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Noteworthy records of abnormal coloration in Mexican bats

Registros notables de coloración anormal en murciélagos mexicanos

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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

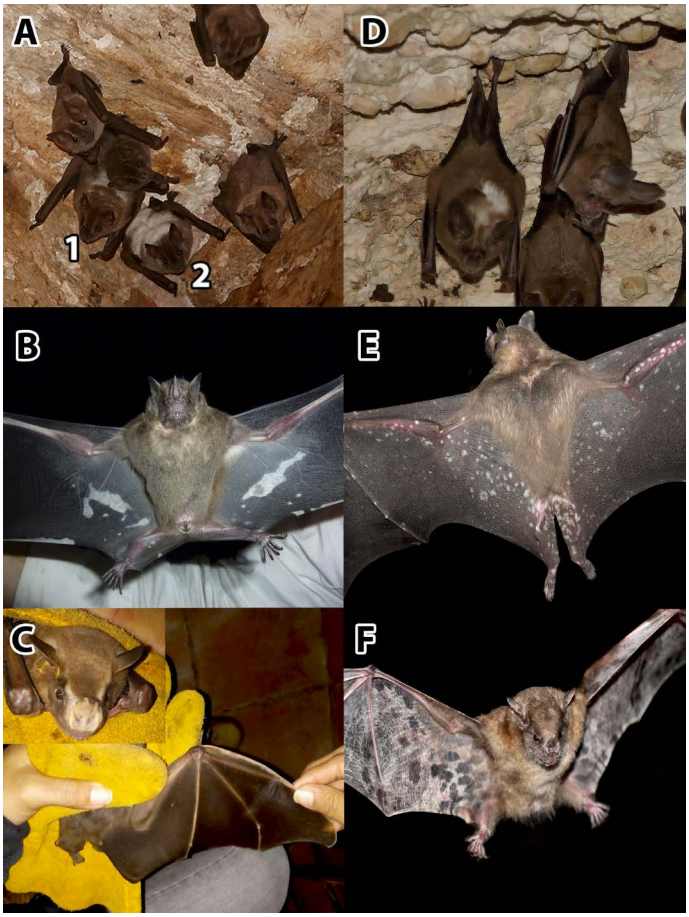

Figure 1. A) Two adults of *Artibeus jamaicensis* with notorious white spots covering most of their back, individual 1 was not captured, individual 2 is an adult male (Photograph of J. Cruzado); B) Adult female of *Artibeus jamaicensis* with white spots at the middle and edge of the plagiopatagium and 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).

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.

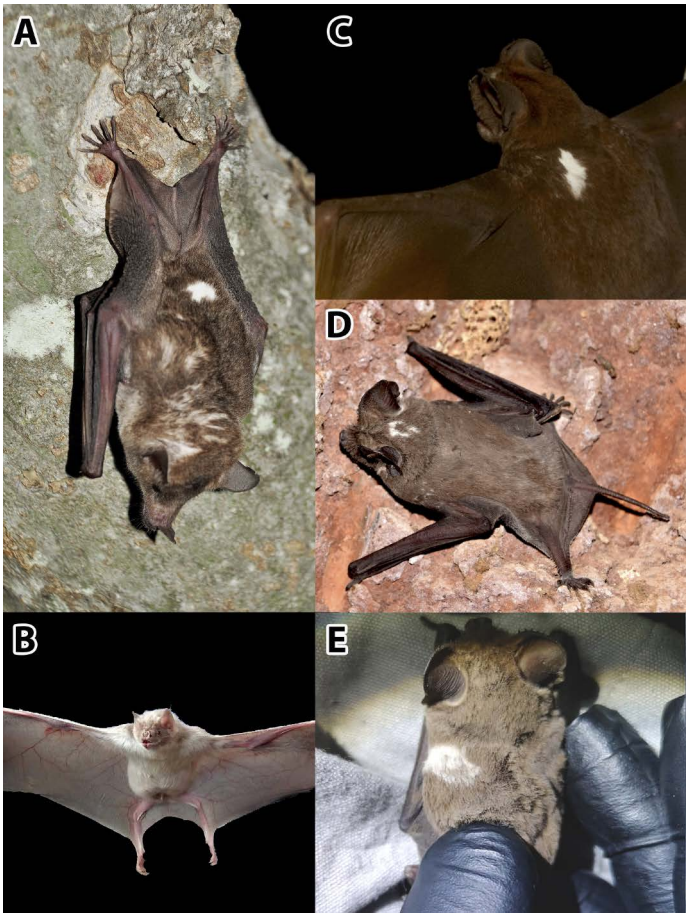

Figure 2. A) Adult male of *Glossophaga soricina* with a white spot in the lower back (Photograph of M. Aguilar); B) Specimen of *Desmodus rotundus* with albinism (Photograph of C. Escorcia-Zuñiga); C) *Nyctinomops laticaudatus* presenting a white spot in its left shoulder (Photograph of M. Aguilar); 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.

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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).