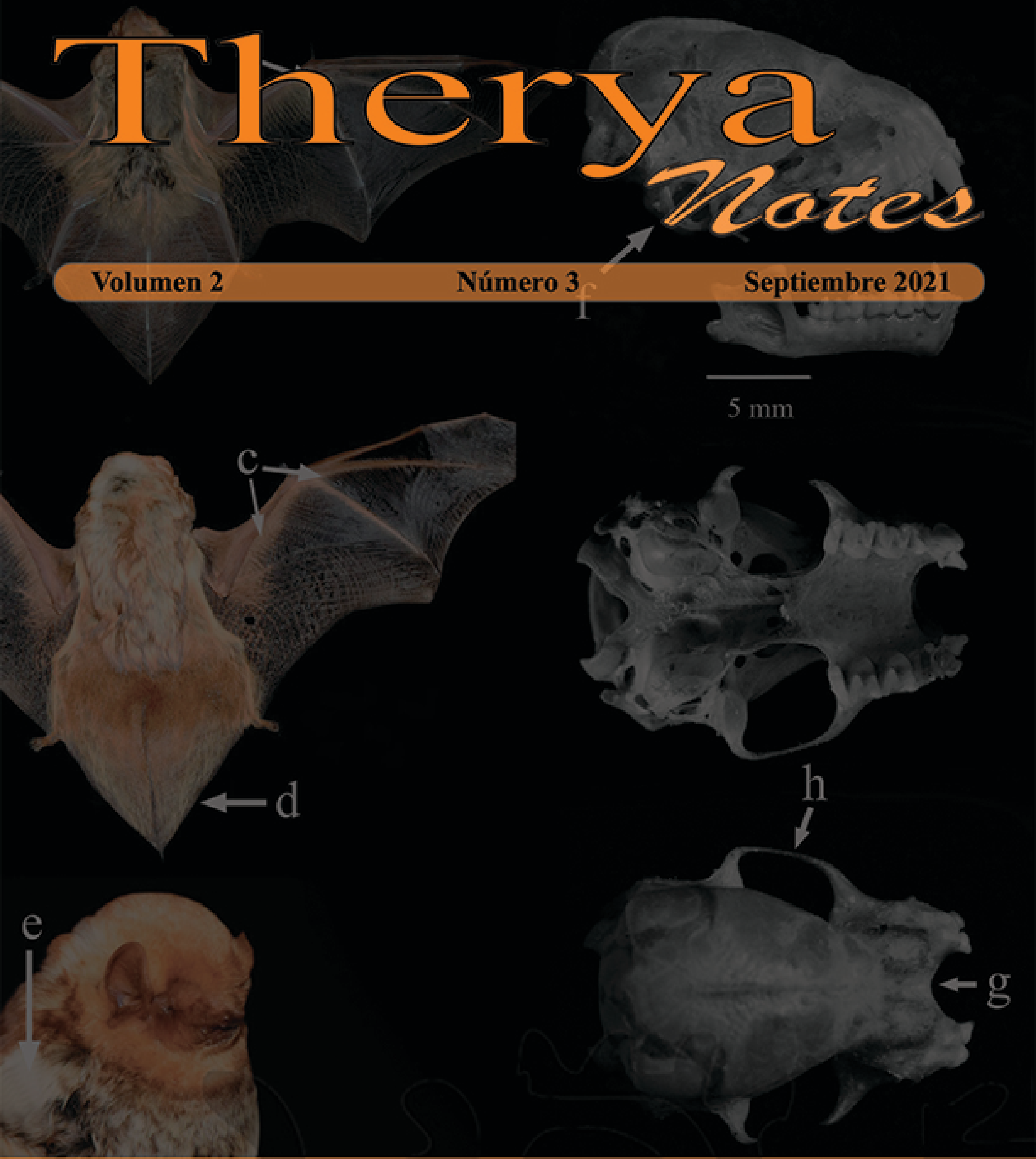
Therya Notes

Volumen 2 Número 3 Septiembre 2021



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

Ejemplar adulto hembra de *Lasiurus arequipa*. Se observan las características del pelaje, la coloración y las estructuras craneales.
(Fotografía de Mamani-Contreras y Aragón-Alvarado 2021)

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."

THERYA NOTES, Volumen 2, fascículo 3, septiembre - diciembre 2021, es una publicación digital cuatrimestral editada por la Asociación Mexicana de Mastozoología A. C. Hacienda Vista Hermosa 107, Colonia Villa Quietud, Coyoacán C. P. 04960. Ciudad de México, México, www.mastozoologiamexicana.org. Editora responsable: Dra. Consuelo Lorenzo Monterrubio (therya_notes@mastozoologiamexicana.com). Reservas de Derechos al Uso Exclusivo No. 04-2022-031012413800-102. ISSN 2954-3614. Responsable de la última actualización de este número, Unidad de Informática de la Asociación Mexicana de Mastozoología A.C. Dra. Consuelo Lorenzo Monterrubio, El Colegio de la Frontera Sur, Carretera Panamericana y Periférico Sur s/n, C. P. 29290, San Cristóbal de Las Casas, Chiapas. Fecha de la última actualización: 1 de septiembre de 2021.

EQUIPO EDITORIAL

Editora general
Dra. Consuelo Lorenzo Monterrubio
El Colegio de la Frontera Sur (ECOSUR)
Carretera Panamericana y Periférico Sur s/n, C. P. 29290. San Cristóbal de Las Casas, Chiapas, México.

Editores asistentes
Dra. Gloria Tapia Ramírez
El Colegio de la Frontera Sur (ECOSUR)
Carretera Panamericana y Periférico Sur s/n, C. P. 29290. San Cristóbal de Las Casas, Chiapas, México.

Dr. Arturo Carrillo Reyes
Universidad de Ciencias y Artes de Chiapas (UNICACH)
Libramiento Norte Poniente No. 1150, Col. Lajas Maciel, C. P. 29018. Tuxtla Gutiérrez, Chiapas, México.

Consejo editorial
Sergio Ticul Álvarez Castañeda
Centro de Investigaciones Biológicas del Noreste S. C.
Av. Instituto Politécnico Nacional 195, La Paz, Baja California Sur 23096 México

Douglas A. Kelt
Universidad de California, Campus Davis
1 Shields Ave, Davis, California 95616 USA

Dr. Robert M. Timm
Natural History Museum & Biodiversity Institute
University of Kansas, Lawrence, Kansas 66045 USA

Dr. Guillermo D'Elía
Instituto de Ciencias Ambientales y Evolutivas
Universidad Austral de Chile, Campus Isla Teja s/n, Valdivia, Chile

Editora de formato
Dra. Cintya Segura Trujillo
Universidad de Guadalajara, Unidad Autlán, Autlán 48900. Jalisco, México

Tesorera
Dra. Malinalli Cortés Marcial
Universidad Autónoma Metropolitana Unidad Xochimilco, Departamento El Hombre y Su Ambiente.
Calz. del Hueso 1100, Coapa, Villa Quietud, Coyoacán, 04960. Ciudad de México, México.

Traductora
M. en C. María Elena Sánchez Salazar

Editores asociados
Dr. Jorge Israel Ayala-Berdón
Catedrático CONACYT, Centro Tlaxcala de Biología de la Conducta
Universidad Autónoma de Tlaxcala, México

Dra. Beatríz del S. Bolívar Cimé
Universidad Veracruzana, Instituto de Investigaciones Forestales

Parque Ecológico "El Haya", carretera antigua a Coatepec, C.P. 91070. Xalapa, Veracruz, México.

Dra. Dulce Itandehui Hernández Aguilar
Laboratorio de Ecología Animal
Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional
CIIDIR-Unidad Oaxaca, Instituto Politécnico Nacional

Dr. Jesús Rafael Hernández Montero
Departamento de Zoología Aplicada y Conservación de la Naturaleza
Instituto y Museo Zoológico - Universidad de Greifswald
Greifswald, Mecklemburgo-Pomerania Occidental, Alemania

Dr. Cristian Kraker Castañeda
El Colegio de la Frontera Sur, (ECOSUR)
Carretera Panamericana y Periférico Sur s/n, Barrio María Auxiliadora, C. P. 29290. San Cristóbal de Las Casas, Chiapas, México.

Dr. José Fernando Moreira Ramírez
Wildlife Conservation Society, Programa para Guatemala
Avenida 15 de marzo casa número 3, Flores Petén, Dirección alterna: 13 calle A 1-26 zona 3, Finca El Zapote. Ciudad de Guatemala, Guatemala.

Dra. Nicté Ordóñez Garza
Universidad San Francisco de Quito
Laboratorio de Biología Evolutiva, Instituto Biosfera, Colegio de Ciencias Biológicas, Avenida Pampite S/N y Diego de Robles, Campus Cumbayá. Quito, Ecuador.

Dra. Tamara Mila Rioja Paradela
Posgrado en Ciencias en Desarrollo Sustentable y Gestión de Riesgos
Universidad de Ciencias y Artes de Chiapas
Libramiento Norte Poniente, No. 1150, Col. Lajas Maciel, C. P. 29039. Tuxtla Gutiérrez, Chiapas, México.

Dr. Romeo A. Saldaña Vázquez
Instituto de Investigaciones en Medio Ambiente Xavier Gorostiaga, S.J.
Universidad Iberoamericana Puebla, Blvd. del Niño Poblano No. 2901,
Col. Reserva Territorial Atlixcáyotl, C. P. 72820. San Andrés Cholula, Puebla.

CONTENIDO

THERYA NOTES 2021, Vol. 2 : 112-116 DOI: 10.12933/therya_notes-21-46 ISSN 2954-3614

Noteworthy records of abnormal coloration in Mexican bats

Registros notables de coloración anormal en murciélagos mexicanos

Melany Aguilar-López[1]*, Pedro Adrián Aguilar-Rodríguez[1], Juan Cruzado-Cortés[2], M. Cristina MacSwiney G.[3], and Jorge Ortega[4]

[1]ECOYDES A. C. Belisario Domínguez 105-2, Colonia Centro, C. P. 42186. Pachuca, Hidalgo, México. E-mail: m.aguilar@ecoydesac.org (MA-L); pedroaguilarr@gmail.com (PAA-R).

[2]Biólogo independiente. Calle 33 número 451, Francisco de Montejo, C. P. 97203. Mérida, Yucatán, México. E-mail: juancruzado@outlook.com (JC-C).

[3]Centro de Investigaciones Tropicales, Universidad Veracruzana. Calle José María Morelos y Pavón 44 y 46, Centro, C. P. 91000. Xalapa, Veracruz, México. E-mail: cmacswiney@uv.mx (MCMG).

[4]Laboratorio de Bioconservación y Manejo, Posgrado de Ciencias Quimicobiológicas, Departamento de Zoología, Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional. Plan de Ayala esquina Carpio s/n, C. P. 11340. Ciudad de México, México. E-mail: artibeus2@aol.com (JO).

*Corresponding author

Permanent atypical coloration in mammals can occur by a congenital condition or environmental causes, but it is expressed by defects in melanocytes (melanin-producing cells) number or function. Around the world, bats have been reported with abnormal coloration, but only a handful of cases are from México. We report records of chromatic disorders in several species captured from different locations in México. Bats were captured with mist nets outside roosting sites or in trails with vegetation. All individuals were released at the capture site. We recorded 9 individuals of Phyllostomidae and 3 of Molossidae with chromatic disorders: 11 white-spotted individuals and 1 with albinism. White spotting is recorded for the first time in *Mimon cozumelae* and the first record for *Leptonycteris yerbabuenae* and *Nyctinomops laticaudatus* in México. Individuals with pigmentary disorders records are rare in nature and reporting the occurrence of these events in bats increases the knowledge of the natural history of species.

Key words: Albinism; Chiroptera; hypopigmentation; Molossidae; Phyllostomidae.

La coloración atípica permanente en mamíferos puede ocurrir por una condición congénita o por causas ambientales, pero se expresa por defectos en el número o función de los melanocitos (células productoras de melanina). Alrededor del mundo, se han reportado murciélagos con coloración anormal en la piel, pero en México se conocen pocos casos. Aquí, presentamos registros de trastornos cromáticos en varias especies capturadas en diferentes lugares de México. Los murciélagos fueron capturados con redes de niebla afuera de los sitios de percha o en senderos con vegetación. Todos los individuos fueron liberados en el sitio de captura. Registramos 9 individuos de la familia Phyllostomidae y 3 de Molossidae con trastornos cromáticos: 11 individuos con manchas blancas y 1 con albinismo. El fenotipo de manchas blancas se reporta por primera vez en *Mimon cozumelae* y el primer registro para *Leptonycteris yerbabuenae* y *Nyctinomops laticaudatus* en México. Los registros de individuos con trastornos pigmentarios son raros en la naturaleza, e informar la ocurrencia de estos eventos en murciélagos aumenta el conocimiento de la historia natural de las especies.

Palabras clave: Albinismo; Chiroptera; hipopigmentación; Molossidae; Phyllostomidae.

Skin coloration in vertebrates is the result of pigments, an extremely varied group of large molecules that reflect light rays (Hoekstra 2006). Melanin is one of the most important pigments and it is found in skin, hair, or fur, and eyes. There are two types of melanin, pheomelanin and eumelanin (Solano 2014), which are produced in the cells called melanocytes, located at the basal layer of the epidermis (Hickman *et al.* 2001; Cappai *et al.* 2015; Ali and Naaz 2018). The pigmentation phenotypes derived from melanocytes are regulated by over 200 gene loci (Lamoreux *et al.* 2010).

However, sometimes the phenotype expressed differs from the chromatic patterns that characterize the species. Cases of atypical coloration can occur for various reasons. Some abnormal colorations could be the result of environmental conditions (*i.e.*, roost atmosphere; Constantine 1958) or the diet (MacSwiney *et al.* 2012), but they are not permanent, and other phenotypes might be related to a genetic condition (Jackson 1997; Lamoreux *et al.* 2010).

Hypopigmentation in mammals is the result of pigment-cell death or the failure in the development of these cells (Lamoreux *et al.* 2010) and includes white spotting, vitiligo, progressive graying, and albinism. White spotting is the congenital absence of viable melanocytes from some or all the areas where they would be regularly present, thus forming white spots among the normally colored skin, and is evident at the birth of the individual (Lamoreux *et al.* 2010). Meanwhile, albinism is the congenital absence of melanin throughout the body due to an inability of viable melanocytes to produce pigments (with the resulting phenotype of absence of integumentary and retinal pigmentation; Lamoreux *et al.* 2010) resulting by several recessive genes interacting (Summers 2009). Both atypical colorations are the most frequently reported in bats (Uieda 2000; Gamba-Ríos 2010; Lucati and López-Baucells 2016; Zalapa *et al.* 2016; Martínez-Coronel *et al.* 2020). To capture an animal with some condition of chromatic disorder has been always of special interest due to the rarity of which these specimens are registered. Here, we present noteworthy mentioning records of abnormal coloration in several bat species captured during different field trips in México.

We compiled records of abnormal coloration in different bat species. These are the results of field captures made by the authors, either by mist-netting in their habitat or recorded at their roost. In all the captured individuals, we measured forearm length, weight, and determined the sex and reproductive status, before taking pictures of their skin condition. We identified the individuals using the guide by Medellín *et al.* (2008). After that, we released them. Due to the lack of agreement in chromatic disorder terminology in bats, we used the terms suggested by Zalapa *et al.* (2016) to name the skin pigmentation abnormalities for this study.

We recorded 12 bats with chromatic disorders, from 9 species. Of these, 7 species belong to the Phyllostomidae family and 2 species to the Molossidae family (Appendix): *Artibeus jamaicensis*, *A. lituratus*, *Desmodus rotundus*, *Glossophaga soricina*, *Leptonycteris yerbabuenae*, *Mimon cozumelae*, *Sturnira hondurensis* (Phyllostomidae); *Nyctinomops laticaudatus* and *Tadarida brasiliensis* (Molossidae; Figures 1A-1F, 2A-2E). The bats were captured in the Mexican states of Guanajuato (1), Hidalgo (2), Oaxaca (2), Tlaxcala (1), Veracruz (1), Quintana Roo (1), and Yucatán (4).

Of the records, 1 individual (a female pregnant *D. rotundus*) was an albino (Figure 2B), while most of the individuals presented the phenotype of non-symmetrical or single "white spots" in their skin and fur, either in their back or shoulder (Figures 1A, 1D, 2A, 2C, 2E), the crown of the head (Figure 2D), or in their nose and lips (Figure 1C). The multiple white spots presented in both wings of *A. jamaicensis*, *L. yerbabuenae*, and *S. hondurensis* (Figures 1B, 1E, 1F) were visible in the inner and upper face of the patagium.

Abnormal colorations have been widely reported in bats, and in México, so far 40 individuals from 15 species in Chiapas, Colima, Hidalgo, Jalisco, Oaxaca and Sonora (Caire and Thies 1988; Zalapa *et al.* 2016; Hernández-Aguilar and Santos-Moreno 2018; Martínez-Coronel *et al.* 2020). Here, we added 11 individuals and 2 species to the previous studies, as well as the states of Guanajuato, Tlaxcala, Quintana Roo, Veracruz, and Yucatán.

There are several records about abnormal skin coloration in bats from around the world (*i.e.*, Uieda 2000; López-Baucells *et al.* 2013; Treitler *et al.* 2013; Zalapa *et al.* 2016; Fernández de Córdoba *et al.* 2017), and frequently reported in cave-dwelling species that conform big colonies or gregarious family groups, especially from the Phyllostomidae and Molossidae families (Lucati and López-Baucells 2016; Zalapa *et al.* 2016). All the species here reported show these specific characteristics. Atypical skin pigmentation has been considered problematic to conspecific communication or to avoid predators, thus, impacting the fitness of the individual (Uieda 2000; Caro 2005), but in bats, reproductive individuals with chromatic disorders have been frequently reported (Sánchez-Hernández *et al.* 2010; García-Morales *et al.* 2012; Zalapa *et al.* 2016; this study), and no behavioral changes associated to the condition are known so far (Harada *et al.* 1991; Uieda 2001; Moreno *et al.* 2020). Protected roost, such as caves, may be beneficial to the survival of bats with chromatic disorders, protecting them from sun burns and being easily spotted by predators (Uieda 2000; Barquez *et al.* 2003; Mantilla-Meluk and Jiménez-Ortega 2011). Also, the bat's nocturnal habits should play a role in the low impact of abnormal pigmentation in their survival.

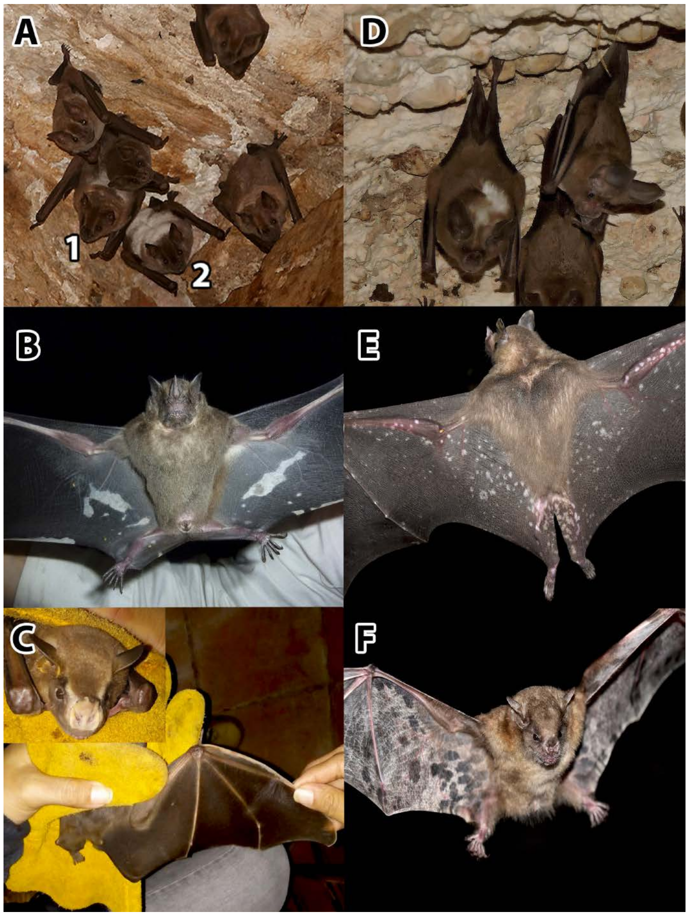


Figure 1. A) Two adults of *Artibeus jamaicensis* with notorious white spots covering most of their back, individual 1 was not captured, individual 2 is an adult male (Photograph of J. Cruzado); B) Adult female of *Artibeus jamaicensis* with white spots at the middle and edge of the plagiopatagium and uropatagium (Photograph of C. MacSwiney); C) Adult female of *Artibeus lituratus* with white spots in noseleaf and upper edge of dactylopatagium (Photograph of P. Aguilar-Rodríguez); D) *Mimon cozumelae* with notable white spot in the upper back (Photograph of Z. Vallado); E) Remarkable white spots in plagiopatagium, uropatagium and ears of *Leptonycteris yerbabuenae* (Photograph of M. Aguilar); F) Specimen of *Sturnira hondurensis* with multiple white spots in both wings (Photograph of M. Aguilar).

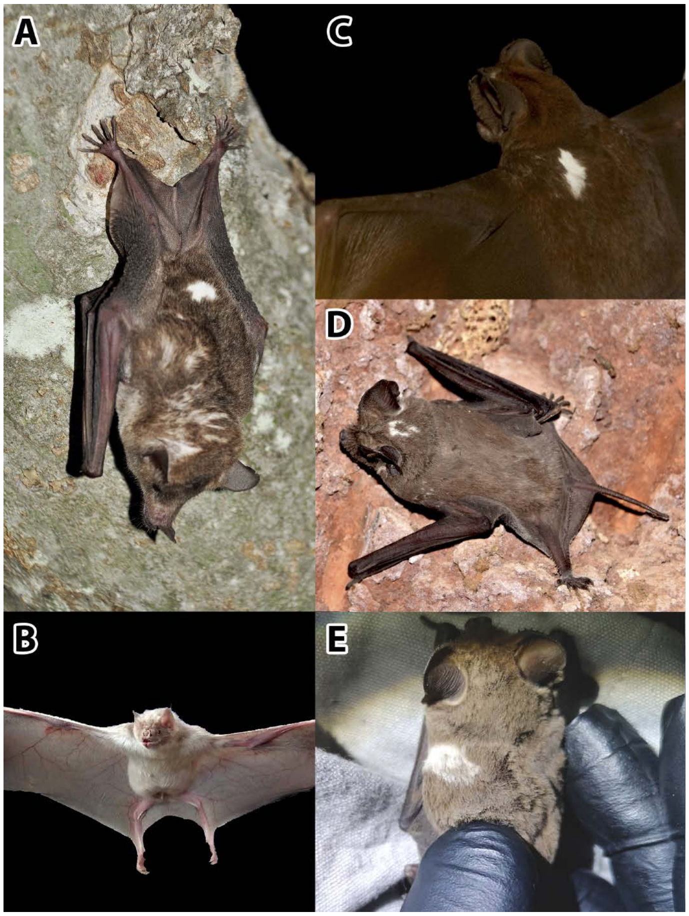


Figure 2. A) Adult male of *Glossophaga soricina* with a white spot in the lower back (Photograph of M. Aguilar); B) Specimen of *Desmodus rotundus* with albinism (Photograph of C. Escorcia-Zuñiga); C) *Nyctinomops laticaudatus* presenting a white spot in its left shoulder (Photograph of M. Aguilar); D) White spot in the hind head of an adult male of *Tadarida brasiliensis* (Photograph of M. Aguilar); E) Adult *T. brasiliensis* with a white spot in the left shoulder (Photograph of I. Cabrera-Castro).

The most common chromatic skin disorder reported in bats (Zalapa *et al.* 2016) seems to be white spotting (sometimes wrongly referred as piebaldism; see Lamoreux *et al.* 2010), with several records occurring in the Neartic and Paleartic zones, but records of bats from the tropics are infrequent. We report for the first-time, white-spotted individuals of *L. yerbabuenae* and *N. laticaudatus* in México, and the first evidence in *M. cozumelae*. In contrast, the Jamaican fruit-eating bat (*A. jamaicensis*), an abundant species in tropical areas, has several records of chromatic disorders both in the wild and captivity, such as white spots (Kwiecinski *et al.* 2001; Sánchez-Hernández *et al.* 2010).

We also highlight the new report of an albino *Desmodus rotundus*. Albino individuals are extremely rare in nature (Caro 2005), occurring likely by inbreeding (Stevens *et al.* 1997), and occurrence of this condition might be associated to the strong roost fidelity in the species reported (Sánchez-Hernández *et al.* 2012). Albino individuals might present visual and immunological pathologies (Pérez-Carpinelli *et al.* 1992; Summers 2009) and being more susceptible to predation (Parsons and Bonderup-Nielsen 1995). In México, albino bats have been captured only for *A. lituratus* (reported as *A. intermedius*), *D. rotundus*, and *G. soricina* (Pozo and Escobedo-Cabrera 1998; García-Morales *et al.* 2010; Sánchez-Hernández *et al.* 2010).

Finally, we emphasize that individuals with pigmentary disorders records are rare in nature and reporting the occurrence of these events in bats increases the knowledge of the natural history of species. Future research will improve our understanding about the causes and implications of these conditions.

Acknowledgements

We thank J. L. Monter Vargas, E. Andablo Amador, E. Gutiérrez, Z. Vallado, A. Tzab, K. Romo and all the field assistants who participated during the field trips and whose invaluable help we were able to obtain these records. Partial financial support was provided by Centro de Investigaciones Tropicales, Universidad Veracruzana (Project #342612019193) and Comisión Nacional de Áreas Naturales Protegidas (CONANP)- Dirección Regional de Centro y Eje Neovolcánico. The valuable feedback from three anonymous reviewers helped improve the manuscript.

Literature cited

Ali, S. A., and I. Naaz. 2018. Biochemical aspects of mammalian melanocytes and the emerging role of melanocyte stem cells in dermatological therapies. International Journal of Health Sciences 12:69-76.

Barquez, R. M., L. V. Carrizo, L. I. Ferro, D. A. Flores, M. I. Mollerach, M. S. Sánchez, and A. P. García López. 2003. Primer caso de albinismo total para *Sturnira erythromos* (Tschudi, 1844) – (Chiroptera-Phyllostomidae). Chiroptera Neotropical 9:166-169.

Caire, T., and M. Thies. 1988. Notes on the occurrence of morphological and color aberrations in bats from Oklahoma, Missouri, and Mexico. Proceedings of the Oklahoma Academy of Science 68:75-76.

Cappai, M. G., M. Picciau, G. Nieddu, I. Sogos, R. Cherchi, and W. Pinna. 2015. Cutaneous metabolic pathway of tyrosine as a precursor to melanin in Asinara's white donkey, *Equus asinus* L., 1758. Italian Journal of Animal Science 14:502-507.

Caro, T. 2005. The adaptive significance of coloration in mammals. BioScience 55:125-136.

Constantine, D. G. 1958. Bleaching of hair pigment in bats by the atmosphere in caves. Journal of Mammalogy 39:513-520.

Fernández de Córdova, J., C. Nivelo-Villavicencio, and P. X. Astudillo. 2017. Primer reporte de leucismo para *Artibeus fraterculus* (Chiroptera: Phyllostomidae) en Ecuador. Revista Biodiversidad Neotropical 7:110-114.

Gamba-Rios, M. 2010. A new case of albinism in the bat *Micronycteris minuta* (Chiroptera: Phyllostomidae) from Costa Rica. Ecotropica 16:59-61.

García-Morales, M., D. Tejeda-Durán, E. S. Ávila-Gómez, C. E. Moreno, and M. S. Akmentins. 2012. Registro de leucismo en *Sturnira ludovici* y *Artibeus jamaicensis* (Phyllostomidae) en México. Chiroptera Neotropical 18:1101-1105.

García-Morales, M., E. J. Gordillo-Chávez, and J. Bello-Gutiérrez. 2010. Primer registro de albinismo en *Glossophaga* *soricina* (Phyllostomidae) en México. Chiroptera Neotropical 16:743-747.

Harada, M., I. Sawada, and K. Aso. 1991. Albinism in the Japanese large-footed bat *Myotis macrodactylus*. Journal of the Mammalogical Society of Japan 16:37-39.

Hernández-Aguilar, I., and A. Santos-Moreno. 2018. First record of hypopigmentation disorders in the Peter´s ghost-faced bat *Mormoops megalophylla* (Chiroptera, Mormoopidae). Mammalia 82:618-621.

Hickman, C. P., L. S. Roberts, and A. Larson. 2001. Integrated principles of Zoology. McGraw-Hill, 11th. Ed. New York, U.S.A.

Hoekstra, H. E. 2006. Genetics, development and evolution of adaptive pigmentation in vertebrates. Heredity 97:222-234.

Jackson, I. J. 1997. Homologous pigmentation mutations in human, mouse and other model organisms. Human Molecular Genetics 6:1613-1624.

Kwiecinski, G. C., L. Zhiren, T. C. Chen, and M. F. Holick. 2001. Observations on serum 25- hydroxyvitamin D and calcium concentrations from wild-caught and captive Neotropical bats, *Artibeus jamaicensis*. General and Comparative Endocrinology 122:225-231.

Lamoreux, M. L., V. Delmas, L. Larue, and D. C. Bennet. 2010. The colors of mice: a model genetic network. Wiley-Blackwell. West Sussex, UK.

López-Baucells, A., M. Mas, X. Puig-Montserrat, and C. Flaquer. 2013. Hypopigmentation in vespertilionid bats: the first record of a leucistic soprano pipistrelle *Pipistrellus pygmaeus*. Barbastella 6:63-70.

Lucati, F., and A. López-Baucells. 2016. Chromatic disorders in bats: a review of pigmentation anomalies and the misuse of terms to describe them. Mammal Review 47:112-123.

MacSwiney, G. M. C., B. Bolívar-Cimé, F. M. Clarke, and P. A. Racey. 2012. Transient yellow colouration of the bat *Artibeus jamaicensis* coincides with pollen consumption. Mammalian Biology 77: 221-223.

Mantilla-Meluk, M., and A. M. Jiménez-Ortega. 2011. First case of albinism in *Uroderma bilobatum* and its implications in the evolution of coat color patterns among Vampyressine bats. Investigación, Biodiversidad y Desarrollo 30:97-100.

Martínez-Coronel, M., M. I. Verona-Trejo, and Y. Hortelano-Moncada. 2020. Anomalías morfológicas y cromáticas en murciélagos de Chiapas, México. Revista Mexicana de Mastozoología, nueva época 10:33-39.

Medellín, R. A., H. T. Arita, and O. Sánchez. 2008. Identificación de los murciélagos de México: clave de campo. Consejo Nacional de Ciencia y Tecnología, Instituto de Ecología, UNAM, 2d. Ed. México City, México.

Moreno, C. R., T. Pollock, L. Sánchez, and E. C. Mora. 2020. Acoustical and morphological comparisons between albino and normally-pigmented Jamaican fruit bats (*Artibeus jamaicensis*). Caribbean Journal of Science 50:1-8.

Parsons, G. J., and S. Bonderup-Nielsen. 1995. Partial albinism in an island population of Meadow Voles, *Microtus pennsylvanicus*, from Nova Scotia. The Canadian Field Naturalist 109:263-264.

Pérez-Carpinell, J., P. Capilla, C. Illueca, and J. Morales. 1992. Vision defects in albinism. Optometry and Vision Science 69:623-628.

Pozo, C., and J. E. Escobedo-Cabrera. 1998. Albinism in *Artibeus intermedius*. Bat Research News 39:27-28.

Sánchez-Hernández, C., A. Rojas-Martínez, J. C. López-Vidal, C. Elizalde-Arellano, M. L. Romero-Almaraz, M. Aguilar-López, and A. Taboada-Salgado. 2012. Leucism in five species of bats from Mexico. Chiroptera Neotropical 18:1123-1127.

Sánchez-Hernández, C., M. L. Romero-Almaraz, A. Taboada-Salgado, J. A. Almazán-Catalán, G. D. Schnell, and L. Sánchez-Vázquez. 2010. Five albino bats from Guerrero and Colima, Mexico. Chiroptera Neotropical 16:522-527.

Solano, F. 2014. Melanin: skin pigments and much more-types, structural models, biological functions, and formation routes. New Journal of Science 2014:498276.

Stevens, G., M. Ramsay, and T. Jenkins. 1997. Oculocutaneous albinism (OCA2) in sub-Saharan Africa: distribution of the common 2.7 –kb P gene deletion mutation. Human Genetics 99:523-527.

Summers, C.G. 2009. Albinism: classification, clinical characteristics, and recent findings. Optometry and Vision Science 86:659-662.

Treitler, J. T., A. López-Baucells, S. Gomes Farias, J. F. Tenaçol Jr., and R. Rocha. 2013. First record of a leucistic piebald *Phyllostomus discolor* (Chiroptera: Phyllostomidae). Chiroptera Neotropical 19:1179-1181.

Uieda, W. 2000. Behavior of an albino vampire bat, *Desmodus rotundus* (E. Geoffroy) (Chiroptera, Phyllostomidae), in captivity. Revista Brasileira de Zoologia 18:641-644.

Uieda, W. 2001. A review of complete albinism in bats with five new cases from Brazil. Acta Chiropterologica 2:97-105.

Zalapa, S. S., S. Guerrero, M. L. Romero-Almaraz, and C. Sánchez-Hernández. 2016. Atypical coloration in bats: frequency and phenotypes in North and Central America, and the Caribbean islands, and new cases from Mexico and Costa Rica. Revista Mexicana de Biodiversidad 87:474-482.

Associated editor: Cristian Kraker-Castañeda
Submitted: May 4, 2021; Reviewed: August 25, 2021.
Accepted: September 1, 2021; Published on line: September 14, 2021.

Appendix

List of the captured bats with chromatic disorders.

Family Phyllostomidae

1) *Artibeus jamaicensis*

Locality: Hacienda Misnebalam, 10 km north of Mérida, Yucatán (21° 09′ 02.9″ N, 89° 35′ 42.4″ W, 6 m). Colony inside an abandoned building, surrounded by low deciduous forest.

Date: December 14th, 2020.

Specimen: Adult male. Forearm length 59 mm.

A second individual was registered in the same roost but not captured (individual 2 in the inset of Figure 1A).

Chromatic disorder: White spotting (Figure 1A).

2) *Artibeus jamaicensis*

Locality: 3.5 km from Felipe Carrillo Puerto, Quintana Roo (19° 36′ 23.3″ N, 88° 03′ 50.3″ W, 30 m). Captured with a mist-net in a trail surrounded by medium semi-evergreen forest.

Date: February 5th, 2011.

Specimen: Adult female. Forearm length 57.8 mm, and weight 40 g.

Chromatic disorder: White spotting (Figure 1B).

3) *Artibeus lituratus*

Locality: Rancho Viejo, Tlalnelhuayocan, Veracruz (19° 31′ 53.71″ N, 96° 58′ 46.86″ W, 1,460 m). Captured in secondary growth of montane cloud forest, with a river nearby.

Date: March 27th, 2018.

Specimen: Adult female. Forearm length 69.8 mm, and weight 54 g.

Chromatic disorder: White spotting (Figure 1C).

4) *Mimon cozumelae*

Locality: Cave near Pixoy, Valladolid, Yucatán (20° 42′ 1.07″ N, 88° 17′ 30.4″ W, 27 m).

Date: January 11th, 2021. Captured during the emergence from the roost. The cave is surrounded by secondary growth of medium semi-evergreen forest.

Specimen: Adult male. Forearm length 58.4 mm, and weight 25 g.

Chromatic disorder: White spotting (Figure 1D).

5) *Leptonycteris yerbabuenae*

Locality: La Ventosa, Juchitán, Oaxaca (16° 30′ 19.192″ N, 100° 57′ 06.405″ W, 20 m). Captured in a vegetation patch with columnar cacti with water nearby.

Date: May 17th, 2017.

Specimen: Adult female. Forearm length 58 mm and weight 26 g.

Chromatic disorder: White spotting (Figure 1E).

6) *Sturnira hondurensis*

Locality: Durango, Zimapán, Hidalgo (20° 54′ 03.539″ N, 99° 14′ 26.444″ W, 2,041 m). Captured in a mist-net over a temporal stream, close to a cabin, in a coniferous forest.

Date: August 22th, 2017.

Specimen: Adult male. Forearm length 42.8 mm and weight 20 g.

Chromatic disorder: White spotting (Figure 1F).

7) *Glossophaga soricina*

Locality: La Ventosa, Juchitán, Oaxaca (16° 30′ 19.192″ N, 100° 57′ 06.405″ W, 20 m). Captured in a vegetation patch with columnar cacti with water nearby.

Date: October 11th, 2016.

Specimen: Adult male with scrotal testes. Forearm length 36 mm and weight 10 g.

Chromatic disorder: White spotting (Figure 2A).

8) *Desmodus rotundus*

Locality: Paraje El Pinalito, El Carricillo, Atarjea, Guanajuato (21° 13′ 00.192″ N, 99° 49′ 52.557″ W, 2,138 m). Captured during the emergence from the roost. The cave is surrounded by semi-arid vegetation.

Date: April 20th, 2021.

Specimen: Pregnant female. Forearm length and weight not measured.

Chromatic disorder: Albinism (Figure 2B).

Family Molossidae

9) *Nyctinomops laticaudatus*

Locality: Cenote Homún, Yucatán (20° 44′ 47.68″ N, 89° 17′ 48.8″ W, 14 m).

Date: October 24th, 2020. Captured during the emergence from the roost. Secondary growth of low deciduous forest.

Specimen: Adult male. Forearm length 43 mm and weight 12 g.

Chromatic disorder: White spotting (Figure 2C).

10) *Tadarida brasiliensis*

Locality: Vaquerías, Metztitlán, Hidalgo (20° 22′ 08.987″ N, 98° 33′ 25.113″ W, 2,058 m). Captured during the emergence from the roost, a non-active mine. The cave is surrounded by semi-arid vegetation.

Date: October 2nd, 2018.

Specimen: Adult male. Forearm length 43.8 mm and weight 10.6 g.

Chromatic disorder: White spotting (Figure 2D).

11) *Tadarida brasiliensis*

Locality: Ex Hacienda Mazapa, Calpulalpan, Tlaxcala (19° 32′ 21.49″ N, 98° 33′ 27.49″ W, 2,722 m). Captured during the emergence from the roost. Colony inside of an abandoned building.

Date: December 20nd, 2019.

Specimen: Adult male. Forearm length 41.1 mm.

Chromatic disorder: White spotting (Figure 2E).

THERYA NOTES 2021, Vol. 2 : 117-124 DOI: 10.12933/therya_notes-21-47 ISSN 2954-3614

First mating report of tayra (*Eira barbara*) in the wild, in Panamá

Primer reporte de apareamiento de tayra (*Eira barbara*) en medio silvestre en Panamá

Rogemif D. Fuentes M.[1]*, Aracelys De Gracia C.[1], Helio Quintero-Arrieta[1], Alexis Baules[2], Madian Miranda[1], and Abel Batista[1, 3]

[1]Fundación Los Naturalistas, P. O. Box 0426-01459. David, Chiriquí, República de Panamá. E-mail: rogemifdaniel@gmail.com (RDFM); aracelys0519@gmail.com (ADGC); helemiqa@gmail.com (HQ-A); mpamela0305@gmail.com (MM); abelbatista@hotmail.com (AB).
[2]Centro de Investigaciones Hidráulicas, Universidad Tecnológica de Panamá, Edificio VIPE, piso 1, Campus central UTP. Ciudad de Panamá, Panamá. E-mail: alexis.baules@utp.ac.pa (AB).
[3]Universidad Autónoma de Chiriquí (UNACHI); Estafeta Universitaria 0427. David, Chiriquí, República de Panamá.
*Corresponding author

There is little information about the mating process of *Eira barbara* (tayra or black cat, as it is known in Panamá), reported only in captivity, by Poglayen-Neuwall (1975). Two camera traps were placed, 220 m apart, within the Altos de Campana National Park, in the border area with the community of El Chileno. The sounds emitted by individuals during the event were analyzed using the PREMIERE PRO-6.0.0 and Raven Pro1.5 software. We describe stages of this process evidenced in a sequence of 8 videos of 10 seconds each, captured by one of our camera traps; we consider the event as a single mount. Both individuals make sounds during the event, which we interpret as frequent clicks 3.19 KHz dominant and 3.23 KHz dominant frequency trills. We compared this event with the one reported in captivity by Poglayen-Neuwall (1975). Both in captivity and in our report, the nuchal grasp and the occasional dragging of the female by the male are observed. We also carried out the first bioacoustics analysis of the mating process of this species.

Key words: Altos de Campana National Park; bioacoustics; camera trap; clicking calls; mating; trills.

Existe poca información acerca del proceso de apareamiento de *Eira barbara* (tayra o gato cutarro, como se le conoce en Panamá), reportado únicamente en cautiverio, por Poglayen-Neuwall (1975). Se colocaron dos cámaras trampa, separadas 220 m, dentro del Parque Nacional Altos de Campana, en la zona limítrofe con la comunidad de El Chileno. Se analizaron los sonidos emitidos por los individuos durante el evento mediante los programas PREMIERE PRO-6.0.0 y Raven Pro1.5. Describimos etapas de este proceso evidenciado en una secuencia de 8 videos de 10 segundos cada uno, captado por una de nuestras cámaras trampa; consideramos el evento como una sola monta. Ambos individuos hacen sonidos durante el evento, que interpretamos como clics con frecuencia dominante de 3.19 KHz y trinos frecuencia dominante de 3.23 KHz. Comparamos este evento con el reportado en cautiverio por Poglayen-Neuwall (1975). Tanto en cautiverio como en nuestro reporte se observa el agarre nucal y el arrastre ocasional de la hembra por parte del macho. También realizamos el primer análisis bioacústico del proceso de apareamiento de esta especie.

Palabras clave: Apareamiento; bioacústica; cámara trampa; llamados en forma de clics; Parque Nacional Altos de Campana; trinos.

Mammals are an essential part of the ecosystems in which they inhabit since they play critical roles in these environments (Wright 2003; Morrison *et al.* 2007); whether in their role as top predators (Sunquist and Sunquist 2002), plant consumers (Fragoso 1999), seed predators (Galetti *et al.* 2015), or seed dispersers (O'Farrill *et al.* 2013), they exert a profound influence on their surroundings that goes beyond species interactions (Morrison *et al.* 2007). Altered or disturbed ecosystems often lack the large and medium-sized mammals' populations that historically inhabited them (Morrison *et al.* 2007); their absence, in turn, could trigger negative cascading effects in the food web, as many of these mammals serve as keystone species in their environment (Bond 1994; Wright 2003). Most of these species are elusive and their natural history is poorly known, so it is imperative to use tools that allow us to learn more about their life traits, population status and function within the ecological communities of the environment (Grotta-Nieto *et al.* 2020).

Camera traps have been one of the most novel and reliable methods for monitoring terrestrial mammal populations (Karanth *et al.* 2004), its main advantages are: the low stress generated to the individuals photographed (McCleery *et al.* 2014; Hobbs and Brehme 2017) and that they enable monitoring elusive species or ones that occur in low densities (Moruzzi *et al.* 2002), such as the neotropical mustelids (Yensen and Tafira 2003; Hernández-Sánchez *et al.* 2017; De Roux *et al.* 2019). Although it is argued that its cost is high, it is more cost-effective in time and money when compared to the intensive field days required to obtain the same observational level (Cutler and Swan 1999; Moruzzi *et al.* 2002); this is in addition to the recent emergence of increasingly cheaper reliable technologies (Rico-Guevara and Mickley 2017; Droissart *et al.* 2021). This method allows important variables to be obtained, such as: relative abundance (Maffei *et al.* 2004), activity patterns (Ávila-Nájera *et al.* 2016), density (Karanth and Nichols 1998; Silver *et al.* 2004; Sollmann *et al.* 2011), diversity (Aranda *et al.* 2012), and animal behavior (Monteza-Moreno *et al.* 2020).

In Panamá, this method has been applied in different ecosystems: tropical rainforest (Moreno and Bustamante 2009); very humid premontane forest (Loria and Méndez-Carvajal 2017); premontane tropical rainforest (González-Hernández *et al.* 2020); dry forest (Méndez-Carvajal 2013); premontane forest and cloud forest (Méndez-Carvajal 2012) to obtain information regarding population status of mammalian umbrella species such as: felids (Moreno and Bustamante 2009), canids (Hody *et al.* 2019), ungulates (Moreno and Meyer 2014; Meyer *et al.* 2016) and to assess the status of large and medium-sized terrestrial mammal communities (Meyer *et al.* 2015). Through the use of camera traps, records have been obtained that have allowed inferring the reproductive behavior of some species (Aranda *et al.* 2012; Mandujano 2019), this has been implemented in other groups such as birds, by placing cameras at nests or nest entrances (Hudson and Bird 2006).

In mammals, reproductive behavior has been inferred through indirect observations, such as the presence of pups (Aranda *et al.* 2012; Ouboter and Kadosoe 2016; Appleton *et al.* 2018; Jansen *et al.* 2020) or pairs of individuals in solitary species (Morrow and Nicole 2009; Ouboter and Kadosoe 2016; Appleton *et al.* 2018). Whereas, direct observations of reproductive behavior in the wild are rare and anecdotal (Faller-Menéndez *et al.* 2007).

Reproductive studies on tayras (*Eira barbara*; or "gato cutarro" as it is known in Panamá) have been conducted in captivity, focusing on copulatory behavior, always highlighting their tendency to vocalize during the act (Poglayen-Neuwall 1975), gestation and care of the cubs (Poglayen-Neuwall 1978; Presley 2000), and analysis of the estrous cycles of the females (Poglayen-Neuwall *et al.* 1989). There are no reports of tayras reproducing in the wild, the closest being the suggestion of reproductive behavior in the Barro Colorado Biological Station, Panamá (Kaufman and Kaufman 1965), but this does not show conclusive evidence of the act and thus remains speculation. The literature (Poglayen-Neuwall 1975, 1978; Poglayen-Neuwall and Poglayen-Neuwall 1976) establishes that *E. barbara* is a diurnal polyestrous species; males are reproductive throughout the year and reach sexual maturity at 18 months of age; females reach metabolic and reproductive maturity by 22 months of age, although adult size for the species is reached in only 6 months (Presley 2000). According to Poglayen-Neuwall *et al.* (1989), females older than 8 years have longer estrous cycles (72-163 days) compared to younger females (38-75 days). Gestation may last a little more than 2 months, and they usually have 1 to 3 offspring that remain with the mother for 200 to 300 days (Poglayen-Neuwall and Poglayen-Neuwall 1976).

The information generated in captivity can be influenced by multiple factors, mainly by captivity *per se* (without omitting changes in behavior as a result of breeding animals together, which are solitary in the wild), which can provide data and observations that do not correspond to behavior in the wild (*e.g.*, Poglayen-Neuwall 1978). Therefore, gathering information from the natural environment that complements what is observed in captivity is one of the best tools for understanding the reproductive behavior of species.

The objective of this paper is to present data on the *in situ* reproduction of a pair of *E. barbara* in Altos de Campana National Park. The event and its details are described: duration of each mating, movements and vocalizations emitted by each individual.

The study area is located in the northwest end of Altos de Campana National Park, with a humid tropical climate and average annual rainfall of more than 2,500 mm. In addition, it is important to note the different forms of relief from valleys, rugged hills and steep slopes, ranging from 300 m to high points such as Cerro Campana at 1,030 m and Cerro La Cruz at 905 m, where there is a temperature oscillation between 15 to 22 °C (Ministerio de Ambiente 2021), limited to the northeast and northwest by farms with fragmented ecosystem and used for anthropogenic activities belonging to the community of El Chileno.

The cameras were installed due to interactions between cattle and jaguar reported by the inhabitants of El Chileno. Installation sites were selected using two criteria: 1) in places with defined trails (felines have been reported to use them with great frequency to patrol their action areas; Chávez *et al.* 2013), and 2) in places where there are no trails (to avoid decreasing the probability of capture of other species such as ungulates and small mammals that do not frequent trails as much; R. Moreno, pers. comm. 2019).

Two camera traps (Ancheer model RD 1006) were installed 220 m apart. Each camera (C01PNAC: 8° 42′ 21.48″ N, 80° 0′ 2.61″ W; and C02PNAC: 8° 42′ 28.97″ N, 80° 0′ 2.33″ W; Figure 1) was placed in a tree 50 cm above the ground, to obtain records of small, medium and large mammals (Noss *et al.* 2013), the undergrowth was removed with a machete just in front of the cameras, to clear the view, in an area of 15 m^2, no olfactory attractants were used. The equipment was installed on March 25, 2018 and was removed on June 15 of the same year.

Sampling effort was quantified by the number of hours (24 each full day or its respective fraction if not completed) multiplied by the number of days that each camera trap was active. For the total, both quantities were added together.

Bioacoustic analysis. The PREMIERE PRO-6.0.0.0 software (Adobe CS6; https://www.adobe.com/es/; Vbroadcast Limited 2021) was used to extract the audio from each video, followed by the Raven Pro1.5 software (Center for Conservation Bioacustic 2014). Determinant aspects for this type of analysis, mentioned below, were analyzed with frequency graphs.

For each vocalization, we analyzed the duration, interval, maximum, minimum and dominant frequencies. Spectral

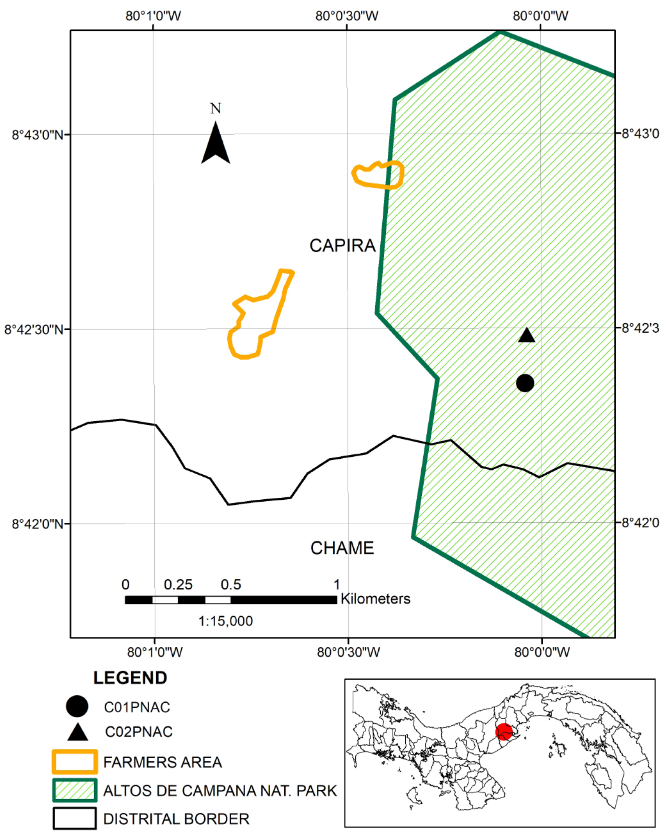


Figure 1. Camera traps location map: shows the northwest limits of the Altos de Campana National Park (green line to the right), the location of the camera traps, C01PNAC (circle) and C02PNAC (triangle) and the producer farms community of El Chileno, where the inhabitants reported incidents with jaguars (orange polygons).

and temporal parameters (frequency) were analyzed, and power spectra were calculated in Raven Pro1.5 (Window: Blackman, Discrete Fourier transform DFT): 2,048 samples, 3 dB filter bandwidth: 0.16 KHz; grid spacing 0.021 KHz; overlap 70.1 % (Charif *et al.* 2004).

Both cameras were active for 82 days 15 hours each, resulting in 3,942 effective camera hours of sampling. On June 15, 2018, at 8:34 am in the C01PNAC camera was recorded the first of 8 videos that captured the act of copulation between a pair of tayras (*E. barbara*), each video has a duration of 10 seconds. The sun rose at 5:59 am and the temperature recorded showed a variation of 1 °C (from 21 to 22 °C) in the 43 minutes that the event lasted (Table 1; Figure 2).

Acoustic properties of the reproductive event. During the reproductive act both individuals emitted tonal rhythmic sounds in the form of short clicking calls (clicking calls; Poglayen-Neuwall 1975) and trills (short, rhythmic series of noisy sounds; Poglayen-Neuwall 1975; Peters 1984). The female emitted a click before the trill at a dominant frequency of 3.19 KHz (fundamental frequency 2.44 KHz) with a duration of 0.06 s, immediately followed by a guttural trill at a dominant frequency of 3.23 KHz (fundamental frequency of 2.34 KHz) and a duration of 0.54 s; a second series of clicks and trills were recorded at dominant frequencies of 3.19 KHz (fundamental frequency of 2.39 KHz) and 2.44 KHz (fundamental frequency of 1.73 KHz), respectively. The interval between this series of clicks and trills was 3.1 s and 1.2 s between two measured cycles, and in one of the cases the click was separated from the trill by 0.57 s. The male emitted a trill at a dominant frequency of 2.79 KHz with a duration of 0.48 s, alternating between female calls (Figure 3).

The individuals present uniform coloration patterns (without spots) in the fur, on the head a dark brown hood up to the neck and the rest of the body black, only in the female, and only in the second video, it can be appreciated the typical throat patch used to identify individuals of *E. barbara* (Villafañe-Trujillo *et al.* 2018). The recorded event lasted 43 minutes; however, at the beginning of the first video the male was already mounting the female, so the exact duration of coitus is unknown, nor was courtship behavior recorded prior to copulation, it is possible that it occurred near the photo-trapping station but outside the camera's range. The whole event is considered as a single mount, since the male does not release the female from the first capture, it is possible that, at some point, while they are getting adjusted, the penetration was interrupted; however, it is a detail that is not perceptible in the videos. The number of mounts in captivity is variable with up to 13 mounts per day (Poglayen-Neuwall 1975) and copulation both in captivity and in the wild occurs crouching, standing or lying on its side. It should be noted that in captivity the presence of lordosis on the female's back was not observed or mentioned (Poglayen-Neuwall 1975; Alves and Borstlemann 2010), a behavior that is visible in the videos filmed.

Breeding events reported in captivity (Poglayen-Neuwall 1975) record average durations between 22 to 45 minutes, sometimes events where the male was unsuccessful (no penetration), a specific case of 45 minutes where the male mounted the female 10 times during this period, and a case of long duration copulation (86 minutes) where the male lost intravaginal contact once (Poglayen-Neuwall 1975), so the duration of our event is within the range reported by Poglayen-Neuwall (1975) in captivity.

The sexual act occurs in a similar way in both scenarios (captivity and wild); however, in the wild this type of events are recorded by chance, being the one reported in this work the first with videographic evidence captured by camera trap, which allowed us to perform the first analysis of bioacoustics of the species during the sexual act in the wild. The video can be found on the youtube channel of Fundación Los Naturalistas (https://youtu.be/v_kXBJEyMkc).

The event occurred during the month of June; captive reports (Poglayen-Neuwall 1975; Alves and Borstlemann 2010) suggest that the activity is possible throughout the year. Both in captivity and in our report, nuchal grasping and occasional dragging of the female by the male is observed. One aspect that was not possible to observe is whether the female maintained any rejection behavior towards the male during courtship, such as has been shown in captivity (Poglayen-Neuwall 1975; Alves and Borstlemann 2010) and which consists of agonistic vocalizations against the male.

Table 1. Description of the mating event of *Eira barbara* in chronological order.

Video/Hour	Description	Figure 2
1) 8:34 am	The male bites the nape of the female while riding her, arching his body to press his pelvic area against the female, keeping his forelimbs in the middle of the female's body, a process known as copulation (Granda-Serrano and Romo-Graniel 2004), the female remains in a lordosis position (Granda-Serrano and Romo-Graniel 2004), after this she gets up with the male on top and moves some steps, a process known as walk (Granda-Serrano and Romo-Graniel 2004), they fall on their left sides and the male continues with the copulation. During this first video the couple emits tenuous vocalizations (Granda-Serrano and Romo-Graniel 2004).	A, B, C
2) 8:39 am	They change position and face the camera, this time the male continues with the mount. However, he tries to accommodate himself and holds the female in the groin area and continues with the copulation, continuing to bite the nape of the female, which partially maintains the lordosis position and moves with difficulty at the time that the male tries to accommodate. The vocalization produced by both increases, but is more noticeable in the male.	A
3) 8:44 am	The couple keeps copulating lying on their left side, the male performs very fast pelvic movements (his back seems to tremble) for six seconds, then he lowers the intensity or frequency of the movement and they resume the initial riding position, finally both are placed in vertical position but the female with the body totally crouched. In this video no one vocalizes.	A, C
4) 8:50 am	Both are observed in the same position and activity as at 8:34 am. However, after three seconds the female shows a remarkable resistance to the male making a 180 degree turn from left to right; however, the mating is not interrupted, the male for his part makes pressure and after six seconds he manages to knock her down on his left side and copulation continues, during this process the male places his leg on the female's thigh and knee and maintains a strong pelvic hug (groin area), on this occasion we can clearly appreciate the male genitalia and penetration. The male vocalizes with greater intensity than the female who only emits a low growl.	A, B, C, D
5) 8:55 am	They rise from their right side where copulation is appreciated, they remain completely crouched and the male generates pressure on the female for eight seconds, then they take a few steps and fall on their left side. Only the female vocalizes very faint.	A, C
6) 9:00 am	They maintain the mount, the male accommodates himself twice, lifting and bending his back with that of the female, each time he bends down again the copulation is appreciated, generating pressure on the female, and finally forcing her to fall on her left side. The hug is pelvic and vocalizes a single individual, a single note apparently.	B, C
7) 9:05 am	The mount is kept with its back to the camera for three seconds, the male makes pelvic pressure on the female once and manages to lay her down on her left side and continues the copulation until the end of the video. They do not vocalize.	D
8) 9:11 am	Initially they are observed crouched in their entirety after two seconds both get up and settle down until they fall on their left side and the male, after the strong hug with the forelimbs, begins again. Both individuals vocalize, producing a quite loud sound.	A, C
9) 9:17 am	The male is seen leaving the place, in the opposite direction to the camera, the female had already left the scene.	-

Although, resistance from the female towards the male was observed and consisted of attempts to break free from the pelvic grasp, in captivity this behavior was accompanied by the release of musk from the female's anal glands (Poglayen-Neuwall 1975), the latter could not be confirmed due to the method employed for the observations (photo-trapping).

On seven occasions, the pair was observed lying on their left sides instead of the right side (once) to perform the behavior described as copulation (Granda-Serrano and Romo-Graniel 2004), where the male performs rapid pelvic movements, the male contracted his thigh muscles so fast that it gave the visual impression of vibration, a procedure that lasts between 5 and 8 seconds per repetition and can be seen in all the videos. This behavior was also observed in captivity, although only once (Poglayen-Neuwall 1975), in neither case was it an obstacle to maintaining copulation.

The female showed resistance to the male on three occasions; however, the fact of biting the nape of the female's neck during the whole event allows the male to face this resistance and to have control to some extent during the act. In the fourth video (8:50 am) we can see the greater resistance of the female; however, the male takes advantage of the above mentioned and manages to lie down next to his partner to continue with the copulation.

We note that the male tends to accommodate when they are partially crouched vertically just before lying on their sides and this is done by bending his pelvic area to the maximum and pressing it against the female forcefully, while hugging her at groin level with his forelimbs also with force, it is visually noticeable changes in the force exerted by the male against the female during the different stages of the event, the latter being where the use of greater force by the male is easily appreciated. The mating pattern and sequence reported in this work is very similar to that reported in captivity in terms of male nuchal grasping and dragging the female to accommodate him, while the female vocalizes and tries to resist, until she is fully receptive and remains silent (Poglayen-Neuwall 1975, 1978). Female vocalizations in captivity seem to occur before and at the end of copulation (Poglayen-Neuwall 1975), while the male vocalizes throughout the act. Whether in captivity (Poglayen-Neuwall 1975) or in the wild, both specimens tend to increase the intensity of the sounds at the end of the act.

In contrast to the above, cases have been reported in which the female takes the initiative by mounting the male without biting the nape of his neck and pushing his flanks

Figure 2. Photographic evidence extracted from the videos: the selected images represent *Eira barbara*'s repetitive behaviors observed in the videos from 8:34 am (first video) to 9:11 am (eighth video). A) The male being on top of the female bites her neck ("Monta"), in a pelvic hug he puts pressure on the female ("Copula"). B) Both the male and the female acquire a position of lordosis, displacement, only a few steps, of the female with the male on top. C) Both individuals lying on their left sides, continue to mount and copulate. D) The testicles of the male are appreciated at the moment that he exerts pressure on the female (copulation) during the mating.

with rhythmic movements of her waist, in addition to excessive preening by both prior to the act (Poglayen-Neuwall 1978). Although this difference could be due to the fact that the specimens were in captivity.

Tayras are diurnal mustelids (Delgado-V. *et al.* 2011; González-Maya *et al.* 2015; Braga *et al.* 2020; Villafañe-Trujillo *et al.* 2021) and this breeding event was recorded during the day contradicting the "nocturnal mating" data suggested by Kaufman and Kaufman (1965) and reinforcing that both captivity and breeding solitary animals together can generate behaviors that are not an accurate reflection of what occurs in free-living individuals.

Most studies on mustelid reproduction have been conducted in captivity in zoos and on northern hemisphere species; for example: *Neovison vison*, *Mustela lutreola*, *Martes martes*, *Mustela sibirica* (Amstislavsky and Ternovskaya

2000). As a group they possess a wide variety of reproductive strategies from which tayras differ in the absence of seasonality (Amstislavsky and Ternovskaya 2000; Presley 2000). Therefore, studies of this type (in the tropics and in the wild) become even more relevant, considering the rapid loss of habitat and diversity in the tropics (Meyer *et al.* 2020).

Field observations (Barro Colorado Island, Panamá) suggest the existence of competitive agonistic behavior between males to copulate with the female (Kaufmann and Kaufmann 1965). Although our records did not capture pre-copulation activity, there is a possibility that the males have to chase the female in the wild until she is subdued before proceeding with the reproductive act.

Little is known about the acoustic behavior of *E. barbara* (Mumm and Knörnschild 2018), although vocalizations of a series of noisy clicks known as clicking calls have been reported (Poglayen-Neuwall 1976). There are data on the vocalizations of neonates or juveniles, in which a series of vocalizations such as squeaks, clicks, grunts, or snorts are reported depending on the state or circumstances (Poglayen-Neuwall 1978); however, during the reproductive act, we report a sequence of vocalizations never recorded before, the trills. The trills emitted during mating and copulation may more closely resemble trill songs reported for other mustelids, although the trill reported in this study appears to be faster with fewer spaces between notes than those reported for another mustelid species in another context, a free-roaming female *Mustela erminea* with her young (see Figure 3b in Peters 1984).

During mating and copulation both individuals produce short clicks and trills, the latter are emitted mainly by the male during mating, at the moment when he presses against the female; during the copulation stage when they are lying on their sides neither of the individuals produces vocalization, when the couple settles down, they produce clicks and trills with a lower intensity (volume) compared to the moment when the male presses against the female (copulation).

The recording of the vocalization of *E. barbara* during mating is the first reported for the species, as well as the recording of video in the wild through camera traps, providing important data on the reproductive biology of this species.

Acknowledgements

We thank the SIN of SENACYT for supporting A. Batista, the community of El Chileno for their support and warm attention, for having opened the doors with the aim of safeguarding wildlife in a persistent conflict between humans and jaguars. To Mr. J. "Culebra" Hernández for his support and collaboration in the field, to the park rangers for their support in the field and his close relationship with the community and its environmental problems and to R. Núñez Meneses for the edition of the video available on the web in support of this investigation. To E. Fox for reviewing the manuscript in the English language. Comments from two anonymous reviewers improved the final presentation of this note.

Literature cited

Alves, R. A. P., and M. A. D. O. Borstelmann. 2010. Etograma do *Eira barbara* (Carnivora:Mustelidae) em cativeiro. Revista de Etologia 9:45-57.

Amstislavsky, S., and Y. Ternovskaya. 2000. Reproduction in mustelids. Animal Reproduction Science 60:571-581.

Appleton, R. D., R. C. Van Horn, K. V. Noyce, T. J. Spady, R. R. Swaisgood, and P. Arcese. 2018. Phenotypic plasticity in the timing of reproduction in Andean bears. Journal of Zoology 305:196-202.

Aranda, M., F. Botello, and L. López-de Buen. 2012. Diversidad y datos reproductivos de mamíferos medianos y grandes en

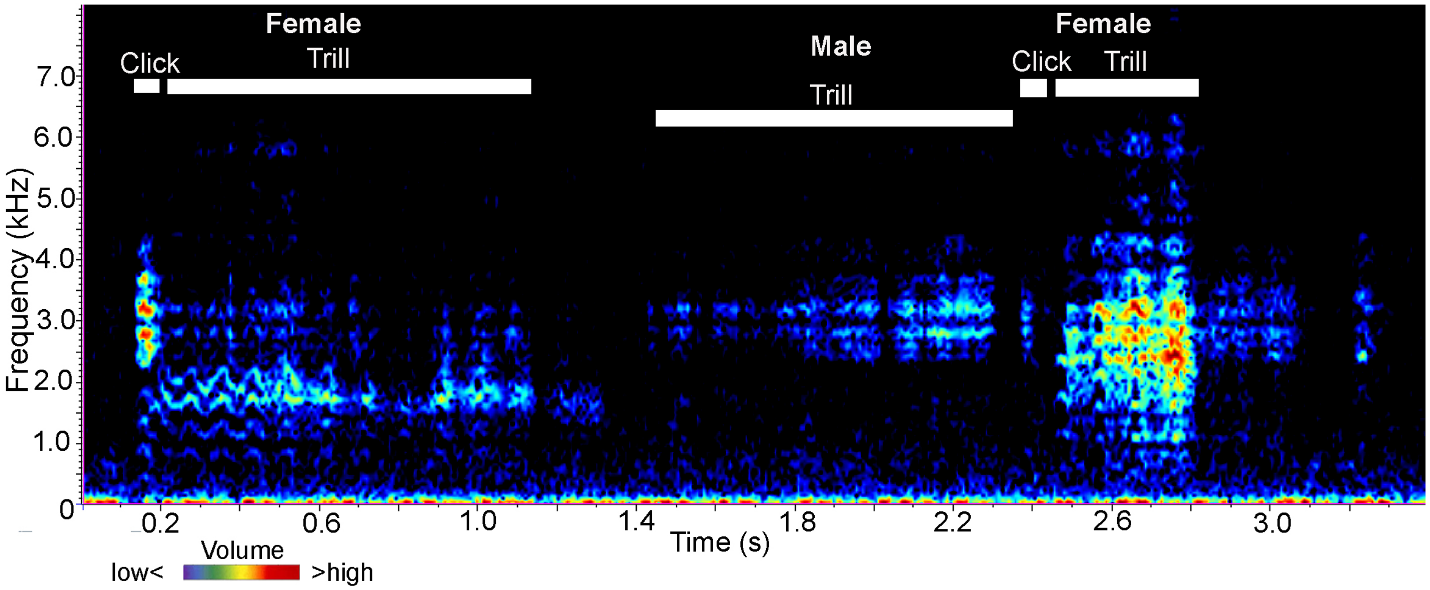


Figure 3. Sonogram of the vocalization of *Eira barbara* individuals during reproductive activity. Male and female calls obtained from the camera trap video footage are shown.

el bosque mesófilo de montaña de la Reserva de la Biosfera Sierra de Manantlán, Jalisco-Colima, México. Revista Mexicana de Biodiversidad 83:778-784.

Ávila-Nájera, D., C. Chávez, M. Lazcano-Barrero, G. Mendoza, and S. Perez-Elizalde. 2016. Overlap in activity patterns between big cats and their main prey in northern Quintana Roo, Mexico. Therya 7:439-448.

Bond, W. J. 1994. Keystone species. Pp. 237-253 *in* Biodiversity and Ecosystem Function (Schulze, E. D., and H. A. Mooney, eds.). Springer Science & Business Media. Berlin, Alemania.

Braga, K. C. L., M. Passamani, and C. Rosa. 2020. Daily tayra (*Eira barbara*, Linnaeus 1758) activity patterns and habitat use in high montane tropical forests. Acta Oecologica 108:1-6.

Center for Conservation Bioacustic. 2014. Raven Pro: Interactive Sound Analysis Software (Version 1.5). The Cornell Lab of Ornithology. Cornell University. Ithaca, U.S.A.

Cutler, T. L., and D. E. Swann. 1999. Using remote photography in wildlife ecology: a review. Wildlife Society Bulletin 27:571-581.

Charif, R. A., C. W. Clark, and K. M. Fristrup. 2004. RAVEN v. 1.2, user's manual. Cornell Laboratory of Ornithology. Ithaca, U.S.A.

Chávez, C., A. De La Torre, H. Bárcenas, R. A. Medellín, H. Zarza, and G. Ceballos. 2013. Manual de fototrampeo para estudio de fauna silvestre. El jaguar en México como estudio de caso. Alianza WWF-Telcel, Universidad Nacional Autónoma de México. México City, México.

De Roux, J. M., E. A. Noguera-Urbano, and H. E. Ramírez-Chaves. 2019. The vulnerable colombian weasel *Mustela felipei* (Carnivora): new record from Colombia and a review of its distribution in protected. Therya 10:207-210.

Delgado-V., C. A., A. Árias-Alzate, S. Botero, and J. D. Sánchez-Londoño. 2011. Behaviour of the Tayra *Eira barbara* near Medellín, Colombia: preliminary data from a video-capturing survey. Small Carnivore Conservation 44:19-21.

Droissart, V., L. Azandi, E. R. Onguene, M. Savignac, T. B. Smith, and V. Deblauwe. 2021. PICT: A low-cost, modular, open-source camera trap system to study plant-insect interactions. Methods in Ecology and Evolution 2021:1-8.

Faller-Menéndez, J. C., L. A. Lago-Torres, A. Hernández-Cardona, M. Calleja-Alvarado, G. C. González, C. C. Tovar, and S. Johnson. 2007. La video-filmación como técnica de estudio de mamíferos silvestres: un ejemplo de jaguares en el noreste de la Península de Yucatán. Revista Mexicana de Mastozoología (Nueva Época) 11:47-56.

Fragoso, J. M. V. 1999. Perception of scale and resource partitioning by peccaries: behavioral causes and ecological implications. Journal of Mammalogy 80:993-1003.

Galetti, M., R. Bovendorp, and R. Guevara. 2015. Defaunation of large mammals leads to an increase in seed predation in the Atlantic forests. Global Ecology and Conservation 3:824-830.

González-Hernández, P. A., I. Gomez De Huertas, R. Vargas, K. M. Gutiérrez-Pineda, and P. G. Méndez-Carvajal. 2020. Uso de dormideros de un grupo de *Aotus zonalis* en Pajonal, Coclé, República de Panamá. Mesoamericana 24:7-21.

González-Maya, J. F., D. Zárrate-Charry, I. M. Vela-Vargas, J. S. Jiménez-Alvarado, and D. Gómez-Hoyos. 2015. Activity patterns of Tayra *Eira barbara* populations from Costa Rica and Colombia: evidence of seasonal effects. Revista de Biodiversidad Neotropical 5:96-104.

Granda-Serrano, C. E., and Z. E. Romo-Graniel. 2004. Enriquecimiento Ambiental para jaguares (*Panthera onca*) en cautiverio en el Parque Museo de la Venta, Villahermosa Tabasco. Bachelor's Thesis, Universidad Autónoma de México. Villahermosa, Tabasco, México.

Grotta-Nieto, F., M. C. H. Mello, R. C. Mello, I. P. Bernardi, E. Carrano, and F. C. Passos. 2020. The role of tayra (*Eira barbara*) as predator of medium and large-sized mammals. Austral Ecology 46:329-333.

Hernández-Sánchez, A., A. Santos-Moreno, and G. Pérez-Irineo. 2017. Abundance of mesocarnivores in two vegetation types in the southeastern region of Mexico. The Southwestern Naturalist 62:101-108.

Hobbs, M. T., and C. S. Brehme. 2017. An improved camera trap for amphibians, reptiles, small mammals, and large invertebrates. PLoS ONE 12:e0185026.

Hody, A. W., R. Moreno, N. F. V. Meyer, K. Pacifici, and R. Kays. 2019. Canid collision—expanding populations of coyotes (*Canis latrans*) and crab-eating foxes (*Cerdocyon thous*) meet up in Panama. Journal of Mammalogy 10:1819-1830.

Hudson, M. A. R., and D. M. Bird. 2006. An affordable computerized camera technique for monitoring bird nests. Wildlife Society Bulletin 34:1455-1457.

Jansen, M., M. Engler, L. M. Blumer, D. I. Rumiz, J. L. Aramayo, and O. Krone. 2020. A camera trapping survey of mammals in the mixed landscape of Bolivia's Chiquitano region with a special focus on the Jaguar. Check List 16:323.

Karanth, K. U., and J. D. Nichols. 1998. Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79:2852-2862.

Karanth, K. U., J. D. Nichols, N. S. Kumar, W. A. Link, and J. E. Hines. 2004. Tigers and their prey: predicting carnivore densities from prey abundance. Proceedings of the National Academy of Sciences 101:4854-4858.

Kaufmann, J. H., and A. Kaufmann. 1965. Observations of the behavior of tayras and grisons. Zeitschrift für Säugetierkunde 30:146-155.

Loria, L. I., and P. G. Méndez-Carvajal. 2017. Uso de hábitat y patrón de actividad del mono cariblanco (*Cebus imitator*) en un agroecosistema cafetalero en la provincia de Chiriquí, Panamá. Tecnociencia 19:61-78

Maffei, L., E. Cuellar, and A. Noss. 2004. One thousand jaguars (*Panthera onca*) in Bolivia´s Chaco? Camera trapping in the Kaa-Iya National Park. Journal of Zoology 262:295-304.

Mandujano, S. 2019. Analysis and trends of photo-trapping in Mexico: text mining in R. Therya 10:25-32.

McCleery, R. A., C. L. Zweig, M. A. Desa, R. Hunt, W. M. Kitchens, and H. F. Percival. 2014. A novel method for camera-trapping small mammals. Wildlife Society Bulletin 38:887-891.

Méndez-Carvajal, P. G. 2012. Preliminary primate survey at the Chucanti Nature Reserve, Darien Province, Republic of Panama. Mesomericana 16:22-29.

Méndez-Carvajal, P. G. 2013. Population size, distribution and conservation status of howler monkeys (*Alouatta coibensis trabeata*) and spider monkeys (*Ateles geoffroyi azuerensis*) on the Azuero Peninsula, Panama. Primate Conservation 26:3-15.

Meyer, N. F. V., H. J. Esser, R. Moreno, F. van Langevelde, Y. Liefting, D. Ros Oller, C. B. F. Vogels, A. D. Carver, C. Nielsen, and P. A. Jansen. 2015. An assessment of the terrestrial mammal communities in forests of Central Panama, using camera-trap surveys. Journal for Nature Conservation 26:28-35.

Meyer, N. F., R. Moreno, E. Sanches, J. Ortega, E. Brown, and P. A. Jansen. 2016. Do protected areas in Panama support intact assemblages of ungulates? Therya 7:65-76.

Meyer, N. F., R. Moreno, C. Sutherland, J. A. de la Torre, H. J. Esser, C. A. Jordan, M. Olmos, J. Ortega, R. Reyna-Hurtado, S. Valdes, and P. A. Jansen. 2020. Effectiveness of Panama as an intercontinental land bridge for large mammals. Conservation Biology 34:207-219.

Ministerio de Ambiente. 2021. *In*: Sistema Nacional de Información Ambiental. Parque Nacional y Reserva Biológica Altos de Campana. https://www.sinia.gob.pa/index.php/parques-nacionales-categoria-ii-de-la-uicn/parque-nacional-y-reserva-biologica-de-altos-de-campana. Accessed 20 July 2021.

Monteza-Moreno, C., M. Crofoot, M. Grote, and P. Jansen. 2020. Increased terrestriality in a Neotropical primate living on islands with reduced predation risk. Journal of Human Evolution 143:102768.

Moreno, R., and A. Bustamante. 2009. Datos ecológicos del ocelote (*Leopardus pardalis*) en Cana, Parque Nacional Darién, Panamá; utilizando el método de cámaras trampa. Tecnociencia 11:1-102.

Moreno, R., and N. Meyer. 2014. Distribution and conservation status of the white-lipped peccary in Panama. Suiform Soundings 13:32-37.

Morrison, J. C., W. Sechrest, E. Dinerstein, D. S. Wilcove, and J. F. Lamoreux. 2007. Persistence of large mammal faunas as indicators of global human impacts. Journal of Mammalogy 88:1363-1380.

Morrow, G., and S. C. Nicole. 2009. Cool sex? Hibernation and reproduction overlap in the echidna. PLoS One 4:e6070.

Moruzzi, T. L., T. K. Fuller, R. M. DeGraaf, R. T. Brooks, and W. Li. 2002. Assessing remotely triggered cameras for surveying carnivore distribution. Wildlife Society Bulletin 30:380-386.

Mumm, C. A. S., and M. Knörnschild. 2018. Mustelid Communication. Pp. 1-11 *in* Encyclopedia of Animal Cognition and Behavior (Vonk, J., and T. Shackelford, eds.). Springer International Publishing. New York, U.S.A.

Noss, A., J. Polisar, L. Maffei, R. Garcia-Anleu, and S. C. Silver. 2013. Evaluando la densidad de jaguares con trampas cámara. Wildlife Conservation Society. New York, U.S.A.

O'Farrill, G., M. Galetti, and A. Campos-Arceiz. 2013. Frugivory and seed dispersal by tapirs: an insight on their ecological role. Integrative Zoology 8:4-17.

Ouboter, P. E., and V. S. Kadosoe. 2016. Three years of continuous monitoring of the large terrestrial mammals of Brownsberg Nature Park, Suriname. Academic Journal of Suriname 7:643-660.

Peters, G. 1984. On the structure of friendly close-range vocalizations in terrestrial carnivores (Mammalia: Carnivora: Fissipedia). Zeitschrift für Säugetierkunde 49:157-182.

Poglayen-Neuwall, I. 1975. Copulatory behavior, gestation and parturition of the tayra (*Eira barbara* L., 1758). Zeitschrift für Saügertierkunde 40:176-189.

Poglayen-Neuwall, I. 1976. Fortpflanzung, Geburt und Aufzucht, nebst anderen Beobachtungen von Makibären (Bassaricyon Allen, 1876). Zoologische Beiträge 22:179-233.

Poglayen-Neuwall, I. 1978. Breeding, rearing and notes on the behaviour of tayras. International zoo yearbook 18:134-140.

Poglayen-Neuwall, I., and I. Poglayen-Neuwall. 1976. Postnatal development of tayras (Carnivora: *Eira Barbara* L., 1758). Zoologische Beiträge 22:345-405.

Poglayen-Neuwall, I., B. S. Durrant, M. L. Swansen, R. C. Williams, and R. A. Barnes. 1989. Estrous cycle of the tayra, *Eira barbara*. Zoo Biology 8:171-177.

Presley, S. J. 2000. *Eira barbara*. Mammalian Species 636:1-6.

Rico-Guevara, A., and J. Mickley. 2017. Bring your own camera to the trap: An inexpensive, versatile, and portable triggering system tested on wild hummingbirds. Ecology and Evolution 7:4592-4598.

Silver, S., L. Ostro, L. Marsh, L. Maffei, A. Noss, M. Kelly, R. Wallace, H. Gómez, and G. Ayala. 2004. The use of camera traps for estimating jaguar (*Panthera onca*) abundance and density using capture/recapture analysis. Oryx 38:148-154.

Sollmann, R., M. M. Furtado, B. Gardner, H. Hofer, A. T. A. Jácomo, N. M. Tôrres, and L. Silveira. 2011. Improving density estimates for elusive carnivores: Accounting for sex-specific detection and movements using spatial capture-recapture models for jaguars in central Brazil. Biological Conservation 144:1017-1024.

Sunquist, M., and F. Sunquist. 2002. Wild cats of the World. The University of Chicago Press. Chicago, U.S.A.

Vbroadcast Limited. 2021. PREMIERE PRO-6.0.0. Adobe CS6 https://www.adobe.com/es. Accessed 4 February 2021.

Villafañe-Trujillo, A. J., C. A. López-González, and J. M. Kolowski. 2018. Throat patch variation in Tayra (*Eira barbara*) and the potential for individual identification in the field. Diversity 10:1-23.

Villafañe-Trujillo, A. J., J. M. Kolowski, M. V. Cove, E. P. Medici, B. J. Harmsen, R. J. Foster, M. G. Hidalgo-Mihart, S. Espinosa, G. Ríos-Alvear, C. Reyes-Puig, J. P. Reyes-Puig, X. M. Da Silva, A. Paviolo, P. Cruz, and C. A. López-González. 2021. Activity patterns of tayra (*Eira barbara*) across their distribution. Journal of Mammalogy 102:772-778.

Wright, J. 2003. The myriad consequences of hunting for vertebrates and plants in tropical forests. Perspective in Plant Ecology, Evolution and Systematics 6:73-86.

Yensen, E., and T. Tarifa. 2003. *Galictis vitatta*. Mammalian Species 727:1-8.

Associated editor: Tamara Rioja-Paradela
Submitted: May 11, 2021; Reviewed: August 5, 2021.
Accepted: September 10, 2021; Published on line: September 23, 2021.

THERYA NOTES 2021, Vol. 2 : 125-131 DOI: 10.12933/therya_notes-21-48 ISSN 2954-3614

The bobcat (*Lynx rufus*) in the Nayarit Coastal Plain, México: presence, relative abundance and activity patterns

El gato montés (*Lynux rufus*) en la llanura costera de Nayarit, México: presencia, abundancia relativa y patrones de actividad

Víctor H. Luja[1]*, Ricardo Rodríguez-Estrella[2], Diana J. Guzmán-Báez[3], and Luis Jiménez[4]

[1]Unidad Académica de Turismo, Universidad Autónoma de Nayarit. Ciudad de la Cultura s/n, C. P. 63000. Tepic, Nayarit, México. E-mail: lujastro@yahoo.com (VHL).

[2]Planeación Ambiental y Conservación. Centro de Investigaciones Biológicas del Noroeste, C. P. 23096. La Paz, Baja California Sur, México. E-mail: estrella@cibnor.mx (RR-E).

[3]Unidad Académica de Agricultura, Universidad Autónoma de Nayarit. Puerto Vallarta - Tepic Compostela, km 9, C. P. 63780. Xalisco, Nayarit, México. E-mail: djgb07@hotmail.com (DJG-B).

[4]Universidad de la Sierra Juárez. Avenida Universidad s/n, C. P. 68725. Ixtlán de Juárez, Oaxaca, México. E-mail: luisjj191095@gmail.com (LJ).

*Corresponding author

The bobcat, *Lynx rufus*, is one of the six wild cats that inhabit México. It is distributed from sea level up to 3,600 m, occupying a wide variety of habitats including deserts, mountain ecosystems and wetlands. However, to date, there is no ecological information on the species in coastal wetlands. The general objective of this work is to provide the first ecological information systematically obtained on the bobcat in the Coastal Plain of Nayarit (NCP). We evaluated their historical and current presence, relative abundance, and activity patterns. We determined the historical presence of the bobcat in the NCP through a search of the words using the keywords "Lynx", "rufus", "lince", "bobcat" and "Nayarit" in electronic databases. We implemented the protocol of the National Jaguar Census using camera traps in a 72 km^2 area to document the bobcat's presence, relative abundance, and activity patterns. Through the database search we find 23 bobcat's records in area of at least 3,000 km^2 of the NCP. From our fieldwork we obtained 30 independent records with a relative abundance of 1.28 bobcat photographs / 100 camera days. We documented the presence of at least 10 different individuals, including adults of both sexes, and possibly a pregnant female. Its activity is nocturnal; 40 % of the records occurred between 00:00 - 06:00 hr. The bobcat inhabits the coastal wetlands of Nayarit. The high values of relative abundance suggest a stable population in the NCP with respect to what has been reported in suitable habitats such as temperate forests and scrubs. Its nocturnal activity coincides with other studies on the species. Although, in general, the bobcat adapts well to disturbance generated by human activities, the impacts that these have on their populations in tropical wetlands are unknown. To ensure the permanence of the species, future work is recommended to know in depth its diet, reproduction, home range and genetic connectivity of this species in the tropical wetlands of western México.

Key words: *Lynx rufus*; presence; species distribution models.

El gato montés, *Lynx rufus*, es una de las seis especies de felinos silvestres que habitan en México. Se distribuye desde el nivel del mar hasta los 3,600 m, ocupando una gran variedad de hábitats entre los que se encuentran los desiertos, ecosistemas de montaña y humedales. Sin embargo, a la fecha, no existe información ecológica de la especie en humedales costeros. El objetivo general de este trabajo es proveer la primera información ecológica obtenida de forma sistemática sobre el gato montés en la Planicie Costera de Nayarit (PCN). Evaluamos su presencia histórica y actual, su abundancia relativa y patrones de actividad. Determinamos la presencia histórica del gato montés en la PCN mediante una búsqueda en bases de datos electrónicas utilizando las palabras: "Lynx", "rufus", "lince", "bobcat" y "Nayarit". Implementamos el protocolo del Censo Nacional del Jaguar usando cámaras trampa en un área de 72 km^2 para documentar la presencia, distribución, abundancia relativa y patrones de actividad del gato montés. A través de la búsqueda en bases de datos encontramos 23 registros de gato montés en un área de al menos 3,000 km^2 de la PCN. A partir de nuestro trabajo de campo obtuvimos 30 registros independientes con una abundancia relativa de 1.28 fotografías de gato montés / 100 días cámara. Documentamos la presencia de al menos 10 individuos diferentes, incluyendo adultos de ambos sexos y una hembra presuntamente embarazada. Su actividad es nocturna; 40 % de los registros ocurrieron entre las 00:00-06:00 hr. El gato montés habita los ecosistemas costeros de Nayarit. Los valores elevados de abundancia relativa sugieren una población estable en la PCN con respecto a lo que ha sido reportada en hábitat ideales para la especie tales como los matorrales y bosques templados. Su actividad nocturna coincide con lo que reportan otros trabajos para la especie. Aunque, en general, el gato montés se adapta bien al disturbio generado por actividades humanas, los impactos que estas tienen sobre sus poblaciones en los humedales costeros aún se desconocen. Para asegurar la permanencia de sus poblaciones es necesario realizar futuros estudios sobre su dieta, reproducción, ámbito hogareño y conectividad genética de la especie en los ecosistemas costeros del occidente de México.

Palabras clave: *Lynx rufus*; modelos de distribución; presencia.

The bobcat (*Lynx rufus*) is one of the 6 wild cats that inhabit México (Ceballos and Oliva 2005). Its geographical distribution extends from the border of the United States of America, including the Baja California Península, both slopes (Pacific and Gulf of México), narrowing towards the Mexican Central Highlands with its southern limit being the state of Oaxaca (Hall 1981; Lariviere and Walton 1997; Phillips *et al.* 2004; Ceballos *et al.* 2006; Sánchez-Cordero *et al.* 2008; Roberts and Crimmins 2010; Monroy-Vilchis *et al.* 2019). Bobcats are extant in México from sea level up to 3,600 m, occupying a wide variety of habitats including wetlands, deserts and mountain ecosystems (Romero 2005). In all these ecosystems the bobcat is considered a mesopredator (Conner *et al.* 2001) and therefore are essential for the maintenance of biodiversity and proper-functioning ecosystems (Ripple *et al.* 2014). Due to the bobcat's wide distribution, abundance, and adaptability, it is not listed in any threaten category, international or nationally. However, some populations in México are experiencing genetic isolation as a result of habitat fragmentation resulting from human activities that may eventually result in local extinctions (López-González *et al.* 2015).

Previous studies of bobcats in México have documented diet, abundance and density in desert, semi-desert and temperate ecosystems at intermediate elevations (Delibes *et al.* 1997; Aranda *et al.* 2002; Burton *et al.* 2003; Medellín and Bárcenas 2010; Elizalde-Arellano *et al.* 2012; López-Vidal *et al.* 2014; López-González *et al.* 2015; Sánchez-González *et al.* 2018), but nothing about coastal wetland populations in the tropics.

In 1903, Allen described a new subspecies of bobcat (*L. r. escuinapae*) whose type locality is Escuinapa, Sinaloa, located in the Pacific Coastal Plain ecoregion, an extensive area of floodplains and marshes that extend from southern Sinaloa to central Nayarit on the Pacific Coast of México (INEGI 1991). Later, Leopold (1959) included bobcats in a mapped range distribution that included the entire state of Nayarit, with no supporting observational information. Similarly, Hall (1981), included the state of Nayarit within the bobcat's range. Prior to this study, there has been no data published on bobcats inhabiting the Pacific Coastal Plain. Therefore, our aim in this work was to provide the first ecological information systematically obtained on the bobcat in the Coastal Plain of Nayarit, confirming its presence along this area. We evaluated their historical and current presence, relative abundance, and activity patterns.

The Pacific Coastal Plain is an elongated and narrow plain (it covers a strip of up to 65 km wide), which extends along the coast from Sonora to Nayarit in western México. It is characterized by being an almost flat relief formed by large flood plains, lakes and swamps aligned parallel to the coast (INEGI 1991). Our study area is located within the Nayarit Coastal Plain (NCP), delimited from the north of Nayarit (Municipality of Tecuala) to the Rio Grande de Santiago (Municipalities of Santiago Ixcuintla and San Blas; Figure 1). The camera trapping study was carried out in 72 km^2 within the sub-province called "Delta of the Rio Grande de Santiago" (INEGI 1991; Figure 2). The northern limit of the study area was the town of Los Corchos (21° 43′ 57″ N, 105° 28′ 12″ W, 3 m; Municipality of Santiago Ixcuintla), south of the mouth of the estuary called "La Boca Cegada" (21° 35′ 46″ N, 105° 24′ 0″ W, 0 m; Municipality of San Blas), to the west the Pacific Ocean and to the east the boundary was established at a distance of approximately 6 kilometres from the coastline (Figure 1). The climate is warm and humid with an average annual temperature of 31.7 °C. The predominant native vegetation is the mangrove (*Avicennia germinans* and *Conocarpus erectus*) with patches of low deciduous forest, palapar, secondary vegetation, farmland, and livestock land (CONAFOR 2015).

We determined the historical presence of the bobcat in the NCP through an electronic search using the keywords "Lynx", "rufus", "lince", "bobcat" and "Nayarit" in the following databases: Open Data Portal of the Biological Collections of the National Autonomous University of México (IBUNAM 2020); Community of Natural History Collections of Vertebrates (VertNet 2020); and the Citizen science portal of the National Commission for the Knowledge and Use of Biodiversity (Naturalista 2020). Only georeferenced records and those confirmed by experts (in the case of Naturalista) were considered as credible records. Finally, we estimated the total area with a presence of bobcat in the NCP as a convex polygon.

To determine the abundance of the bobcat we used camera trapping methodologies that have previously been applied to other felines (*e. g.*, National Jaguar Census, CENJAGUAR; Chávez *et al.* 2013). In October 2018, using Google Earth Pro®, a grid was applied to our study area covering an area of 72 km^2, which was subsequently then divided into 8 quadrants of 9 km^2 each. In each 9 km^2 quadrant, 3 sites were selected where a camera trap would potentially be placed. Each site selected was separated by a minimum of 1 km. Between November and December 2018, the previously chosen sites were verified in the field while looking for evidence of feline sign (footprints, scrapes). A total of 24 sites (stations) were selected where camera traps were then placed (Figure 2). We used Cuddeback® Model Color C1 (Non Typical, Inc., Park Falls, WI) camera traps. We placed 17 single-camera stations and 7 double-camera (2 cameras at the same point, 1 on the opposite side of the other) stations. Cameras were attached to trees 35 to 50 cm above ground level and were placed perpendicular to wildlife passages (Chávez *et al.* 2013). Cameras remained active for 60 days during each sampling session (February-March, 2019 and February-March, 2020).

The resulting images were stored and classified using the methodology proposed by Harris *et al.* (2010). Relative abundance was calculated using the Relative Abundance Index (RAI) using the formula proposed by Maffei *et al.* (2004) and Jenks *et al.* (2011): RAI = (C / SE) x 100 where C = number of photographic captures, SE = sampling effort (number of cameras per monitoring day) per unit of time

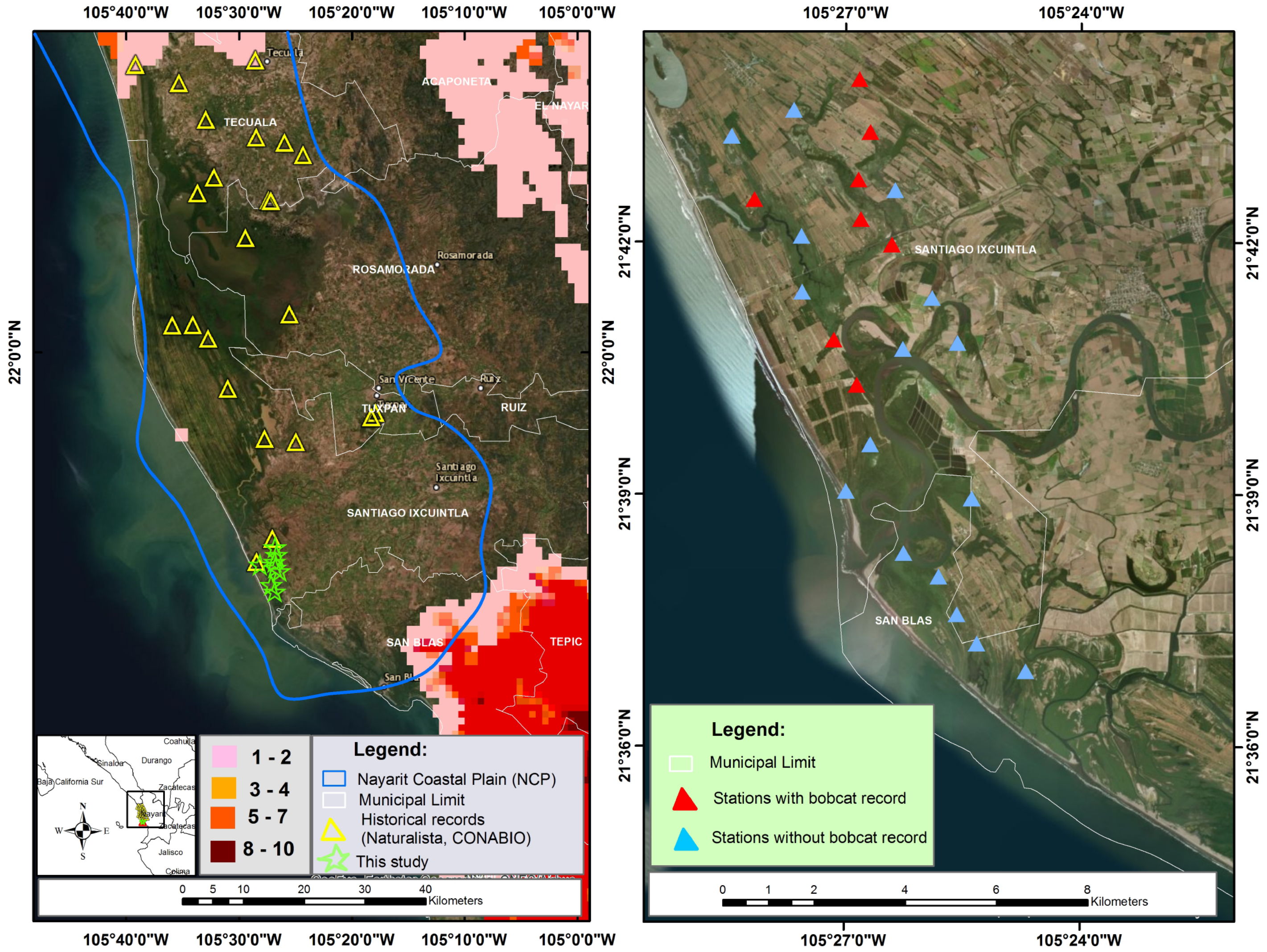


Figure 1. A) Map showing the layer generated by Comisión Nacional para el Conocimiento y uso de la Biodiversidad (CONABIO) with the potential distribution of the bobcat (1-2 low; 8-10 high presence probability), excluding the Nayarit Coastal Plain (blue line), México. The coordinates with the historical records (yellow triangles) and the location of the camera traps (green stars) where the bobcat was photographed in 2019 and 2020 for this study are shown. B) Location of the 24 camera trap stations in the Nayarit Coastal Plain used for monitoring in January-February 2019 and 2020. The red triangles show the presence of bobcat in the Nayarit Coastal Plains, México.

and per 100 camera days (standard correction factor). Naïve occupancy was calculated, which is defined as the proportion of cameras in which a species is registered in relation to the total number of cameras used during monitoring (O'Connell and Bailey 2011). The minimum number of individuals was determined from the identification of each individual by comparing their spot patterns, scars, sex and body sizes (Heilbrun *et al.* 2006). In all cases, at least three natural characteristics were used for the recognition of the same animal (comparing, for example, tail stripes, scars or facial marks on the same flank). Finally, the daily activity patterns were obtained using the Overlap package (Ridout and Linkie 2009) of the computational language R (R Core Team 2013).

We obtained 23 bobcats reported records for the NCP; all records come from CONABIO's Naturalist citizen science portal. The oldest record is from 2009 and the most recent from 2019. Table 1 presents the data from all bobcat records, including those obtained in this study during 2019 and 2020.

The sampling effort during this study was 2,740 camera days (2019: 1,367; 2020: 1,373). A total of 43 bobcat photographs were obtained derived of our fieldwork (Figure 2). Of these, 30 were determined to be independent records (photographs of the same species in the same station within a period greater than 60 minutes) and were used in the abundance and activity analysis. Bobcats were recorded in 8 of 25 stations, with a naïve occupancy of 0.32 (32 %) and a relative abundance of 1.28 bobcat photographs / 100 camera days. It was possible to identify at least 10 different individuals (6 females, 1 male and 3 unidentified). Of the 30 independent records obtained, 12 (40 %) occurred between 00:00-06:00 hr, 9 (30 %) between 06:00-18:00 hr, and 9 (30 %) between 18:00-00:00 hr (Figure 3).

Having reliable information to understand the distribution patterns of a species at different scales is useful for

Table 1. Bobcat (*Lynx rufus*) records obtained from electronic database searches. All the records were found on the Citizen science portal of the National Commission for the Knowledge and Use of Biodiversity (Naturalista 2020). The records product of the field work of the present study are presented in bold.

Source	Collection type	Date (year/month/day)	Geographical coordinates
This study	**Camera trap photo**	**2020/03/18**	**21° 43′ 57.73″ N, 105° 26′ 50.77″ W**
This study	**Camera trap photo**	**2020/02/27**	**21° 41′ 59.65″ N, 105° 26′ 25.85″ W**
This study	**Camera trap photo**	**2020/02/24**	**21° 40′ 51.57″ N, 105° 27′ 09.99″ W**
This study	**Camera trap photo**	**2020/02/02**	**21° 42′ 45.98″ N, 105° 26′ 51.34″ W**
This study	**Camera trap photo**	**2020/01/29**	**21° 43′ 19.89″ N, 105° 26′ 42.49″ W**
Naturalista	Footprint photo	2019/11/07	22° 12′ 31.43″ N, 105° 27′ 22.60″ W
Naturalista	Footprint photo	2019/11/07	22° 12′ 28.28″ N, 105° 27′ 10.24″ W
This study	**Camera trap photo**	**2019/03/25**	**21° 40′ 19.28″ N, 105° 26′ 52.42″ W**
This study	**Camera trap photo**	**2019/03/17**	**21° 42′ 31.76″ N, 105° 28′ 10.94″ W**
This study	**Camera trap photo**	**2019/02/04**	**21° 42′ 17.61″ N, 105° 26′ 49.51″ W**
Naturalista	*Lynx* in wildlife photo	2015/11/24	21° 55′ 00.94″ N, 105° 17′ 54.44″ W
Naturalista	Camera trap photo	2011/11/26	22° 09′ 25.12″ N, 105° 29′ 24.19″ W
Naturalista	Camera trap photo	2011/11/16	22° 20′ 43.09″ N, 105° 24′ 58.65″ W
Naturalista	Camera trap photo	2011/10/13	22° 17′ 16.10″ N, 105° 25′ 57.92″ W
Naturalista	Camera trap photo	2011/08/25	22° 01′ 08.43″ N, 105° 32′ 45.09″ W
Naturalista	Camera trap photo	2011/08/13	22° 02′ 16.31″ N, 105° 34′ 07.29″ W
Naturalista	Camera trap photo	2011/07/31	22° 02′ 13.71″ N, 105° 35′ 56.63″ W
Naturalista	Camera trap photo	2011/07/30	22° 03′ 08.74″ N, 105° 25′ 31.73″ W
Naturalista	Camera trap photo	2011/07/30	22° 19′ 07.80″ N, 105° 32′ 57.93″ W
Naturalista	Camera trap photo	2011/07/30	22° 14′ 24.04″ N, 105° 32′ 13.72″ W
Naturalista	Camera trap photo	2011/07/11	22° 13′ 06.40″ N, 105° 33′ 41.17″ W
Naturalista	Camera trap photo	2011/05/03	21° 42′ 45.18″ N, 105° 28′ 28.07″ W
Naturalista	Camera trap photo	2010/03/23	21° 47′ 36.65″ N, 105° 27′ 44.68″ W
Naturalista	Camera trap photo	2010/01/23	22° 17′ 41.65″ N, 105° 28′ 29.14″ W
Naturalista	Camera trap photo	2010/01/10	22° 22′ 09.35″ N, 105° 35′ 21.21″ W
Naturalista	Camera trap photo	2009/11/16	22° 24′ 00.21″ N, 105° 28′ 33.12″ W
Naturalista	Camera trap photo	2009/12/20	22° 23′ 39.66″ N, 105° 39′ 12.04″ W
Naturalista	Camera trap photo	2009/11/02	22° 16′ 15.23″ N, 105° 24′ 19.30″ W
Naturalista	Camera trap photo	2009/08/24	21° 54′ 39.89″ N, 105° 18′ 16.49″ W
Naturalista	Camera trap photo	2009/08/22	21° 57′ 00.93″ N, 105° 31′ 00.46″ W
Naturalista	Fecal sample photo	2009/06/03	21° 44′ 38.80″ N, 105° 27′ 02.08″ W

both biogeography and conservation (Chefaoui and Lobo 2008). Our results confirmed what was proposed historically by Allen (1903), Leopold (1959) and Hall (1981), who all stated the range of the bobcat included the NCP, where it is rather a common species.

Using a camera trap methodology, we documented for the first time the presence of at least 10 different individuals, including adults of both sexes, and possibly a pregnant female in a coastal wetland located in Nayarit. The relative abundance index obtained in this work (1.28 bobcat photographs / 100 camera days), is similar, for example, to that reported for the bobcat in coniferous forests in Virginia, USA (1.36; Kelly and Holub 2008), and in Tlaxcala, México (1.27; Flores-Morales *et al.* 2019). It is even higher than at sites defined in the species distribution models as ideal ecosystem for the species, such as Sierra Gorda in Guanajuato, where relative abundance values of 0.15 were reported in submontane scrub and 0.09 in pine-oak forest (Charre-Medellín *et al.* 2016). The high values of relative abundance are indicative of a stable population of the bobcat in the NCP with respect to what has been reported in suitable habitats for the species, such as temperate forests and scrubs. Our records are remarkable since the study area is highly fragmented and with patches of mangroves of different sizes connected by secondary vegetation. It is known the bobcat is tolerant and adaptable to some man-made environments, especially males and young bobcats as females had low levels of modified association which posteriorly affects the population viability (Riley *et al.* 2003). In addition, the threshold on habitat loss and fragmentation is in general unknown for the species although a study found that bobcats may occur in fragmented sites but not in small and iso-

Figure 2. A bobcat, *Lynx rufus*, photographed on March 18, 2020 in a mangrove-tropical deciduous forest-farmlands ecotone in the Nayarit Coastal Plains, México.

lated sites (Crooks 2002) while others found this mammal can show a higher degree of adaptation (Riley *et al.* 2003). It is strongly recommended to accounting for landscape connectivity as it is key for management of bobcat populations across fragmented landscapes (Jacques *et al.* 2019).

In general, the activity of the bobcat in the NCP is consistent with the activity that has been registered in populations from other ecosystems where they are extant: 30 % of the records correspond to daytime activity, and 70 % to twilight-night activity (Anderson and Lovallo 2003; Elizalde-Arellano *et al.* 2014; Flores-Morales *et al.* 2019; Serna-Lagunes *et al.* 2019).

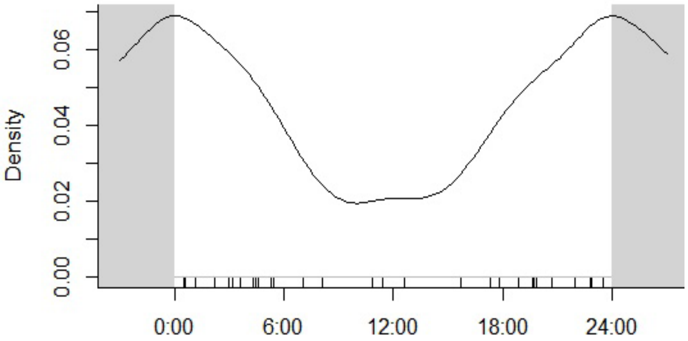


Figure 3. Histogram that shows the activity patterns, from 30 independent photographs, of the bobcat, *Lynx rufus*, in the Nayarit Coastal Plains, México.

The wetlands of the Coastal Plain of Nayarit face serious threats that endanger the permanence of the wildlife that inhabits them (Luja *et al.* 2017), among which is the bobcat. Deforestation for agriculture, livestock and, more recently, the boom in the establishment of shrimp farms, fragment the habitat and generate unfavourable encounters with humans. Although, in general, the bobcat adapts well to disturbance generated by human activities, the impacts that these have on their populations in tropical wetlands are unknown. To ensure the permanence of the species, future work is recommended to know in depth its diet, reproduction, home range and genetic connectivity of this species in the tropical wetlands of western México.

Acknowledgements

We thank P. Virgen, R. Virgen, I. Vallarta, M. Zamudio, D. Guzmán, A. Ponce, L. Ramírez and other people who collaborated in the field work. To R. Thompson, for editing the English and for his comments substantially improved the content of this manuscript. This work was possible thanks to funds granted by the National Council of Science and Technology (CONACyT) for project 3369 "Ecology and Conservation of the jaguar (*Panthera onca*) and its potential prey outside the Natural Protected Areas of Nayarit, México". We also thank M. Cortés for his support in the production of maps, and two anonymous reviewers that improve the manuscript.

Literature cited

Allen, J. A. 1903. A new deer and a new *Lynx* from the state of Sinaloa, Mexico (Vol. 19). By Order of the Trustees of the American Museum of Natural History. New York, U.S.A.

Anderson, E. M., and M. Lovallo. 2003. Bobcat and Lynx. Pp. 758-786 *in* Wild mammals of North America: biology, management and conservation (Feldhamer, G. A., B. C. Thompson, and J. A. Chapman, eds.). The Johns Hopkins University Press. Baltimore, U.S.A.

Aranda, M., O. Rosas, J. D. J. Ríos, and N. García. 2002. Análisis comparativo de la alimentación del gato montés (*Lynx rufus*) en dos diferentes ambientes de México. Acta Zoológica Mexicana 87:99-109.

Burton, A. M., S. N. Pérez, and C. Tovar. 2003. Bobcat ranging behavior in relation to small mammal abundance on Colima Volcano, Mexico. Anales del Instituto de Biología. Serie Zoología 74:67-82.

Ceballos, G., and G. Oliva. 2005. Los mamíferos silvestres de México. Fondo de Cultura Económica. México City, México.

Ceballos, G., S. Blanco, C. Gonzales, and E. Martínez. 2006. *Lynx rufus* (lince, gato montés). Distribución potencial, escala 1:1000000. Instituto de Biología, Universidad Nacional Autónoma de México. México City, México.

Comisión Nacional Forestal (CONAFOR). 2015. Inventario estatal forestal y de suelos-Nayarit 2014. Secretaría de Medio Ambiente y Recursos Naturales. México City, México.

Conner, L. M., B. D. Leopold, and M. Chamberlain. 2001. Multivariate habitat models for bobcats in southern forested landscapes. Pp. 51–55 *in* Proceedings of the Symposium on Current Bobcat Research and Implications for Management. The Wildlife Society 2000 Conference (Woolf, A., C. K. Nielsen, and R. D. Bluett, eds.). Carbondale, Illinois, Southern Illinois University, U.S.A.

Crooks, K. R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488-502.

Charre-Medellin, J. F., G. Magaña-Cota, T. C. Monterrubio-Rico, R. Tafolla-Muñoz, J. L. Charre-Luna, and F. Botello. 2016. Mamíferos medianos y grandes del municipio de Victoria, Reserva de la Biosfera Sierra Gorda Guanajuato, México. Acta Universitaria 26:62-70.

Chávez, C., A. De la Torre, H. Bárcenas, R. A. Medellín, H. Zarza, and G. Ceballos. 2013. Manual de fototrampeo para estudio de fauna silvestre. El jaguar en México como estudio de caso. Alianza WWF-Telcel, Universidad Nacional Autónoma de México. México City, México.

Chefaoui, R. M., and J. Lobo. 2008. Assessing the effects of pseudo-absences on predictive distribution model performance. Ecological Modelling 210:478-486.

Delibes, M., S. C. Zapata, M. C. Blázquez, and R. Rodríguez-Estrella. 1997. Seasonal food habits of bobcats (*Lynx rufus*) in subtropical Baja California Sur, Mexico. Canadian Journal of Zoology 75:478-483.

Elizalde-Arellano, C., J. C. López-Vidal, L. Hernández, J. W. Laundré, F. A. Cervantes, and M. Alonso-Spilsbury. 2012. Home range size and activity patterns of bobcats (*Lynx rufus*) in the southern part of their range in the Chihuahuan Desert, Mexico. The American Midland Naturalist 168:247-264.

Elizalde-Arellano, C., J. C. López-Vidal, L. Hernández, J. W. Laundré, F. A. Cervantes, F. M. Morales-Mejìa, M. Ramìrez-Vargas, L. F. Dávila-Galaviz, A. González-Romero, and M. Alonso-Spilsbury. 2014. Registros de presencia y actividades de algunos mamíferos en el Desierto Chihuahuense, México. Therya 5:793-816.

Flores-Morales, M., J. Vázquez, A. Bautista, L. Rodríguez-Martínez, and O. Monroy-Vilchis. 2019. Response of two sympatric carnivores to human disturbances of their habitat: the bobcat and coyote. Mammal Research 64:53-62.

Hall, R. E. 1981. The mammals of North America. John Wiley and Sons. New York, U.S.A.

Harris, G., R. Thompson, J. L. Childs, and J. Sanderson. 2010. Automatic Storage and Analysis of Camera Trap Data. Bulletin of the Ecological Society of America 91:352-360.

Heilbrun, R. D., N. J. Silvy, M. J. Peterson, and M. Tewes. 2006. Estimating Bobcat Abundance Using Automatically Triggered Cameras. Wildlife Society Bulletin 34:69-73.

Instituto de Biología, Universidad Nacional Autónoma de México (IBUNAM). 2020. *Lynx rufus*. Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México. México. http://datosabiertos.unam.mx/ibunam. Downloaded on April 15, 2020.

Instituto Nacional de estadística y Geografía (INEGI). 1991. Características edafológicas, fisiográficas, climáticas e hidrográficas de México. Instituto Nacional de Geografía Estadística e Informática. México City, México.

Jacques, C. N., R. W. Klaver, T. C. Swearingen, E. D. Davis, J. A. Jenks, C. S. Deperno, and R. D. Bluett. 2019. Estimating density and detection of Bobcats in fragmented Midwestern Landscapes using Spatial Capture–Recapture data from camera traps. Wildlife Society Bulletin 43:256-264.

Jenks, K. E., P. Chanteap, K. Damrongchainarong, P. Cutter, P. Cutter, T. Redford, A. Lynam, J. Howard, and P. Leimgruber. 2011. Using Relative Abundance Indices from Camera-Trapping to Test Wildlife Conservation Hypotheses – An Example from Khao Yai National Park, Thailand. Tropical Conservation Science 4:113-131.

Kelly, M. J., and E. Holub. 2008. Camera trapping of carnivores: trap success among camera types and across species, and habitat selection by species, on Salt Pond Mountain, Giles Country, Virginia. Northeast Naturalist 15:249-262.

Lariviere, S., and L. Walton. 1997. *Lynx rufus*. Mammalian Species. 563:1-8.

Leopold, A. S. 1959. Fauna silvestre de México. Editorial Pax. México City, México.

López-González, C. A., D. Ávila-Aguilar, and M. Cruz-Torres. 2015. Bobcat Abundance (*Lynx rufus escuinapae* J. A. Allen, 1903) in the Parque Nacional El Cimatario, Querétaro, México. Acta Zoológica Mexicana 31:138-140.

López-Vidal, J. C., C. Elizalde-Arellano, L. Hernández, J. W. Laundré, A. González-Romero, and F. A. Cervantes. 2014. Foraging of the bobcat (*Lynx rufus*) in the Chihuahuan Desert: generalist or specialist? The Southwestern Naturalist 59:157-166.

Luja, V. H., C. J. Navarro, L. A. Torres Covarrubias, M. Cortés Hernández, and I. L. Vallarta Chan. 2017. Small protected areas as stepping-stones for jaguars in western Mexico. Tropical Conservation Science 10, 1940082917717051.

Maffei, L., E. Cullar, and A. Noss. 2004. One thousand jaguars (*Panthera onca*) in Bolivias Chaco? Camera trapping in the Kaa-Iya National Park. Journal of Zoology 262:295-304.

Medellín, R. A., and H. Bárcenas. 2010. Estimación de la densidad poblacional y dieta del gato montés (*Lynx rufus*) en Aguascalientes y el Distrito Federal, México. Universidad Nacional Autónoma de México. Instituto de Ecología. Final report SNIB-CONABIO proyect es003. México City, México. http://www.conabio.gob.mx/institucion/proyectos/resultados/InfES009.pdf

Monroy-Vilchis, O., Z. Zarco-González, and M. Zarco-González. 2019. Potential distribution and areas for conservation of four wild felid species in Mexico: Conservation planning. Mammalian Biology 98:128-136.

Naturalista. 2020. Portal de ciencia ciudadana de la Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO). www.naturalista.mx. Downloaded on April 4, 2020.

O'Connell, A. F., and L. Bailey. 2011. Inference for occupancy and occupancy dynamics. Pp. 191-204 *in* Camera traps in animal ecology (O'Connell, A. F., J. D. Nichols, and K. Ullas, eds.). Springer, Japan.

Phillips, S. J., M. Dudík, and R. Schapire. 2004. A maximum entropy approach to species distribution modeling. Proceedings of the twenty-first international conference on Machine learning. Banff, Alberta, Canadá.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria.

Ridout, M. S., and M. Linkie. 2009. Estimating overlap of daily activity patterns from camera trap data. Journal of Agricultural, Biological, and Environmental Statistics 14:322-337.

Riley, S. P. D., R. M. Sauvajot, T. K. Fuller, E. C. York, D. A. Kamradt, C. Bromley, and R. K. Wayne. 2003. Effects of urbanization and habitat fragmentation on Bobcats and Coyotes in Southern California. Conservation Biology 17:566-576.

Ripple, W. J., J. A. Estes, R. L. Beschta, C. C.Wilmers, E. G. Ritchie, M. Hebblewhite, J. Berger, B. Elmhagen, M. Letnic, M. Nelson, O. Schmitz, D. Smith, A. Wallach, and A. Wirsing. 2014. Status and Ecological Effects of the World's Largest Carnivores. Science 343:1241484-1241484.

Roberts, N. M., and S. Crimmins. 2010. Bobcat Population Status and Management in North America: Evidence of Large-Scale Population Increase. Journal of Fish and Wildlife Management 1:169-174.

Romero, F. R. 2005. *Lynx rufus* (Schreber, 1777). Pp. 362-364 *in* Los Mamíferos Silvestres de México (Ceballos, G., and G. Oliva, eds.). Comisión Nacional para el Conocimiento y Uso de la Biodiversidad y Fondo de Cultura Económica. México City, México.

Sánchez-Cordero, V., D. Stockwell, S. Sarkar, H. Liu, C. R. Stephens, and J. Jiménez. 2008. Competitive interactions between felid species may limit the southern distribution of bobcats *Lynx rufus*. Ecography 31:757-764.

Sánchez-González, R., A. D. Hernández-Saint Martin, O. C. Rosas Rosas, and J. García-Chávez. 2018. Diet and Abundance of Bobcat (*Lynx rufus*) in the Potosino-Zacatecano Plateau, Mexico. Therya 9:107-112.

Serna-Lagunes, R., L. R. Álvarez-Oseguera, D. M. Ávila-Nájera, R. Leyva-Ovalle, P. Andrés-Meza, and T. Pablo Barbara. 2019. Temporal overlap in the activity of *Lynx rufus* and *Canis latrans* and their potential prey in the Pico de Orizaba National Park, Mexico. Animal Biology Conservation 42.1:153-161.

VertNet. 2020. National Science Foundation. Where discoveries begin. https://portal.vertnet.org/search?q=Lynx+rufus+Nayarit. Downloaded on April 4, 2020.

Associated editor: Arturo Carrillo-Reyes
Submitted: September 16, 2020; Reviewed: August 2, 2021.
Accepted: September 13, 2021; Published on line: October 6, 2021.

THERYA NOTES 2021, Vol. 2 : 132-139 DOI: 10.12933/therya_notes-21-49 ISSN 2954-3614

Notes on the behavior of opossum (*Didelphis* sp.) in the wild in Usumacinta Canyon, México

Notas sobre el comportamiento del tlacuache (*Didelphis* sp.) en vida silvestre en el Cañón del Usumacinta, México

Fabiola Luna-Jiménez[1], Francisco Botello[1,2]*, Ángel Jiménez-Gómez[3], Vicente Lopez-Moreno[3], Juan Carlos Romero-Gil[3], and Francisco Belmont-Buenrostro[3]

[1]Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México. Circuito exterior s/n, C. P. 04510. Ciudad Universitaria, Ciudad de México, México. E-mail: lunalanie@ciencias.unam.mx (FL-J); francisco.botello@ib.unam.mx (FB).
[2]Departamento de Monitoreo Biológico, Conservación Biológica y Desarrollo Social, A. C. Calle Nueve No. 52, Int. 4, Colonia Espartaco, C. P. 04870. Ciudad de México, México.
[3]Área de Protección de Flora y Fauna Cañón del Usumacinta. Calle 26 No. 187, Colonia Luis Gómez Zepeda, C. P. 86901. Tenosique, Tabasco, México. E-mail: angel.jimenez@sinergiaplus.org (AJ-G); vicentelopezmoreno.bc@gmail.com (VL-M); jcromero@conanp.gob.mx (JCR-G); fjavier.belmont@conanp.gob.mx (FB-B).
*Corresponding author

Opossums are nocturnal, generalist, and opportunistic animals; however, little is known about their behavior in the wild, as most of the studies currently available have been conducted in captive individuals. This note reports the behavior of *Didelphis* sp. living in the wild as captured from camera trap photos and videos, highlighting the use of the tail to carry materials. The study was conducted in the Usumacinta Canyon, state of Tabasco, México. One camera trap was placed on 8 April 2020; it was left operating and set to capture photographs and videos. It was reviewed on 2 May 2020, identifying and sorting out the files corresponding to *Didelphis* sp. The behavior observed was identified, considering the time of capture and the sex of each individual identified. A total of 209 wildlife records were obtained, with 55 pertaining to *Didelphis* sp.; all were captured during the night. Five main types of behavior were identified, including carrying the young on the back and transporting plant material with the tail, mostly leaves of hackberry shrub (*Celtis iguanaea*) to build the nest. Most of the behaviors observed correspond to foraging; however, the behavior of transporting plant material with the tail, presumably to build the nest, is reported for the first time for México. Also, three nighttime peaks of activity are reported, as well as a female carrying the young in the marsupium and later on her back.

Key words: Behavior; camera trap; reproduction; time of activity; use of the tail.

Los tlacuaches son animales nocturnos, generalistas y oportunistas; no obstante, se conoce poco de su conducta en vida silvestre, ya que la mayoría de los estudios existentes son en cautiverio. En esta nota se reporta la conducta de *Didelphis* sp. en vida silvestre utilizando fotos y videos de una cámara trampa, resaltando el uso de la cola para transportar material. En el Cañón del Usumacinta, Estado de Tabasco, México, se colocó una cámara trampa el 8 de abril de 2020; se dejó funcionando y programada para tomar fotografías y videos. Se revisó el 2 de mayo del mismo año, identificando y separando los archivos correspondientes a *Didelphis* sp. Se identificó la conducta observada, considerando la hora y el sexo de cada individuo identificado. Se obtuvieron 209 registros de fauna silvestre, de los cuales 55 correspondieron a *Didelphis* sp., todos capturados durante la noche. Se identificaron 5 conductas principales dentro de las que destacan el tránsito con crías en el lomo y el transporte de material vegetal con la cola, probablemente hojas de garabato (*Celtis iguanaea*) para la construcción del nido. La mayoría de las conductas observadas corresponden al forrajeo; sin embargo, se reporta, por primera vez para México, el comportamiento de transportar material vegetal con la cola, presumiblemente para construir su nido. También, se reportan 3 picos de actividad durante la noche y se observa a una hembra con crías en el marsupio y posteriormente en su lomo.

Palabras clave: Cámara trampa; comportamiento; horario de actividad; reproducción; uso de cola.

México is home to 12 species of marsupials (Didelphidae; Medina-Romero *et al.* 2012; Arcangeli *et al.* 2018), an ancestral group of great relevance for understanding the evolution of mammals. Two of these species are commonly known as opossum; these are very similar to each other. The southern opossum (*Didelphis marsupialis*) is found exclusively in the Mexican southeast, while the northern opossum (*D. virginiana*) is distributed throughout the Mexican territory, except the northwest region (Astua de Moraes *et al.* 2016; Pérez-Hernandez *et al.* 2016); therefore, these two species are sympatric over an extensive region**.**

Opossums are nocturnal, generalist, and opportunistic animals. They thrive in various habitats, even in areas with severe anthropogenic disturbance, and move across long distances in search of resources (McManus 1974; Kimble 1997; Oceguera-González and González-Romero 2008; Coronel-Arellano *et al.* 2021). Behavioral studies on these species are scarce and old; most of them were carried out in individuals observed in captivity or semi-captivity (Pray 1921; Layne 1951; Holmes 1991; Kimble 1997). Opossums have been described as mostly solitary animals with agonist interactions, except during mating and parental care; however, neutral and friendly interactions have also been reported (Holmes 1991; Kimble 1997).

The reproductive biology has been described in more detail for *D. virginiana* (*e.g.*, McManus 1974) than for *D. marsupialis*. Gestation in *D. virginiana* lasts approximately 13 days; the offspring remain in the marsupium for 65 days, attached to a nipple. For this reason, although litters from 18 to 21 individuals have been observed, only 13 survive on average, matching the number of nipples in females. Similar data have been reported for *D. marsupialis*, except for the number of nipples, which are approximately 9, although litters of 10.7 offspring have been reported in captivity (Tyndale-Biscoe and MacKenzie 1976; Dezonne-Motta *et al.* 1983).

The breeding seasons, number of offspring per litter, and number of litters per year vary according to the geographic location. Only a single study has been carried out in México on the reproduction of these species in coffee plantations of central Veracruz (Oceguera-González and González-Romero 2008), reporting that opossums mate at the end of January and produce litters of 7 offspring in both species. A Venezuelan study (Cabello 2006) reported that precipitation determines the reproductive season (in the driest months) for both species, resulting in 3 litters of 3 to 9 offspring per year. In contrast, Tyndale-Biscoe and MacKenzie (1976) suggest that photoperiod is the factor regulating the onset of reproduction in *D. marsupialis*, with 2 large litters (6.5 offspring) or 3 small litters (4.5 offspring) per year.

Similar to other mammal species, opossums build nests in burrows or tree holes to protect their offspring from the environment and other animals. There are specific reports about this behavior for *D. virginiana*, but only one for *D. marsupialis*. The detailed behavior of how *D. virginiana* collects and carries materials to build a nest is as follows. First, it takes a piece of building material with the mouth, then uses the front legs to pass it under the abdomen and places it on the curved tail under its body; last, using the hind legs, it pushes the material to the curve of its tail, which is then rolled over to hold the material during the trip to the nesting site (Smith 1941; Layne 1951). This behavior seems to be the same in *D. marsupialis*, except that when the tail is full, females also use the marsupium to carry the material; the latter may be an exceptional report (Delgado-Velez *et al.* 2014).

The material used to build their nests is not clearly identified, and it may vary depending on the particular ecosystem they inhabit. For instance, a male opossum (*D. virginiana*) in captivity used dry leaves, feathers, and strips of newspaper (Layne 1951). In contrast, the only report on *D. virginiana* in the wild (Smith 1941) mentions the collection of dry leaves from the ground. In a separate report (the oldest mentioning this behavior), the researcher provided the material used (autumn leaves; Pray 1921). Also, a study on the gray short-tailed opossum (*Monodelphis domestica*) has reported that females build nests of better quality than males and that temperature influences nest construction (Fadem *et al.* 1986).

This study reports very interesting data on the reproduction and behavior of *Didelphis* sp. in the wild, obtained from photographs and videos captured during the participatory monitoring program of the Usumacinta Canyon Flora and Fauna Protection Area (APFFCU, for its name in Spanish), which aims to document the species diversity of wild terrestrial vertebrates.

The APFFCU is located in the municipality of Tenosique, state of Tabasco, México. It is bordered by the state of Chiapas, México, to the east and by Guatemala to the south, where the Sierra del Lacandón National Park is located. It comprises 46,128.49 ha, including human settlements, water bodies, induced grasslands, crops, high evergreen rainforest, low thorny sub-deciduous rainforest, high evergreen rainforest with secondary vegetation, and tular vegetation (SEMARNAT 2015).

The daily activities of APFFCU staff include a participatory monitoring program with committees from different localities within the protected area. As part of this program, in the Niños Héroes de Chapultepec ejido on 8 April 2020, the community brigadier Vicente López Moreno placed one Bushnell Model 119975C 12 megapixels (mp) camera trap at geographic coordinates 17° 16′ 18.4″ N, 91° 25′ 10.2″ W (Figure 1) and 564 m, corresponding to a high evergreen rainforest. The camera trap was set to capture one photograph followed by one 15-second video, with a 30-second activation interval in case of motion detection; it was left operating until 2 May 2020, for a total of 25 camera trap days. A sardine can was used as bait only once at the start of the camera trapping period.

The photographs and videos captured were reviewed, sorting out all the captures corresponding to *Didelphis* sp. *Didelphis virginiana* and *D. marsupialis* were differentiated based on the tail coloration: less than half of the tail is black in the northern opossum (*D. virginiana*) while more than half is black in the southern opossum (*D. marsupialis*), according to Aranda-Sánchez (2012). However, we considered that this character alone is insufficient for reliable identification.

The number of photographs and videos was counted, as well as the effective capture time, defined as the period of time that an individual is observed within the 15-second total duration of each video. The time of capture was recorded for all photographs; the sex (female or male) and life stage (adult or young) of each specimen were noted, and an identification key was assigned in each case (Table 1). Whenever possible, the sex was determined from the visualization of the scrotum in males and the marsupium or by carrying offspring, either in the marsupium or on the back, in females.

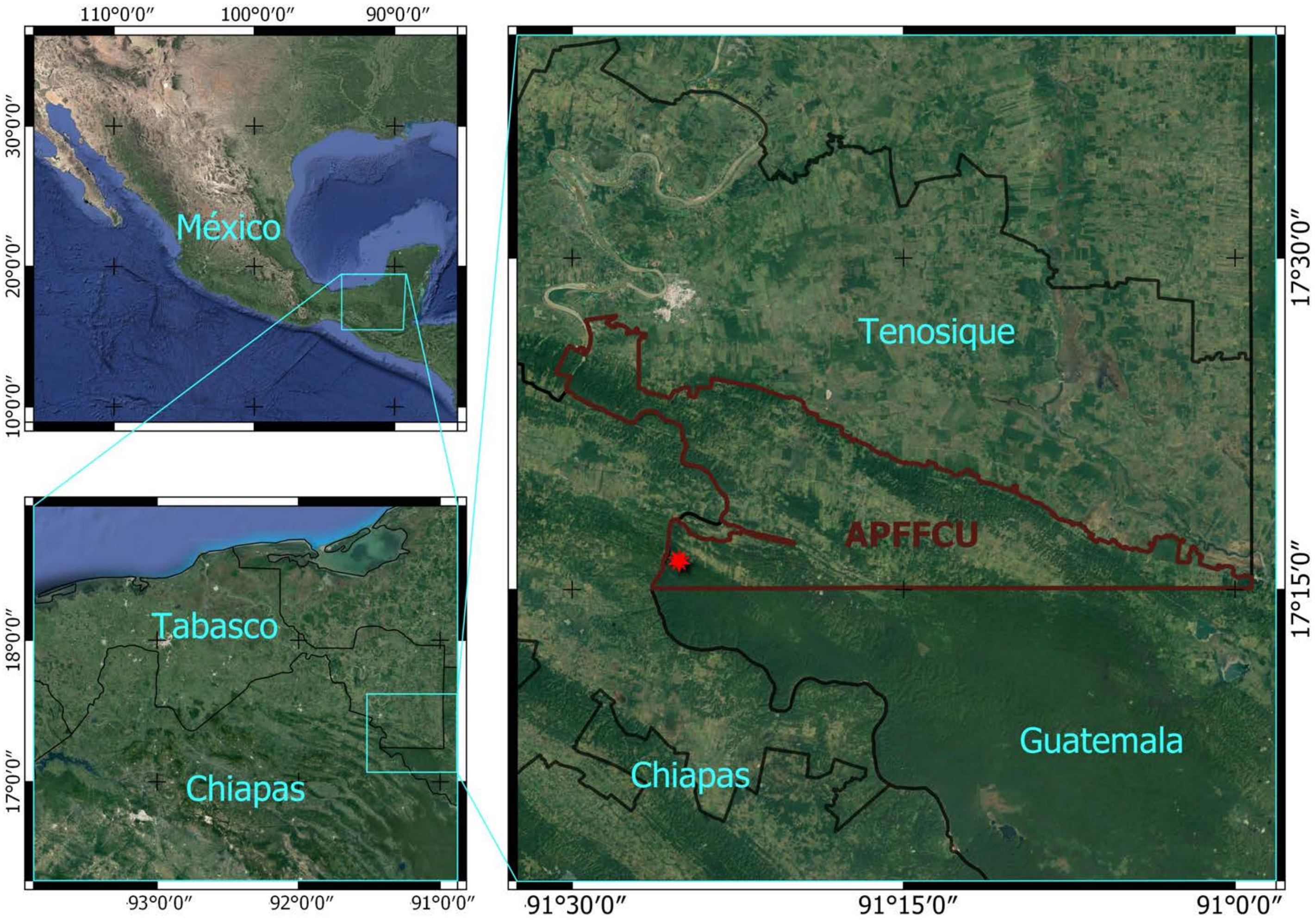


Figure 1. Geographic location of the camera trap (red star) placed in the Usumacinta Canyon Flora and Fauna Protection Area (APFFCU), Tenosique, Tabasco, México.

Aspects such as size, sex, color patterns, and tail shape were considered to characterize each individual, considering the latter two aspects as natural marks that uniquely identify each individual, similar to the identification approach applied for other species such as the ocelote (*Leopardus pardalis;* Gómez-Ramírez *et al.* 2017), leopard (*Panthera pardus;* Webb *et al.* 2020), and chimpanzee (*Pongo* spp.; Spehar *et al.* 2015). The observed behaviors were classified as described in McManus (1974), Holmes (1991), and Kimble (1997).

A total of 209 wildlife records were captured, with 55 pertaining to *Didelphis* sp.: 45 photographs with their respective 15-second video, 5 photographs with no video, and 5 videos with no previous photograph. All captures where the complete tail was observed corresponded to *D. virginiana*, including all the individuals identified. In total, 12 min 30 s of video was filmed, of which 9 min 28 s was the effective capture time during which the animal is observed. All records were captured during the night, with peaks of activity from 01:00 to 02:00 hr, 04:00 to 06:00 hr, and 19:00 to 21:00 hr, with less activity from 21:00 to 24:00 hr (Figure 2).

A total of 56 captures of opossum were obtained; 2 individuals were observed in a single video, and 5 different individuals were identified. 43 records correspond to female opossum, 5 to male opossum, 1 to a young, and 7 to individuals that could not be identified or sexed (Table 1). One female, Th1, was observed with offspring: first, in the marsupium (Figure 3a); later, on her back (Figure 3b). In two captures of Th1, only 5 offspring were observed on the back; in a third capture, 7 offspring were recorded.

Five different types of behavior were identified (Table 2). (1) Grooming: the animal licked its front legs or it cleaned its face with a front leg or it scraped its head with a hind leg or all of the above. (2) Search: the opossum walked slowly, sniffing with the snout directed to the substrate. (3) Substrate manipulation: the animal was removing the substrate with its snout slightly buried in the surface (sometimes with the help of the front legs) and possibly feeding. (4) Passing: the opossum only passed in front of the camera either running, walking, carrying material in its tail or carrying offspring on its back (Figure 3b, 3c, 3d). (5) Arboreal behaviors: climbing up a tree, *i.e.*, the animal was observed climbing up in a vertical position, holding the trunk with

Table 1. Individuals of *Didelphis* sp. identified in the Usumacinta Canyon Flora and Fauna Protection Area (APFFCU), Tenosique, Tabasco, México, including the number of captures and duration of capture.

Individuals identified	No. of captures	Percentage of captures (%)	Duration of capture time (s)*	Percentage of duration of capture (%)
Females**	43	76.79	496	86.56
Th1	33	58.93	399	69.63
Offspring on the back	3	5.36	23	4.01
Offspring in the marsupium	16	28.57	203	35.43
Th2	9	16.07	82	14.31
Males	5	8.93	50	8.73
Tm1	1	1.79	15	2.62
Tm2	4	7.14	35	6.11
Juveniles	1	1.79	15	2.62
Tj1	1	1.79	15	2.62
NI	7	12.50	12	2.09

NI: Unidentified

*Includes photograph-only records (1 photo = 1 second)

**Includes one record where the individual was not identified.

the digits of the four legs (Figure 3e), and climbing off a tree, when the opossum was descending toward the substrate in an almost vertical position, with its tail around the trunk (Figure 3f).

Unfortunately, this study did neither visualize nests nor clearly identify the leaves transported. However, based on the shape and coloration of leaves, the occurrence at the study site, and the local knowledge of one of the co-authors (VL-M) living in the locality, it is suggested that the leaves transported could be from the hackberry shrub, *Celtis iguanaea*.

We decided to identify the opossums observed as *Didelphis* sp. only, since two very similar species of this genus co-inhabit the APFFCU, *D. virginiana* and *D. marsupialis* (SEMARNAT 2015). Although there are morphological features that are unique to each of them, such as those described in Aranda-Sánchez (2012), these were difficult to observe clearly in the black-and-white photographs and videos captured. For the above, we consider that the taxonomic identification based solely on the coloration of the tail is not sufficiently robust. Nonetheless, the individuals captured likely correspond to *D. virginiana*.

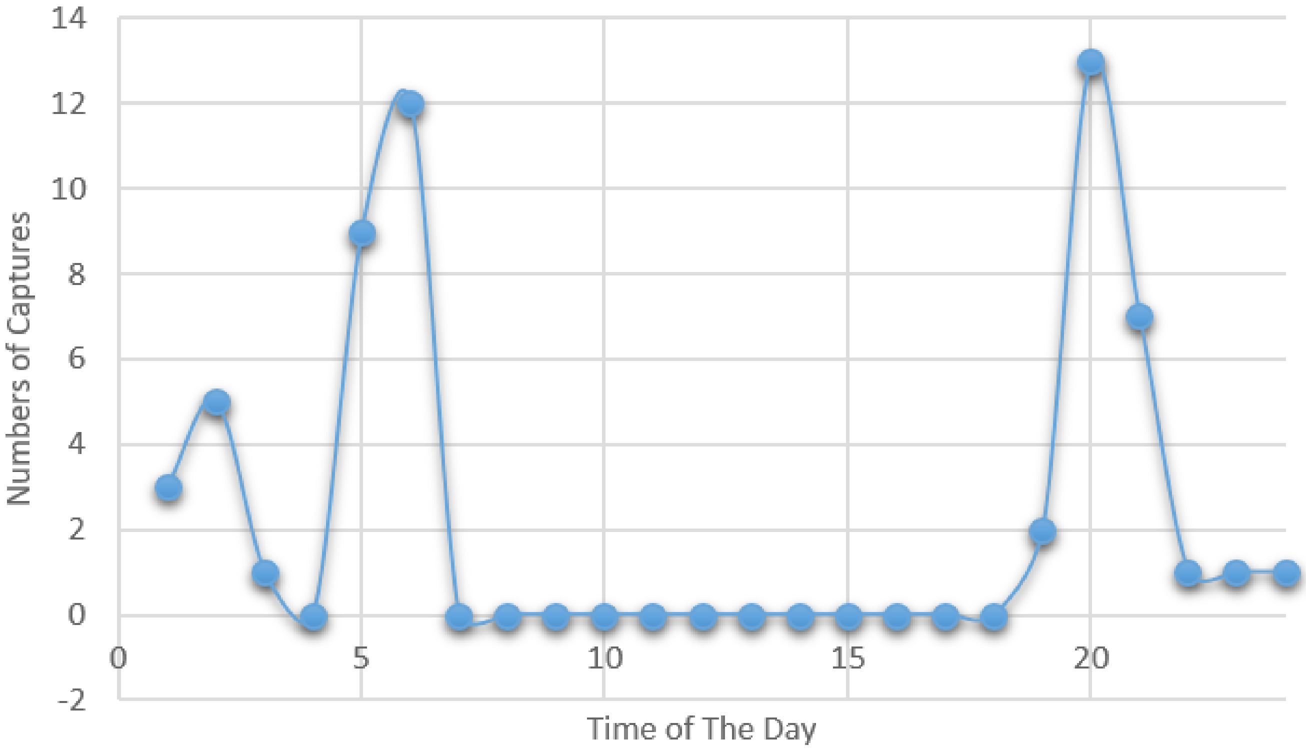


Figure 2. Hours of activity of *Didelphis* sp., according to the number of captures per hour in the Usumacinta Canyon Flora and Fauna Protection Area (APFFCU), Tenosique, Tabasco, México.

Figure 3. Photographs captured with the camera trap that illustrate some of the behaviors observed in *Didelphis* sp. in the Flora and Fauna Protection Area of the Usumacinta Canyon (APFFCU), Tenosique, Tabasco, México. (a) Opossum Th1 (*Didelphis* sp.) carrying offspring in the marsupium. (b) Opossum Th1 (*Didelphis* sp.) carrying offspring on the back. (c and d) Opossum Th2 (*Didelphis* sp.) carrying material with its tail. (e) Opossum Th1 (*Didelphis* sp.) climbing up a tree. (f) Opossum Th1 (*Didelphis* sp.) climbing down a tree.

This study reports that in APFFCU, *Didelphis* sp. displays 3 peaks of activity in April–May (Figure 2): 01:00–02:00 hr, 04:00–06:00 hr, and 19:00–21:00 hr. This differs from the activity described by McManus (1971) for *D. virginiana*, who reported a peak from 21:00 to 02:00 hr in spring in semi-captive specimens in Ithaca, New York, based on direct observations. This discrepancy may be due to methodological or environmental differences, since a separate study of *D. virginiana* in the wild over nearly a year using a methodology similar to the one in the present study (camera traps) and in a study site closer to ours (México City, México) reported two peaks of activity: one around 04:00 hr and another at about 22:00 hr (Coronel-Arellano *et al.* 2021), which are consistent with the findings reported in this note. Although the studies mentioned coincide in describing nocturnal habits, we suggest that the peaks of activity vary according to the latitude and ecosystem because temperature and lighting are different.

Most of our captures were of females, especially Th1 (58.93 %, Table 1). Th1 was observed with their offspring from the time they were in the marsupium to the moment when they were carried on the back (Figure 3a, 3b); the young observed at the end of the camera trapping period belongs to this litter, although there is no assurance that Tj1 is an offspring of Th1. The number of offspring observed in this litter (7) is consistent with the litter size reported in the literature (McManus 1974; Tyndale-Biscoe and MacKenzie 1976; Cabello 2006; Oceguera-González and González-

Table 2. Behaviors identified in *Didelphis* sp. and their variations, observed in the Usumacinta Canyon Flora and Fauna Protection Area (APFFCU), Tenosique, Tabasco, México, including the number of sightings and duration of capture.

Behavior identified	No. of sightings	Percentage of sightings (%)	Duration of capture (s)	Percentage of duration of capture (%)
Grooming	3	4.92	23	4.05
Search	32	52.46	372	65.49
Substrate manipulation	10	16.39	91	16.02
Passing through	11	18.03	66	11.62
Running	1	1.64	1	0.18
Walking	10	16.39	65	11.44
Alone	5	8.20	40	7.04
Carrying material	2	3.28	2	0.35
Carrying offspring	3	4.92	23	4.05
Arboreal behaviors	5	8.20	16	2.82
Climbing up a tree	3	4.92	10	1.76
Climbing off a tree	2	3.28	6	1.06

s = seconds

Romero 2008); however, we first captured 5 young and then 7. The latter could be due to the position of the offspring on the back, which prevented observing all of them; alternatively, they may have not left the marsupium when the images were captured.

Most of the behaviors observed are consistent with foraging: search (65.49 %) and substrate manipulation (16.02 %, Table 2). *Didelphis* sp. is considered a generalist and opportunistic genus; however, there are no studies focused on its foraging behavior, particularly in the wild. Although the passing behavior occurred only in 11.62 % of captures, it provided information that was last reported by Hopkins (1977) for *D. virginiana* and by Delgado-Velez *et al.* (2014) for *D. marsupialis*. Finally, arboreal behaviors (2.82 %), *i.e.*, climbing up (1.76 %) and down a tree (1.06 %), where the less observed behaviors and offer an indication about these habits in this species and its locomotion when climbing.

In captures where an opossum is observed climbing up or off a tree (Figure 3e, 3f), the behavior is very similar to the one observed in *Caluromys philander* (Dalloz *et al.* 2012), especially as regards the use of the tail. When climbing up a tree, the tail is stretched or moved to a position relative to the body so as to maintain balance. In contrast, when an individual is climbing down a tree, the tail is wrapped around the trunk for quick anchoring, if needed; this observation is consistent with Dalloz *et al.* (2012).

Two images captured a female of *Didelphis* sp. (Th2) using the tail to carry material to its nest (Figure 3c, 3d; Table 2); this is the first report of this behavior for México. This behavior has also been reported in other didelphids: *Monodelphis domestica* (Unger 1982; Fadem *et al.* 1986), *M. dimidiata* (González and Claramunt 2000), *C. philander* (Dalloz *et al.* 2012), and *Metachirus nudicaudatus* (Delgado-Velez *et al.* 2014); and in males of *D. virginiana* (Layne 1951; Hopkins 1977) and individuals of *D. marsupialis* (Delgado-Velez *et al.* 2014). Nests of *Marmosa canescens* (Ceballos 1990) have also been reported and described, but the way they carry the material for nest construction is unknown.

Whether the use of the tail to carry material is a learned or an innate behavior is currently unknown; however, this behavior has been reported in young of *D. virginiana* of 88 to 97 days of age with no apparent learning involved (Hopkins 1977). The behavior observed in this study and described above, which has also been reported for other species of the family Didelphidae, may be an ancestral trait typical of didelphids. Further studies are needed, which may be challenging as these organisms are rare and difficult to observe in the wild.

Although in *M. domestica* both males and females are known to build nests, with females being better at it (Fadem *et al.* 1986), it is not clear whether the same holds true for *D. virginiana* or *D. marsupialis*. Unfortunately, nests of *Didelphis* sp. were not observed in this study, although they may be similar to those described for other didelphids. The nests described are spherical or globe-shaped (Unger 1982; Loretto *et al.* 2005). The nests of *M. domestica* have three levels: the first is the base, the second is an inner chamber with thick walls, and the third forms the vaulted ceiling (Unger 1982).

In the present study, the leaves transported could not be clearly identified; however, they probably correspond to the hackberry shrub (*Celtis iguanaea*). The material used by *D. virginiana* and *D. marsupialis* for the construction of their nests consists mainly of dry leaves according to studies conducted in the wild (Smith 1941; Dalloz *et al.* 2012; Delgado-Velez *et al.* 2014), although herbs and plant fibers (Ceballos 1990) or pieces of roots have also been reported (Loretto *et al.* 2005) for other didelphids. In studies under captivity, the material for nest building has been provided, being mostly paper strips (Hopkins 1977; Unger 1982;

Fadem *et al.* 1986; González and Claramunt 2000), and in one case, dried leaves, feathers, and pieces of newspaper (Layne 1951). An experimental study (Unger 1982) suggests that *M. domestica* chooses any materials suitable for construction; however, no other experimental studies explored how other didelphids choose the materials they use for nest building.

The nest-building site varies according to whether nests are on trees, semi-arboreal, or built on the ground, as nests can be found in holes of trees and shrubs, between tree roots, or under the leaf litter layer (Ceballos 1990; Dalloz *et al.* 2012). In addition, opossums have been observed to change their nesting sites within two months (Loretto *et al.* 2005). *Didelphis* sp. is mostly terrestrial, but this does not exclude all the potential nesting sites mentioned above.

Nests are assumed to provide protection from environmental conditions and predation; however, not many studies have evaluated this assumption. Unger (1982) reported that *M. domestica* built nests when days were sunny, suggesting that nests are used to get protection from warm weather. Conversely, Fadem *et al.* (1986) evaluated the effect of temperature, finding that lower ambient temperatures are related to nests built using more material, suggesting that these nests protect from cold weather and contribute to thermoregulation.

In our opinion, further studies on *D. virginiana* and *D. marsupialis* in the wild are needed, for which camera traps are very useful. These studies should include a detailed description of the nests built in the wild and investigate how opposums choose the materials to build their nests, how and where nests are built, whether there are factors affecting nest construction or prompting the relocation of nesting sites, or whether this occurs regularly. These studies will enable us to understand the importance of nesting and its role in reproduction and survival in these species.

Although opossums of the genus *Didelphis* are common, this research reports for the first time for México their behavior regarding the transport of plant material with the tail, presumably to build a nest, and the presence of several individuals at the same site. In addition, this study confirmed the nocturnal habits of *Didelphis* sp., recording 3 peaks of activity during April and May in the APFFCU area. Other behaviors of opossums, such as females carrying their young in the marsupium and on the back, are also reported.

Acknowledgements

To APFFCU community brigades, who are dedicated to monitoring activities. Thanks also to the Direction of the Cañón del Usumacinta Natural Protected Area (ANP) of the National Commission of Natural Protected Areas (CONANP, in Spanish), which since its creation have built the capacities of the ANP inhabitants, and for the efficient follow-up of biological monitoring. We wish to thank two anonymous reviewers whose valuable comments and suggestions contributed to the preparation of this note. And we thank M. E. Sánchez-Salazar for translating the manuscript into English.

Literature cited

Aranda-Sánchez, J. M. 2012. Manual para el rastreo de mamíferos silvestres en México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO), No. 599 A7. México City, México.

Arcangeli, J., J. E. Light, and F. A. Cervantes. 2018. Molecular and morphological evidence of the diversification in the gray mouse opossum, *Tlacuatzin canescens* (Didelphimorphia), with description of a new species. Journal of Mammalogy 99:138–158.

Astua de Moraes, D., D. Lew, L. P. Costa, and R. Pérez-Hernandez. 2016. *Didelphis marsupialis*. *In*: IUCN 2016. The IUCN Red List of Threatened Species. Version 2016. www.iucnredlist.org. Accessed February 24, 2021.

Cabello, D. R. 2006. Reproduction of *Didelphis marsupialis* (Didelphimorphia: Didelphidae) in the Venezuelan Andes. Acta Theriologica 51:427–433.

Ceballos, G. 1990. Comparative natural history of small mammals from tropical forests in western Mexico. Journal of Mammalogy 71:263–266.

Coronel-Arellano, H., M. Rocha-Ortega, F. Gual-Sill, E. Martínez-Meyer, A. K. Ramos-Rendón, M. González-Negrete, G. Gil-Alarcón, and L. Zambrano. 2021. Raining feral cats and dogs? Implications for the conservation of medium-sized wild mammals in an urban protected area. Urban Ecosystems 24:83–94.

Dalloz, M. F., D. Loretto, B. Papi, P. Cobra, and M. V. Vieira. 2012. Positional behaviour and tail use by the bare-tailed woolly opossum *Caluromys philander* (Didelphimorphia, Didelphidae). Mammalian Biology 77:307–313.

Delgado-Velez., C. A., A. Arias-Alzate, S. Aristizábal-Arango, and J. D. Sánchez-Londoño. 2014. Uso de la cola y el marsupio en *Didelphis marsupialis* y *Metachirus nidicaudatus* (Didelphimorphia: Didelphidae) para transportar material de anidación. Mastozoología Neotropical 21:129–134.

Dezonne-Motta, M. F., J. C. de Araujo Carreira, and A. M. Ramos Franco. 1983. A note on reproduction of *Didelphis marsupialis* in captivity. Memorias do Instituto Oswaldo Cruz 78:507–509.

Fadem, B. H., D. B. Kraus, and R. H. Sheffet. 1986. Nest-building in gray short tailed opossums: temperature effects and sex differences. Physiology and Behavior 36:667–670.

Gómez-Ramírez, M. Á., C. E. Gutiérrez-González, and C. A. López-González. 2017. Ocelots thrive in a non-typical habitat of northwestern Mexico. Endangered Species Research 32:471–478.

González, E. M., and S. Claramunt. 2000. Behaviors of captive short-tailed opossums, *Monodelphis dimiata* (Wagner, 1847) (Didelphimorphia, Didelphidae). Mammalia 64:271–285.

Holmes, D. J. 1991. Social behavior in captive Virginia opossums, *Didelphis virginiana*. Journal of Mammalogy 72:402–410.

Hopkins, D. 1977. Nest-building behavior in the immature Virginia opossum (*Didelphis virginiana*). Mammalia 41:361–362.

Kimble, D. P. 1997. Didelphid Behavior. Neuroscience and Biobehavioral Reviews 21:361–369.

Layne, J. N. 1951. The use of the tail by an opossum. Journal of Mammalogy 32:464–465.

Loretto, D., E. Ramalho, and M. V. Vieira. 2005. Defense behaviour and nest architecture of *Metachirus nudicaudatus* Desmarest, 1817 (Marsupialia, Didelphidae). Mammalia 69:417–419.

McManus, J. J. 1971. Activity of captive *Didelphis marsupialis*. Journal of Mammalogy 52:846–848.

McManus, J. J. 1974. *Didelphis virginiana*. Mammalian Species 40:1–6.

Medina-Romero, M., I. Goyenechea, and J. Castillo-Cerón. 2012. Phylogenetic measures applied to the conservation of Mexican marsupials. Revista Mexicana de Biodiversidad 83:1216–1220.

Oceguera-González, A., and A. González-Romero. 2008. Hábitos alimentarios y reproducción de dos especies de tlacuache en cafetales del centro de Veracruz, México. Pp. 295–309 *in* Avances en el Estudio de los Mamíferos de México (Lorenzo, C., E. Espinoza, and J. Ortega, eds.). Publicaciones Especiales Vol. II, Asociación Mexicana de Mastozoología, A. C. Chiapas, México.

Pérez-Hernandez, R., D. Lew, and S. Solari. 2016. *Didelphis virginiana*. *In*: IUCN 2016. The IUCN Red List of Threatened Species. Version 2016. www.iucnredlist.org. Accessed February 24, 2021.

Pray, L. 1921. Opossum carries leaves with its tail. Journal of Mammalogy 2:109–110.

Secretaría del Medio Ambiente y Recursos Naturales (SEMARNAT). 2015. Programa de manejo Área de Protección de Flora y Fauna Cañón del Usumacinta. Secretaría del Medio Ambiente y Recursos Naturales, Comisión Nacional de Áreas Naturales Protegidas. México City, México.

Smith, L. 1941. An observation on the nest-building behavior of the opossum. Journal of Mammalogy 22:201–202.

Spehar, S. N., B. Loken, Y. Rayadin, and J. A. Royle. 2015. Comparing spatial capture-recapture modeling and nest count methods to estimate orangutan densities in the Wehea Forest, East Kalimantan, Indonesia. Biological Conservation 191:185–193.

Tyndale-Biscoe, C. H., and R. B. MacKenzie. 1976. Reproduction in *Didelphis marsupialis* and *D. albiventris* in Colombia. Journal of Mammalogy 57:249–265.

Unger, K. L. 1982. Nest-building behavior of the brazilian bare-tailed Opossum, *Monodelphis domestica*. Journal of Mammalogy 63:160–162.

Webb, E. L., Y. R. Choo, E. P. Kudavidanage, T. R. Amarasinghe, U. G. S. I. Bandara, W. A. C. L. Wanninayaka, P. Ravindrakumar, T. S. Nimalrathna, S. H. Liang, and M. A. H. Chua. 2020. Leopard activity patterns in a small montane protected area highlight the need for integrated, collaborative landscape conservation. Global Ecology and Conservation 23:e01182.

Associated editor: José R. Soto-Shoender
Submitted: June 16, 2021; Reviewed: September 4, 2021.
Accepted: September 14, 2021; Published on line: October 6, 2021.

THERYA NOTES 2021, Vol. 2 : 140-142 DOI: 10.12933/therya_notes-21-50 ISSN 2954-3614

Early observations on the use of termite nests by bats

Primeras observaciones sobre el uso de nidos de termitas por murciélagos

Robert M. Timm[1]*

[1]Natural History Museum & Biodiversity Institute and Department of Ecology & Evolutionary Biology, University of Kansas, Lawrence, KS 66045, U.S.A. E-mail: btimm@ku.edu.

*Corresponding author

The remarkable discovery of Neotropical round-eared bats (Phyllostomidae, *Lophostoma*) actively hollowing out cavities in termite nests for roosting sites has enabled researchers to explore several aspects of their previously unknown behavior. We now know that round-eared bats excavate cavities in *Nasutitermes* nests that are actively used by the termites and the bats roost only in these cavities, as well as a number of other aspects of the bats' behavior. In the early 1800s, a British naturalist, Charles Waterton, observed and published that bats "clear out" and roost in termite nests, and how he was able to ascertain if a termite nest was being used by bats. Waterton's descriptions of this behavior have long been overlooked and now provide us with additional insights on the distribution and ecology of these poorly known bats.

Key words: *Lophostoma*; *Nasutitermes*; Neotropics; Phyllostomidae; roosting behavior; round-eared bats.

El notable descubrimiento de murciélagos de orejas redondeadas neotropicales (Phyllostomidae, *Lophostoma*) que habitan las cavidades en los nidos de termitas como sitios de anidamiento, ha permitido a los investigadores explorar varios aspectos desconocidos de su comportamiento. Ahora sabemos que los murciélagos de orejas redondeadas excavan cavidades en los nidos de *Nasutitermes* que son utilizados activamente por las termitas y que los murciélagos anidan exclusivamente en esas cavidades, entre otros aspectos de su comportamiento de los quirópteros. A principios de la década de 1800, un naturalista británico, Charles Waterton, publicó la observación de que los murciélagos hacen agujeros y se posan en nidos de termitas y cómo fue capaz de comprobar si un nido de termitas estaba siendo utilizado por murciélagos. La descripción por parte de Waterton de este comportamiento se ha obviado durante mucho tiempo y ahora nos proporciona información adicional sobre la distribución y la ecología de estos quirópteros poco conocidos.

Palabras clave: Anidamiento; *Lophostoma*; *Nasutitermes*; Neotrópicos; Phyllostomidae; murciélagos de orejas redondeadas.

One of the remarkable discoveries on roosting behavior in bats is that the Neotropical round-eared bats of the genus *Lophostoma* (Chiroptera: Phyllostomidae) hollow out the nests of the termite genus *Nasutitermes* (Isoptera: Termitidae) for roosting sites. *Nasutitermes* termitaria are large, often 0.5 m or more in length and width, and often 2 or more meters off the ground on the trunks of trees. These nests provide both the termites and bats with a waterproof and warm refuge with a stable temperature regime, as well as providing the bats with a well-camouflaged daytime roost and maternity site. It is currently believed that at least three species of round-eared bats (*Lophostoma brasiliense*, *L. carrikeri*, and *L. silvicola*) roost exclusively in these arboreal termite nest cavities they have excavated. Recent authors have documented that round-eared bats roost only in active *Nasutitermes* termitaria that they regularly modify. Males excavate the cavities, cavity use is tied to social organization, associations stay together year-round, and perhaps the chemical defenses used by the termites contribute to reduced parasite load in the bats (Dechmann *et al.* 2004, 2005; Kalko *et al.* 2006; Dechmann *et al.* 2007; Timm and McClearn 2007; Dechmann and Kerth 2008; York *et al.* 2008).

Round-eared bats historically had been considered uncommon or rare and little was known about their behavior or ecology. Although it was reported that round-eared bats were occasionally found in termite nests, it was believed that they were roosting in cavities excavated by birds. In the first modern study of these bats, Kalko *et al.* (1999:349) wrote, "Possibly, the bats use termite nests opened by nesting birds such as trogons (*Trogon* sp.) or orange-chinned parakeets (*Brotogeris* sp.)". The discovery in the early 2000s that round-eared bats hollow out arboreal termite nests for roosting sites was a breakthrough in unraveling the behavioral ecology of these species because they could be observed at the roost site and captured unharmed (Dechmann *et al.* 2004, 2005).

This roosting behavior and that round-eared bats actually modify the termite nests however, was first observed in the early 1800s and recent researchers seemingly were unaware of these observations. Charles Waterton (born 1785, died 1865), British aristocrat, explorer, and naturalist, described his observations of bats roosting in termitaria: "Independent of the hollow trees, the Vampires have another hiding-place. They clear out the inside of the large ants' nests, and then take possession of the shell .

. . we stopped under an ants' nest; and, by the dirt below, conjectured that it had got new tenants . . . an Indian boy ascended the tree; but, before he reached the nest, out flew above a dozen Vampires" (Waterton 1879:319–320).

To Waterton, all bats were called vampires. He did know what true vampires (= *Desmodus rotundus*) were because he tried in vain to get them to feed on him (they frequently feed upon other members of his traveling party, especially younger people, but were disinclined to choose him). In the explanatory notes later in the book, "the large ant's nest" he discusses were correctly attributed to termite termitaria; today we know this is the genus *Nasutitermes*.

Wateron traveled extensively throughout Guiana in 1812, 1816, 1820, and 1824 as well as in Brazil. His description of bats roosting in termite nests was presented as part of a chapter on his travels in 1824 although he seems to be summarizing observations from his earlier travels also. Now, two centuries later, we can more fully appreciate the observations of this early naturalist and note that he should be attributed with the discovery that *Nasutitermes* termitaria are actively modified and are an effective roost site for Neotropical round-eared bats.

The nearly two centuries between Waterton's observations and the recent "rediscovery" of round-eared bats actively modified *Nasutitermes* nests highlights how cryptic the roost sites can be. When investigators develop a search image and with diligent searching of *Nasutitermes* nests, the cavities created by round-eared bats are visible. There is only a single opening of the cavity and it is always ventrally directed (Figure 1; Figure 2A, B). Not all cavities observed are occupied by a colony or singleton bat but bats are only found in active termite nests. Much remains to be learned about the roosting ecology, social behavior, and relationships among individuals that are found within a cavity; but

Figure 1. An adult female pygmy round-eared bat, *Lophostoma brasiliense*, that was observed as part of the roosting colony in the *Nasutitermes* nest illustrated in Figure 2.

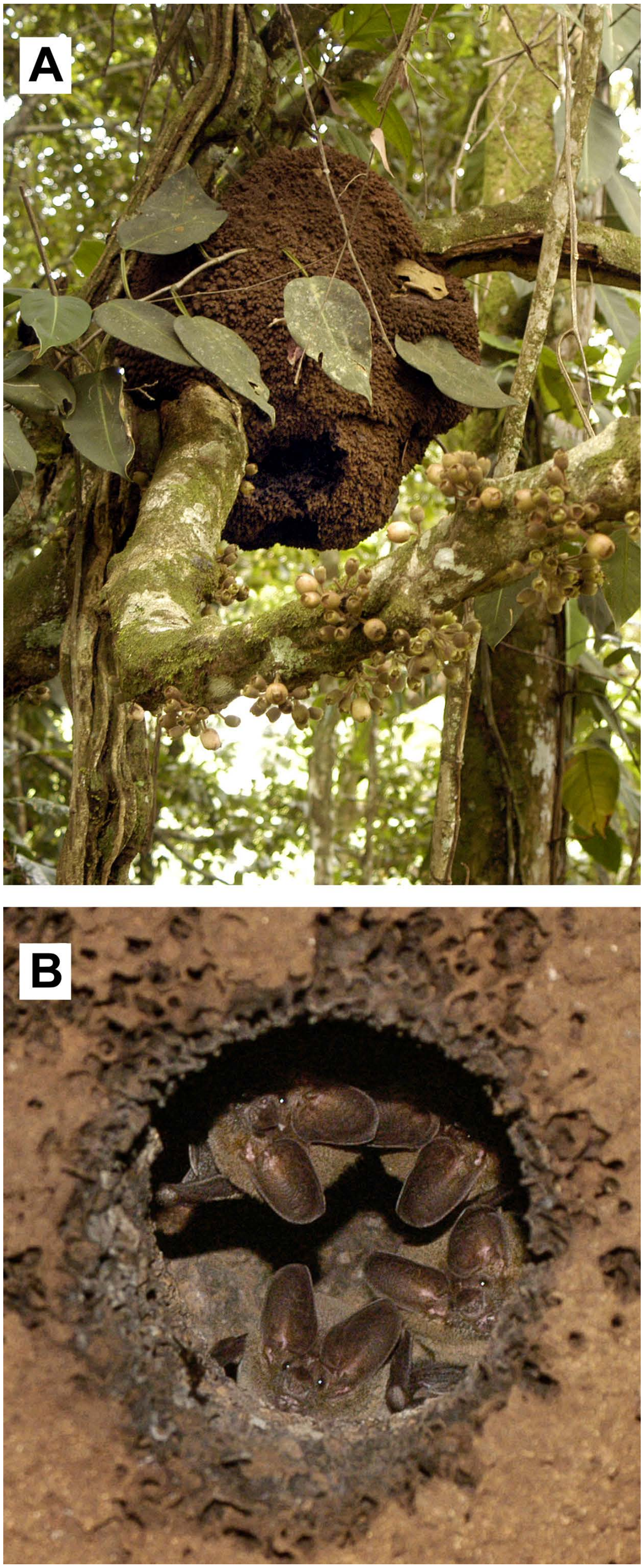


Figure 2. A) Nest of *Nasutitermes* in the melastome *Loreya mespiloides*, at the Bijagual Ecological Reserve in the Caribbean lowlands of northeastern Costa Rica, containing a roosting colony of pygmy round-eared bats (*Lophostoma brasiliense*). Note the roost cavity opening on the underside of the nest. Foliage from a living epiphyte is incorporated into the termite nest. B) Four round-eared bats hanging in the roost cavity are visible from below. Fresh chewing on the termite nest is visible as the dark rough areas. See York *et al.* (2008) for additional details. All photographs courtesy of H. A. York.

Charles Waterton and more recent investigators provide us a route to explore this fascinating behavior.

Acknowledgements

I thank H. A. York for providing the images used as Figures 1 and 2 here that contribute significantly to our understanding of the roosting behavior in these bats. P. F. Foster's efforts in providing outstanding logistic support for researchers and educational classes at Reserva Ecológica Bijagual de Sarapiquí, Heredia, Costa Rica is greatly appreciated. A. Romero provided the Spanish translation for the Resumen. Comments from D. McClearn and two anonymous reviewers improved earlier versions of this manuscript.

Literature cited

Dechmann, D. K. N., E. K. V. Kalko, and G. Kerth. 2004. Ecology of an exceptional roost: energetic benefits could explain why the bat *Lophostoma silvicolum* roosts in active termite nests. Evolutionary Ecology Research 6:1037–1050.

Dechmann, D. K. N., E. K. V. Kalko, B. König, and G. Kerth. 2005. Mating system of a Neotropical roost making bat: the white-throated, round-eared bat, *Lophostoma silvicolum* (Chiroptera: Phyllostomidae). Behavioral Ecology and Sociobiology 58:316–325.

Dechmann, D. K. N., E. K. V. Kalko, and G. Kerth. 2007. All-offspring dispersal in a tropical mammal with resource defense polygyny. Behavioral Ecology and Sociobiology 61:1219–1228.

Dechmann, D. K. N., and G. Kerth. 2008. My home is your castle: roost making is sexually selected in the bat *Lophostoma silvicolum*. Journal of Mammalogy 89:1379–1390.

Kalko, E. K. V., D. Friemel, C. O. Handley, Jr., and H.-U. Schnitzler. 1999. Roosting and foraging behavior of two Neotropical gleaning bats, *Tonatia silvicola* and *Trachops cirrhosus* (Phyllostomidae). Biotropica 31:344–353.

Kalko, E. K. V., K. Ueberschaer, and D. Dechmann. 2006. Roost structure, modification, and availability in the white-throated round-eared bat, *Lophostoma silvicolum* (Phyllostomidae) living in active termite nests. Biotropica 38:1–7.

Timm, R. M., and D. K. McClearn. 2007. The bat fauna of Costa Rica's Reserva Natural Absoluta Cabo Blanco and its implications for bat conservation. Pp. 303–352 *in* The quintessential naturalist: Honoring the life and legacy of Oliver P. Pearson (Kelt, D. A., E. P. Lessa, J. A. Salazar-Bravo, and J. L. Patton, eds.). University of California Publications in Zoology 134:1–981.

Waterton, C. 1879. Wanderings in South America. The northwest of the United States, and the Antilles, in the years 1812, 1816, 1820, & 1824. Macmillan and Co., London, England.

York, H. A., P. F. Foster, M. F. Jones, W. H. Schwarz, and A. L. Vezeau. 2008. Observations of cavity-roosting behavior in Costa Rican *Lophostoma brasiliense* (Chiroptera: Phyllostomidae). Mammalian Biology 73:230–232.

Associated editor: Consuelo Lorenzo
Submitted: August 6, 2021; Reviewed: September 7, 2021.
Accepted: October 5, 2021; Published on line: October 18, 2021.

THERYA NOTES 2021, Vol. 2 : 143-146 DOI: 10.12933/therya_notes-21-51 ISSN 2954-3614

First record of *Lasiurus arequipae* in the Department of Tacna, Perú

Primer registro de *Lasiurus arequipae* para el departamento de Tacna, Perú

Ruth Mamani-Contreras[1,2], and Giovanni Aragón-Alvarado[1,2*]

[1]Colección biológica de Tacna, Universidad Nacional Jorge Basadre Grohmann. Avenida Miraflores s/n, Ciudad Universitaria, C. P. 23000. Tacna, Perú. E-mail: ruthmcontreras88@gmail.com (RM-C); garagona@unjbg.edu.pe (GA-A).

[2]Laboratorio de Genética, Escuela Profesional de Biología Microbiología, Facultad de Ciencias, Universidad Nacional Jorge Basadre Grohmann. Avenida Miraflores s/n, Ciudad Universitaria, C. P. 23000. Tacna, Perú.

*Corresponding author

Lasiurus arequipae was recently described in the Department of Arequipa as a new species endemic to Perú, and its geographic distribution is poorly known. The presence of this species is reported in Lomas de Sama Grande, Department of Tacna, Perú. The specimen was collected during a study on the local fauna of bats, identified with the taxonomic key of Málaga *et al.* (2020), and compared with the holotype and paratypes deposited in the Scientific Collection of the Museum of Natural History at Universidad Nacional de San Agustín, Arequipa, Perú. The specimen is an adult female, preserved as skin, skull, and skeleton (not cleaned). One map of the current distribution of *L. arequipae* and information on the ecology of the species are included. We observed a potential shelter associated with the olive tree. This new record is located 287 km southwest of the town of Huatiapa, which is the closest record site where the first study took place in the Department of Arequipa. This finding brings to 11 the number of species of bats for the Department of Tacna. We recommend further sampling using supplementary methods to expand our knowledge of the natural history and ecology of this species and set conservation actions.

Key words: Atacama Desert; Chiroptera; Lomas de Sama Grande; shelter.

Lasiurus arequipae fue descrita recientemente en el departamento de Arequipa como especie nueva y endémica para Perú, con distribución geográfica poco conocida. Se reporta la especie en Lomas de Sama Grande, departamento de Tacna, Perú. El espécimen fue recolectado durante un estudio sobre la fauna local de murciélagos, identificado con la clave taxonómica de Málaga *et al.* (2020), y comparado con el holotipo y paratipos depositados en la Colección Científica del Museo de Historia Natural de la Universidad Nacional de San Agustín, Arequipa, Perú. Se trata de una hembra, adulto, conservado como piel, cráneo y esqueleto (sin limpiar). Además, se presenta un mapa de distribución actual de la especie y contribuciones sobre su ecología. Destaca la observación de un refugio potencial asociado con el árbol de olivo. Este nuevo registro se ubica a 287 km al suroeste de la localidad de Huatiapa, que es el sitio más cercano de registro en donde se llevó a cabo el primer estudio en el departamento de Arequipa. Este hallazgo eleva a 11 las especies de murciélagos para el departamento de Tacna. Se sugieren esfuerzos de muestreo con métodos complementarios para generar un mayor conocimiento de la historia natural y ecología de esta especie, y establecer acciones de conservación.

Palabras clave: Chiroptera; Desierto de Atacama; Lomas de Sama Grande; refugio.

The genus *Lasiurus* Gray, 1831 belongs to the family Vespertilionidae. It is distributed throughout America, including Hawaii and the Caribbean islands (Baird *et al.* 2015), and has been reported in various habitats ranging from sea level to 3,300 m (Graham 1983). Currently, at least 20 species of *Lasiurus* are recognized, nine of which inhabit South America (Gardner 2008; Baird *et al.* 2015; Baird *et al.* 2017; Málaga *et al.* 2020): *L. atratus* Handley, 1996; *L. blossevillii* (Lesson and Garnot, 1826); *L. castaneus* Handley, 1960; *L. villosissimus* E. Geoffroy, 1806; *L. ebenus* Fazzolari-Corrêa 1994; *L. ega* (Gervais, 1856); *L. egregius* (Peters, 1870); *L. varius* Poeppig, 1835; and *L. arequipae* Málaga, Díaz, Arias and Medina, 2020.

In Perú, 4 species of the genus *Lasiurus* have been reported: *L. blossevillii, L. villosissimus, L. ega* (Pacheco *et al.* 2009), and *L. arequipae,* endemic to the country (Málaga *et al.* 2020). The latter, little known, has a distribution restricted to two localities in the Department of Arequipa, on the western slope of the Andes. This paper reports a new record of *L. arequipae* that extends its geographic distribution based on one specimen collected in Lomas de Sama Grande, Department of Tacna, southern Perú. In addition, information on the ecology of this species is also provided.

The specimen collected corresponds to an adult female (CBT 529), preserved as skin, with the skull removed and skeleton (not cleaned) in 96° ethyl alcohol, deposited in the Tacna Biological Collection (CBT), Faculty of Sciences at Universidad Nacional Jorge Basadre Grohmann, Tacna, Perú. On 16 August 2020 at 16:00 hr, it was found perching on an olive tree (*Olea europaea L.*) and captured by hand, during a study on the local fauna of bats in the Lomas de

Sama Grande crop fields (17° 45′ 46.13″ S, 71° 5′ 48.56″ W, at 555 m). The area is adjacent to the Sama Inclán valley and the urban area of the Sama Inclán district, in the Sama River basin, located at the so-called "head of the Atacama Desert", *i.e.*, the lowlands of the Peruvian Andes western slope. This area comprises a gently sloping terrace and volcanic earth. The local vegetation is seasonal herbaceous, influenced by winter mists; it was converted into agricultural fields, especially for cultivating olive trees, and is surrounded by hills with ravines and dry riverbeds with sparse xeric vegetation (INEI 2000; INEI 2017).

Summers are hot, arid, and generally cloudy, and winters are cool, dry, and mostly clear. Throughout the year, the temperature ranges from 11 °C to 25 °C and rarely drops below 9 °C or above 28 °C. Rainfall is very scarce all year round (Ministerio de Agricultura 2010).

The specimen was identified using the taxonomic key for the genus *Lasiurus* by Málaga *et al.* (2020). It was compared with the external and cranial description of the holotype (MUSA 21058) and paratypes (MUSA 21891, MUSA 21853) of adult specimens deposited in the Scientific Collection of the Museum of Natural History at Universidad Nacional de San Agustín, Arequipa, Perú (MUSA). We recorded the following external and craniodental measurements with a precision caliper ± 0.01 mm, following the nomenclature with which Málaga *et al.* (2020) described the species: total length, ToL; tail length, TL; ear length, EL; hindfoot length, HFL; weight (gr); forearm length, FA; greatest length of skull, GLS; post-orbital constriction, PC; least interorbital breadth, LIB; zygomatic breadth, ZB; breadth of braincase, BB; palatal length, PL; condylobasal length, CBL; mastoidal breadth, MB; width across canines, C-C; width across molars, M-M; length of mandible, LM; length of mandibular toothrow, LMdT; length of maxillary toothrow, LMxT.

The specimen has the morphological characteristics of *L. arequipae* (Table 1; Málaga *et al.* 2020). It differs from other species of the genus *Lasiurus* by the following combinations of diagnostic characters: dorsal coloration is cinnamon to orange with tricolored hairs (black at the base, yellowish in the middle, and cinnamon to dark brown at the tip; Figure 1a); yellowish ventral coloration with bicolored hairs (black at the base and yellowish at the tip; Figure 1b); blackish wing membranes with opaque orange spots along the forearm and metacarpus in dorsal and ventral views (Figure 1c); uropatagium covered with hairs not exceeding the edge in dorsal view (Figure 1d); whitish patches at the insertion of the wings (Figure 1e).

In the skull, the tympanic ring is circular (Figure 1f), V-shaped anterior edge of nasal bones (Figure 1g), and ocular orbits oval in shape in dorsal view (Figure 1h). The specimen metrics, such as forearm length of 47.9 mm and length of maxillary toothrow of 6.1 mm, are within the range reported by Málaga *et al.* 2020 (Table 1). *Lasiurus arequipae* is morphologically most similar to *L. atratus, L. castaneus, L. blossevillii*, and *L. varius,* and differs from these species in that the latter are reddish to dark brown, with U-shaped

Table 1. Comparison of external morphological and craniodental measurements (mm) and weight (gr) of *Lasiurus arequipae* specimens reported by Málaga *et al.* (2020) and in the present study. Abbreviations are defined in the text.

	Arequipa			**Tacna**
	Huatiapa		**Chaucalla**	**Sama Grande (current study)**
	MUSA 21058 (male; holotype)	**MUSA 21891 (female; paratype)**	**MUSA 21853 (male; paratype)**	**CBT 529 (female)**
ToL	120	123	106	131.5
TL	60	64	56	64
EL	12.9	13	11	12.8
HFL	10.3	11	8.6	11.1
FA	46.4	47.6	46.7	47.9
Weight	13	12	12	12.5
GLS	14.2	14.3	13.7	14.2
PC	5	4.9	4.9	4.8
LIB	6.4	6.4	6.1	6.3
ZB	10.8	10.8	10.2	11.1
BB	8.1	8	7.9	8.2
PL	5.2	5.3	4.7	5.3
CBL	14.1	14.5	14	14.1
MB	8.9	8.9	8.6	8.9
C - C	5.4	5.8	5.4	5.9
M - M	6.5	6.8	6.6	7
LM	10.8	11.1	10.4	11.3
LMdT	5.8	6.1	5.8	6.1
LMxT	5	5.2	4.9	5.3

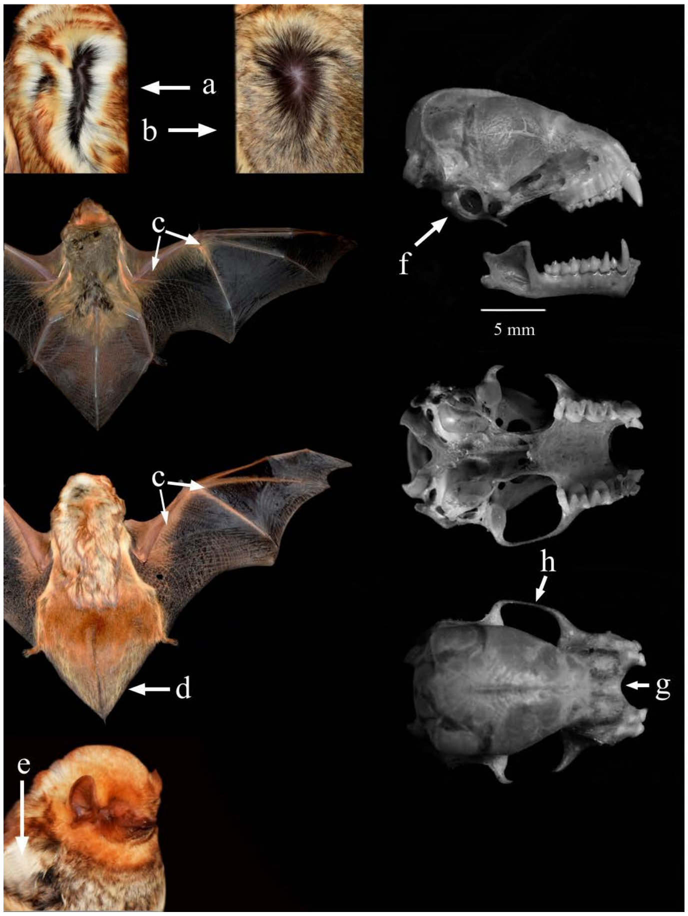


Figure 1. Female adult specimen of *Lasiurus arequipae* (CBT 529). Features of the pelage, coloration, and cranial structures are noted. Pelage and coloration: a) dorsal view, cinnamon to orange coloration with tri-colored hairs (black at the base, yellowish in the middle, and cinnamon to dark brown at the tip); b) ventra view, yellowish coloration with bicolored hairs (black at the base and yellowish at the tip); c) ventral and dorsal views, blackish wing membranes with opaque orange spots along the forearm and metacarpals; d) uropatagium covered with hairs not exceeding the edge in dorsal view; e) whitish patches at the insertion of the wings. Skull: f) lateral view, circular tympanic ring; g) dorsal view, V-shaped anterior edge of nasal bones; h) oval-shaped eye orbits in dorsal view.

anterior edge of nasal bones and oval tympanic ring. *Lasiurus arequipae* and *L. varius* share a similar dorsal coloration (cinnamon to orange) and differ in the color of the wing membrane, which is blackish mottled with opaque orange on both sides of the forearms and metacarpals in the former versus completely blackish in the latter.

The specimen was collected while perching on an olive tree branch along with three individuals, apparently of the same species based on the coloration observed when flying. This finding represents an extension of the distribution currently reported and the first record of *L. arequipae* in the Department of Tacna, in the Sama River valley, and is the southernmost location on the Pacific coast. The location reported here is 287 km southwest of the town of Huatiapa, which is the nearest record site in the Department of Arequipa (Figure 2), corresponding to the study carried out by Málaga *et al.* (2020).

Málaga *et al.* (2020) reported one individual of this species captured in the town of Huatiapa, at an elevation of 726 m in the province of Castilla, and two individuals captured in the town of Chaucalla, at 860 m in the province of La Unión. Both locations are found to the north of the province of Arequipa, and share similar physical and environmental characteristics with the town of Sama (555 m), *i.e.*, presence of terraces with crops, proximity to rivers, and hills with ravines. In addition, the local climate is characterized by narrow variations in temperature and low rainfall, and agricultural activities take place in both areas. Despite the few catches, it can be suggested that *L. arequipae* is associated with such conditions (González and Málaga 1997; Málaga *et al.* 2020).

Lasiurus arequipae is the only species reported for the Department of Tacna that has been recorded perching on a tree as a likely shelter. Tirira (2007) considers that the species in the genus *Lasiurus* are characterized by using branches and leaves of trees and shrubs as temporary shelters in agricultural land, open areas, and close to urban environments and water bodies. With this record, *L. arequipae* adds to the 10 bat species recorded in the Department of Tacna (Aragón and Aguirre 2014; Flores *et al.* 2015; Portugal-Zegarra *et al.* 2020): *Amorphochilus schnablii* Peters, 1877; *Desmodus rotundus* (É. Geoffroy, 1810); *Histiotus macrotus* (Poeppig, 1835); *Histiotus montanus* (Philippi and Landbeck, 1861); *Mormopterus kalinowskii* (Thomas, 1893); *Myotis atacamensis* (Lataste, 1892); *Platalina genovensium* Thomas, 1928; *Promops davisoni* Thomas, 1921; *Tadarida brasiliensis* (I. Geoffroy, 1824); and *Nyctinomops aurispinosus* (Peale, 1848).

Considering the distance from the localities of previous records in the Department of Arequipa, it is suggested that further research using supplementary sampling methods in intermediate and nearby sampling points sharing similar environmental conditions will provide additional valuable information about this species. The implementation of acoustic detection techniques to characterize echolocation pulses and their recognition in free flight, in addition to

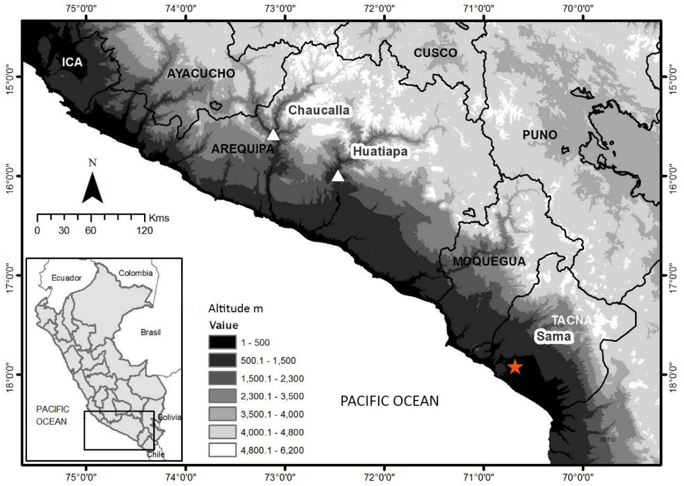


Figure 2. Records of *Lasiurus arequipae* in Perú. The towns of Chaucalla and Huatiapa are shown (white triangles; Málaga *et al.* 2020), as well as the location of the new record in the Department of Tacna, which is the southernmost region of Perú (orange star; CBT 529).

the use of mist nets, will improve further the knowledge of the distribution, natural history, and ecology of *L. arequipae* and will provide elements for the conservation strategies of this species.

Acknowledgements

We wish to thank the Universidad Nacional Jorge Basadre Grohmann of Tacna, Perú, for funding our study with mining royalty funds. To D. Rivera, for his assistance in the laboratory phase; to R. Flores, for assistance in the elaboration of the map; to B. Málaga, for his comments and confirmation in the identification of the specimen registered in Tacna; to M. E. Rodríguez-Posada and L. Trujillo for their suggestions in the drafting of the manuscript; and to the Servicio Nacional Forestal y de Fauna Silvestre (National Forest and Wildlife Service; SERFOR) for issuing the collection permit (AUT-IFS-2020-034) for scientific research purposes. Finally, we appreciate the valuable comments and suggestions provided by the anonymous reviewers that improved earlier versions of this manuscript. M. E. Sánchez-Salazar translated the manuscript into English.

Literature cited

Aragón, G., and M. Aguirre. 2014. Distribución de murciélagos en la región de Tacna (Perú). Idesia 32:119-127.

Baird, A. B., J. K. Braun, M. A. Mares, J. C. Morales, J. C. Patton, C. Q. Tran, and J. W. Bickham. 2015. Molecular systematic revision of tree bats (Lasiurini): doubling the native mammals of the Hawaiian Island. Journal of Mammalogy 96:12553-12574.

Baird, A. B., J. K. Braun, M. D. Engstrom, A. C. Holbert, M. G. Huerta, B. K. Lim, M. A. Mares, J. C. Patton, and J. W. Bickham. 2017. Nuclear and mtDNA phylogenetic analyses clarify the evolutionary history of two species of native Hawaiian bats and the taxonomy of Lasiurini (Mammalia: Chiroptera). Plos One 12:e0186085.

Flores, M., G. Calizaya, V. Pacheco, and G. Aragón. 2015. Distribution of *Promops davisoni* Thomas, 1921 (Chiroptera: Molossidae) in Peru with a new record and southward range extension. Check List 11:1573.

Gardner, A. L. (ed.). 2008. Mammals of South America Vol 1: marsupials, xenarthrans, shrews and bats. 2d. Ed. Smithsonian Institution Press. Washington D. C., U.S.A.

González, O. E., and E. Málaga. 1997. Distribución de aves en el valle de Majes, Arequipa. Onitología Neotropical 8:57-69.

Graham, G. L. 1983. Changes in bat species diversity along an elevational gradient up the Peruvian Andes. Journal of Mammalogy 64:559-571.

Instituto Nacional de Estadística e Informática (INEI). 2000. Conociendo Tacna. Downloaded at https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib0366/Libro.pdf. Accessed 20 August 2021.

Instituto Nacional de Estadística e Informática (INEI). 2017. Tacna compendio estadístico 2017. Downloaded at https://www.inei.gob.pe/media/MenuRecursivo/publicaciones_digitales/Est/Lib1508/libro.pdf. Accessed 20 August 2021.

Málaga, B. A., D. R. Díaz, S. Arias, and C. E. Medina. 2020. Una especie nueva de *Lasiurus* (Chiroptera: Vespertilionidae) del suroeste de Perú. Revista Mexicana de Biodiversidad 91:e913096.

Ministerio de Agricultura. 2010. Estudio de evaluación de recursos hídricos superficiales en las cuencas de los ríos Locumba y Sama. Vol. I. Downloaded at https://www.ana.gob.pe/sites/default/files/normatividad/files/evaluacion_de_rh_superficiales_locumba_-_sama_0_2.pdf. Accessed 23 August 2021.

Pacheco, V., R. Cadenillas, E. Salas, C. Tello, and H. Zeballos. 2009. Diversidad y endemismo de los mamíferos del Perú. Revista Peruana de Biología 16:005-032.

Portugal-Zegarra, G., M. Flores-Quispe, G. Calizaya-Mamani, and G. Aragón. 2020. New record of *Nyctinomops aurispinosus* with an update of its known distribution. Therya Notes 1:67-76.

Tirira, D. G. 2007. Guía de campo de los mamíferos del Ecuador. Ediciones Murciélago Blanco. Quito, Ecuador.

Associated editor: Cristian Kraker-Castañeda
Submitted: March 23, 2021; Reviewed: September 2, 2021.
Accepted: October 6, 2021; Published on line: October 18, 2021.

THERYA NOTES 2021, Vol. 2 : 147-150 DOI: 10.12933/therya_notes-21-52 ISSN 2954-3614

Potential attack of the common vampire bat (*Desmodus rotundus*) on nine-banded armadillo (*Dasypus novemcinctus*) in northern Oaxaca, México

Ataque potencial del vampiro común (*Desmodus rotundus*) a un armadillo de nueve bandas (*Dasypus novemcinctus*) en el norte de Oaxaca, México

Jesús Alejandro Ríos-Solís[1], Juan Carlos López-Acosta[1], and M. Cristina MacSwiney G.[1]*

[1]Centro de Investigaciones Tropicales, Universidad Veracruzana. Calle José María Morelos y Pavón 44, Centro, C. P. 91000. Xalapa, Veracruz, México. E-mail: biol-alex@hotmail.com (JAR-S); carlolopez@uv.mx (JCL-A); cmacswiney@uv.mx (MCMG).
*Corresponding author

The common vampire bat, *Desmodus rotundus*, is considered a predator and an obligate feeder on vertebrate blood of a diverse group of prey, but with preference to both native and exotic mammals. The present record is the first documented potential predation of a nine-banded armadillo, *Dasypus novemcinctus,* by *D. rotundus* in the wild. The observation was recorded on a camera trap set in a secondary growth fragment of tropical evergreen forest in Oaxaca, México. In a 10 second recording, we observed an individual of *D. rotundus* stalking and chasing an individual *D. novemcinctus* that is searching for food in the leaf litter. The present observation along with another study carried out in Brazil, where a vampire bat chased a giant armadillo *Priodontes maximus,* suggest that armadillos might be prey of *D. rotundus*, but the interaction is difficult to document in the wild.

Key words: Chiroptera; ecological interaction; predation; sanguivorous bat; southern México.

El murciélago vampiro común, *Desmodus rotundus*, es un depredador que de forma obligatoria, se alimenta de sangre de vertebrados de un grupo diverso de presas, pero con preferencia a los mamíferos, tanto nativos como exóticos. El presente registro documenta la primera depredación potencial de un armadillo de nueve bandas, *Dasypus novemcinctus*, por *D. rotundus* en vida silvestre. La observación se registró en una cámara trampa colocada en un fragmento de crecimiento secundario de un bosque tropical perennifolio en Oaxaca, México. En una grabación de 10 segundos, observamos a un individuo de *D. rotundus* acechando y persiguiendo a un individuo de *D. novemcinctus* que busca alimento en la hojarasca. La presente observación, junto con otro estudio realizado en Brasil, donde un murciélago vampiro persiguió a un armadillo gigante *Priodontes maximus*, sugiere que los armadillos podrían ser presas de *D. rotundus*, pero la interacción es difícil de registrar en vida silvestre.

Palabras clave: Chiroptera; depredación; interacción ecológica; murciélago sanguívoro; sur de México.

The three vampire bat species are distributed in México (Medellín *et al.* 2008), being the common vampire bat, *Desmodus rotundus*, the most widespread and abundant one. This species is distributed from Sonora and Tamaulipas, México, through Central and South America to the north of Chile and north of Argentina (Reid 2009). *Desmodus rotundus* inhabits a wide range of vegetation types including mature forest, secondary growth, several crops, and pasturelands (Coates-Estrada and Estrada 1986); it occurs from sea level to over 3,500 m (Martins *et al.* 2009), but its distribution is limited to areas warmer than the 10 ºC isotherm in January because of the animal's poor capacity to thermoregulate (McNab 1973).

The common vampire bat is considered a predator and an obligate blood-feeding mammal, feeding on a diverse group of vertebrates, but with preference to mammals (Reid 2009). It has been documented that it can feed on several breeds of livestock such as cows, sheeps, pigs, goats, horses, mules, and poultry (Greenhall 1988; Delpietro *et al.* 1992; Bobrowiec *et al.* 2015), and that it has a strong preference of these over native species, at least in areas under strong human influence (Voigt and Kelm 2006). It also preys on several species of reptiles and birds (Carter *et al.* 2021).

The common vampire bat shows terrestrial locomotion that allows it to sneak up on its prey to feed and to be able to escape if some danger threatens it (Riskin *et al.* 2006). Vampire bats are agile predators that are rarely seen in the wild. However, the use of camera traps in the last years has provided insights about its feeding behavior both in native and exotic species. For example, recent studies have shown predation upon the South American tapir *Tapirus terrestris* (Gnocchi and Srbek-Araujo 2017), the capybara *Hydrochoerus hydrochaeris* (Gonçalves *et al.* 2020), the collared peccary *Pecari tajacu* (Zortéa *et al.* 2018), the exotic wild pig *Sus scrofa* (Hernández-Pérez *et al.* 2019), among others. In the present study, we report the possible predation event of a common vampire bat *D. rotundus* on a nine-banded armadillo, *Dasypus novemcinctus*.

The interaction between the common vampire bat, *D. rotundus,* and the armadillo, *D. novemcinctus*, was registered on a camera trap Cuddeback Model E3 on December 5th 2015, at 20:26 hr in the locality of San Cristóbal La Vega, the municipality of San Juan Bautista Valle Nacional, Oaxaca, México. The camera trap was set at the coordinates 17° 46′ 8.01″ N, 96° 15′ 6.47″ W, in a secondary growth fragment of tropical evergreen forest.

In a 10-second recording, we observed an individual of *D. rotundus* stalking and chasing an individual of *D. novemcinctus* that is searching for food in the leaf litter its forefeet and snout. The individual of *D. rotundus* landed in the proximity of the armadillo, in the following seconds the armadillo moved out of the camera frame, and we observed the vampire moving the head and emitting calls, probably to locate the armadillo and after this, it flew away in the same direction of the armadillo (Figure 1 A-D; Appendix 1).

In the past 10 ten years, photographs and videos taken with camera traps have shown *D. rotundus* feeding on a variety of species in the wild, including wild feral pigs and collared peccaries, lowland tapirs, red brocket deer, white-tailed deer, chital deer, orange breasted falcon, tamandua, giant armadillo and a mountain lion (reviewed by Carter *et al.* 2021). The present record is the first documented potential attack of an armadillo by *D. rotundus* in the wild, based on the behavior displayed by *D. rotundus*, that usually lands close to a potential prey and chase this until find a vulnerable part of the body to bite (Zortéa *et al.* 2018). There is only one previous record of the interaction between *D. rotundus* and *D. novemcinctus*, but it took place in captivity. Greenhall (1988) conducted behavioral studies in the laboratory and observed an individual of *D. rotundus* feeding on the captive *D. novemcinctus*. In this study, *D. rotundus* bit the armadillo in the tail between the scutes and on a foot, with no defensive reaction from the prey.

In a recent study carried out in Brazil, the authors recorded a vampire bat chasing another species of armadillo, the giant armadillo *Priodontes maximus,* in a similar fashion as the observation recorded in the present study (Zortéa *et al.* 2018). These observations suggest that armadillos might be the prey of *D. rotundus*, but the interaction is difficult to document and needs to be confirmed in the wild. In the following years, with the increasing use of camera traps, we might be able to record more interaction events between these two species.

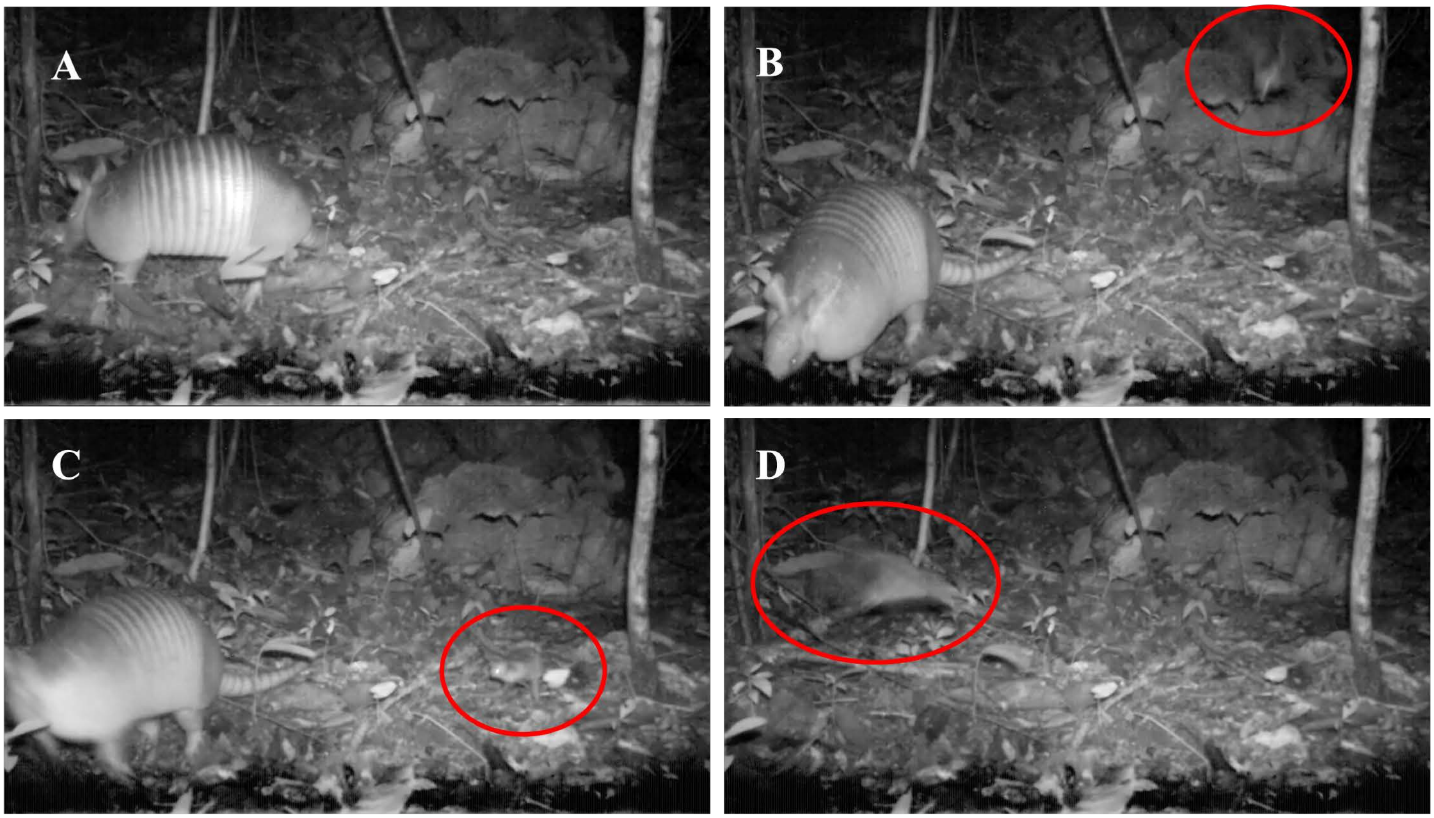


Figure 1. Sequence of the stalking behavior of the common vampire bat *Desmodus rotundus* (encircled in red) to an individual of a nine-banded armadillo *Dasypus novemcinctus*: A) the individual of *D. novemcinctus* is searching for prey in the leaf litter; B) the common vampire bat *D. rotundus* lands in the ground; C) the armadillo moves away while the vampire bat seems to emit vocalizations to locate the armadillo; D) the bat flies in the same direction to the armadillo.

Acknowledgements

The first author thanks Comisión Nacional de Areas Naturales Protegidas (CONANP) for the funding of the project PROCER/RFSIPS/15/2015 and Consejo Nacional de Ciencia y Tecnología for the scholarship (#463734) awarded for his master's studies. We thank the partial financial support provided by the Centro de Investigaciones Tropicales, Universidad Veracruzana, and we also thank the authorities of the ejido of San Cristóbal La Vega, municipio de San Juan Bautista Valle Nacional, Oaxaca, México. We thank the two anonymous reviewers whose comments improved earlier versions of this manuscript.

Literature cited

Bobrowiec, P. E. D., M. R. Lemes, and R. Gribel. 2015. Prey preference of the common vampire bat (*Desmodus rotundus*, Chiroptera) using molecular analysis. Journal of Mammalogy 96:54–63.

Carter, G., B. Brown, I. Razik, and S. Ripperger. 2021. Penguins, falcons, and mountain lions: The extraordinary host diversity of vampire bats. Pp. 151-170 *in* 50 Years of bat research Foundations and New Frontiers (Lim, B. K., M. B. Fenton, R. M. Brigham, S. Mistry, A. Kurta, E. H. Gillam, A. Russell, and J. Ortega, eds.). Springer Nature. Cham, Switzerland.

Coates-Estrada, R., and A. Estrada. 1986. Manual de identificación de campo de los mamíferos de la Estación de Biología "Los Tuxtlas." Universidad Nacional Autónoma de México. México City, México.

Delpietro, H. A., N. Marchevsky, and E. Simonetti. 1992. Relative population densities and predation of the common vampire bat (*Desmodus rotundus*) in natural and cattle-raising areas in north-east Argentina. Preventive Veterinary Medicine 14:13–20.

Gnocchi, A. P., and A. C. Srbek-Araujo. 2017. Common vampire Bat (*Desmodus rotundus*) feeding on Lowland Tapir (*Tapirus terrestris*) in an Atlantic Forest remnant in southeastern Brazil. Biota Neotropica 17:e20170326.

Gonçalves, F., M. Magioli, R. S. Bovendorp, K. M. P. M. de Barros-Ferraz, L. Bulascoschi-Cagnoni, M. Z. Moreira, and M. Galetti. 2020. Prey choice of introduced species by the common vampire bat (*Desmodus rotundus*) on an Atlantic Forest Land-Bridge Island. Acta Chiropterologica 22:167–174.

Greenhall, A. M. 1988. Feeding behavior. Pp. 111–131 *in* Natural history of vampire bats (Greenhall, A. M., and U. Schmidt, eds.). CRC Press. Boca Ratón, Florida, U.S.A.

Hernández-Pérez, E. L., G. Castillo-Vela, G. García-Marmolejo, M. Sanvicente-López, and R. Reyna-Hurtado. 2019. Wild pig (*Sus scrofa*) as prey of the common vampire bat (*Desmodus rotundus*). Therya 10:195–199.

Martins, F. M., A. R. Templeton, A. C. Pavan, B. C. Kohlbach, and J. S. Morgante. 2009. Phylogeography of the common vampire bat (*Desmodus rotundus*): marked population structure, Neotropical Pleistocene vicariance and incongruence between nuclear and mtDNA markers. BMC Evolutionary Biology 9:294.

McNab, B. 1973. Energetics and the distribution of vampires. Journal of Mammalogy 54:131–144.

Medellín, R., H. Arita, and O. Sánchez. 2008. Identificación de los murciélagos de México. Clave de campo. 2d. Ed. Instituto de Ecología, Universidad Nacional Autónoma de México. México City, México.

Reid, F. 2009. A Field Guide to the Mammals of Central America and Southeast Mexico. 2d. Ed. Oxford University Press. New York, U.S.A.

Riskin, D. K., S. Parsons, W. A. Schutt, G. G. Carter, and J. W. Hermanson. 2006. Terrestrial locomotion of the New Zealand short-tailed bat *Mystacina tuberculata* and the common vampire bat *Desmodus rotundus*. Journal of Experimental Biology 209:1725–1736.

Voigt, C. C., and D. H. Kelm. 2006. Host preference of the common vampire bat (*Desmodus rotundus*; Chiroptera) assessed by stable isotopes. Journal of Mammalogy 87:1–6.

Zortéa, M. D. A. Silva, and A. M. Calaça. 2018. Susceptibility of targets to the vampire bat *Desmodus rotundus* are proportional to their abundance in Atlantic Forest fragments? Iheringia, Série Zoologia 108:e2018037.

Associated editor: Jesús R. Hernández-Montero
Submitted: June 22, 2021; Reviewed: August 21, 2021.
Accepted: October 11, 2021; Published on line: November 1, 2021.

Appendix 1

Video of the interaction between a nine-banded armadillo *Dasypus novemcinctus* and the common vampire bat *Desmodus rotundus,* recorded in a secondary forest fragment of evergreen forest in Oaxaca, México.

Video hosted in: http://doi.org/10.5281/zenodo.5007162

THERYA NOTES 2021, Vol. 2 : 151-155

DOI: 10.12933/therya_notes-21-53 I SSN 2954-3614

Plusaetis sibynus (Siphonaptera: Ceratophyllidae): a new record of flea on *Didelphis virginiana*, with a checklist of fleas for this host

Plusaetis sibynus (Siphonaptera: Ceratophyllidae): nuevo reporte de pulga en *Didelphis virginiana*, con lista de pulgas para este hospedero

Yury Glebskiy[1,2]*, Roxana Acosta-Gutiérrez[3], and Zenón Cano-Santana[1]

[1]Laboratorio de Interacciones y Procesos Ecológicos, Facultad de Ciencias, Universidad Nacional Autónoma de México, Ciudad Universitaria, Coyoacán, C. P. 04510. Ciudad de México, México. E-mail: agloti@ciencias.unam.mx (YG); zcs@ciencias.unam.mx (ZC-S).

[2]Posgrado en Ciencias Biológicas, Universidad Nacional Autónoma de México, Edificio D, 1er Piso, Circuito de Posgrados, Ciudad Universitaria, Coyoacán, C. P. 04510. Ciudad de México, México.

[3]Museo de Zoología "Alfonso L. Herrera", Facultad de Ciencias, Universidad Nacional Autónoma de México, Ciudad Universitaria, Coyoacán, C. P. 04510. Ciudad de México, México. E-mail: roxana_a2003@yahoo.com.mx (RA-G).

*Corresponding author

Virginia opossums (*Didelphis virginiana*) are hosts to a variety of fleas that can be important vectors for diseases, including some zoonosis; therefore, it is important to generate knowledge about the fleas that parasite this animal. We present the list of all fleas found on opossums, and the discovery of a species that has not been previously found on *D. virginiana*, neither on other marsupials. We collected fleas from Virginia opossums in the urban area of México City, México, and performed a bibliographical search to determine which species of fleas were previously recorded. We found previous records of 26 species of fleas on opossums, and we added the flea species *Plusaetis sibynus* to this list. *Plusaetis sibynus* is a common flea of rodents (mainly *Peromyscus* and *Neotoma*), representing a potential vector of diseases from these rodents to the opossum and human populations. Further research is needed to assess the role of this flea as a vector of zoonotic diseases.

Key words: Diseases; new world marsupials; *Plusaetis sibynus*; opossum; zoonosis.

El tlacuache de Virginia (*Didelphis virginiana*) es hospedero para una variedad de pulgas que pueden ser importantes vectores para la transmisión de enfermedades, incluyendo zoonosis; por lo tanto, es importante generar conocimiento sobre las pulgas que parasitan a este animal. En este trabajo, presentamos la lista de pulgas que parasitan a los tlacuaches, con la adición de una especie que no ha sido registrada previamente en *D. virginiana*, ni en otros marsupiales. Colectamos pulgas de tlacuaches de Virginia en el área urbana de la Ciudad de México, México, y también realizamos una búsqueda bibliográfica para determinar las especies de pulgas reportadas previamente. Encontramos registros de 26 especies de pulgas en los tlacuaches y añadimos a esta lista la especie de pulga *Plusaetis sibynus*. *Plusaetis sibynus* es una pulga común en roedores (principalmente *Peromyscus* y *Neotoma*), por lo que representa un vector potencial para la transmisión de enfermedades de estos roedores a los tlacuaches, y posteriormente a las poblaciones humanas. Se requieren más estudios para determinar el papel de esta pulga como vector de enfermedades zoonóticas.

Palabras clave: Enfermedades; marsupiales del Nuevo Mundo; *Plusaetis sibynus*; tlacuaches, zoonosis.

Fleas (Siphonaptera), among other parasites, are important vectors that transmit diseases (Krueger *et al.* 2016; Dean *et al.* 2018), both between individuals of the same species and between different species, including the transmission of significant zoonotic diseases like the bubonic plague (Dean *et al.* 2018). However, flea species have a certain range of host species on which they can inhabit, and between which they are likely to transmit the diseases. In this case, we studied fleas parasitizing the Virginia opossum, *Didelphis virginiana* Kerr, 1792, a very common and widely distributed marsupial (McManus 1974), adapted well to the urban environments (Wright *et al.* 2012). Such characteristics point out to the Virginia opossum as an important host of parasites known as vectors of zoonotic diseases, so specific studies are needed. Previous studies show that opossums are vectors of several zoonotic diseases: leptospirosis, salmonellosis (Ruiz-Piña *et al.* 2002), toxoplasmosis (Torres-Castro *et al.* 2016), among others, including microorganisms transmitted by fleas, most remarkable *Rickettsia* (Krueger *et al.* 2016). Therefore, this work aims to report a new species of flea found on a Virginia opossum and offer a checklist of fleas reported previously on this host species.

From January to March 2020, we live-trapped Virginia opossums in six locations in southern parts of the urban area of México City, México (Figure 1), using pitfall traps consisting of plastic containers 75 cm in height and 50 cm

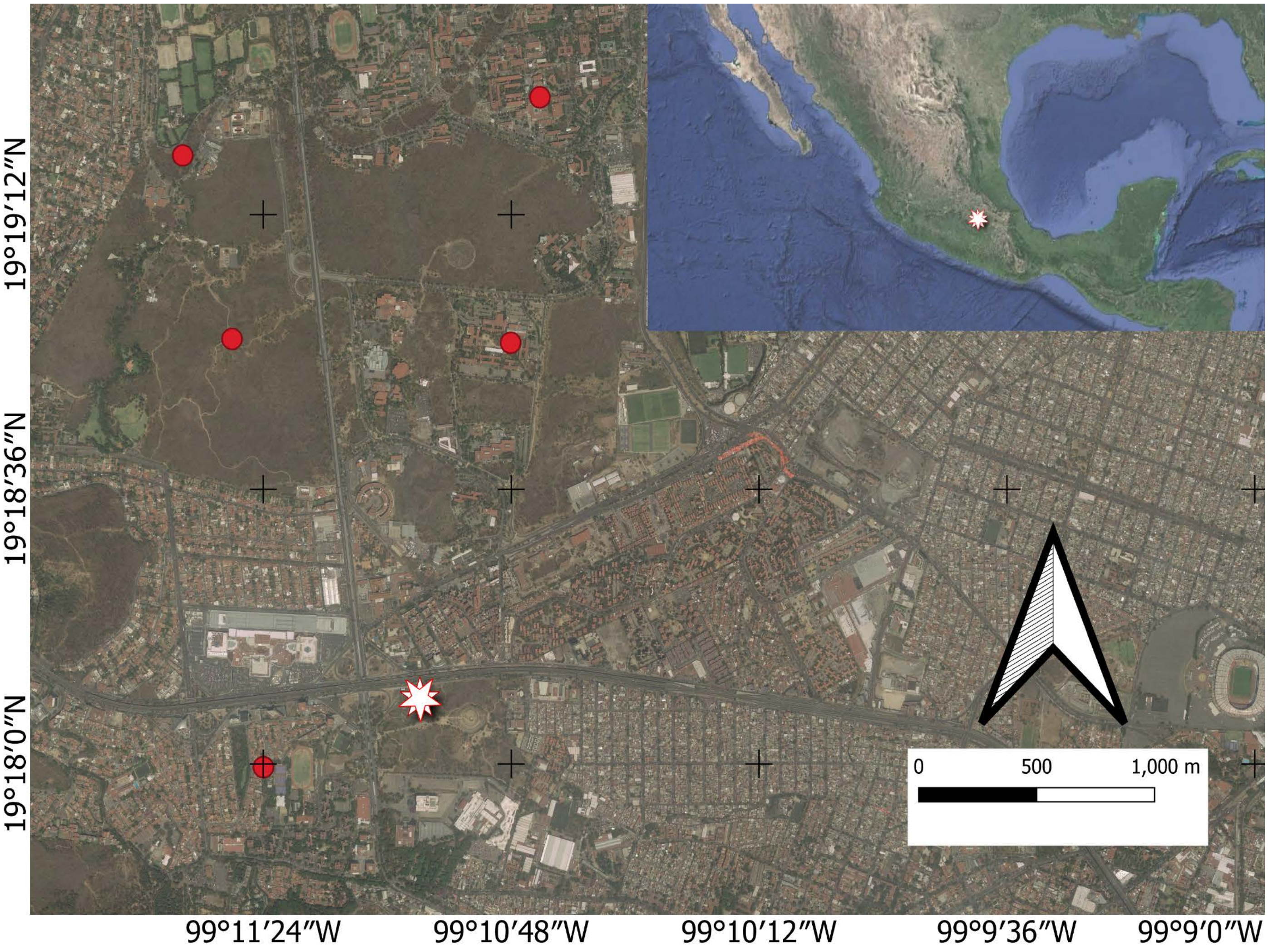


Figure 1. Map of the study sites (red dots). The white star shows the location where *Plusaetis sibynus* was found, notice that this location is surrounded by urban areas.

in diameter. We made a total effort of 144 trap-nights, and fleas were collected from Virginia opossums and stored in vials with 70 % ethanol and labeled (all captured opossums were released). Fleas were identified following Traub (1950), Acosta and Morrone (2003), and Salceda-Sánchez (2004).

Complementarily, we performed a bibliographical search of parasites hosted by the Virginia opossum, using the following terms: "pulga + *Didelphis virginiana*", "flea + *Didelphis virginiana*", and "Siphonaptera + *Didelphis virginiana*".

We captured a total of 32 specimens of Virginia opossums and collected a total of 18 fleas on 12 individuals. Out of the total, 17 fleas were identified as *Ctenocephalides felis* (Bouché, 1835; Pulicidae) by the presence of the genal comb horizontal, usually extending entire length of lower margin of head and located below of eye, the genal spines are equal, and has a low sloping forehead (Salceda-Sánchez 2004), and 1 male individual of *Plusaetis sibynus* (Jordan, 1925) (Ceratophyllidae; Figure 2), by an occiput (in post antennal region) with 2 or more longish bristles behind base of antennal groove and 3 or more in the middle, arranged in rows; eighth tergum with 5 or 6 median and 2 ventral lateral bristles; and the eighth sternum (Traub 1950). This representing the first time *P. sibynus* is found on a Virginia opossum, or any other marsupial.

In the bibliographical search, we found 26 species of fleas belonging to 18 genera, and 5 families, which were previously reported on the Virginia opossum across 4 countries (Table 1). *Plusaetis sibynus* represents species number 27 in the checklist.

Before this work, *P. sibynus* was only reported for rodent species of the genera *Peromyscus*, *Neotoma*, and *Reithrodontomys* (Acosta 2005; Montiel *et al.* 2019). This report unveils a possible vector of zoonotic diseases between the rodents and opossums, and it is especially important since the host rodent genera are common in natural areas (or their remnants, such as parks inside urban areas), but not in the urbanized areas (Bolger *et al.* 1997; Harris *et al.* 2016), so their contact with humans is limited, yet opossums can occur in both (Wright *et al.* 2012). Therefore, hypothetically, the Virginia opossums could act as a bridge for microorganisms of public health concern, between the field rodents and the urban human populations. However, further studies are needed to truly assess the potential of disease transmission via this vector parasitizing Virginia opossums, and the identity of such diseases, especially considering that other species of the genus *Plusaetis* have proven to carry zoonotic bacteria like *Bartonella* (Sánchez-Montes *et al.* 2019).

When analyzing the historical records of fleas on Virginia opossums (Table 1), we found that the most common flea in geographical range, number of reports, and abundance, is the cat flea, *Ctenocephalides felis* (Hernández-Camacho *et al.* 2014; Krueger *et al.* 2016; this study). This finding is relevant since it is a very common flea that can be hosted by many species, including domestic animals (Maina *et al.* 2016); therefore, it can move diseases even closer to human populations. We conclude that the Virginia opossum has an important potential for spreading diseases, and the vectors connecting this species to other animals should be carefully studied.

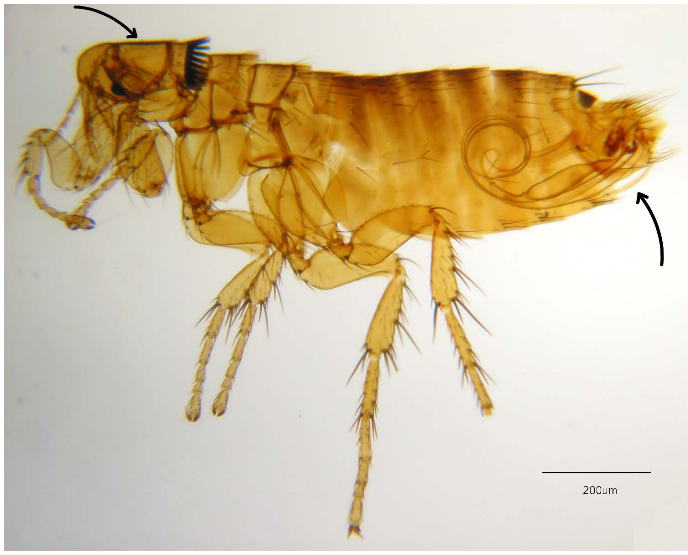


Figure 2. Photograph of the specimen of *Plusaetis sibynus* (male) found on *Didelphis virginiana*. Occiput, upper arrow. Sternum VIII, right arrow.

Table 1. List of families and flea species on the Virginia opossum, *Didelphis virginiana*, and the countries where they are reported.

Species	Country	Reference
Ceratophyllidae		
Nosopsyllus fasciatus (Bosc, 1800)	USA	Elbel 1951
Orchopeas howardi (Baker, 1895)	USA	Mohr and Morlan 1959
Orchopeas leucopus (Baker, 1904)	USA	Whitaker *et al.* 1976
Orchopeas wickhami (Baker, 1895)	USA	Shaftesbury 1934
Oropsylla arctomys (Baker, 1904)	USA	Holland and Benton 1968
Plusaetis sibynus (Jordan, 1925)	México	This study
Hystrichopsyllidae		
Corrodopsylla hamiltoni (Traub, 1944)	USA	Schiefer and Lancaster 1970
Ctenophthalmus pseudagyrtes Baker, 1904	USA	Whitaker *et al.* 1976
Epitedia neotomae Jameson, 1946	USA	McAllister *et al.* 2017
Leptopsyllidae		
Ctenopsyllus catatina (Jordan 1928)	USA	Shaftesbury 1934
Leptopsylla segnis (Schonherr, 1811)	USA	Mohr and Morlan 1959
Odontopsyllus multispinosus (Baker, 1898)	USA	Mohr and Morlan 1959
Pulicidae		
Cediopsylla simplex (Baker, 1895)	USA	Whitaker *et al.* 1976
Ctenocephalides canis (Curtis, 1826)	USA	Whitaker *et al.* 1976
Ctenocephalides felis (Bouche, 1835)	Guatemala, México, USA	Mohr and Morlan 1959; Villalobos-Cuevas *et al.* 2016; Escobar *et al.* 2011; this study
Echidnophaga gallinacea (Westwood, 1875)	USA	Mohr and Morlan 1959
Hoplopsyllus glacialis (Taschenberg, 1880)	México, USA	Schiefer and Lancaster 1970; Hernández-Camacho *et al.* 2014
Pulex irritans Linnaeus, 1759	México, USA	Mohr and Morlan 1959; Villalobos-Cuevas *et al.* 2016
Pulex porcinus Jordan & Rothschild, 1924	México	Villalobos-Cuevas *et al.* 2016
Pulex simulans Baker, 1895	México, USA	Wilson and Bishop 1966
Xenopsylla cheopis (Rothschild, 1903)	USA	Mohr and Morlan 1959
Rhopalopsyllidae		
Polygenis gwyni (C. Fox, 1914)	USA	McAllister *et al.* 2017
Polygenis martinezbaezi Vargas, 1951	México	Hernández-Camacho *et al.* 2014
Rhopalopsyllus australis (Rothschild, 1904)	México	Villalobos-Cuevas *et al.* 2016
Rhopalopsyllus coxi Eads, 1946	USA	Randolph and Eads 1946
Rhopalopsyllus lugubris Jordan & Rothschild, 1908	Costa Rica	Durden and Campbell 2016
Chaetopsylla lotoris (Stewart, 1926)	USA	Whitaker *et al.* 1976

Acknowledgements

We are thankful to I. Castellanos-Vargas and M. Guzmán-Torres for technical support, and to E. G. Vázquez-Domínguez, V. M. Sánchez-Cordero, and two anonymous reviewers for their comments. Also, to the teams of SEREPSA (S. Cram-Heydrich), Cuicuilco Archeological Zone (R. López Valenzuela), Villa Olímpica Sports Center (M. Barrera-Rangel), and Taller de Plantas of the Faculty of Sciences, UNAM (M. E. Muñiz Díaz), for facilitating the permissions and support. This work was possible thanks to a scholarship provided by the CONACYT to YG (CVU 817316), and the PAPIIT grant IN212121 (El efecto de la urbanización sobre el tlacuache *Didelphis virginiana* en un matorral xerófilo de la Ciudad de México), awarded to ZCS.

Literature cited

Acosta, R., and J. Morrone. 2003. Clave ilustrada para la identificación de los taxones supraespecíficos de Siphonaptera de México. Acta Zoológica Mexicana (Nueva Serie) 89:39-53.

Acosta, R. 2005. Relación huésped-parásito en pulgas (Insecta: Siphonaptera) y roedores (Mammalia: Rodentia) del estado de Querétaro, México. Folia Entomológica Mexicana 44:37-47.

Bolger, D. T., A. C. Alberts, R. M. Sauvajot, P. Potenza, C. McCalvin, D. Tran, S. Mazzoni, and M. E. Soulé. 1997. Response of rodents to habitat fragmentation in coastal southern California. Ecological Applications 7:552-563.

Dean, K. R., F. Krauer, L. Walløe, O. C. Lingjærde, B. Bramanti, N. C. Stenseth, and B. V. Schmid. 2018. Human ectoparasites and the spread of plague in Europe during the Second Pandemic. Proceedings of the National Academy of Sciences 115:1304-1309.

Durden, L. A., and D. C. Campbell. 2016. Fleas, Lice, and Epifaunistic Pseudoscorpions of Some Native Mammals in Northwestern Costa Rica. Comparative Parasitology 83:240-244.

Elbel, R. E. 1951. Comparative studies on the larvae of certain species of fleas (Siphonaptera). The Journal of Parasitology 37:119-128.

Escobar, L. E., D. Alvarez, F. J. Villatoro, D. Moran, and A. Estevez. 2011. Two new flea records from Guatemala: *Pulex simulans* and *Echidnophaga gallinacea* (Siphonaptera: Pulicidae), and their host-parasite relationship. Journal of Parasitology and Vector Biology 3:40-43.

Harris, S. E., A. T. Xue, D. Alvarado-Serrano, J. T. Boehm, T. Joseph, M. J. Hickerson, and J. Munshi-South. 2016. Urbanization shapes the demographic history of a native rodent (the white-footed mouse, *Peromyscus leucopus*) in New York City. Biology Letters 12:20150983.

Hernández-Camacho, N., S. Vergara-Pineda, R. Acosta-Gutiérrez, and R. W. Jones. 2014. Nuevos registros de pulgas de tlacuaches *Didelphis virginiana* (Kerr 1792) en Querétaro, México. Therya 5:347-353.

Holland, G. P., and A. H. Benton. 1968. Siphonaptera from Pennsylvania mammals. American Midland Naturalist 252-261.

Krueger, L., Y. Bai, S. Bennett, C. Fogarty, S. Sun, M. Kosoy, A. Maina, K. Nelson, E. Platzer, L. Osikowicz, A. L. Richards, F. Shariar, A. Trinidad, and R. Cummings. 2016. Identification of Zoonotic and Vector-borne Infectious Agents Associated with Opossums (*Didelphis virginiana*) in Residential Neighborhoods of Orange County, California. Proceedings of the Vertebrate Pest Conference 27.

Maina, A. N., C. Fogarty, L. Krueger, K. R. Macaluso, A. Odhiambo, K. Nguyen, C. M. Farris, A. Luce-Fedorow, J. Bennett, S. Jiang, S. Sun, R. F. Cummings, and A. L. Richards. 2016. Rickettsial infections among *Ctenocephalides felis* and host animals during a flea-borne rickettsioses outbreak in Orange County, California. PLoS One 11:e0160604.

McAllister, C. T., L. A. Durden, H. W. Robison, and M. B. Connior. 2017. The fleas (Arthropoda: Insecta: Siphonaptera) of Arkansas. Journal of the Arkansas Academy of Science 71:69-76.

McManus, J. J. 1974. *Didelphis virginiana*. Mammalian Species 40:1-6.

Mohr, C. O., and H. B. Morlan. 1959. The nature of parasitism of the opossum by fleas in southwestern Georgia. The Journal of Parasitology 45:233-237.

Montiel, F. A., A. Estrada-Torres, R. Acosta, M. Rubio-Godoy, and J. Vázquez. 2019. Host species influence on flea (Siphonaptera) infection parameters of terrestrial micromammals in a temperate forest of Mexico. Parasitology 146:670-677.

Randolph, N. M., and R. B. Eads. 1946. An ectoparasitic survey of mammals from Lavaca County, Texas. Annals of the Entomological Society of America 39:597-601.

Ruiz-Piña, H. A., M. A. Puc-Franco, J. Flores-Abuxapqui, I. Vado-Solis, and M. F. Cardenas-Marrufo. 2002. Isolation of *Salmonella enterica* and serologic reactivity to *Leptospira interrogans* in opossums (*Didelphis virginiana*) from Yucatán, México. Revista do Instituto de Medicina Tropical de São Paulo 44:235-237.

Salceda-Sánchez, B. 2004. Clave para la identificación de adultos de las especies de pulgas (Insecta: Siphonaptera), comunes y de mayor importancia médica en México. Folia Entomológica Mexicana 43:27-41.

Sánchez-Montes, S., M. Y. Cabrera-Garrido, C. A. Ríos-Muñoz, A. Z. Lira-Olguín, R. Acosta-Gutiérrez, M. Mata-Galindo, K. Hernández-Vilchis, D. M. Navarrete-Sotelo, P. Colunga-Salas, L. León-Paniagua, and I. Becker. 2019. Detection of *Bartonella* and *Rickettsia* in small mammals and their ectoparasites in México. Therya 10:69-79.

Schiefer, B. A., and J. L. Lancaster Jr. 1970. Some Siphonaptera from Arkansas. Journal of the Kansas Entomological Society 43:177-181.

Shaftesbury, A. D. 1934. The Siphonaptera (fleas) of North Carolina, with special reference to sex ratios. Journal of the Elisha Mitchell Scientific Society 49:247-263.

Torres-Castro, M., H. Noh-Pech, R. Puerto-Hernández, B. Reyes-Hernández, A. Panti-May, S. Hernández-Betancourt, A. Yeh-Gorocica, L. Gonzalez-Herrera, J. Zavala-Castro, and F. I. Puerto. 2016. First molecular evidence of *Toxoplasma gondii* in opossums (*Didelphis virginiana*) from Yucatan, Mexico. Open Veterinary Journal 6:57-61.

Traub, R. 1950. Siphonaptera of Central America and Mexico: a morphological study of aedeagus with descriptions of new genera and species. Fieldiana Zoology 1:1-127 + 54 plates.

Villalobos-Cuevas, V. A., M. Weber, M. Lareschi, and R. Acosta. 2016. Pulgas parásitas de mamíferos pequeños y medianos de Calakmul, Campeche, México y nuevos registros de localidades. Revista Mexicana de Biodiversidad 87:1372-1378.

Whitaker, Jr., J. O., G. S. Jones, and R. J. Goff. 1976. Ectoparasites and food habits of the opossum, *Didelphis virginiana*, in Indiana. Proceedings of the Indiana Academy of Science 86:501-507.

Wilson, N., and P. Bishop. 1966. A New Host and Range Extension for *Pulex simulans* Baker with a Summary of Published Records (Siphonaptera: Pulicidae). American Midland Naturalist 245-248.

Wright, J. D., M. S. Burt, and V. L. Jackson. 2012. Influences of an urban environment on home range and body mass of Virginia opossums (*Didelphis virginiana*). Northeastern Naturalist 19:77-86.

Associated editor: Cristian Kraker-Castañeda
Submitted: September 3, 2021; Reviewed: October 8, 2021.
Accepted: October 14, 2021; Published on line: November 3, 2021.

THERYA NOTES 2021, Vol. 2 : 156-159 DOI: 10.12933/therya_notes-21-54 ISSN 2954-3614

Confirmation of the presence of Abert's squirrel (*Sciurus aberti*) after a century in Sonora, México

Confirmación de la presencia de la ardilla de Abert (*Sciurus aberti*) después de un siglo en Sonora, México

Juan Pablo Gallo-Reynoso[1*], Lucila Armenta-Méndez[1], Samuel Macías-Sánchez[2], Thomas R. Van Devender[3], Gloria Ponce-García[1], and Víctor Hugo Cabrera-Hernández[4]

[1]Centro de Investigación en Alimentación y Desarrollo, A. C., Unidad Guaymas. Carretera al Varadero Nacional km 6.6, Colonia Las Playitas, C. P. 85480. Guaymas, Sonora, México. E-mail: jpgallo@ciad.mx (JPG-R); lucila.armenta@gmail.com (LA-M); gloria.ponce.garcia@gmail.com (GP-G).
[2]Instituto de Biotecnología y Ecología Aplicada, Universidad Veracruzana. Avenida de las Culturas Universitarias No. 101, Col. Emiliano Zapata, C. P. 91090. Xalapa de Enríquez, Veracruz, México. E-mail: macsanch@yahoo.com (SM-S).
[3]Greater Good Charities, 6262 N. Swan Rd., Suite 165. Tucson, Arizona 85718, U. S. A. E-mail: yecora4@comcast.net (TRVD).
[4]Calle 38 y 39 Ave. 29, Col. Armando López Nogales, Agua Prieta, C. P. 84267. Sonora, México. E-mail: victorhugocabrera89@gmail.com (VHC-H).
*Corresponding author

According to several authors, Abert's squirrel (*Sciurus aberti*) is typically found in ponderosa pine (*Pinus ponderosa*) forest, which provides both shelter and food. *Pinus ponderosa* generally occurs between 1,800 and 3,000 m elevation in Wyoming, Colorado, New Mexico, Arizona, and Utah in the United States. In México, *Pinus arizonica* was formerly considered a variety of *P. ponderosa* in northern Sonora. Conifer forests in the Sierra Madre Occidental from southern Durango north to Sonora and Chihuahua are not monospecific but very diverse. Pine-oak forest is dominated by various species of pines and oaks, and mixed conifer forest by Douglas fir (*Pseudotsuga* spp.), spruce (*Picea* sp.), and southwestern white pine (*Pinus strobiformis*). There is a previously confirmed record of Abert's squirrel from the Upper Bavispe River, Sonora, collected by the Lumnholtz Archeological Expedition 1890-92, and another unconfirmed record of a likely *Sciurus aberti* in 1938 in northern Sonora. While conducting mammal surveys on foot (recording tracks of different mammals) and setting up camera traps, we observed the presence of *S. aberti* in the study area. We obtained two photographic records of *S. aberti*, in pine-oak forest in the Sierra Madre Occidental at the town limit of Mesa Tres Ríos, and at 9.4 km southwest of Mesa Tres Ríos, Sonora. *Sciurus aberti* were found on areas with pine-oak and mixed-conifer forests, presumably used for food and cover by Abert's squirrels, demonstrating that these squirrels are not strictly dependent on ponderosa pine (*P. ponderosa*) as previously reported, instead they rely on oak, Arizona (*P. arizonica*) and Apache (*P. engelmannii*) pines, that are widespread in the Madrean Archipelago (Sky Islands Region) and the northern Sierra Madre Occidental (SMO). These observations confirm the predictions of the presence of *S. aberti* and are an important addition to the mammal fauna of Sonora.

Key words: Mesa Tres Ríos; presence; Sciuridae; Sonora.

De acuerdo con algunos autores, la ardilla de Abert (*Sciurus aberti*) se encuentra típicamente en los bosques de pino blanco (*Pinus ponderosa*), árbol que les proporciona refugio y alimento. Estos pinos generalmente se distribuyen entre 1,800 y 3,000 m en Wyoming, Colorado, Nuevo México, Arizona y Utah en los Estados Unidos. *Pinus arizonica* era formalmente considerada una variedad de *P. ponderosa* en el norte de Sonora, México. Los bosques de la Sierra Madre Occidental no son monoespecíficos, los bosques de pino-encino son muy diversos desde Sonora y Chihuahua hasta el sur de Durango en México. Existen también bosques de coníferas mixtos dominados por abetos (*Pseudotsuga* spp.), pinabetes (*Picea* spp.) y piñón (*Pinus strobiformis*). Solo hay un registro previo confirmado de la presencia de la ardilla de Abert obtenido en el Alto Río Bavispe, Sonora, colectada por la Expedición Arqueológica de Lumholtz 1890-92, y otro registro sin confirmar de un probable *S. aberti* en 1938 al norte de Sonora. Mientras se monitoreaban rastros de mamíferos a pie (registros de huellas) y se ponían cámaras-trampa para su registro, se observó la presencia de *S. aberti* en la zona de estudio. Obtuvimos dos registros ocasionales de *S. aberti*, ambos en un bosque de pino-encino en la Sierra Madre Occidental en Sonora en el límite del pueblo de Mesa Tres Ríos, Sonora y a 9.4 km al suroeste de Mesa Tres Ríos, Sonora. Se encontró a *Sciurus aberti* en áreas de pino-encino y bosques mixtos de coníferas, presuntamente usadas por las ardillas de Abert para su alimentación y cobertura, demostrando que estas ardillas no dependen estrictamente del pino ponderosa (*P. ponderosa*) como se ha reportado, sino que dependen del encino y los pinos Arizona (*P. arizonica*) y Apache (*P. engelmannii*), que se encuentran ampliamente distribuidos en el Archipiélago Madrense (Región de las Islas del Cielo) y en la porción norte de la Sierra Madre Occidental (SMO). Estas observaciones confirman la predicción de la presencia de *S. aberti*, y son una importante adición a la fauna de mamíferos de Sonora.

Palabras clave: Mesa Tres Ríos; presencia; Sciuridae; Sonora.

Abert’s squirrel (*Sciurus aberti*) is a high-elevation species inhabiting conifer forests in the western United States and the Sierra Madre Occidental (SMO) in Chihuahua and Durango, México. There are 6 subspecies of *S. aberti* in the southwestern United States and 3 in México (Thorington and Hoffman 2005). *Sciurus aberti barberi* (J. A. Allen 1904) occurs in northwestern Chihuahua and now in eastern Sonora. There is a large gap (345 km in a straight line) in the species distribution between *S. a. barberi* in the SMO, and *S. a. aberti* in the Santa Catalina Mountains in Arizona (Hoffmeister 1986).

The only previous specimen of Abert’s squirrel from the state of Sonora was from the Upper Bavispe (*sic*) River by the Lumholtz Archeological Expedition of 1890-92, *“one skin, in the gray phase, and an additional skull and skeleton”* (Allen 1893). Burt (1938) reported another observation of Abert’s squirrel in Sonora: *“Mountains of northeastern Sonora. Recorded as being seen in oak-covered mountains about Santa Cruz”.* Burt remarked, *“No specimens have been taken in Sonora, but the sight records recorded above probably were of this race”*. Based on Burt’s observation, Nash and Seaman (1977) and Cassola (2017) took the presence of Abert’s squirrel in Sonora for granted. Caire (2019) doubted the presence of the species in the Municipality of Santa Cruz, suggesting that Burt probably observed an Arizona squirrel (*S. arizonensis*) instead. Sandoval *et al.* (2020) reported Abert’s squirrels presence in the State of Chihuahua at Campo Verde Natural Protected Area east of Mesa Tres Ríos.

In the Madrean Archipelago between the northern SMO and the Mogollon Rim in central Arizona, there are 55 Sky Island (SI) mountain ranges, 32 of them in Sonora (Deyo *et al.* 2013; Van Devender *et al.* 2013). These Sky Islands are isolated mountain ranges with crowns of oak woodland and pine-oak forests (Van Devender *et al.* 2013) that support a mixture of species typical of the Madrean Tropical subprovince of the SMO, as well species from the southwestern United States (Reina-Guerrero and Van Devender 2005; Van Devender and Reina-Guerrero 2016; Haire *et al.* 2021). The pine-oak forests on the higher Sky Islands are potential Abert’s squirrel habitat. Here we report two new records of Abert’s squirrel, confirming its presence in Sonora. *Sciurus aberti* is listed under special protection (Pr) by Mexican Official Norm NOM-059-SEMARNAT-2010 (SEMARNAT 2010).

Field expeditions to Mesa Tres Ríos were conducted to survey the presence of Neotropical otters (*Lontra longicaudis*) from August 24-29, 2015 (Gallo-Reynoso *et al.* 2015), and for wildlife distributions in June 2018. We visited several places along the Río Bavispe where the first surveys were conducted 15 years ago to confirm the otter’s continuous presence. Greater Good Charities’ Madrean Discovery Expedition (MDE) to Mesa Tres Ríos was conducted in August 2018, for mammal surveys with wildlife cameras as part of MDE Wildlife Program. The study area included pine-oak forest in the northern SMO in Sonora. Detailed records of our field observations and our corresponding images of Abert’s squirrels and other species of Sciuridae from Sonora are available in the MDE database (https://madreandiscovery.org).

We recorded the presence of Abert’s squirrel at two localities in two different years (2015 and 2018) in the SMO in eastern Sonora. Individuals of Abert squirrels observed were large, they presented the diagnostic characteristic of long and broad ears with hair tufts at the ear apex, as our observations were carried on summer, the ear hair tufts were shorter than in winter when they are long; both presented dorsal dark gray coloration with white undersides typical of the species (Nash and Seaman 1977). The individuals were observed in pine-oak-cypress forest, in rugged, montane terrain near Mesa Tres Ríos, Municipality of Nácori Chico, Sonora. The first observation was on August 26, 2015 at 10:50 hr, near Mesa Tres Ríos town (29° 50’ 54.82” N, 108° 42’ 13.28” W) at 1,845 m (Figures 1 and 2). There were two squirrels eating cones of Arizona pine and moving through the canopy (Figure 2a). The second observation was obtained while setting up a camera trap, it was of

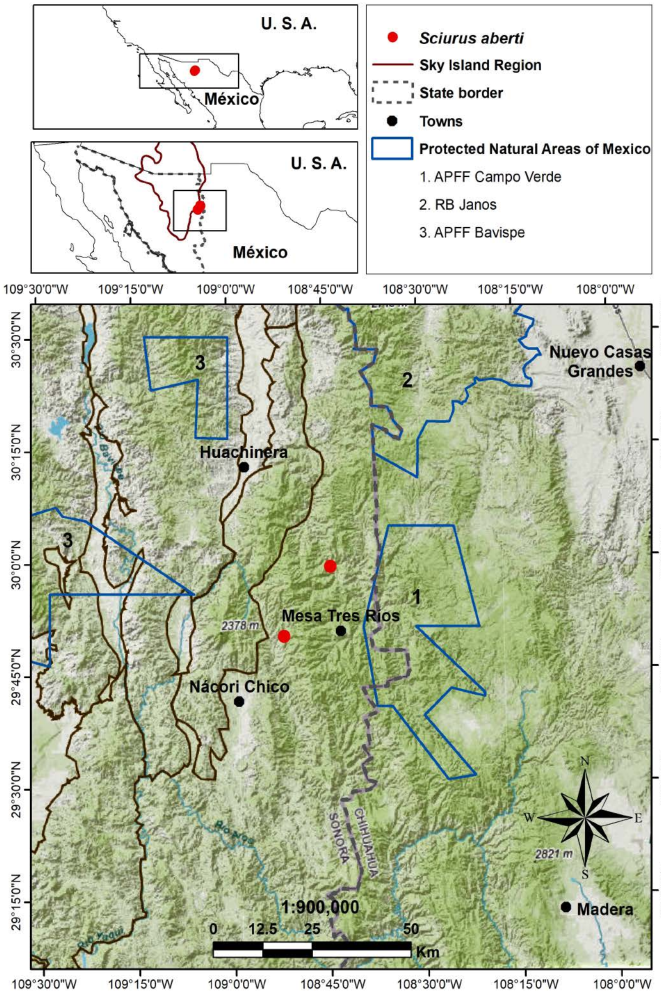


Figure 1. Records location of Abert’s squirrels, *Sciurus aberti*, observed near Mesa Tres Ríos, Sonora (red dots). Near Mesa Tres Ríos town (29° 50’ 54.82” N, 108° 42’ 13.28” W) at 1,845 m and southwest of Mesa Tres Ríos (29° 47’ 17.42” N, 108° 47’ 27.88” W) at 2,020 m. APFF stands for Área de Protección de Flora y Fauna (Protection Area for Flora and Fauna). RB stands for Reserva de la Biosfera (Biosphere Reserve).

Figure 2. a) Specimen of Abert's squirrel (*Sciurus aberti*) in the canopy of an Arizona pine (*P. arizonica*) in a pine-oak forest near Mesa Tres Ríos, Sonora (29° 50′ 54.82″ N, 108° 42′13.28″ W), at 1,845 m. August 26, 2015 (Photo J. P. Gallo-Reynoso). b) Specimen of Abert's squirrel on the ground in a pine-oak forest SW of Mesa Tres Ríos, Sonora (29° 47′ 17.42″ N, 108° 47′ 27.88″ W), at 2,020 m. June 30, 2018 (Photo V. H. Cabrera-Hernández).

a lone individual at El Aguajito del Macho, 9.4 km (straight line) southwest of Mesa Tres Ríos (29° 47′ 17.42″ N, 108° 47′ 27.88″ W) at 2,020 m (Figure 2b). This locality is approximately 11 km (to the South in a straight line) from the first record and 15 km (to the West in a straight line) from the record of Sandoval *et al.* (2020) of an Abert's squirrel at Campo Verde Natural Protected Area in Chihuahua.

Valdez-Alarcón and Téllez-Girón (2005) and Castillo-Gámez *et al.* (2010) mentioned the presence of *S. aberti* in Sonora based on Nash and Seaman (1977) and its association with ponderosa pine (*Pinus ponderosa*). However, ponderosa pine only occurs in Sonora in the Sierras de los Ajos and San José close to the Arizona border (Ferguson *et al.* 2013). Arizona (*P. arizonica*) and Apache (*P. engelmannii*) pines are similar species that are widespread in the Madrean Archipelago (= the Sky Islands Region) and the northern Sierra Madre Occidental (SMO). In fact, *P. arizonica* was formerly considered a variety of *P. ponderosa*. The use of multiple conifer species for food and cover by Abert's squirrels in pine-oak and mixed-conifer forests demonstrates that Abert's squirrels are not strictly dependent on ponderosa pine as previously reported (Edelman and Koprowski 2005; Doumas *et al.* 2015). Pine-oak forest in the SMO near Yécora in eastern Sonora is very diverse with 10 species of pines and 14 species of oaks (González-Elizondo *et al.* 2012; Van Devender and Reina-Guerrero 2016). Sandoval *et al.* (2020) reported Abert's squirrels in a similar habitat at Campo Verde Natural Protected Area (Area de Protección de Flora y Fauna Campo Verde) in the SMO in Chihuahua just east of Mesa Tres Ríos.

After 128 years, these observations confirm the presence of *S. aberti* in the mammal fauna of Sonora and document Abert's squirrels living in pine-oak forest other than areas dominated by ponderosa pine. These observations confirm the predictions of Sandoval *et al.* (2020) on the probable distribution models of *S. aberti* that includes Sonora. The previous record from the Lumholtz expedition only stated that the upper Bavispe River (Allen 1893) locality was probably also near Mesa Tres Ríos where this river originates. Additional squirrels seen in the Mesa Tres Ríos area were the Apache fox squirrel (*Sciurus nayaritensis*), the rock squirrel (*Otospermophilus variegatus*), and the cliff chipmunk (*Neotamias dorsalis*). The Apache fox squirrel is the most common tree squirrel in the Mesa Tres Ríos area and the Sierra Huachinera to the west.

Acknowledgements

This paper is dedicated to the memory of D. E. Brown who identified the second specimen and that has done important work describing the mammals of Sonora. Greater Good Charities has supported the MDE Wildlife camera surveys in Sonora conducting mammal surveys with wildlife cameras and a MDE Scholarship to V. H. Cabrera-Hernández. We are grateful to J. M. Cirett-Galán and N. Villanueva for their assistance in field expeditions and two anonymous reviewers whose comments improved earlier versions of this manuscript.

Literature cited

Allen, J. A. 1893. Article III.-List of mammals and birds collected in Northeastern Sonora and Northwestern Chihuahua, Mexico, on the Lumholtz Archeological Expedition, 1890-92. Bulletin of the American Museum of Natural History 5:27-42.

Burt, W. H. 1938. Faunal relationships and geographic distribution of mammals in Sonora, México. Miscellaneous Publications Museum Zoology, University of Michigan. Michigan, U.S.A. Available at jpgallo@ciad.mx.

Caire, W. 2019. The distribution of the land mammals of Sonora, Mexico. Journal of the Arizona-Nevada Academy of Science 48:40-219.

Cassola, F. 2017. *Sciurus aberti*. The IUCN Red List of Threatened Species 2017: e.T42461A22245623.

Castillo-Gámez, R. A., J. P. Gallo-Reynoso, J. Égido-Villarreal, and W. Caire. 2010. Mamíferos. Pp. 421-436 *in* Diversidad Biológica del estado de Sonora (Molina-Freaner, F. E., and T. R. Van-Devender, eds.). Universidad Nacional Autónoma de México – Comisión Nacional para el Conocimiento y Uso de la Biodiversidad. México City, México.

Deyo, N. S., A. Smith, E. Gilbert, and T. R. Van Devender. 2013. Documenting the biodiversity of the Madrean Archipelago: an analysis of a virtual flora and fauna. Pp. 292-299 *in* Merging science and management in a rapidly changing world: biodiversity and management of the Madrean Archipelago III and 7th Conference on Research and Resource Management in the Southwestern Deserts (Gottfried, G. J., P. F. Ffolliott, B. S. Gebow, L. G. Eskew, and L. C. Collins, comps.). May 1-5, 2012. Proceedings RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Tucson, Arizona, U.S.A.

Doumas, S. L., J. L Koprowski, and W. O. Noble. 2015. Landscape-level assessment of Abert's squirrel and red squirrel in mixed conifer forest. The Southwestern Naturalist 60:240-246.

Edelman, A. J., and J. L. Koprowski. 2005. Diet and Tree Use of Abert's Squirrels (*Sciurus aberti*) in a mixed-conifer forest. The Southwestern Naturalist 50:461-465.

Ferguson, G. M., A. D. Flesch, and T. R. Van Devender. 2013. Biogeography and diversity of pines in the Madrean Archipelago. 2012. Pp. 197-203 *in* Merging science and management in a rapidly changing world: biodiversity and management of the Madrean Archipelago III and 7th Conference on Research and Resource Management in the Southwestern Deserts (Gottfried, G. J., P. F. Ffolliott, B. S. Gebow, L. G. Eskew, and L. C. Collins, comps.). May 1-5, 2012. Proceedings RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Tucson, Arizona, U.S.A.

Gallo-Reynoso, J. P., S. Macías-Sánchez, I. D. Barba-Acuña, L. C. Armenta-Méndez, and G. Ponce-García. 2015. Informe final del proyecto: "Diagnóstico sobre el estado de conservación de la nutria neotropical en el ANP Ajos-Bavispe". Technical Report. Centro de Investigación en Alimentación y Desarrollo, A. C., Unidad Guaymas. Available at jpgallo@ciad.mx.

González-Elizondo, M. S., M. González-Elizondo, J. A. Tena-Flores, L. Ruacho-González, and I. L. López-Enríquez. 2012. Vegetación de la Sierra Madre Occidental, México: una síntesis. Acta Botánica Mexicana 100:351-403.

Haire, S. L., M. Villarreal, C. Cortés-Montaño, A. Flesch, J. Iniguez, J. R. Romo-León, and J. Sanderlin. 2021. Climate refugia for *Pinus* spp. In topographic and bioclimatic environments of the Madrean Sky islands of México and the United States. Research Square (accepted preview) https://doi.org/10.21203/rs.3.rs-391708/v1

Hoffmeister, D. E. 1986. Mammals of Arizona. University of Arizona Press. Tucson, Arizona, U.S.A.

Nash, D. J., and R. N. Seaman. 1977. *Sciurus aberti*. Mammalian Species 80:1-5.

Reina-Guerrero., A. L., and T. R. Van Devender. 2005. Floristic comparison of an Arizona 'sky island' and the Sierra Madre Occidental in eastern Sonora: the Huachuca Mountains and the Yécora area. Pp. 154-157 *in* Connecting Mountain Islands and Desert Seas: Biodiversity and Management of the Madrean Archipelago II (Gottfried, G. J., B. S. Gebow, L. G. Eskew, and C. B. Edminster, comps.). Proceedings RMRS-P-36. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Tucson, Arizona, U.S.A.

Sandoval, S., C. López-González, J. G. Escobar-Flores, and R. O. Martínez-Rincón. 2020. Effect of spatial resolution, algorithm and variable set on the estimated distribution of a mammal of concern: the squirrel *Sciurus aberti*. Écoscience 27:195-207.

Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT). 2010. Norma Oficial Mexicana NOM-059-SEMARNAT-2010. Protección ambiental, especies de flora y fauna silvestres de México, categorías de riesgo y especificaciones para su inclusión, exclusión o cambio, y lista de especies en riesgo. Diario Oficial de la Federación México. Accessed in August 31, 2020.

Thorington, R. W., and R. S. Hoffman. 2005. Family Sciuridae. Pp. 754-818 *in* Mammal Species of the World: A Taxonomic and Geographic Reference (Wilson, D. E., and D. M. Reeder, eds.). 3rd. Ed. (vol. 2). Johns Hopkins University Press. Baltimore, U.S.A.

Valdez-Alarcón, M., and G. Téllez-Girón. 2005. *Sciurus aberti* Woodhouse, 1853. Pp. 542-543 *in* Los mamíferos silvestres de México (Ceballos, G., and G. Oliva, eds.). Comisión Nacional para el Conocimiento y Uso de la Biodiversidad-Fondo de Cultura Económica. México City, México.

Van Devender, T. R., and A. L. Reina-Guerrero. 2016. The tropical Madrean flora of Yécora, Sonora, Mexico. Phytoneuron 7:1-23.

Van Devender, T. R., S. Avila-Villegas, M. Emerson, D. Turner, A. D. Flesch, and N. S. Deyo. 2013. Biodiversity in the Madrean Archipelago of Sonora, Mexico. Pp. 10-16 *in* Merging science and management in a rapidly changing world: biodiversity and management of the Madrean Archipelago III and 7th Conference on Research and Resource Management in the Southwestern Deserts (Gottfried, G. J., P. F. Ffolliott, B. S. Gebow, L. G. Eskew, and L. C. Collins, comps.). May 1-5, 2012. Proceedings RMRS-P-67. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Tucson, Arizona, U.S.A.

Associated editor: Nicté Ordóñez-Garza
Submitted: June 22, 2021; Reviewed: October 15, 2021.
Accepted: November 3, 2021; Published on line: November 9, 2021.

THERYA NOTES 2021, Vol. 2 : 160-165 DOI: 10.12933/therya_notes-21-55 ISSN 2954-3614

Brief characterization of the behavior of the spiny rat *Trinomys setosus* (Rodentia: Echimyidae) in captivity

Breve caracterización del comportamiento de la rata espinosa *Trinomys setosus* (Rodentia: Echimyidae) en cautiverio

FLÁVIA REGINA BUENO[1], ELISABETH SPINELLI DE OLIVEIRA[2], AND WILFRIED KLEIN[2]*

[1]Universidade de São Paulo, Programa de Pós-Graduação em Psicobiologia, Departamento de Psicologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto. Av. Bandeirantes, 3900, Bairro Monte Alegre, CEP 14040-901, Ribeirão Preto. São Paulo, Brasil. E-mail: flaviab.bio@gmail.com (FRB).

[2]Universidade de São Paulo, Departamento de Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto. Av. Bandeirantes, 3900, Bairro Monte Alegre, CEP 14040-901, Ribeirão Preto. São Paulo, Brasil. E-mail: esolivei@usp.br (ESO); wklein@usp.br (WK).

*Corresponding author

Hairy Atlantic spiny rats (*Trinomys setosus*, Echimyidae) are Neotropical caviomorph rodents belonging to an ecologically diverse group, that is relatively unknown from a behavioral point of view. Grooming is considered prevalent in rodents: wild and laboratory individuals employ grooming during 15–50 % of their waking time. We ask if grooming behavior in *T. setosus* is similarly low as in closely related species, and characterize the main behavioral categories seen in the species in detail. We quantified the occurrence of self-grooming (face washing, body washing, washing of the pelvic region, and scratching) during single 30-minute sessions of 16 adult individuals (four males and twelve females), in the context of activity, resting and maintenance categories (defecation and urination). The following behavioral categories were identified: 1) locomotor activity, 2) remaining motionless, 3) defecating, 4) face washing, 5) body washing, 6) washing the pelvic region, 7) scratching, 8) urinating, 9) shaking, 10) vocalizing. Grooming behavior followed the descriptions of stereotypical behavior observed in other rodent species and its occurrence represented 6.7 % (females) and 5.9 % (males) of the time studied. Grooming, seen across a great variety of animal taxa, involves numerous functions besides the primary role of body caring, which are of great importance for an animal's well-being. Compared to commonly studied rodents, *T. setosus* spent relatively little time with grooming behavior, just as its sister species *T. yonenagae*.

Key words: Behavioral repertoire; body cleaning; Brazil; Euryzygomatomyinae; Mammalia.

Las ratas espinosas del Atlántico (*Trinomys setosus*, Echimyidae) son roedores caviomorfos neotropicales pertenecientes a un grupo ecológicamente diverso, muy desconocido desde el punto de vista comportamental. El aseo se considera frecuente en Rodentia, siendo estimado que tanto los roedores silvestres como los de laboratorio empleen de 15 a 50 % de su tiempo de vigilia con esta tarea. De esta forma, nos preguntamos si el comportamiento de aseo en *T. setosus* es similar a aquel observado en especies estrechamente relacionadas, y caracterizamos en detalle las principales categorías de comportamiento observadas en la especie. La ocurrencia de aseo personal (lavado de cara, lavado de cuerpo, lavado de la región pélvica y rascado) fue cuantificada durante sesiones únicas de 30 minutos en 16 individuos adultos (cuatro machos y doce hembras), en el contexto de actividad, reposo y categorías de mantenimiento (defecación y micción). Se identificaron las siguientes categorías de comportamiento: 1) actividad locomotora, 2) permanecer inmóvil, 3) defecar, 4) lavarse la cara, 5) lavarse el cuerpo, 6) lavarse la región pélvica, 7) rascarse, 8) orinar, 9) sacudirse, 10) vocalizar. El comportamiento de aseo siguió las descripciones estereotipadas para otras especies de roedores y su ocurrencia representó el 6.7 % (hembras) y el 5.9 % (machos) del tiempo estudiado. El aseo, visto en una gran variedad de taxones animales, involucra numerosas funciones además del propósito principal del cuidado del cuerpo, que son de gran importancia para el bienestar animal. En comparación con los roedores comúnmente estudiados, como ratas, ratones, hámsteres y conejillos de indias, *T. setosus* destina relativamente poco tiempo al comportamiento de aseo, de forma comparable a su especie hermana *T. yonenagae*.

Palabras clave: Brasil; Euryzygomatomyinae; limpieza corporal; Mammalia; repertorio conductual.

Spiny rats of the family Echimyidae Gray, 1825 occur in Central and South America and the Caribbean. The family represents the greatest current radiation of caviomorph rodents (Upham and Patterson 2012), comprising fully arboreal, scansorial, terrestrial, fossorial, and semiaquatic genera and distributed throughout all neotropical regions (Fabre *et al.* 2013). Brazilian echimyids of the genus *Trinomys* Thomas, 1921 are terrestrial, occupying mainly forested areas of the Atlantic Forest, while some species are also found in xerophilous dune vegetation and in transition areas between the Atlantic Forest and the Cerrado, or the Caatinga, respectively (Lara and Patton 2000; Lara *et al.* 2002).

The hairy Atlantic spiny rat, *Trinomys setosus* Desmarest, 1817, is endemic to Brazil, with a wide distribution in forested areas of the states of Bahia, Espírito Santo, Minas Gerais, Rio de Janeiro, and Sergipe (Pessôa *et al.* 2015). It is a medium-sized rodent with an average head and body length of around 180–226 mm (Iack-Ximenes 2005), darker dorsally and laterally, lighter ventrally, and a typical echimyid tail with short hairs on its extremity (Moojen 1952). Their spiny appearance is caused by the presence of modified aristiform hairs on the dorsal and lateral body wall, which are less robust than the *sensu stricto* spines, and have no known biological function (Hoey *et al.* 2006).

The genus *Trinomys* has been the subject of ecological, morphological, physiological, cytogenetic, and behavioral studies (Lara and Patton 2000; Lara *et al.* 2002; Manaf *et al.* 2003a; Manaf *et al.* 2003b; Marcomini and Spinelli Oliveira 2003; Monteiro *et al.* 2005; Fabre *et al.* 2016; Fabio-Braga and Klein 2018; Courcelle *et al.* 2019; Cantano *et al.* 2023). One interesting behavioral feature that has been described in *T. yonenagae*, a species closely related to *T. setosus*, shows a low rate of grooming (self-cleaning), especially when compared with non-echimyid species (Manaf *et al.* 2003b). In this context it has been shown to exhibit among the lowest grooming rate of any echimyid. However, unlike *T. setosus*, *T. yonenagae* occupies sand dune fields within the semiarid Caatinga in northeastern Brazil, building and using extensive underground tunnel systems (Manaf and Spinelli Oliveira 2000; Rocha 1995; Manaf and Spinelli Oliveira 2009).

Studies have demonstrated the innate character of grooming behaviors (Annable and Wearden 1979; Alberts 1996), and in rodents grooming can be used for a variety of purposes, such as thermoregulation (Shanas and Terkel 1996), social communication (Ferkin *et al.* 2001; Wolff *et al.* 2002), stress reduction (Kalueff and Tuohimaa 2004), and removal of ectoparasites (Hawlena *et al.* 2007). In the present study, we characterize in detail the main behavioral categories of body cleaning behavior in *T. setosus*, and we ask if its rate of grooming is similarly low as it is in its closely related species.

Animals. 16 adult *Trinomys setosus* (12 females, 239.8 ± 47.2 g; 4 males, 271.3 ± 17.8 g) were collected in a secondary forested area of Mata Atlântica, Fazenda Oitinga, Jaguaripe municipality (13° 00´S, 38° 01´ W, BA, Brazil; license n° 54841-1 Sistema de Autorização e Informação em Biodiversidade - SISBIO). The spiny rats were housed at the Animal Facility of the FFCLRP- USP (Laboratório de Ecofisiologia e Comportamento de Roedores Silvestres/LECO), in isolated rooms under stable conditions (24 ± 2 °C, relative humidity of 82 ± 2 %, inverted light: dark cycle of 12:12, 3-120 Lux). Water and food pellets (Nuvilab CR-1) were supplied *ad libitum*, and were weekly complemented with seeds and a variety of fresh fruits and vegetables. Animals were maintained individually in standard laboratory cages (40 × 33 × 16 cm). Animal use was approved by the local animal care committee (Comissão de Ética no Uso de Animais- Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto – CEUA/FFCLRP n° 16.5.576.59.4).

Experimental protocol. Behavioral records were made using a portable camera (Sony®, model Handycam Vision CCD-TRV150), on a tripod. The filming took place during the animals' activity period on seven non-consecutive days in an isolated room of the animal facility (maintained at 25 °C). Individuals were weighed and placed individually into a glass box (25 × 40 × 19 cm), covered by a meshed lid and filmed continuously for 30 minutes. After an animal was filmed, the glass box was cleaned using 70 % ethanol.

Data analysis. A total of six hours and five minutes of filming was analyzed using the "all occurrences" method (Altmann 1974). Videos were observed and analyzed at reduced speed through a video editing program (VLC 2.2.6), while simultaneously transcribing the observed behaviors into the computer program Etholog 2.25 (Ottoni 2000) to quantify absolute frequency and relative duration of each behavior. Behaviors were classified following Manaf and Spinelli Oliveira (2000).

The following behavioral categories were identified for *T. setosus*, whose individual frequencies and relative durations are given in Figure 1 and Table 1.

1. Locomotor activity. This includes either one or more of the following actions: moving around the glass box, sniffing, jumping, digging, and rearing.

2. Remaining motionless. This involves any action that is not related to locomotion, such as freezing and rest-

Table 1. Frequencies and relative durations of behaviors during 30 minutes of observation of *Trinomys setosus*. Data are presented as mean ± standard deviations.

Category	Frequency		Relative duration (%)	
	Females	Males	Females	Males
Locomotor activity	43.4 ± 15.4	37.5 ± 4.8	53.8 ± 27.6	66.3 ± 19.6
Remaining motionless	22.6 ± 14.2	16.3 ± 8.0	37.7 ± 29.2	27.5 ± 19.5
Face washing	17.3 ± 9.7	17.0 ± 7.5	3.8 ± 2.2	3.7 ± 2.2
Body washing	13.8 ± 11.6	14.8 ± 6.3	2.3 ± 3.3	1.8 ± 0.9
Washing of the pelvic region	0.5 ± 1.0	0.0 ± 0.0	0.1 ± 0.3	0.0 ± 0.0
Scratching	6.5 ± 7.8	4.8 ± 2.5	0.5 ± 0.5	0.4 ± 0.2
Defecating	10.3 ± 7.5	7.8 ± 7.6	0.6 ± 0.4	0.4 ± 0.4
Urinating	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Shaking	1.4 ± 1.7	1.0 ± 0.8	0.1 ± 0.	0.1 ± 0.1
Vocalizing	7.8 ± 14.8	0.0 ± 0.0	1.0 ± 2.1	0.0 ± 0.0

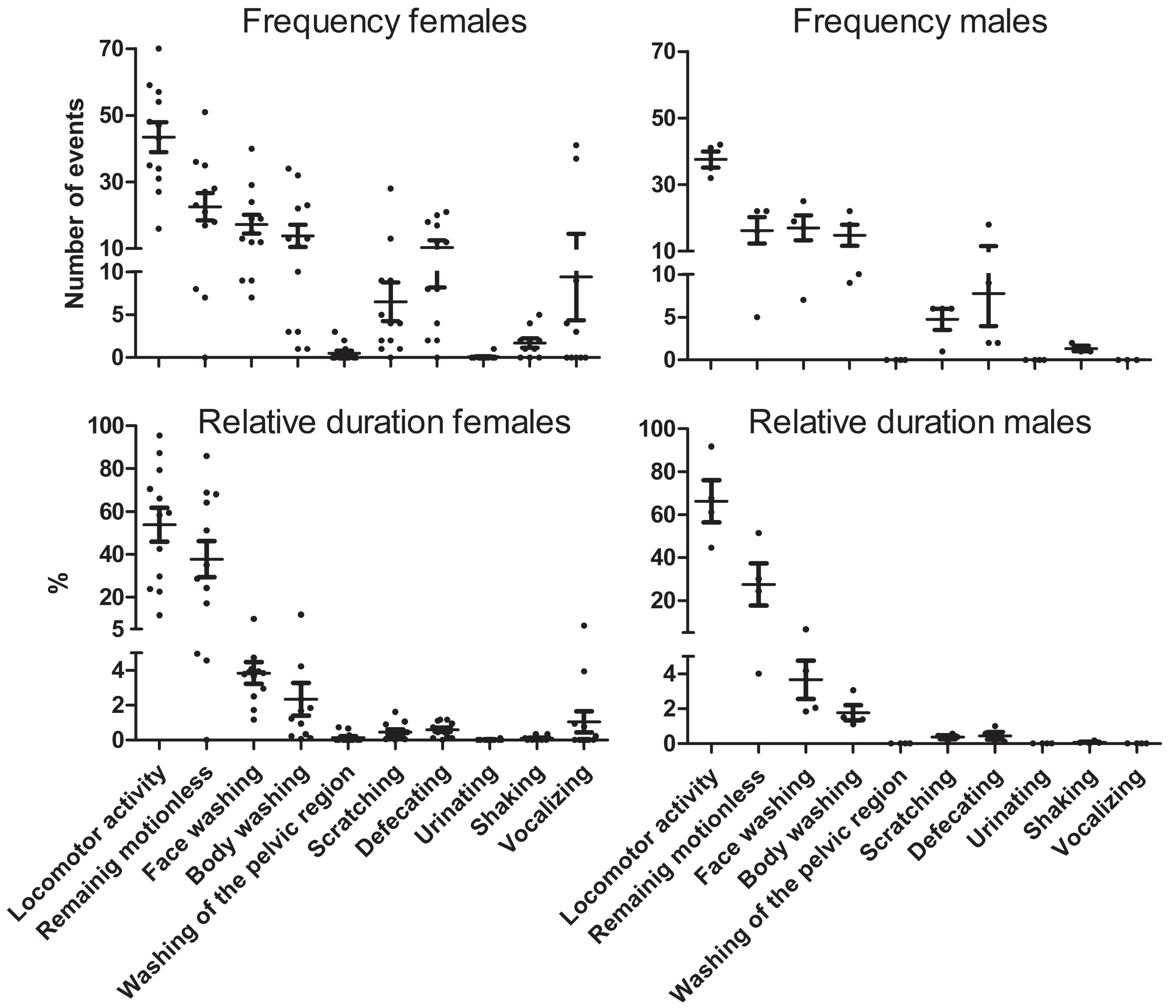


Figure 1. Frequencies and relative durations of behaviors during 30 minutes of observation of *Trinomys setosus*. For reasons of clarity, the y-axes have been split into two different scales. Data are presented as individual values, as well as mean ± S.E.M.

ing or alert postures. In the resting posture, the animal is lying on the stomach with its limbs flexed under the body, assuming a spherical body shape, its tail close to the floor and wrapped around the body. On alert, the animal may be standing using all four legs, with raised ears, open eyes, stretched or raised tail, with or without vibrissae or muzzle movements. The animal may also be standing only on its hind legs, with the perineum resting against the floor, an erect trunk, a taut tail, raised ears, open eyes, with or without vibrissae or muzzle movements.

3. Defecating. With the four legs on the floor, the posterior region slightly lowered, and the tail raised (with small movements of the tail and posterior region of the body), the animal defecates.

4. Face washing. The animal licks the front paws and passes them repeatedly over the face. The movements may extend to other regions of the head, from the region behind the ears to the snout and vibrissae, and in reverse from the snout to the back of the head (Figure 2A).

5. Body washing. The animal directly licks several parts of the body, including the dorsal, lateral, and ventral regions, as well as its paws. This category may include 'combing', which means licking and combing the hair on the flanks, hind legs, abdomen and tail with the incisors teeth (Figure 2B).

6. Washing of the pelvic region. The animal curves its body dorsoventrally, flexing the neck until it touches and licks the pelvic region (Figure 2C).

7. Scratching. The animal uses one of its hind legs to scratch the lateral, ventral, or dorsal regions of the body, as well as the head, including behind the ears, snout and top of the head (Figure 2D).

8. Urinating. The animal urinates with all four feet on the floor, the posterior slightly lowered, and tail raised, with small movements of the tail and the posterior body.

9. Shaking. The animal shakes its head or body by moving one or the other quickly and repeatedly to the right and to the left.

10. Vocalizing. The animal emits a whistle as it repeatedly taps one of the hind limbs on the floor (foot drumming; one hind foot may be tapped repeatedly on the floor, and after a pause, the same foot or the other hind foot may be used), or while moving around the glass box.

Most of the behaviors exhibited by the animals, especially during the initial minutes of filming, corresponded to the exploration of the environment. During the observation period, females showed an overall tendency to exhibit most of the identified behavioral categories more frequently than males. However, the relative durations of the different behaviors were dominated in females and males by 'Locomotor activity' and 'Remaining motionless' categories, comprising more than 90 % of the time spent under observation. The remaining behaviors exhibited, may be relatively frequent, but were only of short duration, even those related to grooming.

The behavioral categories observed in *T. setosus* are commonly described for other rodents (Berridge 1990; Manaf and Spinelli Oliveira 2000; Sabatini and Paranhos da Costa 2001; Kaiser *et al.* 2011). Similar results regarding frequency and duration of behaviors were obtained by Manaf *et al.* (2003b) in a behavioral study of three other species of echimyids—*T. yonenagae*, and the forest dwelling *T. iheringi* and *T. albispinus*, in addition to *Rattus norvegicus*. In an elevated plus maze test and an open field laboratory rats and the spiny rats spent more time in exploratory behaviors, with *R. norvegicus* showing the greatest absolute duration of grooming. Among the echimyids, *T. iheringi* presented the greatest rate of grooming when compared to the other two species. While the behavior of *T. setosus* females and males in the wild is not known, Santos and Lacey (2011) have shown that female *T. yonenagae* visit nearby burrows more frequently than males, suggesting a similar behavior for female *T. setosus*.

Vocal behaviors and foot drumming, which in our study were emitted by females only, were similar to the ones described for *Proechimys* by Emmons and Feer (1997), in which the quick tapping of the hind legs onto the substrate represents a warning sign, especially during defense against predation, and may also function as individual recognition. Additionally, foot drumming has been identified in rodents from arid regions (Randall 1994), including the echimyid *T. yonenagae* (Manaf and Spinelli Oliveira 2000).

Although Manaf and Spinelli Oliveira (2000) have shown that *T. yonenagae* rarely grooms, behaviors related to grooming may constitute between 15 and 50 % of a rodent's awake period, both under wild and laboratory conditions (Kalueff and Tuohimaa 2004; Kalueff *et al.* 2007). Despite this distinction, behavioral studies of the sister species *T. yonenagae* provide a framework to analyze and interpret the behaviors observed in *T. setosus*.

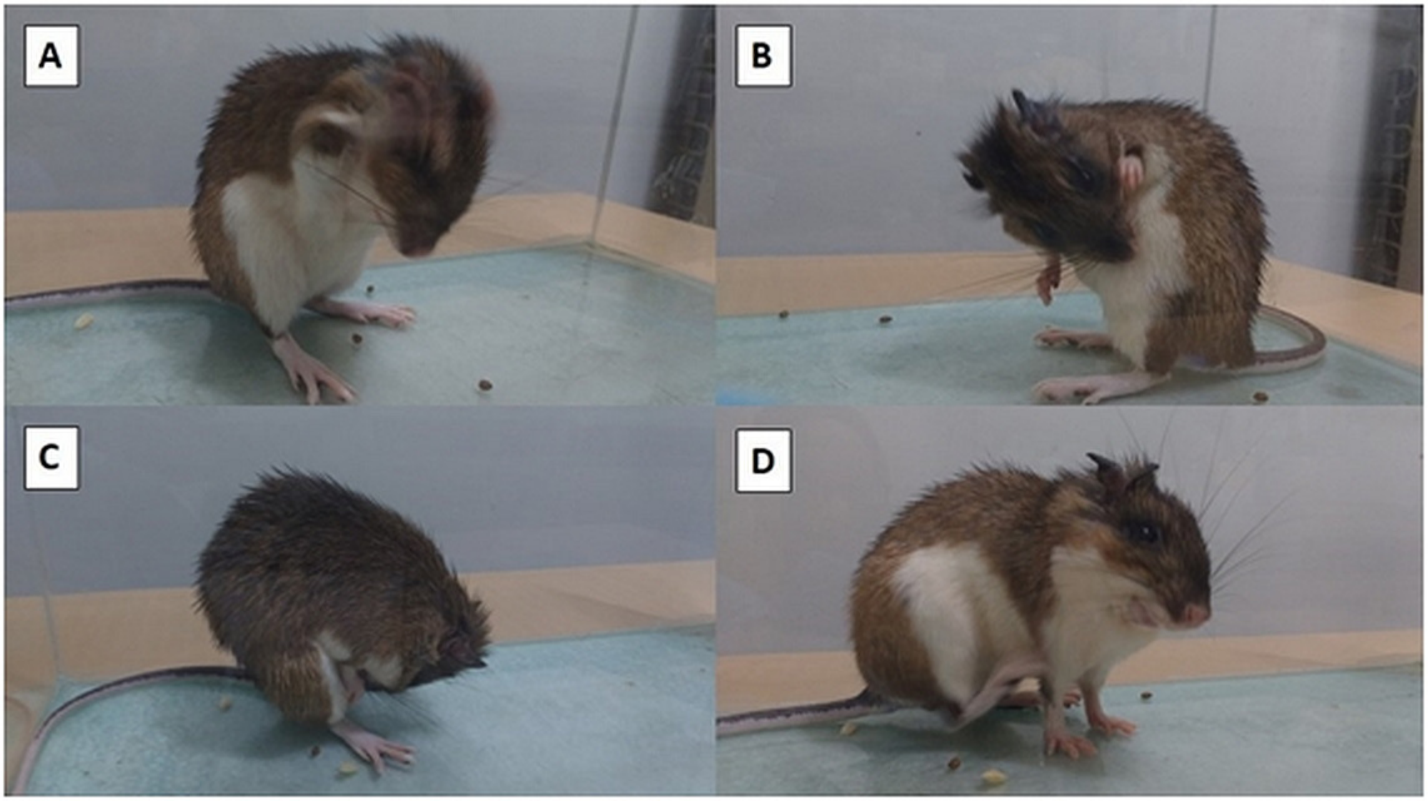


Figure 2. *Trinomys setosus* exhibiting four behaviors related to grooming as observed in our analyses: A) face washing; B) body washing; C) washing of the pelvic region; D) scratching. Photos taken by FRB.

Studies performed on different taxonomic groups have shown that closely related species show minimal differences in grooming behaviors (Farish 1972; Berridge 1990). Possible interspecific variations in grooming behavioral sequences are rarely described in the literature for wild species of rodents since most studies on grooming focus on the description of behavioral subunits. In fact, *T. setosus* shows similar behaviors (washing, combing, scratching, and licking of the anogenital region) related to grooming as described for *T. yonenagae* (Manaf 2000). Differences in grooming behavioral traits in rodents might be related to temporal parameters, or as shown in a comparative study with rats, mice, hamsters, and guinea pigs, might be related to an allometric scale, since the duration of body cleaning cycles was related to the average size of the investigated species (Berridge 1990).

Since *T. setosus* is the sister species of *T. yonenagae*, we could not expect significant differences in its grooming categories. However, the fact that *T. setosus* has twice the body mass of *T. yonenagae* might affect absolute and/or relative duration of the categories, since differences in body size might affect the species' surface to volume ratio, consequently affecting the time needed to clean their body. Therefore, *T. setosus* could be expected to show a lower rate of grooming than its sister species. Such a possible correlation between body size and grooming duration could be tested using animals or species of different sizes, but due to the low variation in *T. setosus* body mass in our study, we cannot make a more direct correlation.

The present study's contribution consists of a brief description of behavioral categories of an endemic Brazilian rodent species, especially related to its grooming behavior. Future fieldwork or experimental studies might benefit from such a description in *T. setosus* and expand it to other species of spiny rats.

Acknowledgements

We thank Maria Sol Brassesco Annichini for revising the Spanish abstract. This work was funded by CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil) and its Academic Excellence Program (PROEX) to FRB (Finance code 001). We would like to thank Thalita Aparecida Riul Prado Gonçalves for her fundamental technical support at the animal care facility of the Laboratório de Ecofisiologia e Comportamento de Roedores Silvestres (LECO). We also thank the two anonymous reviewers whose comments improved an earlier version of this manuscript.

Literature cited

Alberts, C. C. 1996. O comportamento de autolimpeza do gato doméstico *(Felis catus)* e uma proposta para usá-lo como caractere filogenético. Tese de Doutorado, Programa de Pós-Graduação em Psicologia Experimental, Universidade de São Paulo. São Paulo, Brazil.

Altmann, J. 1974. Observational study of behavior: sampling methods. Behaviour 49:227-267.

Annable, A., and J. H. Wearden. 1979. Grooming movements as operants in the rat. Journal of the Experimental Analysis of Behavior 32:297-304.

Berridge, K. C. 1990. Comparative fine structure of action: Rules of form and sequence in the grooming patterns of six rodent species. Behaviour 113:21-56.

Cantano, L. M. R., L. C. Luchesi, J. T. Takata, and P. F. Monticelli. 2023. Behavioral repertoire of the Brazilian spiny-rats, *Trinomys setosus* e *Clyomys laticeps*: different levels of sociality. Brazilian Journal of Biology 83:e241164.

Courcelle, M., M. K. Tilak, Y. L. R. Leite, E. J. P. Douzery, and P. H. Fabre. 2019. Digging for the spiny rat and hutia phylogeny using a gene capture approach, with the description of a new mammal subfamily. Molecular Phylogenetics and Evolution 136:241-253.

Emmons, L. H., and F. Feer. 1997. Neotropical Rainforest Mammals - A Field Guide. 2d. Ed. The University of Chicago Press. Chicago, U.S.A.

Fabio-Braga, A. P., and W. Klein. 2018. Temperature and circadian effects on metabolic rate of South American echimyid rodents, *Trinomys setosus* and *Clyomys bishopi* (Rodentia: Echimyidae). Zoologia (Curitiba) 35:1-6.

Fabre, P. H., T. Galewski, M. K. Tilak, and E. J. P. Douzery. 2013. Diversification of South American spiny rats (Echimyidae): A multigene phylogenetic approach. Zoologica Scripta 42:1-18.

Fabre, P. H., N. S. Upham, L. H. Emmons, F. Justy, Y. L. R. Leite, A. C. Loss, L. Orlando, M. K. Tilak, B. D. Patterson, and E. J. P. Douzery. 2016. Mitogenomic phylogeny, diversification, and biogeography of South American spiny rats. Molecular Biology and Evolution 34:613-633.

Farish, D. J. 1972. The evolutionary implications of qualitative variation in the grooming behaviour of the Hymenoptera (Insecta). Animal Behaviour 20:662-676.

Ferkin, M. H., S. T. Leonard, L. A. Heath, and C. G. Paz-y-Miño. 2001. Self-grooming as a tactic used by prairie voles *Microtus ochrogaster* to enhance sexual communication. Ethology 107:939-949.

Hawlena, H., D. Bashary, Z. Abramsky, and B. R. Krasnov. 2007. Benefits, costs and constraints of anti-parasitic grooming in adult and juvenile rodents. Ethology 133:394-402.

Hoey, K. A., R. R. Wise, and G. H. Adler. 2006. Ultrastructure of echimyid and murid rodent spines. Journal of Zoology 263:307-315.

Iack-Ximenes, G. E. 2005. Sistemática de *Trinomys* Thomas, 1921 (Rodentia, Hystricognathi, Echimyidae). Tese de Doutorado, Programa de Pós-Graduação em Zoologia, Universidade de São Paulo. São Paulo, Brazil.

Kaiser, S. K., T. C. C. Margarido, and M. L. Fischer. 2011. Avaliação do comportamento de cutias *Dasyprocta azarae* e *Dasyprocta leporina* (Rodentia: Dasyproctidae) em cativeiro e semi cativeiro em parques urbanos de Curitiba, Paraná, Brasil. Revista de Etologia 10:68-82.

Kalueff, A. V., and P. Tuohimaa. 2004. Grooming analysis for neurobehavioral stress research. Brain Research Protocols 13:151-158.

Kalueff, A. V., J. W. Aldridge, J. L. Laporte, D. L. Murphy, and P. Tuohimaa. 2007. Analyzing grooming microstructure in neurobehavioral experiments. Nature Protocols 2:2538-2544.

Lara, M. C., and J. L. Patton. 2000. Evolutionary diversification of spiny rats (genus *Trinomys*, Rodentia: Echimyidae) in the Atlantic Forest of Brazil. Zoological Journal of the Linnean Society 130:661-686.

Lara, M. C., J. L. Patton, and E. Hingst-Zaher. 2002. *Trinomys mirapitanga*, a new species of spiny rat (Rodentia: Echimyidae) from the Brazilian Atlantic Forest. Mammalian Biology 67:233-242.

Manaf, P. 2000. Estudo do comportamento social de uma população de *Proechimys yonenagae* (Rodentia: Echimyidae) em cativeiro. Dissertação de Mestrado, Programa de Pós-Graduação em Neurociências e Comportamento, Universidade de São Paulo. São Paulo, Brazil.

Manaf, P., and E. Spinelli Oliveira. 2000. Behavioral repertoire of *Proechimys* (*Trinomys*) *yonenagae* (Rodentia: Echimyidae) in captivity. Revista de Etologia 2:3-15.

Manaf, P., L. Brito-Gitirana, and E. Spinelli Oliveira. 2003a. Evidence of chemical communication in the spiny rat (*Trinomys yonenagae*, Echimyidae): anal scent gland and social interactions. Canadian Journal of Zoology 81:1138-1143.

Manaf, P., S. Morato, S., and E. Spinelli Oliveira. 2003b. Profile of wild Neotropical spiny rats (*Trinomys*, Echimyidae) in two behavioral tests. Physiology and Behavior 79:129-133.

Manaf, P., and E. Spinelli Oliveira. 2009. Female choice in *Trinomys yonenagae*, a spiny rat from the Brazilian Caatinga. Revista Brasileira de Zoociências 11:200-207.

Marcomini, M., and E. Spinelli Oliveira. 2003. Activity pattern of echimyid rodent species from the Brazilian Caatinga in captivity. Biological Rhythm Research 34:157-166.

Monteiro, L. R., V. Bonato, V., and S. F. dos Reis. 2005. Evolutionary integration and morphological diversification in complex morphological structures: mandible shape divergence in spiny rats (Rodentia, Echimyidae). Evolution and Development 7:429-439.

Moojen, J. 1952. Os Roedores do Brasil. Instituto Nacional do Livro. Rio de Janeiro, Brazil.

Ottoni, E. B. 2000. EthoLog 2.2: a tool for the transcription and timing of behavior observation sessions. Behavior Research Methods, Instruments, and Computers 32:446-449.

Pessôa, L. M., W. C. Tavares, J. A. Oliveira, and J. L. Patton. 2015. Genus *Trinomys* Thomas, 1921. Pp. 1015-1016 *in* Mammals of South America, vol. 2 (Patton, J. L., U. F. J. Pardiñas, and G. D'Elía, eds.). The University of Chicago Press, Chicago, U.S.A.

Randall, J. A. 1994. Convergences and divergences in communication and social organization of desert rodents. Australian Journal of Zoology 42:405-433.

Rocha, P. L. B. 1995. *Proechimys yonenagae*, a new species of spiny rat (Rodentia: Echimyidae) from fossil sand dunes in Brazilian Caatinga. Mammalia 59:537-549.

Sabatini, V., and M. J. R. Paranhos da Costa. 2001. Etograma da paca (*Agouti paca*, Linnaeus, 1766) em cativeiro. Revista de Etologia 3:3-14.

Santos, J. W. A., and E. A. Lacey. 2011. Burrow sharing in the desert-adapted torch-tail spiny rat, *Trinomys yonenagae*. Journal of Mammalogy 92:3-11.

Shanas, U., and J. Terkel. 1996. Grooming secretions and seasonal adaptations in the blind mole rat (*Spalax ehrenbergi*). Physiology and Behavior 60:653-656.

Upham, N. S., and B. D. Patterson. 2012. Diversification and biogeography of the Neotropical caviomorph lineage Octodontoidea (Rodentia: Hystricognathi). Molecular Phylogenetics and Evolution 63:417-429.

Wolff, J. O., M. H. Watson, and S. A. Thomas. 2002. Is self-grooming by prairie a predictor of mate choice? Ethology 108:169-179.

Associated editor: Tamara M. Rioja-Paradela
Submitted: August 14, 2021; Reviewed: October 28, 2021.
Accepted: November 5, 2021; Published on line: November 16, 2021.

THERYA NOTES 2021, Vol. 2 : 166-170

DOI: 10.12933/therya_notes-21-56 I SSN 2954-3614

Abundance of aposematic patterns in hooded skunk, *Mephitis macroura*

Abundancia de los patrones aposemáticos en el zorrillo listado sureño, *Mephitis macroura*

Alina Gabriela Monroy-Gamboa[1]*, Mario C. Lavariega[2], and Dagoberto Ramos-Méndez[2]

[1]Centro de Investigaciones Biológicas del Noroeste, S. C. Av. Instituto Politécnico Nacional 195, C. P. 23096. La Paz, Baja California Sur, México. E-mail: beu_ribetzin@hotmail.com (AGM-G).

[2]Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional, Unidad Oaxaca, Instituto Politécnico Nacional. Hornos 1003, C. P. 71230. Santa Cruz Xoxocotlán, Oaxaca, México. E-mail: mlavariegan@ipn.mx (MCL); dmendez_11@hotmail.com (DR-M).

*Corresponding author

Some organisms warn their predators through color patterns. This is the case of the hooded skunk, *Mephitis macroura*. Under the assumption that the coloration of skunks is aposematic, we analyzed the coloration patterns of a population of hooded skunks. We hypothesized that the individuals showing a more contrasting coloration, should be more abundant in open vegetation types than those with a less contrasting pelage coloration. Using camera-traps, we grouped photographs of hooded skunks showing different combinations of color patterns and determined the relative abundance of individuals by color patterns by set and habitat type. We identified 25 individuals in the study area, most of them in induced grasslands, and identified four combinations of color patterns. We found an overlap of the period of activity and space, as well as a higher abundance of the most contrasting color pattern in the most open type of vegetation, accepting our hypothesis. We contribute to a better understanding of the ecologic relations between the habitat and the possible adaptations of some species to their environment like the skunks.

Key words: Banner-bearer; camera trap; carnivores; color pattern; Mixteca region; Oaxaca.

Algunos organismos advierten a sus depredadores a través de patrones de coloración. Este es el caso del zorrillo listado sureño, *Mephitis macroura*. Asumimos que la coloración de los zorrillos es aposemática, por lo que el objetivo fue analizar los patrones de coloración de una población de zorrillo listado sureño. Nuestra hipótesis fue que los individuos que mostraran una coloración más contrastante serían más abundantes en tipos de vegetación abierta que aquellos con una coloración de pelaje menos contrastante. Por medio de cámaras-trampa, agrupamos las fotografías del zorrillo listado sureño mostrando diferentes tipos de combinación de los patrones de coloración y se determinó la abundancia relativa de los individuos por patrones por grupo y hábitat. Identificamos 25 individuos en el área de estudio, la mayoría en pastizales inducidos e identificamos cuatro combinaciones de patrones de coloración. Encontramos una superposición en el periodo de actividad y el espacio, así como una alta abundancia del patrón de coloración más contrastante en el tipo de vegetación más abierta, aceptando nuestra hipótesis. Se contribuye a un mayor entendimiento sobre las relaciones ecológicas entre el hábitat y la posible adaptación de las especies a su ambiente como los zorrillos.

Palabras claves: Abanderado; cámaras-trampa; carnívoros; Oaxaca; patrón de coloración; región Mixteca.

Living organisms have evolved in various ways to survive, including the adoption of defense mechanisms that can be olfactory, auditory, or visual. Visually, the individual catches the attention of potential predators through a warning coloration (Cott 1940; Mochida 2011). This defense mechanism has been studied mainly in plants, invertebrates, amphibians, reptiles, birds, and some mammals (Mochida 2011; Lev-Yadun 2016; Ebersbach *et al.* 2020; Pinheiro-de Castro *et al.* 2020). In mammals, the difference in coloration is not only useful as a functional defense adaptation; it also serves as camouflage, as well as for communication or thermoregulation (Caro 2005; Lindstedt *et al.* 2008).

Skunks have a variety of ways to alert their predators, including auditory, olfactory, and visual mechanisms, and evidence their presence through behavioral and physical signals (Medill *et al.* 2011); their main predators are felids, canids, and birds of prey (Hwang and Larivière 2001). The hooded skunk (*Mephitis macroura*) is a small-sized carnivorous species; its coloration varies among individuals, with different proportions of black and white pelage, and a brown or reddish coloration occasionally present (Dragoo 2009). It has a large, notoriously hairy tail used as a warning banner, which can display diverse color patterns ranging from monochromatic to bicolor (Hwang and Larivière

2001). The color pattern varies among individuals of the same species, geographic area, or population; individuals with whiter pelage are more noticeable from greater distances (Van Gelder 1968). Color patterns do not depend on sex, age, moult, or size (Van Gelder 1968; Dragoo 2009).

In skunks, color patterns can have multiple combinations, although a general pattern is evident (Van Gelder 1959). There are some studies about the relation of coloration patterns in skunks with their environment (Van Gelder 1968; Dragoo *et al.* 2003) but none were conducted with the hooded skunk. Under the assumption that the coloration of skunks is aposematic (conspicuous appearance to warn predators), we analyzed the coloration patterns of a population of hooded skunks living in the Mixteca region of Oaxaca, México. Our working hypothesis was that the individuals showing a more contrasting coloration, that is, aposematic, should be more abundant in open types of vegetation than those with a less contrasting pelage coloration, because the warning results more effective.

The study area is the municipality of Cosoltepec, Huajuapan de León district in the Mixteca region of the state of Oaxaca, México. Sampling was conducted from December 2013 to June 2014. We deployed a grid of 14 camera-traps with no bait within a 19.7 km^2 quadrant, defined as a minimum convex polygon. Camera-traps (Cuddeback®, 3 MB resolution) were placed 30 cm above the ground and 1.5 km apart, these camera-traps only take photographs, were set to operate 24 hours daily with a minimum 30 seconds delay between shots, one at the time. Image records were georeferenced on the VI land use and vegetation series map (INEGI 2016) to corroborate field data (Figure 1).

We classified hooded skunk (*Mephitis macroura*) photographs according to the coloration pattern using a 1-to-5 scale, where one (1) is the pattern with the least contrast and five (5) corresponds to the highest contrast (Hass 2003), as follows: 1) Shadow (Sh): pelage mostly black, may be moderate grizzly on the tail; 2) Hooded (H): all body pelage black, except for the head, which is white; 3) Lined (L): back generally black, showing a white stripe from the chest to the hind legs; it may or may not show secondary white stripes from behind the ears to the scapula or a thin white stripe across the scapula; 4) Silvered (S): white back from nape to tail; and 5) Banner-bearer (BB): abundant whitish pelage in all the back, with lateral stripes (Figure 2). One person did the first classification; later another person corroborated it.

The differential color pattern and particular characteristics allowed identifying individual organisms. Relative abundance was estimated as the percentage of individuals in each color category relative to the total number of

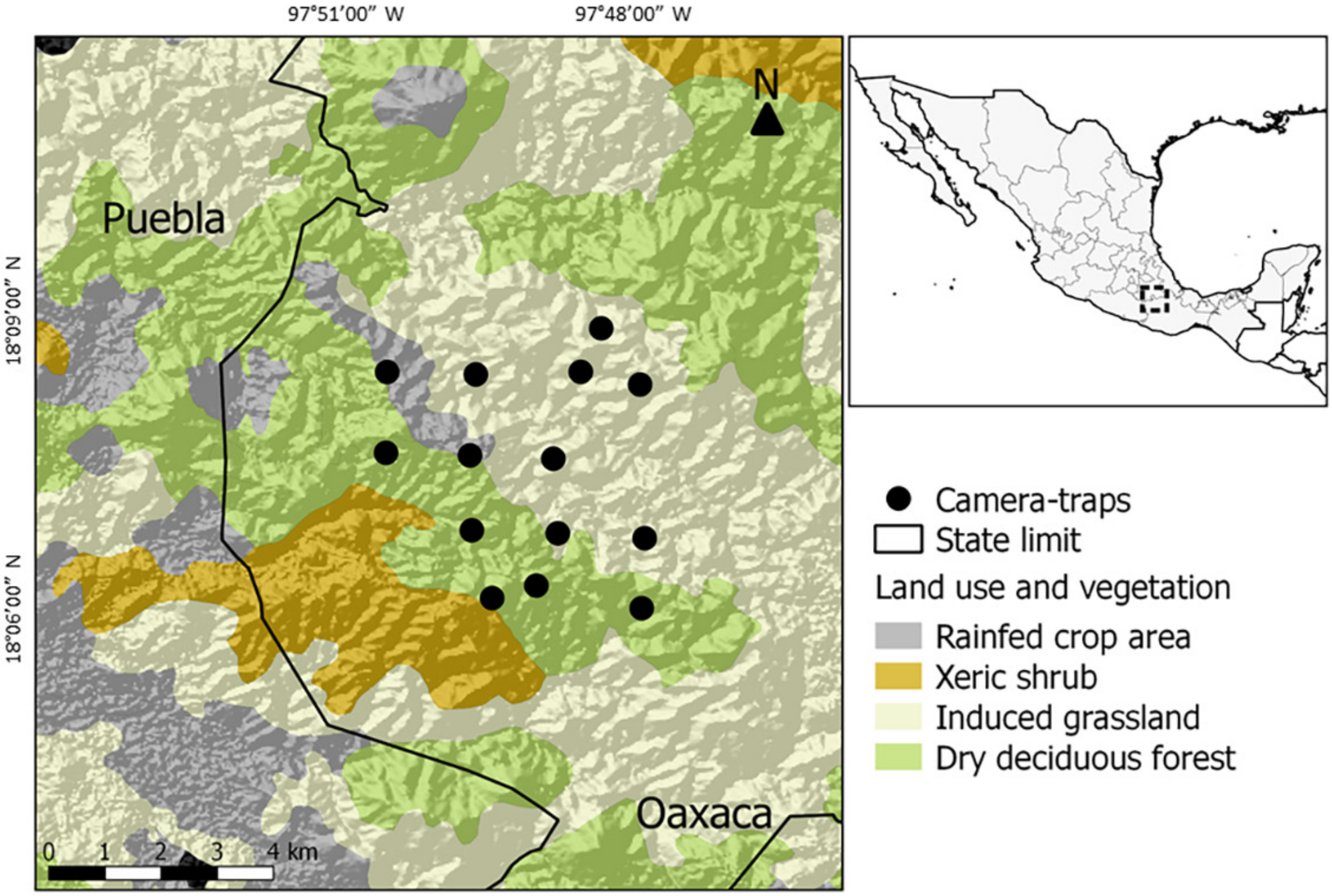


Figure 1. Geographic ubication of the camera-traps (black spots) in the different types of vegetation in Cosoltepec, Oaxaca, México. Vegetation types from INEGI (2016).

individuals sampled. We ran an asymmetry coefficient in Microsoft Excel with the formula "Coeficiente.Asimetria.P" per type of vegetation and coloration patterns to test our hypothesis.

With a sampling effort of 2,520 camera-traps / day, we captured 40 photographs of hooded skunk, considering only 7 of the 14 camera-traps deployed (50 %; 3 placed in induced grassland, 2 in rainfed crops, and 2 in dry deciduous forest); the greatest sampling effort was done in the induced grassland.

We identified 25 individuals, which were assigned to four of the five coloration patterns (Table 1; Figure 2). Most of the individuals (36 %) showed the Banner-bearer coloration pattern (the one with the greatest contrast), and no individuals with the Shadow pattern (the one with the least contrast) were recorded (Table 1).

The induced grassland is the dominant habitat type in the study area; it has secondary shrubby vegetation related to the dry deciduous forest, with extensive cattle and goat farming, whose offspring can be potential prey for medium-sized carnivores. The highest number of hooded skunks (64 %) was recorded in this habitat, 50 % of which were classified as Banner-bearers (Figure 3). The results of the asymmetry coefficient showed a positive asymmetry for induced grassland (0.816). Conversely, the rainfed crop area showed a negative asymmetry (-0.214). For the dry deciduous forest the coefficient resulted zero.

Table 1. Number of individuals of hooded skunk, *Mephitis macroura* and relative abundance by color patterns in Cosoltepec, Oaxaca, México.

Color pattern	Individuals	Relative Abundance
Shadow	N/D	0
Hooded	3	12
Lined	8	32
Silvered	5	20
Banner-bearer	9	36
Total	*n* = 25	100

N/D = No Data

In the rainfed crop area (corn, beans, and squash), characterized by sparse plant cover, no Banner-bearer individuals were recorded; this finding suggests that the rainfed crop area does not favor conspicuous individuals (Fay 2017; Fisher and Stankowich 2018). In contrast, only 8 % of the individuals were recorded in the dry deciduous forest, belonging to the Lined and Banner-bearer types (Figure 3). Only a single individual (Silvered) was recaptured with the same camera-trap in induced grassland during the pre-rainy and rainy seasons.

Figure 2. Color patterns of hooded skunk, *Mephitis macroura* in Cosoltepec, Oaxaca, México. A: Hooded; B: Lined; C: Silvered; D: Banner-bearer.

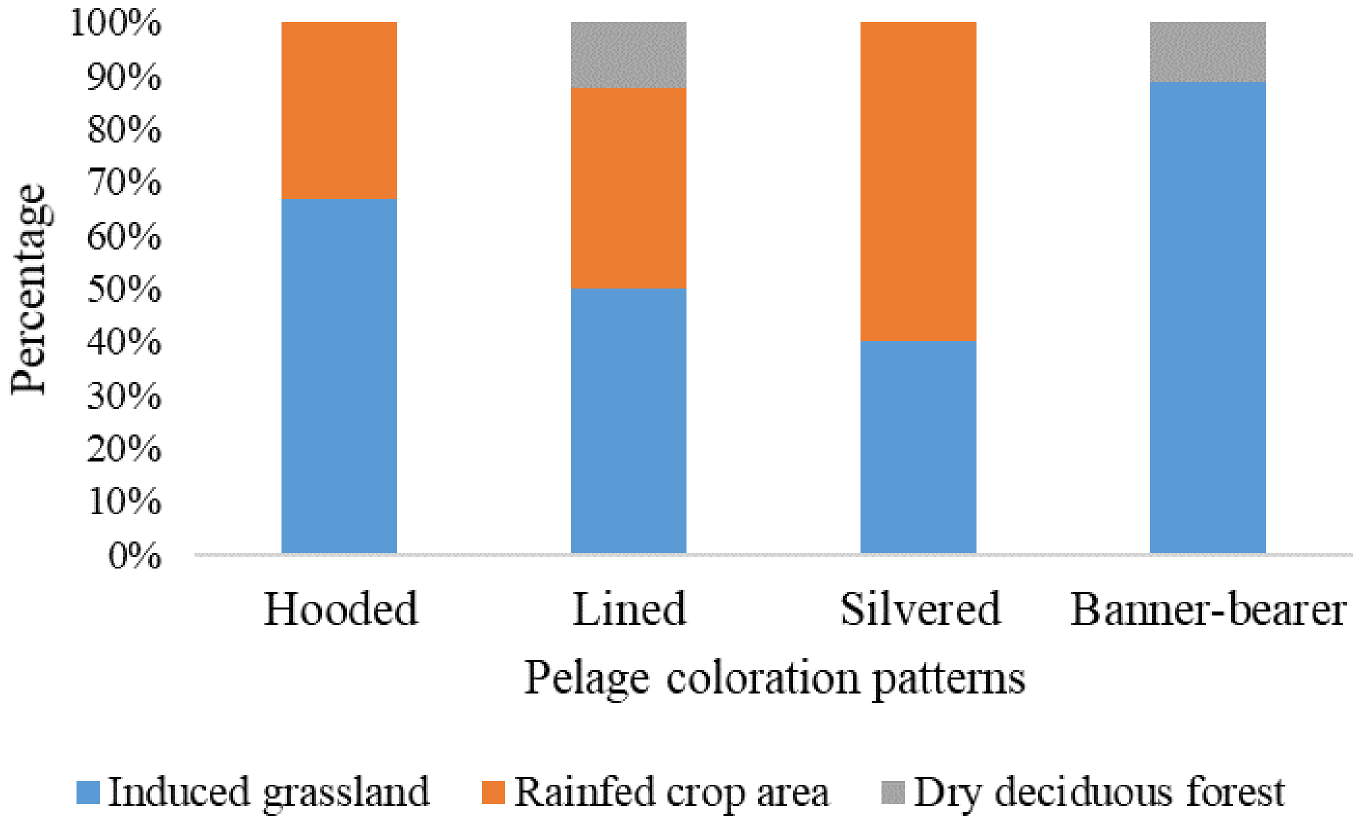


Figure 3. Percentage of individuals of hooded skunk, *Mephitis macroura* by vegetation types and pelage color patterns in Cosoltepec, Oaxaca, México.

The light is an important factor for the black and white species, it is documented that the striped species, like some skunk species, are easier to see in open-lighting areas (Caro *et al.* 2013). The hooded skunks recorded display different combinations of pelage coloration patterns in the study area. The predominant coloration pattern was the Banner-bearer, the one with the greatest contrast, making individuals more conspicuous and easier to spot by predators, unlike the less aposematic Shadow monochromatic coloration, which was not recorded in the study area. Also, the Banner-bearer was the coloration pattern that defined a positive or a negative asymmetry, showing the importance of aposematism in different vegetation types, and demonstrating our hypothesis.

In our study area, Ramos-Méndez (2015) found an overlap of daily activity patterns between the hooded skunk and its potential predators (coyote and bobcat), suggesting that despite its parsimonious movement, the hooded skunk coexists with its predators, and the aposematism is effective for them. This overlap of the period of activity and space, as well as a higher abundance of the most contrasting color pattern and the lower abundance of the least contrasting pattern, suggests that the aposematic coloration of skunks serve to communicate a warning to predators, reducing the likelihood of been selected as prey. These results confirm our hypothesis that a more contrasting coloration (aposematic) are more abundant than those with a less contrasting pelage coloration, because the warning results more effective. Similar findings were realized with other skunk species, they demonstrate that when they have more white fur and they were bigger, the potential predators react to noxious and avoid them (Hunter 2009; Caro *et al.* 2013; Mann 2018; Howell *et al.* 2021). Mann (2018) showed that the coloration patterns in *M. mephitis* have more variation in habitats with more risk of predation. These studies were conducted for terrestrial predators. Recently, a hooded skunk predation by a greater horned owl was reported by Sánchez-Rojas *et al.* (2021). Authors mentioned that probably the aposematism of the skunk was not effective for the raptor. It could be interesting to analyze the relation of the aposematism of skunk species with non-terrestrial predators.

Our results consider that there is an influence of the type of habitat on the degree of aposematism of the hooded skunk exists, but the sample size was remarkably reduced and the induced grassland was the type of vegetation with more sample effort. Although it seems that the least aposematic individuals were associated with sites with a higher vegetation cover, while the most conspicuous individuals tended to be more cosmopolitan. We recommend to replicate this analysis in a bigger scale. The wide distribution range of this species will be ideal to have all the types of habitats and all coloration patterns.

This contributes to the better understanding of the ecological relations between the habitat and the possible physical adaptations of some species to their environment like the skunks.

Acknowledgements

We thank to the municipal and ejidal authorities of Cosoltepec for the permission given to develop this study in their territories. The field work was supported by Secretaría de Investigación y Posgrado, Instituto Politécnico Nacional, with a project managed by M. A. Briones-Salas. Y. M. Martínez-Ayón and B. Riveros-Lara by their valuable support on field. AGM-G thanks to Consejo Nacional de Ciencia y Tecnología (CONACyT) for her postdoctoral fellowship at Centro de Investigaciones Biológicas del Noroeste, S. C. (CVU 206047). The authors thanks to S. T. Castañeda-Álvarez that reviewed early versions of this manuscript and two anonymous reviewers that help to improve it. To M. E. Sánchez for the language edition.

Literature cited

Caro, T. 2005. The adaptative significance of coloration in mammals. BioScience 55:125-136.

Caro, T., T. Stankowich, C. Kiffner, and J. Hunter. 2013. Are spotted skunks conspicuous or criptic? Ethology Ecology & Evolution 25:144-160.

Cott, H. B. 1940. Adaptative coloration in animals. Metheun and Co. London, United Kingdom.

Dragoo, J. W. 2009. Nutrition and behaviour of Striped Skunks. Veterinary Clinics of North America: Exotic Animal Practice 12:313-325.

Dragoo, J. W., R. L. Honeycutt, and D. J. Schmidly. 2003. Taxonomic status of white-backed hog-nosed skunks, genus *Conepatus* (Carnivora: Mephitidae). Journal of Mammalogy 84:159-176.

Ebersbach, J., A. Posso-Terranova, S. Bogdanowicz, M. Gómez-Díaz, M. X. García-González, W. Bolívar-García, and J. Andrés. 2020. Complex patterns of differentiation and gene flow underly the divergence of aposematic phenotypes in *Oophaga* poison frogs. Molecular Ecology 29:1944-1956.

Fay, C. 2017. Aposematic variation and the evolution of warning coloration in mammals. M.Sc. thesis. California State University. California, U.S.A.

Fisher, K. A., and T. S. Stankowich. 2018. Antipredator strategies of striped skunks in response to cues of aerial and terrestrial predators. Animal Behavior 143:25-34.

Hass, C. C. 2003. Ecology of Hooded and Striped Skunks in Southern Arizona. Arizona Game and Fish Department, Heritage Fund. Arizona, U.S.A.

Howell, N., C. Sheard, M. Konen, K. Brockelsby, K. Ono, and T. Caro. 2021. Aposematism in mammals. Evolution 75:2480-2493.

Hunter, J. S. 2009. Familiarity breeds contempt: effects of striped skunk color, shape and abundance on wild carnivore behaviour. Behavioral Ecology 20:1315-1322.

Hwang, Y. T., and S. Larivière. 2001. *Mephitis macroura.* Mammalian Species 686:1-3.

Instituto Nacional de Estadística y Geografía (INEGI). 2016. Conjunto de datos vectoriales de la carta de Uso de Suelo y Vegetación. Escala 1:250,000 Serie VI. Conjunto Nacional. Instituto Nacional de Estadística y Geografía, México. https://www.inegi.org.mx/temas/usosuelo/#Descargas. Accessed in August 2, 2020.

Lev-Yadun, S. 2016. Defensive (anti-herbivory) coloration in land plants. Springer International Publishing, Switzerland.

Lindstedt, C., L. Lindström, and J. Mappes. 2008. Thermoregulation constrains effective warning signal expression. Evolution 63:469-478.

Mann, V. 2018. The characteristics of aposematism and noxious spray in the striped skunk (*Mephitis mephitis*). M. Sc. Thesis. California State University. Long Beach, California, U.S.A.

Medill, S. A., A. Renard, and S. Larivière. 2011. Ontogeny of antipredator behaviour in striped skunks (*Mephitis mephitis*). Ethology Ecology & Evolution 23:41-48.

Mochida, K. 2011. Combination of local selection pressures drives diversity in aposematic signals. Evolutive Ecology 25:1017-1028.

Pinheiro-de Castro, E., R. Demirtas, A. Orteu, C. E. Olsen, M. Saddik, M. Zikan-Cardoso, M. Zagrobelny, and S. Bak. 2020. The dynamics of cyanide defences in the life cycle o fan aposematic butterfly: biosynthesis versus sequestration. Insect Biochemistry and Molecular Biology 116:103259.

Ramos-Méndez, D. 2015. Diversidad, actividad y uso de hábitat de carnívoros en dos sitios con diferente grado de perturbación en el municipio de Cosoltepec, Oaxaca. M. Sc. Thesis. Centro Interdisciplinario de Investigación para el Desarrollo Integral Regional-Unidad Oaxaca. Instituto Politécnico Nacional, Oaxaca, México.

Sánchez-Rojas, G., Z. K. Zepeda-Hernández, J. A. Hernández-Melo, C. A. Maciel-Mata, and J. A. Hernández-Silva. 2021. Predation of the hooded skunk, *Mephitis macroura*, by the great horned owl, *Bubo virginianus*, in the Barranca de Metztitlán Biosphere Reserve, Hidalgo, México. Therya Notes 2:105-108.

Van Gelder, R. G. 1959. A taxonomic revision of the spotted skunks (genus *Spilogale*). Bulletin of the American Museum of Natural History 117:229-392.

Van Gelder, R. G. 1968. The genus *Conepatus* (Mammalia, Mustelidae): Variation within a population. American Museum Novitates 2322:1-38.

Associated editor: José F. Moreira-Ramírez
Submitted: August 9, 2021; Reviewed: November 4, 2021.
Accepted: November 11, 2021; Published on line: November 18, 2021.

THERYA NOTES 2021, Vol. 2 : 171-175 DOI: 10.12933/therya_notes-21-57 I SSN 2954-3614

Abnormal tooth and home range size of a male tayra (*Eira barbara*) in Atlantic Rain Forest, South Brazil

Diente anormal y ámbito hogareño de un viejo de monte (*Eira barbara*) en la Mata Atlántica al sur de Brasil

Rosane Vera Marques[1], Andrea Sarahí Fernández-Montejo[2], and Álvaro José Villafañe-Trujillo[2, 3*]

[1]Unidade de Assessoramento Ambiental, Gabinete de Assessoramento Técnico. Ministério Público do Estado do Rio Grande do Sul CEP. 90.010-210. Porto Alegre, RS, Brasil. E-mail: rosanbat@terra.com.br (RVM).

[2]Laboratorio de Zoología, Facultad de Ciencias Naturales, Campus Juriquilla, Universidad Autónoma de Querétaro. Av. de la Ciencias s/n, Santa Rosa Jáuregui, C. P. 76230. Santiago de Querétaro, Querétaro, México. E-mail: andy.montejo94@gmail.com (ASF-M).

[3]Instituto de Investigaciones Biológicas, Universidad Veracruzana. Av. Luis Castelazo Ayala s/n, Col. Industrial Ánimas, C. P. 91190. Xalapa de Enríquez, Veracruz, México. E-mail: villafanetrujillo85@gmail.com (ÁJV-T).

*Corresponding author

The study of dental abnormalities in mustelids has allowed identifying and describing pathologies of species distributed in different habitats and continents. These analyses have been carried out in dead animals. Through a noninvasive survey, we found a Neotropical mustelid *in situ* with a dental abnormality. We take advantage of this characteristic to obtain ecological information about the species. We describe the camera trap records of a free-living male tayra (*Eira barbara*) from South Brazil with an overdeveloped upper left canine; we used this feature to identify the specimen and recapture it individually. Through the analysis of the Kernel density estimation, we calculated his home range size. We reviewed skulls of tayra in search of dental abnormalities. The male tayra were recaptured in 5 camera stations within the Floresta Nacional de São Francisco de Paula (FLONA-SFP) on 11 different occasions during 7 months (from March to September of 2012), its home range size was 4.79 km^2. We found differences in the number of molars in the mandible in two of the five skulls that we reviewed. Apparently, the abnormal canine has not interfered with the eating habits of the tayra, who has reached adulthood. This tayra could occupy an area outside our survey polygon within the FLONA-SFP; his home range size could be more extensive than we reported.

Key words: Carnivore; diet; diurnal; mammal; mustelid; Neotropics; omnivore; scansorial.

El estudio de anormalidades dentales en mustélidos ha permitido identificar y describir patologías de especímenes distribuidos en diferentes hábitats y continentes. Estos análisis han sido implementados en cráneos de animales muertos. A través de un monitoreo no invasivo, se detectó a un mustélido neotropical *in situ* con una anormalidad dental, esa característica fue aprovechada para obtener información ecológica de la especie. Se analizaron registros de cámara trampa de un cabeza de viejo (*Eira barbara*) en vida libre en el sur de Brasil, el cual presentaba un canino superior izquierdo sobre-desarrollado, esta característica permitió identificarlo individualmente y recapturarlo. Mediante la estimación de densidad de Kernel se calculó el tamaño de su ámbito hogareño. Se revisaron cráneos de la especie en busca de anormalidades dentales. El espécimen fue recapturado en 5 estaciones de foto-muestreo dentro del Floresta Nacional de São Francisco de Paula (FLONA-SFP) en 11 ocasiones diferentes, durante un periodo de 7 meses (Marzo a Septiembre de 2012), el tamaño de su ámbito hogareño fue de 4.79 km^2. Se encontraron diferencias en la cantidad de molares en dos mandíbulas de los cinco cráneos revisados. Aparentemente el canino anormal no ha interferido en la alimentación del espécimen, ya que ha alcanzado la adultez. El cabeza de viejo podría ocupar un área fuera de nuestro polígono de estudio dentro de la FLONA-SFP, por lo cual el tamaño de su ámbito hogareño podría ser más grande de lo que se reporta.

Palabras clave: Carnívoro; dieta; diurno; escansorial; mamífero; mustélido; Neotrópico; omnívoro.

The study on variations in mammals' dental characteristics (size, shape, quantity, and pathologies) provide insights related to feeding habits, evolutive history, life experience and ontogeny (Alt 1999). In mustelids the studies in dental abnormalities have been developed from the study of skulls, which has made it possible to identify pathologies in several species, such as: *Enhydra lutris* (fused teeth, and periodontitis; Winer *et al.* 2012), *Gulo gulo* (additional teeth – polydonty –, congenital lack of teeth – oligodonty –, and root rotation; Jung *et al.* 2016), *Lutra lutra* (deviations from normal dental pattern, polydonty or oligodonty, displacement of the teeth in the tooth row and abnormal shape of teeth; Hauer 2002), *Martes foina* (irregular arrangements, polydonty, oligodonty, unilaterally or bilaterally lack of teeth, rotation, and crown fractures; Konjevi *et al.* 2011), *Martes martes* (size differences between tooth rows, lower incisors of different sizes, tooth twisted or partly erupted, atypical number of incisors, and overdeveloped tooth;

Wolsan 1984), *Meles meles* (numerical variations in the number of premolars; Hancox 1988), and *Neovison vison* (abnormal molars structure; Korablev *et al.* 2013). Here we report the first abnormal tooth record of a living tayra (*Eira barbara*) *in situ*, and the first home range size of the species obtained non-invasively.

The records are the result of camera trap surveys in Floresta Nacional de São Francisco de Paula (located in the municipality of São Francisco de Paula, within the state of Rio Grande do Sul, geographic limits of the FLONA-SFP are: 29° 23′ 31.38″ S, 50° 22′ 55.78″ W (North); 29° 27′ 15.88″ S, 50° 24′ 9.32″ W (South); 29° 26′ 9.53″ S, 50° 22′ 4.01″ W (East); and 29° 24′ 48.85″ S, 50° 25′ 1.45″ W (West); ICMBio 2020), focused on the monitoring of middle-sized and large mammals (Authorization SISBIO / ICMBio nº 26664-1). The FLONA-SFP has an extension of 1,615.6 ha; vegetation is mostly covered by a subtype of Atlantic Forest (*Mixed Ombrophilous Forest*), planted *Araucaria*, *Pinus*, and open fields, the area has rivers, lakes and swamps (Renner *et al.* 2016). The weather is humid, warm, temperate oceanic climate (*Cfb* Köppen-Geiger System; Kottek *et al.* 2006). The mean annual precipitation is 2,240 mm; temperature ranges from -6.5 °C to 34 °C, there is not a dry season (Cademartori *et al.* 2002).

In total 13 camera stations (each with 2 cameras) were installed for the survey of 2012. We used noncommercial camera traps triggered by infrared sensors (Marques and Ramos 2001). Each photograph included the information of date and hour. The sampling effort was 1,825 camera-days; the cameras formed a polygon of 5 km^2. After recording a male tayra with a distinctive dental abnormality, we calculated his home rage with the Kernel density estimation (due to the low number of captures, we selected 75th percentiles to avoid overestimation; Worton 1989). Finally, to determine if there are records of dental abnormalities in the genus *Eira*, we reviewed the skulls of other tayra specimens deposited in different Mammal Collections in México.

On March 4 of 2012 at 16:48 hr, we recorded an adult male tayra (based on the presence of the testicles, which reach full growth at 18 months old; Poglayen-Neuwall 1975) with an overdeveloped upper left canine (Figure 1). Additional records obtained in May ($n = 6$) of the same year allowed us to confirm this distinctive feature.

Figure 1. A) sagittal plane of a tayra (*Eira barbara*) skull with regular size canine (IIB-UV 3783). Capture (C) 1 to 11) Independent captures of tayra male with abnormal upper left canine. Arrow points at the distinctive feature.

This unusual characteristic was used to individually identify this male specimen, which was recaptured on other 10 occasions in four different camera stations, from March to September 2012 (Table 1). The captures occurred mainly during the diurnal period (n = 6, 54.54 %), and in lower proportion during the crepuscular (1 hr before and after sunrise and sunset; n = 3, 27.27 %), and nocturnal (n = 2, 18.18 %) periods. According to the recaptures, the camera traps location, and the Kernel density estimation (ArcGIS version 10; ESRI 2021), the male tayra occupied a minimum area of 4.79 km^2 (Figure 2).

Table 1. Non-invasive records of the tayra (*Eira barbara*) male in Floresta Nacional de São Francisco de Paula, Brazil, through 2012. Each capture (C) is available in Figure 1.

Number of capture	Day	Month	Hour	Latitude	Longitude
C1	4	March	16:48	29° 25′ 39.10″ S	50° 23′ 48.40″ W
C2	3	May	12:50	29° 25′ 23.60″ S	50° 24′ 6.80″ W
C3	12	May	09:03	29° 25′ 23.60″ S	50° 24′ 6.80″ W
C4	20	May	17:47	29° 25′ 39.10″ S	50° 23′ 48.40″ W
C5	27	May	17:40	29° 25′ 23.60″ S	50° 24′ 6.80″ W
C6	31	May	00:30	29° 25′ 23.60″ S	50° 24′ 6.80″ W
C7	31	May	01:41	29° 25′ 23.60″ S	50° 24′ 6.80″ W
C8	2	June	07:57	29° 25′ 9.70″ S	50° 23′ 38.10″ W
C9	13	July	11:31	29° 25′ 39.10″ S	50° 23′ 48.40″ W
C10	17	August	12:32	29° 26′ 20.30″ S	50° 23′ 55.90″ W
C11	11	September	13:54	29° 25′ 7.70″ S	50° 23′ 57.40″ W

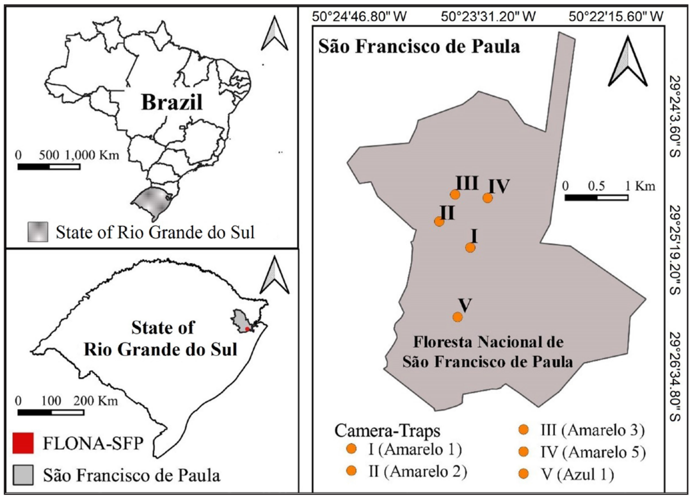


Figure 2. Study area at Floresta Nacional de São Francisco de Paula (FLONA-SFP), South Brazil, the symbols indicate the coordinates where the tayra (*Eira barbara*) were recorded from March to September, 2012. Roman numbers correspond to the name of each camera station.

In order to compare dental abnormalities among specimens, we reviewed 5 different skulls of tayra deposited in: Colección Mastozoológica del Centro de Estudios en Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre de la Universidad Autónoma de Campeche, CEDESU-UAC, *n* = 3; Colección Nacional de Mamíferos, CNMA, *n* = 1; and Colección de Mamíferos del Instituto de Investigaciones Biológicas de la Universidad Veracruzana, IIB-UV, *n* = 1; all these specimens were collected in México. Through a visual analysis we found differences in the number of molars in the mandible (it is not clear if it is a case of polydonty or oligodonty) in 2 (40 %) of the 5 skulls (Figure 3). This information matches with the adult dentition of the species in the literature: incisives 3/3, canines 1/1, premolars 3/3-4, and molars 1/1-2 (Presley 2000).

We do not have a supported explanation to the origin of this abnormal tooth. This could result from an irregular concentration of dental germ, or mutations in genes and proteins that affect tooth morphogenesis (Korablev *et al.* 2013). The physical appearance of the specimen makes us think that the abnormal canine is not an impediment to carry out their feeding habits (tayra is an opportunistic omnivore; Presley 2000). We support our statement on three facts: 1) the specimen is an adult (presence of testicles confirm that); 2) the intercostal spaces are not marked, which indicates that the specimen is fed enough to be within their healthy weight rank (from 2.7 to 7 kg; Presley 2000), and 3) apparently, there is a weight fluctuation during the months of survey (in the records of May, June and August, the specimen looks heavier).

We acknowledge that the home range where this specimen was recorded is small in comparison with previous reports. However, those home range values are the results of more exhaustive surveys and radio-telemetry, which provides coverage over larger areas and constant records of the species (see Table 2). In this study the male tayra was detected only in 5 (38.46 %) of the 13 camera stations. The captures occurred mainly during the diurnal period, matching the statement that tayras exhibit diurnal habits throughout their distribution (Villafañe-Trujillo *et al.* 2021). Besides the abnormal canine, we observed the shape of the left side of their throat patch. Both features allowed us to individually identify this specimen (Villafañe-Trujillo *et al.* 2018). Probably one or more photo captures of the right side of tayras (or photos of specimens walking away from the cameras) belongs to this particular male. To our knowledge there are no impediments for the male tayra in FLONA-SFP to occupy an area outside the survey polygon (which could increase our data of home range size).

The variation in the number of inferior premolars and molars in the literature (Presley 2000), and molars that we report could indicate: 1) that tayra have a dental variation in number of teeth through their range (probably related to the phenotype), 2) that the authors consulted by Presley (2000) inadvertently reported cases of specimens with polydonty (or oligodonty), or 3) the presence of a fourth premolar and second molar are vestigial features that only manifest in some individuals. It is necessary to analyze skulls of tayra collected through the complete range of the species to identify if the variation in the number of inferior premolars and molars is frequent, and if is restricted to a geographic region, phenotype, or sex.

This is the first report of a living Neotropical mustelid with abnormal dental characteristics recorded through a non-invasive method, and the first record for *Eira barbara*. We also report for the first time the home range of the species obtained non-invasively. We encourage the

Table 2. Home range size of *Eira barbara* obtained through radio-telemetry.

Location	Specimen	Length of survey	Number of records	Home range size (km^2)	Reference
Cockscomb Basin Forest Reserve; Belize	Male 1	3 months	20	2.11	Konecny 1989
	Male 2	10 months	95	24.44	
	Female 1	13 months	165	16.03	
Ipanema National Forest, Iperó; Brazil	Female 2	11 months	28	5.3	Michalski *et al.* 2006
Fondo Pecuario Masaguaral, Venezuelan llanos; Venezuela	Female	49 days	118	2.25 to nearly 9.00	Sunquist *et al.* 1989

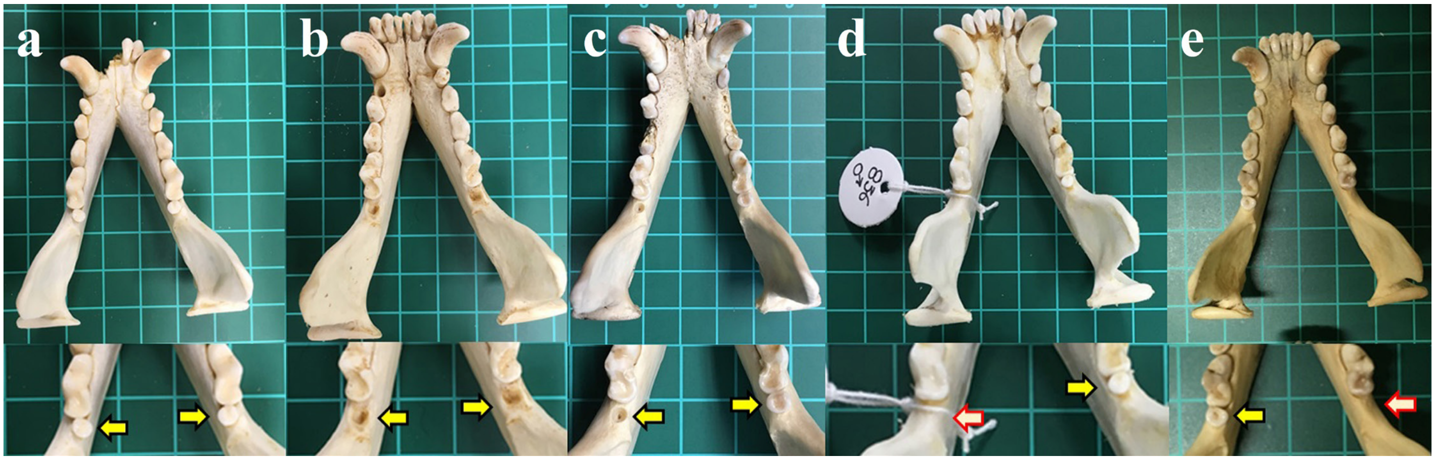


Figure 3. Ventral views of the mandible of five specimens of *Eira barbara* collected in México. The variation in the number of molars is marked (the yellow arrows indicate the presence of a second molar; the white arrows indicates the congenital lack of a second molar). Specimens a (female; CEDESU–UAC 897), b (male; CEDESU–UAC 604), and c (undetermined sex; IIB-UV 3783) had a second molar in both tooth rows (*n* = 4). Specimens d (male; CEDESU–UAC 836) and e (female; CNMA 4160) only had a second molar in one tooth row (*n* = 3). The bottom of the figure shows an enlargement of each mandible.

study of skulls of tayra in Mammal Collections to develop research about variations in dental abnormalities of this species, in order to increase our knowledge of this Neotropical mustelid.

Acknowledgements

RVM wants to thank F. de Miranda Ramos by his technical support (the assembly of the cameras) and assistance in the field. Also thank to the Staff of FLONA-SFP and Instituto Chico Mendes para la Conservación de la Biodiversidad for their effort to maintain that conservation unit. ASF-M and ÁJV-T wants to thank to A. Snyder of the Sedgwick County Zoo for her feedback regarding the teeth of captive tayras. We thank those at the Colección Mastozoológica del Centro de Estudios en Desarrollo Sustentable y Aprovechamiento de la Vida Silvestre de la Universidad Autónoma de Campeche (CEDESU-UAC), in particular O. G. Retana-Guiascón for allowed us to photograph the skulls of specimens "a", "b" and "d" (#897, #604, and #836, respectively). We thank the Colección Nacional de Mamíferos (CNMA), in particular to F. A. Cervantes, Y. Hortelano-Moncada, and J. Vargas-Cuenca for allowed us to photograph the skull of specimen "e" (#4160). We thank those at the Colección de Mamíferos del Instituto de Investigaciones Biológicas de la Universidad Veracruzana (IIB-UV), in particular to C. A. Delfín-Alfonso for allowed us to photograph the skull of specimen "c" (#3783). We thank to C. A. López-González and M. A. Ochoa-Mendoza, and two anonymous reviewers for providing helpful comments to this document.

Literature cited

Alt, K. W. 1999. Spuren in die Vergangenheit. Quintessenz Team Journal 29:685-694.

Cademartori, C. V., R. V. Marques, S. M. Pacheco, L. R. M. Baptista, and M. Garcia. 2002. Roedores ocorrentes em Floresta Ombrófila Mista (São Francisco de Paula, Rio Grande do Sul) e a caracterização de seu hábitat. Comunicações do Museu de Ciências e Tecnologia PUCRS Série Zoologia 151:61-86.

ESRI. 2021. ArcGIS v10.0 Program distributed by the author. Environmental Systems Research Institute, Inc. Redlands. California, U.S.A.

Hancox, M. 1988. Dental anomalies in the Eurasian badger. Journal of Zoology 216:606-608.

Hauer, S. 2002. Population analysis of dental anomalies of otters *Lutra lutra* from eastern Germany. Acta Theriologica 47:339-362.

Instituto Chico Mendes De Conservação Da Biodiversidade (ICMBio). 2020. Plano de Manejo: Floresta Nacional de São Francisco de Paula. In: ICMBio 2021. https://www.icmbio.gov.br/portal/images/stories/docs-planos-de-manejo/plano_manejo_flona_sao_francisco_de_paula_2020. Accessed in 26 April, 2021.

Jung, T. S., G. Rivest, D. A. Blakeburn, E. R. Hamm, A. Van Eyk, P. M. Kukka, and J.-F. Robitaille. 2016. Dental anomalies suggest an evolutionary trend in the dentition of wolverine (*Gulo gulo*). Mammal Research 61:361-366.

Konecny, M. J. 1989. Movement Patterns and Food Habits of Four Sympatric Carnivore Species in Belize, Central America. Pp. 243-264 *in* Advances in Neotropical Mammalogy (Redford, K. H., and J. F. Eisenberg, eds.). Sandhill Crane Pr. Gainesville, U.S.A.

Konjevi, D., V. Njemirovskij, M. Vukovi, A. Slavica, Z. Janicki, I. Severin, and M. Sindii. 2011. Variations in shape, number and position of teeth in Stone Martens from Island Habitats (Croatia) – Preliminary Results. Natura Croatica: Periodicum Musei Historiae Naturalis Croatici 20:215-223.

Korablev, P. N., M. P. Korablev, N. P. Korablev, and I. L. Tumanov. 2013. Odontologic anomaly in the American mink *Neovison vison* (Carnivora, Mustelidae) and possible reasons for its appearance. Russian Journal of Developmental Biology 44:321-325.

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel. 2006. World Map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift 15:259-263.

Marques, R. V., and F. M. Ramos. 2001. Identificação de mamíferos ocorrentes na Floresta Nacional de São Francisco de Paula/IBAMA, RS com a utilização de equipamento fotográfico acionado por sensores infravermelhos. Divulgações do Museu de Ciências e Tecnologia, UBEA/PUCRS 6:83-94.

Michalski, F., P. G. Crawshaw, T. G. De Oliveira, and M. E. Fabián. 2006. Notes on home range and habitat use of three small carnivore species in a disturbed vegetation mosaic of southeastern Brazil / Notes sur le territoire et l'utilisation de l'habitat de trois espèces de petits carnivores dans une végétation mosaïque perturbée au Sud Est du Brésil. Mammalia 70:1-2.

Poglayen-Neuwall, I. 1975. Copulatory behavior, gestation and parturition of the tayra. Zeitschrift für Säugertierkunde 40:176-189.

Presley, S. J. 2000. *Eira barbara*. Mammalian Species 636:1-6.

Renner, S., E. Périco, and G. Sahlén. 2016. List of Odonates from the Floresta Nacional de São Francisco de Paula (FLONA - SFP), with two new distribution records for Rio Grande do Sul, Brazil. Biota Neotropica 16:1-7.

Sunquist, M. E., F. Sunquist, and D. E. Danek. 1989. Ecological separation in a Venezuelan llanos carnivore community. Pp. 197-232 *in* Advances in Neotropical Mammalogy (Redford, K. H., and J. F. Eisenberg, eds.). Sandhill Crane Pr. Gainesville, U.S.A.

Villafañe-Trujillo, Á. J., C. A. López-González, and J. M. Kolowski. 2018. Throat patch variation in Tayra (*Eira barbara*) and the potential for individual identification in the field. Diversity 10:1-23.

Villafañe-Trujillo, Á. J., J. M. Kolowski, M. V. Cove, E. P. Medici, B. J. Harmsen, R. J. Foster, M. G. Hidalgo-Mihart, S. Espinosa, G. Ríos-Alvear, C. Reyes-Puig, J. P. Reyes-Puig, X. M. Da Silva, A. Paviolo, P. Cruz, and C. A. López-González. 2021. Activity patterns of tayra (*Eira barbara*) across their distribution. Journal of Mammalogy 102:772-778.

Winer, J. N., S. M. Liong, and F. J. M. Verstraete. 2012. The Dental Pathology of Southern Sea Otters (*Enhydra lutris nereis*). Journal of Comparative Pathology 149:346-355.

Wolsan, M. 1984. Dental Abnormalities in the Pine Marten *Martes martes* (L.) (Carnivora, Mustelidae) from Poland. Zoologischer Anzeiger Jena 213:119-127.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168.

Associated editor: Jesús R. Hernández-Montero

Submitted: May 27, 2021; Reviewed: October 30, 2021.

Accepted: November 15, 2021; Published on line: November 22, 2021.

THERYA NOTES 2021, Vol. 2 : 176-178 DOI: 10.12933/therya_notes-21-58 I SSN 2954-3614

Report of white-nosed coati (*Nasua narica*) rubbing itself with feces of tayra (*Eira barbara*) in Costa Rica

Reporte de coatí de nariz blanca (*Nasua narica*) que se frota con heces de tayra (*Eira barbara*) en Costa Rica

Frank Fleming[1], and Paul J. Weldon[2]*

[1]Ocho Verde Wildlife Preserve. La Mona de Golfito, Costa Rica. E-mail: ochoverde@gmail.com (FF).
[2]Smithsonian Conservation Biology Institute, National Zoological Park. 1500 Remount Road,
Front Royal, C. P. 22630. Virginia, U.S.A. E-mail: weldonp@si.edu (PJW).
*Corresponding author

Captive coatis (*Nasua* sp.) have been known to fur-rub with various anthropogenic materials, such as manufactured chemicals and soaps, and non-native plants. However, little is known of their anointing behavior or of the anointing materials they use in nature. We recorded the activities of free-ranging mammals in a forest clearing in Costa Rica using a ScoutGuard SG565F trail camera equipped for long-range incandescent white flash to record night images. We observed a male tayra (*Eira barbara*), an omnivorous mustelid, defecate on a fallen tree in a forest clearing. After that, 4.3 days later, an adult male white-nosed coati (*Nasua narica*) approached and nudged the tayra droppings with its snout and forepaws. It then bit a fecal bolus, conveyed it in its mouth to the base of its tail, and rubbed it on its tail using rapid alternating movements of its forepaws. This is a rare documentation of fur-rubbing by a free-ranging procyonid with naturally occurring materials, and of the use of feces for anointing by a mammal.

Key words: Anointing; behavior; chemical ecology; fur-rubbing; scent-rubbing.

Se sabe que los coatis cautivos (*Nasua* sp.) frotan su pelaje con diversos materiales antropogénicos, como productos químicos manufacturados como jabones y plantas no nativas. Sin embargo, poco se sabe de su comportamiento de unción o de los materiales de unción que utilizan en la naturaleza. Registramos las actividades de los mamíferos en libertad en un claro del bosque en Costa Rica utilizando una cámara automática ScoutGuard SG565F equipada con un flash blanco incandescente de largo alcance para grabar imágenes nocturnas. Obtuvimos un registro de un macho de tayra (*Eira barbara*), un mustélido omnívoro, que defecó en un árbol caído en un claro del bosque. Posteriormente, 4.3 días después, un coatí de nariz blanca (*Nasua narica*) macho adulto se acercó y tocó las heces de tayra con su hocico y sus patas delanteras. Luego mordió un bolo fecal, lo llevó en su boca a la base de su cola y lo frotó en su cola usando rápidos movimientos alternos de sus patas delanteras. Ésta es una documentación poco común del frotamiento del pelaje por un prociónido con materiales naturales y del uso de heces para la unción por parte de un mamífero.

Palabras clave: Comportamiento; ecología química; frotar la piel; frotar olor; unción.

Many mammals are known to rub and roll in aromatic plant- and/or animal-derived materials (Reiger 1979; Weldon and Carroll 2007). Various functions for these anointing behaviors have been suggested, such as the use of topically applied chemicals to signal home-range occupancy or to deter ectoparasites (see Charlton *et al.* 2020 for recent discussion). Identifications of the natural materials that elicit anointing in some cases have contributed to hypotheses on its function, as, for example, when mammals fur-rub with plants known to contain insecticidal phytochemicals (*e.g.*, Baker 1996).

Among the various anointing materials used by some mammals are the feces of heterospecifics (Reiger 1979; Ryon *et al.* 1986). Based primarily on observations of captive individuals, Reiger (1979) stated that canids, viverrids, and felids tend to scent-rub with the urine or feces of prey animals. Zhou *et al.* (2020), who recently reported that free-ranging giant pandas (*Ailuropoda melanoleuca*) in China rub and roll in horse manure, stated that attraction to feces for anointing by wild mammals is extremely rare. Here, we report an observation of a free-ranging white-nosed coati (*Nasua narica*) in Costa Rica anointing with the feces of a tayra (*Eira barbara*), an omnivorous mustelid that chiefly consumes fruits, carrion, small vertebrates, and invertebrates (Presley 2000).

Observations were made during 2015 in a humid, lowland, old growth secondary forest in the southwestern corner of Costa Rica near Golfito, Puntarenas province. A site with an open canopy created by fallen trees was monitored using a ScoutGuard SG565F trail camera

(HCO Outdoor Products, Norcross, Georgia) 8MP equipped with a long-range incandescent white flash to record night images. The camera was mounted 1.8 m above ground on a vertical branch facing the trunk of a large fallen tree and was programed to re-set after 30 sec of filming. A variety of vertebrates, including greater grison (*Galictis vittata*), ocelot (*Leopardus pardalis*), Panamanian white-faced capuchin monkey (*Cebus imitator*), agouti (*Dasyprocta punctata*), hog-nosed skunk (*Conepatus leuconotus*), northern tamandua (*Tamandua mexicana*), Tomes spiny rat (*Proechimys semispinosus*), and red-tailed (*Sciurus granatensis*) and Alfaro's pygmy squirrels (*Microsciurus alfari*), were recorded at the site over a period of approximately 4 months.

On December 14, 2015 at 13:12 hr, a male tayra was recorded walking on the fallen tree trunk, lowering its hindquarters, elevating its tail, and depositing at least five light-colored fecal boli (Figure 1a). On December 19 at 10:01 hr, 4.3 days later**,** an adult male white-nosed coati approached and nudged the tayra droppings with its snout and forepaws. It then bit a fecal bolus (Figure 1b), conveyed it in its mouth to the base of its tail, and rubbed it on its tail using rapid alternating movements of its forepaws (Figure 1c), a typical anointing behavior for coatis. The coati fur-rubbed for 20 s before filming was interrupted when the camera re-set. When recording resumed, the coati was out of the activation area.

Reiger (1979), who reviewed scent-rubbing among carnivores, stated that the more arboreal procyonids never scent-rub or do so only under exceptional circumstances, *e.g.*, with artificial scent sources. Historical accounts describe coatis (*Nasua* sp.) in zoos anointing with manufactured chemicals, including benezene, and valerian (*Valeriana officinalis*), a medicinal herb native to Europe and Asia (Schneider 1932; Schneider 1952). More recently, captive white-nosed coatis were reported to fur-rub with lemons and other citrus fruits (Weldon *et al.* 2011). *Citrus* spp. originated in Asia and were transported to the New World during the early 1500s by Portuguese and Spanish conquistadores. Citrus trees are now widespread in America, but it is not known whether free-ranging coatis use their fruits for anointing. Curiously, a group of free-ranging ring-tailed coatis (*Nasua nasua*) on Ilha do Campeche, a resort island in Brazil, self- and allo-anointed with soaps brought by tourists (Gasco *et al.* 2016).

Documentations of fur-rubbing with manufactured substances or non-native plants ultimately may enhance appreciation for the range of chemicals that elicit anointing behaviors. Such observations also may provide preliminary evidence for a species' propensity to anoint. Ryon *et al.* (1986), for example, observed that wolves (*Canis lupus*) exhibited their strongest fur-rubbing responses to manufactured odors, including motor oil and perfume. However, it is unclear whether the reported use of anthropogenic materials can elucidate the origin or function of anointing (see Weldon 2021).

Aside from the use of tayra feces reported here, free-ranging white-nosed coatis in Panamá self- and allo-anoint with tree (*Trattinnickia*) resin, possibly to deter ectoparasites (Gompper and Hoylman 1993). Further observations of free-ranging animals may provide clues on the functional significance of anointing behavior among coatis and other procyonids.

Acknowledgements

H. Drummond and H.W. Greene commented on the paper. S. Cox and W. West (Smithsonian Libraries, Washington, D.C.) provided valuable references. J. Greff (Tonal Vision, LLC, Baltimore, Maryland) prepared Figure 1. Two anonymous reviewers improved earlier versions of the manuscript.

Literature cited

Baker, M. 1996. Fur rubbing: use of medicinal plants by capuchin monkeys (*Cebus capucinus*). American Journal of Primatology 38:263-270.

Charlton, B. D., M. A. Owen, H. Zhang, and R. R. Swaisgood. 2020. Scent anointing in mammals: functional and motivational insights from giant pandas. Journal of Mammalogy 101:582-588.

Figure 1. a) A tayra (*Eira barbara*) defecates on a fallen tree, leaving a fecal pile, b) 4.3 days later, a white-nosed coati (*Nasua narica*) bites a fecal bolus and c) rubs it on its tail.

Gasco, A. D. C., A. M. Pérez-Acosta, and P. F. Monticelli. 2016. Ring-tailed coatis anointing with soap: a new variation of self-medication culture? International Journal of Comparative Psychology 29:1-11.

Gompper, M. E., and A. M. Hoylman. 1993. Grooming with *Trattinnickia* resin: possible pharmaceutical plant use by coatis in Panama. Journal of Tropical Ecology 9:533-540.

Presley, S. J. 2000. *Eira barbara*. Mammalian Species 636:1-6.

Reiger, I. 1979. Scent rubbing in carnivores. Carnivore 2:17-25.

Ryon, J., J. C. Fentress, F. H. Harrington, and S. Bragdon. 1986. Scent rubbing in wolves (*Canis lupus*): the effect of novelty. Canadian Journal of Zoology 64:573-577.

Schneider, K. M. 1932. Das Flehmen (III. Teil). Der Zoologische Garten 5:200-226.

Schneider, K. M. 1952. Einige Bilder zur Paarung der Fleckenhyäne, *Crocuta crocuta* Erxl. Der Zoologische Garten 19:135-149.

Weldon, P. J, and J. F. Carroll. 2007. Vertebrate chemical defense: secreted and topically acquired deterrents of arthropods. Pp. 47-75 *in* Insect repellents: Principles, Methods, and Uses (Debboun, M., S. P. Frances, and D. Strickman, eds.). CRC Press. Boca Raton, Florida, U.S.A.

Weldon, P. J., J. F. Carroll, M. Kramer, R. H. Bedoukian, R. E. Coleman, and U. R. Bernier. 2011. Anointing chemicals and hematophagous arthropods: responses by ticks and mosquitoes to citrus (Rutaceae) peel exudates and monoterpene components. Journal of Chemical Ecology 37:348-359.

Weldon, P. J. 2021. Why do giant pandas (*Ailuropoda melanoleuca*; Carnivora: Ursidae) rub and roll in heterospecific scents? Chemoecology 31:225-226.

Zhou, W., S. Yang, B. Li, Y. Nie, A. Luo, G. Huang, X. Liu, R. Lai, and F. Wei. 2020. Why wild giant pandas frequently roll in horse manure. Proceedings of the National Academy of Science of the United States of America 117:32493-32498.

Associated editor: Tamara M. Rioja-Paradela
Submitted: July 9, 2021; Reviewed: October 28, 2021.
Accepted: November 18, 2021; Published on line: November 23, 2021.