

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

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

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

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

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

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

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

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

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

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

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

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

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

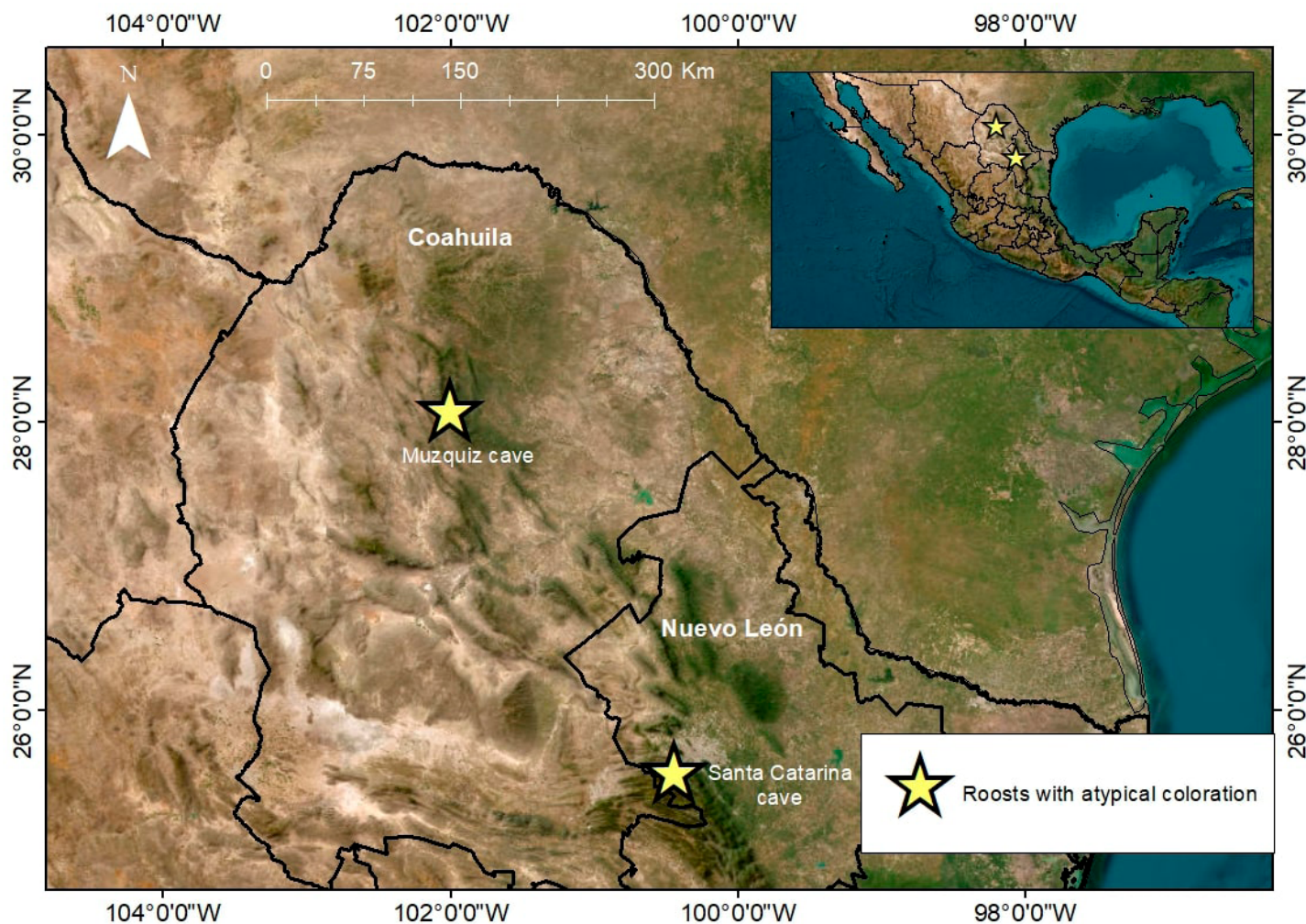


Figure 1. Map of the roosts with mass atypical coloration of cave-dwelling bats.

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

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

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

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

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

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

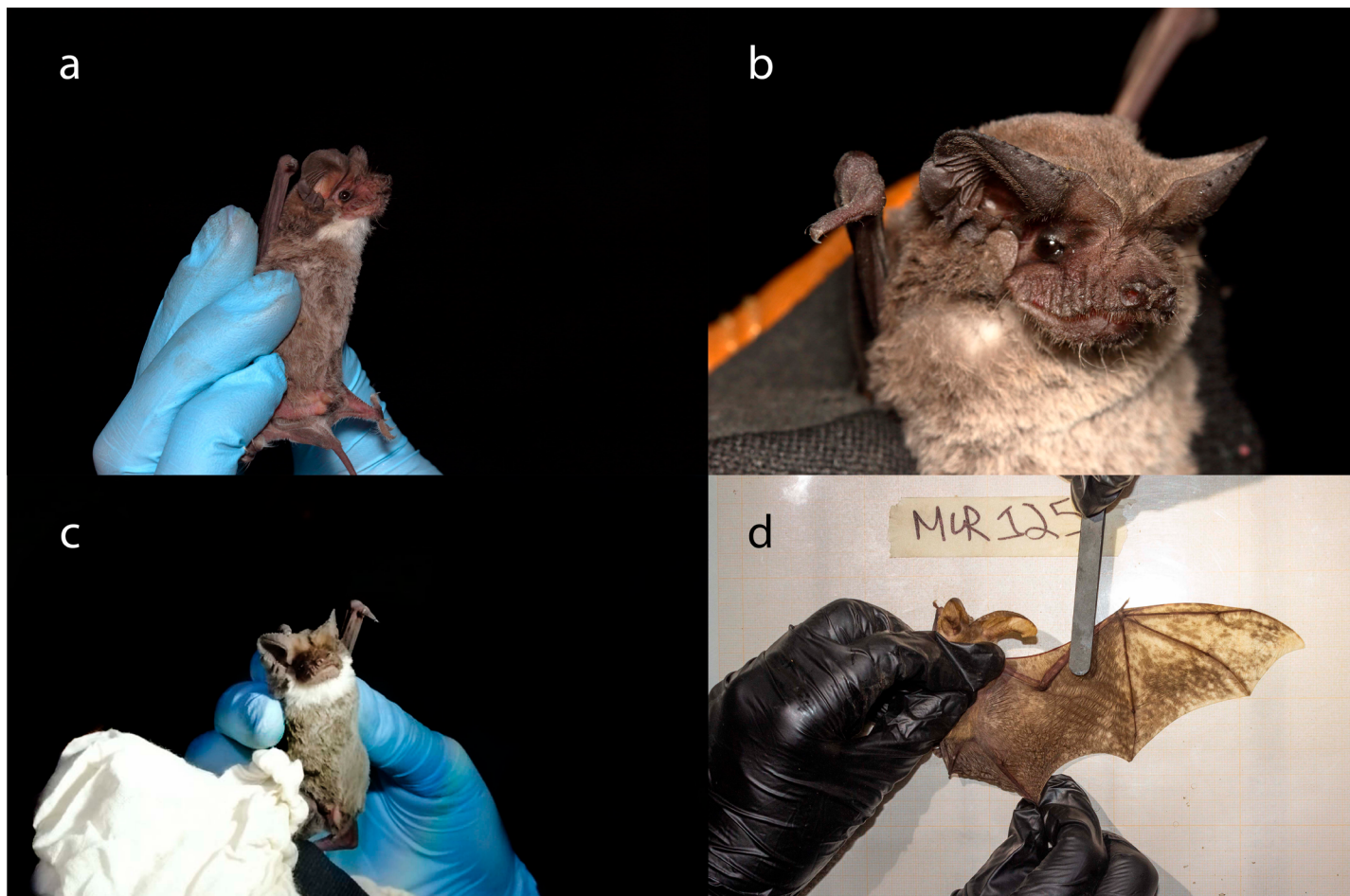


Figure 2. The captured bats with atypical colouration; a-c *Tadarida brasiliensis* exhibiting atypical colouration; d Piebald post-lactating female *Corynorhinus townsendii*.

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

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

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

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

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

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

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

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

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



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

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

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

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

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

Acknowledgements

We thank Fundación SimiPlaneta for funding the project "Rescatando a los murciélagos y sus cuevas". Hábitats Resilientes A.C. for their support and the facilities to work in the field with bats and caves. This paper is dedicated to the memory of our friend H. Rodríguez Vela, who inspired us to pursue careers with bats and caves. He was a burst of light. We want to thank R. Quirino, T. Carrizales, O. Sol,

and H. Gallardo who assisted in all fieldwork. We also thank the two anonymous reviewers who helped improve earlier versions of this note.

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Associate editor: Romeo A. Saldaña Vázquez

Submitted: March 03, 2025; Reviewed: September 09, 2025

Accepted: September 25, 2025

Published on line: April 28, 2026