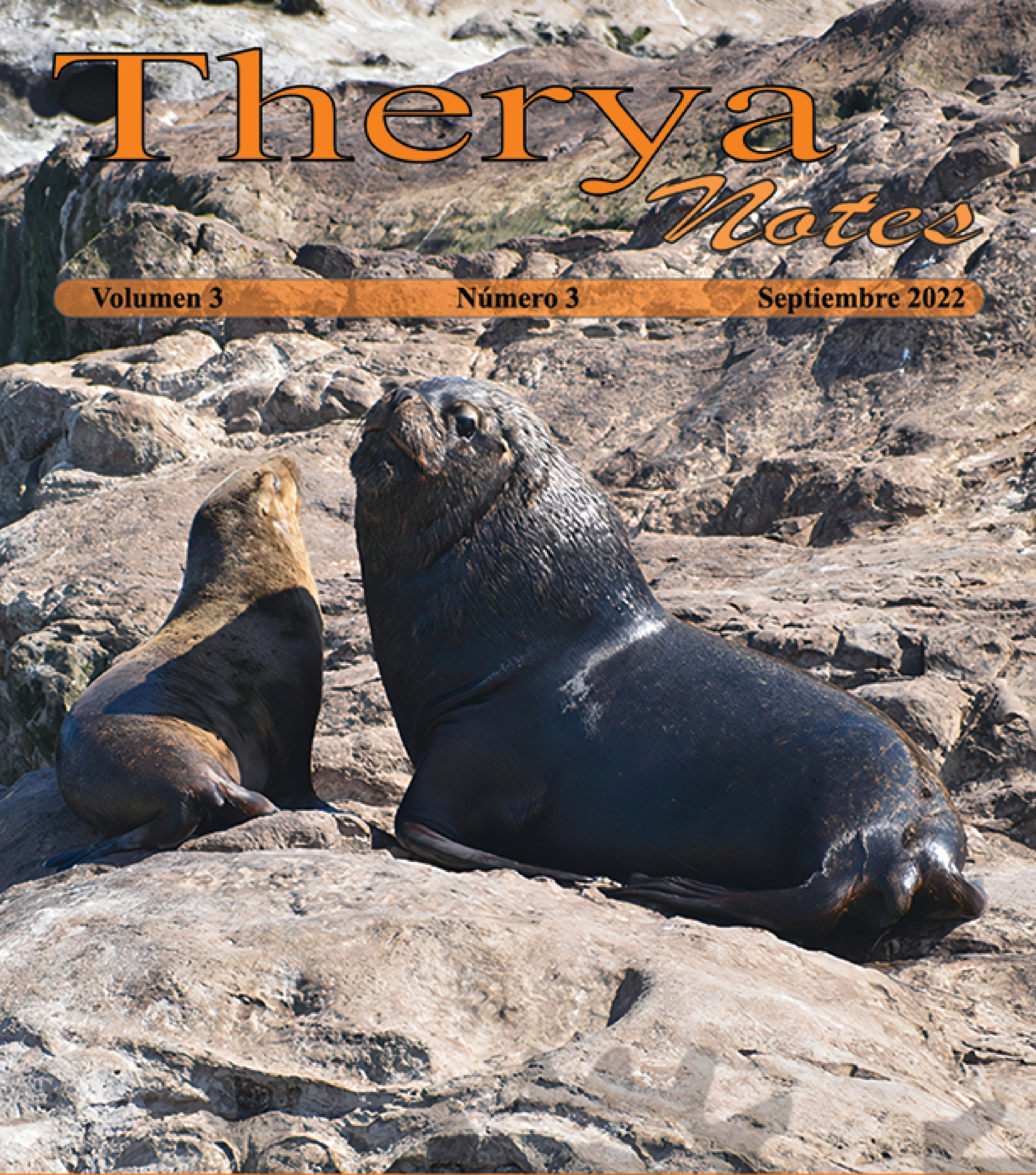
Therya Notes

Volumen 3 Número 3 Septiembre 2022



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

El lobo marino común *Otaria byronia* se distribuye ampliamente en Sudamérica desde Perú pasando por Chile hasta Brasil en los océanos Pacífico y Atlántico, respectivamente. Es una especie abundante y muy vágil. Como todos los pinnípedos, exhibe una reproducción notablemente estacional y sincronizada con ligeras diferencias entre poblaciones. En este fascículo se incluye una nota en la que se hace una descripción detallada de un evento de cópula registrado en la costa central de Chile.
(Fotografía de J. A. Guzmán)

El logo de la AMMAC: "Ozomatli"

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

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CONTENIDO

THERYA NOTES 2022, Vol. 3 : 147-152 DOI: 10.12933/therya_notes-22-87 ISSN 2954-3614

Bucking and charging defense of Baird's tapir (*Tapirella bairdii*) from common vampire bats (*Desmodus rotundus*)

Defensa del tapir centroamericano (*Tapirella bairdii*) frente a vampiros comunes (*Desmodus rotundus*)

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Camera trap studies have captured a wide diversity of wildlife behaviors, highlighting the importance of behavioral ecology in meeting wildlife management and conservation goals. We report on predation attempts by common vampire bats (*Desmodus rotundus*) upon Baird's tapir (*Tapirella bairdii*) and describe the tapir's defensive response. On September 2020, we obtained the records of this interspecific interaction at one camera-trap station located in a buffer zone of the Rincon Rainforest Reserve in northwestern Costa Rica. We recorded vampire attempts to feed on at least 2 individuals of Baird's tapirs. When detecting the bats, tapirs reacted to repel them by shacking, running, spinning, and chasing the bats in flight. These cases add to our current knowledge of tapirs' defensive behavior and are relevant to questioning the evolution of stealthiness in vampire attacks. In addition, it emphasizes the role of monitoring these interspecific interactions in relation to zoonosis in human-modified landscapes.

Key words: Buffer zones; defensive behavior; Guanacaste Conservation Area; interspecific interactions; One Health; zoonotic risk.

Los estudios con cámaras trampa han capturado gran diversidad de comportamientos de la fauna silvestre, resaltando la importancia de la ecología del comportamiento para cumplir con los objetivos de gestión y conservación de la vida silvestre. Reportamos intentos de depredación de vampiros comunes (*Desmodus rotundus*) hacia el tapir centroamericano (*Tapirella bairdii*) y describimos la respuesta defensiva del tapir. En septiembre de 2020, capturamos registros de esta interacción interespecífica en una estación de cámara trampa ubicada en la zona de amortiguamiento de la Reserva Rincón Rainforest en la zona noroeste de Costa Rica. Registramos vampiros intentando alimentarse de al menos 2 ejemplares de tapir centroamericano. Al detectar a los vampiros, los tapires reaccionaban para repelerlos sacudiéndose, corriendo, girando y persiguiendo a los murciélagos en vuelo. Estos registros generan nuevo conocimiento sobre el comportamiento defensivo de los tapires y son relevantes para preguntas relacionadas a la evolución del sigilo en el ataque de los murciélagos vampiro. Además, enfatizan el papel del monitoreo de estas interacciones interespecíficas en relación con la zoonosis en paisajes modificados por humanos.

Palabras clave: Área de Conservación Guanacaste; comportamiento defensivo; interacciones interespecíficas; riesgo zoonótico; Una Salud; zonas de amortiguamiento.

The growing use of camera-traps in field studies of wild mammals has increased the potential and probability to identify new animal behaviors. The rigorous use of these tools has also highlighted the importance of behavioral ecology to achieving wildlife management and conservation goals (Caravaggi *et al.* 2020). Thus far, images recorded by camera-traps of wild animals have depicted a surprising diversity of behaviors (Caravaggi *et al.* 2017). This is even true when camera-traps are used opportunistically, or as a tool to achieve other research or conservation objectives.

Between 1998 and 2015, Baird's tapirs (*Tapirella bairdii*) were recorded in 39.4 % of 94 camera trap studies in Costa Rica (Artavia 2015). Although data from these studies suggest that the relative abundance of tapirs varies widely across the country, there has thus far been little effort to coordinate sampling effort and design among studies. This precludes direct comparisons of important population parameters (relative abundance, absolute abundance, or density) for tapirs and other ungulates (Ramírez-Vargas and Piedra-Castro 2019). Moreover, even less is known regarding the behavior of Baird's tapirs, whether from Costa Rica or anywhere across their range.

The diet of the common vampire bat (*Desmodus rotundus*) purportedly includes tapirs as prey (Sánchez-Cordero *et al.* 2011; Bobrowiec *et al.* 2015); however, the literature makes explicit reference only to 1 tapir species in particular: the lowland or Brazilian tapir (*Tapirus terrestris;* Castellanos and Banegas 2015). We could not find any verified reports of vampire bats feeding on the mountain tapir (*Tapirus pinchaque*), or the Baird's tapir (*T. bairdii*). Interestingly, the blood of wild prey does not appear to be preferred to that of livestock when the latter is present

(Delpietro *et al.* 1992), although tapirs and other mammals constitute native and natural prey.

Here we report on records of predation attempts by common vampire bats (*D. rotundus*) upon Baird's tapirs (*T. bairdii*), and describe the defensive behavior adopted by the tapirs to thwart the attacking bats. These records were obtained during our camera-trap study on human-wildlife interactions.

Between October 2019-April 2021, we deployed 24 camera-trap stations (Bushnell Trophy Cam HD; Bushnell Inc., Overland Park, USA) arranged as a stripe at the interface of multiple protected and private lands. The original purpose of our research was to document human-wildlife interactions, as well as threats due to poaching and other illegal incursions, the presence of domestic animals, and potential conflicts due to depredations by predators. It was also intended to foster the involvement of local communities in monitoring and surveillance of their local ecosystems (Amit and Valverde-Zúñiga per. obs.).

We obtained the specific defensive behavior records described herein for tapirs at one of the stations deployed as part of the above-mentioned study. This station, containing one camera trap operating 24 hr/day, was located in a private livestock farm in the district of Dos Ríos of Upala, northwestern Costa Rica (10° 52' 31" N, 85° 21' 21" W). The area corresponds to secondary evergreen forest of the Tropical Wet Forest life zone with some areas transitioning to Premontane Forest (Holdridge 1967). The site elevation is 697 m and had a mean annual precipitation of 3,000-4,000 mm and mean annual temperature of 22-24 °C (Ortiz-Malavasi 2014). The camera station was situated along a small creek with several potential bat roosting caves at its slopes. It was at 590 m from the farm owner's house, 100-150 m from the nearest cattle pastures (small pastures with < 50 animals each), and 62 m from the nearest protected area (Rincon Rainforest Reserve; Figure 1). This protected area is within the Guanacaste Conservation Area, a World Heritage Site (UNESCO 1999), and was acquired as recently as 2019 through a broader land acquisition strategy and restoration plan (*i.e.*, regenerative pasture occurs ~240 m from the camera). One outcome of this plan has been to reduce livestock density and open pastures in the area.

We obtained records depicting defensive behaviors by Baird's tapirs on 2 independent occasions in the span of 4 days of September 2020 around midnight, and close to the new moon (Appendix 1). In the first record (15 September 2020 at 00:11 hr), a male tapir walked quickly along a trail, making small jumps with its hind legs as it went; then, it stopped suddenly and turned to its right side. The tapir then ran in the opposite direction just as a vampire bat flew in from behind, near the ground to the right of the frame, and then up again. Quickly turning again to his left, the tapir jumped with his front legs and raised its trunk; in response, a vampire bat flew in from the right of the frame, and towards a tree further back. As it did, the tapir quickly walked out of the frame. We interpreted these movements by the tapir as "bucking and charging" motions to repel the vampire bat (Figure 2).

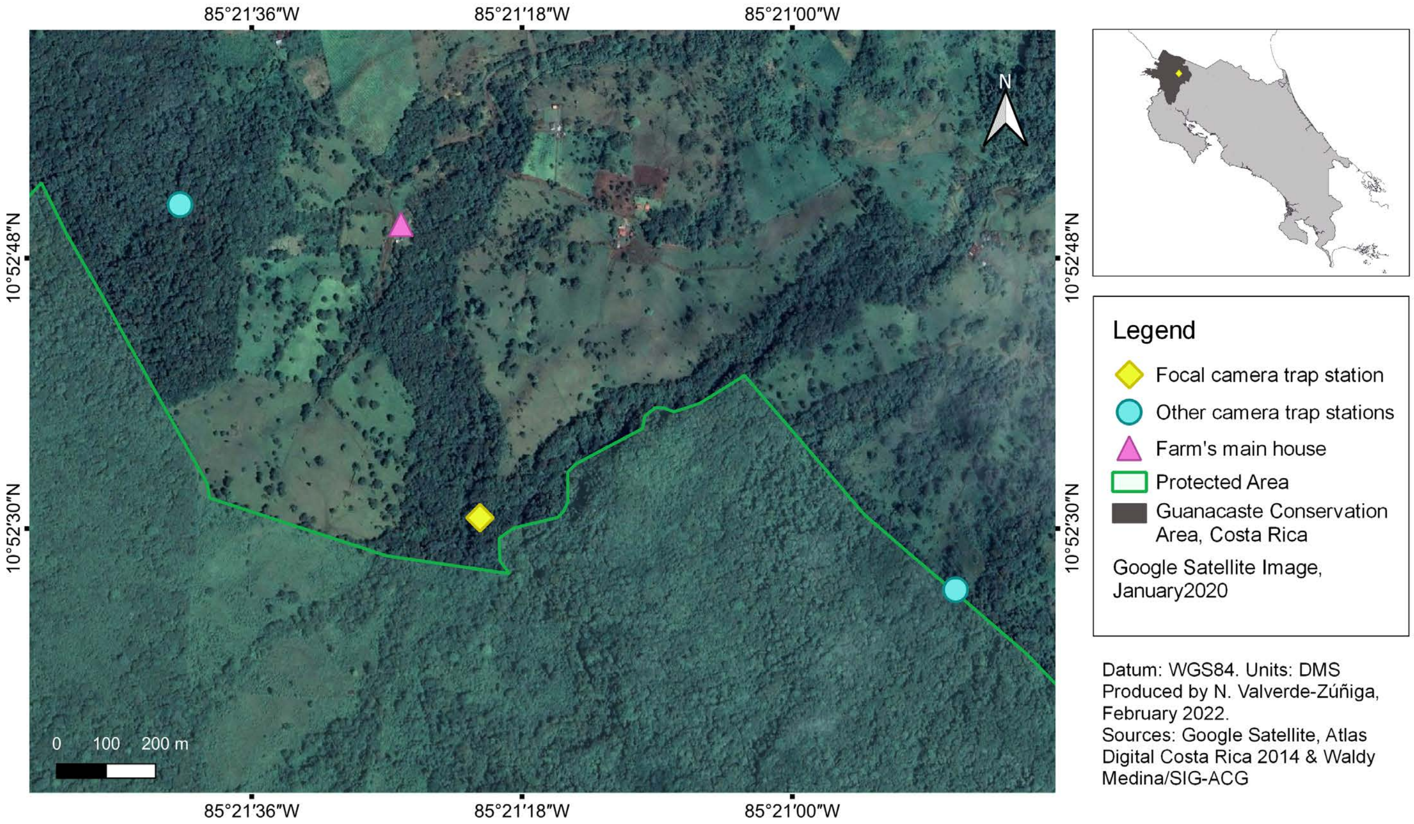

Figure 1. Landscape surrounding the focal camera trap station in relation to the limit of the Rincon Rainforest Reserve (protected area) in Upala, Costa Rica.

In the second record (18 September 2020 at 00:06 hr) we obtained two consecutive video captures (with a delay of 3 s between activations). Initially, a female tapir walked into the frame; followed by a vampire bat that flew in from behind and landed close to the tapir's hind legs. In the subsequent video, from a further plane, a vampire bat flew out and over the tapir, flying in a circle and returning towards the tapir. At the same time, a second vampire bat can be seen flying lower around the tapir. As this happens, the female tapir appeared to make a "running turn", raising her head and shaking her trunk while turning. A minute later, an adult male tapir can be seen walking in the same location as a vampire bat flies and perches on a thin tree, undetected by the tapir; another vampire is seen flying around the frame. To provide further context, we also recorded a prior incident at a different camera station (18 April 2020 at 02:06 hr). This incident photo captures showed a vampire bat lurking near a male tapir attempting to feed on the fruit of a *Parmentiera valerii*. Although in this case, the tapir did not display defensive behavior, it seemed uncomfortable while moving around the tree after it detected the vampire bat, and then leaved the area after spending < 4 min at the site (Appendix 1).

Other big mammals we detected at this site, and around the same time, included jaguar (*Panthera onca*), puma (*Puma concolor*), and white-lipped peccaries (*Tayassu pecari*); the last of which vampire bats also attempted to feed upon.

Desmodus rotundus has extraordinary adaptations for approaching and feeding undetected by its prey (see Greenhall *et al.* 1971 for a description). However, tapirs are well-known for their defensive behavior when disturbed. This is true even when they are disturbed by humans, particularly in the context of females defending their young during encounters in the wild (Castellanos and Gomez 2015).

Compared to other Perissodactyls, tapirids may not be as flexible as equids in their torso-lumbar movements, and they are certainly not armored like rinocerontids (*i.e.*, horns and thick collagen-layered skin); however, tapirs are heavy and bulky animals that can "run" somewhat (Christiansen 2002). In our recordings, *T. bairdii* actively charge against the vampire bats with deliberate movements. The most similar record we could find was a camera trapping video of a lowland tapir (*Tapirus terrestris*) attacked by a common vampire (*D. rotundus*) posted by Alysson Santos from IFRO Campus Ariquemes (Santos 2020). However, our records' individuals of *T. bairdii* exhibited a more energetic and direct attempt to repel and escape from their attackers.

These tapirs' behavior also differs significantly from the response of livestock when disturbed by vampire bats. Cattle exhibit a predominantly passive response, mostly by shaking their heads, flapping their ears and tail, and moving from a place to another. Not surprisingly, cattle is reported as vampire's preferred prey (Greenhall *et al.* 1971; Delpietro 1989; Bobrowiec *et al.* 2015). The relative ease or difficulty with which common vampire bats might successfully feed on tapirs compared to cattle, as well as their foraging response to land-use change is an important conservation question in mixed-use landscapes such as ours (*i.e.*, livestock ranches or agriculture adjacent to protected areas).

To feed successfully, common vampire bats need to approach stealthily; they often try to avoid detection by flying close to their target animal, and then walking until a biting opportunity is possible (Greenhall 2018). We interpret our observations as "failed attacks", whereby bats continued to approach after being initially detected, and with tapirs thus more alert and actively exhibiting defensive behavior. We are unable to speculate about the precise moment where and when the tapirs detected the bats (*e.g.*, before or after they entered the frames), whether bites occurred or not at any point, or if the interactions we observed led to continued attacks, whether successful or failed. This information is beyond the range and scope of our camera traps. Improved sensorial detection by these tapirs and lack of stealth by the bats could be factors to question about these events. Our records could be relevant to future inquiries on community dynamics of predator-prey co-adaptations, especially when evolutionary relationships are affected by anthropogenic landscape changes. Human activities can affect the availability and distribution of resources in a landscape, in some cases creating novel food resources (Becker *et al.* 2018). A relevant example of the vampire bats is the introduction of domestic cattle by Spaniards in the Americas.

Our reports on *D. rotundus* attempts to feed upon *T. bairdii* in proximity to livestock pastures suggests this relationship needs to be further explored under the framework of vampires as zoonotic vectors preying wildlife, cattle, and humans. Monitoring and detection of wild reservoirs that could potentially infect humans is central to zoonotic risk management (Wille *et al.* 2021). Vampire bats are the primary reservoir of the rabies virus in Latin America, a disease affecting livestock production and human populations every year (Schneider *et al.* 2009; Streicker and Allgeier 2016). Streicker and Allgeier (2016) found that cattle presence is a strong predictor of vampire bat density, and that vampire bats prey both on livestock and wildlife only in certain areas.

The current pandemic has shown how easy is to disrupt the separation between the sylvatic and the urban-domestic cycle of a zoonotic disease, particularly in landscapes with intense human-wildlife interactions. Additionally, climate change is expected to expand common vampire bat's suitable habitat (Lee *et al.* 2012), thus monitoring the consequences of this type of interspecific interactions becomes more relevant. In this context, the One Health approach becomes even more relevant, compelling collaborative and interdisciplinary approaches to respond to emerging and global disease management, emphasizing the wildlife health component (Mackenzie and Jeggo 2019). Future research, directed through the One Health approach, might account for the population density of vampire bats, tapirs,

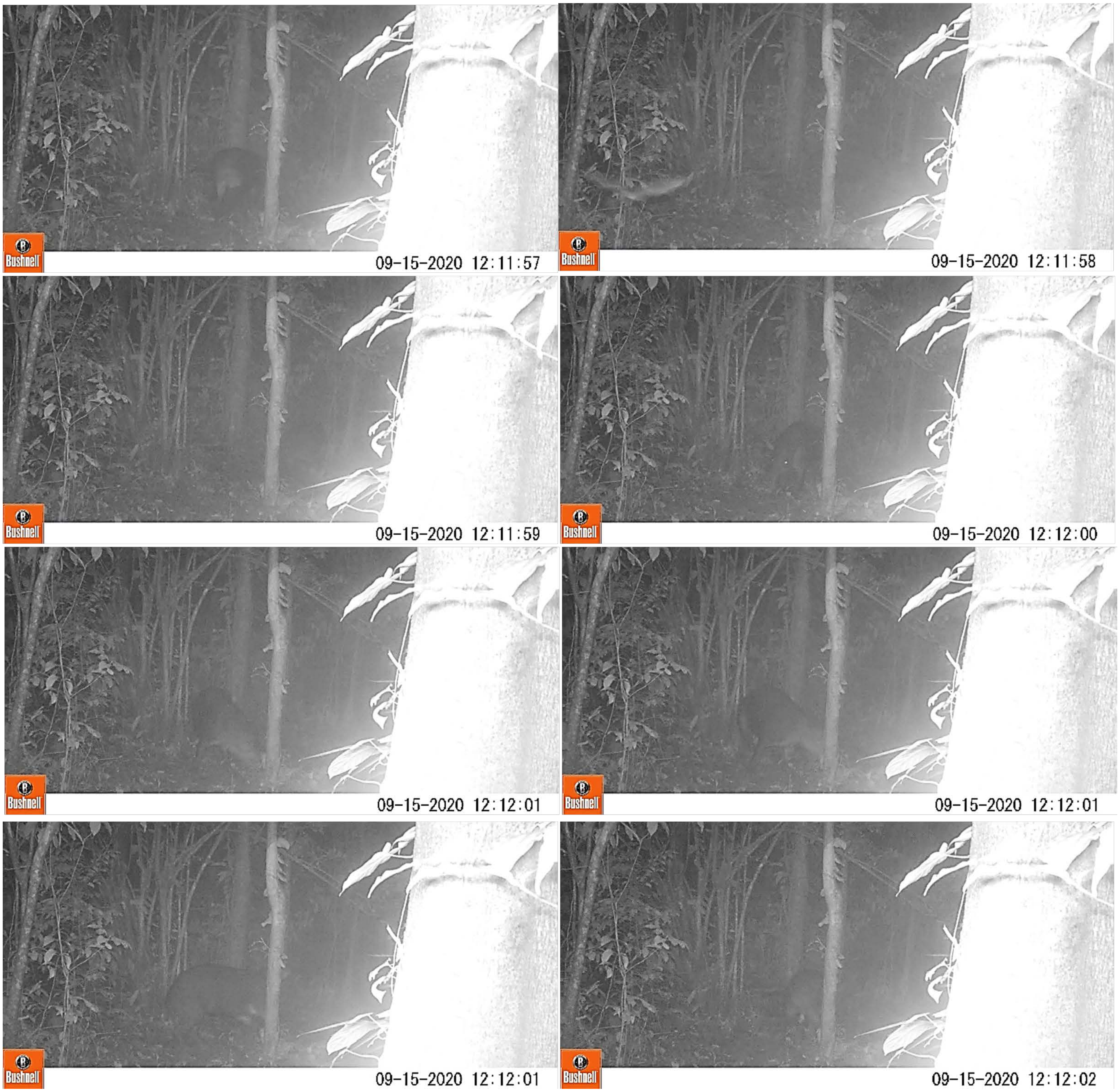

Figure 2. First record of Baird's tapir (*Tapirella bairdii*) bucking and charging behavior towards common vampire bats (*Desmodus rotundus*). Captures recorded in September 2020 at a secondary forest patch within the buffer zone of the Rincon Rainforest Reserve in Upala, Costa Rica.

and livestock, as they relate to landscape alterations, as well as a socio-ecological methods that acknowledges the complex needs of all interacting species, including humans, such as explored by Shapiro *et al.* (2020).

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Appendix 1

Video of complete records depicting defensive behaviors by Baird’s tapirs (*Tapirella bairdii*) during attack attempts by common vampire bats (*Desmodus rotundus*). Captures recorded in September 2020 at a secondary forest patch within the buffer zone of the Rincon Rainforest Reserve in Upala, Costa Rica.

https://drive.google.com/file/d/18Im7cLzKOxcVgrnItTvvRFyDR2sjumRi/view?usp=sharing

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

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

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

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

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

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

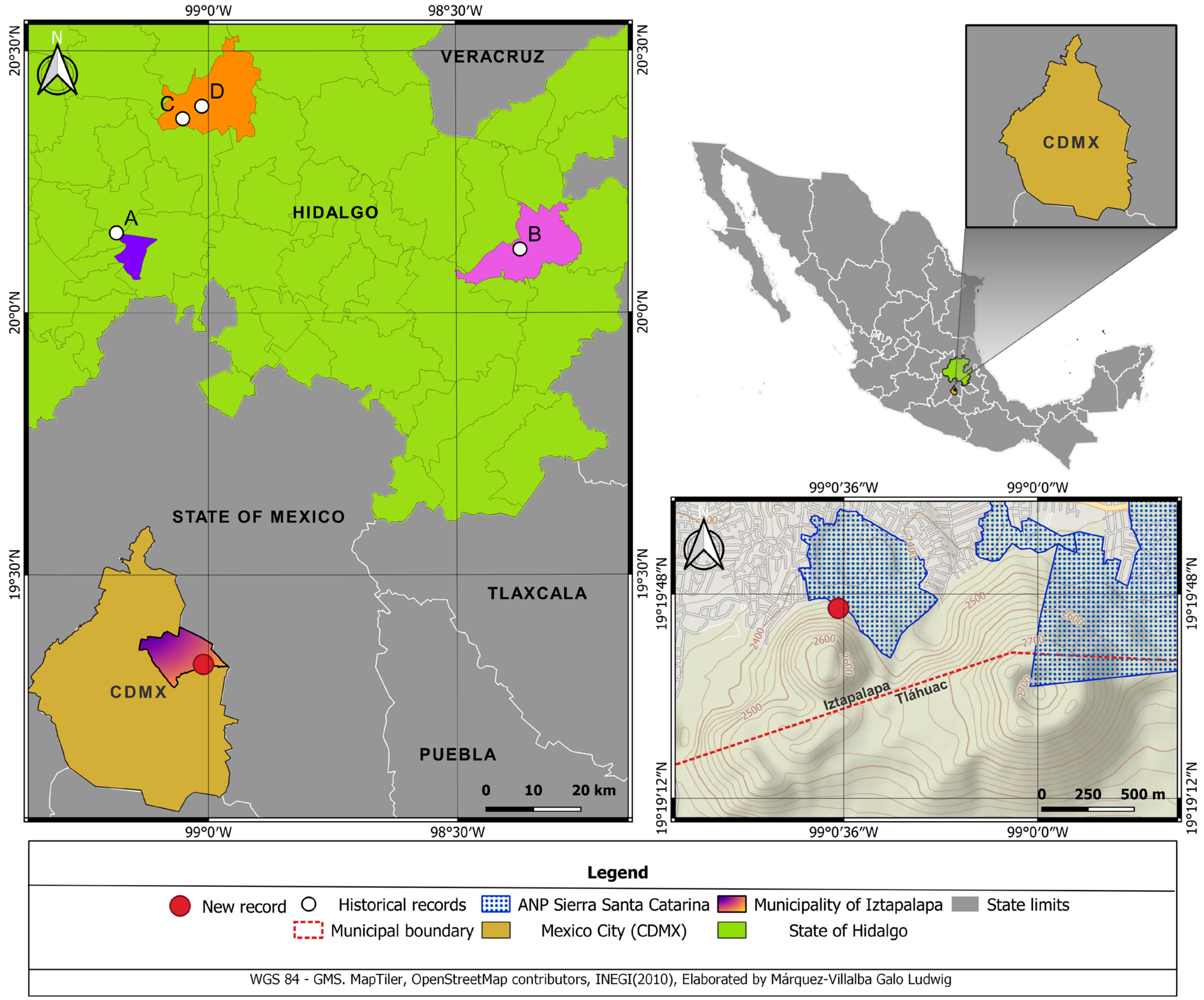
Notiosorex is a genus of North American shrews with 5 known species: *N. cockrumi, N. crawfordi, N. evotis, N. tataticuli,* and *N. villai* (Camargo and Álvarez-Castañeda 2020). These shrews are distributed in arid and semi-arid areas from southwestern United States and the Baja California peninsula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

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

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

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

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



WGS 84 - GMS. MapTiler, OpenStreetMap contributors, INEGI(2010), Elaborated by Márquez-Villalba Galo Ludwig

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

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

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

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

Carraway and Timm (2010) and Rojas-Mártinez *et al.* (2014) reported that this species prefers semi-arid environments with xeric shrubland. Similarly, in Sierra de Santa Catarina, we found grasslands in the lowlands and shrubland patches at higher altitudes, with a rocky substratum of volcanic origin. The dominant vegetation includes the shrubby stonecrop (*Sedum praealtum*), nolina (*Nolina parviflora*), broomstick tree (*Pittocaulon praecox*), white Tepozan (*Buddleia cordata*), Tepozan (*B. parviflora*), woollyjoint pricklypear (*Opuntia tormentosa*), and huizache (*Acacia farnesiana*; GODF 2005).

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

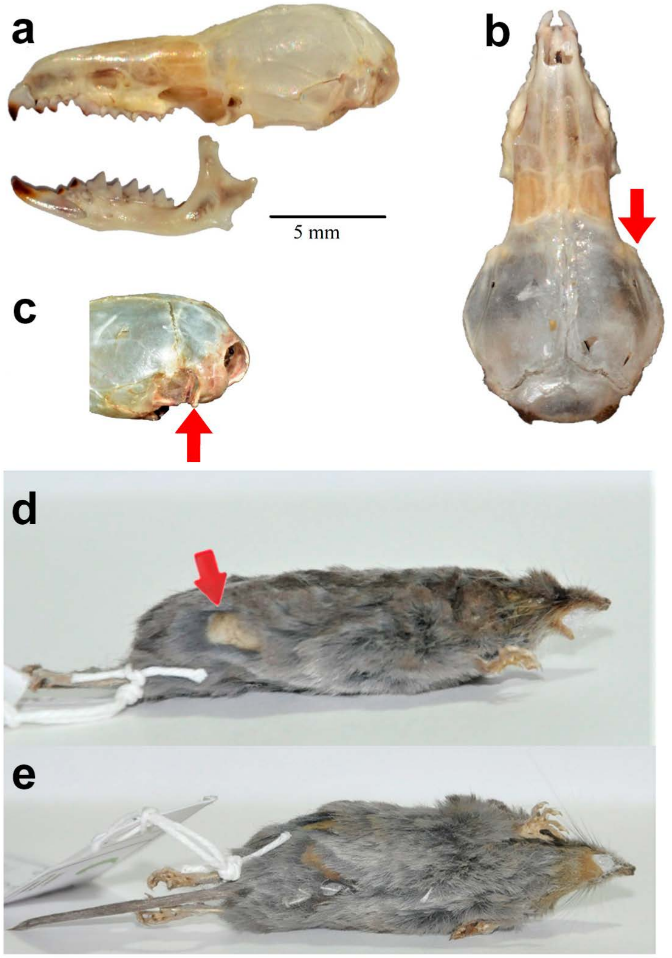


Figure 2. Lateral and dorsal views of the skull, jaw, and skin of an adult male specimen of *Notiosorex crawfordi* (CNMA 50001) collected in Sierra de Santa Catarina, México City. a) The arrow indicates the partial pigmentation of the 3 unicuspid and premolar maxillary teeth; b) lateral extension of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

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

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

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

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

Acknowledgements

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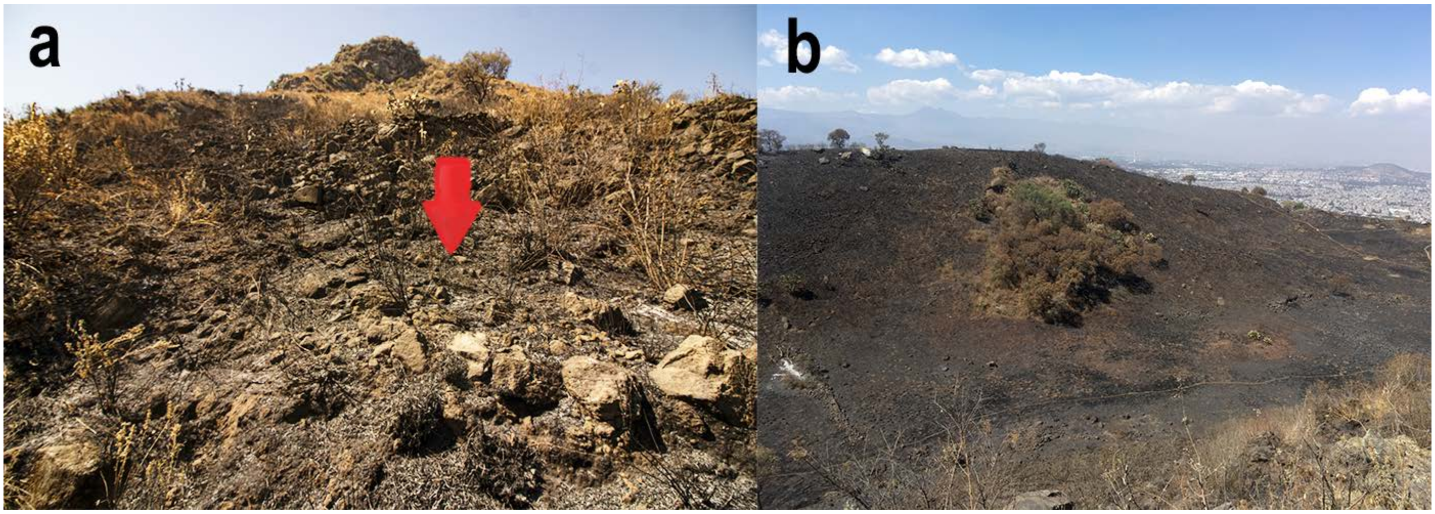

Figure 3. a) View of the area where the *Notiosorex crawfordi* male specimen was collected; b) frequent fires at approximately 30 m from the site of the new record that usually spread around the Tecuautzin Volcano (Iztapalapa municipality) and reaching Mazatepec (mostly in the Tláhuac municipality).

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Off-seasonal copulation of South American sea lion *Otaria byronia* in the Chilean Central Coast

Cópula atemporal del león marino sudamericano *Otaria byronia* en la costa central de Chile

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The South American sea lion *Otaria byronia* inhabit almost continuously from Perú to southern Chile and Brazil to southern Argentina on the Pacific and Atlantic Oceans, respectively. It is an abundant species, with great vagility and reproductive success and, without conservation problems. Like all pinnipeds, *O. byronia* exhibits a reproduction, notedly seasonal and highly synchronized with slight interpopulation differences, being the description of an atemporal copulation the objective for this note. On September 2020 we carried out a field observation in a reproductive rookery of *O. byronia* through binoculars on a rock in the Chilean central Coast. Eight individuals of *O. byronia* were recorded; from them, a couple had courted each other by moving their heads and bodies in unison. Subsequently, the male (sub-adult) mounted the female and they copulated for approximately 20 minutes, after which, she unhurriedly jumped into the sea. During the courtship and copulation only the male emitted sounds, and no mutual aggressive behavior was observed, not even the female opposed to being copulated, nor the 6 other individuals interacted with both. Considering its reproduction during the austral summer, this off-seasonal copulation is unusual for *O. byronia*; unprecedented in Chilean populations and subcontinent, being aspects such as climatic, physiological to anthropogenic factors suggested as causes, or triggers for this event. The foregoing highlights the need to expand studies of marine mammals distributed on the Chilean coast and explore the link and impact of extrinsic factors on populations.

Key words: Distribution; Loanco Cove; mating; pinnipeds; seasonality.

El lobo marino común *Otaria byronia* se distribuye ampliamente en Sudamérica desde Perú pasando por Chile hasta Brasil en los océanos Pacífico y Atlántico, respectivamente. Es una especie abundante, muy vágil y sin problemas de conservación. Como todos los pinnípedos, exhibe una reproducción notablemente estacional y sincronizada con ligeras diferencias entre poblaciones, siendo una cópula atemporal el objetivo de esta nota. Durante septiembre de 2020 se realizó un censo de *O. byronia* en una lobera reproductiva de la costa de Chile central, cuyos individuos sobre una roca fueron observados con binoculares. Ocho individuos de *Otaria byronia* fueron registrados, de éstos, una pareja se cortejaba mutuamente moviendo sus cabezas, cuerpos y se desplazaban al unísono sobre la roca. Posteriormente el macho (un sub-adulto) montó a la hembra y copularon aproximadamente por 20 minutos tras lo cual, ella sin prisa salto al mar. Durante el cortejo, cópula e interacción, solo el macho emitió sonidos y no se observaron conductas agresivas mutuas, ni que la hembra se opusiera a ser copulada. Tampoco se observó que los otros individuos interactuaban con ellos. La reproducción de *O. byronia* ocurre durante el verano austral siendo esta cópula inusual para la temporada, sin precedentes en las poblaciones chilenas y en el subcontinente. Diversos aspectos como factores climáticos, fisiológicos o presión antropogénica se pueden sugerir como causas o detonantes de este evento. Lo anterior destaca la necesidad de ampliar los estudios en mamíferos marinos en la costa chilena, explorando el vínculo e impacto de los factores extrínsecos sobre las poblaciones.

Palabras clave: Caleta Loanco; cópula; estacionalidad; pinnípedos; reproducción.

Reproduction is one of the most relevant aspects of the life history of an organism, which is related in turn behavioral, physiological, and ecological features. For any mammal the reproduction is associated with its reproductive cycle defined as the normal time for a female to reproduce, *i.e.*, to complete the associated processes with the fertile oestrus, ovulation, conception, gestation, birth, and lactation (Pomeroy 2011). In pinnipeds, the female reproductive cycle is characterized by a period of delayed embryo implantation or diapause from 2 to 3 months with a gestation period of 9 months (Costa 1991). The period of delayed implantation confers flexibility of timing of parturition, due to evolutionary adaptations in response to the environment, nutrition, or social influences (Boyd *et al.* 1999; Pomeroy 2011). For the otariids, reproduction is characterized by polygyny strategy, where the breeding animals congregate in colonies and dominant males mate with several females within a harem and keeping other males away to prevent access to the females (Heckel and Schramm 2021). This is the case of the South American sea lion *Otaria byronia* (de Blainville 1820), sin. *O. flavescens* (Shaw 1800), a species distributed almost continuously from Perú to southern Chile on the Pacific Ocean coast, and Brazil to southern Argentina on the Atlantic Ocean (King 1983; Sielfeld *et al.* 2018; Sepúlveda *et al.* 2011; Crespo *et al.* 2021). Like other otariids, the males arrive at the breeding sites earlier than females during the second half of December and they, establish territories or dominance hierarchies with other males (Crespo 1988). The females then arrive to these protected territories where to give birth about 2 or 3 days after their arrival, to then mate, generally with the dominant male (Sielfeld 1983). Mating occurs from January to the first days of March (Acevedo *et al.* 2003) with some day's variations between the Atlantic and Pacific populations (Campagna and Le Boeuf 1988; Acevedo *et al.* 2003; Pavés *et al.* 2005) that are recognized as distinct phylogenetic lineages or Evolutionarily Significant Units ESU (*e.g.*, Túnez *et al.* 2007; Artico *et al.* 2010; Weinberger 2013).

Regarding reproductive cycle of Pacific populations (Chile and Perú), differences have been reported in the timing of breeding season that can extend from 22 of December until May at Punta Negra rookery (20º 50’ S, 70º 10’ W) located in northern Chile, with a peak of newborn pups and mating late in January and mid-February (Acevedo *et al.* 2003) while, at Punta Lobería rookery (38º 39’ S, 73º 29’ W) in the central-south coast of Chile, the peak of births and mating occurs between the last week of January and mid-February (Pavés *et al.* 2005). Although the studies describing breeding times for the South American sea lion over their extensive geographical range, are relatively scarce on Pacific side, especially on Chilean coast (*e.g.*, Acevedo *et al.* 2003; Pavés *et al.* 2005; Pavés *et al.* 2011), the breeding behavior have extensively been studied on the Atlantic coast (*e.g.*, Hamilton 1934, 1939; Vaz Ferreira 1975, 1981, 1982; Ximénez 1975; Campagna 1985). However, no off-seasonal copulation data in the time ranges mentioned above, in both in reviews (*e.g.*, Sielfeld 1983, 1999; Muñoz-Pedreros and Yáñez 2000; Iriarte 2008; Crespo *et al.* 2021) and publications concerning this species in Chile (Aguayo and Maturana 1973; Acevedo *et al.* 2003; Pavés *et al.* 2005; Goetz *et al.* 2008; Sepúlveda *et al.* 2011). Consequently, based on a field record during 2020, we report an off-seasonal copulation for the South American sea lion *O. byronia* on central coast of Chile.

The observations were made in the breeding colony known as Cabo Carranza which includes the Santa Ana and Santos del Mar rookeries to the NW and SW, respectively, of the fisherman's cove of Loanco (35º 34’ 7.2” S, 72º 37’ 91” W), near 40 km South of Constitución city, Maule Region, Chile (Figures 1 and 2). The individuals of *O. byronia* present in the study area, were assessed using visual count for 15 min with binoculars on a big rock (of approximately 500 m^2) distant of approximately 50 m from shore. There, we also recorded the copulation between a male and female by almost 1 hr from 13:00 to 14:00 hr. This sighting was recorded in September 2, 2020 and photographically captured (Figure 3), being part of more broadly seasonal and geographical monitoring for this species in the area (Guzmán, unpublished data).

On the breeding colony of Cabo Carranza (Figure 2) a group of at least 6 individuals of *O. byronia* (among females, sub-adult individual, and just one pup from the previous reproductive season) plus, a couple near them were observed. The couple displayed a courtship behavioral before the copulation, where male (sub-adult) and female caress each other mutually, while moved their heads and bodies back and forth and moved in unison from place to place on the rock (Figure 3). During the mating, the female stayed stationary under the male while he completes insemination. The copula lasted about 20 min and once they ended, the female went calmly to edge of the place and jumped into the sea. During the entire time, only the male vocalized, and we did not observe hostilities, neither that male blocking the free the passage or escape

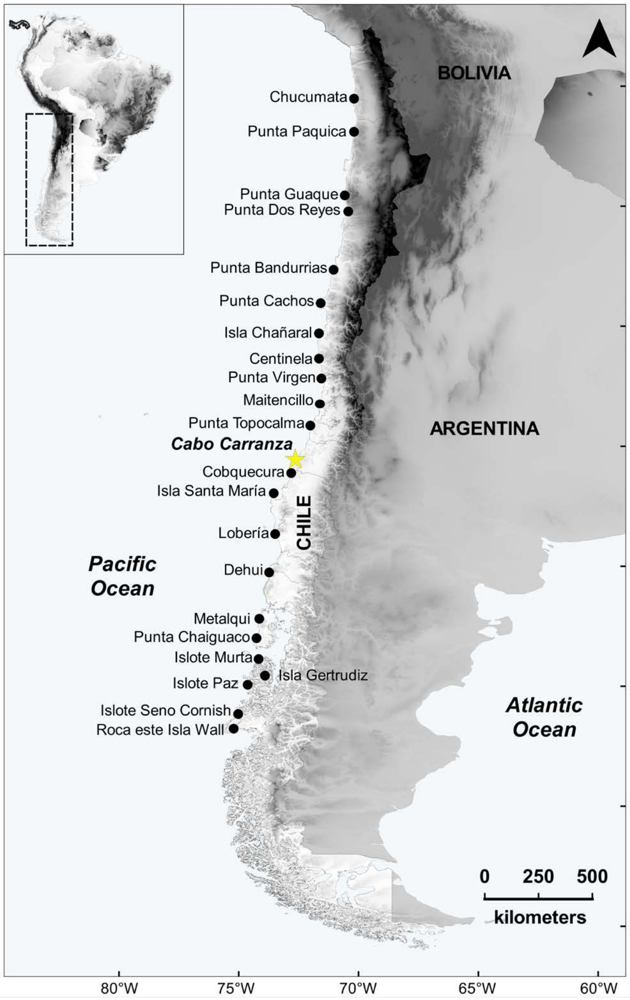

Figure 1. Location of the Cabo Carranza rookery, Región del Maule, Central Chile (star). Black dots indicate some (a few of them) breeding colonies of *Otaria byronia* along the Chilean coast (Appendix 1).

of the female, forcing copulation or, some physical assault between them. Besides this copulating couple the other individuals on the place did not interact with the couple or among themselves.

The scarce data for the reproductive time for Cabo Carranza shows that breeding takes place throughout the summer months, evidenced by offspring as well as adults in reproductive activity (Guzmán, unpublished data). In consequence, the described off-seasonal reproductive behavior is unusual for this species, unprecedented in Chilean populations and in the subcontinent same period (early September). For Cabo Carranza, censuses conducted from 2014 to 2022, are estimated a population between 28 and 6,000 animals with 1,248 individuals recorded for the winter period of 2020 (J. Guzmán per. obs.). In addition, the reproductive females reach 57.9 % of the total population size, with a birth rate of 3.6 %, a value considered below the average for Central Chile (DOPPLER 1996; Sepúlveda *et al.* 2007).

Pinnipeds have amphibious lifestyles with a combination of marine feeding and terrestrial reproduction. Regarding the above, the production is highly seasonal and synchronized with slight interpopulation differences, where climatic oscillations could influence variations of these stages and their noticeable seasonality (*e.g.*, El Niño Southern Oscillation - ENSO) which in turn impacts the food availability (*e.g.*, Sielfeld and Guzmán 2002; Oliveira 2011; Elorriaga-Verplancken *et al.* 2016), anthropogenic disturbances (including fishing activity) that modify population dynamics (*e.g.*, French *et al.* 2011; McHuron *et al.* 2017), or physiological factors (*e.g.*, Boyd 1991). In fact, during ENSO 1997/98 event Sielfeld and Guzmán (2002) reported at the breeding rookery of Punta Patache, numerous abortions, and premature birth since October 1997, with a maximum intensity during December 1997, and massive starvation of yearling and females in emaciated conditions, apparently caused by lack of anchovies, its main food item (Sielfeld *et al.* 2018).

Figure 2. A) "Cabo Carranza rookery" Región del Maule, Central Chile during September 2020; B) individuals (up) on the rock and the copulating couple (below). Photographs by J. A. Guzmán.

Aguayo and Maturana (1973 in Vaz Ferreira 1981) reported evidence for an earlier and probably longer pupping season than the ones on the Atlantic side. In fact, during a population census in October 1965, along the northern Chilean coast between Arica (18º 28′ S, 70º 18′ W) and Taltal (25º 24′ S, 70º 28′ W), they distinguished a newborn pup in 2 rookeries of Arica and Guaneras, indicating a possible calving season, in October 1965, a season that would be outside the normal calving and mating season for this species in January and February of each year (Acevedo *et al.* 2003). Other pups registered during that opportunity were yearlings from the previous breeding season: Punta Baquedano (15 to 20 pups), Punta Condell (30 pups), Punta Mejillones del Norte (140 to 150 pups), Punta Piedra (3 pups), Punta Lobitos (3 pups), Punta Baja (20 to 30 pups), Punta Lobería (70 to 100 pups), Punta Bandurria (20 to 30 pups; see Table 1 and 2 in Aguayo and Maturana 1973). The cause of an earlier reproductive event (calving prior to the summer season in this species) could be explained by an increase in environmental temperature, in this case by the presence of the ENSO event that in 1965/66 had a strong notation (NOAA/National Weather Service 2005). Today it is known that the ENSO events cause a decrease and absence of upwelling and a decrease of the productivity (Arntz and Tarazona 1990) which sustains the nekton, among others the anchovy (*Engraulis ringens*; Zuzunaga 1985; Arntz 1986) consumed by sea lions, birds and cetaceans and causing high mortality rates in these species (Duffy 1990; Limberger 1990). In this situation the females of the sea lions, especially the young females, eventually can advance ovulation and accept the males before the reproduction date in the austral summer. A similar condition with newborn pups on a rookery south of Valparaiso (33° 03′ S, 71° 39′ W) observed at the end of September 1975, also during an ENSO event of strong notation (NOAA/National Weather Service 2005), led Sielfeld (1983) to indicate the South America Sea Lion breeding season between September and March.

A possible hypothesis to explain the previous cases could be the independent or combined action of the mentioned factors on change of the foraging area, physiological and nutritional stress disturbing the timing of the reproductive cycles leading to delayed implantation, abort gestation, advancing the oestrus, or changes in other life history parameters. The mating reported in this note evidenced that the female was receptive to the male, suggesting that her oestrus cycle began earlier than usual. The interaction between the copulatory couple was like the dynamics observed during the reproductive season of this species, although without the competition and the frequent harassment from neighboring males. Since the South American sea lion reproduction takes place during the austral summer (*e.g.*, Pavés *et al.* 2005, 2011), especially during January and February, this reproductive behavior in early September is therefore unusual for this species. So, to fully understand whether this event is results of environmental, anthropogenic, physiological factors or combination of them, it is necessary to intensify the faunistic research for this species and other marine mammals of Chilean coastal and document every off-season event.

Figure 3. Record of the off-seasonal reproductive activity of *Otaria byronia* at Cabo Carranza rookery. From A to D courtship ritual prior to mating; E and F mating process (copulation) and G, end of copulation event. Photographs by J. A. Guzmán.

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Appendix 1

Geographical coordinates of some important breeding colonies (from literature) of the South American sea lion *Otaria byronia* along the Chilean coast.

Location	Latitude	Longitude
Chucumata	20.52 S	70.19 W
Punta Paquica	21.90 S	70.19 W
Punta Guaque	22.68 S	70.28 W
Punta Dos Reyes	24.55 S	70.57 W
Punta Bandurrias	25.22 S	70.43 W
Punta Cachos	27.65 S	71.04 W
Isla Chañaral	29.04 S	71.58 W
Centinela	30.30 S	71.65 W
Punta Virgen	31.35 S	71.65 W
Maintencillo	32.18 S	71.55 W
Punta Topocalma	34.14 S	72.01 W
Cobquecura	36.12 S	72.81 W
Isla Santa María	36.96 S	73.54 W
Lobería	38.66 S	73.48 W
Dehui	40.26 S	73.73 W
Metalqui	42.19 S	74.14 W
Punta Chaiguaco	43.00 S	74.26 W
Islote Murta	43.87 S	74.17 W
Isla Gertrudiz	44.56 S	73.90 W
Isla Paz	44.94 S	74.63 W
Islote Seno Cornish	46.16 S	75.03 W
Roca este Isla Wall	46.77 S	75.21 W

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First case of piebaldism in *Eumops auripendulus* in Costa Rica

Primer caso de piebaldismo en *Eumops auripendulus* en Costa Rica

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Pigmentation anomalies are caused either by a deficiency in, or an excess of melanin, resulting in chromatic disorders of the skin and fur or feathers. The anomaly consisting of white spotting has been reported in bats as leucism or piebaldism. We present the first record of piebaldism in *Eumops auripendulus* in Costa Rica. While monitoring bats in urban areas we measured the forearm of all specimens and noted (among other traits) coat color and length of ears. We checked individuals for the presence of glands and assessed the degree of ossification of the epiphyseal plates in the phalangeal joints. On September 13, 2021, we found a dead male *E. auripendulus* in San Ramón, Costa Rica. The forearm measured 57.5 mm, which is within the range of 57 – 63 mm reported for the species. The bat was a juvenile individual with a white spot in the middle of the abdominal region. Similar instances of aberrant coloration have been defined as piebaldism. The record of a piebald *E. auripendulus* is the second one for a molossid bat done in Costa Rica in a total of 6 cases of chromatic disorders. These aberrant colorations could be related to potentially detrimental circumstances; for example, the presence of white spots may be associated with deafness, which in the case of bats would prevent individuals from using echolocation. Knowledge of cases of color anomalies in bats will help to understand the ecological and physiological implications of this condition.

Key words: Chromatic disorder; hypopigmentation; leucism; mammal; Molossidae.

Las anomalías pigmentarias son causadas por deficiencia o exceso de melanina, lo que resulta en alteraciones cromáticas de la piel y el pelaje o las plumas. La anomalía que consiste en manchas blancas se ha definido en murciélagos como leucismo o piebaldismo. Presentamos el primer registro de piebaldismo en *Eumops auripendulus* en Costa Rica. Mientras monitoreamos murciélagos en áreas urbanas, medimos el antebrazo de todos los individuos y notamos (entre otros rasgos) el color del pelaje y la longitud de las orejas. Buscamos la presencia de glándulas y evaluamos el grado de osificación de las placas epifisarias en las articulaciones falángicas. El 13 de septiembre de 2021 encontramos un macho muerto de *E. auripendulus* en San Ramón, Costa Rica. Su antebrazo midió 57.5 mm, que está dentro del rango de 57 – 63 mm registrado para esta especie. El murciélago era un individuo juvenil con una mancha blanca en la región abdominal media. Casos similares de coloración aberrante se han definido como piebaldismo. El registro de piebaldismo en *E. auripendulus* es el segundo para Molossidae en Costa Rica en un total de 6 casos de desórdenes cromáticos. Estos casos de coloración aberrante podrían estar relacionados con circunstancias potencialmente perjudiciales; por ejemplo, la presencia de manchas blancas puede estar asociada a la sordera, lo que en el caso de los murciélagos les impediría utilizar la ecolocalización. El conocimiento de casos de anomalías cromáticas en murciélagos ayudará a comprender las implicaciones ecológicas y fisiológicas de esta condición.

Palabras clave: Hipopigmentación; leucismo; mamífero; Molossidae; trastorno cromático.

Chromatic disorders in wild fauna are pigmentation anomalies caused by a deficiency in or excess of melanin, both of which result in abnormal skin coloration, fur and feathers (Lucati and López-Baucells 2017). Chromatic disorders are due mainly to genetic alterations (Acosta 2007). However, these disorders can also be caused by environmental factors (Nemésio 2001) and even by the type of food ingested by the animals (Fox 1962; McGlothlin *et al.* 2007; Hudon *et al.* 2013). Abnormal colorations, often called color or chromatic aberrations, occur in all groups of vertebrates (Uieda 2000). Many cases of abnormal colorations have not been reported in the scientific literature, particularly in bats in the tropics (Aguilar-López *et al.* 2021). Detailed reports of atypical colorations are important to identify the different groups of animals affected, the types of chromatic disorders, and the distribution of the anomalies.

In mammals, abnormal colorations have been reported in members of various orders (Veloso-Frías *et al.* 2020). Like other mammals, bats are susceptible to genetic disorders that affect pigmentation (Zortéa and Silva 2017). Chromatic disorders are the most frequent type of anomalies recorded in bats (Lucati and López-Baucells 2017; Zalapa *et al.* 2016; Mahabal *et al.* 2019). White spots have been reported in species of 4 bat families of North and Central

America, including bats of the family Molossidae, although some of those cases have been reported as leucism (*e.g.*, Gamba-Ríos 2010; Zalapa *et al.* 2016; Mejía-Quintanilla *et al.* 2017; Escobar-Anleu and Mora 2018). Bats with white spots are piebald (the color aberration affects only a part of the body) rather than leucistic, a condition that results from total or partial lack of pigmentation on the skin or fur of the whole body (Lucati and López-Baucells 2017). A total lack of pigmentation on the whole body is also found in albino individuals, a condition generally characterized by reduced or absent melanin biosynthesis in melanocytes of the skin, coat, and eyes (Oetting and King 1999; Montilla and Link 2022).

Chromatic disorders previously reported in Costa Rican bats involve only 6 instances, in 5 species of the 120 reported for the country (York *et al.* 2019). There was 1 reported case of albinism in *Micronycteris minuta* (Phyllostomidae; Gamba-Ríos 2010), and several others of leucism: 2 in *Carollia sowelli* (Phyllostomidae; Gamba-Ríos 2010; Escobar-Anleu and Mora 2018), 1 case in *C. castanea* (Mejía-Quintanilla *et al.* 2017), 1 case in *C. perspicillata* (Escobar-Anleu and Mora 2018), and 1 case in *Molossus sinaloae* (Molossidae; Zalapa *et al.* 2016). However, based on the description of these chromatic aberrations, it would appear that all these reported cases of leucism represented piebaldism because these bats only presented white spots rather than a lack of pigmentation in the whole body.

The black bonneted bat *Eumops auripendulus* (Shaw, 1800) is distributed from México to Bolivia and northern Argentina, as well as on the island of Trinidad (Simmons 2005). In Costa Rica, this species can be present throughout the country (Barquez *et al.* 2015). *Eumops auripendulus* is a medium-sized bat with a body length of 74 – 100 mm, a tail length of 42 – 64 mm, and a forearm length of 57 – 63 mm (Mora *et al.* 2021). The species inhabits a wide variety of habitats, including dry forests, rain forests, and coastal plains, and presumable feeds on large insects (Reid 2009). Bats fly very high and fast and perch in small groups of up to 15 individuals in tree hollows, cliffs, and building roofs (Mora *et al.* 2018). They are seldom captured in mist nets (Barquez *et al.* 2015). Although *E. auripendulus* is a rare and little-known species, it is classified as Least Concern (LC) by the IUCN Red List (Barquez *et al.* 2015). This species has long, dark reddish-brown or black fur and without long hairs on the rump (Reid 2009). Here, we report a case of piebaldism in a black bonneted bat found in Costa Rica.

As a part of a project on monitoring bats in urban areas, we found a dead bat at the base of a tree trunk near a coffee plantation (Figure 1). The area is located within the Tropical Premontane Rain Forest life zone (Holdridge 1967). This life zone is characterized by the presence of evergreen trees with heights between 30 and 40 m, and an average rainfall of over 4,000 mm of rain per year. The forest canopy has 2 or 3 strata, a very dense understory, and the forest's ground surface is covered by mosses and ferns (Holdridge 1967). We photographed the dead bat and preserved it in alcohol. The specimen was deposited in the Portland State University Museum of Vertebrate Biology (PSU MVB Mammals 5064). We measured the forearm of the individual and evaluated other characteristics such as coat color, length of fur, length of ears, the shape of the antitragus, the presence or absence of long bristles on the rump, and hair on the edge of the calcar. We followed the field keys of Mora *et al.* (2020, 2021), and the reviews of Reid (2009) and Best *et al.* (2002) to determine the species identity of the individual. We checked the individual for the presence of a gular gland and assessed the age of the bat by verifying the degree of ossification of the epiphyseal plates at the phalangeal joints by examining them against the light of a lantern.

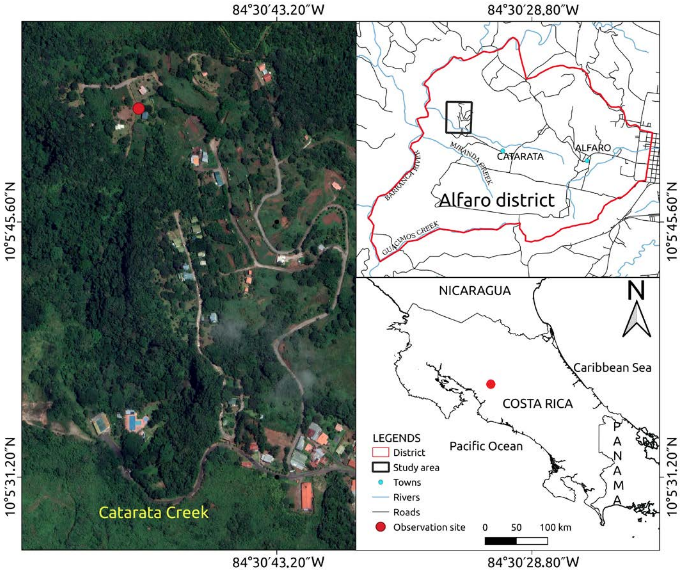

Figure 1. A location where a piebald *Eumops auripendulus* was found dead (red dot) in Cataratas de Alfaro, San Ramón, Alajuela, Costa Rica. Figure made by G. Chaves (Cachí).

On 13 September 2021, we found an individual of *E. auripendulus* in Cataratas de Alfaro, San Ramón, Alajuela, Costa Rica (10° 05' 52" N, 84° 30' 51" W; 988 m). Its forearm measured 57.5 mm, within the range of 57 – 63 mm previously reported for this species. The individual was a juvenile male, with incompletely ossified phalanges and no gular gland. When we examined the bat during the identification process, we noticed a white spot on the lower abdomen (Figure 2), a case of piebaldism as defined above.

White spotting is perhaps the most common chromatic aberration occurring, or at least reported in bats. Zalapa *et al.* (2016) reported 3 species of molossid bats with chromatic aberrations (*M. sinaloae*, *Nyctinomops femorosaccus*, and *Tadarida brasiliensis*). We add the present instance of *E. auripendulus* documented in Costa Rica as piebaldism. It has been suggested that individuals with chromatic aberrations may have problems in conspecific communication, potentially not being able to mate due to the abnormal coloration, or even have greater exposure to predators by standing out among their conspecific group (Martínez-Coronel *et al.* 2020). More importantly, chromatic aberrations could be associated with other potentially harmful effects. For example, the presence of white spots may be associ-

Figure 2. A piebald male *Eumops auripendulus* (PSU MVB Mammals 5064) with a white spot on the fur on the middle of the abdominal region, Cataratas de San Ramón, Alajuela, Costa Rica. Photo: J. M. Mora.

ated with congenital sensorineural deafness (Webb and Cullen 2010), a condition in which disease affects the neural structures of the hearing pathway, which in the case of bats would prevent them from using echolocation. Survival and life expectancy would be severely limited under these circumstances (Martínez-Coronel *et al.* 2020).

We did not find records of any chromatic disorder for *E. auripendulus* within its whole range of distribution. It is only the sixth species reported for Costa Rica with a chromatic disorder, and the second record of piebaldism in the country for bats of the family Molossidae (*M. sinaloae* was reported as a case of white spots without being defined specifically as piebaldism by Zalapa *et al.* 2016).

Molossid bats are much less well known than, for example, phyllostomids, because they are much less commonly captured with mist nets for their study (Kalko and Schnitzler 1998). As a result, reports of chromatic disorders may be biased toward phyllostomids. Species of Molossidae found in Costa Rica generally are dark brown to black in color (Mora *et al.* 2020), thus, it was easy to note the abnormal coloration of the bat we are reporting here. However, the cause of this abnormality is unknown, nevertheless, it may have been influenced by the KIT gene which has been reported as producing the genotypes white spots and general white coloration in laboratory mice (Barsh 2001; Zalapa *et al.* 2016). Its appearance could be related to elevated levels of inbreeding in populations, which would favor mutations that increase the frequency of certain phenotypes (Summers 2009). However, we are unable to indubitably ascertain the direct cause of the abnormal coloration of the black bonneted bat we report here, nor to say whether it played a part in its death. Notwithstanding, the finding of a dead individual marked by piebaldism and no unusual markings certainly is suggestive.

Acknowledgements

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New records of *Sturnira bakeri* in northwestern Ecuador: field notes about the species

Nuevos registros de *Sturnira bakeri* en el noroccidente de Ecuador: notas de campo sobre la especie

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Despite *Sturnira bakeri* is a recently described species, little is known about its intraspecific variation, feeding and flying habits, and reproductive patterns. This research aimed to confirm the presence of this species in northwestern Ecuador by comparing voucher specimens with the available literature. Several specimens of *S. bakeri* were captured in northwestern Pichincha. I collected 2 vouchers, but I focused on a variable specimen (a specimen with some different traits) and compared it with the original species description. Field notes on their physical appearance, reproductive status and other habits are included. The presence of *S. bakeri* in northwestern Ecuador is confirmed based on craniodental characters (such as the presence of bicuspidate upper inner incisors, serrated inner cusps on the lower molars, oval sphenorbital fissure, basisphenoid pits shallow and divided by a midline septum) and measurements similar to previous studies, but with some morphological differences like the shape of the zygomatic arches. *Sturnira bakeri* was found in secondary forests and pastures, it lives in sympatry with *S. ludovici*, and eats fruits of some plant species: *Piper*, *Vismia*, *Cecropia*, *Drymonia*, *Anthurium* and *Psychotria*. Variable specimens complicate species taxonomical identification and species definition. The new records with data about diet and habits help to fill gaps in knowledge about the species in this zone of the neotropics.

Key words: Diet; habits; reproduction; sympatry; taxonomy.

A pesar de que *Sturnira bakeri* es una especie descrita recientemente, se sabe poco sobre su variación intraespecífica, hábitos de alimentación y vuelo, y patrones reproductivos. Esta investigación tuvo como objetivo confirmar la presencia de esta especie en el noroccidente de Ecuador mediante la comparación de especímenes voucher con la literatura disponible. Varios ejemplares de *S. bakeri* fueron capturados en el noroccidente de Pichincha. Recolecté 2 vouchers, pero me enfoqué en un espécimen variable (un espécimen con algunas características diferentes) y lo comparé con la descripción original de la especie. Se incluyen notas de campo sobre su apariencia física, estado reproductivo y otros hábitos. La presencia de *S. bakeri* en el noroccidente de Ecuador se confirmó por características cráneo-dentales (como la presencia de incisivos internos superiores bicúspides, cúspides internas aserradas en los molares inferiores, fisura esfenorbital ovalada, fosas basiesfenoideas poco profundas y divididas por un septo) y medidas similares a estudios previos, pero con algunas diferencias morfológicas como la forma de los arcos cigomáticos. *Sturnira bakeri* fue registrada en bosques secundarios y pastizales, vive en simpatría con *S. ludovici*, y come frutos de varias especies de plantas: *Piper, Vismia, Cecropia, Drymonia, Anthurium* y *Psychotria*. Los especímenes variables complican la identificación taxonómica y la definición de una especie. Los nuevos registros con datos sobre dieta y hábitos ayudan a llenar vacíos de conocimiento sobre la especie en esta zona del neotrópico.

Palabras clave: Dieta; hábitos; reproducción; simpatría; taxonomía.

Sturnira bakeri was formally described as a new species in 2014, the distribution of the species was restricted to the tropical dry forests from the southwestern coast of Ecuador (Velazco and Patterson 2014). A further study expanded its distribution towards the northwestern Perú, in tropical humid forests (Sánchez and Pacheco 2016). Another study reviewed museum specimens and determined the presence of the species in tropical dry and humid forests from southwestern Colombia, the same study reported voucher specimens with characters different to the original species description (Montoya-Bustamante *et al.* 2017).

Many species' original descriptions do not consider the natural intraspecific variation among individuals. They are made on just few specimens, which could hinder taxonomic identification (Jarrín and Clare 2013). The *S. bakeri* original description was made based on 3 specimens (Velazco and Patterson 2014). There are other similar examples of this in the *Sturnira* genus such as *S. aratathomasi* that was described with 3 specimens, *S. sorianoi* described with 3 specimens, and *S. mistratensis* described with only 1 specimen (Peterson and Tamsitt 1968; Vega and Cadena 2000; Sánchez-Hernández *et al.* 2005).

Another problem with species like *S. bakeri* is a lack of information about their feeding and flying habits, as well as their reproductive patterns (Velazco and Patterson 2014). A great part of the diet in Phyllostomid bats is known thank to seed dispersal studies (Saldaña-Vázquez *et al.* 2014; Arias and Pacheco 2019), but the taxonomical identification of seeds dispersed by bats is fairly difficult, which is caused by the limited number of field guides in neotropics about this topic (Kirkbride *et al.* 2006; Lobova *et al.* 2009; Magalhaes de Oliveira and Pereira 2016). Additionally, the diet of Phyllostomid bats is highly variable in space and time (Mello *et al.* 2011). Flying habits allows to understand which habitats or ecosystems are commonly frequented by bats, this is useful when researchers want to look for a specific species (Tirira 2017). Reporting pregnant females or females with juveniles, at specific times of the year, are the base for other researchers to search reproductive patterns, which can be useful in conserving species (Tirira and Burneo 2012).

This research aims to present a variable specimen of *S. bakeri* with interesting characters and compare it with other studies, thus supporting the presence of *S. bakeri* in northwestern Ecuador and contributing with the knowledge of intraspecific variation. I present some data about biological measurements to help in the identification of this species in this part of neotropics. I also provide field notes about feeding and flying habits, and reproductive status of specimens recorded.

As a part of the research project called "Effects of fragmentation on the taxonomic, functional, and phylogenetic structure of mammal communities in northwestern Ecuador", supported by Universidad Central del Ecuador (UCE), I had the opportunity to study living specimens of *S. bakeri* captured between January and August 2021. I captured bats using mist nets in 3 agro-ecological reserves: Pambiliño, Chontaloma and Mashpi Shungo; from northwestern Pichincha at the Andean Chocó. The reference ecosystem was the lowland evergreen forest (LEF) of the western Andes Mountain range, the weather here is quite warm and it presents intense rains most of the year (MAE 2013). I used 4 habitats to capture bats: primary forest (3 nights), secondary forest in natural regeneration (11 nights), secondary forest in assisted regeneration (4 nights) and pastures for cattle (3 nights). Two vouchers were collected and deposited in the Museo Ecuatoriano de Ciencias Naturales (MECN 6797 and MECN 6811) of the Instituto Nacional de Biodiversidad (INABIO) with the research license given by the Ministerio del Ambiente del Ecuador (MAE-ARSFC-2020-0.512). The specimen MECN 6811 held the principal characteristics of the species, but MECN 6797 had some craniodental differences, being a variable specimen.

I focused on the variable specimen (MECN 6797) to compare it with *S. bakeri* original holotype description from the mammal collection of Museo de Zoología de la Pontificia Universidad Católica del Ecuador (QCAZ; Velazco and Patterson 2014), and 2 later descriptions of the species. The first used specimens from the collection of Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM; Sanchez and Pacheco 2016), and the second used specimens from the collection of Universidad del Valle (UV; Montoya-Bustamante *et al.* 2017). The weight was taken in grams with a digital balance for both living specimens and vouchers. The age was determined by seeing the fused degree of hand-wing epiphyses (Jarrín and Kunz 2011). The body and craniodental measurements were taken in millimeters with a digital caliper (Appendix 1, 2; McCarthy *et al.* 2006).

Besides morphological measures, I collected seeds from captured specimens. A common method to obtain bat-dispersed seeds is to keep animals captured in mist nets into cloth bags for 1 hr to defecate, bats usually digest their food during this time because of their fast metabolism. I preserved the seeds in Eppendorf tubes with 70 % alcohol, and each sample was labeled with a unique number to avoid confusion. Although this is a useful method to obtain seeds, it is fairly common that bats usually defecate when they are recently captured in mist nets due to stress, I also preserved these samples (Arias and Pacheco 2019).

I dried all samples in paper envelopes inside a drying machine in the laboratory. Then I separated the dried seeds from other fecal residues. The taxonomical identity of the seeds was determined under the microscope using field guides (Kirkbride *et al.* 2006; Lobova *et al.* 2009; Magalhaes de Oliveira and Pereira 2016). The seeds were deposited at the MECN. I created a map with the known records of the species (Velazco and Patterson 2014; Sánchez and Pacheco 2016; Montoya-Bustamante *et al.* 2017; Romero 2019), and potential records (GBIF 2022; Figure 1). Finally, this note includes some data about the species feeding and flying habits, as well as data about reproductive status.

I captured 14 specimens of *S. bakeri* in the sampling sites. The variable specimen was different from the *S. bakeri* original description in characters such as: the absence of process of glenoid fossa, poorly developed sagittal crest, zygomatic arches with a little concavity at the middle, and clinoid process absent. Despite these differences, it holds the main characteristics used in the original description: serrated inner cusps on the lower molars, bicuspidate upper inner incisors, oval sphenorbital fissure, basisphenoid pits

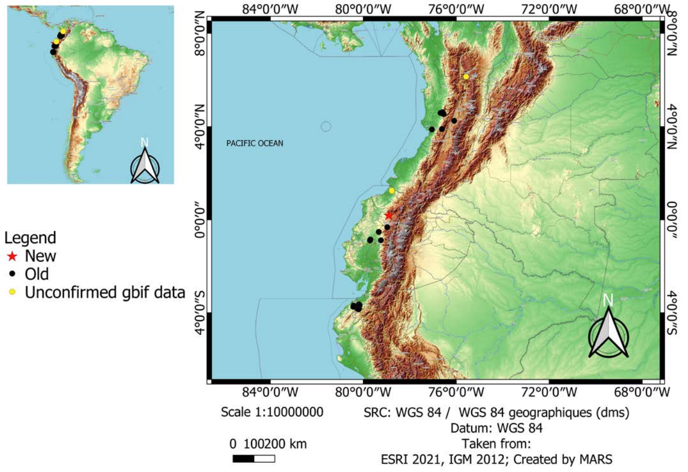

Figure 1. Current distribution of *Sturnira bakeri* in South America. It probably exists in western Andes range from western slopes of Colombia to northwest Perú less than 2,000 m.

Table 1. Comparisons of craniodental measurements (mm) in *Sturnira bakeri* from northwestern Ecuador.

Measurements	MECN 6797 ♀	(Velazco and Patterson 2014) Holotype QCAZ 1463 ♀	(Sánchez and Pacheco 2016) (*n* = 31)	(Montoya-Bustamante *et al.* 2017) (*n* = 7)
Braincase breadth	10.12	10.4	9.88 - 10.92	10.49 - 10.87
Condylocanine length	19.7	20.3	19.41 - 21.22	19.87 - 20.65
Condyloincisive length	20.5	21.1	19.96 - 21.97	20.54 - 22.5
Dentary length	14.37	15	14.32 - 15.86	14.07 - 15.07
Greatest length of skull	21.74	22.7	21.96 - 23.86	21.9 - 23.5
Length of mandibular toothrow	6.98	7.7	6.95 - 8.05	7.36 - 7.96
Postorbital breadth	5.83	5.9	5.58 - 6.42	5.8 - 6.21
Mastoid breadth	11.82	11.9	11.37 - 12.19	11.96 - 12.46
Maxillary toothrow length	6.77	6.9	6.44 - 7.11	6.52 - 7.23
Width at M2	8.13	8.3	7.87 - 8.65	7.62 - 8.29
Zygomatic breadth	12.98	13.5	12.87 - 14.34	13.43 - 14.33

shallow and divided by a low midline septum, tetracolor fur on the back and tricolor on the belly, and the IV metacarpal shorter than the III metacarpal (Velazco and Patterson 2014; Figure 2). The measurements of the voucher specimen were similar to those presented in previous studies (Table 1).

Sturnira bakeri can vary in dorsal fur coloration from light brown to slightly darker brown. Ventrally it can be light brown, whitish and even yellowish in appearance. Some adult individuals are totally grayish, this especially occurs in juvenile and sexually immature (Figure 3). In general, the lateral folds of the ears (pinna) are poorly marked, and some specimens lack them completely.

Pregnant females were captured in April (*n* = 2; the body measurements recorded for all the specimens are shown in Table 2). I found the species flying on secondary forests in natural regeneration (*n* = 5), secondary forest in assisted regeneration (*n* = 4), in pastures for cattle (*n* = 5), but it was not found in primary forest. *Sturnira bakeri* lives in sympatry with other species of the same genus such as *S. ludovici* (Velazco and Patterson 2014). I found 8 different seeds in the feces of the captured bats: *Anthurium* spp., *Vismia* spp., *Drymonia* sp., *Piper aduncum*, *Piper* sp., *Psychotria* sp., *Solanum* sp., and *Cecropia* spp. Seeds like *Drymonia* sp., *P. aduncum,* and *Psychotria* sp., are shared in diet with *S. ludovici* (Kirkbride *et al.* 2006; Lobova *et al.* 2009; Magalhaes de Oliveira and Pereira 2016; Figure 3).

The taxonomical identification of variable specimens is difficult when original descriptions are based on few specimens, this is because it fails in capturing all the possible natural intraspecific variation of species (Jarrín and Clare 2013). A species could be variable across different biogeographic distributions, complicating the taxonomical identification and compromising the species definition (Calderón-Acevedo *et al.* 2022). In fact, some characteristics could be variable depending on the development stage and sex, as example, it has been reported that there exists age and sex variation in skull characters in many mammalian species, including the human beings (Šrámek and Benda 2014; Avelar *et al.* 2017; Voyta 2017). This study, added to previous studies, show that *S. bakeri* can vary in morphology between different zones in the Neotropics (Sánchez and Pacheco 2016; Montoya-Bustamante *et al.* 2017), which will facilitate identification for other researchers. I consider that the best characteristics to identify *S. bakeri* are: serrated inner cusps on the lower molars and bicuspidate upper inner incisors, oval sphenorbital fissure, shallow basisphenoid pits, medium size (average ± standard deviation, and range and number of individuals in parenthesis; see Appendix 1 for measurements): FA = 43.42 ± 1.59 (41.11 - 47.32; *n* = 24), GLS = 22.50 ± 0.54 (21.74 - 23.5; *n* = 9), CIL = 21.24 ± 0.58 (20.5 - 22.5; *n* = 9), these data are based in sizes

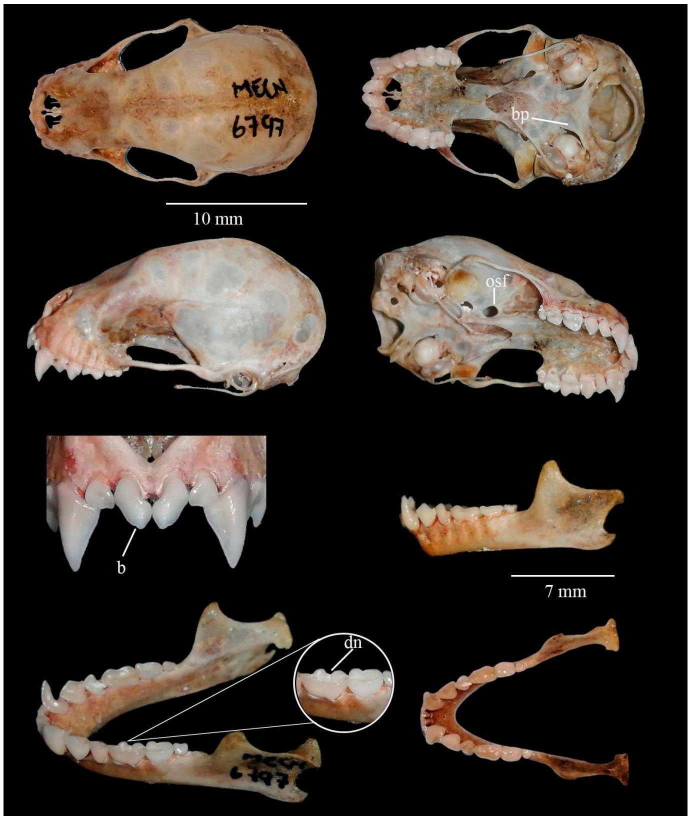

Figure 2. Details from the skull and jaws of *Sturnira bakeri* (MECN 6797). bp = basiesphenoid pits are shallow and divided by a low midline septum; osf = oval sphenorbital fissure; b = bicuspidate upper inner incisors; dn = deep notch at lower molars.

Table 2. Body measurements and another data for *Sturnira bakeri* captured in northwestern Ecuador. FA = Forearm length, EL = Ear length, HF = Hind foot length, TL = Total length, W = Weight on gr., Rep. S. = Age and / or Reproductive state.

Specimens	FA	E	HF	TL	W	Sex	Rep. S.
S. bakeri MECN 6797	41.81	13.56	12.36	55.8	17	♀	Adult
S. bakeri MECN 6811	43.32	13.71	12.4	59.73	23	♀	Adult
S. bakeri	44.7	13.71	13	55.78	24	♀	Adult
S. bakeri	45.63	14.86	14.4	63.15	23	♀	Pregnant
S. bakeri	41.81	13.56	11.5	55.8	17	♀	Juvenile
S. bakeri	47.32	10.25	11.1	69.56	25	♀	Pregnant
S. bakeri	44.83	12	11.3	57.53	18	♂	Juvenile
S. bakeri	43.14	12.1	11.6	58.42	25	♀	Adult
S. bakeri	44.31	11.19	11.14	60.84	26	♂	Adult
S. bakeri	41.3	11.1	11.5	59.35	20	♀	Adult
S. bakeri	43.15	14.52	10.52	64.98	28	♂	Adult
S. bakeri	41.95	11.81	11.18	61.36	23	♂	Adult
S. bakeri	43.55	11.88	12.56	55.18	22	♂	Adult
S. bakeri	44.07	12.36	11.43	52.75	21	♂	Adult
Minimum	41.3	10.25	10.52	52.75	17	-	-
Maximum	47.32	14.86	14.4	69.56	28	-	-
Mean	43.64	12.62	11.86	59.30	22.29	-	-
Standard deviation	± 1.67	± 1.38	± 1.00	± 4.47	± 3.36	-	-

from this study and previous studies (Velazco and Patterson 2014; Montoya-Bustamante *et al.* 2017), and a restricted distribution to the western slopes of the Andes (Jarrín and Clare 2013; Velazco and Patterson 2014).

Despite *S. bakeri* is considered as a least concern species (Tirira 2021), there exist threatens for the populations of the species in this part of neotropics due to fast habitat fragmentation in the Andean Chocó, which is caused by cattle ranching, agriculture, deforestation and gold mining activities (Jarrín and Kunz 2011). Other places where the species is known like the western ecosystems of tropical dry forest from Ecuador and Perú, are near to disappear due to cattle ranching and agriculture (MAE 2013), more studies will be necessary for monitoring the status conservation and reproductive patterns of the species.

In addition to the cited vouchers, biogeographical and genetic evidence supports *S. ludovici* presence in the western slopes of Ecuador (Jarrín and Clare 2013; Velazco and Patterson 2013; Molinari *et al.* 2017). The information about diet could be useful to understand niche partition with sympatric species such as *S. bakeri* (Macarthur and Levins 1967), but it is difficult to understand in which dimension of the niche they exactly differ without further studies. There is a hypothesis about that many bats differs in the temporal use of fruits depending on the state of ripeness (Freeman 1988), the fruit mass, size and hardness have been considered as important factors affecting the dietary specialization for Phyllostomid bats (Saldaña-Vázquez *et al.* 2014), this suggest that serrated inner molars on *S. bakeri* could be useful for hard not-quite ripe fruits, while flattened inner molars in *S. ludovici* could be useful for soft ripe fruit. Current research considers that there exist intrinsic factors (such as feeding behavior, mouth morphology, bite force and digestive physiology) an extrinsic factor (such as fruit physical characteristics, ingestible material of fruits, fruit secondary metabolites, fruit nutrients and energy, and spatio-temporal availability of fruits) determining the dietary specialization and community structure in Phyllostomid bats (Saldaña-Vázquez *et al.* 2014). Bats from the

Figure 3. Natural color variation and diet of *Sturnira bakeri*. From left to right: A-C = three adult males (the first male lacks lateral fold of the ears, third male has grayish skin). D = pregnant female, E-F = *Anthurium* spp., G-I = *Vismia* spp., J = *Drymonia* sp. , K = *Piper aduncum*, L = *Piper* sp., M = *Psychotria* sp., N = *Solanum* sp., O-P = *Cecropia* spp., Blue grids scales are 1 mm x 1 mm.

genus *Sturnira* have been considered to be specialist in the consume of *Piper* and *Solanum,* other species preferred by these bats are *Ficus*, *Cecropia* and *Vismia* (Saldaña-Vázquez *et al.* 2014; Arias and Pacheco 2019). The dietary items identified as *Anthurium, Psychotria,* and *Drymonia* are new for the diet composition of the genus.

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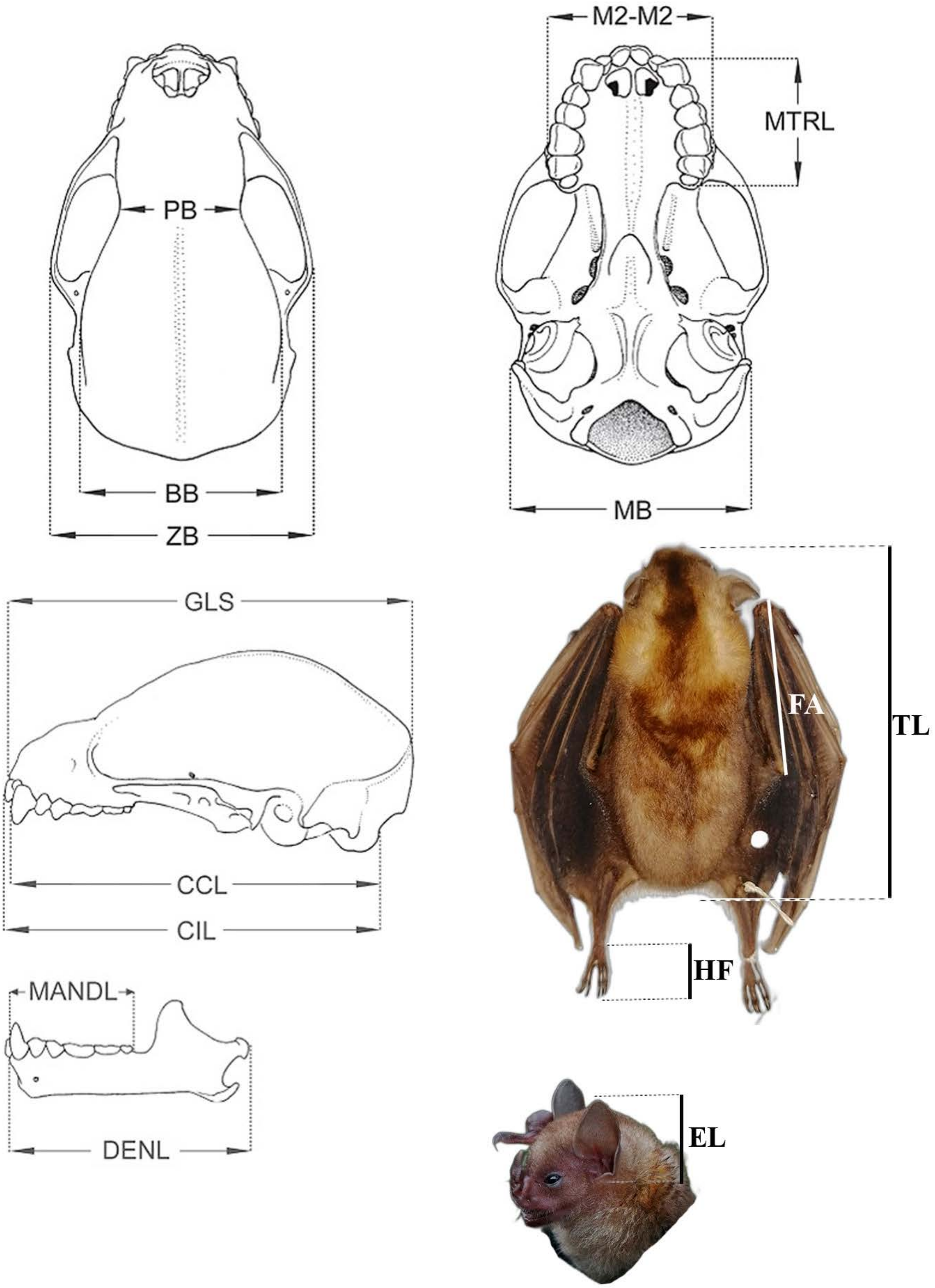
Appendix 1

Craniodental and body measurements used for this research.

Measurements	Description
Ear length (EL)	Distance from ear notch to ear tip.
Forearm length (FA)	Distance from the elbow (tip of the olecranon process) to the wrist including the carpals (this measurement is made with the bat wing at least partially folded).
Hind foot length (HF)	Distance along foot from anterior edge of calcar to most distant claw.
Total length (TL)	Dorsally, distance from tip of the last vertebra to nose tip.
Braincase breadth (BB)	Greatest breadth of the globular part of the braincase, excluding mastoid and paraoccipital processes.
Condyloincisive length (CIL)	Distance between a line connecting the posteriormost margins of the occipital condyles and the anterior most point on the upper incisors.
Condylocanine length (CCL)	Distance between a line connecting the posteriormost margins of the occipital condyles and a line connecting the anteriormost surface of the upper canines.
Dentary length (DENL)	Distance from midpoint of condyle to the anteriormost point of the dentary.
Greatest length of skull (GLS)	Distance from the posteriormost point on the occiput to the anteriormost point on the premaxilla (excluding the incisors).
Length of mandibular toothrow (MANDL)	Distance from the anteriormost surface of the lower canine to the posteriormost surface of m3.
Mastoid breadth (MB)	Greatest breadth across the mastoid region.
Maxillary toothrow length (MTRL)	Distance from the anteriormost surface of the upper canine to the posteriormost surface of the crown of M3.
Postorbital breadth (PB)	Least breadth at the postorbital constriction.
Width at M2 (M2-M2)	Greatest width of palate across labial margins of the alveoli of M2s.
Zygomatic breadth (ZB)	Greatest breadth across the zygomatic arches.

Appendix 2

Craniodental and body measurements considered in this study. See descriptions in Appendix 1. Modified from Velazco and Patterson (2014).



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Potential predation on the tiger rat snake *Spilotes pullatus* by the gray fox *Urocyon cinereoargenteus*

Probable depredación de la serpiente voladora *Spilotes pullatus* por la zorra gris *Urocyon cinereoargenteus*

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Studies on diet allow understanding trophic relationships within biotic communities. The gray fox is a solitary mammal with activity during daytime and nighttime hours. It has an omnivorous diet, with flexible and opportunistic habits. The tiger rat snake is a diurnal colubrid with a remarkable ability to move between tree branches. The potential predation event was recorded in Komchén de los Pájaros, a locality in northern Yucatán. We placed 8 camera traps from 23 December 2019 to 31 December 2021; 6 worked as separate stations and 2 as a dual station. They were set to remain operational 24 hr a day. On 4 December 2021, a gray fox (*Urocyon cinereoargenteus*) was recorded at station 4. The photo shows a moving fox carrying a tiger rat snake (*Spilotes pullatus*) in the snout. Although there is no evidence of the fox actually feeding on the snake, this may have occurred. Few reptile species have been recorded in the diet of *U. cinereoargenteus*. To date, only the green iguana *Iguana iguana* and the Texas alligator lizard *Gerrhonotus infernalis* have been reported as prey. No such records are currently available for *S. pullatus*. Although we found no direct evidence that the gray fox actually consumed the snake, this is potentially the first record of a predator-prey interaction between these species.

Key words: Camera traps; diet; Komchén; predator; tropical forest.

Los estudios sobre la dieta permiten entender las relaciones tróficas entre las comunidades bióticas. La zorra gris es un mamífero de hábitos solitarios y activo tanto de día como de noche, tiene una dieta omnívora, con hábitos alimentarios flexibles y oportunistas. La serpiente voladora es un colúbrido de actividad diurna con una amplia agilidad entre las ramas de los árboles. La zona donde se obtuvo el registro de la zorra fue en Komchén de los Pájaros, se ubica al norte del estado de Yucatán. Del 23 de diciembre de 2019 hasta el 31 de diciembre de 2021, se colocaron 8 cámaras-trampas, 6 funcionaron como estaciones independientes y 2 como una estación doble. Fueron programadas para su funcionamiento de 24 horas. El 4 de diciembre de 2021, se registró en la estación 4 a una zorra gris (*Urocyon cinereoargenteus*). La imagen muestra a la zorra en marcha y llevando en el hocico a una serpiente voladora (*Spilotes pullatus*), aunque sin evidencia de que la consumiera, lo que indica que potencialmente pudo existir dicho evento. Se han registrado pocas especies de reptiles en la dieta de *U. cinereoargenteus*, hasta ahora se han identificado a la iguana *Iguana iguana*, y la lagartija caimán norteña *Gerrhonotus infernalis.* Para el caso específico de *S. pullatus* no hay ningún registro actual. Aunque no encontramos evidencia de que la zorra gris consumiera a la serpiente, potencialmente este sería el primer registro de esta interacción.

Palabras clave: Depredador; dieta; fototrampas; Komchén; selva baja.

Wildlife species consume the food that is available in their habitat. Therefore, their diet functions as a link between the local resources, being a key driver of balance in ecosystems (Ojasti and Dallmeier 2000). Studies on diet allow understanding trophic relationships between biotic communities (Villalobos *et al.* 2014; Viteri-Pasch and Mármot-Kattán 2019), as well as the quantity and quality of the food consumed (Ojasti and Dallmeier 2000; Cruz-Espinoza *et al.* 2010).

The gray fox *Urocyon cinereoargenteus* is listed as Least Concern in the Red List of the International Union for the Conservation of Nature (IUCN; Roemer *et al.* 2016). It is a medium-sized predator weighing between 3 kg and 5 kg (Fritzell and Haroldson 1982), with solitary habits, and active during daytime and nighttime hours (Fuller and Cypher 2004). This fox is distributed from southern Canadá to northern Venezuela and Colombia, except for some mountainous regions in the northern United States and eastern Central America (Fritzell and Haroldson 1982). In México, it is distributed throughout the country (Roemer *et al.* 2016), inhabiting almost all vegetation types (Fritzell and Haroldson 1982).

Urocyon cinereoargenteus has an omnivorous diet with flexible feeding habits like the coyote *Canis latrans*, the raccoon *Procyon lotor*, and the jaguarundi *Herpailurus yagouaroundi* (Guerrero *et al.* 2002). Among the studies on the diet and food webs of the gray fox, it is worth highlighting the works of Errington (1935), Wood (1954), Fritzell and Haroldson (1982), Hockman and Chapman (1983), Arnaud and Acevedo (1990), Novaro *et al.* (1995), Guerrero *et al.* (2002), Villalobos *et al.* (2014), Harmsen *et al.* (2019), and Wong-Smer *et al.* (2022). Its diet includes fruits, nuts, grains (seeds), small vertebrates, and invertebrates.

For its part, the snake *Spilotes pullatus* is listed as Least Concern in the IUCN Red List (Arzamendia *et al.* 2019). Its maximum size is about 260 mm to 270 mm (Köhler 2008), and it feeds mainly on small mammals, birds, and eggs (Lee 1996). This snake is a diurnal colubrid commonly found among tree branches, sometimes on the ground, and frequently near water bodies (Harrington *et al.* 2018). It is distributed in México in the states of Tamaulipas, Veracruz, Tabasco, Querétaro, Hidalgo, northern Oaxaca, Chiapas, and the Yucatán Peninsula, southward through Belize, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panamá, and Argentina, inhabiting dry and wet forests from sea level to 1,500 m (Köhler 2008). It was reported in Yucatán by Lee (1996) and later confirmed by González-Sánchez *et al.* (2017).

There are no records of predator-prey interactions between these two species. There are records of *S. pullatus* being preyed on by the great black hawk, *Buteogallus urubitinga* (Gerhardt *et al.* 1993). Furthermore, a predation attempt by the middle American indigo snake *Drymarchon melanurus* was also reported (Oakley and Theodorou 2020). Considering the importance of understanding and studying these interactions, this note reports the potential predation of *S. pullatus* by *U. cinereoargenteus* in northern Yucatán.

The interaction between the gray fox and the tiger rat snake was recorded in Komchén de los Pájaros, a private area voluntarily dedicated to conservation. The protected area comprises 300 ha of tropical deciduous forest (Flores and Espejel 1994) located in northern Yucatán, in the kilometer 1.5 of the Dzemul-Xtampú road section, in the south of the Dzemul municipality (21° 13' 30" N, 89° 19' 17.03" W; 21° 13' 38.64" N, 89° 20' 18.60" W; 21° 12' 14.7" N, 89° 20' 22.91" W; 21° 12' 9.36" N, 89° 19' 17.03" W; Figure 1). Altitude ranges from 0 to 15 m (INEGI 2005), and the dominant soil type is Leptosol (INEGI 2009). The prevailing climate is warm sub-humid with summer rains (INEGI 2009). The dry season in this area lasts from 7 to 8 months (November to June), slightly attenuated by "Norte" winter rains or storms.

A systematic sampling was conducted as part of a terrestrial vertebrate monitoring program from 23 December 2019 to 31 December 2021. We selected 4 permanent sites (2, 4, 6, 9; Figure 1) according to accessibility (paths) and water availability (artificial drinking troughs and cenotes) to capture the highest diversity of species, according to O'Brien *et al.* (2011). Simultaneously, a non-systematic sampling was conducted, consisting of 4 temporary camera traps set at each site to capture photos over 2 months (1, 3, 5, 7, 8, 10, 11, 12, 13; Figure 1). Sampling sites were selected based on previous records of mammal tracks (scats or footprints). The permanent sites 2 and 6 worked as a dual station for 6 months (January-July 2021). Eight camera traps were used for the sampling; 1 Moultrie (M-4000), 1 Primo (63053), 3 Bushnell HD (119876), and 3 CuddeBack (h-1453). Camera traps were placed on tree trunks 50 cm above the ground. Each camera was set to capture photos 24 hr per day, with 3 consecutive shots per capture event. The memory cards were reviewed weekly.

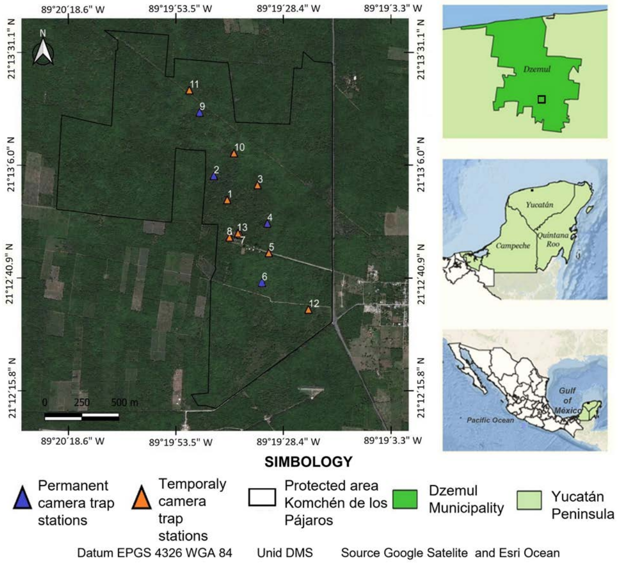

Figure 1. Distribution and location of the monitoring stations at Komchén de los Pájaros, Yucatán, México.

A sampling effort of 623 trap days (14,952 hr) was recorded from 23 December 2019 to 31 December 2021. In total, 157 records of gray fox (*U. cinereoargenteus*) were captured with the camera traps. On 4 December 2021 at 11:40 hr, a gray fox was captured at station 4 (21° 13' 22.72" N, 89° 19' 50.34" W; Figure 2). The photo shows a moving gray fox carrying a tiger rat snake (*S. pullatus*) in the snout, which may have been either preyed on or picked as carrion. The snake showed the highly noticeable black-greenish yellow dorsal pattern with both colors balanced in proportion and yellow scales with black edges forming transverse stripes (Pérez-Higareda *et al.* 2007). These characteristics are typical of *S. pullatus*, allowing its identification with the guide by Lee (1996) and Köhler (2008). We recorded no evidence of the gray fox actually consuming the snake; however, the record of the fox carrying the snake in its snout suggests a likely predator-prey interaction between these species.

The predator-prey interaction between *U. cinereoargenteus* and *S. pullatus* has not been previously reported, so this is the first record of the potential predation of the tiger rat snake by a gray fox. Few reptile species are currently reported in the diet of *U. cinereoargenteus*. The green

Figure 2. Gray fox (*Urocyon cinereoargenteus*) carrying a tiger rat snake (*Spilotes pullatus*) in its snout at Komchén de los Pájaros, Yucatán, México.

iguana *Iguana iguana* was recorded in a tropical deciduous forest on the coast of Jalisco (Guerrero *et al.* 2002), and the Texas alligator lizard *Gerrhonotus infernalis* in a pine-oak forest in Nuevo León (García-Bastida *et al.* 2018). In the particular case of *S. pullatus*, there are no current records showing that it is preyed on by the gray fox. These reports suggest that the gray fox is a highly adaptable species (Guerrero *et al.* 2002) due to its generalist habits (Ceballos and Galindo 1984) and the ability to adapt its diet to the resources locally available (Villalobos *et al.* 2014). Moreover, Neale and Sacks (2001) reported that *U. cinereoargenteus* focus its diet on the most abundant food source. The record of the potential predation of *S. pullatus* by *U. cinereoargenteus* reported herein shows the likely opportunistic behavior of the gray fox. Therefore, we suggest considering the tiger rat snake as a component of the gray fox diet.

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New records for the gray mouse opossum (*Tlacuatzin canescens*) in Sonora, México

Nuevos registros de tlacuache ratón gris (*Tlacuatzin canescens*) en Sonora, México

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The gray mouse opossum (*Tlacuatzin canescens*) is one of the smallest marsupials in México. It is found primarily along the Pacific littoral zone and the neighboring coastal mountain range, from Alamos, Sonora southward to Oaxaca and Chiapas, as well as in isolated populations on the Tres Marias Islands and in the northern part of the Yucatán Peninsula. The new records of *T. canescens* were mainly acquired from long-term motion-triggered camera monitoring on the Northern Jaguar Reserve and ranches participating in the Viviendo con Felinos® program, which monetarily compensates ranchers for supporting the protection of wildlife, especially felines on their property. We documented 7 new records of *T. canescens* in Sahuaripa, Sonora. Three motion-triggered camera records, 3 dead encounters, and 1 live encounter in the Northern Jaguar Reserve obtained between 2015 and 2020. The new *T. canescens* records correspond to a northward range expansion for the species of at least 240 km beyond the previously known species' range. The Northern Jaguar Reserve, whose mission is to protect part of the northern jaguar (*Panthera onca*) population, also represents a refuge for smaller species such as the gray mouse opossum, which is a Mexican endemic marsupial.

Key words: Northern Jaguar Reserve; range extension; Sahuaripa; Viviendo con Felinos®.

El tlacuache ratón gris (*Tlacuatzin canescens*) es uno de los marsupiales más pequeños de México. Se le encuentra a lo largo del litoral del Pacífico desde la región de Álamos, Sonora hasta Oaxaca y Chiapas. También en poblaciones aisladas en las Islas Tres Marías y al norte de la Península de Yucatán. Los nuevos registros de *T. canescens* fueron obtenidos principalmente de un monitoreo con cámaras automáticas en la Reserva Jaguar del Norte® y un rancho que participa en el programa Viviendo con Felinos®, el cual compensa monetariamente a los dueños por apoyar la protección de la vida silvestre en su propiedad, especialmente felinos. Se documentaron 7 registros de *T. canescens* en Sahuaripa, Sonora. Tres registros son de cámaras automáticas, 3 corresponden a animales que fueron encontrados muertos, y 1 avistamiento de un ejemplar vivo en la Reserva Jaguar del Norte® entre 2015 y 2020. Estos nuevos registros de *T. canescens* corresponden a una extensión de distribución para la especie en por lo menos 240 km al norte del rango de distribución antes conocido. La Reserva Jaguar del Norte®, cuya misión es proteger parte de la población más norteña de jaguares (*Panthera onca*), también representa un refugio para especies menores como el tlacuache ratón gris, el cual es un marsupial endémico de México.

Palabras clave: Ampliación de distribución; Reserva Jaguar del Norte®; Sahuaripa; Viviendo con Felinos®.

The gray mouse opossum (*Tlacuatzin canescens*) formerly known as *Marmosa canescens* (Voss and Jansa 2003) is one of the smallest marsupials in North America (Ceballos and Oliva 2005), and 1 of 8 marsupials found in México (Medina-Romero *et al.* 2012). This species is endemic to México (Zarza *et al.* 2003) and is listed in the Mexican Official Norm NOM-059-SEMARNAT-2010 (SEMARNAT 2019). This is the official document that lists the threatened plants and animals in México. *Tlacuatzin canescens* is listed as Least Concern by the International Union for Conservation of Nature (IUCN; Martin 2017), but there is limited information about the status of their populations.

Tlacuatzin canescens is primarily found along the Pacific littoral zone and the neighboring coastal mountain range from Sonora southward to Oaxaca and Chiapas (Voss and Jansa 2003; Zarza *et al.* 2003), as well as in isolated populations on the Tres Marias Islands and in the northern part of the Yucatán Peninsula (Voss and Jansa 2003; Zarza *et al.* 2003; Reid 2009). Within its range, the gray mouse opossum occupies a diversity of habitats from agricultural lands, scrublands (Zarza *et al.* 2003; Reid 2009), dry hills (Reid 2009) and savanna-like grasslands, to semi-deciduous (Zarza *et al.* 2003), deciduous (Voss and Jansa 2003; Zarza *et al.* 2003; Reid 2009), tropical evergreen (Voss and Jansa 2003) and secondary forests (Voss and Jansa 2003; Zarza *et al.* 2003; Ceballos and Oliva 2005). *Tlacuatzin canescens* is typically associated with pristine habitat and although it has been found in fragmented and disturbed habitats (Ibarra-Cerdeña *et al.* 2007), research is limited and is inconclusive as to whether it can thrive in such environments. The upper elevational limit for *T. canescens* is 2,300 m (Ceballos and Oliva 2005; Reid 2009), but it is most frequently found below 1,000 m (Ceballos and Oliva 2005).

Tlacuatzin canescens is nocturnal and scansorial (Ceballos and Oliva 2005), typically relying on nests in bushes and trees as a place to hide and rest during the day (Ceballos 1990); however, individuals of this species may spend more time on the ground compared to other mouse opossum species like those in the *Marmosa* and *Marmosops* genus (Reid 2009). We present new records of *T. canescens* in east-central Sonora, México, in the municipality of Sahuaripa.

The new records of *T. canescens* were found within the Northern Jaguar Reserve and a nearby cattle ranch in the east-central region of the state of Sonora, México (Figure 1). The reserve covers an area of 230 km^2 and due to its isolated location has minimal human impact. The Pilares y La Sierpe cattle ranch is a member of the Viviendo con Felinos® program which monetarily compensates ranchers for photographs of wildlife, especially living felines on their ranches, and for supporting the protection of wildlife on their property. The combined area of the reserve and participating ranches constitutes a conservation area exceeding 700 km^2.

The vegetation in the area is a heterogeneous mosaic of mostly xerophilous and subtropical thorn scrub, relicts of tropical deciduous forest, and riparian vegetation. Oak woodlands and natural grasslands are present at elevations above 1,000 m. This vegetation is interspersed within large areas of non-native buffel grass (*Pennisetum ciliare*; Felger *et al.* 2001; Gutiérrez-González *et al.* 2015). Mean annual precipitation is 400 mm with winter rains accounting for 18 % of the annual total rain. The mean annual temperature varies from 16 °C in winter to 30 °C in summer, with extreme temperatures ranging between –7 °C and 43 °C (Brown 1994; García and Conabio 1998).

To study part of the northernmost breeding jaguar (*Panthera onca*) population, the Northern Jaguar Reserve and surrounding cattle ranches have been monitored since late 1999 (Gutiérrez-González *et al.* 2015). The quantity of cameras deployed, and the camera locations varied over time depending on access to the properties. The camera brands and models used depended upon equipment availability and include Cuddeback Capture and Attack (Non-Typical Inc., Green Bay, WI, USA) and Stealth cam (GSM Outdoors, Irving, TX, USA). For a more complete description of the camera monitoring design, see Gutiérrez-González *et al.* (2015). With few exceptions, locations selected for cameras were chosen to maximize the detection of felines with an emphasis on capturing photos of jaguars. In 2019, two motion-triggered cameras were installed in 3 trees to specifically detect individuals of *T. canescens*. To improve detection probabilities, these cameras were baited with a mixture of oats and peanut butter. Other camera-traps were located for jaguar monitoring and were not baited. Cameras installed to specifically detect *T. canescens* were deployed in tree branches at least 1 m above the ground. Bait was located in front of the cameras to improve chances of detection. During regular road maintenance work within the Northern Jaguar Reserve, field workers sighted and photographed 2 dead, small, mouse-like mammals.

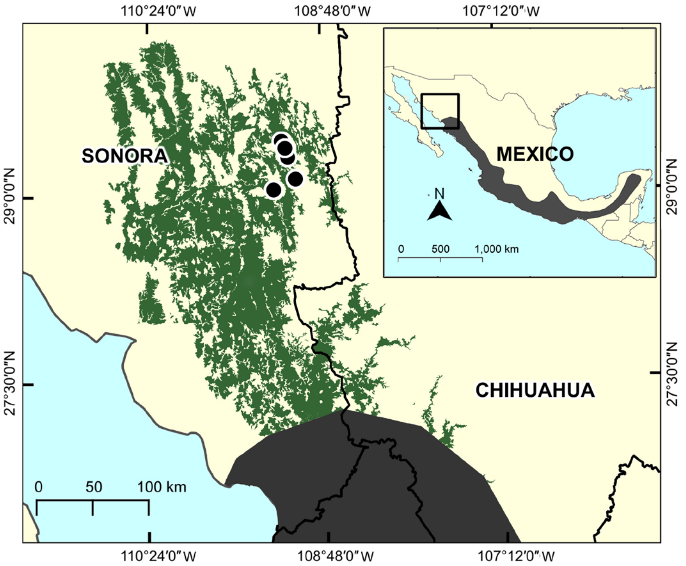

Figure 1. *Tlacuatzin canescens* records in Sonora, México (dots) compared with the northern distribution reported for the species (dark gray). Green shows tropical deciduous forest patches where the species can potentially be present.

We documented the first records of *T. canescens* in the eastern part of the state of Sonora, México. Camera-traps recorded *T. canescens* on June 21, 2015, and May 12, 2019, on the Northern Jaguar Reserve, and on September 17, 2017, on the Pilares y la Sierpe Ranch. Two dead *T. canescens* were found on the reserve, 1 on November 18, 2018, and 1 on November 3, 2019, while performing regular maintenance on conservation lands. Another dead individual was recorded on February 1, 2019, in an area adjacent to the town of Sahuaripa. Due to the body decomposition, it was not possible to collect the individuals for biological collection or to recover the skull or bones. One living *T. canescens* was observed and photographed on May 21, 2020. Coordinates and notes of each encounter are shown in Table 1 and photographic records are shown in Figure 2.

We present 7 records of *Tlacuatzin canescens* from Sonora, México that extend the northern range of the species by 240 km by air from its previously documented location (Voss and Jansa 2003; Zarza *et al.* 2003; SEMARNAT 2015). Since the camera monitoring was not designed to detect *T. canescens* or any other small species, it was impossible to determine the density of the gray mouse opossum within the conservation area. While little is known about the ecology and distribution of the species, it appears to adapt to fragmented and human-dominated landscapes (Ceballos and Oliva 2005). It is possible that additional individuals may be found farther north (Ceballos and Oliva 2005). The gray mouse opossums referenced in this paper were found in areas associated with tropical vegetation, such as tropical deciduous forest, with sufficient vegetation cover and resources for the species to thrive (Ceballos and Oliva 2005).

The gray mouse opossum is an important pollinator for some plants like *Stenocereus queretaroensis* and *Agave cupreata* (Ibarra-Cerdeña *et al.* 2007; Arreola-Gómez and Mendoza 2020). Other species of *Stenocereus* and *Agave* are present in our study area; however, no information is available about the interactions of these species. While the Northern Jaguar Reserve and surrounding cattle ranches currently provide a safe habitat for *T. canescens*, climate change, and habitat fragmentation outside our study area, may impact the future distribution of the species.

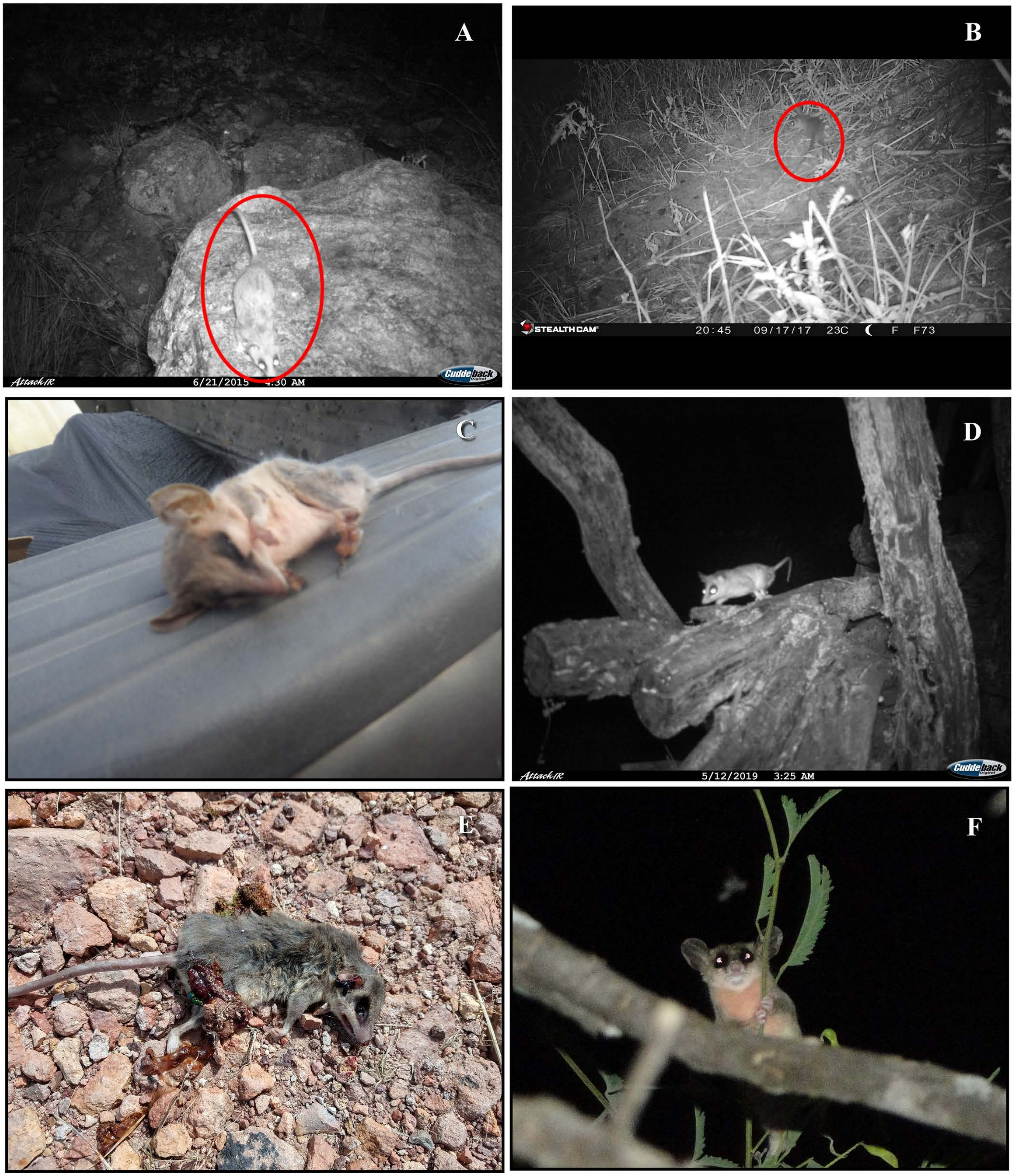

Figure 2. Photographs of each *Tlacuatzin canescens* encounter or detection during 2015-2020. Letters in the figure correspond to each encounter. The related data can be found in Table 1. Camera-trap records are circled in red for easier visualization.

Table 1. Detailed records of *Tlacuatzin canescens* that extends its distribution range in Sonora, México. See corresponding photographs in Figure 2.

Date	Notes	Picture
June 21, 2015	Record type: Motion-triggered camera photograph. Coordinates: 29° 23’ 3.36” N, 109° 8’ 15.15” W. Altitude: 959 m. Vegetation: Oak woodland. Location: Northern Jaguar Reserve. Photo credit: Northern Jaguar Project/Naturalia.	A
September 17, 2017	Record type: Motion-triggered camera photograph. Coordinates: 29° 8’ 15.79” N, 109° 2’ 27.03” W. Altitude: 1,216 m. Vegetation: Gallery forest. Location: Pilares y la Sierpe Ranch. Photo credit: Asociación Conservación del Norte/Northern Jaguar Project.	B
November 18, 2018	Record type: Dead specimen. Coordinates: 29° 26’ 29.52” N, 109° 9’ 29.58” W. Altitude: 590 m. Vegetation: Mesquite. Location: Northern Jaguar Reserve. Photo credit: Braulio Duarte López.	C
February 1, 2019	Record type: Dead specimen. Coordinates: 29° 3’ 22.14” N, 109° 14’ 21.54” W. Altitude: 456 m. Vegetation: Mesquite. Location: Sahuaripa, Sonora. Observer: Heraclio Duarte López.	No photo
May 12, 2019	Record type: Motion-triggered camera photograph. Coordinates: 29° 23’ 51.65” N, 109° 7’ 34.65” W. Altitude: 700 m. Vegetation: Mesquite. Location: Northern Jaguar Reserve. Photo credit: Asociación Conservación del Norte/Northern Jaguar Project.	D
November 3, 2019	Record type: Dead specimen. Coordinates: 29° 20’ 23.65” N, 109° 7’ 31.49” W. Altitude: 1,040 m. Vegetation: Oak woodland. Location: Northern Jaguar Reserve. Photo credit: Miguel A. Gómez-Ramírez.	E
May 21, 2020 21:30 hr (UTC -7)	Record type: Visual encounter of a live specimen. Coordinates: 29° 23’ 35.94” N, 109° 8’ 22.31” W. Altitude: 740 m. Vegetation: Gallery forest. Location: Northern Jaguar Reserve. Photo credit: Federico Mora-Carrillo.	F

Tlacuatzin canescens is the only mammal endemic to México found within the Northern Jaguar Reserve. As such, its discovery adds conservation value to the area that includes jaguar, ocelot (*Leopardus pardalis*), neotropical river otter (*Lontra longicaudis*), badger (*Taxidea taxus*), Mexican long-tongued bat (*Choeronycteris mexicana*), and Crawford's gray shrew (*Notiosorex crawfordi*; Flesch *et al.* 2020).

Additional camera-trapping efforts with a focus on small mammals could provide more evidence of the presence of the gray mouse opossum within the Northern Jaguar Reserve as well as the discovery of additional species, which could serve as indicators of habitat quality. Adding regular trapping would permit the sampling of some specimens for biological collections. Due to body decomposition, it was not possible to obtain additional information from these specimens; however, despite their decomposed state, reporting such findings can be valuable in determining current species distribution.

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Sciurus alleni and *Otospermophilus variegatus* winter activity in Nuevo León, México

Actividad invernal de *Sciurus alleni* y *Otospermophilus variegatus* en Nuevo León, México

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Water and food availability during winter is essential for the survival of non-hibernating squirrels in temperate forests; tree and ground squirrels have different survival strategies during winter. This note reviews the winter activity and behavior of *Sciurus alleni* and *Otospermophilus variegatus* at ground level. Using camera traps, in a water spring and in a natural wildlife crossing, within a walnut forest (*Juglans mollis*), the activity and behavior of both squirrels was recorded; furthermore, by direct observation, the search, storage and dispersion of nuts was analyzed. The winter activity pattern of *S. alleni* is long bimodal in both sites and for *O. variegatus* it depends on the habitat of the site ranging from short unimodal to multimodal. *Sciurus alleni* stores nuts on a scattered pattern. The type of behavior is situational depending on the site of observation, drinking water at the water spring, and travelling at the wildlife crossing. The presence of a chipmunk *Neotamias solivagus* was also recorded confirming its activity during winter. *Sciurus alleni* is active during the whole winter even on sub-zero temperatures and at twilight, differing from *O. variegatus* which displayed short periods of activity, showing that both squirrels have different strategies to avoid overlapping their niche. The results of this study revealed the importance of water sources and walnut trees for the survival of *S. alleni* and *O. variegatus* in the cold and dry winter season in the forests of Cumbres de Monterrey National Park.

Key words: Behavior; camera trap; hot spots; nut dispersion; squirrels.

La disponibilidad de agua y alimento durante el invierno es esencial para la supervivencia de ardillas no hibernantes en bosques templados; las ardillas arbóreas y terrestres tienen diferentes estrategias para sobrevivir en invierno. Esta nota reporta la actividad y comportamiento de *Sciurus alleni* y *Otospermophilus variegatus* a nivel del suelo durante el invierno. Usando cámaras trampa, en un ojo de agua y en un paso de fauna, en un bosque de nogal encarcelado (*Juglans mollis*), la actividad y comportamiento de ambas ardillas fue registrada; además, por observación directa se analizó la búsqueda, almacenaje y dispersión de nueces. El patrón de actividad invernal de *S. alleni* es bimodal largo en ambos sitios y para *O. variegatus* es según el hábitat del sitio de unimodal corto a multimodal. *Sciurus alleni* almacena nueces en forma dispersa. El tipo de comportamiento es situacional según el sitio de observación, bebiendo en el ojo de agua o tránsito en el paso de fauna. La presencia del chichimoco *Neotamias solivagus* también fue registrada confirmando su actividad durante el invierno. *Sciurus alleni* es activa todo el invierno aún en temperaturas congelantes y en el crepúsculo, a diferencia de *O. variegatus* que presentó cortos períodos de actividad, mostrando que ambas ardillas tienen diferentes estrategias para evitar traslape de nicho. Estos resultados revelan la importancia de las fuentes de agua y los nogales silvestres para la supervivencia de *S. alleni* y *O. variegatus* en la temporada fría y seca de invierno en bosques del Parque Nacional Cumbres de Monterrey.

Palabras clave: Ardillas; cámaras trampa; comportamiento; dispersión de nueces; sitios de interés.

The survival of small mammals that do not hibernate during winter is strongly determined by weather conditions and the availability of food and water for thermogenesis (Merrit and Zegers 2002; Kilpatrick 2003). Maintaining body temperature in low temperature environments consumes a high amount of energy and water, which can produce a negative energy balance with a high possibility of death (Feist and White 1989; Olson *et al.* 2017). For these reasons, during the winter or the dry season mammals must develop efficient strategies and activity patterns to survive (Halle and Stenseth 2000). The Sciuridae family has members that may or may not hibernate, or with short periods of torpor, and with different energy storage strategies, some with body fat and others with food storage spaces (Thorington *et al.* 2012). Tree squirrels *Sciurus* spp. and ground squirrels *Otospermophilus* spp. are of interest due to the different strategies they use to survive during cold or dry weather seasons (Ortega 1991; Halle and Stenseth 2000). Non-territorial tree squirrels (*Sciurus* spp.) may store food using scatter-hoarding methods and have little ability to protect the food source (Stapanian and Smith 1978), while *Otospermophilus variegatus* do not store food and instead accumulate body fat and may be a facultative hibernator depending on weather conditions (Oaks *et al.* 1987; Waterman 1996). Furthermore, acorns and walnut trees nuts (*Juglans* spp.) are an important source of energy for squirrels (Smith and Follmer 1972; Sundaram *et al.* 2017) since they have a low rate of degradation and thus a long storage life (Vander-Wall 2001; Sutton *et al.* 2016).

The north of México, due to its latitude and orography, presents regions with cold and dry winters, such is the case of the mountains in the state of Nuevo León, where long periods of low rainfalls are common between the months of October and May in addition to temperatures below the freezing point for several consecutive days (García 2004).

In Llanitos community (25° 32´ 48″ N; 100° 31´ 28″ W, 2,210 m), Santa Catarina, Nuevo León, within Cumbres de Monterrey National Park, in mixed forests including pines (*Pinus* spp.), oaks (*Quercus* spp.), walnut (*Juglans mollis*), madrone (*Arbutus xalapensis*), black cherry (*Prunus serotina*), cedars (*Juniperus* spp.) and hawthorn (*Crataegus mexicana*; Mercado-Morales 2020), there is presence of the tree squirrel *Sciurus alleni*, and the ground squirrel *Otospermophilus variegatus*, both species with important winter activity at ground level to feed of walnuts and acorns (Mercado-Morales 1985; Oaks *et al.* 1987; Best 1995a). Due to walnut trees availability and water sources, this site allows high activity of both squirrels at ground level, and thus allows the study of their activity patterns and behavior on the ground during the coldest and driest months, even with limited tools (one camera trap per site).

As a result of 3 years of observation, 2 sites were located close to Llanitos community where both squirrels displayed activity during winter. The first one 650 m north of Llanitos, at 2,380 m, in a ravine with a water spring of less than 2 m^2 of water surface, location named Ojo de Agua (ODEA); 11 people live in Llanitos and use this water spring with a hose. The second location, at 750 m southeast of Llanitos, 2,170 m, between 2 forest patches of walnut (*J. mollis*) with few oaks, flanked by a small mountain creek and a rock wall creating a funnel for wildlife transit, location named Nogalillos (NOGA), the creek had very little water flowing during the study. Both sites are considered interesting for the observation of winter activity at ground level for both species of squirrels due to the water and food availability. From December 27, 2020, to March 20, 2021, a camera trap Neewer 1015 was placed in NOGA (45 cm from the ground in a walnut tree) and a camera trap MixMart HC-800A was placed in ODEA (at a distance of 7 m and a height of 2 m, due to the slope of the place, directed at an angle of 45° towards the water spring), both recorded the time of day (GMT-6) and temperature in degrees Celsius; they were programmed to capture 3 consecutive pictures and a 10 second video which allows to confirm the observation and the behavior of the mammals; a break of 1 minute between pictures. Nine different types of behaviors were analyzed depending on each photographic record and sustained by the videos, according to Shuttleworth (2000) and Koprowski and Corse (2005): drink, eat, grooming, interspecific and intraspecific interactions, rest, searching, travelling and vigilance. For the analysis, only the individual records of each species with a timeframe greater than 5 minutes between pictures were accounted (time considered adequate for the type of behavior of constant traveling when they are on the ground and they don't stay more than a minute drinking or resting in the ground), except when it was possible to identify different individuals (by coloration, tail length, body volume or scrotal testes) or when 2 or more individuals appear in the same image.

Furthermore, to understand the behavior of searching, storage, or dispersion of nuts by both squirrels, from January 6 to 8, 2021, a small experiment was carried out. In a walnut forest 500 m SE from Llanitos in a visibly delimited area of 25 m^2, on January 6, 2021, in the morning all nuts in the ground were removed by hand to leave the site 24 hr without nuts. On January 7, 2021, before sunrise, 30 new *J. mollis* nuts were placed, these were obtained randomly from a nearby area. For 2 consecutive days, from sunrise to sunset, observations were conducted from a vantage point 30 m away from the site with binoculars, taking notes of the activity of the squirrels and their interaction with the 30 placed nuts.

In the study area, the last rainfall (48 mm) was registered on September 18, 2020; there was no recorded rain during the study and the temperatures oscillated between -8 °C and 32 °C. On December 27, 2020, the sunrise was at 7:24 hr and the sunset was at 17:58 hr with 10:33 hr of daylight and on March 21, 2021, the sunrise was at 6:45 hr and the sunset was at 18:55 hr for a total of 12:08 hr of daylight, a difference of 1:35 hr of sunlight between the start and the end of the study. We need to consider that due to the geographical location of the study area sunlight appears 2 hr after the sunrise and sunlight vanishes 2 hr earlier than the sunset due to orographic shadow, which in turn affects the environmental temperature in both sites (ODEA and NOGA). The photographs and videos for this study were archived in the photographic collection of the Mammals Collection of the Facultad de Ciencias Biológicas of the Universidad Autónoma de Nuevo León (UANL).

From both camera traps in 156 effective days, 9,447 images and 3,149 videos were obtained between 6:00 hr and 19:00 hr, 743 records were from tree squirrels *S. alleni,* 70 % in ODEA and 30 % in NOGA; for ground squirrel *O. variegatus* 78 records were obtained, 47 % in ODEA and 53 % in NOGA. At least 4 different *S. alleni* individuals were identified and 2 *O. variegatus* in NOGA and at least 7 different *S. alleni* individuals and 4 *O. variegatus* in ODEA. There were no records of juvenile individuals. In 150 camera trap-days (96 % of total that the cameras were active) there was a record of *S. alleni* and only in one third of the camera trap-days there were records of *O. variegatus* due to several three-to-six-day lapses without presence on the spot.

The activity of *S. alleni* was long bimodal (active during 100 % of daylight) in both locations doubling the activity during the morning. The activity of *O. variegatus* was short unimodal (less than 35 % of time with daylight) at noon in NOGA and multimodal in ODEA (Figure 1a). For the ground squirrel, 13 records of ODEA were obtained between 15:00

hr and 18:00 hr (31 % in ODEA, 17 % in both sites) and its activity started on the morning after 10:00 hr when the sunlight hits directly; in ODEA the activity is extended during sunset specially for drinking water. For *S. alleni,* 19 records were before the sunrise and 7 after the sunset thus 4 % of the records are with crepuscular activity, double at sunrise than in sunset. Integrating records from both locations (Figure 1b), *S. alleni* is long bimodal pattern with a high peak activity 2 hr after sunrise and a low peak 2 hr before sunset, with a short resting phase (25 % of day), and for *O. variegatus* a unimodal pattern at noon with little noticeable activity in the afternoon. In relation to the activity and the environmental temperature, for *S. alleni* 48 records (6.5 %) in 14 different days were at freezing temperatures between -8 °C and -1 °C (Table 1; Figure 2 a, b); 88.5 % of all records were at temperatures below 20 °C. For *O. variegatus* 5 records (6.5 %) in 3 different days were at temperatures between 0 °C and 9 °C, with 43.5 % of the records in temperatures above 20 °C.

In the site for observation of dispersion and storage of nuts, *S. alleni* on the first day located 18 nuts of the 30 placed, 3 were rejected, 6 were buried beneath the leaves of the same area, 4 were eaten after climbing a tree and 5 were taken more than 30 m away from the observation area. On the second day, 7 nuts were found, 2 of them were rejected, 4 were eaten on top of a tree, 1 was taken away. Furthermore, from the 6 buried ones the day before, 4 were retrieved and were taken away. The time taken to open and eat each nut was between 9 and 18 minutes (average 15.6 minutes), 26.6 % were eaten immediately after found, 33.3 % ware taken away to distant places. The rejected nuts were vain nuts, it took less than 2 seconds for the squirrels to detect it and reject them. No ground squirrel was seeing on those 2 days.

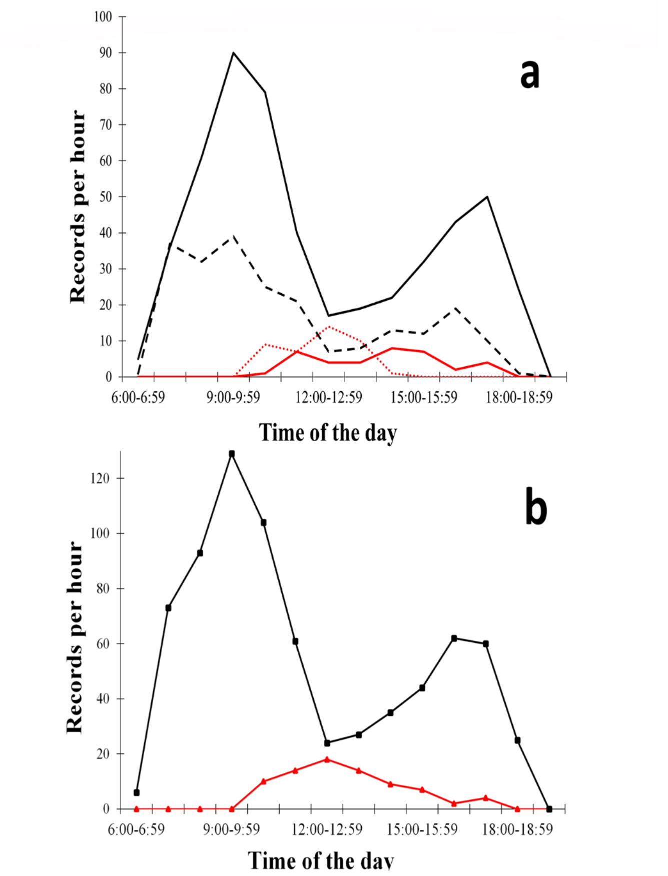

Figure 1. Squirrels recorded by camera trap by hour per day in Llanitos, Santa Catarina, Nuevo León from December 27, 2020, to March 21, 2021. a) *Sciurus alleni* in ODEA (continuous black line) and NOGA (dashed black line) and *Otospermophilus variegatus* in ODEA (continuous red line) and NOGA (dotted red line). b) Winter activity pattern in both locations (ODEA and NOGA) for *Sciurus alleni* (black line) and *Otospermophilus variegatus* (red line).

Table 1. Activity records by environmental temperature range in percent of *Sciurus alleni* and *Otospermophilus variegatus* by camera trap. *n* = quantity of records for each species in the sites ODEA and NOGA together in winter season from Nuevo León, México.

Environmental temperature	*Sciurus alleni*	*Otospermophilus variegatus*
	n = 743	*n* = 78
-8 °C to -1 °C	6.5	-
0 °C to 9 °C	36.0	6.5
10 °C to 19 °C	46.0	50.0
20 °C to 32 °C	11.5	43.5

Regarding the observed behavior in the 821 images and 426 videos (71 minutes) with record of activity for both squirrels (Table 2), in ODEA, for *S. alleni* in 49.4 % of the records they are drinking water (Figure 2c) and in 25 % they are travelling. For *O. variegatus*, in 62 % of the records they are drinking and vigilance (Figure 2d). In NOGA, for *S. alleni* in most of the records they are travelling and searching; for *O. variegatus* in 78 % they are travelling and watching. Thirty intraspecific encounters were recorded of 2 individuals of *S. alleni* and 4 encounters of 3 individuals; 7 intraspecific encounters of 2 individuals of *O. variegatus* were recorded (Figure 2e). In 4 occasions interspecific encounters between both species were recorded (Figure 2f). All encounters intra and interspecific were non agonistic, even in the presence of *S. alleni* male with scrotal testes.

The chipmunk *Neotamias solivagus* was recorded in 5 different days in ODEA between 9:00 hr and 12:00 hr with temperature between 4 °C and 13 °C (Figure 2g, h, i). Two times *N. solivagus* was recorded with *S. alleni* with no sign of aggression. Other recorded species during the day were black bear (*Ursus americanus*; Figure 2j), puma (*Puma concolor*; Figure 2k) and white tail deer (*Odocoileus virginianus*). Cacomixtle (*Bassariscus astutus)* and gray fox (*Urocyon cinereoargenteus*) were active during the sunrise or sunset when *S. alleni* was active too.

The long bimodal activity pattern of *S. alleni* is as the one reported by Mercado-Morales (1985) for all the year in a warmer and more humid zone of Nuevo León. The long bimodal patterns are related to species that live in habitats with warm winters and high energy attainment (Halle and Stenseth 2000). With higher ambient temperature and sun light (insolation) during mid-day, the activity of *S. alleni* is reduced and the activity of *O. variegatus* starts, this allows them to avoid competition for resources in a location where tree squirrels are more abundant and active than ground squirrels.

Table 2. Behaviors recorded by camera trap in percentage of *Sciurus alleni* and *Otospermophilus variegatus* in each site of observation (ODEA and NOGA). *n* = quantity of records for each species in each site in winter season from Nuevo León, México.

Behaviors recorded	***Sciurus alleni***		***Otospermophilus variegatus***	
	ODEA	**NOGA**	**ODEA**	**NOGA**
	n = 518	*n* = 225	*n* = 37	*n* = 41
Travelling	25.10	58.67	10.81	65.85
Drinking	49.42	0.00	43.24	0.00
Searching	9.85	25.78	8.11	7.32
Vigilance	10.23	7.56	18.92	12.20
Intraspecific interactions	4.44	3.11	8.11	7.32
Interspecific interactions	0.77	0.00	10.81	0.00
Resting	0.00	2.22	0.00	7.32
Eating	0.19	2.22	0.00	0.00
Grooming	0.00	0.44	0.00	0.00

Differing from *S. alleni* long bimodal activity pattern, other tree squirrels in temperate forests in winter such as *S. niger, S. carolinensis, S. arizonensis, S. nayaritensis* and *S. vulgaris* their activity pattern is unimodal (Thompson 1977; Tonkin 1983; Koprowski 1994; Halle and Stenseth 2000; Koprowski and Corse 2005; Wassmer and Refinetti 2016; Steen and Barmoen 2017; Ciurej *et al.* 2019). Wassmer and Refinetti (2019), document with telemetry that in winter some individuals of *S. niger* are unimodal and some other bimodal, this can even vary day by day for everyone, remaining in the nest up to 77 % of the time, considering important the climatic factors, social interactions, and the personality of each individual in the description of the activity patterns. For Mexican neotropical squirrels, Ramos-Lara and López-González (2017), report that *S. aureogaster* is unimodal and *S. oculatus* is multimodal where they coexist; but where only *S. aureogaster* is present it is bimodal (Mora-Ascencio *et al.* 2010; Ramos-Lara and Cervantes 2011). *Sciurus deppei*, a tropical squirrel from the east and south of México, is bimodal and spends up to 60 % of the time in the ground (Best 1995b). *Sciurus colliaei,* a tropical squirrel from western México is bimodal, but in cloudy days can be active all day (Best 1995c). The tropical tree squirrel *S. ingrami* in Brazil is bimodal the whole year (Bordignon and Monteiro-Filho 2000). It is possible that bimodal winter activity pattern of *S. alleni* differs from other squirrels in tempered and cold forests because in Nuevo León even in winter days with over 20 °C are common at noon and this squirrel rests at the time of highest temperature; furthermore, this rest at noon is important for digestion (Koprowski and Corse 2005). Kilpatrick (2003) mentions the importance of using solar radiation to reduce the thermoregulation costs in *S. carolinensis* during winter by spending time feeding in the sun, which is not detected in *S. alleni* as it is highly active from the sunrise even at subzero temperatures for a couple of hours without sunshine due to the orographic shadow in both study locations.

The short unimodal activity pattern that is displayed by *O. variegatus* in NOGA is similar to the other reported for the species in sites where there is no hibernation and the multimodal pattern that was displayed in ODEA while drinking water after 15:00 hr (30 % of records) is not known for the species (Oaks *et al.* 1987). This shows the importance of drinking water for the squirrel in cold and dry conditions, possibly because there is not enough water in the food.

The span of consecutive days with no record for *O. variegatus* are related to the days with minimum temperatures below freezing point and maximum temperatures lower than 10 °C, our data suggests that *O. variegatus* may entered a state of torpor due to the low temperatures for up to 6 consecutive days in 3 different occasions (Oaks *et al.* 1987; Ortega 1991; Waterman 1996).

The time taken to open and eat each nut for *S. alleni* is similar as the one reported by Smith and Follmer (1972). The nuts were eaten immediately after finding them, similar to what was reported by Tamura *et al.* (1999) where 32.6 % of the nuts are eaten immediately during all seasons of the year; the nuts were taken away to distant places, possibly safer to protect themselves from cold and predators (Preston and Jacobs 2009). The scatter-hoarding behavior of *S. alleni* (Figure 2l) is common in the tree squirrels of tempered forests (Preston and Jacobs 2009; Zong *et al.* 2014; Sundaram 2017), differing from more neotropical squirrels in México and Central America that do not store food (Best 1995d; Ramos-Lara and Cervantes 2011; Sutton *et al.* 2016). As an exception of squirrels that do not store or burry nuts regularly in tempered forests, is *S. nayaritensis,* in the Sierra Madre Occidental, which is very active on the ground all year (Best 1995e) and also *S. arizonensis*, from tempered deciduous forests in Arizona and north Sonora (Best 1995f). The results suggested that *S. alleni* has an influence on the walnut seed dispersion by selecting viable nuts to store on the ground, when these nuts are forgotten it favors their germination (Stapanian and Smith 1984; Tamura *et al.* 1999; Vander-Wall 2001; Steele *et al.* 2011). The absence of *O. variegatus* during the observations of walnut dispersion, may be because the ambient temperature was below 15 °C with sub-zero temperatures in the sunrise, but it is common to see this species feed from nuts when the weather conditions are appropriate; however, in 3 years of observations in Llanitos, the ground squirrel was never observed burying nuts.

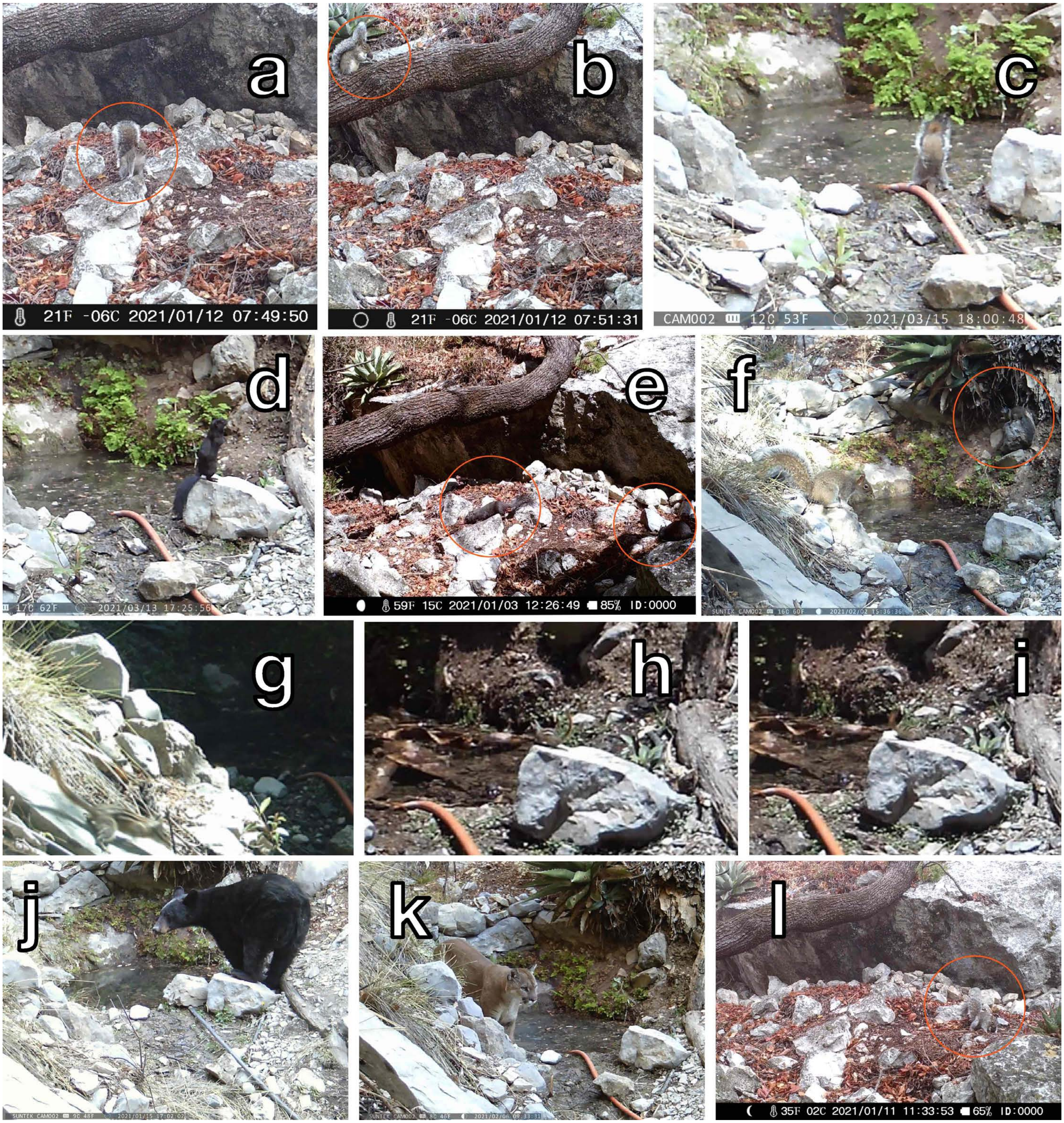

Figure 2. a) *Sciurus alleni* travelling on the ground and b) feeding on a tree branch at -6 °C environmental temperature (NOGA). c) *Sciurus alleni* drinking water at the water spring (ODEA). d) *Otospermophilus variegatus* showing a vigilance behavior (ODEA). e) Non agonistic intraspecific encounter of two *Otospermohilus variegatus* displaying a searching behavior (NOGA). f) Interspecific encounter between *Sciurus alleni* and *Otospermophilus variegatus* at the water spring (ODEA). g, h and i) *Neotamias solivagus* in ODEA. j) *Ursus americanus* and k) *Puma concolor* in ODEA. l) *Sciurus alleni* burying a nut of walnut *Juglans mollis* (NOGA).

The high percentage of records drinking and travelling in ODEA, as well as travelling in NOGA, are in line with the situational characteristic of the site. With low percentage of records searching primarily vigilance to be looking for predators, others risk, or social situations are complementary behaviors of their daily activity (McAdam and Kramer 1998; Shuttleworth 2000). Behaviors of rest and eat have very low number of records because both locations are at ground level and not well suited to these behaviors that are more likely to be seen on trees and safer locations (Wauters *et al.* 1992). Oaks *et al.* (1987) mentioned that *O. variegatus* is tolerant to water deprivation of more than 100 days in captivity, what differs from the obtained data where they arrive at the location to drink water regularly in the wild, and considering the water is important for thermoregulation (Feist and White 1989), this confirms why both squirrels spend time drinking water during the winter in this dry and cold forest. Mercado-Morales (1985) mentions that in some places *S. alleni* is abundant and in others it is not present, it is possible that the abundance of squirrels could be related to the proximity of water sources, at least in the dry and cold season, since in places with more than 1 km away from water sources it is rare to observe *S. alleni.*

The *Neotamias solivagus* record in ODEA is 2.4 km north from the recent record of the species for Nuevo León (Mercado-Morales 2020) confirming its winter activity; with only 5 records it is not possible to determine if this chipmunk is an occasional visitor to ODEA or could come out of some seasonal lethargy or torpor, it is important to mention that this chipmunk is too small for the camera trap to record all its activity.

In relation to the intra and interspecific encounters between the 3 species of squirrels, perhaps agonistic behavior is not displayed during winter as no females are in estrus (Best 1995a; Oaks *et al.* 1987); furthermore, this confirmed that the 3 species are non-territorial in winter to defend water and food source areas. The other mammals recorded during the day could be considered predators and/or competitors.

The results of this study revealed the importance of water sources and walnut trees for the survival of *S. alleni* and *O. variegatus* in the cold and dry winter season and demonstrate that both squirrels have different strategies to avoid overlapping of niche. It is confirmed that *S. alleni* stores nuts in a scattered pattern. This knowledge is important for the conservation of squirrels, the integral management of forests and to carry out subsequent studies even with few material resources (camera traps) to carry them out when hot spots of wildlife activity are located.

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First record of *Glyphonycteris daviesi* to the state of Roraima in Brazil

Primer registro de *Glyphonycteris daviesi* al estado de Roraima en Brasil

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The genus *Glyphonycteris* comprises 3 species that inhabit lowlands and forested mountains of Central and South America. Of the 3 species that occur in Brazil, *Glyphonycteris daviesi* is reported in humid forests but little is known about its distribution limits. We started from a voucher specimen deposited in the Mammals Collection of the Department of Vertebrates at the National Museum, Rio de Janeiro, Brazil. We analyzed the external, cranial, and dental features that have been reported as diagnostic in previous studies and documented georeferenced occurrences of the species in Brazil. We verified that the specimen was an individual of *G. daviesi*. Therefore, we describe the first record of this species for the state of Roraima, at approximately 407 km northwest of the previous closest known record in Manaus. This collection belongs to a male, within the potential distribution for the species according to the IUCN. The landscape from which the collection comes is mainly composed of *campinaranas* (Amazonian ecosystems associated with poor and sandy soils with periodic flooding), humid forests, and floodplains. We confirm that *G. daviesi* occurs in regions of conserved tropical humid forests, corroborating other reports, and in variable vegetation types, from fields to forested areas.

Key words: *Campinaranas*; distribution; Phyllostominae; rainforest; Roraima.

El género *Glyphonycteris* comprende 3 especies que habitan en tierras bajas y montañas boscosas de América Central y del Sur. De las 3 especies que se encuentran en Brasil, *Glyphonycteris daviesi* se reporta en bosques húmedos pero se sabe poco sobre sus límites de distribución. Partimos de un ejemplar depositado en la Colección de Mamíferos del Departamento de Vertebrados del Museo Nacional, Rio de Janeiro, Brasil. Analizamos las características externas, craneales y dentales que han sido reportadas como diagnósticas en estudios previos y documentamos ocurrencias georreferenciadas de la especie en Brasil. Verificamos que el espécimen se trata de un individuo de *G. daviesi*. Por lo tanto, presentamos el primer registro de esta especie para el estado de Roraima, aproximadamente a 407 km al noroeste del registro anterior más cercano en Manaus. Este registro pertenece a un macho, dentro de la distribución potencial para la especie según la IUCN. El paisaje del que proviene el registro está compuesto principalmente por *campinaranas* (ecosistemas amazónicos asociados a suelos pobres y arenosos con inundaciones periódicas), bosques húmedos y llanuras aluviales. Confirmamos que *G. daviesi* está presente en regiones de bosques húmedos tropicales conservados, corroborando otros reportes, y en tipos de vegetación variados, desde campos hasta áreas boscosas.

Palabras clave: *Campinaranas*; distribución; Phyllostominae; Roraima; selva húmeda tropical.

The Subfamily Glyphonycterinae comprises the genus *Glyphonycteris* Thomas, 1896 (Garbino *et al.* 2020). *Glyphonycteris* was considered a subgenus within *Micronycteris* by Sanborn (1949) and Simmons (1996), later elevated to the category of genus by Simmons and Voss (1998). The genus *Glyphonycteris* is characterized by the absence of a cutaneous appendix in the region of the head that connects the two ears, and the upper internal incisor teeth like the canines, among other morphological traits (Simmons and Voss 1998). Its distribution extends from western México to southeastern Brazil (Tirira *et al.* 2016). The group is considered monophyletic based on molecular data and within the family Phyllostomidae (Baker *et al.* 2003).

Currently, *Glyphonycteris* comprises 3 nominal species: *Glyphonycteris behnii* (Peters, 1865), *G. daviesi* (Hill, 1964), and *G. sylvestris* Thomas, 1896 (Williams and Genoways 2007). These are poorly known species that inhabit lowlands and forested mountains of Central and South America (Williams and Genoways 2007), and all of them occur in Brazil (Garbino *et al.* 2020).

Glyphonycteris daviesi is reported in humid forests (Pine *et al.* 1996; Gregorin and Rossi 2005). The species is omnivorous, but little is known about its feeding habits (Reis *et al.* 2017). Its distribution is restricted to Latin America, from Costa Rica to Southeastern Brazil (Pine *et al.* 1996; Reis *et al.* 2017). In Brazil, *G. daviesi* is known to the states of Amapá, Amazonas, Pará, Rondônia, Bahia, and Espírito Santo (Pine *et al.* 1996; Simmons 1996; Bernard and Fenton 2002, 2007; Marques-Aguiar *et al.* 2003; Sampaio *et al.* 2003; Gregorin and Rossi 2005; Castro and Michalski 2015; Farneda *et al.* 2018; Vela-Ulian *et al.* 2021).

The south of the state of Bahia and the north of Espírito Santo are characterized by the Atlantic Forest of southeastern Brazil, known as Hiléia Baiana. The latter region is considered similar to the Amazon Forest (Gregorin and Rossi 2005), where most records of *G. daviesi* are concentrated. The Amazon and the Atlantic Forest are considered the biomes with the greatest biodiversity in the world. These biomes show high rates of endemism, species richness, and diversity, but both are suffering from severe deforestation (Ribeiro *et al.* 2009; Sobral-Souza *et al.* 2018). Human impacts and climate change are mainly responsible for species loss in both biomes, most severely in the Atlantic Forest (Tabarelli *et al.* 2005; Kirby *et al.* 2006; Sobral-Souza *et al.* 2018). Most of the records of this species come from well-conserved humid forests. Here, we present the first record of *G. daviesi* for the state of Roraima based on a museum voucher specimen and document the vegetation types for its occurrences in Brazil.

The voucher specimen (MN70526) was collected and previously identified in a mammal inventory in the Viruá National Park Management Plan on April 5, 2007 (Oliveira *et al.* 2009) and deposited in the Mammals Collection of the Department of Vertebrates at the National Museum, Rio de Janeiro, Brazil. In the inventory, Chiroptera species were sampled mainly with a mist net, and occasionally by active search. We verified the identification based on external, cranial, and dental features, comparing with data available in the literature (Clarke and Racey 2003; Gregorin and Rossi 2005; Gardner 2007; Reis *et al.* 2017). Measurements were made with a digital caliper with 0.1 mm precision. The nomenclature followed Garbino *et al.* (2020).

The collection locality is in the municipality of Caracaraí, along the Branco River (1° 13' 0'' N, 61° 08' 0'' W), near a small, forested mountain range (Serra do Preto). The lower Branco River basin is characterized by a landscape composed of a mosaic of open areas, represented mainly by meadows and shrubby areas known as *campinaranas* (ecosystems associated with poor and sandy soils with periodic flooding), humid forests, and floodplain forests (Eden and Mcgregor 1992; Oliveira *et al.* 2009; ICMBio 2014). The vegetation of the Viruá National Park left bank of Branco River, has a characteristic that distinguishes it from the savannas of the Branco-Rupununi River complex, with hydromorphic - sandy soils with low water flow. During the rainy season (May to September), most of the area is flooded (Veloso *et al.* 1991; Mendonça *et al.* 2013). The climate in the region is "Af" (Köppen's climate classification) without a dry season, with average annual temperatures in the lowlands between 26-27 °C, an average monthly range of 2-3 °C, and annual rainfall of 2,500-2,800 mm (Alvares *et al.* 2013).

We obtained georeferenced occurrences of *G. daviesi* in Brazil based on several authors (Pine *et al.* 1996; Simmons 1996; Bernard and Fenton 2002, 2007; Marques-Aguiar *et al.* 2003; Sampaio *et al.* 2003; Gregorin and Rossi 2005; Farneda *et al.* 2018; Vela-Ulian *et al.* 2021) and in the databases the Global Biodiversity Information Facility or GBIF (GBIF.org 2021) and SpeciesLink (CRIA 2011). We plotted the records using the ArcGIS Desktop software system (Ormsby *et al.* 2010) and included the IUCN distribution polygon for this

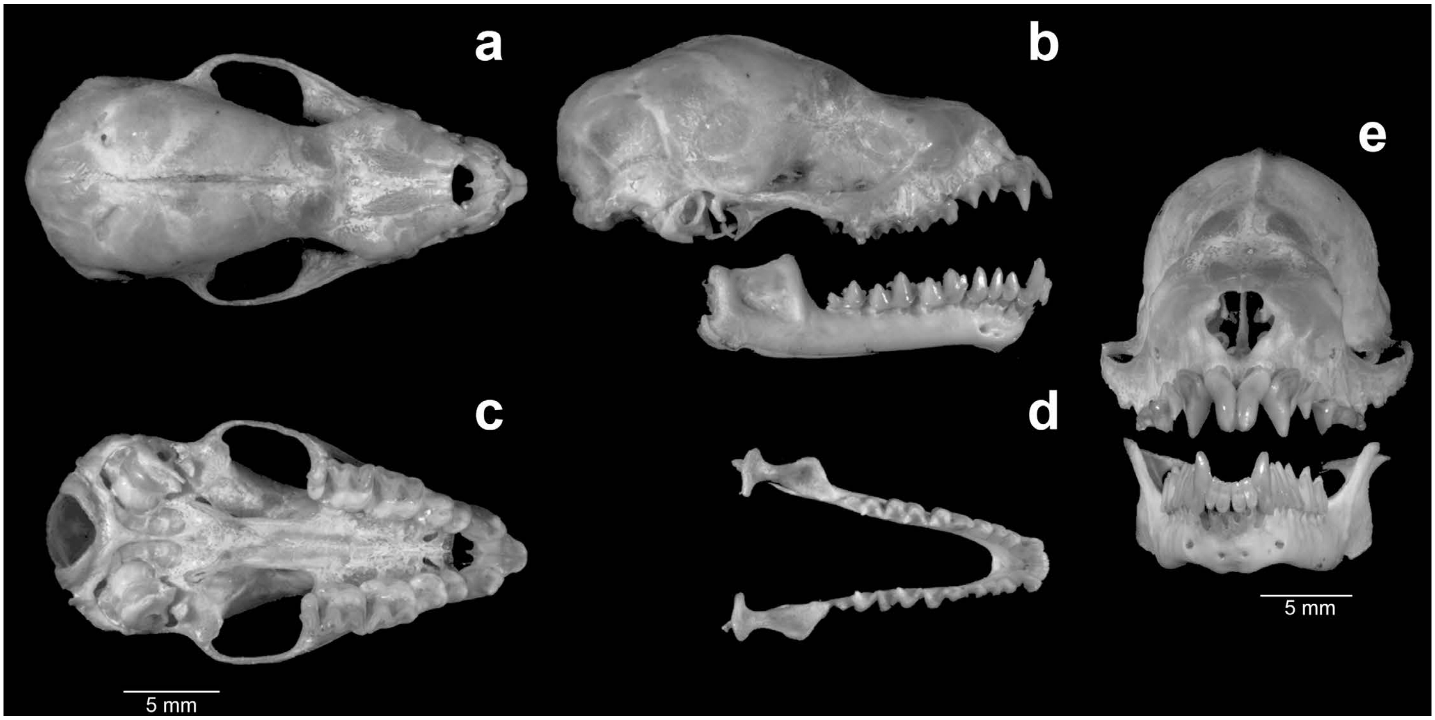

Figure 1. Male specimen of *Glyphonycteris daviesi* (MN70526) from the Viruá National Park, in the State of Roraima, Brazil. (a) dorsal, (b) lateral and (c) ventral view of the skull, (d) view of the mandible, and (e) frontal view of the mandible and skull, showing one pair of upper incisors, and crowns of lower incisors anteriorly-posteriorly long and transversely narrow.

species. Complementarily, we documented the vegetation types for its occurrences in Brazil based on the literature and field data available in the inventory report in the region of occurrence (Oliveira *et al.* 2009).

We verified the identity of the specimen as *G. daviesi*. Despite the overlapping geographic distribution of species of *Glyphonycteris* in some locations, *G. daviesi* is the largest representative of the genus and can be set apart from the others by morphological characters. The specimen we analyzed is an adult male, with the smallest number of teeth and a dental formula totaling 32 teeth (i 1/2, c 1/1, pm 2/3, m 3/3), a pair of upper incisors, long crowns in the posterior-anterior orientation, and narrow transversally oriented mandibular incisors (Figure 1). The forearm length is 57.04 mm, and the skull total length is 25.9 mm, and it is within the range of measurements of other specimens of *G. daviesi* (Table 1). Therefore, we present the first record of this species for the state of Roraima, northern Amazon, and document the vegetation types for its occurrences in Brazil (Figure 2; Table 2).

Glyphonycteris daviesi is the largest species of the genus (Gardner 2007; Reis *et al.* 2017) and can be clearly distinguished by having one pair of upper incisors, and crowns of lower incisors anteriorly-posteriorly long and transversely narrow (Hill 1964). The measurements of the voucher specimen analyzed here, compared to the literature records are within the range of size variation reported for this species (Hill 1964; McCarthy and Ochoa 1991; Simmons and Voss 1998; Clark and Racey 2003; Gregorin and Rossi 2005; Morales-Martínez and Suárez-Castro 2014; Table 1).

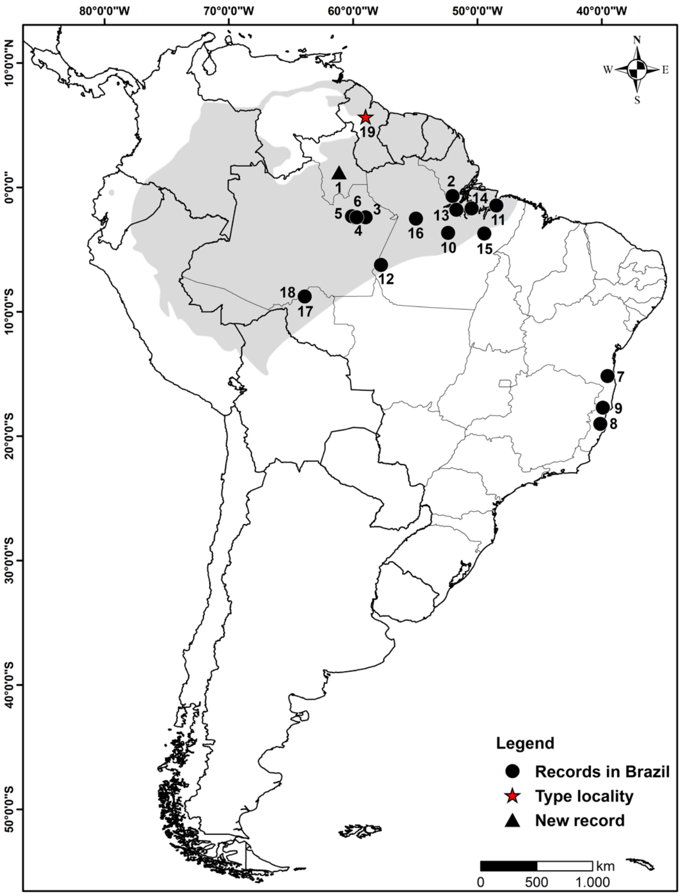

Figure 2. Map with the IUCN distribution polygon in gray, with the potential area of occupancy of *Glyphonycteris daviesi*. The numbering is in correspondence with the collection localities in Table 2.

The closest record of *G. daviesi* to the one we described, is 407 km southeast, in the Dimona Reserve (Smithsonian INPA PDBFF Reserve) in the state of Amazonas, Brazil (Sampaio *et al.* 2003), with a predominant habitat of Terra Firme Dense Amazon Forest (Pires and Prance 1985; Sampaio *et al.* 2003). Most records come from highly conserved sites, very

Table 1. Summary of external and cranial-dental measurements of the specimen of *Glyphonycteris daviesi* from Roraima, Brazil, compared to the specimens reported by Hill (1964) holotype from Guyana, McCarthy and Ochoa (1991) from Venezuela, Simmons and Voss (1998) from French Guiana, Clark and Racey (2003) from Trinidad, Gregorin and Rossi (2005) from Brazil, and Morales-Martínez and Suárez-Castro (2014) from Colombia. Measurements are given in millimeters and weights in grams. In parentheses the number of individuals examined.

	Present study	Guyana	Venezuela	French Guiana		Trinidad	Brazil	Colombia
Character	Male (1)	Female (1)	Male (2)	Female (1)	Male (1)	Female (1)	Female (2)	Male (1)
Weight	16		20 - 23	20	17.4	22	24 - 25	18
Total body length	67.24	79		83	80	83.8		71
Tail length	11.36	10.4		10	10	8.7	5.7 - 6.5	5
Hindfoot length	14.99	16.8		17	17	15		15
Ear length	25.44	17		28	27	26.5	26.4 - 26.2	24
Forearm length	57.04	57.5	53.6 - 54	57	52.5	56.4	56.2 - 58.1	55.1
Greatest length of skull	25.9	27.2	26.3 - 26.1	24.56		24.36	27 - 27.4	24.6
Condyle-incisor length	22.56	24.7	24.9 - 25.2	24.58		25.32	24.9 - 25.6	23.4
Maxillary toothrow length	10.92	11.1	10.5 - 10.7	10.27		11.7	10.9 - 11	10.2
Breadth across upper molar	9.44	9.3	8.5 - 9	8.98		9.2	9.3 - 9.6	8.8
Breadth across upper canines	4.43	5.2					4.9 - 5.1	
Postorbital length	5.75		5.9 - 6.1	5.97		6.36		
Zygomatic breadth	12.89	13.3	12.1 - 12.6	12.68		12.68	14 - 13.9	12.9
Braincase breadth	9.97	10.9	10.3 - 10.8	10.27		12	10.5 - 10.7	10.5
Mastoid breadth	10.81	11.3	10.7 - 10.8	10.87				10.6
Mandible length	17.55	18.5					19.4 - 19.9	
Mandibular toothrow length	10.50	11.3	9.3 - 9.7					

similar to the area of the collection locality that we documented (Silva *et al.* 2020), and the new record of *G. daviesi* is within the potential distribution for the species according to IUCN (Solari 2018; Figure 2). Viruá National Park, where the specimen was documented, was created in 1998 and consists of a preserved area with virtually no evidence of recent human activity (ICMBio 2014).

Although of little concern in the list of threatened species (Solari 2018), *G. daviesi* seems uncommon in degraded areas. In Bolivia, *G. daviesi* is classified as vulnerable (Solari 2018), mainly due to the loss of primary forests, and the reduction and fragmentation of its habitat (montane forests and flood plains), that are regional threats (Aguirre 1999). The genus may harbor species particularly sensitive to anthropic pressures. Another species of the same genus, *Glyphonycteris behnii*, was already considered as vulnerable (VU) in the official list of threatened species in Brazil (IN MMA 444/2014); however, it is recently assessed in the Red List of Threatened Species as data deficient (DD; Zortea *et al.* 2016).

Forest degradation and loss, and land use change, consequences of intense human pressure, have been recognized as the main direct threats to biological diversity in tropical regions (Souza *et al.* 2020). Deforestation also influences the issue of climate change, as it is one of the sources of greenhouse gas emissions (Van der Werf *et al.* 2009). Therefore, one of the concerns for this type of species is the rapid deterioration of its habitat and climate change, caused by human activities, which could lead to the loss of it up to 98 % by 2050 (Aguiar *et al.* 2016). In response to habitat loss, the main conservation action is the creation of protected areas (Kirby *et al.* 2006; Ribeiro *et al.* 2009; Sobral-Souza *et al.* 2018). Also, forest regeneration may be associated with a significant recovery in the functional and taxonomic diversity of bats (Farneda *et al.* 2018). Animalivorous bats, such as *G. daviesi*, can also benefit from secondary forest regeneration (Farneda *et al.* 2018).

Finally, with the present record, we confirm that *G. daviesi* occurs in regions of conserved tropical humid forests, corroborating other reports, and in variable vegetation types, from fields to forests, such as open Amazonian areas and *campinaranas*.

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Table 2. Locations with confirmed records of *Glyphonycteris daviesi* in Brazil, type of vegetation, references and geographic coordinates. The numbering is in correspondence with the distribution map in Figure 2.

	Locality	Vegetation	References	Coordinates
1	Brazil: Roraima, Viruá National Park	Amazonian rainforest , Campinaranas	Present study	1° 13' 0'' N, 61° 08' 0'' W
2	Brazil: Amapá, Ajuruxi River, Cajari Reserve, Vila Maranata	Varzea forest	Castro and Michalski (2015)	0° 33' 2'' S, 51° 33' 49'' W
3	Brazil: Amazonas, Manaus	Amazonian continuous forest	Silva *et al.* (2020)	2° 24' 0'' S, 59° 0' 0'' W
4	Brazil: Amazonas, Manaus, Central Amazonia	Amazonian rainforest, continuous primary forest and secondary forest	Farneda *et al.* (2018)	2° 25' 0'' S, 59° 50' 0'' W
5	Brazil: Amazonas, Manaus, Dimona Reserve	Fragments Amazonian rainforest	Sampaio *et al.* (2003)	2° 24' 0'' S, 59° 43' 0'' W
6	Brazil: Amazonas, Manaus, Gaviao Reserve	Amazonian rainforest undisturbed	Sampaio *et al.* (2003)	2° 25' 0'' S, 59° 45' 0'' W
7	Brazil: Bahia, Jussari, Serra do Teimoso Farm	Rainforest that shares several flora elements with eastern Amazon forest	Gregorin and Rossi (2005)	15° 09′ 25'' S, 39° 32′ 15'' W
8	Brazil: Espírito Santo, Sooretama, Sooretama Biological Reserve	Atlantic Forest	Vela-Ulian *et al.* (2021); CRIA (2011)	19° 05' 0'' S, 40°15' 0'' W
9	Brazil: Bahia, Una, Una Biological Reserve	Tropical lowland rainforest (Hiléia baiana)	Faria *et al.* (2006)	15° 17' 36'' S, 39° 04' 31'' W
10	Brazil: Pará, Altamira, Xingu River	Amazonian rainforest	Pine *et al.* (1996)	3° 39' 0'' S, 52° 22' 0'' W
11	Brazil: Pará, Belém	Amazonian rainforest	Pine *et al.* (1996); Simmons (1996); CRIA (2011); GBIF (2021)	1° 27' 0'' S, 48° 29' 0'' W
12	Brazil: Pará, Jacareacanga, near the Teles Pires River	Amazonian rainforest	CRIA (2011)	6° 13' 0'' S, 57° 45' 0'' W
13	Brazil: Pará, Melgaço, Caxiuanã	Amazonian rainforest	GBIF (2021)	1° 47' 0'' S, 51° 41' 0'' W
14	Brazil: Pará, Melgaço, Ferreira Penna Scientific Station	Amazonian rainforest	Marques-Aguiar *et al.* (2003)	1° 40' 0'' S, 50° 28' 0'' W
15	Brazil: Pará, Tucuruí, Caraipe area	Amazonian rainforest	Pine *et al.* (1996)	3° 42' 0'' S, 49° 27' 0'' W
16	Brazil: Pará, Village of Alter do Chão	Amazonian primary forests	Bernard and Fenton (2002, 2007)	2° 30' 0'' S, 54° 57' 0'' W
17	Brazil: Rondônia, Porto Velho	Amazonian rainforest	CRIA (2011)	8° 45' 42'' S, 63° 54' 14'' W
18	Brazil: Rondônia, Porto Velho, Teotônio Waterfall	Amazonian rainforest	Pine *et al.* (1996)	8° 46' 0'' S, 63° 54' 0'' W
19	Type locality - Guyana: Bartica, along the Potaro Road	Amazonian rainforest	Hill (1964)	5° 41' 0'' N, 58° 59' 0'' W

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Bioacoustic description of the alarm call of the stump-tailed porcupine (*Coendou rufescens*)

Descripción bioacústica del canto de alarma del puerco espín de cola corta (*Coendou rufescens*)

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Acoustic communication in rodents is complex and varied. However, bioacoustic studies of rodents in the wild are limited and scarce, most are performed, under controlled laboratory conditions. We recorded the alarm call of the short-tailed porcupine in the wild for the first time. Recordings were obtained in Guabisai, Sangay National Park, Ecuador. We opportunistically recorded the alarm call of an adult female *Coendou rufescens* in a direct encounter during its capture process. We analyzed 37 notes of 21 calls, categorizing the notes into 4 different types based on their spectral, temporal, and intensity characteristics (*i.e.*, fundamental, dominant and harmonic frequencies). The alarm call of *C. rufescens* consists of up to 4 notes. The sounds vary, ranging from chirps to nasal sounds, with the dominant frequency ranging from 0.34-2.50 kHz. The notes have different spectral and temporal characteristics. Therefore, the alarm call of *C. rufescens* presents a repertoire with different types of notes. Our preliminary observations suggest that their different types of sound are probably associated with anti-predatory behaviors, therefore we considered these sounds as alarm calls. This report provides baseline information for future bioacoustic studies on this species.

Key words: Alarm calls; dominant frequency; notes; repertoire; rodents.

La comunicación acústica en los roedores es compleja y variada. Sin embargo, los conocimientos sobre la acústica de los roedores en ambientes naturales son limitados y escasos. La mayor parte de estudios acústicos, han sido realizados en condiciones de laboratorio. Hemos grabado por primera vez los cantos del puercoespín de cola corta en un entorno natural. Las grabaciones fueron obtenidas en Guabisai, Parque Nacional Sangay, Ecuador. Grabamos de manera oportunista el canto de alarma de una hembra adulta de *Coendou rufescens* en un encuentro directo durante su proceso de captura. Se analizaron 37 notas de 21 cantos, clasificando las notas en 4 tipos diferentes basados en características espectrales, temporales y de intensidad (*i.e.*, frecuencias fundamentales, dominantes y armónicas). El canto de alarma de *C. rufescens* consta de hasta 4 notas. Los sonidos varían y van desde chirridos a sonidos nasales, con una frecuencia dominante que oscila entre 0.34 y 2.50 kHz. Las notas tienen características espectrales y temporales diferentes. Por lo tanto, el canto de alarma de *C. rufescens* presenta un repertorio con diferentes tipos de notas. Nuestras observaciones preliminares sugieren que sus diferentes tipos de sonido están probablemente asociados a comportamientos antipredadores, por lo que consideramos estos sonidos como cantos de alarma. Este reporte proporciona información de referencia para futuros estudios bioacústicos en esta especie.

Palabras clave: Canto de alarma; frecuencia dominante; notas; repertorio; roedores.

Acoustic communication in animals is very varied, using different types of sounds (*e.i.,* acoustic signals) to transmit a specific message or information (Simmons *et al.* 2003; Bradbury and Vehrencamp 2011). Rodents are a group of animals with very stealthy and silent behaviors, as they are under a high level of predation pressure. Because of this characteristic and despite being the most numerous order of mammals, very little is known about their acoustic communication (Brudzynski and Fletcher 2010). Much of the knowledge about rodent acoustic communication comes from controlled environments in the laboratory and few studies have described calls in the wild (Dent 2018).

The stump-tailed porcupine *Coendou rufescens* (Gray, 1865) is a medium-sized species, with a characteristic reddish color and a short non-prehensile tail (Voss 2015; Barthelmess 2016). It is a nocturnal arboreal and solitary species, that feeds mainly on wood, small insects and larvae (Vallejo and Boada 2021). It is distributed in the Andes of Colombia, Ecuador, northern Perú and Bolivia, across an altitudinal range from 800–4,387 m (Alberico *et al.* 1999; Voss 2011; Ramírez-Chaves *et al.* 2016; Acosta *et al.* 2018).

The bioacoustics studies in *Coendou* Lacépède, 1799 are somewhat scarce (Roberts *et al.* 1985). Even though research is available that presents integrative results (*e.g.*, Woods 1973; Voss *et al.* 2013; Torres-Martínez *et al.* 2019), the information about the calls in the wild is limited to observations and qualitative analysis (*i.e*., anecdotal reports available in handbooks, videos and websites). This information gap occurs in the genus *Coendou* and most of the Old and New world porcupines.

The most comprehensive study describing the calls of this genus was done by Roberts *et al.* (1985). They described and categorized the calls of *Coendou prehensilis* (Linneo 1758) into different types of sound, assigning to each one a specific social context. Therefore, considering that the calls and most of the behavioral repertoire of *Coendou rufescens* are unknown (Voss 2015), we contribute to the knowledge of this species by describing for the first time the calls of *C. rufescens*, with quantitative information about its spectral and temporal parameters.

On April 28, 2015, 2 individuals of *C. rufescens* approached our cabin (basecamp) in Guabisai, Sangay National Park, Ecuador (2° 23' 19'' S, 78° 18' 59'' W, datum WGS84; 2,554 m) at 18:50 hr. We unexpectedly and opportunistically recorded an adult female *C. rufescens* while emitting calls in a direct encounter, being intercepted and cornered for capture. The individual was detected approached the cabin (basecamp), apparently searching pieces of wood to gnaw (Brito and Ojala-Barbour 2016). We recorded the calls using an Olympus® WS-802 digital recorder with a sample rate of 44.1 kHz and 16-bit resolution and saving the files in an uncompressed WAV format.

We performed acoustic analyses using Raven Pro v1.6 (K. Lisa Yang Center for Conservation Bioacoustics at the Cornell Lab of Ornithology 2022), with the following settings: Hann window, 90 % overlap and DFT size of 512 points. We plotted the oscillograms and spectrograms with the Seewave R-package v2.2.0 (Sueur *et al.* 2008; R Development Core Team 2022). We used a Hanning window type with 90 % overlap, FFT window width of 512 points. We also used a frequency limit of 18 kHz and a dynamic range of -80–0 dB. We imported the WAV files using the tuneR package v1.4.1 (Ligges et al. 2018).

We analyzed 37 notes from 21 calls, corresponding to a single individual. We classified the notes of the calls, using their spectral structure as the main classification criterion (*i.e*., fundamental, dominant and harmonic frequencies). We calculated the mean, maximum, minimum and standard deviation of the analyzed parameters.

We determined the following temporal and spectral parameters (see Figure 1): Fundamental frequency (FF): is the first harmonic or is the lowest frequency in the frequency spectrum; Dominant frequency (DF): frequency of highest energy or with the highest intensity determined

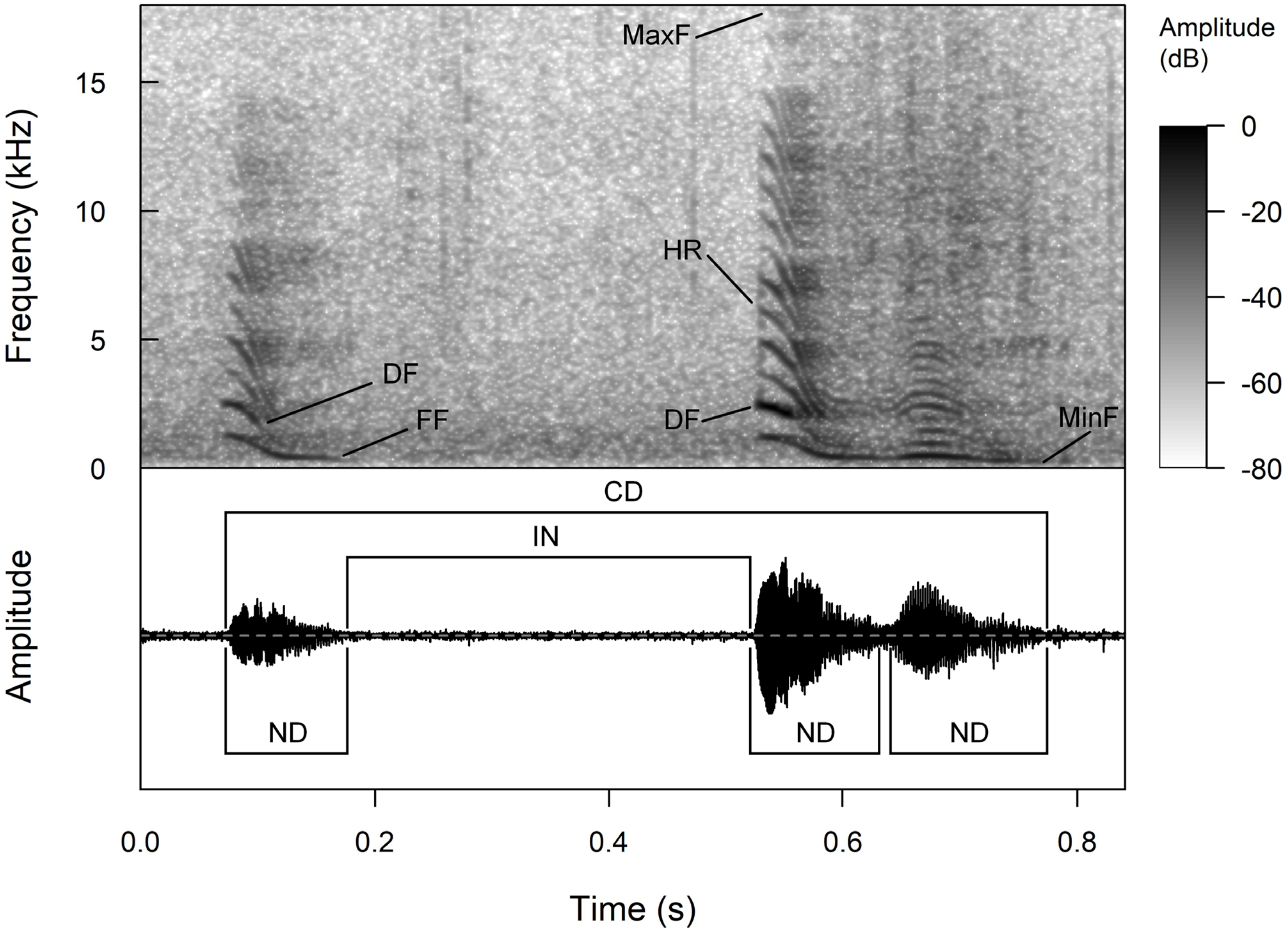

Figure 1. Acoustic parameters analyzed in the call of *Coendou rufescens* (MECN 4343). Abbreviations correspond to: FF = Fundamental frequency; DF = Dominant frequency; MinF = Minimum frequency; MaxF = Maximum frequency; HR = Harmonics; CD = Call duration; ND = Note duration; IN = interval between notes; kHz = kilohertz; dB = decibel; s = second.

from the Fourier transform; Frequency modulation (FM): difference of frequencies between the initial and final points in an acoustic structure; Minimum frequency (MinF): lowest visible frequency in the spectrum; Maximum frequency (MaxF): highest visible frequency value in the spectrum; Number of harmonics detected (NH): number of bands present in the frequency spectrum. A harmonic is an overtone that is a multiple of the fundamental frequency; Call duration (CD): time from beginning to end of one call; Interval between calls (IC): time between distinct calls; Call rate (CR): total number of calls calculated over a given time; Notes per call (NC): Number of notes that make up a call. In this analysis we consider a note to be the main subunit of a call; Note duration (ND): time from beginning to end of one note; Note rise time (NRT): time from the beginning to the point of maximum amplitude of note; interval between notes (IN): time between distinct notes; Note rate (NR): total number of notes calculated in a given period of time.

Definitions, terminology and acoustic measurements followed methodology detailed on Francescoli (1999), Tokumaru *et al.* (2004) and Brito *et al.* (2017). We complement the information on the acoustic parameters, following the measures and definitions proposed by Cocroft and Ryan (1995), Hartmann and Candy (2014), Köhler *et al.* (2017) and Sueur (2018).

Recordings can be accessed through the Fonoteca Zoológica del Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain (FZ sound code 12023) in the following link (http://bit.ly/3UO9vSs). In addition, we collected the specimen and deposited it at the Instituto Nacional de Biodiversidad, Quito, Ecuador (MECN 4343; skin and skull). The specimen collected is part of the reports and observations obtained in the project "Diversidad de pequeños vertebrados en dos áreas del Parque Nacional Sangay" (see Brito and Ojala-Barbour 2016; Romero *et al.* 2018).

The alarm call of *C. rufescens* is composed by the emission of a series of 1 to 3 short notes, with a mean dominant frequency of 1.30 kHz. Their sounds are very varied, ranging from chirps to nasal sounds that can be described as moan, gasp or growl. We report the spectral and temporal parameters in Table 1.

The call of *C. rufescens* do not present stereotyped notes. They have 4 different types of notes, emitted as a single call, or as a series of notes in the same call. The different types of notes present differences at the level of its spectral and temporal structure. Type 1 note shows many visible harmonics and a frequency with descending modulation (Figure 2A). Type 2 note is very similar to type 1; however, it has a lower number of harmonics and a higher value at the frequency modulation (Figure 2B). The sounds of these 2 types of notes are high-pitched squeaks, which show a higher intensity compared to the other types of notes, therefore, they are easily heard and are the most common in the repertoire. Type 3 note has a slight modulation in its first harmonic, with an ascending-descending modulation (∩-shaped) that is most noticeable from the fourth harmonic. It is a nasal sound that can be described as subtle moans or growls of short duration and medium intensity (Figure 2C). Type 4 notes are constant frequency, with undifferentiable harmonics. Their sounds are very similar to low intensity exhalations or gasps (Figure 2D). Temporal and spectral measurements of the notes are shown in Table 1.

The call of *C. rufescens* is a repertoire of different types of notes, which can be associated with defensive behaviors

Table 1. Descriptive statistics of call parameters of one individual of *Coendou rufescens*. The measurements of the 4 types of notes are also shown (see text for description of each one). The abbreviations correspond to: FF= Fundamental frequency; DF= Dominant frequency; FM= Frequency modulation; MinF= Minimum frequency; MaxF= Maximum frequency; NH= Number of harmonics; CD= Call duration; IC= Interval between calls; CR= Call rate; NC= Notes per call; ND= Note duration; NRT= Note rise time; IN= interval between notes; NR= Note rate. The abbreviations used in units of measurement correspond to: kHz = kilohertz; ms = milliseconds; /min= per minute; /s = per second.

Parameters	**Call**	**Notes**			
	(general)	**Type 1**	**Type 2**	**Type 3**	**Type 4**
FF (kHz)	0.34-1.21 (0.67 ± 0.33)	0.34-0.82 (0.51 ± 0.17)	0.34-1.21 (0.93 ± 0.34)	0.47-0.52 (0.49 ± 0.02)	0.34-0.39 (0.38 ± 0.02)
DF (kHz)	0.34-2.50 (1.30 ± 0.82)	0.47-2.15 (0.80 ± 0.44)	0.99-2.50 (2.06 ± 0.42)	0.47-2.02 (0.99 ± 0.90)	0.34-0.39 (0.38 ± 0.02)
FM (kHz)	0.13-0.90 (0.67 ± 0.21)	0.43-0.73 (0.55 ± 0.11)	0.73-0.90 (0.82 ± 0.05)	0.13-0.17	–
MinF (kHz)	0.10-0.32 (0.21 ± 0.06)	0.10-0.20 (0.17 ± 0.03)	0.11-0.32 (0.23 ± 0.06)	0.21-0.32 (0.26 ± 0.06)	0.20-0.29 (0.24 ± 0.04)
MaxF (kHz)	12.26-20.62 (15.03 ± 1.65)	13.40-20.62 (15.24 ± 1.97)	13.17-19.07 (15.49 ± 1.53)	13.16-15.32 (14.09 ± 1.11)	12.26-14.80 (13.89 ± 0.87)
NH	6-21 (12.74 ± 3.89)	11-21(17 ± 3.51)	10-16 (12.38 ± 1.41)	10-14 (12.33 ± 2.08)	6
CD (ms)	47-1088 (348.90 ± 327.52)	–	–	–	–
IC (ms)	932-4641 (2227.45 ± 1025.39)	–	–	–	–
CR (/min)	12.77-55.61 (26.83 ± 10.51)	–	–	–	–
NC	1-3 (1.62 ± 0.74)	–	–	–	–
ND (ms)	47-180 (97.53 ± 23.76)	72-132 (101.05 ± 17.22)	81-180 (108.14 ± 21.08)	67-120 (86.93 ± 28.87)	47-84 (67.52 ± 14.32)
NRT (ms)	8-46 (28.67 ± 8.58)	12-46 (34.86 ± 11.76)	16-40 (26.94 ± 6.43)	29-31 (29.37 ± 1.26)	8-44 (26.16± 14.45)
IN (ms)	86-685 (29.20 ± 15.19)	–	–	–	–
NR (/s)	1.18-6.67 (1.84 ± 3.47)	–	–	–	–

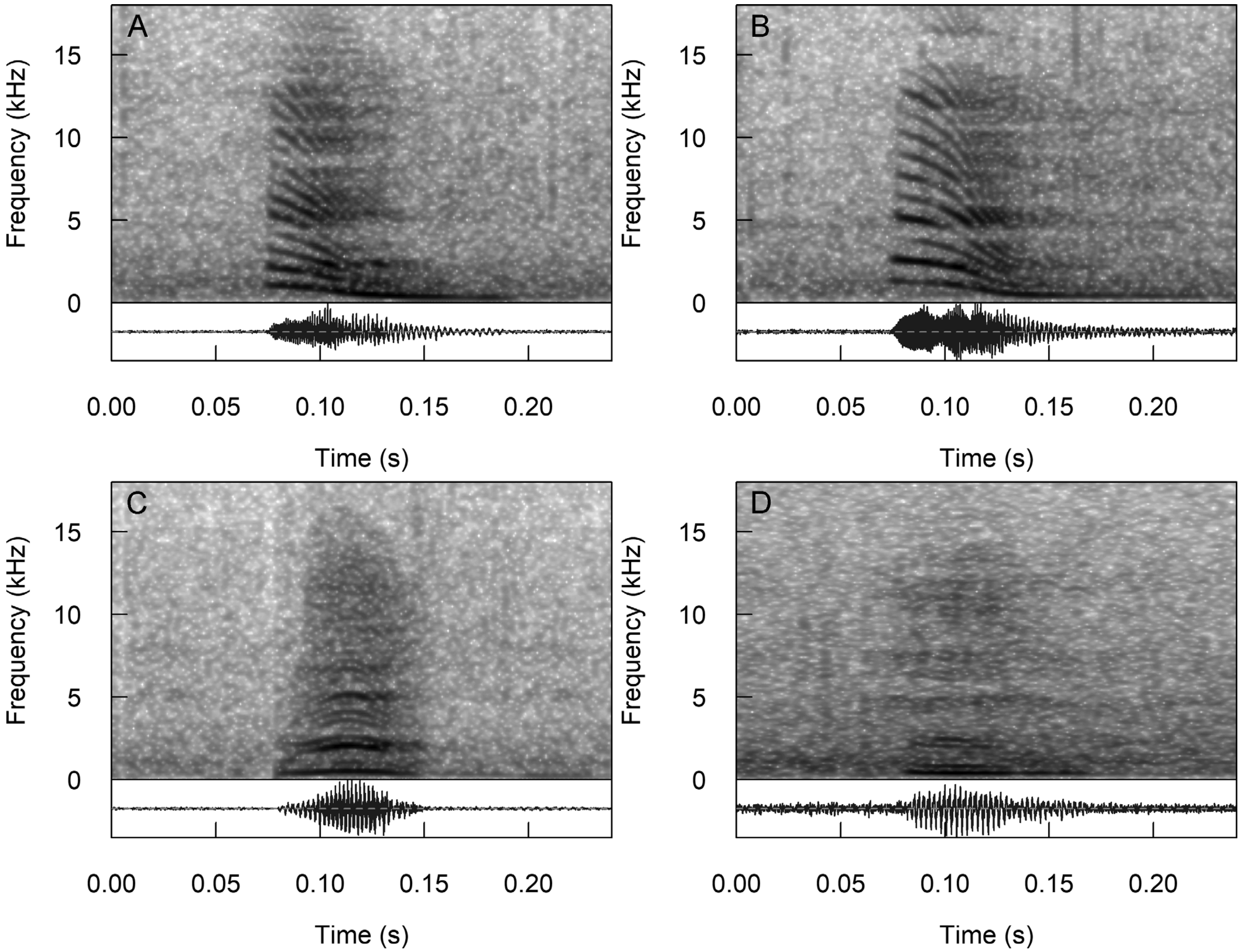

Figure 2. Types of notes present in the call of *Coendou rufescens* (MECN 4343). A= type 1; B = type 2; C = type 3; D = type 4; kHz = kilohertz; s = second.

(alarm calls). In this report, we classified and characterized 4 types of notes that compose the call of *C. rufescens* from recordings obtained in the wild for the first time.

A previous description of the calls of a *Coendou* species was made by Roberts *et al.* (1985). They classified the calls of *C. prehensilis*, based on Eisenberg *et al.* (1975), into 2 general categories: broadband and tonal sounds. According to this classification, the calls of *C. rufescens* would be classified as tonal sounds because their duration and harmonic characteristics. The calls of *C. rufescens* differ from those of *C. prehensilis*, because they present higher values of maximum frequency (3–10 kHz in *C. prehensilis*) and a lower fundamental frequency (0.2–2.5 kHz in *C. prehensilis*). In both species, the dominant frequency typically coincides with the fundamental frequency.

We do not associate any sound emitted by *C. rufescens* with a specific context due to the preliminary and descriptive character of our study. However, Roberts *et al.* (1985) mention that sounds with descending modulation are related to aggressive or threatening contexts. In rodents, alarm calls are emitted as part of an antipredator behavior and its purpose is to discourage or evade attack (Shelley and Blumstein 2004; Okanoya and Screven 2018). For the peculiarity of the recording event (*i.e.*, emitting calls in a direct encounter when it was cornered), these calls could be alarm calls (Blumstein 2007). It is important to highlight that the recordings analyzed in this study were obtained opportunistically and we cannot completely infer the function of the calls. However, this descriptive report can be useful as baseline information for future acoustic studies on the species. Future studies should take into account the behavioral context in order to infer specific functions (*e.g.*, alarming, anti-depredatory, aggression, distress) of different types of calls emitted in natural conditions.

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