In México, 32 % of the reports correspond to the basal layer, 17 % to the premontane, 46 % to the montane, and 4 % to the subalpine layers. At higher altitudes, above 4,000 m, reports are concentrated in areas near the Pico de Orizaba (4,578 m), the Popocatépetl Volcano (4,210 m), and the Nevado de Toluca (4,110 m; Figure 3a). For their part, Guatemala and Costa Rica have reports from the basal to the subalpine layers, while Honduras and Nicaragua have only for the montane layer. Guatemala has 36 % of the records on the basal floor, 25 % on the premontane, 21 % on the montane, and 18 % on the subalpine layers. Costa Rica has 31 % on the basal floor, 19 % on the premontane, 38 % on the montane, and 12 % on the subalpine layers. At the highest altitudes of Guatemala and Costa Rica, above 3,000 m, coyotes have been recorded in the vicinity of Todos Santos Cuchumatán in Guatemala at 3,700 m, and at several sites in Costa Rica located in the Central Volcanic Mountain Range (Volcán Irazú, 3,328 m) and Talamanca Mountain Range (Parque Nacional Chirripó) 3,535 m; Cerro de la Muerte, 3,362 m; Parque Nacional Tapantí, 3,223 m; Cerro Vueltas, 3,121 m). On the other hand, Belize, with a predominantly low terrain, and Panamá, with a varied relief, concentrate most reports on the basal floor. All the reports for Belize and 97 % of the reports for Panamá correspond to the basal floor.

In Costa Rica, *Canis latrans* is distributed from the basal layer to the subalpine layer at altitudes of up to 3,500 m (Vaughan 1983; Wainwright 2007; GBIF.org 2024; iNaturalist.org 2024). This study confirmed that in the PNC and Costa Rica, the coyote thrives more than 300 m above the altitudinal limit previously reported in the literature and biodiversity platforms. The present study reported a total

Figure 2. Photographs of scats of the coyote, *Canis latrans*, measured during the walk through the subalpine layer of the Parque Nacional Chirripó, Costa Rica: a) Base Crestones trail (3,440 m); b-c) Valle de Los Conejos (3,470 m–3,473 m); d-h) Main trail (3,490 m–3,697 m); i) top of Cerro Chirripó (3,821 m). The scale corresponds to the diameter of a 50-colon coin (27.5 mm).

of 23 new records above 3,500 m from MNCR's "Moorlands" project (n = 10) and this study (n = 13). Of the 13 traces recorded above 3,500 m in the present study, 3 were recorded at 3,821 m, the highest altitude in Costa Rica.

Although we did not find traces of coyotes below 3,400 m in El Jardín and Los Arrepentidos, the sources surveyed reported its presence in these areas. Local muleteers informed of sightings and traces 7 km off El Jardín. Furthermore, the MNCR has records of coyote scats in Los Arrepentidos, an area between El Jardín and the Base Crestones lodge. Our findings also coincide with previous MNCR records (footprints, scats, and sightings) in Valle de Los Conejos and adjacent trails in the Cerro Chirripó foothills and 100 m below its summit.

Although not all scats were measured, their visible components, degradation characteristics, and deposition sites supported their identification as *C. latrans* feces. In fact, a higher frequency of scat deposition halfway through narrow paths to increase its detectability by other conspecifics is more common for *C. latrans* than for *P. concolor* and other feline species (Harmsen *et al.* 2010; Barja and List 2014). Pumas have much larger home ranges than coyotes (Elbroch *et al.* 2017), which should affect the frequency of territorial marking across time and space. The other canid with scats similar to those of the coyote is the gray fox, *U. cinereoargenteus*, but these measure less than 10 cm (Chame 2003), and the presence of this canid has not yet been recorded by sighting or photo trapping in the PNC (SINAC, pers. comm., September 2024). However, the gray fox has been recorded by the MNCR at 3,440 m in the Irazú Volcano, in the Central Volcanic Mountain Range, approximately 68 km from the study area. Feral dogs are rare in the protected areas from which the records originate; however, they thrive in other areas of the country at lower altitudes (M. Aguilar and A. Mora, SINAC, pers. comm., September 2024). Given this information, we must be cautious of the possibility of a misidentification of the scats examined, as no genetic analyses were performed (Morin *et al.* 2016).

The availability of food, shelters, trails, and strategic defecation sites on the subalpine layer of the PNC is essential to understanding some ecological aspects of the coyote. Regarding food availability, the "Moorlands" project records of the rabbit *S. dicei* and field mice of the genus *Reithrodontomys* on trails between the Base Crestones lodge and Valle de Los Conejos and the presence of the mouse *S. xerampelinus* at the top of Cerro Chirripó

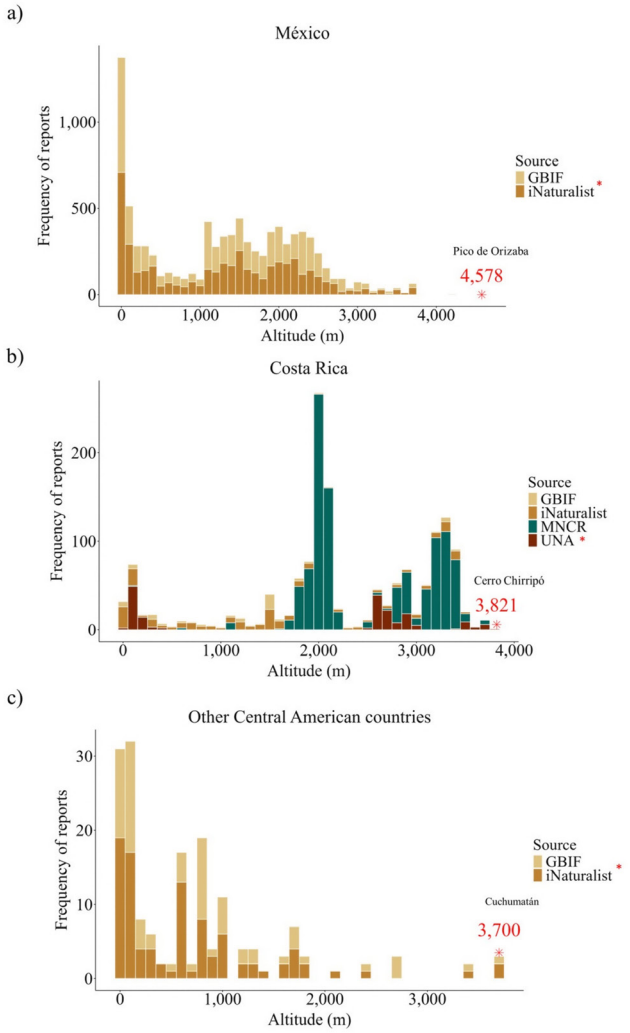

Figure 3. Graphs of frequency of *Canis latrans* reports from the GBIF and iNaturalist platforms and the projects "Ethnoecology of *C. latrans*" of the Universidad Nacional (UNA) and "Moorlands" of the Museo Nacional de Costa Rica (MNCR): a) for México; b) for Costa Rica; c) for other Central American countries.

(Mora *et al.* 2021) could be related to the presence of the coyote. The existence of small caves in the PNC rock system suggests the availability of shelters for coyotes. In addition, the sequence of traces recorded during the ascent and the behavior of the coyote, which marks its territory at visible sites that maximize the detectability of its odors (Chame 2003; Barja and List 2014), suggest that it is a trail commonly used by this canid.

The high daily movement capacity of the coyote is a common feature of omnivores with predominantly carnivorous habits and high aerobic resistance (Hancock and Hedrick 2018), which has likely contributed to its broad geographic distribution. In addition to this ability, the coyote exhibits behavioral adaptations that allow it to use different types of habitats (*e.g.*, open forests, mixed coniferous forests, and closed Abies-Picea forests) in deep-snow landscapes at high elevations in temperate latitudes (Dowd *et al.* 2014). Therefore, during its migratory movements through Mesoamerica, the coyote probably already had the adaptations required to reach the highest altitudes of mountainous regions, such as those of México, Guatemala, and Costa Rica.

This work gathered coyote records for México and Central America available from the GBIF and iNaturalist platforms, seeking to document the altitudinal range of this canid. We found that available data are relatively scarce (except for México), particularly for most altitudinal floors of Central America, with a prominent deficit for the subalpine layer. However, we found new coyote records above 3,500 m for the PNC and Costa Rica. Our findings suggest that this species could be more common in Central America than previously reported (Ordóñez-Garza *et al.* 2008; Méndez-Carvajal and Moreno 2014; Jones *et al.* 2020).

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Predation attempt of *Phyllostomus hastatus* on *Artibeus jamaicensis* in Panamá

Intento de depredación de *Phyllostomus hastatus* sobre *Artibeus jamaicensis* en Panamá

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The family Phyllostomidae includes the species *Phyllostomus hastatus*, which is distinguished by its large size and wide distribution; it is an omnivorous bat that feeds mainly on invertebrates and fruits. However, there are reports of predation on small vertebrates, such as bats, of which the cases documented in the scientific literature are usually few. Using 2 5-ring mist nets, 12 m long by 2.5 m wide, placed mainly at ground level on the banks of the Pedro Miguel River, in an area of secondary tropical lowland vegetation, captures were made by monitoring the abundance and richness of bats in Camino de Cruces National Park. On July 30, 2024, in Camino de Cruces National Park, Panamá, we reported a predation attempt by *P. hastatus* on *Artibeus jamaicensis*. To the best of our knowledge, this constitutes the first predator-prey interaction between both bats and highlights the opportunistic role of *P. hastatus* as a predator.

Key words: Behavior; Chiroptera; diet; foraging; omnivore; predation.

La familia Phyllostomidae incluye la especie *Phyllostomus hastatus*, que se distingue por su gran tamaño y amplia distribución; siendo un murciélago omnívoro que se alimenta principalmente de invertebrados y frutos. Sin embargo, existen informes de depredación de pequeños vertebrados, como murciélagos, de los que los casos documentados en la literatura científica suelen ser pocos. Por medio del uso de 2 redes de niebla de 5 anillos de 12 m de largo por 2.5 m de ancho, colocadas principalmente a nivel del suelo a orillas del río Pedro Miguel, en una zona de vegetación secundaria de tierras bajas tropicales, se realizaron capturas mediante el monitoreo de la abundancia y riqueza de murciélagos en el Parque Nacional Camino de Cruces. El 30 de julio de 2024, en el Parque Nacional Camino de Cruces, Panamá, reportamos un intento de depredación por parte de *P. hastatus* sobre *Artibeus jamaicensis*. Hasta donde es de nuestro conocimiento, esta constituye la primera interacción depredador-presa entre ambos murciélagos y resalta el papel oportunista de *P. hastatus* como depredador.

Palabras claves: Alimentación; Chiroptera; comportamiento; depredación; dieta; omnívoro.

Phyllostomus hastatus Pallas (1767), is a dark brown to reddish brown omnivorous species (Laval and Rodríguez-Herrera 2002) belonging to the subfamily Phyllostominae of the family Phyllostomidae (Wilson and Mittermeier 2019), considered the second largest bat in the Neotropical region (Taylor and Tuttle 2019). It is distributed from southern Belize and eastern Guatemala, through Central America to South America including Colombia, Venezuela, Ecuador, Perú, Bolivia, Paraguay and Brazil, also present on the islands of Margarita and Trinidad (Aguirre 2019; Kraker-Castañeda *et al.* 2023). It usually inhabits large colonies that can comprise up to more than 100 individuals inside caves, tree holes or abandoned houses in a wide variety of ecosystems ranging from primary to secondary forest and even in cultivated or disturbed areas from sea level to 1,800 m (McCracken and Bradbury 1981; Aguirre 2019).

It is known that due to its large size and weight ranging from 55 g to 140 g (Reid 2009; Aguirre 2019), *P. hastatus* requires a continuous supply of protein-rich food (Cortés-Delgado and Jimenéz-Ferbans 2014; Callejas *et al.* 2022). *Phyllostomus hastatus* tends to feed mainly on insects of the orders Orthoptera, Blattodea, Hymenoptera and Coleoptera (Santos *et al.* 2003), due to their larger body size and its exoskeletons composed of chitin rich in nitrogen and amino acids essential for protein synthesis (Meyer *et al.* 2011). *Phyllostomus hastatus* usually consumes fruits and many seeds of *Cecropia peltata* L. (Ascorra and Wilson 1992) and other plant species of the families Myrtaceae, Musaceae, Solanaceae, Anacardiaceae and Passifloraceae (Santos *et al.* 2003).

Although it is known that it can also feed on small vertebrates such as birds and mammals, including bats (Costa

et al. 2010), records of predation on bats by *P. hastatus* tend to be unusual to observe in the field, where most cases are probably not reported in the scientific literature because they do not present illustrative evidence (de Souza *et al.* 2020). Therefore, in this note we present a direct observation of a predation attempt by *P. hastatus* on an individual of the species *Artibeus jamaicensis* Leach, 1821.

Our observation takes place in Camino de Cruces National Park located north of Panamá City, Panamá Province, coordinates 9° 02' 17.0" N, 79° 36' 45.9 " W (Figure 1), has 4,950 ha of secondary vegetation of tropical lowland semi-deciduous type, quite intervened (ANAM 2010), there is an abundant presence of wild grasses *Saccharum spontaneum* in the surrounding area and a dominance of tree species such as *Anacardium excelsum*, *Cecropia peltata*, *Terminalia amazonia*, *Cedrela odorata*, *Swietenia macrophylla*, *Ficus insipida*, *Enterolobium cyclocarpum* and *Guazuma ulmifolia*. In general, the park is located between 30 to 150 m above sea level with slopes between 4° to 15°; average annual rainfall of 1,801 to 2,100 ml; average annual temperature of 26 °C and a tropical climate with a prolonged dry season (ANAM 2010). Captures were made by monitoring the abundance and richness of bats in the park using 2 12 m long 2.5 m wide 5-ring mist nets, placed mainly at ground level in open spaces between vegetation, ecotones and over shallow rivers and streams (Kunz *et al.* 2009).

On July 30, 2024, at 11:27 hr, around a gallery forest, between 5 and 7 m from the bank of the Pedro Miguel River, with an abundant presence of *Ficus insipida*, we report a predation attempt by *P. hastatus* on a 43 g female subadult individual of *A. jamaicensis* that was trapped in the net (Figure 2). The predator, which was previously located flying over the sampling point, pounced on the net, causing strong bites on the dorsum and rostrum of *A. jamaicensis* (Figure 3). However, due to the presence of the researchers, the entanglement of the *A. jamaicensis* and the fact that the area of the net could not support the weight of both specimens due to the struggle and was therefore damaged, the individual of *P. hastatus* finally flew away from the net (Figure 2). Minutes later another individual of *P. hastatus* was observed approaching and colliding with the net, but without making any specific attack. The attacked *A. jamaicensis* female died shortly thereafter, probably due to the bite on her face. The specimen of *A. jamaicensis* was not collected due to not having the necessary equipment for its conservation until the end of the field tour, the individual presented the following morphometric data: 60 mm (forearm), 76 mm (body), 12 mm (hind foot), 15 mm (ear).

It should be noted that, during the night and the predation event, it was observed that some individuals of *A. jamaicensis* and other species captured such as *Carollia perspicillata* (Linnaeus, 1758), *C. castanea* Allen, 1890

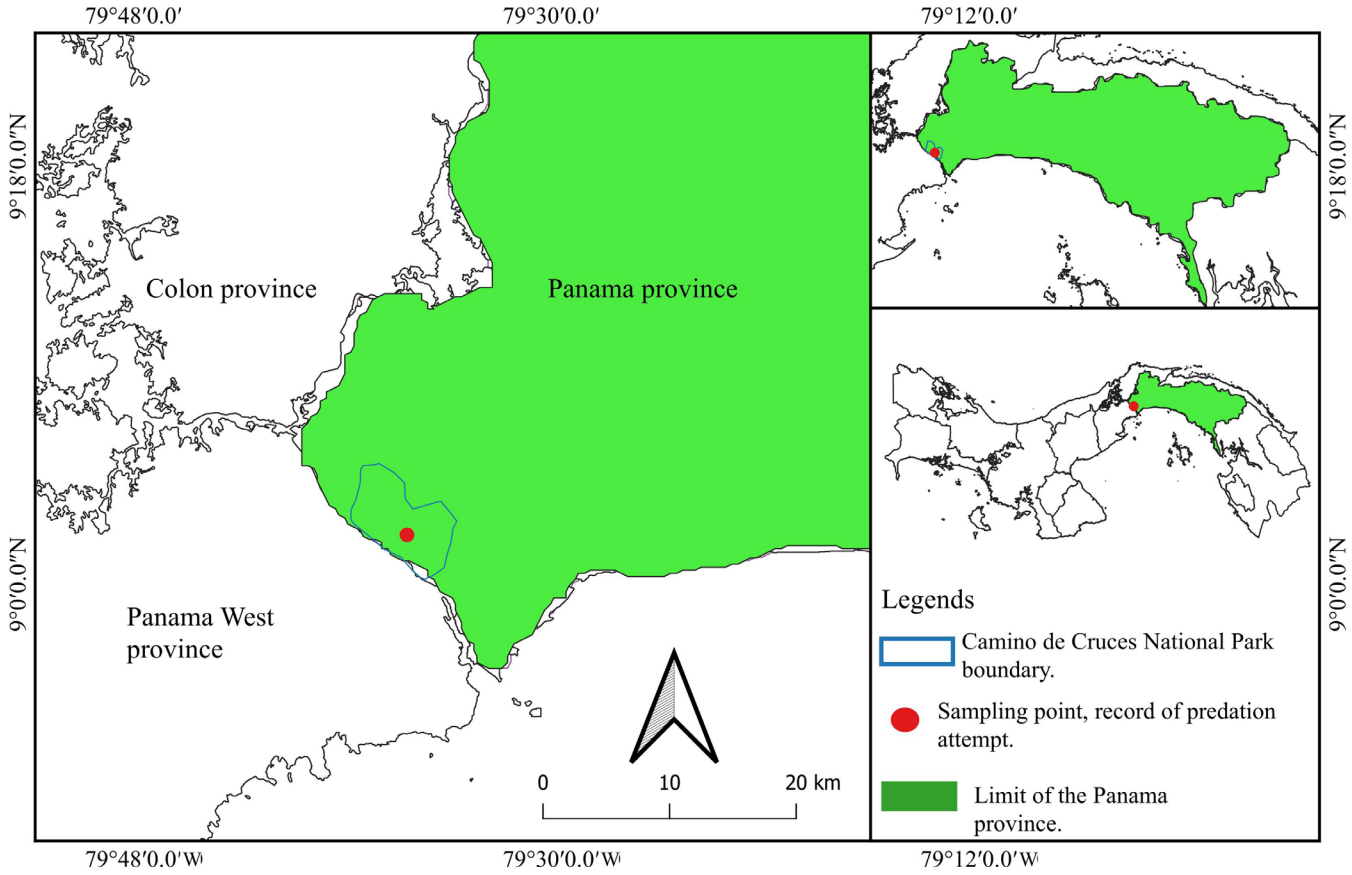

Figure 1. Recorded point of attempted predation (red point) of the greater spear-nosed bat, *Phyllostomus hastatus* on the Jamaican fruit bat, *Artibeus jamaicensis* in Camino de Cruces National Park, Panamá.

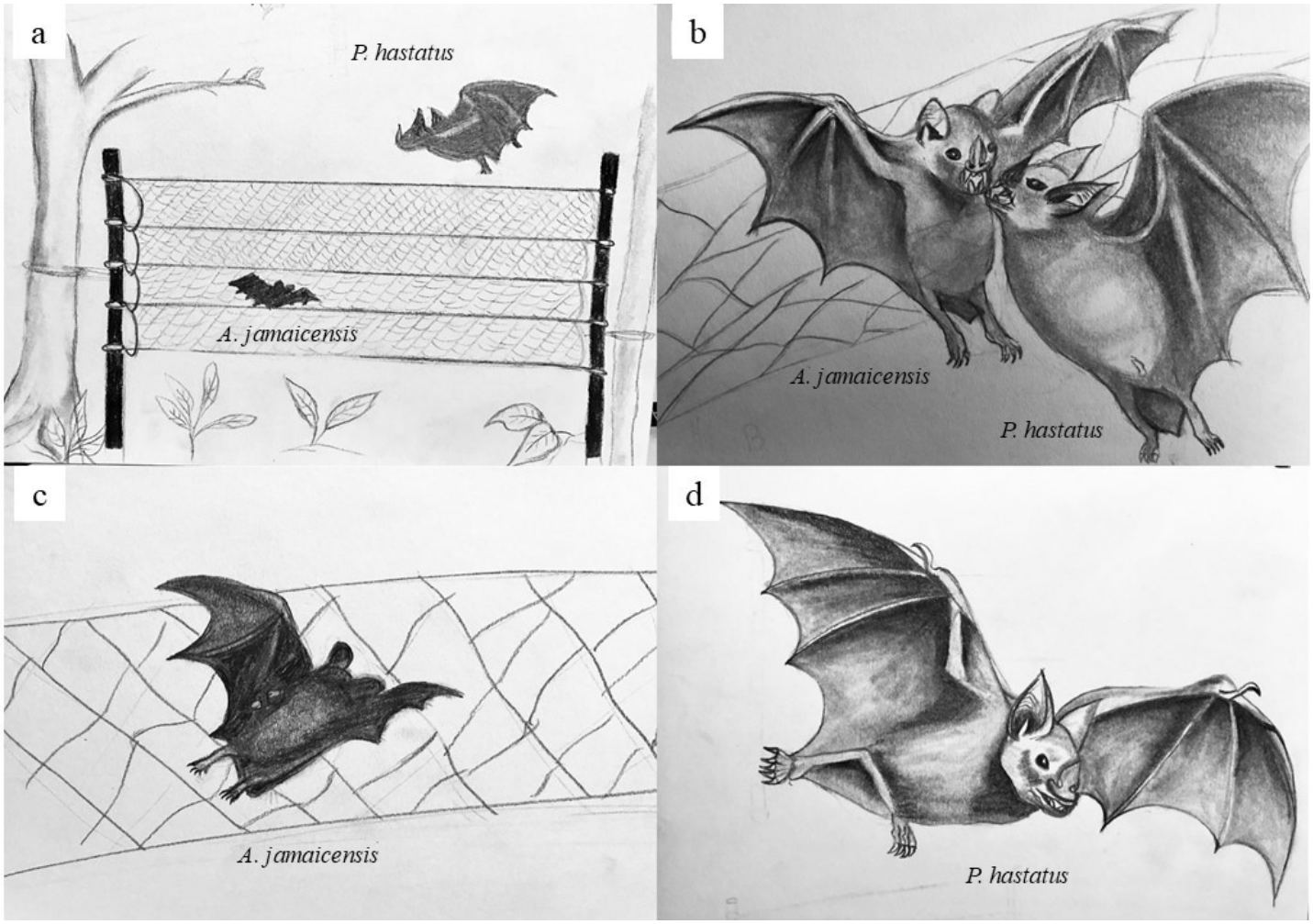

Figure 2. Interpretive drawing of predation attempt recorded in Camino de Cruces National Park, Panamá; sequence as described in the results section. a and b) Arrival in flight and attack of *Phyllostomus hastatus* on *Artibeus jamaicensis*; c) wounded *A. jamaicensis*; d) withdrawal of *P. hastatus*. Drawing author: H. Peralta.

and *Dermanura watsoni* (Thomas, 1901), emitted loud vocalizations for help. However, no attempts by *P. hastatus* towards these individuals were observed.

The individuals involved in the event were identified by means of the characters present in York *et al.* (2019) for the case of *A. jamaicensis* and by direct observation of the morphological aspect and large size described in Reid (2009) for the case of *P. hastatus*. Due to the spontaneous nature of the event and the lack of photographic equipment at the time, it was not possible to capture the attack by means of photographs; therefore, the description is presented by means of illustrative drawings.

It is known that *P. hastatus* can prey on other small bats, smaller than 50 g both in the field and in captivity (Nowak 1999), especially those that are often found associated with the same roosts, such as *Molossus molossus* Pallas (1766) and *M. rufus* Geoffroy (1805) (McNab 2003). However, the first observation of this behavior in the wild was reported by de Souza *et al.* (2020), who describe a predation event of *P. hastatus* on *C. perspicillata* in an abandoned house in the municipality of Paraúna, Goiás, Brazil.

On the other hand, so far, this predatory behavior by *P. hastatus* towards other smaller bat species trapped in mist nets had been previously reported by Oprea *et al.* (2006), which recorded 4 predation events involving 2 individuals of *Glossophaga soricina* Pallas (1766), 1 of *Carollia perspicillata* and 1 of *Myotis nigricans* Schinz (1821) in Southeastern Brazil. Apparently, although predation by carnivorous species on other bats captured in mist nets seems to be a rare event, it can be repeated on several occasions; for example, Nogueira *et al.* (2006) observed a similar case of predation of *C. perspicillata* by *Chrotopterus auritus* Peters (1856) in southwestern Brazil. In another case Guevara *et al.* (2022) reported an attempted predation on nets of *Eptesicus furinalis* D'Orbigny and Gervais (1847) by *Phyllostomus discolor* Wagner (1843) in eastern Panamá. According to Bigai and Faria (2018), bats trapped in mist nets are easy prey not only for predatory bats, but also for a range of other mammalian animals such as felids, canids, and marsupials; and birds such as night herons and owls.

According to de Souza *et al.* (2020), although the data and literature do not suggest that this behavior in *P. hastatus* is common, it can be assumed that this species may be an opportunistic consumer of small bats, attacking incapacitated adults, neonates and juveniles with limited flight capabilities, and probably bats within roost (Oprea

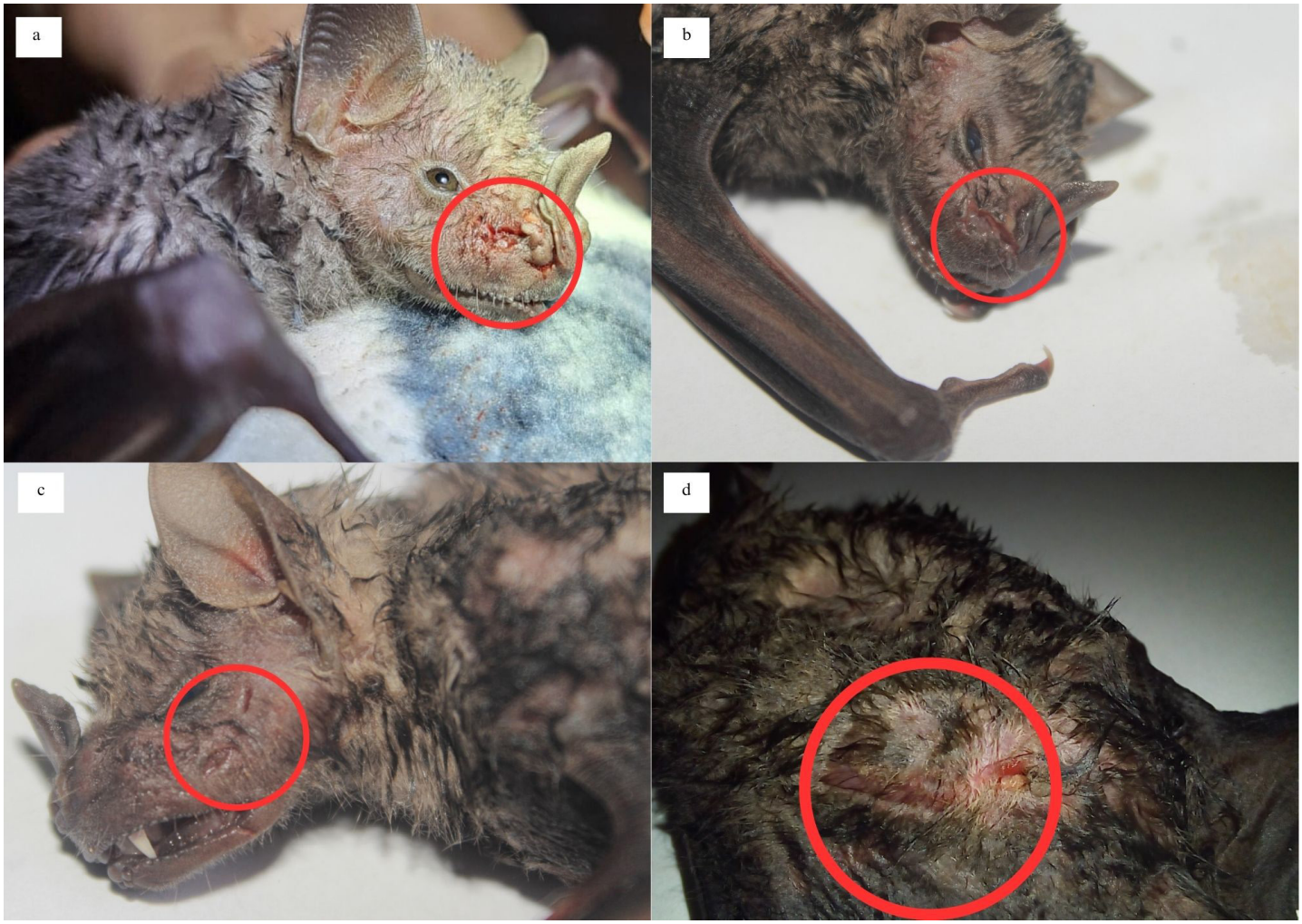

Figure 3. Wounds caused by the bites of *Phyllostomus hastatus* on different parts of the body of *Artibeus jamaicensis*. a and b) Right side of the rostrum; c) left side of the rostrum; d) lower dorsal area, left side.

et al. 2006). In Panamá, the specific diet of *P. hastatus* in different ecosystems is unknown, so future studies based on the stomach contents of the species may shed light on which other vertebrates or common bats of similar size to *A. jamaicensis* such as *C. perspicillata* or genera such as *Vampyrodes* and *Molossus*, are potential prey for this opportunistic predator.

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Two new vertebrate prey species in the diet of the agouti, *Dasyprocta punctata*, recorded in the highlands of Costa Rica

Dos nuevas especies de vertebrados en la dieta de la guatusa, *Dasyprocta punctata*, registradas en las tierras altas de Costa Rica

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The Central American agouti, *Dasyprocta punctata*, has traditionally been considered an herbivore, primarily feeding on fruits and seeds. However, there are reports of this rodent consuming 3 vertebrate species: a mouse (in captivity), a bird, and a worm lizard. In this study, we add 2 new vertebrate species to the diet of the agouti: a bird and a mammal. We conducted research and led natural history tours in the Monteverde region of Costa Rica. Monteverde is well-known for its biological reserves and ecotourism activities. The villages of Monteverde and Santa Elena are situated within the Tropical Montane Cloud Forest, a relatively narrow elevational band with frequent cloud cover throughout much of the year. On 2 separate occasions, we observed agoutis preying on vertebrate species in Monteverde. On June 8, 2023, we saw an adult agouti with a juvenile nine-banded armadillo, *Dasypus novemcinctus*, in its mouth. On July 12, 2024, we observed another agouti pursuing and consuming 2 chicks of the black-breasted wood-quail, *Odontophorus leucolaemus*. These 2 new prey items suggest the opportunistic carnivorous tendencies of the agouti. It appears to capture young animals that do not pose a significant threat or require considerable effort to catch, nor do they cause collateral damage. In this way, the agouti obtains some essential nutrients that it does not get from its usual plant-based diet during lean times.

Key words: Birds; mammals; Monteverde; opportunistic; predation.

La guatusa centroamericana, *Dasyprocta punctata*, ha sido tradicionalmente considerada un herbívoro, alimentándose principalmente de frutos y semillas. Sin embargo, existen informes de este roedor consumiendo 3 especies de vertebrados: un ratón (en cautiverio), un ave y una lagartija gusano. En este estudio, añadimos 2 nuevas especies de vertebrados a la dieta de la guatusa: 1 ave y 1 mamífero. Llevamos a cabo investigaciones y guiamos tours de historia natural en la región de Monteverde, Costa Rica. Monteverde es bien conocido por sus reservas biológicas y sus actividades de ecoturismo. Los poblados de Monteverde y Santa Elena están situados dentro del Bosque Nuboso Tropical Montano, una franja altitudinal relativamente estrecha con cobertura de nubes frecuente durante gran parte del año. En 2 ocasiones separadas, observamos guatusas depredando especies de vertebrados en Monteverde. El 8 de junio de 2023, vimos a una guatusa adulta con un armadillo de nueve bandas juvenil, *Dasypus novemcinctus*, en la boca. El 12 de julio de 2024, observamos a otra guatusa persiguiendo y consumiendo 2 polluelos de la codorniz serrana pechinegra, *Odontophorus leucolaemus*. Estos 2 nuevos ítems de presa sugieren tendencias carnívoras oportunistas de la guatusa. Parece ser que este roedor captura animales jóvenes que no representan una amenaza significativa ni requieren un esfuerzo considerable para ser capturados, ni causan daños colaterales. De esta manera, la guatusa obtiene algunos nutrientes esenciales que no obtiene de su dieta habitual basada en plantas durante tiempos de escasez.

Palabras clave: Aves; depredación; mamíferos; Monteverde; oportunista.

The diets of animals reveal their adaptations and ecological roles, making dietary analysis crucial for ecological, evolutionary, and paleo-biological research (Verde Arregoitia and D'Elía 2021). While trophic levels offer a broad perspective on diet, detailed dietary data at a finer scale are essential for a deeper understanding of ecology and natural history (Verde Arregoitia and D'Elía 2021).

Rodents are the most diverse order of mammals, with over 2,600 species described (ASM 2024). This order spans a wide spectrum of body sizes and showcases remarkable diversity in feeding ecology (Verde Arregoitia and D'Elía 2021). Rodents, in fact, constitute the most diverse group of mammals, exhibiting extraordinary ecomorphological diversification that is closely tied to their varied diets and locomotor behaviors (Kay and Hoekstra 2008).

Most rodents have a diet that combines vegetation, seeds, and arthropods (Landry 1970). Strictly carnivorous diets are rare among this order (Merritt 2010). For instance, while murids are generally opportunistic feeders, some have developed specialized carnivorous diets, such as the amphibious Indo-Pacific water-rats, *Hydromys* (Fabre *et al.* 2017). In the Americas, grasshopper mice (3 species of *Onychomys*) are obligate carnivores, primarily feeding on arthropods but also preying on lizards and other rodents like *Perognathus*, *Peromyscus*, and *Microtus* (Rosas Zaragoza and Hernández Canchola 2024).

Larger rodents predominantly rely on vegetation. For example, all Hystricomorphs are primarily or mainly herbivorous, although some may opportunistically include insects and other animal items in their diet (Wilson *et al.* 2016). While most Echimyidae feed on fruits, some, like *Proechimys*, include fungi in their diet, and others, like *Thrichomys*, primarily feed on arthropods but also include plant parts (Fabre *et al.* 2016). Some Hutias, such as *Capromys pilorides*, eat mollusks, insects, shoals of dead seafood including crustaceans and fish, and even lizards (Fabre *et al.* 2016). Lizards, therefore, are one of the few vertebrates reported as food for Hystricomorphs. However, Dasyproctidae have been reported to exhibit a high degree of omnivory (Gilbert and Lacher Jr. 2016). Despite this, a preference for fruit consumption is widespread among Neotropical rodents (Fabre *et al.* 2016).

The Central American agouti, *Dasyprocta punctata* Gray, 1842 (Dasyproctidae), is found from southern México to northern and western Colombia, western Venezuela, and northwestern Ecuador (Mora 2000). In Costa Rica, it is distributed throughout most of the country, primarily in warm forests on both the Pacific and Caribbean slopes up to 2,743 m (Mora 2000; Marín *et al.* 2020). The agouti inhabits a variety of environments, including dry, gallery, humid, and secondary forests, as well as orchards, gardens, and plantations (Emmons 2016; Reid and Gómez Zamora 2022).

The Central American agouti primarily has an herbivorous diet, consisting mainly of seeds, fruits and seedling cotyledons (Jansen *et al.* 2012; Gilbert and Lacher Jr. 2016). Occasionally, it also consumes flowers, leaves, fungi, and insects, especially when fruit supplies are low (Emmons 2016). The agouti's diet is diverse, occasionally including flowers, leaves, fungi, and insects, especially when fruits are scarce (Emmons 2016). It may browse on leaves when fruit availability is low, and in captivity, it has been observed eating carrots, potatoes, and cassava (Smythe 1978). The agouti does not show strong dietary selectivity, likely optimizing foraging efficiency by remaining flexible in its food choices (Eberhart 2006). However, food seasonality influences its home range and social behaviors, with larger ranges observed in response to fluctuating food availability (Aliaga-Rossel *et al.* 2008; Emsens *et al.* 2013).

Additionally, there are reports of agoutis preying on a mouse in captivity in Panamá (reported as *Heteromys pictus* by Smythe 1978), a clay-colored thrush, *Turdus grayi*, in the wild in Costa Rica (Ramírez Calvo *et al.* 2018), and a worm lizard, *Amphisbaena alba*, in Colombia (Cáceres-Martínez *et al.* 2020). While its primary diet includes fruits and seeds, its role as both a seed disperser and seed predator is well-recognized and has significant implications for the regeneration and succession processes of Neotropical forests (Smythe 1978; Hallwachs 1986; Wright and Duber 2001; Jansen *et al.* 2012; Patton and Emmons 2015; Cáceres-Martínez *et al.* 2020).

Despite extensive research on mammals, diet data for specific species can vary significantly in detail and coverage (Verde Arregoitia and D'Elía 2021). In this study, we present 2 new vertebrate species identified as prey for the Central American agouti.

During our routine ecotourism and research activities in the Monteverde region of the Tilarán mountain range, Costa Rica, we observed 2 predation events involving the Central American agouti. During a casual walk, we observed an agouti preying on a small mammal on the property of Hotel El Establo, Monteverde (10° 18' 49" N, 84° 48' 56" W; 1,415 m; Figure 1). During a birdwatching tour, we found another agouti feeding on a bird along the Alondra trail in the Curi-Cancha Reserve, Monteverde (10° 18' 30" N, 84° 48' 13" W; 1,500 m; Figure 1).

Monteverde is a well-known area for ecotourism in Costa Rica (Nadkarni and Wheelwright 2000). The villages of Monteverde and Santa Elena are located within the Tropical Montane Cloud Forest, a relatively narrow elevational zone with frequent cloud cover throughout much of the year (Nadkarni and Wheelwright 2000). The vegetation in Monteverde consists of an evergreen forest with a few deciduous species, particularly on the Pacific slope, and is noted for its moderate epiphyte diversity and abundance (Haber 2000).

On June 8, 2023, we observed an agouti walking with an animal hanging from its mouth. We followed the agouti and took photographs. After the agouti dropped the prey, we inspected it closely and identified it as a young nine-banded armadillo, *Dasypus novemcinctus* (Linnaeus, 1758; Figure 2a). The armadillo was dead and showed wounds inflicted by the agouti's teeth (Figure 2c).

On July 12, 2024, at 08:47 hr, we heard the alarm call of the black-breasted wood-quail, *Odontophorus leucolaemus* Salvin, 1867. A female and 4 chicks were seen running from an agouti that was chasing them, but we lost sight of them as they moved into the forest. However, a few minutes later, we spotted the agouti again. This time, the agouti was consuming a chick, with only the feet visible (Figure 2b). After finishing the first chick, it grabbed another one that was beside it and consumed it as well.

We identified 2 new animal prey items in the diet of the Central American agouti: chicks of the black-breasted wood-quail and a juvenile nine-banded armadillo. Traditionally, the food habits of the Central American agouti have been described as primarily herbivorous, with a diet consisting mainly of seeds and fruits (Jansen *et al.* 2012; Cáceres-Martínez *et al.* 2020). When fruit supplies are low,

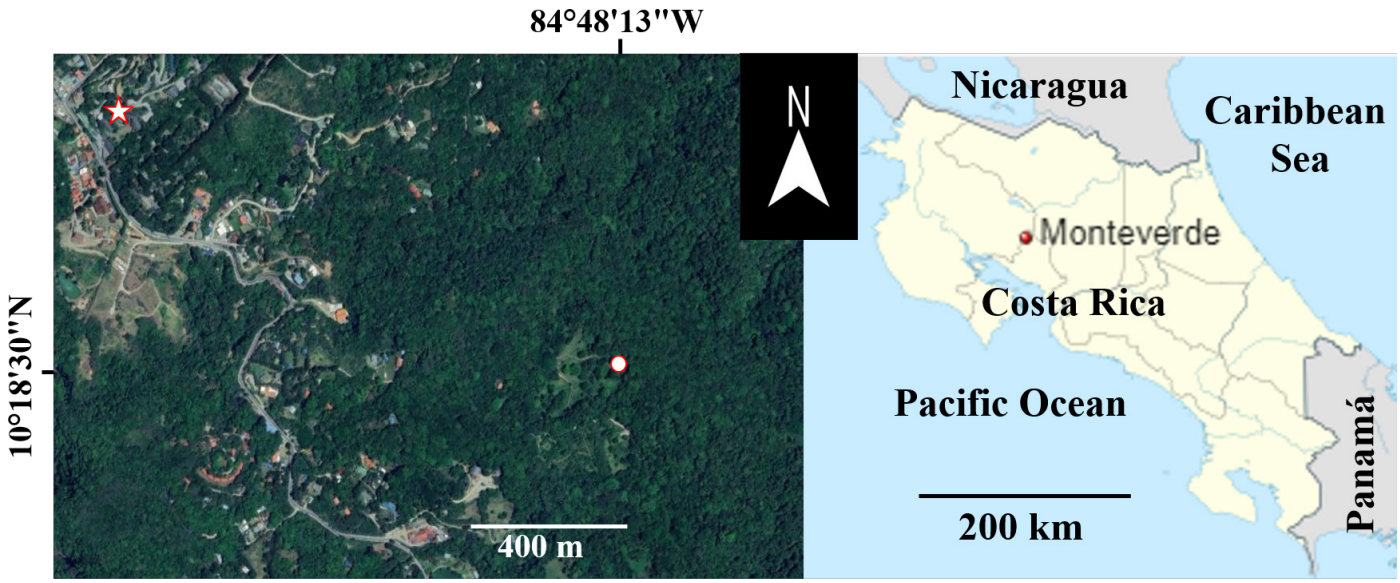

Figure 1. Locations where 2 Central American agoutis, *Dasyprocta punctata*, were observed preying on a juvenile nine-banded armadillo, *Dasypus novemcinctus* (white star), and a black-breasted wood-quail, *Odontophorus leucolaemus* (white dot), in Monteverde (indicated by the red dot on the map of Costa Rica). The figure is based on Google Earth (left section) and Wikipedia, under the Creative Commons Attribution-ShareAlike 3.0 license (right section).

small amounts of plant material and fungi are also included (Emmons 2016). However, there are reports of this rodent preying on and consuming animal prey, including a mouse in captivity, a clay-colored thrush, and an amphisbaenian (Smythe 1978; Ramírez Calvo *et al.* 2018; Cáceres-Martínez *et al.* 2020). This further illustrates that the diets of terrestrial mammals are often more complex than the simple classifications of herbivore, omnivore, or carnivore (Pineda-Munoz and Alroy 2014).

Notably, the clay-colored thrush, like the black-breasted wood-quail chicks and the juvenile nine-banded armadillo, was a young individual. This type of prey (young animals) does not pose a significant threat or require considerable effort to capture, nor does it result in collateral damage (Ramírez Calvo *et al.* 2018). The ease of capture is often a critical factor for small vertebrates that are not specialized in preying on other vertebrates when deciding whether to exploit predation opportunities (Acosta and Morún 2014; Ramírez Calvo *et al.* 2018).

The reported cases suggest that the Central American agouti actively pursues and captures animal prey. For instance, a male agouti, after moving stealthily, suddenly pounced on a clay-colored thrush chick, capturing it with its front paws and then killing it with its incisors (Ramírez Calvo *et al.* 2018). In the case of the amphisbaenian, the agouti paused, then swiftly snapped at the ground, detecting and capturing the worm lizard with its mouth (Cáceres-Martínez *et al.* 2020). Although we did not observe the agouti capturing the armadillo, its cadaver showed signs of incisor marks (Figure 2c). The agouti definitely pursued and killed the quail chicks.

These predation events may reflect the agouti's opportunistic behavior, taking advantage of available food resources (Ramírez Calvo *et al.* 2018). These last authors noted that the agouti follows monkey troops to consume the fruits they drop, as reported by Smythe (1978). While animal prey might be difficult to obtain given the agouti's primarily terrestrial and herbivorous habits, such prey would represent a valuable source of protein and fats, as they are known to consume in captivity (Ramírez Calvo *et al.* 2018).

During season of fruit scarcity, the Central American agouti consume roots and crabs (Smythe 1978). During fruiting seasons, the diet comprises around 37 % fruit pulp and 44 % seeds, supplemented with other plant and animal matter (McWilliams 2009). In the off-season, it relies on cached seeds, roots, and various plant and animal sources (McWilliams 2009). Agoutis may take advantage of easy preys during these fruit shortage times, explaining its predatory behavior.

Some species also exhibit specific behaviors to counteract the metabolic loss of sodium, chloride, and potassium ions (Denton 1982). This phenomenon is particularly evident among herbivores, as the naturally low sodium content in plant tissues often fails to meet their nutritional needs (Lundquist and Varnedoe Jr. 2006). For instance, Hoffmann's two-toed sloth, *Choloepus hoffmanni*, ingests sand for salt (Durán-Apuy and Mora 2023), and the herbivorous mountain tapir, *Tapirus pinchaque*, in Colombia drinks mineral-rich water at salt licks (Lizcano and Cavelier 2004). Some primates also occasionally consume small vertebrates and bird eggs to obtain additional nutrients (Nowak 1999).

Understanding the dietary habits of species is crucial for assessing functional diversity, evolutionary patterns, and the ecological roles they play (Verde Arregoitia and D'Elía 2021). The diet data of vertebrates, including

those from species previously considered strictly herbivorous, offer valuable insights into their niches and can significantly inform conservation and management strategies (González-Maya *et al.* 2017; Grossnickle *et al.* 2019). Despite the challenges inherent in characterizing diets due to complex foraging patterns (Ungar 2010; Nielsen *et al.* 2018), recent findings on the Central American agouti reveal its opportunistic feeding behaviors, including predation on small vertebrates. Such observations underscore the importance of considering cryptic trophic traits in herbivorous species and contribute to a more comprehensive understanding of their ecological roles (Cáceres-Martínez *et al.* 2020).

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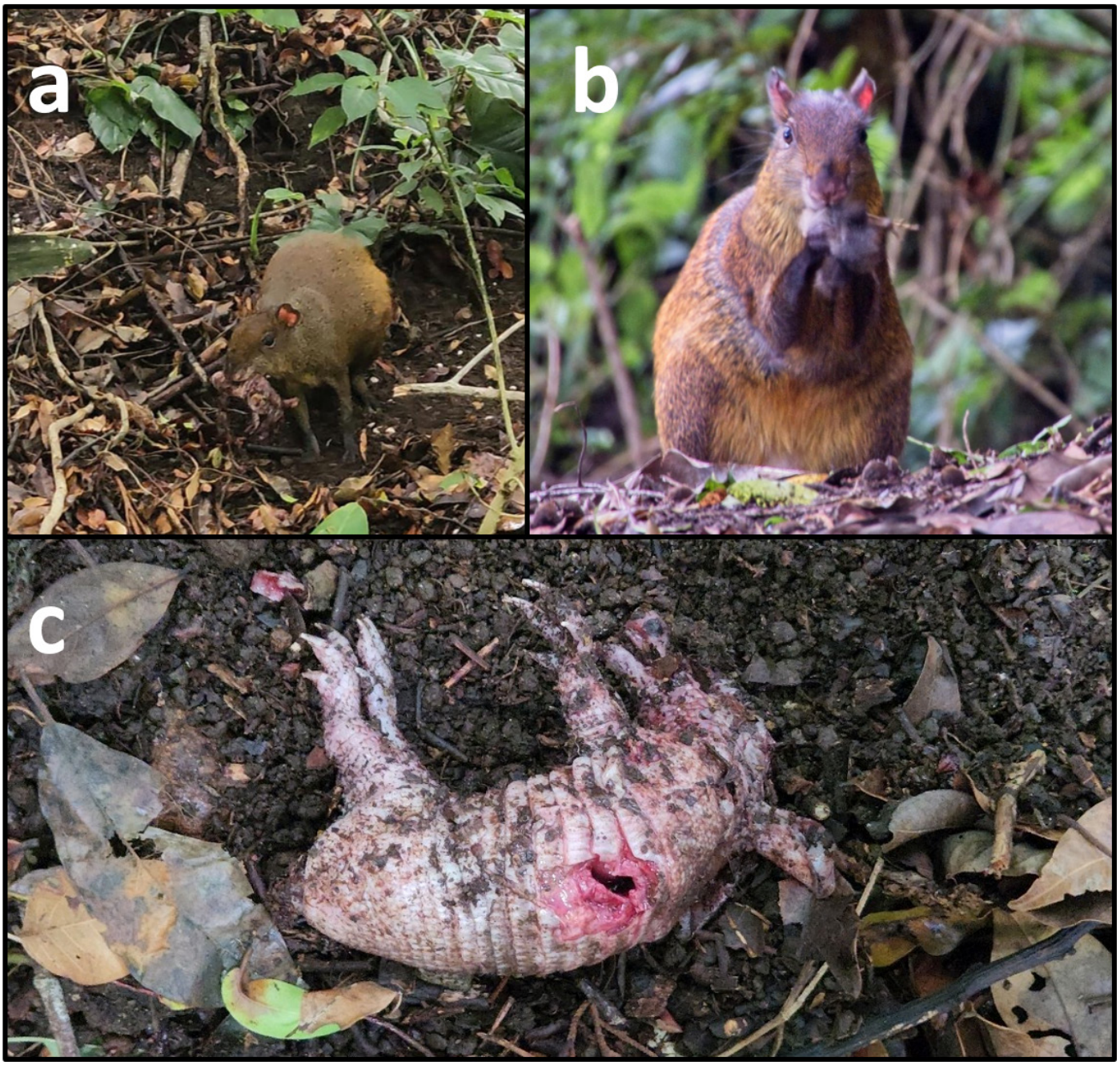

Figure 2. a) A Central American agouti, *Dasyprocta punctata*, with a young nine-banded armadillo, *Dasypus novemcinctus*, in its mouth. b) A Central American agouti consuming a chick of the black-breasted wood-quail, *Odontophorus leucolaemus* (photo by N. Gupte). c) The young armadillo dropped by the agouti. Images available at josemora07@gmail.com.

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The Sinaloan mastiff bat (*Molossus sinaloae*) is indeed found in Sinaloa, México

El murciélago mastín de Sinaloa (*Molossus sinaloae*) está presente en el estado de Sinaloa, México

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Research on *Molossus sinaloae* reflects challenges in its taxonomy due to its wide geographic distribution. Despite its scientific name referencing the state of Sinaloa, México, its presence there has been questioned due to its inhabitation of xerophytic vegetation, contrasting with the typical mountain habitat. In the winter of 2023, 2 specimens of *M. sinaloae* were opportunistically collected in northern Sinaloa. Subsequently, their taxonomy was reviewed, and morphological measures were taken. Records of Sinaloan mastiff bat presence in northern México were analyzed by comparing data from scientific collection databases. We collected 2 adult individuals of *M. sinaloae*, 1 male and 1 female, in the city of Los Mochis, Sinaloa, México. These records are the northernmost ever recorded for the species and support a range expansion of ~ 463 km north of its current known distribution. Our analysis of the species most recent records in México evidence that *M. sinaloae* is commonly distributed in the Pacific Coastal Plain. The new reported records suggested that *M. sinaloae* is not limited by geographic barriers. The biogeographical importance of the Nearctic region is highlighted by our documentation of the Sinaloan mastiff bat, unobserved in Sinaloa, México, for close to 90 years.

Key words: Ecotonal zone; geographic extension; Molossidae; Pacific Coastal Plain; taxonomy.

Las investigaciones sobre *Molossus sinaloae* reflejan desafíos en su taxonomía debido a su amplia distribución geográfica. A pesar de que el nombre científico de la especie hace referencia al estado de Sinaloa, México, su presencia en éste ha sido cuestionada por habitar vegetación xerófila, contrastante con el típico de montaña. En el invierno de 2023, se registraron 2 ejemplares de *M. sinaloae* en el norte de Sinaloa. Posteriormente, se revisó su taxonomía y se tomaron medidas morfológicas. Se analizaron registros de la presencia del murciélago mastín de Sinaloa en el norte de México comparando registros en bases de datos de colecciones científicas. Nosotros colectamos 2 individuos adultos de *M. sinaloae*, 1 macho y 1 hembra, en la ciudad de Los Mochis, Sinaloa, México. Estos registros son los más septentrionales jamás documentados para la especie y respaldan una expansión de su rango de distribución de ~ 463 km al norte de su distribución conocida actual. Nuestro análisis de los registros más recientes de la especie en México evidencia que *M. sinaloae* se distribuye comúnmente en la Planicie Costera del Pacífico. Los nuevos registros reportados sugieren que *M. sinaloae* no está limitada por barreras geográficas. La importancia biogeográfica de la región Neártica se destaca documentando al murciélago mastín de Sinaloa, que no se había observado en Sinaloa, México, durante casi 90 años.

Palabras clave: Extensión geográfica; Molossidae; Planicie Costera del Pacífico; taxonomía; zona ecotonal.

The Sinaloan mastiff bat (*Molossus sinaloae*) is a medium-sized aerial insectivore bat (Schnitzler and Kalko 2001). The foraging behavior of the species may pose a challenge for capturing it through traditional bat collection methods, such as mist nets, since it may detect them or fly above them (Flaquer *et al.* 2007). *Molossus sinaloae* primarily inhabits evergreen forests, dry deciduous forests, and grasslands (Jennings *et al.* 2002). The northernmost records of the species are in the southern region of the state of Sinaloa, in the Pacific coast of México, with its range extending throughout central and southern México, to countries including Trinidad and Tobago, Guyana, Suriname, French Guiana, and Colombia (Jennings *et al.* 2002).

The Sinaloan mastiff bat is a polytypic species with 2 subspecies; *M. sinaloae sinaloae* and *M. s. trinitatus* (Dolan 1989; Simmons and Voss 1998; Jennings *et al.* 2002). In *M. sinaloae trinitatus*, the anterior border of the interpterygoid fossa does not reach a line crossing the posterior edge of the upper molars, whereas in *M. s. sinaloae*, this border extends beyond this line (Goodwin 1959; Goodwin and Greenhall 1964).

The species *M. sinaloae* was described in 1906 based on an adult female deposited in the American Museum of Natural History (AMNH 2452) from Escuinapa, Sinaloa, México (22° 42' 19.746" N, 105° 48' 44.7768" W; Figure 1). The holotype (AMNH 2452) was collected in an area with seasonally

dry tropical forest vegetation. Three specimens were collected in 1935 near the locality of Cacalotán, approximately 30 km north of Escuinapa, in the same vegetation type, these records represent the latest reported for the state of Sinaloa, México (GBIF 2024).

In the state of Sinaloa, *M. sinaloae* is associated with subtropical vegetation characterized by thorny shrubs and cacti, predominantly dominated by Mimosaceae and columnar cacti. The species has also been found associated with xerophytic thorn forests, cultivated fields of agave (Birney *et al.* 1974), and tree-lined streams (Watkins *et al.* 1972). It has even been recorded inhabiting the leaves of coconut palms in various regions of México (de la Torre 1955; Lukens and Davis 1957; Goodwin 1959). The species has often been found roosting in houses and other man-made structures throughout its distribution (Jennings *et al.* 2002).

The species has been also registered to inhabit the coastal and montane areas of the Pacific region of Jalisco (Watkins *et al.* 1972). The species seems to be common in the seasonally dry tropical forests of the Mexican Pacific coast from Sinaloa to Chiapas, México. The most recent records of the species are in the states of Sinaloa, Nayarit, Jalisco, Colima, Michoacán, Guerrero, Estado de México, Morelos and Puebla (Álvarez 1968; Álvarez-Castañeda 1996; Orozco-Lugo *et al.* 2014; GBIF 2024; Figure 1). This study confirms the presence of *M. sinaloae* in the northernmost region of the state of Sinaloa, expanding the geographic distribution range for the species in the Pacific Coastal Plain in northwest México.

During the winter of 2023, 2 adult bats, 1 male and 1 female, of the species *M. sinaloae* were opportunistically collected in an anthropized environment within the Instituto Tecnológico de Los Mochis, located at an altitude of 26 m, the specimens were found dead beneath a black olive tree (*Terminalia buceras*). They were prepared as museum specimens (dry skin, skull and postcranial skeleton extracted) and deposited in the Colección de Mamíferos, Universidad Autónoma de Nuevo León (collection numbers UANL 4320, male, and UANL 4321, female). Muscle tissue samples were extracted and preserved in Eppendorf tubes with ethanol 96 %. The specimens were identified to species level following the taxonomic keys of Medellín *et al.* (2008) and Álvarez-Castañeda *et al.* (2017).

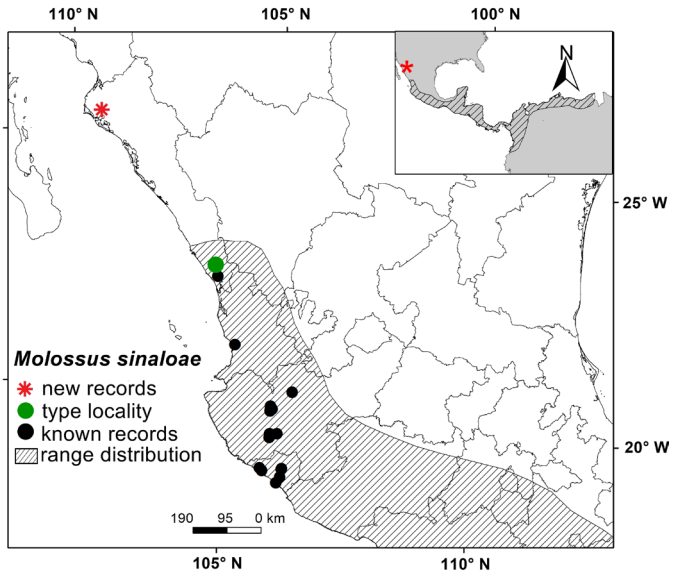

Figure 1. Map of the known distribution of *Molossus sinaloae*. The red asterisk represents the new records for the species. The green dot corresponds to the type locality, and the black dots represent records of specimens from the states of Sinaloa, Nayarit, Jalisco, Colima, Michoacán, Guerrero, Estado de México, Morelos and Puebla deposited in scientific collections. Distribution area of the species in other states is represented by the shaded area according to Miller *et al.* (2016).

Previous records of *M. sinaloae* in México were checked in the VertNet database (www.vertnet.net) and GBIF (GBIF 2024). Measurements of the specimens were taken with a caliper to the nearest mm in the external characters and to the nearest tenth of mm in the cranial characters. Measurements were compared with those of Mesoamerican populations available in the literature (Dolan 1989; Álvarez-Castañeda 1996; Jennings *et al.* 2002; Orozco-Lugo *et al.* 2014).

The 2 adult bats, 1 male and 1 female, of the species of *M. sinaloae* were opportunistically collected in the city of Los Mochis, at the facilities of the Instituto Tecnológico de Los Mochis, in the municipality of Ahome Sinaloa, México (25° 52' 52.32" N, 109° 9' 39.96" W, 26 m). The male individual was slightly bigger than the female. The body and craneal measures of the specimens here reported fall within the range of previous reports in México, Honduras and Costa Rica (Table 1; Figure 2). The fur of both specimens is dark brown opaque on the dorsal side (Figure 3), with a two-toned coloration at the base of the ventral part.

According to our review of previous records of *M. sinaloae*, our records here reported represent the northernmost locality for *M. sinaloae*. The previous northernmost record was the holotype specimen of *M. sinaloae* (AMNH 2452) from Escuinapa, in the south of the state of Sinaloa, México. The new records expand the known distribution of the species ~ 463 km to the north. According to our literature review, the size of *M. sinaloae* varies across its distribution (Table 1). However, giving the low samples sizes recorded at each locality (Table 1) we cannot be sure that the measures are representative for the species. However, overall, the bats from Los Mochis are similar to those in Jalisco, México. In males from Jalisco, México, total length is 13.71 % greater than new records, tail length is 1.85 % shorter, and maximum skull length is 3.46 % shorter and in females, total length is 8.82 % greater, tail length is 3.06 % shorter, and maximum skull length is 2.26 % shorter. Bats from regions further south and east have an average forearm length of 48 mm, positioning them between previously reported measurements of 41.5 mm (Álvarez-Castañeda 1996) and 53 mm (Orozco-Lugo *et al.* 2014), with a forearm length of 50.5 mm noted along the Pacific coast (Dolan 1989). In contrast, bats from Honduras and Costa Rica are slightly smaller than those from Jalisco and Sinaloa, especially in total and tail length. The maximum skull length is shorter to those recorded in Honduras and Costa

Table 1. Body and skull measurements (in mm) of *Molossus sinaloae*. Means of male and female bats for each variable and population are displayed separated by a comma. Measurements taken from Dolan (1989).

Country (sample size, sex)	*México (1 male, 2 female)	*Honduras (7 male, 16 female)	*Costa Rica (11 male, 13 female)	New records in Sinaloa (1 male, 1 female)
Total length	141, 129.5	120, 115	127.9, 122.6	124, 119
Length of tail	53, 47.5	45.6, 43.4	46.5, 43.4	54, 49
Length of ear	17, 16	15, 15	15.8, 14.9	19, 18
Length of forearm	51.5, 49.5	47.1, 47.1	49.3, 47.8	47, 49
Greatest length of skull	22.3, 21.6	20.9, 19.8	21.8, 20.3	23.1, 22.1
Condylobasal length	20.2, 19.3	18.6, 17.7	19.5, 18.3	20.4, 18.5
Breadth of braincase	10.1, 10	9.9, 9.6	10, 9.7	10.3, 10.2
Length of maxillary toothrow	8.1, 7.9	7.2, 7	7.6, 7.3	16.1, 15.7
Breadth across M3-M3	9.7, 9.3	8.9, 8.5	9.1, 8.7	9.6, 9.6
Breadth across canines	5.7, 5.4	5.3, 5	5.5, 5.1	6, 5.4

Figure 2. Dorsal, ventral, lateral, and mandibular views of the skull of the male *Molossus sinaloae* specimen UANL 4320. Record at the northwest edge of its distribution in Los Mochis, Sinaloa, México (UANL 4320; 25° 52' 52.32" N, 109° 9' 39.96" W). Image available at issaccamargo@gmail.com.

Rica compared to the new records (Table 1). Slight sexual dimorphism is observed in several anatomical characteristics (Table 1). Overall, males tend to display larger body dimensions than females in most of the analyzed measurements. For example, total length, tail length, and maximum skull length tend to be larger in males compared to females across all analyzed locations (Dolan 1989).

The altitude of 26 m where the bats were found in Ahome, Sinaloa, México is the lowest elevations reported for the species since *Molossus sinaloae* has been previously recorded in Mesoamerica at altitudes ranging from 60 m in Guatemala (Jones 1966), to 750 m in western Jalisco, México

Figure 3. *Molossus sinaloae* (UANL 4320). Record at the northwest edge of its distribution in Los Mochis, Sinaloa, México (25° 52' 52.32" N, 109° 9' 39.96" W). Image available at issaccamargo@gmail.com.

(Watkins *et al.* 1972). In South America has been recorded from below 1,160 m in northern Venezuela (Eisenberg 1989), to 2,400 m in Colombia (Marinkelle and Cadena 1972).

The new records suggest that the distribution of *M. sinaloae* is not restricted by geographic barriers in the state of Sinaloa, México. Sinaloa is situated in a key transition zone between the Nearctic and Neotropical regions, contributing to a significant reservoir of biotic diversity. *Molossus sinaloae* might well be common in the lowlands of the Pacific region of Sinaloa, and the paucity of records might be due to the difficulty in detecting the species with traditional capture methods due to its flight habits above the canopy (Jennings *et al.* 2002), and the scarce efforts of monitoring and collecting bats in the state. We emphasize the biogeographical significance of the Nearctic region by documenting the Sinaloan mastiff bat almost 90 years without records in Sinaloa, México.

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New occurrences of *Dasyprocta nigriclunis* expands species distribution in Caatinga, northeast Brazil

Nuevas ocurrencias de *Dasyprocta nigriclunis* expanden la distribución de la especie en la Caatinga, nordeste de Brasil

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The boundaries between *Dasyprocta* species are still in debate and the distribution of agoutis is also uncertain, especially at Caatinga, northeast Brazil, where both *D. prymnolopha* and *D. nigriclunis* exists and there are discordances in synonymize or not these taxa. This note aims to report new records of *D. nigriclunis* obtained through camera trap monitoring, which expands its distribution area. The survey of *Dasyprocta* was conducted in Catimbau National Park, Pernambuco State, from June 2023 to July 2024, and in Dom Inocêncio, Piauí State, from January 2019 to June 2022. Camera traps were installed ~40 cm above the ground, programmed to capture 3 photos at 1-min intervals between bursts, and operated 24 hr/day. An interval of 1 hr was used to define independent records, once *Dasyprocta* species stay for a long time foraging in front of the cameras. The Brazilian government, through Instituto Chico Mendes de Conservação da Biodiversidade, recognizes and considers *D. nigriclunis* a valid species. Thus, we report 50 new records across 15 survey sites. These findings increase the geographic range of *D. nigriclunis*, improve the data for the Brazilian Extinction Risk Assessment, indicates potential collection sites and highlights the need of mammals' survey at Caatinga.

Key words: Agouti; Brazilian endemic species; camera trap; dry forest; geographic range.

Los límites entre las especies del género *Dasyprocta* aún están en debate y la distribución de las pacas también es incierta, especialmente en la Caatinga, donde *D. prymnolopha* y *D. nigriclunis* existen y hay discordancias sobre sí estos taxones deben ser sinonimizados o no. Esta nota tiene como objetivo reportar nuevos registros de *D. nigriclunis* obtenidos mediante el monitoreo con cámaras trampa, lo que amplía su área de distribución. El levantamiento de *Dasyprocta* se realizó en el Parque Nacional Catimbau, en el estado de Pernambuco, de junio de 2023 a julio de 2024, y en Dom Inocêncio, en el estado de Piauí, de enero de 2019 a junio de 2022. Las cámaras trampa se instalaron a ~40 cm del suelo, programadas para capturar 3 fotos a intervalos de un minuto entre ráfagas, y operaron 24 hr/día. Se utilizó un intervalo de 1 hr para definir registros independientes, ya que las especies de *Dasyprocta* suelen pasar largos períodos alimentándose frente a las cámaras. El gobierno brasileño, a través del Instituto Chico Mendes de Conservación de la Biodiversidad, reconoce y considera *D. nigriclunis* una especie válida. Así, reportamos 50 nuevos registros en 15 sitios de muestreo. Estos hallazgos amplían el rango geográfico de *D. nigriclunis*, mejoran los datos para la Evaluación del Riesgo de Extinción en Brasil, indican posibles sitios de recolección y destacan la necesidad de realizar inventarios de mamíferos en la Caatinga.

Palabras clave: Bosque seco; cámaras trampa; distribución geográfica; especie endémica brasileña; pacas.

Agoutis are caviomorph rodents of the genus *Dasyprocta* Osgood, 1915, widely distributed from southern México to Argentina (Patton and Emmons 2015). However, the boundaries between some *Dasyprocta* species are uncertain, so the species number of this genus could vary from 10 (Patton and Emmons 2015) to 13 species (Teta and Reyes-Amaya 2021). One example is *Dasyprocta nigriclunis,* which its validity is not consensual (Percequillo *et al.* 2024). Thomas (1917) stressed doubts about the distinction of *D. nigriclunis* and *D. prymnolopha* and after his opinion, most authors synonymized *D. nigriclunis* to *D. prymnolopha* (Moojen 1952; Cabrera 1961; Woods 1993; Patton and Emmons 2015). The purported synonymization is based on Thomas (1917) who stressed doubts based only on description of Osgood (1915) and examination of specimens of Lamarão, a municipality in the state of Bahia in the North-East region of Brazil. The subsequent authors which followed the Thomas' opinion (Moojen 1952; Cabrera 1961; Woods 1993; Patton and Emmons 2015) also did not examine neither the specimens quoted by Thomas (1917) nor the type of *Dasyprocta nigriclunis*. The taxonomic decision of these authors was based on a fragile argumentation: the Thomas' opinion. The examination of photographs of *D. nigriclunis* type, and comparisons with specimens of *D. prymnolopha* cited by Thomas (1917) stress the differences observed by Iack-Ximenes (1999). Based on morphological data Iack-Ximenes (1999) suggest that *D. nigriclunis* is a distinct species and not related to *D. prymnolopha*.

According to Iack-Ximenes (1999) revision*, Dasyprocta nigriclunis* is an endemic species from northeast Brazil, recognized by a black rump, with no pheomelanic hairs on the sides of the rump and thighs; a black hood starting from the nape extending sometimes until the shoulder's region; sides olivaceous. This species occurs above 400 m at Cerrado and Caatinga biomes (Iack-Ximenes 1999; Oliveira and Bonvicino 2011). Based on the Brazilian assessment of *D. nigriclunis* (Percequillo *et al.* 2024), available on official System of Biodiversity's Extinction Risk Assessment (SALVE; ICMBio 2024), there are few records about *D. nigriclunis*, being currently known from the Brazilian states of Tocantins (Iack-Ximenes 1999), Bahia (Osgood 1915; Iack-Ximenes 1999; Campos *et al.* 2019) and Piauí (Zaher 2000; Lima 2009).

Dayprocta prymnolopha was included in leporina group by Iack-Ximenes (1999) based on wide pheomelanic basal band in the eumelanic hairs of the rump. Iack-Ximenes (1999) included in the leporina group the following species: *D. aguti* (now recognized as *D. iacki*), *D. leporina, D. aurea, D. croconota, D. prymnolopha* and *D. catrinae*. The leporina group was previously recognized by Thomas (1898) as "*Dasyprocta aguti* and the Species allied to it" or the red- and yellow- rumped agoutis. Despite some variation, the rump of *Dasyprocta prymnolopha* has the black crest between lateral pheomelanic areas with variable width. The pheomelanic region of the rump is formed by 2 types of hairs: hairs with pheomelanic basal and distal region, and 2 or 3 pheomelanic bands interspersed with 1 or 2 eumelanic bands; pheomelanic monocromatic hairs with basal region faded. The pattern of rump coloration and hair types differ *D. prymnolopha* from *D. nigriclunis*.

Here, we reported new records of the *Dasyprocta nigriclunis* obtained by camera trapping monitoring that increases the distribution area of this species at Pernambuco and Piauí states in Brazil, both in the Caatinga biome.

We pooled data from 2 independent camera trap (CT) surveys (Bushnell, models 119739, 119949C and 119932C) conducted in 2 studied sites, installed at ~ 40 cm above the ground, programmed to take 3 photos at 1-min intervals between bursts, and operating 24 hr/day, and since these are semi-arid regions, the cameras were installed on trails and near bodies of water, with at least 1 km of distance between them. We used the web platform Wildlife Insights (https://www.wildlifeinsights.org/) to store, organize, and identify all the imagens from focal species records from Catimbau National Park (CNP). The records obtained in Dom Inocêncio were manually sorted.

We installed 15 CT at Dom Inocêncio, from January 2019 to June 2022, and others 10 CT at the CNP, from June 2023 to July 2024. We considered one hr interval for independent records, once *Dasyprocta* species stay for a long time foraging in front of the cameras.

One site where *D. nigriclunis* were recorded is the CNP (Figure 1), the only federal protected area in Pernambuco State, northeast Brazil (excluding the Marine Protected area of Fernando de Noronha). There was only one previous study with mammals at CNP, which did not record *D. nigriclunis* (Geise *et al.* 2010). With an area of 62,300 ha, the CNP was created in 2002 and includes caatinga vegetation (a Brazilian semi-arid biome with unique and vast dry forest and shrubland ecosystem located in the northeastern), in the transition of "agreste" to "sertão" (transitional between the wetter coastal areas and the drier interior), at Buíque, Tupanatinga and Ibimirim municipalities and located at the Raso da Catarina ecoregion (Velloso *et al.* 2002). Other records were obtained at the municipality of Dom Inocêncio (Figure 1), which is located in the Caatinga of the arid hinterland, southeastern part of the state of Piauí, close to the border with the state of Bahia, at Southern Sertaneja Depression ecoregion (Velloso *et al.* 2002). The vegetation in the sampling areas is the wooded steppe savanna (IBGE 2004). The climate of the study area is classified as Köppen's Bsh type, marked by high temperatures, low pluviosity, temporary rivers (Medeiros *et al.* 2020) and its fauna and flora are adapted to semiarid conditions.

On QGIS, we estimated the Extent of Occurrance (EOO) for *D asyprocta nigricluinis* based on this new data and previous records, by calculating the minimum convex polygon around them (IUCN 2022). Then, by overlapping EOO and the current species distribution area (Percequillo *et al.* 2024; ICMBio 2024), we calculate an additional area of potential occurrence of *D. nigriclunis*.

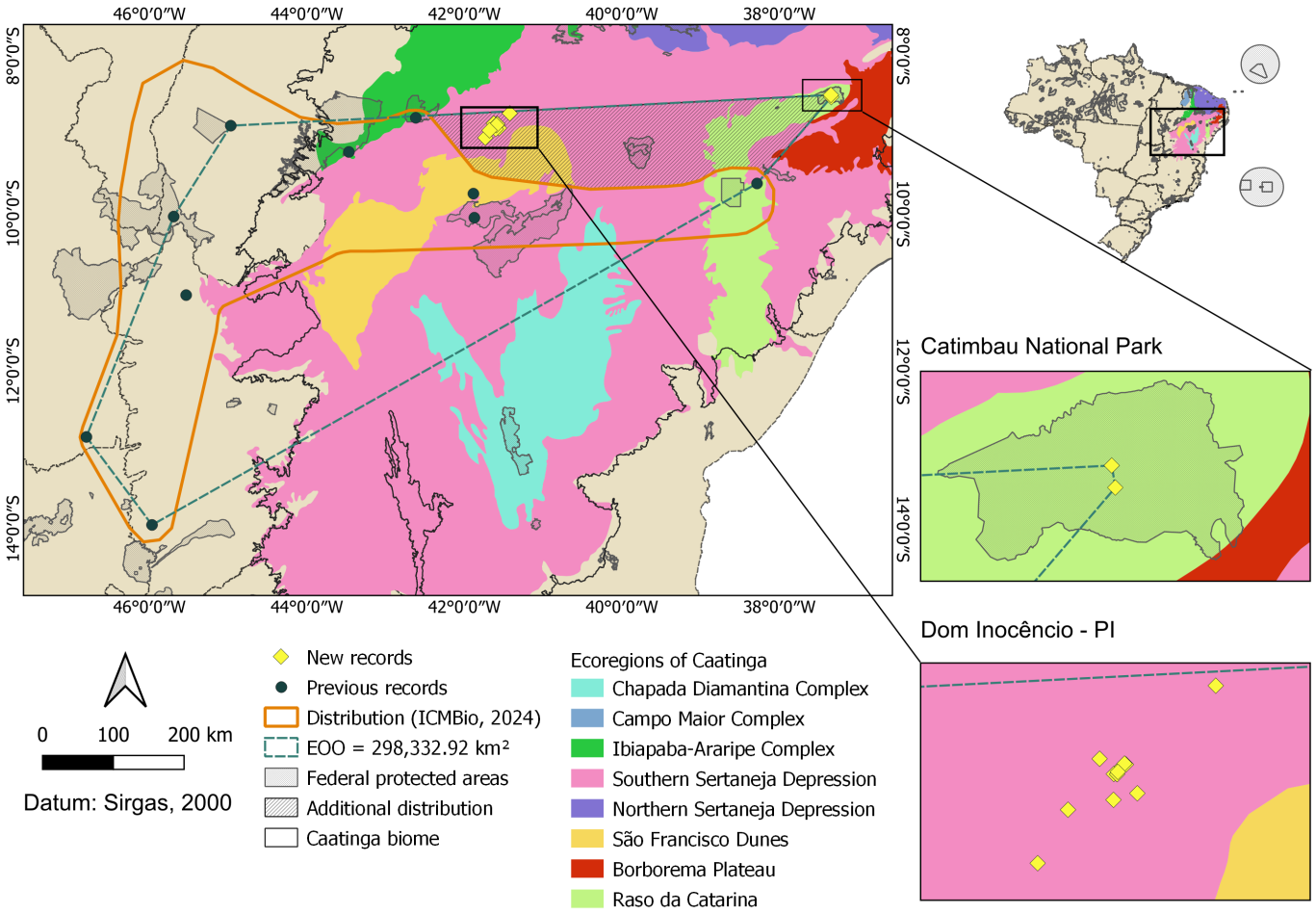

Figure 1. New records, and distribution of *Dasyprocta nigriclunis* and studied sites at Caatinga biome, states of Pernambuco and Piauí, northeast of Brazil. Distribution of *Dasyprocta nigriclunis* (Percequillo *et al.* 2024; ICMBio 2024); and EOO: proposed Extent of Occurrence.

We obtained 50 new records of *Dasyprocta nigriclunis* in 15 different survey points (Table 1), including 24 independent records at only 2 of 10 survey points at CNP, located 3,100 m apart. The records were taken at the localities of Juá Farm, which gather most of the records, and Cattle Road (Table 1). The first records were obtained at Juá Farm on July 16, 2023, and several others since then, while Cattle Road had only 2 records, on October 30 and November 13, 2023. At Dom Inocêncio, *D. nigriclunis* had 26 independent records in 13 survey points (Table 1) during all day, from 4:55 to 21:25 hr (Figure 2). The furthest records, on CNP, were 160,977 km away from the previous data. Based on these data, the EOO for *D.nigriclunis* was estimated in 298,332,92 km^2, and we found a new area of 51,524.68 km^2 with potential distribution of the species (Figure 1).

Camera traps documentation have increased the number of localities where *Dasyprocta nigriclunis* have been recorded. This is a similar situation to other species of Brazilian *Dasyprocta*, where the number of new records was added based on indirect methods of species identification (ICMBio 2024). Despite the value of camera traps for species identification in surveys, there are limitations to these kinds of data. For some species of *Dasyprocta,* new data for geographic distribution are currently based only on indirect information, without specimens collected to add information to improve our understanding about zoogeography, evolution, and systematics of Dasyproctidae.

A recent diagnosis of mammal's collections in Brazil, conducted by the Brazilian Collections Committee of the Brazilian Society of Mammalogists found out that both specimens of northeast and Dasyproctidae family are poorly represented on Brazilian collections (Chiquito *et al.* 2021). For example, only 6 localities reported here are based on specimens deposited in collections and, in the last 30 years, new specimens of *Dasyprocta* have rarely been added to mammal collections. The present total sample available in Brazilian collections for *Dasyprocta nigriclunis* is based on 11 specimens, which is unsatisfactory to taxonomic and morphological studies (Museum of Zoology of the University of São Paulo - MZUSP: 3963, 3964, 3965, 30315; University of Brasília - UNB: 1599, 1561; National Museum of Rio de Janeiro - MNRJ: 24223, 24224, 24225; Serra das Confusões National Park - PNSC 156, 157). We suggest researchers add efforts to collect specimens of *Dasyprocta* and other species poorly sampled in mammal collections. As an alternative to captures, genomic studies can be conducted for taxonomic definitions using specimens in collections, in addition to expanding surveys with environmental DNA techniques.

Table 1. Coordinates (WGS 84) for each survey point with records of *Dasyprocta nigriclunis* in both studies sites.

Study site	Latitude	Longitude	Number of records
Catimbau National Park - Juá Farm	8° 31' 12" S	37° 20' 26" W	22
Catimbau National Park - Cattle Road	8° 29' 34" S	37° 20' 42" W	2
Dom Inocêncio - Piauí	8° 52' 8" S	41° 35' 19" W	2
Dom Inocêncio - Piauí	8° 52' 49" S	41° 36' 4" W	2
Dom Inocêncio - Piauí	8° 43' 35" S	41° 25' 23" W	1
Dom Inocêncio - Piauí	8° 52' 51" S	41° 35' 43" W	1
Dom Inocêncio - Piauí	8° 54' 51" S	41° 33' 36" W	1
Dom Inocêncio - Piauí	8° 51' 49" S	41° 34' 48" W	1
Dom Inocêncio - Piauí	8° 51' 14" S	41° 37' 33" W	2
Dom Inocêncio - Piauí	8° 52' 50" S	41° 35' 43" W	2
Dom Inocêncio - Piauí	8° 51' 44" S	41° 34' 57" W	1
Dom Inocêncio - Piauí	8° 55' 32" S	41° 36' 6" W	2
Dom Inocêncio - Piauí	8° 52' 36" S	41° 35' 38" W	1
Dom Inocêncio - Piauí	8° 56' 34" S	41° 40' 52" W	2
Dom Inocêncio - Piauí	9° 2' 10" S	41° 44' 2" W	8

However, fresh material is also needed to obtain high quality DNA for genomic and metabarcoding techniques (Coba-Males *et al.* 2023).

New species were described for the northeast of Brazil based on collected specimens, including an agouti, *Dasyprocta iacki* (Feijó and Langguth 2013), showing the importance of these kind of materials. However, authors consider that there are still a few specimens collected from this region and some collects are very old (Feijó and Langguth 2013). Brazil has legislations and a system to provide licenses to collect in protected areas for scientific purposes (ICMBio 2022), so the Catimbau National Park and Dom Inocêncio are 2 potential sites to collect *D. nigriclunis*. Once agoutis are already hunted in Caatinga (Alves *et al.* 2016; Barboza *et al.* 2016), which is prohibited with very specific conditions (Brasil 1998), we also suggest that the hunting oversight could destine these animals to university and museums.

The new camera trap records, dates and hours, lead us to infer that the Black-rumped agouti have a strong fidelity with territory and habitat use. Furthermore, the new records published in this study should improve the data of *D. nigriclunis* on SALVE plataform (ICMBio 2024), to increase the distribution area of this species, including a new protected area (see the old and new occurrence points in the Figure 2), which is a relevant factor to extinction risk assessment (IUCN 2022; ICMBio 2024). These findings highlight the lack of information of mammal surveys at the Caatinga Biome and its protected areas, which should receive more initiatives in research. In this way, we recommend that a mammal survey should be carried out in other protected areas near to the Catimbau National Park, one example is the Ecological Station Raso da Catarina, which also is situated in the same ecoregion of CNP and has poor information about its mammals' species.

Figure 2. Records of *Dasyprocta nigriclunis* obtained by camera trap survey at Catimbau National Park, Pernambuco, and Dom Inocêncio, Piauí, Brazil. a and b) Juá Farm; c) Cattle Road; d, e, and f) Dom Inocêncio. a) D: 07/16/2023, H: 07:25; b) D: 21/12/2023, H: 06:14; c) D: 13/11/2023, H: 06:12; d) D: 26/01/2019, H: 16:45; e) D: 14/07/2019, H: 16:46; f) D: 03/02/2021, H: 16:58. D = Date, H = Hour. Images available at christian.berlinck@icmbio.gov.br.

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Nesting of the variegated squirrel, *Echinosciurus variegatoides rigidus,* on a power line pole using plastic ropes and a weedy plant in Cañas, Costa Rica

Anidación de la ardilla variegada, *Echinosciurus variegatoides rigidus,* en un poste de línea eléctrica usando cuerdas plásticas y una maleza en Cañas, Costa Rica

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Arboreal squirrels construct dreys using twigs, often cut from living trees. Some species use plant material to fill out the structure, but anthropogenic materials are occasionally incorporated as well. In Costa Rica, there are 5 squirrel species, the variegated squirrel, *Echinosciurus variegatoides*, being the largest and most common. This species builds nests of leaves and twigs high in the trees. On November 6, 2021, while traveling from our base to a protected area for wildlife monitoring, we stopped in Cañas, Guanacaste, in northwestern Costa Rica. At 15:00 hr, we observed a variegated squirrel nesting on a power line pole. We monitored the squirrel's behavior for approximately 10 min and recorded the observations with photographs and 2 videos. The squirrel was observed nesting on the platform between a power line pole and an electrical transformer. The nest was constructed using a combination of green leaves, twigs, and plastic ropes of at least 3 different colors, indicating they might be of different types. The plant material used in the nest construction was identified as *Commelina* sp., a problematic weedy plant. This finding is novel, as there are no previous reports of this species nesting on such infrastructure, which has not been documented as a nesting site for squirrels. Furthermore, there are few known instances of squirrels using anthropogenic materials for nesting. We discuss this case in the context of squirrel nesting behavior in Costa Rica and the implications of current urban development.

Key words: *Commelina*; Costa Rica; dreys; electrical infrastructure; plant material; Sciuridae.

Las ardillas arbóreas construyen nidos usando ramitas, a menudo cortadas de árboles vivos. Algunas especies utilizan material vegetal para completar la estructura, pero ocasionalmente también se incorporan materiales antropogénicos. En Costa Rica, hay 5 especies de ardillas, la ardilla variegada, *Echinosciurus variegatoides* es la más grande y común. Esta especie construye nidos de hojas y ramitas en lo alto de los árboles. El 6 de noviembre de 2021, mientras viajábamos hacia un área protegida para el monitoreo de fauna silvestre, hicimos una parada en Cañas, Guanacaste, Costa Rica. A las 15:00 hr, observamos a una ardilla variegada anidando en un poste de línea eléctrica. Observamos el comportamiento de la ardilla durante aproximadamente 10 min y registramos las observaciones con fotografías y 2 videos. La ardilla fue observada anidando en la plataforma entre un poste y un transformador eléctrico. El nido fue construido utilizando una combinación de hojas verdes, ramitas y cuerdas de plástico de al menos 3 colores diferentes, lo que sugiere que podrían ser de diferentes tipos. El material vegetal utilizado en la construcción del nido fue identificado como *Commelina* sp., una maleza problemática. Este hallazgo es novedoso, ya que no existen informes previos de esta especie anidando en infraestructura como esta, que no ha sido documentada como sitio de anidación para ardillas. Además, hay pocos casos conocidos de ardillas utilizando materiales antropogénicos para anidar. Discutimos este caso en el contexto del comportamiento de anidación de las ardillas en Costa Rica y el desarrollo urbano.

Palabras clave: *Commelina*; Costa Rica; infraestructura eléctrica; material vegetal; nido de ardilla; Sciuridae.

Nest building is a behavior that has evolved across many taxa but is primarily associated with endothermic animals, which can maintain body temperature above ambient levels (Gedeon *et al.* 2010). While some larger mammals regularly construct nests, this behavior is more common in smaller mammals, typically those weighing less than a kilogram (Deeming 2023). Mammalian nests are often made from fresh plant materials (Deeming 2023). For example, the white-naped squirrel, *Simosciurus nebouxii* (I. Geoffroy St.-Hilaire, 1855), builds nests in treetops, usually using plant material from the supporting tree or nearby trees (Lajo-Salazar *et al.* 2018; Ayala *et al.* 2021).

However, mammals may also use human-origin materials for nest construction. In Poland, hazel dormice, *Muscardinus avellanarius* Linnaeus, 1758, have been observed using artificial threads in nest building (Zaytseva 2006), while in Finland, the European hedgehog, *Erinaceus europaeus* Linnaeus, 1758, has been found incorporating plastic bags or wrapping paper into their nests (Rautio *et al.* 2014). Similarly, European mole, *Talpa europaea* (Linnaeus, 1758), has been known to use paper or plastic sheeting in their nests (Gorman and Stone 1990). In the Americas, 4 mammal species have been reported to use plastic waste for nest or burrow construction (Ayala *et al.* 2023).

Arboreal squirrels (Sciuridae) construct dreys, typically built on a platform of large twigs (10–15 cm in length), often cut from living trees (Deeming 2023). Some species use dead leaves, moss, and bark to fill out the structure, and the nest is often lined with softer materials like moss, thistledown, dried grass, feathers, or wool (Deeming 2023). Occasionally, anthropogenic materials such as paper and wool thread are also used (Bosch and Lurz 2013; Deeming 2023). In Perú, for example, the white-naped squirrel has been documented using single-use plastic bags to construct their nests (Ayala *et al.* 2021). The Indian palm squirrel, *Funambulus palmarum* Linnaeus, 1766, has been observed using plastic, which is abundant in its habitat, to build nests (Mohan and Singh 2018). Although the Indian palm squirrel usually builds nests using natural materials, it appears to be adapting to changes in its habitat (Mohan and Singh 2018).

In Costa Rica, the family Sciuridae is represented by 5 species, 2 of which belong to the genus *Echinosciurus* (Mora and Ruedas 2023). The largest of these is the variegated squirrel, *Echinosciurus variegatoides* (Ogilby, 1839), which is diurnal, arboreal, and territorial (Reid 2009). This species is highly variable in appearance, with long, soft fur that ranges in color depending on its distribution and subspecies (Harris 1937). It is found from southern México to Panamá (Hoffmann and Thorington 2005), at elevations ranging from 0 to 1,800 m, although it can inhabit areas up to 2,600 m (Reid 2009). *Echinosciurus variegatoides rigidus* (Peters, 1863) is found in mountains and valleys of central Costa Rica from Puntarenas east to Juan Viñas, and from Liberia in the north to Cartago in the south (Harris 1937).

The variegated squirrel builds its nests, or dreys, in tree hollows or on branches (Reid 2009). The nests are spherical constructions made of leaves and twigs, placed high in the canopy (Koprowski *et al.* 2016). The materials are arranged in a seemingly disorganized fashion, often located in tree forks (Mora 2000). The nests measure approximately 20 to 30 cm in diameter, and females build them at heights ranging from 6 to 15 m or more above the ground (Medina-Fitoria *et al.* 2018; Mencía 2021).

In contrast to birds, which frequently use electrical infrastructure for nesting worldwide (Moreira *et al.* 2023), reports of squirrels nesting on power lines or other electrical structures are extremely rare or nonexistent (Hamilton *et al.* 1987). In this study, we document, for the first time, a variegated squirrel constructing a nest on a power line post, utilizing both a weedy plant and plastic materials.

On November 6, 2021, while traveling from our base to a protected area to monitor birds, we made a stop at Cañas, Guanacaste, Costa Rica (10° 25' 49" N, 85° 05' 33" W; 80 m; Figure 1). At 15:00 hr we observed a variegated squirrel nesting at a power line pole. We observed the squirrel behavior for about 10 min and took pictures and 2 videos.

Cañas is a small city located in northwestern Costa Rica, within the Tropical Dry Forest Life Zone (*sensu* Holdridge 1967). The Tropical Dry Forest is considered the most heavily utilized and disturbed ecosystem in the world (Janzen 1988). The Tropical Dry Forest is found between 0 and 600 m and has a warm climate year-round. Temperatures range from 25 to 30 °C, with annual rainfall between 1,100 and 1,500 mm. However, there is a pronounced dry season, with no effective rainfall, lasting from 4 to 9 months (Bolaños *et al.* 2005).

Cañas is the first district and the head city of the Cañas county, the sixth one of the Guanacaste province (Piedra Quesada 2017). This district covers an area of 193.09 km^2 and has an average elevation of 86 m (Piedra Quesada 2017). Cañas county has a total population of 33,393 inhabitants, with the district of Cañas accounting for the majority, comprising 26,577 inhabitants (Sánchez V. *et al.* 2023).

The variegated squirrel is highly common in the Cañas area, demonstrating its status as a generalist species. It occupies a variety of habitats, from forested zones to disturbed areas like agricultural and urban environments (Mora 2000). Within the city of Cañas, it is less frequently observed but not rare, appearing in areas with trees, such as plazas, or using electrical cables to move between trees and buildings (J. Mora, pers. obs.). This squirrel also uses cables to connect urban areas to the outskirts. Surrounding Cañas city are agricultural zones and riparian vegetation along the Cañas River (Mora 2001).

We observed the variegated squirrel nesting on the platform located between a power line pole and an electrical transformer in the heart of the city, just two blocks from a major highway (Figure 2a). The videos can be viewed on the https://youtu.be/WAB5l35nFoM, and https://youtu.

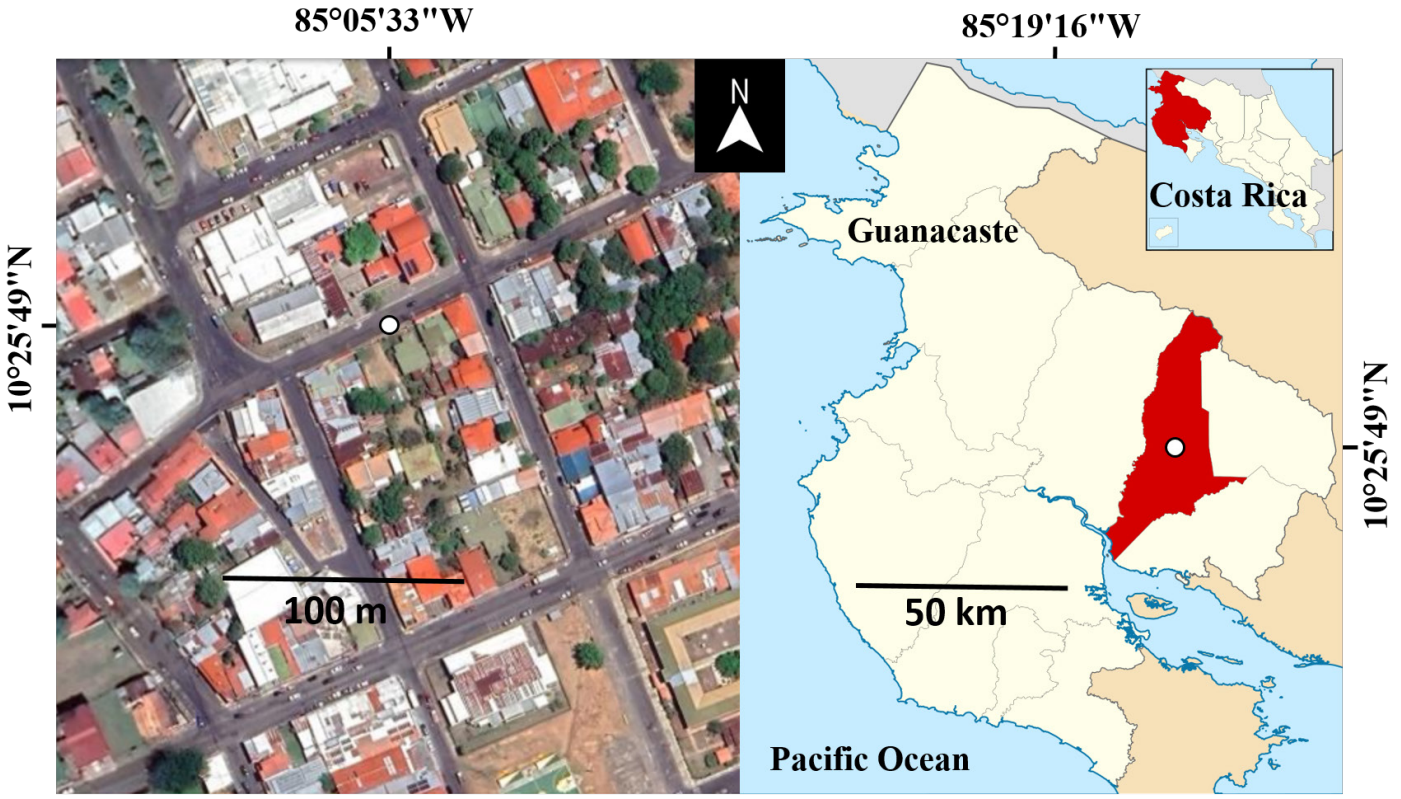

Figure 1. Site (white dot) where a variegated squirrel, *Echinosciurus variegatoides rigidus*, was found nesting on a power line post at Cañas County (highlighted in red), in the Guanacaste Province (outlined in white but shown in red on the map of Costa Rica). Figure based on Google Earth (left section) and Wikipedia under the Creative Commons Attribution-ShareAlike 3.0 license (right section).

be/3EcjMFF13zU. The nest was built using a combination of green leaves, twigs, and plastic ropes (Figure 2b). Notably, the plastic ropes came in at least 3 different colors (black, blue, and white) suggesting they might be of different types (Figure 2). The plant material used for nest construction was identified as *Commelina* sp. (Commelinaceae), a weedy problematic plant (Q. Jiménez, comm. pers.). The plant sections observed were green/living, and it may be thriving without a soil substrate (Figure 2). Plants of the genus *Commellina* are often associated with various agricultural and ecological challenges due to their invasive behavior and adaptability to diverse environments (Isaac *et al.* 2013). Some species can establish dense stands that compete with crops, significantly reducing yields (Webster *et al.* 2005). These plants may release allelopathic compounds that inhibit the growth of neighboring vegetation or act as alternate hosts for nematodes and viruses, posing additional threats to agricultural productivity (Isaac *et al.* 2013). *Commellina* species thrive under a wide range of conditions and exhibit high resistance to environmental stresses, making controlling their spread particularly challenging (Webster *et al.* 2005).

Nests play a vital role in the reproduction and survival of many organisms by providing thermal insulation against the external environment and serving as a refuge from potential predators (Ramos-Lara and Cervantes 2007). The variegated squirrel typically builds nests out of leaves and twigs in tall trees (Ceballos and Valdéz Alarcon 2014; Koprowski *et al.* 2016). On the Nicoya Peninsula of Costa Rica, the trees selected for nesting were leafy, with many branches, and the nests were established at heights over 15 m (Monge 2019). According to one record made by Monge (2019), a squirrel built a nest in a mango tree, *Mangifera indica*, using green leaves from the same tree, which were transported one at a time or in small branches. In Panamá, the variegated squirrel constructs compact nests made of leaves, placed in the tops of tall, slender trees (Best 1995). Similarly, the Mexican red-bellied squirrel, *Sciurus aureogaster* F. Cuvier, 1829 in Michoacán, México, builds nests in the tallest and largest trees, typically close to the main trunk (Ramos-Lara and Cervantes 2007).

In some instances, squirrels have utilized human-made structures for nesting. For example, the gray squirrel, *Sciurus carolinensis* Gmelin, 1788, is known to construct leaf dreys, den in tree cavities, and even use artificial nesting sites such as wooden boxes in North America (Shuttleworth *et al.* 2016, and references therein). Occasionally, they build nests within the eaves or attic spaces of buildings (Shuttleworth *et al.* 2016). However, reports of squirrels nesting on power lines or electrical infrastructure are rare or nonexistent, although these structures are commonly used as travel corridors, rest sites, and dispersal (Hamilton *et al.* 1987). However, such activities can cause power outages and become a nuisance, when squirrels use utility poles and substations (Frazier and Bonham 1996).

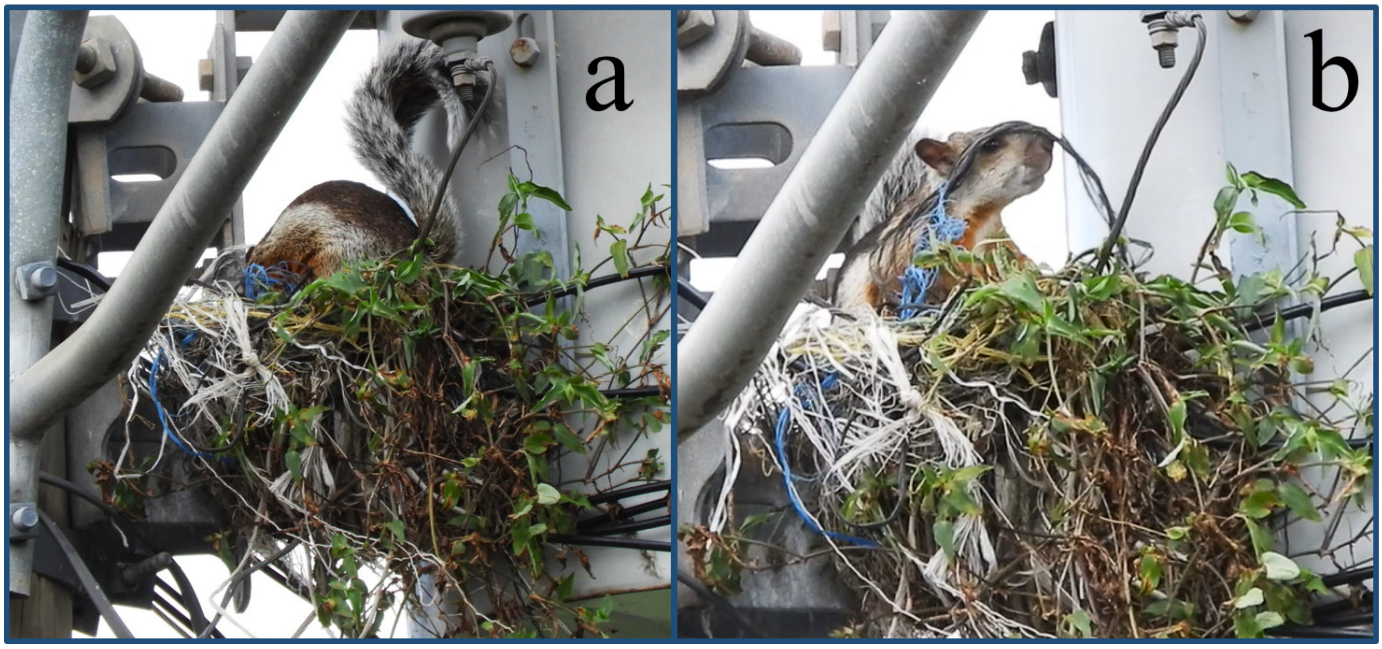

Figure 2. a) A female variegated squirrel, *Echinosciurus variegatoides rigidus*, on a nest constructed between a pole and an electrical transformer; b) the variegated squirrel arranges plastic ropes in its nest. Cañas, Guanacaste, Costa Rica.

In this study, the variegated squirrel nested on a power line pylon, even though 2 trees were located approximately 30 m from the site (Figure 1). Interestingly, birds such as the white stork, *Ciconia ciconia*, are well-known for nesting on power lines, with over 283 bird species documented using such structures in Brazil alone (Moreira *et al.* 2018; Biasotto *et al.* 2022). In addition to birds, power lines are increasingly used by mammal species such as marsupials, edentates, procyonids, and primates, as these structures allow for quick and easy movement between forest patches (Bastidas-Domínguez *et al.* 2021).

However, the use of electrical facilities by wildlife comes at a cost. Between June 2018 and June 2019, 947 cases of non-human primate electrocutions were reported in Costa Rica (Rodríguez *et al.* 2020). This figure only accounts for detected and reported events, as incidents that did not cause power outages were not counted, and not all power companies maintain records of such occurrences (Rodríguez *et al.* 2020). In addition, electrical problems, such as outages and electrocutions can be caused not only by nesting animals but also by their predators, such as snakes, raccoons and others (Frazier and Bonham 1996; James *et al.* 1999).

Plastic materials used in nesting can pose significant risks to wildlife. Plastic ropes, like those documented in this study as used by the variegated squirrel and reported here for the first time, could potentially cause entanglement or asphyxiation (Blettler and Mitchell 2021; Thrift *et al.* 2023). Although no cases of terrestrial mammals being entangled in plastic have been reported to date (Ayala *et al.* 2023), several mammalian species have been observed incorporating plastic waste into their nests. While plastic ropes may offer structural support and insulative benefits, their use likely also reflects their availability in the environment.

Plastic pollution is a significant global concern and a recognized driver of environmental change (Ayala *et al.* 2023). The use of plastic waste in nests and burrows by mammals is a relatively new observation, and its potential short- and long-term impacts on their survival remain uncertain (Mohan and Singh 2018; Ayala *et al.* 2023). One related issue is plastic ingestion, which is not confined to marine species; terrestrial mammals like the coyote, *Canis latrans* Say, 1823, and the coati, *Nasua nasua* Linnaeus, 1766, have also been frequently reported ingesting plastic materials (Ayala *et al.* 2023). Furthermore, plastics contain harmful chemicals like bisphenol-A (BPA), which disrupts endocrine systems and has been linked to carcinogenesis in animals (Ayala *et al.* 2023). These combined risks underscore the urgency of addressing plastic pollution for the protection of both wildlife and ecosystems.

The plant material used by the squirrel, *Commelina* sp., also presents challenges, as it is known to be difficult to eradicate (Isaac *et al.* 2013). *Commelina* species are considered invasive in some regions due to their ability to root easily from small fragments, making them particularly troublesome in disturbed habitats (Webster *et al.* 2005; Isaac *et al.* 2013). The squirrel may have found the plant suitable for its nest or may have inadvertently included it as part of the construction.

Nest materials used in nest construction can serve various purposes, such as aiding in temperature regulation, providing comfort for occupants, and reducing ectoparasite loads while repelling moisture (Patterson *et al.* 2007). For instance, shredded bark from eastern white cedar, *Thuja occidentalis*, used by *Glaucomys sabrinus* (Shaw, 1801), and *Tamiasciurus hudsonicus* (Erxleben, 1777), has been shown to offer antiparasitic and thermoregulatory benefits (Pat-

terson *et al.* 2007). Notably, these squirrels did not choose cedar bark solely based on its availability, suggesting a functional preference for its properties (Patterson *et al.* 2007).

Green vegetation used in avian nests suggests that animals may exploit the antiparasitic properties of specific plant species that emit volatile compounds (Patterson *et al.* 2007). Secondary metabolites present in plants serve as natural defenses against herbivory and disease (Clark and Mason 1988). When incorporated into nests, these compounds may reduce ectoparasite loads in the nesting environment (Patterson *et al.* 2007). This is also observed in some mammals, such as dusky-footed woodrat, *Neotoma fuscipes*, which place California bay, *Umbellularia californica*, leaves around their nest sites (Hemmes *et al.* 2002). Laboratory tests showed that flea larva loads were reduced by 74 % when incubated with torn California bay leaves for 72 hr (Hemmes *et al.* 2002). The *Commelina* sp. used by the variegated squirrel may similarly provide some level of ectoparasite control in its nesting environment, potentially offering functional benefits beyond structural purposes.

Our observation of the variegated squirrel nesting on a power line pylon, incorporating plastic waste and a problematic, weedy plant, underscores the global impact of human activities on wildlife. The rapid expansion of urban areas in recent decades has led to significant changes in species behavior, survival, and dispersal (Corrales-Moya and Sandoval 2021). As a result, species adapting to urban environments often modify their behavior to exploit new resources introduced by humans (Caballero *et al.* 2016; Corrales-Moya and Sandoval 2021). Monitoring such behaviors is essential for developing effective wildlife conservation strategies.

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